Naval Facilities Engineering Command
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MOORING MAINTENANCE MANUAL

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ABSTRACT

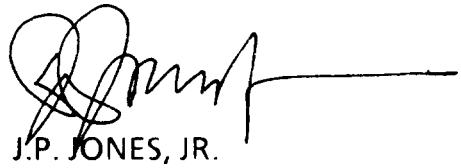
The Commander, Naval Facilities Engineering Command (COMNAVFAC-ENGCOM) has the overall responsibility for the budgeting, funding, procuring, installing, operating, and maintaining of fleet moorings worldwide. To support him in the control and management of these worldwide systems, this manual has been prepared for use by subordinate units. It contains a compendium of procedures to be followed in maintaining mooring material in suitable condition for use by operational fleet surface vessels and submarines. It additionally contains numerous illustrations and photographs of mooring material and inspection, maintenance, and storage procedures.

FOREWORD

This manual contains background information and procedural guidelines concerning the maintenance of Navy fleet moorings and spare fleet mooring material. This includes mooring installation and recovery procedures, the refurbishing and overhaul of mooring material ashore and afloat, inspection criteria and guidelines, inventory storage criteria, and the utilization of cathodic protection systems to effectively reduce the corrosion rate of mooring material.

The materials and procedures detailed herein have been prepared to assist the user in establishing and sustaining an effective fleet mooring maintenance program. Although it is not mandatory that field units follow the recommended procedures, they have been developed from the best technical sources available to the Naval Facilities Engineering Command (NAVFACENGCOM) and represent many years of practical and successful field experience.

Recommendations for modification or improvement of this document should be submitted through appropriate channels to the Naval Facilities Engineering Command.



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1.0 INTRODUCTION

1.1 GENERAL

1.1.1 SCOPE. This manual contains maintenance procedures applicable to Navy fleet mooring components and systems. Coverage includes the types of mooring hardware, mooring equipment installation, inspection, recovery, repair, overhaul, and refurbishment. Manual content is extended to include other related information and data in support of the maintenance activities such as requirements for reports and records; storage and disposition of components; inventory management and control; and planning, programming, and budgeting the program. Procedures are also provided for reporting fleet mooring conditions, relocations, and accidents. Chapter 1.0 discusses fleet moorings in general, describes various types of buoy systems and their applications, and briefly outlines overall fleet mooring maintenance actions. Subsequent chapters provide the detailed procedures and instructions for the installation, recovery, and maintenance of fleet mooring components. Descriptions of fleet mooring components are contained in Appendix B. A glossary of fleet mooring terms is provided in Appendix C.

1.1.2 PURPOSE. This manual is intended to serve as a standard guide for the maintenance of fleet moorings. It is a standard guide in that an allowable margin of freedom or variation in the application of the maintenance procedures is permitted if unusual environmental conditions, adverse physical factors, and/or nonavailability of support equipment so dictate.

1.1.3 EXCLUSIONS. Fleet mooring design is not addressed in this manual. Refer to NAVFACENGCOM design manuals DM-26.5, “Fleet Moorings,” and DM-26.6, “Mooring Design Physical and Empirical Data, ” for design guidance, as necessary. In addition, the following types of moorings/buoys are not considered in this document:

- Fixed moorings including platforms, islands, dolphins, spud moorings, and other similar types defined in DM-26.4, “Fixed Moorings.”
- Fuel transfer buoys (known as single anchor leg moorings (SALMs) or catenary anchor leg moorings (CALMS)).
- Floating drydocks, etc., including Auxiliary Repair Drydocks Medium (ARDM)
- Navigational aids.

1.1.4 RELATED PUBLICATIONS. The following publications are associated with mooring maintenance as presented in this manual:

DM-7.1	Soil Mechanics, Foundations and Earth Structures
DM-26.3	Coastal Sedimentation and Dredging
DM-26.4	Fixed Moorings
DM-26.5	Fleet Moorings
DM-26.6	Mooring Design Physical and Empirical Data
DM-35	Drydocking Facilities

Design requirements and other related data such as determining forces acting on mooring components or computing anchor chain subassembly lengths are contained in DM-26.5 and DM-26.6.

1.1.5 PROGRAM RESPONSIBILITY. Responsibility for the Navy fleet mooring maintenance program has been assigned to the Commander, Naval Facilities Engineering Command (COMNAVFACENGCOM), and encompasses budgeting, funding, procuring, installing, maintaining, and repairing fleet moorings. (In general, this policy is not applicable to moorings which are a part of the North Atlantic Treaty Organization (NATO)). To support, control, and manage this worldwide system, CO MN AVFACENGCOM established the Fleet Mooring Maintenance (FMM) program to ensure the following:

1.1.5.1 ● That existing fleet moorings are maintained in a suitable condition for their intended use.

1.1.5.2 ● That maintenance is conducted in a timely manner and that this be accomplished by:

- Planning and scheduling required actions.
- Centrally procuring required mooring material.
- Establishing an automated Fleet Mooring Inventory control system.

1.1.5.3 ● Reductions in mooring maintenance costs should be realized and this will be accomplished by replacing (over the next few years) existing moorings with upgraded moorings consisting of:

- Polyurethane covered foam buoys,
- Grade 3 (FM 3) chain and accessories,
- High capacity anchors, and
- Chain stud anode cathodic protection systems.

Future maintenance actions for upgraded moorings will be based on the results of mooring inspections and not on a specified periodic basis.

1.1.6 PLANNING, PROGRAMMING, AND BUDGETING. Shore activities responsible for the maintenance of fleet moorings must advise COMNAVFACENGCOM, through their cognizant Engineering Field Division (EFD), of mooring material requirements for the repair or overhaul of fleet moorings and the O&MN funding required to support maintenance labor and equipment costs. These requirements will be consolidated by the EFDs, and a request will be submitted to COMNAVFACENGCOM for the funds required to support the fleet mooring maintenance budget. In addition, the following requirements apply:

1.1.6.1 Procurement. All new mooring material will be centrally procured by COMNAVFACENGCOM and will be shipped initially to one of three major

stockpoints: PWC Subic Bay, PWC San Diego, or CBC Gulf port. In response to a shore activity's request, required mooring material will be shipped to the activity from one of the stockpoints for use in overhauls, repairs, new installations, etc.

1.1.6.2 Inventory. Annually, COMNAVFACENGCOM will request shore activities which have mooring material in storage ashore to provide an inventory of the type, size, quantity, and condition of this material.

1.1.7 REPORTING REQUIREMENTS. Reports of mooring failures and specific mooring maintenance actions will be submitted to COMNAVFACENGCOM. Basic reporting requirements will include the following:

1.1.7.1 Mooring Failure Report. In the event of a mooring failure, a letter report will be sent to NAVFACENGCOM within 30 days that will include the following information:

- Type and class of mooring.
- Vessel (if any) using the mooring at time of failure.
- Wind, wave, and current conditions at time of failure.
- Type/description of failed component (if known).
- Extent of any damage caused as a result of the failure.
- Corrective action taken to counter the assumed cause of failure.

1.1.7.2 Followup Failure Report. A second summary letter report will be sent to NAVFACENGCOM (within 90 days of the original failure) that will include the following information:

- Mooring design and as-built drawings.
- Observed defects in the component that failed.
- Cause of failure as determined by investigation.
- Serial number of chain or component if new when installed.
- Extent of repairs required.

- Actual or estimated cost of work involved.
- Recommendations for mooring design improvements.
- Requirement for and priority of a replacement mooring.

1.1.7.3 Other Reports. Shore activities will report to NAVFACENGCOM within 45 days any installation, removal, relocation, or overhaul of a fleet mooring.

1.1.8 FLEET MOORING MAINTENANCE. Fleet mooring maintenance includes all actions taken to ensure that moorings are safe, reliable, and in satisfactory condition. Maintenance may range from a simple annual surface inspection of a buoy to a complex operation involving recovery, refurbishment, and reinstallation of an entire mooring.

1.1.8.1 Maintenance Functions. Mooring maintenance actions will include the following:

- Minor above-water repairs of buoys and topside mooring components.
- Removal of buoys for painting or repairs ashore.
- Replacement of the riser chain because of wear or corrosion.
- Replacement of depleted zinc anodes.
- Inspection and preservation of ashore inventory.
- Underwater inspections of installed moorings.
- Repair or relaying of a mooring damaged by a collision or a severe storm.

1.1.8.2 Inspections. Inspections are perhaps the most important, but often the most neglected, of all maintenance performed. One of the primary purposes of inspections is to detect any deficient conditions which require immediate remedial attention. Often overlooked is that inspection results should be used to plan future maintenance of both installed moorings and inventory ashore. If maintenance is performed

on a routine basis, costs may be higher than need be because action is taken sooner than required. On the other hand, if maintenance is performed without regard for inspection results, the importance of a particular inspection may be diminished in the inspector's view. If this happens, even critical repair requirements may be overlooked.

1.1.8.3 Inspections and Maintenance Planning. The importance of inspection results as a maintenance planning tool will increase as more long-life upgraded moorings are introduced into the system (see Paragraph 1.2.3). These moorings are designed to remain in service for extended periods of time, thus making possible a reduction in expenditures for both maintenance and new material. If the improved components are regularly replaced on a schedule, based on the maintenance needs of older components, then overall mooring maintenance costs will surely decline. A well planned and aggressively managed maintenance program, supported by a comprehensive inspection plan, is the most effective way to keep costs down while continuing to provide reliable service to the fleet.

1.2 DESCRIPTION

1.2.1 GENERAL. Fleet moorings are pre-existing facilities used to provide temporary berthing for fleet units in ports and harbors where pier space is limited or unavailable. The most common types of fleet moorings consist of one or more buoy systems made up of surface buoys, riser and anchor chain subassemblies, fittings, and anchors. A vessel will moor with its lines or anchor chain connected to shackles, ground rings, or other mooring components on top of the buoy.

1.2.2 TYPES OF FLEET MOORINGS. Several basic types of fleet moorings are discussed below. Most of these are riser or non-riser buoy systems (refer to Paragraph 1.2.6); some do not require a buoy. Special fleet moorings and floating drydock moorings are also discussed briefly, but are not addressed in the later chapters of this manual.

1.2.2.1 Free Swinging. This mooring consists of a single buoy to which a ship is attached by means of bow lines or anchor chain. The ship is free to swing 360 degrees around the buoy as it responds to environmental loading conditions (weather vane). This type of mooring may use either a riser or non-riser buoy system (see Figure l-l).

1.2.2.2 Bow and Stern Mooring. This mooring is designed mainly for use by a single ship secured by its bow and stern lines to two buoy systems (see Figure 1-2). This mooring is normally installed near a shoreline, parallel to the direction of the water current, and outside the normal navigational channel. Riser buoy systems (see Paragraph 1.2.6.1) are normally used in this type of mooring.

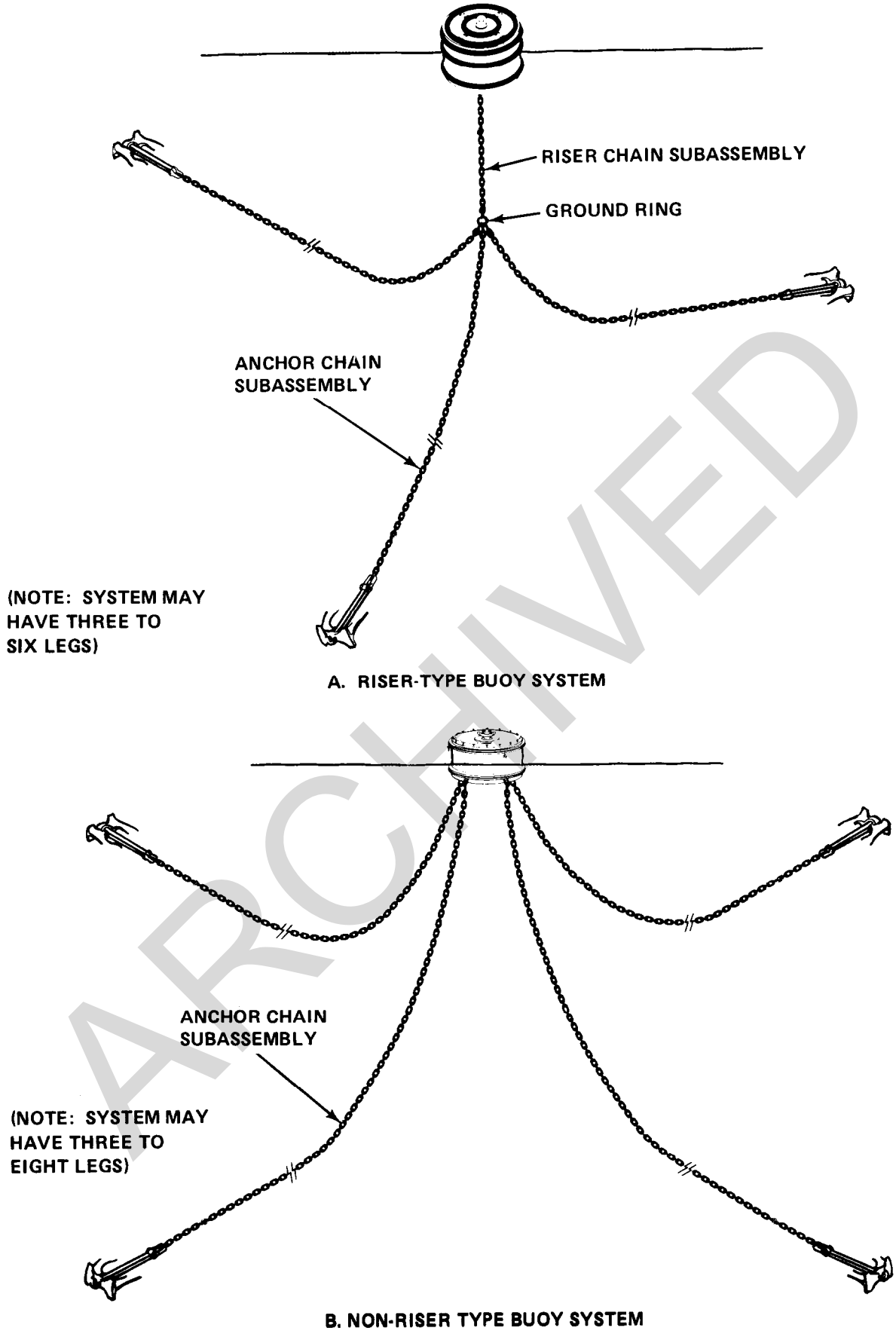


Figure 1-1, Free Swinging Fleet Moorings

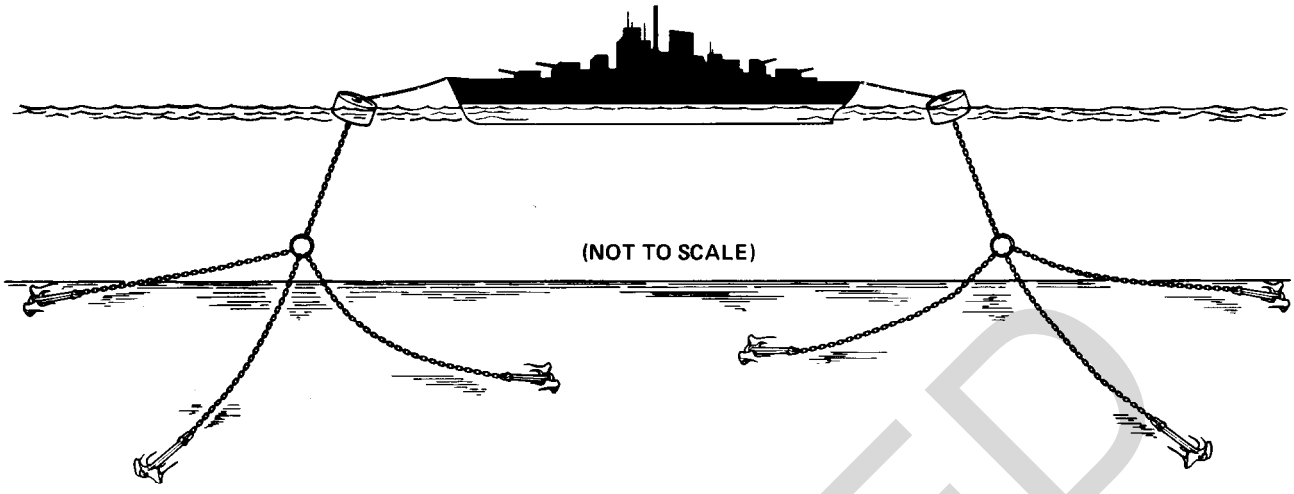


Figure 1-2. Bow/Stern Mooring

1.2.2.3 Spread Mooring. This mooring is designed for use by a single vessel or a cluster of ships. Except for single vessel use, ships are held together by interconnecting lines and separated by camels or fenders. Chain legs attached to the sides of the ship(s) maintain the vessel(s) in proper position. Figure I-3 provides a schematic drawing of this mooring, which is primarily used by the Navy to moor Medium Auxiliary Repair Drydock (ARDM) and Large Auxiliary Floating Drydock (AFDB) classes of vessels.

1.2.2.4 Mediterranean Mooring. This mooring is used primarily by Fleet Tenders. In this mooring configuration, the ship is moored perpendicularly to a wharf or pier with stern lines to ashore bollards. The bow is secured by two or more bow lines that may be attached to riser buoy systems (see Paragraph 1.2.6.1). Each bow line or riser subassembly may in turn be connected to two anchor chain subassemblies leading to anchors or stake

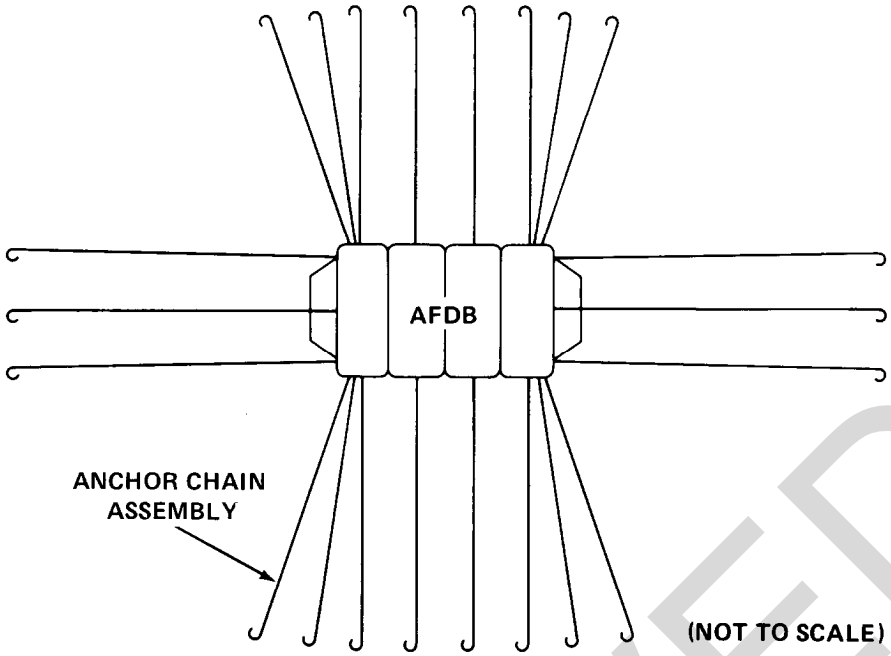


Figure 1-3. Spread Mooring

piles. Figure 1-4 depicts a typical Mediterranean mooring. Tenders are moored in this fashion to allow simultaneous nesting of submarines or destroyers along both the port and starboard sides.

1.2.2.5 Buoy Dolphins. Dolphins simulate a longer pier to accommodate larger ships breasted alongside a pier or alongside one or more finger piers by acting as bow and stern moorings. Dolphins may consist of a group of pilings driven close together into the bottom or may employ a buoy system. When buoy systems are used as dolphins they are called buoy dolphins (see Figure 1-5).

1.2.2.6 Special Mooring. A specialized mooring is structured in a nonstandard configuration and is designed either to satisfy a unique mooring application or to meet a specific operational requirement. Examples of special moorings are:

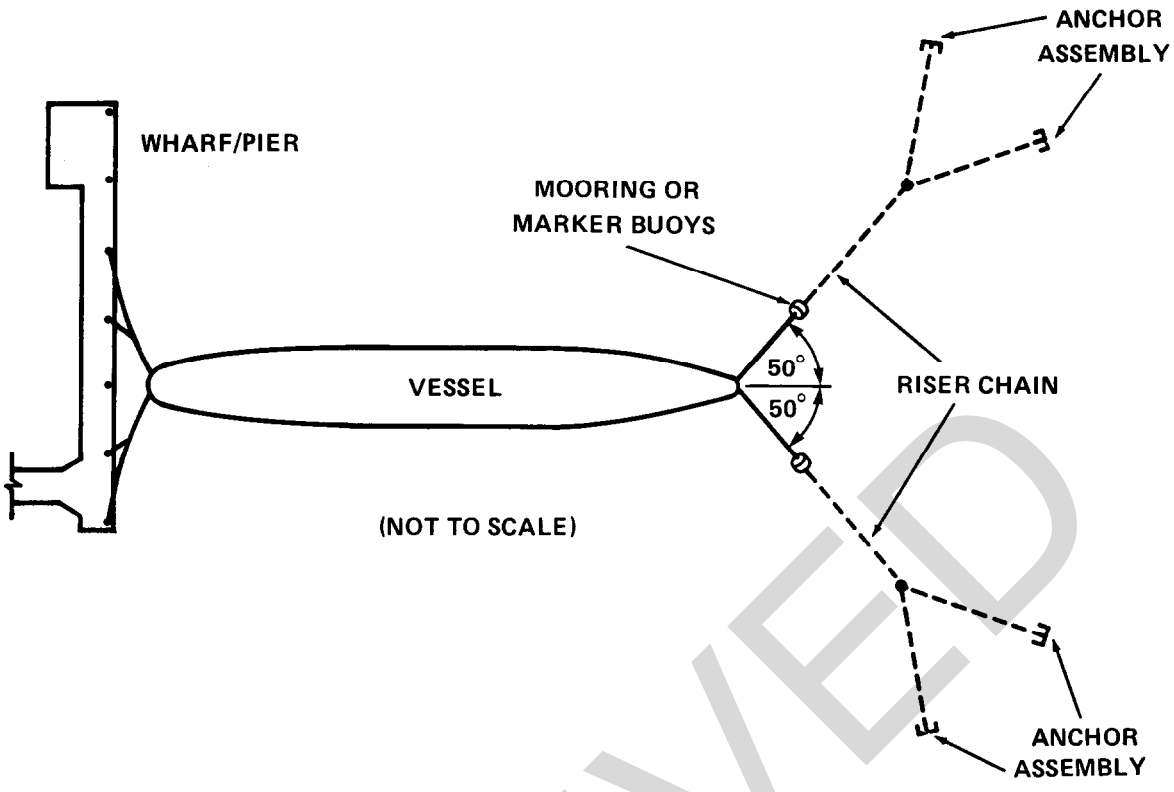


Figure 1-4. Mediterranean Mooring

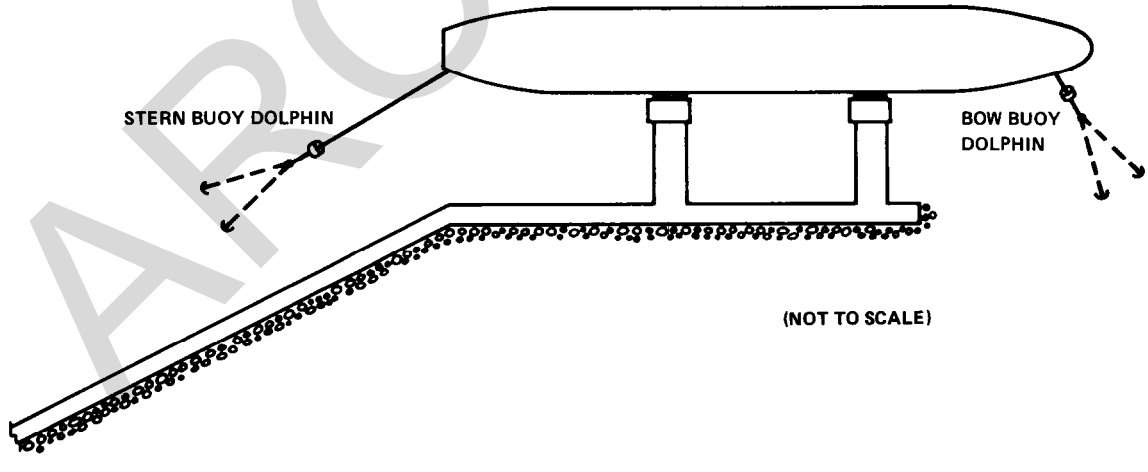


Figure 1-5. Buoy Dolphin Mooring

- Those temporarily installed in an Amphibious Objective Area (AOA) for utilization by amphibious support ships.
- Typhoon, hurricane, storm moorings.
- Those installed in exposed areas that are subject to considerable current, tide, wind, and wave actions.
- Those installed in geographical areas where abnormal bottom conditions require propellant embedment anchors (PEAs).
- Those designed to provide restricted watch circles.
- Those designed for use by submarines and containing a riser fendering system which precludes damage to the submarine's sonar dome when moored to the buoy.

1.2.3 UPGRADED MOORINGS. All existing fleet moorings will be replaced with upgraded mooring material. It is intended that these moorings will remain installed for extended periods of time without overhaul vice the current 3- to 5-year time period between overhauls. The upgraded moorings will include urethane coated foam buoys, improved FM 3 chain and associated components, cathodic protection, and a more efficient anchor assembly.

1.2.4 MOORING CLASSIFICATIONS. NAVFAC DM 26.6, "Mooring Design Physical and Empirical Data, " identifies the different classes of fleet moorings. A fleet mooring is classified according to its holding capacity. Table 1-1 lists the classes of Navy fleet moorings and the required size of the riser and anchor chain subassemblies. These standard classes have been designed to support the various types and sizes of operational fleet vessels. The larger classes (AA through CC) are configured with paired anchor legs attached to spider plates, and can have six to eight anchor chain subassemblies (see Figure 1-6).

Table 1-1. Classes of Navy Fleet Moorings

Class	Holding Capacity (Ibs)	Type of Anchor Chain Subassemblies	Chain Size (in)	
			Riser	Anchor
AA	300,000	Twin	4	2-3/4
BB	250,000	Twin	3-1/2	2-1/2
c c	200,000	Single	3-1/2	2-1/4
DD	175,000	Single	3	3
A	150,000	Single	2-3/4	2-314
B	125,000	Single	2-1/2	2-1/2
c	100,000	Single	2-1/4	2-1/4
D	75,000	Single	2	2
E	50,000	Single	1 -3/4	1 -3/4

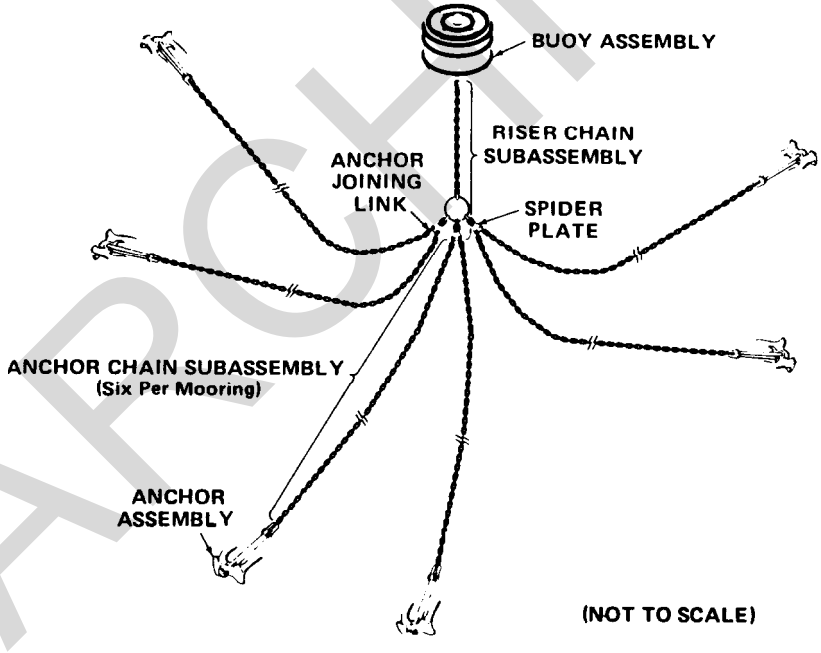


Figure 1-6. Typical Large Riser-Type Mooring

1.2.5 MAJOR FLEET MOORING ASSEMBLIES. A typical fleet mooring is made up of one or more buoy systems. Each buoy system in turn consists of a specific combination of the four basic assemblies listed below.

1.2.5.1 ● Buoy assembly, which includes the following:

Hull subassembly.

Fender subassembly.

Chafing strip subassembly.

1.2.5.2 ● Chain assembly, which includes the following:

Riser subassembly.

Anchor chain subassembly.

1.2.5.3 ● Anchor assembly.

1.2.5.4 ● Cathodic protection assembly.

Moorings which do not require a buoy will, of course, consist only of the chain, anchor, and cathodic protection assemblies.

1.2.6 TYPES OF BUOY SYSTEMS. Although there are many specific buoy system designs, there are only two basic types of buoy systems: riser and non-riser. Each of these types is defined by the configuration of the anchor, chain, and buoy assemblies which make up the buoy system.

1.2.6.1 Riser Buoy System. This system consists of a hawsepipe or tension bar type buoy, a riser chain subassembly (which includes a ground ring), anchor chain subassemblies, and anchors. The single riser connects the buoy to the ground ring located about 10 feet above the bottom. Two, three, or four anchor chains run from the ground ring to the anchors (see Figure I-I).

1.2.6.2 Non-Riser BUOY System. Previously called a telephone-type buoy system, the non-riser system consists of a relatively large buoy held in place by three to eight anchor chain subassemblies and anchors. Each of the anchor chains is attached to a padeye on the lower side of the buoy hull. A ship using this buoy connects its chain or bow lines to a swivel in the center of the buoy's deck. The non-riser system has a relatively small watch circle compared to the riser-type buoy system (see Figure l-l).

1.2.7 MOORING COMPONENTS. Appendix B contains descriptions and drawings of the components normally used in fleet moorings. The components are grouped into categories related to the four basic assemblies which make up a fleet mooring: buoys, chain and accessories, anchors, and cathodic protection. The terminology used in Appendix B is preferred for use in all fleet mooring documentation, correspondence, reports, drawings, etc. Other common names are included which reflect usage by the offshore industry. However, the standard terminology appearing in Appendix B should be used so that a common understanding of terms will exist among those responsible for designing, maintaining, and managing fleet moorings. This becomes especially important with respect to as-built documentation, inventory reports, and requests for material.

2.0 MOORING INSTALLATION AND RECOVERY

2.1 PREPARATION

2.1.1 GENERAL. This chapter describes methods for installing and recovering moorings in sheltered waters and provides the general procedures for accomplishing these tasks. Installation and recovery of both riser and non-riser buoy systems are covered. Procedures set forth may be modified to suit local environmental conditions and/or material constraints, or to accommodate a special mooring design. The procedures developed herein assume that the tasks will be accomplished using a floating crane or crane barge for installation and recovery.

2.1.2 PLANNING AND PREPARATION. Development of a plan is a necessary requirement prior to commencing operations. The plan should include the equipment needed and the procedures necessary for accomplishment of the task. Design drawings, as well as materials required, should also be included. Recovery plans should take into account the as-built drawings. The plan should be prepared well enough in advance to allow riggers, crane and barge operators, design engineers, and others to review and comment on the details. Prior to commencement of offshore operations, all persons involved should understand the general sequence of events that will occur and their specific responsibilities in the effort. The plan should also take into consideration the following:

2.1.2.1 **Preparation.** Thorough preparation is one of the principal keys to a successful mooring installation or recovery operation. Proper ashore preparations will ensure that offshore operations will be expeditiously and efficiently carried out. As examples:

- A floating crane will be provided for the installation or recovery of mooring components. The size and placement of required temporary padeyes must be determined and action taken to install these padeyes on the deck of the barge.

- Physical fit checks of all mooring materials should be accomplished to ensure proper assembly of the mooring in accordance with design specifications.
- If being installed, chain stud anodes should be attached to the chain prior to moving the material offshore. After anode installation, caution must be taken in handling the chain to preclude damage to or loss of the anodes.

2.1,2.2 Environmental Factors. Since offshore operations can be strongly influenced by environmental conditions, plans should be made flexible enough to allow for unexpected delays due to inclement weather or rough seas.

2.1.3 TOOLS AND EQUIPMENT REQUIRED. The floating crane or other suitable platform will be stocked with all tools needed not only for the planned operation, but also for any field modifications or in place repairs that may be required. Tools, equipment, and materials for the effort should include the following items:

- Welding and cutting equipment.
- High-pressure seawater pump (100 psi) or a water blaster.
- Spare parts (e.g., locking pins, punches, retaining pellets, etc.). A good source is BUSHIPS No. 52603-840327.
- Lubricants, preservative greases, coatings, etc.

2.1.4 PRE-INSTALLATION LAYOUT. Mooring components will be laid out on the crane barge, prior to offshore operations, in an arrangement governed by procedures established for installation of the mooring. Chains shall be placed so that they will readily pay out during a controlled installation. Figure 2-1 illustrates a typical mooring material/component layout on a crane barge. The mooring should be assembled on the barge to the maximum extent possible prior to departing for installation operations to minimize assembly activity offshore.

2.1.5 PRE-INSTALLATION POSITIONING. A mooring is designed for installation at a specific site. The characteristics of the site (e.g., water depth, bottom conditions) will determine the mooring design features such as length of riser and anchor chain subassemblies and fluke angle of the anchor. It is important, therefore, that the mooring be placed in the location for which it was designed, since a misplaced mooring would require the expense and effort of reinstalling the entire system. Equipment used for positioning the mooring is described below.

