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*** FM 55-501**

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FM 55-501

MARINE CREWMAN'S HANDBOOK

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Authentication

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Preface

The US Army watercraft fleet is made up of all types of vessels, including oceangoing vessels, tugs, landing craft, barges, and amphibians. Although all of these vessels operate on water, their missions are different. The watercraft operator must have the skills and knowledge to perform the tasks required on any of these vessels.

This FM is for the 88K watercraft operator, skill levels 1 through 4. It will provide the subject matter that relates directly to the common technical tasks listed in STP 55-88K14-SM-TG.

The US Army's environmental strategy into the 21st century defines the Army's leadership commitment and philosophy for meeting present and future environmental challenges. It provides a framework to ensure that environmental stewardship ethic governs all Army activities. The Army's environmental vision is to be a national leader in environmental and natural resource stewardship for present and future generations, as an integral part of all Army missions. The Army's environmental vision statement communicates the Army's commitment to the environment.

The proponent of this publication is HQ TRADOC. Send comments and recommendations on DA Form 2028 (Recommended Changes to Publications and Blank Forms) directly to Commander, US Army Combined Arms Support Command, ATTN: ATCL-AT, 401 1st Street, Suite 227, Fort Lee, Virginia 23801-1511.

Unless this publication states otherwise, masculine nouns and pronouns do not refer exclusively to men.

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Chapter 1

Introduction to Army Watercraft

Army watercraft are used in the following operations: harbor, coastal, interisland, and LOTS. They are also used for other operations such as ocean towing and security patrols. This chapter addresses these operations and the categories of watercraft.

WATERCRAFT OPERATIONS

1-1. US Army watercraft play a major role in projecting and sustaining combat forces. From established ports to LOTS operations, Army watercraft provides a flexible means of moving troops and supplies. Through prepositioning and self deployable vessels, the Army's fleet of diverse watercraft are capable of playing a dynamic part in the Army Strategic Mobility Program.

MISSION

1-2. The mission of Army watercraft is to support the Army's RSOI movement plan. Army watercraft provide the vital link between the offshore arrival of combat power, loaded aboard strategic sealift ships, and placing that power ashore in a ready-to-fight configuration. The Army watercraft fleet must be prepared to do this mission anywhere in the world. This is accomplished by the following means:

- Transport of personnel and cargo between ship and shore and on inland waterways.
- Floating equipment support for terminal operations within a fixed-port or unimproved port facility complex.
- During riverine operations.
- Lighterage for cargo and personnel from ships lying offshore to transfer-segregation areas beyond the beach lines in LOTS operations.

HARBOR OPERATIONS

1-3. This includes the movement of cargo and personnel within a harbor and the protected waters in the vicinity of the harbor. Tugs, barges, and floating cranes discharge and transfer cargo; small craft provide ferrying service; and picket boats conduct security patrols. Tugs are used for providing berthing service for oceangoing vessels and for fire fighting in the port area.

INTERISLAND AND COASTAL OPERATIONS

1-4. Large watercraft carry cargo and personnel from central ports to smaller outlying installations (such as sub-ports, radar installations, and other terminals). Where larger oceangoing freighters cannot navigate, LSVs and landing craft can safely transport cargo through shallow waters and narrow winding channels.

LOGISTICS-OVER-THE-SHORE OPERATIONS

1-5. This includes ship-to-shore operations moving cargo and personnel onto a prepared beachhead from larger vessels anchored offshore. This operation is the most difficult and time consuming. Planning, timing, and a skilled Weather Eye means the difference in success or failure in this type of cargo operation. Landing craft, amphibians, and causeway ferry systems are normally used for such operations. Tugs with barges, floating cranes, and LSVs may also be used where causeway piers have been installed on the beach.

WORLD WIDE MISSIONS

1-6. Army watercraft are capable of deployment to any theater of operation around the world. Vessels such as the LSV and the 128-foot tug are capable of self deployment. The LCU 2000, while capable of self deployment, may also be transported aboard heavy lift ships. The remainder of the smaller vessels in the fleet also uses this method of transportation.

CLASSES OF WATERCRAFT

1-7. There are three classes of Army watercraft. These classes include the following:

- Class A vessels.
- Class B vessels.
- Class C vessels.

CLASS A VESSELS

1-8. These are the self-sustaining vessels that are self-propelled and designed for continuous operation. They are commanded by WOs licensed to serve on class A vessels according to AR 56-9. Within this class of vessels are two subclasses. They are as follows:

- ***Class A-1 Vessels.*** This class of vessel normally operate in coastal waters.
- ***Class A-2 Vessels.*** This class of vessel is fully ocean capable.

CLASS B VESSELS

1-9. These are nonself-sustaining vessels that are self-propelled. They are commanded by NCOs, certified to serve on class B vessels according to AR 56-9. The crews are small and generally these vessels do not have living space accommodations. To perform continuous operations, complete crew changes must be made. These vessels require significant shoreside support. Two crews, running in two 12-hour periods, can perform 24-hour operations.

CLASS C VESSELS

1-10. All nonpropelled floating equipment, such as cranes, dry and liquid barges, and refrigerated barges are classified as class C vessels. This class is further divided into the following two subclasses:

- ***Class C-1 Vessels.*** This class of vessel are the nonpropelled floating craft having berthing facilities aboard for assigned personnel.
- ***Class C-2 Vessels.*** This class of vessel are nonpropelled manned vessels having no berthing facilities aboard.

DESCRIPTIONS OF LOGISTICS SUPPORT VESSEL

1-11. The Army's mission for watercraft requires a fleet of over 20 different types of vessels. These vessels differ greatly in design and use.

DESCRIPTION OF LOGISTICS SUPPORT VESSEL

1-12. The LSV (Figure 1-1) is a self deployable vessel designed to transport combat vehicles and sustainment cargo worldwide. It is capable of performing cargo loading and discharge by RO/RO or crane supported LO/LO operations. The characteristics of the vessel are as follows:

Length overall: 273 feet
Beam: 60 feet
Displacement (weight): 4,199 long tons
Deck area: 10,500 square feet (up to 24 M1 main battle tanks or 50 double stacked 20-foot ISO containers)
Payload: 2,000 tons (equivalent to 86 C-141 payloads)
Range: Light - 8,200 nautical miles at 12.5 knots, loaded - 6,500 nautical miles at 11.5 knots
Crew Size: 8 WOs and 24 enlisted

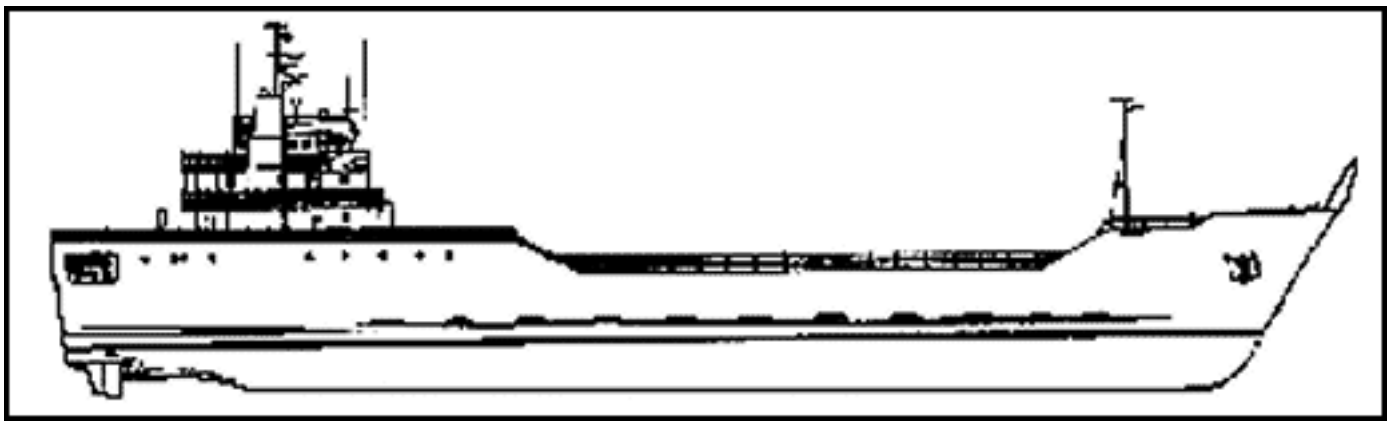


Figure 1-1. Logistics Support Vessel

DESCRIPTION OF LCU 2000

1-13. The LCU 2000 (Figure 1-2) provides worldwide transport of combat vehicles and sustainment cargo. Like the LSV, it provides intratheater movement of cargo and equipment. The LCU 2000 can perform missions ranging from RO/RO discharge of LMSR's to LOTS operations on unimproved beaches. The characteristics of the vessel are as follows:

Length overall: 174 feet
Beam: 42 feet
Displacement (weight): 1,087 long tons (loaded)
Deck area: 2,500 square feet (5 M1 main battle tanks or 24 double stacked, 20-foot ISO containers)
Payload: 350 tons (equivalent payload of 15 C-141 aircraft loads)
Range: Light - 10,000 nautical miles at 12 knots, loaded - 6,500 nautical miles at 10 knots
Crew size: 2 WOs and 11 enlisted

