



Single Point Mooring

Maintenance and Operations Guide (SMOG)

Third Edition 2015



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The OCIMF mission is to be the foremost authority on the safe and environmentally responsible operation of oil tankers, terminals and offshore support vessels, promoting continuous improvement in standards of design and operation

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Introduction

This Guide contains technical recommendations and guidance for the operation and maintenance of single point moorings (SPMs). It supersedes the following documents:

- *Single Point Mooring Maintenance and Operations Guide* (2nd edition, 1995).
- *Guidelines for the Handling, Storage, Inspection and Testing of Hoses in the Field* (2nd edition, 1995).
- *SPM Hose Ancillary Equipment Guide* (3rd edition, 1987).

All three publications have been updated to reflect gained experience, revised procedures, current best practices and equipment developments.

This Guide builds on previous recommendations. The following are among the new or significantly changed topics included in this edition:

- Section 2 – Design of SPM systems, including preliminary design considerations, site selection and the cargo transfer system including hose systems.
- Section 3 – Operation of SPMs now includes:
 - Operating environmental limits.
 - Guidance to ensure hoses are lifted safely within tanker crane capacity.
 - Guidance and actions regarding ship/shore cargo quantity comparison.
 - Qualification and training of personnel, including Mooring Master skills and competence.
- Section 4 – Inspection and maintenance now includes time-based schedules based on terminal experience and more detailed inspection procedures for mooring systems. Flushing procedures are also addressed.
- Section 5 – This section is devoted to the use of hoses, including:
 - Storage, handling and hose string assembly.
 - Hose time in service data from terminals.
 - Specific guidance following overpressure.
 - Hose inspection and testing.
 - Information on marine breakaway couplings.
- Appendix A – Contains health, safety, security and environment (HSSE) guidance, referencing *Marine Terminal Management and Self Assessment* (MTMSA) processes.
- Appendix D – Provides information on support vessels and the use of tugs.

This Guide does not intend to cover specialised deep-water moorings, such as steel riser applications. The sections on hoses cover the applications included in the *Guide to Manufacturing and Purchasing Hoses for Offshore Moorings* (2009).

The Guide contains recommendations on safety, design and good operating practices. However, it is recognised that if more stringent international, national or local regulations apply, those regulations must take precedence.

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Abbreviations

API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials (now known as ASTM International)
BS/EN	British Standards/European Norm
CALM	Catenary Anchor Leg Mooring
ETOP	Emergency Towing-Off Pennant
FPSO	Floating Production, Storage and Offloading Unit
HAZID	Hazard Identification
HAZOP	Hazard and Operability (analysis)
HPU	Hydraulic Power Unit
HSSE	Health, Safety, Security and Environment
IACS	International Association of Classification Societies
IAPH	International Association of Ports and Harbors
ICS	International Chamber of Shipping
IMO	International Maritime Organization
ISGOTT	International Safety Guide for Oil Tankers and Terminals
ISO	International Organization of Standardization
ISPS	International Ship and Port Facility Security
MAWP	Maximum Allowable Working Pressure
MBC	Marine Breakaway Coupling
MBL	Minimum Breaking Load
MBR	Minimum Bend Radius
MMA	Mooring and Manoeuvring Area
MTMSA	Marine Terminal Management and Self Assessment
OCIMF	Oil Companies International Marine Forum
PFS	Process Flow Scheme
PLEM	Pipeline End Manifold
PPE	Personal Protective Equipment
QRC	Quick Release Coupling
RWP	Rated Working Pressure
SALM	Single Anchor Leg Mooring
SPM	Single Point Mooring
SWL	Safe Working Load
UKC	Under Keel Clearance

Glossary

Within this Guide, the terms below have the following meanings:

B

Banksman A person who directs the operation of a crane.

Bow chain stopper A mechanical device for securing chafe chains (see below) on board a tanker.

C

Cathodic protection The prevention of corrosion by electrochemical techniques.

Chafe chain A length of stud link chain at the end of a single point mooring (SPM) hawser. It passes through a ship's fairlead and connects the SPM hawser to a tanker's bow chain stopper.

Class A Classification Society is a non-governmental organisation (NGO) that establishes and maintains technical standards for the construction and operation of ships and offshore structures.

Conventional tanker An oil tanker equipped for regular trading. It is not specially designed or adapted for loading at offshore terminals that require specialised mooring or bow loading equipment.

D

Displacement The mass of water displaced by a vessel, at a given draught, in metric tonnes.

E

Enclosed space A space that:

- Has limited openings for entry and exit.
- Has unfavourable natural ventilation.
- Is not designed for continuous worker occupancy.

Ex Code e (Ex e) Increased safety standard for motors, lighting and junction boxes. Robust and high quality equipment to IEC/EN standard 60079-7.

Ex Code i (Ex i) Intrinsically safe standard for instrumentation, measurement and control to IEC/EN standard 60079-11, 25 and 27.

F

Flow rate The linear velocity of flow of liquid in a pipeline, as measured in metres per second.

G

Gas free A tank, compartment or container is gas free when sufficient fresh air has been introduced into it to lower the level of any flammable, toxic or inert gas to that required for a specific purpose, e.g. hot work, entry, etc.

H

Hazardous area An area that is regarded as dangerous for the purposes of the installation and use of electrical equipment. Such areas are graded into hazardous zones according to the probability of the presence of a flammable gas mixture.

M

Marine breakaway coupling (MBC) A device designed to protect the cargo transfer system and the hose assembly against surge pressures and/or axial tension in the hose. It automatically shuts off liquid flow and separates before the hose's integrity is damaged.

Messenger rope A light fibre rope used to heave the mooring pick-up rope on board the tanker.

Minimum breaking load (MBL) The manufacturer's declared minimum breaking load of a new rope or chain. It does not allow for splicing or wear and tear.

Mooring leg A chain assembly used to moor a buoy to the seabed.

P

Pelican or slip hook A type of rigging shackle that includes an arrangement to facilitate quick release.

Permit to work A document issued by a responsible person that allows work to be performed in compliance with a Safety Management System (SMS).

Petroleum Crude oil and the liquid products derived from it.

Pick-up rope A fibre rope used to lift the mooring chafe chain on board the tanker.

Pigging In the context of pipelines, pigging refers to the practice of using devices known as pigs to perform various maintenance operations on a pipeline.

Pipeline end manifold (PLEM) A structural base supporting a piping manifold. It facilitates the subsea termination of the pipeline and the connection to the marine hoses.

Piping class A pipe's pressure rating.

Q **Quick release coupling (QRC)** A manual or hydraulic mechanical device used to clamp the rail hose presentation flange to the ship's manifold without the use of bolts.

R **Rated working pressure (RWP)** This is also known as, and is equivalent to, the maximum rated working pressure, and the maximum allowable working pressure (MAWP). *The International Safety Guide for Oil Tankers and Terminals* (ISGOTT) (Reference 12) states that rated working pressure is the common oil industry reference that defines the maximum cargo system pressure capabilities. This pressure rating is not expected to account for dynamic surge pressures, but it does include nominal pressure variations to a maximum of 10%, as would be expected during normal cargo transfer operations, due to the change in velocity that results from the shutting down of a pump or the closing of a valve.

S **Safe working load (SWL)** A load less than the yield or breaking load, by a safety factor defined by code, standard or good engineering practice.

Single point mooring (SPM) An integrated mooring arrangement for bow mooring a conventional tanker. For example, a conventional tanker's bow mooring arrangements to a catenary anchor leg mooring (CALM), a single anchor leg mooring (SALM) or a floating production, storage and offloading unit (FPSO).

Snubbing chain A length of suitably sized chain used to support hoses when connecting to a tanker's manifold.

Solitary wave or Soliton A large single wave.

Summer deadweight The displacement at summer draught, minus the lightship weight in metric tonnes.

Surge pressure Occurs in a cargo transfer system when the flow in a pipeline is stopped too quickly by closing a valve or stopping a pump. The water or oil will attempt to continue flowing, causing an increase in pressure that can damage the pipe.

T **Tandem mooring** A hawser mooring arrangement between two vessels, either bow-to-bow or bow-to-stern. In the context of this Guide, tandem mooring refers to the mooring arrangement between the bow of a conventional tanker and the stern or bow of an FPSO.

Tonne Metric tonne equalling 1,000 kilograms.

U **Under keel clearance (UKC)** The distance between the vessel's bottom, at its deepest point of immersion, and the seabed or any objects resting on the seabed (for example, submarine pipelines, manifolds or concrete clumps).

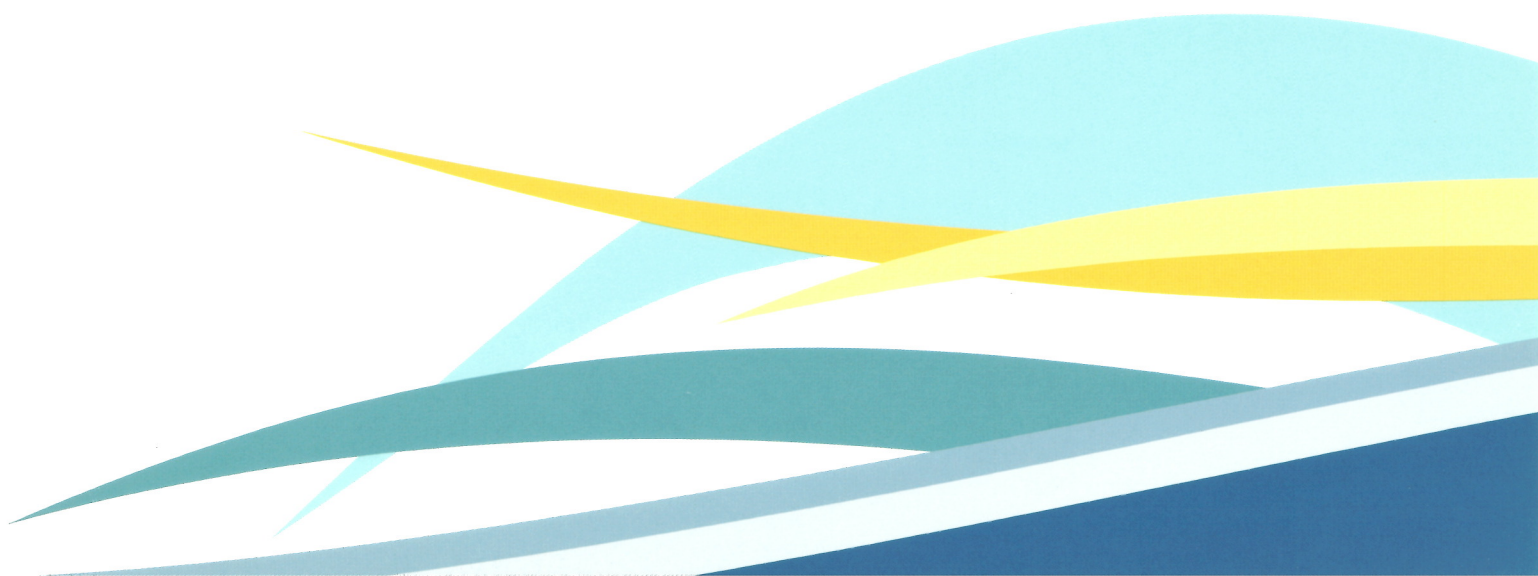
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- 20** ASME B31.3 Process Piping; refer to paragraph 304.5.1 for torque settings (refers to ASME 8, Division 1, Appendix 2)
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Section one

Description of single point moorings

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Single point moorings (SPMs) are particularly suited to the handling of large tankers at offshore locations. The tanker is moored to a single buoy by one or two hawsers, with the buoy moored to the seabed by one or more anchor legs. At an SPM, cargo transfer between the tanker and the seabed pipeline end manifold (PLEM) is through a flexible hose system, which allows a moored tanker to weathervane around the SPM. This feature significantly improves the operating envelope of the terminal when compared to fixed-pier or multi-buoy mooring berths.

Some SPMs are designed to handle a number of different cargoes. However, fixed-pier berths, which offer more flexible pipeline and loading arm configurations, can handle a greater range of cargoes.

There are two types of SPM buoy commonly in use as tanker terminals; the catenary anchor leg mooring (CALM) buoy and the single anchor leg mooring (SALM) buoy.

1.1 - Catenary anchor leg mooring buoys

CALM buoys are moored to the seabed, usually by six or eight anchor chains. A floating hose system connects the tanker's amidships manifold to the buoy and a submarine hose system connects the buoy to the PLEM.

CALM buoys are typically either turntable or turret types. Each type has different rotating parts, but both turntable and turret buoys have the same functionality, marine operation and operating envelope.

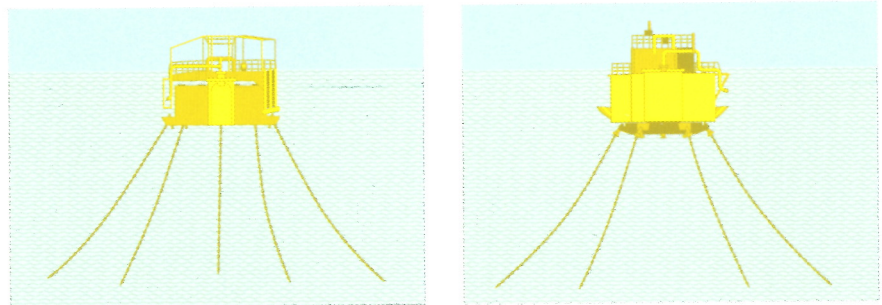


Figure 1.1: Types of catenary anchor leg mooring buoy (NB: for clarity not all anchor chains shown)

1.1.1 Turntable buoy

The turntable buoy has a fixed body with anchor chains attached to its perimeter. A rotating turntable is mounted on top of the buoy body via a large-diameter bearing, which allows a moored tanker to weathervane. In some designs, the turntable may be replaced by fabricated arms.

The turntable typically carries three platforms:

- Mooring platform, providing the connection for the mooring hawser.
- Cargo piping support and/or hose piping platform.
- Counterbalance and/or boat landing platform.

Cargo piping runs through the central space of the buoy via the cargo swivel, over the turntable and then overboard to the floating hose arrangement. The centre well is normally open at the bottom, providing a moon pool in the centre of the buoy.

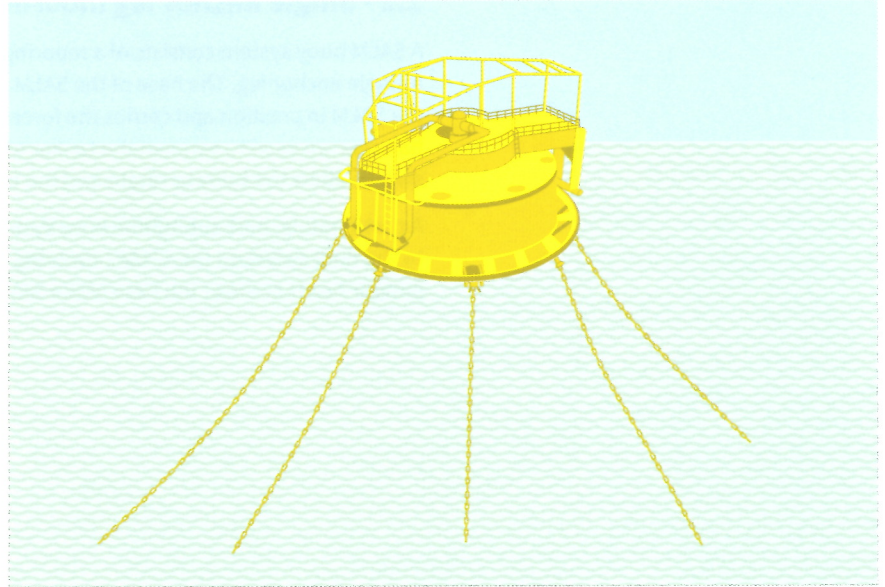


Figure 1.2: *Typical turntable buoy*

1.1.2 Turret buoy

Turret buoys usually have an enclosed central well and a deckhouse.

On a turret buoy, the mooring platform, cargo piping support and counterbalance platform are integrated into the buoy body, which rotates around a central turret. The buoy body provides buoyancy and, because it rotates, it allows a moored tanker to weathervane around the turret.

Anchor chains are attached to the lower end of the turret, which connects to the buoy body through a large-diameter bearing. Cargo piping runs through the central space of the turret, via the cargo swivel and over the buoy deck, to the overboard pipe connection for the floating hose arrangement.

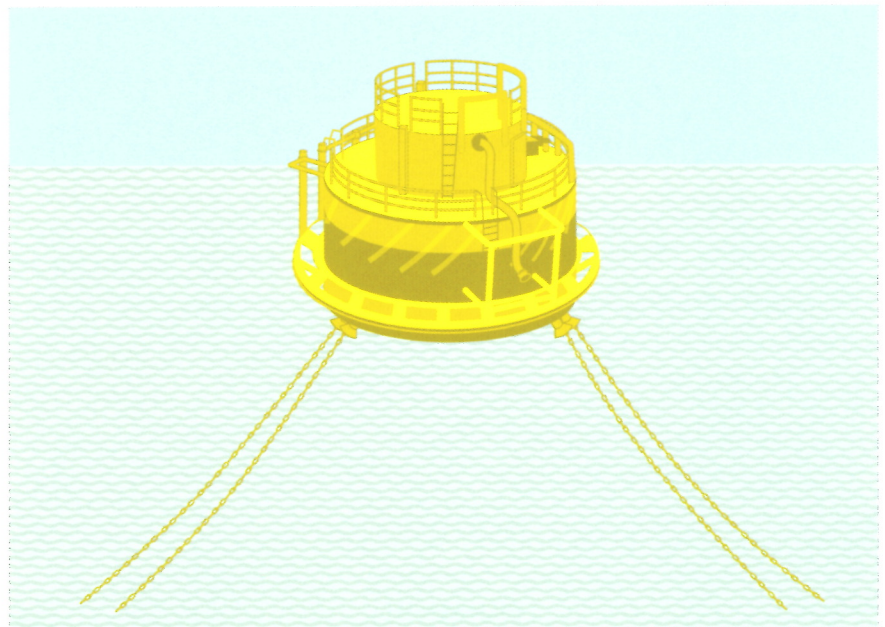


Figure 1.3: *Typical turret buoy*

1.2 - Single anchor leg mooring buoy

A SALM buoy system consists of a mooring buoy attached to a gravity or pile base by a single anchor leg. The base of the SALM buoy is the main structural part that holds the SALM in position and carries the forces from the tanker mooring loads. One or two hawsers are used to connect the tanker to the buoy and the anchor leg, and cargo swivels allow the buoy to rotate and the tanker to weathervane.

A part-floating, part-submarine hose system connects the tanker's amidships manifold to the fluid swivel on the SALM's mooring base, as shown in figure 2.4. Rigid piping or jumper hoses connect the base of the SALM to a seabed PLEM.

Section two

Design of single point moorings

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2.1 - General design considerations

This section provides guidance on the planning and design of new single point mooring (SPM) terminals, from the initial concept to site selection and system design.

2.1.1 Conceptual risk assessment of proposed terminal

When planning a new facility served by an SPM, it is recommended that an assessment and risk analysis takes place that considers, as a minimum:

- Health, safety, security and environment (HSSE).
- Petroleum cargo types, throughput and utilisation requirements (see section 2.1.3).
- Range of tanker sizes to be handled (see section 2.1.4).
- Operations and maintenance philosophy, including power, control and monitoring requirements (see section 2.1.5).
- Environmental and site conditions (see section 2.1.6).
- Geographic site location, boundary limits and available water depths (see section 2.1.7).

2.1.2 Establishing design considerations

During the initial planning of an SPM, it is recommended that design considerations for the facility are established that include:

- Mooring and unmooring operations and the physical constraints of the mooring and hose-handling system.
- Safe operation of the facility and its ongoing maintenance. Studies are normally undertaken as a joint effort involving various specialists with engineering, operations and commercial interests.
- Risk of damage to the SPM when it is subjected to environmental conditions with various recurrence intervals, e.g. 50 and 100 year extreme events.
- Planned life and intended use of the SPM.
- Total cost of ownership, including the business impact of the SPM being unavailable.
- Third party constraints, e.g. adjacent industrial and leisure activities, proximity to fishing grounds, local authority limitations and the movement of marine traffic in the area.
- Environmental limitations for operations. This includes reviews of available historical information or data from similar facilities operating in the area.

2.1.3 Products to be handled

SPMs usually have one, two or occasionally three separate cargo lines. The number of cargo lines is limited by both the relatively high cost of subsea pipelines and the risk of multiple hose strings becoming entangled.

Batch handling techniques may enable multiple cargo products to be transferred through a single line, although product separation is unlikely to be as efficient as it is when separate lines are used.

It is recommended that the range of petroleum products likely to be handled should be identified and a full assessment of each product's composition is completed. The properties of the products to be handled will impact on the design of the system. This is particularly true where aromatic hydrocarbons (e.g. benzene) and toxic and corrosive gases (e.g. hydrogen sulphide (H_2S)) are likely to be handled. Hose liners, buoy swivel seals, expansion joints and any ancillary equipment seals should be constructed from materials that are fully compatible with the aromatic content and handling temperature of the intended products.

The implications of any potential for gelling (wax formation) due to a product's high pour point or high viscosity should be fully assessed and appropriate operational or design measures established.

2.1.4 Tankers and system capacities

The SPM should be designed to accommodate the full range of tanker sizes expected. It is recommended that the intended system availability and capacities are analysed to ensure that the design of the SPM and its various components are capable of

handling the intended ship sizes within the industry accepted turn-around times for loading and/or discharging. This will ensure efficient use of the facility and protect the associated shore terminal from operational disruptions. The following parameters are typically modelled:

- Import/export profiles.
- Pipeline and SPM system flow rates and capacity.
- Tanker scheduling.
- Parcel size.
- Tanker pumping capacity.
- SPM availability:
 - Planned SPM use and berth occupancy.
 - Mooring/unmooring operational windows.
 - Environmental limits and predicted downtime.
 - Predicted maintenance downtime.
 - SPM spares policy.
 - Use and availability of tugs and support vessels.
- Shore terminal:
 - Storage tank capacity.
 - Cargo segregation and number of grades.
 - Cargo throughput.
 - Turnaround and maintenance requirements.
 - Export pump capacity.
 - Custody transfer system.
 - Pressure surge protection.

2.1.5 Operation and maintenance philosophies

Detailed design criteria for an SPM terminal will be affected by the proposed operation and maintenance philosophies that are essential for the successful performance of the terminal.

When defining the operation and maintenance philosophies, the elements that should be considered include:

- Marine operations.
- Flushing hoses and pipelines.
- Inspecting pipelines.

Detailed inspection and maintenance requirements for hoses and pipelines are included in section 4.

2.1.5.1 Marine operations

The marine operations to be assessed include:

- Use of tugs, including static towing.
- Pilotage, passage and contingency planning.
- Mooring.
- Hose connection.
- Cargo transfer operations.
- Communications.
- Emergency and oil spill response.
- Inspection, repair and maintenance of the SPM.
- Support vessel operation and maintenance.
- Diving support. Site selection may be influenced by dive capability, e.g. avoiding areas of strong currents and depths below 50 metres for all SPM components.
- Shore-based facilities, for example hose warehouse and floating hose string building.

2.1.5.2 Flushing requirements

Flushing is increasingly carried out from support vessels rather than from tankers (see section 4.7). SPMs have specific requirements for flushing that affect their design.

Hoses and pipework may need to be flushed for operational or maintenance reasons. Operational reasons may include:

- Separation of different petroleum products.
- Clearance of cargo from the line to prevent possible solidification and line blockage.
- Clearance of cargo from the line to prevent environmental pollution.

Maintenance reasons for flushing may include:

- Disconnection of hose strings from the SPM.
- Replacement of floating or submarine hoses.
- Hydrostatic pressure tests on the SPM and hoses.
- Replacement of swivel and buoy piping.
- Inspection of pipelines and loading of the pipeline inspection guide (pig) trap.
- Commissioning or decommissioning the SPM.

When developing flushing requirements and procedures, issues that should be considered include:

- The ability to isolate parts of the cargo transfer system.
- The flushing fluid and its compatibility with hose liner and system seals.
- Flush fluid storage, reception and disposal.
- The use of soft or gel pigs to remove petroleum residues.
- Flushing direction, i.e. towards the shore, towards the SPM or loop flushing.
- Process monitoring of the flush.
- Effectiveness of the flush. Terminals should develop procedures, including the minimum volume, pressure or flow rate required to remove all oil residues. Terminals have successfully used gel pigs to ensure an effective flush with minimum water use.
- Position of the fluid interface in the transfer system.
- Cargo system design and equipment such as valves, tie-in points and bypasses.
- Identification of isolated sections of pipelines (dead legs).
- Ability to perform a hydrostatic pressure test.

2.1.5.3 Pipeline inspection

SPMs may have specific requirements for pipeline inspection that affect their design.

