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SCOPE

This Design Practice covers cargo transfer hose systems for the loading and discharge of ships and barges at offshore berthing facilities such as Multiple–Buoy Mooring Systems (MBM), also known as Conventional Buoy Moorings (CBMs), and Single Point Mooring Systems (SPMs). Information is provided on the types of offshore berthing systems, cargo transfer systems, offshore hose type, and hose design parameters. As selection of hose systems requires knowledge on the use of hoses, pertinent information is provided on hose purchasing, storage, installation, and testing. Although some information is provided on the operational aspects, the document is not intended to cover ongoing inspection and maintenance of hoses and ancillary equipment.

This section of the Design Practice is applicable for offshore hoses used in the transfer of crude oil and petroleum products. Conventional dock hoses are covered in [Section XXXI-G](#).

REFERENCES

DESIGN PRACTICES

- DP XXIII-A Basic Loading System
- DP XXXI-E Offshore Berth Design
- DP XXXI-I Minimum Safety Requirements for Marine Terminals
- DP XXXI-J Ship-To-Shore Electrical Isolation

GLOBAL PRACTICES

- GP 19-1-1 Paint and Protective Coatings

OTHER REFERENCES

American Society for Testing and Materials

ASTM A36 / A36M, *Standard Specification for Carbon Structural Steel*

ASTM A153-01, *Standard Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware*

American Society of Mechanical Engineers

ASME B31.3, *Process Piping*

ASME SEC IX, BPVC SECTION IX, *Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators Addenda - 1995; Addenda - 1996; Interfiled (Boiler and Pressure Vessel Codes)*

Dunlop Oil & Marine

Offshore Hose Manual

Installation & Maintenance Guide for Flexible Hose Systems & Ancillary Equipment at Offshore Oil Terminals.

Oil Companies International Marine Forum

OCIMF-1, *Guidelines for the Handling, Storage, inspection and testing of Hoses in the Field, Second edition 1995*

OCIMF-2, *Guide to Purchasing, Manufacturing and Testing of Loading and Discharge Hoses for Offshore Moorings-Fourth Edition 1991*

OCIMF-3, *SPM Hose System Design Commentary – Second Edition 1993*

OCIMF-4, *SPM Hose Ancillary Equipment Guide*

OCIMF-5, *Single Point Mooring Operations and Maintenance Guide*

Society for Protective Coatings

SSPC SP 5, *Joint Surface Preparation Standard White Metal Blast Cleaning*, NACE No. 1: 1999 (Steel Structures Painting Manual, Ch 2 - Surface Preparation Specs.)

SSPC SP 10, *Joint Surface Preparation Standard Near-White Metal Blast Cleaning*, NACE No. 2: 1999 (Steel Structures Painting Manual, Ch 2 - Surface Preparation Specs.)

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INTRODUCTION

TYPES OF OFFSHORE HOSES

Offshore hoses are used mainly in Multiple Buoy Mooring (MBM) and Single Point Mooring (SPM) systems and they generally fall into two categories – Floating and Submarine hoses.

Floating Hoses

Floating hoses allow connection between a floating buoy manifold and a ship's manifold. Submarine hoses allow connection between a sub-sea pipe manifold and an underbuoy manifold or directly to ship manifold in a MBM system.

Submarine Hoses

Submarine hoses may be connected to a buoy in different configurations as will be discussed in the following sections. In MBM systems they normally lie on the seabed when not in use. The underbuoy SPM hoses generally have a configuration which may be classified as - Chinese Lantern, Lazy-S or Steep-S. The type of system and configuration that is selected depends upon the environmental and site conditions.

Long Length Floater Hoses On Reel

These hoses are mounted on a metal reel and are pulled out to the ship from the shore for rapid deployment. For certain facilities they replace the submerged pipeline and are considered as a low cost alternative. These hoses are not covered by OCIMF.

PRODUCT SERVICE

The offshore hose design practice is applicable for the transfer of the following products:

- Crude Oil and Petroleum Products at temperatures ranging from –20°F (–29°C) to 180°F (80°C).

HOSE CONSTRUCTION

The basic construction of the floating and submarine hoses is mainly the same and consists of the lining, reinforcement plies, helical wires, holding plies and cover.



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SYNTHETIC RUBBER HOSES

Hoses are made of rubber reinforced with textile fabric, textile cord or steel wire cord layers. Additional reinforcement is also provided in the form of one or more embedded wire helix. The inner most layer is called the Lining and protects the main carcass from contact with the product. The next layer over the lining is called the main plies which comprises of a number of textile cords (mainly Rayon) applied spirally along the hose length, each layer being at equal but opposite angles. This provides most of the strength to the hose.