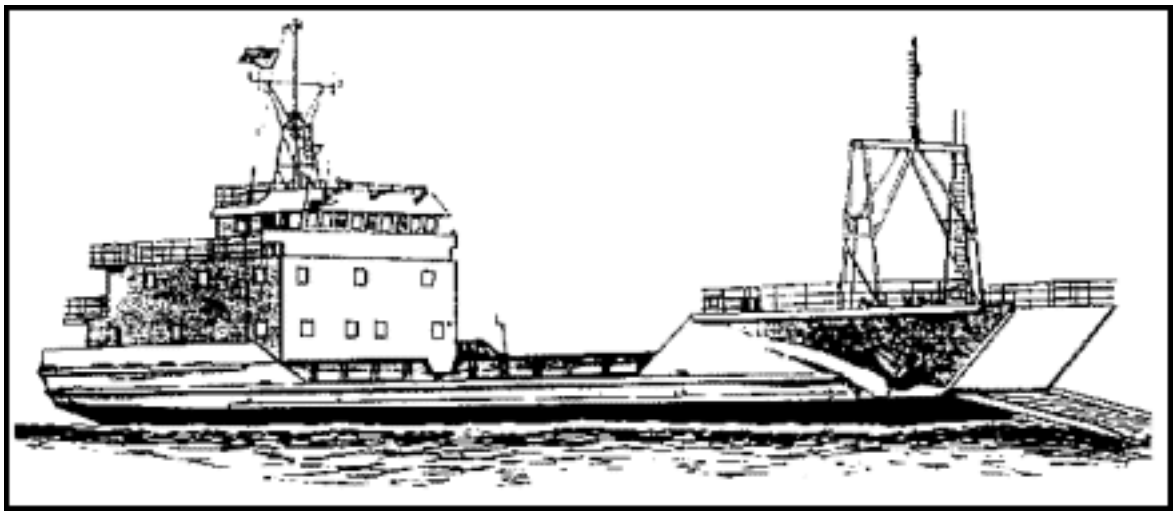


Figure 1-2. LCU 2000

DESCRIPTION OF LCU 1600

1-14. The LCU 1600 (Figure 1-3) is used to transport combat vehicles and sustainment cargo from ship-to-shore, shore-to-shore, and in retrograde operations. Intratheater transport is also accomplished using harbor and inland waterway routes. The characteristics of the vessel are as follows:

Length overall: 135 feet
Beam: 30 feet
Displacement (weight): 390 long tons (loaded)
Deck area: 1,785 square feet (2 M1 main battle tanks or 10 double stacked, 20-foot ISO containers)
Payload: 184 tons (equivalent payload capacity of 7 C-141 aircraft loads)
Range: Light - 1,200 nautical miles at 12 knots, loaded - 1,100 nautical miles at 11 knots
Draft: Light - 6 feet, loaded - 7 feet
Crew size: 2 WOs and 12 enlisted

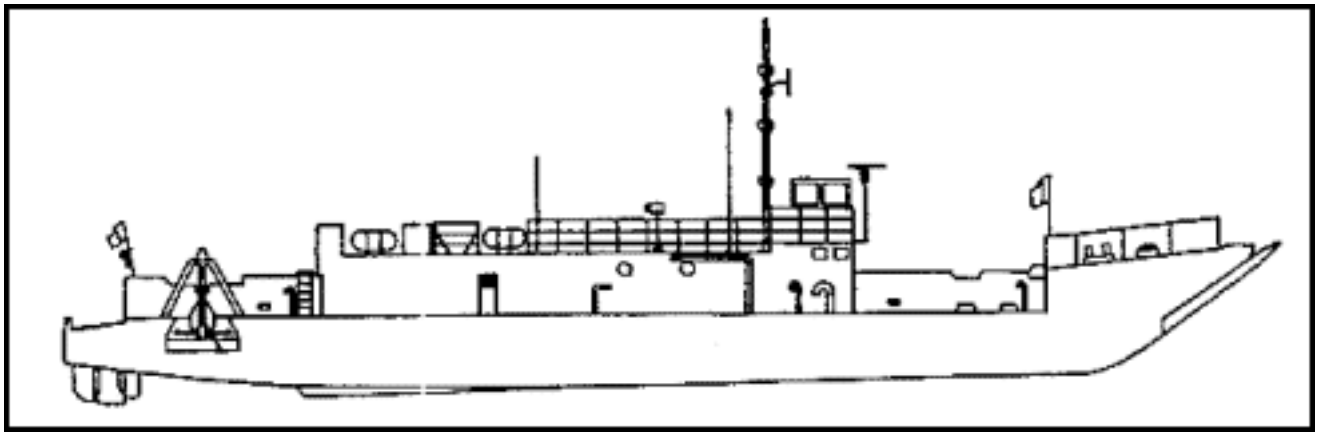


Figure 1-3. LCU 1600

DESCRIPTION OF THE LCM-8

1-15. The LCM-8 (Figure 1-4) is used to transport cargo, troops, and vehicles from ship-to-shore or in riverine operations. It is also used in lighter and utility work in harbors. It is designed for use in rough or exposed waters and is capable of operating through breakers and grounding on the beach. The bow ramp permits RO/RO operations with wheeled and tracked vehicles. Its small size allows for use in confined areas. The characteristics of the vessel are as follows:

Length overall: 74 feet
Beam: 21 feet
Displacement (weight): 111 long tons (loaded)
Deck area: 620 square feet (two 20-foot ISO containers or 200 combat troops)
Payload: 53 tons (equivalent payload capacity of 2 C-141 loads)
Range: Light - 332 nautical miles at 11 knots, loaded - 271 nautical miles at 9 knots
Draft: Light - 3.5 feet, loaded - 5 feet
Crew size: 6 enlisted for 24-hour operations (two shifts)

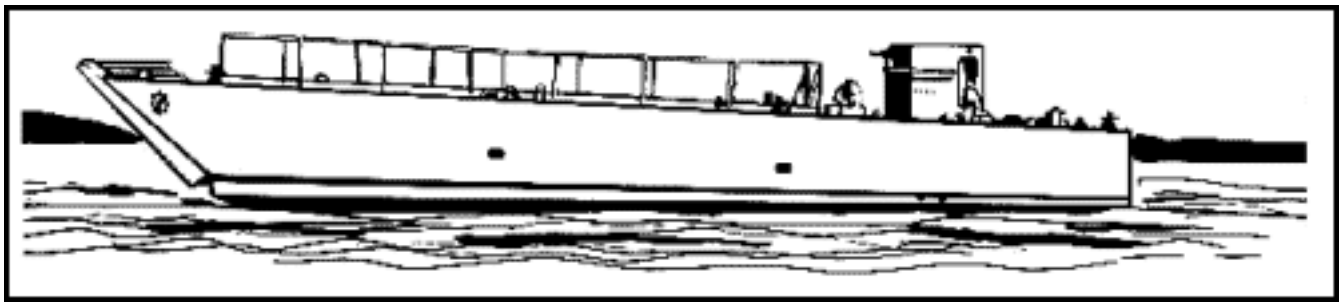


Figure 1-4. LCM-8

DESCRIPTION OF THE LARGE TUG, 128-FOOT

1-16. The 128-foot LT (Figure 1-5) is used for ocean and coastal towing operations. It is also used to dock and undock large ships. It has a secondary mission, which is to perform general purpose harbor duties (such as positioning floating cranes and so forth). The LT is equipped to accomplish fire fighting duties, a significant capability particularly where ammunition ships are being worked. It is also used to perform salvage and recovery operations for other watercraft disabled or damaged along the coastal MSR. The 128-foot tug is totally self deployable. The characteristics of the vessel are as follows:

Length overall: 128 feet
Beam: 36 feet
Displacement (weight): 1,057 long tons (loaded)
Bollard Pull: 58 tons
Range: Light - 5,000 nautical miles at 13.5 knots, loaded - 5,000 nautical miles at 12 knots
Draft: Light - 14.5 feet, loaded - 17 feet
Crew size: 8 WOs and 15 enlisted