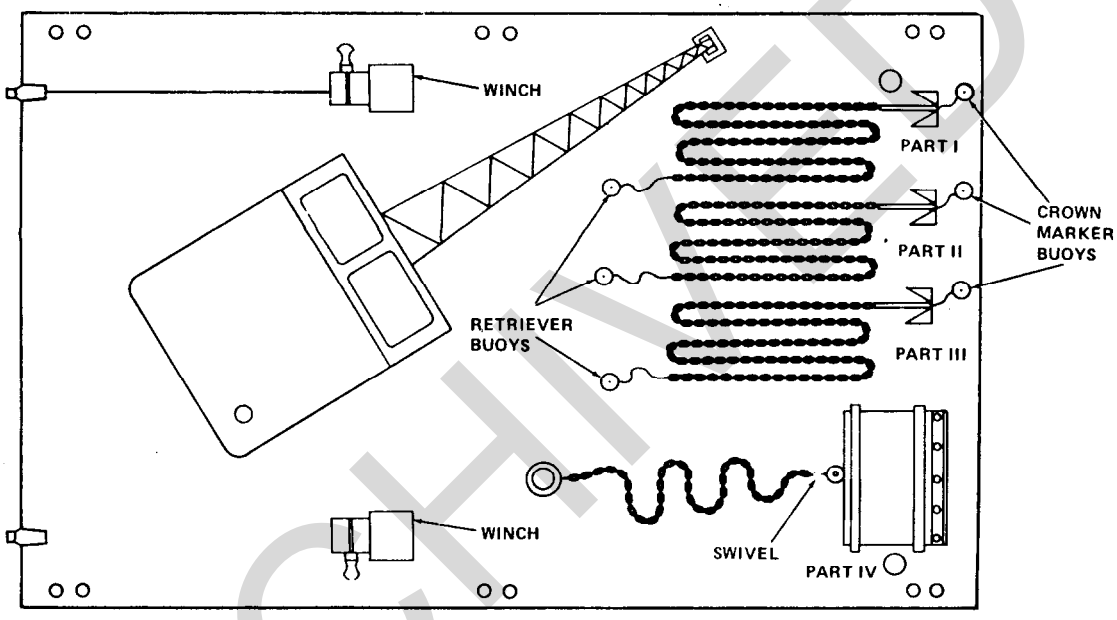


Figure 2-1. Typical Layout of Mooring Equipment Aboard a Crane Barge

2.1.5.1 Marker Buoys. To ensure that the mooring is installed in the right location and that the anchor chain assemblies are properly orientated, marker buoys should be placed at the desired points at the site before installation begins. A center marker buoy will be used to indicate the position of the buoy; ring markers will be used to indicate anchor locations; and range markers will be used to assist in anchor chain subassembly orientation (see Figure 2-2). Correct placement of anchors will ensure that the anchor legs are straight and taut. Range buoys may

be used in conjunction with the ring markers to aid crane barge movement along proper lines of bearing as it lays the anchor chain subassemblies.

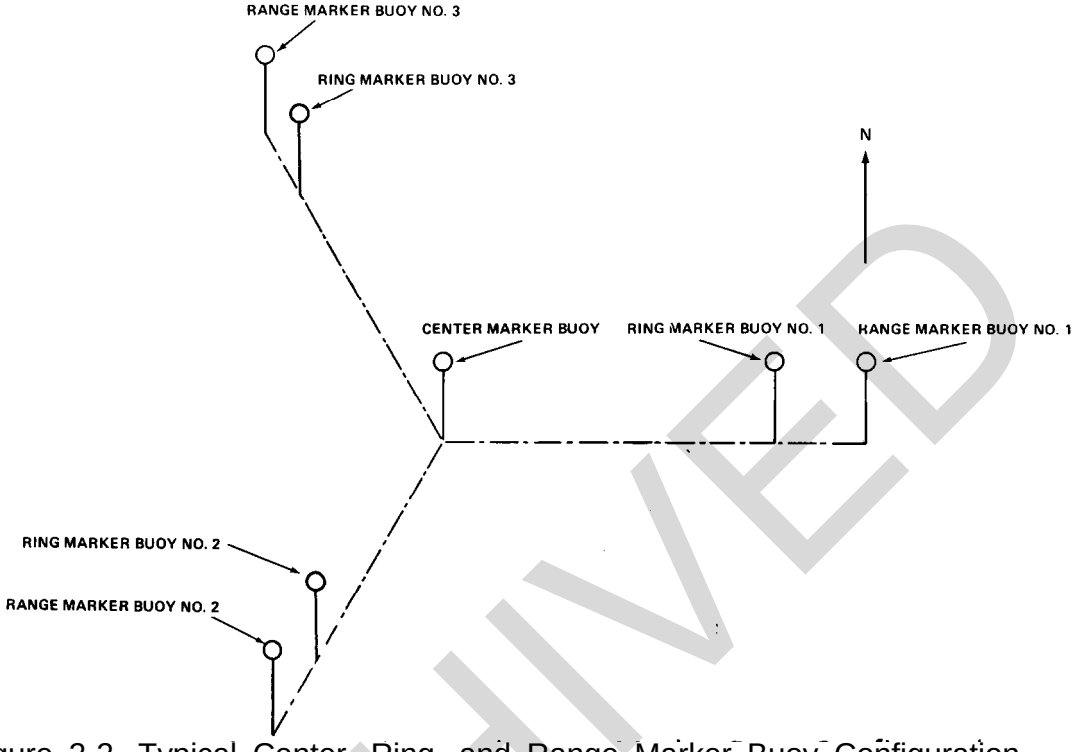


Figure 2-2. Typical Center, Ring, and Range Marker Buoy Configuration

2.1.5.2 Other Positioning Equipment. Correct positioning of marker buoys is determined by the use of transits, theodolites, electronic distance measuring (EDM) devices, and other similar equipment. Marker buoy locations should be referenced to established benchmarks or fixed landmarks such as beacons, towers, smokestacks, or corners of buildings. If the mooring is to be installed close to a pier, a dolphin, or a fixed structure, the correct position of the markers can be determined by direct measurement using a measured line or similar aid. Marker buoys may be placed from a small boat or any other suitable vessel. Marker buoys should be checked before and during mooring installation to verify that they have remained in their correct positions.

2.1.6 PRE-INSTALLATION INSPECTION. A final inspection shall be made of all mooring material before any item leaves the storage area or prior to the material being laid out on the crane barge deck. This will include a check of all chain connections, joining links, and other fittings for proper and secure assembly.

2.1.7 FIELD CHANGES OF DESIGN. Moorings are usually designed for a specific application at a specific site. The chain size, anchor weight, anchor fluke angle, length of anchor chain subassemblies, length of riser chain, buoy size, and other factors have been determined based on the holding power requirements and planned location of the mooring. Field changes to design specifications and planned installation procedures should not be made without approval of the cognizant design engineer because incorrect actions could adversely affect the performance and reliability of the mooring.

The choice of the type, size, and configuration of anchors is a design consideration for a particular mooring or a particular mooring location. Recent work in mooring design by the Naval Civil Engineering Laboratory, Port Hueneme, California, has resulted in a much better understanding of anchor holding capacity. This information is incorporated in DM-26.6 and is not presented here. The important consideration is that anchor selection is a complex design problem and that small changes to items such as fluke angle, stabilizer length, and orientation when placed on the bottom, can drastically affect the holding capacity of the mooring.

2.1.8 AS-BUILT DRAWINGS. Accurate as-built records (such as shown in Figure 2-3) must be maintained on all installed moorings. As-built drawings should be prepared immediately following the installation, and copies shall be submitted to NAVFACENGCOM (Code 1002).

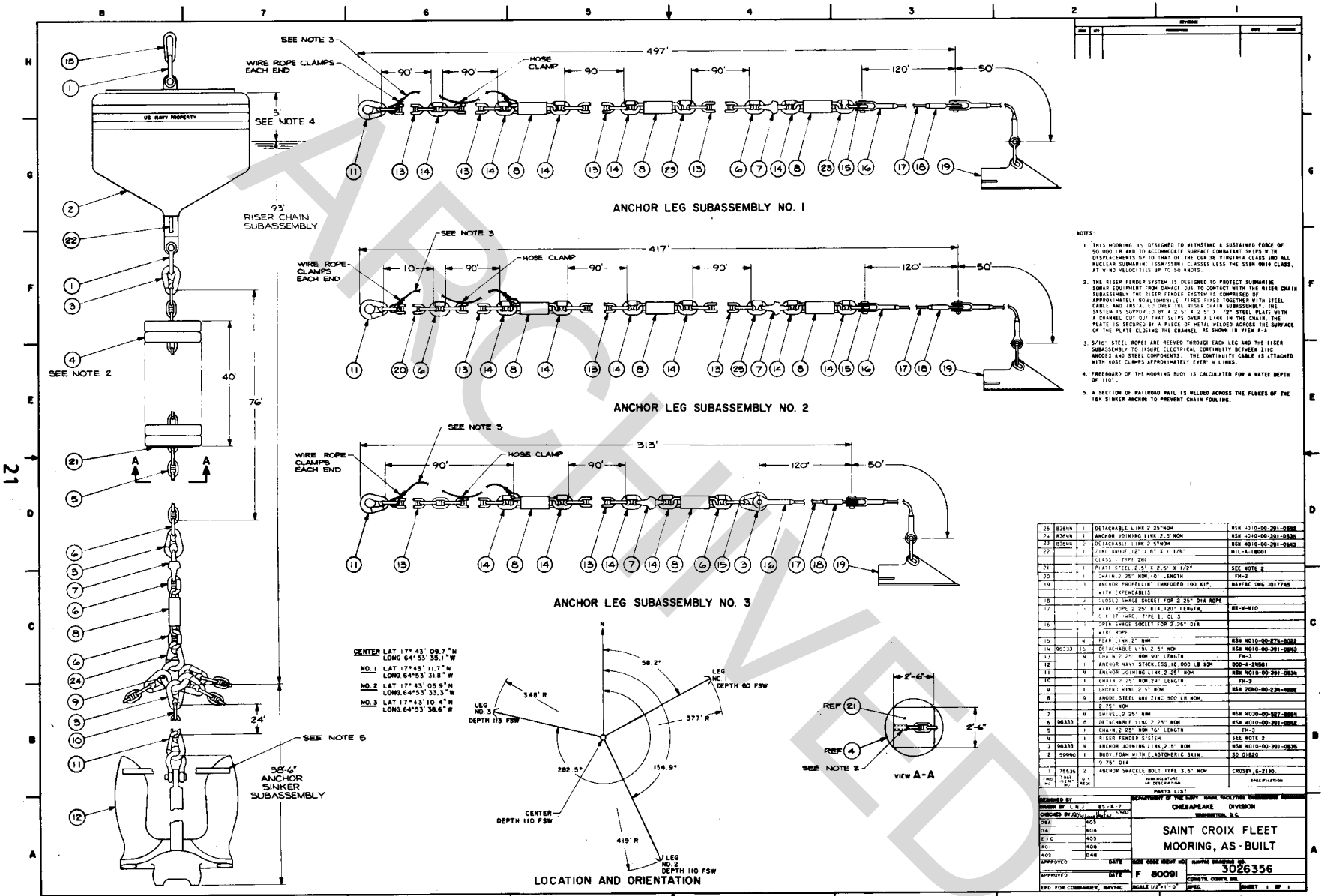


Figure 2-3. Typical As-Built Documentation

2.2 INSTALLATION INSTRUCTIONS

2.2.1 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.

2.2.2 RISER-TYPE MOORING SYSTEM. Installation of this mooring system shall generally follow the procedure set forth below.

2.2.2.1 Preinstallation Assembly. A three-legged riser-type mooring system is normally assembled in three parts:

- 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 (see Figure 2-4).
- Part III. This part is the third anchor chain subassembly with a sinker and anchor.

2.2.2.2 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. Appendix E provides tables of 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 Appendix E, Figure E-2). The range marker buoys should be

installed about 50 feet beyond the ring marker buoys on the extens of the lines from the center marker buoy to the ring marker buoys.

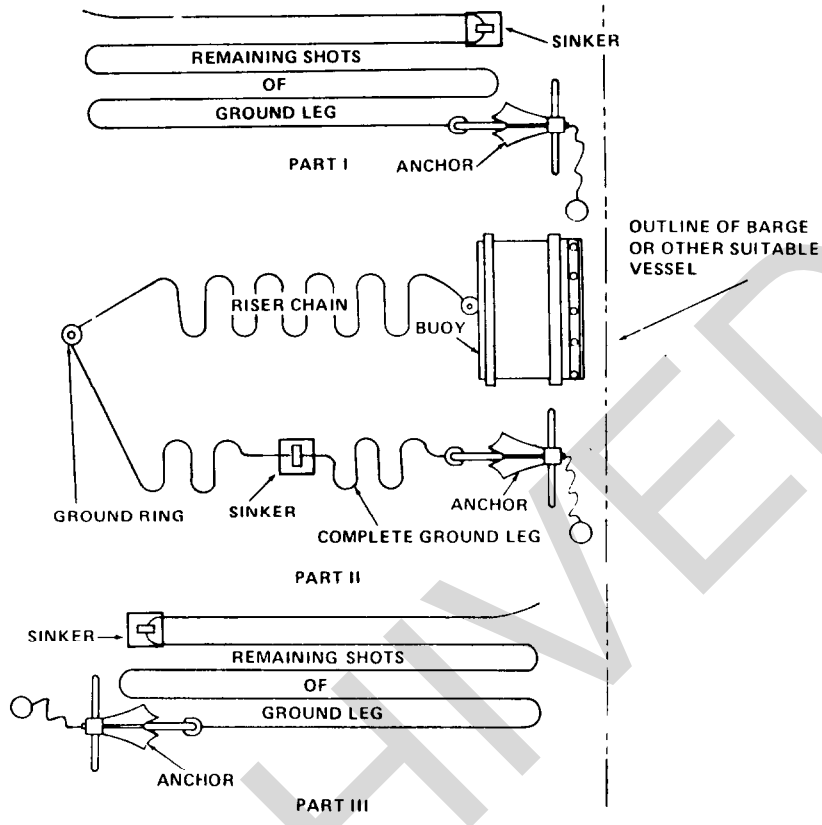


Figure 2-4. Typical Riser-Type Mooring Material Pre-Installation Layout

NOTE
Refer to Paragraph 2.2.2.1 for references to "Part I," "Part II," and "Part III" in the procedures that follow.

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.

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 l). During some installations, it may be necessary to weld the anchor flukes (see Figure 2-5) to a predetermined angle.

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

Figure 2-5. Welding Anchor Flukestoa Required 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 2-6. The crane lowers the anchor and chain simultaneously over the side. When installing moorings equipped with chain stud anodes (see Section 8.3.1.1), 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.
- 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

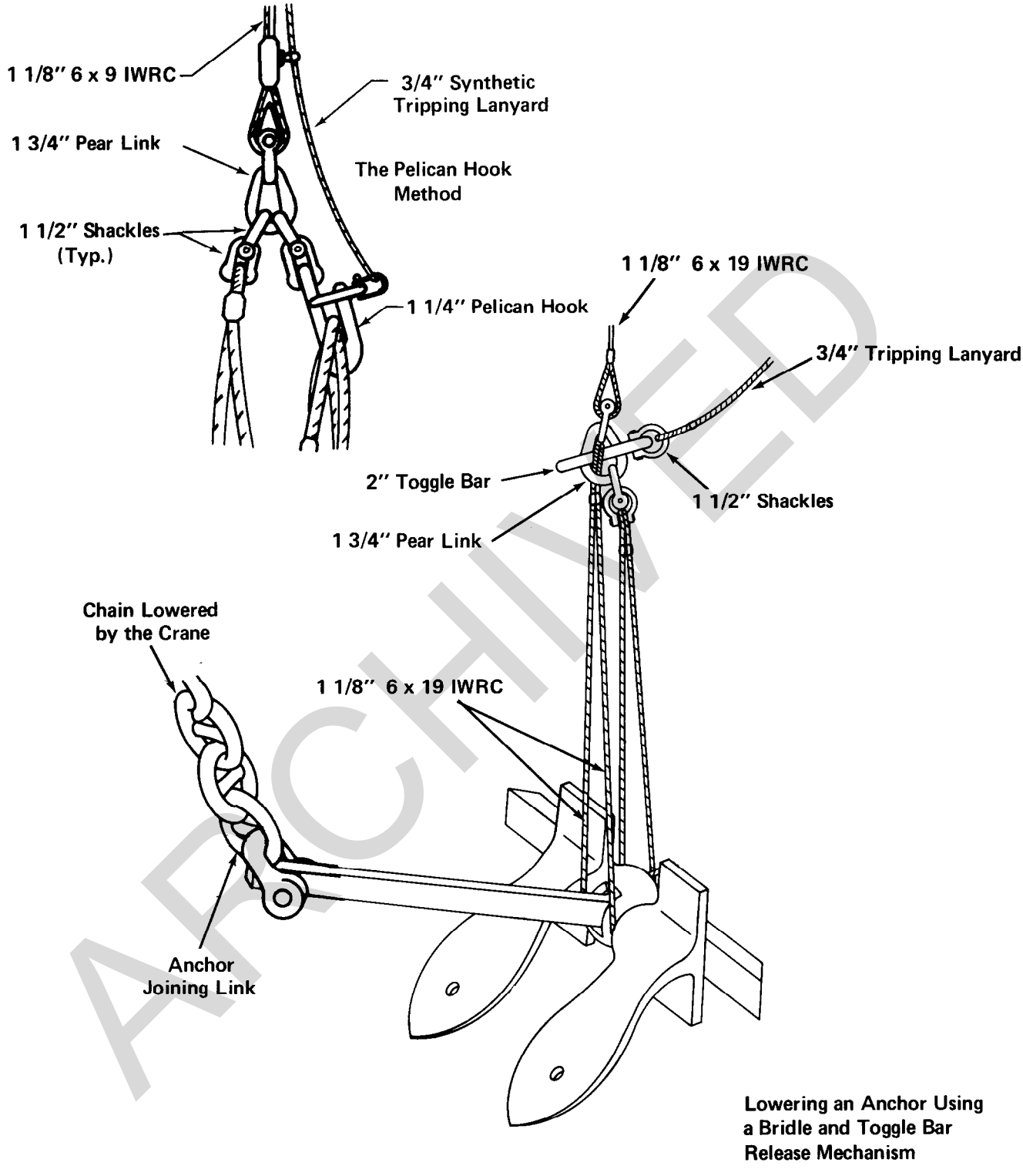


Figure 2-6. Lifting Bridle and Release Mechanism

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.

2.2.2.3 Pull Testing of Anchors. Procedures for pull testing anchors are contained in Appendix E. Fleet moorings will be pull tested to the holding capacity of the mooring class listed in Table 1-1.

2.2.2.4 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.

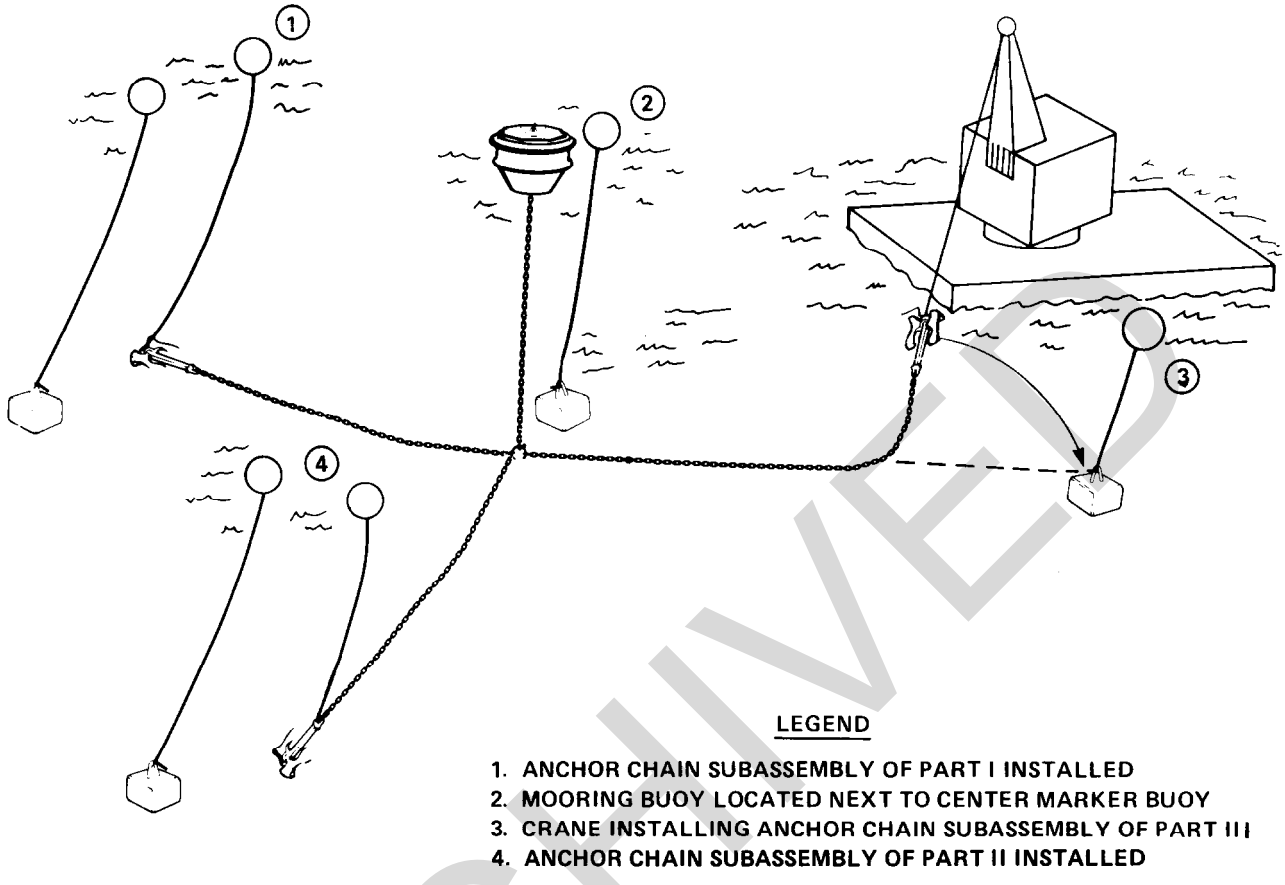


Figure 2-7. Typical Riser-Type Mooring Installation

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.

2.3 RECOVERY INSTRUCTIONS

2.3.1 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 (see Figure 2-8).

> 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 2-9).
- 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 are accessible.
- Stopper off one subassembly (see Figure 2-10).

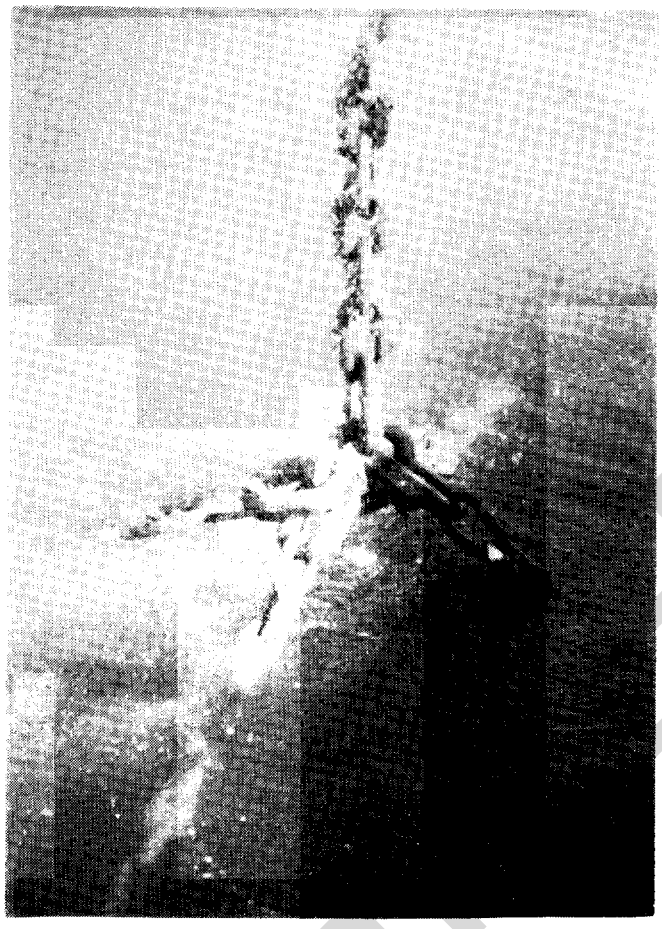


Figure 2-8. Lifting the Ground Ring to Deck Level

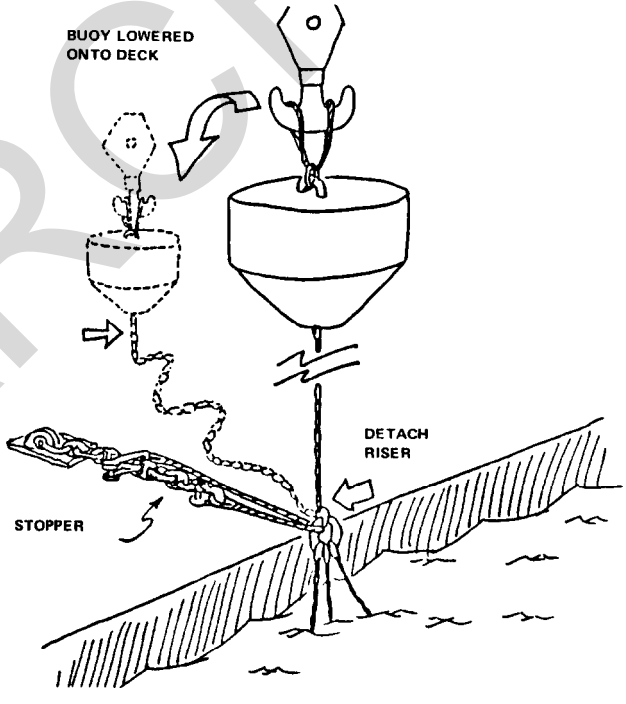


Figure 2-9. Ground Ring Stoppered Off on Deck

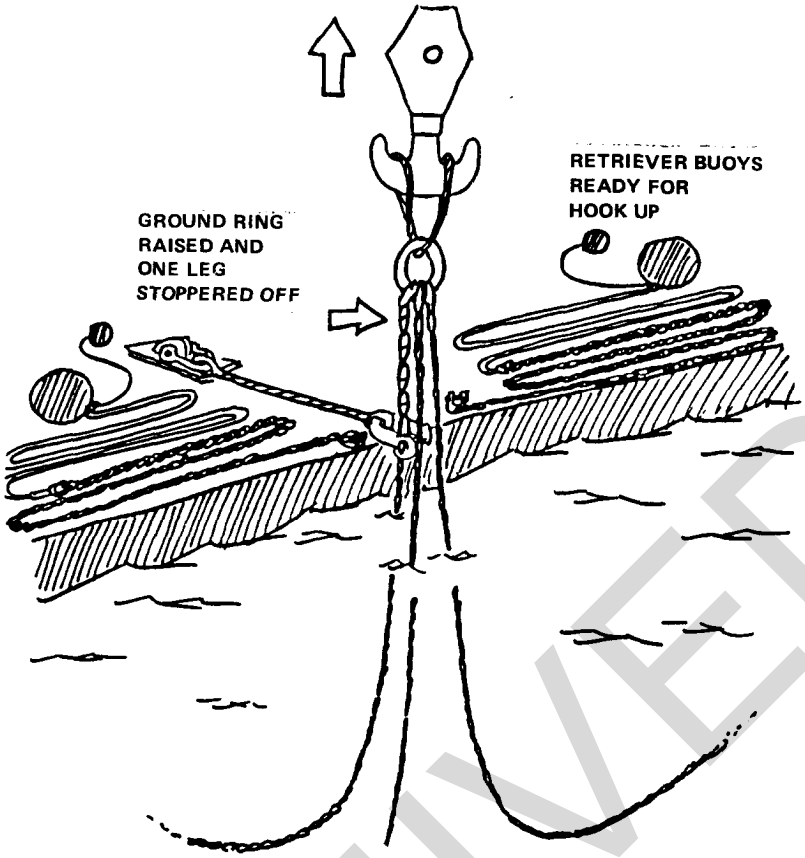


Figure 2-10. One Leg Stoppered Off

- 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 2-1 1). Disassemble the chain joining link, if possible, and disconnect the ground ring from the subassembly.
- Sling the chain to the main hoist, raise and remove the stopper.
- Continue raising until the next chain joining link is above deck.

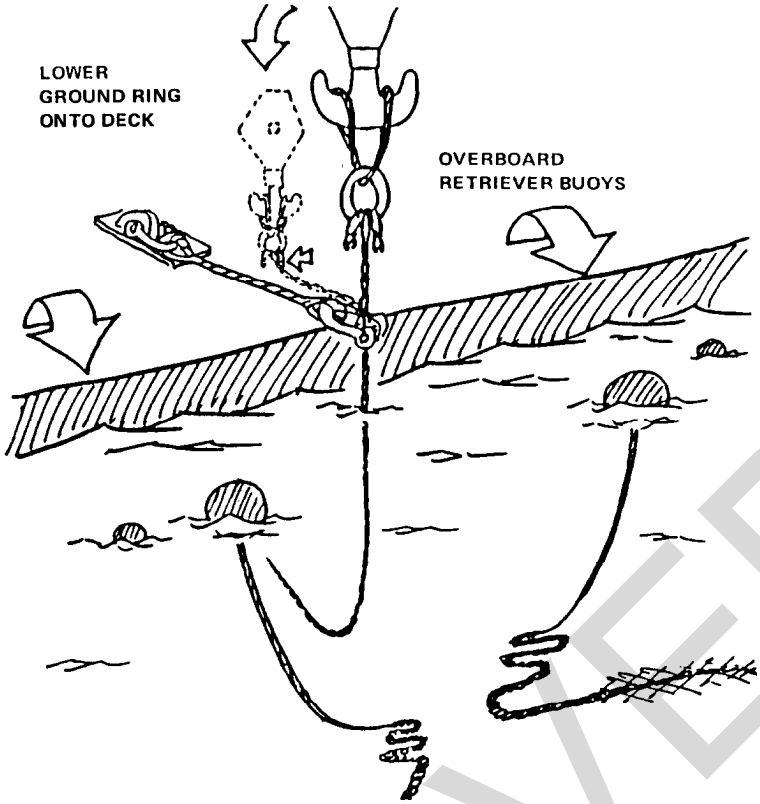


Figure 2-11. Two Anchor Chain Subassemblies Overboarded

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.

> NOTE
> All components recovered should be washed down with seawater before being brought aboard the barge. Use a high-pressure hose for this purpose (see Figure 2-12).

- 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.

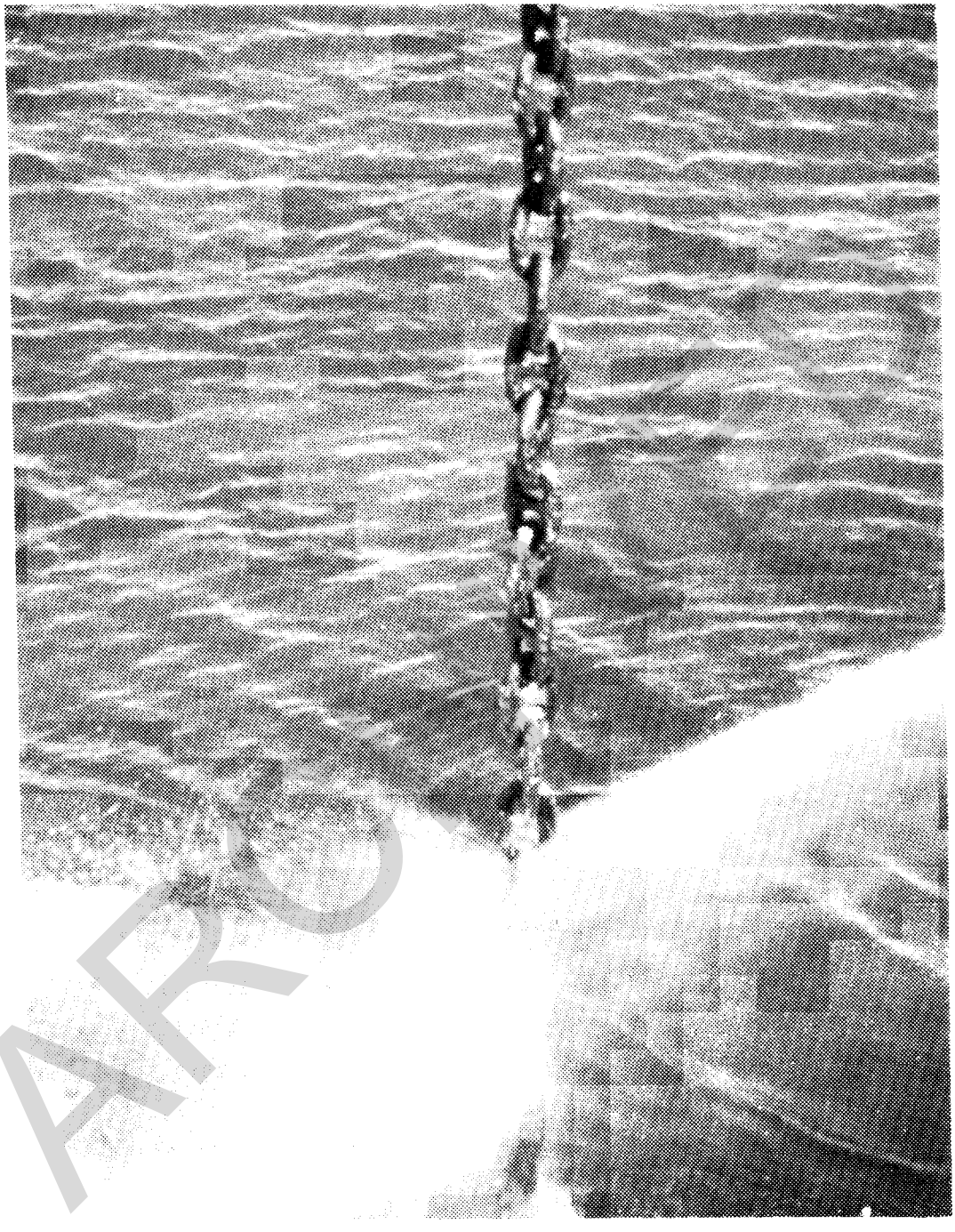


Figure 2-12. Using High Pressure Hose for Cleaning

3.0 INSPECTIONS

3.1 GENERAL

3.1.1 OVERALL REQUIREMENTS. All mooring components, either in use or in storage, must be periodically inspected to determine their current material condition and their future maintenance requirements. The importance of these inspections cannot be overemphasized because the effectiveness of any maintenance program will always depend on how often and how well these checks and services are performed. Inspection plans, therefore, should take into consideration the critical elements of frequency of inspections and the thoroughness, completeness, and quality of work.