Terminals should develop an inspection scheme for the subsea pipeline and the PLEM. It will usually be necessary to design the cargo transfer system so that intelligent pigs may be run between the PLEM and the shore. It is not usually possible to run a pig through the hoses and buoy piping.

Typical aspects to consider when defining pig requirements are:

- Arrangements for loading and unloading the pig to and from the pipeline.
- The use of cleaning pigs to remove residues and prepare the pipeline for inspection.
- In-line inspection procedures and the running of intelligent pigs.
- The need to pig pipelines before commissioning.
- Operational requirements to run soft or gel pigs to batch different petroleum types.

2.1.6 Environmental design conditions

ISO 19901-1 (Reference 1) provides guidance on the meteorological and oceanographic factors affecting the design and operation of offshore terminals. The following should also be considered:

- Water depth and tidal ranges, with reference to chart datum.
- Temperature:
 - Air temperatures.
 - Seawater temperatures, both surface and subsea.

- Marine growth thickness as a function of the geographic location and water depth.
- Water salinity.
- Visibility in air and water.

2.1.6.1 Tanker motion study/analysis

The results of the meteorological and oceanographic assessment should be used to conduct a tanker motion study/analysis for the various types of tankers likely to operate at the berth, in a variety of load and ballast conditions. The findings of this study will enable the following parameters to be identified:

- Mooring-load bearing performance requirements for all components of the tanker mooring system.
- Environmental operating limits.
- Operational availability of the berth: forecast periods of uptime and downtime.
- Required under keel clearance (UKC) permissible under specified environmental conditions (see section 2.2.3).

2.1.7 Hydrographic, geotechnical and geophysical surveys

Soil borings at the PLEM site, mooring leg anchor/pile sites and pipeline route should be performed before a detailed engineering design is created for the SPM system. The geotechnical report should provide sufficient engineering information to support the design of the PLEM's foundation and pipeline and to enable the evaluation of the anchor/pile points for the SPM's mooring legs. The geotechnical report should also include information on silting and scouring.

Hydrographic, geotechnical and geophysical surveys should be used to determine the:

- Water depth in the approaches to the SPM, in the SPM area and along the pipeline route.
- Features of the seabed relevant to the SPM's design, such as outcrops, reefs or obstacles.
- Sub-seabed conditions to a suitable depth for PLEM design, anchor or pile system design, pipeline stability and trenching.

It is recommended that surveys are performed over a large enough area to enable the optimal selection of pipeline routes, PLEM location and tanker approach.

2.2 - Site selection and layout

2.2.1 General

It is recommended that simulation studies are used to verify the proposed tanker approach and manoeuvres into the berth and to identify all possible situations in which tug support may be required.

Consideration should be given to tanker approach and departure routes to and from the berth. It should be possible for a tanker to manoeuvre into a berth with limited or no assistance from tugs. The tanker's ability to leave the berth rapidly in an emergency should be taken into account.

2.2.2 Provision of an adequate manoeuvring area

Measures to reduce risk in the manoeuvring area usually include:

- Establishing an exclusion zone.
- Burying pipelines.
- Creating rock berms or other protective structures.

The design process should take account of the need for adequate manoeuvring room around the SPM. There are no fixed rules that can be applied to determine the minimum manoeuvring area or the minimum clearance from fixed facilities or obstructions. These should be determined by a risk/consequence assessment that takes into account the:

- Route tankers will take from the sea to approach the SPM.
- Tug assistance to be used.

- Mooring operation.
- Size of the swinging area around the SPM, taking into account the hawser length, maximum tanker length and, where required, adequate space for tugs and static towing arrangements.
- Departure procedures.
- Tanker breakout and emergency departure procedures.
- Operational environmental conditions.
- Tanker draught and water depth at each stage of operations.
- Passage plan's final abort position.
- Detailed input from the local harbour authority and pilots.

The SPM site should be selected to remain a safe distance from obstructions and to avoid:

- Interaction of tankers with adjacent facilities during normal approach and departure.
- Channels and anchorages.
- Existing infrastructure, such as pipelines and cables.
- Navigational buoys.
- Fishing activities.
- Environmentally sensitive areas.

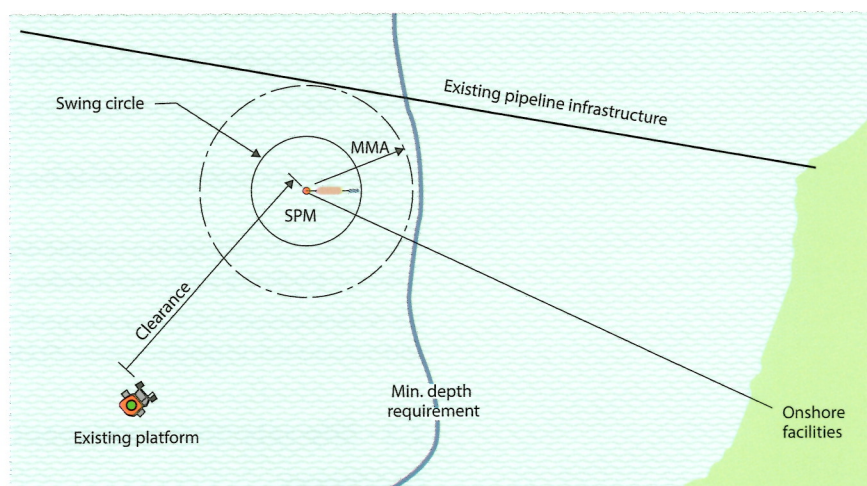


Figure 2.1: Single point mooring manoeuvring area

2.2.3 Provision of adequate water depth

Port authorities and tanker operators may stipulate a minimum UKC that should be taken into account when designing the berths.

When selecting a suitable site, adequate water depth for the full range of ships that may call at an SPM is a key factor. To maintain an adequate UKC, the water depth must be sufficient at the berth and in the approach and manoeuvring areas.

Terminals should develop their own UKC policy based on the following considerations:

- **Transit UKC.** Water depths are critical when a tanker is in transit from and to deep water. It is important that the appropriate transit UKCs are defined in consultation with the local harbour authority, pilots and tanker operators. Calculation of the transit UKC requirement involves consideration of:
 - Tidal height.
 - Waves (including swell and long period oscillations).
 - Squat.
 - Seabed material.
 - Bathymetry inaccuracies.
 - Water density.
 - Appropriate safety factors.

- **Berth UKC.** The SPM should be located to ensure adequate water depth in the immediate berth area. The calculation should include a wave response analysis for determining a ship's heave and pitch, which will ensure adequate berth UKC is available in the worst case environmental conditions.
- **Seabed obstructions.** The SPM should be sited in sufficient water depth for tankers to achieve the required UKC to avoid damaging the PLEM and subsea pipelines when moored during the worst case environmental conditions.

The position of the PLEM and a tanker's clearance from it may influence the choice of hose configurations (see section 2.6.1). For example, the Lazy 'S' system requires an offset PLEM, while the Chinese lantern PLEM is located directly below the SPM.

2.3 - Mooring load transfer system and load analysis

The basis for a mooring system design depends on the peak mooring loads exerted by the tanker on the system. Environmental forces should be considered from all directions.

The designer should be aware of the significance of the various factors and how mooring loads and mooring performance could be affected by a change in a parameter.

2.3.1 Mooring load transfer system

The mooring load transfer system comprises the load bearing components that transfer loads from the tanker bow chain stopper, through the SPM, to the seabed mooring leg anchor points. The SPM components designed to transfer the mooring loads vary for different SPM designs.

Typically, SPM buoys are anchored to the seabed by six or eight anchor chains that are designed to remain functional if one anchor leg fails. No anchor leg catenary should come into contact with the pipeline, PLEM or submarine hoses when the buoy moves under either operational or survival conditions. The mooring analysis should include a finite element stress analysis through the most highly loaded mooring path, taking into account the entire system from anchor point to tanker.

2.3.1.1 Hawser and chafe chain

Single or double mooring hawser and chafe chain arrangements should be fitted in accordance with the *Recommendations for Equipment Employed in the Bow Mooring of Conventional Tankers at Single Point Moorings* (Reference 2).

2.3.1.2 Mooring legs

Mooring legs are often stud link chain, which is more resistant to kinking and knotting than open link chain. The stud link chain should be specified to an appropriate offshore marine quality grade. In deep water, the weight of the anchor legs may be reduced by combining stud link chain with lightweight materials, e.g. high strength alloy link chain, steel wire rope or fibre rope.

The design minimum breaking load (MBL) of the mooring legs should be based on the maximum design load.

2.3.1.3 Anchor points

The anchor chains for the buoy should be fixed to the seabed by an appropriately designed anchor system comprising piles, high holding power anchors or gravity structures.

2.3.2 Environmental factors and abnormal loads

Environmental loads to consider for the SPM system include:

- Wind loads.
- Current loads.
- First and second order wave drift forces based on:
 - Wave height and period.
 - Swell height and period.
 - Wave slamming.

- Abnormal weather and environmental events, such as tropical revolving storms, local wind phenomena and solitary waves.
- Marine growth.

The design should also take account of abnormal loads that may be encountered, including:

- Tanker impact or collision.
- Support vessel or shipping collision.
- Drifting objects.
- Dropped objects.
- Fire and explosion.
- Operational malfunction or error.
- One or more anchor legs failing.
- One or more buoy compartments being flooded.

2.4 - Petroleum cargo transfer system

2.4.1 Process flow scheme

The cargo transfer system should be detailed in a functional layout, typically in a process flow scheme (PFS). The layout should be based on the philosophies for operating and maintenance, control and monitoring and pipeline inspection. The PFS should show the entire system from end to end, including:

- Pipelines and storage facility.
- Buoy piping layout.
- Swivel layout.
- PLEM piping layout.
- PLEM pigging arrangement.
- Submarine hose arrangement.
- Floating hose arrangement.
- Spool pieces, with piping to hose diameter transitions.
- Redundancy in cargo transfer system, submarine hoses, swivel paths, floating hoses.
- Operational valves.
- Valve types and actuators.
- Maintenance isolation valves.
- Emergency shutdown valve arrangement.
- Crossovers and bypasses.
- System safeguards, such as surge relief and marine breakaway couplings (MBCs).
- Draining and flushing points.

2.4.2 Cargo transfer system and surge analysis

The cargo transfer system should be developed in accordance with the specified piping class and designed to accommodate cargo pressure loads, thermal loads and external environmental loads. A steady-state hydraulic analysis should be performed to determine the normal operational conditions and associated pressures, the required line sizes and the pump capacity. Thermal effects should be considered to determine thermally induced stresses and pressures as well as the need for pressure relief systems.

A surge analysis should be performed to establish peak system pressures for the following upset conditions at the tanker and/or terminal:

- Accidental valve closure.
- Pump shutdown.
- Emergency shutdown.

Where surge pressures cannot be accommodated in the cargo transfer system, a pressure relief system should be provided. Surge protection at SPMs can be technically

difficult to incorporate. Where surge tanks are used, the system should include provision for safely emptying the tanks.

Recommendations and guidance on the testing of floating hoses is contained in the *Guide to Manufacturing and Purchasing Hoses for Offshore Moorings (GMPHOM)* (Reference 3).

2.5 - Single point mooring buoy design

2.5.1 Design and construction codes and standards

Most members of the International Association of Classification Societies (IACS) provide rules for constructing and maintaining buoys under Class. When working with shipyards and contractors, many SPM operators build buoys under Class rules for reasons of quality assurance and independent sign-off. Some SPM operators maintain SPMs in Class, but others do not. In all cases, an inspection and maintenance system suitable for the specific location and operational requirements should be used.

The materials, equipment and components for an SPM should be of proven design and constructed to meet the requirements of relevant design codes. Framework codes and standards relating to SPMs, pipework, offshore components and materials have been developed and published by the following internationally accepted standards organisations:

- International Organization for Standardization (ISO).
- ASME (founded as the American Society of Mechanical Engineers).
- BS/EN (British Standards/European Norm).
- American Petroleum Institute (API).
- ASTM (formerly known as the American Society for Testing and Materials).

2.5.2 Hazardous area classification for flammable gases and vapours

Area classification of the buoy should be carried out using an appropriate code, e.g. IEC 60079-10 (Reference 4).

Area classification is a method of analysing and classifying an environment where explosive atmospheres may be present. The main purpose of area classification is to provide information for selecting and installing apparatus that can be used safely in that environment.

Hazardous areas are classified into zones based on an assessment of the frequency of occurrence and duration of explosive gas atmospheres, as shown in table 2.1.

Zone	Explosive gas atmosphere is:
Zone 0	Present continuously or for long periods
Zone 1	Likely to occur in normal operation
Zone 2	Not likely to occur in normal operation and, if it occurs, will exist for only a short period

Table 2.1: Hazardous area classifications

Electrical equipment should be selected based on the appropriate zone and design code, as recommended by buoy manufacturers and suppliers.

Instruments and electrical equipment should be housed in enclosures with an ingress protection rating of at least IP56 (Reference 6). IP56-rated enclosures are suitable for use offshore and protect their contents from seawater. Junction boxes and control panels should be Ex e rated, and all other equipment should be Ex i rated.

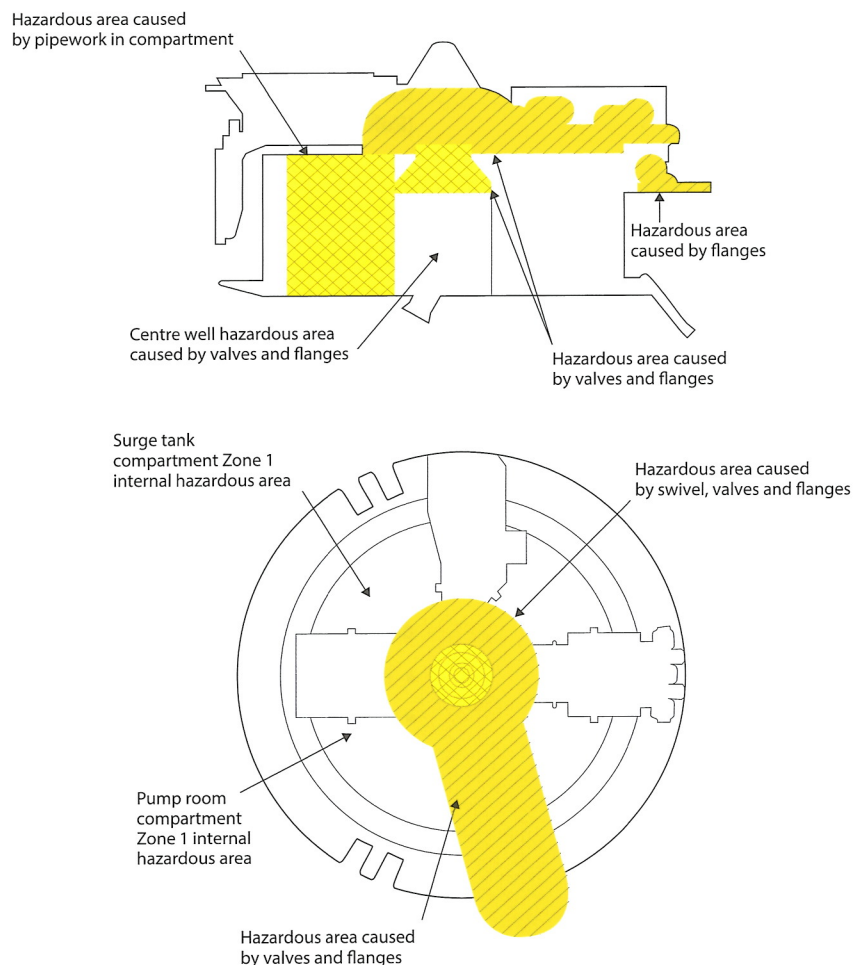


Figure 2.2: Typical hazardous area classification

2.5.3 Power, control and monitoring philosophies

2.5.3.1 Power philosophy

The primary power system on the buoy is typically an electrical battery based system installed in an appropriate waterproof (IP56 (Reference 6)) and ventilated enclosure that has drain plugs.

The power system should be charged from solar panels and/or wind generators via regulators designed to prevent overcharging. The charging rate and battery capacity should be based on the calculations of load duty, with an allowance for periods of heavy duty and low charging (for example, in fog).

Remote PLEM valves are typically operated through a hydraulic power unit (HPU). The hydraulic accumulators in the HPU should have sufficient capacity for the required number of valve strokes. The HPU is usually driven either from an external power supply on the support vessel or by a hand pump on the SPM. Some SPMs may have the PLEM valves controlled from the shore terminal via subsea hydraulic control lines.

The winch system at the SPM is normally driven from a separate power supply or from the support vessel.

2.5.3.2 Control and monitoring philosophy

Data communication with the SPM is usually via:

- Fibre optic cable.
- Electrical cable.
- Direct hydraulic umbilical.
- Wireless telemetry.

Data may be displayed and recorded locally or remotely and may include:

- Cargo pressure.
- Cargo temperature.
- Mooring hawser load monitoring.
- Valve position monitoring and/or operation.
- Surge tank high level alarm and blanketing pressure.
- Navigation aids – monitoring and operation.
- Swivel leak detection.
- Gas detection.
- Double carcass hose leak detection.
- Hydraulic system status.
- Battery and telemetry system status.
- Anemometer and metocean data.
- Tanker berthing aid.
- Security systems.
- Cargo flow measurement and comparison. Note that flow measurement accuracy is limited because of the short pipe lengths available.

Data should be stored to enable events to be analysed and investigated. For example, terminals have found it useful to be able to view historic pressure and hawser load information.

2.5.4 Corrosion protection

The buoy and PLEM should be protected from corrosion using both cathodic protection based on anodes and a suitable paint/coating system.

Corrosion protection systems should have a service life compatible with the buoy and PLEM's design life in water, bearing in mind the anticipated docking intervals and possibilities for maintenance in-situ.

2.5.4.1 Paint and coatings

A suitable marine coating system, as specified by the manufacturer or terminal operator, should be applied to the PLEM and the buoy. Where excessive marine growth is anticipated, a final coat of anti-fouling paint may be advisable.

A thermal sprayed aluminium (TSA) coating system is advised where high corrosion rates are expected.

The final colour of the SPM should be highly visible. Markings (such as those for draught and anchor point numbers) should be made in clearly visible colours.

To protect pre-fabricated steelwork (such as gratings, ladders, stair-treads and handrails), galvanising in accordance with ISO 1461 (Reference 5) is advisable.

Areas where people walk, such as the buoy deck, turntable deck and deckhouse, should have non-skid surfaces.

2.5.4.2 Cargo transfer system

Internal corrosion of the cargo transfer system's pipelines and components, in particular that due to microbial-influenced corrosion (MIC), is of increasing concern. The suitability of oil-carrying components and internal coatings should be assessed.

The potential interaction between piping components and various cargoes and fluids that may enter the pipeline during installation, operation and maintenance should be reviewed.

Attention should be given to valves and fittings. Where a potential for internal corrosion is identified, consideration should be given to the use of:

- Increased corrosion allowance.
- Corrosion resistant materials.
- Internal coating systems.

- Operation and maintenance procedures that minimise the potential for corrosion, such as flushing and filling with non-corrosive liquids between operations.
- Corrosion inhibitors.

2.5.4.3 Cathodic protection

A passive cathodic protection system, using galvanic anodes, should be provided for the PLEM and the submerged part of the SPM. On the PLEM, the cathodic protection system should include fittings such as valves and actuators.

Pipelines are typically protected from corrosion by impressed current cathodic protection systems. The PLEM and pipeline cathodic protection systems should be compatible.

Anodes are typically bolted to mounting brackets and then further tack-welded to ensure electrical continuity and positive grounding of the anode to the steelwork. When attaching the anodes to the SPM or PLEM, the following should be taken into account:

- The need to provide easy access for divers to inspect and replace them.
- How diver trap hazards can be avoided.
- To avoid obstructions for divers, they should not protrude below the bottom of the buoy body or turret and should not be fitted on top of the skirt.

2.6 - Hose system design

Hose manufacturers and offshore system designers provide system design support for both new projects and existing terminals, using computing facilities with industry-standard marine analysis software.

Figures 2.3–2.5 illustrate some commonly found SPM hose systems.

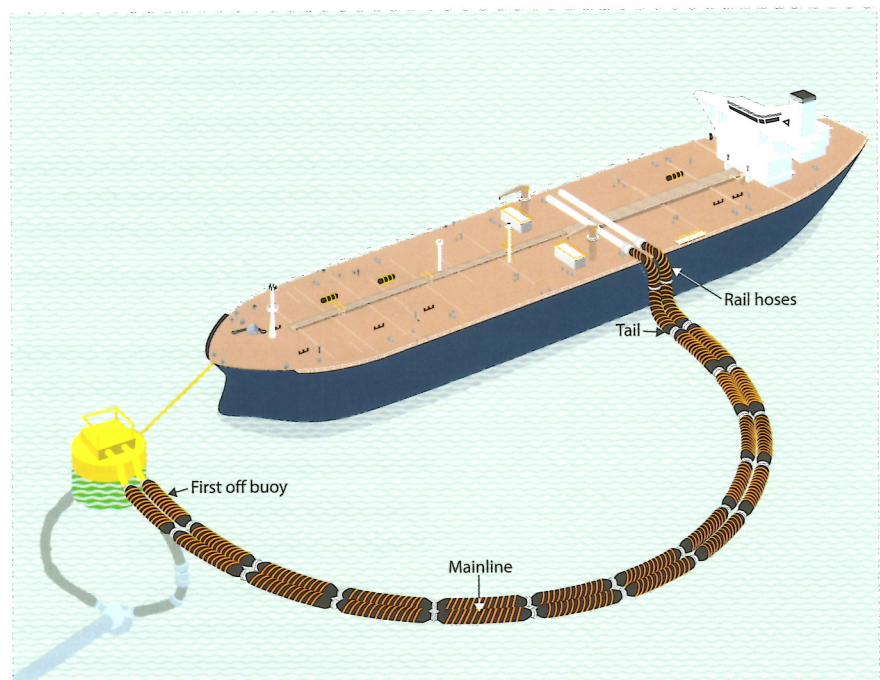


Figure 2.3: Example of catenary anchor leg mooring floating hose system

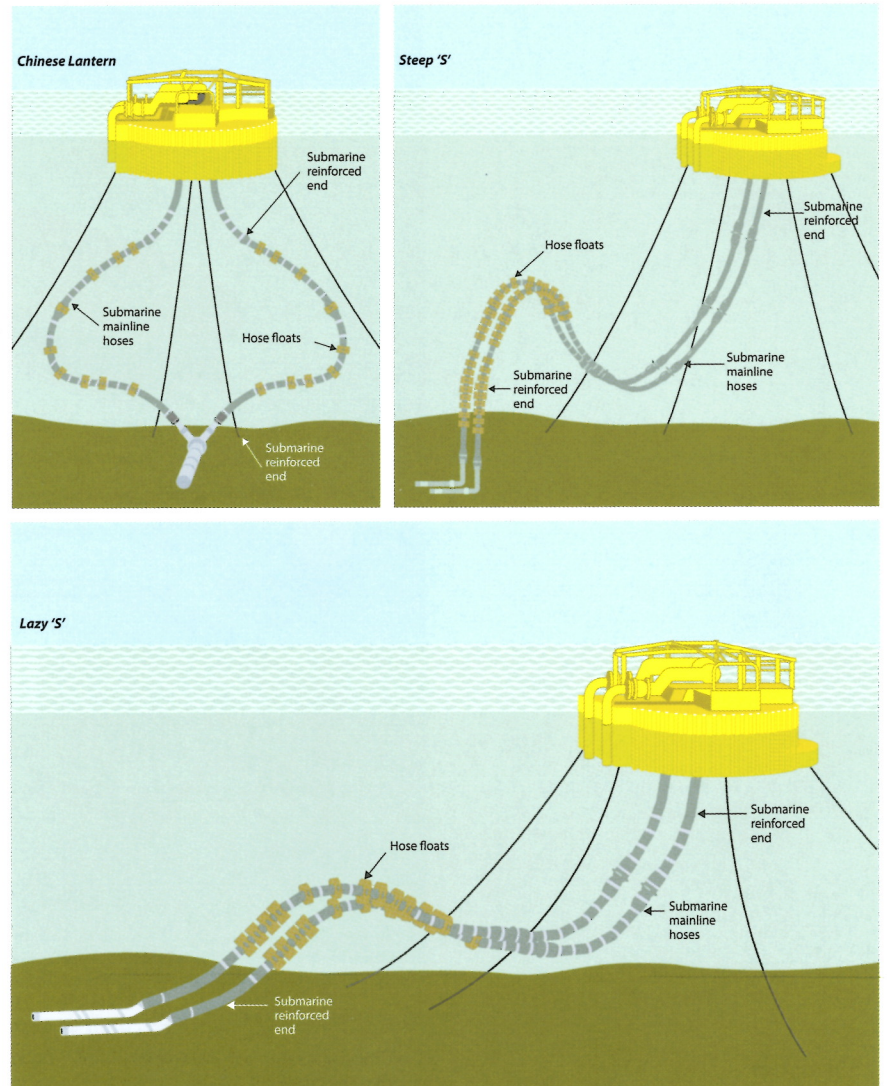


Figure 2.4: Examples of catenary anchor leg mooring submarine hose systems

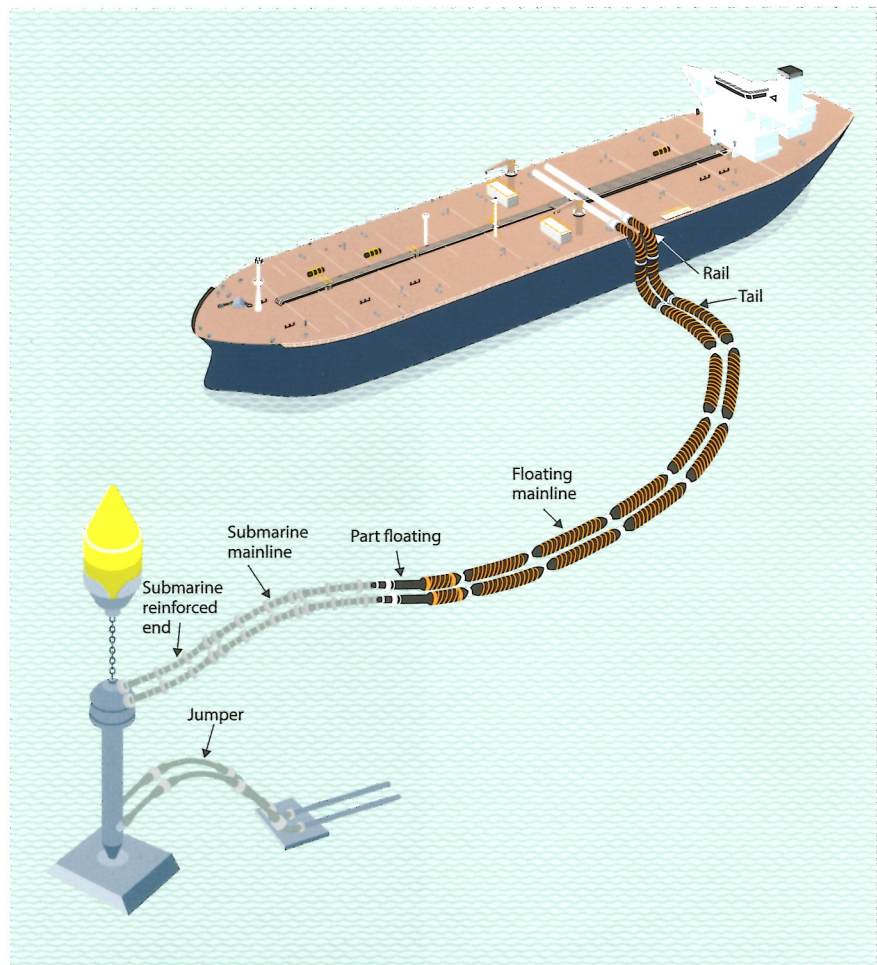


Figure 2.5: Example of single anchor leg mooring hose system

Further details of hose types, their design, manufacture and performance are contained in the *Guide to Manufacturing and Purchasing Hoses for Offshore Moorings (GMPHOM)* (Reference 3).