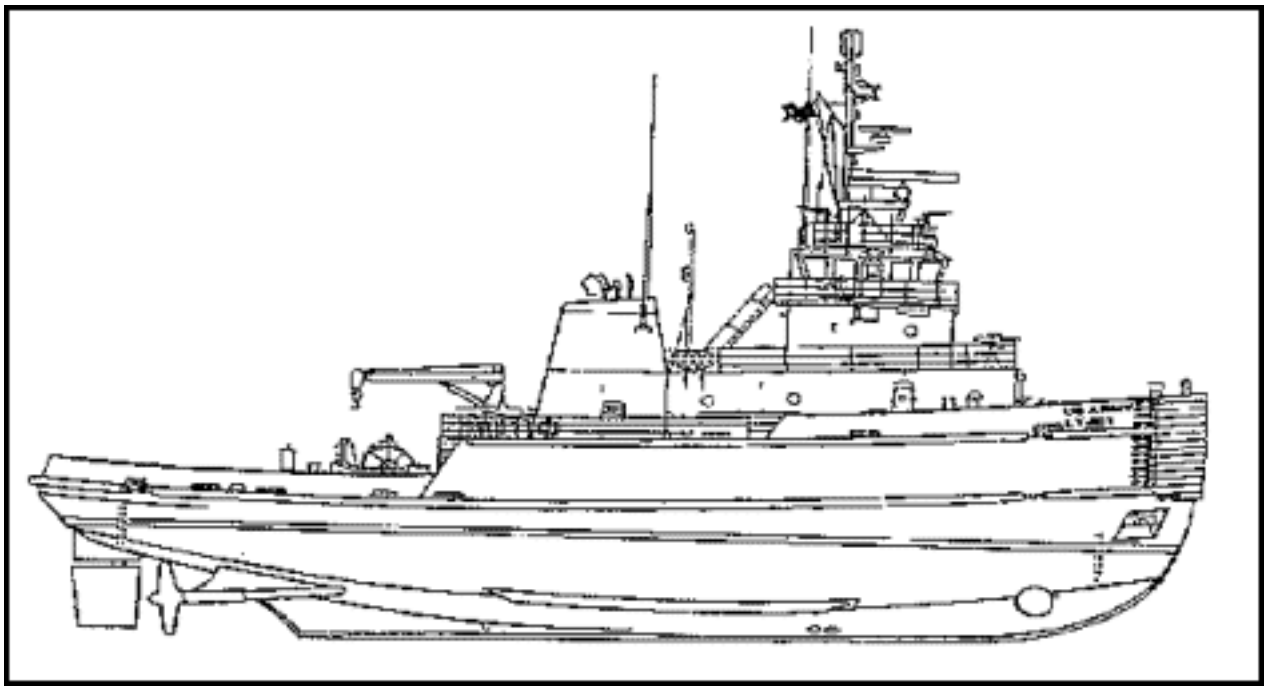


Figure 1-5. Large Tug, 128-Foot

DESCRIPTION OF THE LARGE TUG, 100-FOOT

1-17. The 100-foot LT (Figure 1-6) is used to berth and unberth large oceangoing vessels and for towing within the harbor areas. Secondary missions include general utility uses, fire fighting, and salvage operations. It is also used for limited offshore and coastal towing between terminals. The characteristics of the vessel are as follows:

Length overall: 107 feet
Beam: 27 feet
Displacement (weight): 390 long tons (loaded)
Bollard pull: 13.8 long tons/31.5 long tons
Range: Light - 3,323 nautical miles at 12.8 knots
Draft: Light - 11.5 feet, loaded - 12.5 feet
Crew size: 4 WOs and 12 enlisted

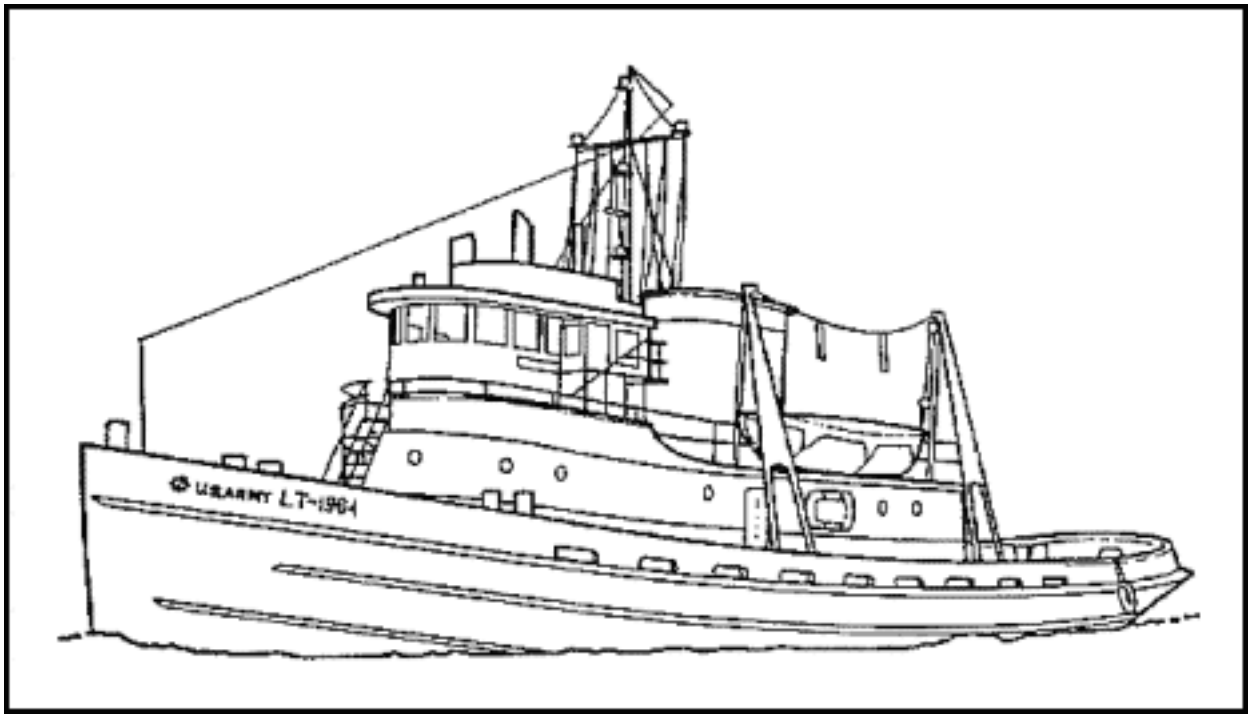


Figure 1-6. Large Tug, 100-Foot

DESCRIPTION OF THE PUSHER TUG, 60-FOOT

1-18. The 60-foot PT (Figure 1-7) is capable of moving cargo barges and lighters of various types within a harbor, port, or LOTS anchorage. The PT is a shallow draft vessel with enough horsepower to tow and husband LASH other barges in harbors, inland waterways, and along coastlines. It is capable of operating in sea state 3. It can also assist in the docking and undocking of ships, movement of floating cranes, and line haul duties. It is transportable aboard LASH ships to the operation area. It is not self deployable. The characteristics of the vessel are as follows:

Length overall: 60 feet
Beam: 22 feet
Displacement (weight): 105 tons light
Bollard pull: 15 long tons
Range: Light - 720 nautical miles at 6 knots, loaded - variable with tow type
Draft: 6 feet
Crew size: 2 WOs and 10 enlisted

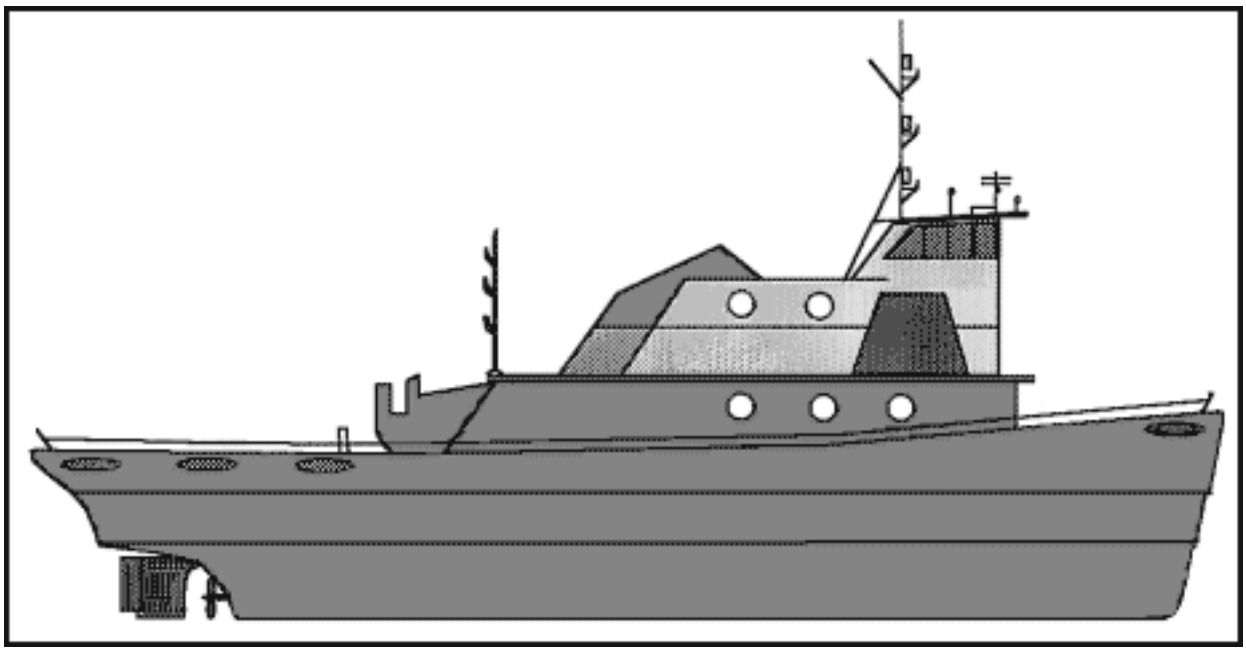


Figure 1-7. Pusher Tug, 60-Foot

DESCRIPTION OF THE SMALL TUG, 65-FOOT

1-19. The ST (Figure 1-8) is used to move nonpropelled barges in harbors and on inland waterways. Secondary missions include utility uses, fire fighting, salvage, and assisting in the docking and undocking of large vessels. The characteristics of the vessel are as follows:

Length overall: 71 feet
Beam: 19.5 feet
Displacement (weight): Light - 100 long tons, loaded - 122 long tons
Bollard pull: 8.75 tons
Range: Light - 1,700 nautical miles, loaded - variable depending on the tow configuration
Draft: Light - 7.5 feet, loaded - 8.5 feet
Crew Size: 2 WOs and 10 enlisted

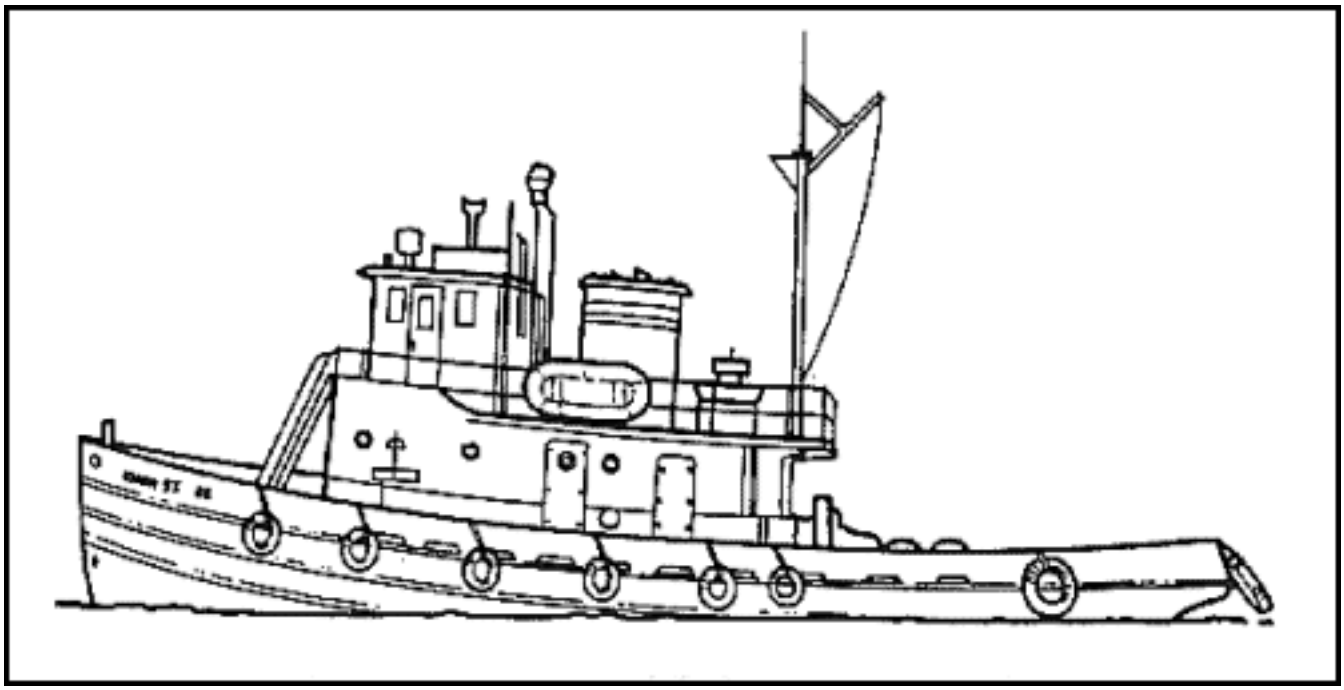


Figure 1-8. Small Tug, 65-Foot

DESCRIPTION OF THE LIGHTER, AMPHIBIOUS RESUPPLY CARGO, 60-TON

1-20. The LARC-LX (Figure 1-9) is used to transport tracked and wheeled vehicles (including beach preparation equipment and sustainment cargo) from ship-to-shore or inland transfer points. The LARC-LX is the only amphibian in the US Army's inventory and the only vessel capable of landing on a beach through a breaking surf. The characteristics of the vessel are as follows:

Length overall: 63 feet
Beam: 27 feet
Displacement (weight): 88 long tons (light)
Deck area: 527 square feet (4 20-foot ISO containers or 125 combat equipped soldiers)
Payload: 60 tons (2 C-141 loads)
Range: Land - 60 tons cargo, 150 statue miles at 14 MPH; water - 60 ton load, 75 nautical miles at 6 knots
Draft: Light - 7.5 feet, loaded - 9 feet
Crew size: 12 enlisted

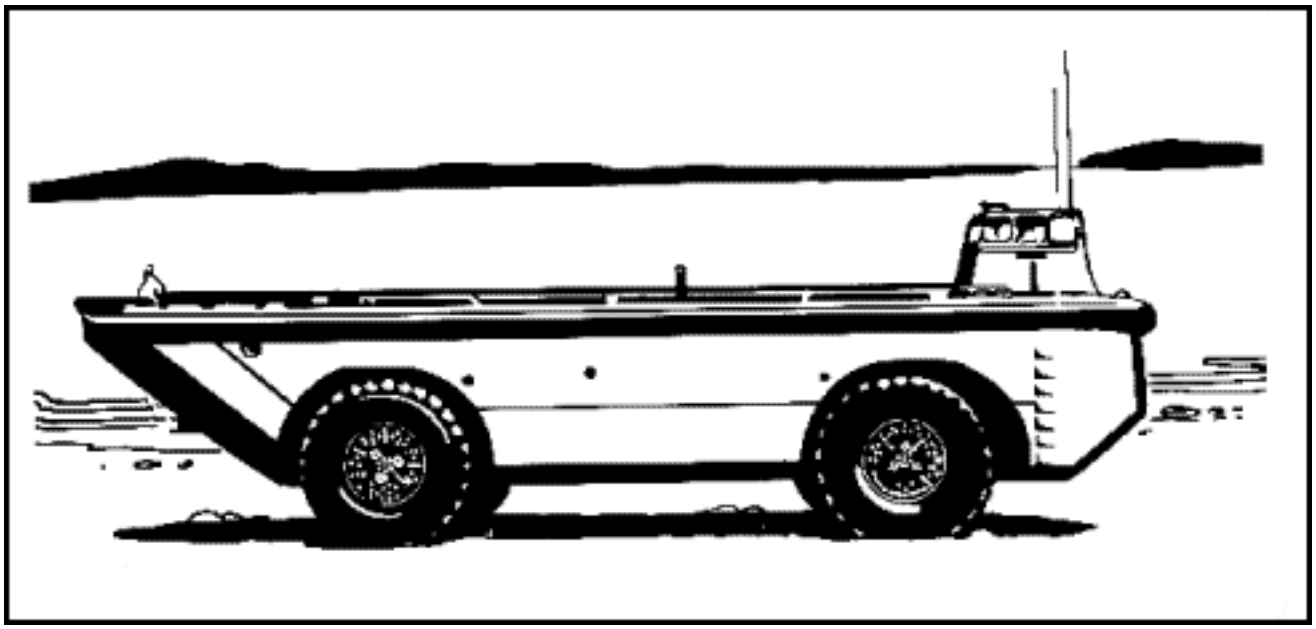


Figure 1-9. Lighter, Amphibious Resupply Cargo, 60-Ton

DESCRIPTION OF THE BARGE DERRICK, 115-TON

1-21. The BD (Figure 1-10) is used to load and discharge heavy lift cargo that is beyond the capacity of a normal ship's gear. This provides the lift and reach needed to discharge the heaviest of projected Army cargo from LMSR's and commercial container ships to accomplish strategic deployment. It is capable of lifting a 75-ton main battle tank from the centerline of a nonself-sustaining ship. The 89-ton BD cannot support this operation. The BD 115-ton is deployable worldwide by towing or heavy lift aboard a submersible heavy lift ship. The characteristics of the vessel are as follows:

Length overall: 200 feet
Beam: 80 feet
Boom length: 220 feet
Capacity: 115 long tons at 80 foot radius
Draft: Light - 7 feet, 4 inches
Crew size: 2 WOs and 13 enlisted

Note: The 89-ton BD has the same mission as the 115-ton BD.

