UFC 4-150-09
27 February 2019

UNIFIED FACILITIES CRITERIA (UFC)

PERMANENT ANCHORED MOORINGS OPERATIONS AND MAINTENANCE

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PERMANENT ANCHORED MOORINGS, OPERATIONS AND MAINTENANCE

U.S. ARMY CORPS OF ENGINEERS

NAVAL FACILITIES ENGINEERING COMMAND (Preparing Activity)

AIR FORCE CIVIL ENGINEER CENTER

Record of Changes (changes are indicated by **1**\ ... /**1**/)

Change No.	Date	Location

This UFC supersedes MO-124, dated August 1987.

FOREWORD

The Unified Facilities Criteria (UFC) system is prescribed by MIL-STD 3007 and provides planning, design, construction, sustainment, restoration, and modernization criteria, and applies to the Military Departments, the Defense Agencies, and the DoD Field Activities in accordance with USD (AT&L) Memorandum dated 29 May 2002. UFC will be used for all DoD projects and work for other customers where appropriate. All construction outside of the United States is also governed by Status of Forces Agreements (SOFA), Host Nation Funded Construction Agreements (HNFA), and in some instances, Bilateral Infrastructure Agreements (BIA). Therefore, the acquisition team must ensure compliance with the most stringent of the UFC, the SOFA, the HNFA, and the BIA, as applicable.

UFC are living documents and will be periodically reviewed, updated, and made available to users as part of the Services' responsibility for providing technical criteria for military construction. Headquarters, U.S. Army Corps of Engineers (HQUSACE), Naval Facilities Engineering Command (NAVFAC), and Air Force Civil Engineer Center (AFCEC) are responsible for administration of the UFC system. Defense agencies should contact the preparing service for document interpretation and improvements. Technical content of UFC is the responsibility of the cognizant DoD working group. Recommended changes with supporting rationale should be sent to the respective DoD working group by submitting a Criteria Change Request (CCR) via the Internet site listed below.

UFC are effective upon issuance and are distributed only in electronic media from the following source:

- Whole Building Design Guide web site http://www.wbdg.org/ffc/dod.

Refer to UFC 1-200-01, *DoD Building Code (General Building Requirements)*, for implementation of new issuances on projects.

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UNIFIED FACILITIES CRITERIA (UFC)
NEW SUMMARY SHEET

Document: UFC 4-150-09, *Permanent Anchored Moorings, Operations and Maintenance*

Superseding: MO-124, Mooring Maintenance Manual, August 1987
FPO-1-84(6), Fleet Mooring Inspection Guidelines, 1984
FPO-1-88(40), Fleet Mooring Buoy Surface Inspection Guidelines, December, 1988
NAVFAC P-1110, Fleet Mooring Handbook

Description: The UFC 4-150-09, *Permanent Anchored Mooring, Operations and Maintenance* represents another step in the joint Services effort to bring uniformity to the maintenance and operations of moorings. This UFC contains extensive modifications in the following areas:

- Inclusion of lessons learned from past operations
- The use of commercial, industrial and offshore industry standards where appropriate
- Updating, conversion and combining of several NAVFAC manuals and local command guidelines to a more uniform format and a document to be used by all services with general updates and revisions

Reasons for Document:

The existing guidance was inadequate for the following reasons:

- Need to convert to UFC format
- Incorporation of changes described above
- Update to referenced documents

Impact:

The following direct benefits will result from the update of UFC 4-150-09, *Permanent Anchored Moorings, Operations and Maintenance*

- Although primarily a U.S. Navy document, a single, comprehensive, up to date criteria document exists to cover mooring operations and maintenance.
- Eliminates misinterpretation and ambiguities that could lead to conflicts.
- Facilitates updates and revisions and promotes agreement and uniformity of design and construction between the Services.

Unification Issues:

- There are no unification issues.

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CHAPTER 1 INTRODUCTION

1-1 BACKGROUND.

This UFC provides requirements, guidance and procedures for operation and maintenance of permanent anchored moorings for U.S. Department of Defense (DoD) vessels. This manual provides important technical data, information and recommended procedural guidelines for the operation, inspection, maintenance, repair, removal and refurbishment. This document will supersede all the documents and drafts of documents currently being used to conduct inspections, maintenance and repairs of fleet moorings, such as the NAVFAC P-1110 Fleet Mooring Handbook, FPO-1-84(6) Fleet Mooring Underwater Inspection Guidelines, NAVFAC MO-124, Mooring Maintenance Manual, etc. OPNAVINST 5450.348 states NAVFACENGCOM serves as the technical authority responsible for permanent anchored "fleet" moorings for the U.S. Navy.

1-2 PURPOSE AND SCOPE.

This UFC provides requirements, guidance and procedures for operation and maintenance of permanent anchor moorings for U.S. Department of Defense (DoD) vessels. This manual provides important technical data, information and recommended procedural guidelines for the operation, inspection, maintenance, repair, removal and refurbishment.

A mooring is any structure whose purpose is to restrain a ship's movement and keep it in a relatively fixed location. A mooring is of two general types, fixed moorings and compliant anchor moorings. Fixed moorings are defined as a system that includes both tension and compression members. These systems include facilities like piers and wharves, the components that connect the vessel to the fixed facility (lines, chain, etc.) as well as the fendering used to protect the vessel from damage due to contact with the facility. Compliant anchor moorings are defined as a stationary system that includes primarily tension members with mooring loads transferred into the earth via anchors. Active ship's anchor systems are excluded. This manual only addresses compliant anchor moorings, but many of the procedures described here are applicable to the inspection and maintenance of fixed mooring systems or their components.

This document standardizes mooring inspection procedures for both surface and underwater inspection and assist inspection personnel by describing the various typical permanent anchor mooring types and materials used and defining what should be accomplished before, during and after a mooring inspection. Also defined are the types of data and documentation that must be gathered and captured in the inspection report. The inspection's Engineer-in-Charge (EIC) will evaluate the inspection data and provide an assessment of the mooring's condition to meet its design requirements.

The document provides the inspector with a standard inspection template for the inspection of a mooring system, a sample preliminary inspection results email, a sample inspection report, inspection checklist, details of go no-go gauges and other inspection tools, and guidance on surveying of permanent anchor mooring buoys and anchors.

This document provides guidance for the maintenance and repair of the moorings based on the results of the inspection.

1-3 APPLICABILITY.

The information presented in this manual is applicable to planners, quality assurance and quality control personnel, supervisors and technicians who are involved in DoD mooring operations, inspections, and maintenance.

Planners can use this information to assist in developing budgetary input, inspection schedules and maintenance and repair schedules. The information will be useful in preparing specific plans for each major task and evolution in the life cycle of a mooring system.

In addition to safety, Quality Assurance (QA) and Quality Control (QC) must be the paramount consideration in the execution of every phase of the operation of a mooring system. The information will assist QA personnel in determining the number and type of checks and inspections that must be performed to ensure that the stringent quality control procedures are adhered to. QC personnel will find the information useful for identifying test equipment and procedures and personnel qualifications necessary to meet the requirements of the QC plan.

Supervisory personnel will use the information to assist in selection equipment and qualified personnel for each task and in executing each task in the safest and most efficient manner possible.

Technicians will find the manual useful as a training tool and a useful reference.

1-4 GENERAL BUILDING REQUIREMENTS.

Comply with UFC 1-200-01, *DoD Building Code (General Building Requirements)*. UFC 1-200-01 provides applicability of model building codes and government unique criteria for typical design disciplines and building systems, as well as for accessibility, antiterrorism, security, high performance and sustainability requirements, and safety. Use this UFC in addition to UFC 1-200-01 and the UFCs and government criteria referenced therein.

1-5 BEST PRACTICES.

APPENDIX A provides documentation on Best Practices to be used during the operations, inspections, maintenance and repair of mooring systems. Included in this appendix is a section on Safety.

1-6 GLOSSARY.

APPENDIX M contains acronyms, abbreviations, and terms.

1-7 REFERENCES.

APPENDIX N contains a list of references used in this document. The publication date of the code or standard is not included in this document. In general, the latest available issuance of the reference is used.

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CHAPTER 2 TECHNICAL REQUIREMENTS

2-1 PERMANENT ANCHOR MOORINGS.

2-1.1 Compliant Anchor Mooring Systems.

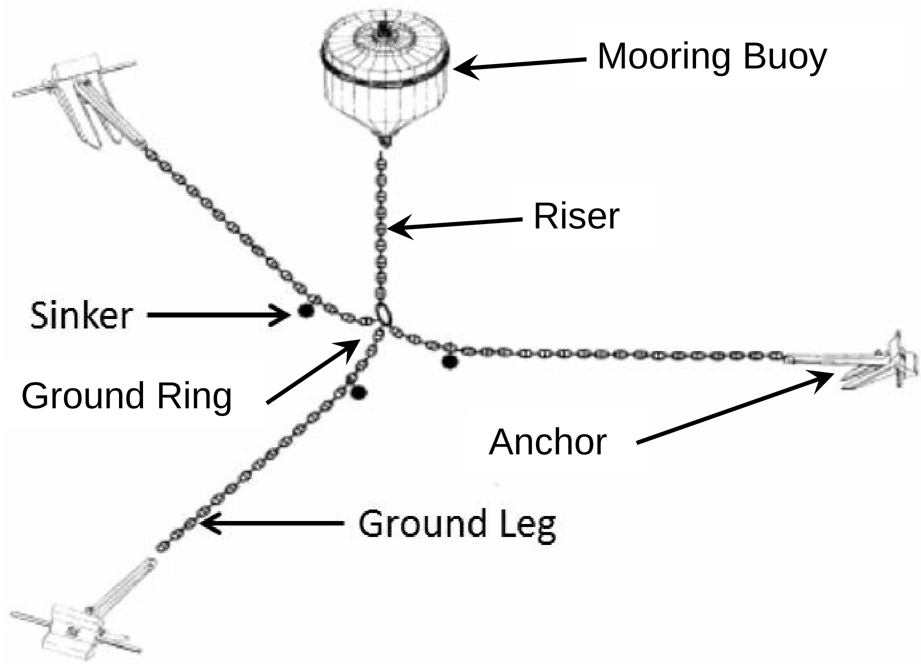
A compliant anchor mooring is used to provide temporary or permanent berthing for vessels in ports and harbors where pier space is limited or unavailable or in the open ocean. The most common moorings consist of one or more buoy systems. A buoy system includes the surface mooring buoy, the attendant chain, the anchor(s), the fittings, and the accessories. There are mooring systems that do not require a surface mooring buoy. Buoy and non-buoy mooring systems are described in subsequent paragraphs of this chapter. The complete mooring is defined by type and by classification, regardless of the existence of a surface mooring buoy. Type refers to the physical configuration of the mooring and classification refers to the holding capacity. There are several basic types of mooring systems, each serving a specific purpose and each offering advantages and disadvantages. The most commonly used mooring arrangements are discussed below.

2-1.1.1 Single Point (Free Swinging) Mooring System.

A single point mooring (SPM) system consists of a single buoy or attachment point to which a ship may moor. This single point of attachment permits the ship to swing freely and weathervane in response to environmental loading such as wind and currents. Single point moorings consist of an attachment point (in most cases a buoy), a riser assembly and either one or multiple ground leg assemblies. Most SPM systems used by the Navy have a buoy, a riser assembly with three ground legs attached to the riser by a ground ring and equally separated from each other (Figure 2-1). Ground legs can be secured to the seafloor by a variety of anchoring assemblies including gravity anchors, drag anchors, stake piles or embedded plate anchors. The single point mooring, having only one surface attachment point, minimizes material requirements, installation effort, and maintenance requirements.

The major disadvantages of this type of mooring are the large amount of real estate required by the moored vessel and the possibility of the vessel "fishtailing" or "horsing" about the buoy. A free-swinging mooring must be sufficiently clear of shoreline, shoal waters, structures, and other moorings. This will allow the moored ship to swing freely about the mooring, without interference, as it responds to the weather conditions.

Figure 2-1 Riser-Type Single Point Mooring



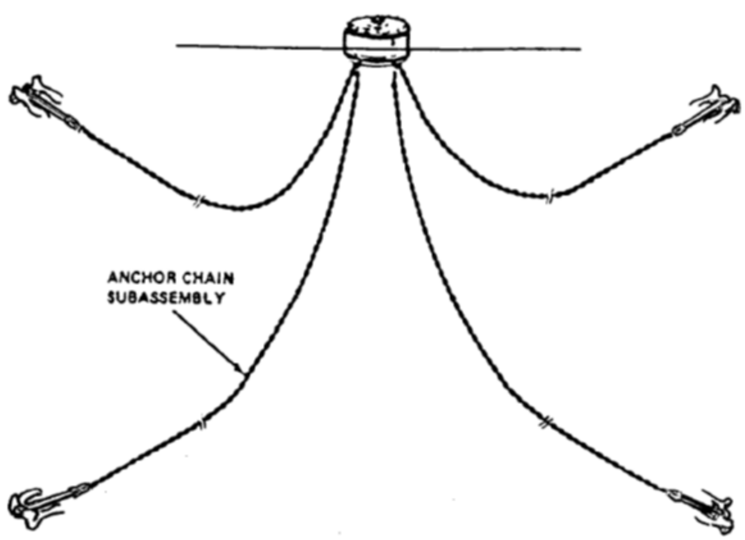
Single point moorings have three mooring configuration types. One type is the "Riser-Type" mooring with a buoy, a riser assembly and three ground legs attached to the riser by a ground ring, equally separated from each other as shown in Figure 2-1. Many single point moorings in the fleet mooring program are configured as a riser-type mooring. The riser-type mooring is preferred because it allows the ship to moor with a short hawser and not risk any damage to its hull by rubbing against a chain.

The second configuration type is the single riser-leg type mooring where a single chain assembly acts as both the riser and ground leg and is connected to either a plate anchor or in special cases, another type of anchor assembly. Figure 2-2 shows a Single Riser Leg Mooring. Most single riser-leg moorings in the Navy are secured to an embedded plate anchor and are used to create a spread moor (Paragraph 2-1.1.3 and Figure 2-5).

Figure 2-2 Single Riser Leg Mooring

The third configuration type is the “non-Riser” type mooring. In the non-Riser type mooring, the ground legs are attached directly to padeyes or chain capture devices on the buoy. These moorings do not permit the buoy to rotate and can be used to bring up electrical power or signal (telephone) cables or fuel lines to the ship. Although these moorings have the largest holding capacities, ships must be careful when mooring to them. A ship that is moored too closely, risks damaging its hull with the chain that is suspended in the catenary. There are some moorings within Department of Defense that utilize a non-riser type mooring. Figure 2-3 shows a Non-Riser Mooring.

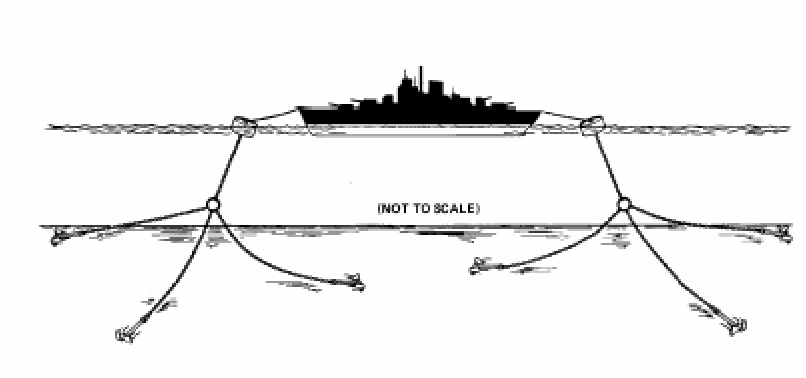
Figure 2-3 Non-Riser Mooring



2-1.1.2 Bow and Stern Mooring System.

A bow and stern mooring system provides two surface points to which a ship may attach its fore and aft mooring lines (Figure 2-4). Bow and stern moorings consist of two single point mooring systems. Most bow and stern moorings have two single point riser-type moorings consisting of a mooring buoy, a riser assembly and two ground leg assemblies.

Figure 2-4 Bow and Stern Mooring

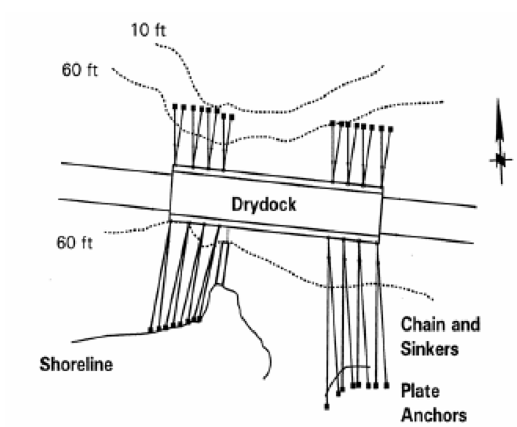


This type of mooring is designed to maintain the orientation of the moored ship into the prevailing currents and requires less area than a single point mooring. The major disadvantage of a bow and stern mooring is that each leg of the mooring usually must have a greater holding capacity than a single point mooring to resist strong loads imposed on the mooring legs by broadside winds.

2-1.1.3 Spread Mooring.

A spread mooring system (Figure 2-5) is installed to moor a single ship or cluster of ships in a fixed position for a long period of time. This system is used primarily to provide berthing for inactive ships or to moor floating dry-docks.

Figure 2-5 Spread Mooring



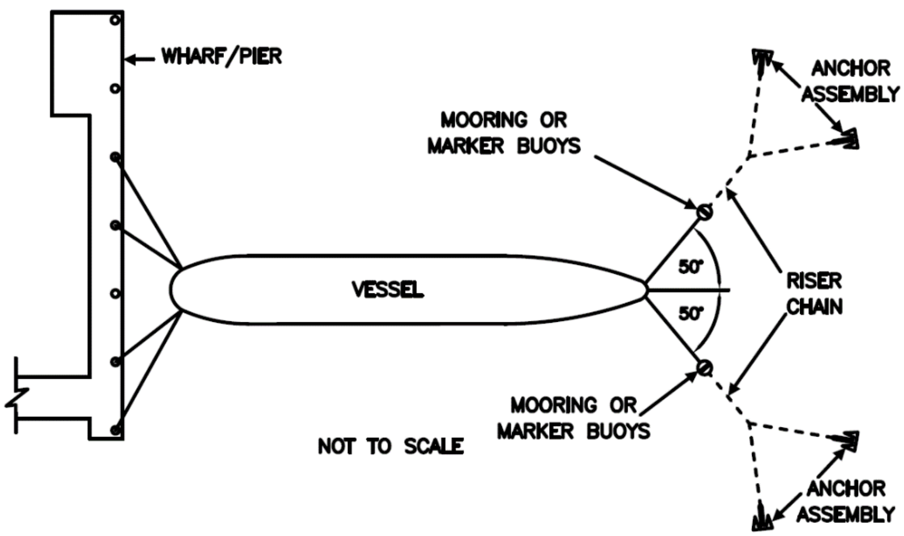
A spread mooring consists of four or more single point moorings installed in a specified pattern to provide multiple attachment points for the moored vessel(s). Single point moorings within a spread mooring may or may not have a buoy for an attachment point. Ship chains are either attached to the buoy or directly to the mooring's riser.

2-1.1.4 Mediterranean Mooring.

A Mediterranean mooring (Med-moor) is similar to a bow and stern mooring. The vessel is oriented perpendicular to a wharf or pier, or parallel, centered and in line with the end of a pier. The stern is generally secured to shore fittings on the pier or wharf. The bow of the vessel is secured using mooring chains to buoy attachment points provided on two single point moorings (Figure 2-6).

The moorings consist of a buoy, a riser-leg or multiple ground legs secured to a common riser with a ground ring. Under normal circumstances, ground legs for the bow moorings in a Med-moor are secured by either multiple drag anchors or a buried large deadweight anchor.

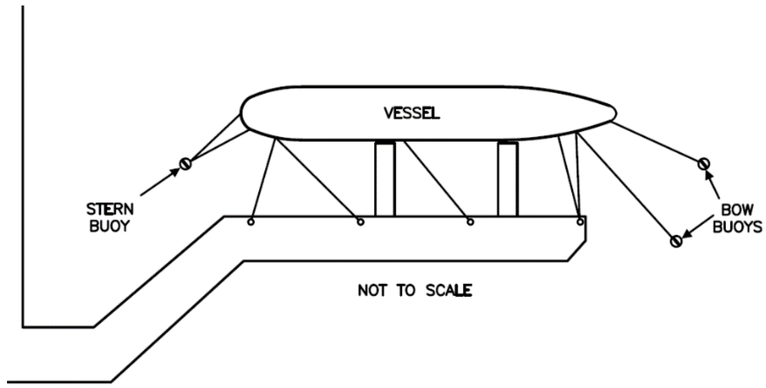
Figure 2-6 Mediterranean Mooring



2-1.1.5 Buoy Dolphins Mooring.

Single point moorings acting as mooring dolphins are installed to provide bow and stern attachment points for a ship moored alongside a short pier or to one or more finger piers (Figure 2-7). Single point moorings with buoy are used instead of permanent concrete or timber dolphins. The length of the ship that may moor to the buoy dolphins is limited by the distance between the buoys.

Figure 2-7 Buoy Dolphin Mooring System



2-1.2 Mooring Systems Assemblies.

2-1.2.1 Buoy Assembly.

The buoy assembly consists of the buoy and the top jewelry (to connect the vessel to the mooring buoy. See the descriptions of the various components in Section 2-2.

2-1.2.2 Riser Assembly.

The riser assembly connects the ground ring to the buoy. It consists of chain (or other tensile strength member) and all the connecting hardware used to connect the riser to the buoy (usually including a riser swivel shackle) as well as to connect the riser to single or multiple ground leg assemblies (usually an anchor joining link and a ground ring). See the descriptions of the various components in Section 2-2.

2-1.2.3 Ground Leg Assembly.

Ground leg assemblies consist of the chain (or other tensile strength member) and associated hardware to connect the anchor to the ground ring. Sinkers may also be used on the ground legs to help minimize or reduce the dynamic loads put on the mooring system by the moored vessel. See the descriptions of the various components in Section 2-2.

2-1.2.4 Riser Leg Assembly.

Riser leg assemblies consist of the chain (or other tensile strength member) and associated hardware to connect the buoy directly to the anchor assembly. Sinkers may be used on the ground legs to help minimize the dynamic loads put on the mooring system by the moored vessel. See the descriptions of the various components in Section 2-2.

2-1.2.5 Anchor Assembly.

The anchor assembly consists of the anchor that holds the system in place, and the hardware to connect the anchor to the ground leg or riser leg assembly. See the descriptions of the components in Section 2-2.

2-1.2.6 Cathodic Protection Assembly.

This assembly helps prevent corrosion of the mooring system by providing zinc anodes to corrode before the steel in the mooring system. Anodes are usually attached to each chain link as well as to the bottom of the buoy's attachment padeye. See the descriptions of the components in Section 2-2.

2-2 MOORING COMPONENTS.

2-2.1 Mooring Buoys.

Mooring buoys are classified based on their shape and their construction. The type of buoy used in a mooring depends on the mooring's rated capacity and the method of attachment used by the serviced vessel. Buoys are generally equipped with a center tension bar which provides a lower padeye attachment for the mooring riser and an upper padeye attachment for an anchor bolt shackle where connecting hardware to secure the vessel is attached to. Buoys may also be equipped with a hawse pipe that allows the riser chain to pass through the center of the buoy and be the attachment point for connecting hardware to secure the vessel. Both of these two styles are designed for riser-type moorings.

Buoys may also be designed to attach directly to multiple ground legs. These buoys are prevented from rotating by the attached ground legs. These types of buoys are used when electrical power wires, communication wires or fuel hoses are being brought up to vessel from the sea floor. One would find this type of buoy on a non-riser type mooring system.

A buoy's size depends primarily on the weight of the mooring system it must support in the water column. The following types of buoys are utilized.

Peg-Top Buoys – Peg-Top buoys have bottoms that are conical in shape and upper vertical sides, similar to the drum buoy. The buoy serves to support a riser type system. They may have either a tension bar or a hawse pipe design. They may be coated with either a standard ship paint, a fiberglass coating or a polyurethane coating. Peg-Top buoys can be manufactured of steel or of foam encapsulating steel core and covered by an outer nylon reinforced urethane shell.

Drum Buoys – Drum buoys are so called because of their resemblance to the shape of a drum. Drum buoys are available in a variety of sizes and are used to support a riser type buoy system, having a hawse pipe or tension bar through them. They may be coated with either a standard ship paint, a fiberglass coating or a polyurethane coating.

Drum buoys can be manufactured of steel or of foam encapsulating steel core and covered by an outer nylon reinforced urethane shell.

Non-Riser Type Buoys – Non-riser type buoys are also shaped like a drum but have no hawse pipe or tension bar. Instead, they have padeyes or chain capture devices equally spaced around the bottom perimeter of the hull for attaching ground leg chains and have a swivel fitting on the top to support the top jewelry. These buoys are generally larger than riser-type buoys because of the added weight of the several chains they must support in the water column and because they are a load-bearing member of the mooring system. Non-riser buoys are also known as “telephone buoys”.

Spherical Buoys – Spherical buoys are normally used only to mark and retrieve the riser chain of a mooring system. Ships attach their mooring hardware directly to the riser chain rather than to the buoy. The most commonly used spherical buoy is of steel construction, 54 inches (1.37 m) in diameter and may be foam filled.

2-2.1.1 Foam Buoys.

The foam buoy (Figure 2-8) is a buoy encased in rigid, closed-cell foam that is covered by a flexible crossed-linked polyethylene foam bonded to the rigid interior foam. The entire foam assembly is then encased in a urethane elastomer (Figure 2-9). Two sizes of foam peg-top buoys are primarily stocked in the Fleet Mooring Program; 8-foot (2.44 m) diameter (referred to as a small foam buoy) and 11.5-foot (3.51 m) diameter (referred to as a medium foam buoy). General data is provided in Table 2-1.

Figure 2-8 Foam Buoy

Figure 2-9 Foam Buoy Cross Section

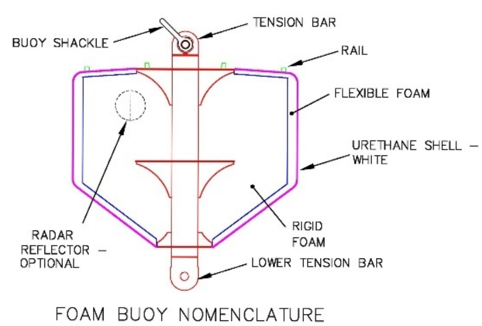


Table 2-1 Foam Buoy Data

PARAMETERS	8 ft BUOY	11.5 ft BUOY
Size	Small	Medium
Weight in Air	4,500 lbs (2,041 kg)	10,400 lbs (4,717 kg)
Net Buoyancy	15,000 lbs (6,804 kg)	39,000 lbs (17,690 kg)
Working Buoyancy (24 inch freeboard)	6,150 lbs (2,790 kg)	20,320 lbs (9,217 kg)
Reserve Buoyance (24 inch freeboard)	8,850 lbs (4,014 kg)	18,680 lbs (8,473 kg)
Proof Load on Tension Bar	300,000 lbs (1,334 kN)	600,000 lbs (2,669 kN)
Working Load on Tension Bar	150,000 lbs (667 kN)	300,000 lbs (1,334 kN)
Diameter Overall (w/fenders)	8 ft 6 in (2.591 m)	12 ft (3.658 m)
Diameter of Hull	8 ft (2.438 m)	11 ft 6 in (3.505 m)
Length of Hull Overall	7 ft 9 in (2.362 m)	8 ft 9 in (2.667 m)
Length of Tension Bar	11 ft 4 in (3.454 m)	13 ft 1 in (3.988 m)
Height of Cylindrical Portion	4 ft 4 in (1.321 m)	5 ft 7 in (1.702 m)
Height of Conical Portion	3 ft 5 in (1041 mm)	3 ft 2 in (9652 mm)
Bar Thickness (top/bottom)	4.5/3 in (114/76 mm)	5/3.5 in (127/89 mm)
Padeye ID (top/bottom)	3.5/3.5 in (89/89 mm)	4.5/5 in (114/127 mm)
Shackle on Top	3 in	4 in
Maximum Chain Size	2.75 in	4 in
Minimum Recommended Riser Weight	1,068 lbs (484 kg)	7,500 lbs (3402 kg)
Riser Weight for 24 inch Freeboard	8,850 lbs (4,014 kg)	18,680 lbs (8,473 kg)
Maximum Recommended Riser Weight	7,500 lbs (3,402 kg)	21,264 lbs (9,645 kg)
Moment to Heel 1 degree (Min Riser Wt)	108 ft-lbs (14.9 m-kg)	1,183 ft-lbs (163.6 m-kg)
Moment to Heel 1 degree (Max Riser Wt)	648 ft-lbs (89.6 m-kg)	2,910 ft-lbs (402.3 m-kg)

A foam buoy is superior to a steel buoy for a number of reasons:

- It will not flood or sink if the outer shell is punctured, see Figure 2-10;
- It is considerably lighter than the steel buoy that would be required to support the equivalent weight of chain in the water column;
- It requires significantly less preventive and corrective maintenance, resulting in lower projected operation and maintenance (O&M) costs than for a steel buoy;
- The resiliency of the foam greatly reduces the probability of damage to a vessel from a collision.

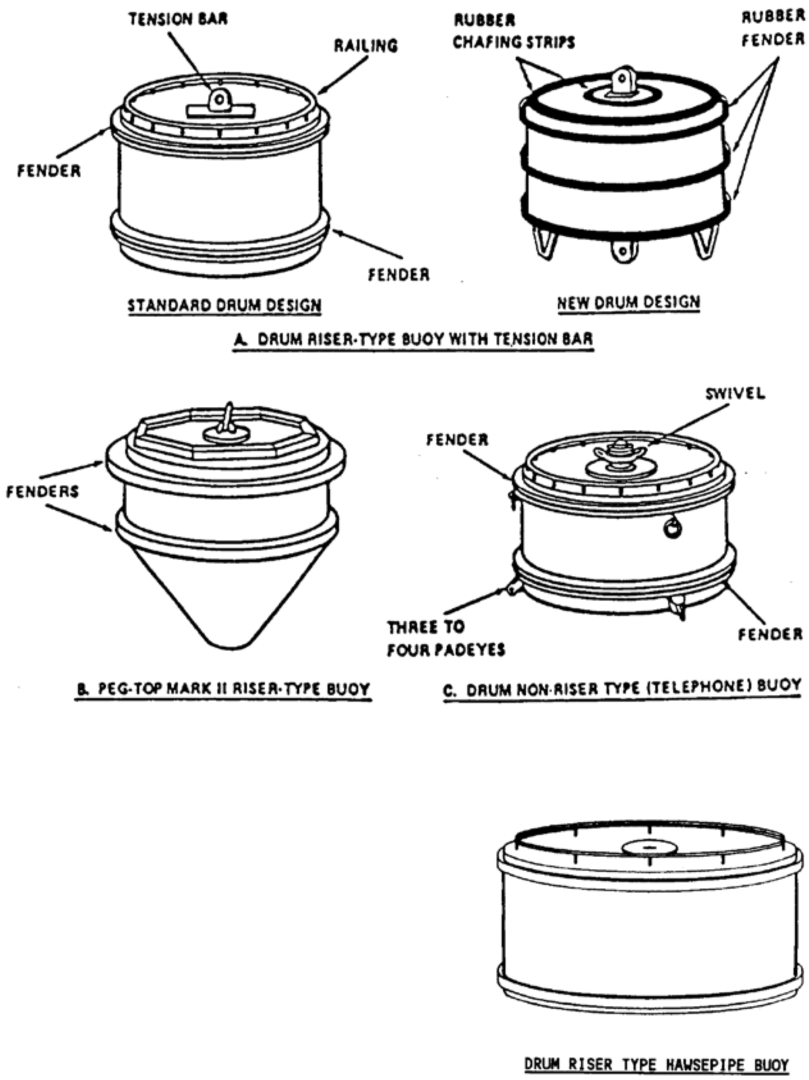
The working buoyancy is the amount of weight the buoy can support and still maintain a 2-foot freeboard above the deck line (when level). The deck line of a buoy is at the elevation on the buoy top shell where the top deck transitions to the buoy sides. For the buoys listed in Table 2-1, the deck line is at the bottom of the outer chafe rail.

Figure 2-10 Punctured Foam Buoy

2-2.1.2 Steel Buoys.

Older riser type buoys were fabricated out of steel. Like the foam buoys, most steel buoys have either a tension bar or a hawse pipe to bring the mooring load from the vessel to the chain/anchors. All non-riser buoys have been constructed of steel. See Figure 2-11 for various types of steel buoys.

Figure 2-11 Steel Buoys



Note:

All efforts should be made to replace steel buoys with foam buoys since steel buoys are much more difficult to inspect and maintain. Steel tension bar buoys can still be used, but hawse pipe buoys shall be taken out of service, disassembled and disposed of in accordance with local steel recycling programs.

2-2.1.3 Buoy Accessories.

2-2.1.3.1 Chafing Strips.

Chafing strips are heavy, molded rubber strips attached to the buoy at the top edge and around the top jewelry to prevent wear in the areas where the ship's mooring chain or hawser may drag against the buoy. Additionally, chafing strips provide both foot and hand hold points for operators. Not all buoys are equipped with chafing strips. Standard small and medium foam buoys have urethane chafing strips integrally casted as part of the outer shell or attached to the buoy's shell.

2-2.1.3.2 Rails.

Some steel buoys have rails attached to the outer perimeter of the top of the buoy to serve the same purpose as chafing strips. The rails are usually made of steel. Recent foam buoy procurements are using either D-rubber toe rails or cast elastomer toe rails in lieu of urethane chafing strips used for the standard Fleet Mooring foam buoy.

2-2.1.3.3 Fenders.

Fenders are installed in one or more rows around the circumference of the buoy's sides to absorb the shock of collision and prevent damage to the buoy hull. Fenders may be wood, rubber or a combination of the two materials. The fenders may be may be connected to steel buoy using studs, welded brackets (segmented or continuous) or metal retaining bands. Standard small and medium foam buoys have a single fender that is integrally casted as part of the outer shell (sometimes referred to as a rub rail).

2-2.1.3.4 Reflective Markings.

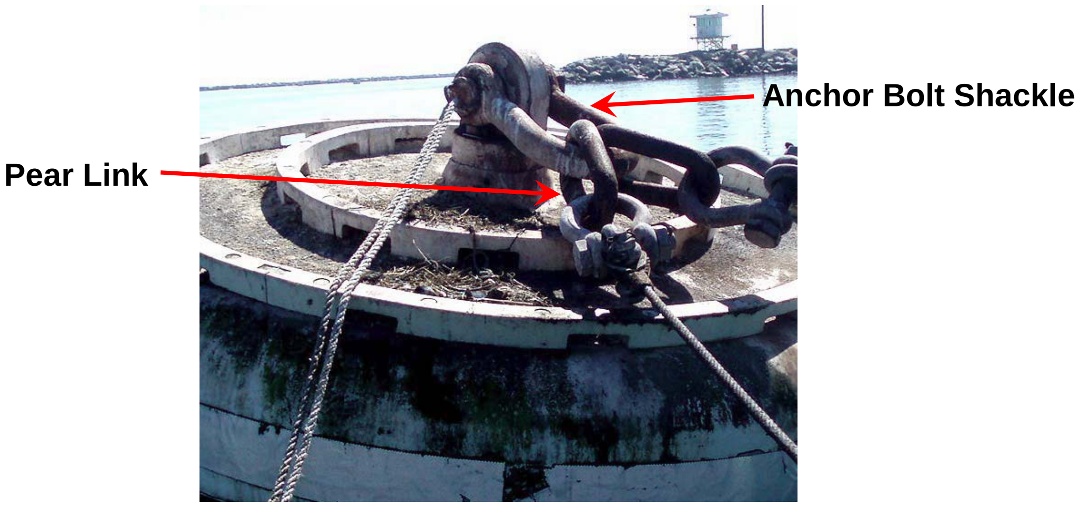
Mooring buoys are painted white or are coated with a white material. However, to make them more visible at night, one or more rows of reflective tape is bonded to the circumference of the buoy's sides. Mooring buoys within the Navy's restricted zone generally have white reflective tape. Mooring buoys in other locations will have reflective tape conforming to the cognizant USCG authority. Figure 2-12 illustrates a buoy with two strips of reflective tape.

Figure 2-12 Reflective Tape on Foam Buoy

2-2.1.3.5 Top Jewelry.

Top jewelry is the fitting or fittings attached to the chain or the tension bar padeye on top of the buoy. Top jewelry serves as the transition piece from the installed mooring system to the ship's mooring hawser or chain. Standard top jewelry has become an anchor bolt shackle and two pear links (Figure 2-13).

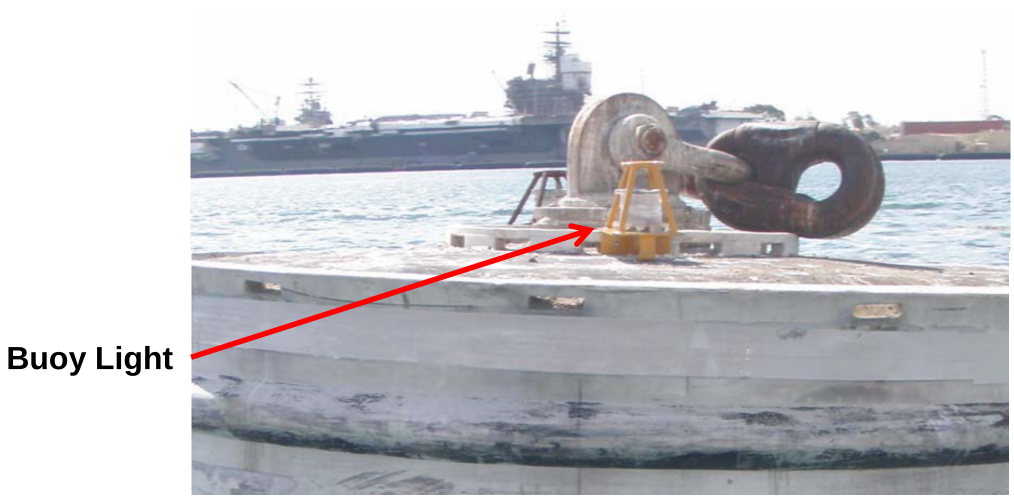
Figure 2-13 Top Jewelry on a Buoy



2-2.1.3.6 Buoy Lighting.

The lighting requirements will be specified by the United States Coast Guard (USCG) on the approved Aids to Navigation Application. If buoy lighting is required, it must be maintained by the custodian. See Figure 2-14.

Figure 2-14 Buoy Light



2-2.2 Anchors.

The most commonly used anchoring systems are either direct embedment anchors or drag-embedment anchors. Embedment anchors, by design, are installed below the seafloor and are not visible for inspection. The most common direct embedment anchors used by the Navy are plate anchors. Other direct embedment anchors include pile anchors and propellant embedment anchors (PEA). As of 2010, no PEA anchors are in service for U.S. Navy moorings.

The most common drag-embedment anchors found are either the Navy stockless anchor or the high capacity NAVMOOR anchor. Other types of drag embedment anchors that may be found include the NAVFAC STATO anchor and LWT anchor. Drag embedment anchors are generally not visible for inspection since they will tend to bury themselves during proof loading of the ground legs during installation. However, in hard rocky or even dense sand seafloors, they may be partially or completely visible for inspection.

Other anchor types that are found are deadweight or gravity anchors. Though they can be shaped to aid the anchor in digging into the soil and may be jetted into the seafloor during installation, they primarily resist mooring forces through their large submerged weight.

2-2.2.1 Direct-Embedment Anchors.

2-2.2.1.1 Plate Anchor.

Plate anchors can be used in place of the much larger and costlier pile anchor or a standard drag anchor. Like a pile anchor, installation equipment is composed of standard pile driving barges and hammers. The plates are driven into the soil using a follower that is removed when the anchor reaches proper depth. Plate anchors can be used in soils with poor engineering properties or where there is not enough room for the long legs of a typical drag anchor mooring. Plate anchors have been proven to hold well in soils that are not good candidates for drag anchors, such as coral limestone and hard glacial till. Figure 2-16 shows a picture of a plate anchor and Figure 2-15 provides a schematic of how to install a plate anchor.

Figure 2-15 Plate Anchor Installation Schematic

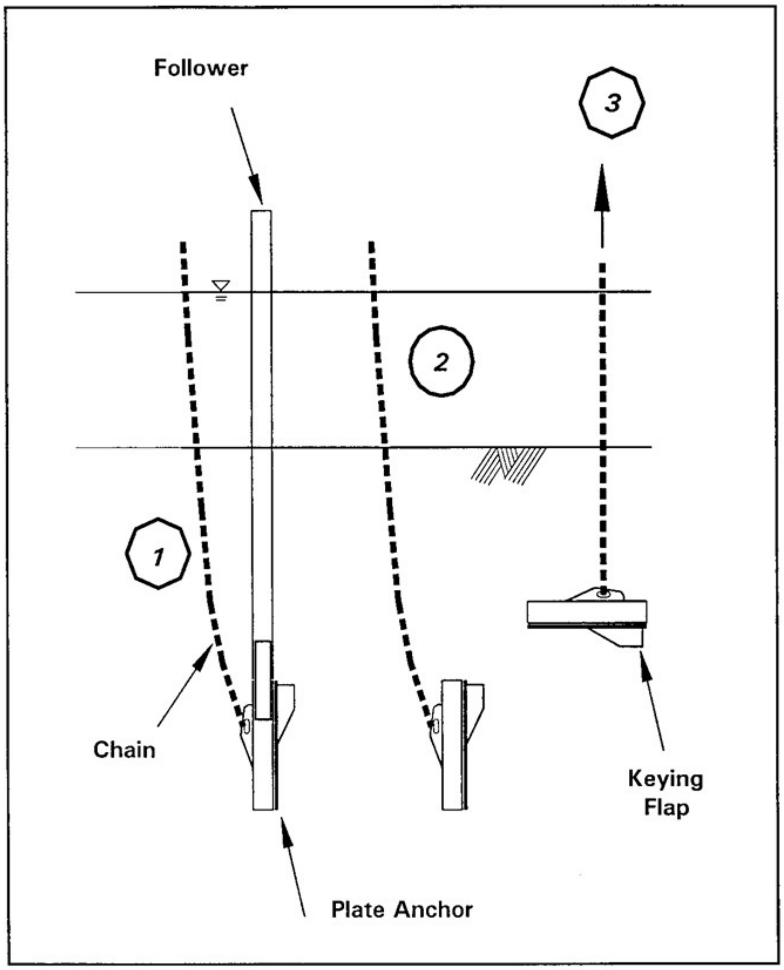


Figure 2-16 Plate Anchor

2-2.2.1.2 Pile Anchor.

Pile anchors are fabricated from structural steel shapes, such as H beams, or pipes with appropriate attachment points for connecting the ground leg chain. Pile anchors are installed by driving, drilling and grouting, or other underwater construction methods. Pile anchors can resist large uplift forces or horizontal forces from various directions and are generally installed in bottom soils characterized by stiff clays or medium to dense sands. Pile anchors develop holding power as a result of the surface friction of the soil in which they are driven.

2-2.2.1.3 Propellant-Embedment Anchor (PEA).

PEAs are composed of a plate anchor attached to wire rope pendants. During installation, the PEA fluke is fitted to a reaction vessel that houses a cannon barrel. When the reaction vessel touches the seafloor, the explosive charge in the barrel explodes, embedding the fluke into the bottom. PEAs usually have a wire rope to chain connector. Due to environmental concerns, life cycle of the wire pendant and training of operators, PEA anchors are no longer installed by the Navy. All existing Navy moorings utilizing PEA anchors have been either disestablished or replaced with mooring systems that utilize another type of anchoring system.

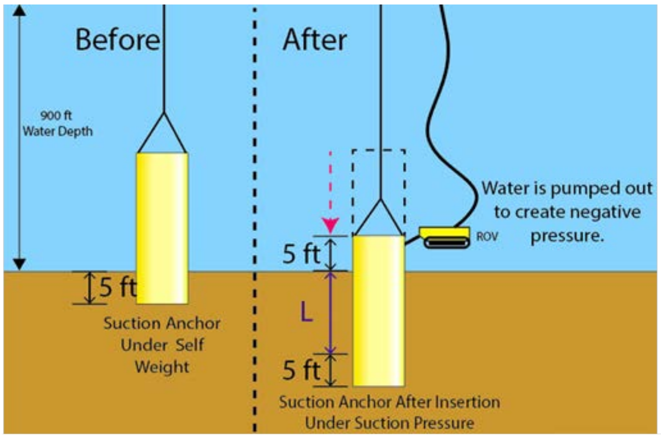
2-2.2.1.4 Suction Anchor.

A suction anchor can effectively be described as an upturned bucket that is embedded in the marine sediment. This embedment is achieved by creating a negative pressure inside the anchor skirt; securing the anchor into the seabed. The foundation can also be rapidly removed by reversing the installation process, applying an overpressure inside the anchor skirt.

The concept of suction technology was developed by the oil and gas industry for projects where gravity loading is not sufficient for pressing foundation skirts into the ground. The technology was also developed for anchors subject to large tension forces due to waves and stormy weather. The suction anchor technology functions very well in a seabed with soft clays or other low strength sediments. The suction anchors are in many cases easier to install than piles, which must be driven (hammered) into the seabed. Mooring lines are usually attached to the side of the suction anchor at the optimal load attachment point, which must be calculated for each anchor. Once installed, the anchor acts much like a short rigid pile and is capable of resisting both lateral and axial loads.

Suction anchors have not been used in Navy moorings but their existence should be recognized and they may be used in the future. See Figure 2-17.

Figure 2-17 Suction Anchor



2-2.2.2 Drag-Embedment Anchors.

There are many types of drag embedment anchors in existence. Navy Stockless and NAVMOOR anchors are the most common used in Navy moorings and are currently stockpiled by the Fleet Mooring Program. This document will limit its description to those two types of anchors.

2-2.2.2.1 Navy Stockless Anchor.

This type anchor is a drag-embedment anchor, ranging in size from 5,000 to 40,000 pounds (22 to 178 kN). Navy stockless anchors are used extensively in Navy applications, primarily because of the availability of the anchors. The Navy stockless anchor is prone to overturning, or rolling over to an upside-down orientation, during proof testing. The possibility of this type failure can be minimized by welding stabilizers to the anchor. Flukes are generally fixed at a specified angle based on the expected soil conditions at the site. Figure 2-18 shows a Navy stockless anchor with stabilizers and flukes fixed. Characteristics of the most common Navy stockless anchors used in fleet mooring are provided in Table 2-2.

Figure 2-18 Navy Stockless Anchor with Stabilizers

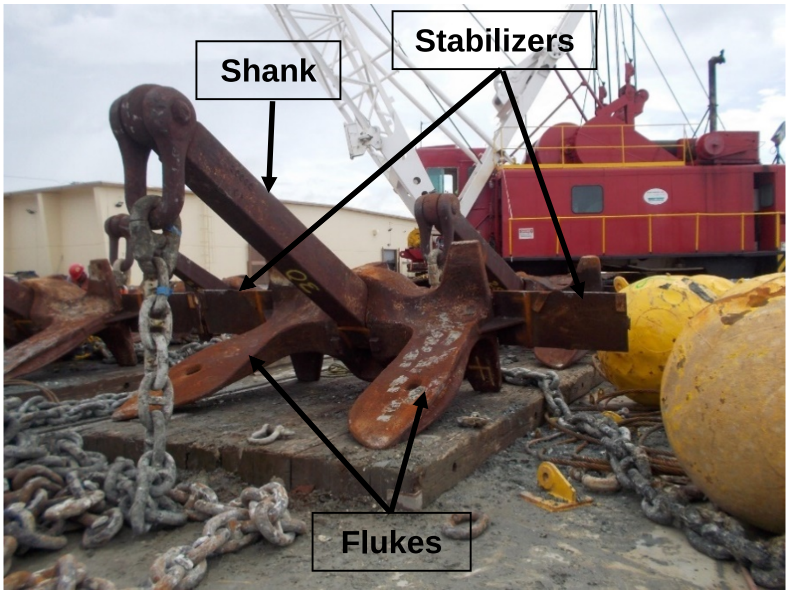


Table 2-2 Navy Stockless Anchor Characteristics

Anchor Nominal Size	20-kip	25-kip	30-kip
Anchor Wt. in Air, lbs (kg)	20,000 (9,072)	25,000 (11,340)	30,000 (13,608)
Length, inches (mm)	127.25 (3,232)	137 (3,479)	145.63 (3,699)
Stabilizer Extension, inches (mm)	45 (1,143)	48 (1,219)	50 (1,270)
Fluke Length, feet (mm)	7.65 (2,331)	8.24 (2,511)	8.94 (2,724)
Fluke Area, ft^2 (m^2)	35.1 (3.26)	40.7 (3.78)	46.9 (4.35)

2-2.2.2.2 NAVMOOR Anchor.

The NAVMOOR anchor is a high capacity drag-embedment anchor designed specifically for mooring use. The anchor's flukes are streamlined hollow shells which enable good penetration in hard soils. The large tripping palms are permanently affixed to the anchor to ensure reliable tripping in soft soils. Some designs are equipped with a 32-degree stopping wedge attached to one side to provide maximum holding power in sand or hard clay. Removing the wedge and welding the flukes open to 50 degrees provides maximum holding power in soft mud. NAVMOOR anchors can come in a number of sizes, but the most common sizes found in Navy moorings are 12,000 pounds (NAVMOOR10) and 18,000 pounds (NAVMOOR15). Figure 2-19 shows a NAVMOOR10 anchor. Characteristics of NAVMOOR anchors in use are provided in Table 2-3.

Figure 2-19 NAVMOOR10 Anchor

Table 2-3 NAVMOOR Anchor Characteristics

Anchor Size	NAVMOOR10	NAVMOOR15
In Air Weight, lbs (kg)	12,400 (5625)	19,200 (8709)
Overall Length, inches (m)	192 (4.9)	219 (2.6)
Stabilizer Width, inches (m)	192 (4.9)	219 (2.6)
Fluke Length, feet (m)	8.54 (2.60)	9.73 (2.97)
Fluke Area, ft^2 (m^2)	38.54 (3.58)	50.07 (4.65)
Proof Load, 1000 lbs (kN)	165 (734)	213.7 (950.6)
Tandem Link Padeye Diameter, inches (mm)	3.5 (88.9)	4 (101.6)
Shank Shackle Size, inches (mm)	3 (76.2)	3.5 (88.9)

2-2.2.3 Deadweight Anchors.

Any heavy object that can be placed on the seafloor can be used as a deadweight anchor if it can be shown that the anchor selected is capable of satisfying design requirements. Deadweight anchors can rest on the seafloor, be partially or completely buried, or dig into the bottom under load. The most common type of deadweight anchor encountered in fleet moorings is the Pearl Harbor anchor which is designed to dig into the soil to a limited extent as the anchor is dragged. The ultimate holding power of the deadweight anchor is the minimum force required to overturn, lift, or drag the large weight over the bottom. Resistance to uplift, or vertical force, is simply the submerged weight of the anchor plus the suction and friction effects of the bottom soil. Figure 2-20 shows a Pearl Harbor style deadweight anchor.

Figure 2-20 Pearl Harbor Style Deadweight Anchor

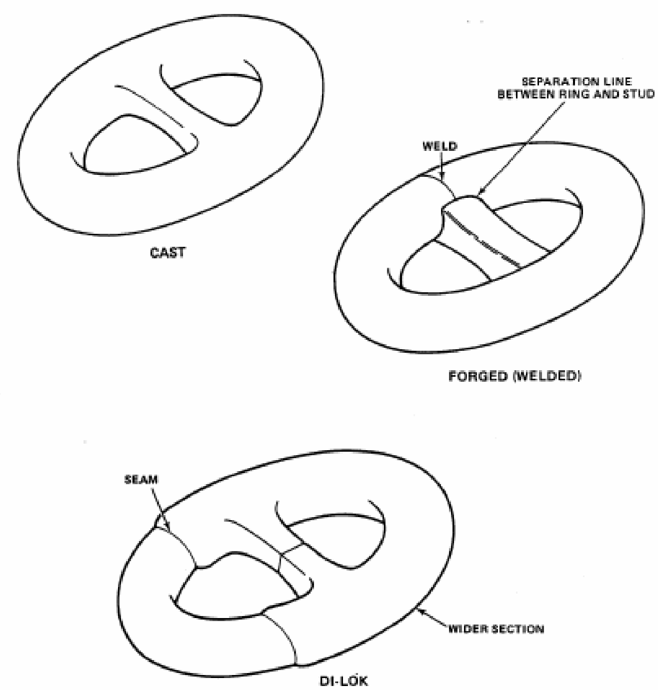
2-2.3 Chain.

2-2.3.1 Chain Grades and Types.