An inner steel reinforcement wire (helical wire) is often placed in the rubber hose to add strength and resist delamination of inner layers. When the main carcass is placed over the wire reinforcement or the wire reinforcement is embedded in the lining, the hose is referred to as a rough bore hose. When the inner steel reinforcement is not employed, the hose is referred to as a smooth bore hose. The rough bore hose is mainly for dock and industrial applications. The OCIMF offshore hose is a smooth bore hose, which is especially designed for heavy-duty use.

The core or central component of a hose is referred to as the carcass and provides the strength against internal pressures, tension, and other loads. The carcass consists of various combinations of fabric and/or metal elements such as textile fabrics, helix wire reinforcement, and woven cords.

The outermost layer of the hose construction is called the cover and protects the carcass from abrasion, wear & tear, and attack from external elements and/or chemical action. When the carcass does not have a wire reinforcement or steel rings but gains its strength from only fabrics or woven cords (plies), the hose is referred to as a helix free or soft-wall rubber hose. These hoses have the ability to recover after crushing or kinking. However, after repeated kinking they will memorize the location of the kink and are then more susceptible to kinking. These hoses are used mainly in MBM systems and as a Rail hose in a SPM.

Rubber hoses are cured (vulcanized) in autoclaves where the various layers are fully bonded together to form a homogenous hose construction. Hose lengths are dictated by transportation limitation. Lengths up to 40 ft (12.20 m) are available, but more typically are provided in 35 ft (10.67 m) lengths. For most offshore applications, hose diameters are in the range of 12 in (305 mm) to 24 in (610 mm).

Smooth bore and Helix free hoses can be manufactured either electrically continuous or electrically discontinuous.

End fittings are typically built-in nipples that are vulcanized into the hose body. Swage fittings should not be used. When fittings without nipples are used, careful consideration should be given when connecting these hoses to the hoses, which are fitted with a nipple. There may be a need for a transition piece (spool piece) allowing connection between the two hose types. Hoses with fittings without a nipple do not require a gasket as these have rubber flange faces. If these faces are damaged the hose may have to be retired from service. Therefore extra care must be paid when handling these types of hose.

FLOATING HOSES

The floating hoses have a closed-cell buoyancy material (usually a float sponge) integrally built in around the hose body and under the cover for extra buoyancy. At the ends of the hose, the buoyancy material is tapered smoothly down towards the flange to reduce risk of damage when inserting bolts and tightening of nuts. This design provides minimum reserve buoyancy of 20% over the entire hose length for mainline hoses. The cover is about 6 mm thick and is made of synthetic, oil resistant rubber with resistance to abrasion, weathering and seawater. In the early designs the buoyancy was provided by foam plastic floatation beads, which were fitted around the hose at fixed distances.

The first floating hose off-the-buoy has the buoyancy material over only half its length. The end connected to the buoy has no buoyancy in order to reduce stress in the hose. The overall buoyancy of this hose is about 5%.

OCIMF requires the polyurethane covered hoses to be orange in color and the rubber covered hoses to be black with an orange spiral.

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SUBMARINE HOSES

Submarine loading hoses are normally specified as a heavy-duty hose. They are capable of operating to a water depth of 76 m when full of product.

Kinking of a submarine hose at the point where it touches the sea floor is a problem at multiple buoy berths. Wire helix reinforced hoses do not flatten during normal handling, but will permanently deform when kinked or crushed. A Helix free or soft wall hose is now available from many manufacturers. The Helix free hose can withstand kinking and crushing and restore to normal shape but only on few occasions as they can memorize the kink location.

To assist the divers in making underwater connections, a straight white stripe parallel to the longitudinal axis of the hose and in line with the center of a flange bolt hole is provided by the manufacturer. The width of the stripe is 50 mm.

The submarine hoses attached to either end of the buoy are reinforced for additional strength.

The submarine hoses are mainly fitted with detachable floats of sufficient number to provide optimum system configuration for a long hose life.