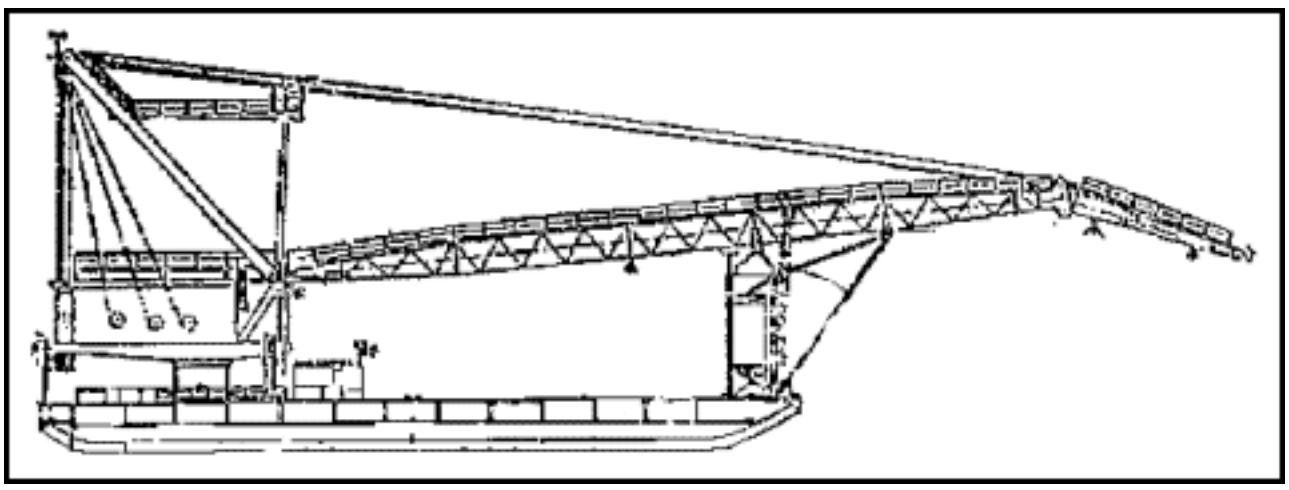


Figure 1-10. Barge Derrick, 115-Ton

DESCRIPTION OF THE DECK CARGO BARGE (BC 231A)

1-22. The Army employs numerous types of barges. The basic configuration is the BC (Figure 1-11). It is used to transport containers, general cargo, and wheeled vehicles. It can be used in harbors, LOTS sites, and on inland waterways. The characteristics of the vessel are as follows:

Length overall: 120 feet
Beam: 33 feet
Displacement (weight): 760 long tons loaded
Cargo Capacity: 585 long tons
Draft: Light - 2.5 feet, loaded - 8 feet
Crew size: 2 enlisted for barge maintenance

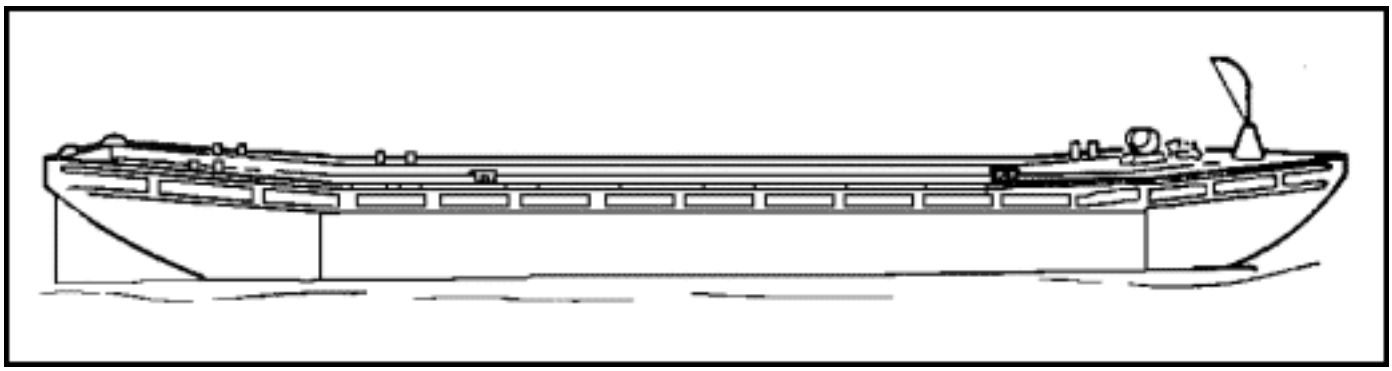


Figure 1-11. Barge Cargo

DESCRIPTION OF THE BARGE DERRICK, 89-TON

1-23. The BD 89T (Figure 1-12) is used to load and discharge heavy lift cargo that is beyond the capacity of the ship's gear. It is commonly called the 100 ton crane, which is the short ton capacity rating. The BD 89T can be towed to overseas locations or deck loaded aboard a semisubmersible ship for transport.

Length overall: 140 feet
Beam: 70 feet
Displacement (weight): 1,630 long tons loaded
Cargo Capacity: 89 long tons at 80 foot radius
Draft: Light: Not available; Loaded: 6.3 feet
Crew size: 2 WOs and 13 enlisted for 24-hour operations

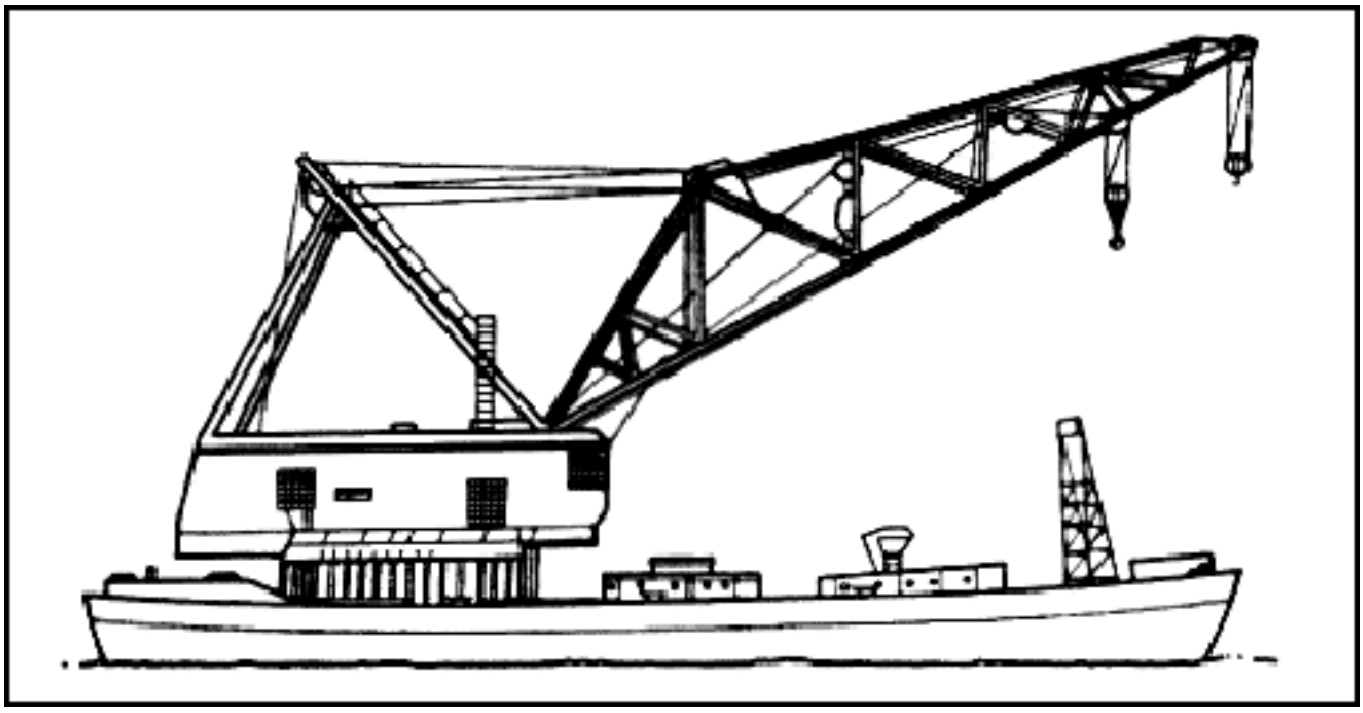


Figure 1-12. Barge Derrick, 89-Ton

DESCRIPTION OF THE BARGE, DECK CARGO (BC 7005)

1-24. The BC 7005 (Figure 1-13) is used to transport containers, general cargo, and wheeled and tracked vehicles in harbors and inland waterways. It is particularly suited for transporting vehicles due to its flush deck without fore and aft sheer. This barge is built without skegs, making it easy to maneuver at port terminals where piers are in close proximity to one another. The BC 7005 can be deck loaded aboard large ships or towed to overseas locations.