Chain grade is determined by the properties of the steel used to form the chain links. Chain manufactured to NAVFAC specifications for mooring purposes is similar in chemical content to that manufactured to commercial standards meeting the classification of American Bureau of Ships (ABS) Grade 3 (ABS3). Chain and chain accessories procured by the Navy for use in Fleet Moorings are classified as Fleet Mooring Grade 3 or FM3. FM3 chain and chain accessories have tighter mechanical property parameters imposed than those imposed on corresponding Grade 3 chain manufactured to commercial standards. Other commercially available chain grades use different steel alloys to have either higher or lower tensile strengths.

Chain type is identified by the manufacturing process used to form the links. The different chains that may be encountered in existing moorings include forged stud link, cast, and Dilok chain (Figure 2-21). The majority of installed Navy moorings utilize FM3 stud-link chain. Dilok and cast chains are no longer manufactured. However, since some of these types of chain may still remain in the system (in older moorings installed prior to 1990), they are described here for recognition purposes.

Figure 2-21 Types of Chain



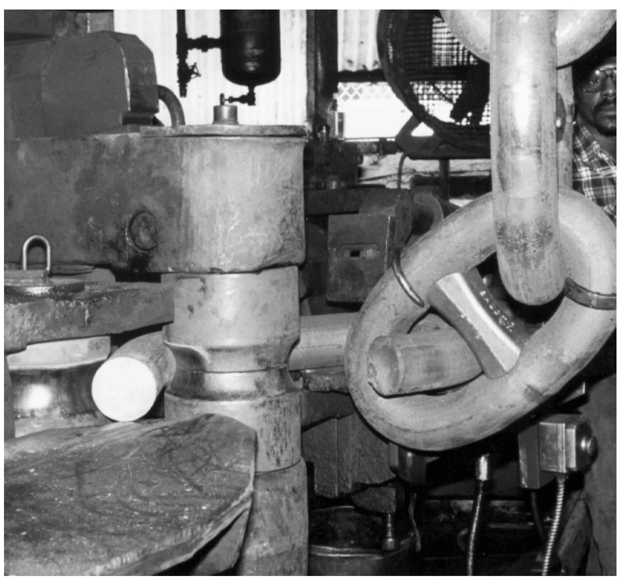
2-2.3.1.1 Stud-Link Chain.

Each link of stud-link chain is formed by bending a length of heated bar stock into the shape of a link and flash welding the ends together. A center crossbar, or stud, is inserted into the link while it is still hot and pressure is applied to both sides of the link to secure the stud in place. Stud-link chain is also referred to as flash-butt-welded chain. The stud in each link of FM3 chain is welded to the link on the end opposite the flash-butt weld. The welding of the stud is unique to FM3 chain as it is not required on ABS chains. The primary purpose of the weld is to provide a metallic path to the chain link for the sacrificial anode that is attached to the stud on FM3 stud-link chain. In addition to unique identification stamping requirements, the presence of this weld, along with a threaded hole attachment point on the stud for the zinc anode, is the primary method of identification of FM3 chain as opposed to commercial stud-link chain. Chain-stud zinc anodes are discussed in Section 2-2.6.2.2. Figure 2-22 shows the forming of a link of stud-link chain and Table 2-4 shows the characteristics of FM3 chain.

Table 2-4 FM3 Chain Characteristics

NOMINAL SIZE (inches)	1.75	2	2.25	2.5	2.75	3.5	4
NUMBER OF LINKS PER SHOT	153	133	119	107	97	77	67
LINK LENGTH *(avg.)*, inches (mm)	10.63 (270)	12.15 (309)	13.67 (347)	15.20 (386)	16.70 (424)	21.26 (540)	24.30 (617)
WEIGHT PER SHOT IN AIR *(min.)*, (lbs (kg)	2,525 (1,145)	3,276 (1,486)	4,143 (1,879)	5,138 (2,331)	6,250 (2,835)	10,258 (4,653)	13,358 (6,059)
BREAKING STRENGTH, 1,000 lbs (kN)	352 (1,556)	454 (2,019)	570 (2,535)	692 (3,078)	826 (3,674)	1,285 (5,716)	1,632 (7,259)
WORKING STRENGTH *(33% of break)*, 1,000 lbs (kN)	117.2 (521)	151.2 (672)	189.8 (844)	230.4 (1025)	275.1 (1224)	427.9 (1903)	543.5 (2418)

Figure 2-22 Formation of Stud-Link Chain



2-2.3.1.2 Cast Chain.

Cast chain, as the name suggests, is formed by a die-casting method. This type chain is easily recognizable as the stud is integral to the link and there is no link butt joint.

2-2.3.1.3 Dilok Chain.

Each link of Dilok chain is formed from two U-shaped sections, male and female. The male section has a forged, serrated, stem end while the female section has hollowed ends. The male ends are inserted into the heated female ends and drop forged. This results in the heated interior of the female section forming to the serrated stem on the male end and creating a lock. Use of Dilok chains are not recommended for mooring use due to the inability to inspect corrosion that may be present inside the “locked” ends.

2-2.3.2 Chain Markings.

The stud of the last link of each shot of FM3 chain bears a symbol or marking that shows the contract year and serial number of the shot. Additionally, the stud of each link bears permanent markings that denote chain size, manufacturer and “FM3”. The markings on the last link of each shot are stamped; the markings on the stud of each link are raised figures. Note that for ABS anchor chain, markings are on the end link body.

2-2.4 Chain Accessories.

2-2.4.1 Joining Links.

There are two main types of joining links, Chain Joining Links (CJL) and Anchor Joining Links (AJL) found in U.S. Navy mooring systems.

There are two different designs for joining links based on the manufacturer and how they are put together: the Baldt type and the Kenter type. The Baldt type can be distinguished by the two T-shaped plates that enclose the pin and make up the stud. The Kenter style has two C- shaped halves with a removable stud. The two C-shaped halves of a Kenter style link are similar.

CJLs are normally used to connect two shots of chain or chain to another chain component with a similar wire diameter and look similar to a normal chain link. Figure 2-23 and Figure 2-24 show the different types of CJLs.

It is important to not interchange parts between connecting links, especially the Kenter style or they may not properly be reassembled.

Figure 2-23 Baldt Style Chain Joining Link

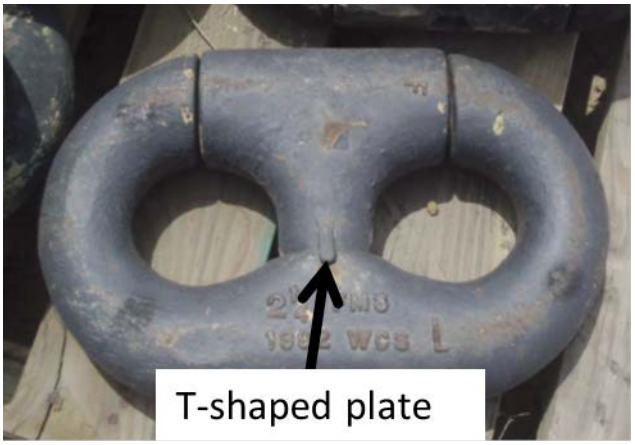
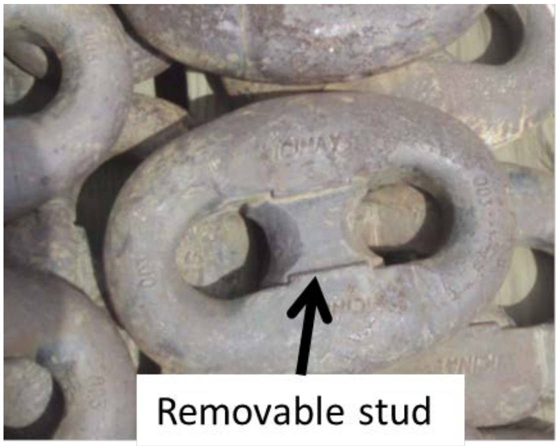


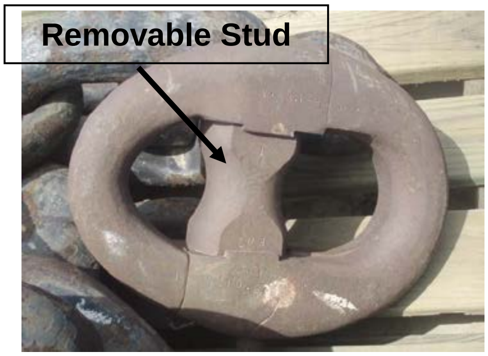
Figure 2-24 Kenter Style Chain Joining Link



AJLs are used to connect chain to chain components with a larger diameter (ground rings, spider plates, shackles on anchors, etc.). It is larger on one end to accommodate the larger diameter wire of those components. Figure 2-25 and Figure 2-26 show the different types of AJLs.

Figure 2-25 Baldt Style Anchor Joining Link

Figure 2-26 Kenter Style Anchor Joining Link



When a connecting link is reassembled, the pieces are secured with a pin which is held in place by a lead plug. Lead plugs are either pounded into place using a heavy hammer or the lead is melted into the hole from a long lead bar. All joining links should have a visible lead plug (some cleaning may be required for joining links that are below the waterline to locate the lead plug) in the large pin hole (see Figure 2-27). Figure 2-28 shows a missing lead plug.

Figure 2-27 Lead Plug in CJL

Figure 2-28 Missing Lead Plug

Disassembled joining links should not be mixed with parts from other disassembled links as the tracking of serial number data on the installed link would be interrupted and the mixing of parts may result in the joining link not be able to be reassembled due to fit interferences among the mixed parts.

Safety Note

All personnel at or near a mooring component being secured by lead shall wear PPE commensurate with EM 385-1-1 (such as safety glasses, foot protection, floatation vest) and other required PPE for mooring operations.

2-2.4.2 Ground Ring.

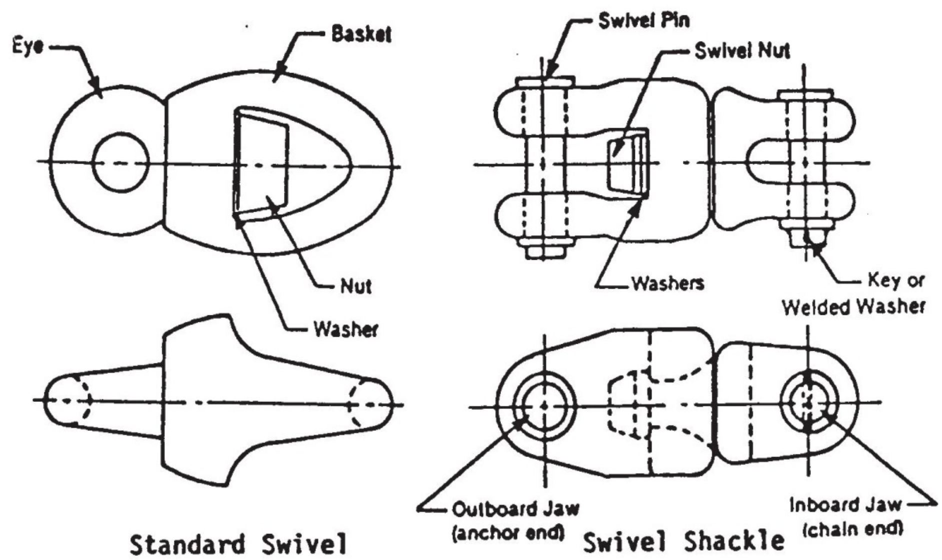
The ground ring is a steel ring used in a riser type mooring to connect multiple chain leg assemblies to the riser chain. Ground rings are classified by the size chain they support, and not the bar diameter of the ground ring. Figure 2-29 shows a ground ring.

Figure 2-29 Ground Ring

2-2.4.3 Swivel Fittings.

Swivel fittings are used in mooring systems to prevent twisting of the chain legs during installation and to prevent twisting of the riser chain during use. See Figure 2-30 shows the different types of swivels.

Figure 2-30 Swivel Fittings



2-2.4.3.2 Riser Swivel Shackle.

A riser chain subassembly should contain a riser swivel (Figure 2-31) that is attached to the lower tension bar padeye of a buoy before the riser chain starts. The purpose of the swivel is to permit a ship to swing 360 degrees around a buoy without twisting the riser chain. Swivel shackles are capable of rotating 360 degrees when supporting a full shot of chain of its rated size. The jaws on the riser swivel shackle are different sizes on each end, one end is designed to fit over a link of chain and the other end to fit over the padeye on the buoy. Pins on the riser swivel shackle are secured by tapered stainless pins which are then prevented from coming out with lead plugs (Figure 2-32) similar to joining links.

Figure 2-31 Riser Swivel Shackle

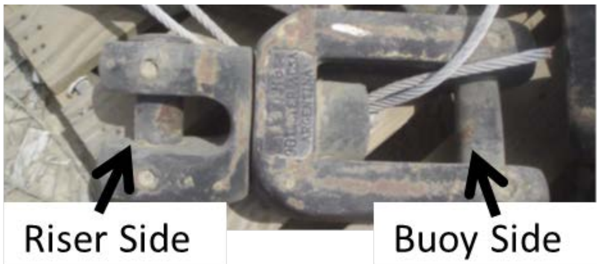
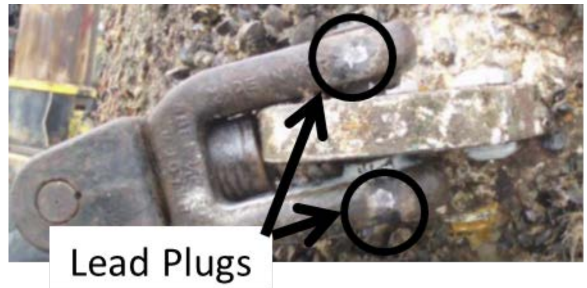


Figure 2-32 Lead Plugs Securing the Riser Swivel Shackle



2-2.4.3.3 Chain Swivel Shackle.

The chain swivel shackle is a swivel fitting with jaws of equal size on both ends (as opposed to the Riser Swivel Shackle that has different size jaws). The jaw openings are sized to fit over a link of a specified size of chain. A chain swivel shackle is secured in the same manner that the riser swivel shackle is.

2-2.4.3.4 Standard Swivel.

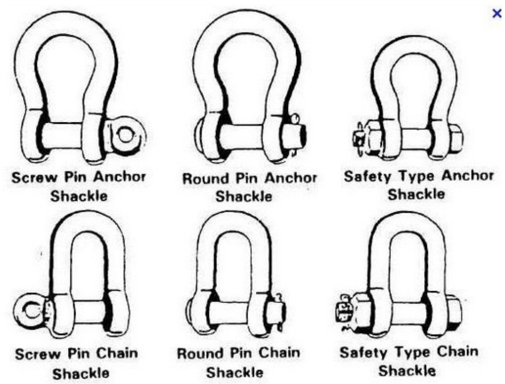
The standard swivel (Figure 2-33) has a fitting on each end to accommodate a standard link of chain. This fitting may be used on either a ground leg or the riser leg of a mooring system and are attached to the chain using a CJL.

Figure 2-33 Standard Swivel

2-2.4.4 Shackles.

Shackles come in three general types, depending on how the bolt is fastened to the body: Round Pin which uses a cotter pin to ensure that the pin doesn't slip out; Screw Pin, in which the pin screws directly into the body of the shackle; and Bolt Pin (sometimes called a Safety Type Shackle), which uses a bolt and nut/cotter pin combination. Figure 2-34 shows the various shackles. The primary shackle type used on mooring systems is the bolt pin.

Figure 2-34 Shackles



2-2.4.4.1 Anchor Shackle.

Anchor shackles (Figure 2-35) have also been referred to as bow shackles. With a large "O" shape to the bale, this shackle can take loads from many directions without developing as much side load. However, the larger, wider bale does reduce its overall strength when compared to a chain shackle. Anchor shackles are usually found on the top jewelry of a mooring tension bar foam buoy. Anchor shackles may also be found connecting the riser chain to the lower tension bar padeye on steel buoys or foam buoys as well. They may also be found as connecting hardware between ground leg assemblies and the riser assembly.

Anchor shackles used on the surface are equipped with a cotter pin or a safety bolt and nylok nut. Anchor bolt shackles used below the waterline, in addition to the cotter pin or safety bolt, will have a fillet weld between the outer perimeter of the nut and the shackle bolt (Figure 2-36).

Figure 2-35 Anchor Shackle

Figure 2-36 Anchor Shackle for Underwater Use

2-2.4.4.2 Chain Shackle.

Chain shackles, sometimes referred to as a D-Shackle, are narrow shackles whose bale has a similar shape as one end of a link of chain, with a threaded pin (bolt) and nut closure and the nut is secured with a cotter pin or safety bolt with a nylok nut although some are secured with a non-threaded pin held in place with a driven pin similar to a joining link. The shackle bale can take high loads primarily in line only as side and racking loads may twist or bend a chain shackle (Figure 2-37). Consequently, chain shackles are not generally used in mooring systems.

Figure 2-37 Chain Shackle

2-2.4.4.3 Sinker Shackle.

Sinker shackles (Figure 2-38) are similar to a chain shackle but have a longer and narrower bale. With their long and narrow bale, sinker shackles are used to attach a sinker to a ground leg or a suspended riser chain assembly by slipping over a chain link.

Figure 2-38 Sinker Shackle

2-2.4.4.4 Plate Shackle.

Plate shackles (Figure 2-39) consist of 2 plates in the shape of a “dog bone”, 2 bolts with nuts and are primarily used to attach a sinker to a ground leg assembly. After the plate shackle is attached to the sinker and ground leg, the nuts are also secured to the bolts with a fillet weld to the outside of the bolt. Plate shackles are not normally used on moorings to carry the mooring loads, due to their lack of strength and their susceptibility to bending.

<u>Safety Note</u>

Follow safe welding procedures per EM 385-1-1 and wear required PPE for welding operations.

Figure 2-39 Plate Shackle Attaching Sinker to Chain

2-2.4.5 Sinkers.

Sinkers, or clump weights, are attached to the chain legs in the water column to provide damping to a mooring system to reduce dynamic peak tensions. Sinkers are generally concrete clumps or modified stockless anchors that have their flukes welded close and an additional padeye welded at the anchor crown (Figure 2-40). Sinkers generally range in weight from 3,000 to over 25,000 pounds (13.3 to 111.2 kN) in air.

Figure 2-40 Navy Stockless Anchor Rigged as a Sinker

2-2.4.6 Pear Link.

A pear link (Figure 2-41) is an open link, wider at one end then at the other. It may also be called a pear-shaped link or pear-shaped ring. It is often used as top jewelry on a buoy, serving as the attachment point for the lines from the moored vessel.

Figure 2-41 Pear Link

2-2.4.7 Spider Plate.

The spider plate (Figure 2-42) is a steel plate or casting, triangular in shape, with a hole at each point of the triangle. It is most commonly used to connect the two chains of a paired-leg assembly to a single attachment to provide additional holding capacity. NAVFAC stocks a 4-inch (102 mm) and a 2.25-inch (57 mm) spider plate.

Figure 2-42 Spider Plate

2-2.4.8 Yoke Assembly.

The yoke assembly (See Figure 2-43) is specially configured to connect the two chains of a paired anchor installation to a single ground leg. The assembly generally consists of two modified (two cross plates are welded between end plates to form 1 assembly) plate shackles, a spider plate and a chain swivel shackle or it may consist of three modified plate shackles and a spider plate, eliminating the swivel shackle. They may be found on old mooring systems with tandem anchors installed in the 1980's.

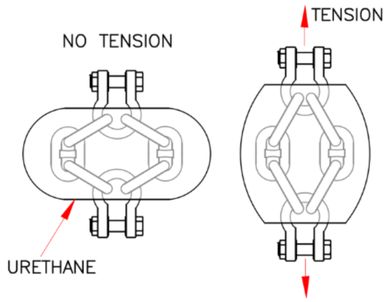
Figure 2-43 Yoke Assembly

2-2.4.9 Kinetic Links.

A Kinetic Link is a short open loop segment of chain links that is encased in polyurethane. A shackle is provided at both ends for attachment of the kinetic link within a mooring riser or ground leg. Like sinkers, they are used to provide a shock absorber to minimize dynamic loads. Figure 2-44 is a picture of kinetic links. Figure 2-45 is a drawing of the kinetic link details. There are some very specialized moorings that have single or multiple kinetic links within the mooring riser or ground leg assemblies. As attached sinkers provide similar damping of dynamic loads and are less expensive to construct, kinetic links are not generally used.

Figure 2-44 Kinetic Links

Figure 2-45 Kinetic Link Details



2-2.4.10 Chain Equalizer.

Chain equalizers are specialty hardware that can be used to moor large vessels to pier or wharf fittings or 2 ground legs to a single riser on a buoy (See Figure 2-46). Chain equalizers distribute the tension equally to both parts of chain as the vessel or buoy responds to environmental forces. Although equalizers contain no movable parts, they do resemble large pulleys. The chain is free to slide back and forth through the equalizer so that each end of the chain is under equal tension. Figure 2-47 shows a chain equalizer.

Figure 2-46 Chain Equalizer on a Mooring

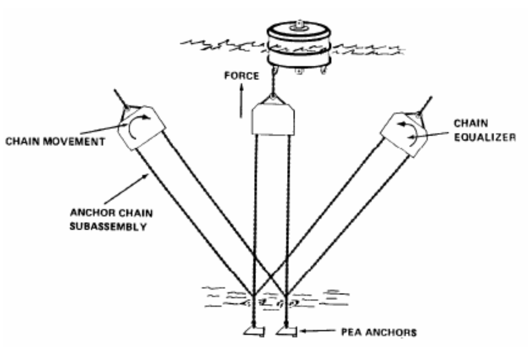


Figure 2-47 Chain Equalizer

2-2.5 Miscellaneous Special Links.

There are a variety of special links used in industry to connect chain and chain accessories that sometimes make their way into mooring systems. The PEAR LINK, described in Paragraph 2-2.4.6 is the only special link used in U.S. Navy mooring systems today. Other special links that may be encountered in older, existing fleet moorings are the ENLARGED LINK or B-LINK, the END LINK or E-LINK, and the C-LINK. The B-link is an adaptor used between the last common link of a chain and the E-link. The E-link is a studless link used as the last link in a shot of chain. The C-link is similar to the E-link but has an off-center stud. The use of these special links, other than the Pear link, should be avoided in mooring installations whenever possible.

Drawings for FM3 mooring components are provided in APPENDIX G.

2-2.6 Cathodic Protection System.

The galvanic action of seawater, acting electrolytically on the submerged portions of a mooring system, greatly increases the rate of corrosion on these components. This galvanic action can be inhibited by impressing a negative electrical potential on the exposed steel surfaces thus prolonging the useful life of the mooring system. The required electrical potential is provided by attaching sacrificial anodes to all steel surfaces with the water column.

2-2.6.1 Cathodic Protection for Buoys.

The submerged portion of a steel buoy must be cathodically protected. Buoy anodes, manufactured from a zinc composition in accordance with MIL-A-18001, are attached to the buoys in such a manner that the anodes are protected from impact or collision. They may be on the bottom of the buoy, in seachests built into the buoy, or attached to the sides of the buoy, depending on the type of buoy. The lower padeye of foam tension bar buoys is also protected by anodes (see Paragraph 2-2.6.2.2)

2-2.6.2 Cathodic Protection for Chain.

All chain in a mooring system that is between the mudline and the buoy must be cathodically protected. Protection is achieved by attaching anodes in such a manner that each link is protected. Several methods and several types of anodes have been used for this purpose. The preferred method is the chain-stud anode; however, since other methods may still be encountered on existing mooring systems, each method will be discussed below.

2-2.6.2.1 Clump Anodes.

A clump anode is simply a cast zinc shape attached to the chain assembly using a sinker shackle or other methods of attachment. Sometimes, approximately 500 pounds (2.2 kN) of zinc is cast over an elongated chain link and this is called a link anode. A wire rope, called a continuity cable, is attached to the clump anode and passed through every 4th link of the chain to provide continuity throughout the chain leg. Hose clamps are then used to secure the continuity wire to every 8th link.

Generally, one clump anode is used for every shot (90 feet (27.4 m)) of chain in the ground leg or riser. These methods are less effective than the stud link anode method discussed in section 2-2.6.2.2 for several reasons: (1) The continuity between links may be lost when the chain is not in tension and; (2) The contact area between the chain link and the continuity wire must be cleaned to bare metal to ensure conductivity and (3) No assurance is given that the connecting wire rope will remain in constant contact throughout the chain leg especially at locations where the chain leg is moving due to loading or tidal effects. Figure 2-48 shows clump anodes in storage.

Figure 2-48 Link and Clump Anodes

2-2.6.2.2 Chain-Stud Anodes.

This method of protecting chain consists of an anode attached to the stud of each link of FM3 mooring chain. Attaching an anode to each link ensures maximum protection as each link is in contact with an anode whether or not the system is in tension. Additionally, the anodes are easily replaced by divers and do not require removal of the mooring system for this routine maintenance task. Replacement of chain-stud anodes generally occurs during the fleet mooring underwater inspection. All FM3 chain links are manufactured with a tapped 0.375-16UNC-2B hole in each stud to accept an anode. Currently, chain-stud anodes are made from a zinc alloy.

Figure 2-49 provides details of the chain stud link anode assembly and Figure 2-50 shows the assembly on the stud of a chain link. Table 2-5 provides the characteristics of the chain-stud anodes. Though there is a specified chain-stud anode for each nominal size of FM3 chain, current maintenance practices are to replace chain-stud anodes with ones manufactured for a larger size of chain and to stockpile only a few sizes of zinc anodes. Two to four chain-stud anodes are also attached to the lower padeye on fleet mooring foam tension bar buoys (Figure 2-51).

Figure 2-49 Chain Stud Anode Assembly

Figure 2-50 Chain Stud Anode Installed

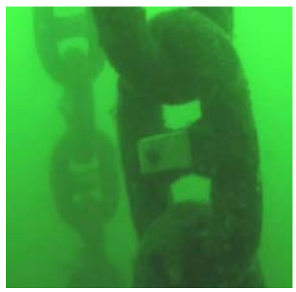


Figure 2-51 Chain Stud Anode on Buoy Tension Bar

Table 2-5 Chain Stud Anode Characteristics

NOMINAL SIZE (inches)	1.75	2	2.25	2.5	2.75	3.5	4
ANODE WEIGHT lbs (kg)	0.80 (0.36)	1.10 (0.5)	1.38 (0.63)	1.70 (0.77)	2.04 (0.93)	3.58 (1.62)	4.41 (2.0)
SCREW LENGTH inches (mm)	1.25 (31.8)	1.5 (38.1)	1.75 (44.5)	1.75 (44.5)	2.00 (50.8)	2.25 (57.2)	2.25 (57.2)
ANODE WIDTH inches (mm)	1.50 (38.1)	1.62 (41.2)	1.75 (44.5)	1.94 (49.3)	2.06 (52.3)	2.38 (60.5)	2.69 (68.3)
ANODE LENGTH inches (mm)	3.25 (82.6)	3.5 (88.9)	3.5 (88.9)	3.5 (88.9)	4.0 (101.6)	5.5 (139.7)	6.0 (152.4)
ANODE HEIGHT inches (mm)	.73 (18.54)	.90 (22.86)	.94 (23.88)	.97 (24.64)	1.15 (29.21)	1.31 (33.27)	1.32 (33.53)
ANODE SURFACE AREA in^2 (mm^2)	14.6 (9,419)	18.2 (11,742)	21.9 (14,129)	24.6 (15,871)	26.4 (17,032)	40.6 (26,194)	50.7 (32,710)
ANODE VOLUME in^3 (mm^3)	3.10 (50,800)	4.28 (70,137)	5.42 (88,818)	6.64 (108,810)	8.01 (131,260)	14.06 (230,400)	17.32 (283,820)
LINK GAP inches (mm)	3.74 (93.98)	4.24 (107.7)	4.74 (120.4)	5.24 (133.1)	5.74 (145.8)	7.48 (189.99)	8.48 (215.39)
ANODES PER FULL DRUM (approx.)	1106	822	615	550	400	158	122
WEIGHT PER FULL DRUM (approx.) lbs (kg)	976 (443)	979 (444)	917 (416)	993 (450)	869 (394)	602 (273)	550 (249)
RECOMMENDED ANODE SIZE FOR CHAIN SIZE	2.75	2.75	2.75	2.75	4	4	4

Notes:

1. All screws are SAE .375-16UNC-2A, Grade 5, Hex Cap.
2. All screw heads are 9/16 inch.

2-2.7 Wire Rope.

In general, wire rope is not used by the Navy in mooring systems. The service loads for offshore mooring lines are extremely difficult to predict and, thus, difficult to maintain a safe working load. The permanent immersion of mooring lines in seawater poses problems with corrosion and corrosion-assisted fatigue and access to the rope for regular inspections. Wire ropes are used in commercial moorings, especially for semi-submersible platforms. Since this type of platform is typically used for exploratory drilling, the mooring lines are constantly being hauled in to permit the rig to be moved to another location. This permits a better inspection of the wire rope on a reasonable basis. New mooring designs are now using synthetic rope instead of wire rope.

Wire ropes may also be found in deep water moorings, such as tension leg platforms, where the weight of chain would be prohibitive.

Wire rope is a loosely applied term, referring to a multitude of different constructions. The general accepted terminology is:

- Wire – is a single wire filament.
- Strand – is a number of single wires wound helically around a central wire in a series of concentric layers
- Rope – a number of strands wound helically together around a core of other strands (or of synthetic or natural fiber materials). The core can be composed of fiber, another wire strand, or an independent wire rope (IWRC). See Figure 2-52 and Figure 2-53.
- Cable – a number of ropes wound helically together

Figure 2-52 Structure of Wire Rope

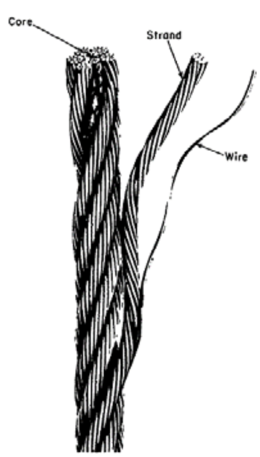
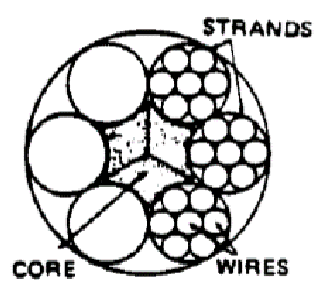


Figure 2-53 Wire Rope Structure

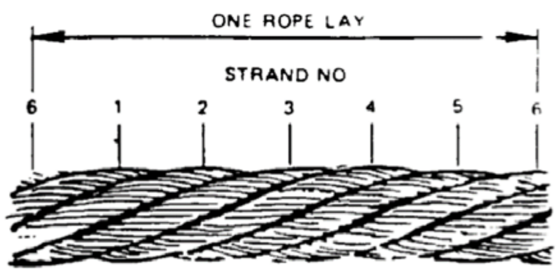


Most common construction of wire ropes are 6x19, 6x25 or 6x37, meaning there are six strands on the outside of the rope composed of 19, 25 or 37 wires respectively, with the six strands wrapped around either a fiber or a wire core. The more wires that are used to construct a strand, the more flexible the rope will be but the more susceptible the rope will be to physical damage or corrosion problems.

In addition to the rope diameter, other items to know in describing wire rope are:

- Lay length - distance parallel to the axis of the rope in which the outer strands make one complete turn (or helix) about the axis of the rope. See Figure 2-54.

Figure 2-54 Lay Measurement of Wire Rope



- Lay direction of strand – The direction of the lay of the outer layer of wires in relation to the longitudinal axis of the strand.
- Lay direction of rope – The direction of the lay of the outer strands in relation to the longitudinal axis of the rope
- Lay Type – Ordinary or regular lay has the lay direction of the strand in the opposite direction to the lay direction of the rope while Lang lay has the strand lay direction in the same direction as the rope lay. See Figure 2-55.
- Core Type – The core of the rope can be made from either natural fibers (fiber core usually hemp or sisal) or steel (IWRC – Independent Wire Rope Core). See Figure 2-56.

Figure 2-55 Wire Rope Lays

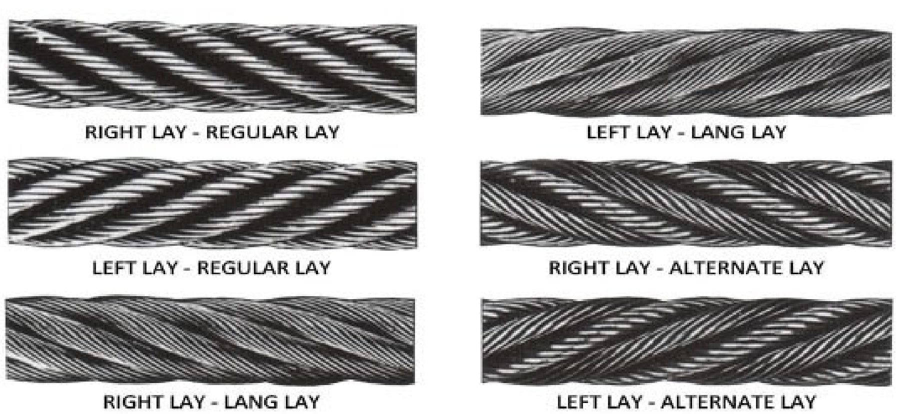


Figure 2-56 Wire Rope Cores

Safety Note

Wear appropriate gloves when handling wire rope.

2-2.8 Synthetic Line.

Natural fiber ropes (Manila, hemp, jute, sisal) have been in use since the beginnings of boating. For working lines, they have largely been replaced by synthetic lines. Synthetic lines come in two main types, low tenacity ropes composed of older synthetic fibers (polyester, polyethylene, polypropylene, nylon) or newer, high tenacity fibers such as: aramid (Kevlar); HMPE (High Modulus Polyethylene such as Spectra, Dyneema, Amsteel).

The use of synthetic lines for anything other than tying the vessel to the mooring is relatively uncommon. Commercially, the high tenacity synthetics might be used for extremely deep-water moorings, but for DoD uses, they are extremely uncommon.

Like wire ropes, synthetic lines are extremely difficult to inspect, if they cannot be removed from the mooring. In addition, damage to inner filaments may not be apparent.

Synthetic ropes are typically constructed in a 3-strand twisted rope, 8-strand or 12-strand braid, 8-strand plaited, double braid or a core-dependent braid. The difference between a double braided rope and a core-dependent braided rope is that with the double braid, the load is shared by both the inner rope and outer jacket while with a core-dependent braided rope, the outer jacket simply acts to provide abrasion protection and the load is take strictly by the inner rope.

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CHAPTER 3 MOORING INSPECTION

Safety Warning:

Ensure all personnel have, maintain, and wear PPE (steel toed shoes, personal floatation vest, hard hat and other PPE for specific tasks i.e. leather gloves, safety glasses, etc.).

Daily safety briefs should emphasize everyone's responsibility for applying risk management.

3-1 MOORING INSPECTION PLANNING.

This section describes the responsibilities and inspection planning tasks of each person involved in a mooring inspection as well as the equipment and material that will be needed to conduct a thorough inspection.

3-1.1 Mooring Program Manager.

The Program Manager is responsible for program management of the inspection portion of the mooring program. He will perform the following program tasks in support of planning for the mooring inspection:

- Reviews all available historical maintenance records and develops a list of those moorings which should be scheduled for underwater inspection during a particular fiscal year.
- Develops the planned mooring inspection schedule for the next three fiscal years.
- Submits mooring inspection requests to the Underwater Construction Teams (UCT).
- Designates a Mooring Inspection Engineer-in-Charge (Inspector) for each planned mooring underwater inspection during the current fiscal year.
- Maintains an archive of previous inspection reports, mooring configuration drawings, property records and mooring usage charts of current moorings.
- Maintains an adequate supply of chain-stud anodes at the mooring inventory to support changing out zinc anodes during inspections.
- Provides the inspector with a copy of the last underwater inspection report, mooring usage chart, and latest drawings of the moorings scheduled for inspection.
- Provides the inspector with catalog dimensional information for the mooring components to be inspected at the site.

- Allocates funding for the onsite inspection and post-inspection documentation.
- Ensures that the inspection report is provided to the custodian.
- Reviews and approves the inspection report to include its findings and recommended maintenance actions.
- Executes required maintenance actions on moorings in accordance with the inspection report.
- Funds local activity custodians to execute annual surface inspections or performs annual surface inspections using other in-house or contracted assets.
- Informs the local activity custodian of the planned fleet mooring inspections at their site.

3-1.2 Mooring Inspection Engineer-In-Charge (EIC or Inspector).

The Inspector is responsible for planning and monitoring the inspection. The Inspector is also responsible for collecting the inspection notes, the pictures, and the survey data. The inspector may execute portions of the mooring inspection such as the performing the surface inspection tasks and surveying the buoys. If the inspector is Navy dive certified, the inspector may become a part of a military dive inspection team. The Inspector, whether or not dive qualified, must interpret the results of the inspection before leaving the site to ensure that that the inspection is complete. Upon return, it is the Inspector’s responsibility to send out written preliminary inspection results within 14 calendar days and the completed inspection report within 60 calendar days, to include any supporting engineering documentation for inspection results.

The Inspector will establish a tentative schedule for the mooring inspection in conjunction with available dive support team. This schedule will be based on the maximum availability of station support, anticipated favorable weather conditions, vessel movement, and diver availability. The inspection may be required to meet deployment scheduling requirements of the supporting dive team. The dive team must be familiar with the project requirements in order to assist in inspection planning. Equipment requirements must be coordinated with the dive team. The Inspector shall perform the following program tasks in support of planning for the mooring inspection:

- The Inspector shall review the mooring drawings and previous inspection reports to determine the required amount of time that will be needed on site to perform the inspection, amount and size of chain-stud anodes required for the inspection, the size and quantity of go/no-go gauges and other inspection tools needed.
- The Inspector shall arrange for area clearances, camera clearances or passes, passport, and on-site transportation. If using a contractor dive team, he will coordinate the administrative requirements for the contractors with the local shore activity.

- The Inspector shall arrange for his (her) own travel requirements.
- The Inspector shall provide the mooring program manager a cost estimate for the inspection. This estimate will be reviewed by the program manager to verify adequate funding for the inspection is available.
- In conjunction with the inspection dive team, the Inspector shall plan the inspection procedures to be used on the inspection for surface and underwater inspection tasks, anode replacement and survey requirements.
- The Inspector or the dive team's designated representative shall coordinate any logistical requirements required at or by the shore activity to perform the inspection with the activity's mooring custodian.
- The Inspector shall contact the local activity's mooring custodian of the planned inspection schedule and brief the custodian on the goals of the inspection. Obtain, from the mooring custodian, any base operational requirements, Force Protection requirements, and vessel mooring requirements that may impact the inspection.
- The Inspector shall coordinate and arrange with the local activity's custodian, the assigned inspection dive team, and the mooring program manager for all required inspection tools to include survey equipment, go no-go gauges, calipers, etc.
- If the dive team has the responsibility to plan and execute the logistical requirements for the inspection, the Inspector should then coordinate with the dive detachment to ensure that all required tools and equipment are identified and arranged to be available for the inspection.
- If the inspection is being performed by a contractor dive team, the Inspector shall arrange for review and approval of the contractor's dive plan by a qualified District Diving Coordinator (DDC) at the location of the inspection or in accordance with command policy.
- The inspector shall arrange for base logistical support at the inspection location in accordance with established command policy.
- In conjunction with the project superintendent, the Inspector shall conduct an in-brief to the local activity's custodian going over the goals of the inspection, the inspection schedule, and communication and safety procedures to be followed during the inspection period.

3-1.2.1 Inspection Planning Information.

The Inspector should obtain the following information from the Mooring Program Manager (MPM) and the mooring custodian. This information should be thoroughly reviewed by the Inspector prior to departure for an inspection site:

- Class and type of moorings to be inspected.
- Latest "as-built" documentation, usage chart and property records of the moorings to be inspected.
- Copies of mooring configuration drawings.
- Last inspection report and installation report or latest mooring repair documentation report.
- Geographic positions of moorings, if not in previous installation or inspection reports.
- Type of cathodic protection system and its last reported condition.
- Environmental data; such as seasonal weather and potential for extreme weather, tides and currents during the inspection period at the site, water depth and type bottom at the moorings, and any potential diving hazards at the site (such as obstructions, ship movements, sonar operations, intakes, etc.).

3-1.2.2 Inspection Planning Equipment.

The Inspector should carry to, or make arrangements for, the following to be on the inspection site:

- Inspection data sheets and forms.
- Digital still camera and digital video camera.
- Tape measure (20-foot (6.1 m) minimum).
- Local nautical and tide charts.
- Calculator.
- Pre-inspection briefing data.
- Survey equipment when it is not available on site.
- Calipers. Tear drop (or outside) type calipers are recommended but dial and vernier type calipers will also work but it may be easier to maneuver the tear drop calipers into the tight places to take measurements. The calipers need to open large enough to fit over the pieces to be measured (such as 24-inch sized calipers). See Figure 3-1 and Figure 3-2.
- Go/No-Go gauges.
- Underwater voltmeters.
- Inclinometer (if necessary).
- Anodes with screws (if necessary).
- 9/16-inch hand wrench (to remove old anodes).
- Pneumatic wrench with 9/16-inch socket (for attaching anodes).
- Cleaning tools to remove growth and coating on selected chain links for inspection.

Figure 3-1 Diver Using Tear Drop Calipers

Figure 3-2 Tear Drop (Outside) Calipers

The dive team might be capable of providing some of this equipment. The Inspector should coordinate with the dive team supervisor or dive detachment OIC to ensure what equipment will be provided by the divers.

3-1.2.3 Anode Replacement Planning.

Most Fleet Moorings have been installed with FM3 chain which has a chain-stud anode attached to every link. Inspections generally include replacing these anodes. Subsequent to the initial installation, some fleet mooring's original anode size has been replaced with larger anodes on subsequent inspections. It is the Inspector's responsibility to determine the size and quantity of the anodes that will be installed.

Anodes are currently located at the Naval Construction Battalion Center (CBC) Gulfport, MS or CBC Port Hueneme, CA, the fleet mooring inventory sites, and can be shipped to either the project site or to the assigned dive team by submitting a DD1149 shipping document. A sample DD1149 is provided in APPENDIX C.

3-1.2.4 Survey Planning.

It is the Inspector's responsibility to ensure the surveying is conducted by qualified individuals and that the surveying is conducted correctly. It is the Inspector's responsibility to ensure the survey calculations are correct and that the results are transferred to the coordinate system required by the activity.

Initially, mooring surveying of the buoys utilized single or multiple transits, tripods, electronic distance measurement devices (EDM) and prism poles and surveying was done by surveying the buoys from single to multiple survey benchmarks using conventional surveying principles. These techniques are rarely used today.

Recent mooring surveying and inspections have been performed using commercial Global Positioning System (GPS) handheld receivers that are linked to either a nearby U.S. Coast Guard (USCG) beacon, FAA satellites (SBAS) or a commercial service such as OMNISTAR to receive corrections to provide sub-meter survey accuracy. GPS allows a more efficient method of obtaining the geographic location of the mooring. The GPS unit can be set up to provide the coordinates in the required coordinate system used by the shore activity. Programs such as CORPSCON or GeoGraphic Calculator are available for coordinate system conversions to other datum's such as World Geographic System 1984 (WGS84) latitudes and longitudes, Universal Transverse Mercator (UTM) Northings and Eastings (units in meters), or state plane coordinates, Northings and Eastings, in either North American Datum (NAD) 1927 (units in US Feet) or 1983 (units in meters). Figure 3-3 shows a hand-held GPS being used to survey the location of a buoy.

There are numerous commercial GPS devices available. Low cost units generally have limited coordinate systems to use as well as reduced levels of accuracy.

If practical, mooring buoys should be surveyed during periods of slack tide and with no attached vessels. For mooring systems secured by embedment anchors, a low-cost GPS is adequate. Mooring systems secured with drag embedment anchors should have the buoy and found anchors surveyed with a GPS having sub-meter accuracy.

Figure 3-3 Using a Handheld GPS to Survey a Mooring

3-1.2.5 Notes and Reports.

It is the Inspector's responsibility to collect the inspection notes, the survey data, the pictures, and the inspection results. It is recommended that the Inspector use waterproof paper and pens. The Inspector must make a preliminary assessment of the results before leaving the site in order to ensure the inspection is completed. Upon return from the site, the Inspector must write the inspection report within 60 days.

An inspection sheet template (APPENDIX D) and an inspection report template (APPENDIX E) that the inspector can utilize to help in planning for the inspection. Items, such as points of contact information, references, email addresses, mooring class, type and configuration, buoy sizes, riser and ground leg sizes, project site maps, etc., are information that is provided in the inspection report that are needed for the inspection planning process.

As section one and the majority of section two of the inspection report are standardized information, the Inspector can complete a good portion of the inspection report before arriving on site for the inspection.

3-1.3 Inspection Dive Team.

Dive teams can be provided through a variety of sources, as selected by the PM/EIC/Inspector and as dictated by the situation and based on the available schedules and funding. The dive team can be from the Navy UCTs, other DoD diving units, commercial divers, or AE divers. It is important that the Inspector understand the differences in using these different groups.

Much of the fleet mooring inspections are performed by a diving detachment from the UCTs. For inspections performed by the UCTs, a lot of the inspection planning will be executed by the detachment OIC and Project Superintendent as the inspection provides an opportunity to develop project planning and management skills. The EIC/Inspector should coordinate with the OIC or Project Superintendent ensuring all required logistical requirements are accounted for. The EIC/Inspector is still responsible for submitting the completed inspection report.

3-1.3.1 Dive Team Responsibilities.

The responsibilities of the assigned diving team or detachment include:

- Interface with the Inspector on all inspection planning matters to ensure that the Inspector is aware of the planned dates of the inspection, the type of diving that will be utilized, the estimated duration on site for the inspection, and any equipment requirements for the inspection that the dive team cannot provide.
- Coordinates with the Inspector to ensure that all logistical arrangements to perform the inspection are occurring; including diving equipment, inspection tools, shipping of anodes to the project site, and if necessary, arranging for local chamber support, dive platform support, forklift support, etc.
- Arranges for own travel orders, area clearances, camera clearances or passes, passports, and on-site transportation. If using a contractor dive team, the Inspector coordinates these administrative requirements for the contractors with the local shore activity.
- Based on the inspection requirements and site conditions, plans for either scuba or surface-supplied diving. A means of diver to surface communications should be incorporated into the selected diving procedures (Figure 3-4).

- Develops the inspection safety plan and diving emergency plans to include phone numbers and directions to the nearest hospital or urgent care center, nearest recompression chamber (Figure 3-5), etc.
- Plans dive operations in accordance with the US Navy Diving Manual, or if using non-DoD divers, diving regulations in accordance with EM 385-1-1.

Figure 3-4 Inspection Diver using SCUBA with Diver/Topside Communications Equipment

Figure 3-5 Portable Recompression Chamber at Dive Site

Figure 3-6 Surface Supplied Diver Entering Water

3-1.3.2 Dive Team Inspection Tools and Equipment.

In addition to inspection and anode replacement tools listed in paragraph 3-1.2.2 and 3-1.2.3, the dive team provides the following equipment and material required for the underwater inspection:

- Underwater digital camera or digital camera in a housing with a strobe and spare batteries.
- Underwater digital video camera system.
- Cleaning equipment (wire brushes, K-bars, chipping hammers, chisels, etc.).
- 100-foot (30.5 m) underwater tape measure.
- Marker tags (such as nylon zip ties) to relocate or mark links or accessories.
- Hand-held radios.
- Underwater compass.
- Underwater writing tablets and grease or underwater pencils.
- Binoculars.
- Surface marker buoys with lines to mark the location of anchors.
- All diving equipment and small boats as required.
- Tide tables and nautical charts of the project area.

The underwater writing tablets can be developed specifically for inspection of riser assemblies, ground leg assemblies, buoy assemblies or even specific mooring components (riser swivel shackles, joining links, etc.) that can aid the inspector. Example inspection sheets are provided in APPENDIX D.

3-1.4 Shore Activity Custodian.

The activity custodian, whose moorings are scheduled for inspection should provide support to EIC and the inspection team by forwarding, when requested, the following information:

- Copies of the latest local area harbor charts.
- Historical use and future plans for the existing moorings and future moorings.
- Clearances and passes for inspection team members and their cameras.
- Coordinates of known benchmarks and personnel cognizant of their location.
- Responses to requests for other pertinent inspection data.
- Information regarding protocol requirements to include force protection requirements.
- Information regarding ship movements or mooring usage that may impact the planned inspection schedule.

It is the responsibility of the Inspector to request the cooperation and support of the activity in matters related to the inspection.

3-1.5 Go/No-Go Gauges.

A list of inspection tools and equipment are presented in sections 3-1.2.2 and 3-1.3.2 One of the primary inspection tool used for underwater mooring inspections are Go/No-Go gauges. These gauges come in single link and double link sizes for nominal chain sizes ranging from 1.75 to 4 inches (44 to 102 mm). One side of the gauge has a jaw opening that is equal to 90% of the original wire diameter (OWD) while the other jaw on the gauge has an opening equal to 80% of the original wire diameter. For double link gauges, one jaw is equal to 2 x 0.9 x OWD of the nominal chain size with the other side equal to 2 x 0.8 x OWD of the nominal chain size.

Go/No-Go gauges should be made from stainless steel with a thickness of 1/4 inch (6 mm) minimum. Gauges can be made from aluminum but must be thick enough to avoid being bent during inspection operations. A hole on the gauge should be provided to attach a lanyard.

It is recommended that a white strip of electrical tape be wrapped around the middle of the jaws representing 90% of the OWD for easy identification by the divers.

A fabrication drawing for Go/No-Go gauges for common chain sizes is provided in APPENDIX H. Jaw gap dimensions for fleet mooring chain sizes are provided in Table 3-1. Figure 3-7 shows a double link Go/No-Go gauge for 2.5-inch (64 mm) nom FM3 chain.

Figure 3-7 Double Link Go/No-Go Gauge for 2.5" FM3 Chain

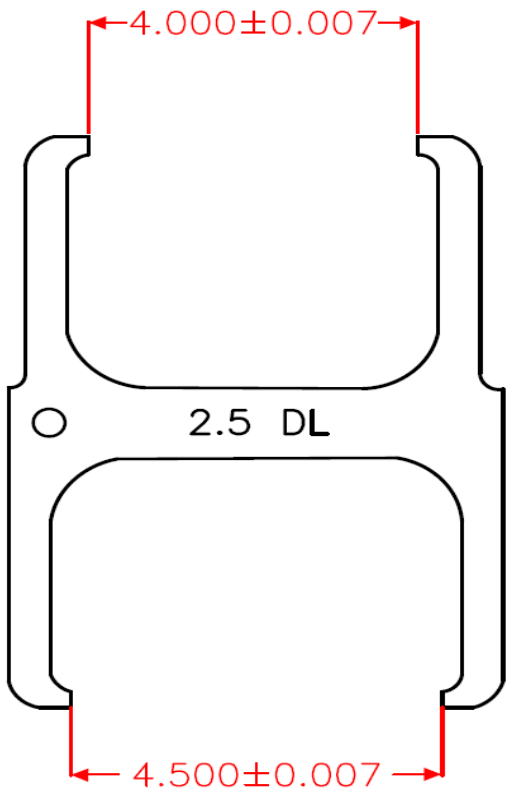


Table 3-1 Go/No-Go Gauges

Diameter	Single Link		Double Link	
	.90D	.80D	.90D	.80D
inches	inches	inches	inches	inches
4.0	3.60	3.20	7.20	6.40
3.5	3.15	2.80	6.30	5.60
3.0	2.70	2.40	5.40	4.80
2.75	2.475	2.20	4.95	4.40
2.5	2.25	2.00	4.50	4.00
2.25	2.025	1.80	4.05	3.60
2.0	1.80	1.60	3.60	3.20
1.75	1.575	1.40	3.15	2.80

3-2 MOORING INSPECTION.

3-2.1 Inspection Responsibilities.

3-2.1.1 Inspector Responsibilities.

The primary responsibility of the Inspector is Quality Assurance. The Inspector will ensure that all of the data collected is accurate and complete enough to make an informed evaluation of the condition of the mooring.

The assigned Inspector should arrive on site a minimum of one working day before the start of the inspection. This provides the opportunity to meet with appropriate station personnel in order to:

- Brief station personnel on the plans, techniques, and purpose of the inspection.
- Obtain any information concerning the moorings that was previously unavailable.
- Confirm mooring usage or ship movements during the inspection period in order to establish the order in which the moorings will be inspected.
- Obtain the latest weather forecast for the local area.
- Obtain other information from the shore activity custodian that may affect the inspection.