3.1.2 INSPECTION CLASSIFICATIONS AND TYPES. For the purposes of this manual, inspections are classified as either in-service or out-of-service. In-service inspections are performed on installed moorings; out-of-service inspections are performed on components stored ashore. There are four basic types of in-service inspections, as follows:

- Annual surface inspections.
- Underwater inspections.
- Lift inspections.
- Damage/failure inspections.

The above in-service types are addressed and discussed in this chapter. Out-of-service inspections are covered in chapters 5.0,6.0,7.0, and 8.0.

3.1.3 PURPOSE. The primary purpose of in-service inspections is to determine the general physical condition of the buoy(s) and chain assemblies. The results of these inspections are used to decide if a mooring is safe for continued use. Routine inspections also provide an opportunity to detect and remedy minor material deficiencies. Future maintenance requirements are strongly dependent on the results of periodic in-service inspections.

3.1.4 PERSONNEL. Because in-service inspections are conducted offshore, and often under less than ideal conditions, experienced personnel, as well as reliable equipment, are required to accomplish these tasks. Topside personnel or divers will be used to clean and inspect a representative portion of the buoy hull and chain assemblies. The inspection report of their findings will then be used to assess the condition of the entire mooring. Measurements taken, observations made, and data accumulated must, therefore, be highly accurate and complete in these instances.

3.2 INSPECTION PROCEDURES

3.2.1 GENERAL. The following paragraphs contain descriptions of the four basic types of in-service inspections and provide guidelines for performing these inspections.

3.2.2 ANNUAL SURFACE INSPECTIONS. Shore activities that operate and maintain fleet moorings must inspect the visible portion of each mooring buoy at least once each year. The purpose of this annual surface inspection is to ensure that the buoy and its topside hardware, fenders, and chafing strips are in satisfactory condition, and to verify that the mooring has not been dragged from its proper location.

3.2.2.1 Buoy Inspection. The buoy should be closely examined to determine its overall condition. The following should be documented:

- Caliper measurements of the upper jewelry whenever these appear to be excessively worn out or in marginal condition (see Figure 3-l).
- in addition, any excess top jewelry or wire rope cables attached to the buoy should be reported.
- Physical damage such as holes, dents, metal distortion, or listing (see Figure 3-2).
- Measurement of the buoy's freeboard.

Figure 3-1. An Example of Severely Worn Top Jewelry

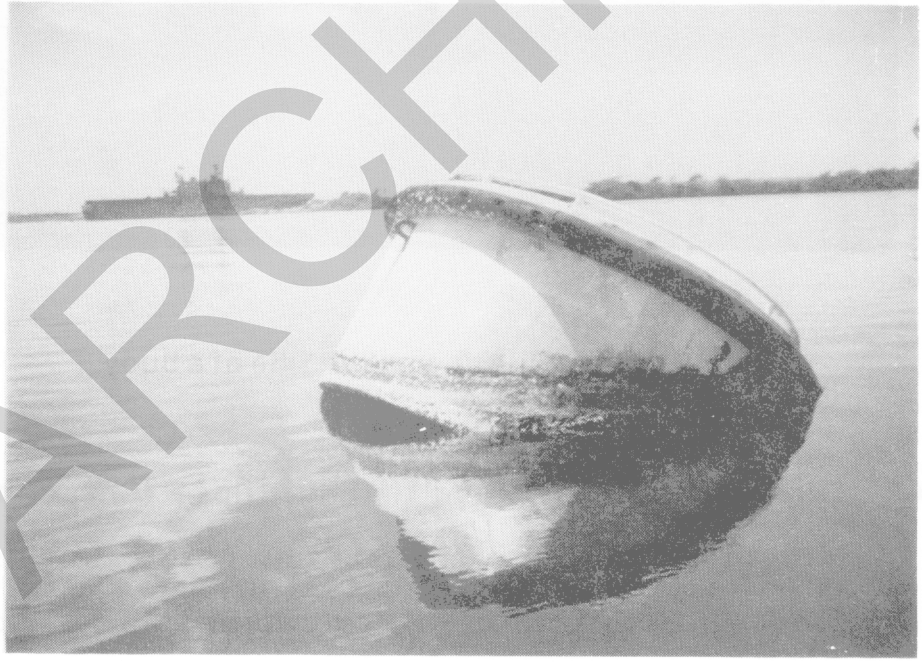


Figure 3-2. Severe Buoy List

- Condition of fiberglass on fiberglass-coated buoys. (Fiberglass should be inspected and any cracks, wear, peeling, or rust bleeding identified.)
- Condition of paint on painted buoys. (Paint should be checked for cracking, chipping, and/or peeling.)
- Condition of water drains and buoy surface penetrations. (Examine for broken parts, surface rust, and surface pitting.) (See Figure 3-3.)

Figure 3-3. Pitting/Rusting on the Side of a Buoy

- Condition of fenders and chafing strips. (Check for physical integrity and secure connections to the buoy's surface. Fender/chafing strip brackets or studs will be inspected for corrosion and/or cracks.)

3.2.2.2 BUOY Location. If it is suspected that a mooring has been dragged from its desired geographic location, the current position of its buoy will be

verified by sighting from known positions ashore using a transit, a theodolite, or any instrument of comparable precision.

3.2.2.3 Documentation. The results of the surface inspection shall be fully documented (see Figure 3-4, “Sample Surface Inspection Form”) and filed in the inspecting activity’s maintenance files for future reference. A copy of this form should be forwarded to CHESNAVFACENGCOM Code FPO-1 for entry into the FMM archives. if a buoy is found to be in relatively poor condition or in need of repair or overhaul, complete information concerning funding and the material required to correct the observed deficiencies should be reported to CHESNAVFACENGCOM.

3.2.3 UNDERWATER INSPECTIONS. The purpose of mooring underwater inspections is to determine the general condition of buoys and chain assemblies and to verify or update existing as-built drawings and maintenance records. Each fleet mooring will be inspected by divers every 2 to 3 years. CHESNAVFACENGCOM has the overall responsibility for all of these underwater mooring inspections and will make arrangements for each inspection, analyze the raw data observed, and prepare reports of the inspection findings. Divers assigned for each inspection will inspect only a portion of the submerged buoy hull and chain assemblies in order to compile a general description of the mooring’s condition. Consistent measurements obtained during each inspection will provide a good indication of the mooring’s overall condition. Obviously, underwater inspections cannot fully substitute for a complete inspection involving recovery of the mooring and the measurement and evaluation of each component.

3.2.4 LIFT INSPECTIONS. In the past, a buoy and riser chain were lifted as high as possible out of the water and a visual inspection of the buoy, its upper and lower jewelry, and accessible portions of the riser chain subassembly was conducted to determine wear, corrosion, or deterioration. Lift inspections have been

BUOY SURFACE INSPECTION FORM

ACTIVITY/STATION NAVSTA Key West BUOY (MOORING) NO. T-4 BUOY TYPE Peg TOP (12'0" X 9'6")

INSPECTION DATE 26 November 1986 CHIEF INSPECTOR J.A. Carlos OBSERVED FREEBOARD (IN) 42

TOP JEWELRY

COMPONENT TYPE	AS-BUILT DIAMETER	MEASURED DIAMETER	COMMENTS
End Link	3 1/4"	3 1/8"	> 90%
Bow Shackle	2 3/4"	2 1/2"	> 90%
Shackle	2 1/4"	2"	Between 80% and 90% Should be replaced.

BUOY

COMPONENT	TYPE	DAMAGE			RUST				CONDITION			COMMENTS
		MAJOR	MINOR	NONE	HEAVY	MODERATE	LIGHT	NONE	GOOD	FAIR	POOR	
HULL	STEEL			x			x		x			10° List
COATING	FIBER ___ PAINT ___ GLASS ___ OTHER ___ POLYURETHANE ___			x			x		x			Light Rust Bleeding on Top. Two inches Marine Growth.
FENDER	RUBBER ___ WOOD ___ BRACKET ___ STUD ___ OTHER ___									x		Missing 20% of Lower Fender. Upper Splintered.
CHAFING STRIP	RUBBER ___ WOOD ___ BRACKET ___ STUD ___ OTHER ___								x			Two Strips.
OTHER	HATCH BOLTS					x						

NOTE: FOR ADDITIONAL COMMENTS, USE SEPARATE SHEET OF PAPER

Figure 3-4. Sample Surface inspection Form

discontinued in favor of underwater diver inspections and will no longer be conducted. To avoid disturbing the anchors, a mooring should be lifted only when the buoy and/or riser chain require repair or replacement, or when the mooring is being completely removed.

3.2.5 MOORING DAMAGE/FAILURE INSPECTIONS. Fleet moorings can be damaged by collisions or dragged out of position by heavy winds or seas. They can also fail because of broken mooring components. An inspection of mooring damage, drag, or failure should be conducted as soon as possible after detection. If a collision has occurred, then the purpose of the inspection is to determine the extent of the damage and whether the buoy is in danger of sinking. If the buoy is found to have hull damage and is in danger of sinking, a marker buoy should immediately be attached to it so that the buoy's position will be marked in the event that it sinks. Arrangements should then be made to recover the buoy at the earliest opportunity so that repairs can be accomplished. If the buoy is undamaged, but the mooring has been pulled off location, arrangements should be made to recover the mooring and reinstall it in its proper position.

3.2.5.1 Inspection Procedures. Inspection will include the following:

- Visual inspection of the buoy's hull and associated fenders for damage (dents, broken fenders, scrapes, hull punctures, etc.).
- Check for buoy drag and the excursion of the entire mooring (new positions should be sighted from known benchmarks ashore and recorded).
- Check for riser chain failures which will cause buoys to float free from their intended position. Free floating buoys should either be towed to shore or temporarily attached to an anchor.

3.2.5.2 Documentation. The results of the damage inspection shall be fully documented. In all cases of damage or suspected damage to a fleet

mooring, the cognizant port authority should be notified so that the mooring will not be used. At most Navy installations, this authority rests with the Port Services Officer. A failure report must also be submitted as detailed in Paragraph 1.1.7.1 of this document.

4.0 IN-SERVICE MAINTENANCE AND REPAIR

4.1 GENERAL

4.1.1 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.
- Minor repairs to cathodic protection systems.

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 of the maintenance functions listed above are covered in this chapter except for cathodic protection, which is discussed in Section 8.0.

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

- Crane barge or floating crane.
- Tugboat, mule, or other vessel (for maneuvering and positioning the crane platform).
- High-pressure water pump and hose (for cleaning).

4.2 PROCEDURES

4.2.1 BUOY REPLACEMENT (RISER-TYPE). A buoy in a riser-type system can be replaced without removing the mooring. Proceed with the replacement as follows:

- Lift the buoy out of the water and wash it down with seawater from a high pressure hose.
- Secure the riser chain to a bitt or cleat with a wire rope sling.
- Detach the buoy from the chain by removing the anchor joining link or buoy shackle located directly under the buoy.

NOTE

If a replacement joning link is not available, the removed joining link can be cleaned, recoated with a preservative grease, and reused to secure the new buoy to the riser chain.

- Secure new buoy to riser chain.
- Lower new buoy into position in the water.

NOTE

When a tension bar type buoy is lifted onto a barge deck, it should be placed on railroad ties or on chocks to prevent damage to the lower portion of the tension bar.

4.2.2 RISER REPLACEMENT. Riser replacement will be accomplished as follows:

- Lift the buoy and its attached riser chain out of the water and wash down with a high-pressure hose.
- Hoist buoy and riser chain aboard the barge.
- Hold the ground ring on a deck stopper.
- Disconnect riser from the ground ring and buoy.
- Attach new riser to the buoy and ground ring.
- Reinstall buoy and riser in the water.

The above steps are standard procedure for moorings installed in shallow water. In deep water, however, the ground ring, in all probability, will not be able to be lifted

on the deck of the barge without disturbing the anchors. In this situation the mooring will have to be recovered in order to replace the riser, and then reinstalled (refer to Section 2.0).

4.2.3 BUOY REPLACEMENT (NON-RISER-TYPE). 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 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 subassemblies. When one of the subassemblies is cut, the buoy will be pulled in the direction of the opposing" leg. This pull will result in a potentially dangerous 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 in accordance with the procedures set forth in Section 2.0. In many non-riser installations, significant slack exists in the anchor chain 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.

4.2.4 MINOR REPAIRS. In-service minor repairs to a buoy, such as replacing a fender, repairing an upper hull puncture, patching fiberglass or polyurethane, replacing anodes, or spot painting the buoy, can be accomplished without taking the buoy ashore. Detailed procedures for the refurbishment of buoys, chain, and chain accessories are contained in Chapters 5 and 6. Although emergency

replacement of smaller sizes of mooring chain components can be accomplished underwater by divers, mooring component replacement, welding, and other minor repairs should be accomplished aboard a crane barge. 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 (See Paragraph 5.3.2.5 for leak test procedures).

WARNING
Buoy manhole covers should not be removed while the buoy is in the water.

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:

4.2.4.1 Welding/Cutting. 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.

4.2.4.2 Shackles/Joining Links. 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 (see Figure 4-l). 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.

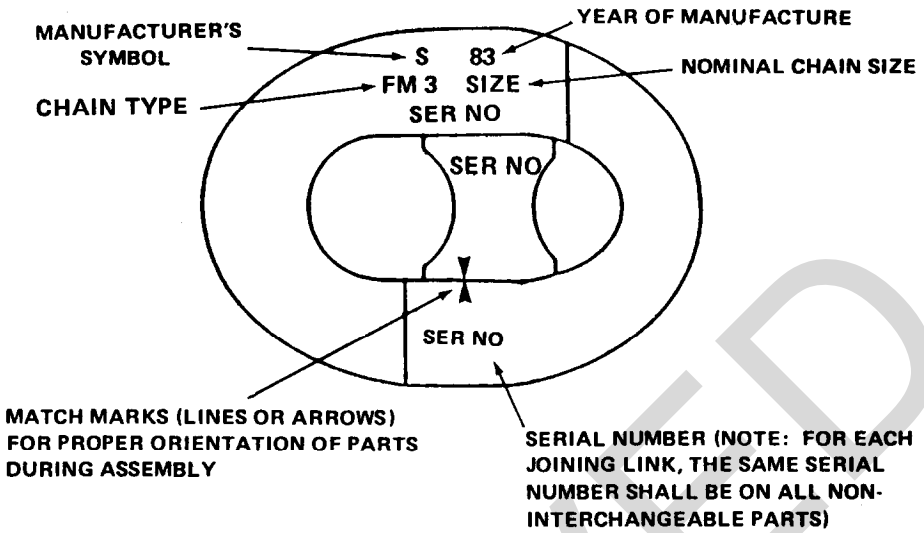


Figure 4-1. Mooring Material Markings

4.2.5 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 airhose 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. MI L-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 water. Either type of coating should completely cover the steel and extend at least one-half inch over the cleaned coating surrounding the steel.

5.0 ASHORE INSPECTION AND REFURBISHMENT OF BUOYS

5.1 GENERAL

5.1.1 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 must be conducted.

5,1.2 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 shackle and joining links from the buoy, as necessary.

NOTE

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.

5.2. INSPECTION PROCEDURES

5.2.1 PRELIMINARY INSPECTION. Before beginning the preliminary inspection, a 1-foot-square section of the top and bottom and four l-foot-square 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 (see Figures 5-1 and 5-2).
- Check the hawsepipe (if the buoy is so constructed) for rust, cracks, pitting, or other material abnormalities.
- 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.
- Check the interior of the buoy for rust or corrosion.

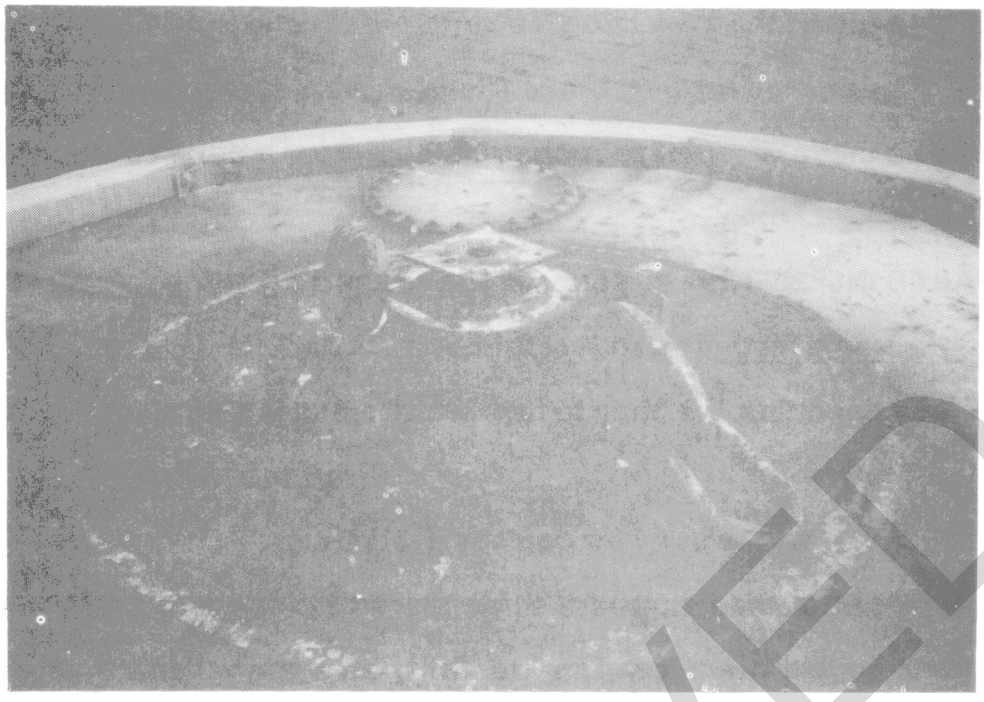


Figure 5-1. Heavy Rusting of Top Deck and Jewelry

Figure 5-2. Severe Top Deck Corrosion

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.

5.2.2 DETAILED INSPECTION. Perform detailed inspection as follows:

5.2.2.1 Ultrasonic Testing. Conduct this test as follows:

- Sandblast the buoy to near white metal in accordance with SSPC-SP-10.
- 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. (Refer to Paragraph 5.2.2.2 following.)

5.2.2.2 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 G46-76, “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 G46-76 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:

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

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.

5.2.2.3 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 will be performed to determine the extent of the defects.

5.2.2.4 Air Test. Air test each chamber/compartment in the buoy. Maintain 2 psi design pressure in each compartment for 30 to 45 minutes (see Paragraph 5.3.2.5 for procedures).

5.2.2.5 Documentation. The results of all inspections (both preliminary and detailed) will be fully documented and filed for future reference. If a buoy or its components are found to be in unsatisfactory condition, the inspection results should be used in planning and estimating future repair or replacement material requirements and associated labor costs. Replacement components should be requested from CHESNAVFACENGCOM.

5.3 BUOY REPAIRS AND MODIFICATIONS

5.3.1 GENERAL. Steel buoy repairs and modifications will include manhole cover replacement, test plug and aperture maintenance, fender and chafing strip repairs, welding requirements, and air pressure testing of the buoys.

5.3.2 PROCEDURES. Buoy repair and modification will be accomplished as described below.

5.3.2.1 Manhole Cover Replacement. Manhole cover replacement will be accomplished as follows:

NOTE

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

- Clean and lubricate the studs and use chaser nuts where required.
- Replace old gasket with a new l/8-inch silicone rubber gasket held in place with RTV silicone gasket adhesive sealant (M IL-A-46106); apply sealant only to bottom surface of gasket.
- Lift manhole cover by the extension lip and position it over studs.

CAUTION

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

- 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 of torque.

5.3.2.2 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.

5.3.2.3 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 studbolts, 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 on center. Figure 5-3 illustrates the recommended attachment of fendering and chafing strips.

5.3.2.4 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, "The Structural Welding Code."

5.3.2.5 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 a test plug fitted with a gauge in the top of each buoy compartment.
- Pressurize each compartment with 2 pounds per square-inch of air pressure for a minimum of 30 minutes after stabilization of pressure.
- Brush all joints and seams with a solution of commercial leaktesting 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 leak testing solution before applying surface primers.

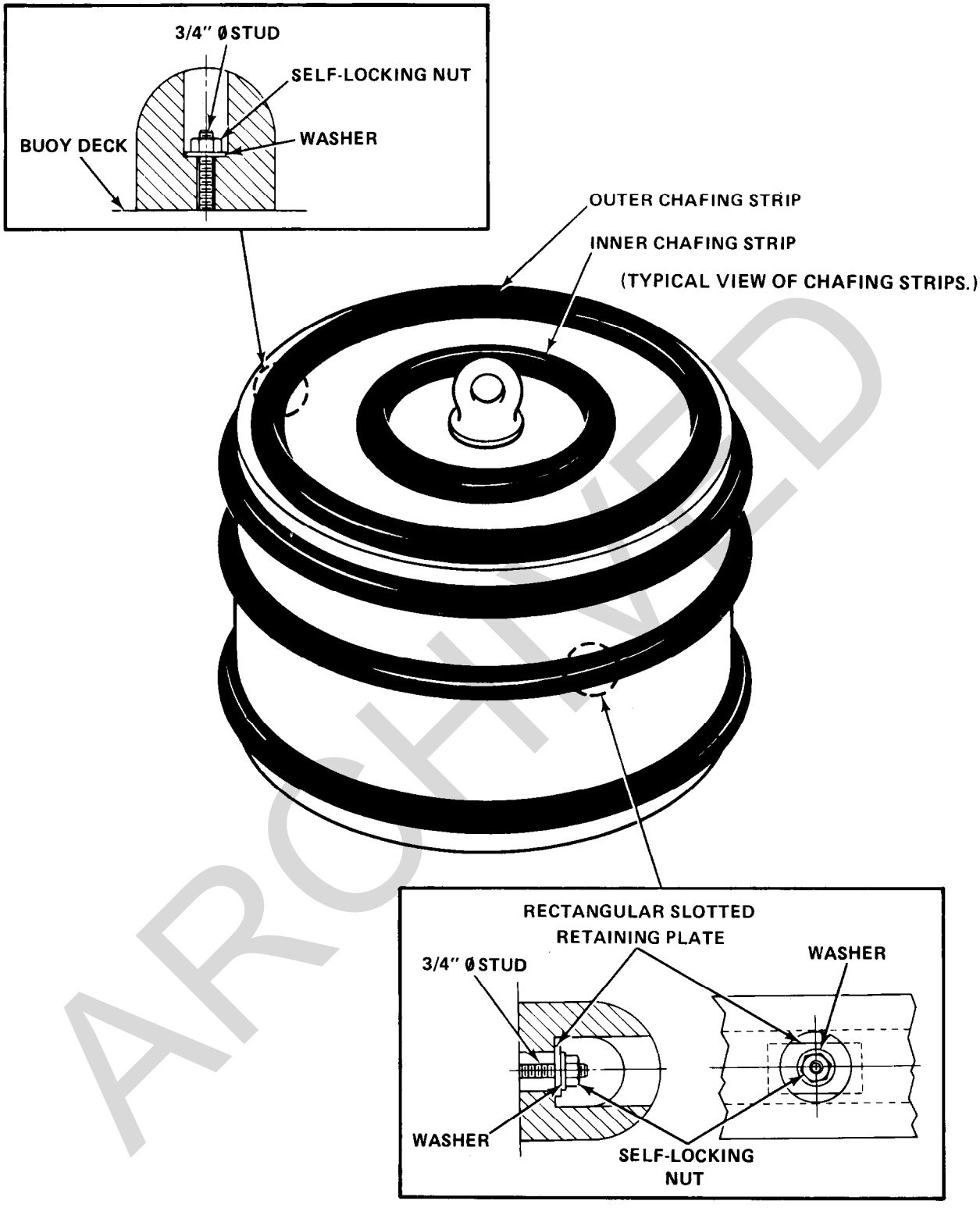


Figure 5-3. Recommended Installation of Fenders on Fleet Mooring Buoys

5.4 PROTECTIVE COATINGS

5.4.1 PREPARATION FOR APPLICATION. -Preparation of buoys for application of protective coatings will include the following:

- Remove fenders, chain links, steelplates, etc. from the mooring buoy.
- When possible, open buoy manhole and check the interior of the buoy for rust and water damage.
- Examine hull for areas that may need repair or replacement.
- Pits found that are 3/16 of an inch deep or more will be filled with clad-welding or epoxy repair compounds conforming with MI L-C-24176 and in accordance with the applicable sections of the Naval Ships Technical Manual, NAVSEA S9086-AA-STM-000.
- 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 l/2-inch steelplate 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.

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

- 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.

5.4.2 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 severly damaged and major repairs are required, the manufacturer of the buoy should be contacted for advice and/or assistance.

5.4.3 FIBERGLASS POLYESTER RESIN (FPR) COATING REPAIRS. Fiberglass patches will be applied as instructed below:

- Immediately after sandblasting the areas to be repaired (as noted in Paragraph 5.4.1), apply one coat of pretreatment primer (MIL-P-15328, Formula 117), 0.3 to 0.5 mil thickness. The thickness of the primer shall not exceed 0.5 roil. Film thickness will be checked with a microtest thickness guage or a comparable instrument.
- After the pretreatment primer has dried, apply one coat of clear polyester resin (M IL-R-21 607) to the surfaces that are to receive the FPR coating patches.

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

- Commence with the first FPR lamination, which consists of the polyester resin and chopped fiberglass mat (M IL-M-43248). Accomplish lamination as follows:
  - Apply the mat to the pre-coated surface and roll or squeeze to remove all lumps and air bubbles.
  - Lay on additional polyester resin until the mat is thoroughly wet.
  - Roll or squeeze until smooth, adding additional resin as necessary.
- Immediately after the first lamination apply three additional laminations, as follows, to give a maximum dry film thickness of 3/16 of an inch.
  - One lamination of fiberglass woven roving (MI L-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 2 inches to a maximum of 6 inches.

  - 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 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-polyster lamination sprayed on the surface being refinished at the rate of 2 ounces per square foot.

- 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.

5.4.4 PAINT COATINGS. General coating operations, materials, and safety precautions are described in NAVFAC MO-1 10, “Paints and Coatings. ” The recommended coating system for mooring buoys is the Navy epoxy-polyamide system for interior and exterior ship surfaces (M IL-P-24441). Procedures for its use are thoroughly described in the Naval Ships Technical Manual (NAVSEA S9086-AA-STA-00). For optimum results, this coating should be applied to dry steel cleaned to a near white metal surface.

- The above coating should be applied in three coats, each at about 4-roil film thickness, to give an approximate 3-roil dry film thickness per coat and a minimum 8-roil 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 500 to 60°F; 1 to 1 1/2 hours at 60° to 70°F; and 1/2 to 1 hour above 70° 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 percent, 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. 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 roils 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 (M IL-P-24441, Formula 152) is still tacky (within 4 to 6 hours after its application). If the epoxy has hardened, a tack coat (1 to 2 roils wet film thickness) must be applied and allowed to cure for 4 hours before the first coat of antifouling paint is applied.

5.4.5 QUALITY OF WORK. All of the workmanship on the coating systems shall be in accordance with the Naval Ships Technical Manual, NAVSEA S9086-AA-STM-000. 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 asset forth in the specifications and manuals noted herein.

6.0 ASHORE INSPECTION AND REFURBISHMENT OF CHAIN AND ACCESSORIES

6.1 GENERAL

6.1.1 SCOPE. The purpose of inspecting chain and accessories is to make a sound qualitative decision as to the disposition of these items. There are two types of inspections: preliminary and detailed. The preliminary inspection is performed in the known wear areas and will determine whether the chain and accessories are in adequate condition for continued use, whether a detailed inspection is required, or whether the items should be disposed of. In the detailed inspections, each link of chain and each accessory is thoroughly inspected for corrosion, cracks, wear, pitting, elongation, or other abnormalities. Based on the results of this inspection, a decision is made either to refurbish and retain the material or to dispose of it.

6.2 INSPECTION AND REFURBISHMENT

6.2.1 PRELIMINARY INSPECTION. Before commencing the inspection, the chain assembly will be disassembled into individual shots or into the shortest whole chain lengths. The ground ring, swivels, joining links, and shackles will be removed. Shackles and joining links should be kept together as complete units, including pins. Shackle pins and tapered locking pins should be used only in their original parent component. Preliminary inspection will include the following:

- Visually inspect all accessories and chain for abnormal wear, deformation, cracks, or missing studs. Studs should not be removed from chain links for any reason. Links found without studs should be cut from the length of chain and discarded.
- Take single or double link measurements (as described in Paragraph 6.2.2) in known or suspected high wear areas, such as the first two to four links on each end of a shot, the wear zone on each anchor leg assembly (where the chain links are shiny), and components used in the riser subassembly or used as buoy jewelry.

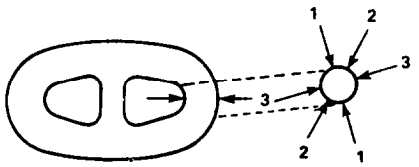
- Classify chain and accessories as good, fair, or poor according to the criteria described in Paragraph 6.2.2 below. All material in good or fair condition will undergo a detailed inspection before it is recoated and returned to inventory for future use. Any material classified in poor condition (wire diameter less than 80 percent of original size, cracked or deformed, etc.) is unsuitable for future use and should be disposed of through normal channels.
- Isolated links in poor condition may be cut from a length of chain to salvage the usable portion. In such cases the remaining links must all be carefully examined during the subsequent detailed inspection.

6.2.2 DETAILED INSPECTION. After the preliminary inspection, (if it is recommended that a detailed inspection be performed), the chain will be sandblasted in accordance with the latest edition of the "Steel Structures Painting Manual, Vol. II, Systems and Specifications, " Specification SSPC-SP-6. Detailed inspection of chain and its accessories will include the following:

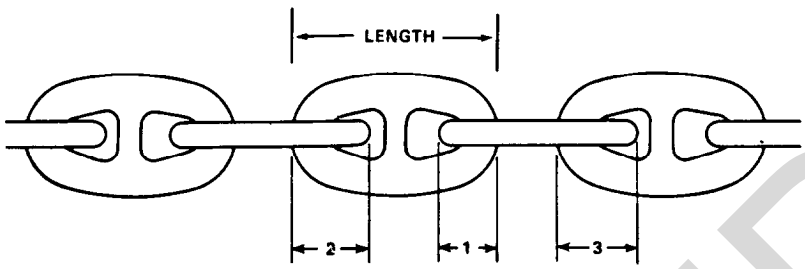
- Take single link caliper measurements of the wear areas at the ends of the chain links and accessories (anchor joining links, shackles, chain joining links, etc. (see Figure 6-l). The condition of the chain will be determined as follows:

CONDITION	AMOUNT OF DETERIORATION
Good	90% or greater of original wire diameter measured.
Fair	80-90% of original wire diameter measured.
Poor	80% or less of original wire diameter measured.

- Carefully inspect each accessory or chain link for cracks, corrosion, elongation or other deformations, and other abnormalities. Any

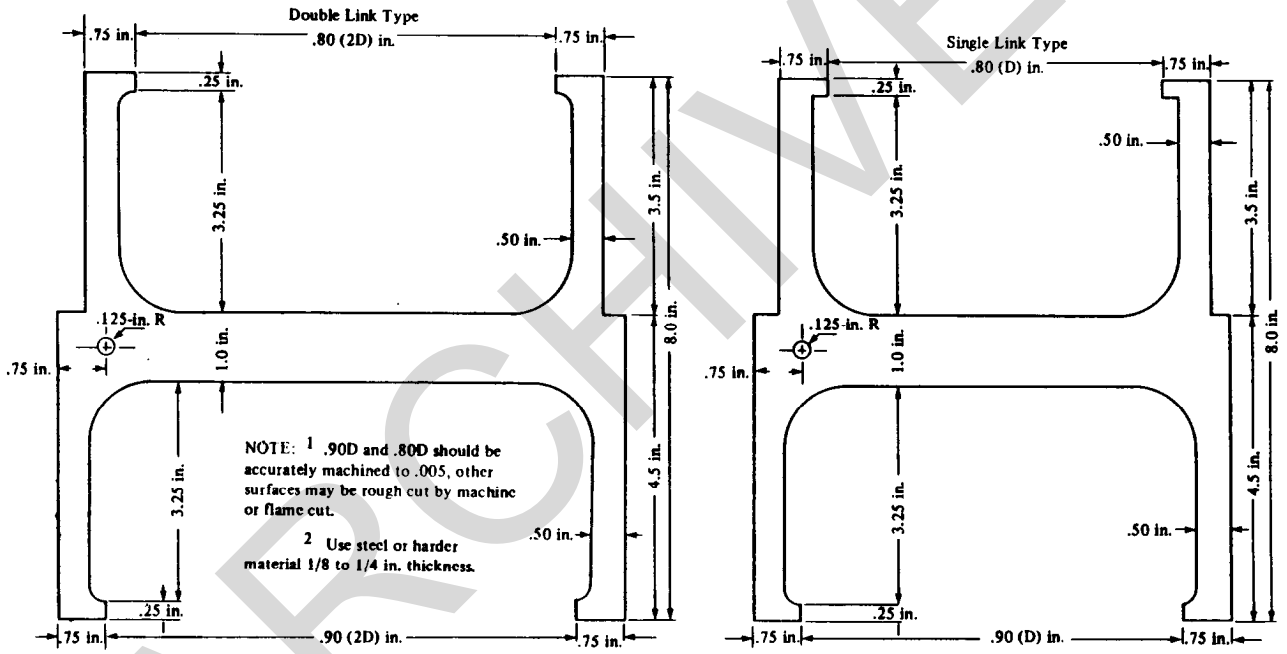


SINGLE LINK MEASUREMENT



DOUBLE LINK MEASUREMENT

LOCATIONS FOR TAKING CHAIN LINK MEASUREMENTS



D"	Single Link		Double Link		D"	Single Link		Double Link		D"	Single Link		Double Link	
	.90D	.80D	.90(2D)	.80(2D)		.90D	.80D	.90(2D)	.80(2D)		.90D	.80D	.90(2D)	.80(2D)
6-1/2	5.850	5.20	11.70	10.40	3-1/2	3.150	2.80	6.300	5.600	2	1.800	1.600	3.600	3.200
6	5.400	4.80	10.80	9.60	3	2.700	2.40	5.400	4.800	1-7/8	1.687	1.500	3.375	3.000
5-1/2	4.950	4.40	9.90	8.80	2-3/4	2.475	2.200	4.950	4.400	1-3/4	1.575	1.400	3.150	2.800
4-1/2	4.050	3.60	8.10	7.20	2-1/2	2.250	2.000	4.500	4.000	1-1/2	1.350	1.200	2.700	2.400
4	3.600	3.20	7.20	6.40	2-1/4	2.025	1.800	4.050	3.600	1-1/4	1.125	1.000	2.250	2.000

Figure 6-1. Location of Caliper Measurements of Wear Areas In Chain and Accessories

components containing cracks, deformations, or severe localized corrosion will be classified in “poor” condition.