Length overall: 110 feet
Beam: 32 feet
Displacement (weight): 120 long tons (light)/690 long tons (loaded)
Cargo Capacity: 570 long tons
Draft: Light: 1.75 feet; Loaded: 7.5 feet
Crew size: 2 enlisted for barge maintenance

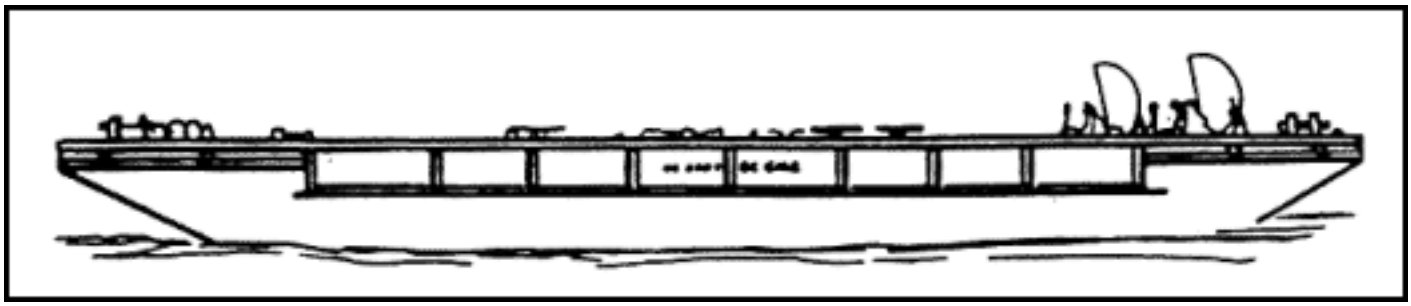


Figure 1-13. Barge, Deck Cargo

DESCRIPTION OF THE MODULAR CAUSEWAY SYSTEM (CAUSEWAY FERRY)

1-25. The CF (Figure 1-14) is used for the movement of rolling, break bulk, and containerized cargo from an oceangoing vessel directly to the shoreside logistics operation or to a fixed or semi-permanent pier. It can support RO/RO and LO/LO operations. The CF is constructed of modular causeway sections and can be deployed aboard container ships and other cargo-type vessels. The characteristics of the CF are as follows:

- One powered modular causeway section.
- Two modular causeway (intermediate sections).
- One combination beach and sea-end section.
- Crew required to assemble and operate consist of 4 enlisted for powered section and 12 enlisted for 24-hour operations.

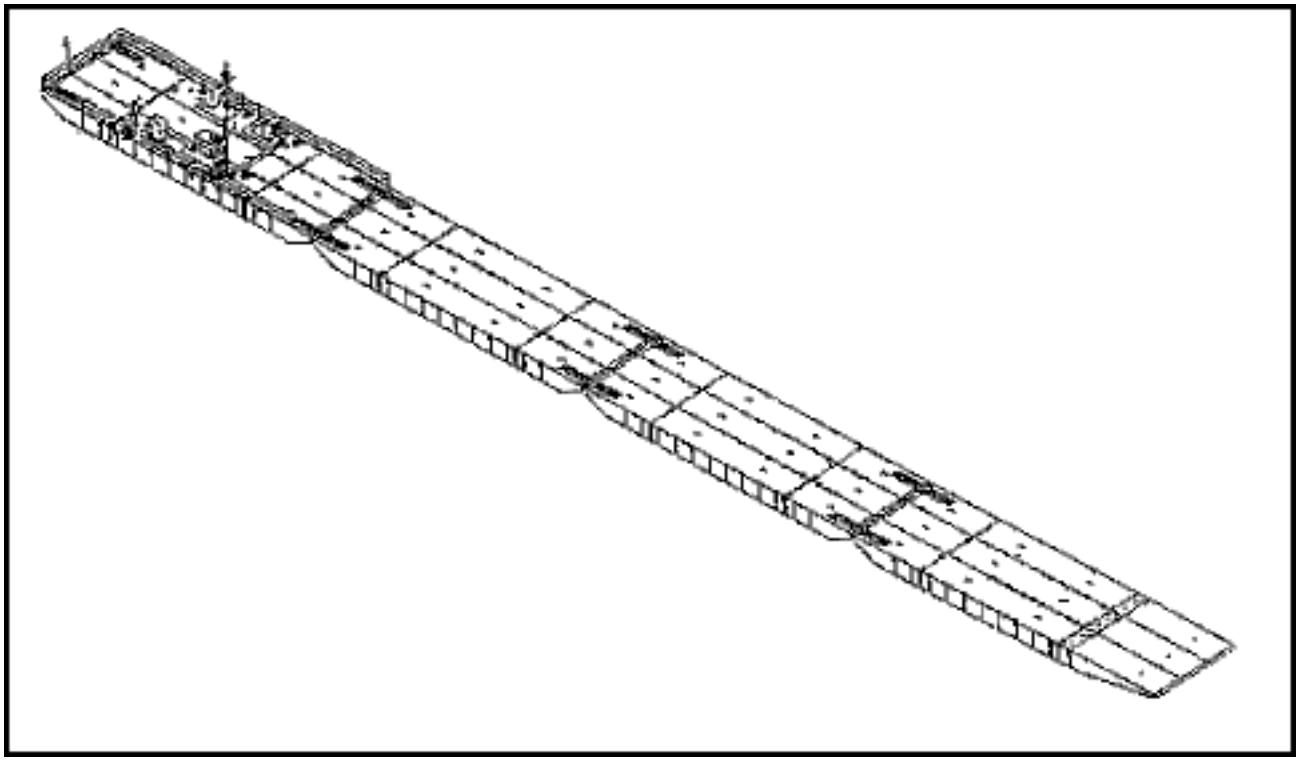


Figure 1-14. Causeway Ferry

DESCRIPTION OF THE MODULAR CAUSEWAY SYSTEM (RO/RO DISCHARGE FACILITY)

1-26. The RRDF (Figure 1-15) provides the essential interface between Army lighterage and RO/RO ships. It receives tracked and wheeled vehicles when driven across the RRDF from the RO/RO ship directly onto an Army lighter moored to the RRDF. The RRDF is constructed of modular causeway sections and can be deployed aboard container ships and other cargo-type vessels. The characteristics of the RRDF are as follows:

- Six modular causeway sections.
- One combination beach and sea-end section.
- Two side-loadable warping tugs.
- One lighting, fendering, and anchoring system.
- Crew required to assemble consist of 11 enlisted for the main section and 20 enlisted (2 crews) for warping tug for 24-hour operations.

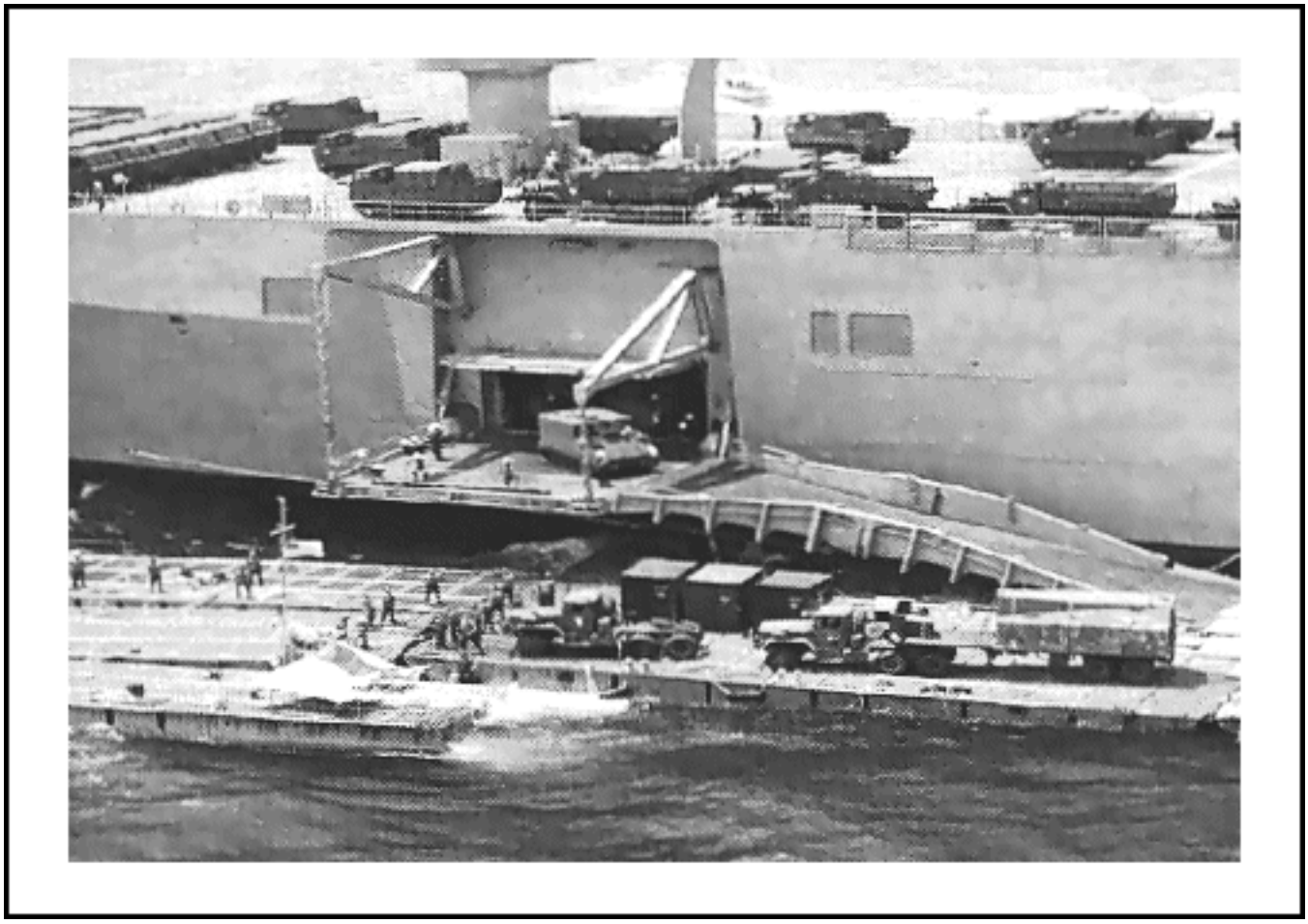


Figure 1-15. RO/RO Discharge Facility

DESCRIPTION OF THE MODULAR CAUSEWAY SYSTEM (FLOATING CAUSEWAY)

1-27. The FC (Figure 1-16) provides a dry bridge for the discharge of cargo from lighters directly to the beach logistics operation. The FC is constructed of modular causeway sections and can be deployed aboard container ships and other cargo-type vessels. The characteristics of the FC are as follows:

- Seventeen modular causeway (intermediate) sections.
- Two combination beach and sea-end section.
- One anchor system.
- Two side-loadable warping tugs (powered sections).
- Crew required to assemble and operate consist of 13 enlisted for the main segment and 20 enlisted (2 crews) for warping tug for 24-hour operations.