LONG LENGTH FLOATER HOSES

Unlike traditional offshore and dock hoses that are manufactured in standard lengths, floater hoses are manufactured as one continuous length of 500 feet or more as required. The long lengths are achieved by vulcanizing to eliminate mechanical splices, connectors such as swaging, crimping and clamps. The hoses are lightweight, flexible and collapsible enough for storage on metal reels. They are normally manufactured in 2 inch to 8 inch internal diameter, and up to 200 psi working pressure. Most have positive buoyancy for any liquid cargo with specific gravity less than water i.e. <1.0. However, some are only rated for products with a specific gravity of 0.85.

Floater hoses are more suitable for areas with calm sea conditions and they can be reeled in quickly in case of sudden storms.

Hoses are normally delivered with 150 lb raised flange (RF) aluminum flanged ends and re-attachable end couplings. Some manufacturers provide hoses with steel flanges but these may require floatation attachments to improve buoyancy.

Floater hoses are not manufactured to any industry standards. Further, OCIMF Guideline for Offshore Hoses and ExxonMobil IP3-11-1 for Dock Hoses do not apply to floater hoses. Instead, the most quoted technical criteria from the manufacturers is Safety Factor - a ratio of burst pressure over working pressure.

If floater hoses are to be utilized in the ExxonMobil system then a purchase specification that identifies the appropriate technical requirements to ensure hose quality should be prepared and approved by EMRE.

HOSES FOR SINGLE POINT MOORINGS (SPMS)

TYPES OF SPMS

Catenary Anchor Leg Mooring (CALM)

The most straightforward example of a Single Point Mooring is the "Catenary Anchor Leg Mooring" (CALM). A typical CALM system, as shown in [Figure 1](#), consists of the mooring buoy, the chain and anchor system, mooring assemblies, and floating and submarine hose strings. This is the most widely used SPM design, owing to its inherent reliability, robustness and track record for reliable service.

Single Anchor Leg Mooring (SALM)

The Single Anchor Leg Mooring (SALM) consists of a mooring buoy at the sea surface, which is attached to a base on the sea floor by a single anchor leg (refer to [Figures 4 and 5](#)). The buoy is drawn down against its buoyancy by tension in the anchor leg. Tankers' moor to the buoy with mooring hawsers. A swivel in the anchor leg or in the buoy allows the tanker to weather-vane around the mooring point. A fluid swivel is mounted concentric about the anchor leg, either on top of the base or on top of the riser pivoted from the base. Cargo hoses connect to an arm on the fluid swivel and rise to the surface, where they float and extend to the tanker's manifold.

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HOSE SYSTEMS FOR CALMS

Floating Hoses

Floating hoses for SPMs usually consist of two independent strings. Their sizes and lengths are based on specified pumping rates and on the size of the largest tanker to use the buoy. Separate flotation for each string is provided by either bead floats, or more commonly by integral flotation material built into the hose. However, bead floats are no longer used as these can be easily caught and damaged. The use of integral flotation is mandatory according to OCIMF-1.

Most designs consist of multiple strings of hose segments, which can be up to 4. Relatively large bore strings are most often used at high throughput crude transfer terminals, whereas bunker fuel and refined products are usually transferred through smaller bore strings.

The first hose off-the-buoy is subjected to high stresses and strains due to the motion of the buoy and the hose string. The hose end, which is connected to the buoy manifold connection is, therefore, reinforced with extra plies of high tensile reinforcing material and may also have additional wire helix. This hose normally has flotation over the outboard half of the hose length to reduce stress at the buoy connection end.

The hoses comprising the main floating line are designed for full buoyancy and are provided with flotation over their entire length. This is distributed in such a manner that the hoses float evenly when connected in a string. The main line floating hose is connected to the tail hoses by a tapered hose so that the tail section of the hose string is of smaller bore size than the main line hose, thus reducing the weight of the tail section. This arrangement is typical when the main line hose is larger than 16 in bore and a reduction in tail hose string is required to reduce the lifting weight to the tanker's manifold. The tail section of the hose string is generally not smaller in bore than the mainline section when the mainline hose string is 16 in bore or smaller.

The tapered hose normally has a built-in tapered bore to ensure full flexibility throughout the string line. Steel reducers are also used between the mainline hose and the tail hose, but they introduce rigidity and extra weight to the string line. Sometimes a single, large bore mainline string will be split into twin, smaller bore tail strings for easier tanker handling by using a floating Y-piece.

The tail hoses are the last few hoses in the string before the rail hose. These are sometimes smaller in diameter than the main line hoses as mentioned. These hoses are more flexible than the main line hose mainly due to smaller bore. Additional flexibility is required at the breakwater position due to the movement of the tanker during the transfer operation, and due to the change in draft of the vessel when loading or unloading. For a Very Large Crude Carrier (VLCC) the change in draft from fully loaded condition to ballast condition can be as much as 11 meters.