- Material in good or fair condition should be recoated, tagged, and returned to the inventory for use. Material in poor condition is unsatisfactory for use in fleet moorings and should be discarded.
- Isolated links in poor condition may be cut from a length of chain to salvage the portions in good or fair condition.
- Keep shackles and joining links together as complete units (including pins).
- Coat the mating surfaces of the joining links and swivels with a molybdenum disulfide grease (M IL-G-23549) or an equivalent lithium based grease. The results of all inspections (both preliminary and detailed) will be fully documented and filed for future reference. Inspection results should be used in planning and estimating future repair or replacement requirements and associated labor costs.

6.2.3 PROTECTIVE COATINGS. Application of protective coatings should be performed as follows:

- Spray, dip, or brush the abrasive blasted chain with an approved rust preventative (MI L-C-16173 Grade 11 1).
- Place the chain on a clean surface to dry.

NOTE
Coating operations should be avoided on cold, damp days.

7.0 ASHORE INSPECTION AND REFURBISHMENT OF ANCHORS

7.1 GENERAL

7.1.1 SCOPE. Anchors for fleet moorings generally require very little maintenance and are seldom subject to failure. Although little maintenance is expected, this chapter will cover the maintenance checks that should be performed whenever an anchor is removed from service. Maintenance will encompass inspections, tests, and repairs of the anchors.

7.2 INSPECTION AND REFURBISHMENT

7.2.1 GENERAL. 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.

7.2.2 PRELIMINARY INSPECTION. The purpose of a preliminary inspection is to determine whether an anchor is in satisfactory condition for continued operational use. If abnormalities are found and the condition of the anchor is suspect, then a detailed inspection of the anchor is performed. The preliminary inspection of an anchor will include the following:

- Clean the anchor with a stream of water from a high-pressure hose.
- Take at least two caliper measurements of the wire diameter of the anchor shackle. One measurement should be taken at the wear zone of the lugs of the shackle. If the wire diameter of the shackle measures greater than 90 percent, the shackle is accepted. If the measurement is 90 percent or less, the shackle must be replaced.

- Visually check the anchor for casting irregularities, cracks, or obvious mechanical damage. On STATO, NAVMOOR, and other welded anchors, all welds should be checked for cracks, fissures, corrosion, or other defects. If present, stabilizers and their attachment points should be inspected for cracks or other signs of weakness.
- Conduct a hammer test to determine if there are any invisible cracks or other abnormalities. To accomplish this test, a crane is required to lift the anchor off the ground by its anchor shackle. The palm of each fluke is then struck with a 5-pound (or larger size) hammer. A ringing tone indicates that there are no abnormalities in the structure of the fluke. A dull “thump” indicates that the fluke structure contains serious cracks or other abnormalities.

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.

7.2.3 DETAILED INSPECTION. This inspection will be conducted only 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 anchor by sandblasting to near white metal.
- Visually inspect anchor for cracks or casting irregularities. Pay particular attention to anchor flukes and welds.
- Perform a liquid dye penetrant or magnetic particle test on any suspected cracks or abnormalities in accordance with MIL-STD-271, "Non-Destructive Testing Requirements for Metals.”

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 (MI L-P-2430). 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.

8.0 CATHODIC PROTECTION SYSTEMS

8.1 GENERAL

8.1.1 SCOPE. Shore activities responsible for the operation and maintenance of fleet moorings expend considerable time and money maintaining moorings in a safe, reliable condition. The highly corrosive effect of seawater necessitates a continuous program of preventive and corrective maintenance. The frequency of maintenance actions is directly related to the rate of corrosion and wear of the mooring chain and other components. Recent analysis of the maintenance of fleet moorings, with and without cathodic protection over extended periods of time, indicates that the use of an effective cathodic protection system (CPS) can significantly reduce the corrosion rate of mooring chain, yielding an attendant savings in maintenance costs.

8.1.2 APPLICATION. Cathodic protection of steel submerged in seawater is achieved by impressing a negative electrical potential on the surfaces exposed to the seawater. Several systems have been developed to supplement protective coatings in an effort to reduce corrosion of fleet mooring chain and accessories. Typically, the required electrical potential is provided by sacrificial zinc anodes which are gradually consumed while catholically protecting the steel components. Cathodic protection of the submerged portion of the buoy may also be provided by sacrificial anodes attached to the hull. Anchors normally do not require cathodic protection because bottom mud isolates the anchors from the corrosive effects of the seawater.

8.1.3 EFFECTIVENESS. The cathodic protection system and the protective coatings on the mooring components work together to keep the underwater portion of the buoy and the chain assembly from corroding. It is estimated that such a system, properly installed and maintained, can provide complete protection for IS years in aggressive environments, and for longer periods at milder locations, before anode

replacement becomes necessary. Additional anodes can then be installed without removal of the mooring. Buoy anodes are not used when the buoy is fiberglass or polyurethane coated; only the chain and the lower portions of the tension bars on these buoys must be protected.

8.2 CATHODIC PROTECTION FOR BUOYS

8.2.1 ENVIRONMENTAL CONSIDERATIONS. In designing a cathodic protection system, the extremes of favorable and unfavorable environmental conditions should be considered. Favorable local environmental conditions (low salinity, minimal tide, quiescent water, low dissolved oxygen content, low temperatures, and moderate currents) result in longer periods of time between preventive or corrective maintenance. Unfavorable local environmental conditions (high salinity, high tidal variations, turbulent water, high dissolved oxygen content, high temperature, and strong currents) increase the wear and corrosion rates and decrease the time between required maintenance actions. Cathodic protection is beneficial in all environmental conditions but especially where unfavorable local conditions exist.

8.2.2 ANODES. Anodes for use on buoys are readily available. One commonly used is a zinc casting 36 inches long with a nominal cross-sectional area of 16 square inches. The anode weighs approximately 150 pounds, and is cast on a 48-inch-long 3/4-inch-diameter pipe (see Figure 8-I). The composition of the zinc is in conformance with MI L-A-18001. Buoy anodes must be secured in a location where they will not be subjected to impact by vessels; for example, on the bottom of drum-type buoys, in a sea chest built into core portions of peg-top riser-type buoys, or within protective cages welded to the conical side of a peg-top buoy. These anodes should be located about 4 inches from buoy surfaces.

The new foam buoy hulls do not require cathodic protection and, therefore, anodes are not attached to it. The lower portion of its steel tension bar member,

however, is exposed to sea water and must be protected. This is accomplished by attaching one chain stud anode on either side of the exposed portion of the tension bar.

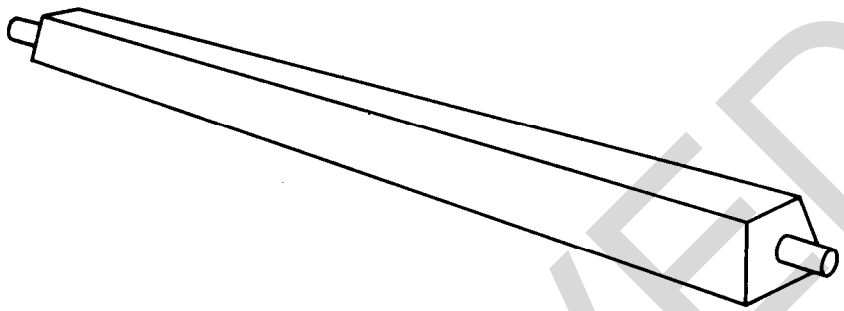


Figure 8-1. Buoy Anode

8.2.3 INSTALLATION OF ANODES. Buoy anodes are usually installed while the buoys are being overhauled ashore. Replacement can also be accomplished at a mooring site during a regularly scheduled maintenance inspection by lifting the buoy out of the water and removing and replacing the anodes while the buoy is on deck. Whether the installation of the buoy anodes are on the bottom, in a sea chest, or within a protective cage, a pair of angle iron brackets are installed which will support each buoy anode. The brackets are welded directly to the buoy hull and generally have threaded fittings for simple anode installation and replacement.

The fittings are of clean, unpainted metal to ensure good electrical continuity between the zinc anode and the buoy hull. Where recessing of the anode is necessary, the brackets are located in a conveniently sized sea chest built to house the anode and its fittings (see Figure 8-2). Alternately, protective cages can be fabricated so as to have sufficient diameter and length to fit over the anode installation (See Figure 8-3).

8.3 CATHODIC PROTECTION FOR MOORING CHAIN

8.3.1 ANODES. Zinc anodes are used for cathodic protection of mooring chain. There are basically three types of commercially available sacrificial anodes (zinc composition conforming with MIL-A-18001). These are chain stud anodes, link anodes, and clump anodes.

Figure 8-2. Buoy Anode Recessed Within a Sea Chest

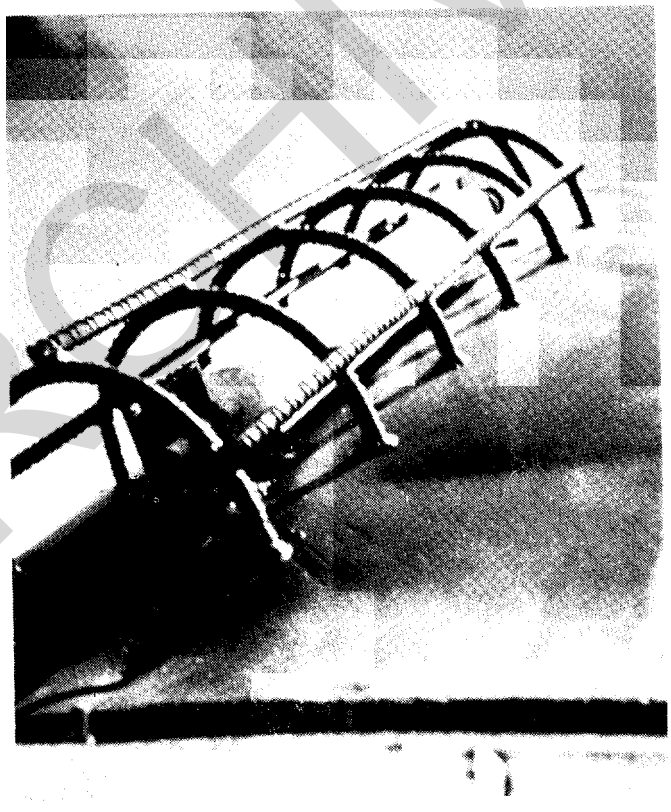


Figure 8-3. Anode Protective Cage

8.3.1.1 Chain Stud Anode. This cathodic protection system consists of an anode and a bolt assembled to the stud link as shown in Figure 8-4. For each size chain, a particularize bolt and anode are required (see Table 8-l). Each anode is stamped with its type. During anode installation on each chain link, the recommended torque to be applied to the bolt is 25-35 foot-pounds. If, when attempting to replace a depleted anode, a bolt head is found to be missing, the center of the remaining bolt should be tapped with a counter-clockwise l/8-inch thread so that it can be removed using a counter-clockwise threaded bolt and a hand- or electric-powered wrench.

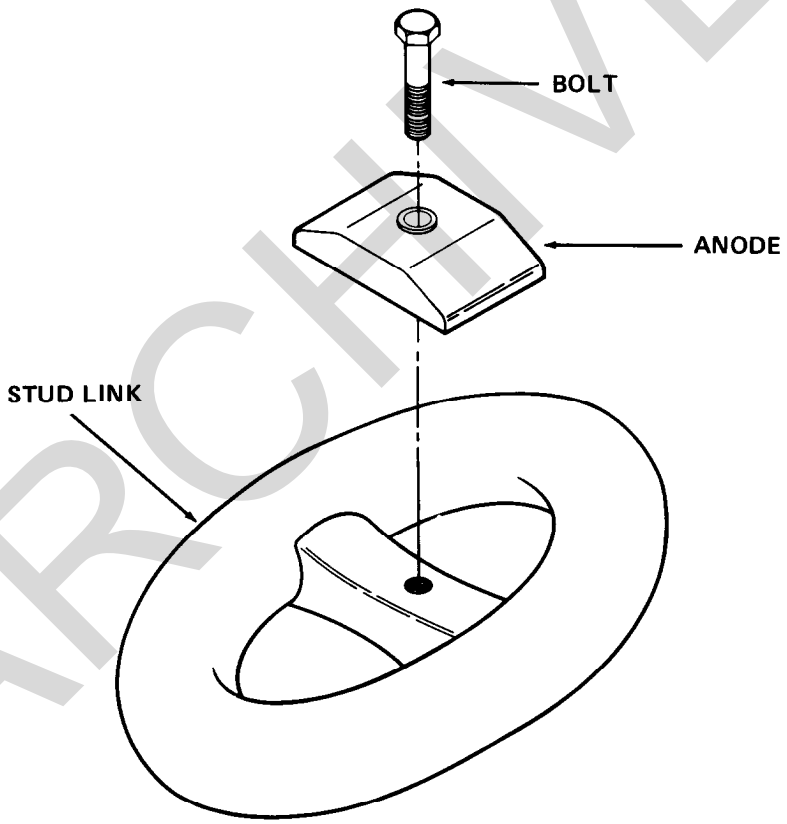


Figure 8-4. Chain Stud Anode Assembly

Table 8-1. Chain Stud Anode Screw Assembly

Chain/Anode Size	Screw Length
1 1/4	1
1 3/4	1 1/4
2	1 1/2
2 1/4	1 3/4
2 1/2	1 3/4
2 3/4	2
3	2
3 1/2	2 1/4
4	2 1/4

8.3.1.2 Link Anode. This design incorporates an elongated chain link which is an in-line component of the mooring. The anode (see Figure 8-5) consists of approximately 500 pounds of zinc cast onto the chain link. If the chain is in tension, the electrical connection to the mooring chain is provided by the exposed metal-to-metal surfaces in the grip area of the links. A modification of the link anode incorporates a wire rope which provides the electrical continuity throughout the chain when the links are not in tension.

8.3.1.3 Clump Anode. This anode is similar in configuration to a small sinker weight. The required amount of zinc is cast around a steel “hairpin” and attached to the chain with a standard sinker shackle or with modified attachment hardware.

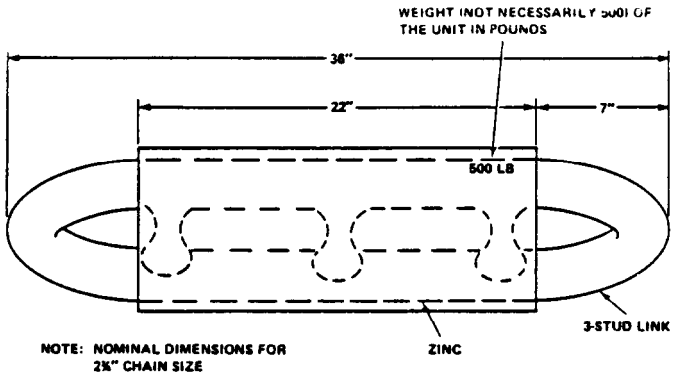


Figure 8-5. Link Anode Design

This anode also requires the use of a wire rope, which is woven through the chain to provide electrical continuity. Wire clips or hose clamps are used to connect the wire rope to the anodes and to the chain links.

8.3.2 INSTALLATION. For proper operation of the cathodic protection system, the anodes, wire ropes, and fittings should be free of paint, grease, dirt, or coatings. The wire ropes and fittings will be catholically protected by the anodes. A cathodic protection system installation can be most easily and economically accomplished at the time of the regularly scheduled mooring overhaul and prior to installation of the mooring system.

8.3.2.1 Chain Stud Anode. This type anode is attached to each stud in the chain link. The attachment will normally be accomplished by the chain manufacturer. However, divers or ashore personnel may be required to replace missing or deteriorated anodes. Installation requires bolting the proper anode to the chain link stud as previously shown in Figure 8-4. In some cases new chain shots may be shipped with the studs drilled for these anodes, but with anodes not installed. In these cases, the threaded holes will be lubricated with an electrically conductive graphite lubricant (VV-G-671) to reduce the probability of corrosion, and the hole fitted with a steel screw to prevent it from being filled with coating material (see Figure 8-6). The lubricant will not degrade the cathodic protection system and does not have to be cleaned out before installing the anode.

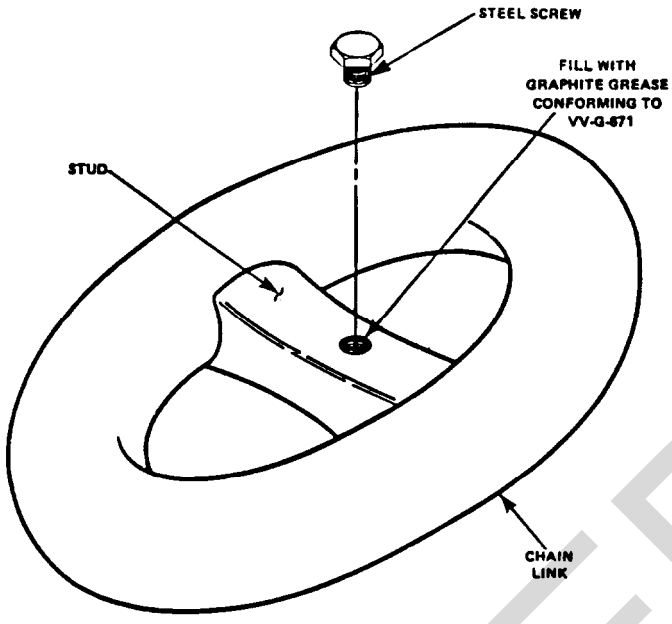


Figure 8-6. Protecting Drilled Studs

8.3.2.2 Link Anode. Link anodes are installed between lengths of chain with two chain joining links (see Figure 8-7). The installation must be completed onshore or on the crane barge before the mooring is installed. A reliable electrical path is normally provided by a wire rope continuity cable clamped to the link portion of the anode and attached to the chain as described in Paragraph 8.2.3.4.

8.3.2.3 Clump Anode. Clump anodes are usually installed ashore during mooring overhaul. The anode is attached to the chain with wire rope (see Figure 8-8). To provide an electrical path from the anode to the chain, a wire rope continuity cable must be clipped or clamped to the anode's hairpin and attached to the chain as described in the following paragraph.

8.3.2.4 Wire Rope. The wire rope, used to provide the electrical continuity, is normally 5/8- to 3/4-inch-diameter galvanized steel. Wire ropes of these diameters have the strength characteristics needed for this purpose, and yet are flexible enough for interweaving through the chain links. The wire rope should be interwoven through every fourth link *in* a shot and

Figure 8-7. Link Anode Installed in a Chain Section

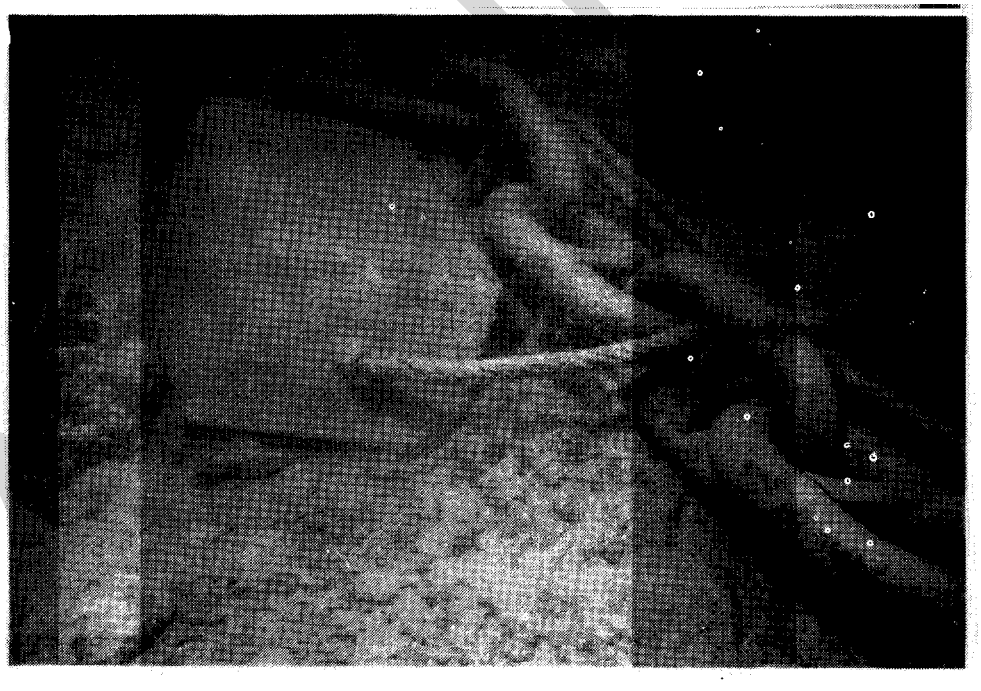


Figure 8-8. Clump Anode and Chain as Viewed Underwater

attached to every eighth link with a hose clamp, wire clip, or U-bolt. Prior to attaching the continuity wire to the chain link, part of the link must be cleaned to bare metal so that the chain link and the continuity wire have good metal-to-metal contact. This is important for a sound electrical connection.

8.3.3 ANODE REPLACEMENT. An anode should be replaced if less than 25 percent of its original weight remains. Replacement should be accomplished by trained personnel, and equipment and materials should be on hand, both ashore and on crane barges, to support this activity. Replacement of chain stud anodes can easily be handled by divers. However, replacement of in-line link anodes, clump anodes, and buoy anodes is more difficult for divers. In addition, divers will find it difficult to replace any anodes in areas where the bottom is muddy or where the anchor chain subassembly is partially buried.

9.0 STORAGE OF MOORING MATERIALS

9.1 GENERAL

9.1.1 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, coal tar, or other suitable preservatives as detailed in Chapters 5.0,6.0, and 7.0.
- All components should be tagged or labelled 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. The paragraphs that follow provide additional details and other considerations for Fleet Mooring Inventory (FMI) storage.

9.1.2 STORAGE AREA REQUIREMENTS. Shore activities requiring spare mooring materials and those activities designated as stock points for the FM I will require a suitable storage area. The following should be observed:

- The FMI 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.

9.2 STORAGE PROCEDURES

9.2.1 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 an inverted position (see Figure 9-l).

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.

9.2.2 CHAIN AND CHAIN ACCESSORIES. Chain is normally stored ranged out in tiers, bailed a single shot at a time on a pallet, loaded in shipping crates, or in bundles. The ground where the chain is stored should be clear of all debris and

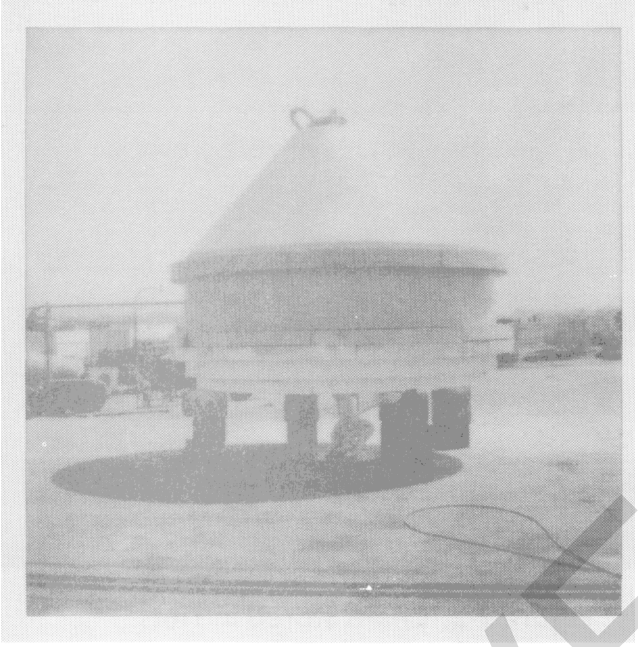


Figure 9-1. Proper Storage of a Peg Top Buoy

growth, and well drained. To prevent its intermixing with older grades of chain, FM 3 chain and accessories should always be stored separately.

9.2.2.1 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 (see Figure 9-2).
- 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.

9.2.2.2 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.

Figure 9-2. Chain Stored in Tiers

9.2.2.3 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 9-3). Five standard-sized crates have been constructed for the various chain sizes. The design of one of these crates is shown in Figure 9-4.

9.2.2.4 Bundled Chain. Chain will be bundled by reeving wire rope through the last link on each end of the shot and through two other links, each approximately 30 feet from the nearest end of the shot. The ends of the wire rope shall be secured to each other to form a sling which may be used to lift the entire shot. When lifted, the total length of the shot/sling combination shall not exceed 20 feet.

9.2.2.5 Accessories. Accessories should be boxed, crated, or banded to pallets. Components of the same size, type, and condition should be stored together for inventory control and ease of access. Parts for joining links

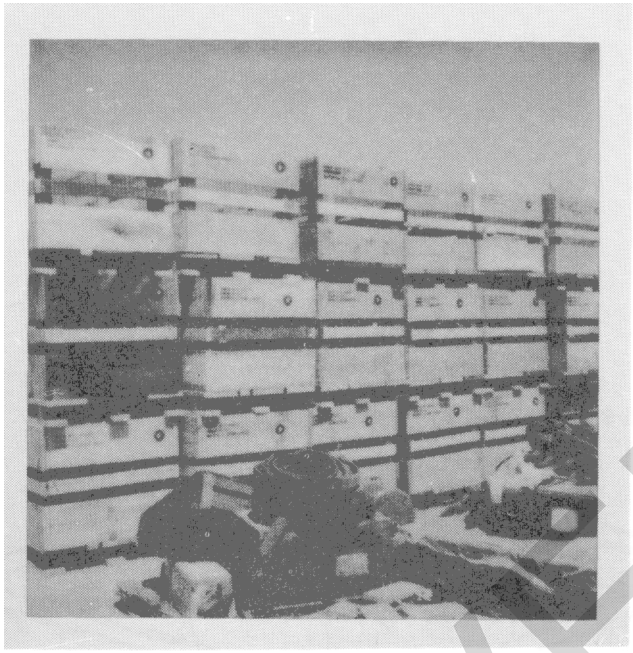


Figure 9-3. Stacking Crates of Chain

and pins for shackles should not be mixed or interchanged, but stored together as matched sets to ensure proper fit in the field. All joining links and shackles should be stored clean, free of rust, well-greased, and loosely assembled. Joining links should never be disassembled and their parts stored separately.

9.2.3 ANCHORS. Store anchors as follows:

- 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 in a vertical position, these identification marks are not visible. When stored vertically, this information should be transferred to a suitable tag or stenciled to the anchor's shank.

9.2.4 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

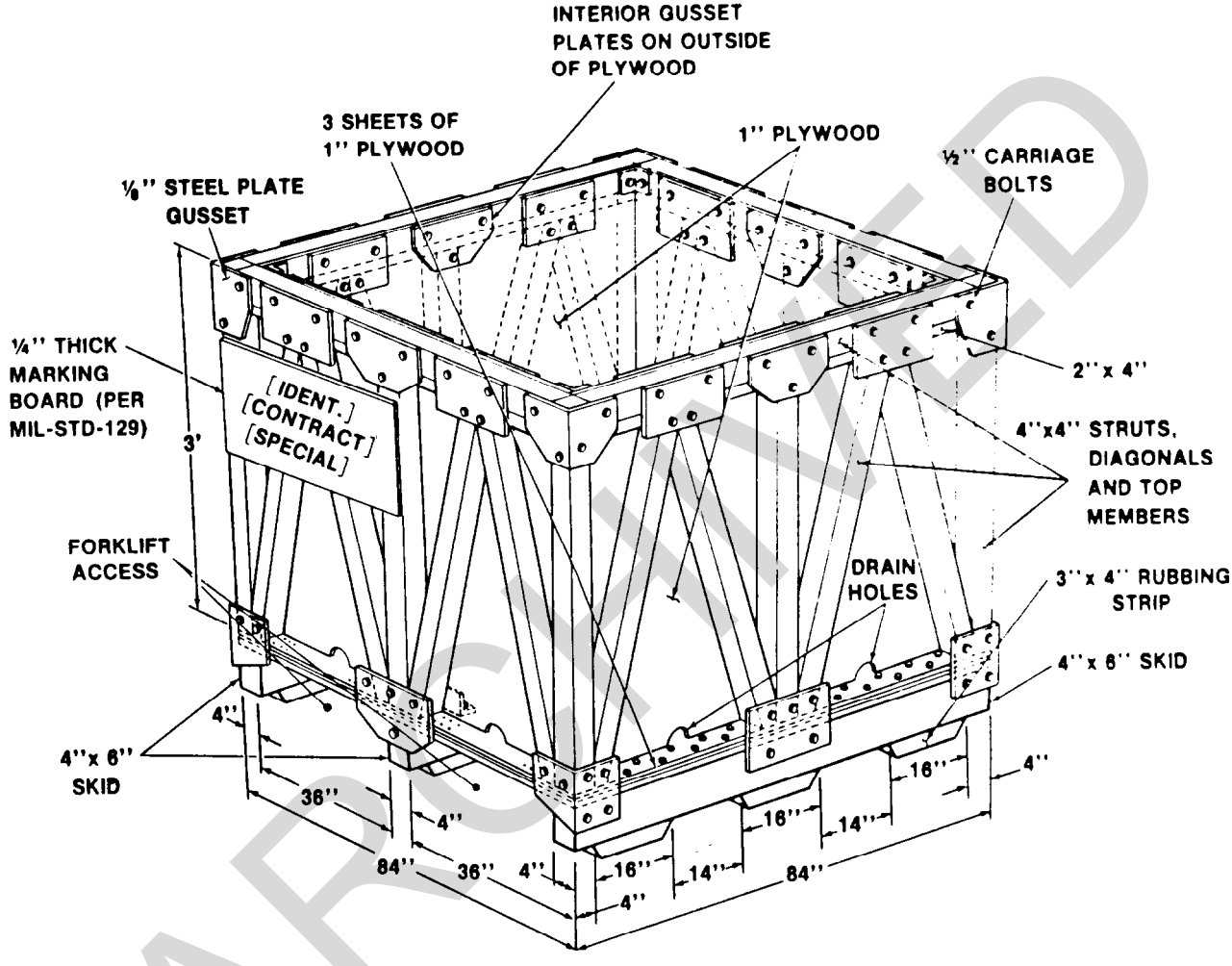


Figure 9-4. Overseas Shipping Container for 3 1/2- and 4-inch Chain (14,000 lb. Capacity)

corrosion of the anodes. Chain stud anodes should be stored in 55-gallon steel drums with removable, bolt-on type lids. Only one size of anode shall be packed in each drum. Cathodic protection material should be kept clean and should not be painted or coated with oil or grease during either storage or use.

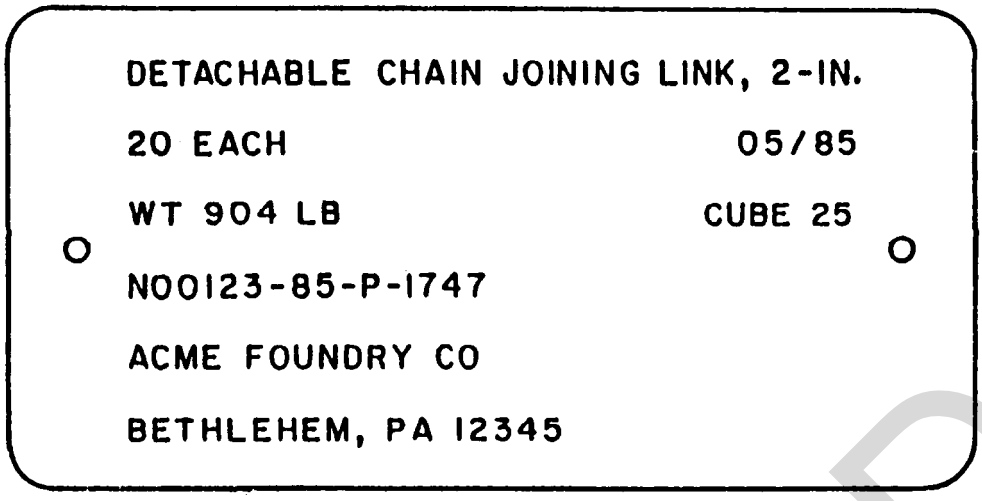
9.2.5 MARKING AND IDENTIFICATION. Marking and identification of components will be accomplished as described below.

9.2.5.1 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.