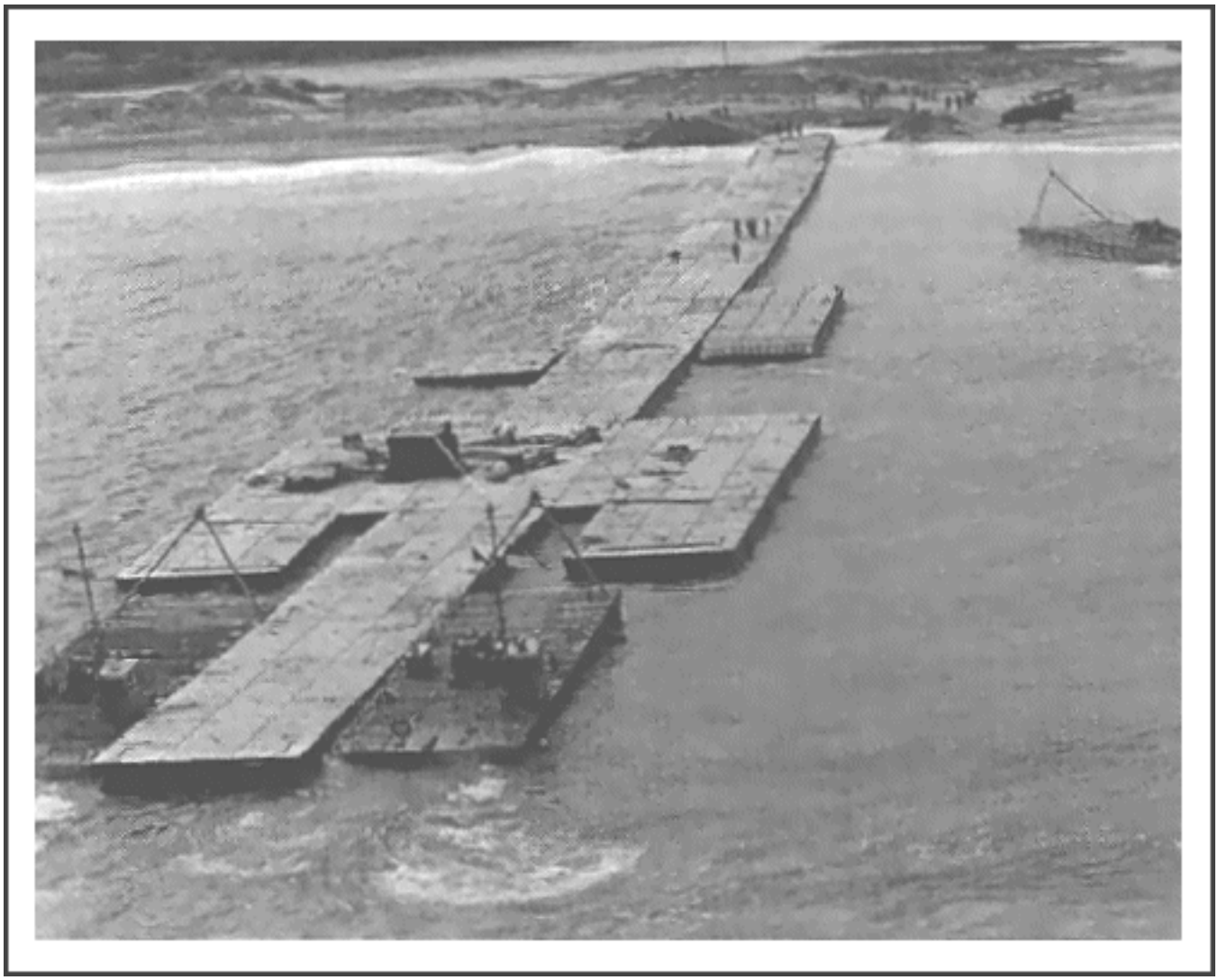


Figure 1-16. Floating Causeway

Search

Chapter 2

Shipboard Life

The successful operation of a watercraft depends directly on the capabilities and knowledge of each crew member. The commanders and the watercraft operators are responsible for ensuring that the watercraft are operated according to federal, state, and DA regulations. This chapter discusses the requirement for marine certification, customs and courtesies, watch standing procedures, shipboard sanitation and pollution control, and the marine logbook.

MARINE QUALIFICATION

2-1. Qualification for marine personnel incorporates a twofold process of certification and licensing. This twofold process is as follows:

- **Certification.** Verifies an individual's knowledge of common marine tasks by MOS and SL.
- Licensing. Verifies that an individual has the knowledge and ability to perform vessel-specific tasks on a designated vessel. Watercraft operators will operate only those vessels for which they are licensed.

ARMY REGULATION 56-9

2-2. This AR prescribes the responsibilities, policies, and procedures for the authorization, assignment, operation, maintenance, sanitation, and safety of Army watercraft. It also defines the procedures for verifying the qualifications of Army marine personnel and for SL and/or vessel type.

MARINE QUALIFICATION BOARD

2-3. The MQB is responsible for evaluating and recommending approval of actions on the issuing, denying, suspending, or revoking of an USAML. The MQB also prepares, administers, and grades the appropriate examinations for the required USAML.

MARINE SERVICE RECORD (DA FORM 3068-1)

2-4. This form is the method that a soldier's sea service is tracked and reported to the MQO. This document becomes a permanent part of each soldier's sea service record and IAW AR 25-400-2 is maintained by the MQO for up to 40 years.

SKILL LEVELS OF WATERCRAFT OPERATORS

2-5. Marine certification is an essential requirement for promotion in the marine field. Advancing from one SL to another requires demonstrated improvement of skills and knowledge. It also requires the recommendation of the commander. The following paragraphs give an overview of deck duties according to SL.

SL 1, USAML Annotated "Seaman (88K10),"Pay Grades E-1 Through E-4.

2-6. A seaman assigned to harbor craft, landing craft, or amphibians will be required (under supervision) to demonstrate the following general seamanship duties:

- Perform marlinespike seamanship.
- Handle mooring lines and hawsers when docking and undocking.
- Perform deck maintenance by using hand and power tools to prepare metal surfaces for painting; maintaining standing rigging, running rigging, and deck machinery. Also follows preventive maintenance procedures.
- Stand helm watch, lookout watch, and towing watch.
- Participate in shipboard emergency drills (such as fire fighting, abandon ship, man overboard, and NBC operations).
- Perform fire and emergency rescue procedures.
- Recognize international distress signals.
- Interpret single-flown international code flags having a special meaning.
- Communicate with other vessels and shore stations using correct radiotelephone procedures.
- Serve as a relief operator.
- Demonstrate a sound understanding of the Army’s environmental ethics.
- Demonstrate the proper response to a fuel spill.

SL 2, USAML Annotated "Watercraft Operator of Class B and Class C Vessels (88K20)," Pay Grade E-5

2-7. The coxswain or amphibian operator is responsible for the operation, maintenance, and welfare of his vessel and crew. Small craft are versatile and are assigned to various types of operations. The craft requires constant maintenance and must be available for dispatch on short notice. The coxswain is required to work side-by-side with his seamen and engineers in maintaining his craft and stowing equipment and gear. The coxswain performs the following:

- Exercises complete charge of his vessel, passengers, and cargo while underway and ensures compliance with safety regulations.
- Handles his craft skillfully when maneuvering or mooring and exercises good seamanship practices at all times.
- Knows the principles of advanced piloting and dead reckoning as well as the use of charts, compass, pelorus, and other navigational instruments.
- Supervises first aid according to the procedures outlined in FM 21-11.
- Maintains an accurate log and keeps fuel and supplies at authorized maximum levels.
- Manipulates the helm and engine controls to dock, undock, beach, and retract during LOTS operations.
- Communicates with other vessels and shore stations using correct radiotelephone procedures.
- Operates the vessel at all times according to COMDTINST M16672.2C

(Navigation Rules, International-Inland).