The rail hose connects the tail hose string section to the tanker's manifold. The hose is extremely flexible as it has to go over the rail at tanker side. The buoyancy of the hose is redistributed to provide concentrated buoyancy at each end for the support of the required equipment. The tanker end of each hose string is normally provided with a blind flange, quick-coupler device with spool piece, a butterfly-type valve, hang-off chain, and pickup buoy and chain. The hose normally has the pick-up and snubbing chain lugs welded onto the fittings. Scuff pads may be provided to resist abrasion. OCIMF requires the hoses of this type to be identified on the tanker connection end by a double white circumferential band, 50 mm wide, with a spacing of 50 mm, bearing the word "Tanker End". The main line floating hoses are normally provided with several evenly spaced, battery-powered winker lights operated by sun switches to provide nighttime illumination.

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Underbuoy Hoses

The underbuoy hoses are submersed hoses and consist of either single or multiple hose strings, connecting the PLEM to the buoy piping. The basic hose configurations normally used are the Chinese Lantern, the Lazy-S and the Steep-S, (refer to [Figures 1-3](#)). The determination of which basic type of configuration to use is based on the water-depth, normal and extreme tides, wave and current conditions, buoy excursions, position of chains and submarine pipeline including PLEM, maximum tanker draft as well as weight and stiffness of hoses including minimum bending radius. It is important to check the maximum and minimum excursions, both with the tanker moored (maximum operating condition) and without the tanker moored (survival condition). Either of these extreme conditions could lead to over-bending the hoses and overstressing the PLEM and buoy flange connections. Hose configurations are typically checked for the buoy motion envelope by computer hose-analysis programs. In areas where currents exceed 3 knots, flow induced (vortex) vibration effects should be investigated.

The hose string lengths are chosen to be compatible with the buoy excursions. Underbuoy hose configuration is maintained by underwater bead floats, adjustable flotation tanks, or both. Valves are occasionally provided in the underbuoy strings at the underbuoy pipe inlet but valves are always provided at the PLEM manifold to isolate one or more strings for maintenance and operational purposes.

Chinese Lantern Hose Configuration

The chinese lantern configuration places the buoy above the plem. the buoy is directly above the plem when the system is in equilibrium position and maximum mis-alignment of the buoy is normally designed not to exceed 1.5 m in any direction. The number of hose strings invariably matches the floating hose system. The number, net buoyancy and location of the underwater floats are determined by computer analysis or by scaled model tests. The hose strings should remain in an acceptable configuration during anticipated extreme buoy excursions. Both oil filled as well as seawater filled conditions should be considered. Removal of some floats may be required after initial installation, which occurs with hoses filled with seawater.

A buoy connection angle of 15 degrees to the vertical, and PLEM outlet angle of 45 degrees are commonly used.

The first off-the-PLEM and buoy connection submarine hoses are additionally reinforced at one end to withstand the higher stresses associated with flexible hose connection to the rigid pipe work. Standard submarine hoses are used between the buoy and PLEM connection hoses. The correct configuration is maintained by installing floats on the hoses. The hose design have location collars built into the body of the hose to facilitate attachment of floats both prior to installation and subsequently underwater if required. See [Figure 1](#)

Lazy-S Hose Configuration

In this configuration the pipe-line manifold position is offset from the vertical axis of the buoy. The hose strings form the characteristic "S" shape. The horizontal distance between the center of buoy and the PLEM should not vary more than 1.5 m from the design distance. The PLEM outlet angle is normally in the range of 15 - 30 degrees to the horizontal. A greater hose string length is required for the Lazy "S" and also some form of buoyancy is needed to control the slack hose. This is achieved by the use of one or more large buoyancy tanks or by bead floats (standard floats clamped on to the hose) or the combination of the two.

Bead float support can lead to less stress in the hose because the buoyancy is distributed more evenly along the hose string and the floats may offer less resistance to environmental forces. In case of buoyancy tanks, the hose attachment should be designed so that the weight of the hoses is suspended from the buoyancy tank. The environmental forces affecting the tank will thus have a lesser effect on the hose string. However, the introduction of buoyancy tank support rigidity into an otherwise flexible hose system can compromise hose string behavior and performance.