Prior to beginning diving operations, the Inspector shall brief the Dive Superintendent on the latest information obtained from station personnel and ensure that the Dive Superintendent is aware of any changes to the inspection procedures. As the lead of this inspection, the Inspector is authorized to modify inspection procedures on site as necessary, as long as modifications are acceptable to the Dive Superintendent in maintaining diver safety. In addition, the Inspector must:

- Interface with the Dive Superintendent in all matters related to the inspection.
- Report the status of the inspection and advise the program manager and the activity custodian of any schedule or procedural changes.
- Arrange with the Dive Superintendent to conduct the post dive briefing at the completion of each dive.
- Evaluate the inspection data as it is gathered and determine if additional data is required.
- Brief activity personnel on mooring conditions following completion of the inspection.

Prior to beginning diving operations, the Inspector shall brief the Dive Superintendent on the latest information obtained from station personnel and ensure that the Dive Superintendent is aware of any changes to the inspection procedures. As the lead of this inspection, the Inspector is authorized to modify inspection procedures on site as

necessary, as long as modifications are acceptable to the Dive Superintendent in maintaining diver safety. In addition, the Inspector must:

- Interface with the Dive Superintendent in all matters related to the inspection.
- Report the status of the inspection and advise the program manager and the activity custodian of any schedule or procedural changes.
- Arrange with the Dive Superintendent to conduct the post dive briefing at the completion of each dive.
- Evaluate the inspection data as it is gathered and determine if additional data is required.
- Brief activity personnel on mooring conditions following completion of the inspection.

3-2.1.2 Dive Team Responsibilities.

The Dive Superintendent is the interface between the Inspector and the inspecting divers. The Dive Superintendent is responsible to:

- Interface with the Inspector on all inspection-related matters.
- Ensure safe performance of the underwater portion of the inspection.
- Provide underwater photographs and video as required.
- Submit all inspection data, notes, and inspection-related film to the Inspector prior to departing the site.
- Accompany and assist the Inspector in briefing station personnel.

3-2.2 Inspection Limitations.

3-2.2.1 Mooring Inspection Limitations.

Moorings are inspected using underwater inspection procedures to the maximum extent possible to include riser assemblies, ground leg assemblies and anchor assemblies. The riser or ground leg is inspected as far as practicable until the riser or ground leg assembly is completely buried and unable to be inspected by the diver. The use of lift bags or other lifting devices to raise riser and ground leg assemblies out of the seafloor are not used during mooring inspections for diver safety. Most portions of the ground legs that are completely buried and unavailable for inspection are generally unaffected by tidal changes and have seen minimal movement. The inspection results obtained on the riser or ground leg that are in the moorings “thrash zone” (portion of the mooring riser and ground legs that are raised and lowered by tidal effects) will provide a good indication of the overall condition of the mooring riser or ground legs. Moorings that are in locations with a large tidal change (> 5 foot (1.5 m)) should be inspected during periods of high tides. As fleet moorings proof test drag-embedment anchors, these anchors will be buried and unable to be inspected unless they are in hard soil conditions. Embedment anchors are also not available for inspection.

3-2.2.2 Diving Limitations.

The majority of moorings are installed in harbor locations where the water depth is less than 50 feet (15.2 m), making them suitable for dive operations performed using either scuba or surface supplied diving within the no-decompression dive limits (though it may take more than 1 dive to fully inspect a mooring). A few moorings (i.e. outer Apra Harbor, Guam; and Wilson Cove, San Clemente Island, CA) are in water depths between 130 to over 190 feet (39.6 to 57.9 m) sea water (FSW) and may require restrictions, command approval, and decompression diving procedures. Portions of some moorings may have to be inspected using remotely operated vehicle (ROV) equipment. Moorings that are in water depths 100 feet (30.5 m) or greater should be identified early in the inspection planning phase to ensure proper diving procedures, equipment and command clearances are planned and obtained prior to arrival at the project site.

3-2.3 Mooring Rating Criteria.

3-2.3.1 Mooring Rated Condition.

Moorings are satisfactory or unsatisfactory for continued use based on an engineering assessment of all inspection data – buoy condition, chain measurements, anchor and buoy position, and other factors. The relationship between mooring condition and rating is summarized below and in Table 3-2.

- If the mooring chain wire diameter measures between 90% and 100% of its original wire diameter and surface components measure 90% to 100% of the original wire diameter, the mooring is considered as C1 (formerly referred to as Good).
- If the mooring chain wire diameter measures between 90% and 100% of its original wire diameter and only topside components measure 80% to 90% of their original wire diameter, the mooring is assessed as C2 (formerly referred to as Fair).
- If the mooring chain wire diameter measures between 80% and 90% of its original wire diameter and topside components measure at least greater than 80% of their original diameter, the mooring is assessed as C3 (also formerly referred to as Fair).
- If the mooring chain or surface components measure less than 80% of the original wire diameter for the required mooring class, the mooring is assessed as C4 and is not satisfactory for continued use (formerly referred to as Poor).

Table 3-2 Mooring Rating Criteria

FACLITY RATING	FACILITY IMPACT ON OPERATIONS	FACILITY CONDITION
C1- FACILITY OPERATIONAL	No impact on operations.	Condition of mooring is considered satisfactory for continued use.
C2 – FACILITY PARTIALLY OPERATIONAL AT A REDUCED CAPACITY	Mooring may be unable to be used at its full design capacity. An engineering assessment is required. Restrictions could impair operations. Vessels may have to find alternate facilities to moor.	Mooring inspection has revealed irregular or degraded surface materials and may no longer be able to hold rated capacity. Topside components or mooring buoy must be replaced or repaired to restore to original design condition
C3 – FACILITY PARTIALLY OPERATIONAL AT A REDUCED CAPACITY	Mooring may be unable to be used at its full design capacity. Restrictions could impair operations. An engineering assessment is required. Vessels may have to find alternate facilities to moor.	Mooring chain or underwater connecting jewelry is degraded and may no longer be able to hold rated capacity. Underwater components must be replaced or repaired to restore to original design condition.
C4 – FACILITY NOT OPERATIONAL	Mooring is restricted from use. Vessels must use alternate facilities. Failure of mooring is imminent.	Mooring must be replaced. Mooring chain or connecting jewelry has degraded below 80% of required Mooring Class.

3-2.3.2 Mooring Condition Readiness.

Mooring condition readiness is a numerical value assigned to a mooring that provides the mooring custodian or local Public Works Officer (PWO) an assessment of the mooring's readiness condition using the Infrastructure Condition Assessment Program (ICAP). It is similar to the Mooring Rated Condition described in paragraph 3-2.3.1 above, but through the assigned numerical value, provides additional information as to the condition of the mooring and sustainment requirements. The mooring condition readiness values and associated condition is shown in Table 3-3.

Table 3-3 Mooring Condition Readiness Scale

VALUE	CONDITION
90	All > 90%; minimal corrosion present.
80	All > 90%; moderate corrosion present or partial damage to fenders or chafe rails or reflective tape in need of replacement.
75	All > 90%; heavy corrosion present or fenders or chafe rails completely missing or top jewelry not secure.
70	All > 90%; buoy refurbishment required.
60	Topside < 90%; minimal to moderate corrosion present.
55	Topside < 90%; moderate to heavy corrosion present.
50	Below water connection assembly not secure.
40	Underwater < 90%; minimal to moderate corrosion present.
30	Underwater < 90%; moderate to heavy corrosion present.
20	Underwater < 80%; minimal corrosion present or legs dragged off location.
10	Underwater < 80%; moderate corrosion present.
0	Underwater < 80%; heavy corrosion present or a ground leg is detached.

3-2.4 Chain Wire Diameter Sampling.

The most common measurements performed in the mooring underwater inspection is selective sampling using Go/No-Go gauges. A selective sampling of chain wire diameter measurements is used to evaluate the condition of a mooring. See Appendix L-1 for a video link for the inspection of chain using double and single link Go/No-Go Gauges.

3-2.4.1 Selective Sampling Locations on the Riser Assembly.

For a riser assembly in water depths less than 90 feet (27.4 m), minimum selective sampling is performed at three locations; (1) One or two links below the buoy connection in the splash zone (area near the surface where it is rich in oxygen due to wave action and the presence of uniform corrosion may be present); (2) At mid-water depth; and (3) Just above the seafloor or the ground ring connection in the thrash zone (area where mechanical wear may be present due to mechanical wear by cyclical tidal action). If the riser is in water depths greater than 90 feet (27.4 m), then the amount of mid-water selective sampling should be increased by one for every 30 feet (9.1 m) the water depth is greater than 90 feet (27.4 m).

For example, if the water depth at the mooring site is 100 feet (30.5 m), minimum selective sampling should be performed in the splash zone just below the buoy connection, the thrash zone just above the seafloor or ground ring connection and two interior locations on the riser. These four locations should be approximately equally separated from themselves.

Since FM3 connecting links have a larger bar diameter than their corresponding nominal size FM3 chain, measurements are taken one to two links away to ensure that a connecting link is not part of the double link measurement.

3-2.4.2 Selective Sampling Locations on a Ground Leg Assembly.

For a ground leg assembly, minimum selective sampling is performed just past the ground leg's connection to the ground ring, at 30 feet (9.1 m) intervals, and one to two links from its connection to the anchor or where the ground leg disappears into the mud line and cannot be further inspected. The number of links for approximately 30 feet (9.1 m) of FM3 chain is provided in Table 3-4.

Table 3-4 Chain 30 Foot Length Link Count

CHAIN SIZE	LINK QTY	CHAIN SIZE	LINK QTY
1.75	51	2.75	32
2	43	3.5	26
2.25	40	4	22
2.5	36		

3-2.4.3 Double Link and Single Link Go/No-Go Gauges.

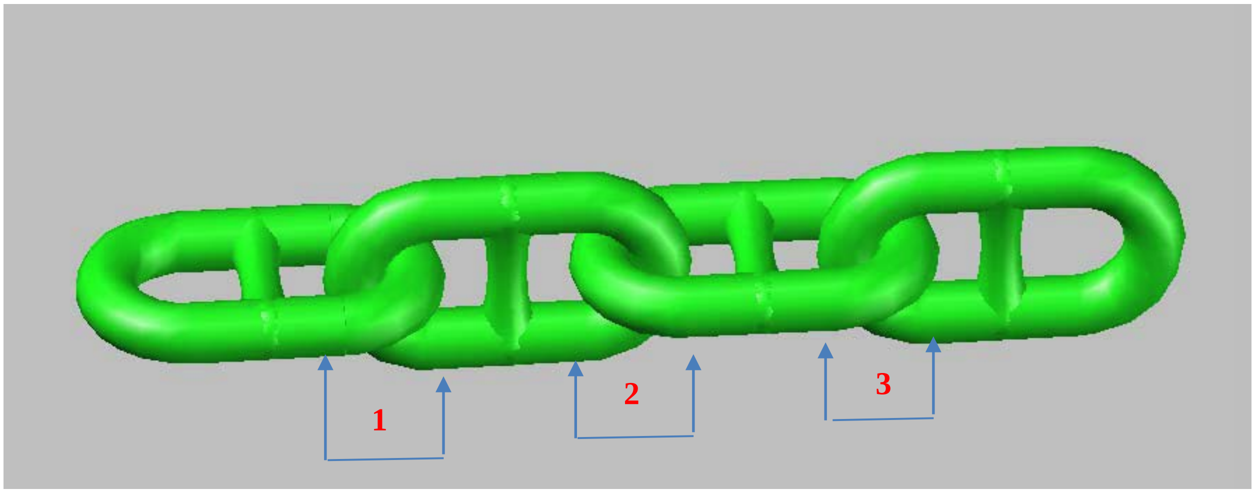
Go/No-Go gauges come in single link and double link sizes. Double link gauges are used to measure the combined bar diameter of two joined links where the two links connect under tension to detect the combined effects of corrosion and mechanical wear. Suspended portions of chain, particularly the riser, are in tension so double link Go/No-Go gauges are frequently used to inspect riser assemblies.

Single link gauges are used to measure the bar diameter of an individual chain link. Single link gauges are used on portions of the riser and ground legs that are not in tension or are slack. Portions of a ground leg or riser that is laying along the seafloor may be slack since its weight is being supported by the seafloor and chain tension is resisted by static friction between the chain links and the seafloor. Chain not in tension will have points of no contact between adjacent links and must be inspected using single link gauges procedures.

3-2.4.4 Measurement Set.

At each selective sampling location, a measurement set is taken using either the double link or the single link Go/No-Go gauges. A measurement set is defined as three consecutive measurements of a chain link joint. A chain link joint contains the connected ends of two adjacent chain links. A measurement set will contain both chain link connection points for 2 chain links and one chain link connection point for 2 other chain links. Therefore, one measurement set provides inspection data on 4 chain links. Figure 3-8 shows one measurement set with three consecutive measurements.

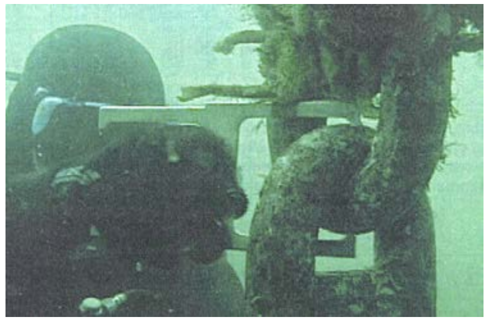
Figure 3-8 Measurement Set



3-2.4.5 Double Link Measurement Set.

Each of three consecutive measurements are taken using double link gauges as shown in Figure 3-9. At each measurement, both ends of a chain link joint are measured simultaneously with one measurement as the double link gauge is held approximately parallel to the plane bisecting the long axis of the joined chain links in performing the measurement.

Figure 3-9 Double Link Measurement at a Chain Link Joint

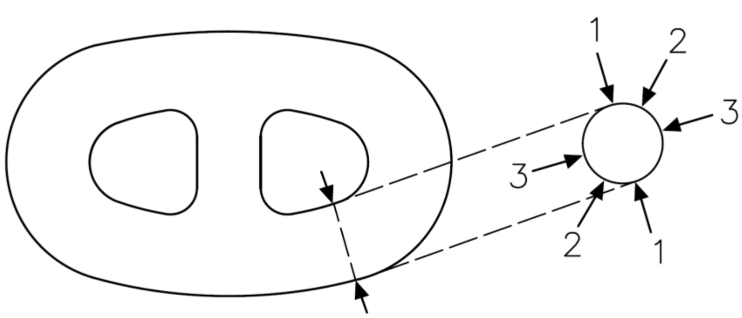


3-2.4.6 Single Link Measurement Set.

Single link measurements are more time consuming because one must take multiple single link measurements on both chain links in a single chain link joint. Since the links are slack or have a gap somewhere between them, one must measure the link from several (at least three) directions of approach around the link. Care must be taken to do these measurements as far as practical from the stud of the chain link, as this area is normally larger in diameter and generally not a contact point for wear. As the other joined link will tend to hinder taking single link measurements, several measurements are taken from different directions of approach as close as possible to where the chain contact points on the link are.

Once one chain link end is done, the same quantity of single link measurements is taken on the adjacent end of the other joined link. When both ends are inspected multiple times from different approach directions, that constitutes one measurement. This is repeated at the next two adjacent chain link joints to complete the measurement set at that location on the mooring assembly. Figure 3-10 shows single link gauge measurements on the end of one chain link.

Figure 3-10 Single Link Measurement



3-2.4.7 Using the Correct Go/No-Go Gauge Size.

Though one of the planning requirements is to review prior inspection reports and obtain a copy of the mooring configuration drawing, the inspector and inspecting divers should not take the information for granted and verify the chain size prior to performing chain measurements using the Go/No-Go gauges. This can be done in the field by fully cleaning the marine growth and excessive corrosive materials off one chain link a few feet below the buoy connection and measuring the overall outer length of a single link using a ruler. The length of the link divided by 6 will provide the nominal chain size. Chain link lengths for fleet mooring chain are provided in Table 3-5.

Table 3-5 Chain Link Lengths

CHAIN SIZE	LINK LENGTH (inches/centimeters)	CHAIN SIZE	LINK LENGTH (inches/centimeters)
1.75	10.5 (26.67)	2.75	16.5 (41.91)
2	12 (30.48)	3.5	21 (53.34)
2.25	13.5 (34.29)	4	24 (60.96)
2.5	15 (38.10)		

3-2.4.8 Cleaning of Chain Link Joint for Inspection.

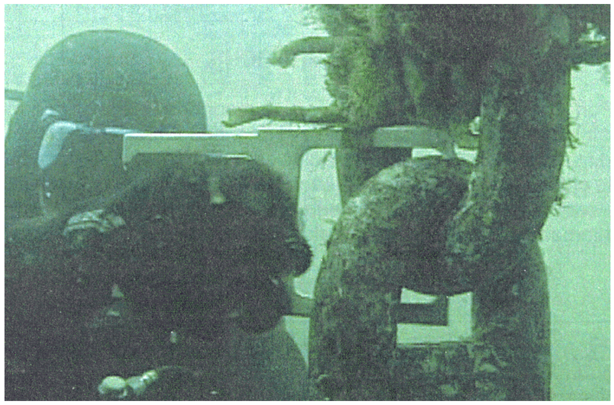
One of the important steps in the mooring inspection is the proper cleaning of the chain links for inspection. The portion of the chain links for inspection is cleaned to “bare metal”, i.e. all the marine growth is removed as well as heavy oxidation materials in the areas of the chain link where single or double link measurements are to be taken (Paragraph 3-2.4.1 and Paragraph 3-2.4.2). Note that the entire link doesn’t have to be cleaned, just the outer side of the ends of each link in a chain link joint where the gauge measurements will be taken. Note for single link measurements, a larger portion of the chain link ends will require cleaning. Due to the proximity of available light, increased presence of oxygen, less motion and sometimes warmer temperature, not to mention that the movement of the chain in the thrash zone can keep the links free of growth and corrosion, there will be more cleaning required in the splash zone than the thrash zone.

Safety Warnings:

Failure to properly clean the inspection area of the chain links may provide erroneous measurements leading the inspector, custodian, and users of the mooring system to an improper conclusion on the mooring condition that could result in an unsafe mooring condition for a moored vessel.

Divers should be aware of the potential movement of the chain, especially when working on the ground legs.

Figure 3-11 Chain Link End Cleaned for Inspection



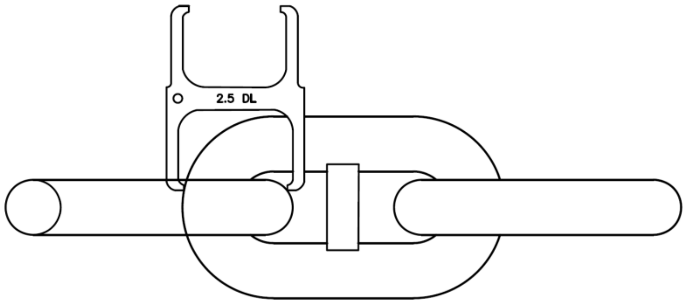
3-2.4.9 Go/No-Go Gauge Measurements.

Whether you are using double link or single link Go/No-Go gauges the procedural steps at each measurement location are the same. Once the inspecting divers have verified the chain size and have the correct set of gauges and the chain link areas have been cleaned, the following steps are performed:

(1) Note the water depth at the measurement set location on the riser or ground leg. When taking readings on a ground leg, note the distance from the ground ring to the measuring set location. On the riser, this measurement is less critical but the diver should still note the distance between the buoy shackle and the measurement set location.

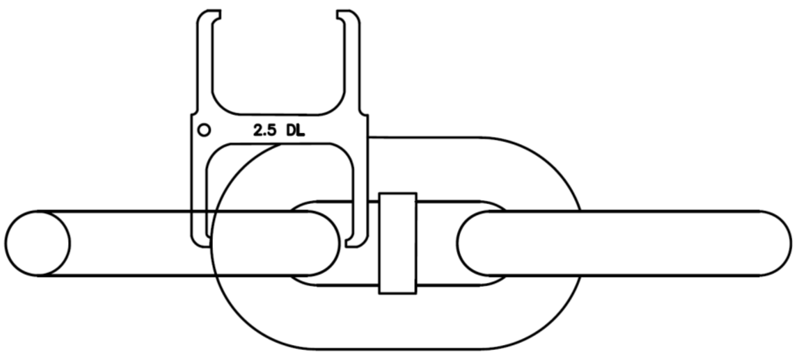
(2) Start with the 90% side (the larger of the two jaws) of the gauge. It is recommended that a single white strip of electrical tape be wrapped around the sides of the 90% jaw for easy recognition in low visibility conditions. Try to pass the 90% jaw over the end of the link (or the ends of both chain link ends at a chain joint if using double link gauges). If the gauge does not pass through, then the measurement is recorded as >90% of the chain's original wire diameter (OWD). See Figure 3-12. Then the inspecting diver would proceed onto the next consecutive measurement location. (Remember for using single link gauges one has to inspect the ends of both connected links individually from at least three angles of approach.)

Figure 3-12 Chain >90% of OWD Using Double Link Go/No-Go Gauges



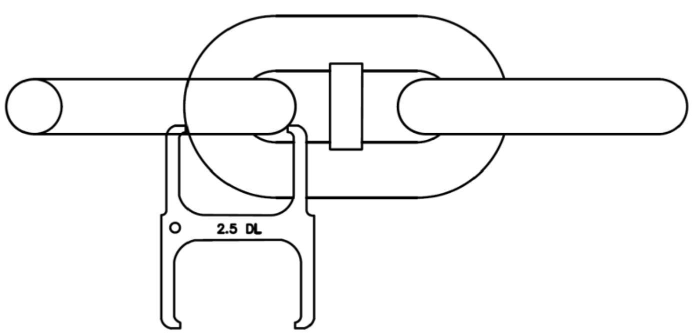
(3) If the >90% jaw does pass through (or if doing single link gauge measurements the 90% jaw passes through on at least one time), we know that the chain is <90% of OWD. See Figure 3-13.

Figure 3-13 Chain <90% of OWD Using Double Link Go/No-Go Gauges



(4) The diver then will flip the gauge so the 80% jaw (smaller of the two jaws on the gauge) and repeat the measurement process. If the 80% jaw does not pass through, then the measurement is recorded as >80% of OWD. See Figure 3-14. Then the inspecting diver would proceed on to the next measurement location.

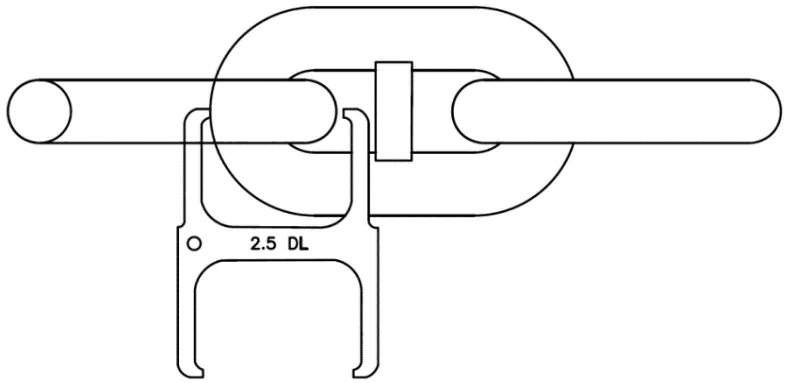
Figure 3-14 Chain >80% of OWD Using Double Link Go/No-Go Gauges



(5) If the >80% jaw does pass through (or if doing single link gauge measurements, the 80% jaw passes through on at least one time), then the

measurement is recorded as <80% of OWD. We don't know the exact %, but we do know that it is <80% of OWD. See Figure 3-15.

Figure 3-15 Chain <80% of OWD Using Double Link Go/No-Go Gauges



(6) Attach a tie-wrap (zip tie) around the stud(s) on both links (for double measurements) or single link (for single link measurements) that were <90% of OWD. The inspecting divers should get a still photo showing the 90% or 80% jaw passing through the single link or link joint or a video recording of the measurement. Then the inspecting diver would proceed on to the next measurement location.

(7) The above sequence is repeated at each measurement location within a measurement set and at each selective sampling location on the riser and ground leg. For mooring risers and exposed portions of ground legs that are 9 links or less in length, perform single or double link measurements on all chain links as described in Paragraph 3-2.4.1 and 3-2.4.2.

Some moorings have oversized chain on the mooring riser and/or ground legs that are located in the thrash zone to extend the mooring's operational use before sustainment operations are required. Oversized mooring chain that is found to be <80% OWD should be remeasured using calipers, to the maximum extent possible to determine its actual % remaining to allow for an engineering assessment on the continued use of the oversized mooring chain.

3-2.4.10 Go/No-Go Gauge Measurement Evaluation.

Measurements >90% of OWD indicate that the chain is still in "Good" condition. Measurements between 80% and 90% of OWD indicate that the chain is in "Fair" condition. Measurements <80% of OWD indicate that the chain is in "Poor" condition.

Once all ground leg assemblies and riser assemblies are fully inspected, the mooring is assigned an overall rating per section 3-2.3 based on the lowest condition found. As the mooring is only as good as the "weakest" link, only one measurement found to be between 80% and 90% of OWD will require the entire mooring system to be rated in C2 or C3 (Fair) condition. Likewise, all it takes is one measurement <80% of OWD for the entire mooring system to be rated in C4 (Poor) condition. It takes all measurements to be >90% of OWD for the mooring system to be rated in C1 (Good) condition.

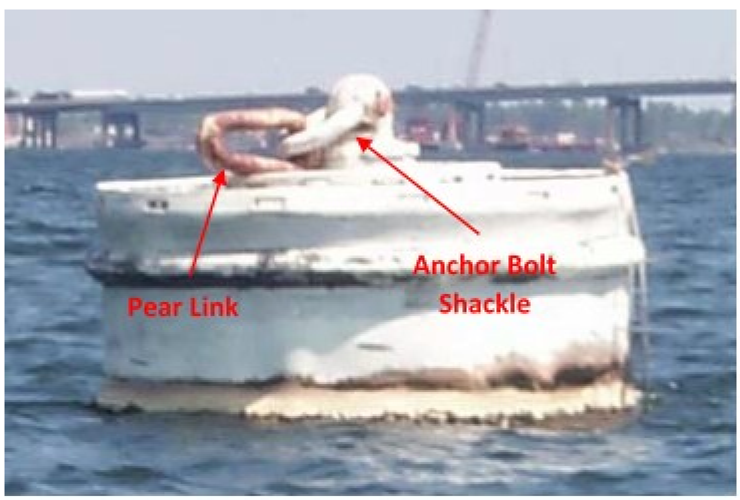
Locations where a measurement <80% of OWD is found should be verified by the dive superintendent, inspector or project superintendent. Additionally, still photo or video documentation should be performed at any location where measurements were found to be <90% of OWD to aid the mooring custodian to seek funding to repair the mooring.

3-2.5 Top Jewelry Inspection Requirements.

Standard top jewelry on fleet moorings include an anchor bolt shackle and two pear links (Figure 3-16). Inspection of top jewelry and surface inspection of mooring buoys should be done on an annual basis. See Appendix L-4 for a video showing the methods to inspect the top jewelry on the buoy.

Similar condition terms as “Good”, “Fair” and “Poor” as described in paragraph 3-2.4.10 will be used in evaluating top jewelry components. The inspection report should note the type and quantity of top jewelry present on the buoy.

Figure 3-16 Buoy Top Jewelry



3-2.5.1 Anchor Bolt Shackle.

Anchor bolt shackles are inspected by caliper measurements at their wear points, an assessment of its overall condition with regard to mechanical wear, corrosion, serviceability, and security of shackle components. See Table 3-6 for Anchor Bolt Shackle dimensions.

- Using calipers, measure the bar diameter of the shackle’s pin between the bale of the shackle and the tension bar padeye Figure 3-17).

Figure 3-17 Measure Pin Diameter Close to Tension Bar Padeye

- Using calipers, measure the bar thickness of the bale of the shackle by its connection points with other hardware (Figure 3-18 and Figure 3-19).

Figure 3-18 Measure Wear Point Using Calipers

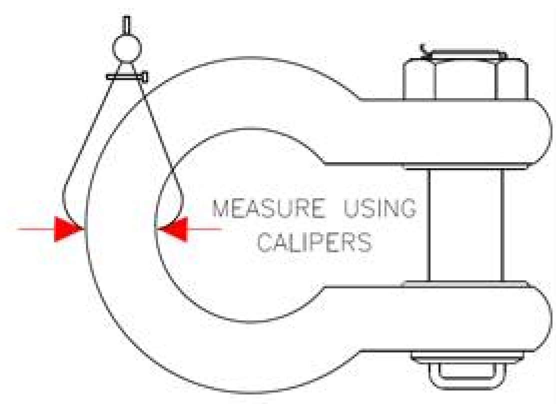
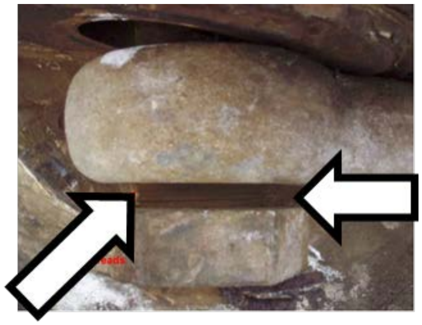


Figure 3-19 Measure Along Wear Point Axis

- Verify if the correct shackle size is on the buoy. Fleet mooring 8 foot (2.44 m) diameter (small) foam buoys have a 3-inch (76 mm) anchor bolt shackle. Fleet mooring 11.5-foot (3.51 m) diameter (medium) buoys have a 4-inch (102 mm) anchor bolt shackle (Figure 3-20).
- Verify if a cotter pin or safety bolt is present on the shackle nut. Note its condition with regard to corrosion.
- Check if the nut is tight on the shackle pin (Figure 3-21).

Figure 3-20 3-inch Shackle on Medium Foam Buoy

Figure 3-21 Nut on Shackle Pin Not Fully Seated



- Note the overall condition of the shackle with regard to corrosion (Figure 3-22 and Figure 3-23).

Figure 3-22 Minimal Corrosion

Figure 3-23 Heavy Corrosion

For mechanical wear at the pin and bale contact points, the buoy anchor bolt shackle is assessed as C1, C2 or C4 using similar criteria as done for chain measurements. Table 3-6 provides catalog dimensions for Fleet Mooring anchor bolt shackles and 90% and 80% levels. Rust products should be removed prior to performing caliper measurements to obtain accurate measurements at the wear points.

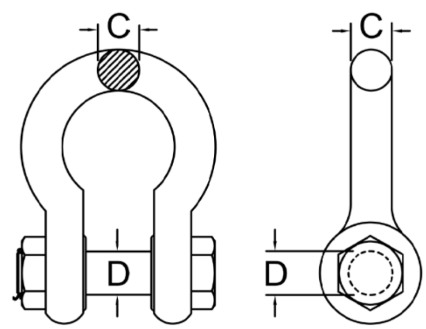
Assessment of the overall condition of the shackle is generally based on the judgment of the inspector. If the shackle shows excessive corrosion, it should be scheduled for replacement. Note that the safe working load of a 3-inch Crosby G-2140 anchor bolt shackle (smallest shackle found on fleet mooring foam buoys) is 110 tons (979 kN) and will be found on Class E moorings that are rated for 25 tons (222 kN). As the buoy shackle is significantly stronger than the mooring rating, moderate to heavy corrosion can be tolerated provided that caliper measurements are >90% of the design dimensional value. However, if the shackle is assessed to have excessive corrosion, it should be scheduled for replacement.

Shackles found without a safety bolt or cotter pin should be corrected by either the local custodian or the inspection team. The absence should be documented in the inspection report as well as the corrective action taken.

Loose nuts should be tightened up immediately by the local custodian or the inspection team. This finding should be documented in the inspection report as well as the corrective action taken.

Table 3-6 Anchor Bolt Shackle Dimensions

Size (inch)	Location	Catalog (inch)	90%	80%
3	Pin	Dim D – 3.25	2.93	2.60
3	Bale	Dim C – 3.62	3.26	2.90
4	Pin	Dim D – 4.25	3.83	3.4
4	Bale	Dim C – 4.56	4.10	3.65



3-2.5.2 Pear Links.

Pear links are inspected by caliper measurements at their wear points, as well as an assessment of its overall condition with regard to corrosion.

- Using a tape, measure the inside length of the pear link.
- Using a tape, measure the overall length of the pear link.
- Using calipers, measure the bar diameter of the pear link at both ends as close as possible to the contact points (Figure 3-24).
- Verify that the correct size pear links are on the buoy. The pear link size should be equal or greater in diameter than the required size chain for the design class rating for the mooring.
- Record the serial number, year of manufacture and manufacturer of the pear link. Typical serial number information on fleet mooring pear links are shown in Figure 3-25.

Figure 3-24 Wear Point & Direction On Fleet Mooring Pear Link

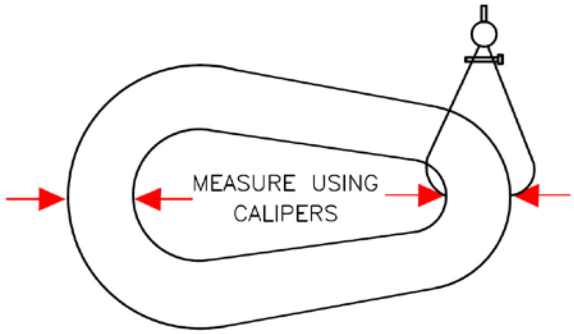
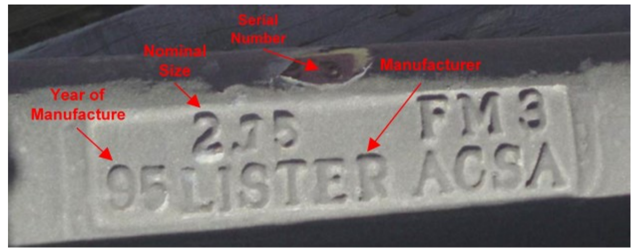


Figure 3-25 Pear Link Marking Data



3-2.6 Mooring Buoy Inspection Requirements.

3-2.6.1 Surface Inspection of Mooring Buoys.

Surface inspection of the buoy includes freeboard measurements, damage assessment, tension bar padeye condition assessment, reflective tape, and chafing and fender rail damage assessment. If the buoy has a navigation light, it should be inspected for functionality and its attachment bracket inspected for condition assessment. See Appendix L-5 for a video showing the techniques for a surface inspection of a foam Buoy.

- For foam buoys, record the serial number, contract number, year of manufacture and manufacturer of the buoy. Typical serial number information on foam buoys are shown in Figure 3-26.

Figure 3-26 Foam Buoy Identification Plate

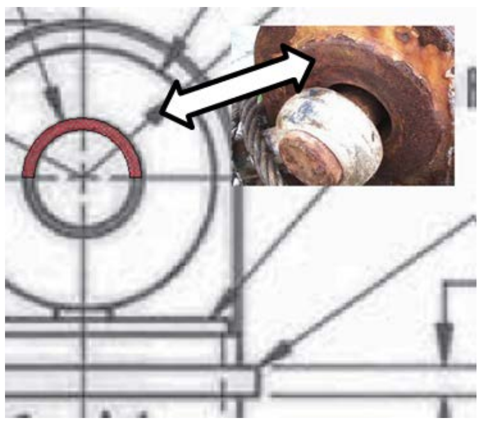
- Record the size (diameter), type (foam or steel), style (drum or peg top), method of connection (tension bar of hawse pipe) presence or absence of any attached vessels. If the identification plate is illegible, exclude the fenders when measuring the buoy diameter.
- Note the overall condition of the tension bar padeye with regard to corrosion (Figure 3-27 and Figure 3-28).

Figure 3-27 Minimal Corrosion on Tension Bar Padeye

Figure 3-28 Excessive Corrosion on Tension Bar Padeye

- Visually inspect the condition of the wear bushing inside the padeye along the upper half of the padeye hole in the direction of pull (Figure 3-29).

Figure 3-29 Location of Tension Bar Padeye Wear Bushing



- Record the freeboard of the buoy from the waterline to the deck line (the top flat surface of the buoy, not counting the rub rails) at the edge of the buoy. Measure from the top surface of the buoy. If the buoy has a severe list due to an attached vessel or excessive attached hardware, measure the high and low sides to obtain an average freeboard.
- Assess the buoy hull for damage, holes and or dents. On steel buoys, note level and type of corrosion (i.e. pitting, rust bleeding, level of corrosion) on buoy shell. If buoy has an outer fiberglass or urethane coating note any cracks, peeling or other damage (Figure 3-30).

Figure 3-30 Outer Coating Loss on Steel Buoy

- Visually inspect the upper chafing rails for damage. Remove debris from drainage holes on chafing rails. On a buoy, record the quantify of chafing strips, method of attachment and presence of any broken mounting brackets, bolts, etc.
- Visually inspect the fenders for damage. On a steel buoy, record the quantity of fenders, method of attachment and presence of any broken mounting brackets, bolts, etc.
- Assess the condition of the reflective tape and legibility and correctness of buoy identification markings.
- Note and record any significant listing not caused by a moored vessel, the moored diving platform or top jewelry.

Tension bar padeyes are made from mild A36 grade steel, which is a softer steel than that used for the shackle pin. Consequently, they are subject to elongation of the padeye in the direction of the load once the wear bushing has worn through. Dents to the outer buoy shell should be inspected closely, especially on steel buoys, to ensure that the water tightness of the buoy is not compromised. These buoys should be monitored in annual inspections as these points will form local points of corrosion that will spread over time.

Assessment of the overall condition of the buoy is generally based on the judgment of the inspector. Buoys with damaged fenders, chafing rails, reflective tape in need of replacement, minor dents to the hull on foam buoys, moderate corrosion on the tension bar padeye may still be satisfactory for continued fleet use as these are either minor repairs or do not affect the ability of the buoy to support the suspended portions of the mooring system or reduce its load carrying capacity.

Depending on the level of corrosion on the buoy tension bar padeye, the amount of outer hull damage, presence of an unexplained buoy list or excessively low freeboard (i.e. is the freeboard significantly less than from the last inspection?), condition of the padeye wear bushing, the buoy may be assessed as in C2 (Fair topside) or C4 (Poor topside) condition. Assessing the buoy in Poor condition indicates that there is sufficient damage or corrosion on the buoy indicating a significant reduction in buoyancy and/or mooring load capacity or its condition presents a risk of either loss of buoyancy, mooring load capacity or operational safety if not immediately replaced or repaired.

A rating of C4 (Poor) on a buoy will also cause the entire mooring system to be rated in C4 condition and unsatisfactory for continued fleet use. Lack of marine growth cover or the removal of the outer cover in one area of the buoy may be an indication of a vessel coming into contact with the buoy. Usually, impact damage will be seen above the waterline.

Note:

All efforts shall be made to replace steel buoys with foam buoys since steel buoys are much more difficult to inspect and maintain. Steel tension bar buoys can still be used, but hawse pipe buoys should be taken out of service.

3-2.6.2 Subsurface Inspection of Mooring Buoys.

While a surface inspection of a mooring buoy should be conducted on an annual basis, the subsurface buoy inspection will normally be conducted with the underwater inspection of the mooring system as a whole. Divers shall thoroughly inspect the buoy below the waterline.

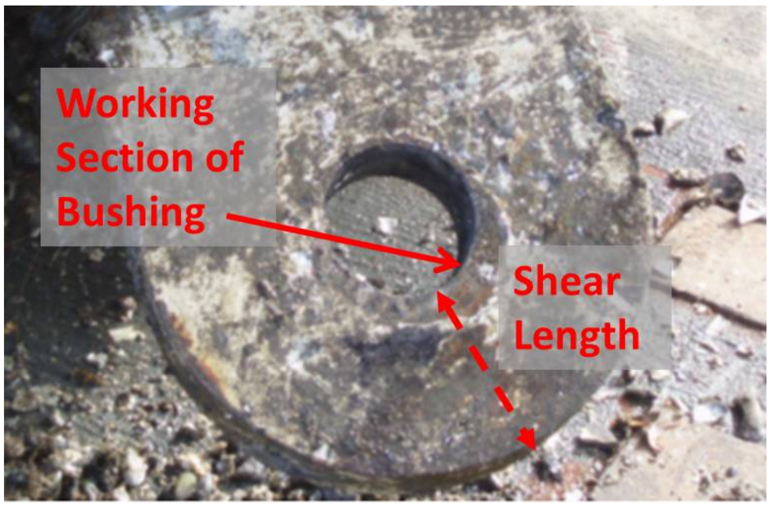
Safety Warning:

Divers should use extreme caution when working directly below a live/moving buoy.

- Record marine growth thickness. Care should be taken not to puncture the outer urethane shell on foam buoys or fiberglass/urethane coating on steel buoys.
- Lack of growth cover may be an indication of a vessel coming into contact with the buoy. In most cases, impact damage will also be seen above the waterline.
- Clean off the lower tension bar and visually inspect the condition of the lower tension bar zinc anodes. Replace zinc anodes if the remaining amount of zinc anode is >25% depleted.
- Visually inspect any submerged fenders for damage. On a steel buoy, record the quantity of fenders, method of attachment and presence of any broken mounting brackets, bolts, etc.
- Clean off the lower tension bar padeye and visually inspect the condition of the wear bushing inside the padeye along the lower half of the padeye hole in the direction of riser pull (Figure 3-31).

- Measure the tension bar thickness and shear length of the lower tension bar padeye (Figure 3-31). Divers should look for the bushing seam then trace it toward the wear direction. They should note if it thins out or if the base metal of the padeye is being penetrated. The measurement of the shear length is difficult with the swivel shackle in the way. It is suggested that divers use a thin metal rule to make that measurement.

Figure 3-31 Lower Tension Bar Padeye



Information from the underwater inspection of the buoy is combined with the inspection results from the above water inspection of the buoy to provide an overall buoy assessment as described in Paragraph 3-2.6.1

3-2.6.2.1 Bottom Buoy Jewelry Inspection Requirements.

The most common bottom buoy jewelry is the riser swivel shackle or the anchor bolt shackle.

3-2.6.2.2 Riser Swivel Shackle.

The riser swivel shackle is the most common connection of the mooring riser to the buoy. The inspection includes pin diameter caliper measurements, checking for full assembly and verification that tapered pins securing the swivel pins are secured by lead plugs. See Appendix L-2 for a video showing the techniques to inspect a Riser Swivel Shackle.

- Thoroughly clean off all marine growth on the swivel shackle at the swivel “gap” and along the front and back of the narrow sides of both the upper and lower jaw. Verify the presence of 2 lead plugs per side on both the upper and lower jaws (Figure 3-32).
- Using calipers, measure the bar diameter of the upper riser swivel shackle’s pin by the tension bar padeye. Measure the pin closest to the

buoy shackle or riser chain to not accidently measure the casted shim located on the inside of the swivel top and bottom bales.

- Using calipers, measure the bar diameter of the lower riser swivel shackle's pin by the end link on the mooring riser.

Figure 3-32 Riser Swivel Shackle Inspection Points

- Thoroughly clean off all marine growth by the swivel "gap" (Figure 3-32). Inspect the swivel gap for uniformity all around the swivel. The swivel "gap" should be less than 0.75-inch (19 mm). Gaps larger than 0.75-inch (19 mm), may indicate that the swivel shackle is in the process of coming apart. As shown in Figure 3-33, the outer sleeve is secured to the lower jaw extension with an all-around fillet weld. Larger gaps may indicate that this weld has failed and the lower portion of the swivel shackle is starting to unscrew itself from the upper jaw. If a gap >0.75-inch (19 mm) is measured, the divers should clean off the top of the jaw extension and inspect the condition of the weld as well as the level of the lower jaw extension to the locking tube. A failed weld or the lowering of the jaw extension in the locking tube is a sign that the swivel shackle is in need of immediate replacement. Moorings that have a "loose" riser swivel shackle are assessed as C4 and unsatisfactory for continued fleet use. Riser swivel measurement points are shown in Figure 3-34, Figure 3-35, Figure 3-36, and Figure 3-37.

Figure 3-33 Welding of Lower Jaw Extension

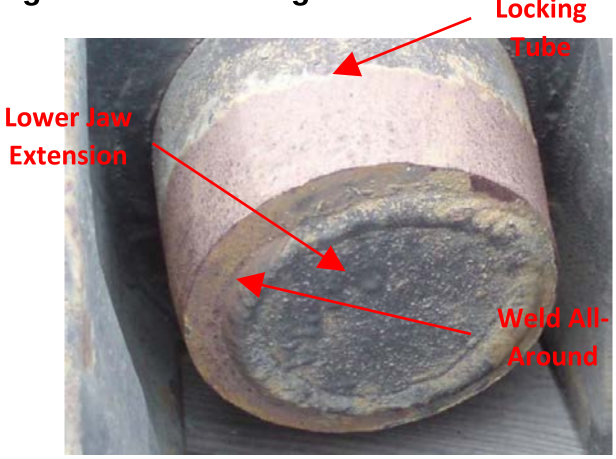


Figure 3-34 Top of Riser Swivel Shackle by Buoy

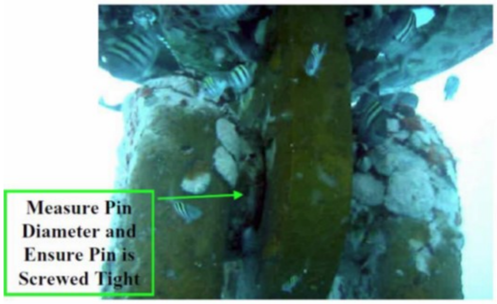


Figure 3-35 Cleaning and Inspection of Swivel Gap

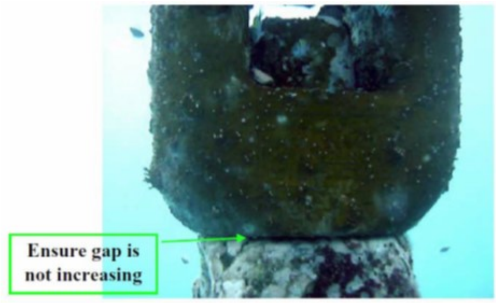


Figure 3-36 Bottom of Riser Swivel Shackle by Chain

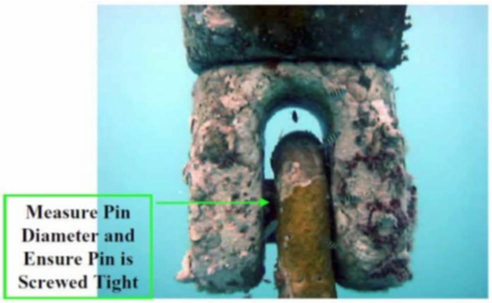
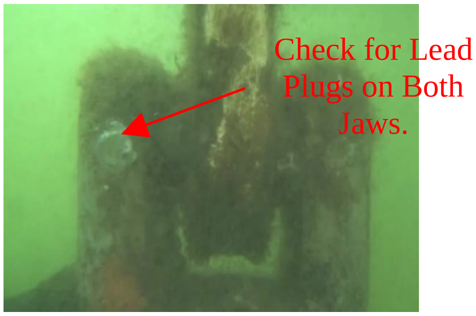


Figure 3-37 Lead Plugs in Riser Swivel Shackle Jaw



3-2.6.2.3 Anchor Bolt Shackle.

The anchor bolt shackle is inspected in a similar manner as stated in Paragraph 3-2.5.2.

- Clean the anchor bolt shackle.
- Using calipers, measure the bar diameter of the shackle's pin between the bale of the shackle and the tension bar padeye (Figure 3-17).
- Using calipers, measure the bar thickness of the bale of the shackle by its connection points with other hardware (Figure 3-18 and Figure 3-19).
- Verify if a cotter pin or safety bolt is present on the shackle nut. Note its condition with regard to corrosion.
- Check if the nut is tight on the shackle pin (Figure 3-21).
- Check if the nut is secured to the anchor bolt with a fillet weld. Check the condition of the fillet weld.

3-2.7 Riser Chain Subassembly Inspection Requirements.

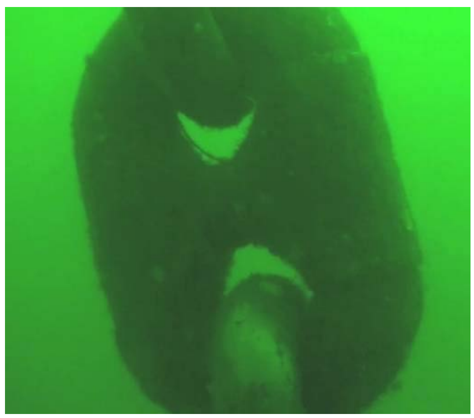
Inspection of the riser assembly includes verification of riser chain size, selective sampling and inspection of connecting hardware found along the mooring riser.

- Determine selective sampling locations in accordance with Paragraph 3-2.4.1. Clean one link near the buoy that will be the upper measurement set.
- Record type of chain found (i.e., forged, cast or Dilok).
- At the upper measurement set location, measure the overall outer length of a single link using procedures described in Paragraph 3-2.4.7
- At each measurement set, record water depth below the waterline. If the riser is laying along the seafloor, a link count referenced to the touchdown point on the seafloor or a connecting link may be used instead.
- At each measurement set, perform go/no-go gauge measurements per procedures as described in 3-2.4.5 (Figure 3-38). Record results.
- Note the presence of pitting found on any areas of links cleaned for measurements as well as on chain that is already "cleaned" in the thrash zone (Figure 3-40). Measure the diameter and depth of any pits found and record results. The length of the pits can be measured using the tape, while any probe that goes into the pit can be used to measure the depth of the pit.
- At chain joining link locations along the riser, clean off the connecting link, note type of CJL (Kenter, Baldt), report any broken, missing or loose parts and verify that a lead plug is secured in the large pin hole on top of the joining link

Figure 3-38 Double Link Go/No-Go Measurement

FM3 chain joining links are larger than the size chain they attach to (Figure 3-39). Therefore, they should look larger than the attached chain.

Figure 3-39 Chain Joining Link



Though chain joining links are the most common connection hardware found on a riser between the buoy connection and the ground ring or anchor connection, other connecting hardware may be found. They should be inspected in accordance with information provided throughout this manual.

Though most moorings have a riser made from a single size chain, some moorings use a larger size riser chain in the thrash zone. Therefore, mooring configuration drawings should be checked ahead of time and taking a link length measurement for each measurement set will prevent using the wrong size gauges.

Examples of worn chain found during inspections is shown in Figure 3-40, Figure 3-41, and Figure 3-42.

Figure 3-40 Pitting Corrosion on Chain in the Thrash Zone

Figure 3-41 Worn 3.5-inch Chain with Stud Missing

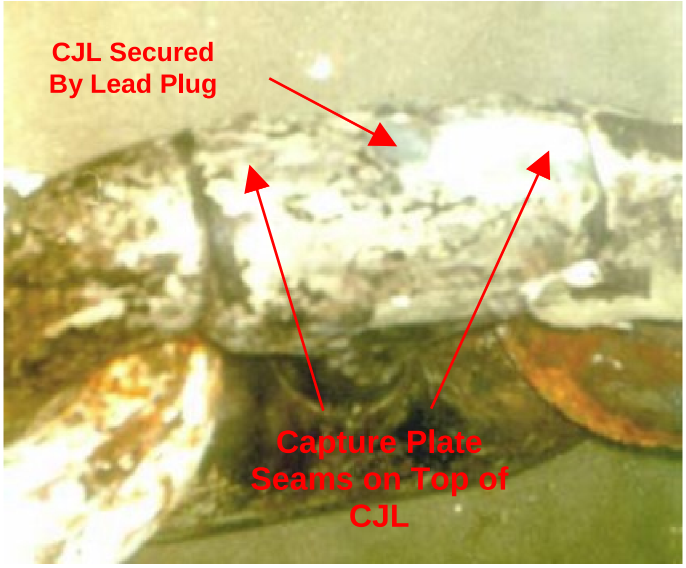
Figure 3-42 OWD <80% Chain in Mooring Thrash Zone

3-2.8 Connecting Hardware Inspection Requirements.

Chain joining links may be found along the riser and the riser is generally secured to a ground ring with an anchor joining link. The inspection process for both types of connecting links is the same. See Appendix L-3 for a video link showing the techniques to inspect chain and anchor joining links.

- Clean the connecting link of marine growth to identify the seams of the T-shaped capture plates (Baldt style-Figure 2-23 or Figure 2-25) or the link joints (Kenter-style-Figure 2-24 or Figure 2-26).
- Check the joining link for complete assembly.
- Check that the connecting link is at least equal or larger than the chain that is attached to it.
- Verify that the top pin hole on the connecting link is filled with lead (Figure 3-43). For the Kenter style joining link, there is no top or bottom pin hole. The larger hole is filled with lead while the other smaller hole is not. The large hole is located on top of the Baldt-style joining link where the T-shaped capture plate seams are located.

Figure 3-43 Lead Plug Present on CJL



3-2.9 Ground Ring Assembly Inspection Requirements.

The ground ring assembly consists of a ground ring and several anchor joining links (Figure 3-44) connecting the riser, ground legs and sometimes a sinker. Anchor joining links are inspected in accordance with the procedures outlined in Paragraph 3-2.4.8.