2.6.1 Catenary anchor leg mooring floating hose string

The appropriate length of a hose string will be determined by the terminal equipment used, together with the dimensions of the largest tanker accepted at the terminal.

Terminals should specify hose string lengths and set maximum tanker size limits to ensure that:

- Hoses are not subjected to loads greater than the allowable axial load.
- Bends tighter than the minimum bend radius (MBR) are not introduced.

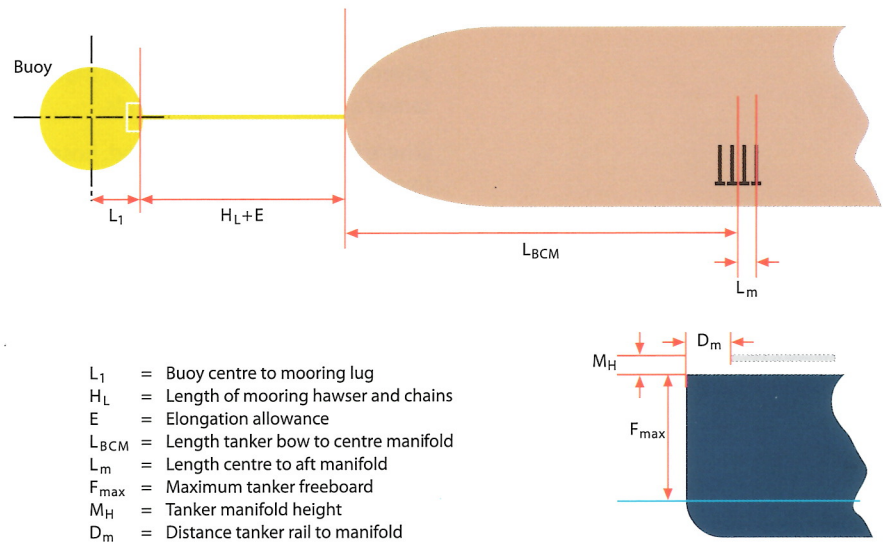


Figure 2.6: Calculation of length of catenary anchor leg mooring floating hose string

There are a number of ways to calculate the optimum hose string length, one example is set out below:

$$\text{Total length (TL)} = L_1 + (H_L + E) + (L_{BCM} + L_m) + F_{max} + M_H + D_m + \text{teardrop allowance}$$

Example calculation:

L_1	Buoy centre to mooring lug	5.0 m	
H_L	Buoy end chafe chain	2.0 m	
	Mooring hawser	50.0 m	
	Chafe chain outside bow of tanker	5.0 m	
E	Elongation allowance	11.0 m	(1)
L_{BCM}	Maximum tanker bow to centre manifold	145.0 m	
L_m	Centre to aft manifold	4.5 m	(2)
F_{max}	Maximum tanker freeboard	16.6 m	
M_H	Tanker manifold height	2.1 m	(3)
D_m	Distance tanker rail to manifold	4.6 m	(3)
	Teardrop allowance	10 m	(4)
Calculated length of minimum hose string		255.8 m	(5)

Notes on calculation:

1. The terminal should select the appropriate hawser elongation at the break load. The example uses an allowance of 22% elongation, which is typical of a used double-braid polyamide hawser.
2. Distances are worked to the aft manifold position, this being the worst case.
3. Manifold distance and height are taken from *Recommendations for Oil and Chemical Tanker Manifolds and Associated Equipment* (Reference 7).
4. The recommended allowance for hose bends (teardrop allowance) of 10 m has been verified by computer modelling.
5. The overall length of the hose string should include every hose, spool or Y piece and marine breakaway coupling.

Marine breakaway couplings (MBCs) (where fitted) should not be overloaded. It should be ensured that, in a near-breakout situation, neither the hoses nor the MBC part before the hawser does.

Terminals handling a large range of tanker sizes may need to consider setting a minimum bow to centre manifold length, particularly where currents, tides and adverse weather conditions exist that may cause hoses to tangle, lie around the tanker's bow or form tight bends.

Where two hose strings are used, hoses may chafe against each other. Terminals have found that an additional or longer hose in the aft (outer) string helps to reduce this risk.

2.6.2 Electrically discontinuous hoses

2.6.2.1 Manifold connection

There is a risk of electrical arcing at the manifold during connection and disconnection of cargo hoses. This is because of the possible differences in electrical potential between the ship and the terminal. Arcing may also be caused by static accumulation caused by fluid flow on unearthed steel items. There should be a means of electrical isolation to protect against the risk of arcing, as shown in figure 2.7.

Electrical isolation should be provided by an insulating flange or by including in each hose string one length only of electrically discontinuous hose. The insertion of such a resistance completely blocks the flow of stray currents through the hose string.

Electrical isolation is typically achieved by including a single length of electrically discontinuous hose adjacent to the tanker rail hose, so that the two systems are isolated but all flanges are bonded via electrically continuous hoses to either end and to the sea. The single length of non-conducting hose must not be short-circuited by being filled with seawater or by contact with external metal, such as hose handling equipment.



Figure 2.7: Recommended method for providing electrical isolation

It should be noted that every type of hose becomes electrically continuous when filled with seawater. Terminals that water-flush hoses should be aware of this characteristic.

Previous guides have recommended other combinations of electrically discontinuous hose. These are, however, less certain to prevent arcing. Terminals choosing another method should complete a risk assessment to demonstrate the method's acceptability, taking into account the potential risks illustrated in the examples shown in figures 2.8 and 2.9.

Figure 2.8 illustrates the use of two electrically discontinuous hoses and the area for concern. The flange between rail and tail hose is isolated and may accumulate an electrical charge, causing a risk of arcing. The position is outboard and away from the manifold. It is possible, but not certain, that the hose support chain may bond the flange.

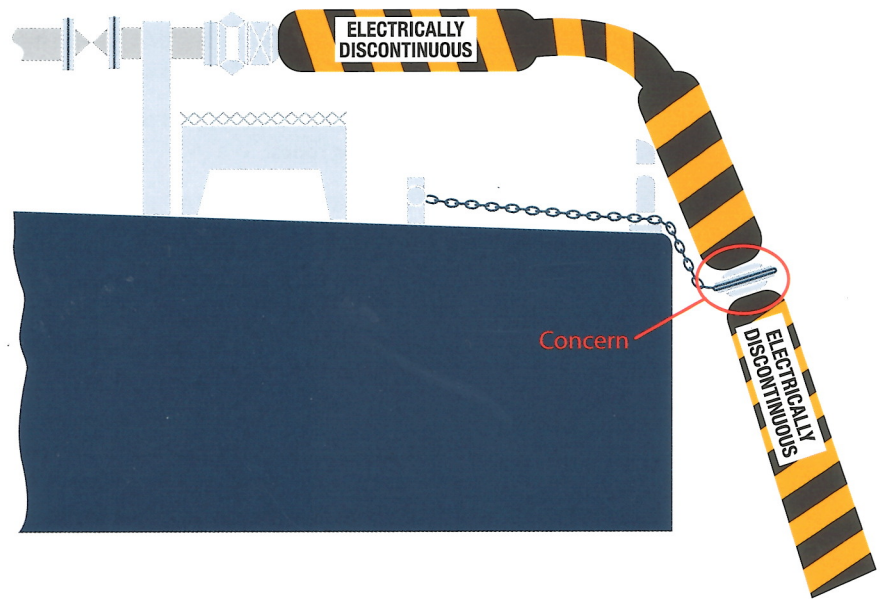


Figure 2.8: *Discontinuous rail and tail hoses*

Figure 2.9 illustrates the use of a discontinuous rail hose and the areas for concern. The isolating length of hose may be short-circuited by the hose support chain. A risk of electrical arcing exists when the chain is connected and disconnected. There may be risk of electrical arcing while the hose is blanked and well away from the manifold.

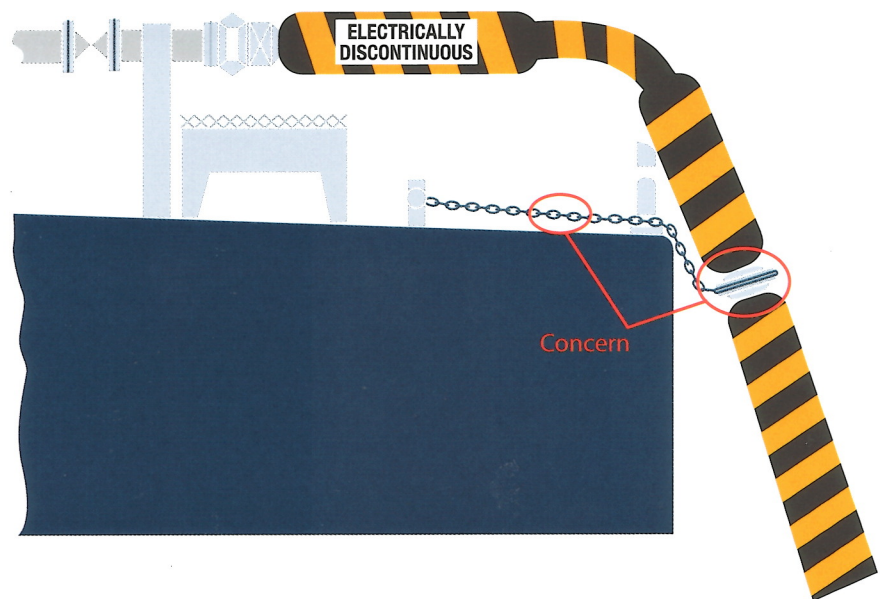


Figure 2.9: *Discontinuous rail hose*

2.6.2.2 Use of electrically discontinuous hoses with cathodic protection systems

Buoys, pipelines and the PLEM may be protected from corrosion by sacrificial anodes or impressed current systems. Such systems may be connected to hose systems to provide external corrosion protection by the use of electrically continuous hoses. Alternatively, cathodic protection systems may be isolated, to prevent rapid loss from sacrificial anodes, by the use of electrically discontinuous hose.

2.7 - Pipeline end manifold

The PLEM facilitates the subsea termination of the pipeline and the connection to the submarine hose strings. The PLEM is comprised of a structural base supporting the PLEM pipework and the end of the pipeline.

The base structure for the PLEM may be gravity-based or, if the soil data indicates the need, have a piled foundation.

The pipework of the PLEM is typically designed for the service life of the SPM. The pipework may be welded or it may be made up from bolted spool pieces so that pipework may be replaced without disturbing the base of the PLEM.

A protection frame is fitted over the manifold to protect the piping from falling objects or fouling ropes.

The design of the subsea pipeline and PLEM should be in accordance with applicable standards, for example BS PD 8010-2 (Reference 8) and API 1111 (Reference 9).

Sufficient rigging points and pad eyes should be provided on the PLEM for the hoses to be installed. The design of the PLEM should allow for flushing the hoses before removal, preferably by injecting water at the low point of the system. A pipeline inspection guide receiver/launcher connection should be considered to enable pipelines to be inspected.

Where remotely operated valves are installed, the design should consider the potential for generating surge pressures and the setting of appropriate valve closure times. Consideration should be given to valves that fail open, fail closed or fail remaining in the last set position, based on the system safety design.

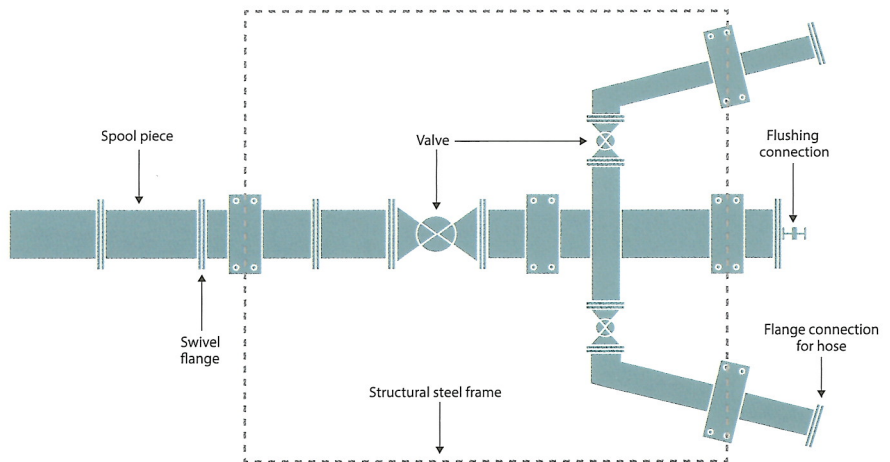
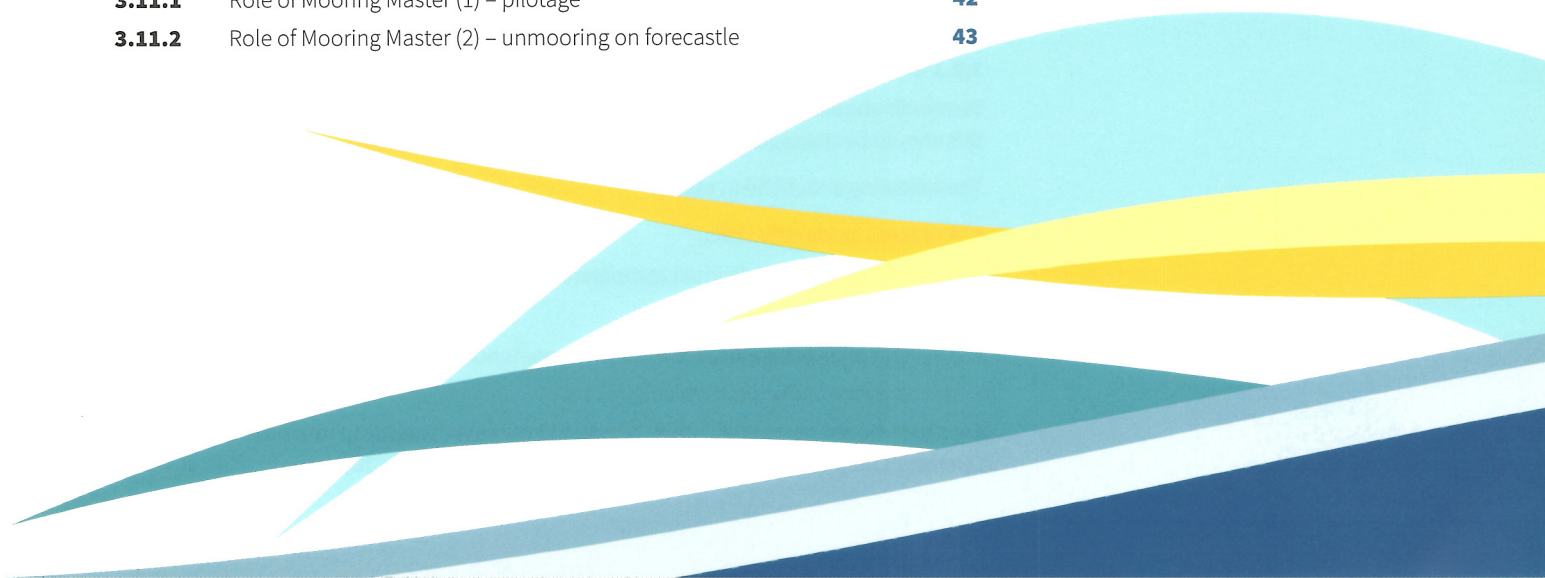


Figure 2.10: Typical pipeline end manifold

Section three

Operation of single point moorings

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3.1 - Management of safety, occupational health and security

Terminals should have a process in place to assess their standards for health, safety, security and environment (HSSE) and to ensure that these standards are continuously improved.

The process described in *Marine Terminal Management and Self Assessment (MTMSA)* (Reference 10) was developed by OCIMF as a standardised tool for global application. The aim of the MTMSA process is to help terminal operators measure and improve the effectiveness of their berth operations management systems and the management of the ship/shore interface. Appendix A provides a summary of the management processes that should be applied to a single point mooring (SPM) terminal to effectively manage HSSE.

3.1.1 Hazard and operability analysis

Hazard and operability (HAZOP) analysis is a documented, structured and systematic technique for system examination and risk management. In particular, HAZOP is often used to identify potential hazards in a system and to identify operability problems that are likely to lead to safety incidents.

HAZOP uses the following techniques/tools:

- Hazard Identification (HAZID).
- Identification of control points.
- Brainstorming.
- Qualitative risk assessment.
- Inductive risk assessment (a bottom-up approach to identifying risk).
- Potential failure and consequence of components.
- Use of subject matter experts to predict deviations based on past experiences and general subject matter expertise.

For HAZOP to be effective, the selection of subject matter experts is important. The subject matter experts should include a safety engineer, the operating unit's process engineer, terminal management, the Mooring Master/pilot and support vessel crew. Terminals should apply the HAZOP technique to SPM operations, including but not limited to:

- Cargo transfer.
- Flushing SPM cargo systems.
- Storage, on support vessels, of petroleum from flushing or draining SPM cargo systems.
- Operations following the parting of marine breakaway couplings (MBCs).

The results of the HAZOP study should be documented and will assist with the development of appropriate procedures. Some terminals have used the HAZOP technique during the risk assessment process to assess marine operations, particularly the transit, berthing and mooring of tankers to SPMs.

3.2 - Qualifications and training

3.2.1 Competence and training of personnel

Terminals should ensure that personnel are trained and competent in their duties, and this should be managed within a competency assurance system.

The following should be in place:

- A process to identify skills.
- A system to assess individual competence and identify training needs.
- Formal training.
- A system of ongoing reassessment of competence.
- Maintenance of personal training records.

For shore-based personnel, terminals should consider adopting the *Marine Terminal Operator Competence and Training Guide (MTOCT)* (Reference 16).

All personnel, including contractors undertaking maintenance work, should receive safety training for normal, upset and emergency conditions that is appropriate to the task and the workplace.

3.2.2 Competence of Mooring Masters

Reference should be made to the OCIMF's *Competence Assurance Guidelines for Mooring, Loading and Lightering Masters* (Reference 17). This publication contains recommendations concerning the skills and knowledge that Mooring Masters require to safely conduct marine operations at an SPM terminal. The guidelines provide recommendations on the development and implementation of a competency assessment system for Mooring Masters, together with guidance on the required competencies and knowledge.

Most Mooring Masters hold Class 1 certificates of competency and have tanker experience. Some terminals accept lesser qualifications and experience. They build appropriate additional requirements into their training programmes, managed with a competency assurance system.

3.3 - Pre-arrival procedures

3.3.1 Nomination and tanker acceptance criteria

All terminals should establish procedures to ensure that tankers calling at the terminal meet minimum standards of safe operation. Tankers should be approved through a vetting procedure and terminals should have procedures and criteria in place to ensure that the tanker is suitable and compatible with the berth.

At SPMs, the acceptance criteria should include as a minimum:

- Maximum draught and freeboard.
- Maximum and minimum displacement.
- Length from bow to centre manifold.
- Maximum manifold height above water.
- Safe working load (SWL) for manifold crane or derrick.
- Manifold – conforms with *Recommendations for Oil and Chemical Tanker Manifolds and Associated Equipment* (Reference 7).
- Bow stoppers – conform with *Recommendations for Equipment Employed in the Bow Mooring of Conventional Tankers at Single Point Moorings* (Reference 2).
- Requirements for tugs and SWL of securing points.
- Any requirements for continuous slow running astern of main engines.
- Any requirements for flushing hoses.

When determining the above criteria, it is important that the terminal has a complete and up to date understanding of the water depth, the actual weight of hoses and fittings to be lifted, the length of floating hose string and the arrangement of the mooring hawser and chafe chain.

3.3.2 Pre-arrival exchange of information

All terminals should establish procedures to manage the exchange of information between the tanker and the terminal before the tanker arrives. As part of the information exchange, the tanker should inform the terminal of any deficiencies. The pre-arrival exchange of information is detailed in *ISGOTT* (Reference 12) and should include details of items specific to SPM terminals:

- Pilot boarding position.
- Safe access for personnel.
- Local navigation warnings.
- Preparations for mooring:
 - Bow chain stopper.
 - Winch drum.
 - Messenger.

- Berthing manoeuvres and mooring plan.
- Use of tugs.
- Cargo requirements, including hydrogen sulphide (H₂S) levels.
- Estimated schedule.
- Communication: primary and secondary.
- Environmental limits.
- Garbage.
- Hose handling:
 - Procedures.
 - The number and size of hoses.
 - Hose lift weight.
- Manpower requirements for all operations.
- Security: confirm the tanker security level (ISPS Code (Reference 11)).
- Number of shore personnel attending the tanker and their accommodation requirements.
- Support craft and their use.
- Tanker's main engines and deck machinery readiness.

3.3.3 Pre-arrival inspection of single point moorings

All terminals should establish procedures and checklists to ensure that the SPM is ready in all respects to accept the tanker. A pre-berthing SPM inspection schedule is included in section 4.3.1.

3.3.4 Pre-berthing exchange of information

All terminals should establish procedures to manage the exchange of information between the tanker's Master and the pilot/Mooring Master, as detailed in *ISGOTT* (Reference 12). There should be a conference after the Mooring Master has boarded, but before the approach to the berth begins. The conference should include the following items specific to SPM terminals:

- Communications: agree the modes of communication to be employed during mooring and cargo transfer operations.
- Tanker's manoeuvring characteristics: any machinery or navigation equipment deficiencies.
- Berthing plan – approach:
 - Turning locations.
 - Abort contingency plan.
 - Speed of approach.
 - Use of tugs, bollard pull and suitability of ship's fittings for making fast.
 - Use of the forecastle party.
- Mooring procedure:
 - Use of messengers and winches.
 - Hawsers - number and length.
 - Chafe chain.
- Use of support vessels.
- Manpower requirements: the Mooring Master should outline the manpower to be provided by the tanker during mooring, hose connection and cargo operations. The tanker's Master should confirm that sufficient trained and competent staff are available to meet these requirements and that periods of rest have been properly incorporated into the watchkeeping arrangements.
- Personal protective equipment (PPE) requirements and safety awareness.
- Weather forecast, currents and environmental limits.