9.2.5.2 Color Coding. It is also 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:

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

9.2.5.3 Identification. Identification of chain and accessories shall be on tags of 0.031-inch thick aluminum alloy 1100 or 3003, attached using 0.031-inch diameter 300 series corrosion resisting steel wire through 0.125-inch diameter holes at each end of the tag. Characters shall be metal stamped using 0.25-inch high characters. Tag size and information content shall be as specified in Figure 9-5. 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.



EXAMPLE TAG

Figure 9-5. Shipping Tag

9.2.5.4 Chain and Accessories. Chains and accessories are marked and identified as follows:

- The size and the name of the manufacturer are stamped or forged on each chain link or accessory during manufacture.
- New FM 3 chain will also have a unique serial number on each accessory and on the links at the end of each shot of chain (see Figure 9-6). 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.

  Contents, etc.

An artist's drawing of an overseas shipping container for chain accessories is depicted in Figure 9-7.

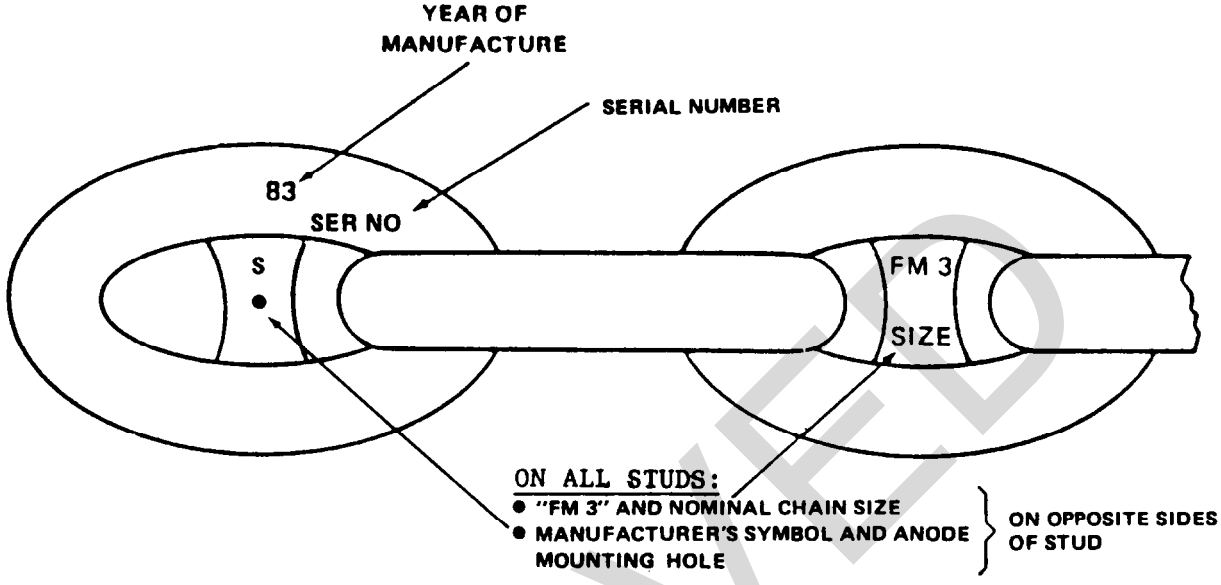


Figure 9-6. Chain Markings

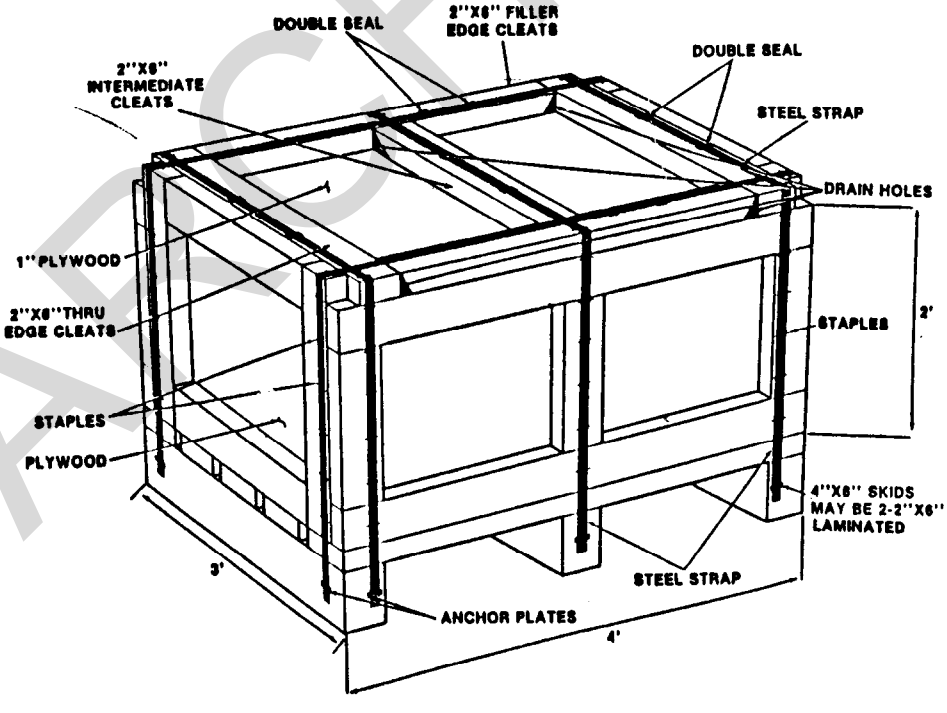


Figure 9-7. Overseas Shipping Container for Chain Accessories (3000 lb. Capacity)

9.2.5.5 BUOYS. New buoys should have an identification plate 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.

9.2.5.6 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, and
- Serial number.

9.2.6 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

REFERENCES

1.1 NAVFAC DESIGN MANUALS

	TITLE
DM-7	Soil Mechanics, Foundations, and Earth Structures
DM-26.3	Coastal Sedimentation and Dredging
DM-26.4	Fixed Moorings
DM-26.5	Fleet Moorings
DM-26.6	Mooring Design Physical and Empirical Data
DM-35	Drydocking Facilities

1.2 NAVFAC MAINTENANCE ORDERS

	TITLE
MO-110	Painting and Protective Coatings

1.3 NAVAL SHIPS TECHNICAL MANUALS

	TITLE
NAVSEA S9086-AA-STM-000	Naval Ships Technical Manual (latest revision): Chapter 581, Anchors and Anchoring; Chapter 050, Readiness and Care of Vessels in Inactive Status; and Chapter 631, Preservation of Ships in Service

1.4 NAVFACENGCOM PUBLICATIONS

	TITLE
NAVFACENGCOM P-71 5.0	EPS Wharf building Handbook (T R-Service) (November 1979)

1.5 NATIONAL BUREAU OF STANDARDS

	TITLE
--	Organic Coating properties, Selection and Use; Building Science Series 7 (February 1968)

1.6 OTHER PUBLICATIONS

TITLE

Keane, John D., "Steel Structures Painting Manuals, " Volume 2, "Systems and Specifications, " (latest edition) Steel Structures Painting Council, Pittsburgh, Pennsylvania

Book of Standards (latest revision), American Wood Preservers' Association, Washington, D.C.

deBoer, F. L., "Fiberglass Coatings for Fleet Moorings," Navy Civil Engineer, pp. 16-17 (March 1970)

Rules for Building and Classing Steel Vessels (latest edition), American Bureau of Shipping, New York, New York

Rules for Building and Classing Single Point Moorings, American Bureau of Shipping, New York, New York (1975)

APPENDIX B

MOORING COMPONENTS

APPENDIX B

MOORING COMPONENTS

1.1 GENERAL. This appendix discusses the various types of fleet mooring material components currently in use and describes their distinctive characteristics. For clarity, sketches of these components are included (all figures may be found at the end of this appendix).

1.2 FLEET MOORING BUOYS. The size of the buoy used in a particular fleet mooring is dependent on the depth of the water and the weight of the chain suspended in the water column. Figure B-1 shows the four types of buoys commonly used in fleet moorings.

1.2.1 BUOY SYSTEMS. Buoy systems fall into two categories, riser and non-riser-types, depending upon the configuration of the ground tackle securing them to the sea floor. Riser-type systems have a single point at the center of the bottom of the buoy to which a riser chain is attached. The non-riser-type system has a larger buoy with three to four padeyes attached to its circular bottom edge. Each of these padeyes is attached to one or more anchor leg subassemblies.

1.2.2 BUOY TYPES. The following types of buoys are currently utilized in fleet moorings:

1.2.2.1 Drum BUOY. This buoy is normally made of steel and is available in a variety of sizes. The shape of the buoy resembles a drum, and it is primarily used in smaller classes of moorings. The older standard design has a paint or fiberglass coating while the newer design has a polyurethane coating. This type of buoy contains either a tension bar or a hawsepipe (see Figure B-l).

- Tension Bar. A tension bar is a steel bar which passes through the center of the buoy with padeyes on top and bottom. The new

foam buoy has a 10-inch diameter pipe used as a tension bar. The lower padeye is connected to the upper link of the riser chain. A moored vessel can be connected to the upper padeye by its anchor chain, wire rope, or mooring hawsers.

- Hawsepipe. A hawsepipe is a cylindrical tube passing through the center of the buoy. The riser chain is passed through this tube and its upper Iink is held on the top of the buoy with a slotted chain plate. The lower portion of the riser chain within the hawsepipe is protected from wear by a rubbing casting which encircles the chain and greatly reduces the probability of chain abrasion. A moored vessel ties directly to the riser chain. The buoy is nonstructural in that the mooring load passes through the buoy via the riser chain.

1.2.2.2 Peg Top Buoy. This buoy is also used to support riser-type moorings, and includes either a tension bar or hawsepipe. Peg top buoys are conically shaped, with the top deck area considerably larger than the bottom surface (See Figure B-l).

1.2.2.3 Non-Riser-Type Buoy. These buoys are larger than those used in riser-type moorings since they have the additional weight of three or more ground legs to support in the water column. These buoys have a swivel at the top to which the moored vessel's anchor chain or hawser is attached. Three or four padeyes, to which the anchor leg assemblies are connected, are equally spaced around the buoy's hull (see Figure B-l).

1.2.2.4 Foam Buoy. This is the latest buoy design approved by the Navy. The buoy consists of a tension bar encompassed by a rigid closed-cell interior foam which is covered by a flexible cross-linked polyethylene foam adhered to the rigid interior foam. The overall foam buoy is encased

within a minimum of a 3/4-inch thick aliphatic urethane elastomer shell (see Figure B-l).

This buoy is vastly superior to the older steel formed buoy in that:

- If its outer hull is punctured, it will not flood and sink.
- It is considerably lighter than the steel buoy required to support a comparable weight in the water column.
- It requires minimum preventative and corrective maintenance.
- Its resilient construction greatly reduces the probability of damage caused by collision with mooring ships.
- The projected operational maintenance costs are considerably less than those of the standard steel buoy.

1.3 CHAIN AND CHAIN ACCESSORIES. Mooring chain not only secures the buoy in a predetermined position, but its weight also serves to absorb energy caused by the dynamic motion of moored vessels. Chain is usually manufactured in 15-fathom (90-foot) lengths, called shots. The chain diameter required for a particular mooring will vary depending on the anticipated maximum load. Mooring chain links normally have center crossbars, called studs, to retain the original shape of the link and to prevent the chain from kinking when it is piled in a heap. The wire diameter of fleet mooring chain links normally varies from 1-3/4 to 4 inches.

1.3.1 CHAIN TYPES. Chain currently manufactured consists of cast, dilok, or flash butt-welded links. Figure B-2 contains schematic drawings of these three types of chain links.

1.3.1.1 Cast Chain. A distinctive feature of this type of chain is that the studs are solid and cast integrally with the links. Cast chain is also made to commercial link standard dimensions.

1.3.1.2 Dilok Chain. A dilok link, which is chiefly used in a ship's anchor chain, and not fleet moorings, is made of two forged U-shaped pieces. A

forged stem of one piece (the male) contains a series of parallel serrations giving an appearance of concentric rings. The other socket piece (the female) has holes at each end. in joining the two pieces to form a link, the pierced socket section is heated, then the stems of the other section are inserted into the holes. The socket section is then forged with a drop hammer, forcing its material around the indentations in the other piece's stems, while both pieces are held in die blocks (see Figure B-3). Each chain link is made to commercial link standard dimensions, which are 6 wire diameters long by 3.6 wire diameters wide.

1.3.1.3 Flash Butt-Welded Chain. Each link of this chain is formed by bending a heated rod into an open chain link shape and flash welding the two butt ends. While the link is still hot, a stud is inset-ted and the link is pressed on both sides to secure the stud. After cooling, one or both ends of the stud may be welded to the link (see Figure B-4).

1.3.2 CHAIN GRADES. The properties of the steel used in the manufacture of chain for the Navy follow specifications that are similar to the rules followed in the manufacture of commercial chain. For commonly available chain, there are three different material qualities designated: Grades 1, 2, and 3, respectively. Grade 3 (which is used as FM 3 chain) has the highest strength of the three and is the grade currently being procured by the Navy for fleet mooring use and is singularly suited for application of a cathodic protection system. Figure B-5 depicts a comparison of the breaking strengths of these different materials.

1.3.3 CHAIN ASSEMBLY ACCESSORIES.

1.3.3.1 Chain Joining Link. This link is also called a detachable joining link, a chain connecting link, a detachable link, a lugless joining shackle, a detachable connecting link, or a Kenter shackle. This link is used to connect two shots of chain, two A-links, a swivel and an A-link, etc. Its wire diameter should be the same size as the mooring components it connects. The two chain joining links commonly found in the Fleet Mooring Inventory are the Baldt and Kenter types, named after the companies which developed their designs. Figures B-6 and B-7 provide sketches of and dimensional information concerning the Baldt and Kenter designs, respectively. Procedures for assembling a Kenter type chain joining link are contained in Appendix D.

1.3.3.2 Anchor Joining Link. This link is also called a detachable anchor connecting link. This component joins the end of a chain composed of common links to any of various enlarged mooring components, such as a ground ring, a buoy padeye, an end link, or an anchor shackle. Figures B-8 and B-9 provide sketches of and dimensional information for the Baldt and Kenter types of anchor joining links.

1.3.3.3 Shackles. Although there are many types of shackles available and in use throughout industry, there are four basic types of shackles used in fleet moorings:

- Joining Shackle. This shackle is also called a D-link, a D-shackle, or a joining shackle, “D” type, and is used to connect lengths of chain. The shackle is similar in shape to an anchor joining shackle but smaller in size. Figure B-10 provides a schematic of a typical joining shackle and a dimensional table of its various sizes.

- Anchor Joining Shackle. This shackle is also called a bending shackle, an F-link, an F shackle, or an end shackle. It is an enlarged joining shackle used to connect lengths of chain which have larger sized chain end links.
- Buoy Shackle. This type of shackle is similar to the anchor joining shackle, except that it has a round pin. It is used as top jewelry. A schematic drawing of this shackle and its various dimensions is shown in Figure B-Ii.
- Sinker Shackle. This shackle has elongated shanks and is designed to fit over the width of a chain link and attach a sinker bail to the chain. This type shackle is not considered a structural component of a mooring. Figure B-12 provides a schematic drawing of a sinker shackle and its various dimensions.

1.3.3.4 Common Stud Link Chain. This link is also called a common link, a stud link, or an A-link chain. This chain is the basic component of a fleet mooring and is normally manufactured in 90-foot (I-shot) lengths. A schematic drawing of a common stud link and its various dimensions is shown in Figure B-13.

1.3.3.5 Enlarged Link. This link is also called a B-link. It is a large common stud link which acts as an adapter and is used between the last common stud link of a chain and the end link. Figure B-14 provides a schematic drawing of an enlarged link and its dimensions.

1.3.3.6 End Link. This link is also called an E-link or an open end link. It is used as the last link on a shot of chain, allowing a joining shackle or other type joining link to connect two shots of chain together. Figure B-15 provides a schematic drawing of an end link and a dimensional table of its various sizes.

1.3.3.7 C-Link. This link is similar to an end link except that it has an off-center stud. Offsetting the stud provides sufficient space for the lugs of a shackle to pass through the larger opening.

1.3.3.8 Pear Link. This link is also called a pear-shaped link, a pear-shaped ring, or a pear-shaped end link. This is an end link with one end larger than the other (see Figure B-16). When cast/forged onto a ground ring, as shown in Figure B-16, it is used as an adapter to connect the ground ring to an anchor joining link (see Figures B-8 and B-20).

1.3.3.9. Swivel. A swivel is used to prevent twisting of the riser chain subassembly of a riser-type, free-swinging mooring, and is also used in each anchor chain subassembly (near the anchor) to prevent the chain from twisting during installation (see Figure B-17). This standard swivel is normally manufactured with a similar sized common link on each end.

1.3.3.10 Swivel Shackle (Chain). This component can be used in place of the standard swivel. Both ends of the swivel shackle are required to fit a common link of a specified nominal chain size and are procured without attached common links (see Figure B-18).

1.3.3.11 Modified Swivel Shackle (Riser). This modified swivel shackle has two different jaw sizes and is designed to be used in lieu of the standard swivel in a riser. The top end of the riser swivel shackle is required to fit a shackle eye plate of the tension bar while the other end will be sized to fit the upper riser link to which it will attach (see Figure B-19).

1.3.3.12 Ground Ring. This is a large steel ring in a riser-type mooring which joins a riser chain subassembly to three or more anchor chain subassemblies. Figure B-20 shows a schematic drawing of FM3 ground rings. The size of the ring for withstanding a particular proof load may vary widely due to different manufacturing processes.

1.3.3.13 Spider Plate. This is a steel plate or casting, triangular in shape, that has three or more holes for joining several chains together (see Figure B-21).

1.3.3.14 Chain Equalizer. The equalizer is a half-rounded type of fitting (similar to a nonmovable pulley) with wide jaws through which an anchor chain subassembly is passed and then connected to two separate anchors. When tension is applied to the mooring, the chain has free movement to slide through the equalizer until the loads are equal in both subassembly legs (see Figure B-22).

1.4 ANCHORS. Fleet moorings are held in place by some type of bottom anchoring system. The types described below are normally used for this purpose.

1.4.1 NAVY STANDARD STOCKLESS. These anchors are used extensively in fleet moorings primarily because of their availability. However, they are prone to rotate after reaching their maximum holding power, which results in a pullout. To reduce the possibility of rotation, stabilizers are often welded to the anchor. The older type stabilizers consisted of a 1-inch wall-thickness pipe of variable diameters. A newly designed l/2-inch wall-thickness square tube (NAVFAC Drawing No. 1404456) will be used for future stabilizers (see Figure B-23). Navy standard stockless anchors range in size from 500 to 40,000 pounds.

1.4.2 NAVFAC STATO. These anchors were developed for the Naval Facilities Engineering Command as permanent mooring-type anchors. The stabilizers have been designed and tested for maximum stability (see Figure B-23). The angle between the shank and the flukes is adjustable in the field to a 34-degree angle or a 50-degree angle for operations in sand and mud, respectively. STATO anchors range in size from 200 to 15,000 pounds.

1.4.3 NAVMOOR ANCHOR. This is a prototype anchor being designed for primary use in fleet moorings vice ships. Its holding power is considerably higher than other anchors.

1.4.4 STAKE PILES. This type of anchoring system which consists of wood or steel pilings driven into the bottom can be used in certain moorings as an anchor. The disadvantages of this type system are that the stake pile is fixed and cannot absorb shock energy as well as an anchor, and that a pile-driving rig is required for installation.

1.4.5 PEARL HARBOR ANCHOR. This anchor is essentially a concrete sinker with a wedge shape (see Figure B-23). It is relatively inexpensive to build and can be fabricated onsite. The size and weight required to obtain adequate holding power, however, make the anchor bulky and difficult to handle.

1.4.6 PROPELLANT-EMBEDMENT ANCHOR (PEA). This relatively new anchor has been utilized in a number of recent mooring installations. An anchor fluke is emplaced in a gun assembly. The entire assembly, consisting of the gun (launch platform), downhaul cable, and anchor fluke (see Figure B-24), is lowered to the bottom. The gun is then fired and the fluke, depending upon the material of the ocean bottom, is driven 10 to 40 feet into the subsurface strata (see Figure B-25). Attached to the fluke is a wire rope downhaul cable (2 to 3 inches in diameter). The upper end of this downhaul cable is then connected to a wire rope pendant and the anchor chain subassembly or is directly connected to the anchor chain subassembly by swage and shackle fittings. The gun assembly is recovered for re-use. A photograph of a propellant-embedment anchor being prepared for installation is shown in Figure B-26.

1.5 CATHODIC PROTECTION SYSTEMS. Cathodic protection is an electrical method of preventing corrosion of metallic structures in a conducting medium (usually water or soil) by placing an electrical charge upon them. The charge is supplied by direct current from an anode that consumes itself (sacrificially) in generating the current or by rectified alternating current. Cathodic protection systems are discussed in Section 8 of this manual.

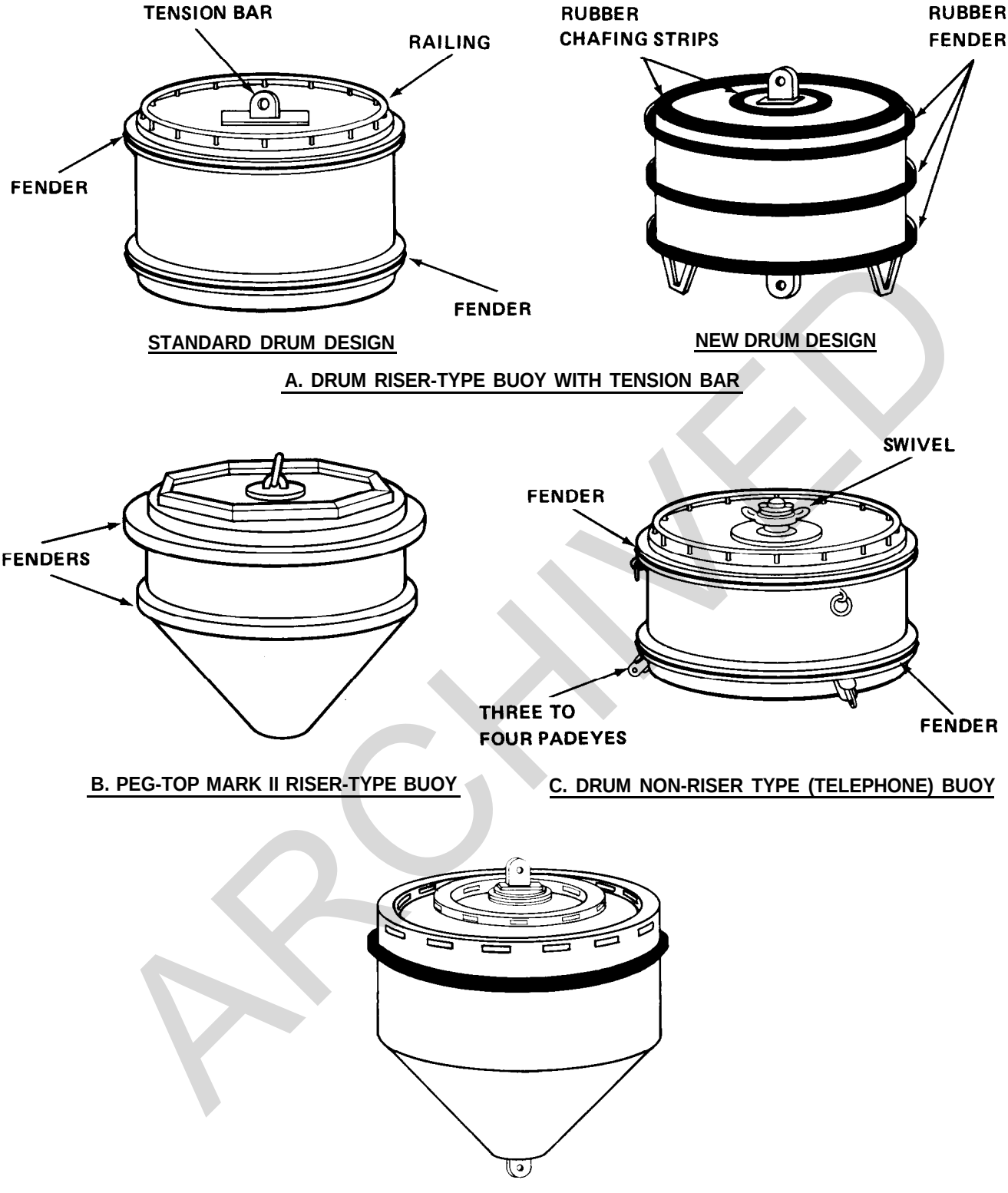


Figure B-1. Commonly Used Fleet Mooring Buoys

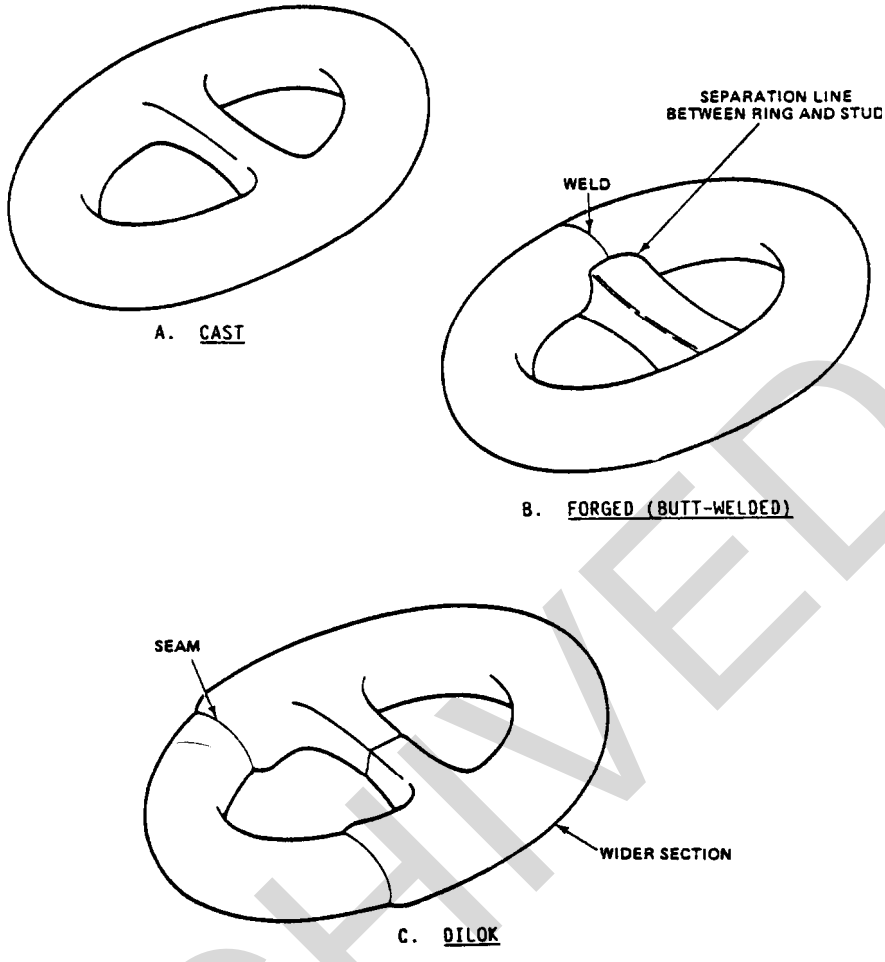


Figure B-2. Typical Chain Links

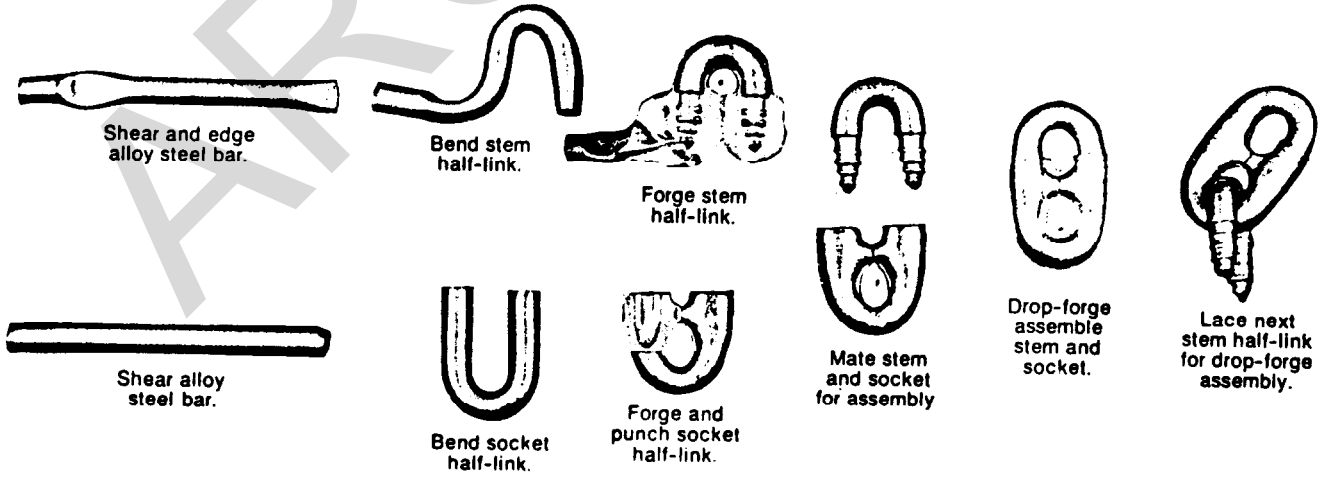
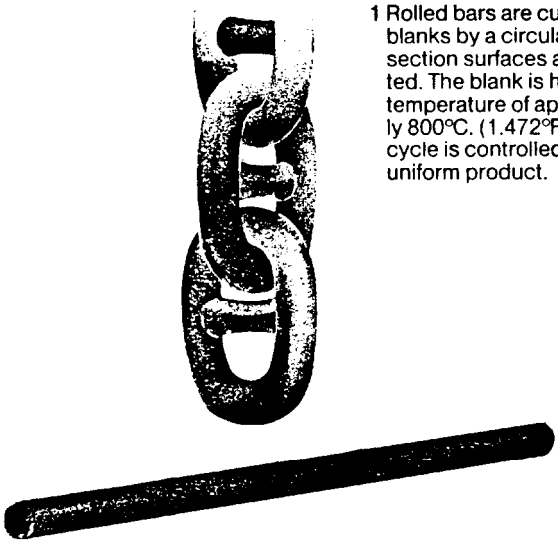
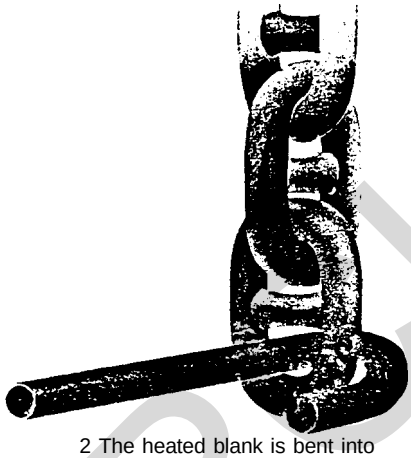


Figure B-3. Manufacturing Dilok Chain

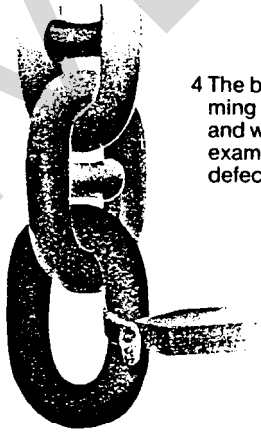


1 Rolled bars are cut into blanks by a circular saw. The section surfaces are inspected. The blank is heated to a temperature of approximately 800°C. (1.472°F.). Heating cycle is controlled to insure uniform product.

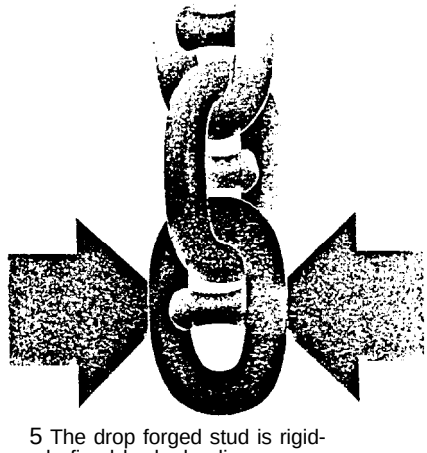


2 The heated blank is bent into the chain.

3 The link is welded in a flash welding machine. Welding parameters are strictly controlled during the entire welding cycle.



4 The burr is removed in a trimming machine. Link surface and weld-area are carefully examined for defects. Any defective links are removed.