Figure 3-44 Ground Ring Assembly

- Check the ground ring for roundness (i.e. has it elongated in one direction?).
- Measure the inside diameter of the ground ring.
- Clean and measure the bar diameter of the ground ring near a connecting link (or at locations that show evidence of wear).

3-2.10 Sinker Connection Inspection Requirements.

Sinkers found on the riser are generally secured with a sinker shackle or a sinker hook. Sinkers found on the ground legs are generally secured with a plate shackle (Figure 3-45).

- Clean and check the plate shackle, sinker shackle or sinker hook for complete assembly.
- Check that the shackle nuts are tight on the shackle bolts.
- Check the integrity of the fillet welds that secure the plate shackle nut to the plate shackle bolt. For sinker shackles, check for the presence of a safety bolt or cotter pin.

Figure 3-45 Sinker and Plate Shackle

Safety Note:

Divers should inspect the connections of suspended sinkers with caution as motions imposed on the mooring system from surface weather conditions or attached vessels can cause the suspended sinker to move within the water column.

3-2.11 Ground Leg Chain Assembly Inspection Requirements.

3-2.11.1 Chain Measurements.

Ground legs are inspected using similar procedures performed for the riser chain assembly (Paragraph 3-2.7). The first measurement set is taken one to two links from the ground ring assembly. Subsequent measurement sets are performed along the ground leg every 30 feet (9.1 m) until reaching the anchor assembly or the ground leg buries into the seafloor and is no longer available for inspection. At the point of burial, a final measurement set is taken.

Connecting hardware such as chain joining links or sinker connections found along the ground ring are inspected using procedures outlined in Paragraphs 3-2.8 and 3-2.10.

Measurement sets on the ground leg will most likely include double link as well as single link measurements. As double link measurements are performed at locations where the chain is under tension, measurements taken on the suspended portions of the ground leg are usually done using double link Go/No-Go gauges. Measurements along portions of the ground leg that is lying on the seafloor may have to be performed using single link Go/No-Go gauges as the chain may be slack and gaps between the adjoining links may be present. The inspecting divers should carefully inspect the ground leg chain along the bottom to determine the correct type of Go/No-Go gauges to use.

Double and single link measurement procedures are addressed in Paragraph 3-2.4.

3-2.11.2 Compass Headings.

A compass heading should be taken for each ground leg. The compass heading should be referenced for the ground leg's direction from either ground ring to the anchor or vice-versa. The inspecting diver should record which reference was done during the inspection. Sometimes it is difficult to initially determine the ground leg direction (Figure 3-46) due to poor visibility, burial of the ground leg into the seafloor close to the ground ring, a minimal length of ground leg visible or excess slack in the mooring leg near the ground ring assembly. It is recommended that the diver swim out the leg until a consistent heading is obtained.

Figure 3-46 Ground Legs Just Below the Ground Ring

3-2.12 Anchor Assembly Inspection Requirements.

Anchors assemblies are generally buried and unable to be inspected. However, in locations having a hard bottom, embedment drag anchors may be partially buried or visible on the seafloor.

Safety Note:

While inspecting the anchors, divers should not go under the flukes or shank of the anchor.

Inspection of anchor assemblies include the following:

- Checking the connection hardware for presence of lead plugs on connecting hardware.
- Inspect the swivel gap for uniformity all around the swivel. The swivel "gap" should be minimal. For safety, the diver should not go under the anchor.
- Record whether the flukes are pointing into the seafloor or away from the seafloor. Record whether the flukes appear to be fixed or not fixed.
- Record the presence or absence of stabilizers. Check if the stabilizers are still welded along the back of the anchor crown.
- Referencing Figure 3-47, measure the width of the anchor's flukes along the backside (dimension B), the fluke length (dimension C) and the length of the anchor's shank (dimension A). This will aid in determining the size of the anchor.
- Record the presence of anchors found upside down or improperly installed (Figure 3-48 and Figure 3-49).
- Attach a plumbed surface float to the anchor crown. This can be used to obtain a location coordinate for the anchor as well as to verify the compass heading of the attached ground leg.

Figure 3-47 Stockless Anchor Nomenclature

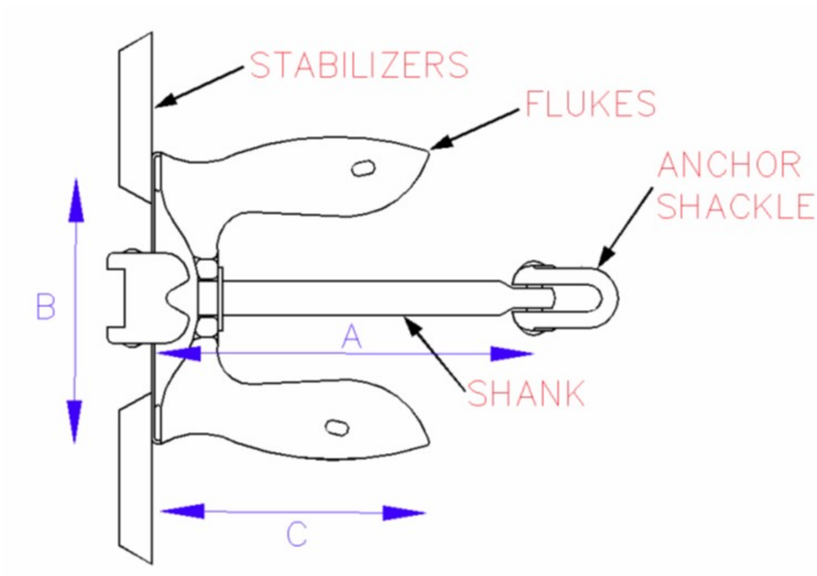


Figure 3-48 Upside Down Anchor

Figure 3-49 Upside Down Anchor and Incorrect Alignment

3-2.13 Cathodic Protection System Inspection Requirements.

3-2.13.1 Fleet Mooring Chain Link Zinc Anodes.

Records should be checked to determine if zinc anodes have been used on the mooring, but, it is pointed out that all chain used for fleet mooring ground legs and risers have been fabricated with a threaded hole in the chain link stud to attach a sacrificial zinc anode (Figure 3-50). As part of the mooring underwater inspection, zinc anodes, if present, should be inspected and replaced as required.

Figure 3-50 Zinc Anode Installed on a Chain Link

Existing zinc anodes are replaced when the anodes are less than 75% of their original size. Anodes that appear to be >75% of their original size should be tapped with a cleaning tool Figure 3-51 or a dive knife to see if the anode is actually solid or if it easily crumbles, indicating that it is spent and requires replacement. A representative anode from the riser and each ground leg should be brought to the surface and compared with a replacement anode to determine if the existing anodes require replacement.

Figure 3-51 Tapping the Zinc Anode

In addition to noting the reduction in volume of the existing anodes, divers should also check for the presence of the oxidation deposit on the zinc anodes. A whitish coating indicates that the anodes are working properly. A black coating, or no coating at all indicates that the anodes are not working properly, most likely due to a break in the metallic path (i.e. the zinc anode is not tight on the chain link, or there is some debris preventing metal-to-metal contact between the chain's stud and the anode's sleeve).

3-2.13.2 Assessment of the Chain's Cathodic Protection System.

Assessment of the chain's cathodic protection system is done either visually, or with a bathycorrometer, or both.

It is expected that zinc anodes installed previously will exhibit some degradation. This loss of individual link zinc anode material may be complete, leaving nothing more than the anode's sleeve and screw. This is common to moorings in areas with a strong tidal current and near the surface. In some cases, a good percentage of the anode will still be present. This may be found in moorings where tidal currents are relatively weak and the chain links are fully encrusted with soft coral growth.

The evidence of a white oxidation on the surface area of the individual anodes, in addition to having some percentage of depletion (remember to tap the anode with a knife or metal tool to determine its actual remaining size), will provide the inspector with an assessment of the chain's cathodic protection.

A diver-held bathycorrometer can also be used to provide a measure of the effectiveness of the cathodic protection system. (Figure 3-52).

Figure 3-52 Diver-Held Bathycorrometer

A diver held Bathycorrometer consists of a silver/silver chloride reference electrode, a self-cell, a digital voltmeter and a probe. The unit operates by measuring the potential difference between the reference electrode and the material being measured. The potential reading is displayed on a liquid crystal display.

The bathycorrometer should be soaked in water at the dive site for 20 to 30 minutes prior to initial use. In addition, the area of the chain that will be in contact with the bathycorrometer's probe must be cleaned to bare metal.

Readings between -0.80 to -0.90 Volt will indicate that the cathodic system is performing properly. After the attachment of new zinc anodes, a full day should be allowed for the cathodic protection system to set up before checking with the Bathycorrometer.

3-2.13.3 Oversize Chain Link Zinc Anodes.

When possible, oversized zincs are used to replace existing zincs to extend the cathodic protection to the next underwater inspection cycle. Table 2-5 provides recommended "oversized" zinc anodes per nominal chain size. As the length of the anode screw differs between various anode sizes, when replacing existing anodes with oversized anodes, be sure to use the screws that come with the new oversize anodes.

Note:

Regardless of using the design anode size or oversized anodes, the mounting hole must be free of debris and the anode tightened to the recommended torque for the anodes to work properly.

3-2.13.4 Replacement of Mooring Chain Link Zinc Anodes.

Mounting holes for anodes are on the same side of every other chain link in a shot as shown in Figure 3-53.

Replacement of zinc anodes is generally performed using the following procedures:

- Using an adjustable wrench or a 9/16-inch socket wrench, remove the existing anode screw and anode body from the chain link. For chain links that do not show an existing zinc anode, some cleaning of the chain link at the stud may be required to find the remaining anode. If all that is found is a screw inside a sleeve, that indicates that the anode material has been completely consumed. Pneumatic wrenches can be used as long as they are powered from a separate air source.
- Using a small brush, clean out the anode mounting hole of debris.
- Attach a new anode to the stud of the chain link using a new screw.
- Tighten the anode to the chain link by applying a torque approximately 20 to 30 foot-pounds (27 to 41 N-m).
- See Figure 3-54 for a picture of a diver attaching an anode to a chain link.

As the bolts are only 3/8-inch in diameter, applying too much torque could shear the screw. If the zinc feel's tight when grabbed by the diver's hand, it has sufficient torque to provide the necessary metallic path for the cathodic protection to properly perform.

Figure 3-53 Location of Anode Mounting Holes on FM3 Chain Links

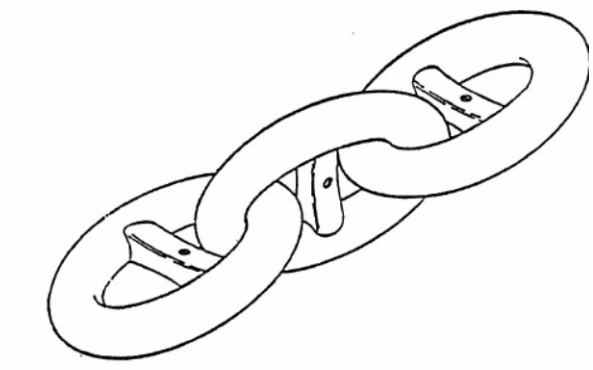


Figure 3-54 Diver Attaching Anode to Chain

Periodically, the diver will find chain links where the anode bolts were sheared at the stud during installation, preventing anodes to be attached to the chain link. The quantity of chain links unable to attach a zinc anode to should be recorded in the comment section of the mooring's inspection data sheet.

In addition to replacing the anodes on the chain, divers should replace the anodes on the bottom padeye of the buoy, see Figure 3-55.

Figure 3-55 Diver Installing a Zinc Anode on the Bottom Buoy Padeye

There are several methods that have been used on site to perform anode change out operations. Most methods involve the initial removal of the existing anodes, the initial loose attachment of new anodes followed by the tightening up of the new anodes. A supply of zincs is usually placed in a canvas bag positioned near the divers by topside support personnel. These tasks are usually divided among a dive buddy team based on diving conditions at the site, the quantity of zincs to be replaced and the direction of the dive supervisor. Divers should police up the area, removing zinc anodes and screws and all other materials.

CHAPTER 4 DOCUMENTATION OF MOORING INSPECTION RESULTS

4-1 RECORDING OF MEASUREMENTS IN THE FIELD.

Recording of measurements and observations in the field should be performed as soon as possible during the inspection to ensure that the data is not lost and that all required measurements are taken during the dive to minimize additional dives and the associated logistics to obtain the missing inspection data.

The data can be recorded by the diver using a dive slate. If topside communications are available, the information should be provided concurrently with the inspection process and recorded by topside personnel. Table 4-1 provides a list of necessary inspection data for type or mooring component to be recorded.

Table 4-1 Inspection Data

Component	Data Recorded	Comments
Buoy Assembly Inspection Data		
Buoy Topside	Type and condition of buoy hull Diameter Freeboard Serial Plate Date (manufacturer, contract #, serial #, manufacture date) Buoy surveyed location Fender type and condition Chafe rail type and condition Reflective tape condition. Replacement of reflective tape if needed Tension bar padeye corrosion condition	Usually performed by the On-site Engineer Note type of survey system used, accuracy and datum of coordinates
Topside Jewelry	Pin diameter for shackles Pear Link measurements Assessment of cotter pins or safety bolts for shackles Wear assessment on shackles Wear assessment on pear links Serial number data on topside jewelry (spec, serial #, manufacturer) Top jewelry corrosion condition	Usually performed by the On-site Engineer
Buoy Below the Waterline	Condition of the buoy Marine growth assessment Tension bar padeye condition Wear bushing assessment	

Component	Data Recorded	Comments
Riser Assembly Inspection Data		
Riser Connecting Hardware Below the Waterline	Pin diameter for shackle or riser swivel shackle If riser swivel shackle, verify lead plugs and swivel gap measurement If anchor bolt shackle, assessment of cotter pins or safety bolt and bale measurement	
Riser	Water depth of all measurement sets Go/No-Go results for each measurement in a set Anode condition assessment (% depletion, oxidation coating) Type and amount of marine growth on riser	
Anodes	Percent remaining on existing anodes Size of replacement anodes Quantity of anodes replaced on the riser	25 – 30 ft-lbs (34 – 41 N-m) torque
Connecting Links	Type of connecting link Presence of lead plug on top of connecting link Assembly assessment of connecting link Wear assessment	Only the hole on top will be leaded
Sinkers	Assessment of attachment hardware of sinker to riser Condition of sinker	
Ground Ring	Inside diameter Bar thickness near connected components	

Component	Data Recorded	Comments
Ground Leg Inspection Data		
Ground Leg	Link distance of measurement sets from ground ring Go/No-Go results for each measurement in a set Anode condition assessment (% depletion, oxidation coating) Type and amount of marine growth on ground legs Leg compass headings to or from anchor and ground ring Location of legs along seafloor and assessment (buried or exposed, twisted, slackness, entanglement, etc.)	Single link go/no go gauges may be required
Anodes	Percent remaining on existing anodes Size of replacement anodes Quantity of anodes replaced on ground legs	25 – 30 ft-lbs (34 – 41 N-m) torque
Swivels	Presence of 4 lead plugs on open jaw swivels Gap assessment Wear assessment on pins	
Connecting Links	Type of connecting link Presence of lead plug on top of connecting link Assembly assessment of connecting link Wear assessment	Only the hole on top will be leaded
Shackles	Assessment of cotter pin and/or safety bolt Shackle nut to bolt weld assessment (except for topside shackles) Pin and bale wear assessment and measurements	
Sinkers	Assessment of attachment hardware of sinker to riser or ground leg Condition of sinker	

Component	Data Recorded	Comments
	Anchor Assembly Inspection Data	
Anchors	Type of Anchor Percentage of burial for anchors located Orientation of anchor Are the flukes fixed or free Are there stabilizers? If so, assess the condition of the weld along the anchor crown. Measure the anchor (fluke length, distance between flukes, shank length)	Note type of survey system used, accuracy and datum of coordinates
Shackles	Assessment of cotter pin and/or safety bolt Shackle nut to bolt weld assessment (except for topside shackles) Pin and bale wear assessment and measurements	
Anchor Joining Link	Type of AJL Presence of lead plug on top of connecting link Assembly assessment of AJL Wear assessment	Only the hole on top will be leaded
	Miscellaneous	
Water Conditions	Current condition Visibility Max water depth during inspection	
Seafloor	Type Presence of a crater caused by the ground ring	

An inspection form for each major component or subassembly that can be used to develop inspection slates is provided in APPENDIX D.

4-2 MOORING INSPECTION FORM.

Inspection results are recorded for each mooring using a mooring inspection form. Sample mooring inspection forms for both mooring surface inspections as well as mooring underwater inspections are provided in APPENDIX E.

The form is broken into 3 parts; (1) General Information; (2) Inspection Measurement Results; and (3) Inspection Comment Results.

4-2.1 General Information.

This section contains general information listing the following information:

- Mooring identification and report number
- Mooring assessment and condition ratings
- Mooring survey results
- Mooring zinc anode results
- Mooring buoy topside and top jewelry results

Provide both a geodetic location as well as Northing and Easting location for survey results. Provide the size and quantity of zinc anodes replaced. Provide caliper results of top jewelry measurements.

It is recommended that measurements found to be in C2 or C4 condition be highlighted in the inspection sheet.

4-2.2 Underwater Inspection Measurement Results.

This section is devoted primarily to recording the results of the Go No-Go gauge measurement sets or individual link measurements. If measuring the chain links using calipers, record these results in this section as well.

- If recording by measurement sets, record the condition % of the smallest of the 3 consecutive measurements. In the inspection comment results section, provide additional detail as to the actual measurements taken for the measurement set in the riser or ground leg block. If all measurements in a measurement set are identical, record this as “all 3 >90 (or >80 or <80)” in the condition % block.
- If recording each specific chain link measurement, then record the specific location and condition % result for each.

For riser swivel shackles and ground rings, catalog dimensions for measurement points, the nominal size of the component and the caliper measurement is recorded. Note that assessment of connecting components, presence of lead plugs, etc. are provided in the respective block on the Inspection Comment Results section.

Provide the location from waterline for riser measurements or from a well-defined reference hardware location for ground legs (i.e. the ground ring) either in feet (most commonly used for the riser) or in links (most commonly used for ground legs).

It is recommended that measurements found to be in C3 or C4 condition be highlighted in the inspection sheet.

4-2.3 Inspection Comment Results.

This section provides the inspector to record a more detailed and descriptive evaluation of the condition of the mooring for several different subjects. A minimum list of subject areas is provided in the APPENDIX F inspection forms. Additional subject areas may be added to the form as deemed necessary by the inspector. For example, a separate subject block may be provided for each specific ground leg, or inspection information on all the ground legs may just be provided under one block.

The following comment headings are provided in the basic inspection form.

General: State the final condition assessment of the mooring to include both its condition rating (i.e. C1-C4) and overall condition readiness (Maximo) value. If the mooring has been downgraded from its original design use, state the revised limitations to its usage. State what is required to return the mooring to a rating of C1 and its intended design use. Record vessel class moored to the vessel during the inspection. List marine conditions (i.e. currents, tide conditions) encountered during the inspection.

Buoy: List serial data found on the buoy. Provide supporting documentation to the buoy inspection results provided in section one.

Top Jewelry: List serial data found on top jewelry components. Provide supporting documentation to the top jewelry inspection results provided in section one. State presence or absence of cotter pins, safety bolts, lead plugs, etc. Provide any additional caliper measurements taken.

Riser: State the overall condition of the riser (i.e., good, fair, poor) and how measurements were taken (i.e. single or double link). Summarize the overall results of caliper measurements. If measurement sets have different results, then provide this detail in this section. Provide assessment to swivel shackles, connecting links and other attachments as to wear, assembly, presence/absence of lead plugs, caliper measurements, etc. State water depth of the ground ring recorded during the inspection.

Ground Legs: State the overall condition of the ground legs (i.e., good, fair, poor) and how measurements were taken (i.e. single or double link). Summarize the overall results of caliper measurements. If measurement sets have different results, then provide this detail in this section. Provide assessment to swivel shackles, connecting links and other attachments as to wear, assembly, presence/absence of lead plugs, etc. List the headings of the ground legs and the heading reference (i.e. from ground leg toward the anchor, or vice-versa). State if and when ground legs become buried and unable to be inspected. State tension condition and overall layout of the ground legs (i.e. are they slack or in tension; do they generally head in a straight line or have significant changes in headings; are they twisted with other legs, etc.). If sinkers are found, state their location and condition assessment of the sinker's attaching hardware. One may add additional blocks for each ground leg if needed.

Anchors: If anchors are found, state the overall condition of the anchors, whether they are buried and how deep, if the flukes are pointing up or down, if there are stabilizers. Record the percentage of anchors improperly installed or upside down. State the measurements of the anchors and verify the proper size. State if the anchors were surveyed (results though will be included in the survey paragraph below).

Anodes: State the size anode used for replacement. State the quantity of anodes replaced on the mooring system to include those installed on the buoy's lower tension bar padeye. State the overall assessment of the existing anodes found on the mooring system.

Marine Growth: Provide an overall condition assessment as to the type, hardness and amount of marine growth found on the bottom of the buoy, the top section of the riser, the bottom section of the riser and on the ground legs.

Survey: State whether the mooring buoy was surveyed or not. If the anchors are also surveyed, provide results in this block as well. State the type of survey equipment used and its reported accuracy. List the complete datum description used to record the survey and its surveyed reference measurements (i.e. U.S. feet or meters). State if a vessel was using the mooring during the survey. State software used for any coordinate conversions.

Bottom: State the type of soils found at the mooring.

Photo: Provide an identification photo of the mooring buoy. If the buoy identification is stenciled on the buoy, ensure that it is visible in the photo. Other specific photos from the underwater inspection of interest would be provided in section 3 of the body of the main report (Engineering Results).

It is recommended that supporting statements for C2, C3 or C4 conditions be highlighted in within the inspection comments.

4-3 INSPECTION FIELD OUT BRIEF.

A post-inspection out brief (debrief) should be performed by both the EIC and the project dive superintendent, providing initial results of the mooring inspection and any immediate revisions to the operational use of the mooring known at the time. The post-inspection debrief should be presented to the local activity custodian, but may include representatives from vessels, FEC or base tenants as local protocols dictate.

Ensure that the activity custodian knows that a preliminary inspection email providing initial inspection results will be sent out within 2 weeks and that the final inspection report will be provided within 90 calendar days.

4-4 PRELIMINARY INSPECTION EMAIL.

A preliminary inspection email is sent out by the EIC within 2 weeks of completion of the on-site inspection for underwater inspections only. The inspection message should be addressed to the local activity custodian's command as well as any activity that uses the moorings. Other commands whose responsibilities include base and mooring conditions should be included. The diving detachment's command (or private company) should also be included.

The preliminary inspection email should provide preliminary results of the inspection to include whether zinc anodes were changed out or not. The message should include contact information for the Inspector and when the detailed inspection report is expected to be released.

A sample preliminary inspection email is provided in APPENDIX E. This sample provides the body of the email.

4-5 DOWNGRADING OF FLEET MOORING SYSTEMS.

A mooring that is assessed to be in C2 or C3 condition (Fair) is downgraded to the next lower mooring class until repairs are performed to return the mooring system back to a C1 (Good) condition and satisfactory for continued fleet use.

Moorings that are assessed to be in C2 or C3 condition should be evaluated by a mooring engineer to determine what restrictions must be imposed on the mooring system until repairs can be performed to restore the mooring to its original design requirement. These restrictions can include reductions in environmental criteria before the vessel must vacate the mooring or a reduction in vessel class that can use the mooring under the original design criteria. The mooring capacity of the assessment must be within the downgraded class.

Sometimes the downgraded mooring class may not impact mooring operations at the site as the design vessel may have changed over the life of the mooring and current design requirements (i.e. a smaller class vessel) are lower than the original mooring design criteria (sometimes the inspector may find that the requirements for the mooring have increased requiring upgrades to the mooring as well as an engineering evaluation of the mooring for the new increased requirements). If the mooring was overdesigned for the design vessel (i.e. larger size components were used due to availability rather than what the design would call for) then the mooring in its interim class may still meet the original mooring requirement. Nevertheless, a full engineering evaluation of a downgraded mooring is required.

4-6 MOORING INSPECTION DOCUMENTATION REPORT.

A mooring inspection report is sent out by the EIC within 90 calendar days of completion of the on-site inspection. The inspection is provided to the local activity custodian's command as well as any activity that uses the moorings. In addition, the report should be sent to concerned higher commands as well as the inspecting organizations commands.

The inspection report is divided into three sections as described below.

4-6.1 Section One – Purpose.

This section states who, when and where the inspection was performed. It states the purpose of the inspection, as well as the use of zinc anodes. The section should include the inspection rated condition and condition readiness criteria of the mooring.

4-6.2 Section Two – Inspection.

This section provides background information on the location of the mooring systems that were inspected, their mooring configuration, the type of diving requirements used to perform the inspection, the type of survey used to perform the inspection and representative photographs of the mooring system buoys or components. To aid in inspection planning for future inspections at the location, a table should be included that lists all moorings at the location, their riser and ground leg chain sizes, the buoy type and diameter and, if appropriate, the quantity of zincs replaced during the inspection. A Points of Contact (POC) table is included at the end of Section 2, providing a listing of the points of contact for the inspection. Theses POC's are usually the Inspector, Mooring Manager, the custodian, the diving superintendent, etc.

4-6.3 Section Three – Results.

This section provides the inspection results, discussion of inspection findings, results of engineering analysis and recommendations for mooring sustainment actions, repairs, upgrades, etc.

4-6.4 References.

A separate section, after Section 3, Results, and before any Appendices. References used to document the inspection report are included here. These references will always include the design and installation reports but can also include from this guideline, mooring drawings, software analysis of the mooring, previous inspection reports, etc.

4-6.5 Documentation Report Appendices.

The following appendices are included in the inspection report document.

- **Appendix A -** Inspection Data: Provides the completed mooring inspection forms for all moorings inspected.
- **Appendix B -** Survey Results: Provides a description of the survey equipment used during the inspection, benchmarks used and surveyed location of buoys and/or anchors computed during the inspection. If using a DGPS (Differential Global Positioning System), what was used to

provide what was used to serve as the base station or what commercial service was used. The coordinates used to record results are provided in Easting and Northings as needed by the local activity or custodian. If different, results should also be provided in the same datum used for prior inspections. Results should also be provided in geodetic latitudes and longitudes, World Geodetic System 1984 (WGS84). This Appendix may also include the actual survey data and tables listing comparison of surveyed locations between the inspection and prior inspections and/or installations.

- **Appendix C -** Mooring Usage Charts: Provide a copy of the current mooring usage chart for all inspected moorings. These charts are revised in accordance with results obtained during the inspection. Actions such as downgrading the mooring, new design requirements, rated conditions below C1 would require an updated mooring usage chart be provided to the custodian.
- **Appendix D -** Mooring Property Records: Provide a copy of the current mooring property record to include the most recent mooring configuration drawings for all inspected moorings. These records are revised in accordance with results obtained during the inspection. As these records also tell the custodian when the next planned fleet mooring action is to be performed (i.e. sustainment, repair, upgrade, removal, etc.) as the next scheduled inspection, they are updated as part of the documentation of an underwater inspection.
- **Appendix E -** Engineering Analysis: This section provides support documentation of engineering analysis performed as part of the inspection report. These files may consist of wind and current force calculations, chain wear assessment, analysis input and output files, etc.

Since the mooring inspection report is standardized, completion of sections one and two are very similar in format and content to prior inspection reports for that site. The Inspector will spend the majority of his/her time completing section three as well as Appendices A. B and E (if necessary).

A mooring inspection report template is provided in APPENDIX F.

CHAPTER 5 MOORING MAINTENANCE AND REPAIR

Safety Warning:

Ensure all personnel have, maintain, and wear PPE (steel toed shoes, personal floatation vest, hard hat and other PPE for specific tasks i.e. leather gloves, safety glasses, etc.).

Daily safety briefs should emphasize everyone’s responsibility for applying risk management.

5-1 MOORING STUD LINK ANODE REPLACEMENT.

Anode replacement has been covered previously, see Section 3-2.13, and is usually done as part of a mooring inspection. The method to replace these anodes is repeated here.

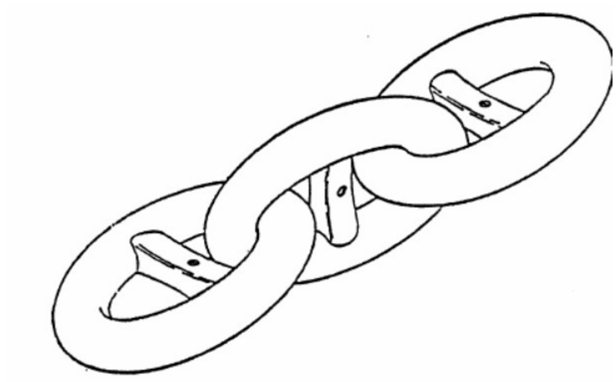
Replacement of zinc anodes is generally performed using the following procedures:

- Using an adjustable wrench or a 9/16-inch socket wrench, remove the existing anode screw and anode body from the chain link. For chain links that do not show an existing zinc anode, some cleaning of the chain link at the stud may be required to find the remaining anode. If all that is found is a screw inside a sleeve, that indicates that the anode material has been completely consumed.
- Using a small brush, clean out the anode mounting hole of debris.
- Attach a new anode to the stud of the chain link using a new screw.
- Tighten the anode to the chain link by applying a torque approximately 20 to 30 foot-pounds (27.1 to 40.7 N-m).

As the bolts are only 3/8-inch (9.5 mm) in diameter, applying too much torque could shear the screw. If the zinc feel's tight when grabbed by the diver's hand, it has sufficient torque to provide the necessary metallic path for the cathodic protection to properly perform.

Mounting holes for anodes are on the same side of every other chain link in a shot as shown in Figure 5-1.

Figure 5-1 Location of Anode Mounting Holes on FM3 Chain Links



Periodically, the diver will find chain links where the anode bolts were sheared at the stud during installation, preventing anodes to be attached to the chain link. The quantity of chain links unable to attach a zinc anode to should be recorded in the comment section of the mooring's inspection data sheet.

There are several methods that have been used on site to perform anode change out operations. Most methods involve the initial removal of the existing anodes, the initial loose attachment of new anodes followed by the tightening up of the new anodes. A supply of zincs is usually placed in a canvas bag positioned near the divers by topside support personnel. These tasks are usually divided among a dive buddy team based on diving conditions at the site, the quantity of zincs to be replaced and the direction of the dive supervisor. Diving operations shall be performed in accordance with US Navy Diving Manual (DoD dive units) or EM35-1-1, chapter 30 (non DoD dive units).

5-2 MOORING IN-SERVICE MAINTENANCE AND REPAIR.

5-2.1 Scope.

In-service maintenance and repair will be limited to the following:

- Minor underwater repairs.
- Minor buoy and riser assembly repairs.
- Replacement of damaged buoys and/or riser assemblies.

It should be noted that sufficient lift capability will be needed for replacement of buoys and/or riser assemblies and, in many instances, for repairs.

All mooring hardware must be tied down to prevent unplanned movements on the deck during transiting or from vessel motions during operations.

5-2.2 Equipment.

The following equipment must be readily available for use as needed:

- Crane barge, floating crane or vessel with lifting capacity, stability, quantity and size hooks, boom length and reach and if at all possible, means of self-mooring.
- A chain capture device (CCD) to securely stop off the chain to permit placement of the buoy onto the deck without personnel going underneath the load or in the fall zone.
- Tugboat, mule, or other vessel (for maneuvering and positioning the crane platform).
- Plenty of spare mooring connector hardware.
- High-pressure water pump (100 psi) and hose (for cleaning).
- Oxygen/acetylene kit and welder for chain cutting and welding operations.

5-2.3 Procedures.

Safety Warning:

At no time shall personnel be directly under a suspended load when the load is out of the water. Personnel on the barge deck shall be kept clear of the fall zone of the buoy and the riser chain to the maximum extent possible. The fall zone includes the area where a suspended load may fall. Personnel should be aware that the fall zone is moving as the buoy is lifted over the deck. Only qualified personnel, in accordance with EM385-1-1, under specific instruction from the designated Marine Construction Superintendent, may enter the fall zone to handle a load.

The buoy should be lifted only as high as minimally required.

Operation planning must include the use of a chain capture method that minimizes the necessity for personnel to work under suspended load.

Use a Load Indicating Device (LID) or crane equipped LID or Load Moment Indicator to determine the load for all installation/retrieval lifting operations.

Every attempt should be made to plan operations that keep DIVERS from working under the load. If no alternatives can be found, every effort should be done to minimize the diver’s time spent under the load.

5-2.3.1 Buoy Replacement (Riser-Type Mooring System).

A buoy in a riser-type mooring system can be replaced without removing the mooring. Proceed with the replacement as follows:

5-2.3.1.1 Lifting the Buoy out of the Water.

While planning the lift, make sure the type of buoy is known (foam or steel, peg-top or drum, tension bar or hawse pipe). If steel, make sure that the inspection showed no evidence of buoy flooding (visible holes, listing, etc.). Conduct pre-lift inspections of all connections on buoys prior to connection. If the buoy is flooded, it can still be lifted, but the weight of the entrapped water must be taken into account. If a tension bar buoy, make sure that there is no evidence of damage/excessive wear to the tension bar. If there is damage, it would be best to lift the buoy from the riser just below the buoy. If a steel hawse pipe buoy, then it is extremely difficult to ascertain the strength of the capture plate assembly between the riser and the buoy. Therefore, lift the buoy from the riser rather than from the top jewelry. Do not use the side pad eyes for lifting unless specific “as built” drawings of the buoy are available that a Professional Engineer can use to determine the padeye’s working capacity for the planned use (i.e. lifting, lashing, maneuvering of buoy in water, small boat tie-downs, etc.). The crane should have two hooks, a main and an auxiliary of sufficient lift capacity at the working area. Use the main hook to lift from the riser and the auxiliary hook to lift and control the buoy in a 2-point pick. Attaching to the riser may require either divers to attach rigging or a heavy and long wire rope assembly to secure the mooring riser in either a choker hitch or in a basket hitch. Alternatively, remove the capture plate and lower the mooring riser to the bottom for future recovery. Recover the buoy by itself by lifting from suitable padeyes or from a chain bridle or other lifting device that is passed through the hawse pipe. The lift plan for recovery of steel hawse pipe buoys should be reviewed by a Professional Engineer. The lift plan must meet requirements of EM 385-1-1 for critical lifts as all in-water mooring lift operations are critical lifts.

On the newer foam hawse pipe buoys, the hawse pipe extends out of the urethane shell. The capture plate and its connecting bolts to the hawse pipe flange are exposed, but it is still difficult to determine the condition of the bolts. On these foam hawse pipe buoys, the existing capture plate and bolts can be replaced with new bolts and a capture plate specifically used for lift operations only.

Make sure you are familiar with crane safety and how it applies in this application. Review Paragraph 5-2.4 below on Crane Safety. Prepare and submit critical lift plans in accordance with EM 385-1-1 for acceptance by the cognizant authority. Ensure that operations are conducted within allowable wind and/or sea state conditions. It is preferable to conduct these types of operations during periods of minimal winds (moderate breeze, 11 knots or less), low tide and slack current conditions and from an anchored barge or a barge with winch operated spuds.

As floating crane or material barges generally have a freeboard between 5 to 8 feet, review the mooring drawings and water levels at the site to ensure that the mooring buoy will be able to be lifted onto the deck of the barge.

The following are generic steps for replacement of a mooring buoy:

- Bring the vessel alongside the buoy such that the crane can reach the buoy. If the vessel has its own anchors, anchor the vessel alongside the buoy. If the vessel is a spud barge, drop the spuds to the bottom to maintain position. Otherwise use the vessels drives or supporting tugboats to maintain position.
- Tie a soft line from the vessel to the buoy.
- Conduct a pre-lift briefing, if not already done so, with all personnel to include signalmen, riggers, crane operator, marine construction superintendent, safety personnel, deck winch operators and representatives from supporting tugboats.
- Rig the buoy in accordance with the accepted critical lift plan.
- Lower the crane hook(s) and attach the rigging to the crane hook(s).
- Begin taking in on the crane until the crane begins to see a load and the wire becomes taut.
- Untie the soft line from the vessel to the buoy.
- At this point, the vessel is effectively moored. The further up and out of the water, the tighter the mooring and the less movement will be seen. However, care must be taken not to overload the anchors, so continue to monitor the vessel location and use the vessels propulsion system to maintain position.
- Continue to lift the buoy until the bottom of the buoy is between 5 and 10 feet (1.5 and 3.1 m) over the chain capture device on the deck of the barge.
- Position the mooring riser into the chain capture device and secure the mooring riser into the chain capture device. One should keep at least 5 feet (1.5 m) of mooring riser chain above the chain capture device’s locking mechanism.
- Lower the buoy onto the deck (see Figure 5-2). Add blocking, bracing or tiedowns to prevent buoy rolling or movement during operations.

Figure 5-2 Mooring Riser Secured into a CCD

- Attach a secondary connection to the mooring riser, if not integral to the chain capture device. The secondary connection should be designed to support the loads as configured.
- Disconnect the mooring buoy from the riser. This can be done by either disconnecting the connecting hardware (usually either a riser swivel shackle or an anchor bolt shackle and anchor joining link) or one can cut the mooring riser (using an oxygen/acetylene torch) 2 to 3 full links above where it is secured in the chain capture device. Then use a spare chain joining link to reconnect the new buoy to the riser.

<u>Safety Warning:</u>

Adhere to EM 385-1-1 and OSHA 1910.253 for safe use of oxygen/acetylene torch.

- Disassemble the connections to the bottom of the buoy from the riser.
  - If the bottom connection is a swivel shackle, melt the lead plugs on the upper bale of the swivel shackle to remove the tapered pins. Place dunnage underneath the swivel shackle to prevent it from dropping onto the deck and potentially onto a worker's foot. Using a heavy sledge hammer, remove the top swivel pin until it clears the buoy padeye. Ensure all appropriate personal protective equipment (PPE) is being used (i.e. gloves and eye protection).
- If the riser connection to the buoy is an anchor shackle-anchor joining link combination, remove cotter pins and/or safety bolts and if present, grind the weld off between the nut and pin. Place dunnage from dropping onto the deck and potentially onto a worker's foot underneath the shackle. Take off the shackle nut and pin to disconnect it from the buoy. Melt the lead plug and using a pin punch and a sledge, knock out the tapered that holds the AJL together. ensure that the tapered pin is not knocked overboard.

Disassemble the AJL, making sure to save all the parts. Ensure all appropriate personal protective equipment (PPE) is being used (i.e. steel toes shoes, life vest, hard hat, gloves and eye protection).

- If the connecting hardware cannot be disassembled, you can cut it using a torch.
- Rig and swing the removed buoy to its storage location on the deck. It is recommended that the buoy be lifted using a 2-point pick. For hawse pipe buoys, attach rigging to the chain pigtail sticking out of the hawse pipe at both ends. For tension bar buoys, one can use the top buoy shackle as one connection point and the empty bottom buoy padeye as the other connection point. Using a 2-point lift on a tension bar pegtop shaped buoy will make it easier to place the buoy into a buoy cradle, if present or on dunnage if no buoy cradle is available. Providing that the bottom connecting hardware is in satisfactory condition, one could also attach rigging to the bottom buoy connection hardware, move the buoy to its storage location and disconnect the hardware at that location.
  - Note that as the buoy is already on its side, another option would be to flip the buoy upside down and store the buoy on its top. If doing so, one must remove the top jewelry from the top of the buoy. Bear in mind that enough dunnage is needed under the buoy to keep the top tension bar padeye or top deck capture plate assembly off the deck.
  - For either option, personnel should be clear of the moving fall zone and the buoy should be lifted only as high as minimally required.
- Disconnect the crane from the old buoy.

5-2.3.1.2 Installing the New Buoy.

The following are generic steps for installation of the replacement mooring buoy:

- Pre-rig the new buoy’s bottom connection using either the removed connecting hardware or new connecting hardware.
  - Confirm that the AJL is fully assembled and lead plug is properly in place. For the buoy shackle, confirm that all the safety features are used, the cotter pin is in and spread and that the nut is tack welded to the shackle.
  - If using a riser swivel shackle, confirm that the swivel shackle is fully assembled and all 4 lead plugs are properly in place.
  - Confirm and note the manufacturing data for all components installed onto the new buoy to include the new buoy as well as the chain joining link if joining a short piece of chain to the mooring riser.
- Rig the original or new top jewelry on to the buoy. Confirm that all safety features are used on the attached top jewelry, such as cotter pins and/or safety bolts on shackles and buoy release hooks.

- If a section of the mooring riser was cut to free the old buoy, and if this cut section of chain is still in good condition, attach it to the new buoy's connecting hardware.
- Connect the crane to the new buoy using a 2-point pick to place the buoy sideways near the mooring riser. Lift the new buoy and swing it over where the riser chain is tied to the vessel. Personnel should be clear of the moving fall zone and the buoy should be lifted only as high as minimally required.
- Lower the buoy to the deck with the bottom connecting hardware of length of chain close to the bitter end of the riser. Place dunnage along both sides of the buoy to keep the buoy from rolling.
- Using a CJL, attach to riser to the chain under the buoy. Confirm that the lead plug is properly in place.
- Rig the connected buoy in accordance with the accepted critical lift plan. Disconnect the secondary connection to the mooring riser.
- Lift the buoy and swing outboard until the riser is over the chain capture device. Continue to lift until the load of the riser chain is on the crane. Once the load is off the chain capture device, release the mooring riser from the chain capture device.
- Lower the buoy into the water. When the sling is slack, tie the buoy to the ship using a soft line and then rigging from the mooring system. Untie the soft line, freeing the buoy.
- Move the vessel away from the buoy.
- Using high-pressure hose, wash the marine growth from the old buoy if permitted by local base policy. Otherwise, using flat shovels or scrapers, remove marine growth and place into plastic bags for disposal in accordance with local base policy.

An operational risk management (ORM) approach should be used to develop specific buoy replacement procedures based on local environmental conditions, project equipment and vessels and experience of the deck force.

Safety Warning:

If lifting a hawse pipe buoy, treat the lift as if the capture plate assembly is damaged and lift from below, while simultaneously lifting the buoy. On the newer ATFP and FMP foam hawse pipe buoys, the bolts that make this connection are exposed, but it is still difficult to determine the condition of the bolts. On these foam hawse pipe buoys, the existing capture plate and bolts can be replaced with new bolts and a capture plate specifically used for lift operations only.

Safety Warning:

Additional care is needed to make sure the additional loads on the crane (from lifting the ground ring out of the water) are taken into account. In addition, the stability issues based on these extra loads must also be accounted for.

Safety Warning:

If the tension bar is damaged, it is best to lift the buoy from below to take most of the weight off of the buoy/tension bar. A secondary crane hook should be used to simultaneously lift the buoy, keeping the buoy weight off the lift.

Section 5-2.3.2 through 5-2.3.6 provides an overview of some of the mooring sustainment operations. Actual procedures used are dependent on local environmental conditions, the mooring design, local environmental permit requirements, project equipment and vessels and experience of the deck force. These conditions will require the project team to develop a detailed execution plan specific to the mooring system to be repaired.

5-2.3.2 Riser Replacement.

Make sure you are familiar with crane safety and how it applies in this application. Review Paragraph 5-2.4 below on Crane Safety. Prepare and submit critical lift plans in accordance with EM 385-1-1 for acceptance by the cognizant authority. Ensure that operations are conducted well within allowable wind and/or sea state conditions. It is preferable to conduct these types of operations during periods of minimal winds (moderate breeze, 11 knots or less), low tide and slack current conditions and from an anchored barge or a barge with winch operated spuds.

Site conditions (water depth, currents, tides, predominant winds), mooring riser age and/or condition (C3 or C4), amount of chain slack (can the portion to be replaced be brought onto the deck of the work barge?) mooring configuration (riser-leg or riser-type), presence of ground legs (must the ground ring be brought on deck?, is there sufficient slack in the ground legs or must one or more be removed?), previous installation documentation will require the repair team to develop specific plans and procedures for the mooring ground leg repair operations.

The buoy removal from the mooring riser and subsequent attachment to the repaired mooring riser can be performed as described in Paragraph 5-2.3.1.2. Whether the riser is attached to multiple ground legs via a ground ring (Riser-type) or is a single riser that is attached to the anchor (riser-leg) will dictate the specific installation procedures.

For a riser-leg mooring system, the primary concern would be if the portion of the riser needing replacement can reach the deck with enough slack for the deck force to secure the riser into a CCD and perform the repairs. The local tides should be consulted and the repair procedures developed to perform the repairs at a decreasing tide level and be completed before the tide levels start to significantly increase (particularly at locations that have a large diurnal tide range). The repair team should monitor the tides to ensure that the secured mooring riser doesn't overload its deck attachments.

For a riser-type mooring system, the presence and condition of multiple ground legs will dictate the installation procedures. If the ground legs do not have sufficient slack for the portion of the mooring riser to be repaired to deck with enough slack for the deck force to secure the riser into a CCD and perform the repairs, then one or multiple ground legs may have to be removed. Additionally, any attached ground legs will need to be secured onto additional deck attachment points. Once the mooring riser is repaired, some additional chain may need to be added to the last detached ground leg to get all of the mooring system reconnected before lowering the system overboard to a point where the mooring buoy can be reattached.

An operational risk management (ORM) approach should be used to develop specific riser replacement or repair procedures based on local environmental conditions, project equipment and vessels and experience of the deck force.

5-2.3.3 Ground Leg Section Replacement

Make sure you are familiar with crane safety and how it applies in this application. Review Paragraph 5-2.4 below on Crane Safety. Prepare and submit critical lift plans in accordance with EM385-1-1 for acceptance by the cognizant authority. Ensure that operations are conducted well within allowable wind and/or sea state conditions. It is preferable to conduct these types of operations during periods of minimal winds (moderate breeze, 11 knots or less), low tide and slack current conditions and from an anchored barge or a barge with winch operated spuds.

Replacement of sections of the ground leg is usually performed on the portion of the ground leg that is connected to the ground ring.

Site conditions (water depth, currents, tides, predominant winds), mooring age and/or condition (C3 or C4), amount of chain slack (or lack thereof), mooring configuration (riser-leg or riser-type), previous installation documentation (how were the ground legs originally installed? Do they have sufficient slack? Estimated catenary forces of the ground legs once the end is recovered on deck), will require the repair team to develop specific plans and procedures for the mooring ground leg repair operations.

If only a few links need to be replaced, and there is sufficient slack in the ground legs, then each ground leg can be cut from the ground ring and the short section replaced in a similar manner as replacing a riser segment.

It is preferable to replace long sections of a ground leg using a double drum winch with two wires recovering the ground leg over a roller (see Figure 5-3) in a “hand-over-hand” procedure with the anchoring system, or tugboats, pulling the crane barge in the direction of the ground leg. The other ground legs can remain attached to the ground ring with a recovery wire attached to the ground ring or attached riser segment and to a pick-up buoy. Once the worn section of the ground leg is recovered, multiple stoppers are secured to the ground leg on the portion of the ground leg near the barge edge that will remain. One can then replace the worn portion of the ground leg in a similar manner as replacing a riser segment as described in Paragraph 5-2.3.2.

Figure 5-3 Recovery of a Ground Leg over a Roller

The repaired ground leg is placed back into the water using the double drum winch in a similar fashion, but in reverse, with the anchoring system, or tugboats, pulling the crane barge back toward the ground ring pick-up buoy.

The ground ring is recovered and the replaced ground leg reattached to the ground ring. Note that it may be required to detach the next ground leg to be repaired first.

This process is followed until all ground legs are repaired as required. The last ground leg may need to be lengthened in order to be attached to the ground ring.

An operational risk management (ORM) approach should be used to develop specific ground leg replacement or repair procedures based on local environmental conditions, project equipment and vessels and experience of the deck force.

5-2.3.4 Buoy Replacement (Non-Riser-Type Buoy).

A non-riser-type buoy will be more difficult to retrieve than a riser-type. If the mooring has been properly installed, there will be a catenary section of chain suspended in the water between the buoy and the anchor. If the catenary angle is large (as in a taut, properly installed mooring), then it may not be possible to stopper off all four anchor chain leg subassemblies on the barge deck simultaneously. It should also be noted that, in this type of installation, the buoy is kept in place by balanced opposing forces created by the catenaries of the anchor chain leg subassemblies. When one of the leg subassemblies is cut, the buoy will be pulled in the direction of the opposing leg. This pull will result in a potentially dangerous side loading (horizontal force) on the crane boom, especially if the buoy is being held aloft when the chain is cut. Connecting the replacement buoy to the anchor chain subassemblies is also difficult under these conditions. Therefore, in the case of a taut mooring, it is recommended that the non-riser buoy system be completely recovered prior to replacing the buoy, and that the mooring be reinstalled. This may involve the use of divers and cutting the chain at the seafloor. However, in many non-riser installations, significant slack exists in the anchor chain leg subassemblies directly below the buoy. In such cases, it may be possible to lift the buoy and simultaneously stopper off the legs on the barge deck. The new buoy can then be connected to the anchor chains and replaced in the water. There are actually very few of these buoys still in service with DoD, therefore procedures will need to be developed that are unique to that site.

5-2.3.5 Steel Buoy Minor Repairs.

In-service minor repairs to a steel buoy, such as replacing a fender, repairing an upper hull puncture, patching fiberglass or polyurethane, replacing anodes, replacement of the top hardware or spot painting the buoy, can be accomplished without taking the buoy ashore. In most cases, it is better to lift the buoy on to the deck rather than attempt the repair with the buoy still in the water.

Safety Warning:

Never cut or weld to the surface on an enclosed void (such as a steel buoy) until the interior has been properly ventilated and gas free. Potentially explosive gases can accumulate within the buoy.

Safety Warning:

No person should enter the buoy while the buoy is still in the water. A person should only enter the buoy when there is no possibility of the buoy sinking, i.e. either on the deck of the barge or ashore.

Entry of personnel into a buoy must comply with EM 385-1-1 and cognizant base requirements for confined space entry.

Safety Warning:

On a steel buoy, the buoy manhole cover must not be removed while the buoy is still in the water.

If a wood fender has been damaged and requires replacement, have a new fender cut to shape and holes drilled as required. While this should work, a drill and properly sized bit should be brought out to the buoy. Simply remove the bolts holding the fender in place and remove the old fender. Replace it with the new fender.

If the fender attachments have been damaged, it will be necessary to scarf off the old attachment pieces and weld on new ones. This can be done on site but must be accomplished on the deck of the barge. Never cut or weld to a surface on an enclosed void as potentially explosive gases can accumulate within the buoy. Open the manhole cover and let the buoy ventilate before any cutting or welding. A fan or blower can speed up the ventilation process. Once the interior has been properly ventilated and assured that it is gas free by a certified marine chemist, cutting and welding can occur.

If it is necessary to enter a buoy, this should be done only when the buoy is ashore or aboard a barge where there is no possibility of the buoy's sinking. Special care must be taken to reseal the manhole and assure watertight integrity.

During the inspection of a mooring buoy, its associated top and bottom hardware should be closely inspected to determine whether any components need to be reconditioned or replaced. When reconditioning/replacement is required, the following should be observed:

- Welding chain appendages or cutting out retaining pins or rivets with a torch should never be done because heating will introduce internal stresses and reduce the strength of heat-treated steel components.
- Ensure that shackles, joining links, and other such fittings with removable parts are treated with an appropriate grease preservative and refitted. Care should be taken not to interchange matched parts of joining links. This can be avoided by tagging each part of the joining link with a unique identification number or by matching the stamped numbers on the parts. Locking pins of joining links and shackles should never be welded in place due to the probable resultant loss of tensile strength of the component.

5-2.3.6 Steel Buoy Coatings.

Because protective coatings are frequently damaged by impact or abrasion, it may be necessary to make in-service repairs to coatings of mooring buoys. In order to repair these coatings, it is necessary to first clean the exposed steel and the area surrounding the steel of rust, salt, and loose material. This can be accomplished by wire brushing the steel (preferably power wire brushing) or by scrubbing with a bristle brush and then drying the area with an air hose connected to an oil free compressor (when required). The intact coating surrounding the damaged areas should be abraded to ensure proper bond of the repair material. There are several proprietary putty-like coatings available called splash-zone compounds, that can be spread over the cleaned area, wet or dry. MIL P-28579(YD) describes such a curing epoxy-polyamide formulation. There are also available a number of proprietary brush on coatings that can be applied to damp surfaces and will cure either above or under the water. Either type of coating should completely cover the steel and extend at least 1/2 inch (13 mm) over the cleaned coating surrounding the steel.

General coating operations, materials and safety precautions are described in NAVFAC MO-110, Paints and Coatings. The recommended coating system for steel mooring buoys is the Navy epoxy-polyamide system for interior and exterior ship surfaces, MIL-DTL-24441D(SH). Procedures for its use are described in Naval Ships Technical Manual, NAVSEA S9086-VD-STM-010 and S9086-VD-STM-020. For optimal results, the coating should be applied to a clean dry surface.