3.4 - Environmental operating limits

Terminals should have clear, documented environmental operating limits and should define actions to be taken during adverse environmental events. The environmental limits should define thresholds for:

- Personnel transfer.
- Manoeuvring and berthing.
- Stopping loading or discharging.
- Disconnecting hoses.
- Manoeuvring for unberthing and departure.
- Support vessel operations.

Most SPM berths are in open sea and weather conditions may change rapidly. It is, therefore, important that safe environmental operating limits are established and enforced. Terminals should also make use of local weather forecasting services. At SPMs, limits are usually set with regard to environmental parameters such as:

- Wind speed/direction.
- Wave height/period and/or swell.
- Current.
- Visibility.

When tankers are made fast the hawser loads, monitored by telemetry, are often used as a basis for operating limits. Hawser loads may be staged, as conditions worsen, to allow lead time to respond. For example, hawser load conditions may be established to initiate:

- Stopping cargo transfer.
- Disconnection of hoses.
- Departure from the SPM.

Decisions to depart from the SPM should take into account the abort passage plan, sailing window and available water depths.

Some terminals choose not to berth tankers at night. In general, provided that adequate lighting is available, night berthing at SPMs poses no specific additional risks. Terminals should ensure adequate workplace lighting, particularly on support vessels, the SPM, pilot ladders, the forecastle and the manifold area.

3.5 - Personnel and equipment transfer between support vessel and tanker

Personnel should transfer by pilot ladder, or by a combination of pilot ladder and accommodation ladder, at the designated area off the berth. A combination ladder should be used if the freeboard of the tanker is greater than 9 m. The berthing plan should provide for the tanker to make a lee when weather conditions require.

Offshore terminals may consider boarding pilots by helicopter. Recommendations are contained in the *Guide to Helicopter/Ship Operations* (Reference 13). Further details and other transfer methods are discussed in the *Ship to Ship Transfer Guide* (Reference 14).

The tanker is responsible for providing safe access for all personnel boarding, in compliance with the *Shipping Industry Guidance on Pilot Transfer Arrangements* (Reference 15). Before boarding the tanker, the Mooring Master should confirm with the tanker that the ladder is ready, properly rigged and secured. Personnel should transfer one at a time, wearing PPE in compliance with terminal regulations. Luggage or backpacks should not be carried or worn while climbing. These should either be lifted separately or pre-slung and lifted with the manifold gear.

The support vessel should keep clear of the ladder so that any personnel who fall will not come into contact with it. Toolboxes containing hose connection gear should be transferred once personnel have boarded.

3.6 - Tanker berthing and mooring

Procedures for berthing and mooring will vary according to specific conditions at the terminal. This Guide recommends the use of two Mooring Masters. The number of other personnel involved will depend on the specific conditions at the terminal.

Procedures at the terminal should predetermine the requirements for tugs and support vessels. Some terminals use multipurpose craft that combine the duties of support vessels and tugs. Typical types of support vessel and their use are described in Appendix D.

3.6.1 Role of Mooring Master (1) – pilotage

On arrival at the tanker bridge, the Mooring Master should check the tanker's position, speed and track before conducting the pre-berthing exchange of information. The Mooring Master should advise the Master on all manoeuvres, including the approach direction and the appropriate speed to be taken at each stage of the approach. The final approach should only be started once all personnel, the tanker, support vessels and tugs are ready.

If tugs are required, they should be connected clear of the SPM and other field obstructions. The Mooring Master should instruct the support vessels to tow the hose string clear and stretch out the mooring and pick-up rope towards the tanker. Other methods may be considered, such as tying back hoses to the SPM or using pneumatic line throwers to send messengers away.

To best enable the tanker to be handled at slow speed and stopped as necessary, the direction of the final approach should stem the wind or current. The tanker's speed at each stage of the manoeuvre should be carefully monitored and within the planned range. The approach course should be set to one side of the SPM to avoid contact with the SPM, moorings and hoses if the tanker overshoots.

Distances between the tanker's bow and the SPM may be measured by radar or pilot aid. As the tanker closes in on the SPM, the Mooring Master may visually judge these distances.

3.6.2 Role of Mooring Master (2) – mooring on forecastle

On arrival at the forecastle, the Mooring Master should ensure that:

- The tanker's mooring arrangement is satisfactory.
- The bow fairlead and winch storage drum are positioned to safely handle the pick-up rope and provide a direct lead through the bow fairlead and bow chain stopper to the storage drum.
- Both anchors are fully home and secured.

Under the guidance of the Mooring Master, a responsible deck officer should be on the forecastle to instruct the ship's crew. The mooring team should participate in a toolbox meeting to discuss all procedural and safety aspects of the task. Particular attention should be given to:

- Definition of roles and responsibilities.
- Not standing in the snap-back zone or in the bight of any rope.
- Not having more people than necessary in the vicinity of the ropes.
- Ensuring the pick-up rope is not used to heave the tanker into position.

The ship's messenger rope should be prepared from the aft part of the forecastle, back through the bow fairlead and chain stopper and, finally, turned onto the winch storage drum. If there are two hawsers, two messenger ropes should be rigged.

At the appropriate distance from the SPM, the Mooring Master should instruct the ship's crew to lower the ship's messenger rope to the mooring launch, where the messenger rope should be connected to the hawser pick-up rope before the launch moves clear. Bow thrusters should be stopped to avoid the possibility of fouling.

Note: the hawser pick-up rope is designed only to lift the mooring chafe chain on board the tanker with little tension. It is never to be used to heave the tanker into position.

The messenger rope should be winched onboard with minimal or no manual handling and followed by the hawser pick-up rope, which should be carefully guided through the bow fairlead and chain stopper and onto the storage drum.

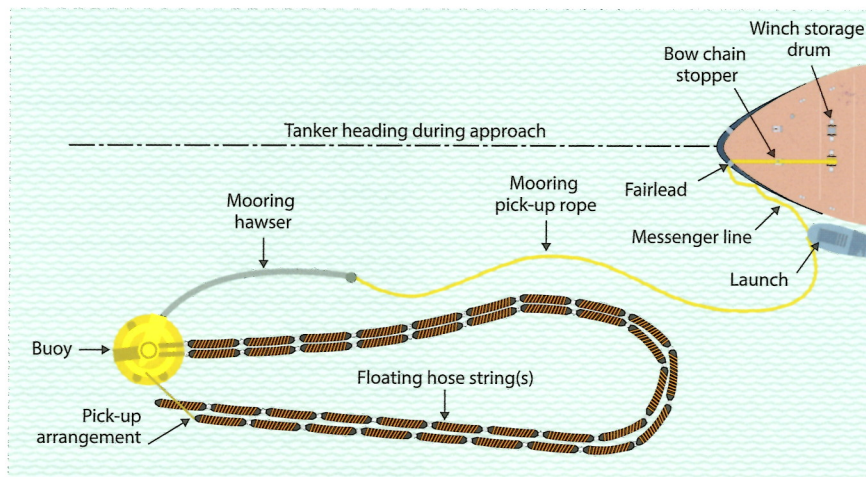


Figure 3.1: Mooring diagram

At this stage, the Mooring Master should continuously monitor and report the tanker's progress toward the final moored position relative to the heaving in of the pick-up rope. The chafe chain should be lifted clear of the water and carefully heaved through the bow fairlead, into the chain stopper and finally secured on the chosen chain link. The tanker should be stopped over the ground in this position.

The chain stopper must be secured with a locking pin or other mechanism. Hydraulic chain stoppers should be isolated and locked to prevent their accidental release.

If two hawsers are used, the second is connected using the same procedure. When secured, both mooring assemblies must be of equal length.

The Mooring Master may only leave the forecastle to commence the hose connection when:

- The tanker is stopped and brought up.
- The mooring is under steady tension.
- The bow watchman is in place.

3.7 - Connecting rail hoses

3.7.1 Lifting rail hoses

Terminals should calculate and record the weight of hoses to be lifted on board by tankers. It is essential that nominated tankers are equipped with a crane or derrick that has a suitable SWL. Terminals should supply ancillary equipment that is subject to documented formal inspection and testing and has suitable SWLs.

The lifting weight of hoses depends on:

- Weight of individual hoses.
- Weight of hose contents – oil or water.
- Freeboard of the largest tanker acceptable in the berth in ballast condition.
- A lift above deck of 7.5 metres (*ISGOTT* (Reference 12)).
- Weight of ancillary equipment.
- Wave height. A dynamic load factor of 1.5 should be applied in significant waves that are greater than 1 m (*ISGOTT* (Reference 12)).

Calculations and studies show that in the worst (heaviest) case, once a dynamic load factor is applied, the design lifting weight of a rail hose system sometimes exceeds the SWL of hose lifting lugs and/or the tanker's crane. Terminals operating in offshore areas with very large tankers, e.g. 21 bar double carcass hoses and heavy ancillary equipment, should be particularly vigilant (see Appendix B).

3.7.1.1 Safe working load of tanker cranes

The SWLs prescribed for the lifting equipment of tankers are shown in table 3.1. In some instances, the hose lift weight may be limited by the hoisting capacity of the tanker's crane or derrick.

Summer deadweight of tanker (tonnes)	Minimum SWL of hose handling crane (tonnes)
5,000 or less	2
5,001 to 16,000	5
16,001 to 25,000	10
25,001 to 60,000	10
60,001 to 120,000	15
120,001 to 160,000	20
Over 160,000	20

Table 3.1: Minimum safe working load of tanker cranes

Source: Recommendations for Oil and Chemical Tanker Manifolds and Associated Equipment (Reference 7)

When carrying out equipment transfers to and from support vessels, including lifting hoses using the ship's crane, an extension pennant should be used with an equal SWL to that of the crane. This is to ensure sufficient safety clearance from the crane block for the crew handling the equipment. The crane block should be marked in such a way that it is visible under all operational conditions.

3.7.1.2 Safe working load of rail hose lifting lugs

The SWLs of rail hose lifting lugs for hoses of different diameters are shown in table 3.2 (from the *Guide to Manufacturing and Purchasing Hoses for Offshore Moorings (GMPHOM)* (Reference 3)). The 2009 edition of this guide recommended an increase in the SWL of lifting lugs. The 1991 edition was withdrawn in June 2012 and hoses constructed before that date are likely to have a lower SWL than shown here.

Hose diameter		Safe working load		Proof load	Minimum breaking load
mm	Inches	kN	Tonnes	kN	kN
500	20	200	20.4	500	1000
400	16	150	15.3	375	750
300	12	100	10.2	250	500
250	10	70	7.1	175	350
200	8	50	5.1	125	250
150	6	40	4.1	100	200

Table 3.2: Safe working load of rail hose lifting lugs

Source: Guide to Manufacturing and Purchasing Hoses for Offshore Moorings (Reference 3)

A worked example, demonstrating a method to calculate the hose lift weight, is provided in Appendix B.

All lifting lugs are hard-stamped with a certified SWL, and a copy of the lug test certificate is included with the hose manufacturer's report. Further information is available in the OCIMF information paper *A Study into Crane Loads Associated with Hose Handling at Offshore Terminals*.

3.7.2 Procedure for connecting rail hoses

Before connecting the hose, the Mooring Master should check that the:

- Hose handling equipment, manifold and securing points comply with terminal and industry standards.
- SWL of the tanker's lifting equipment is sufficient for the planned lift.
- Tanker is securely moored.
- Mooring Master, deck officer, a competent crane operator and a competent banksman are present at the manifold.
- Manifold and spill tank are clean, empty and gas free.

The hose team should participate in a toolbox meeting to discuss all procedural and

safety aspects involved in connecting the hose. At a minimum, particular attention should be given to:

- Roles and responsibilities.
- Potential hand and/or finger hazards.
- Manual handling techniques.
- Not having more people than necessary in the vicinity of the manifold.
- Instructing the crane operator to take instructions from only one, nominated, person.
- Access to and care of the manifold working platform.

Hoses are handled one at a time, with the forward hose being connected first. Suitable deck fittings and fairleads are prescribed in *Recommendations for Oil and Chemical Tanker Manifolds and Associated Equipment* (Reference 7).

The following describes a typical hose connection procedure:

1. The support vessel should tow the end of the hose string to a position directly underneath the tanker's crane and connect the hook to the hose lifting chain. The support vessel should then move clear of the lifting area.
2. Before the hose is lifted above the deck, it should first be raised to deck level so that the Mooring Master can visually inspect the security and condition of the lifting equipment.

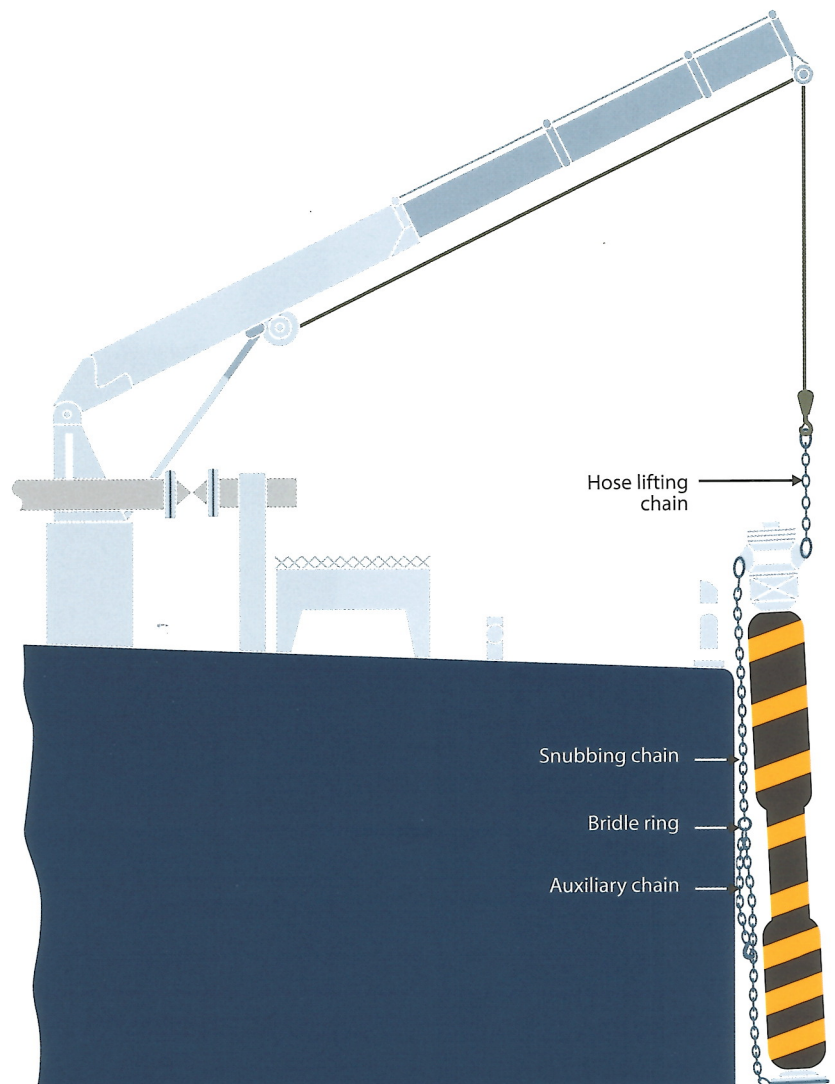


Figure 3.2: Rail hose connection (1)

3. The hose should then be lifted above deck level to enable the snubbing chain to be passed inboard through a fairlead and secured to a suitable deck fitting.
4. The snubbing chain length is adjusted so that the hose presentation flange will lower into a position just inboard of the tanker manifold flange. This will ensure the full weight of the hose is supported by the snubbing chain and that the hose lies in a smooth curve, slightly clear of the tanker rail.

Snubbing chains were traditionally secured using slip hooks (pelican hooks), which were in turn secured by wire rope to deck fittings. Terminals have now developed alternative methods with the aim of reducing risk to personnel, and enabling easy adjustment and securing of the snubbing chains, including:

- Shackling a wire rope to the chain, passing one turn around a pair of bollards then leading to a portable manual wire puller, allowing downward adjustment.
 - Using a chain stopper secured on a chain necklace over a cruciform bollard.
 - Using snatch blocks.
5. Lateral hose movement can be restricted by loosely securing the hose to the tanker rail using turns of fibre rope or a webbing strap. This will also assist in lining up the hose to the manifold flange.

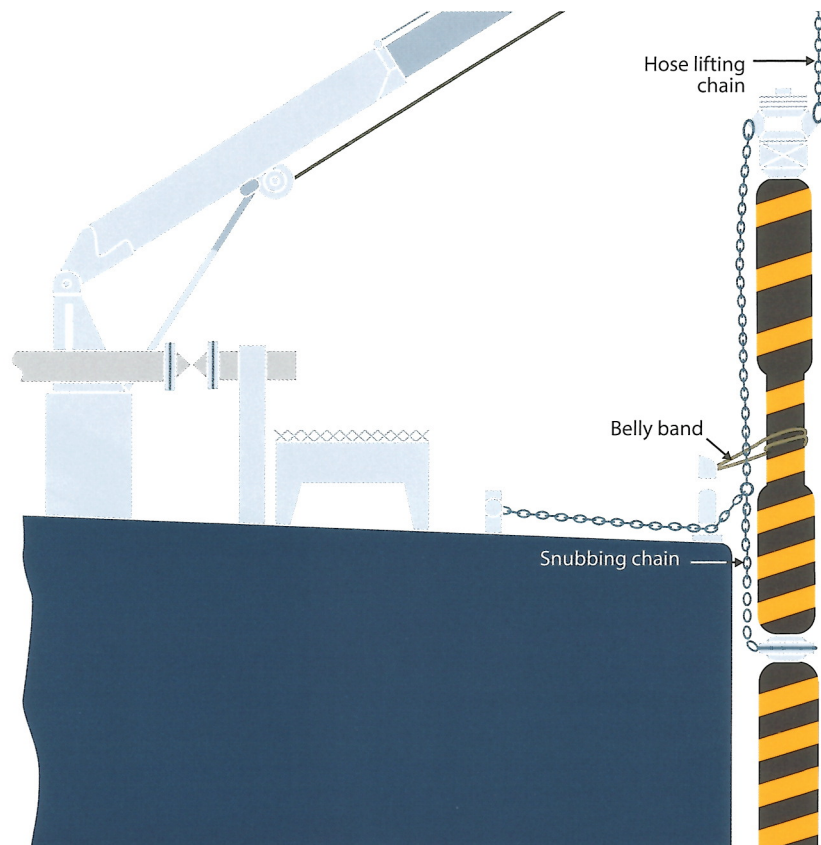


Figure 3.3: Rail hose connection (2)

6. The hose presentation flange should be lowered to the manifold working platform. Before removing the blind flange, check that the hose end valves (if fitted) are fully closed and that the terminal has confirmed that the hoses are depressurised.
7. The hose flange is lifted to the tanker manifold using the crane and manoeuvred into position using appropriate rigging equipment. Some terminals use a rotating flange to line up the boltholes.
8. The hose connection is completed using either a new gasket and a full set of bolts, or a quick release coupling (QRC) with an O-ring seal.

Bolts should be tightened with a torque wrench or an impact wrench to the correct torque setting. QRC fittings should be tightened following the manufacturer's instructions and using the correct tools.

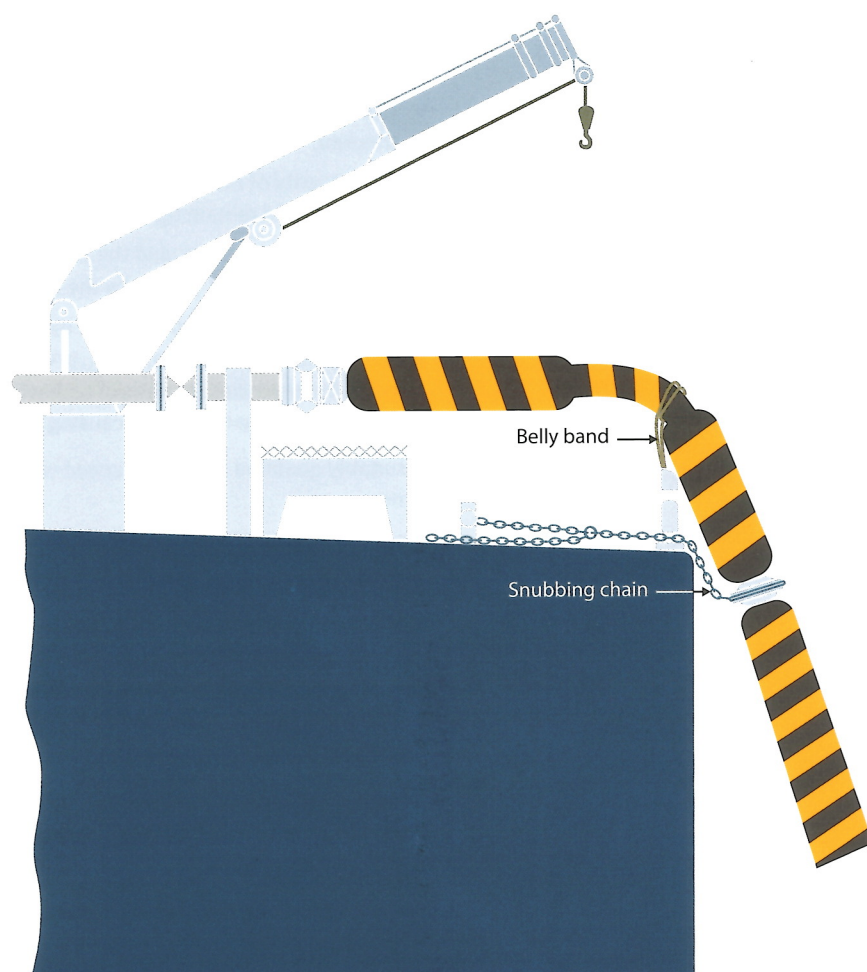


Figure 3.4: Rail hose connection (3)

9. A second, aft, hose may then be connected in the same manner.
10. Finally, hose end valves should be mechanically locked in the open position.
11. An SPM hose string that is not to be used for the operation may be secured at deck level ready to slip.

3.8 - Operations of tankers in berths

3.8.1 Responsibilities

The tanker's Master and the Mooring Master share joint responsibility and accountability for the safe conduct of operations while the tanker is at the terminal.

Before cargo operations begin, the Master (or the Master's representative) and the Mooring Master should:

- Agree in writing the:
 - Cargo transfer procedures, including the maximum loading or unloading rates.
 - Action to be taken in the event of an emergency.
- Complete and sign the ship/shore safety checklist.

Terminals may want to give the Masters of visiting tankers written details of the terminal's expectations about the joint responsibility for the safe conduct of operations, and ask that the tanker's personnel co-operate to meet these expectations. An example of the text for a letter to the Master of a visiting tanker, the ship/shore safety checklist and guidelines for the use of both documents are given in *ISGOTT* (Reference 12).

3.8.2 Management of moorings and cargo hoses

One Mooring Master should remain on watch at all times to monitor the position of the tanker with respect to the SPM, the mooring loads and weather conditions.

- The condition and security of the chain stopper, chafe chain and hawser should be checked.
- The integrity of the cargo hose connections should be checked and the snubbing chains should remain tight, with no abrasion or undue movement.
- The cargo hose strings and the SPM should be visually checked for leaks and, if necessary, checked closely by the support vessel.

Two Mooring Masters should be on duty during periods of heavy workload, such as during mooring, hose handling, pre-cargo discharge, critical stages of the cargo transfer, emergencies, periods of high winds or heavy seas and whenever the tanker's position relative to the SPM is causing concern or cannot be maintained.

A suitably qualified and experienced watchkeeping officer should be on duty at all times.

When the tanker is moored at the SPM, the tanker should provide two deck watchkeepers, one on the forecastle and one at the manifold, at all times.

Some terminals have demonstrated, by risk assessment, that conditions allow the deck watch to be reduced to one person who monitors both the forecastle and the manifold area. These terminals provide Mooring Masters with station monitoring or telemetry systems to monitor the hawser load and cargo pressure, and have support vessels stationed nearby.

The watchkeeping officer should brief both deck watchkeepers on their duties and responsibilities. Terminals may consider providing written guidelines for the forecastle watch (see Appendix C).

Many terminals have found that, to manage moorings, it helps to use a tug while the tanker is made fast (see Appendix D).

3.8.3 Operational communications

Both primary and secondary means of communication should be established between the tanker and the terminal. Radio equipment should operate on a dedicated channel that is free of other traffic.