5 The drop forged stud is rigidly fixed by hydraulic pressure while the link is still hot.

Figure B-4. Producing Flash Butt-Welded Chain

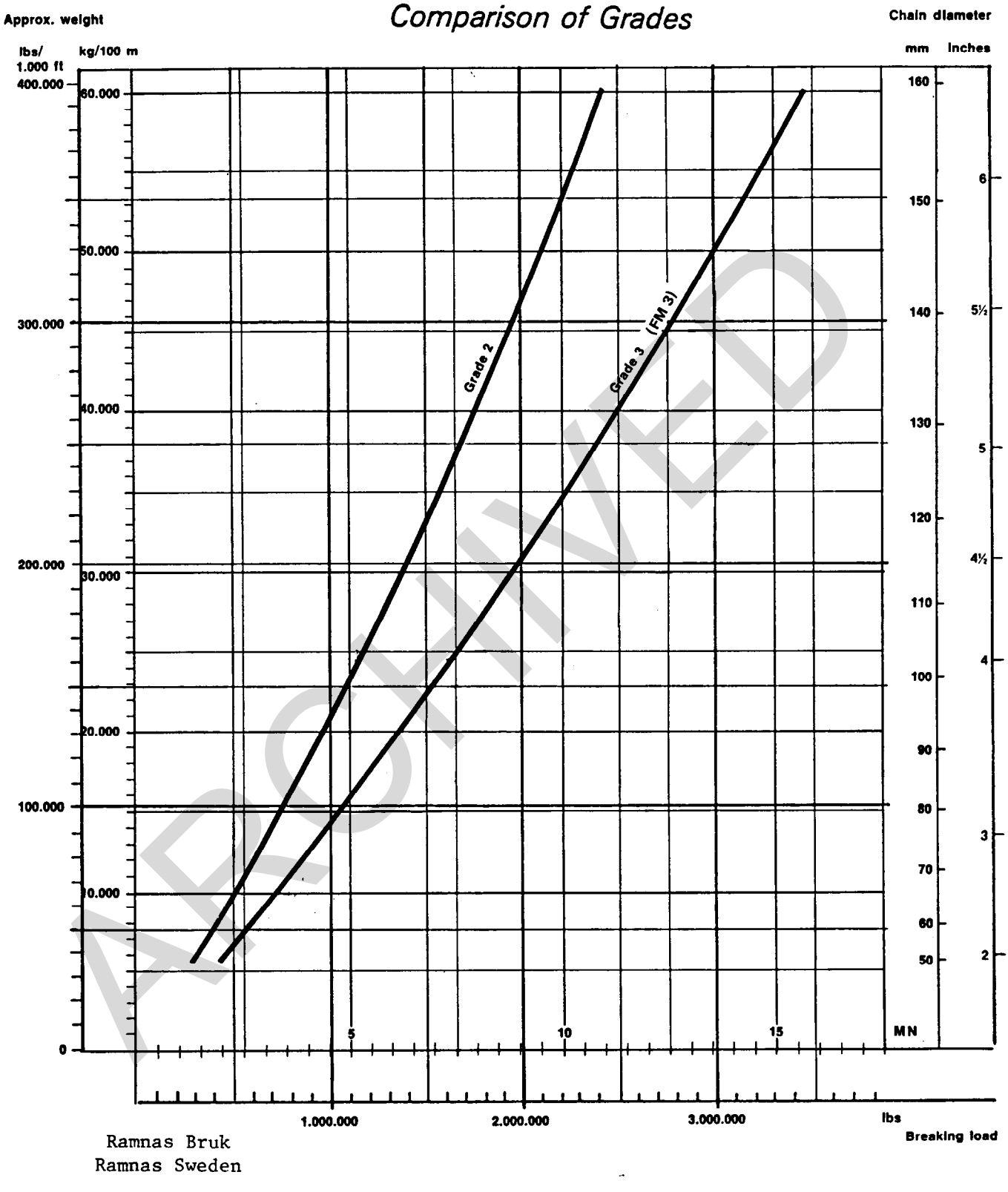
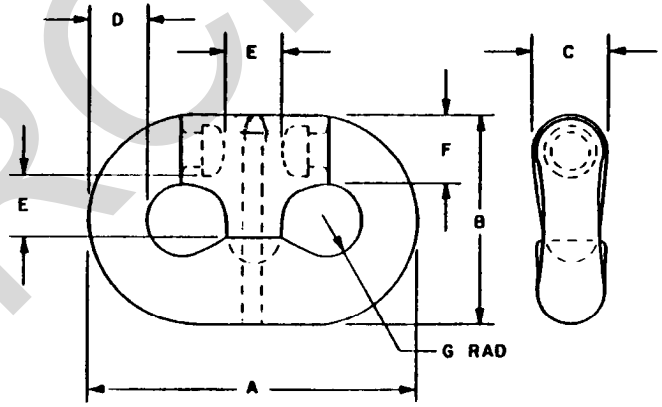


Figure B-5. Chain Breaking Strengths

TYPICAL CHAIN JOINING LINK-BALDT TYPE
(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 1/4	7.31	7.69	4.88	5.13	1.69	1.78	1.22	1.23	1.37	1.44	1.49	1.57	0.79	0.63
1 3/4	10.24	10.76	7.31	7.69	2.38	2.50	1.71	1.79	1.95	2.05	2.16	2.27	1.16	1.22
2	11.70	12.30	7.56	7.94	2.44	2.56	1.95	2.05	2.25	2.37	2.44	2.56	1.28	1.35
2 1/4	13.16	13.84	8.50	8.94	2.74	2.88	2.19	2.31	2.56	2.69	2.74	2.88	1.46	1.54
2 1/2	14.63	15.38	9.45	9.93	3.05	3.20	2.44	2.56	2.80	2.95	3.05	3.20	1.61	1.70
2 3/4	16.09	16.91	10.54	11.08	3.60	3.78	2.80	2.95	3.17	3.33	3.60	3.78	1.77	1.86
3	17.55	18.45	11.33	11.92	3.66	3.84	2.93	3.08	3.44	3.62	3.66	3.84	1.92	2.02
3 1/2	20.60	21.65	13.44	14.13	4.69	4.93	3.66	3.84	4.02	4.23	4.39	4.61	2.35	2.47
4	23.40	24.60	15.11	15.89	5.06	5.32	3.90	4.10	4.51	4.74	4.81	5.06	2.62	2.75



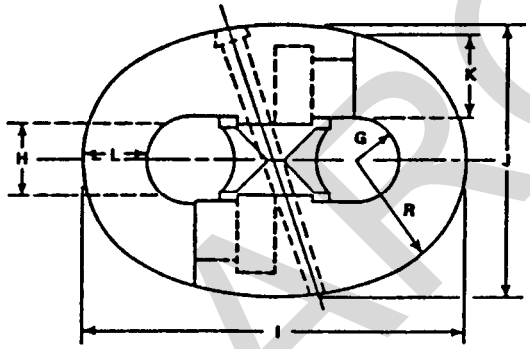
NOTE :

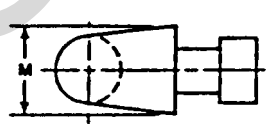
ALL CHAIN JOINING LINKS MUST BE COMPATIBLE WITH THE COMMON STUD LINK OF THE SAME NOMINAL SIZE.

Figure B-6. Chain Joining Link- Baldt Type

TYPICAL CHAIN JOINING LINK
(All Dimensions in Inches)

Nominal Diameter	G(min)	G(max)	H(min)	H(max)	I(min)	I(max)	J(min)	J(max)	K(min)	K(max)	L(min)	L(max)	M(min)	M(max)	R(min)	R(max)	N(min)	N(max)
1 1/4	0.84	0.87	1.41	1.44	7.48	7.53	5.23	5.28	1.7	1.76	1.23	1.28	1.64	1.70	2.26	2.31	0.691	0.726
1 3/4	1.17	1.22	1.98	2.02	10.47	10.54	7.32	7.39	2.4	2.49	1.72	1.79	2.30	2.38	3.16	3.24	0.691	0.726
2	1.34	1.39	2.26	2.31	11.96	12.04	8.36	8.44	2.7	2.84	1.96	2.04	2.63	2.72	3.61	3.70	0.691	0.726
2 14	1.51	1.56	2.54	2.60	13.46	13.55	9.41	9.50	3.1	3.20	2.21	2.30	2.96	3.08	4.06	4.16	1.075	1.130
2 1/2	1.68	1.74	2.83	2.89	14.95	15.05	10.45	10.55	3.4	3.55	2.45	2.55	3.29	3.40	4.51	4.63	1.075	1.130
2 3/4	1.84	1.91	3.11	3.18	16.45	16.56	11.50	11.61	3.76	3.91	270	2.81	3.62	3.74	4.96	5.09	1.075	1.130
3	2.01	2.09	3.39	3.47	17.94	18.06	12.54	12.66	4.1	4.26	2.94	3.06	3.95	4.08	5.42	5.55	1.075	1.130
3 in	2.35	2.43	3.96	4.04	20.93	21.07	14.53	14.77	4.8	4.97	3.43	3.57	4.60	4.76	6.32	6.48	1.382	1.453
4	2.68	2.78	4.52	4.62	23.92	24.08	16.72	16.88	5.5	5.68	3.92	4.08	5.26	5.44	7.22	7.40	1.382	1.453





NOTE

ALL CHAIN JOINING LINKS MUST BE COMPATIBLE WITH THE COMMON STUD LINK OF THE SAME NOMINAL SIZE.

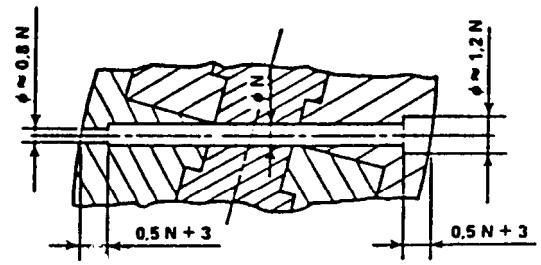


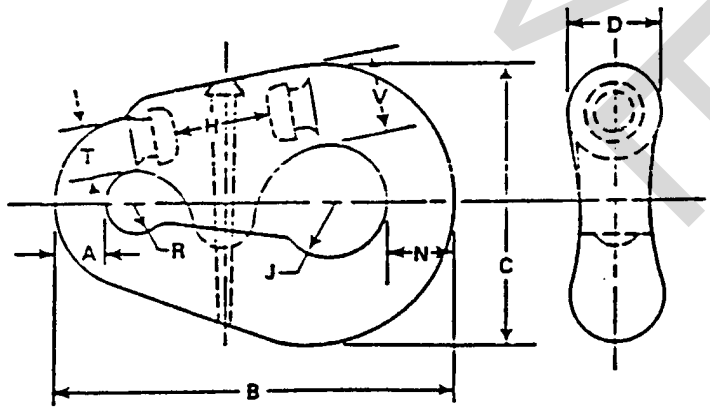
Figure B-7. Chain Joining Link - Kenter Type

TYPICAL ANCHOR JOINING LINK - BALDT TYPE

Nominal Diameter	A(min)	A(max)	B(min)	B(max)	C(min)	C(max)	D(min)	D(max)	H(min)	H(max)
1 1/4	1.52	1.60	11.64	11.86	8.05	8.20	2.25	2.37	3.17	3.33
1 3/4	1.95	2.05	14.73	15.02	10.14	10.36	2.93	3.08	3.84	4.04
2	1.95	2.05	14.72	15.03	10.13	10.38	2.93	3.08	3.84	4.04
2 1/4	2.32	2.43	17.70	18.05	12.17	12.45	3.53	3.72	4.63	4.87
2 1/2	3.05	3.20	21.94	22.31	14.66	14.97	4.51	4.74	5.73	6.02
2 3/4	3.05	3.20	21.94	22.31	14.66	14.97	4.51	4.74	5.73	6.02
3	3.05	3.20	21.92	22.33	14.64	14.98	4.51	4.74	5.73	6.02
3 1/2	3.53	3.72	25.53	25.97	16.31	16.69	5.12	5.38	5.73	6.02
4	4.63	4.87	34.77	35.23	22.30	22.70	7.31	7.69	7.31	7.69

	J(min)	J(max)	N(min)	N(max)	R(min)	R(Max)	T(min)	T(max)	V(min)	V(max)
1 1/4	1.65	1.73	1.83	1.92	1.01	1.06	1.52x1.71	1.60x1.79	2.16	2.27
1 3/4	2.01	2.11	2.44	2.56	1.22	1.28	2.25x2.32	2.37x2.43	2.83	2.98
2	2.01	2.11	2.44	2.56	1.22	1.28	2.25x2.32	2.37x2.43	2.83	2.98
2 1/4	2.47	2.59	2.92	3.08	1.43	1.51	2.38x2.80	2.50x2.95	3.38	3.56
2 1/2	2.92	3.08	3.66	3.84	1.86	1.95	3.29x3.05	3.46x3.20	4.27	4.48
2 3/4	2.92	3.08	3.66	3.84	1.86	1.95	3.29x3.05	3.46x3.20	4.27	4.48
3	2.92	3.08	3.66	3.84	1.86	1.95	3.29x3.05	3.46x3.20	4.27	4.48
3 1/2	3.05	3.20	4.75	5.00	2.07	2.18	4.27x3.90	4.48x4.10	5.00x5.12	5.25x5.38
4	4.14	4.36	6.34	6.66	2.80	2.95	5.00	5.25	6.95	7.30

(All Dimensions in Inches)



NOTE

THE SMALL END OF THE ANCHOR JOINING LINKS MUST BE COMPATIBLE WITH THE COMMON STUD LINK OF THE SAME NOMINAL SIZE.

Figure B-8. Anchor Joining Link - Baldt Type

TYPICAL ANCHOR JOINING LINK - KENTER TYPE

Nominal Diameter	A(max)	B(max)	C(min)	C(max)	H(rnin)	H(max)	J(max)	J(min)	K(max)	-M(min)	N(min)	N(max)	P(min)	P(max)
1 1/4	1.88	1.56	0.75	1.00	1.47	1.50	2.06	1.25	1.56	1.50	1.50	1.75	2.12	2.75
1 3/4	2.63	2.19	1.05	1.40	2.06	2.10	2.89	1.75	2.19	2.10	2.19	2.45	2.98	3.85
2	3.00	2.50	1.20	1.60	2.36	2.40	3.30	2.00	2.50	2.40	2.50	2.80	3.40	4.40
2 1/4	3.38	2.81	1.35	1.80	2.65	2.70	3.71	2.25	2.81	2.70	2.81	3.15	3.83	4.95
2 1/2	3.75	3.13	1.50	2.00	2.95	3.00	4.13	2.50	3.13	3.00	3.13	3.50	4.25	5.50
2 3/4	4.13	3.44	1.55	2.20	3.24	3.30	4.54	2.75	3.44	3.30	3.44	3.85	4.68	6.05
3	4.50	3.75	1.80	2.40	3.54	3.60	4.95	3.00	3.75	3.60	3.75	4.20	5.10	6.60
3 1/2	5.25	4.38	2.10	2.80	4.13	4.20	5.78	3.50	4.38	4.20	4.38	4.90	5.95	7.70
4	6.00	5.00	2.40	3.20	4.72	5.00	6.50	4.00	5.00	4.80	5.00	5.60	6.80	8.80

(All Dimensions in Inches)

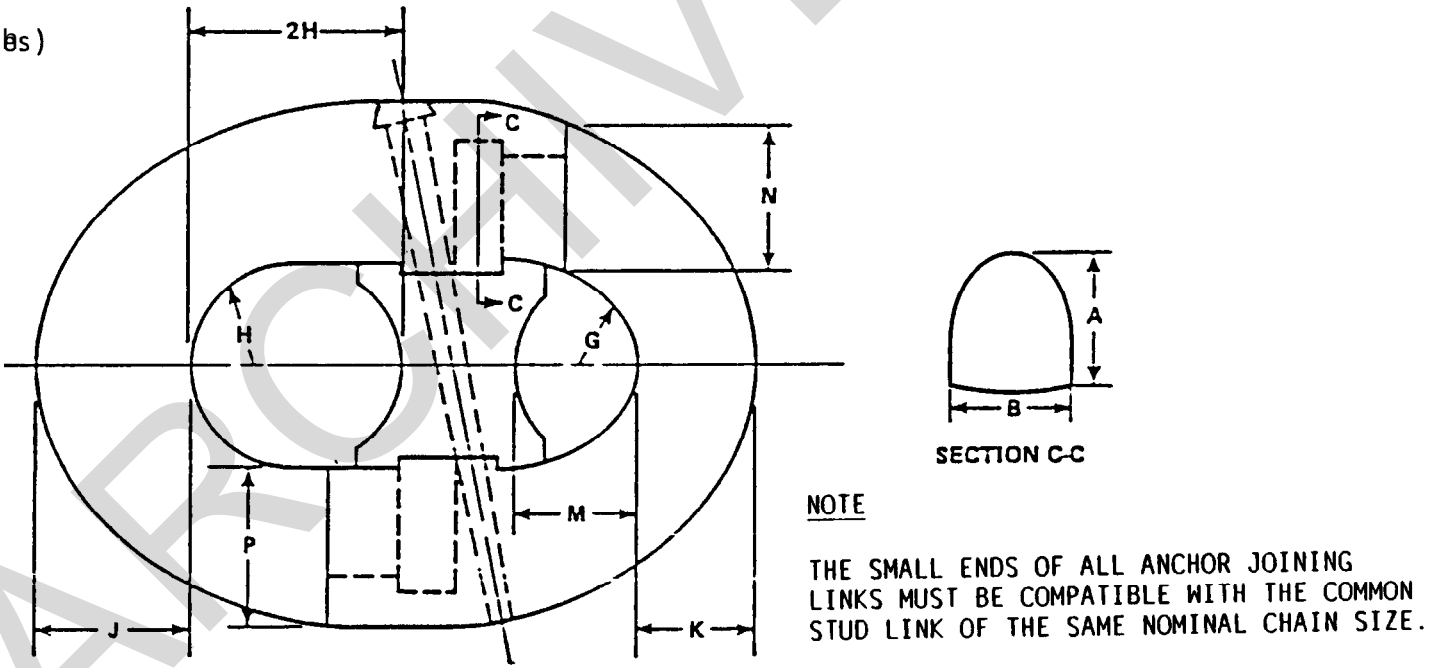
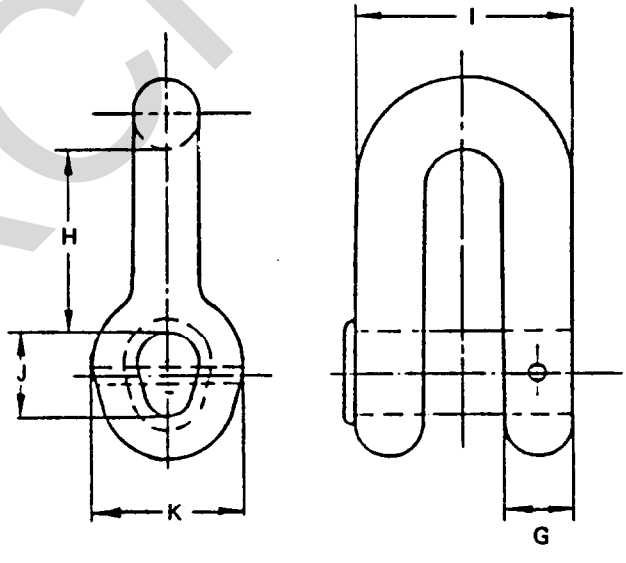


Figure B-9. Anchor Joining Link - Kenter Type

TYPICAL JOINING SHACKLE DIMENSIONS
(All Dimensions in Inches)

Nominal Diameter	G (min)	G (max)	H (min)	H (max)	I (min)	I (min)	J (min)	J (max)	K approx.
1 1/4	1.58	1.67	4.14	4.36	4.88	5.13	1.95	2.05	3.50
1 3/4	2.22	2.33	5.80	6.10	6.83	7.18	2.73	2.87	4.90
2	2.54	2.67	6.63	6.97	7.80	8.20	3.12	3.28	5.60
2 1/4	2.85	3.00	7.46	7.84	8.78	9.23	3.51	3.69	6.30
2 1/2	3.17	3.33	8.29	8.71	9.75	10.25	3.90	4.10	7.00
2 3/4	3.49	3.66	9.12	9.58	10.73	11.28	4.29	4.51	7.70
3	3.80	4.00	9.95	10.46	11.70	12.30	4.68	4.92	8.40
3 1/2	4.44	4.66	11.60	12.20	13.65	14.35	5.46	5.74	9.80
4	5.07	5.33	13.26	13.94	15.60	16.40	6.24	6.56	11.20



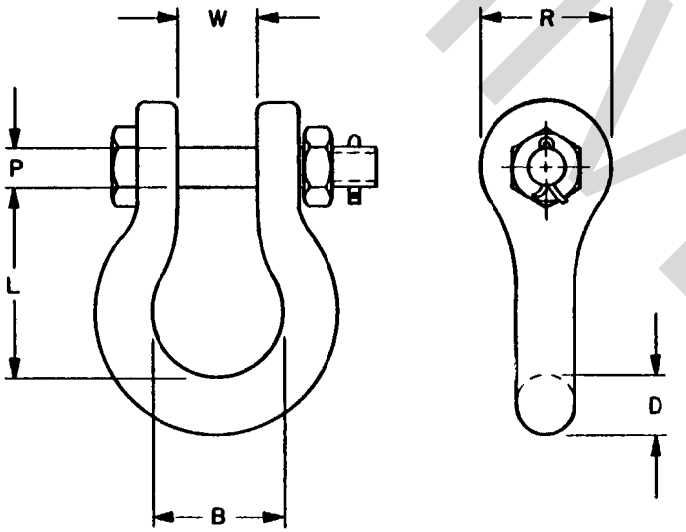
ALL JOINING SHACKLES MUST FIT THE END LINK

Figure B-10. Joining Shackle

BOLT TYPE BUOY SHACKLE - CROSBY TYPE

Nominal Size	W(min)	W(max)	P(min)	P(max)	R(min)	R(max)	L(min)	L(max)	D(min)	D(max)	B(min)	B(max)	Breaking Load (min. pounds)
1 1/4	1.97	2.09	1.35	1.41	2.91	3.09	4.57	4.81	1.19	1.31	3.17	3.33	144,000
1 3/8	2.13	2.37	1.46	1.54	3.22	3.40	5.00	5.50	1.32	1.44	3.51	3.75	162,600
1 1/2	2.26	2.50	1.59	1.67	3.54	3.72	5.50	6.00	1.44	1.56	3.76	4.00	204,100
1 3/4	2.76	3.00	1.95	2.05	4.21	4.43	6.75	7.25	1.69	1.81	4.88	5.13	300,000
2	3.13	3.37	2.19	2.31	4.88	5.13	7.50	8.00	1.94	2.06	5.61	5.89	420,000
2 1/2	3.88	4.38	2.68	2.82	5.85	6.15	9.75	11.25	2.55	2.69	7.06	7.44	660,000
3	4.75	5.25	3.17	3.33	6.34	6.66	12.25	13.75	2.93	3.08	7.68	8.08	1,020,000
3 1/2	5.00	5.50	3.66	3.84	7.75	8.25	13.88	15.38	3.41	3.59	8.78	9.23	1,440,500
4	5.25	5.75	4.14	4.36	8.75	9.25	13.75	15.25	3.90	4.10	9.75	10.25	1,800,000

(All Dimensions in Inches)

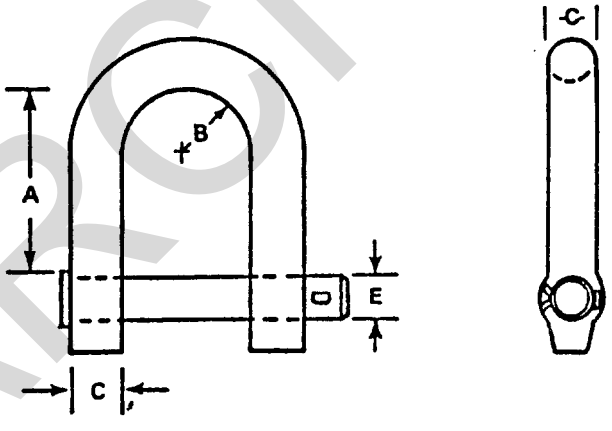


NOTE: NOMINAL SIZES ARE THE MANUFACTURER'S NOMENCLATURE AND DO NOT CORRESPOND TO THE NOMINAL CHAIN SIZE; SPECIFIC SHACKLES WILL NOT NECESSARILY HAVE THE SAME STRENGTH CHARACTERISTICS AS CHAIN OF THE SAME NOMINAL SIZE. BUOY SHACKLES SHALL INCLUDE BOLT, NUT, AND COTTER PIN.

Figure B-11. Buoy Shackle

TYPICAL SINKER SHACKLE
(All Dimensions in Inches)

Dimension Equation	.5d	8d	.59d	d	1.3d
1114	6.25	10	.73	1.25	1.63
1 3/4	8.75	14	1.03	1.75	2.28
2	10.0	16	1.18	2.0	2.6
2 1/4	11.25	18	1.32	2.25	2.93
2 1/2	12.5	20	1.47	2.5	3.25
2 3/4	13.75	22	1.62	2.75	3.58
3	15	24	1.77	3.0	3.9
3 1/2	17.5	28	2	3.5	4.55
4	20.0	32	2.36	4.0	5.2



ALL SINKER SHACKLES MUST FIT OVER THE COMMON STUD LINK

Figure B-12. Sinker Shackle

(All Dimensions in Inches)

Nominal Diameter	A (min)	A (max)	B	C (min)	C (max)	E (min)	E (max)	F (min)	G (min)	H (max)
1 1/4	7.50	7.69	1.63	1.25	1.28	4.44	4.56	1.20	1.05	1.25
1 3/4	10.50	10.76	2.28	1.75	1.79	6.21	6.39	1.50	1.41	1.50
2	12.00	12.30	2.60	2.00	2.05	7.10	7.30	1.65	1.59	1.77
2 1/4	13.50	13.84	2.93	2.25	2.31	7.99	8.21	1.18	1.59	2.09
2 1/2	15.00	15.38	3.25	2.50	2.56	8.88	9.13	1.95	1.64	2.23
2 3/4	16.50	16.91	3.58	2.75	2.82	9.76	10.04	2.10	1.00	2.40
3	18.00	18.45	3.90	3.00	3.08	10.65	10.95	2.25	1.94	2.62
3 1/2	21.00	21.53	4.55	3.50	3.59	12.43	12.78	2.40	2.38	3.12
4	24.00	24.60	5.20	4.00	4.10,	14.20	14.60	2.70	2.58	3.58

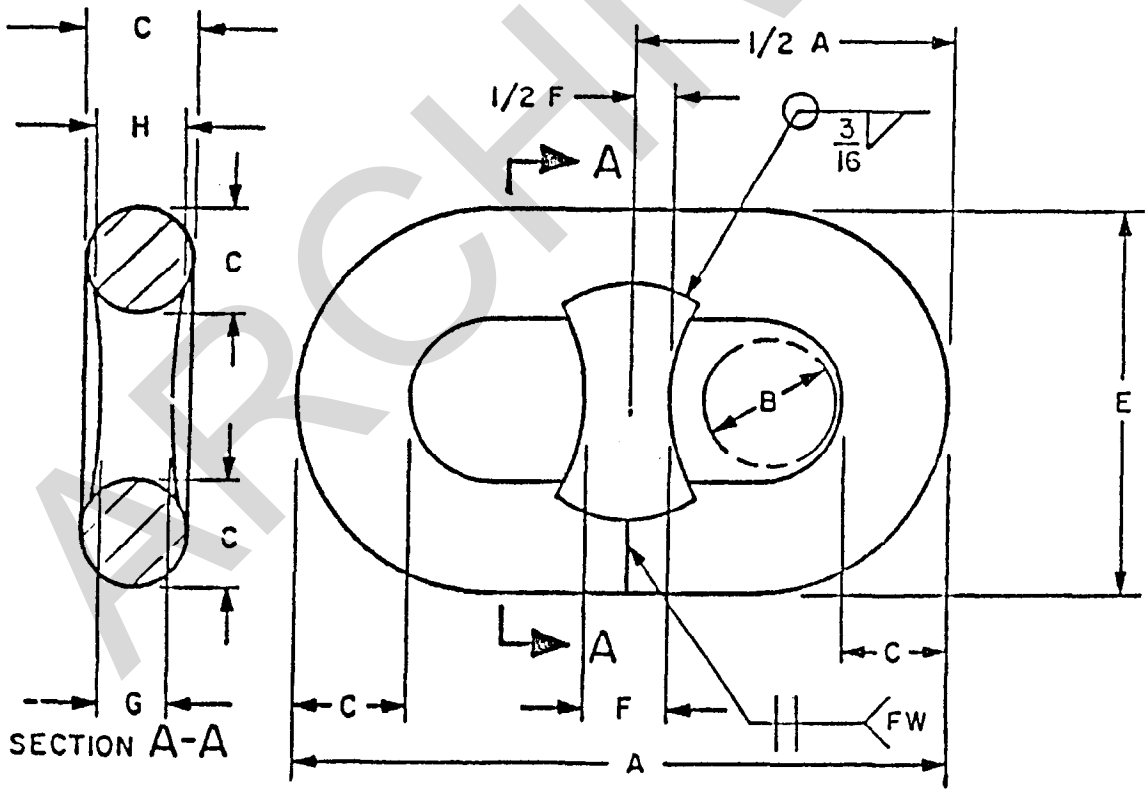


Figure B-13. Common Stud Link Chain

ENLARGED LINK
(All Dimensions in Inches)

Nominal Diameter	A (min)	A (max)	B	C (min)	C (max)	E (min)	E(max)
Dimension Equation	6.6d	6.75d	1.43d	1.1d	1.1ld+T	3.91d	4.01d
1 1/4	8.25	8.44	1.78	1.37	1.41	4.89	5.01
1314	11.55	11.81	2.50	1.93	2.0	6.84	7.02
2	13.2	13.5	2.86	2.20	2.26	7.82	8.02
2 1/4	14.85	15.2	3.20	2.47	2.56	8.8	9.02
2 1/2	16.5	16.88	3.58	2.75	2.84	9.78	10.03
2314	18.15	18.56	3.90	3.03	3.12	10.75	11.03
3	19.8	20.25	4.30	3.30	3.39	11.73	12.03
3 1/2	23.1	23.63	5,0	3.85	3,94	13.69	14.04
4	26.4	27.0	5.72	4.40	4.5	15.64	16.04

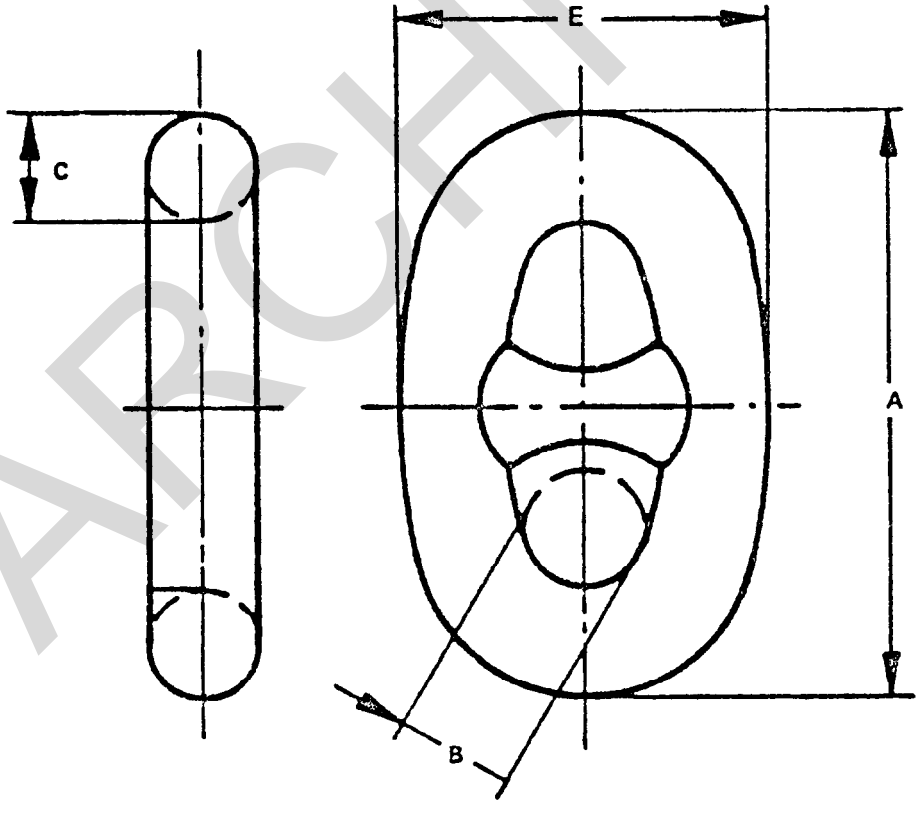


Figure B-14. Enlarged Link

END LINK
(All Dimensions in Inches)

Nominal Diameter	A (min)	A (max)	C (min)	C (max)	D (min)	D (max)
1 1/4	8.44	8.63	1.50	1.53	4.94	5.06
1 3/4	11.81	12.08	2.10	2.16	6.91	7.09
2	13.50	13.80	2.40	2.49	7.90	8010
2 1/4	15.19	15.53	2.70	2.79	8.89	9.11
2 1/2	16.88	17.25	3.00	3.1	9.88	10.13
2 3/4	18.56	18.98	3.30	3.4	10.86	11.14
3	20.25	20.70	3.60	3.69	11.85	12.15
3 1/2	23.65	24.15	4.20	4.29	13.83	14.18
4	27.0	27.60	4.80	4.89	15.80	16.20