Fiberglass patching should be accomplished in accordance with NAVSEA 0900-LP-006-0010. Fiberglass coating materials should be prepared and applied by personnel who have demonstrated proficiency in the application of the materials.

5-2.3.7 Foam Buoys.

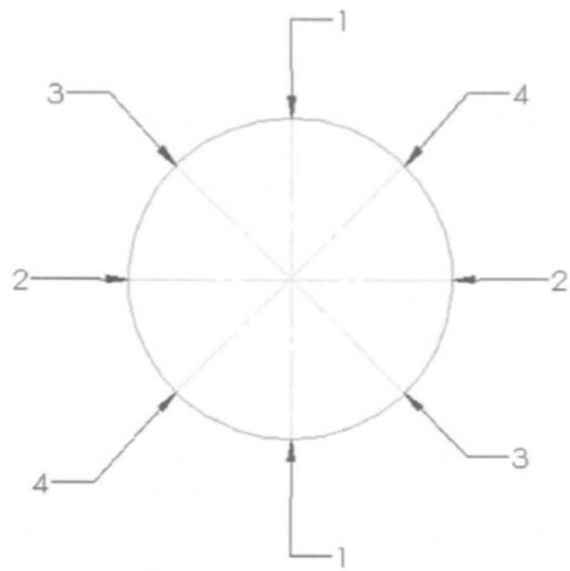
Minor damage to foam-filled polyurethane buoys can be repaired with commercially available patching kits containing the materials and procedures necessary to affect the repairs. Field repairs to the buoy hull should be limited to small rips, tears, punctures or gouges in the buoy skin and underlying foam.

The exposed tension bar and padeye on the tension bar should be cleaned to SSPC-SP3, Power Tool Cleaning and meet acceptable standard as listed in SSPC VIS-3 to permit proper inspections. The exposed tension bar and padeye should be coated with a phenalkamine epoxy meeting NAVSEA MIL-PRF-24647 to provide a dry film thickness of 8 to 12 mils. A topcoat of an aliphatic acrylic polyurethane finish having a dry film thickness of 2-4 mils should then be applied.

Chipped or missing paint on the padeye can be touched up with an epoxy-polyamide coating applied in accordance with MIL-C-22751D.

The bushing in the padeye should be inspected and replaced if the bushing has lost 50% or more of its original thickness (1/4-inch) or is severely corroded. To inspect the bushing, clean off rust and other debris using a steel wire brush. Using inside calipers, measure the inside diameter of the tension bar padeye with the bushing (Figure 5-4). Determine the remaining minimum thickness of the bushing by reviewing the buoy drawings to determine the original inside diameter of the bushing, padeye and bushing thickness.

Figure 5-4 Bushing inspection Points



If the bushing needs to be replaced, a new bushing of same size and material conforming to Abrasion-Resistant Bushing steel, ASTM A519, Grade 4140 should be used. Replacement bushings should be fabricated ahead of time to have onsite during foam buoy field refurbishment operations. Remove the existing bushing using a small right-angle grinder having a thin cut off wheel that can pass through the bushing, or a reciprocating saw with a 6 inches long blade. Care must be taken that you don't cut into the padeye itself. The appropriate PPE should be worn (specifically gloves and safety glasses).

Installation of the replacement bushing requires an interference fit of 0.001 to 0.004 inch (0.025 to 0.102 mm) radially. Clean and debur the inside of the padeyes to remove any sharp edges for the bushing to hang up on. Sand the edges and inside diameter of the padeye smooth and clean with rags and a degreaser.

Apply an epoxy adhesive to the inside diameter of the padeye just immediately before the bushing is installed.

The bushing should be cooled with liquid nitrogen to cause it to shrink in size and allow for it to be installed into the padeye. The bushing should be handled with pliers when placing into the liquid nitrogen and into the tension bar padeye. In addition to standard PPE for barge operations (steel toed, shoes, floatation vest, hard hat) leather gloves and safety glasses should be worn.

If the padeye was found to be enlarged in one area, it may need to be rounded out and an evaluation be made if the tension bar padeye is still strong enough to meet its design requirements for the mooring. Unless spare bushings having a larger outer diameter are available, a standard sized bushing may have to be used with a high strength epoxy to fill the gap. The mooring system may have to be downgraded until the buoy is replaced.

If there is a chance for bushing replacements to be performed during field repairs, it may be more cost efficient to replace the foam buoy with a spare foam buoy and complete foam buoy refurbishment ashore.

Replacement of the reflective tape involves removal of the old tape using a wide scraper and removing remaining adhesives from the buoy shell using warm soapy water, isopropyl alcohol or a biodegradable cleanser. Apply the replacement reflective tape tightly around the buoy shell using a squeegee insuring that air bubbles are removed. Attach the top band 6 inches below the buoy deckline and the next band 6 inches below the top band so that both tape bands are in the top 2 feet from the top deck of the buoy (mooring buoys should maintain an average minimum freeboard of 2 feet below its deckline). Note that for the standard small and medium foam buoys applying the reflective tape just above and just below its single urethane fender will keep both tapes within the top two feet.

As it is much easier to be replaced when the buoy is on deck, replacement of reflective tape should always be part of mooring repair operations that involve recovery of the buoy. However, though it is more difficult, the reflective tape can be replaced with the buoy in the water from a small boat.

Reflective tape replacement should be planned to be performed as part of the three-year underwater inspection.

Major repairs on foam buoys should be undertaken only with the advice and assistance of the buoy manufacturer.

should be undertaken only with the advice and assistance of the buoy manufacturer.

5-2.4 Crane Safety.

See APPENDIX B for a discussion of crane safety.

5-3 MOORING INSTALLATION AND REMOVAL OPERATIONS OVERVIEW

5-3.1 Scope

Installation and removal operations overview will be limited to the following:

- Installation of a drag embedment riser-type or riser-leg mooring system.
- Installation of an embedment anchor riser-leg mooring system.
- Removal of a drag embedment riser-type or riser-leg mooring system.
- Mooring anchor pull test.

This section provides an overview of some of the mooring installation operations. Actual procedures used are dependent on local environmental conditions, the mooring design, local environmental permit requirements, project equipment and vessels and experience of the deck force. These conditions will require the project team to develop a detailed execution plan specific to the mooring system to be installed, modified, repaired or removed.

All mooring hardware must be tied down to prevent unplanned movements on the deck during transiting or from vessel motions during operations.

5-3.2 Equipment

The following equipment must be readily available for use as needed:

- Crane barge, floating crane or vessel with sufficient lifting capacity, stability, quantity and size hooks, boom length and reach and if at all possible, means of self-mooring.
- A chain capture device (CCD) to securely stop off the chain to permit placement of the buoy onto the deck without personnel going underneath the load or in the fall zone.
- Tugboat, mule, or other vessel (for maneuvering and positioning the crane platform).
- Spare mooring connecting hardware.
- High-pressure seawater (100 psi) pump and hose (for cleaning) for removal operations.
- Oxygen/acetylene kit and welder for chain cutting and welding operations.

5-3.3 Procedures Overview

Safety Warning:

Every attempt should be made to plan operations that keep personnel from working under the load. If no alternatives can be found, every effort should be done to minimize the time spent under the load.

5-3.3.1 Drag Embedment Riser-Type or Riser-Leg Installation

Safety Note:

While preparing the anchors, positioning on deck for deployment and deploying the anchor, personnel should not go under the flukes or shank of the anchor.

Make sure you are familiar with crane safety and how it applies in this application. Review APPENDIX B on Crane Safety. Prepare and submit critical lift plans in accordance with EM385-1-1 for acceptance by the cognizant authority. Ensure that operations are conducted well within allowable wind and/or sea state conditions. It is preferable to conduct these types of operations during periods of minimal winds (moderate breeze, 11 knots or less), low tide and slack current conditions and from an anchored barge or a barge with winch operated spuds.

Site conditions, such as water depth, currents, tides, predominant winds, soil conditions (type soil, bottom slope), environmental constraints and restrictions (presence of corals, mammal watches, construction window, turbidity constraints, eelgrass, etc) as well as available installation vessels (type and capacity of floating crane barge, tugboats and material barges) and the mooring system design (number of legs, type of drag embedment anchors, length of ground legs, allowable ground leg slack, chain sizes, etc) will require the installation team to develop specific plans and procedures for the mooring installation operations.

For a drag embedment mooring system installation, unique concerns would be the (1) Anchor's fluke angle; (2) Orientation of the anchor as placed on the bottom; and (3) Its final location after proof testing.

The soil conditions will dictate the desired angle between the anchor flukes and the anchor shank (fluke angle). Most drag embedment anchors typically used, such as the common U.S. Navy stockess anchor, STATO and NAVMOOR anchors have a desired fluke angle for mud or sand/stiff clay or hard bottom conditions. Though the stockless anchor with flukes fully open is at the fluke angle for mud condition, it is still recommended to fix the flukes at the fully open position to ensure that it will bury into the soil during proof testing. Not fixing the flukes to its desired fluke angle may lead to excessive drag distances to meet the proof load or failure of the anchor to meet the proof load. The above drag embedment anchors should be equipped with stabilizers to reduce the risk of the anchor rolling during proof testing. Typical drag embedment anchor features are shown in Figure 5-5. Fluke angles for sand or mud for these typical drag anchors are shown in Figure 5-6.

Figure 5-5 Features of a drag anchor

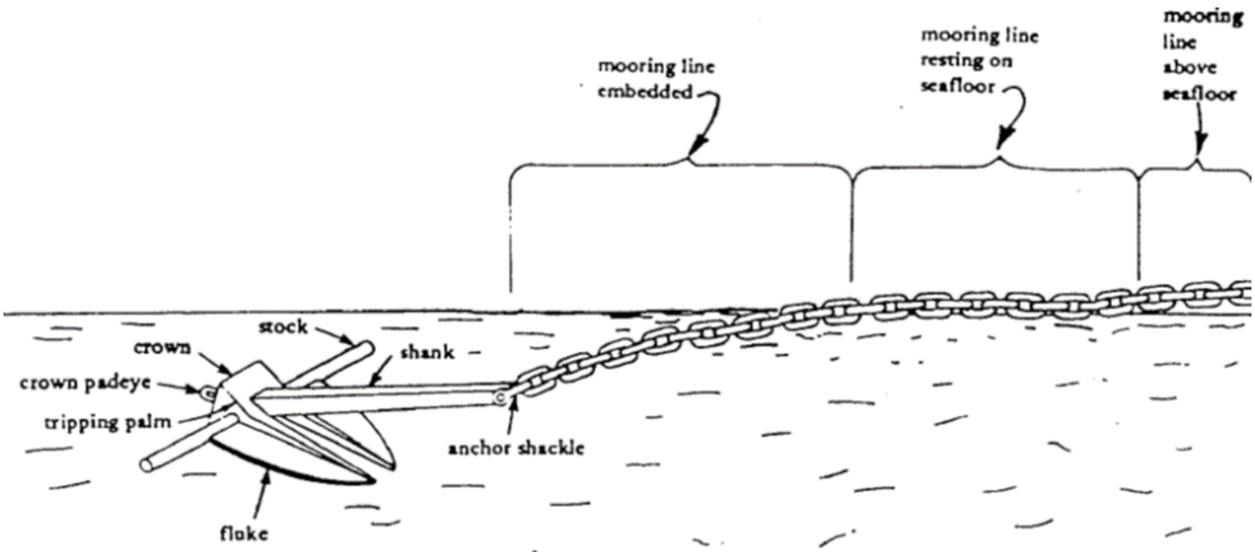
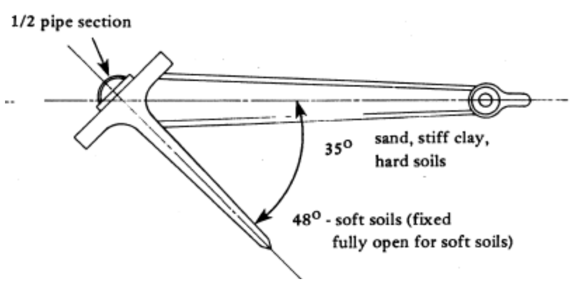
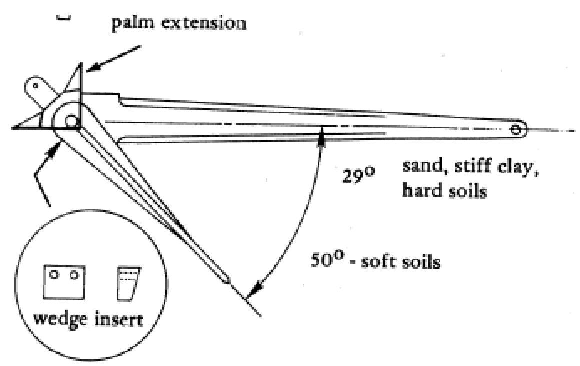


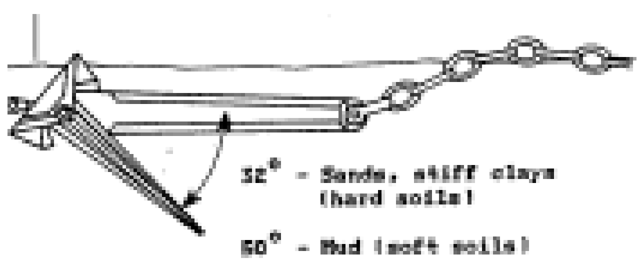
Figure 5-6 Fluke Angle Recommendations



Navy Stockless Anchor



STATO Anchor



NAVMOOR Anchor

High capacity drag embedment anchors such as the NAVMOOR come with a sand wedge that can be welded onto the shank if soils are not soft/mud conditions (see

Figure 2-19). Otherwise, steel plate or bar can be used to lock the flukes in the desired angle (see Figure 2-18 for a stockless anchor).

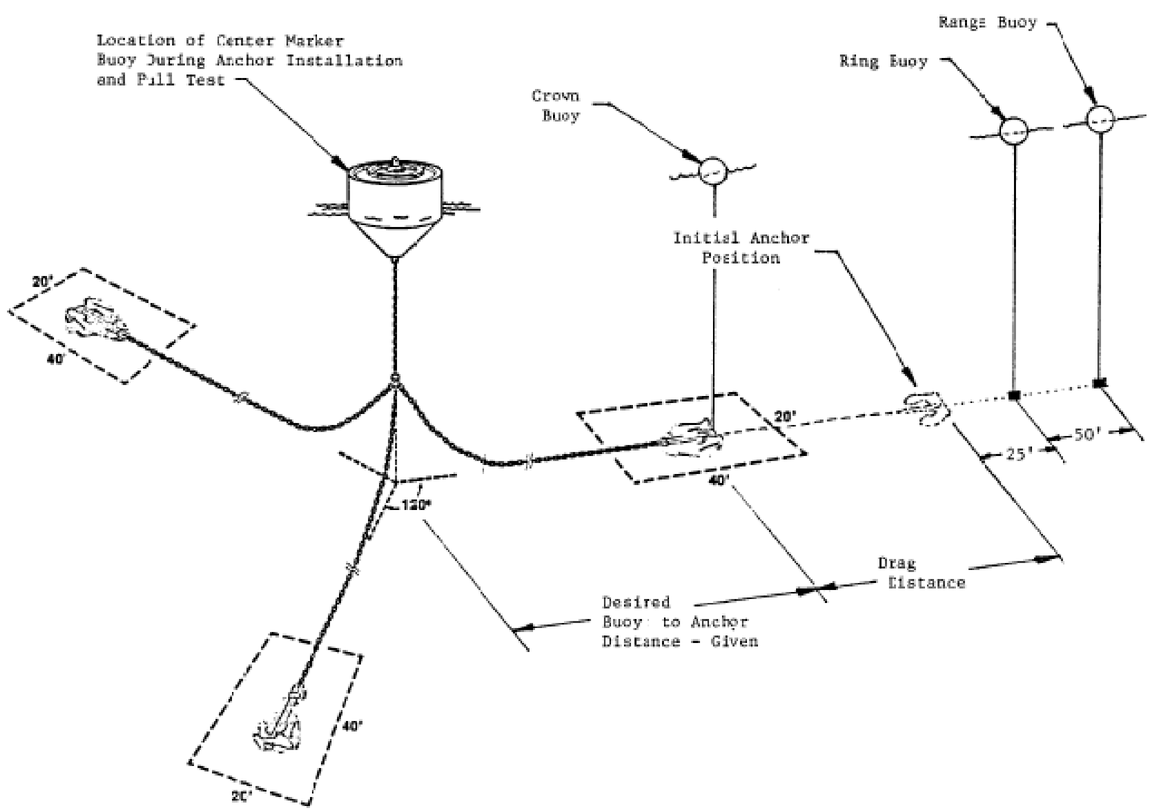
Once the flukes have been fixed, the anchor needs to be placed on the bottom with the flukes angled down toward the bottom and not toward the surface. As most locations, water depth is less than 50 FSW (MLLW) and floating crane barges with sufficient boom height will allow for a stockless anchor to be rigged and lowered in a horizontal configuration (Figure 5-7, NAVMOOR and Figure 5-8). Care must be taken to ensure that the attached ground leg chain does not impose any significant lateral tension on the anchor during deployment and initial touchdown. Lowering the anchor in a vertical orientation with its crown onto the seafloor risks the anchor's flukes not digging into the seafloor and the anchor sliding along the seafloor; particularly for the stockless anchor in soft sediments.

Figure 5-7 NAVMOOR Anchor Deployment

Figure 5-8 Stockless Anchor Deployment

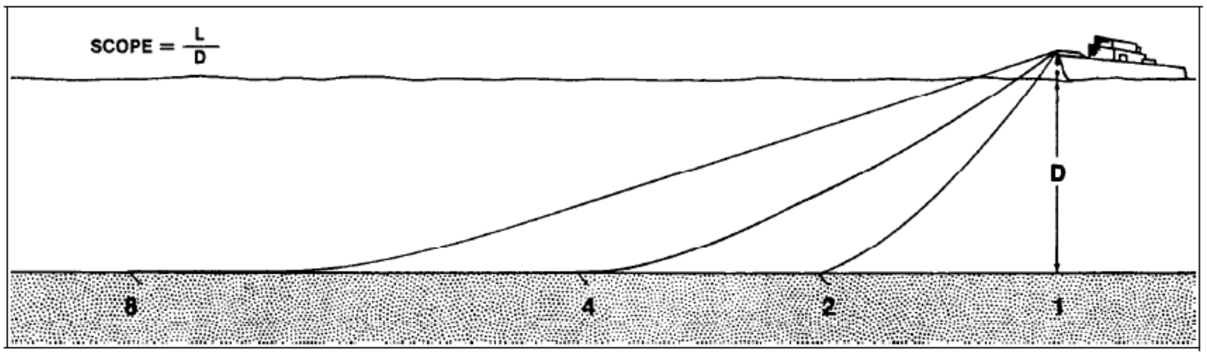
Several technical references are available to estimate drag distances for various types of drag embedment anchors. Drag distance is dependent on (1) soil conditions; (2) depth of the soil as there must be sufficient depth of soil for the anchor to develop its resistance; (3) fluke length; and (4) anchor line scope. For typical drag embedment anchors such as stockless, STATO or NAVMOOR, in addition to UFC 4-159-03, technical references such as ex-Naval Civil Engineering Laboratory (NCEL) tech data sheet 83-09 (Stockless and STATO anchor) and 87-05 (NAVMOOR) provide guidance on estimating drag anchor distances. Additionally, APPENDIX H provides drag distance tables taken from NAVFAC MANUAL MO-124. During installation operations, a marker buoy is placed both at the mooring center (where the buoy would ideally be) and at the location to initially place the anchor as well as a range marker to aid the installation team as shown in Figure 5-9. A crown buoy is also attached to the anchor.

Figure 5-9   Anchor Placement Allowable Area



As drag anchor capacity is based on a near horizontal orientation of the attached ground leg (6^{O} or less), it is important to proof test the anchor along the design direction of the ground leg and at an anchor line scope of 10:1 (10 feet of anchor line per foot of water depth) as shown in Figure 5-10. If the anchor ends up further away from its design distance to the mooring center (buoy), additional chain can be added to the ground leg (a reason to have spare chain and connecting hardware on site). However, if the anchor ends up closer to the mooring center, the ground leg may not have sufficient scope for the anchor to meet its design load at the desired factor of safety. Though this can be modified by the addition of sinkers along the ground leg, spare sinkers are usually not available and the anchor may have to be recovered and reinstalled at a location further away from the initial drop point and slightly off to one side to avoid the anchor dragging into the disturbed soil from the first proof test. APPENDIX I provides an extract from MO-124 of general installation procedures for a drag embedment riser-type mooring system.

Figure 5-10 Drag Embedment Anchor Proof Test Orientation



Scope is the ratio of length of rode (L) to depth of water (D), plus allowance for heigth of bow above water. At (1) length of rode equals the depth. At (2) rode length is twice the depth, at (4) four times the depth. Note how the angle between rode and bottom decreases. At (B) the scope is 8:1 and the short length of chain at the anchor lies flat on the bottom.

For all drag embedment anchor installation operations, all plans and procedures should ensure the following:

- Only qualified welders and riggers are used.
- Connecting links are secured with lead.
- Underwater shackles are secured.
- Ground legs or riser-legs are installed without twists and along its design path on the seafloor within 5 degrees.
- Data on all installed mooring components, such as manufacturer, specification, size, year of manufacturer and serial number are recorded from the anchor to the buoy.
- Critical lift plans are developed, reviewed and accepted by the cognizant authority.
- A roller or curved surface should be placed over the edge of the barge for ground leg deployment.
- A CCD is used.
- Hard points where rigging is to be positioned are protected with softeners.
- Rigging is designed and certified and with sufficient capacity, as placed, to withstand planned tensions with a recommended reserve of 25%. Rigging shall meet requirements of EM 385-1-1, as well as NAVFAC P-307 or the applicable agency document.

An operational risk management (ORM) approach should be used to develop specific riser-type or riser-leg drag embedment anchor mooring system installation procedures based on local environmental conditions, project equipment and vessels and experience of the deck force. APPENDIX J provides an extract from MO-124 of general procedures for drag embedment anchor pull testing.

5-3.3.2 Drag Embedment Anchor Riser-Type or Riser Leg Removal

Make sure you are familiar with crane safety and how it applies in this application. Review APPENDIX B on Crane Safety. Prepare and submit critical lift plans in accordance with EM385-1-1 for acceptance by the cognizant authority. Ensure that operations are conducted well within allowable wind and/or sea state conditions. It is preferable to conduct these types of operations during periods of minimal winds (moderate breeze, 11 knots or less), low tide and slack current conditions and from an anchored barge or a barge with winch operated spuds.

Site conditions, such as water depth, currents, tides, predominant winds, soil conditions (type soil, bottom slope), environmental constraints and restrictions (presence of corals, mammal watches, construction window, turbidity constraints, eelgrass, etc) as well as available installation vessels (type and capacity of floating crane barge, tugboats and material barges) and the mooring system design (number of legs, type of drag embedment anchors, length of ground legs, ground leg slack, chain sizes, etc) will require the installation team to develop specific plans and procedures for the mooring removal operations.

For a drag embedment mooring system removal, unique concerns would be (1) Removal of the initial ground leg; and (2) Break out of the buried drag embedment anchor.

For some riser-type mooring systems where there is insufficient slack, one or more ground legs may have to be disconnected from the common ring by divers cutting a chain link on the ground leg near the common ground ring using underwater cutting techniques. Underwater cutting (Figure 5-11) is performed using surface supply diving techniques and specific dive and crane operating procedures and diver safety requirements in accordance with the US Navy Diving Manual or EM 385-1-1 will need to be adhered to.

Once the first ground leg is cut off, it can be recovered by the installation team. The remaining 2 ground legs can be brought on deck and 1 ground leg cut off topside and then recovered as well.

The amount of force needed to free the drag anchor will depend on (1) Size and type of drag embedment anchor; (2) type of soils; (3) embedment depth; (4) time the anchor has been installed; and (5) whether the anchor was proof tested during installation or has been loaded to its design load during operational use.

As drag embedment anchors are designed to withstand horizontal forces by soil resistance on the face of the flukes that face the ground leg, recovery of the anchor is best accomplished by either (1) Applying a vertical force once the crane barge is directly over the anchor; (2) pulling the anchor in the opposite direction to how it is installed; or (3) A combination of both.

Figure 5-11 Navy Diver Cutting Connecting Shackle

Drag anchors embedded in sands can achieve their holding capacity with minimal burial (1 to 2 fluke lengths) while drag anchors embedded in soft sediments bury deeper to achieve their holding capacity (2.5 to 4.5 fluke lengths). Breakout of a drag anchor will be more sudden in sand and more gradual in soft sediments.

The ground leg should be attached to the primary hook of the floating crane barge with strong rigging that has a working load equal to the maximum load that the crane can apply based on its load chart. Breakout of 9-ton NAVMOOR anchors proof tested in soft sediments in New York City harbor for one week were on the order of 60 to 70 tons during recovery operations.

When applying a vertical load over the embedded anchor, the load should be applied in a slow manner and gradually building up to the allowable load that can be applied by the crane and or attached rigging and ground leg hardware. The load should be carefully monitored by a calibrated load cell rigged in line between the ground leg and the crane hook. It may be best to slowly reduce the load to no less than the weight of the anchor and suspended ground leg and then repeat the load every 10 minutes.

Breakout of the anchor will be seen by a reduction in load tension along with the raising of ground leg chain out of the water. Once this is noticed, the load can be held and then reduced as needed as the anchor comes out of the seabed (Figure 5-12). This technique is more suitable for soft sediment conditions than sand conditions.

Figure 5-12 NAVMOOR Anchor Recovery

For sand conditions as well as soft sediments, one can secure the end of the ground leg chain to a suitable deck attachment point on a tugboat or the crane barge and then transit the tugboat or barge in the opposite direction of how the anchor was initially set. This technique may need to be repeated to free the anchor.

Other techniques such as jetting or securing the ground leg to a deck fitting overnight to allow for an incoming tide to break the anchor free may need to be considered. Jetting will require divers and additional equipment and may not be practical due to time (cost) constraints. Calculations will be needed to ensure that any deck connection used to secure the ground leg will not break off when using the tide to free the anchor. For most applications, gradual vertical lifts on the anchor from a floating crane barge and/or with pulling the anchor it its opposite set direction will be suffice in recovery of the anchor.

APPENDIX I provides an extract from MO-124 of general installation procedures for a drag embedment riser-type mooring system.

For all drag embedment anchor removal operations, all plans and procedures should ensure the following:

- Only qualified welders and riggers are used.
- Critical lift plans are developed, reviewed and accepted by the cognizant authority. Break out of the anchor would be a critical lift.
- A roller or curved surface should be placed over the edge of the barge for ground leg deployment.
- A CCD is used.

- Hard points where rigging is to be positioned are protected with softeners.
- Rigging is designed and certified and with sufficient capacity, as placed, to withstand planned tensions with a recommended reserve of 25%. Rigging shall meet requirements of EM 385-1-1, as well as NAVFAC P-307 or the applicable agency document.

An operational risk management (ORM) approach should be used to develop specific riser-type or riser-leg drag embedment anchor mooring system removal procedures based on local environmental conditions, project equipment and vessels and experience of the deck force.

APPENDIX K provides an extract from MO-124 of general removal procedures for a drag embedment riser-type mooring system.

5-3.4 Embedment Anchor Installation

Make sure you are familiar with crane safety and how it applies in this application. Review APPENDIX B on Crane Safety. Prepare and submit critical lift plans in accordance with EM385-1-1 for acceptance by the cognizant authority. Ensure that operations are conducted well within allowable wind and/or sea state conditions. It is preferable to conduct these types of operations during periods of minimal winds (moderate breeze, 11 knots or less), low tide and slack current conditions and from an anchored barge or a barge with winch operated spuds.

Site conditions, such as water depth, currents, tides, predominant winds, soil conditions (type soil, bottom slope), environmental constraints and restrictions (presence of corals, mammal watches, construction window, turbidity constraints, eelgrass, etc), available installation equipment (follower and hammers), installation vessels (type and capacity of floating crane barge, tugboats and material barges) and the mooring system design (plate anchor size, required embedment depth, required pull test type and load, chain sizes, etc) will require the installation team to develop specific plans and procedures for the mooring installation operations.

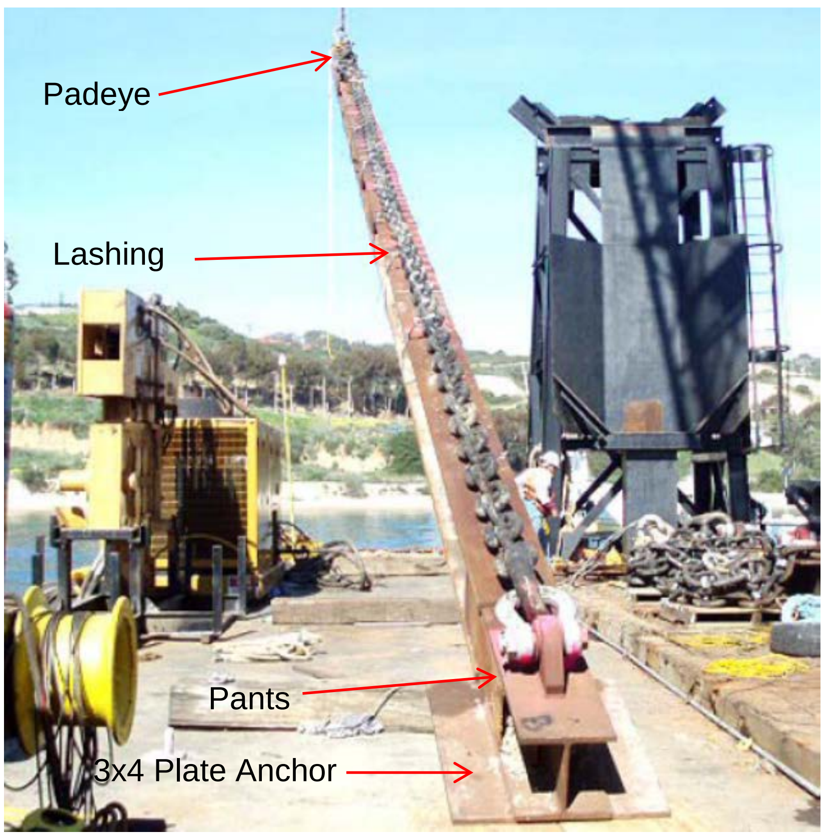
For an embedment mooring system installation, unique concerns would be the (1) Plate (or pipe) anchor follower system rigging and handling; and (2) Driving hammers.

A follower is a beam that is used to embed the plate anchor into the seabed to its required tip depth. It is usually a W14x283 beam but can also a combination of pipe with a W14x283 stinger. The length of the stinger is based on the required embedment depth for the anchor as well as its structural resistance to bending. The anchor end of the follower has an extension, commonly referred to as the “pants” that slides over the plate anchor beam to capture the plate anchor. Lifting as well as chain padeyes are found on the hammer end of the follower. The padeyes are spaced below the top of the follower to allow for placement of the driving hammers. The length of the follower is determined by the required plate (or pipe) anchor embedment depth, water depth, tides and barge freeboard.

Unlike conventional pile driving for piers and wharves where refusal criteria will govern the capacity of the pile for bearing, multiple variables in the plate anchor capacity equation are related to the embedment depth below the seafloor for the plate anchor. At locations with little or no knowledge of the soils, a soil boring may need to be obtained and a wave equation analysis (WEAP) may need to be performed to determine the required hammers to drive the anchor to its design tip depth.

The initial shot of mooring chain is stretched tight along the top of the follower and secured to a suitable turnbuckle. The total length of chain should be kept to 1 shot, but it must be long enough for deck personnel to secure to a barge deck fitting once the anchor has been driven to its tip elevation. Wire rope lashing is spaced out at an interval between 5 to 10 feet to tightly secure the chain to the follower. A rigged follower is shown in Figure 5-13. Rigged follower means that the anchor and mooring chain are secured on the follower.

Figure 5-13 Rigged Follower



The follower design should be performed by a Professional Engineer to ensure that it is structurally strong enough for driving and well as lifting operations to include both chain and lifting padeyes.

Lift plans should be detailed for handling of the follower at all stages to include positioning an empty follower onto the barge, lifting the rigged follower to be placed into its template (Figure 5-14) and lowering the empty follower onto the barge after extraction of the follower.

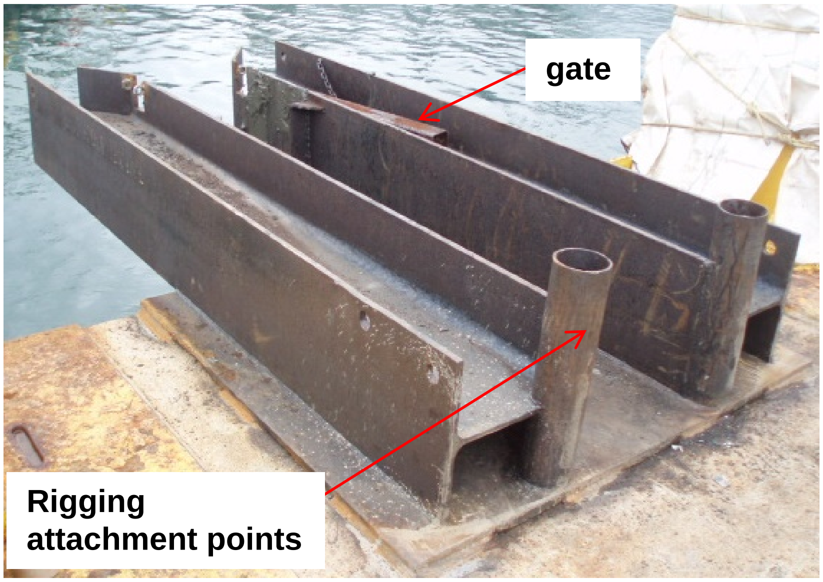
General steps for follower rigging and handling include:

- Positioning of the follower on dunnage on the crane barge or material barge.
- Positioning of the plate anchor into the follower pants
- Laying out the initial shot of chain along the top of the follower.
- Securing the rigged mooring leg tightly on the follower.
- Attaching lift rigging as well as safety rigging.
- Inspecting the follower and completing the follower checklist.
- Lifting the follower to a vertical position near the template in accordance with the accepted lift plan. Softeners such as welded slotted pipe should be used at locations along the follower where lifting rigging will come into contact.
- Positioning the follower into the template and lowering the follower until its weight is supported by the seabed. The follower is plumbed and template gate (lateral piece of steel used to help alignment of the follower and prevent it from coming out of the template if the rigged follower self-penetration is minimal) is closed.

Another piece of equipment needed for follower operations is either a manlift or a man basket. These are needed for personnel to disconnect lift rigging from the follower to free the crane hooks for lifting of the hammers. They will also be used at the end to reattach lifting rigging to remove the follower from the template. Both pieces of equipment have specific safety requirements for both personnel and equipment operation that are found in EM 385-1-1. Deck personnel will be needed to be trained in the use of fall protection.

The follower is usually positioned with the chain facing the barge for ease of operations by deck personnel. For hard clay or sand soil conditions, it is not important for the plate anchor padeye to be aligned along the design path of the mooring leg as the chain will be vertical at the anchor. This can be calculated using the program Chain-Soil Analysis Program (CSAP) and the anchor depth adjusted during the design period to ensure the chain is vertical. However, for soft sediment conditions, it is important for the padeye to be aligned with the design path of the mooring leg as the chain will not be vertical at the padeye.

Figure 5-14 Follower Template



Once the follower is positioned in the template, its weight supported by the seabed and lifting rigging detached, it is ready to be driven using conventional pile driving techniques.

Most embedment anchor installation operations have both a vibratory and an impact hammer. The vibratory hammer is generally used to extract the follower from the embedded anchor and the impact hammer is used to drive the embedment anchor to its design tip depth. For sand and mud conditions, the vibratory hammer can be used to drive the anchor partway or to its design tip depth.

Driving the rigged follower is similar to conventional pile driving operations to include operating the hammers and completing a driving record. The follower is also marked at 1-foot increments with the forward edge of the plate (top of pipe) anchor being the “zero” mark.

Unlike conventional pile driving operations, a chain is attached to the beam being driven. This chain usually has chain link zinc anodes attached on all chain links or on an upper portion. As the screws for the zinc anodes are only 3/8-inch and designed to secure the zinc anode at a 20 to 30 foot-pound torque, personnel need to be aware of zinc anodes falling off during driving operations, particularly when the vibratory hammer is being used. Several wraps of electrical tape will reduce the potential for zinc anodes from falling, but it is still a safety concern so deck personnel need to stay clear.

The design of the padeye as well as the addition of the mooring chain will increase the driving resistance of the rigged follower. Additionally, the anchor center of gravity will not be aligned with the follower and attached chain. This will create a bending moment to be generated each time the rigged follower is hit with the hammer. At locations with hard soils with multiple anchors to be embedded, spare follower sections/stingers will need to be available to perform repairs to the lower section of the follower. Bending usually occurs near the joint between stinger and pipe (Figure 5-15) or at the point along a W14x283 where lateral stiffener plates end or the upper embedment of the follower into a hard soil layer.

Figure 5-15 Bent Follower Stinger

Once the follower is extracted, a suitable sea water pump will be needed to remove the plug of soil that normally forms within the flanges of the follower at cohesive soil conditions. As the extracted follower will form a vertical plug below the seabed, sometimes steel plate is welded between the flanges to stiffen the follower at the bottom end. However, this adds additional cost and weight to the follower.

For all embedment anchor installation operations, all plans and procedures should ensure the following:

- Only qualified welders and riggers are used.
- Connecting links are secured with lead.
- Underwater shackles are secured.
- Data on all installed mooring components, such as manufacturer, specification, size, year of manufacturer and serial number are recorded from the anchor to the buoy.
- A rigged follower lift plan is developed by a Professional Engineer, reviewed and accepted by the cognizant authority.
- Critical lift plans are developed, reviewed and accepted by the cognizant authority.
- The follower design, to include associated attachment padeyes is performed by a Professional Engineer.

- A follower checklist is developed and completed prior to lift operations to verify the anchor and mooring chain is properly configured, oriented, positioned, secured along the follower, component data is recorded and lift rigging is correctly positioned according to the accepted lift plan.
- A driving record is completed to include information on the type hammer, fuel setting, recording of blow counts per foot of driving, water depth, tide, average blow count per minute, start and end times, type of follower and helmet/cushions used, final anchor tip depth to include adjustment to required datum (i.e. MLLW, etc.) and final anchor horizontal anchor location in required datum (i.e. Northings and Eastings to state plane or UTM coordinates, etc.).
- A CCD and a follower template are used.
- Hard points where rigging is to be positioned on the follower are protected with softeners.
- Rigging is designed and certified and with sufficient capacity. Rigging shall meet requirements of EM 385-1-1, as well as NAVFAC P-307 or the applicable agency document.

An operational risk management (ORM) approach should be used to develop specific embedment anchor mooring system installation procedures based on local environmental conditions, project equipment and vessels and experience of the deck force.

5-3.5 Mooring Anchor Pull Tests

Make sure you are familiar with crane safety and how it applies in this application. Review APPENDIX B on Crane Safety. Prepare and submit critical lift plans in accordance with EM385-1-1 for acceptance by the cognizant authority. Ensure that operations are conducted well within allowable wind and/or sea state conditions. It is preferable to conduct these types of operations during periods of minimal winds (moderate breeze, 11 knots or less), low tide and slack current conditions and from an anchored barge or a barge with winch operated spuds.

Site conditions, such as water depth, currents, tides, predominant winds, soil conditions (type soil, bottom slope), installation equipment (winches and multi-part blocks), available installation vessels (type and capacity of floating crane barge, tugboats and material barges), type of anchor (drag embedment or embedment anchor) and type of pull test (vertical or horizontal) will require the installation team to develop specific plans and procedures for the mooring pull test operations.

Unlike mooring hardware, mooring anchor pull tests are used to proof the installed anchor to only its design load. Plate anchors and high capacity drag embedment anchors have a design load factor of safety of 2 to its ultimate holding capacity. Drag embedment anchors such as the stockless anchor have a design load factor of safety of 1.5 to its ultimate holding capacity.

Generally, two types of mooring pull tests are performed. Horizontal pull tests are always performed on drag embedment anchors. APPENDIX J provides an extract from MO-124 for guidance on drag embedment anchor pull tests.

Vertical pull tests are usually performed on embedment anchors, but soil and design requirements at the specific site may require a horizontal pull test. Horizontal pull tests are usually performed by pulling one newly installed embedment anchor against another newly installed embedment anchor to increase installation efficiency.

All mooring pull tests should include the use of a calibrated remote load cell placed in line and at a location where frictional effects from the pull test configuration can be eliminated. For vertical pull tests, the load cell is positioned inline between the ground leg chain and the crane hook, as shown in Figure 5-16.

Figure 5-16 Vertical Pull Test Load Cell Positioning

Horizontal pull tests involving two embedment anchors have one end referred to as the “running” end and its opposite end referred to as the “static” end. The static end is where the mooring chain on one embedment anchor is secured to a suitable deck attachment point. The load cell is positioned just outside of the edge of the barge in line with the static leg. This provides a readout of the pull test tension on the embedment anchors eliminating the contributions of friction between the chain and the deck of the barge. Figure 5-17 shows the load cell placement on a static leg.

For horizontal pull tests involving only one anchor, the load cell should still be positioned in line with the mooring leg and at a location where frictional contributions can be eliminated from the load cell readout.

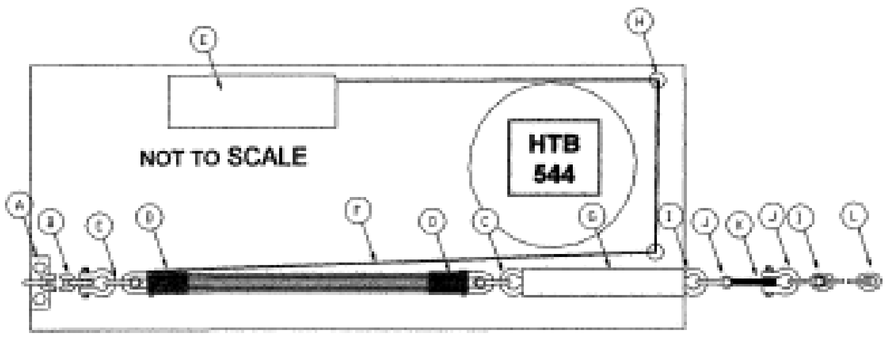
Figure 5-17 Horizontal Pull Test Load Cell Positioning

Embedment anchors installed in mud or soft sediments may have a wire rope between the anchor and the mooring chain to aid in the leg cutting through the soil and to minimize the keying (or net upward movement) distance to obtained the required test load.

The running end is usually configured with a multi-block system with wire rope reeved through the blocks. The reeving of the blocks will impose additional tensions on the individual wire rope parts as well as the friction between the running leg being pulled onto the barge (a roller or softener should be used where the running leg is to be pulled onto the barge). Though the load cell is positioned to avoid frictional contributions, pull test wire rope and other rigging must be sufficiently sized to account for all frictional contributions. Several sources are available to aid the design engineer in computing the additional frictional tensions.

For most horizontal pull tests, the barge should end up in vicinity of the middle between embedded anchors. This will mean adding additional chain to both the static and the running end, with more chain added to the running end. At the beginning of the pull test, the barge is positioned closer to the static anchor so at the completion of the pull test it ends in vicinity of the center between the anchors. It is still preferable to work in half to full shots of chain to minimize the amount of connecting links used. A general pull test schematic is shown in Figure 5-18.

Figure 5-18 Horizontal Pull Test Configuration



A	BOLSTER
B	RUNNING CHAIN LEG
C	DOUBLE 3-INCH G-2140 CROSBY SHACKLES
D	140 TON MCKISSICK 6-SHEAVE BLOCKS
E	AMERICAN WINCH
F	1.25-INCH 6X19 IWRC EIPS WIRE ROPE 13-PART
G	8 FT W14X283 LBS I-BEAM PADEYE
H	DECK SHEAVE
I	SINGLE 3-INCH G-2140 CROSBY SHACKLE
J	125 TON G-2160 CROSBY SHACKLE
K	EILON RON2000 125 TON LOAD CELL
L	STATIC CHAIN LEG

Both vertical and horizontal pull tests should be executed in a slow controlled manner by applying the load in increments of 5 to 10 tons until the pull test load is achieved. At each increment and wait of one minute should be done to allow for deck personnel to record the applied load, time, number of chain links recovered (from a reference point) and to visually check the rigging.

Upon completion of the pull test, the final embedment depth of the plate anchor padeye should be recorded. The actual orientation of the anchor plate is not known due to (1) A Factor of Safety of 2 is used for embedment anchors; and (2) Conservative estimates of soil strength during anchor design. The padeye location can be determined from the driving record, anchor drawing and results from the pull tests. It should be at or below the design depth for the anchor; however, embedment anchors that pass the pull test are generally not recovered unless post-test calculations or other geometry considerations indicate otherwise. This consideration would most likely be at a location with soft sediment or mud conditions.

For all mooring anchor pull test operations, all plans and procedures should ensure the following:

- Only qualified welders and riggers are used.
- Connecting links are secured with lead.

- A pull test plan is developed by a Professional Engineer, reviewed and accepted by the cognizant authority.
- Load cells have current calibration and positioned inline to the line of pull with the least amount of frictional or other effects. For horizontal pull tests, the load cell is positioned just outboard of the barge between the fixed deck attachment and the standing leg.
- A pull test rigging checklist is developed and completed prior to pull test operations to verify the pull test is properly configured and pull test rigging is correctly positioned according to the accepted pull test plan.
- A pull test record is completed to include information on the type load cell, depth of anchor padeye below the seabed at the start and end of the pull test, water depth, tide, link count at the start and end of the test above a reference point, links pulled in during pull test increments and final padeye depth below the seabed to include required datum (ie MLLW, etc).
- A CCD is used to secure the chain before and after a vertical pull test and after completion of horizontal pull tests.
- Rigging is designed and certified and with sufficient capacity, as placed, to withstand planned tensions to include additional tensions from frictional forces at the running end as well as within multi-part blocks. Rigging shall meet requirements of EM 385-1-1, as well as NAVFAC P-307 or the applicable agency document.

An operational risk management (ORM) approach should be used to develop specific mooring pull test procedures based on local environmental conditions, project equipment and vessels and experience of the deck force.

5-4 ASHORE INSPECTION AND REFURBISHMENT OF BUOYS.

5-4.1 Scope.

Ashore inspection and refurbishment of buoys will include visual inspections, repairs, tests, and replacement of damaged components. There are two types of buoy inspections: preliminary and detailed. The purpose of a preliminary inspection is to determine whether the buoy is in a condition for a further, more detailed inspection and subsequent refurbishment or whether it should be disposed of at this stage. If the results of the preliminary inspection indicate that refurbishment will be cost-effective, then a detailed inspection will be conducted. The buoy must be cleaned, completely inspected, and tested for airtight integrity to determine all repair requirements. The buoy can also be sandblasted to near white metal and, if required, a liquid dye penetrant or magnetic particle test conducted.

5-4.2 Preparation for Ashore Inspections.

Prepare the buoy(s) for ashore inspection as follows:

- Clean off buoy with high-pressure water during recovery.
- When brought ashore, place the buoy on chocks (railroad ties, cinder blocks, etc.) to keep the tension bar clear of the ground. For ease of working, the peg-top type buoy should be placed inverted on chocks.
- Remove the top and bottom jewelry, fenders, chafing strips, and manhole covers. Mark manhole cover positions before removal for later replacement in the same location.
- Remove shackles and joining links from the buoy, as necessary. After removal, shackles and joining links should be reassembled as complete units, including pins. Shackle pins and tapered locking pins should be used only in their original parent component.

5-4.3 Inspection Procedures.

Bear in mind that most of these inspection procedures are geared toward steel buoys. Inspections of foam buoys can be accomplished on the deck, since the fendering and chafing rails are integrally cast as part of the buoy. If the inspection reveals that damage to the buoy has occurred, it is often easier to repair the damage ashore and replace the buoy with another one.

5-4.3.1 Preliminary Inspection.

Before beginning the preliminary inspection, a 1-foot-square (0.09 m^2) section of the top and bottom and four 1-foot-square (0.09 m^2) sections (two above and two below the water line) of the side hull plates should be cleaned to bare metal. Visually inspect these four sections for pitting. In addition, perform a visual inspection as follows:

- Inspect the fenders and chafing strip fastenings for corrosion and wear.
- Check hull and deck plates for corrosion, cracks, pitting, and watertight integrity.
- Inspect the upper and lower ends of the tension bar (if the buoy is so constructed) for wear, cracks, rust, or pitting.
- If the buoy is a non-riser (telephone) type, check the padeyes for wear or cracks.
- Check the overall condition of the paint, fiberglass, or polyurethane coating.
- Ensure that the buoy is gas free by ventilating and certification by a marine chemist.
- Check the interior of the buoy for rust or corrosion.

Note:

If the buoy is a steel hawse pipe type, remove the buoy from service without doing any additional work by turning it in to the base steel recycling or local DLA Disposition Services.

Based on the results of this inspection (i.e., internal structural weaknesses, hull plate cracks, severe pitting or rusting, broken tension bar, excessive corrosion, etc.), a decision will be made whether to prepare the buoy for a detailed inspection or to dispose of it.

5-4.3.2 Detailed Inspection.

Detail Inspection is performed as follows:

Ultrasonic Inspection:

- Sandblast the buoy to near white metal in accordance with SSPC-SP-10/NACE 2.
- Inspect the buoy for damage, cracks, etc.
- Conduct an ultrasonic thickness test at four points on the buoy top, four points on the bottom, and eight points around the circumference of the hull. Four of the foregoing eight points will be below the waterline and four above the waterline.
- Using a pitting gauge, measure the depths of any pits observed on the hull of the buoy.

Pitting Inspection:

A visual inspection of the buoy hull plates will be made for pitting. The extent of pitting will determine the remaining life of the plates. ASTM G46-94, “Standard Guide for Examination and Evaluation of Pitting Corrosion” will be the standard reference used to evaluate the damage and to formulate a quantitative expression that will indicate its significance. To obtain a quantitative expression, ASTM G46-94 recommends that the deepest pit be measured, and that metal penetration be expressed in terms of the maximum pit depth or the average of the 10 deepest pits. Metal penetration can also be expressed in terms of a pitting factor. This is a ratio of the deepest metal penetration to the average metal penetration as shown in the following relationship:

$$Pitting\ Factor = \frac{Deepest\ Metal\ Penetration}{Average\ Metal\ Penetration}$$

A pitting factor of “one” represents uniform corrosion. The larger the number, the greater the depth of penetration. Pits will be rated in terms of density, size, and depth.

Welds:

Carefully check all welds, both internal and external, for cracks or corrosion. If any cracks, fissures, or other flaws are found or are suspected, then a liquid dye penetrant or magnetic particle test should be performed to determine the extent of the defects.

Buoy Air-Pressure Test:

Each buoy compartment will be tested for tightness at the joints by the application of air pressure. Unless the buoy is under cover, at least 2 hours of clear weather will be required for the test. The gauge used for the test must have a current calibration certification. Proceed as follows:

- Install a test plug fitted with a gauge in the top of each buoy compartment.
- Pressurize the compartment to 2 pounds per square inch (14 kPa). Allow 30 minutes to pass after pressure stabilization.
- Brush all joints and seams with a commercial leak testing solution. A 2% solution of potassium bichromate may be added to the leak testing solution to inhibit rust.
- Leaks detected will be repaired and the buoy retested.
- When all tests and repairs are finished, completely remove the leak testing solution before applying surface primers.

5-4.4 Buoy Repairs and Modifications.

5-4.4.1 General.

Steel Buoy repairs and modification will include manhole cover replacement, test plug and aperture maintenance, fender and chafing strip repairs, welding requirements and air pressure testing.

5-4.4.2 Procedures.

Steel buoy repair and modifications will be accomplished as follows:

5-4.4.2.1 Manhole Cover Replacement.

Manhole cover replacement will be accomplished as follows:

- Clean and lubricate the studs and use chaser nuts where required.
- Make match marks on the cover and the buoy body to ensure that the manhole cover goes in the proper location and in the correct orientation.
- Remove the manhole cover.

- Replace old gasket with a new 1/8-inch (3.2 mm) silicone rubber gasket held in place with RTV silicone gasket adhesive sealant (MIL-A-46106). Apply sealant only to bottom surface of gasket.
- Lift manhole cover by the extension lip and position it over studs.
- Lower manhole cover on studs.
- Secure cover bolts. Tighten in at least three steps using an opposite bolt tightening sequence. Apply final 45 foot-pounds (61 N-m) of torque.