It is usual for the Mooring Master to have portable UHF/VHF radio equipment to communicate with the terminal control room. The watchkeeping officer should carry a terminal supplied portable radio at all times to communicate with the Mooring Master. Deck and forecastle watchkeepers should be provided with portable radios to communicate with the watchkeeping officer.

3.9 - Cargo transfer

All terminals should have procedures to ensure that:

- A pre-transfer exchange of (cargo) information is undertaken.
- The ship/shore safety checklist is completed.
- Cargo transfers are conducted in accordance with a written agreed loading or discharge plan.

The above are detailed in *ISGOTT* (Reference 12).

A suitably qualified and experienced watchkeeping officer should be on duty at all times in the cargo control room. A Mooring Master should also be in the cargo control room, during cargo tank topping off and other critical operations, to effectively communicate loading rate requirements to the terminal and to mitigate the risk of surge pressure incidents.

If any abnormal or unexpected event occurs, such as the tanker moving out of position or unusual pressure readings are experienced, cargo operations should be stopped until the situation is resolved.

The Mooring Master should monitor and record the cargo transfer rate and compare the volume of cargo transferred and received every hour, at an agreed time. Any significant discrepancy between ship and shore cargo figures should be acted on in accordance with the example flow chart in figure 3.5.

Terminals should:

- Be disciplined in monitoring the difference between cargo transferred from the ship and that received on shore.
- Continually refine the percentage difference at which to take action. The figure should not be so small that alarms are too frequent and are ignored, nor be so large that alarms are never raised.
- Insist that tankers make every effort to calculate accurate figures.

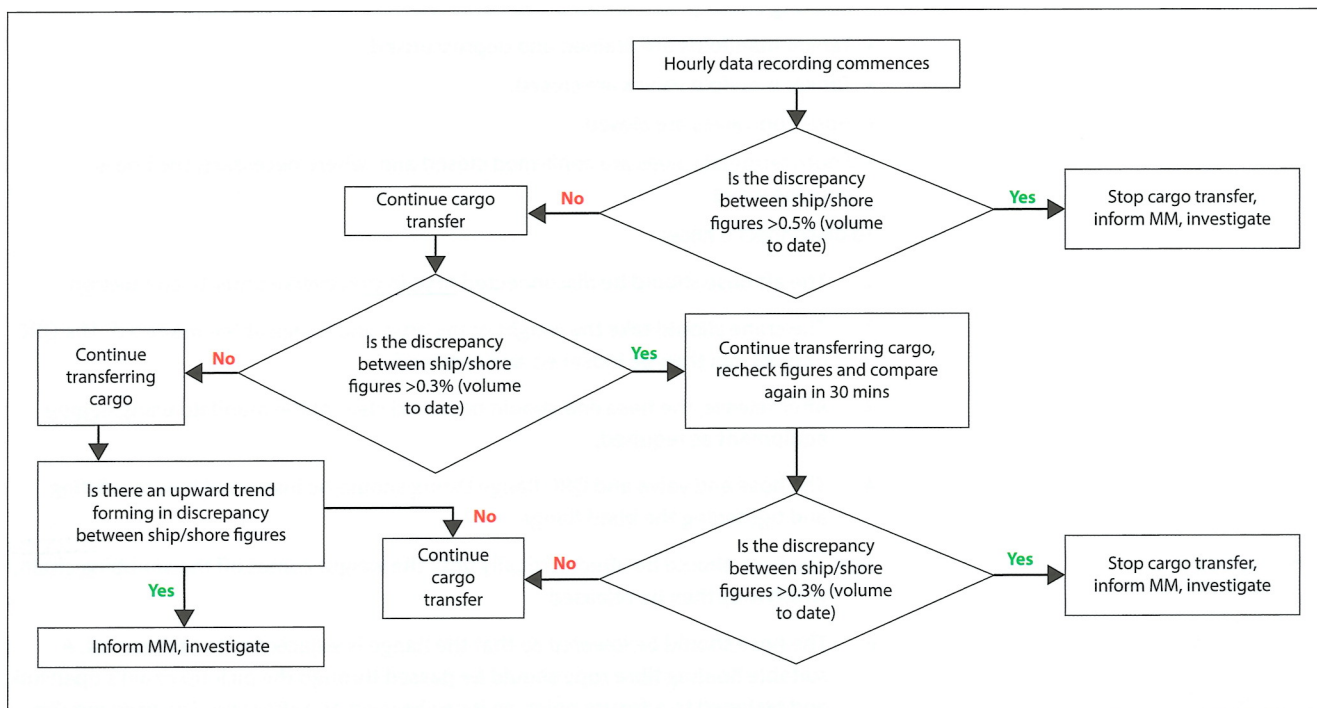


Figure 3.5: Ship/shore cargo quantity comparisons

The pressures at the tanker manifold, SPM and shore should also be recorded and used to help identify any potential irregularity.

3.9.1 Emergency shutdown

All terminals should have a procedure that identifies the circumstances in which cargo operations must be stopped immediately. These should be clearly agreed and understood by the Mooring Master and the watchkeeping officer.

The emergency shutdown sequence is:

1. Stop the cargo transfer pump on shore or on board.
2. Close the valve nearest to the pump.
3. Ensure that the flow has stopped and that the pipeline pressure is zero.
4. Slowly close the ship's manifold valve and the shore isolating valve.

3.9.2 Surge pressures

Incorrect operation of pumps and valves may produce pressure surges in a pipeline system. These surges may damage pipelines and hoses.

Information should be exchanged and written agreement reached between the tanker and the terminal concerning:

- The control of flow rates.
- Valve closure.
- Pump speeds.

- The minimum number of tanks to be open for loading at one time.

Tankers and terminals should have standard operating procedures to manage tank changes and prevent surge pressures. In particular, tankers and terminals should ensure that the:

- Valves to an empty tank are fully open before closing any other valve.
- Tanker and terminal communicate effectively before and during every tank change.

3.10 - Disconnecting hoses

Before commencing hose disconnection the Mooring Master should check that the:

- Tanker remains securely moored.
- Mooring Master, deck officer and a competent crane operator are present.
- Tanker manifolds are drained and depressurised.
- Tanker manifold valves are closed.
- Hose end valves are closed.
- Shore terminal valves are confirmed closed and, where necessary, the line is depressurised.

To disconnect a hose:

1. The aft hose should be disconnected first, in the reverse order to connection.
2. The crane should take the weight of the hose and flange at the manifold. The QRC or bolts can then be loosened and removed.
3. After release, the hose end should be pulled clear of the manifold using rigging equipment as required.
4. The hose end valve and QRC flange O-ring should be inspected before refitting and tightening the blind flange.
5. The hose should be lifted vertically until the weight comes off the snubbing chain, which may then be released.
6. The hose should be lowered so that the flange is adjacent to the tanker rail. A suitable floating fibre rope should be passed through the pick-up chain's open link and fastened to a secure point, so it can be used as a slip rope. The hose may be lowered close to the water and secured before releasing the crane hook.
7. The second hose string should be disconnected using the same procedure.
8. Before the tanker departs, either:
 - Lower the hoses to the support vessel and tow them clear, or
 - slip the hoses at water level into the sea directly from the slip ropes as the tanker moves astern, clear of the berth, so that they do not foul the tanker's propellers. This method does not require the use of a support vessel and may be preferred in adverse weather conditions.

3.11 - Departure from the single point mooring

3.11.1 Role of Mooring Master (1) – pilotage

The Mooring Master should advise the Master on manoeuvres to depart from the SPM, and should instruct the support vessels to tow the hose string clear and clear the hawser pick-up rope when released.

Departure should be started only once the tanker's engines, the forecastle party and the support vessels are ready. The tanker's main engines should be tested only when a Mooring Master is ready on the forecastle.

The tanker should be backed away slowly from the SPM, stemming the wind or current, before setting the appropriate course clear of the SPM to sea. The initial backing-away from the SPM should generally be made at less than 0.25 kts, allowing time for the pick-up rope to be winched out and released in a controlled manner and without tension.

3.11.2 Role of Mooring Master (2) – unmooring on forecastle

Under the guidance of the Mooring Master, a responsible deck officer should be on the forecastle to instruct the tanker's crew.

1. The mooring team should participate in a toolbox meeting to discuss all procedural and safety aspects of the task.
2. Before unmooring the tanker, the Mooring Master should ensure that there is no load on the mooring hawser. If necessary, the Mooring Master should request a brief engine ahead movement.
3. The hawser pick-up rope should be heaved taut until the weight is off the stopper tongue. The chain stopper securing pin should be removed and the stopper opened and secured in the open position.
4. The hawser pick-up rope should be paid out slowly, ensuring that the chain clears the stopper and bow fairlead, until finally the chafe chain and support buoy are in the water.
5. The hawser pick-up rope should then be paid out in a controlled manner, at the speed of the winch, and finally let go. The tanker's sternway should not exceed the winch speed.

Where two hawsers are used, they may be disconnected simultaneously. However, the mooring hawsers should not be crossed when lowered into the water. It may also be necessary to release and lower the hawser pick-up ropes one at a time, allowing the support vessel to tow each one clear in turn.

Section four

Inspection and maintenance of single point moorings

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This section provides guidance on the effective maintenance of critical items of equipment. Maintenance is often made difficult by access considerations and the need to schedule maintenance when the single point mooring (SPM) is not in use.

These guidelines are not designed to replace manufacturers' instruction manuals or statutory regulations, but to provide a description of the maintenance requirements of a typical SPM.

The maintenance of SPMs and their equipment is important, particularly with regard to lubrication and corrosion protection, because of the environmental conditions to which SPMs are exposed.

Records of maintenance work are a legal requirement in many countries. At a minimum, records should be kept of the results of inspections, measurements, tests and any remedial work or replacements carried out. This recorded data should be used to monitor deterioration and failure rates and to judge the adequacy of remedial work performed. It also serves as evidence to support any decision to perform the work more or less frequently at a particular site or during investigation following a failure.

4.1 - Inspection and maintenance principles

A successful maintenance regime optimises the availability of equipment and ensures that installed equipment retains its designed safety features while costs are managed.

In general, maintenance is either reactive or proactive:

- Reactive maintenance is carried out on an as-needed basis, usually when a failure or fault has occurred. With this approach, the facility may incur unplanned downtime while repair and recommissioning take place.
- Proactive maintenance is scheduled and is designed to pre-empt failure and minimise unplanned downtime. With this approach, the risk and consequences of failure are assessed and an optimised inspection and maintenance regime is established.

The principles in this document are based on proactive maintenance – a tailored inspection schedule to suit each item of equipment and its supporting infrastructure.

The inspection schedule typically includes:

- Regular planned inspection to ensure safe, reliable and efficient operation.
- Periodic review of operating conditions to assess their possible effect on the conclusions of the previous inspection report and planned inspection intervals.

A facility's maintenance is influenced by decisions taken during its design. The operations and maintenance philosophy is prepared at an early stage during the design process and the inspection regime is linked to the maintenance philosophy.

The degree and frequency of the inspection and maintenance of equipment depends on many factors, but the main considerations are safety, environmental protection and operability. To predict the safe operating life of the facility and the need for repairs or replacements, management may require up to date information on the condition of the plant and its rate of deterioration.

It is not possible to specify the maintenance intervals for equipment in all locations because they depend on factors such as:

- The age of the equipment.
- Environmental conditions.
- Criticality of service.
- Timing of SPM shutdowns.
- The manufacturers' recommendations.

Potential problems may be identified at an early stage with simple processes, such as pre-operating checks and visual observations by operating personnel.

4.1.1 Guidance on designing an inspection and maintenance plan

Records of all reviews and assessments should be retained.

To a large extent, an inspection and maintenance schedule for a new facility will be based on the manufacturers' recommendations, together with generic experience from similar facilities in comparable operating and physical environments. The risks associated with maintenance induced failures should always be considered.

The schedule considers the physical nature of the individual components of the facilities and their importance in maintaining operability. To optimise the amount of maintenance work carried out, techniques such as reliability-centred maintenance and condition monitoring may be applied.

The steps to design an effective inspection and maintenance plan are:

1. List assets

Develop an inventory of the structures and equipment to be included in the maintenance scheme.

2. Identify failure modes

Identify the modes in which each structure or equipment type is most likely to fail.

3. Criticality assessment

Criticality is the combination of the probability of failure and its consequence. The criticality levels of individual items of SPM equipment need to be assessed by performing a desktop study that looks at the inherent risk associated with each individual failure mode.

Steps 2 and 3 are often combined in a failure modes, effects and criticality analysis (FMECA), to determine possible failure modes and effects on the system operation, such as unsafe situations or shutdown.

4. Complete a remaining life assessment

A reliability-centred maintenance schedule can be prepared for each element of the facility once each element's rate of deterioration has been established. Until this has been done, maintenance will almost inevitably be carried out in line with manufacturers' recommendations.

Where possible, rates of deterioration should be determined by inspection activities. In this section, generic reliability data from the industry is used as the basis for the guidance on inspection schedules.

5. Plan the inspections

The objective of the inspection plan is to record the condition of the equipment and its rate of deterioration over time. In most cases it takes a number of years to gather information, during which time the inspection and maintenance schedule can be progressively optimised.

Higher criticality items should receive the most attention and be inspected most frequently. A managed run to failure strategy can be adopted for some low or negligible criticality items. Safety should be the priority when considering the frequency of inspections.

The type and scope of the inspection should also be defined when creating the inspection plan. Because invasive inspections may require equipment to be dismantled and materials tested and sampled, it should be expected that visual inspections will be carried out more frequently than invasive inspections.

The schedule should also identify any requirement for supporting services, such as scaffolding, specialist equipment, remotely operated vehicles or contractors, e.g. divers.

6. Plan the maintenance

It may be worthwhile optimising the maintenance of items with high associated maintenance or replacement costs over a long term. For example, a cost benefit

analysis may show that regular painting of a steel structure will extend its lifetime and may be more efficient than early replacement.

7. Combine inspection and maintenance tasks

Combine the inspection and maintenance tasks of all individual items into one plan.

8. Conduct reviews

Reviews should verify that the SPM systems are operated and maintained in accordance with the design intent. As part of a change management process, reviews should be carried out when changes occur to the terminal facilities or operations, such as changes to equipment, the cargoes handled or to the operational parameters.

4.2 - General precautions

Terminals should ensure clear accountability for all equipment in the SPM system, including the shore facilities, beach crossing, submarine pipelines, pipeline end manifold (PLEM), SPM and support vessels. Responsibility for maintaining the equipment is sometimes split between departments, between marine and shore-based engineers for example. Where this is the case, terminals should ensure that the boundaries of responsibility are agreed and understood.

Before carrying out maintenance work, the following precautionary measures should be taken:

- Maintenance work should not be carried out when a tanker is moored.
- Cargo transfer operations should be completed and the tanker disconnected.
- Risk assessment and hazard identification (HAZID) should be completed.
- Permits to work and a toolbox meeting should be completed.
- The turntable should be positioned and secured to allow safe access.
- In accordance with enclosed space entry procedures, the centre well and buoy internal compartments must be tested for gas, thoroughly ventilated and checked as gas free before personnel are permitted to enter them.
- Gas-freeing precautions should be implemented when opening pipework or hoses.
- Ear defenders should be worn when testing the foghorn.
- Temporary safety barriers should be erected around any exposed drops or open hatches.
- Earthing precautions to protect bearings should be taken before welding takes place.

4.3 - Inspection and maintenance schedules

The schedules in this section are typical outlines of routines at terminals. They provide a starting point from which terminals can use their own complete list of equipment and detailed manufacturers' recommendations to build specific inspection procedures.

The experience of terminals and oil companies suggests that most SPM inspection and maintenance items may be considered on a time-based schedule. Some items should be considered for additional inspection after storms or adverse sea and weather conditions.

When multiple items share the same operating conditions, terminals generally inspect on a rotating batch principle, for example inspecting one or two mooring legs to infer the condition of the others.

When an SPM has been operated for several years, inspection periods may be increased or decreased according to the results and the condition of components.

4.3.1 Pre-berthing inspection

Before a tanker berths, pre-berthing checks should be carried out from the support vessel and from on board the SPM. Checks of the pick-up rope, chafe chain, rail hose and hose lifting equipment should also be made as they are brought on board the tanker.

Table 4.1 summarises items to be included in a pre-berthing checklist.

SPM	Confirm
SPM location	Correct location
Trim and freeboard	Trim and draught normal
Hatches	Hatches in place and closed
Navigation aids	Lights and fog signal working
Body, turntable and platforms	No damage
Fendering	Serviceable condition
Electrical systems	Function test OK
Telemetry	Function test OK
Area around SPM	No sign of oil
Fluid swivel and piping	No sign of oil seepage
Overboard pipework	No sign of oil seepage
Expansion joint	No sign of oil seepage
Valves	Working and set correctly
Instrumentation and gauges	Working
Alarms and trips	Working and set correctly
HPU and hydraulics	Working
Mooring bridle/uni-joint	Connections secure
Hawser	No damage, shackles secure
Hawser floats	Laced up, none missing
Support buoy	Floating, not tangled
Pick-up rope	Not worn, not tangled
Hoses	
Area around hoses	No sign of oil seepage
Hose flange and nipple areas	No sign of oil seepage
Centre well	No sign of oil
Double carcass leak detection	Not activated
Hose flanges	No movement or loosening
First off the buoy connection	No movement or loosening
Connections to MBC and spools	No movement or loosening

Table 4.1: Pre-berthing checklist

4.3.2 Buoy and structure inspection

Item	Frequency			Remarks
	Monthly	3 Months	Annual	
SPM location		X		GPS Frequency of plumb line checks to align with other diver activities
Hatches			X	Check for watertightness, gaskets remain in good condition and bolts tight
Structural survey				X Check condition of coating, thickness verification, deformation or indentation. Test for cracks
Main bearing			X	Check for adequate grease returns, running clearances and main bearing bolt tension
Soundings	X			Check that tanks are empty, no water ingress
Internal inspection			X	Check for mechanical damage, deformation, corrosion, signs of water ingress
Cathodic protection			X	Measure efficiency, check anodes are secured and not depleted
Fendering			X	Check for damage
Paintwork		X	X	Check for signs of coating breakdown; touch up paint where required
Underwater inspection			X	Diving inspection of structure; remove any growths

Table 4.2: Inspection schedule buoys and structure

4.3.3 Lubrication

Item	Frequency			Remarks
	Monthly	6 months	Annual	
Central pipe swivel bearing	X			Lubricate in accordance with the manufacturer's guidance and schedule
Main bearing	X			Check grease system is working and that grease is being displaced
Valve gearboxes		X		Lubricate in accordance with the manufacturer's guidance and schedule
Winches and wires			X	Lubricate in accordance with the manufacturer's guidance and schedule
Lifting equipment		X		Lubricate in accordance with the manufacturer's guidance and schedule
Load cell/uni-joints	X			
Turntable locking pins and guides	X			
Sheaves, door hinges		X		
Grease analysis			X	Check for any metal particles, dirt and signs of deterioration. Grease analysis may be undertaken more frequently as it provides timely advice of emerging bearing problems

Table 4.3: Lubrication schedule**4.3.4 Mooring legs and anchor point inspection**

Item	Frequency			Remarks
	3 months	Annual	3–5 years	
Chain angles	X			Adjust if necessary. Physical chain angle checks may be supplemented by alternative buoy position monitoring methods, such as using GPS tracking
Inspection of mooring (anchor) legs and buoy chain hawse		X		Visual or remotely operated vehicles check for any wear or damage
Chain wear-down			X	Measure wear-down of chain on deck, from the buoy end through to the seabed thrash zone
Anchors or piles			X	Check connections, where visible Buried piles and chain typically have >30 years life

Table 4.4: Inspection schedule mooring legs and anchor points

4.3.5 Cargo transfer system inspection

Time based				
Item	Monthly	3 months	Annual	Remarks
Torque arm	X			Prior to berthing
Fluid swivel	X			Prior to berthing
External leakage	X			Prior to berthing
Piping			X	Measure steel thickness on bends and inspect for any sign of cracking
Pressure test pipework			X	Annual
Piping supports			X	Secure, no undue movement or corrosion
Valve operation	X			Pre-berthing
Expansion joint	X			Pre-berthing
Relief valves			X	Overhaul, calibrate and test the valves

Table 4.5: Inspection schedule cargo transfer system**4.3.6 Pipeline end manifold inspection**

Frequency			
Item	Annual	3–5 years	Remarks
PLEM piping		X	
PLEM structure		X	Normal design life is 30 years
PLEM foundation		X	
Valves	Pre-berth		Check they are working and set correctly
Subsea pipeline		X	

Table 4.6: Inspection schedule PLEM**4.3.7 Electrical, instrument and safety inspection**

Frequency				
Item	Monthly	3 months	Annual	Remarks
Electrical systems			X	Function test; check condition of insulation, connections
Instruments and controls			X	Function test
Telemetry			X	Function test
Hydraulic power unit (HPU)			X	Check accumulators, piping, valves for correct operation
Safety equipment		X		Check the condition of lifebuoys, extinguishers, handrails, ladders
Navigation aids			X	Function test, check electrical connections are in good condition
Batteries		X		Service battery and fully charge
Enclosures		X		Check watertight, seals and boxes in good condition, no water ingress
Solar panels		X		Check output and condition, clean panels
Wind generators		X		Check output, condition, blades

Table 4.7: Inspection schedule electrical, instruments and safety

4.3.8 Post tanker departure inspection

SPM	Confirm
Trim and freeboard	Trim and draught normal
Hatches	Hatches in place and closed
Navigation aids	Lights and fog signal working
Area around SPM	No sign of oil
Valves	Set in accordance with terminal procedure
Hawser and pick-up rope	Floating clear or removed
Hoses	
Area around hoses	No sign of oil seepage
Hoses and pick-ups	Not tangled or crossed

Table 4.8: *Inspection post tanker departure***4.4 - Mooring system**

The following inspection procedures for mooring system assemblies are based on terminals' experiences. Terminals should also refer to *Recommendations for Equipment Employed in the Bow Mooring of Conventional Tankers at Single Point Moorings* (Reference 2).

Details of tests and inspections for hoses are given in section 5.

4.4.1 Mooring hawser

Hawsers should be specified in compliance with *Guidelines for the Purchasing and Testing of SPM Hawsers* (Reference 18).

4.4.1.1 Hawser handling – storage

Hawsers should be stored off the ground, typically in a wooden box, to provide a covered, cool, dry, well ventilated, dark space where air can freely circulate.

Hawsers should be lifted using suitable fibre rope or webbing slings. Wire rope should never be used.

4.4.1.2 Hawser handling – in service

Hawsers should never be dragged over sharp or rough edges.

Mooring Masters should instruct tug and line boat Captains on correct hawser handling techniques.

Hawsers that are not to be used for prolonged periods should be removed and stored.

4.4.1.3 Hawser pre-arrival inspection

The Mooring Master should visually inspect the following during the pre-berthing inspection:

- Hawsers: The inspection should document any damage such as cuts, external abrasion and/or fusion, missing hawser floats, damage to the thimble, unexpected torsion or other irregularities.
Excessive twist should be worked out before berthing.
- Mooring shackles: Ensure locking pins are in place.
- Hawser end fittings, mooring bridle/uni-joint, floating production, storage and offloading unit (FPSO) hawser reel, support buoy and mooring messenger: Inspect for damage or corrosion.

Hawser assemblies with any damage or defects should be considered for removal from service for more detailed inspection.

4.4.1.4 Hawsers removed from service

Any damage should be documented. Records for all hawsers should be kept in a database.

After removal from service, hawsers should be visually inspected, including opening thimbles to inspect for any signs that the fibres have fused. Hawsers intended for re-use should be stored correctly.

Destructive testing of hawsers to acquire data on service life history is recommended. Due to the high break loads involved, the test is usually carried out by sampling and testing individual yarns, a process termed ‘realisation’.

4.4.1.5 Hawser service life policy

The new dry breaking strength and energy absorption performance of hawsers will deteriorate during service depending on factors such as service life, cyclic load history, hawser type, construction, environmental conditions, damage and stowage arrangements. Terminal operators should consider these factors when choosing the appropriate hawser for the mooring system and when setting hawser retirement criteria.

The three methods typically used to determine hawser retirement are:

1. Terminals operating load monitoring telemetry with computer based residual hawser strength calculations have found the residual strength predictions compare well with the results obtained from destructive testing.
2. Time-based retirement criteria are set based on the hours in use, time in service or number of tankers.
3. Time-based retirement criteria are set based on the hours in use, time in service or number of tankers (as above), but particularly high mooring loads are also recorded and the reduction in life estimated.

Manufacturers should provide hawser retirement advice based on a combination of their own recommendations, the intended use and service conditions, any previous terminal experience and the results of hawser testing.