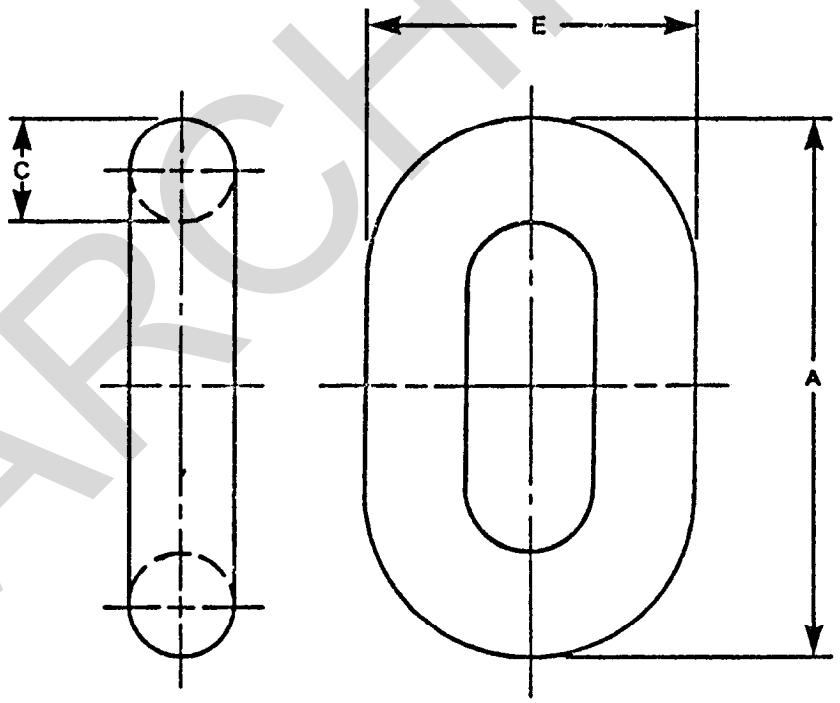
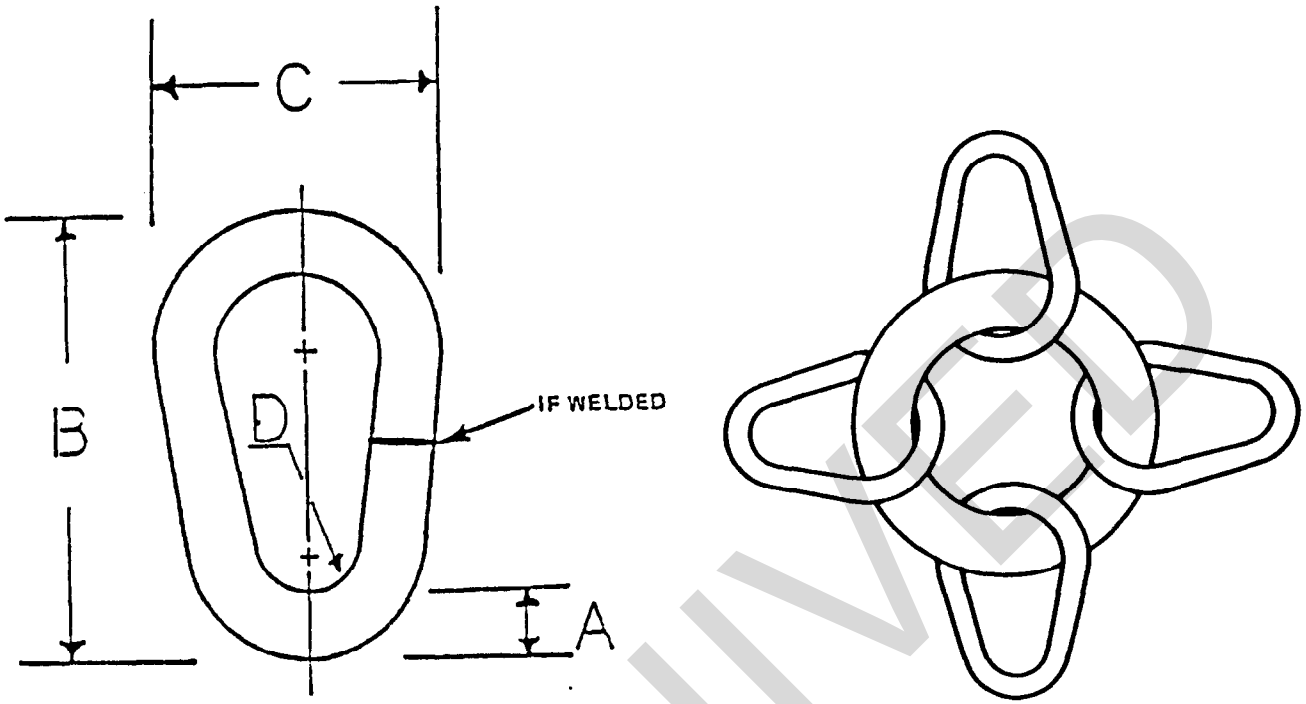


Figure B-15. End Link



(All Dimensions in Inches)

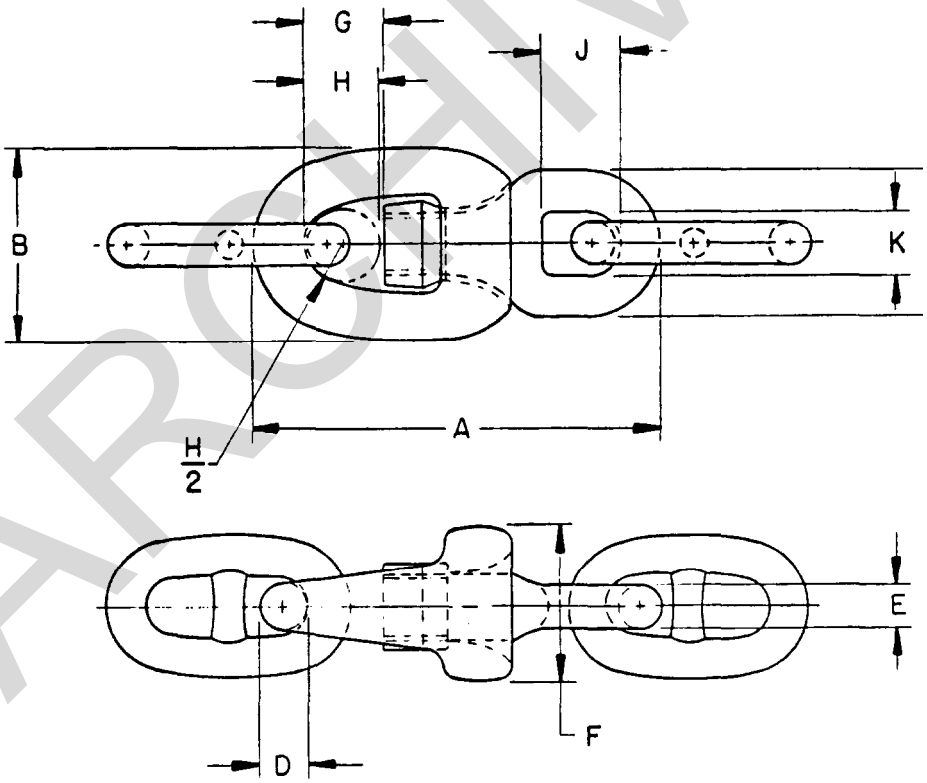
Nominal Chain Size	A (min)	A (max)	B (min)	B (max)	C (max)	C (mIn)	D (max)	D (min)
1 1/4	1.28	1.34	10.70	10.76	5.55	5.61	.95	1.01
1 3/4	1.84	1.91	15.29	15.35	7.94	8.00	1.38	1.44
2	2.20	2.30	18.33	18.43	9.51	9.61	1.64	1.74
2 1/4	2.33	2.42	19.35	19.45	10.04	10.14	1.73	1.83
2 1/2	2.58	2.67	21.40	21.50	11.11	11.21	1.92	2.02
2 3/4	2.83	2.92	23.44	23.54	12.17	12.27	2.11	2.21
3	3.06	3.19	25.27	25.39	13.22	13.34	2.28	2.40
3 1/2	3.82	3.94	31.60	31.72	16.41	16.53	2.85	2.97
4	4.19	4.31	34.66	34.78	18.00	18.12	3.13	3.25

Figure B-16. Pear Link

TYPICAL SWIVEL
(All Dimensions in Inches)

Nominal Chain Size	A (min)	A (max)	B (min)	B (max)	C (min)	C (max)	D (min)	D (max)	E (min)	E (max)
1 1/4	12.19	12.81	5.72	6.02	4.39	4.61	1.46	1.54	1.22	1.28
1 3/4	17.06	17.94	8.01	8.43	6.14	6.46	2.05	2.15	1.71	1.79
2	21.03	22.11	10.31	10.83	7.02	7.38	2.63	2.77	1.95	2.05
2 1/4	21.94	23.06	10.31	10.83	7.90	8.30	2.63	2.77	2.19	2.31
2 1/2	25.91	27.23	12.60	13.24	8.78	9.23	3.22	3.38	2.44	2.56
2 3/4	26.81	28.19	12.60	13.24	9.65	10.15	3.22	3.38	2.68	2.82
3 1/2	34.13	35.88	16.04	16.86	12.29	12.92	4.10	4.31	3.41	3.59

Nominal Chain Size	F (min)	F (max)	G (min)	G (max)	H (min)	H (max)	J (min)	J (max)	K (min)	K (max)
1 1/4	4.63	4.87	2.29	2.41	2.17	2.29	2.29	2.41	1.95	2.05
1 3/4	6.48	6.82	3.25	3.41	3.07	3.23	3.25	3.41	2.73	2.87
2	8.34	8.76	4.15	4.37	3.94	4.14	3.71	3.91	3.12	3.28
2 1/4	8.34	8.76	4.15	4.37	3.94	4.14	4.15	4.37	3.51	3.69
2 1/2	10.19	10.71	5.07	5.33	4.81	5.05	4.63	4.87	3.90	4.10
2 3/4	10.19	10.71	5.07	5.33	4.81	5.05	5.07	5.33	4.29	4.51
3 1/2	12.97	13.63	6.50	6.84	6.14	6.46	6.50	6.84	5.46	5.74



NOTE: SWIVELS SHALL BE PROVIDED WITH TWO COMMON LINKS OF THE SPECIFIED NOMINAL CHAIN SIZE, ATTACHED AS SHOWN.

Figure B-17. Swivel

TYPICAL CHAIN SWIVEL SHACKLE
(All Dimensions in Inches)

Nominal Diameter	A (min)	A (max)	B (min)	B (max)	C (min)	C (max)	E (min)	E (max)	F (min)	F (max)
1 1/4	15.81	16.63	6.90	7.26	4.99	5.25	1.61	1.69	2.04	2.14
1 3/4	20.91	21.99	9.07	9.53	6.83	7.18	2.22	2.34	2.80	2.94
2	25.36	26.66	11.21	11.79	7.99	8.39	2.57	2.71	3.29	3.45
2 1/4	27.44”	28.84	12.29	12.92	8.76	9.20	2,84	2.98	3.61	3.79
2 1/2	31.89	33.53	13.74	14.44	9.83	10.32	3.23	3.39	4.07	4.27
2 3/4	34.09	35.83	15.04	15.82	10.74	11.30	3.49	3.67	4.42	4.64
3	38.74	40.72	16.43	17.27	12.05	12.67	3.76	3.96	4.99	5.25
3 1/2	45.90	48.26	19.34	20.34	13.82	14.52	4.45	4.67	5.53	5.81
4	52.11	54.79	21.96	23.08	15.74	16.54	5.06	5.32	6.44	6.78

Nominal Diameter	G (min)	G (max)	H (min)	H (max)	K (min)	K (max)	P (min)	P (max)
1 1/4	2.30	2.42	1.76	1.86	4.99	5.25	,9.87	10.37
1 3/4	2.99	3.15	2.38	2.50	6.83	7.18	12.90	13.56
2	3.69	3.87	2.76	2.90	7.99	8.39	15.81	16.63
2 1/4	4.03	4.23	3.07	3.23	8.76	9.20	16.97	17.84
2 1/2	4.56	4.80	3.45	3.63	9.83	10.33	20.04	21.06
2 3/4	4.95	5.21	3.76	3.96	10.74	11.30	21.22	22.31
3	6.03	6.33	4.07	4.27	12.05	12.67	23.96	25.18
3 1/2	6.30	6.62	4.84	5.08	13.82	14.52	29.63	31.15
4	7.22	7.59	5.53	5,81	15.74	16.54	33.39	35.11

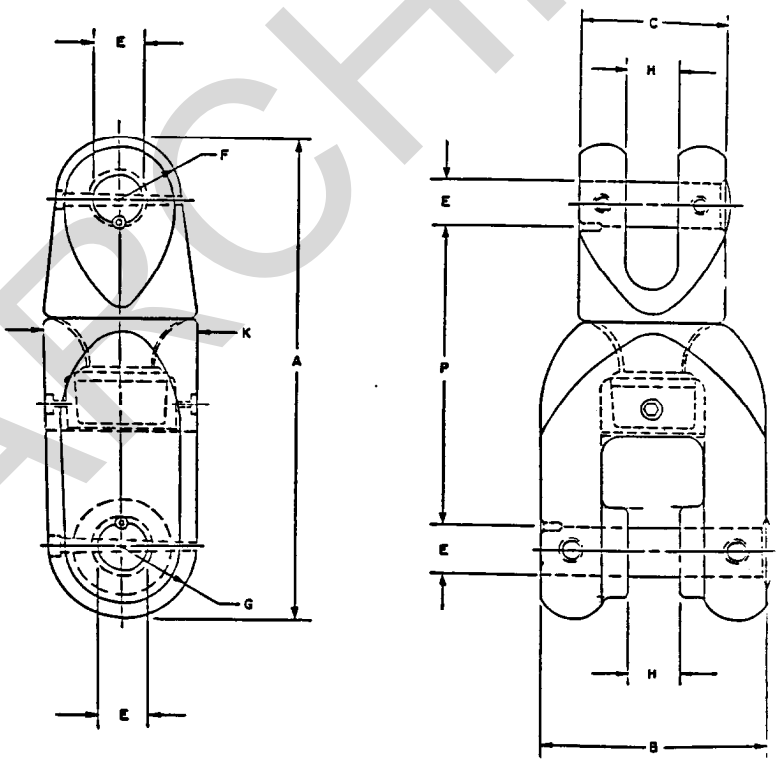
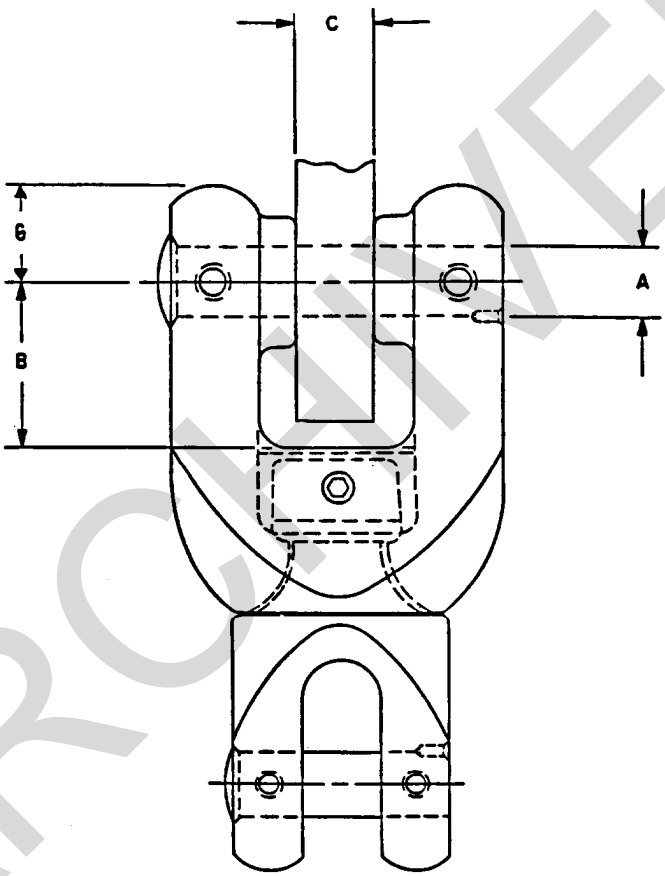


Figure B-18. Typical Chain Swivel Shackle

TYPICAL RISER SWIVEL SHACKLE
(All Dimensions in Inches)

Nominal Chain Size	A (min)	A (max)	B (min)	C (min)	C (max)	G (max)
1 1/4	1.61	1.69	5.62	3.19	3.50	5.25
1 3/4	2.22	2.34	5.62	3.19	3.50	5.25
2	2.57	2.71	5.62	3.19	3.50	5.25
2 1/4	2.84	2.98	5.62	3.19	3.50	5.25
2 1/2	3.23	3.39	5.62	3.19	3.50	5.25
2 3/4	3.23	3.39	5.62	3.19	3.50	5.25

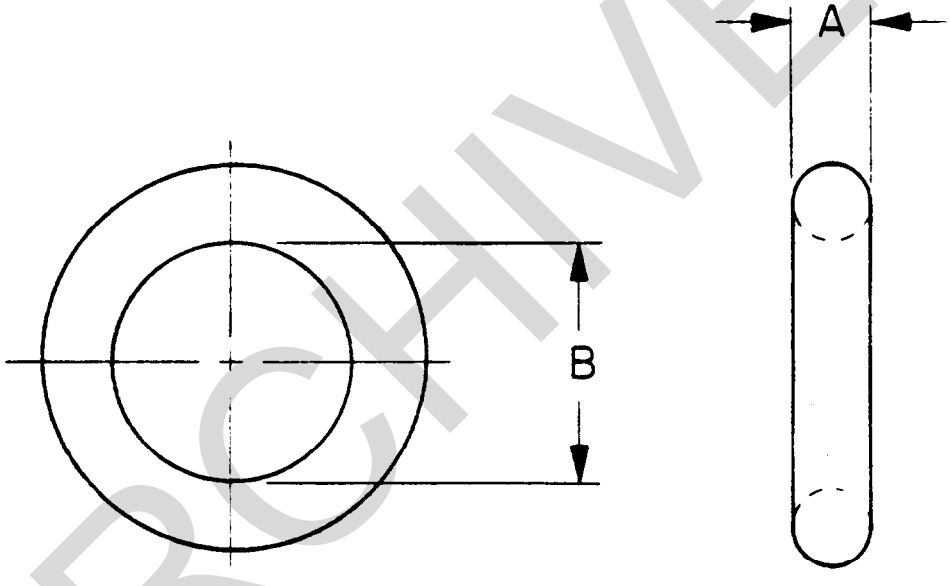


NOTE : THE TOP END OF A RISER SWIVEL SHACKLE IS REQUIRED TO FIT A SHACKLE EYE PLATE OF A FLEET MOORING BUOY. THE BOTTOM END OF THE RISER SWIVEL SHACKLE WILL BE THE SAME SIZE AS THE CHAIN SWIVEL SHACKLE AND WILL BE REQUIRED TO FIT A COMMON LINK OF THE SPECIFIED NOMINAL CHAIN SIZE, BUT THE COMMON LINK SHALL NOT BE PROVIDED WITH THE RISER SWIVEL SHACKLE. RISER SWIVEL SHACKLES SHALL MEET ALL CHEMICAL, MECHANICAL, PHYSICAL AND TESTING REQUIREMENTS SPECIFIED FOR THE SWIVEL OF THE SAME NOMINAL CHAIN SIZE.

Figure B-19. Typical Riser Swivel Shackle

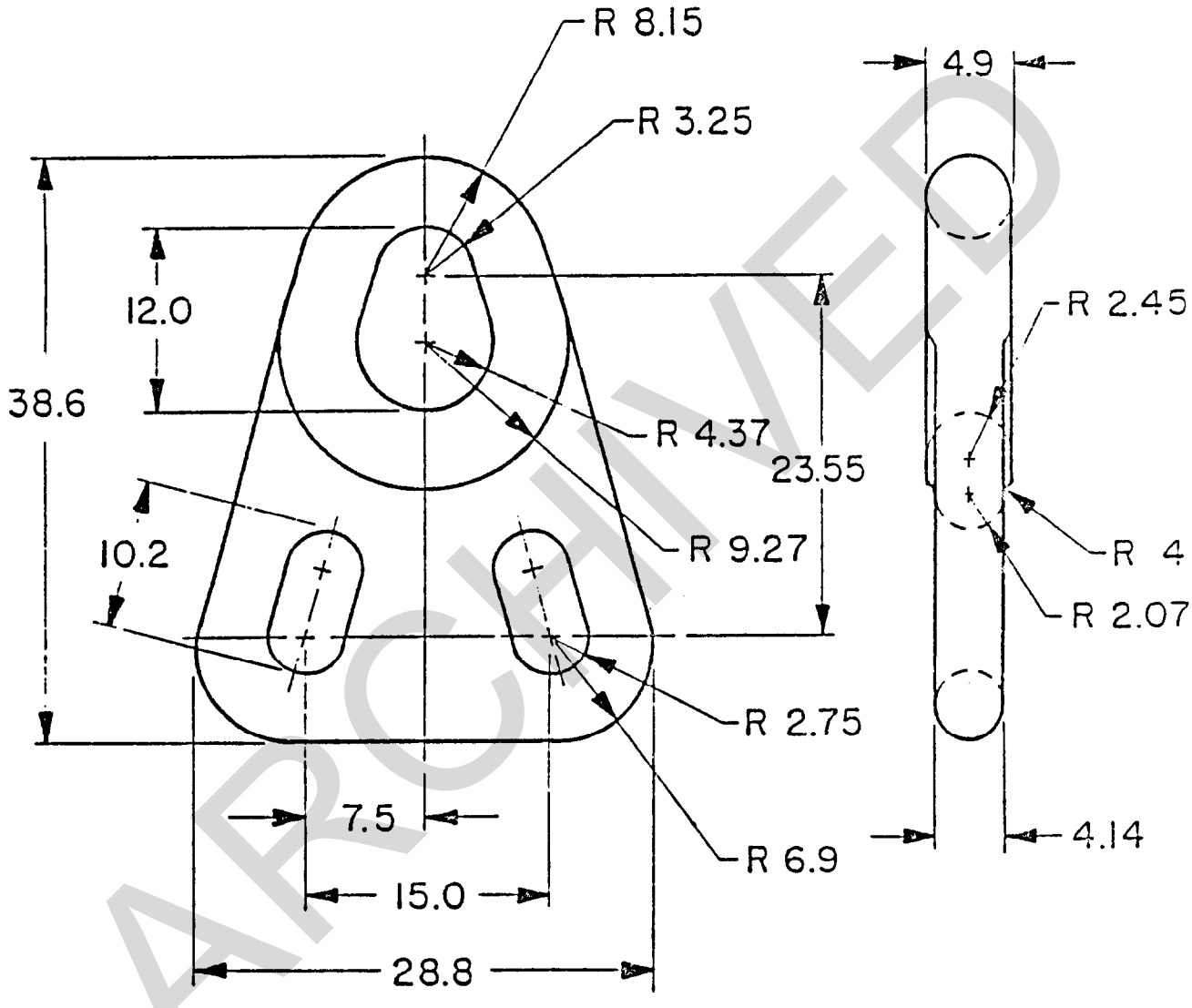
TYPICAL GROUND RING
(All Dimensions in Inches)

Nominal Chain Size	A (min)	A (max)	B (min)	B (max)
1 1/4	1.20	1.34	4.34	4.40
1 3/4	1.84	1.91	6.21	6.21
2	2.02	2.30	7.02	7.13
2 1/4	2.33	2.42	7.86	7.96
2 1/2	2.58	2.67	8.69	8.79
2 3/4	2.83	2.92	9.53	9.62
3	3.06	3.19	10.34	10.47
3 1/2	3.81	3.94	12.84	12.96
4	4.18	4.31	14.09	14.21



NOTE: GROUND RINGS SHALL FIT THE LARGE END OF AN ANCHOR JOINING LINK OF THE SAME NOMINAL CHAIN SIZE AS THE GROUND RING.

Figure B-20. Ground Ring



(All Dimensions in Inches)