Note:

Each manhole cover will be replaced on the opening from which it was originally removed. Match marks shall be made on cover and deck plate prior to removal to facilitate its replacement in the correct location and position.

Exercise care in lowering the cover on the studs so that stud threads and gasket are not damaged.

5-4.4.2.2 Test Plugs and Hull Apertures.

Clean and check test plug threads before placement of the plugs in the hull apertures. Teflon sealant tape should be applied to the threads to ensure a watertight seal.

5-4.4.2.3 Fenders and Chafing Strips.

Overhauled steel buoys will be provided rubber fenders and chafing strips. In most cases, this will require removal of the wooden fenders and their channeling, and the wooden chafing strips and connecting brackets. Channeling and brackets will be replaced by stainless steel stud bolts, 3/4-inch in diameter by 2 1/2 inches long (10 threads per inch). The bolts will be positioned and welded to conform to predrilled holes in the rubber fenders and chafing strips. If the rubber fenders and chafing strips are not predrilled, they will be drilled to conform to the positions of the stud bolts. Spacing of the bolts shall not exceed 16 inches (406 mm) on center.

5-4.4.2.4 Welding.

All welding will be accomplished by trained and qualified personnel following accepted procedures and standards contained in the latest edition of AWS D1.1, *Structural Welding Code - Steel*.

Safety Warnings:

Never cut or weld to the surface on an enclosed void (such as a steel buoy) until the interior has been properly ventilated and gas free. Potentially explosive gases can accumulate within the buoy.

Use qualified welding procedures and follow safe welding procedures per EM 385-1-1 and wear required PPE for welding operations

5-4.4.2.5 Buoy Air Pressure Test.

Each buoy compartment will be tested for tightness at the joints by the application of air pressure. Unless the buoy is under cover, at least 2 hours of clear weather will be required for the test. The gauge used for the test must have a current calibration certification. Proceed as follows:

- Install the test plug fitted with a gauge in the top of each buoy compartment.
- Pressurize each compartment with 2 pounds per square-inch (14 kPa) of air pressure for a minimum of 30 minutes after stabilization of the pressure.
- Brush all joints and seams with a solution of commercial leak testing fluid. Two percent potassium bichromate may be added to the solution to inhibit the formation of rust.
- Leaks detected will be repaired and the buoy retested.
- When all tests and repairs are completed, completely remove the leak testing solution before applying surface primers.

5-4.5 Protective Coatings.

5-4.5.1 Preparation for Application.

Preparation of buoys for application of protective coatings will include the following:

- Remove fenders, chain links, steel plates etc. from the buoy.
- When possible, open the buoy manhole and check the interior of the buoy for rust and water damage.
- Examine the hull areas that may need repair or replacement.
- Pits found that are 3/16 inch (4.8 mm) deep or more will be filled with clad welding or epoxy repair compounds conforming with MIL-C-24176.
- Buoys which are fiberglassed should have a steel reinforcing ring welded around the outside edge of the manhole opening if one is not already

present. The purpose of the ring is to provide a clean, secure surface on which to seat the manhole cover gasket as well as to reinforce the buoy deck. The ring should be of 1/2-inch (13 mm) steel plate and should extend a minimum of two inches outward from the edge of the manhole opening. If a ring is not used, then the manhole opening must be welded closed using flush steel plates which are reinforced on the underside by steel backup strips. If this is the case, the buoy will have to be cut open for subsequent inspections.

- Sandblast exterior surfaces of the metal hull in accordance with the latest edition of the *Steel Structures Painting Manual, Vol. II, Systems and Specifications*, Specification SSPC-SP-10. All sharp and irregular edges will be ground smooth. Be aware of potential for presence of Chromium VI during removal of existing coatings on older type steel buoys.

Note:

Do not apply paints or fiberglass coatings to the top surface of the reinforcing ring.

No sandblasted surface will remain uncoated for more than 4 hours.

Be aware of the presence of hazardous components such as lead or chromium VI that may be present on remaining coatings on old steel buoy coatings.

5-4.5.2 Foam Filled Elastomer Covered Buoys.

In the event of small rips, tears, punctures, or gouges in the skin and underlying foam, a repair kit containing the components and procedures required to accomplish minor repairs can be obtained from commercial vendors. If the buoy should be severely damaged and major repairs are required, the manufacturer of the buoy should be contacted for advice and/or assistance.

5-4.5.3 Fiberglass Polyester Resin (FPR) Coating Repair.

Fiberglass patches will be applied as follows:

- Sandblast the area around the repair to ensure a clean surface.

Note:

The term sandblasting here is used as a general term. Sand is not the recommended media for blasting fiberglass, softer media is recommended such as walnut shell grit, plastic grit or even dry ice.

No sandblasted surface will remain uncoated for more than 4 hours.

- Immediately after sandblasting the areas to be repaired, apply one coat of pretreatment primer (MIL-P-15328, Formula 117), 0.3 to 0.5 mil (7.6 to 12.7 μm) thickness. The thickness of the primer shall not exceed 0.5 mil (12.7 μm). Film thickness will be checked with a microtest thickness gauge or a comparable instrument.
- After the pretreatment primer has dried, apply one coat of clear polyester resin (MIL-R-21607) to the surfaces that are to receive the FPR coating patches.
- Commence with the first FPR lamination, which consists of the polyester resin and chopped fiberglass mat (MIL-M-43248). Apply the mat to the pre-coated surface and roll/squeeze to remove all lumps and air bubbles. Lay on additional polyester resin until the mat is thoroughly wet. Roll/squeeze until smooth, adding additional resin as necessary.
- Immediately after the first lamination is ready, apply three additional laminations, as follows, to give a maximum dry film thickness of 3/16 inch (4.8 mm). One lamination of fiberglass woven roving (MIL-C-19663) will be applied in a manner similar to the initial lamination. Apply one lamination of fiberglass mat. Apply one lamination of fiberglass woven roving. Note: Adjacent portions of mat or woven roving in all laminates shall overlap a minimum of 6 inches (152 mm).
- Apply additional polyester resin coatings for each successive lamination before and after the individual lamination reinforcement. The reinforcement will be rolled and squeegeed as in the initial lamination, and the polyester resin will be added and distributed, as needed, before starting the next lamination.
- Apply a generous, smooth-finished topcoat of the polyester resin mixture on the final lamination. The topcoat will be pigmented with 4 ounces (0.113 kg) of white color pigment per gallon of resin.
- NOTE: Personnel applying the FPR may, in lieu of the laminations of fiberglass mat, use a chopped fiberglass-polyester lamination sprayed on the surface being refinished at the rate of 2 ounces per square foot (0.61 kg/m2).
- If breaks occur on the surface such as around the tension bar, padeyes, and bolts and studs, the FPR coating will be edge-finished carefully using polyester resin.

5-4.5.4 Paint Coatings.

General coating operations, materials, and safety precautions are described in UFC-3-190-06, *Protective Coatings and Paints*. The recommended coating system for mooring buoys is the Navy epoxy-polyamide system for interior and exterior ship surfaces (MIL-P-24441 Type III). Procedures for its use are thoroughly described in the Naval Ships Technical Manual (NAVSEA S9086-VD-STM-010). For optimum results, this coating should be applied to dry steel cleaned to a near white metal surface, SSPC-SP-10/NACE 2. As a minimum, surfaces should be cleaned to commercial blast, SSPC-SP-6/NACE 3.

- The above coating should be applied in three coats, each at about 4-mil (101.6 μm) film thickness, to give an approximate 3-mil (76.2 μm) dry film thickness per coat and a minimum 8-mil (203.2 μm) total dry film thickness. There should be 16 hours of curing time between coats. The first coat should be the green primer (Formula 150); the second, haze gray (Formula 151); and the third, white (Formula 152).
- The two components of all MI L-P-24441 coatings should be mixed in equal volume by first thoroughly stirring each component separately and then stirring them together. After mixing, there should be a waiting period of about 2 hours at 50 to 60 °F (10 to 15.6 °C); 1 to 1 1/2 hours at 60 to 70 °F (15.6 to 21.1 °C); and 1/2 to 1 hour above 70 °F (21.1 °C) before applying the coating to ensure complete curing later. The mixed paints do not require thinning, but the low temperature application properties can be improved by adding 10%, by volume, of a mixture of equal parts of n-butyl alcohol and AMSCO Super High Flash Naphtha, or an equivalent mixture.

Usual paint spray equipment, either conventional or airless, can be used. The pot life of the mixed coating is about 6 hours at 73 °F (22.8 °C). If more than 7 days elapse between epoxy coats, the surface should be cleaned with water and detergent, rinsed with fresh water, dried, and then a tack coat (1 to 2 mils (25.4 to 50.8 μm) wet film thickness) of the last coat applied before application of the next full coat.

The above coating system, when properly applied, will provide at least 3 to 5 years of protection, depending upon the severity of the environment. Experience has shown that an antifouling paint is usually unnecessary because fouling will not damage the coating, add a significant amount of weight to the buoy, or otherwise adversely affect the mooring. In addition, the effective life of antifouling paint is usually much shorter than the time between buoy overhauls, so that significant fouling will still occur before the next overhaul. Should an antifouling paint be desired for the underwater portion of the buoy, MIL-P-15931, Formula 121/63, applied in two coats, is recommended. The antifouling paint, which is red, must be applied while the topcoat of epoxy (MIL-P-24441, Formula 152) is still tacky (within 4 to 6 hours after its application). If the epoxy has hardened, a tack coat of MIL-P-24441 (1 to 2 mils (25.4 to 50.8 μm) wet film thickness) must be applied and allowed to cure for 4 hours before the first coat of antifouling paint is applied.

Safety Note:

Painters shall use the appropriate PPE.

MSDS for all components shall be readily available on site.

All painting shall comply with USACE EM 385-1-1.

The emphasis is on the replacement of steel buoy with foam buoys. Over the 20 year life of a buoy, the steel buoy will normally require 4 overhauls while the foam buoy will require minimum maintenance, bringing a huge cost savings over that 20 year life span to the operator.

5-4.5.5 Quality of Work.

All of the workmanship on the coating systems shall be in accordance with the Naval Ships Technical Manual, NAVSEA S9086-VD-STM-010. The work shall be performed by or under the immediate and direct supervision of skilled personnel who have demonstrated a continuing proficiency in the application of multilayered coatings on extensively contoured areas similar and comparable to the exterior of mooring buoys. Quality of workmanship shall meet the highest standards as set forth in the specifications and manuals noted herein.

5-4.5.6 Coating Documentation Report.

After a buoy is coated, a documentation report, traceable to the buoy, should be prepared that shows the coatings used, the date the coatings were applied, the surface preparation performed to include surface profile measurements, wet and dry film measurements, measurement of ambient conditions during coating operations, QC procedures used, etc. The report shall be placed as part of the mooring documentation and provided to the mooring custodian. Sufficient inspection should be performed to ensure that the surface was properly prepared, the coating properly prepared and applied and the required dry film thickness and coverage obtained.

5-5 ASHORE INSPECTION AND REFURBISHMENT OF CHAIN AND ACCESSORIES.

5-5.1 Scope.

Chain and fittings are inspected to determine their suitability for continued use in the mooring system. The inspection process is two-phased, PRELIMINARY and DETAILED.

The preliminary inspection is conducted to determine if the chain or fitting is adequate for continued use, if it can be made serviceable by repair or refurbishment, or if it should be disposed of.

The results of the preliminary inspection are analyzed to determine the need for further inspection. If the results of the preliminary inspection indicate that the chain or fitting can be made serviceable by repair or refurbishment, a detailed inspection is conducted to develop a specification for the repair or refurbishment. If the preliminary inspection results indicate that the chain is adequate for continued use, then a detailed inspection should also be conducted to ensure that no faults in the chain have been missed prior to returning to service.

In planning an inspection of mooring chain and fittings, the inspection activity should consult the cognizant authority for guidance as to the extent of the inspection required. Some of the material in the mooring may be planned for reuse if found acceptable and some may be scheduled for disposal without further action.

5-5.2 Preliminary Inspection.

All fittings should be disassembled, removed from the chain, and reassembled as complete units until ready to be inspected. When joining links are disassembled, care should be taken that the parts of one joining link are not interchanged with the parts from another joining link. Chain should be arranged in shots or partial shots so that each link is accessible for inspection. Known or suspected high wear areas should be thoroughly cleaned with a scaling tool and wire brush or lightly sandblasted to SSPC SP-2 or SP-3 criteria.

The preliminary inspection should begin with a visual inspection of each fitting and each chain link. Visually inspect each link of chain for abnormal wear, cracks, deformation, or missing studs. Mark all links with obvious problems and all areas to be measured.

After the visual inspection is complete, measurements should be taken in known or suspected high wear areas and in any suspect areas noted during the visual inspection. Take single or double-link measurements on the first two to four links of chain at the end of each shot or partial shot and at any location in the chain where high wear is indicated by shiny metal or visible loss of wire diameter. Remember that the chain must be under tension to take accurate double-link measurements.

Disassemble each fitting and visually inspect each component of the fitting for indications of wear, deformation, or cracks. Pay particular attention to pins and pin locking holes. Check pins for loose fit before disassembling. Measure the wire diameter of joining links, shackles, and ground rings at known or suspected high wear areas. Reassemble all fittings as complete units on completion of the inspection. Apply a liberal coating of grease to all internal surfaces of joining links (mating surfaces, pins and pin locking holes) prior to reassembly. Grease should be in accordance with MIL-PRF-10924.

Based on the results of the preliminary inspection, tentatively classify the chain and fittings as good, fair, or poor in accordance with Table 5-1. Chain and fittings tentatively classified as good or fair should be retained for detailed inspection; chain and fittings tentatively classified as poor should be disposed of through normal disposal procedures.

Table 5-1 Classification of Mooring Component Condition

Condition	Amount of Deterioration
Good	90% or greater of original wire diameter
Fair	80 – 90% of original wire diameter
Poor	80% or less of original wire diameter

5-5.3 Detailed Inspection.

All chain and fittings that have been tentatively classified as good or fair as a result of the preliminary inspection should receive a detailed inspection to determine the action required to return the components to serviceable status. No further inspection should be conducted on chain or fittings that do not pass the visual inspection for any reason other than a slight deterioration of wire diameter. Before beginning the detailed inspection, all chain and fittings to be inspected should be sandblasted in accordance with the latest edition of the Steel Structures Painting Manual, Vol. II, Systems and Specifications, Specification SSPC-SP-6/NACE-3.

Single-link measurements should be taken on each link of the chain. Visually inspect each link for cracks, deformation, missing studs, or any other abnormalities. If a crack is suspected but not readily obvious to the naked eye, conduct an MT in the suspected area.

The wire diameter of each fitting should be taken in normal wear areas and in any areas designated as suspect as a result of the preliminary inspection. Check for worn pins, worn pin locking holes, cracks, or deformation. If cracks are suspected, conduct an MT to verify. Disassemble each joining link and shackle and inspect all components. Reassemble as complete units. Apply a liberal coating of grease to all internal surfaces of joining links in accordance with MIL-PRF-10924 prior to reassembly.

Classify the chain and fittings in accordance with Table 5-1. Material classified as good or fair may be coated and returned to inventory. It should be tracked separately, by classification, from new material. Material classified as poor, should be disposed of through normal disposal procedures.

The results of all inspections, including a record of all measurements taken, should be included in the pertinent material history file or mooring maintenance file and a copy forwarded the mooring manager.

5-5.4 Protective Coatings.

Chain and fittings classified as good or fair should be should be abrasive blasted to Steel Structures Painting Manual, Vol. II, Systems and Specifications, Specification SSPC-SP-6 or NACE-3. Spray, dip, or brush the abrasive blasted chain/fittings with an approved rust preventative (MIL-PRF-16173 Grade 1). Place the chain on a clean surface to dry. Once dry, put the chain back into inventory noting the condition of this chain.

- If the chain/fittings have not been sitting around too long after the blasting for the detailed inspection and no visible rust, dirt, etc. is apparent, then a reblasting is not required.
- For accessories with pins or bolts, ensure that the applied coating is not too thick. Otherwise, it will be difficult to remove or assemble the shackle pins or bolts.
- Coating operations should be avoided on cold/damp days.

5-6 ASHORE INSPECTION AND REFURBISHMENT OF ANCHORS.

5-6.1 Scope.

The primary purpose of inspecting an anchor is to determine its general physical condition and its suitability for reuse. The inspection of an anchor should only be conducted when the anchor is either temporarily aboard a barge or in a storage area ashore. There are two types of anchor inspections: preliminary, which can be conducted either aboard a barge or ashore, and detailed, which is normally conducted ashore. These inspections should be accomplished as soon as possible after the anchor is removed from the water.

5-6.2 Preliminary Inspection.

The anchor should be cleaned with a high-pressure water wash-down before beginning the preliminary inspection. When cleaned, the anchor should be laid on the deck or on the ground within reach of a crane so that it can be lifted and turned to gain access to all surface areas.

Every surface for the anchor and anchor shackle should be visually inspected for the presence of cracks, casting irregularities, abnormal wear, or any other obvious damage or defect. Caliper measurements should be taken to determine the wire diameter of the anchor shackle at the bow and at the wear area at the lugs of the shackle. Ensure that the shackle is free to move, not frozen in position.

Visually check the anchor for casting irregularities, cracks or obvious mechanical damage. If the anchor is of welded construction (STATO or NAVMOOR), or if the anchor has stabilizers welded to it, all weldments should be closely scrutinized for cracks, fissures, pitting corrosion, or other defects. Special attention should be paid to the very end of the shank, the fit of the shackle in the shank, and the base of the flukes.

A hammer test will determine whether there are major invisible cracks or other abnormalities in the anchor. The test is conducted by suspending the anchor from a crane hook and striking each fluke with a large (> 5 pounds or 2.2 kilograms) hammer. If a ringing tone results the anchor is sound. If a dull thud results, there are serious cracks or other irregularities in the anchor.

The results of the above preliminary inspection measurements, observations, and tests should be documented. If the inspected anchor is determined to be in satisfactory condition as a result of this inspection, no further effort will be expended, and the anchor will be made ready for further use or placed in a designated storage area. Anchors returned to service or placed in inventory in a ready status should be coated with a black-gloss solvent-type paint (MIL-P-2430).

5-6.3 Detailed Inspection.

A detailed inspection will only be conducted if, as a result of the preliminary inspection, abnormalities are suspected or if the condition of the anchor is questionable. The detailed inspection will include the following:

- Clean the anchor by abrasive blast clean to SSPC-SP-10/NACE-2 near white blast cleaning.
- Visually inspect the anchor for cracks or casting irregularities. Pay particular attention to the anchor flukes and welds.
- Perform a liquid dye penetrant or magnetic particle test on any suspected cracks or abnormalities in accordance with NAVSEA Technical Publication T9074-AS-GIB-010/271 Requirements for Non-Destructive Testing Methods.
- If the results of this testing indicate that cracks or other abnormalities do exist, a decision will have to be made to determine if these abnormalities can be corrected by grinding and welding or if they are too numerous or too deep for economical refurbishment of the anchor. If repairs can be made, then as soon as they are accomplished, the anchor should be protectively coated with a black-gloss solvent type paint (MIL-P-24380). If it is determined that refurbishment of the anchor is not economically feasible, then the anchor may be retained in storage for future use as a sinker/clump or disposed of. All findings/results of the detailed inspection shall be fully documented and filed.

CHAPTER 6 STORAGE OF MOORING MATERIALS

6-1 GENERAL REQUIREMENTS.

Mooring components are usually stored in open areas near a coastline, thus exposing them to weather and a marine environment. To prevent deterioration while in storage, some preventive maintenance will be required in addition to the routine material handling and inventory control tasks normally performed by a storage facility. The job of handling, maintaining, and controlling stored components will be made much easier if some basic guidelines, as noted below, are followed.

- The storage area should be large enough to permit efficient movement of forklifts, cranes, and other large mobile equipment.
- Arrangement of components should allow easy access for inspections, inventory checks, and selection.
- To reduce corrosion, all components except cathodic protection materials should be coated with paint, approved rust preventatives, or other suitable preservatives as detailed in CHAPTER 5.
- All components should be tagged or labeled to ensure proper identification and accurate inventory reporting.
- Chain accessories such as joining links, swivels, ground rings, and shackles should be crated or banded together on pallets to permit easy handling.

6-2 STORAGE AREA REQUIREMENTS.

Shore activities requiring spare mooring materials will require a suitable storage area. The following should be observed:

- The mooring materials should normally be stored in a secure area designated by activity personnel responsible for space allocation.
- The storage area should be on solid ground or on improved surfaces, and graded for drainage.
- The area should be large enough, as well as configured, to allow easy access of equipment and personnel involved in chain handling and other maintenance operations.
- The area should be close to maintenance areas, transportation equipment, and the waterfront to reduce both maintenance and transportation costs.

6-3 STORAGE PROCEDURES.

6-3.1 Buoys.

Store buoys as follows:

Place all drum type buoys on chocks or dunnage, with all metal parts clear of the ground, and tilted (using additional chocks or dunnage under one side) to facilitate water runoff.

Store peg-top buoys in a horizontal position (see Figure 6-1).

Figure 6-1 Proper Storage of a Foam Peg Top Buoy

Foam buoys should be stored on specially designed wood buoy cradles to avoid a permanent flat spot.

Buoys should be periodically inspected to aid in the detection and prevention of localized corrosion areas. If corrosion is found, corrective action should be implemented. Corrosion commonly develops in the web of channel irons securing wooden fenders, in the hull behind rubber fendering, and on the nuts/studs used to secure manhole covers, fenders, and chafing strips. Ground or chock contact points are also susceptible to higher corrosion rates. Any area on the top of the buoy that could collect water is susceptible to accelerated corrosion. In addition, the steel cradle for foam buoys should be inspected for corrosion.

6-3.2 Chain and Chain Accessories.

Chain is normally stored ranged out in tiers, a single shot of chain placed on a pallet, loaded in shipping crates, or in bundles. The ground where the chain is stored should be clear of all debris and growth, and well drained.

Mooring chain and accessories of different specifications and grades should always be stored separately, to prevent mooring components of a lesser grade being mixed into a mooring system that requires a higher grade of chain or accessories.

6-3.2.1 Tiered Chain.

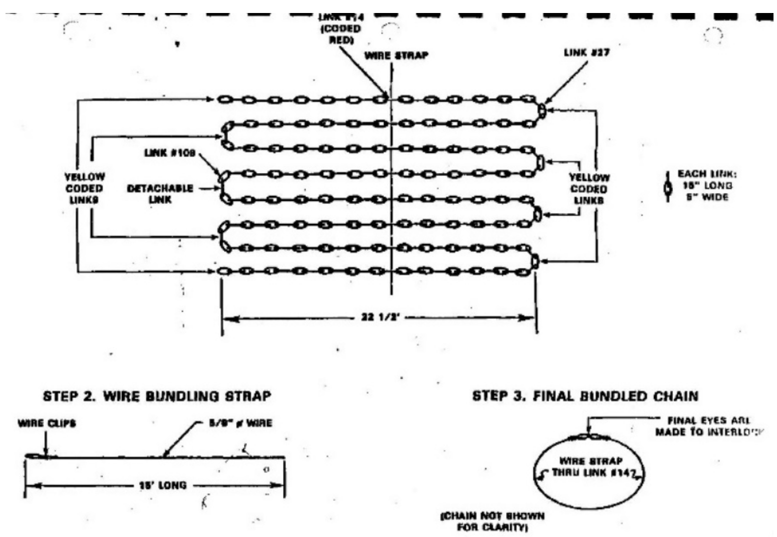
Store chain in tiers as follows:

- Lay chains down stretched out taut and free of turns.
- Pile tiers in multiple layers to reduce storage space.
- Each tier should contain chain of similar construction, size, and condition for ease of access and accurate inventory control.
- The ends of each length of chain should have an identification tag attached to it which contains the chain size (in inches), type (cast/forged/etc.), length (in feet), and manufacturer.

6-3.2.2 Palletized Chain.

Chain may also be stored and handled on pallets. Normally, chain is palletized in single shot lengths to reduce handling weights and to simplify inventory. Chain pallets normally consist of wooden or steel pallets onto which the chain is piled or bundled (see Figure 6-2).

Figure 6-2 Chain Bundling Method



It is recommended that the lashing not be used to lift the pallet/chain bundle unless it meets the local base policy for lift operations. One can pass the lifting sling through the captured links that can be used for lift operations or the pallet with the chain can be lifted with a forklift.

6-3.2.3 Crated Chain.

Reusable wooden crates can be used for the shipment and storage of chain and will normally contain a single shot of chain. The crates can be stacked to reduce deck space requirements if not loaded beyond the design capacities stamped on the crates (see Figure 6-3).

Figure 6-3 Stacked Crates of Chain

6-3.3 Mooring Accessories.

Store mooring accessories by type, by size and by specification/grade in either a crate, box or on a pallet. Connecting links, anchor bolt shackles and riser swivel shackles should be greased and loosely assembled, but they should never be stored disassembled and the parts stored separately. Plate shackles may be stored disassembled.

6-3.4 Anchors.

Place anchors on dunnage and in a vertical position. Store according to type and size for ease of inventory control. U.S. Navy anchors have identification marks cast, stamped, or cut on the anchor crown. When stored vertically, this information should be transferred to a suitable tag or stenciled to the anchor's shank.

6-3.5 Cathodic Protection Materials.

Larger anodes stored outside should be sealed in plastic liners and boxed to preclude premature galvanic action. Do not store anodes in the open or near other dissimilar metals, which could result in corrosion of the anodes. Chain stud anodes should be stored in HDPE 57-gallon plastic drums with removable lids. Only one size of anode shall be packed in each drum. Store screws in sealed plastic bags to prevent corrosion.

Cathodic protection material should be kept clean and should not be painted or coated with oil or grease during either storage or use.

6-3.6 Marking and Identification.

Marking and identification of components should be accomplished as described.

6-3.6.1 General.

Proper marking and identification of all mooring components will assist in conducting inventories, will help prevent use of improper or substandard materials, and will speed assembly and installation times when required components must be drawn from inventory.

6-3.6.2 Color Coding.

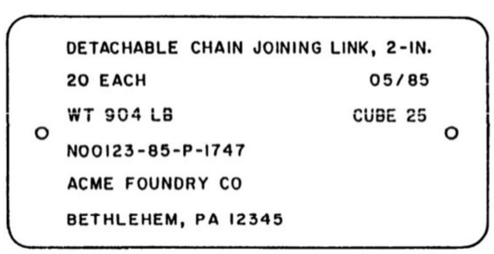
It is good practice to color code chain to identify its condition. Recommended colors to be applied to the last link on each end of a chain length are:

- White - for chain in new or good condition.
- Yellow - for chain in fair condition.
- Red - for chain in poor condition and ready for disposal.

6-3.6.3 Identification.

Identification of chain and accessories shall be on tags of 0.031-inch (0.787 mm) thick aluminum alloy 1100 or 3003, attached using 0.031-inch (0.787 mm) diameter 300 series corrosion resisting stainless steel wire through 0.125-inch (3.175 mm) diameter holes at each end of the tag. Characters shall be metal stamped using 0.25-inch (6.35 mm) high characters. Tag size and information content shall be as shown in Figure 6-4. On chain shots, tags shall be attached to the last link on each end of the shot. Tags will be attached snugly to each accessory in a location away from the grip area of the component and shall be bent to conform to the contour of the component to minimize risk of snagging or damaging the tag.

Figure 6-4 Example Shipping Tag

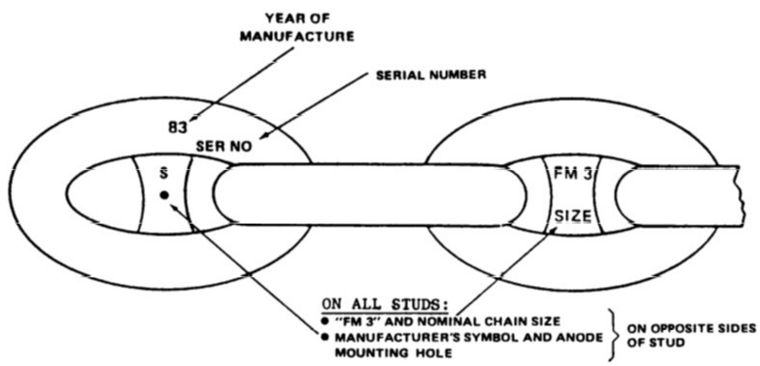


6-3.6.4 Fleet Mooring Inventory Chain and Accessories.

Chain and accessories procured under contract for the Fleet Mooring Inventory are marked and identified as followed:

- The size and the name of the manufacturer are stamped or forged on each chain link or accessory during manufacture.
- New FM3 chain will also have a unique serial number on each accessory, on the end links of each shot, and on the 3rd link from each end of chain (see Figure 6-5). The serial number will be used together with documentation furnished by the manufacturer (heat number, chemical composition, etc.) to monitor the performance of different heats of chain.
- Crates used to ship new chain and accessories from the manufacturer will be marked to show: contents, weight, contract and shipping data, and stacking limitations.

Figure 6-5 Chain Markings



6-3.6.5 Buoys.

New buoys should have an identification plate (Figure 6-6) showing the following:

- Serial number,
- Manufacturer,
- Date of manufacture,
- Diameter,
- Height,
- Weight in air,
- Maximum tension bar load, and
- NAVFAC drawing number.
- This plate should be protected during sandblasting and should not be painted or coated.

Steel buoys in service may not have an identification plate. If they are to remain in service an identification plate with the above information, based on available information, should be attached to the top of the buoy near, but not onto the tension bar (to avoid welding onto the load carrying component of the buoy). A serial number should be generated for maintenance and operations tracking purposes.

Figure 6-6 Buoy ID Plate

6-3.6.6 Anchors.

Identification information for anchors is cast on the crown, on the flukes, or on the side of the shank. Minimum information provided is as follows:

- Manufacturer
- Weight
- Serial number

6-3.7 Pre-Issue Inspection.

Items that are issued from inventory should be inspected prior to shipping or movement from the storage facility. A bill of material should be reviewed to ascertain the components required and a check of all material sizes accomplished. To ensure all mooring components fit when shipped to the field, a physical fit check should be accomplished prior to shipment. The many configurations and designs of mooring hardware increase the likelihood of a misfit if a physical fit check is not accomplished.

APPENDIX A BEST PRACTICES

A-1 NOTES AND SAFETY WARNINGS.

This section will highlight by repetition all the boxed warnings and safety notices throughout this document.

All efforts should be made to replace steel buoys with foam buoys since steel buoys are much more difficult to inspect and maintain. Steel tension bar buoys can still be used, but hawse pipe buoys shall be taken out of service, disassembled and disposed of in accordance with local steel recycling programs.

All personnel at or near a mooring component being secured by lead shall wear PPE commensurate with EM 385-1-1 (such as safety glasses, foot protection, floatation vest) and other required PPE for mooring operations.

Follow safe welding procedures per EM 385-1-1 and wear required PPE for welding operations.

Wear appropriate gloves when handling wire rope.

Ensure all personnel have, maintain, and wear PPE (steel toed shoes, personal floatation vest, hard hat and other PPE for specific tasks i.e. leather gloves, safety glasses, etc.).

Daily safety briefs should emphasize everyone’s responsibility for applying risk management.

Failure to properly clean the inspection area of the chain links may provide erroneous measurements leading the inspector, custodian, and users of the mooring system to an improper conclusion on the mooring condition that could result in an unsafe mooring condition for a moored vessel.

Divers should be aware of the potential movement of the chain, especially when working on the ground legs.

All efforts shall be made to replace steel buoys with foam buoys since steel buoys are much more difficult to inspect and maintain. Steel tension bar buoys can still be used, but hawse pipe buoys should be taken out of service.

Divers should use extreme caution when working directly below a live/moving buoy.

Divers should inspect the connections of suspended sinkers with caution as motions imposed on the mooring system from surface weather conditions or attached vessels can cause the suspended sinker to move within the water column.

While inspecting the anchors, divers should not go under the flukes or shank of the anchor.

Regardless of using the design anode size or oversized anodes, the mounting hole must be free of debris and the anode tightened to the recommended torque for the anodes to work properly.

Ensure all personnel have, maintain, and wear PPE (steel toed shoes, personal floatation vest, hard hat and other PPE for specific tasks i.e. leather gloves, safety glasses, etc.).

Daily safety briefs should emphasize everyone’s responsibility for applying risk management.

At no time shall personnel be directly under a suspended load when the load is out of the water. Personnel on the barge deck shall be kept clear of the fall zone of the buoy and the riser chain to the maximum extent possible. The fall zone includes the area where a suspended load may fall. Personnel should be aware that the fall zone is moving as the buoy is lifted over the deck. Only qualified personnel, in accordance with EM385-1-1, under specific instruction from the designated Marine Construction Superintendent, may enter the fall zone to handle a load.

The buoy should be lifted only as high as minimally required.

Operation planning must include the use of a chain capture method that minimizes the necessity for personnel to work under suspended load.

Use a Load Indicating Device (LID) or crane equipped LID or Load Moment Indicator to determine the load for all installation/retrieval lifting operations.

Every attempt should be made to plan operations that keep DIVERS from working under the load. If no alternatives can be found, every effort should be done to minimize the diver’s time spent under the load.

Adhere to EM 385-1-1 and OSHA 1910.253 for safe use of oxygen/acetylene torch.

If lifting a hawse pipe buoy, treat the lift as if the capture plate assembly is damaged and lift from below, while simultaneously lifting the buoy. On the newer ATFP and FMP foam hawse pipe buoys, the bolts that make this connection are exposed, but it is still difficult to determine the condition of the bolts. On these foam hawse pipe buoys, the existing capture plate and bolts can be replaced with new bolts and a capture plate specifically used for lift operations only.

Additional care is needed to make sure the additional loads on the crane (from lifting the ground ring out of the water) are taken into account. In addition, the stability issues based on these extra loads must also be accounted for.

If the tension bar is damaged, it is best to lift the buoy from below to take most of the weight off of the buoy/tension bar. A secondary crane hook should be used to simultaneously lift the buoy, keeping the buoy weight off the lift.

Never cut or weld to the surface on an enclosed void (such as a steel buoy) until the interior has been properly ventilated and gas free. Potentially explosive gases can accumulate within the buoy.

No person should enter the buoy while the buoy is still in the water. A person should only enter the buoy when there is no possibility of the buoy sinking, i.e. either on the deck of the barge or ashore.

Entry of personnel into a buoy must comply with EM 385-1-1 and cognizant base requirements for confined space entry.

On a steel buoy, the buoy manhole cover must not be removed while the buoy is still in the water.

Every attempt should be made to plan operations that keep personnel from working under the load. If no alternatives can be found, every effort should be done to minimize the time spent under the load.

While preparing the anchors, positioning on deck for deployment and deploying the anchor, personnel should not go under the flukes or shank of the anchor.

If the buoy is a steel hawse pipe type, remove the buoy from service without doing any additional work by turning it in to the base steel recycling or local DLA Disposition Services.

Each manhole cover will be replaced on the opening from which it was originally removed. Match marks shall be made on cover and deck plate prior to removal to facilitate its replacement in the correct location and position.

Exercise care in lowering the cover on the studs so that stud threads and gasket are not damaged.

Never cut or weld to the surface on an enclosed void (such as a steel buoy) until the interior has been properly ventilated and gas free. Potentially explosive gases can accumulate within the buoy.

Use qualified welding procedures and follow safe welding procedures per EM 385 1 1 and wear required PPE for welding operations

Do not apply paints or fiberglass coatings to the top surface of the reinforcing ring.

No sandblasted surface will remain uncoated for more than 4 hours.

Be aware of the presence of hazardous components such as lead or chromium VI that may be present on remaining coatings on old steel buoy coatings.

The term sandblasting here is used as a general term. Sand is not the recommended media for blasting fiberglass, softer media is recommended such as walnut shell grit, plastic grit or even dry ice.

No sandblasted surface will remain uncoated for more than 4 hours.

Painters shall use the appropriate PPE.

MSDS for all components shall be readily available on site.

All painting shall comply with USACE EM 385-1-1.

Wind and current conditions will usually dictate which subassembly is laid first.

Divers may be used to inspect connections and to check the orientation and tautness of the anchor chains. They may also be used to jet the anchors into the bottom if included as part of the design specification.

Ensure that the anchor is not recovered and reset in the furrow or disturbed bottom area caused by the initial pull test.

In the case of a taut mooring, one anchor chain subassembly may have to be separated from the ground ring by cutting the first A-link below the ground ring with a torch.

If the joining link cannot be removed, cut the first A-link with a torch.

A-2 SAFETY.

Safety is critical for all work on and around moorings, including inspection work and repair work.

Daily safety briefs should emphasize everyone’s responsibility for applying risk management. Pay attention to what could go wrong and how it could go wrong.

Ensure all personnel have, maintain, and wear PPE (steel toed shoes, personal floatation vest, hard hat and other PPE for specific tasks i.e. leather gloves, safety glasses, etc.).

APPENDIX B CRANE SAFETY

B-1 CRANE SAFETY.

The definitive reference on crane safety is NAVFAC P-307, Management of Weight Handling Equipment (for Navy shore activities) and EM 385-1-1 (U.S. Army Corps of Engineers and NAVFAC Contractors). This section is not meant as a replacement for this standard but as a guide to help the users of this manual understand the basics as they apply to mooring work. Note that chapter 11 of NAVFAC P-307 lists requirements for NAVFAC Contractors performing weight handling operations at a Navy facility.

In general, you will be dealing with one of two types of cranes, either floating cranes which are built into a ship or barge or mobile cranes that are temporarily mounted on the deck of a barge or ship. There are many advantages to using a floating crane. The load curves include the listing of the vessel and other naval architectural considerations and you don't have to worry about tying the crane down. On the other hand, mobile cranes are more readily available. You just have more planning efforts prior to the project.

B-2 CRANE SAFETY GUIDELINES.

The following documents serve as the basis for crane safety, as applicable.

a) SECNAVINST 11260.2, Navy Weight Handling Program for Shore Activities.
b) NAVFAC P-307, Weight Handling Program Management
c) OPNAVINST5100.23, Navy Occupational Safety and Health Program Manual
d) NAVSEA 0989-030-7000, Lifting Standard (If Applicable)
e) USACE 385-1-1, Safety and Health Requirements Manual
f) 29 CFR 1926 Subpart CC, Safety and Health Regulations for Construction, Cranes & Derricks in Construction
g) ASME B30.5 Mobile Cranes
h) ASME ASME B30.22 Articulating Boom Cranes,
i) ASME B30.9 Slings
j) ASME B30.26 Rigging Hardware

B-3 PLANNING.

As you begin planning the inspection/repair, you begin working toward a selection of a crane. If the work is being done by contract, you need to check the crane's documentation, including the certificate of compliance (required by both NAVFAC P-307 and ACOE EM 385-1-1), as well as additional required documentation as described in section 11 of NAVFAC P-307 and Chapter 16 of EM385-1-1. The documentation needs to be supplied to the contracting officer. If the crane being considered is run by the military, as opposed to a commercial entity, the military organization will be maintaining the crane's documentation. Documentation needs to be current. Most contractor cranes will have to submit an annual and a quadrennial certification for the floating crane.

In addition, crane operator certifications, to include medical examiner's certification, and rigger and signal person's qualifications should also be provided and be current.

If a mobile crane is to be mounted on a barge or vessel, this and additional information needs to be provided.

- A naval architectural stability analysis of the barge or vessel while conducting the planned lifts as well as lifts at the rated loads and reaches. Reduced load charts are usually required to ensure that the list/trim is taken into account for the additional loading it will impose on the crane and that the barge/vessel does not exceed its maximum list or trim. This revised load chart must be present in the cab of the crane during operations.
- An analysis of the barge/vessel's deck should be conducted. This analysis shall include loading on the deck of the outriggers and of the tie-downs. The outriggers shall rest on wooden blocking. The tie downs should be calculated to resist any lateral loads the crane may sustain. Except for crawler cranes without outriggers, the cranes shall be used with the outriggers.

A lift plan should be developed detailing all the lifts, reaches and loads expected to be seen. In addition, required critical lift plans need to be developed, detailing the lift plan with the maximum load and reach, and submitted to the cognizant authority for their approval. Requirements for critical lift plans are in both EM 385-1-1 and NAVFAC P-307.

B-4 MOBILIZATION.

The first thing that may need to be done in preparing the vessel is to obtain a "Gas Free" Certificate from a marine chemist. This will permit you to weld padeyes or other hold down devices to the vessel as well as to cut things off the vessel if needed. These padeyes will be needed to secure a mobile crane and possibly to tie down the mooring hardware. However, before any welding, cutting, grinding, etc. can be done on the vessel, a "Hot-Work" Certificate may also need to be obtained.

Once the welding is complete and inspected by qualified personnel, the crane will be brought on board, set up and tied down in accordance with the approved barge stability analysis and engineering drawings for the positioning of the mobile crane. Remember that the crane must be on its outriggers and the outriggers on wooden blocks. Before the crane can be operated on board the vessel, it must be inspected by the Navy Crane Center. This inspection involves two items. The first is an inspection to ensure that the crane is properly tied down and that it is ready to operate. The second is a test lift of the critical lift. The crane will pick up a weight equal to the maximum weight as described in the critical lift plan and hold it out at its expected reach. The inspection will not just test the crane but ensure that the list and trim caused by that lift are within allowable limits.

Once these tests have been conducted, the crane can be used on the vessel to support all operations.

B-5 OPERATIONS.

While many of the safety concerns with operating a crane on a vessel are the same as when operating a crane ashore, there are several additional concerns that need to be considered during at sea operations.

While weather is always a concern, wind and waves become much larger additional factors at sea. Waves and seas cause rolling, pitching and swaying motions of the vessel, which, in turn, cause swinging of the lifted load. Wind, especially gusty winds, also cause swinging of the loads. The use of tag lines to help control this swinging motion is useful but only to a point. If the weather becomes too severe, it will be necessary to halt operations. In absence of guidance from the crane manufacturer, a maximum wind speed of 15 knots (7.717 meters/second, 17.262 mph, 25.317 fps) shall be used.

Cranes are not designed to take side loading. While this is true, for either ashore or at sea operations, it is more likely to be attempted at sea, especially during mooring repairs. The desire might well be to keep the load (buoy) close to the deck, dragging the chain out of the water. While this does help to eliminate the distance that the load can fall if something fails, it places a large side load on the crane, very potentially damaging the crane and making it unusable. A better practice is to lift the buoy, secure the mooring riser in a CCD and remove the buoy. Then lift the rest of the mooring riser as needed, secure it into a CCD and lower the riser to the deck. Personnel on the barge deck shall keep clear of the fall zone of the buoy and the riser chain unless qualified and directed to complete a specific task under the direction of the Marine Construction Supervisor.

Use extreme care in lifting of any hawsepipe buoy or any tension bar buoy where the conditions of the tension bar is questionable. The actual lift point should be below the buoy on the riser chain. An auxiliary crane hook can be used to support the weight of the buoy while the main crane hook lifts the riser chain. Ensure the rigging methods are appropriate to support both the hawse pipe buoy and riser chain to ensure that both the buoy and riser chain are adequately supported during the lift.

B-6 DEMOBILIZATION.

While there is little beyond standard safety concerns during demobilization, before any cutting, welding or grinding is done on the vessel, a Gas-Free Certificate and a Hot-Work Permit need to be obtained.

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APPENDIX C SAMPLE 1149

SHIPPING CONTAINER TALLY —— 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50

REQUISITION AND INVOICE/SHIPPING DOCUMENT

RESET PAGE

OMB No. 0704-0246
OMB approval expires Apr 30, 2009

The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to the Department of Defense, Executive Services Directorate (0704-0246). Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ORGANIZATION. RETURN COMPLETED FORM TO THE ADDRESS IN ITEM 2.

1. FROM: *(Include ZIP Code)* ATTN: First & Last Name **Phone/Email:** Office phone/government email address
Activity: NAME & UNIT IDENTIFICATION CODE
Address: COMMAND ADDRESS
City/St/Country/Zip: CITY, STATE XXXXX

2. TO: *(Include ZIP Code)* POC: First & Last Name **Phone/Email:** Office phone/government email address
Activity: NAME & UNIT IDENTIFICATION CODE
Address: FULL SHIPPING ADDRESS
City/St/Country/Zip: CITY, STATE XXXXX NO FPO OR AP ADDRESS FOR OCONUS SHIPMENTS

3. SHIP TO - MARK FOR
POC Name, Phone Number and email
Mark for: Mooring Inspection at XXXXX

SHEET NO.	NO. OF SHEETS	5. REQUISITION DATE	6. REQUISITION NUMBER
1	1	2016-11-01	12 digit number assigned by shipping

7. DATE MATERIAL REQUIRED *(YYYYMMDD)*: 2017-01-31
8. PRIORITY: III - 9 THRU 15
9. AUTHORITY OR PURPOSE: Mooring Underwater Inspection & Zinc Anode Change Out
10. SIGNATURE:
11a. VOUCHER NUMBER & DATE *(YYYYMMDD)*:
12. DATE SHIPPED *(YYYYMMDD)*:
b.
13. MODE OF SHIPMENT: Surface (Ship)
14. BILL OF LADING NUMBER:
15. AIR MOVEMENT DESIGNATOR OR PORT REFERENCE NO.:

4. APPROPRIATIONS DATA
TAC NO: XXXX WORK CENTER: XXXXX
TAC OWNER: XXXXXXX JON: XXXXXX
ADDITIONAL SHIPPING INSTRUCTION: Forklift is required for loading
Door to Door delivery to XXXXX
AMOUNT: $ 5,500.00

ITEM NO. (a)	FEDERAL STOCK NUMBER, DESCRIPTION, AND CODING OF MATERIEL AND/OR SERVICES (b)	UNIT OF ISSUE (c)	QUANTITY REQUESTED (d)	SUPPLY ACTION (e)	TYPE CON-TAINER (f)	CON-TAINER NOS. (g)	UNIT PRICE (h)	TOTAL COST (i)
1	ZINC ANODE, 2.5-INCH W/SCREW; 550 PER DRUM, WEIGHT APPROX 1000 LBS	DR	1				$ 5,550.00	$ 5,550.00
								$ 0.00
								$ 0.00
								$ 0.00
								$ 0.00

16. TRANSPORTATION VIA AMC OR MSC CHARGEABLE TO XXXX
17. SPECIAL HANDLING

18. RECAPITULATION OF SHIPMENT	TOTAL CON-TAINERS	TYPE CON-TAINER	DESCRIPTION	TOTAL WEIGHT	TOTAL CUBE
ISSUED BY					
CHECKED BY					
PACKED BY	0		← TOTAL →	0	0

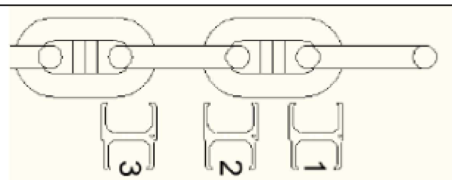
19. RECEIPT	DATE *(YYYYMMDD)*	BY	
CONTAINERS RECEIVED EXCEPT AS NOTED			SHEET TOTAL $ 5,550.00
QUANTITIES RECEIVED EXCEPT AS NOTED			GRAND TOTAL $ 5,550.00
POSTED			20. RECEIVER'S VOUCHER NO.

DD FORM 1149, JUL 2006 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100
PREVIOUS EDITION IS OBSOLETE.
Adobe Designer 8.0

APPENDIX D SAMPLE MOORING INSPECTION SHEETS

The following are sample mooring inspection sheets for various points on the mooring.

MOORING ________

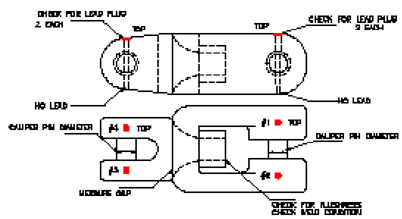


SET	DEPTH	>90%	>80%	<80%
1				
2				
3				
4				
MAX DEPTH				

RISER INSPECTION

MOORING ________

SWIVEL

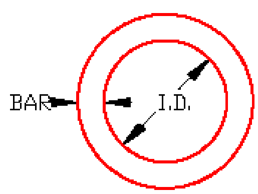


PLUGS

0	1	2	3	4

T-PIN		IN
B-PIN		IN
GAP		IN

GROUND RING



BAR		IN
I.D.		IN

RISER INSPECTION

MOORING ________ LEG________

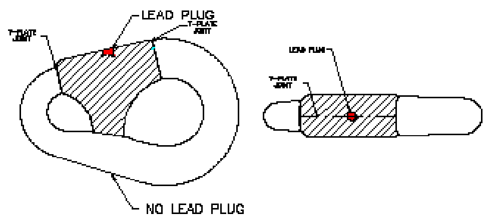
SINGLE GAUGES IF CHAIN IS SLACK	

SET	LINK COUNT	>90%	>80%	<80%
1				
2				
3				
4				
MAX DEPTH				

LEG INSPECTION

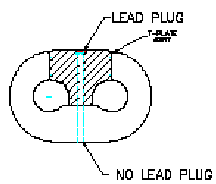
MOORING ________ LEG______

ANCHOR JOINING LINK



PLUG	YES	NO
INTACT	YES	NO

CHAIN JOINING LINK



CJL #1	LINK COUNT	
PLUG	YES	NO
INTACT	YES	NO
CJL #2	LINK COUNT	
PLUG	YES	NO
INTACT	YES	NO

LEG INSPECTION

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APPENDIX E SAMPLE PRELIMINARY INSPECTION EMAIL

The following is a sample of a preliminary inspection email:

NAVFAC Engineering and Expeditionary Warfare Center (EXWC) East Coast Detachment conducted an underwater inspection of Fleet Mooring 7 located in vicinity of pier 1 at Naval Weapon Station (NWS) EARLE on 21 July 2010. The inspection was conducted by an engineer from EXWC and divers from underwater construction team one. The following is a preliminary report of the inspection results:

A. Fleet Mooring 7 was found to be in C3, fair condition, due to measurements on the riser chain between 80% and 90% of its original wire-diameter.

B. Measurements on the top jewelry pear links were found to be between 80% and 90% of its original wire diameter.

Mooring will be scheduled for repair in FY11 by the Fleet Mooring Program.