4.4.2 Chafe chain

Whenever a tanker is secured, the Mooring Master should check the condition of the chafe chain and the connection to the hawser. Connections to the flotation buoy should also be checked. The chain should be inspected for distortions and cracks as well as excessive wear and/or corrosion.

Each month, the chafe chains should be inspected and the diameter of the chain measured between the links with callipers. Any chain with a mean diameter measuring 10% below its nominal size should be replaced. Inspection intervals should be modified depending on the wear rates experienced, or after high cyclic mooring loads.

Chain links with any of the following should be removed or replaced:

- >10% wear.
- Missing stud.
- Excessively loose stud.
- Noticeable deformation.
- Cracks at the toe of the stud weld that are extending into the base material.
- Deep surface cracks or gouges.

4.4.3 Pick-up rope

After the tanker has berthed, a close inspection of the pick-up rope should be carried out to determine when it should be replaced.

4.4.4 Support buoy

The mooring chain support buoy should be inspected for external damage while the tanker is moored to the SPM. During monthly chafe chain inspections, the support buoy chain should also be checked for any wear and to ensure that all connections are secure.

4.4.5 Single point mooring bridle/joint

Before the tanker arrives at the SPM, the elements of the mooring bridle/joint assembly should be checked, including spherical bushes, load cells, chain, connecting shackles and tri-plates. The assembly should be examined for deformation, cracks and

excessive wear in between chain links and connections, particularly at the connecting pins. A full inspection should be undertaken if unusual wear, cracks or deformation are noted.

On a three-monthly basis, the mooring bridle/joint, tri-plate, chain links, spherical bushes and load cells should be inspected for:

- Deformation.
- Cracks.
- Corrosion.
- Excessive wear.

Parts should be replaced where necessary. Load cell bushes should be greased.

The diameter of the chain should be measured between the links with callipers. Any chain with a mean diameter measuring 10% below its nominal size should be replaced. There should be no evidence of cracks or deformation. At the same time, the condition of the wooden deck sheathing should be inspected.

Item	Frequency			Remarks
	Monthly	3 months	Annual	
Mooring hawser	Pre-berthing			Visual inspection. Floats intact. Shackles secure. No damage or corrosion
Chafe chain	X			Inspect and measure wear
Pick-up rope	From tanker			Inspect and replace when necessary
Support buoy	X			Inspect from each tanker. Monthly inspection with chafe chain
Mooring bridle/uni-joint	Pre-berthing	X		Visual check. Inspect and measure wear

Table 4.9: Inspection schedule mooring system

4.5 - Lifting equipment

Terminals should have a process in place to ensure that all lifting equipment is designed, constructed, checked and maintained as necessary to keep it safe for use.

Terminals should comply with national regulations such as, in the UK, the *Lifting Operations and Lifting Equipment Regulations (LOLER)* (Reference 21).

Guidance for offshore lifting may also be found in *Lifting and Hoisting Safety Recommended Practice* (Reference 22) and *Technical Guidance on the Safe Use of Lifting Equipment Offshore* (Reference 23).

The rail hose lifting and support assembly is the main item of terminal lifting equipment referred to in this Guide. Each component and assembly should be identified and be fully traceable, and records should be kept of checks, inspections, examinations and test certificates.

Terminals should:

- Make simple pre-use checks as hoses are lifted.
- Complete regular inspections from the support vessel deck. These should be at monthly intervals.
- Carry out a systematic and detailed annual examination of all the components, including retesting and certification.
- Replace hose lifting equipment whenever necessary.

4.6 - Spares policy

The terminal operator should, by conducting a risk assessment and cost/benefit analysis, determine the appropriate quantity of spares to have available. The quantity of spares may be optimised by considering risk, criticality, commonality, sharing and supplier held spares and by using sound engineering judgement. The following factors should also be considered:

- Business impact of downtime.
- Business pressures to remain in operation.
- Cost/benefit of spares.
- Local and industry experience.
- The risk of damage.
- Wear rates.
- Lead time to supply spares.
- Shelf life of spares.

4.6.1 Consumables

The experience of terminals indicates that, as a minimum, some consumable spares are necessary, including:

- Hose stud bolts, nuts and gaskets.
- Manifold connection stud bolts, nuts, gaskets and tools.
- Rail hose lifting chain, snubbing chain and shackles.
- Hose lights and batteries.
- Pick-up rope.
- Navigational light lamps.
- Lubricants.
- Where applicable, double carcass leak detection spares.

4.7 - Line flushing operations

Serious incidents have occurred during line flushing operations at SPMs through the lack of effective controls, non-adherence to procedures and the use of inappropriate equipment. Because the use of water is thought to be safe, terminals may have underestimated the hazards and consequences.

Terminals should have a documented philosophy for water flushing, which should include:

- Applying a hazard and operability (HAZOP) analysis.
- Referring to a process flow diagram of the infrastructure, from the pumping source to the final containment, including any support vessel or tanker systems involved.
- Using written working procedures, including controls and communication.

4.7.1 Flushing

Water flushing is commonly carried out to evacuate petroleum cargoes from SPMs before any of the following operations:

- Maintenance and inspection.
- Replacement of hoses.
- Disconnection of hose strings.
- Hydrostatic testing.
- Inspection of pipelines, such as by intelligent pipeline inspection guide (pig).

Flushing may also be required to prevent environmental pollution.

A small number of terminals routinely flush SPMs after each cargo operation. Typically, these terminals have procedures with the following precautions in place for tankers to carry out a flush on completion of discharge:

- Tanker nomination and acceptance criteria for flushing.
- Flush operation procedures.
- Shore tanks and terminal systems to handle free water.
- Corrosion protection throughout the cargo system.
- Cargo measurement and quality procedures.

4.7.2 Ensuring an effective flush

Terminals should develop procedures for an effective flush that removes all petroleum residues. Procedures that should be taken into account include:

- Minimum volume.
- Pressure.
- Flow rate.
- Previous cargo and time in the pipeline.

Some terminals have successfully used gel pigs to ensure an effective flush using the minimum volume of water.

4.7.3 Flushing from support vessels

Support vessels that are required to carry out flushing operations should be designed, equipped and manned to carry out the operations safely.

Traditionally, flushing was carried out from or to tankers. It is now more common for flushing to be carried out from support vessels because of the changes in tanker ballast systems and the difficulties caused by tankers retaining oily water on board.

The following precautions should be considered before any flushing takes place from a support vessel.

4.7.3.1 General precautions

Support vessels should have a flushing system that complies with the following requirements:

- The pump and piping should be fit for purpose and designed to deliver the required pressure and flow rate.
- The flushing system should be independent of, and physically isolated from, any other system.
- The system should be designed with a physical means of preventing the backflow of petroleum liquids and gases into the support vessel.
- A pressure/vacuum gauge should be fitted in a position where it will reliably indicate the pressure before valves to the hose connection are opened.
- Flush system components should be rated at a pressure that is consistent with the maximum working pressure.
- Ventilation systems to the accommodation and machinery spaces should not permit the ingress of vapours from the working deck or flush pump area.
- The flush system should be independent of the firewater system, so that the firewater main may be kept pressurised and ready for use.

Terminals should comply with the following requirements regarding support vessel charters:

- Terminals should have in place criteria for accepting support vessels.
- Contract terms should be in place.
- Support vessels should be specified, manned and equipped to undertake line clearance activities in accordance with the terminal's procedure.
- The support vessel should be positively examined to confirm it is consistent with the inputs and findings from the HAZOP.

Before any flushing operation commences the following should be in place:

- A written procedure that the support vessel's Master and crew are familiar with and have agreed.

- The terminal's procedure should be reviewed and signed off by all the relevant disciplines involved in the activity, including:
 - Terminal operations.
 - Maintenance.
 - Process engineering.
 - HSSE
 - The support vessel's Master and/or Operations Superintendent.
- Single point accountability for the activity should be established within the terminal operations and maintenance disciplines. Under no circumstances should a support vessel's marine contractor conduct flushing without effective operational control and oversight from terminal personnel.
- Effective communications should be established between the operation locations, for example the SPM, support vessel, tank farm and control room.
- Support vessel crews should be specifically trained in flushing operations, including an awareness of *ISGOTT* (Reference 12) and the basic hazards of petroleum.
- Support vessel crews should complete their own job safety analyses and risk assessments.
- The flush pump should be started and pipework pressurised before valves to the hoses are opened.
- Where line clearance is to a tank, the tank should be at as low a level as possible to minimise back pressure. In any event, the maximum back pressure should be documented in the flush procedure.

Section five

Handling, storage, testing and inspection of hoses at single point moorings

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The purpose of this section is to ensure that hoses perform satisfactorily through their life, from delivery to retirement.

Hose strings provide a critical link between the single point mooring (SPM) and the tanker. Hoses are constantly subjected to the dynamic forces of the sea, which can result in severe loads and stresses within the hose.

For hoses to be reliable and have a long life, it is important that they are handled and stored correctly and are inspected and tested in a consistent manner and at appropriate intervals.

5.1 - Hose lifting and storage

5.1.1 Hose lifting

Hoses are robustly constructed for the marine environment but can be damaged by improper handling, leading to failure or premature retirement.

Care should be taken to adequately support hoses at all times to prevent over-bending (kinking) or point loading that may permanently deform the buoyancy material.

Hose covers should be protected from abrasion and cuts. Hoses should not be dragged across the ground. The use of rollers or castors should be considered wherever lifting by crane is not practical.

The recommended method of lifting a single hose is to use a lifting bar and three lifting straps of adequate safe working load (SWL). The lifting straps should, preferably, be flat nylon or equivalent reinforced cloth bands of at least 150 mm in width to prevent chafing of the hose cover. Flat lifting straps also help to prevent deformation of the flotation medium.

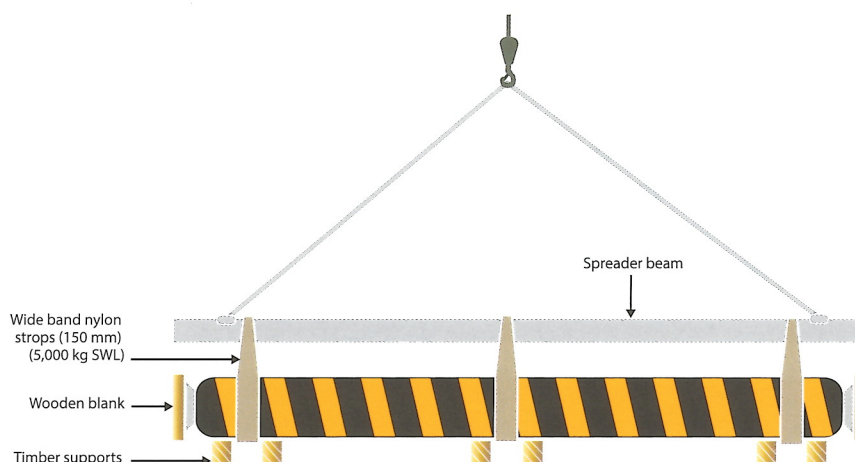


Figure 5.1: Typical spreader lifting bar

A hose should never be lifted by a single sling at the midpoint or by two slings positioned one at each end. When moving a hose, it should be lifted properly and set down with care on adequate supports.

5.1.2 Hose storage

The lining and body of hoses are constructed from elastomers that, after manufacture, will continue to age. It is important to minimise this aging by storing hoses correctly. The main causes of premature aging are heat and direct sunlight. Hoses should also be protected from external damage, pests and contact with solvents, corrosive liquids or vapours. Hoses should not be stored next to operating equipment that generates ozone or heat, nor in workshops where welding, cutting or grinding takes place.



Figure 5.2: Warehouse hose storage

Hoses should be stored in a warehouse or properly constructed fabric store that allows ventilation around the entire hose.

Figure 5.3 shows a suitable store constructed using the following guidelines:

- The fabric should not be in direct contact with the outer cover of the hose.
- The fabric should not be in direct contact with the hoses. There should be an air gap between the hoses and the fabric to allow free circulation of air. This may be achieved by building a scaffolding structure or by stacking an empty pallet on top of the loaded pallets, modified to form a roof, and fitting the fabric over it.
- The fabric should be large enough to shade all the hoses, not just those on the top pallets.
- The fabric should be UV stabilised and provided with grommets for rope lashings.
- The fabric should provide around 75%–90% shading to help keep the hoses cool and to allow rainwater to drain away.



Figure 5.3: Example of shaded hose storage

In locations where extreme hot or cold temperatures apply, additional measures may be necessary (for example, storing the hoses in a climate controlled warehouse).

Hoses should be stored on steel-framed pallets. Those described in the *Guide to Manufacturing and Purchasing Hoses for Offshore Moorings (GMPHOM)* (Reference 3) are suitable for both transit and storage. The pallets may be stacked up to three high, reducing the area required for storage. Pallets also allow easy access for personnel to examine hoses, check serial numbers and insert lifting straps.

Both ends of hoses should be covered with blanks, typically made from wood or plastic, and bolted to the flange faces as follows:

- New hoses can be blanked with either solid or ventilated wooden blanks.
- Used hoses should be fitted with ventilated blanks to allow volatile vapours to escape.
- Ventilation holes should be covered with gauze to stop pests entering.

Hoses moved from oil service to storage should first be drained completely and flushed fully with water to remove any toxic or combustible vapours.

5.2 - Hose string assembly and handling

5.2.1 Hose flange bolting

5.2.1.1 Stud bolt

Hose flanges should be bolted together using stud bolts that conform to ASTM A193 Gr. B7 and nuts that conform to ASTM A194 Gr. 2H (Reference 19).

Bolts and nuts should be coated with a suitable system to protect against corrosion. Terminals have found that fluoropolymer coatings are effective.

5.2.1.2 Gaskets

For low pressure application, the most versatile gasket is the non-asbestos fibre gasket. However, spiral wound gaskets are often preferred, due to the poorer performance of non-asbestos fibre when dynamic loads act on the flange, affecting joint tightness. The design of spiral wound gaskets offers the advantages that it prevents gasket blow-out, is ridged and is available in a selection of different filler materials (polytetrafluoroethylene (PTFE) etc.).

Gasket selection for hoses and piping interfaces should be carried out in conjunction with the system designer and the hose manufacturer.

5.2.1.3 Bolt tensioning

In all circumstances, a leak-tight joint should be guaranteed.

The most common way of tensioning the bolts is by controlled torque wrenching, using either manual or hydraulic torque wrenches. The method chosen will depend on bolt loading, access, clearance and tooling availability.

The required torque setting of the bolts should be determined in conjunction with the system designer and the hose manufacturer, considering the load conditions on the joint during installation, commissioning, operation and in survival conditions. The method used to calculate the torque setting should be aligned with common piping practices, such as in ASME B31.3 (Reference 20). The required bolt torque will also depend on the bolt material, coating, lubrication and gasket type.

Tables 5.1 and 5.2 provide details of the bolt requirements for standard hose flange sizes. A typical torque value used by some terminals, based on a 60% yield value, is included.

Flange size			Bolts		Typical torque 60% yield
Nominal diameter	Nominal pipe size	Bolt diameter	No.	Type of thread	N-m
200 mm	8"	3/4"	8	UNC	357
250 mm	10"	7/8"	12	UNC	575
300 mm	12"	7/8"	12	UNC	575
350 mm	14"	1"	12	UN8	862
400 mm	16"	1"	16	UN8	862
500 mm	20"	1 1/8"	20	UN8	1265
600 mm	24"	1 1/4"	20	UN8	1780

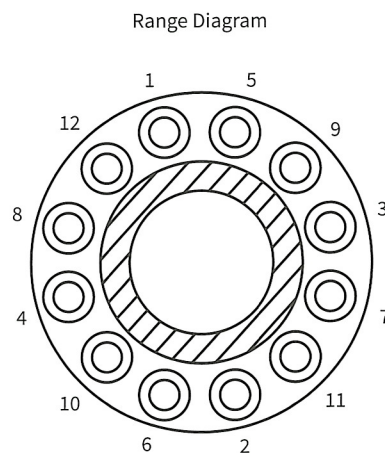
Table 5.1: Flange rating: ASME B16.5, Class 150

Flange size			Bolts		Typical torque 60% yield
Nominal diameter	Nominal pipe size	Bolt diameter	No.	Type of thread	N-m
200 mm	8"	7/8"	12	UNC	575
250 mm	10"	1"	16	UNC	862
300 mm	12"	1 1/8"	16	UNC	1265
350 mm	14"	1 1/8"	20	UN8	1265
400 mm	16"	1 1/4"	20	UN8	1780
500 mm	20"	1 1/4"	24	UN8	1780
600 mm	24"	1 1/2"	24	UN8	3186

Table 5.2: Flange rating: ASME B16.5, Class 300 (Reference 29)

Typical tightening process

After the flange has been assembled and all nuts have been run down by hand with the joint in place, wrench tightening should follow the sequence of the numbers indicated on the flange diagram in figure 5.4.

**Figure 5.4:** Flange diagram

Marking the numbers on the flange with a wax crayon aids in keeping track of the tightening process.

During the following steps, any gap between the flanges should be kept even all around the circumference and nuts should be made up approximately the same amount on each end of the bolt.

1. First time around, the nuts should be just snugged with a hand wrench.
2. Second time around, the nuts should be tightened firmly with the same wrench.

A torque wrench should then be used for the following steps:

3. Third time around, apply approximately 25% recommended torque.
4. Fourth time around, apply approximately 75% of recommended torque.
5. Fifth time around, apply 100% of recommended torque.
6. Continue tightening nuts all around until they do not move under 100% recommended torque.

Nuts should be re-torqued periodically. It should be noted that most of the short-term bolt preload loss occurs within 24 hours after initial tightening.

5.2.2 Handling hose strings

Care should be taken to avoid over-bending or kinking the hoses when launching hose strings from a beach, slipway or the deck of a support vessel. Hoses should never be dragged over the ground or deck. The use of rollers should be considered.

5.2.2.1 Hose towing

Floating hoses may be towed full of water or air on the surface of the water. Submarine hoses should be towed on the surface and full of air.

Blind flanges should be fitted at both ends of the hose string to protect the face of the flange and prevent foreign objects passing through the hose and damaging the liner. Bleeder valves on the blind flanges can help to provide controlled sinking into place. Blind flanges should be fitted with towing eyes.

The towing bridle is typically attached to a pad eye welded onto a blind flange bolted to the first off the buoy hose. Blind flanges on submarine hoses should be removed at the surface, before the hose is installed, to prevent risk to divers from pressure differences.

Parts of the hose string that have insufficient integral buoyancy, such as the first off the buoy hose, tanker rail hose and spool pieces, should be fitted with additional floats to ensure they do not sink.

The towing force applied by the tug should not exceed the hose's allowable axial load, as defined by the manufacturer. Generally, loads are controlled and acceptable by towing at speeds not exceeding five knots.

Where a suitable towing vessel is available, the first off the buoy hose may be lifted and secured on the aft deck. A secondary tow line should also be made fast. This method has proved more secure than free towing in situations where the loss of the tow could result in sinking of the hose string.

When towing in congested channels or harbours, a secondary tail boat, connected to the tanker rail hose blind flange, is usually needed to assist.

5.3 - Hose service life

5.3.1 Demonstrating the integrity of hose systems

Terminals should be able to demonstrate the integrity of hose systems. The following are the suggested means of doing so, some of which may be combined:

- Carry out a hydrostatic pressure test in-situ at a planned frequency.
- Test hoses on shore at a planned frequency.
- Double carcass leak detection (only where leak detection is functioning correctly and is routinely checked).
- Records of previous hose life and results of destructive tests.
- Manufacturer's life calculations based on a comprehensive understanding of the operating conditions.
- Inspection of hoses in-situ.

Terminals that choose not to carry out a hydrostatic pressure test in-situ, nor test hoses on shore, should be cautious when determining a service life policy. Similarly, terminals that carry out an annual hydrostatic test and are able to monitor hose condition by onshore inspection and testing may set longer service life periods.

5.3.2 Determining hose service life

The criteria used to determine hose service life are complex. Currently, service life can only be estimated by empirical means using observations, inspections, tests from hoses in service and destructive tests.

The *Guide to Manufacturing and Purchasing Hoses for Offshore Moorings (GMPHOM)* (Reference 3) has introduced a dynamic test requirement for prototype hoses for the first time. Technology is also being developed that will allow continuous recording of the environmental loads on hoses in service. In future, these developments may provide a basis for predicting service life.

The philosophies typically used for determining service life are currently:

- **Time based**

Terminals set a time period or number of tanker operations after which a hose is retired.

- **Condition based**

Hoses are brought on shore for individual testing or internal inspection.

Terminals reporting the longest service life, as shown in table 5.3, all use this approach.

- **Time based with interim condition checks**

For example, a first off the buoy hose was removed after three years in service. After successful inspection and hydrostatic pressure and vacuum tests, it was returned to service for a further year.

A variety of factors affect the service life of hoses, including:

- The ability of terminals to demonstrate the integrity of hoses.
- The ability of terminals to demonstrate the effectiveness and frequency of inspections and tests.
- System type and design.
- Manufacturer's input. It is vital that operators and manufacturers share detailed information about local conditions, hose design and required performance.
- Type of hose and its construction and position in the string. For example, the following hoses may require different policies for service life:
 - Mainline floating.
 - Submarine.
 - Tanker rail.
 - Tail.
 - Reinforced hoses, such as first off the buoy or floating production, storage and offloading unit (FPSO) connection hose.
- Severity of operating conditions:
 - Water depth, currents, wave height/period.
 - Number of loading/discharge operations.
 - Type and temperature of oil cargoes handled.
 - Ambient air and sea temperatures, humidity, ozone, high sunlight.
- Lifting and handling – offshore and onshore.
- Likelihood of mechanical damage (typically from boats or abrasion).
- Storage.
- Changes to operating or environmental conditions, manufacturer or hose type.

To help predetermine service life, terminals should maintain a comprehensive statistical database of hose history that includes:

- Time in service (terminals have found that throughput volumes have less relevance).
- Number of tanker operations – especially relevant to rail hoses.
- Location of hose in the string.
- The manufacturer’s report for each hose, containing certificates and test results.
- Results of inspections.
- Results of tests.
- Results of tests on retired hoses.
- Hose failures (root-cause analysis required).
- Position in hose string.
- Time in storage.

Terminals should determine their own policies for setting hose service life, but are encouraged to share results with other terminals.

It is essential to consider differences in system design, hose type and service, and operating conditions when comparing hose service life at different terminals.

5.3.2.1 Examples of hose time in service

This section provides a practical illustration of the time in service of floating hoses that terminal operators have chosen as appropriate in their terminal. It is not data of hose failure and is included for information only. The data is from 22 different terminals, operating 36 berths and 49 hose strings. The time in service is the time between the hose’s first use and retirement, including any storage time in used condition.

Hose type	Average time in service (years)	Shortest time in service (years)	Longest time in service (years)
First off buoy	3.7	1	6
Mainline	5.6	4	13
Tail	4.5	2	6
Tanker rail	3.7	1	5

Table 5.3: Service time chosen by terminal operators

The table shows that policies for hose service life vary considerably between terminals with differing operating conditions.

The figures include those for both double and single carcass hoses. The average time in service of double carcass mainline hoses was 7.1 years. There was little difference between the times in service for single and double carcass hoses located as first off the buoy, tail and tanker rail hoses.

5.4 - Guidance following overpressure and accidents

5.4.1 Overpressure

Table 5.4 contains guidance for hoses subjected to overpressure.

Pressure	Action	Notes
1.5 x Rated Working Pressure (RWP)	It is advisable to inspect hoses visually in-situ before resuming cargo operations. Any damaged hoses should be discarded.	Hoses may be subjected to a proof pressure of 1.5 x RWP during an annual hydrostatic test, for example, and so should be unaffected.
1.5–2.5 x RWP	It is advisable to remove hoses from service and carry out a hydrostatic pressure test, a vacuum test and an electrical test. If testing is successful, the hoses may be returned to service. Any damaged hoses should be discarded.	Pressures of 1.5–2.5 x RWP are higher than those to which new hoses are subjected during acceptance tests.
Over 2.5 x RWP or above the allowable axial load	Hoses should be removed from service and visually inspected. Any damaged hoses should be discarded. If hoses are to be re-used: - One visually undamaged hose should be subjected to a burst test. - If the burst test is successful, the remaining hoses may be retested using a hydrostatic pressure test, a vacuum test and an electrical test. - If this testing is successful, the remaining hoses may be returned to service.	Prototype hoses withstand 5 x RWP (before bursting) without failing or leaking. However, this test does not indicate whether hoses are damaged internally.

Table 5.4: Guidance for hoses subjected to overpressure

5.4.2 Vacuum

Vacuum may be caused by temperature cooling of residual product inside the hose and should be avoided by managing the pressure in systems. Any hoses exposed to vacuum should be removed from service, inspected and tested.