Figure B-21. Spider Plate

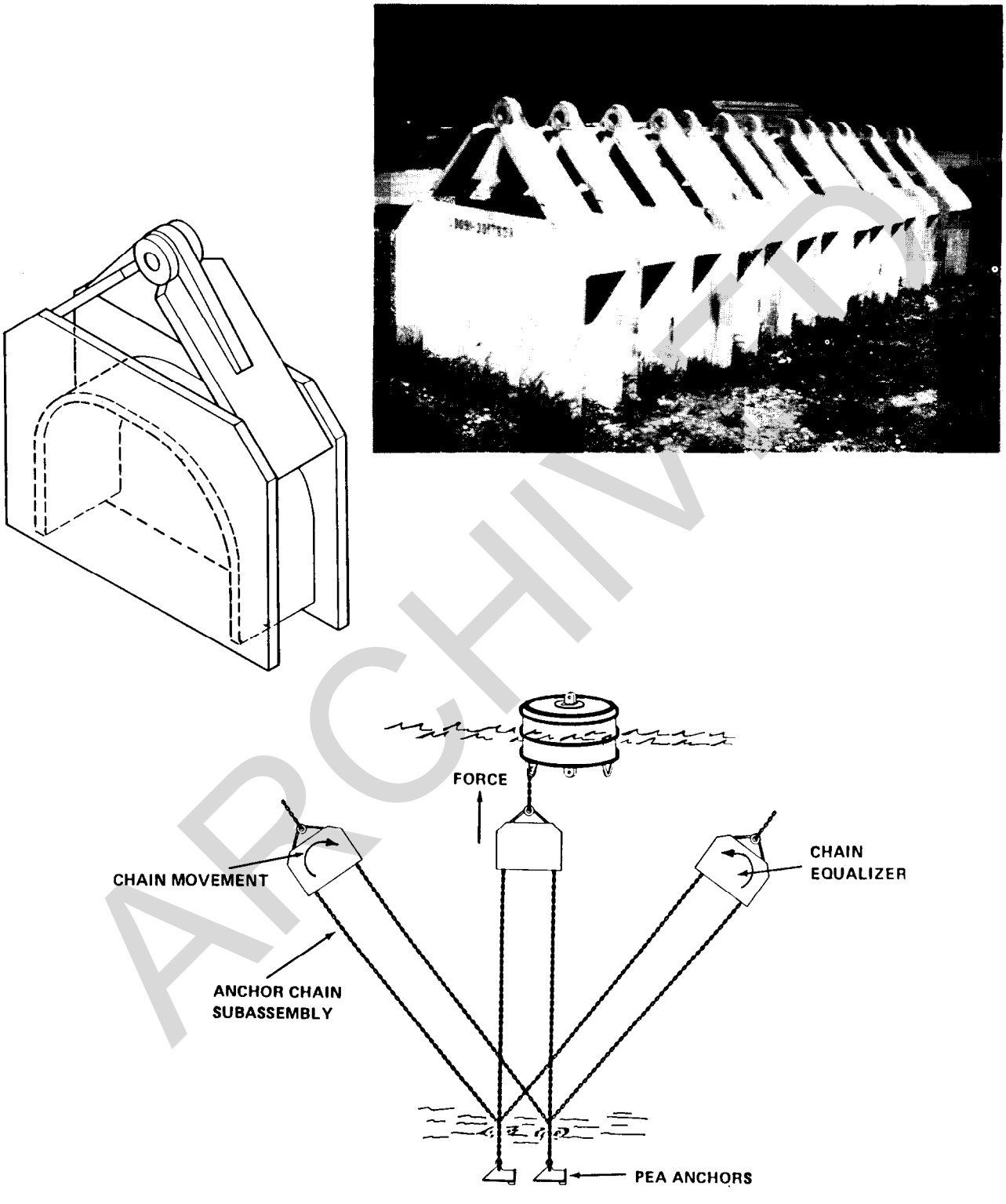


Figure B-22. Chain Equalizer and Its Use

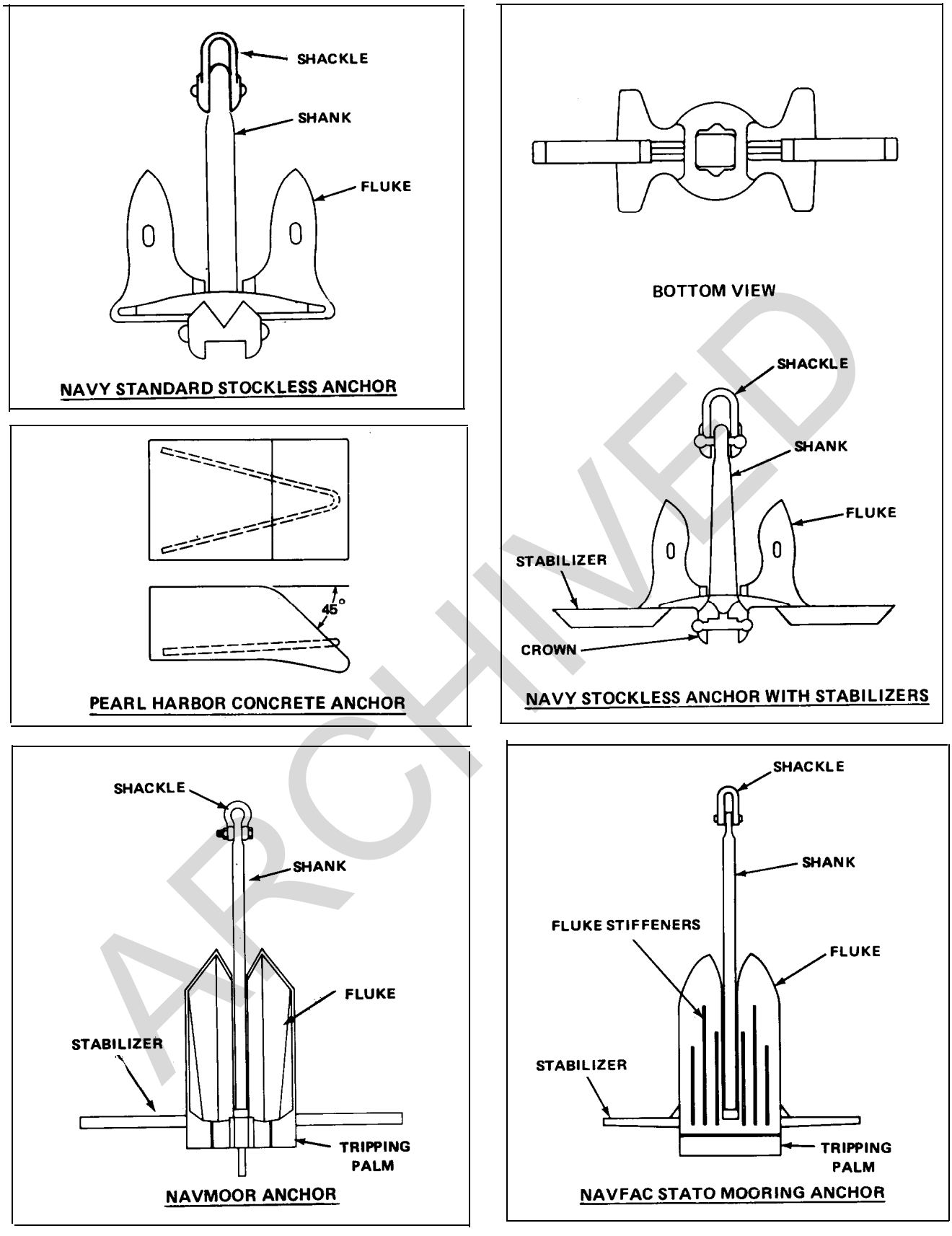


Figure B-23. Typical Mooring Anchors

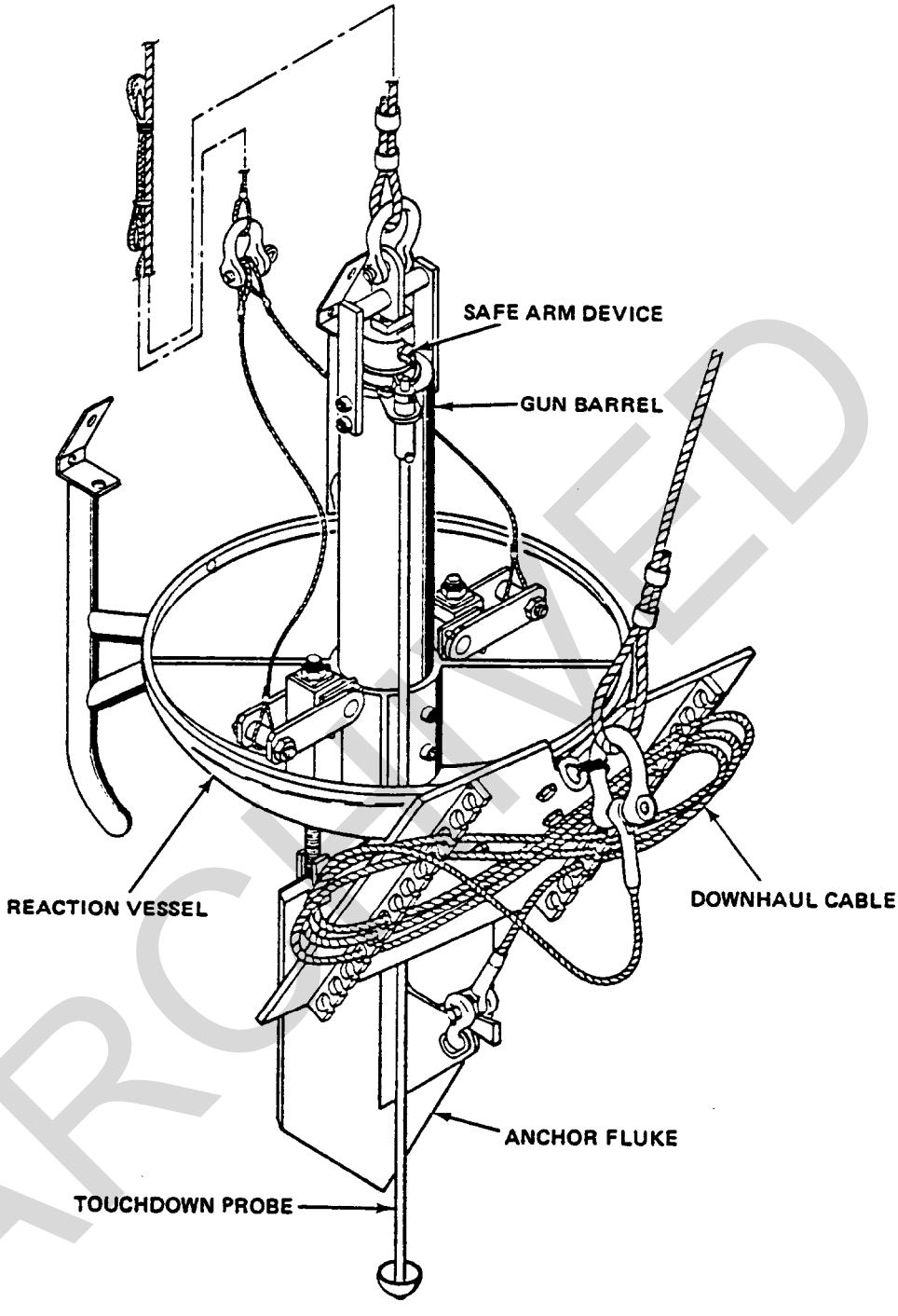


Figure B-24. NCEL Propellant-Embed merit Anchor

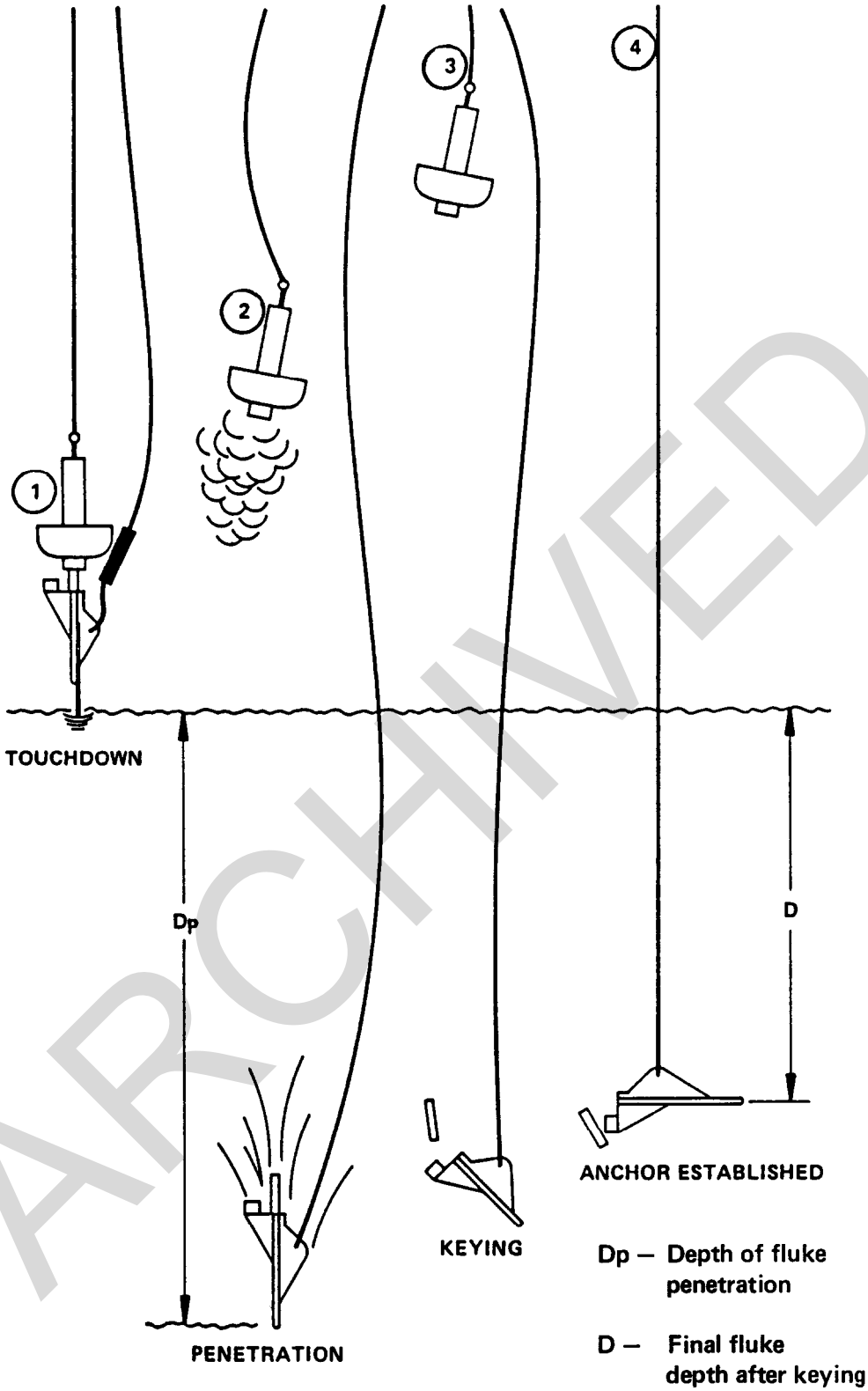


Figure B-25. Penetration and Keying of a Propellant-Embedment Anchor

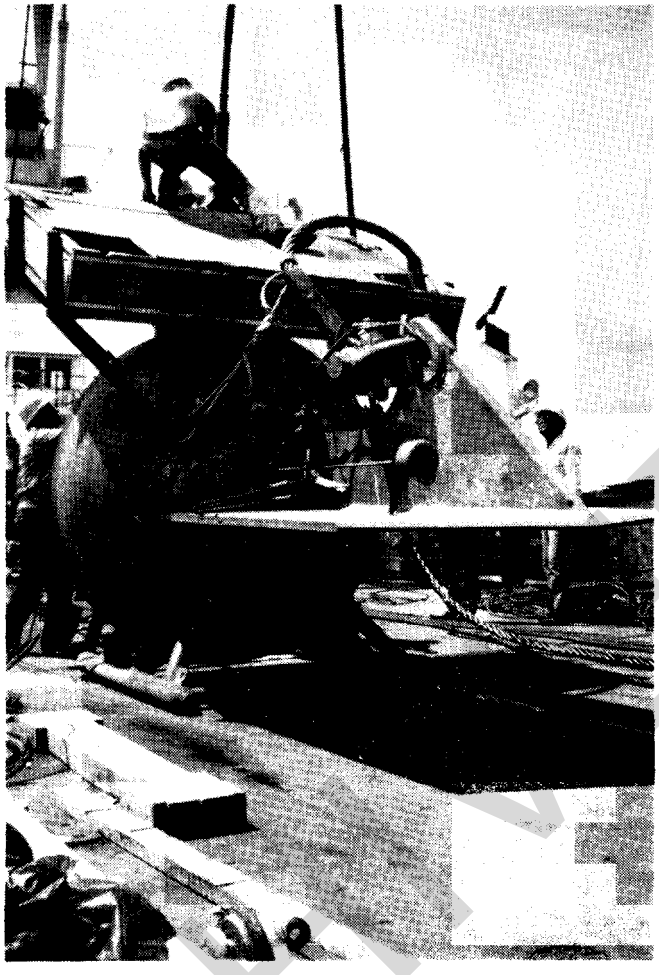


Figure B-26. PEA Being Prepared for Installation

APPENDIX C

GLOSSARY

Accessories	Links, shackles, rings, swivels, and other hardware used to connect lengths of chain to each other or to another mooring component.
Anchor Chain Subassembly	The portion of the chain assembly which connects the anchor(s) to the ground ring (in a riser-type buoy system) or to the buoy (in a non-riser-type buoy system).
Anode	An electrode from which electrons flow; the source of current for cathodic protection systems.
ARDM	Auxiliary Repair Drydock, Medium. Floating Drydock for repair of medium sized vessels.
Benchmark	A permanently fixed point of known location used for reference during surveys and positioning.
Bolster	Rounded metal surfaces that prevent chafing.
Camel	A float used as a fender between two ships or between a ship and a pier.
Catenary	The curved portion of chain suspended in the water column which provides a spring or elastic effect in a mooring system.
Cathodic Protection	An electrical method of preventing metal corrosion in an electrolyte by placing an electrical charge on exposed submerged metal.
Center Marker Buoy	A small buoy used during installations to temporarily mark the location at which the mooring buoy is to be installed.

Chafing Strips	Curved lengths of rubber or wood secured to the top deck of a buoy to protect the coating from impact and abrasion.
Clump	A steel or concrete weight attached to anchor chain subassemblies to dampen the effects of a sudden strain on the mooring.
Component (of a mooring)	Any separate part or piece of hardware which is a pat-t of the mooring system.
Continuity Cable	A wire rope which is used to provide an electrical path between an anode and the metal which it protects.
Corrosion	The deterioration of a metal or alloy by an electrochemical reaction with its environment.
Dragging	The pulling of a mooring from its installed location, but not involving disconnection, break, or structural failure in any of its components (see Failure).
Dunnage	Material used in blocking and securing mooring components.
Electrical Potential	A quantity in an electrical field measured (in volts) with reference to some known level of potential such as a silver-silver chloride reference half-cell.
Electrolyte	A nonmetallic medium such as seawater, which is capable of conducting electricity by movement of ions rather than electrons.
Failure (of a mooring)	The loss of a mooring's ability to hold a load caused by a break, disconnection, structural failure, or

	other flaw in one or more of the mooring components (see Dragging).
Fenders	Curved lengths of rubber or wood secured to the side plates of a buoy hull to protect the buoy from impact and abrasion.
Fit Check	Temporary physical assembly of a mooring's components to ensure that the components will fit together as called for in the mooring design.
Fittings	See Accessories.
Fix	The determination of the geographic position of an object in the water by means of angles, bearings, distances, etc.
Fixed Moorings	A mooring which consists of platforms, cells, islands, dolphins, or similar structural systems permanently fixed in a position to which a ship is secured.
Fleet Mooring Inventory (FMI)	All mooring assemblies, subassemblies, and components in use in the water or stored ashore.
Fluke	The broad arms or palms of an anchor which provide the load-holding capability when buried.
Fluke Angle	The measured angle between the flukes and the shank of an anchor.
Foul	To entangle, obstruct, or jam. Not clear for running.
Fouling	An accumulation of deposits and marine growth on materials and structures immersed in seawater for extended periods of time.

Galvanic Corrosion	An accelerated form of corrosion which occurs in an electrolyte (such as seawater) when dissimilar metals are in contact with each other.
Ground Leg	See Anchor Chain Subassembly.
Grip Area	The area of contact between chain links and/or accessories when a chain assembly is in tension.
Hawsepipe	A steel pipe or tube which runs vertically through the center of a buoy and through which the riser chain passes.
In-Service Mooring	An operational mooring installed at an assigned location.
Jewelry	The shackles (or anchor joining links) attached to the top and bottom of the buoy, as well as any other components attached to or in place of the top shackle (rings, pear links, etc.).
Mediterranean Mooring	A mooring in which a ship's bow is moored to buoys or comparable systems and its stern is tied up to the pier.
Mil Thickness	The dry film thickness of a paint or other coating; each mil equals one one-thousandth of an inch.
Mooring Class	An alphabetic designation used to indicate the holding capacity of a mooring; see Table 1-1 and DM 26.6.
Mooring Platforms	An isolated platform consisting of concrete or timber decks supported on pilings.

New Installation (of a mooring)	The placement of a mooring at a new location usually involving the assignment of a new mooring number.
Out-of-Service	An installed mooring which is unoperational (because of damage or deterioration, etc.) or a mooring or mooring components which are temporarily stored ashore.
Overhaul	The complete recovery, refurbishment, and reinstallation of an existing mooring.
Pelican Hook	A hinged hook fitted with a sliding or hinged link held closed by a ring which is used to provide instantaneous release of chain, anchors, wire rope, etc.
Pendant	A length of line or wire rope fitted with an eye or block atone or both ends.
Pickup Buoy	A small buoy used to facilitate retrieval of sunken objects (see Retriever Buoy).
Pitting Corrosion	A highly localized and self-accelerating form of corrosion that generally occurs on the surface of metals immersed in seawater.
Range	To lay out a length of chain in a straight line.
Range Buoys	Small buoys temporarily installed along a line of bearing to assist in movement and orientation of a crane barge during mooring installations.
Recovery (of a mooring)	The complete retrieval of all mooring components.
Refurbishment	The cleaning, inspection, repair, and reconditioning of mooring components ashore.

Repair (of a mooring)	The correction or remedy of a defective condition while a mooring is in service.
Retriever Buoy	A relatively small buoy attached by a wire rope to an anchor or an anchor chain subassembly. This buoy marks the position of the mooring material to which it is attached and precludes a search for this material during recovery operations.
Ring Marker Buoy	Used to denote the position at which a mooring anchor is to be installed. It also marks the direction of an anchor chain subassembly from the desired position of the mooring buoy.
Riser Subassembly	Vertical chain extending from a ground ring upward to a mooring buoy; includes the ground ring and attached joining links.
Rust Bleeding	A rust-colored discoloration of surrounding coating caused by localized corrosion of exposed metal.
Sacrificial Anode	A metallic anode (usually zinc) which supplies electrons for cathodic protection of another metal, thereby consuming or “sacrificing” itself.
Shot	A 15-fathom (90-foot) length of chain.
Sinker	See Clump.
Splash Zone	The region immediately above the high tide level; the splashing action of waves keeps this area continually wetted by highly oxygenated seawater; materials suffer accelerated rates of corrosion in this zone.

Spud Mooring	A mooring which is used to secure a floating dock to a pier or series of mooring platforms. The spuds are usually H shaped steel sections fastened vertically to the side of the pier at two or more locations.
Stake Piles	Steel or wood piling anchors driven vertically into a firm bottom.
Stud	The center cross bar in steel chain link.
Taut	The condition of a chain, line, wire rope, or mooring when under sufficient tension to cause it to assume a straight line.
Tension Bar	A heavy steel load carrying member which runs vertically through the center of a buoy and to which the riser chain is attached at the bottom and mooring lines are attached at the top.
Toggle Bar	Bar or pin fitted into an eye or ring; used to permit a quick release.
Tripping Palms	Projections from an anchor that trips the flukes at an angle for embedding.
Upgraded Mooring	A mooring which consists of FM 3 fleet mooring chain, a cathodic protection system, high capacity anchors, and a urethane-coated foam filled buoy.
Watch Circle	The area swept by a vessel as it revolves about a mooring point.
Wear Zone	The portion of the chain assembly near the bottom which experiences the highest rate of wear due to abrasion of seafloor material.

Weather Vane	A vessel free swinging around a mooring buoy to assume an orientation which presents the least resistance to the combined effect of wind and current.
Wire Diameter	The diameter of the bar stock from which chain and accessories are manufactured; also, the nominal size of chain and accessories as measured across the smallest diameter of the load bearing structure.

APPENDIX D

KENTER JOINING LINK ASSEMBLY

KENTER JOINING LINK

Kenter Joining Link. The Kenter-type joining link is of alloy steel and constructed in three parts, one of which is the stud. The two main parts and stud have matching numbers and arrow on the stud which is lined up with an arrow on the main part for ease of assembly (See Figure D-l). The two main parts are attached to the ends of the chain in the vertical position and then fitted together, the stud slides in place and locks the whole link. The stud is secured by hammering a tapered pin into the hole drilled diagonally through all three parts of the joining link. This hole is tapered, and when the pin is driven home, a small conical recess, called the "Dovetail Chamber" is left clear above its head. A lead pellet is hammered broad end first into this chamber so as to fill it completely and thereby keep the pin in place. During the final stage of hammering the lead pellet into the Dovetail Chamber, precaution must be taken to prevent flat, small pieces of lead from flying off the joining link into the face or eyes. The assembly procedure is depicted on the last two pages of this appendix.

Prior to assembly, the internal mating surfaces of a Kenter joining link should be coated with a molybdenum disulphide grease (MIL-G-23549) or an equivalent lithium based grease. When assembling and before inserting a lead pellet, any remaining lead in the Dovetail Chamber must be reamed out with a reamer tool Failure to do this could result in the new lead pellet working out. After assembly the link is painted with anchor chain paint, MI L-P-24380 (NSN 8010-00-145-0332 an NSN 8010-00-145-0341 for 1 and 5 gallon cans respectively).

When disassembling a Kenter joining link, the locking pin is driven out with a "drift." To part the link, a top swage must always be used between the hammer and link. The swage is shaped to the curvature of the link so that machined surfaces are not damaged (See Figure D-2).

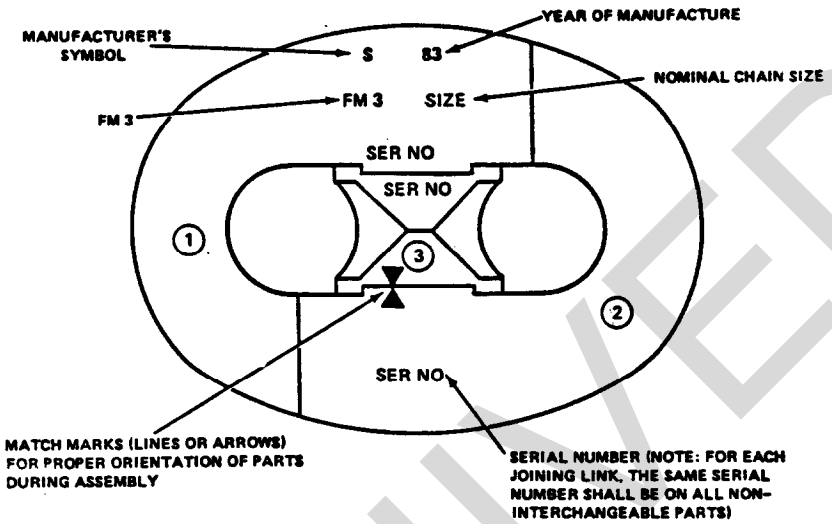


Figure D-1. A Kenter Joining Link

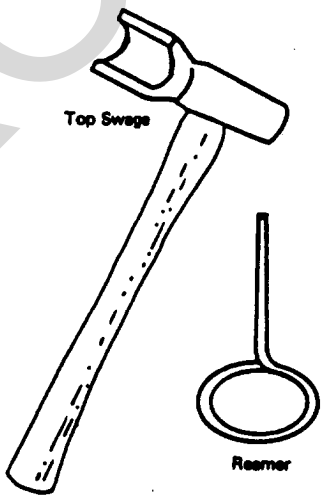
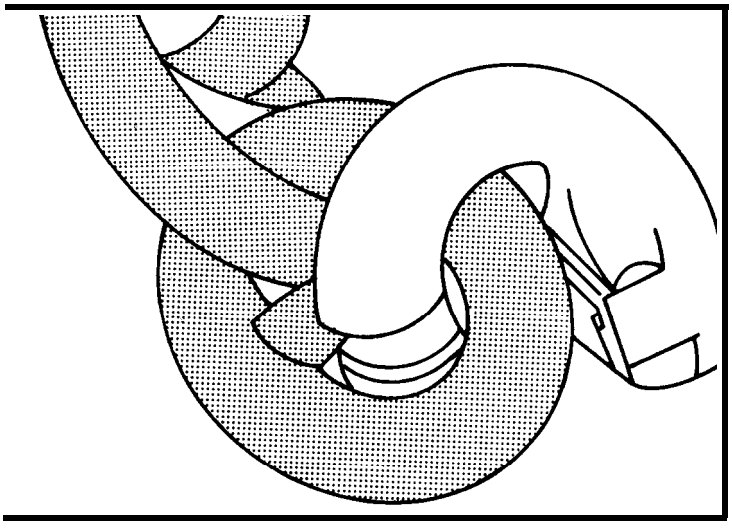


Figure D-2. A Top Swage and Reamer

KENTER JOINING LINK

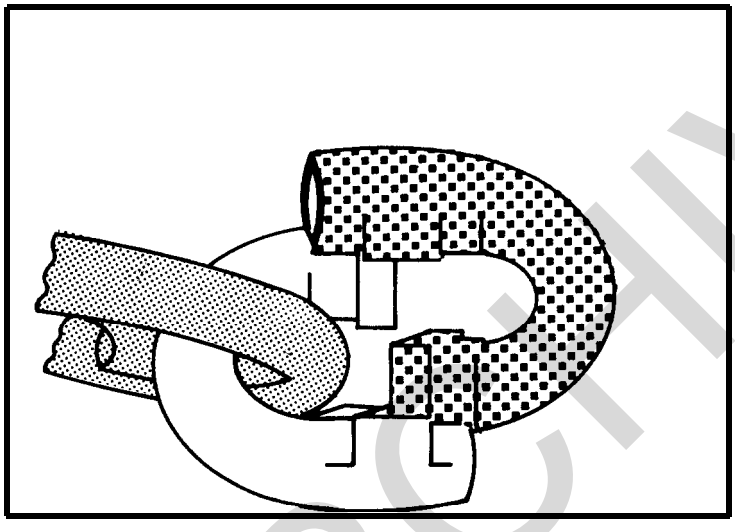
ASSEMBLY PROCEDURE



1

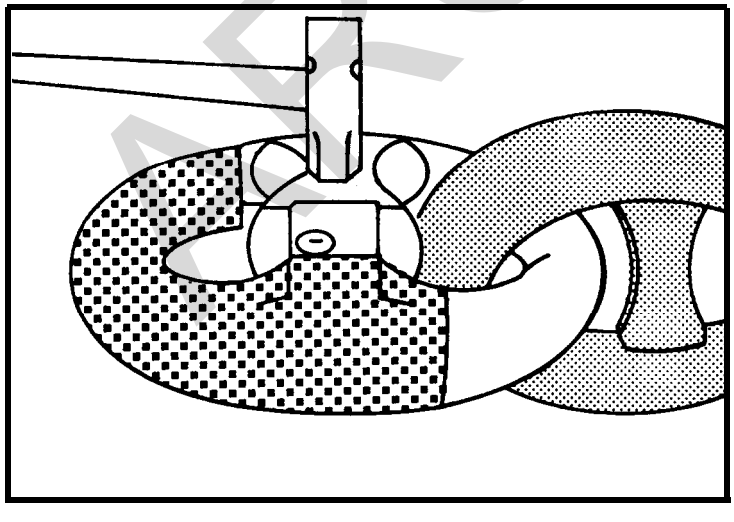
The half Kenter link is reeved in the chain link.

(Only one of the chain links is shown).



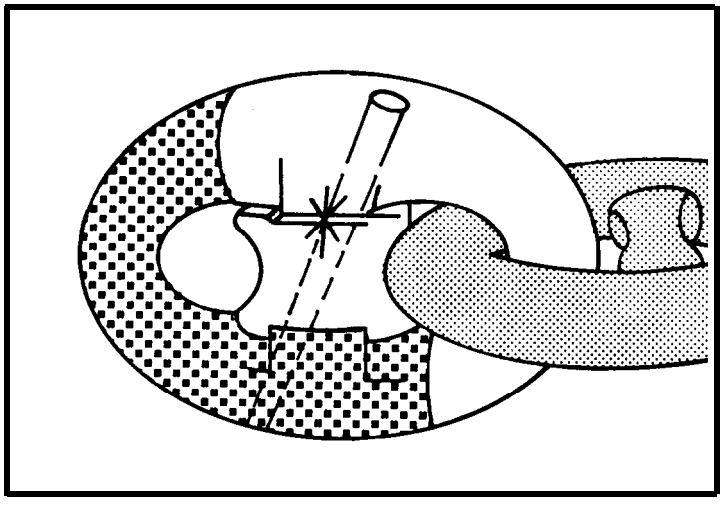
2

The link halves are inserted one in the other and driven together.



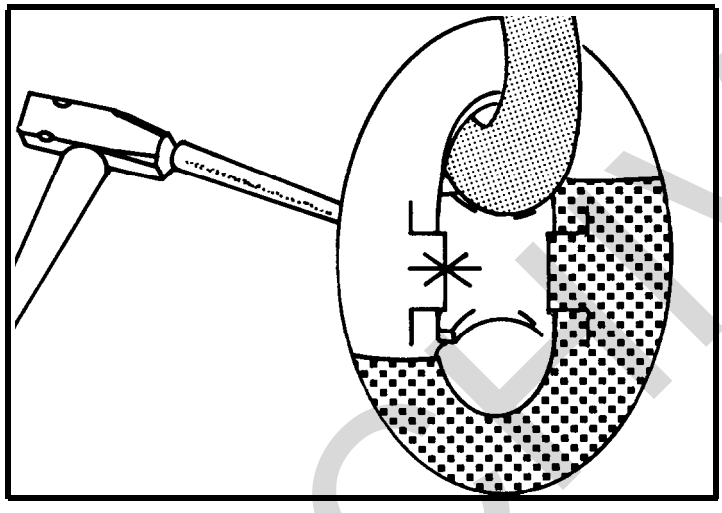
3

The center chock is inserted.



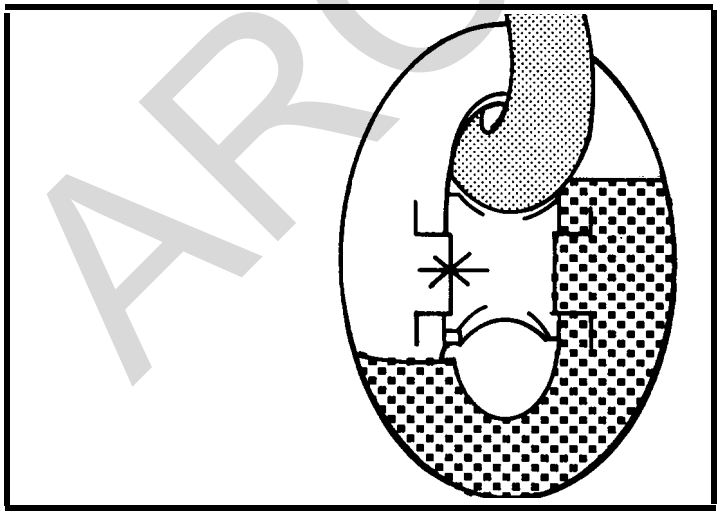
4

Just for a trial the taper pin is inserted in the center chock. When the center chock is in correct position the taper pin can without a hammer be inserted as shown on the figure which also shows the center chock in correct position.



5

The taper pin is driven in and is secured by the lead pellet which is inserted into place with a hammer.



6

Assembled Kenter joining link.

APPENDIX E

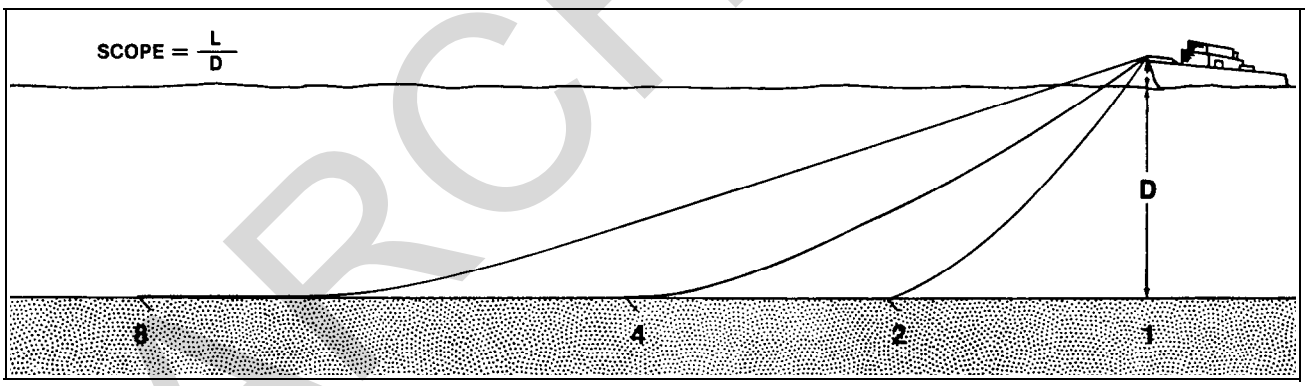
ANCHOR PULL TEST REQUIREMENTS

APPENDIX E

ANCHOR PULL TEST REQUIREMENTS

1.0 GENERAL. This appendix establishes the procedures for setting and pull testing of anchor legs. Tables of predicted anchor system drag distance are included to assist in initial anchor positioning.

1.2 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 E-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.



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.

Figure E-1. Mooring Leg Scope

1.2.1 DRAG DISTANCE

- Single Anchors. The predicted anchor drag distance for single anchors can be obtained from Table E-1.

- Tandem Anchor Systems. The predicted anchor drag distance for tandem anchor systems can be obtained from Table E-2.

1.2.2 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.

1.2.3 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' long by 20' wide allowable anchor area (see Figure E-2). 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.

1.3 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.

1.3.1 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.

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

1.3.2.2 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.

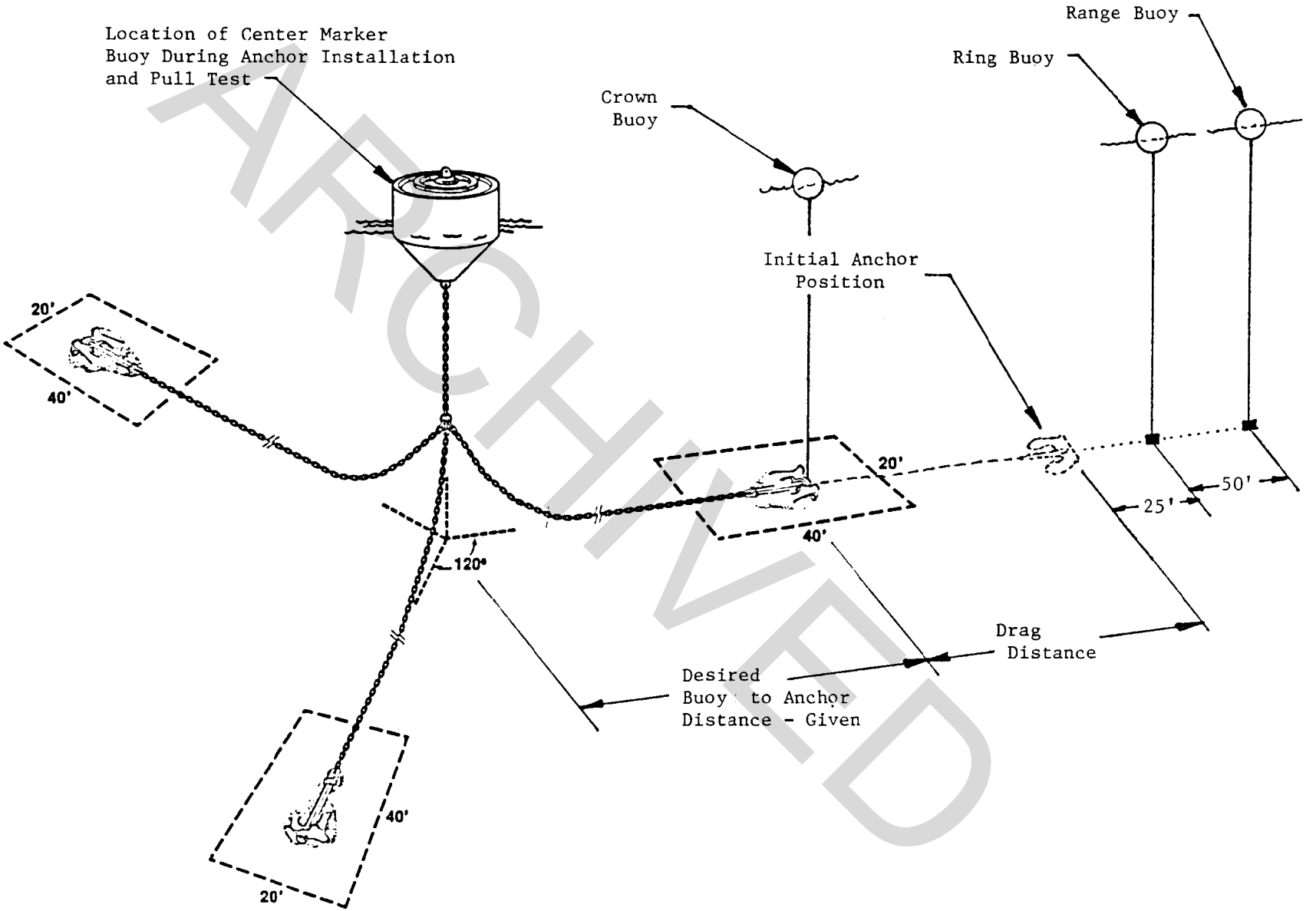


Figure E-2. Allowable Anchor Area

1.3.2.3 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 maybe 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.

1.3.2.4 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.

PREDICTED SINGLE ANCHOR DRAG DISTANCES

TABLE E-1

Anchor: Stockless Anchor with Stabilizers and Flukes Fixed at approximately 450

Seafloor Type: Mud

Anchor Weight (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

PREDICTED SINGLE ANCHOR DRAG DISTANCES

TABLE E-1 (Continued)

Anchor: Stockless Anchor with Stabilizers and Flukes Fixed at approximately 360

Seafloor Type: Sand

Anchor Weight (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

PREDICTED SINGLE ANCHOR DRAG DISTANCES

TABLE E-1 (Continued)

Anchor: Stato Anchor with Stabilizers and Flukes Fixed at approximately 50°

Seafloor Type: Mud

Horizontal Design Load (Kips)

Anchor Weight (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

PREDICTED SINGLE ANCHOR DRAG DISTANCES

TABLE E-1 (Continued)

Anchor: Stato Anchor with Stabilizers and Flukes Fixed at approximately 30°

Seafloor Type: Sand

Horizontal Design Load (Kips)

Anchor Weight (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.	20.	22.	24.	27.	30.	32.	34.	37.	41.	44.	46.	48.

Drag Distance (Feet)

*Exceeds anchor ultimate holding capacity

PREDICTED TANDEM ANCHOR DRAG DISTANCES

TABLE E-2

Anchor: Tandem Stockless Anchors with Stabilizers and Flukes Fixed at approximately 45°

Seafloor Type: Mud

Anchor Weight (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 system ultimate holding capacity

PREDICTED TANDEM ANCHOR DRAG DISTANCES

TABLE E-2 (Continued)

Anchor: Tandem Stockless Anchors with Stabilizers and Flukes Fixed at approximately 36°

Seafloor Type: Sand

Anchor Weight (Kips)	Horizontal Design Load (Kips)											
	25.	50.	75.	100.	125.	150.	175.	200.	225.	250.	275.	300.
	Drag Distance (Feet)											
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.

*Exceeds anchor system ultimate holding capacity

PREDICTED TANDEM ANCHOR DRAG DISTANCES

TABLE E-2 (Continued)

Anchor: Tandem Stato Anchors with Stabilizers and Flukes Fixed at approximately 50°

Seafloor Type: Mud

Anchor Weight (Kips)	Horizontal Design Load (Kips)											
	25.	50.	75.	100.	125.	150.	175.	200.	225.	250.	275.	300.
	Drag Distance (Feet)											
5.		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.

*Exceeds anchor system ultimate holding capacity

PREDICTED TANDEM ANCHOR DRAG DISTANCES

TABLE E-2 (Continued)

Anchor: Tandem Stato Anchor with Stabilizers and Flukes Fixed at approximately 30°

Seafloor Type: Sand

Anchor Weight (Kips)	Horizontal Design Load (Kips)											
	25.	50.	75.	100.	125.	150.	175.	200.	225.	250.	275.	300.
	Drag Distance (Feet)											
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.

*Exceeds anchor system ultimate holding capacity