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APPENDIX F UNDERWATER INSPECTION REPORT TEMPLATE

FLEET MOORING UNDERWATER INSPECTION RESULTS

Mooring Id	XX	Activity	XX
Report Date	Month Year	Report Number	XX

GENERAL INSPECTION INFORMATION

Design Class	AAA,AA,A,B,C,D,E,F,G	Rated Capacity (1000 lbs.)	100
Buoy Type	Foam, tension bar	Buoy Dia. (ft.)	12
Mooring Type	Riser-Type	Quantity of ground legs	3
Anchor Type	Stockless	Anchor Size (kip)	20
Riser size (in)	2.5	Ground leg size (in)	2.5

OVERALL INSPECTION ASSESSMENT

Mooring Condition Readiness	C1/2/3/4	Inspection Date	mm/dd/yyyy
Mooring Rated Condition (ICAP)	50	Required Repairs	X
Current Class	X	Rated Capacity (1000 lbs.)	100
Divers	Organization – last names	Engineer-In-Charge	X
Buoy Freeboard (in)	XX	Water Visibility (ft.)	X
Water Depth (ft.)	XX	Bottom condition	X

INSPECTION SURVEY RESULTS

System Datum Geodetic	WGS84	Latitude	Nxx° xx' xx.xx"	Longitude	Wxxx° xx' xx.xx"
System Datum Projected	State NAD83/ UTM Zone XXY	Northing	XXXXX	Easting	XXXXXX

INSPECTION CATHODIC PROTECTION RESULTS

% Anodes Depleted (0-99)	XX%	Anodes Replaced (Y/N)	Y/N
Replacement Anode Size (in)	X.X	Quantity Of Anodes Replaced	X

BUOY TOPSIDE INSPECTION ASSESSMENTS

Component	Type/ Qty	Damage/ Wear	Corrosion/ Discoloration	Overall Condition
Connection	Padeye/Hawse	X	X	X
Padeye Bushing		X	X	X
Hawse Pipe Bolts/Screws	XX or N/A	X	X	X
Hull	Pegtop/Drum	X	X	X
Coating	Urethane/Paint	X	X	X
Fender	Single Urethane	X	X	X
Reflective Tape	Double Tape	X	X	X
Chafe Strips	Urethane/Rubber	X	X	X

BUOY TOP JEWELRY INSPECTION MEASUREMENTS

Item	Inspection Point	Catalog Value (in)	Caliper Results (in)	Condition (%)
Buoy Shackle	Bale	4.56	4.375	96
Buoy Shackle	Pin	4.25	4.125	97
Pear Link	Minimum Bale	4.25 – 4.37	4.0625	96

INSPECTION MEASUREMENT RESULTS

Item	Criteria	Inspection Point	Unit of Measure	Reference Point	Size (in)	Condition (%) / (in)
Riser	All 3 >90	13	Feet	Waterline	2.75	All 3 >90
Riser	All 3 >90	30	Feet	Waterline	2.75	All 3>90
Riser	All 3 >90	40	Feet	Waterline	2.75	All 3 >90
Ground Leg 1	All 3 >90	2	Links	Ground Ring	2.50	All 3 >90

FLEET MOORING UNDERWATER INSPECTION RESULTS						
Mooring Id	XX		Activity	XX		
Report Date	Month Year		Report Number	XX		
Ground Leg 1	All 3 >90	37	Links	Ground Ring	2.50	All 3 >90
Ground Leg 1	All 3 >90	72	Links	Ground Ring	2.50	All 3 >80
Ground Leg 1	All 3 >90	107	Links	Ground Ring	2.50	**All 3 <80**
Ground Leg 2	All 3 >90	1	Links	Ground Ring	2.50	All 3 >90
Ground Leg 2	All 3 >90	37	Links	Ground Ring	2.50	2 >90;1>80
Ground Leg 2	All 3 >90	72	Links	Ground Ring	2.50	All 3 >80
Ground Leg 2	All 3 >90	107	Links	Ground Ring	2.50	**All 3 <80**
Ground Leg 3	All 3 >90	2	Links	Ground Ring	2.50	All 3 >90
Ground Leg 3	All 3 >90	37	Links	Ground Ring	2.50	1 >90;2>80
Ground Leg 3	All 3 >90	72	Links	Ground Ring	2.50	2>80;**1<80**
Ground Leg 3	All 3 >90	107	Links	Ground Ring	2.50	**All 3<80**
Swivel Pin	4.45 – 4.67	Top Pin	Inch	Top Pin	3.50	4.50
Swivel Pin	4.45 – 4.67	Bottom Pin	Inch	Top Pin	3.50	**3.50**
Ground Ring	5.25 – 5.50	Bar	Inch	Ground Ring	2.25	5.25
Ground Ring	11.70 – 12.30	Inside Diameter	Inch	Ground Ring	2.25	12.50

INSPECTION COMMENT RESULTS	
Comment Type	Comment
General	
Buoy	
Top Jewelry	
Riser	
Ground Legs	
Anchors	
Anodes	
Marine Growth	
Survey	
Bottom	
Photo	

Notes and legend for completing inspection sheet

<table>
<tr><th colspan="2">GENERAL INSPECTION INFORMATION</th></tr>
<tr><td>Activity</td><td>List Activity</td></tr>
<tr><td>Report Date</td><td>List report date as shown on cover page</td></tr>
<tr><td>Report Number</td><td>List report number as shown on cover page</td></tr>
<tr><td>Design Class</td><td>List the design Class of the mooring.
The following table lists the standard fleet mooring classes
<table>
<tr><th>CLASS</th><th>CAPACITY (1000 lbf)</th><th>CLASS</th><th>CAPACITY 1000 lbf)</th></tr>
<tr><td>AA</td><td>300</td><td>C</td><td>100</td></tr>
<tr><td>BB</td><td>250</td><td>D</td><td>75</td></tr>
<tr><td>CC</td><td>200</td><td>E</td><td>50</td></tr>
<tr><td>DD</td><td>175</td><td>F</td><td>25</td></tr>
<tr><td>A</td><td>150</td><td>G</td><td>5</td></tr>
<tr><td>B</td><td>125</td><td>SPEC</td><td>OTHER</td></tr>
</table>
If the mooring's rated capacity does not match the standard class, then it is "SPEC" and its rated capacity is as stated in its design report.</td></tr>
<tr><td>Rated Capacity</td><td>List the original corresponding rating of the mooring per design.
Note that units are already defined in "Rated Capacity" cell. Ensure rated capacity matches design class (unless "SPEC").</td></tr>
<tr><td>Buoy Type</td><td>List buoy shape (drum or pegtop) if not a standard Fleet Mooring (small or medium) buoy, material type (foam or steel) & style (tension bar or hawse pipe)</td></tr>
<tr><td>Buoy Diameter</td><td>List buoy diameter of the hull, in feet. Note that standard fleet mooring foam tension bar buoys have diameters of 8 feet (small) or 11.5 feet (medium).
Note that units are defined in "Buoy Dia." cell.</td></tr>
<tr><td>Mooring Type</td><td>Riser-type - riser with ground ring and 1 to multiple ground legs
Riser-leg - single riser from buoy to anchor.</td></tr>
<tr><td>Anchor Type</td><td>Pile, Plate, Propellant embedment, Deadweight; stockless, NAVMOOR; STATO; LWT, Concrete Pearl Harbor, etc.</td></tr>
<tr><td>Anchor Size</td><td>For pile anchors, list diameter and length
For propellant embedment anchors list rated capacity
For plate anchors list plate dimensions in ft.
For other anchors, list nominal weight.
This data is found in the mooring's installation report or the moorings design and/or as-built drawings.
Note that units are defined in "Anchor Size" cell.</td></tr>
<tr><td>Riser size</td><td>List nominal size(s) of chain on the riser.
Note that units are defined in "Riser Size" cell.</td></tr>
<tr><td>Ground leg size</td><td>List nominal size(s) of chain on the ground leg(s).
Note that units are defined in "Ground Leg Size" cell.</td></tr>
<tr><td>Quantity ground legs</td><td>List quantity of ground legs</td></tr>
</table>

<table>
<tr><th colspan="2">OVERALL INSPECTION ASSESSMENT</th></tr>
<tr><td>Current Class</td><td>List the corresponding Class of the mooring based on the results of the inspection.
The following table lists the standard fleet mooring classes
<table>
<tr><th>CLASS</th><th>CAPACITY (1000 lbf)</th><th>CLASS</th><th>CAPACITY 1000 lbf)</th></tr>
<tr><td>AA</td><td>300</td><td>C</td><td>100</td></tr>
<tr><td>BB</td><td>250</td><td>D</td><td>75</td></tr>
<tr><td>CC</td><td>200</td><td>E</td><td>50</td></tr>
<tr><td>DD</td><td>175</td><td>F</td><td>25</td></tr>
<tr><td>A</td><td>150</td><td>G</td><td>5</td></tr>
<tr><td>B</td><td>125</td><td>SPEC</td><td>OTHER</td></tr>
</table>
If the mooring’s rated capacity does not match the standard class, then it is “SPEC” and its rated capacity is as stated in its design report.</td></tr>
<tr><td>Rated Capacity</td><td>List the corresponding rating of the mooring based on the results of the inspection.
Note that units are already defined in “Rated Capacity” cell. Ensure rated capacity matches design class (unless “SPEC”).</td></tr>
<tr><td>Mooring Rated Condition (ICAP)</td><td>The following table lists mooring condition rating values based on the results of the inspection.
<table>
<tr><th>VALUE</th><th>CONDITION</th></tr>
<tr><td>90</td><td>All >90%; minimal corrosion present</td></tr>
<tr><td>80</td><td>All >90%; moderate corrosion present or partial damage to fenders or chafe rails or reflective tape in need of replacement</td></tr>
<tr><td>75</td><td>All >90%; heavy corrosion present or fenders or chafe rails completely missing or top jewelry not secure</td></tr>
<tr><td>70</td><td>All >90%; buoy refurbishment required or replacement of attached buoy connection hardware required.</td></tr>
<tr><td>60</td><td>Topside <90%; minimal -moderate corrosion present</td></tr>
<tr><td>55</td><td>Topside <90%; moderate-heavy corrosion present</td></tr>
<tr><td>50</td><td>Below water connection assembly not secure</td></tr>
<tr><td>40</td><td>Underwater <90%; minimal -moderate corrosion present</td></tr>
<tr><td>30</td><td>Underwater <90%; moderate-heavy corrosion present</td></tr>
<tr><td>20</td><td><80%; minimal corrosion present or legs dragged off location</td></tr>
<tr><td>10</td><td><80%; moderate corrosion present</td></tr>
<tr><td>0</td><td><80%; heavy corrosion present or a ground leg detached</td></tr>
</table></td></tr>
</table>

<table>
<tr><td>Mooring Condition Readiness</td><td>The following table lists the mooring condition readiness based on the results of the inspection.
<table>
<tr><th>RATING</th><th>MOORING CONDITION</th></tr>
<tr><td>C1 (Good)</td><td>Mooring is in Good condition and considered satisfactory for continued use.</td></tr>
<tr><td>C2 (Fair)</td><td>Topside measurements between 80% and 90% recorded. Mooring can be repaired without underwater work. Mooring may be unable to be used at its full design capacity. Restrictions could impair operations. Vessels may have to find alternate facilities to moor. An engineering assessment is required. Restrictions could impair operations. Failure of mooring is possible.</td></tr>
<tr><td>C3 (Fair)</td><td>Below waterline measurements between 80% and 90% recorded. Mooring will require underwater work for repairs. Mooring may be unable to be used at its full design capacity. An engineering assessment is required. Restrictions could impair operations. Failure of mooring is probable.</td></tr>
<tr><td>C4 (Poor)</td><td>Measurements found <80%. Mooring is restricted from use until repairs are completed. Failure of mooring is imminent.</td></tr>
</table>
</td></tr>
<tr><td>Required Repairs</td><td>List the mooring component(s) requiring repair or replacement to restore the mooring to C1 condition. If none, state “None”</td></tr>
<tr><td colspan="2">INSPECTION SURVEY RESULTS</td></tr>
<tr><td colspan="2">The coordinate results shown in this section should match what is provided in the survey appendix of the inspection report.</td></tr>
<tr><td>Datum
Geodetic</td><td>Provide coordinates in WGS84 geodetic latitude and longitude or geodetic datums used on nautical charts at the mooring location.</td></tr>
<tr><td>Latitude/Longitude</td><td>Provide as WGS84 in degrees-minutes-seconds to at least 2 decimal places. Include N or S for latitudes, E or W for longitudes.</td></tr>
<tr><td>Datum
Projected</td><td>Provide projected datum (ie NAD83, NAD27), state plane to include Zone identifier and units used. If using UTM WGS84, provide Zone identifier and use meters for units.</td></tr>
<tr><td>Northings/Eastings</td><td>Provide to at least 2 decimal places.</td></tr>
<tr><td colspan="2">INSPECTION CATHODIC PROTECTION RESULTS</td></tr>
<tr><td>% Anodes Depleted (0-99)</td><td>Provide an overall assessment of the percentage of anodes depleted. Anodes that crumble or disintegrate when tapped are considered to be depleted.
Note % defines the amount of the zinc that has been depleted.</td></tr>
<tr><td>Anode Size</td><td>List size anodes, by size, used for replacement.</td></tr>
<tr><td>Anode quantity</td><td>List qty, by size, anodes replaced.</td></tr>
<tr><td colspan="2">BUOY TOPSIDE INSPECTION ASSESSMENTS</td></tr>
<tr><td colspan="2">This section is used to describe the type of mooring buoy and to assess its’ overall condition.</td></tr>
<tr><td>Connection</td><td>List type of buoy connection; tension bar padeye or hawse-chain.</td></tr>
<tr><td>Padeye Bushing</td><td>Condition of wear bushing on upper padeye.</td></tr>
<tr><td>Hull</td><td>List type of hull form; peg-top, spherical or drum.</td></tr>
</table>

Hawse pipe bolts or screws	If applicable, list type and quantity of bolts or screws; list whether exposed or recessed.
Coating	List coating type; urethane (foam buoys), fiberglass, painted, none.
Fender/Rubrail	List type (urethane, rubber, wood, etc) and quantity.
Reflective Tape	List type (tape) and quantity.
Chafe/Rub Rails	List type (steel pipe, urethane, D-rubber, etc) and quantity.
Damage	Describe as major, moderate, minimal or none. For condition of buoy hull, hawse-chain connection buoy capture plate assembly (to include connecting hardware), fenders, chafe rails, reflective tape.
Wear	Describe as major, moderate, minimal or none. For assessment of tension bar padeyes and tension bar padeye bushings and hawse-chain buoy capture plate assembly (to include connecting hardware).
Discoloration	Describe as heavy, moderate, minor or none. Discoloration of non-metal components due to rust bleeding from metal components on buoy hull, etc. UV degradation or fading of reflective tape.
Corrosion	Describe as major, moderate, minimal or none. Corrosion of external steel buoy connections or other components to include haws pipe assembly connecting hardware.
Overall condition	Describe overall buoy condition as Good, Fair or Poor.
BUOY TOP JEWELRY INSPECTION MEASUREMENTS	
This section documents go no/go and caliper measurements of components inspected on top of the mooring buoy.	
Buoy Shackle	
Bale	Define bale dimension from catalog for new shackle. Take caliper measurements on the bale of the shackle *at the wear point and in the wear direction.* Ensure all rust debris is cleaned off prior to taking caliper measurement. List actual percentage based on “caliper measurement/minimum catalog value).
Pin	Define pin dimension from catalog for new shackle. Take caliper measurements on the pin adjacent to the buoy padeye *near the wear point*. Ensure all rust debris is cleaned off prior to taking caliper measurement. List actual percentage based on “caliper measurement/minimum catalog value).
Pear Link	
Bend	Define pear link bar diameter minimum and maximum dimensions from catalog values. Take caliper measurements on the bend of the pear link at the *wear point and in the wear direction*. Can report the smallest measurement of the 2 pear link bales. Ensure all rust/debris is cleaned off prior to taking caliper measurement. List actual percentage based on “caliper measurement/minimum PD value).
Chain Link or Joining Link	
Link Bar	Define bar dimension from catalog for new link.

	Take caliper measurements on the bar of the link *at the wear point and in the wear direction near contact points.* Ensure all rust debris is cleaned off prior to taking caliper measurement. List actual percentage based on "caliper measurement/minimum catalog value). If connecting link is an anchor joining link, take caliper measurements of bar diameters at both the larger and smaller ends and report both findings.
INSPECTION MEASUREMENT RESULTS	
This section documents go no/go and caliper measurements of components inspected on the mooring system below the buoy. **Record go no/go measurement results or caliper measurements in bold red font and highlight go no/go measurement results or caliper measurements found to be <90% in yellow.**	
Item	State mooring component inspected (riser, ground leg 1, ground leg 2, swivel shackle, ground ring, etc). Riser Set - a set of 3 consecutive go no-go measurements taken on the riser. Riser Link - one go no-go measurement taken on a riser link. Ground Leg 1 set - a set of 3 consecutive go no-go measurements taken on ground leg 1. Ground Leg 1 link - go no-go measurement taken on a link on ground leg 1.
Criteria	Criteria is "all 3>90" for measurement sets or ">90" for individual link measurements. Inspection points for riser and ground legs are taken as measurement sets. For accessory components, criteria is the minimum to maximum catalog value for the dimensions to be measured on the accessory component.
Inspection Point	Location of the measurements along the mooring riser, ground leg or on the accessory component. This cell entry is based on the entered data for Unit of Measure and Reference Point.
Unit of Measure	State units of measurements (inches, feet, meters, etc) or Links for the inspection points.
Reference Point	State the reference point for the inspection point for the inspected component. For risers, the reference point is usually the waterline. For ground legs, this can be the ground ring if the unit of measure is the links. For accessory components, repeat the name of the item being inspected.
Size/(in)	List the nominal size of the mooring chain or accessory component being inspected. *Note that this cell is not to record your measurement finding.*
Condition (%)/(in)	Reported as "All 3>90, All 3 >80 or All 3<80. If measurements within a set are not the same, provide the breakdown (ie; 2>90;1>80, etc). For connecting or accessory components, record the actual calipered measurement taken (in inches).
INSPECTION COMMENT RESULTS	
Below are some of the most common inspection comment blocks. Others can be added/removed by the document writer as needed to document inspection results of the mooring system. These sections are used to provide additional information on the inspection findings.	
General	State buoy's Mooring Condition Readiness and operational use or restrictions. State if and type of vessel moored to the buoy during the inspection. If Mooring Condition Readiness is C2 or worse, list required repairs to restore mooring to its original design rating and a C1 condition. Example: *Mooring X is in C1 (Good) condition and satisfactory for continued use as a Class Y mooring. No vessel attached to the buoy during inspection.*

Buoy	State the type of mooring buoy (type, shape, connection, diameter) and identification plate data (Manufacturer, serial number, contract number, month/year of manufacture). State condition of fenders, chafing or rub rails, reflective tape and any other buoy hull accessories. State condition of the buoy hull. State condition of padeye bushings. State condition of and if buoy zinc anodes were replaced. State hull condition. Assess buoy heel. Assess buoy draft.
Top Jewelry	List top jewelry components attached to the mooring buoy. State condition of all top jewelry components to include levels of corrosion and assessment of caliper measurements to its listed minimum catalog value. State size, manufacturer, year and serial numbers of top jewelry components.
Riser Assembly (includes, attachment hardware to the buoy and ground ring, ground ring, riser or ground ring sinker and ground leg connecting hardware on the ground ring)	State the condition of the riser. State type of measurements, type go/no gauges, quantity of measurements and locations the riser was measured. State the results of the go/no go measurements. If measurements are found to be <90%, list the location and amount of the riser (number of links) that needs to be repaired. Example: "*The riser is in good condition.* Consecutive *measurement sets were taken at four locations along the riser using double link go, no-go gauges. All measurements were found to be >90% of original wire diameter*". State the results of the inspection of the riser swivel shackle to include swivel shackle gap measurement, presence and quantity of lead plugs. State assessment of swivel shackle pin caliper measurements to its listed minimum catalog value. All four lead plugs in the swivel shackle were intact. If found, list water depth of chain joining links, presence of lead plug and joining link assembly assessment. If available for inspection, state assessment of ground ring bar caliper and inside diameter measurements to its listed minimum catalog value. State water depth of ground ring. If available for inspection, state quantity of anchor joining links connected to the ground ring, presence of lead plugs and joining link assembly assessment. If found, state presence, water depth and condition of sinkers found on riser or attached to the ground ring.
Ground Legs	State if all or quantity of ground legs buried and unable to be inspected. State the condition of all ground legs. State type of measurements, type go/no gauges, quantity of measurements and locations the ground legs was measured. State point of burial for ground legs inspected. Example: "Consecutive m*easurement sets were taken every 30 feet along all ground legs using double link go, no-go until the ground leg became buried and unable to be inspected. All measurements were found to be >90% of original wire diameter*". List ground leg headings from ground ring toward anchor. If found, list link count or chain length from the ground ring of chain joining links, presence of lead plug and joining link assembly assessment. *Note-a separate comment block may be used for each ground leg.*
Anchors	State if the anchors are buried and unable to be inspected. For drag embedment or deadweight anchors that are found and inspected, state if stabilizers are present, if the anchor is rightside up or upside down, if aligned with the ground leg heading, if the anchor is partially buried or completely exposed and the condition of connecting links and swivel shackles that attaches the anchor to the ground leg.

Anodes	State size of replacement anodes and quantity of new anodes installed on mooring riser, ground legs and lower buoy tension bar padeye. List any installation problems in attaching new anodes (i.e. sheared bolts, missing studs, etc).
Marine Growth	Describe marine growth type (soft, hard, shells) thickness and location along the riser (top, middle, bottom) and bottom of buoy.
Survey	If the buoy was surveyed, list the equipment used to perform the survey. If a GPS was used, list the accuracy of the GPS to include quantity of satellites, and level of precision (ie PDOP or HDOP). State the system and datum used to include units (i.e. US Feet or meters). State software used for coordinate conversions. Other than the dive or survey boat, state if a vessel was moored to the buoy during the survey.
Bottom	Describe the type of seafloor conditions found at the mooring site.
Photo	Provide a identification photo of the buoy that shows the entire buoy. The buoy should fill up the majority of the photo, and if present, include the stenciled buoy name.

WITHIN A REPORT, BE CONSISTENT IN COMMENT FORMAT THROUGHOUT ALL INSPECTION SHEETS.

APPENDIX G FM3 MOORING COMPONENT DATA

This Appendix provides data on FM3 components. Data on commercial components can be obtained from the manufacturer or distributer.

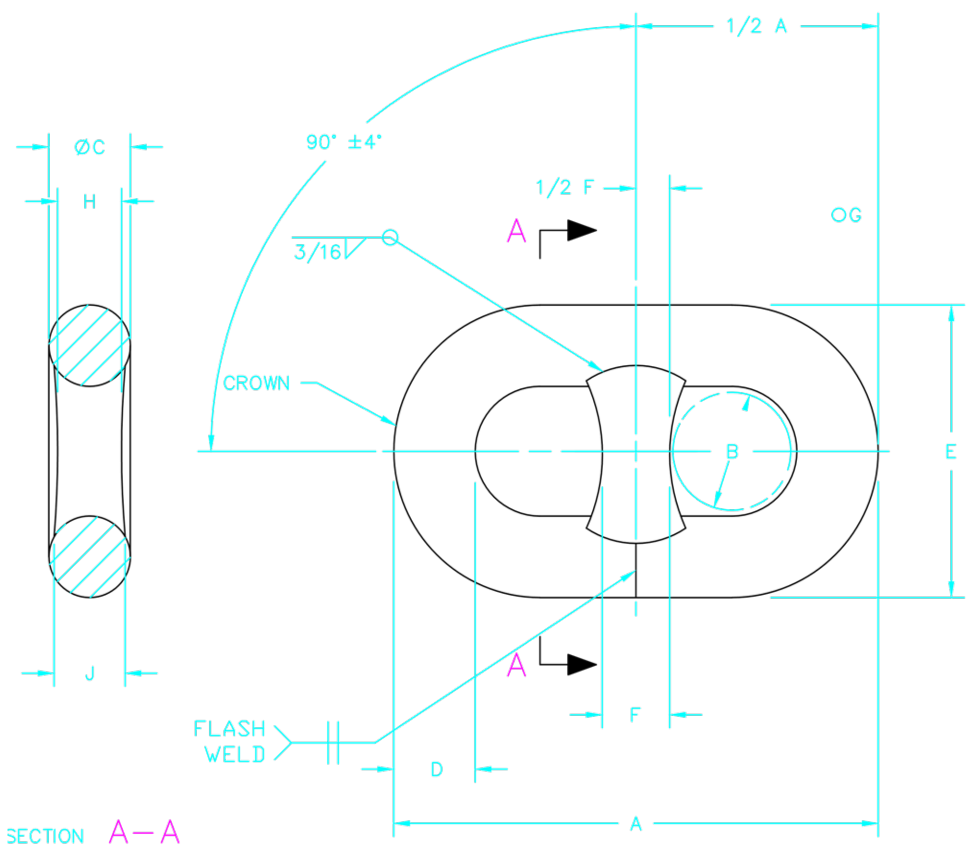
G-1 FM3 STUD LINK CHAIN.

Figure G-1 FM3 Stud Link Chain

(All Dimensions in Inches)

Nominal Diameter	A (min)	A (max)	B (min)	C (min)	C (max)	D (min)	E (min)	E (max)	F (min)	G (min)	H (max)
1−3/4	10.50	10.76	2.62	1.75	1.81	1.69	6.21	6.50	1.50	1.41	1.58
2	12.00	12.30	3.00	2.00	2.06	1.94	7.10	7.37	1.65	1.59	1.77
2−1/4	13.50	13.84	3.42	2.25	2.34	2.19	8.04	8.35	1.80	1.59	2.09
2−1/2	15.00	15.38	3.76	2.50	2.59	2.44	8.88	9.20	1.95	1.64	2.23
2−3/4	16.50	16.91	4.12	2.75	2.84	2.79	9.76	10.18	2.10	1.80	2.48
3	18.00	18.45	4.49	3.00	3.09	2.94	10.65	11.05	2.25	1.94	2.62
3−1/2	21.00	21.53	5.25	3.50	3.59	3.38	12.43	12.81	2.40	2.38	3.12
4	24.00	24.60	6.20	4.00	4.10	3.88	14.40	14.78	2.70	2.58	3.58

Note: 'C' dimension is tolerance range for bar stock
'D' dimension is minimum bar diameter at crown
'E' dimension does not include flashing at weld

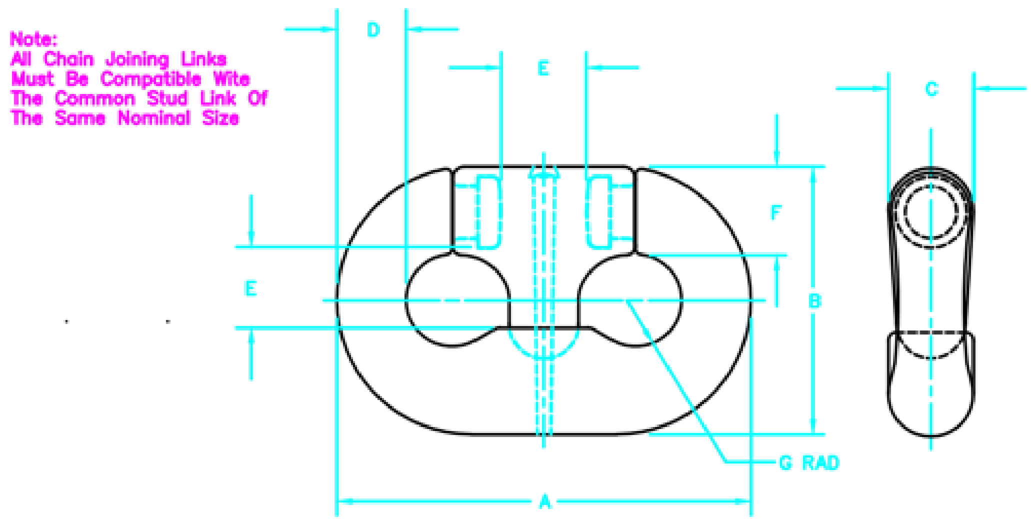


G-2 FM3 CHAIN JOINING LINK.

Figure G-2 FM3 Chain Joining Link Data

(All Dimensions In Inches)

Nominal Diameter	A (min)	A (max)	B (min)	B (max)	C (min)	C (max)	D (min)	D (max)	E (min)	E (max)	F (min)	F (max)	G (min)	G (max)
1–3/4	11.97	12.03	7.72	7.78	2.33	2.61	1.97	2.03	2.34	2.47	2.47	2.53	1.30	1.33
2	13.47	13.53	8.69	8.75	2.61	2.95	2.22	2.28	2.65	2.78	2.78	2.84	1.45	1.51
2–1/4	14.79	15.03	9.65	9.72	2.90	3.28	2.47	2.53	2.91	3.06	3.06	3.12	1.64	1.67
2–1/2	16.47	16.53	10.78	10.84	3.59	4.03	2.84	2.90	3.25	3.30	3.44	3.50	1.80	1.83
2–3/4	18.34	18.41	11.98	12.03	3.97	4.47	3.16	3.22	3.34	3.40	3.81	3.87	1.89	1.92
3	19.72	19.78	12.84	12.91	4.38	4.62	3.34	3.40	3.47	3.63	4.06	4.17	2.11	2.18
3–1/2	23.22	23.28	14.97	15.03	4.67	5.26	3.84	3.90	4.58	4.72	4.72	4.78	2.61	2.64
4	25.40	25.60	17.34	17.40	6.33	6.67	4.34	4.40	5.22	5.38	5.84	5.91	2.87	2.91



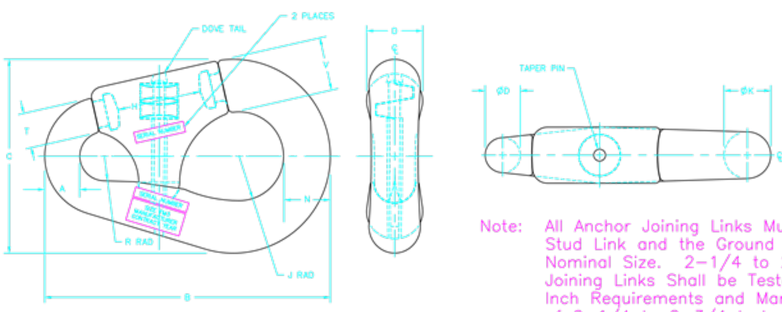
G-3 FM3 ANCHOR JOINING LINK.

Figure G-3 FM3 Anchor Joining Link Data

(All Dimensions in Inches)

Nominal Diameter	A (min)	A (max)	B (min)	B (max)	C (min)	C (max)	D (min)	D (max)	H (min)	H (max)	J (min)	J (max)
1-3/4	1.97	2.03	14.84	14.90	10.22	10.28	3.00	3.18	3.91	3.97	2.05	2.08
2	2.34	2.41	17.84	17.90	12.28	12.34	3.62	3.86	4.72	4.78	2.51	2.54
2-1/4	3.09	3.15	22.09	22.15	14.78	14.84	4.75	5.03	5.84	5.91	2.98	3.01
2-1/2	3.09	3.15	22.09	22.15	14.78	14.84	4.75	5.03	5.84	5.91	2.98	3.01
2-3/4	3.09	3.15	22.09	22.15	14.78	14.84	4.75	5.03	5.84	5.91	2.98	3.01
3	3.59	3.66	25.72	25.78	16.47	16.53	5.25	5.57	6.06	6.17	3.11	3.14
3-1/2	3.59	3.66	25.72	25.78	16.47	16.53	5.25	5.57	6.06	6.17	3.11	3.14
4	4.87	5.12	36.77	37.23	23.75	24.25	7.87	8.12	7.87	8.12	4.25	4.50

Nominal Diameter	N (min)	N (max)	R (min)	R (max)	T (min)	T (max)	V (min)	V (max)
1-3/4	2.47	2.53	1.23	1.26	2.22 X 2.34	2.38 X 2.41	2.87	2.94
2	2.97	3.03	1.45	1.48	2.41 X 2.84	2.47 X 2.91	3.44	3.50
2-1/4	3.72	3.78	1.89	1.92	3.09 X 3.34	3.15 X 3.41	4.34	4.41
2-1/2	3.72	3.78	1.89	1.92	3.09 X 3.34	3.15 X 3.41	4.34	4.41
2-3/4	3.72	3.78	1.89	1.92	3.09 X 3.34	3.15 X 3.41	4.34	4.41
3	4.67	5.06	2.11	2.14	3.97 X 4.34	4.03 X 4.41	5.09 X 5.22	5.16 X 5.28
3-1/2	4.64	5.06	2.11	2.14	3.97 X 4.34	4.03 X 4.41	5.09 X 5.22	5.16 X 5.28
4	6.68	7.06	2.95	3.06	6.00	6.16	7.68	8.06



Note: All Anchor Joining Links Must Fit The Common Stud Link and the Ground Ring of the Same Nominal Size. 2-1/4 to 2-3/4 Inch Anchor Joining Links Shall be Tested to the 2-3/4 Inch Requirements and Marked With The Range of 2-1/4 to 2-3/4 Inches. Same Requirement for 3 and 3-1/2 Inch Sizes.

G-4 FM3 GROUND RING.

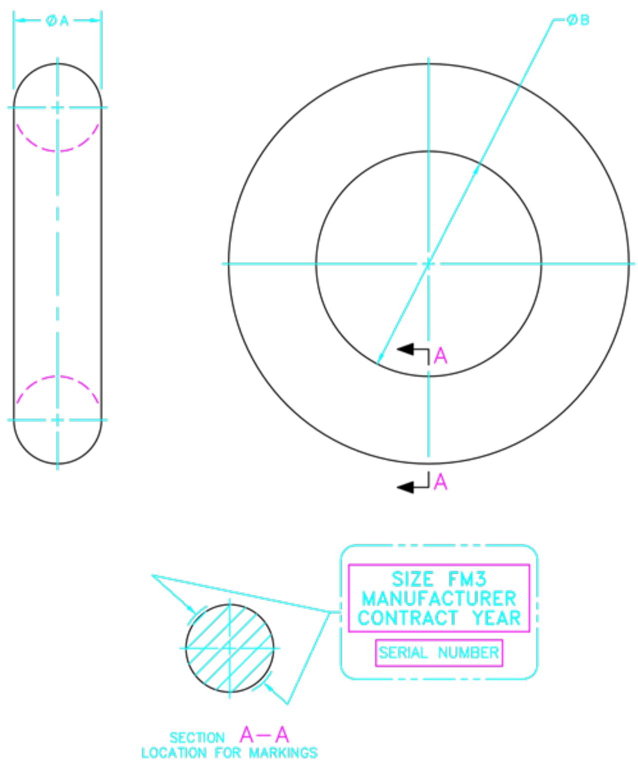
Figure G-4 FM3 Ground Ring Data

(All Dimensions in Inches)

Nominal Diameter	A (min)	A (max)	B (min)	B (max)
1-3/4	3.41	3.59	8.78	9.23
2	3.66	3.84	10.24	10.76
2-1/4	5.25	5.50	11.70	12.30
2-1/2	5.25	5.50	11.70	12.30
2-3/4	5.25	5.50	11.70	12.30
3	5.50	5.75	13.16	13.84
3-1/2	5.75	6.00	13.16	13.84
4	7.31	7.69	19.00	19.95

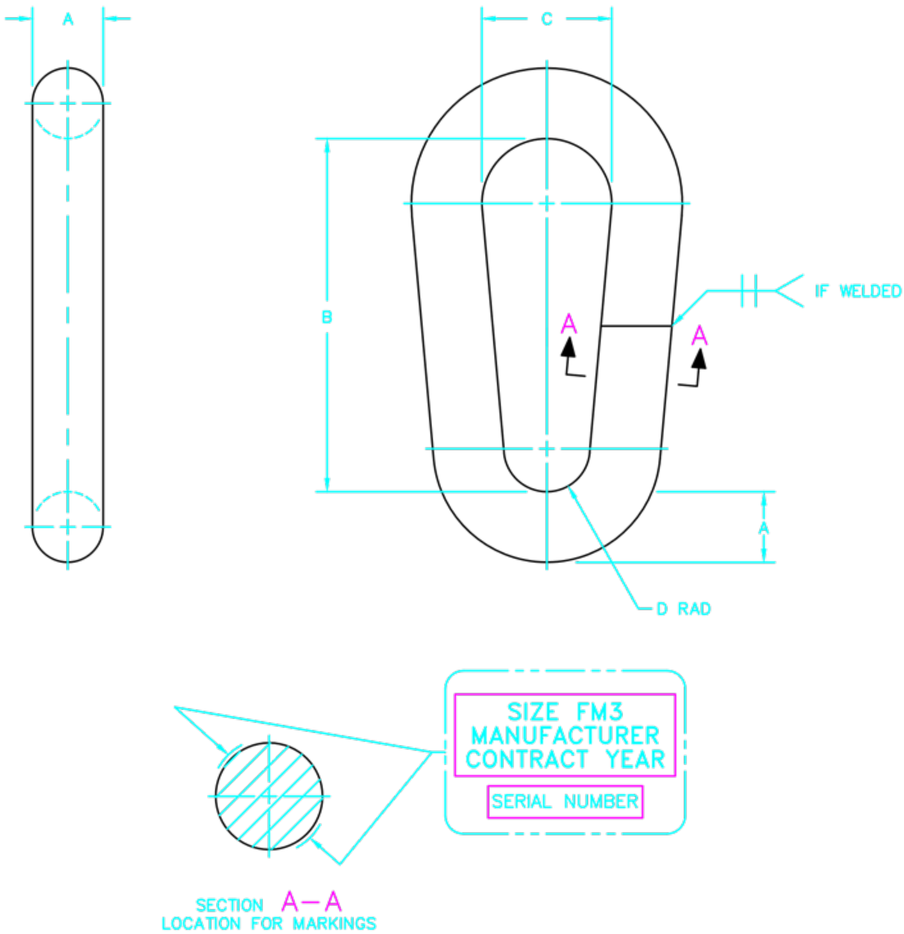
NOTE:

1. 2-1/4 to 2-3/4 inch Ground Rings shall be tested to the 2-3/4 inch requirements and marked with the range of 2-1/4 to 2-3/4.
2. Markings shall be as specified in Section 3.8.



G-5 FM3 PEAR LINK.

Figure G-5 FM3 Pear Link



(All Dimensions in Inches)

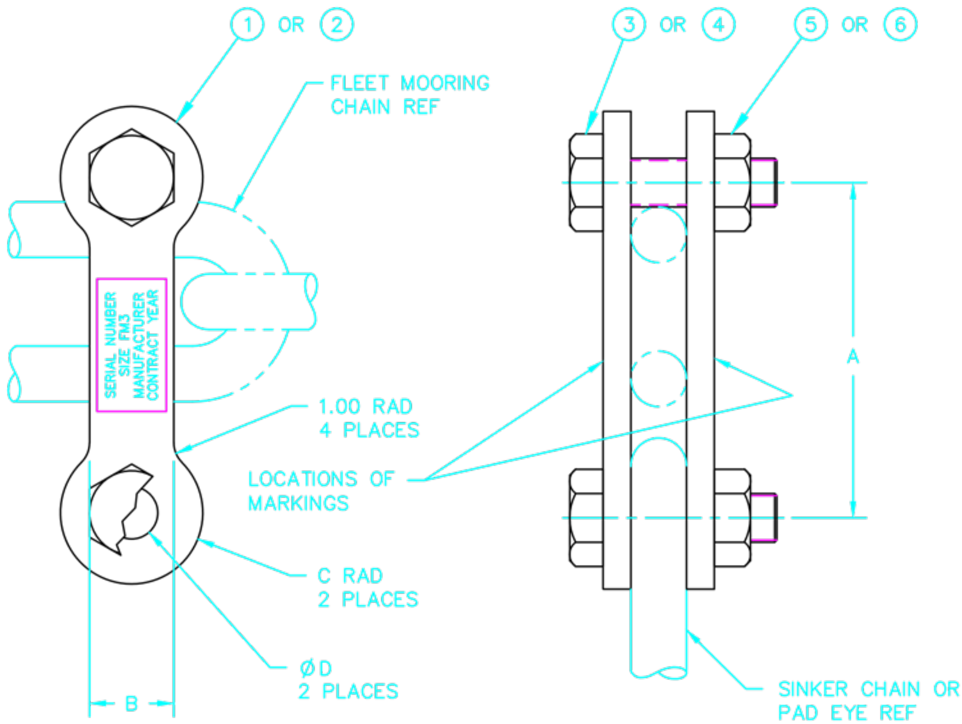
Nominal Diameter	A (min)	A (max)	B (min)	B (max)	C (min)	C (max)	D (min)	D (max)
1–3/4	2.25	2.38	11.50	11.67	4.19	4.32	1.38	1.44
2	2.50	2.63	13.73	14.03	4.91	5.21	1.64	1.74
2–1/4	2.75	2.87	14.50	14.69	5.37	5.50	1.73	1.83
2–1/2	3.00	3.13	16.16	16.34	5.92	6.05	1.92	2.02
2–3/4	3.50	3.63	17.17	17.88	6.47	6.60	2.11	2.21
3	3.75	3.83	19.21	19.33	6.82	7.28	2.28	2.40
3–1/2	4.25	4.33	23.90	24.08	8.77	8.90	2.85	2.79
4	4.75	4.87	26.22	26.40	9.61	9.74	3.13	3.25

NOTES:

1. MARKINGS SHALL BE AS SPECIFIED IN SECTION 3.7.

G-6 PLATE SHACKLE.

Figure G-6 Plate Shackle



DASH NO.	SINKER CHAIN OR PAD EYE DIA REF	DIM. A ±.12	DIM. B ±.12	RAD C ±.12	DIA D ±.06
–1	1 3/4 TO 2	12.06	3.03	2.56	1.88
–2	2 1/4 TO 4	22.06	4.03	3.56	2.38

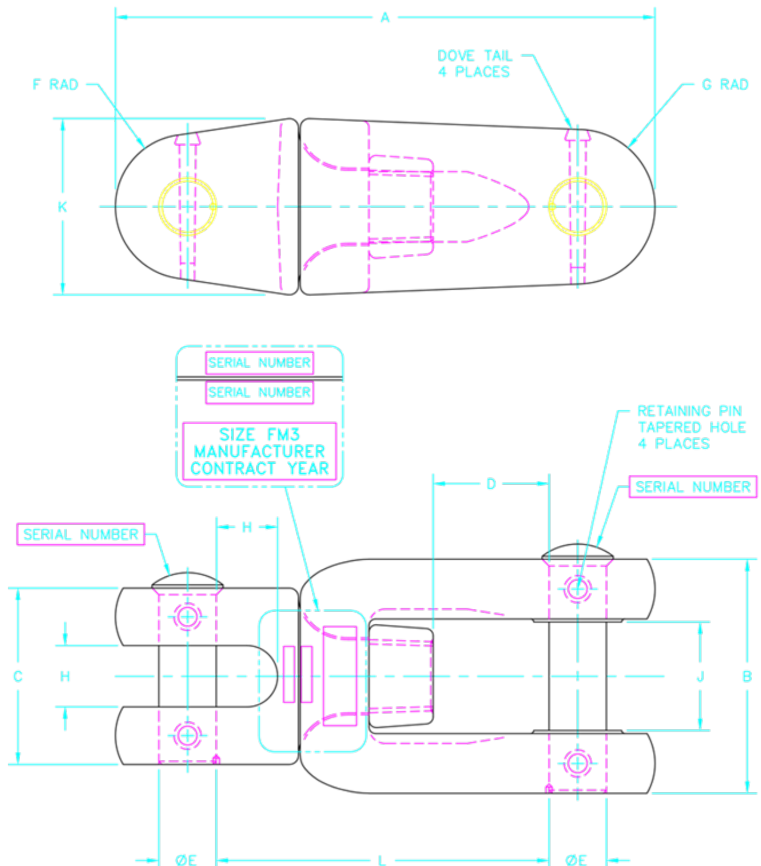
2	–	6	GRADE DH	NUT, HEAVY, HEX, 2.250–8UN–2B	ASTM A563	STEEL
–	2	5	GRADE DH	NUT, HEAVY, HEX, 1.750–8UN–2B	ASTM A563	STEEL
2	–	4	GRADE BD	BOLT, HEX HD, 2.250–8UN–2A X 9.25L	ASTM A354	STEEL
–	2	3	GRADE BD	BOLT, HEX HD, 1.750–8UN–2A X 6.25L	ASTM A354	STEEL
2	–	2		PLATE, 1.25 STK	ASTM A36	STEEL
–	2	1		PLATE, 1.00 STK	ASTM A36	STEEL
QTY REQD	QTY REQD	FIND NO.	PART OR IDENTIFYING NO.	PART OR IDENTIFYING NO.	SPEC	MATERIAL
–2	–1	PARTS LIST				

NOTES:

1. PLATE SINKER SHACKLE MARKINGS SHALL BE AS SPECIFIED IN SECTION 3.7.

G-7 FM3 RISER SWIVEL SHACKLE DATA.

Figure G-7 FM3 Riser Swivel Shackle Data



(Dimensions are specified on following page.)

(All Dimensions in Inches)

Nominal Diameter	A (min)	A (max)	B (min)	B (max)	C (min)	C (max)	D (min)	E (min)	E (max)	F (min)	F (max)
1–3/4	20.91	22.44	9.07	9.53	6.83	7.18	5.62	2.22	2.34	2.80	2.94
2	25.36	26.66	11.21	11.79	7.99	8.39	5.62	2.57	2.71	3.29	3.45
2–1/4	27.44	30.50	12.29	12.92	8.76	9.20	8.00	2.84	2.98	3.61	3.79
2–1/2	31.89	33.53	13.74	14.44	9.83	10.32	8.00	3.23	3.39	4.07	4.27
2–3/4	34.09	35.83	15.04	15.82	10.74	11.30	8.00	3.23	3.39	4.42	4.64
3	38.74	40.72	16.43	17.27	12.05	12.67	9.00	3.76	3.96	4.99	5.25
3–1/2	45.90	48.26	19.34	20.34	13.82	14.52	9.00	4.45	4.67	5.53	5.81
4	52.11	54.79	21.96	23.08	15.74	16.54	9.00	4.62	4.87	6.44	6.78

Nominal Diameter	G (min)	G (max)	H (min)	H (max)	J (min)	J (max)	K (min)	K (max)	P (min)	P (max)
1–3/4	2.99	3.15	2.38	2.50	3.75	4.87	6.83	7.18	12.90	14.75
2	3.69	3.87	2.76	2.90	3.75	4.87	7.99	8.39	15.81	16.63
2–1/4	4.03	4.23	3.07	3.23	3.75	4.87	8.76	9.20	16.97	19.56
2–1/2	4.56	4.80	3.45	3.63	3.75	4.87	9.83	10.33	20.04	21.06
2–3/4	4.95	5.21	3.76	3.96	3.75	4.87	10.74	11.30	21.22	22.31
3	6.03	6.33	4.07	4.27	3.75	4.87	12.05	12.67	23.96	25.18
3–1/2	6.30	6.62	4.84	5.08	3.75	4.87	13.82	14.52	29.63	31.15
4	7.22	7.59	5.53	5.81	3.75	4.87	15.74	16.54	33.39	35.11

Note: Pin diameter to hole diameter looseness shall be +.090 max. for sizes 2–1/2, 2–3/4, 3, 3–1/2, 4, and +.072 max. for sizes 2 1/4, 2, 1 3/4.

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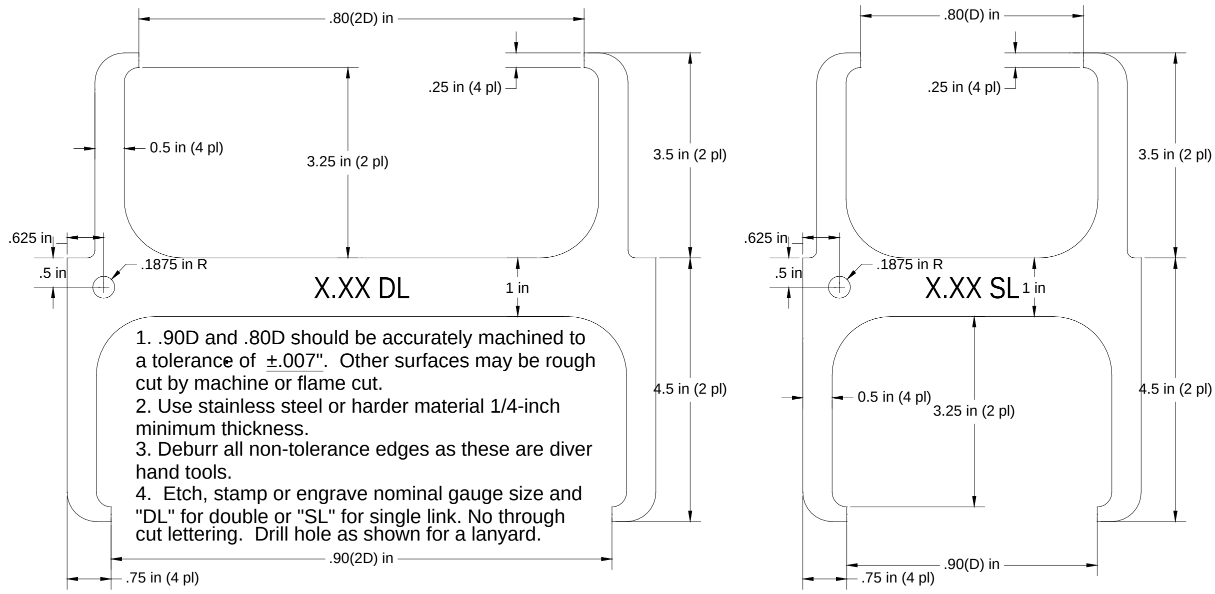
APPENDIX H GO/NO-GO GAUGE DIMENSIONS



Diameter	Single Link		Double Link		Diameter	Single Link		Double Link	
	.90D	.80D	.90D	.80D		.90D	.80D	.90D	.80D
inches	inches	inches	inches	inches	inches	inches	inches	inches	inches
6.5	5.85	5.20	11.20	10.40	2.5	2.25	2.00	4.50	4.00
6.0	5.40	4.80	10.80	9.60	2.25	2.025	1.80	4.05	3.60
5.5	4.95	4.40	9.90	8.80	2.0	1.80	1.60	3.60	3.20
4.5	4.05	3.60	8.10	7.20	1.785	1.687	1.500	3.375	3.000
4.0	3.60	3.20	7.20	6.40	1.75	1.575	1.40	3.15	2.80
3.5	3.15	2.80	6.30	5.60	1.5	1.350	1.200	2.700	2.400
3.0	2.70	2.40	5.40	4.80	1.25	1.125	1.000	2.250	2.000
2.75	2.475	2.20	4.95	4.40					

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APPENDIX I GENERAL INSTALLATION PROCEDURES FOR A DRAG EMBEDMENT ANCHOR/RISER TYPE MOORING SYSTEM

The following is an excerpt from MO-124 providing general installation instructions for a drag embedment riser type mooring system.

I-1 GENERAL.

General installation procedures for the typical three-legged riser mooring system are presented below. The procedures are preceded by a description of the main parts of the mooring system which should be assembled before offshore operations begin.

I-1.1 Riser-Type Mooring System.

Installation of this mooring system shall generally follow the procedure set forth below.

I-1.1.1 Preinstallation Assembly.

A three-legged riser-type mooring system is normally assembled in three parts (see Figure I-1):

- Part I. This part is the first anchor chain subassembly with a sinker and anchor.
- Part II. This part includes the buoy, the riser chain subassembly from the buoy to the ground ring, and the second anchor chain subassembly with a sinker and anchor.
- Part III. This part is the third anchor chain subassembly with a sinker and anchor.

I-1.1.2 Installation Procedures.

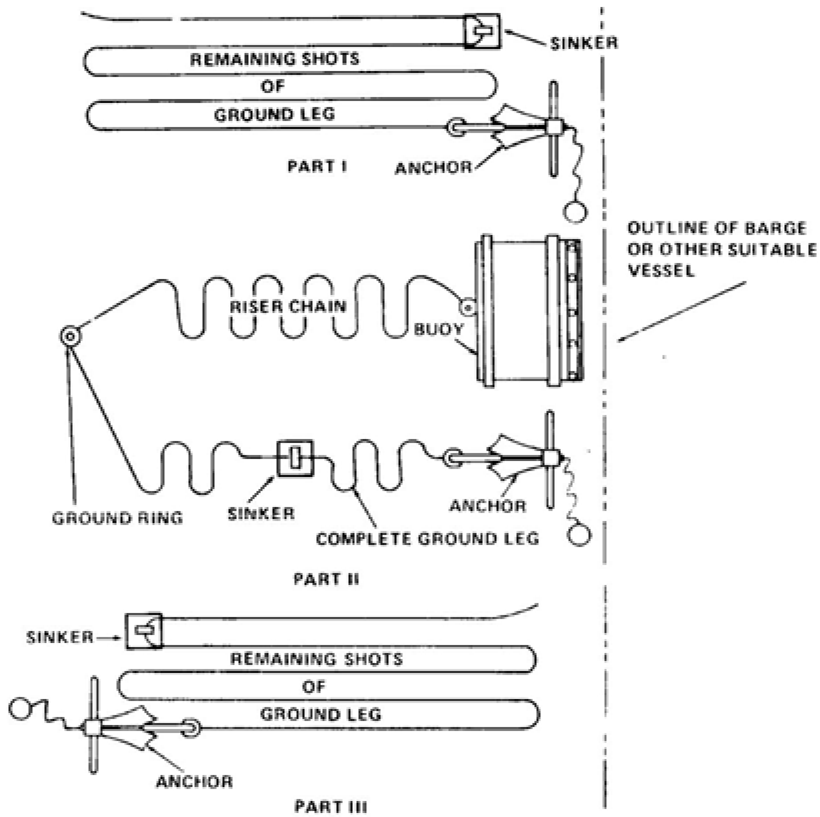
The marker buoys will be placed in their desired locations. The center marker buoy will be placed in the desired position of the mooring buoy. The ring marker buoys will be installed 25 feet past the point that the anchors will be lowered to the bottom and released. Predicted drag distance of the anchor is needed to determine this point. Table J-1 through Table J-8 provides predicted drag distances. The desired final location of the anchors should be indicated on the design drawing. provided by the mooring designer. After pulling the anchor to set it and test its capacity, (see 2.2.2.3) the final position of the anchor must be within a 40 foot by 20-foot box with the desired location at the center of the box (see Figure I-4). The range marker buoys should be installed about 50 feet beyond the ring marker buoys on the extension of the lines from the center marker buoy to the ring marker buoys.

Before beginning installation of the system, the free end of the first anchor chain subassembly of Part I should be attached to a pickup buoy for easy recovery during the placement operation.

Note:

Wind and current conditions will usually dictate which subassembly is laid first.