Vacuum affects submarine hoses in two ways:

- Vacuum causes dramatic changes to the shape of an individual hose, affecting the buoyancy of the hose, which subsequently changes the shape of the hose system. This could damage the hose due to excessive stress caused by bending and kinking of the hose system.
- Empty submarine hoses in vacuum are unsupported internally and may be crushed by the external water pressure.

5.4.3 Loads from breakout or mishandling

Hoses may be damaged or fail when subjected to high axial loads (such as those following a tanker breakout), if dragged over the ground, or if subjected to other mishandling, e.g. being towed at high speed.

The allowable axial load of a hose is the lowest predicted damaging or failure load divided by a safety factor of three (as shown in the calculation below), and is defined by the hose manufacturer.

$$\text{Allowable axial load} = \frac{\text{lowest predicted damaging or failure load}}{3}$$

Hoses that have been subjected to loads greater than the allowable axial load should be removed from service and tested as described in table 5.4. For example, in the breakout of a fully bolted 16-inch hose manifold connection, the entire hose string is likely to be overloaded and will require testing.

5.4.3.1 Accidental sinking of floating hoses

Permanent damage to a floating hose that is accidentally sunk may be avoided by recovering it as quickly as possible.

When sunk to a depth of 20 m and for more than 24 hours, the flotation layer of a hose will start to be compressed and damaged. Damaged hoses should be retired or returned to the manufacturer for the flotation layer to be replaced.

5.5 - Hose inspection and testing requirements

New hoses will have passed a series of acceptance tests after manufacture, as described in the *Guide to Manufacturing and Purchasing Hoses for Offshore Moorings (GMPHOM)* (Reference 3), and are ready for use providing they have been stored as described in section 5.1.2.

Unused hoses that have been stored for over five years should be tested and inspected before use, as described in section 5.7. Hoses that have been removed from service with the intention of being re-used should be tested and inspected before installation, as described in section 5.7.

Figure 5.5 is a guide to the installation of new, stored and used hoses.

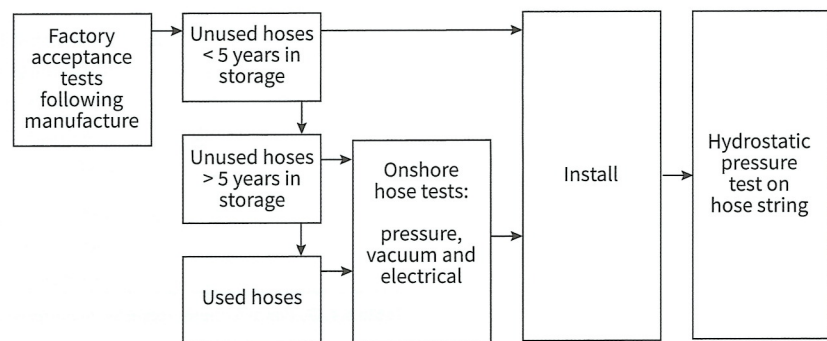


Figure 5.5: Hose installation tests

Terminals should develop, maintain and follow a documented hose inspection and testing programme. Figure 5.6 is a guide to aid terminals to develop requirements for a hose inspection and testing programme.

In-situ Pre-berth	In-situ 3 months	Annual (optional)	On shore 3-5 years	Retired (optional)
Floating hose inspection				
	Submarine hose inspection			
		Hydrostatic pressure test (Note 1)		
			Onshore thorough visual inspection (Note 2)	
			Onshore tests	
				Burst test, material test, dissection (Note 3)

Notes

1. Where no annual pressure test is carried out, onshore testing should be increased.
2. Thorough visual inspection should be considered the minimum requirement.
3. Testing a small representative sample should be considered the minimum requirement.
4. At some locations a diving/ROV inspection may be necessary before each operation. At others, an inspection may be undertaken at established monthly or quarterly intervals.

Figure 5.6: Hose inspection and test requirements

5.6 - Inspection and testing of hose strings in-situ

5.6.1 Inspection of floating hoses

In-service inspections of floating hoses should be undertaken from a service craft, possibly in conjunction with a dive team.

Inspections should be carried out before each tanker operation, or at an established weekly or monthly interval, which check for:

- Leaks or oil seepage: paying particular attention to the flanges and nipple areas.
- Double carcass leak detection systems: checking that they are functional and have not been activated.
- Integrity of flange bolts: paying particular attention to the first off the buoy hose connection and connections to marine breakaway coupling (MBC) or spool pieces, which are prone to loosening.
- Damage caused by external impact: particularly damage to the hose cover and flotation, which could be caused by service or passing vessels or by the hose wrapping around the buoy.
- External deformation: particularly any sign of kinking, bulges or necking. Pay particular attention to the first off the buoy and tanker rail hoses.

- Blistering of the cover.
- Abrasion, scuffing, cuts or tears to the hose cover.
- Tangled or crossed hose strings.
- Corrosion and pitting of flanges and end fittings.
- Buoyancy of hoses, which should be floating level at the normal height.
- Marine growth: this may become excessive and require removal to maintain buoyancy and allow visual inspections. Hard marine growth should be removed to prevent chafing between hoses.
- Deterioration in the condition of any ancillary equipment connected to the floating hose string.

5.6.2 Inspection of submarine hoses

In-service inspections of the underwater hoses should be undertaken by divers/ROV at a frequency determined by site-specific conditions. At some locations, a diving inspection may be necessary before each operation. At others, an inspection may be undertaken at established monthly or quarterly intervals.

The diving inspection should check:

- Leaks or oil seepage: paying particular attention to the flanges and nipple areas.
- Double carcass leak detection systems: checking that they are functional and have not been activated.
- Integrity of flange bolts: paying particular attention to the buoy and pipeline end manifold (PLEM) connections.
- Damage caused by external impact: particularly any damage that may have been caused by contact with buoy anchor chains.
- External deformation: particularly any sign of kinking, bulges or necking.
- Abrasion, scuffing, cuts or tears to the hose cover.
- Tangled or crossed hose strings.
- Corrosion and pitting of flanges and end fittings.
- Buoyancy tanks: any signs of damage, corrosion or loss of buoyancy.
- Hose floats: any missing or damaged floats. Pay particular attention to the fastenings (some terminals fit additional securing straps).
- Umbilical lines and fixings.
- Marine growth: this may become excessive and require removal to maintain hose configuration and allow visual inspections.

The configuration of the subsea hoses at various points should be recorded and depth measurements taken. After giving due regard to the density of the contents, comparisons can be made with the original design and previous measurements.

Hose configurations should be adjusted when required. Hose configurations outside the design tolerances may cause excessive bending or other damage that will reduce service life.

5.6.3 Hydrostatic pressure testing of hose strings in-situ

This section provides guidance to operators for the hydrostatic pressure testing of hose strings required, to check hose integrity following installation and when hose changes have been made.

The hydrostatic test consists of filling the hose string with water, bleeding out any air remaining and then raising the internal pressure to the rated working pressure (RWP) of the hoses, or the normal operating pressure plus 50%. Once the pressure has stabilised, it should be held for at least three hours without noticeable loss of pressure (after allowing for temperature changes).

During the pressure test, the hoses should be inspected visually as described in section 5.6.1 and, for double carcass hoses only, the leak detection system checked.

Some terminals choose to carry out this test annually as part of their regime for setting service life periods.

5.7 - Testing hoses on shore

5.7.1 Thorough visual inspection

Hose strings should be dismantled and cleaned to allow close inspection of the areas shown in figure 5.7.

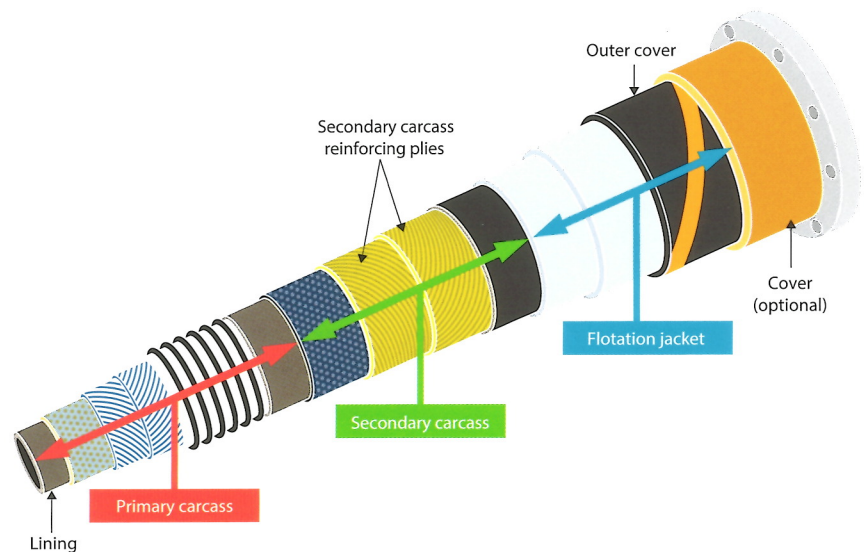


Figure 5.7: Simplified hose components

The hose should be examined for any signs of crushing or kinking and any permanent distortion, longitudinal ridges or bulges. Bulged areas should be marked and further examined by conducting the hydrostatic pressure test described in section 5.7.2. If these areas enlarge, become hard or show other detrimental changes indicating a leak or ruptured reinforcement, the hose should be retired from service.

The following should be checked:

- Outer cover.** The outer cover is an elastomeric layer applied over and along the entire hose body to protect it from marine and environmental elements. The cover should be cleaned and carefully examined for damage, such as cuts, gouges, tears or abrasions. If the flotation or reinforcement layers are exposed, the extent of the damage should be further investigated with a hydrostatic pressure test. On double carcass hoses, any deep cuts in the cover should be carefully examined to ensure there is no underlying damage to the secondary carcass reinforcing plies or to the secondary carcass cover. The hose should be retired from service if the integrity of the secondary carcass is in doubt.
- Flotation jacket.** Damage to flotation may be repaired using the manufacturer's procedures and advice. The cover may show surface cracking or crazing due to prolonged exposure to sunlight or ozone, although such deterioration is not normally a cause for retirement.
- Lining.** The lining protects the hose body from the cargoes being conveyed. It is an elastomeric layer applied along the entire bore, excluding end fittings where appropriate. The lining is a critical element of the hose and should appear smooth and without defects. A camera should be passed along the hose bore to allow detailed examination. The hose bore should be examined for evidence of blisters, bulges or any signs of separation. Any defects should be further investigated by conducting a vacuum test as described in section 5.7.3. Any perforation of the lining is cause for the hose to be retired from service.

- **End fittings.** The end fittings consist of steel flanges and nipples that are mechanically and chemically bonded to the hose carcass. Exposed internal and external steel surfaces of flanges and nipples should be cleaned and examined for cracks, excessive corrosion or pitting, as such conditions are cause for the hose to be retired from service. Exposed internal and external steel surfaces (not flange-sealing faces) may be protected with epoxy paint. Minor damage to hot-dip galvanised fittings may be touched up with zinc-rich paint.

5.7.2 Hydrostatic pressure test

Each hose should be subjected to a hydrostatic pressure test to ensure its integrity before it is returned to service. The test is performed using water as the test medium.

The procedure is as follows:

1. Lay out the hose so that it is straight and level, on rollers that will allow free (frictionless) movement of the hose when the test pressure is applied.
Note: If hoses are laid on the ground, friction will reduce the hose's temporary elongation and make comparison with the factory acceptance test invalid.
2. Install pressure recording equipment.
3. Blind the hose and fill it with water, ensuring that all air is vented from the bore.
4. Apply a pressure of 0.7 bar gauge and measure the overall length of the hose assembly. Designate this length as L1.
5. Increase the pressure from 0.7 bar gauge to 0.5 x RWP. Hold the pressure for ten minutes while also inspecting the hose for leaks.
6. Reduce the pressure to zero.
7. Increase the pressure to the RWP. This is the factory test pressure and is the pressure at which hose length comparisons are made. Hold the pressure for ten minutes while also inspecting the hose for leaks. Measure the overall length of the hose assembly. Designate this length as L2.
8. Increase the pressure to 1.5 x RWP. Hold the pressure for five minutes, while also inspecting the hose for leaks.
9. Reduce the pressure to zero.
10. Calculate the temporary elongation of the hose using the following formula:

$$\text{Temporary elongation \%} = \frac{(L2 - L1) \times 100}{L1}$$

The calculated temporary elongation should not exceed the factory acceptance test result by more than 2%.

11. Hose length should be compared against the factory acceptance test results to detect any permanent deformation.
During these tests, there should also be no evidence of sweating, leaking or unusual distortion.

5.7.3 Vacuum test

Before undertaking a vacuum test, clear plastic windows should be attached to both ends of the hose so that the interior can be inspected visually by shining a beam of light from one end to the other.

Each hose should be tested to minus 0.85 (–0.85) bar gauge for ten minutes. The inside of the hose should be examined for any signs of collapsing, blistering or deformity, or the appearance of oil or water. The outside of the hose should not show any deformity or blistering.

5.7.4 Electrical test

With the hose empty, electrical tests should be carried out in accordance with the procedures described in *ISGOTT* (Reference 12). These should be done both before and

after the hydrostatic test. The hose length should be supported or suspended by non-conductive materials, with flange rims cleared above ground level.

Electrically discontinuous hose should have a resistance of not less than 25,000 ohms measured flange to flange. Testing of electrically discontinuous hose should be carried out by using a 500 volt tester. Resistance, measured from flange to flange, should be as shown in table 5.5.

	Resistance
Electrically discontinuous hose	Not less than 25,000 ohms
Electrically continuous hose	Higher than 0.75 ohms/m

Table 5.5: *Electrical continuity and discontinuity test*

5.7.5 Minimum bend radius test (optional)

A minimum bend radius (MBR) test, as described in the *Guide to Manufacturing and Purchasing Hoses for Offshore Moorings (GMPHOM)* (Reference 3), with internal visual inspection may be performed to reveal faults (e.g. deformation, kinks, out-of-roundness and helix wire displacement) that are not apparent when the hose is lying straight. During the test, a push rod camera inserted into the hose to check the bore makes it easy to see any kinks or weak points in the hose.

5.7.6 Weight test (optional)

A weight test may be performed and the weight compared with that of the hose when new.

Additional weight may indicate that oil has penetrated the carcass, or that seawater has penetrated the flotation jacket.

5.8 - Destructive testing of hoses after retirement

The destructive testing of a proportion of retired hoses may determine failure modes and establish data that determine hose service life and retirement criteria. Manufacturers and operators are encouraged to develop and share such programmes for destructive testing. Different destructive tests are described below.

Note: The method of proper disposal of hoses and hose materials should be considered. Hoses are difficult to disassemble and the components degrade slowly.

5.8.1 Burst tests

A full risk assessment and adequate safety procedures should be in place to ensure the safety of personnel and property during burst tests. The pressure required to burst used hoses may exceed 100 bar and therefore suitable blind flanges and equipment should be used for this test.

Burst tests are typically performed using water as the test medium. The procedure is:

1. Lay out the hose so that it is straight and level, on rollers that will allow free (frictionless) movement of the hose when pressure is applied.
2. Vent and fill the hose.
3. Raise the pressure to 5 x RWP.
4. Maintain this pressure for 15 minutes, checking for any signs of failure.
5. Raise the pressure until the hose fails.
6. Record the failure pressure, mode and location.

Burst test results may be used to estimate the service life of similar hoses. Operators have found that the typical burst test pressures of used hoses are very high: used hoses often perform better than the prototype hose requirement of at least 5 x RWP. The high burst pressures measured indicate the remaining strength of hoses, but it should be remembered that bursting is rare and is not the only failure mode.

Double carcass hoses may also be burst to test the secondary carcass containment and the effectiveness of the leak detection installed.

5.8.2 Material tests

While in service, the lining is subjected to compression and tension caused by the cyclic action of the marine environment and by offshore handling operations. The lining also experiences shear forces applied by the friction of the cargo flow. These forces, combined with the effects of exposure to aromatic hydrocarbons in oil cargoes, can cause the lining to deteriorate. The lining material may also deteriorate in storage due to exposure to heat and ozone.

Tests for the lining and cover materials of hoses are specified in the *Guide to Manufacturing and Purchasing Hoses for Offshore Moorings (GMPHOM)* (Reference 3). Test results may be compared with those in *GMPHOM* or those of original materials to indicate service life.

Samples can be removed from the hose lining and cover for laboratory testing. These tests are used to verify the aged condition and the physical properties of the material.

5.8.3 Hose dissection

Hoses may be dissected to determine their failure mode. Dissected hoses can also be inspected and further tests performed of the hose reinforcing plies, fillers, helix wires and breaker materials and their respective adhesion levels, which may indicate the remaining life of the hose.

5.9 - Hose ancillary equipment

The following items of ancillary equipment attach to the basic hose strings. Some are necessary in order to operate and others are optional and included because some terminals have found them useful.

Note: A number of refinements to ancillary equipment, such as remotely operated hose connectors, emergency release systems and bow loading systems, have been developed and used at specialised, deep-water terminals and are considered to be outside the scope of this Guide.

5.9.1 Marine breakaway couplings

Marine breakaway couplings (MBCs) may be fitted in flexible hose strings as one of the options to protect hoses from damage following a breakout or destructive surge event (usually when pressures exceed $2.5 \times \text{RWP}$). MBCs also reduce pollution following a tanker breakout or surge event in which hoses tear apart or burst.

Terminals have found that, for MBCs to work properly, it is important to design, operate and maintain them correctly. Further information is available from OCIMF's *Information Paper on Marine Breakaway Couplings* (Reference 24).

5.9.1.1 Assessing the requirement to fit a marine breakaway coupling

The requirement for an MBC should be determined as a result of a risk assessment that considers the:

- Process flow scheme.
- Results of surge analysis.
- Breakout risk assessment (historical experience within a region may provide quantitative input to the risk assessment).

5.9.1.2 Design considerations

Before installing MBCs, consideration should be given to the:

- External loads an MBC will be subjected to in the hose system from operations, waves, current and hose string handling by support vessels.
- Internal loads an MBC will be subjected to from operating and surge pressures and changes of temperature.
- Design, specification and make-up of the hose system and entire cargo transfer system.
- MBC positioning and flotation.

5.9.1.3 Maintenance

The manufacturer's recommendations on installation, handling, visual examination and maintenance (particularly maintenance intervals) should be strictly adhered to. Maintenance should be carried out by the manufacturer or specially trained personnel to ensure that it is undertaken correctly and that only approved parts are used.

Specific fittings and tools for the opening, flushing and draining of the hose sections, following MBC activation, should be readily available.

The MBC should be regularly cleaned of marine growth to enable visual examination of the casing for any early signs of partial separation.

5.9.1.4 Operation

Terminals should have site-specific operating procedures for recovering oil filled, separated hose sections. The procedures should include pollution response and the flushing or draining of hoses to minimise further pollution. These operations should be subjected to a hazard and operability (HAZOP) analysis.

Following a separation incident, reconnection of MBCs and hose systems should be done in accordance with manufacturers' recommendations and site-specific procedures.

Every MBC separation incident should be investigated thoroughly to identify the root cause of the event, preferably with the involvement and co-operation of the manufacturer. Operating and maintenance practices should then be adapted to take account of lessons learnt.

The findings of an investigation into some instances of unexpected MBC separation and the possibility of break bolt fatigue were reported in an OCIMF MBC Information Paper. If fatigue were to occur, it would be almost impossible to recognise. Operators should, therefore, be cautious about any operations that add even small additional loads across the MBC. Terminals should consider the following precautions:

- Support craft should not be permitted to moor at the end of hose strings.
- Support vessels capable of applying a dynamic load in excess of the activation load of the MBC should not be used to handle hoses.
- Support vessels and equipment should be suitable for recovering the hose and MBC. For example, shallow-angled ramps, lifting beams or other means approved by manufacturers that will not apply loads to the MBC should be used.
- Care should be taken to avoid applying loads to the MBC during launching or towing the hose string. Towing should be from the buoy end of the string to reduce stresses. Alternatively, the MBC should only be inserted when the hose string is at the field.



Figure 5.8: Separated marine breakaway coupling (MBC)

5.9.2 Rail hose ancillary equipment

5.9.2.1 Rail hose lifting and support assembly

The hose snubbing chain supports the weight of the hose and fluid when the rail hose is connected to the tanker manifold. Typically, snubbing chains are made from alloy steel lifting chains of suitable size and SWL, using a safety factor of 5.

An auxiliary chain may be connected to a bridle ring that is fitted in the middle of the snubbing chain, as shown in figure 5.9, to ease making fast.

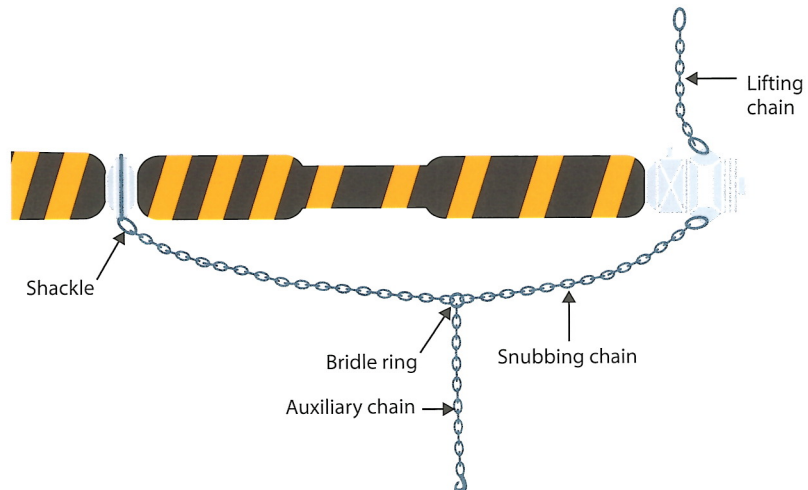


Figure 5.9: Rail hose lifting assembly

Appendix B provides example calculations of hose lift weight.

5.9.2.2 Quick release coupling

The rail hose may be connected to the tanker manifold by fully bolted means or by using a quick release coupling (QRC). One type of QRC that is used is the cam type that connects the hose to the tanker manifold using a number of cams. Cam type couplings are manufactured in two basic designs:

- Short spool.
- Studded.

Should the cams be damaged, the short spool type enables the QRC to be bolted to the tanker manifold flange.

5.9.2.3 Hose blind flange

When not connected to the tanker, the rail hose should be blanked using a blind flange.

Two types of blind flange are typically used:

- Lightweight, which may not be pressure rated. These are lighter and easier to disconnect and remove from the rail hose at the tanker manifold and reduce the risk of injury to personnel.
- Heavier weight, which are pressure rated. These should be used when pressure testing hose strings.

5.9.2.4 Hose end valve

A valve may be fitted at the tanker end of the rail hose. These valves are typically of a wafer butterfly type, meeting the following requirements:

- The valve seats, seals, bushings, packing glands, stem and disc should be suitable for the cargoes handled and the seawater environment.
- Design flow velocity should be specified to ensure proper stem and disc design.
- The valve should be lever or gear operated and fitted with a removable handwheel.
- A means for mechanically locking the disc in the fully open or closed position should be provided to prevent the disc slamming shut, which could result in surge pressures and damage.

5.9.3 Miscellaneous hose ancillary equipment

5.9.3.1 Floating hose marker beacons

Flashing lights are typically used to mark the position of the floating hose string during darkness. Lights may be mounted on short stands, about 1 m high, bolted to every other hose flange in an upright position. The light and lens housing should be watertight and contain the light control components and a battery pack.

Battery life may be extended by using a daylight sensor, solar charging or efficient lamps such as LEDs. One terminal has reported successful use of a disposable solar-charged light glued directly to the hose cover. Such lights should be a safe distance of at least 600 mm from hose flanges.

5.9.3.2 Restrictor bars

Restrictor bars are sometimes provided between two or more submarine hose strings to prevent excessive multi-directional movements or separation. The use of restrictor bars for floating strings is not recommended, however, because experience indicates that hose life is longer without these attachments.

5.9.3.3 Hose towing blank

A hose towing blank is a blind flange fitted with towing eyes and bleeder valves, bolted to the first off the buoy hose.

5.9.3.4 Submarine hose bead floats

Submarine hose systems require buoyancy at selected points to establish appropriate hose configurations. Floats attach to retaining collars that are vulcanised to the submarine hose cover. Standard float and collar sizes and their test requirements are given in the *Guide to Manufacturing and Purchasing Hoses for Offshore Moorings (GMPHOM)* (Reference 3).

5.9.3.5 Submarine hose buoyancy tanks

Buoyancy tanks may be used as an alternative or addition to floats. The tanks should be designed as pressure vessels for the appropriate depth of water. The buoyancy of the tank is adjustable by using compressed air or by introducing seawater.

To prevent the buoyancy tanks from becoming pressure vessels when brought to the surface, relief valves set at a differential pressure of 5 psi should be installed.

Where two or more under-buoy hose strings with buoyancy tanks are used, the hose spool connections should be suspended from the tanks.