The first-off-the-PLEM, and buoy connection hoses are of the one-end reinforced type as used for the Chinese Lantern. Standard submarine hoses are used between the buoy and PLEM connection hoses, although one-end reinforced hose types may be used at buoyancy tank connections. See [Figure 2](#)

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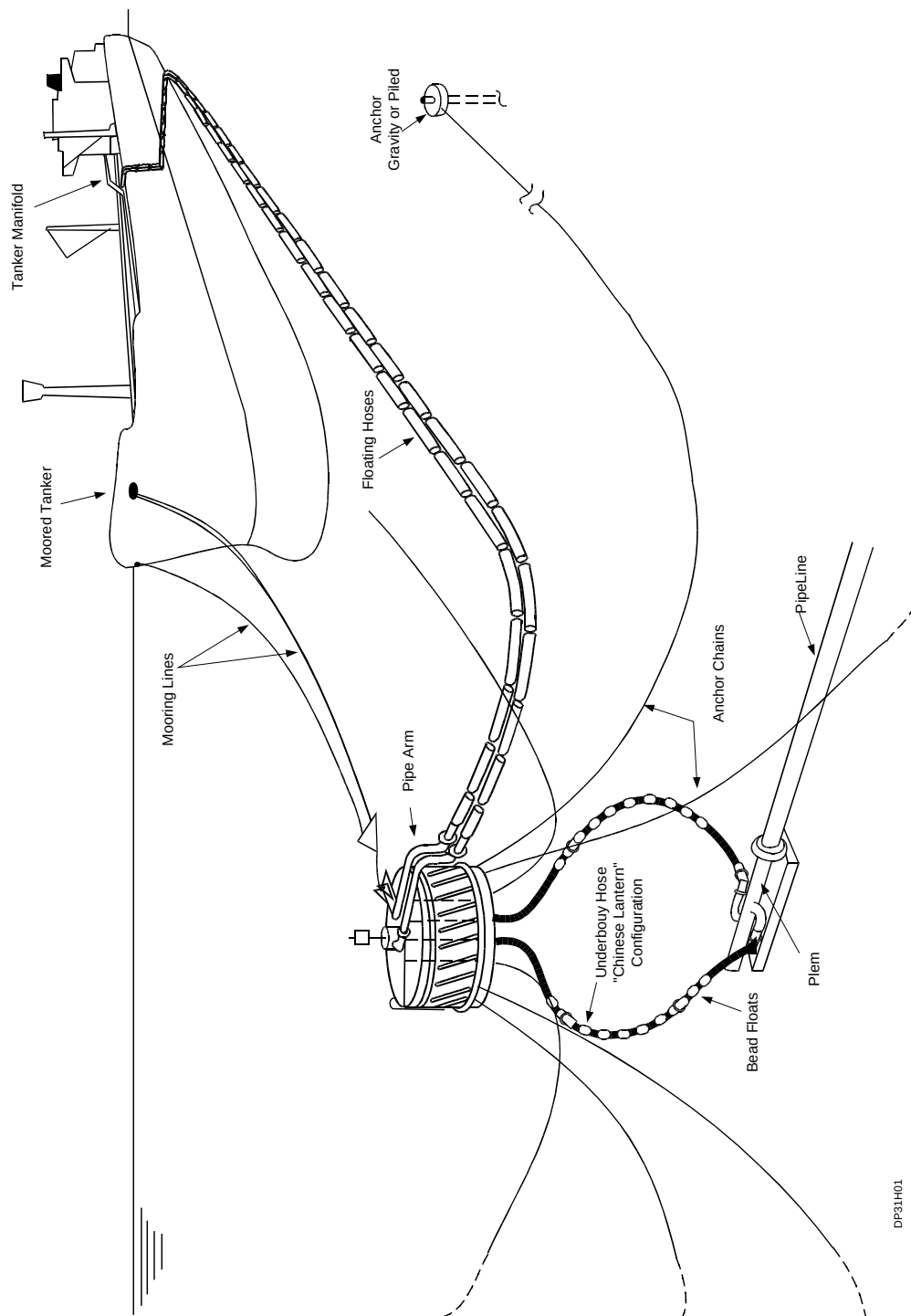
Steep-S Configuration

In the Steep-S configuration an intermediate buoyancy tank is used to provide the necessary flotation for the submarine hose string which is connected between the underside of the buoy and the PLEM. Both the PLEM outlet as well as the buoy inlet are normally 0 degrees to the vertical or close to it. This configuration is normally used in water depths exceeding 45 m. The buoyancy tank is positioned almost directly above the manifold with the number of vertical hoses depending upon the water depth and vessel draft. The remainder of the string is angled away from the tank in the approximate form of a catenary to form the Steep "S" configuration.