Figure I-1 Typical Riser-Type Mooring Material Pre-Installation Layout

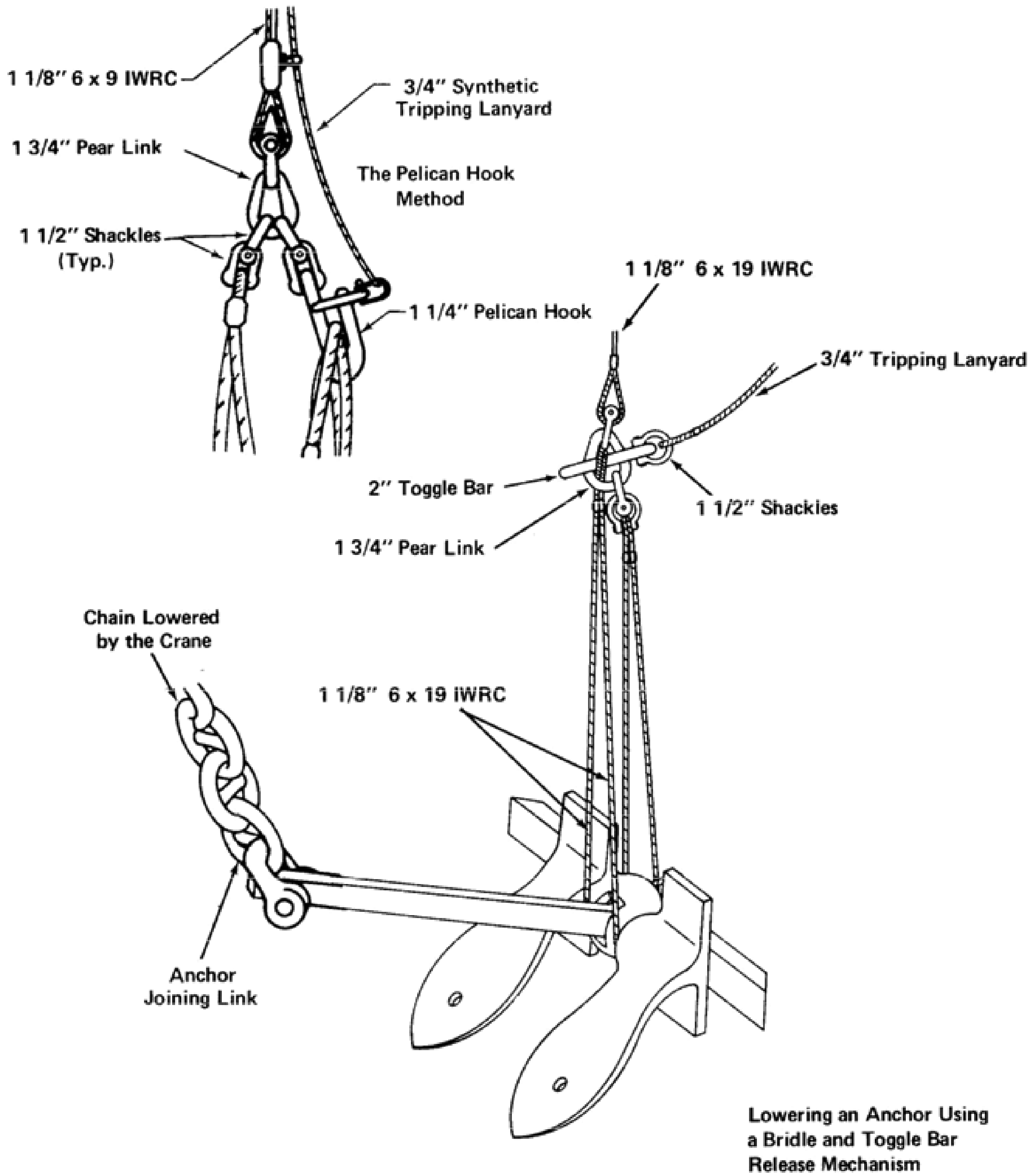


These general installation procedures should then be followed:

- Position the crane barge near one of the ring marker buoys (the one within 25 feet of the desired position for the anchor of the first anchor chain subassembly of Part I). During some installations, it may be necessary to weld the anchor flukes to a predetermined angle.
- The first anchor is slung by a bridle in a horizontal position and has attached to it a crown marker buoy and one anchor leg subassembly. The anchor is fitted with a pelican hook or a toggle bar quick release system as shown in Figure I-2. The crane lowers the anchor and chain simultaneously over the side. When installing moorings equipped with chain stud anodes, care must be exercised that the chain does not drag over sharp edges which can result in some of the anodes being stripped off.

- Upon reaching the bottom, release the anchor and recover the bridle. Move the barge toward the center marker buoy while slowly lowering the chain with a flat catenary.

Figure I-2 Lifting Bridle and Release Mechanism



- Upon approaching the center marker buoy, pull the subassembly taut so that the anchor is properly set. Then, lower the bitter end of the chain (with a pickup buoy attached to it) to the bottom.
- The crane barge now proceeds to the second marker buoy and lowers the anchor (of Part II) 25 feet from the marker toward the center marker buoy. The anchor is fitted with a quick release mechanism and has a crown buoy attached to it.
- Upon reaching the bottom, release the anchor and recover the bridle. Move the barge toward the center marker buoy while slowly lowering the chain with a flat catenary. Upon approaching the center marker buoy, pull the subassembly taut so that the anchor is properly set. Then, using the pickup buoy, retrieve the end of the first anchor chain subassembly and attach it to the ground ring. Attach the bitter end of the third anchor chain subassembly (Part Ill) to the ground ring also. Then lower the ground ring, riser, and buoy into the water alongside the center marker buoy.
- The crane barge will slowly lower the third anchor chain subassembly while proceeding toward the third ring marker. This ring marker and its range marker should be used to ensure that the chain is being installed in a straight line.
- When approaching the ring marker buoy, pull the anchor until the chain leg is taut and then lower the anchor (in a bridle with the flukes pointed downward) to the bottom and release it using the quick release mechanism (see Figure 2-7).
- Conduct a final inspection of the mooring. Site the three crown marker buoys from ashore. The positions of these three markers will be the positions of the anchors. If available, have divers make an underwater inspection of the mooring installation.
- Remove all marker buoys with their cables and anchors.

I-1.1.3 Pull Testing of Anchors.

Fleet moorings will be pull tested to the holding capacity of the mooring class listed in APPENDIX J.

I-1.1.4 Installation Barge.

Whenever possible, the YD or similar barge type craft to be used for mooring installation should be equipped with two stern winches to be used for pulling on kedge anchors. The installation barge should have the capability to anchor itself.

Note:

Divers may be used to inspect connections and to check the orientation and tautness of the anchor chains. They may also be used to jet the anchors into the bottom if included as part of the design specification.

Figure I-3 Typical Riser-Type Mooring Installation

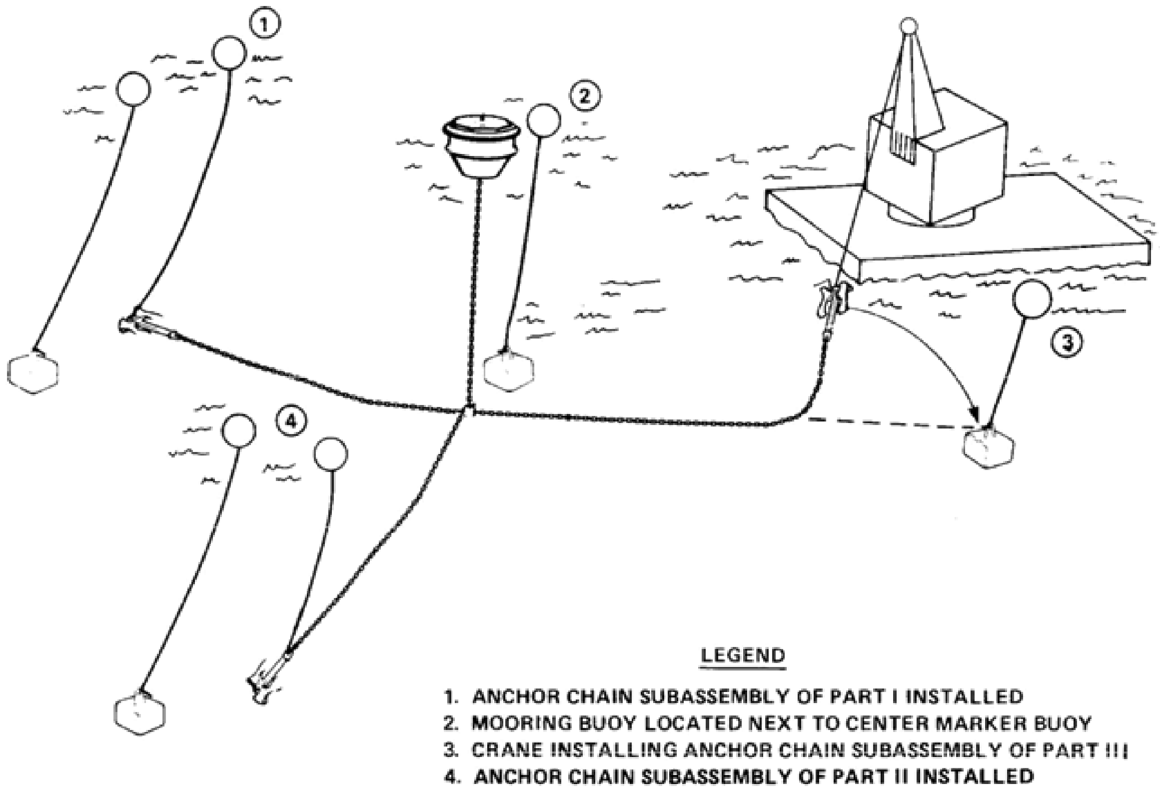
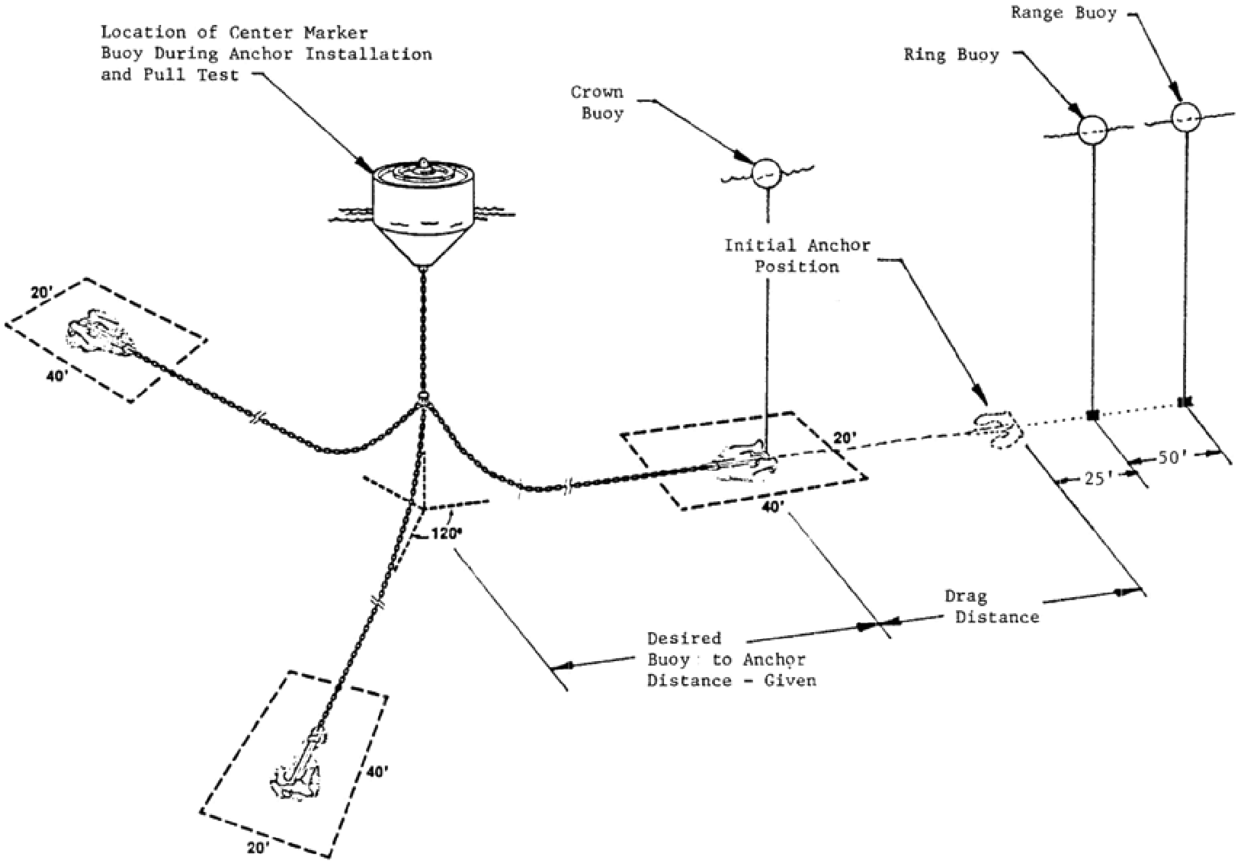


Figure I-4 Allowable Anchor Areas



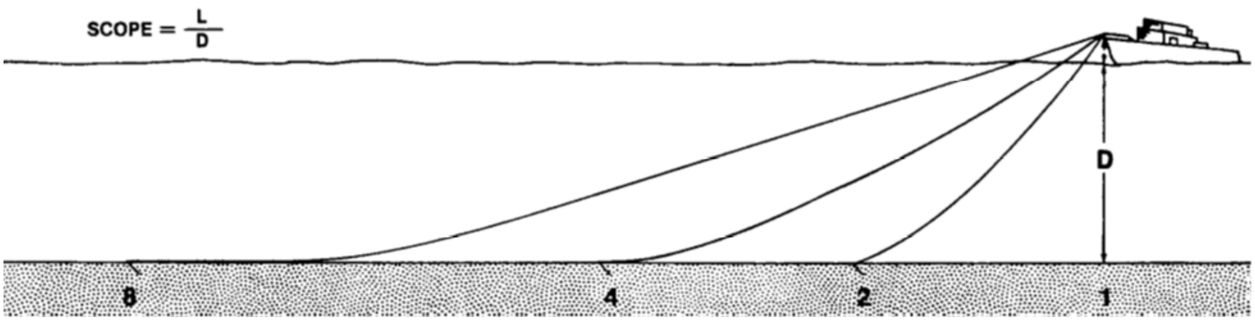
APPENDIX J DRAG EMBEDMENT ANCHOR PULL TESTING GUIDANCE

The following is an excerpt from MO-124 providing general installation instructions for a drag embedment anchor pull testing.

J-1 SETTING DRAG ANCHORS.

Proof setting of each anchor leg should be accomplished using harbor tugs, Fleet tugs or by pulling diametrically opposite anchor legs against each other. When setting the anchor, it is desirable to have a 10 to 1 scope (see Figure J-1 for definition) in the mooring line. This may be accomplished by adding chain or a work wire. The anchor drag distance to achieve the specified load level must be known to enable proper anchor placement prior to proof loading. Setting shall be accomplished by pulling to the design load of the mooring.

Figure J-1 Mooring Leg Scope



Scope is the ratio of length of rode (L) to depth of water (D), plus allowance for height of bow above water. At (1) length of rode equals the depth. At (2) rode length is twice the depth, at (4) four times the depth. Note how the angle between rode and bottom decreases. At (B) the scope is 8:1 and the short length of chain at the anchor lies flat on the bottom

J-2 DRAG DISTANCE.

- Single Anchors. The predicted anchor drag distance for single anchors can be obtained from Table J-1 through Table J-4.
- Tandem Anchor Systems. The predicted anchor drag distance for tandem anchor systems can be obtained from Table J-5 through Table J-8.

J-3 LOAD MEASUREMENT.

While setting the anchor, it is desirable to monitor the loads. A currently calibrated dynamometer should be placed in line to measure the load.

J-4 FINAL ANCHOR POSITION.

It is expected that the desired holding capacity can be achieved during setting and that the anchor will be within the 40-foot-long by 20-foot-wide allowable anchor area (see

Figure I-4). If after setting, the desired load is not obtained, or if the anchor drags outside the tolerance box, then the anchor must be repositioned and the pull test repeated.

J-5 PULL TESTING.

After the anchor is set, the pull test should be conducted. It is important that a length of chain equal to the total length of riser and ground leg be used for the test. Use of shorter chain lengths will create an uplift force on the anchor.

J-6 LOADING PROCEDURE.

Each anchor leg should be pull tested independently. The vessel performing the pull should gradually build up to the proof test load. Increase the load in 10,000 pound increments up to the required proof test load. After each 10,000-pound increase allow the dynamometer reading to stabilize. Once the required pull test load is reached, allow the dynamometer reading to stabilize, then hold the pull test load for 3 minutes.

J-6.1 Anchor Leg Adequate.

If the desired load is obtained and the anchor is positioned within the tolerance box, the anchor leg is adequate.

J-6.2 Anchor Leg Inadequate.

If either the pull test load is not achieved or the anchor is out of position, the anchor must be repositioned and the pull test repeated.

J-6.3 Pull Test Not Achieved.

If the pull test load cannot be achieved, the anchor system design may not be correct. Several options exist for increasing the anchors capacity:

- Changing the anchor fluke angle. Usually the fluke is fixed fully open for muds and partially open (approximately 35°) for sands.
- Soaking. When deploying anchors in silt or clay (muds) it is desirable to allow the anchors to soak. “Soaking” of an anchor is the practice of allowing a newly embedded anchor to rest for a period of time, typically 24 hours, before applying the required proof load.
- Jetting. If a drag anchor does not bury to a sufficient depth to develop the required capacity, it may be possible to use divers to jet the anchor to the required depth. The anchor should be jetted to a depth equal to or greater than the length of the anchor fluke.

J-6.4 Anchor Out of Position.

If the anchor is not within the tolerance box, reposition the anchor accordingly, reset and repeat the pull test

Note:

Ensure that the anchor is not recovered and reset in the furrow or disturbed bottom area caused by the initial pull test.

Table J-1 Drag Distance - Stockless Anchor with Stabilizers and Flukes Fixed at approximately 45^0, Seafloor Type: Mud

Anchor Wt (kips)	Horizontal Design Load (Kips)											
	25	50	75	100	125	150	175	200	225	250	275	300
6.	54.	*	*	*	*	*	*	*	*	*	*	*
7.	32.	*	*	*	*	*	*	*	*	*	*	*
8.	21.	*	*	*	*	*	*	*	*	*	*	*
9.	13.	*	*	*	*	*	*	*	*	*	*	*
10.	9.	*	*	*	*	*	*	*	*	*	*	*
11.	6	183.	*	*	*	*	*	*	*	*	*	*
12.	6.	99.	*	*	*	*	*	*	*	*	*	*
13.	6.	64.	*	*	*	*	*	*	*	*	*	*
14.	5.	47.	*	*	*	*	*	*	*	*	*	*
15.	5.	40.	*	*	*	*	*	*	*	*	*	*
16.	5.	33.	*	*	*	*	*	*	*	*	*	*
17.	4.	27.	*	*	*	*	*	*	*	*	*	*
18.	4.	22.	154.	*	*	*	*	*	*	*	*	*
19.	4.	17.	95.	*	*	*	*	*	*	*	*	*
20.	3.	14.	77.	*	*	*	*	*	*	*	*	*
21.	3.	12.	64.	*	*	*	*	*	*	*	*	*
22.	2.	10.	53.	*	*	*	*	*	*	*	*	*
23.	2.	8.	48.	*	*	*	*	*	*	*	*	*
24.	2.	8.	42.	202.	*	*	*	*	*	*	*	*
25.	1.	8.	37.	152.	*	*	*	*	*	*	*	*
26.	1.	8.	33.	104.	*	*	*	*	*	*	*	*
27.	1.	7.	29.	89.	*	*	*	*	*	*	*	*
28.	1.	7.	25.	78.	*	*	*	*	*	*	*	*
29	1.	7.	21.	68.	*	*	*	*	*	*	*	*
30.	0.	7.	19.	59.	245.	*	*	*	*	*	*	*
	Drag Distance (Feet)											

*Exceeds anchor ultimate holding capacity

Table J-2 Drag Distance - Stockless Anchor with Stabilizers and Flukes Fixed at approximately 36^0, Seafloor Type: Sand

Anchor Wt (kips)	Horizontal Design Load (Kips)											
	25	50	75	100	125	150	175	200	225	250	275	300
5.	20.	*	*	*	*	*	*	*	*	*	*	*
6.	19.	*	*	*	*'	*	*	*	*	*	*	*
7.	18.	37.	*	*	*	*	*	*	*	*	*	*
8.	17.	33.	*	*	*	*	*	*	*	*	*	*
9.	17.	29.	*	*	*	*	*	*	*	*	*	*
10.	17.	28.	*	*	*.	*	*	*	*	*	*	*
11.	17.	27.	46.	*	*	*	*	*	*	*	*	*
12.	17.	26.	43.	*	*	*	*	*	*	*	*	*
13.	17.	26.	39.	*	*	*	*	*	*	*	*	*
14.	17.	25.	37.	*	*	*	*	*	*	*	*	*
15.	17.	24.	35.	*	*	*	*	*	*	*	*	*
16.	17.	24.	34.	52.	*	*	*	*	*	*	*	*
17.	17.	23.	33.	49.	*	*	*	*	*	*	*	*
18.	17.	23.	32.	46.	*	*	*	*	*	*	*	*
19.	18.	23.	32.	44.	*	*	*	*	*	*	*	*
20.	18.	23.	31.	41.	*	*	*	*	*	*	*	*
21.	18.	22.	31.	40.	57.	*	*	*	*	*	*	*
22.	18.	22.	30.	39.	54.	*	*	*	*	*	*	*
23.	18.	22.	30.	38.	52.	*	*	*	*	*	*	*
24.	18.	22.	29.	37.	50.	*	*	*	*	*	*	*
25.	18.	22.	29.	36.	48.	*	*	*	*	*	*	*
26.	17.	22.	28.	36.	46.	62.	*	*	*	*	*	*
27.	17.	23.	28.	36.	45.	60.	*	*	*	*	*	*
28.	17.	23.	28.	35.	43.	58.	*	*	*	*	*	*
29	17.	23.	28.	35.	43.	56.	*	*	*	*	*	*
30.	17.	23.	27.	35.	42.	54.	*	*	*	*	*	*
	Drag Distance (Feet)											

*Exceeds anchor ultimate holding capacity

Table J-3 Drag Distance - STATO Anchor with Stabilizers and Flukes Fixed at approximately 50^0, Seafloor Type: Mud

Anchor Wt (kips)	Horizontal Design Load (Kips)											
	25	50	75	100	125	150	175	200	225	250	275	300
5.	4.	23.	64.	158.	*	*	*	*	*	*	*	*
6.	3.	15.	45.	96.	236.	*	*	*	*	*	*	*
7.	2.	10.	34.	68.	127.	322.	*	*	*	*	*	*
8.	2.	7.	25.	52.	93.	168.	398.	*	*	*	*	*
9.	1.	6.	18.	43.	72.	120.	205.	*	*	*	*	*
10.	1.	6.	14.	35.	57.	94.	148.	280.	*	*	*	*
11.	1.	5.	11.	27.	50.	76.	118.	183.	352.	*	*	*
12.	0.	4.	9.	21.	43.	63.	96.	140.	216.	418.	*	*
13.	0.	4.	8.	18.	36.	56.	81.	118.	169.	266.	*	*
14.	0.	3.	7.	15.	29.	50.	68.	99.	138.	200.	333.	*
15.	0.	3.	7.	13.	24.	43.	61.	85.	118.	158.	229.	395.
16.	0.	3.	6.	10.	21.	37.	55.	73.	102.	138.	188.	265.
17.	0.	2.	6.	10.	18.	32.	50.	66.	90.	120.	156.	216.
18.	0.	2.	5.	9.	16.	27.	44.	61.	78.	106.	138.	179.
19.	0.	2.	5.	8.	14.	24.	39.	56.	71.	94.	122.	156.
20.	0.	1.	5.	8.	12.	21.	34.	51.	66.	83.	109.	139.
21.	0.	1.	4.	7.	11.	19.	30.	46.	61.	75.	98.	124.
22.	0.	1.	4.	7.	10.	17.	26.	41.	56.	70.	88.	112.
23.	0.	1.	4.	7.	10.	15.	24.	36.	52.	66.	79.	102.
24.	0.	1.	3.	6.	9.	13.	22.	32.	47.	61.	74.	92.
25.	0.	1.	3.	6.	9.	12.	20.	28.	43.	57.	70.	83.
26.	0.	0.	3.	5.	8.	11.	18.	26.	39.	53.	66.	78.
27.	0.	0.	2.	5.	8.	11.	16.	24.	35.	49.	62.	74.
28.	0.	0.	2.	5.	8.	10.	15.	22.	31.	44.	58.	70.
29	0.	0.	2.	5.	7.	10.	13.	21.	28.	41.	54.	66.
30.	0.	0.	2.	4.	7.	10.	12.	19.	26.	37.	50.	63.
	Drag Distance (Feet)											

*Exceeds anchor ultimate holding capacity

Table J-4 Drag Distance - STATO Anchor with Stabilizers and Flukes Fixed at approximately 30^0, Seafloor Type: Sand

Anchor Wt (kips)	Horizontal Design Load (Kips)											
	25	50	75	100	125	150	175	200	225	250	275	300
5.	15.	21.	28.	39.	55.	*	*	*	*	*	*	*
6.	15.	20.	27.	36.	45.	63.	*	*	*	*	*	*
7.	15.	20.	27.	32.	42.	51.	77.	*	*	*	*	*
8.	15.	20.	26.	30.	39.	47.	59.	91.	*	*	*	*
9.	15.	20.	25.	30.	36.	45.	53.	67.	103.	*	*	*
10.	15.	21.	24.	30.	33.	42.	50.	58.	74.	116.	*	*
11.	16.	20.	24.	29.	33.	40.	47.	55.	65.	88.	*	*
12.	16.	20.	24.	28.	33.	37.	45.	52.	59.	72.	101.	*
13.	16.	20.	24.	28.	33.	36.	43.	50.	57.	65.	79.	114.
14.	17.	20.	24.	27.	32.	36.	41.	48.	55.	61.	72.	91.
15.	17.	20.	24.	27.	32.	36.	39.	46.	53.	59.	65.	78.
16.	17.	20.	24.	27.	31.	36.	38.	44.	51.	57.	63.	72.
17.	17.	20.	24.	27.	31.	35.	38.	42.	49.	55.	61.	67.
18.	18.	20.	24.	27.	30.	35.	38.	41.	47.	54.	59.	65.
19.	18.	20.	24.	27.	30.	34.	38.	41.	46.	52.	58.	63.
20.	18.	20.	24.	27.	30.	34.	38.	40.	44.	50.	56.	62.
21.	18.	20.	24.	27.	30.	33.	37.	40.	43.	49.	55.	60.
22.	19.	21.	24.	27.	30.	33.	37.	40.	43.	47.	53.	59.
23.	19.	21.	24.	27.	30.	32.	36.	40.	43.	46.	52.	57.
24.	19.	21.	24.	27.	30.	32.	36.	40.	42.	45.	50.	56.
25.	19.	21.	24.	27.	30.	32.	36.	40.	42.	45.	49.	54.
26.	19.	21.	24.	27.	30.	32.	35.	39.	42.	44.	47.	53.
27.	20.	21.	24.	27.	30.	32.	35.	39.	42.	44.	46.	52.
28.	20.	21.	24.	27.	30.	32.	35.	38.	42.	44.	46.	50.
29	20.	22.	24.	27.	30.	32.	34.	38.	41.	44.	46.	49.
30.	0.	0.	2.	4.	7.	10.	12.	19.	26.	37.	50.	63.
	Drag Distance (Feet)											

*Exceeds anchor ultimate holding capacity

Table J-5 Drag Distance - Tandem Stockless Anchors with Stabilizers and Flukes Fixed at approximately 45^0, Seafloor Type: Mud

Anchor Wt (kips)	Horizontal Design Load (Kips)										
	25	50	75	100	125	150	175	200	225	250	275	300
5.	6.	*	*	*	*	*	*	*	*	*	*	*
6.	4.	54.	*	*	*	*	*	*	*	*	*	*
7.	4.	32.	*	*	*	*	*	*	*	*	*	*
8.	3.	21.	*	*	*	*	*	*	*	*	*	*
9.	3.	13.	70.	*	*	*	*	*	*	*	*	*
10.	2.	9.	47.	*	*	*	*	*	*	*	*	*
11.	2.	6.	35.	183.	*	*	*	*	*	*	*	*
12.	1.	6.	27.	99.	*	*	*	*	*	*	*	*
13.	1.	6.	21.	64.	*	*	*	*	*	*	*	*
14.	0.	5.	15.	47.	200.	*	*	*	*	*	*	*
15.	0.	5.	12.	40.	128.	*	*	*	*	*	*	*
16.	0.	5.	10.	33.	79.	*	*	*	*	*	*	*
17.	0.	4.	7.	27.	63.		*	*	*	*	*	*
18.	0.	4.	7.	22.	50.	154.	*	*	*	*	*	*
19.	0.	4.	7.	17.	44.	95.	*	*	*	*	*	*
20.	0.	3.	7.	14.	38.	77.	*	*	*	*	*	*
21.	0.	3.	6.	12.	33.	64.	179.	*	*	*	*	*
22.	0.	2.	6.	10.	28.	53.	124.	*	*	*	*	*
23.	0.	2.	6.	8.	23.	48.	90.	*	*	*	*	*
24.	0.	2.	6.	8.	19.	42.	77.	202.	*	*	*	*
25.	0.	1.	5.	8.	17.	37.	65.	152.	*	*	*	*
26.	0.	1.	5.	8.	15.	33.	56.	104.	*	*	*	*
27.	0.	1.	5.	7.	13.	29.	51.	89.	224.	*	*	*
28.	0.	1.	5.	7.	11.	25.	46.	78.	177.	*	*	*
29	0.	0.	4.	7.	10.	21.	42.	68.	132.	*	*	*
30.	0.	0.	4.	7.	9.	19.	38.	59.	101.	245.	*	*
	Drag Distance (Feet)											

*Exceeds anchor ultimate holding capacity

Table J-6 Drag Distance - Tandem Stockless Anchors with Stabilizers and Flukes Fixed at approximately 36^0, Seafloor Type: Sand

Anchor Wt (kips)	Horizontal Design Load (Kips)											
	25	50	75	100	125	150	175	200	225	250	275	300
5.	13.	20.	32.	*	*	*	*	*	*	*	*	*
6.	13.	19.	27.	*	*	*	*	*	*	*	*	*
7.	13.	18.	25.	37.	*	*	*	*	*	*	*	*
8.	13.	17.	24.	33.	*	*	*	*	*	*	*	*
9.	13.	17.	23.	29.	42.	*	*	*	*	*	*	*
10.	13.	17.	22.	28.	38.	*	*	*	*	*	*	*
11.	13.	17.	21.	27.	34.	46.	*	*	*	*	*	*
12.	13.	17.	21.	26.	32.	43.	*	*	*	*	*	*
13.	13.	17.	20.	26.	31.	39.	*	*	*	*	*	*
14.	13.	17.	20.	25.	30.	37.	47.	*	*	*	*	*
15.	13.	17.	20.	24.	29.	35.	44.	*	*	*	*	*
16.	13.	17.	20.	24.	29.	34.	41.	52.	*	*	*	*
17.	13.	17.	20.	23.	28.	33.	39.	49.	*	*	*	*
18.	13.	17.	20.	23.	28.	32.	37.	46.	*	*	*	*
19.	13.	18.	20.	23.	27.	32.	36.	44.	53.	*	*	*
20.	13.	18.	20.	23.	27.	31.	35.	41.	50.	*	*	*
21.	13.	18.	20.	22.	26.	31.	35.	40.	48.	57.	*	*
22.	13.	18.	20.	22.	26.	30.	34.	39.	46.	54.	*	*
23.	13.	18.	20.	22.	26.	30.	34.	38.	44.	52.	*	*
24.	14.	18.	20.	22.	25.	29.	33.	37.	42.	50.	58.	*
25.	14.	18.	20.	22.	25.	29.	33.	36.	41.	48.	56.	*
26.	14.	17.	20.	22.	25.	28.	32.	36.	40.	46.	54.	62.
27.	14.	17.	20.	23.	25.	28.	32.	36.	40.	45.	52.	60.
28.	14.	17.	21.	23.	25.	28.	32.	35.	39.	43.	50.	58.
29	14.	17.	21.	23.	25.	28.	31.	35.	38.	43.	49.	56.
30.	14..	17.	21.	23.	25.	27.	31.	35.	38.	42	47.	54.
	Drag Distance (Feet)											

*Exceeds anchor ultimate holding capacity

Table J-7 Drag Distance - Tandem STATO Anchors with Stabilizers and Flukes Fixed at approximately 50^0, Seafloor Type: Mud

Anchor Wt (kips)	Horizontal Design Load (Kips)											
	25	50	75	100	125	150	175	200	225	250	275	300
5.	0.	4.	10.	23.	41.	64.	99.	158.	324.	*	*	*
6.	0:	3.	6.	15.	29.	45.	66.	96.	140.	236.	*	*
7.	0.	2.	5.	10.	19.	34.	48.	68.	94.	127.	182.	322.
8.	0.	2.	5.	7.	14.	25.	39.	52.	70.	93.	122.	168.
9.	0.	1.	4.	6.	11.	18.	30.	43.	55.	72.	93.	120.
10.	0.	1.	3.	6.	8.	14.	22.	35.	46.	57.	74.	94.
11.	0.	1.	3.	5.	7.	11.	18.	27.	39.	50.	60.	76.
12.	0.	0.	2.	4.	7.	9.	15.	21.	32.	43.	53.	63.
13.	0.	0.	2.	4.	6.	8.	12.	18.	25.	36.	46.	56.
14.	0.	0.	1.	3.	5.	7.	10.	15.	21.	29.	40.	50.
15.	0.	0.	1.	3.	5.	7.	9.	13.	18.	24.	34.	43.
16.	0.	0.	1.	3.	4.	6.	8.	10.	16.	21.	28.	37.
17.	0.	0.	0.	2.	4.	6.	8.	10.	13.	18.	24.	32.
18.	0.	0.	0.	2.	4.	5.	7.	9.	11.	16.	21.	27.
19.	0.	0.	0.	2.	3.	5.	7.	8.	10.	14.	19.	24.
20.	0.	0.	0.	1.	3.	5.	6.	8.	10.	12.	17.	21.
21.	0.	0.	0.	1.	3.	4.	6.	7.	9.	11.	15.	19.
22.	0.	0.	0.	1.	2.	4.	5.	7.	9.	10.	13.	17.
23.	0.	0.	0.	1.	2.	4.	5.	7.	8.	10.	11.	15.
24.	0.	0.	0.	1.	2.	3.	5.	6.	8.	9.	11.	13.
25.	0.	0.	0.	0.	1.	3.	4.	6.	7.	9.	10.	12.
26.	0.	0.	0.	0.	1.	3.	4.	5.	7.	8.	10.	11.
27.	0.	0.	0.	0.	1.	2.	4.	5.	7.	8.	9.	11.
28.	0.	0.	0.	0.	1.	2.	4.	5.	6.	8.	9.	10.
29	0.	0.	0.	0.	1.	2.	3.	5.	6.	7.	9.	10.
30.	0.	0.	0.	0.	1.	2.	3.	4.	6.	7.	8.	10.
	Drag Distance (Feet)											

*Exceeds anchor ultimate holding capacity

Table J-8 Drag Distance - Tandem STATO Anchors with Stabilizers and Flukes Fixed at approximately 30^0, Seafloor Type: Sand

Anchor Wt (kips)	Horizontal Design Load (Kips)											
	25	50	75	100	125	150	175	200	225	250	275	300
5.	12.	15.	18.	21.	25.	28.	34.	39.	45.	55.	78.	*
6.	13.	15.	18.	20.	24.	27.	30.	36.	41:	45.	52.	63.
7.	13.	15.	18.	20.	23.	27.	29.	32.	37.	42.	46.	51.
8.	13.	15.	18.	20.	22.	26.	28.	30.	34.	39.	43.	47.
9.	14.	15.	18.	20.	22.	25.	28.	30.	32.	36.	40.	45.
10.	14.	15.	18.	21.	22.	24.	27.	30.	32.	33.	38.	42.
11.	15.	16.	18.	20.	22.	24.	26.	29.	32.	33.	35.	40.
12.	15.	16.	18.	20.	22.	24.	26.	28.	31.	33.	35.	37.
13.	15.	16.	18.	20.	23.	24.	26.	28.	30.	33.	35.	36.
14.	16.	17.	18.	20.	23.	24.	26.	27.	30.	32.	34.	36.
15.	16.	17.	18.	20.	22.	24.	26.	27.	29.	32.	34.	36.
16.	16.	17.	18.	20.	22.	24.	26.	27.	29.	31.	34.	36.
17.	16.	17.	18.	20.	22.	24.	26.	27.	28.	31.	33.	35.
18.	17.	18.	19.	20.	22.	24.	26.	27.	28.	30.	32.	35.
19.	17.	18.	19.	20.	22.	24.	26.	27.	28.	30.	32.	34.
20.	17.	18.	19.	20.	22.	24.	26.	27.	29.	30.	32.	34.
21.	17.	18.	19.	20.	22.	24.	26.	27.	29.	30.	31.	33.
22.	18.	19.	19.	21.	22.	24.	26.	27.	29.	30.	31.	33.
23.	18.	19.	20.	21.	22.	24.	26.	27.	29.	30.	31.	32.
24.	18.	19.	20.	21.	22.	24.	26.	27.	29.	30.	31.	32.
25.	18.	19.	20.	21.	22.	24.	26.	27.	29.	30.	31.	32.
26.	19.	19.	20.	21.	22.	24.	26.	27.	29.	30.	31.	32.
27.	19.	20.	20.	21.	22.	24.	26.	27.	29.	30.	31.	32.
28.	19.	20.	21.	21.	22.	24.	26.	27.	29.	30.	31.	32.
29	19.	20.	21.	22.	23.	24.	26.	27.	29.	30.	31.	32.
30.	19.	20.	21.	22.	23.	24.	26.	27.	29.	30.	31.	32.
	Drag Distance (Feet)											

*Exceeds anchor ultimate holding capacity

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APPENDIX K GENERAL REMOVAL PROCEDURES FOR A DRAG EMBEDMENT RISER TYPE MOORING SYSTEM

The following is an excerpt from MO-124 providing general installation instructions for a drag embedment riser type mooring system.

K-1 GENERAL

General removal procedures for the typical three-legged riser mooring system are presented below. The procedures are preceded by a description of the main parts of the mooring system which should be assembled before offshore operations begin.

K-1.1 RISER-TYPE MOORING SYSTEM.

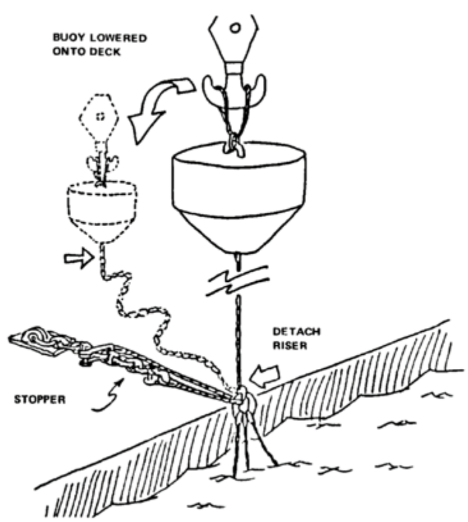
These systems are recovered by removing one anchor chain subassembly at a time. Proceed as follows:

- Sling the buoy from the top jewelry.
- Lift the buoy and riser until the ground ring is level with the deck of the crane barge.

> **Note:**
> In the case of a taut mooring, one anchor chain subassembly may have to be separated from the ground ring by cutting the first A-link below the ground ring with a torch.

- Stopper off the ground ring (see Figure K-1).

Figure K-1 Ground Ring Stoppered Off on Deck



- Lower the buoy down to the deck on its side. Disconnect the riser, and either block the buoy on its side or place it on blocks to avoid damaging the tension bar.

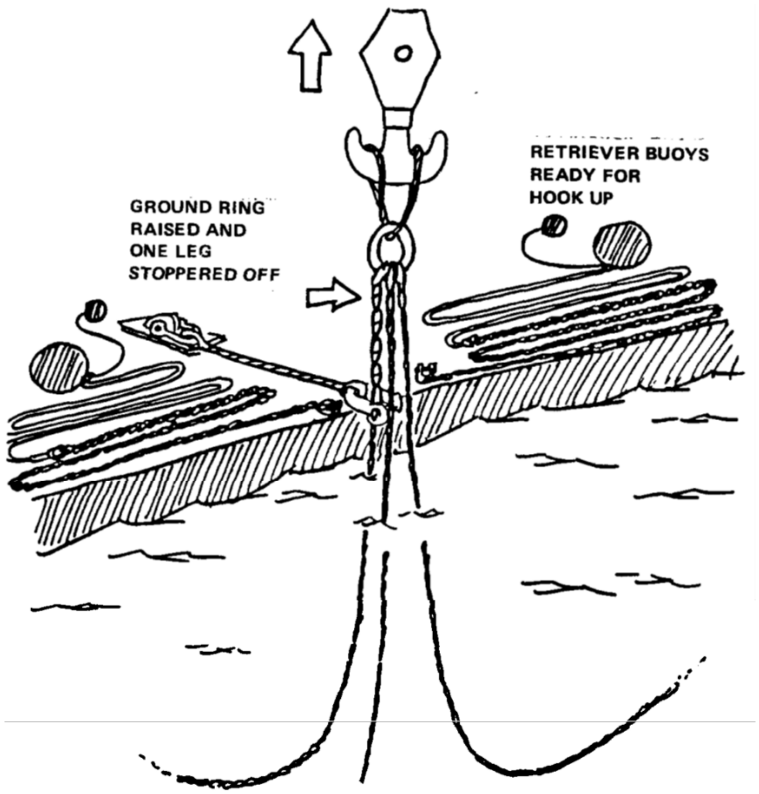
- Disconnect the riser from the ground ring and buoy.

Note:

If the joining link cannot be removed, cut the first A-link with a torch.

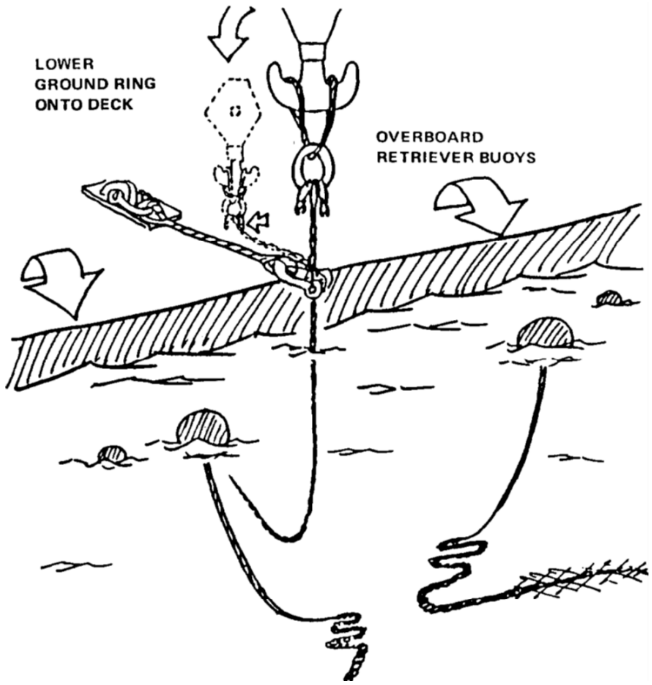
- Sling the ground ring and lift it until the anchor chain subassemblies accessible.
- Stopper off one subassembly (see Figure K-2).

Figure K-2 One Leg Stoppered Off



- Attach a retrieval buoy to each of the other two subassemblies. The third subassembly and the ground ring will be considered together. Fake the retriever buoy lines on deck to allow easy running.
- Cut one subassembly free from the ground ring one link below the chain joining link. Allow the chain to drop and retriever buoy to run free and over the side.
- Repeat with the other leg that has a retriever buoy attached. Lower the ground ring on deck (see Figure K-3). Disassemble the chain joining link, if possible, and disconnect the ground ring from the subassembly.

Figure K-3 Two Anchor Chain Subassemblies Overboarded



- Sling the chain to the main hoist, raise and remove the stopper.
- Continue raising until the next chain joining link is above deck. Stopper the chain, 3 links below the chain joining link, and lower the chain joining link to the deck for disassembly,
- When severed, move this shot of chain aside.
- Sling the chain and continue lifting and detaching chain shots as before.
- When all of the chain has been recovered, bring the anchor aboard.
- Pick up a retriever buoy and, using the same procedures, recover a second subassembly and anchor. Then recover the third.

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APPENDIX L VIDEO LINKS

L-1 INSPECTION OF MOORING CHAIN USING SINGLE AND DOUBLE LINK GO/NO GO GAUGES.

http://www.wbdg.org/ffc/dod/unified-facilities-criteria-ufc/ufc-4-150-09/inspection-b

L-2 INSPECTION OF RISER MOORING SWIVEL SHACKLE.

http://www.wbdg.org/ffc/dod/unified-facilities-criteria-ufc/ufc-4-150-09/inspection-e

L-3 INSPECTION OF CHAIN AND ANCHOR JOINING LINKS.

http://www.wbdg.org/ffc/dod/unified-facilities-criteria-ufc/ufc-4-150-09/inspection-c

L-4 SURFACE INSPECTION OF ANCHOR BOLT SHACKLE AND PEAR LINKS.

http://www.wbdg.org/ffc/dod/unified-facilities-criteria-ufc/ufc-4-150-09/inspection-d

L-5 SURFACE INSPECTION OF FOAM-FILLED BUOY.

http://www.wbdg.org/ffc/dod/unified-facilities-criteria-ufc/ufc-4-150-09/inspection-a

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APPENDIX M GLOSSARY

M-1 ACRONYMS.

ABS	American Bureau of Ships
AFCEE	Air Force Center for Engineering and the Environment
AJL	Anchor Joining Link
ASME	American Society of Mechanical Engineers
ATFP	Anti-terrorism / Force Protection
AVG	Average
AWS	American Welding Society
BIA	Bilateral Infrastructure Agreement
CBC	Naval Construction Battalion Center
CCD	Chain Capture Device
CFR	Code of Federal Regulations
CJL	Chain Joining Link
CO	Commanding Officer
CSAP	Chain-Soil Analysis Program
DDC	Designated Dive Coordinator
DLA	Defense Logistics Agency
DoD	Department of Defense
EDM	Electronic Distance Measurement
EIC	Engineer-in-Charge
EXWC	Engineering and Expeditionary Warfare Center
FAA	Federal Aviation Administration
FEC	Facilities Engineering Command
FM	Fleet Mooring
FMG	Fleet Mooring Grade

FMP	Fleet Mooring Program
FPO	Fleet Post Office
FPR	Fiberglass Polyester Resin
FRP	Fiber Reinforced Polymer
FSW	Feet Sea Water
GPS	Global Positioning System
HQUSACE	Headquarters, U.S. Army Corps of Engineers
HDPE	High Density Polyethylene
HMPE	High Modulus Polyethylene
HNFA	Host Nation Funded Construction Agreements
IAW	In Accordance With
ICAP	Infrastructure Condition Assessment Program
IWRC	Independent Wire Rope Core
LWT	Light Weight Type Anchor
Med-Moor	Mediterranean Mooring
Mil	Military
MLLW	Mean Lower Low Water
MPM	Mooring Program Manager
MT	Magnetic Testing
NAD	North American Datum
NAVFAC	Naval Facilities Engineering Command (NAVFACENGCOM)
NAVSEA	Naval Sea Systems Command
NCC	Navy Crane Center
NDT	Non-Destructive Testing
O&M	Operations and Maintenance
OEM	Original Equipment Manufacturer

OIC	Officer In Charge
OSHA	Occupational Safety and Health Administration
OWD	Original Wire Diameter
PEA	Propellant Embedment Anchors
POC	Point Of Contact
PPE	Personal Protective Equipment
PWO	Public Works Office
QA/QC	Quality Assurance/Quality Control
ROV	Remotely Operated Vehicle
SDS	Safety Data Sheet
SPM	Single Point Mooring
SOFA	Status of Forces Agreements
UCT	Underwater Construction Team
UFC	Unified Facilities Criteria
U.S.	United States
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
UTM	Universal Transverse Mercator
WEAP	Wave Equation Analysis of Piles
WGS84	World Geodetic System 1984

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APPENDIX N REFERENCES

GOVERNMENT

UNIFIED FACILITIES CRITERIA

http://www.wbdg.org/ccb/browse_cat.php?o=29&c=4

UFC 1-200-01, *DoD Building Code (General Building Requirements)*

UFC 3-190-06, *Protective Coatings and Paint*

UFC 4-159-03, *Mooring Design*

UFC 4-150-08, *Inspection of Mooring Hardware*

NAVAL FACILITIES ENGINEERING COMMAND

NAVFAC P-307, *Management of Weight Handling Equipment*

NAVFAC P-1110, *Fleet Mooring Handbook*

NAVFAC MO-124, *Mooring Maintenance Manual*

NAVFAC MO-104.1, *Maintenance of Fender Systems and Camels*

FPO-1-84(6), *Fleet Mooring Underwater Inspection Guidelines*

FPO-1-88(40), *Fleet Mooring Buoy Surface Inspection Guidelines*

NAVAL SEA SYSTEMS COMMAND

NAVSEA Technical Publication, T9074-AS-GIB-010/271, *Requirements for Nondestructive Testing*

NAVSEA 0900-LP-006-0010, *Reinforced Plastics Preventive Maintenance and Repair Manual*

NAVSEA Naval Ships Technical Manual, Chapter 583, S9086-TX-STM-010, *Boats and Small Craft*

NAVSEA Naval Ships Technical Manual, Chapter 631(V1), S9086-VD-STM-010, *Preservation of Ships in Service General*

NAVSEA Naval Ships Technical Manual, Chapter 631(V2), S9086-VD-STM-020, *Preservation of Ships in Service Surface Preparation and Painting*

NAVSEA Naval Ships Technical Manual, Chapter 631(V3), S9086-VD-STM-030, *Preservation of Ships in Service Surface Ship/Submarine Applications*

NAVSEA Naval Ships Technical Manual, Chapter 634, S9086-VG-STM-010, *Deck Coverings, General*

US NAVY DIVING MANUAL, SS521-AG-PRO-010.

MILITARY SPECIFICATIONS AND STANDARDS

PERFORMANCE SPECIFICATION, MIL-PRF-16173E, *Corrosion Preventive Compound, Solvent Cutback, Cold-Application*

DETAIL SPECIFICATION, MIL-DTL-24441D(SH), *Paint, Epoxy-Polyamide, General Specification For*

DETAIL SPECIFICATION, MIL-P-28579(YD), *Plastic Compound Epoxy-Polyamide, Marine Splash Zone Application*

DETAIL SPECIFICATION, MIL-C-24176, *Cement, Epoxy, Metal Repair and Hull Smoothing*

DETAIL SPECIFICATION, MIL-C-19663, *Cloth, Woven Roving, For Plastic Laminate*

DETAIL SPECIFICATION, MIL-M-43248, *Mats, Reinforcing, Glass Fiber*

DETAIL SPECIFICATION, DOD-P-15328, *Primer (Wash), Pretreatment (Formula No. 117 For Metals)*

DETAIL SPECIFICATION, DOD-P-24380, *Paint, Anchor Chain, Solvent Type, Gloss Black*

DETAIL SPECIFICATION, MIL-R-21607, DETAIL SPECIFICATION, DOD-P-15328, *Primer (Wash), Pretreatment (Formula No. 117 For Metals)*

DETAIL SPECIFICATION, DOD-P-15328, *Primer (Wash), Pretreatment (Formula No. 117 For Metals)*

DETAIL SPECIFICATION, MIL-R-21607, *Resins, Polyester, Low Pressure Laminating, Fire-Retardant*

DETAIL SPECIFICATION, MIL-P-15931, *Paint, Antifouling, Vinyl (Formulas No. 121A, and 129A)*

UNITED STATES ARMY CORPS OF ENGINEERS

USACE EM 385-1-1, *Safety and Health Requirements Manual*

U.S. NAVY, OFFICE OF THE CHIEF OF NAVAL OPERATIONS

OPNAVINST 5450.348, *Mission, Functions, and Tasks of Naval Facilities Engineering Command*

NON-GOVERNMENT

AMERICAN WELDING SOCIETY

AWS D1.1, *The Structural Welding Code*

NATIONAL ASSOCIATION OF CORROSION ENGINEERS

NACE No. 3, Commercial Blast Cleaning

NACE No. 2, *Near White Blast Cleaning*

SOCIETY FOR PROTECTIVE COATINGS

SSPC SP-6, *Commercial Blast Cleaning*

SSPC SP-10, *Near White Blast Cleaning*

SSPC SP-2, *Hand Tool Cleaning*

SSPC SP-3, *Power Tool Cleaning*

OCCUPATIONAL HEALTH AND SAFETY ADMINISTRATION (OSHA)

Directive CPL 02-00-151 (29 CFR Part 1910 Subpart T)