To enable individual hoses in the string to be installed and replaced, revolving lap-joint flanges should be provided at one or both ends of the buoyancy tank's spool piping.

5.9.3.6 Reducing spools (or hoses)

Reducing spools may be used to connect hoses of different diameters, typically to connect 400 mm diameter tail hoses to 500 mm or 600 mm diameter mainline hose strings.

Spools are constructed to the required pipework specifications. They are usually covered in a buoyant layer of polyethylene foam and coated with an abrasion resistant tough polyurethane elastomer skin.

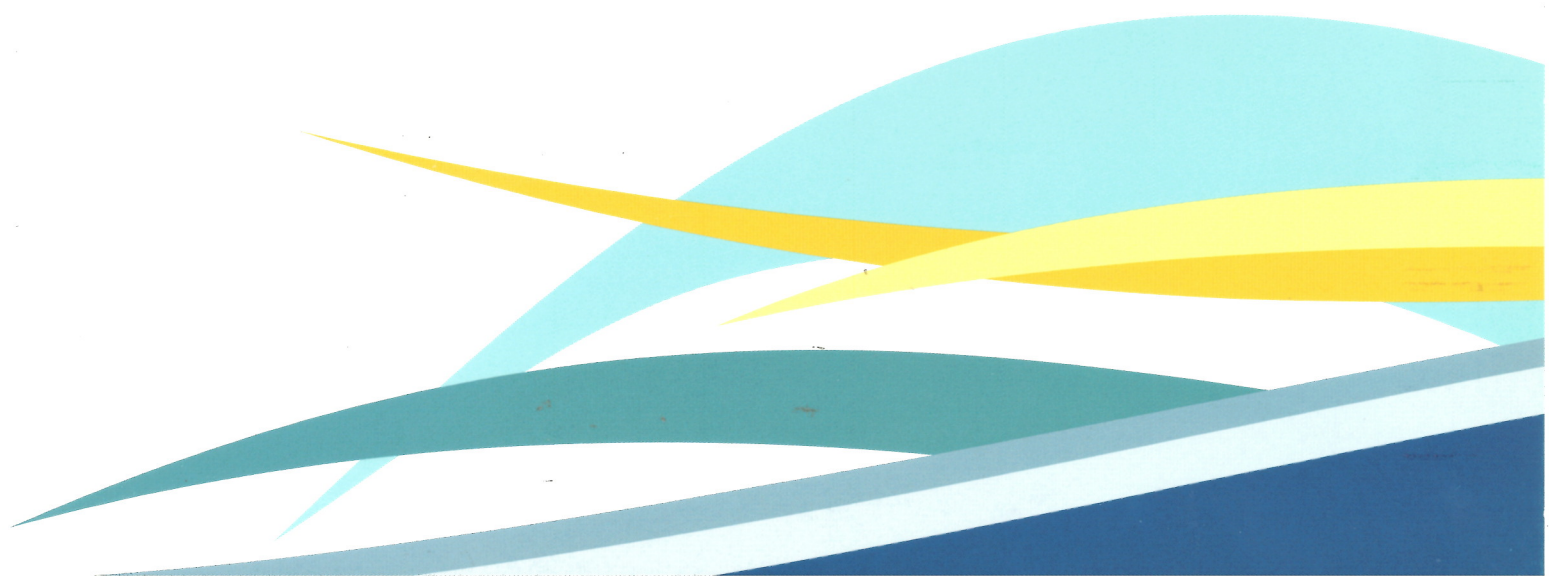
5.9.3.7 Y pieces and Y tanks

Y pieces or tanks may be used to split a single floating hose string into two, typically to connect two 400 mm diameter tail hose strings to a single 500 mm or 600 mm diameter mainline hose string.

Y pieces are constructed in a similar manner to spool pieces. Y tanks consist of a watertight steel case, which may be foam filled, around the pipework to provide flotation.

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Appendix A: The Elements of MTMSA applied to SPM Management

1. Management, leadership and accountability

- | | |
|-------------------|--|
| Terminals should: | <ul style="list-style-type: none"> • Establish and maintain a documented management system. • Have a clear understanding of roles and responsibilities. • Ensure that work instructions and procedures are fit for purpose, easy to understand and are subject to formal review on a periodic basis. • Ensure that documents demonstrating compliance with regulations, procedures and accepted industry guidance and codes of practice are maintained and up to date. • Maintain berth compatibility criteria and ensure that nominated tankers are suitable for the berth. • Have a system in place to ensure that visiting tankers meet minimum standards for safe operation. • Ensure that visiting tankers are provided with information on all relevant local regulations and terminal safety requirements that apply to the safe management of the ship/shore interface. |
|-------------------|--|

2. Management of personnel

- | | |
|-------------------|--|
| Terminals should: | <ul style="list-style-type: none"> • Establish and maintain policies and procedures for selecting, recruiting, training and managing the performance of terminal personnel. • Establish policies and procedures to manage contractors effectively. |
|-------------------|--|

3. Port and harbour operations

- | | |
|-------------------|--|
| Terminals should: | <ul style="list-style-type: none"> • Clearly define environmental limits for: <ul style="list-style-type: none"> - Tanker berthing and departure. - The operation of support vessels. • Monitor the performance of pilotage services, tugs and support vessels. Monitor defect and reliability reporting. • Establish procedures for ongoing information exchange. |
|-------------------|--|

4. Terminal layout

- | | |
|--|---|
| In particular, SPM terminals should ensure that: | <ul style="list-style-type: none"> • Safe means of access and personnel transfer is provided. • Procedures address safe hose lifting operations. • Hoses and cargo transfer equipment are suitable for the intended service. |
|--|---|
-

5. Ship/shore interface

An effective ship/shore interface is required at all times, but particularly during the following operations:

- Exchanging information between Master/pilot before the ship proceeds to berth.
 - Manoeuvring the vessel to the berth. In particular, an effective bridge resource management team is required.
 - Mooring operations on the bow of the tanker.
 - Connecting hoses.
 - Pre-cargo transfer conference, including completing the ship/shore safety checklists.
 - Cargo start-up.
 - Monitoring the cargo operation.
 - Dealing with cargo disputes, for example ship/shore quantity differences.
 - Monitoring the tanker's position in relation to the SPM, particularly in adverse environmental conditions.
 - Dealing with emergency situations.
 - Cargo completion.
 - Disconnecting hoses.
 - Exchanging information between Master/Mooring Master/pilot before departing from the berth.
 - Unmooring operations on the bow of the tanker.
 - Manoeuvring the tanker clear of the berth.
 - Cargo documentation.
-

6. Cargo transfer operations

In particular, SPM terminals should have procedures and systems in place to address:

- Inspection of the berth and equipment before a ship arrives.
 - Roles and responsibilities of Mooring Masters and terminal staff.
 - Emergency shut-down procedures that define the circumstances under which cargo operations must be stopped immediately.
 - Clearly defined environmental operating limits.
 - Prevention of surge pressures.
 - Verification of quantities transferred.
 - Cargo measurement and sampling activities, including those undertaken by third party cargo surveyors.
-

7. Maintenance management

Terminals should:

- Have structured processes and procedures in place to maintain the integrity of the SPM and ancillary equipment.
-

8. Management of change

Terminals should:

- Have procedures in place to manage temporary and permanent changes and to ensure that standards are not compromised.
-

9. Incident investigation and analysis

Terminals should:

- Ensure that incidents, accidents and near misses are reported, investigated and followed up.
 - Ensure that lessons are learnt with the aim of preventing recurrence.
 - Post information about incidents in industry forums to help identify and resolve specific safety concerns.
-

10. Management of safety, occupational health and security

- Terminals should:
- Have a comprehensive safety management programme that includes:
 - Hazard and operability (HAZOP) analysis.
 - Risk assessment and management processes that ensure that residual risks are reduced to as low as reasonably practicable.
 - Permit to work systems.
 - Site safety inspections.
 - Site safety meetings.
 - Provision and use of personal protective equipment (PPE).
 - Provision and use of life saving appliances (LSA) and first aid equipment.
 - Occupational health programme.
 - Provide a security policy that complies with the provisions of the International Ship and Port Facility Security (ISPS) Code (Reference 11).
 - Give particular attention to security issues associated with the remote offshore location of the berth, such as the prevention of unauthorised access to the berth and moored tankers.
-

11. Environmental protection

- Terminals should:
- Ensure that the following are in place:
 - Environmental policy.
 - Procedure for identifying and controlling all potential sources of pollution.
 - Waste management plan.
 - In particular, address:
 - Provisions to safely drain or isolate the tanker rail hose before it is disconnected.
 - Containment of spills around the tanker's deck or manifold area.
 - Procedures to flush clean hose strings before testing or removing them.
 - Procedures to control the waste from tankers.
 - Procedures to control the waste and emissions from support vessels.
-

12. Emergency preparedness

- Terminals should have:
- Emergency response plans that address all credible scenarios and the possible need for emergency evacuation.
 - An oil spill response plan that links to local and national plans and considers the sharing of regional resources.
 - Where necessary due to the remoteness of the SPM's location, emergency support and pollution response from the terminal's support vessels.
-

13. Management system review

- Terminals should:
- Have in place a formal internal programme to audit the management system to verify its effectiveness and promote continuous improvement.
-

Appendix B: Calculating the hose lift weight

The worked examples in this section show how to calculate the maximum weight that the tanker will lift. The weight of hoses varies significantly between type, rated working pressure (RWP) and manufacturer. For example:

- 15 bar RWP hoses use ASME Class 150 flanges.
- 21 bar hoses use the considerably heavier ASME Class 300 flanges.

The calculations in this section have assumed the heaviest lifting weights likely to be encountered and that the hoses are:

- The heaviest type available.
- Full of water.
- Fitted with hose end valves.
- Fitted with quick release couplings (QRCs).

The calculation assumes the part tail hose not lifted out of the water is floating fully supported and does not add to the lifting weight.

Terminals should input their actual hose weights when using the calculations demonstrated in this section. Terminals should also ascertain the various weights of each item of equipment in use and input those weights into the calculation.

The safe working load (SWL) of hose lifting lugs varies with hose diameter and year of manufacture. All lugs are stamped with the SWL and test certificates are provided in every manufacturer's report.

Example 1: Lifting 400 mm hoses with a lifting lug SWL of 15.3 tonnes to a typical 150,000 deadweight tonne (DWT) tanker with a crane SWL of 15 tonnes.

Ballast freeboard	15.525 m
Lift height	7.5 m
Length of hoses to be lifted	23.025 m
Rail hose	9.1 m
Tail hose	10.7 m
Part of tail hose that is out of water	3.225 m
Weight of components	tonnes
Rail hose	3.950
Tail hose	4.170
Part tail hose	1.257
Blank	0.067
Chain and shackles	0.200
Valve	0.092
QRC	0.171
Bolts and gaskets	0.048
Weight	9.955
Dynamic load factor	1.500
Calculated lifting weight (Weight x Dynamic load factor)	14.932

Outcome: The lift is within the tanker's crane capacity and SWL of the hose lifting lug.

Example 2: Lifting 400 mm hoses with a lifting lug SWL of 15.3 tonnes to a typical 300,000 DWT tanker with a crane SWL of 20 tonnes.

Ballast freeboard	17.331 m
Lift height	7.5 m
Length of hoses to be lifted	24.831 m
Rail hose	9.1 m
Tail hose	10.7 m
Part of tail hose that is out of water	5.031 m
Weight of components	tonnes
Rail hose	3.950
Tail hose	4.170
Part tail hose	1.961
Blank	0.067
Chain and shackles	0.200
Valve	0.092
QRC	0.171
Bolts and gaskets	0.048
Weight	10.659
Dynamic load factor	1.500
Calculated lifting weight	15.988

Outcome:

The lift is within the tanker crane capacity, but exceeds the SWL of the hose lifting lug. The operation should only take place in sheltered wave conditions (less than 1 m waves) where the dynamic load factor is not applicable or the hose lift weight must be reduced by considering:

- Use of 15 bar RWP hoses.
- Use of a lighter type of hose.
- Reducing the ancillary equipment used.
- Lifting from two hose lugs with Y or two chain legs.

Appendix C: Forecastle watchman guide

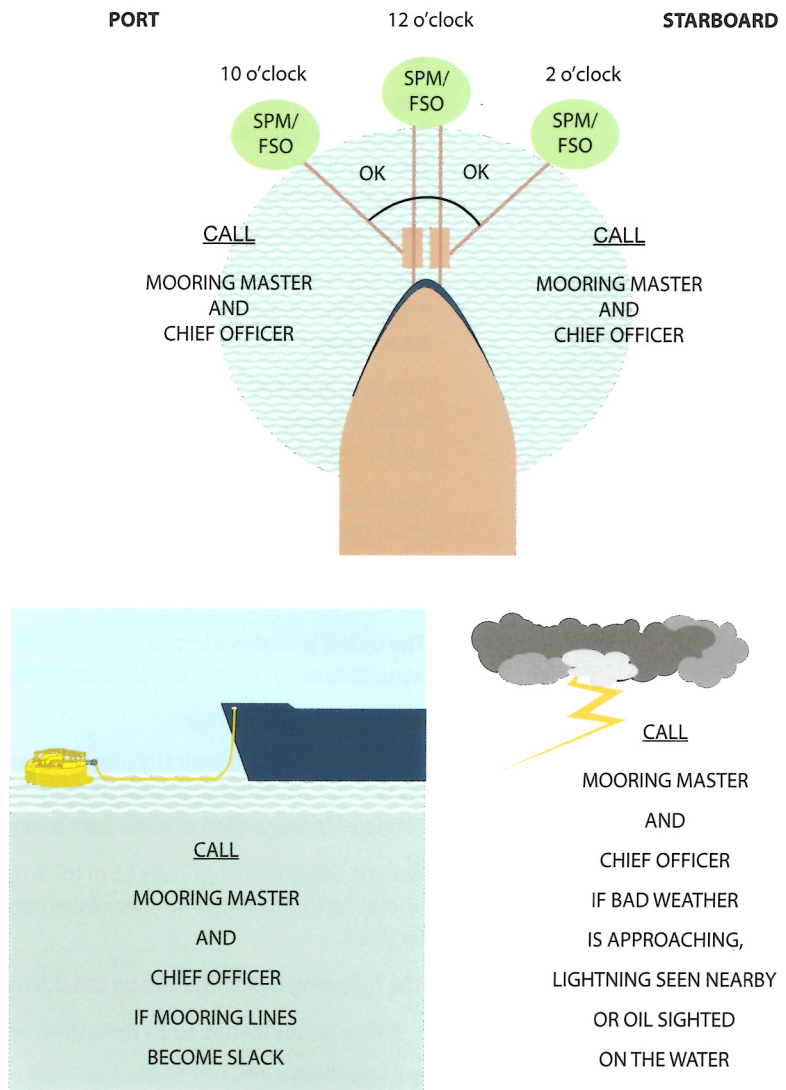


Figure C1: Forecastle watchman guide

Appendix D: Support facilities for single point moorings

D1 Maintenance support vessels

This section describes the factors to consider when choosing support vessels for operating and maintaining single point moorings (SPMs).

The physical needs of each individual terminal will determine the choice of support vessels. The specific conditions at the offshore location will dictate the operational and technical requirements. A number of shipyards provide standard specifications for generic offshore support vessels and mooring launches. The designs include multipurpose vessels capable of carrying out many of the roles required at SPMs.

Two types of vessel in common use are described in this section – mooring launches and multipurpose support and maintenance vessels – although the requirements may be combined into one or more vessels.

The size, type and number of support vessels used at terminals vary considerably. Terminals may have support vessels available continuously or only when tankers berth and when maintenance is required.

Support vessels should be managed following the International Safety Management (ISM) Code of the International Maritime Organization (IMO). Guidance designed to help owners assess, measure and improve their management systems is given in *Offshore Vessel Management and Self Assessment (OVMSA)* (Reference 25).

The OCIMF's Offshore Vessel Inspection Database (OVID) is a recommended means of assurance when offshore vessels are considered for charter.

D1.1 Mooring launches

A mooring launch is typically used to stretch out the mooring hawser and take the pick-up rope to the berthing tanker. Launches are also used to transfer personnel to the SPM and tanker and to provide light towing duties.

Generic designs are typically 13 m to 26 m in length. Launches may be daughter vessels operating from a larger mother vessel, which may reduce the requirement for crew facilities.

The following factors should be considered when selecting an SPM launch:

- Safety issues identified by risk assessment.
- Competency and training of the crew.
- Weather and sea state for operations.
- Suitability for designed roles.
- Towing point, towing capability and quick release arrangement.
- Mooring and hose equipment to be carried or towed.
- Engines and manoeuvrability.
- Propellers: should be shrouded to avoid fouling or damage to hoses.
- Visibility from wheelhouse.
- Suitability for personnel transfer: shipside rail openings or platforms should be provided to safely embark personnel, including to a pilot ladder and to the SPM.
- Emergency support:
 - Fire-fighting.
 - Pollution response.
 - Rescue and evacuation.
- Endurance (fuel, water, stores).
- Crew facilities, depending on:
 - Time on station.
 - Crew size and reliefs.
 - Availability and proximity of port facilities.

D1.2 Multipurpose support and maintenance vessels

Multipurpose support and maintenance vessels may be purpose designed and built or they may be modified tug, supply or anchor handling vessels.

These vessels typically provide static towing and emergency response capabilities and support operations and maintenance activities at the SPM.

The following tasks should be considered when selecting the vessel:

- Static towing.
- Emergency support:
 - Fire-fighting.
 - Pollution response.
 - Rescue and evacuation.
- SPM operation and maintenance:
 - Hose handling.
 - Power services supply to the SPM, for example electricity, air, hydraulics and water.
 - Hydraulic valve operation.
 - Maintenance of SPM system components and mooring legs.
 - Maintenance of navigational aids.
 - Hose and SPM buoy flushing.
 - Floating/submarine hose change-out.
 - Leak testing of hose strings and SPM piping.
 - Mooring hawser change-out.
- Optional capabilities:
 - Dive support.
 - Four-point mooring.

The terminal's local conditions and the design role envisaged will dictate hull dimensions, but generic designs are typically around 50 m long.

Some of the factors that may be considered for inclusion in a multipurpose support and maintenance vessel design are described below.

D1.2.1 General

During the SPM design phase, the roles required of the support vessel should be confirmed, together with the weather and sea states for operations:

- Safety issues and risk assessment.
- Competency and training of the crew.
- The wheelhouse should offer all-round visibility (including upwards) and a good view of the main working deck and winches.
- The vessel's structures and fendering should be suitable for coming alongside tankers and the SPM:
 - Stowed or recessed anchors.
 - Fixed fenders and rubbing strakes should be fitted, in preference to tyres on chains, to avoid fouling of lifting chains, towing ropes and messengers.
- Suitability for personnel transfer, with shipside rail openings or platforms to safely embark personnel, including to a pilot ladder.
- Endurance (fuel, water, stores).
- Crew facilities, depending on time on station and proximity of port facilities.
- Safe manning – crew size and reliefs.
- Accommodation for Mooring Masters, hose crew and port officials.
- Accommodation for maintenance and dive crews. Major maintenance is normally carried out within weather or tide windows. Facilities should support personnel engaged in shift work.

- Search lights capable of illuminating the SPM and tanker's shipside.
- Facilities for pumping bilge water to shore.

D1.2.2 Propulsion

Vessels are typically twin screw, with bow thrusters to provide the required manoeuvrability for working alongside the SPM and tanker, while maintaining a station relative to the tanker's stern when towing from either the bow or the stern.

Directional control should be suitable for working in a tideway/current combined with a seaway.

The horsepower and bollard pull required will depend on the overall duties of the vessel, although a bollard pull capability of 50 to 90 tonnes is typical.

When designed for static towing, engines should be capable of slow running for prolonged periods.

Propellers should be shrouded to avoid fouling or damage to hoses.

Exhaust systems should ensure there is no ignition hazard and that fumes pass clear of the working deck and tanker deck when working alongside. Spark arrestors fitted on exhausts should be inspected and confirmed to be in good condition.

D1.2.3 Emergency response

Support vessels may be fitted with fire-fighting equipment, typically to the fire-fighting (Fi-Fi) ship 1 or 2 classification. To hold the Fi-Fi classification, the pumps and piping systems used for water monitors are to be used only for fire-fighting and water spray. Independent sea suctions are to be provided for each pump.

Pollution response equipment should be considered. This may include lined or coated dispersant tanks, together with the necessary pumps and spray booms, in areas where dispersant use is accepted. Storage should be provided for other oil spill clean-up equipment.

A fast recovery craft (FRC) with an effective launch and recovery system should be used for emergency responses.

D1.2.4 Hose flushing

Support vessels may be fitted with equipment to flush hoses, pipework or pipelines with water. It is recommended that systems are designed with a physical means of preventing the backflow of petroleum liquids and gases into the support vessel's system.

Crews should be adequately trained for this operation and written procedures should be in place. Job safety analyses and risk assessments should be carried out before commencing flushing operations.

To ensure an effective flush, the pump and piping system for flushing should be suitably designed to deliver the required pressure and flow rate.

D1.2.5 Deck, lifting and other requirements

The design of a support vessel's deck and equipment will depend on the terminal's needs and local conditions.

The following list of equipment should be considered during the design phase:

- Double drum towing/anchor handling winch.
- Stern roller.
- Locking forks and towing pins.
- Crane with sufficient reach and capacity.
- Tugger winches and capstans.
- Deck safe working area.
- Helicopter winching area.
- Deck storage for hoses, mooring hawsers and anchor chain.
- Securing strong points.

- Freeboard suitable for all operations.
- Service air compressors.
- Hydraulic power unit.
- Water jetting equipment if marine growth is a problem.
- Welding and cutting equipment.
- Workshop.
- Store room.

D1.2.6 Dive support

Diving support will be required at the SPM. Some terminals contract-in dive support vessels when required. Others fit out the multipurpose support vessel to provide dive support. To undertake diving operations, the support vessel will require a four-point mooring (or dynamic positioning Classification), a recompression chamber and a safe means of access, such as a moon pool.

D2 Use of tugs in operational support

It is recommended that the tug's towing gear is used and that the safe working load (SWL) of the tanker securing points are identified. Recommendations for ships' fittings for use with tugs are contained in *Mooring Equipment Guidelines (MEG)* (Reference 26).

D2.1 Use of tugs for mooring and unmooring

Whether tugs are required should be determined in a formal risk assessment process. At some SPMs the designed manoeuvring room, combined with the weathervane function, means that tankers may approach the berth and moor without tug assistance. Other SPMs may require one or two tugs due to the approaches and port conditions. Local port or harbour authorities may require the use of tugs.

The terminal should have a documented policy in place that covers the number and bollard pull of tugs required and describes their use in the mooring, static towing and unmooring operations.

D2.1.1 Static towing

Many terminals have found that, to manage the tanker to the SPM, it is advantageous to make use of a tug while the tanker is made fast. Static towing usually involves towing right astern at low power for a continuous period, and is particularly useful in tidal or varying current or wind conditions. Static towing helps to maintain a steady, low mooring load on the hawser and avoids peak loads, yo-yoing and riding up to the SPM.

Towing over the bow of the tug rather than stern reduces risks and improves tug sea keeping capabilities. In rough seas, a long towline may be necessary. Communication with the Tug Master should be established to ensure that the relative position of the tanker with respect to the SPM is effectively managed.

D2.1.2 Emergency towing-off pennants

Guidance on the use of emergency towing-off pennants (ETOPs) is contained in *ISGOTT* (Reference 12) and in an OCIMF information paper, *Recommendations for Alternatives to Traditional Emergency Tow-Off Pennants* (Reference 27).

Terminals should be aware of the use of ETOPs and the risks of personal injury when rigging them. Where a tug is already made fast, or in areas where tugs are not readily available, there should be no requirement to rig ETOPs.

D3 Diving services

SPM terminals will require diving services during installation and for maintenance tasks. Some terminals may require divers for routine operational tasks, such as closing pipeline end manifold (PLEM) valves. The terminal design and operation will dictate the frequency of diving operations and it is recommended that, wherever possible, the need for diver intervention is designed out or the use of remotely operated vehicles (ROVs) is considered.

Diving contractors should be selected on the basis of their technical capability, safety record, safety management systems, rules and procedures. Diving operations should be organised, planned and executed using the International Association of Oil and Gas Producers (OGP) *Diving Recommended Practice* (Reference 28).

D3.1 Terminal organisation and responsibilities for diving

The terminal operator or owner should appoint an on-site representative(s) with the necessary experience and knowledge for the task, as described in the OGP recommended practice.

The Master of a support vessel from which diving is to take place has overall responsibility for the safety of the vessel and all personnel on it.

The terminal should also ensure that all simultaneous activities are managed to ensure the safety of the diving operation. All other work should be controlled by procedures to ensure that those tasks are carried out in a way that does not affect the safety of the dive team.



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