Hose sections which are attached to the PLEM and surface buoy connection are of the one-end reinforced type. One-end reinforced hoses may also be used at the buoyancy tank connections. See [Figure 3](#)

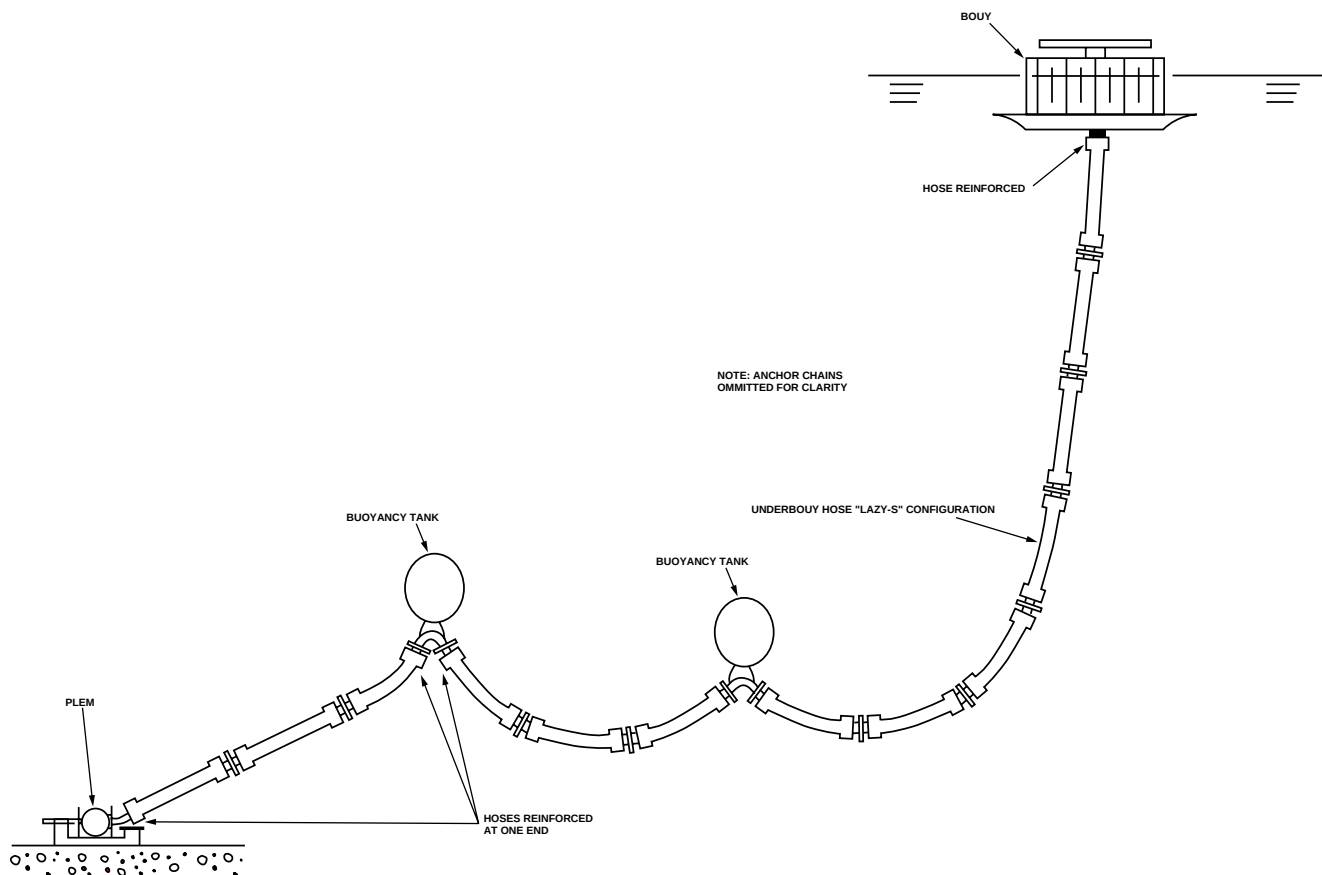
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Figure 1
Typical Design of Catenary Anchor Leg Mooring



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Figure 2
Lazy-S Configuration



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Figure 3
Steep-S Configuration