SL 3, USAML Annotated "Watercraft NCO/Boatswain (88K30)," Pay Grade E-6

2-8. The watercraft boatswain is the senior NCO of the deck crew. He may operate a large amphibian (LARC-LX) or he may supervise the operation of a large or medium amphibian section or squad. Aboard class A vessels the boatswain will:

- Check all deck machinery and equipment for operating condition, reporting all discrepancies to the mate.
- Ensure that the vessel is secured for sea before it leaves its moorings.
- Supervise the stowage of mooring lines and fenders when leaving port.
- Prepare the anchor for use when arriving or departing.
- Responsible to the mate for maintenance of the gear and equipment of the deck department as well as the conduct, discipline, and direct supervision of deck department personnel.
- Assign, under the supervision of the mate, deck department personnel to watches and details.
- Perform the first mate’s duties on craft not authorized a mate.

SL 4, USAML Annotated "Mate, Class A-1 Freight and Towing Vessels Upon Coastal and Inland Waters; Radar Observer (88K40)," Pay Grade E-7

2-9. The mate at this SL can function as either a Quartermaster aboard a class A vessel or be assigned as mate aboard an LCU. The mate acts as assistant to the master and assumes the master’s responsibilities during his absence. The mate is specifically responsible for the following:

- Ensuring that all of the master’s instructions are obeyed.
- Supervising the deck department. When in port, the mate will supervise deck maintenance, cargo operations, and general ship’s business. At sea, the mate will take charge of the navigation of the ship during his watch, inform the master of any unusual circumstances that may arise, know the ship’s position, and ensure that all watch standers are alert and attentive to the details of their duties. Before relieving the watch, the mate will read and initial the remarks in the master’s night order log.
- Keeping up and ordering charts and publications required aboard ship.
- Assisting the master in the pilothouse in adverse weather, in confined waters, or as required.
- Notifying the master when any unusual obstructions to navigation are discovered, when the vessel appears to be approaching danger, and when unusual changes in the weather or other unexpected occurrences are observed.
- Maintaining the prescribed course. When necessary to avoid sudden danger, the mate will take action without awaiting the master’s instructions.
- Being familiar with and complying with federal and local pollution laws.

SHIPBOARD CUSTOMS AND COURTESIES

2-10. The military has many customs and courtesies in which they follow. Watercraft personnel must also follow certain rules of customs and courtesies required aboard ship.

FLYING THE NATIONAL ENSIGN

2-11. There are certain situations and times that the national ensign (Figure 2-1) is flown. The national ensign will be flown 24 hours a day during war or when sailing in unfriendly waters.

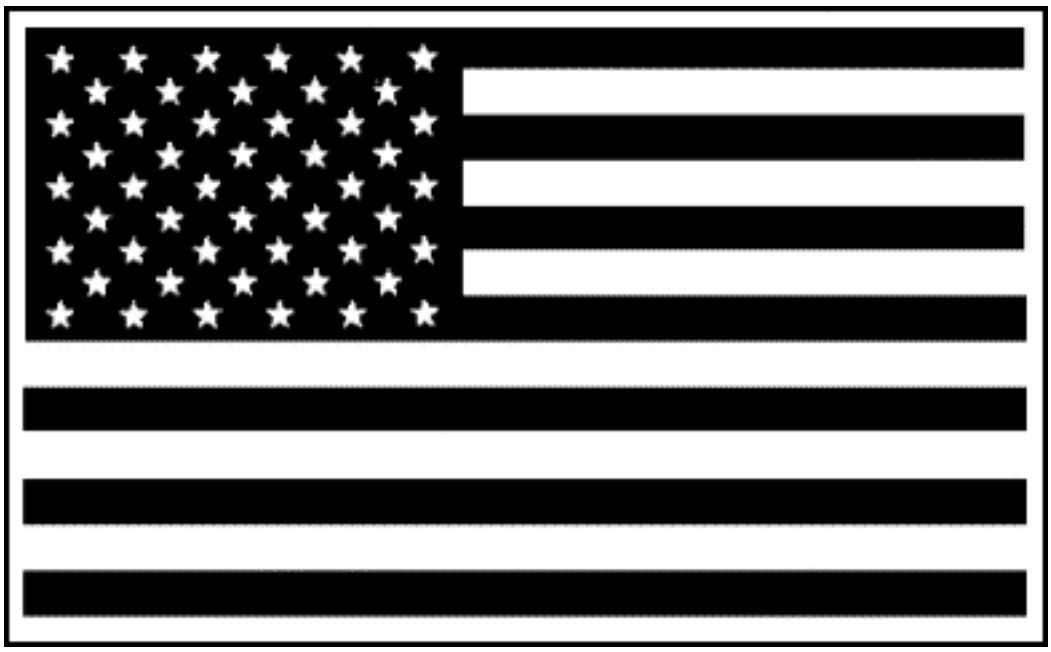


Figure 2-1. National Ensign

Ship Underway

2-12. When an Army ship is underway, the ensign is flown from sunrise to sunset. When underway, class A ships fly the national ensign from the main mast or the aftermast. On ships fitted with only one mast (such as an LCM-8), the ensign is flown from the outboard halyard on the starboard yardarm.

At Anchor or Moored

2-13. When the ship is at anchor or tied up to the pier, the ensign is flown from the flagstaff. The ensign will be flown from 0800 until sunset.

HALF-MASTING THE ENSIGN

2-14. The custom of flying the national ensign at half-mast is observed as a tribute to the dead. The Army follows the half-mast custom carefully and according to specific regulations. Whenever the ensign is to be flown at half-mast, it is first raised to the closed-up position (the top-most position) on the gaff and then lowered to half-mast position. The ensign is flown half-mast during the following times.

Memorial Day

2-15. Memorial Day is a time to remember the US men and women who lost their lives serving their country. On this day, the national ensign is flown at half-mast from 0800 to sunset.

President's Death

2-16. When official word is received of the death of the President of the United States, all US vessels display the ensign at half-mast, starting at 0800 of the following day and for 29 days thereafter. The same ceremony is observed upon the death of an ex-President or President-elect. Upon the death of the Vice President or certain other high government officials, the ensign remains at half-mast for only 14 days.

Death Aboard Vessel

2-17. If a death occurs aboard an Army vessel, the national ensign is flown half-mast until the remains are transferred from the ship. The ceremonies appropriate at Army installations are conducted upon the death of an officer, warrant officer, or enlisted.

CHURCH PENNANT

2-18. The church pennant (Figure 2-2) is unique in that it is the only flag or pennant flown on the same halyard as and above the national ensign. It flies only during divine services onboard Army vessels.

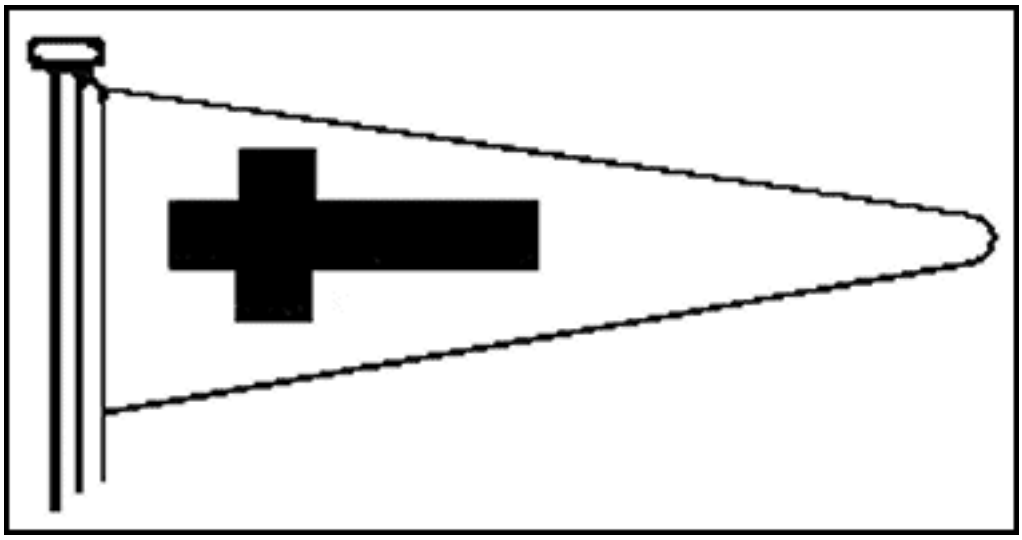


Figure 2-2. Church Pennant

UNION JACK

2-19. The blue, star-studded field in the corner of the US flag is the canton of the national ensign. Since each star represents a state, the canton symbolizes the union of the states of the US. The union jack (Figure 2-3) must be the same size as the canton of the national ensign flown from that particular vessel. The union jack is flown only on those Army ships commanded by commissioned officers or warrant officers. The union jack is flown only when the ship is at anchor or moored to a pier. It is flown from 0800 to sunset from the jack staff at the bow of the vessel. The union jack is raised after the national ensign and lowered before the national ensign at evening colors. When the national ensign is flown half-mast, the union jack is also flown half-mast. The union jack is never dipped as a salute.

TRANSPORTATION CORPS FLAG

2-20. The TC flag (Figure 2-4) is flown from sunrise until sunset on the forward mast. On vessels not fitted with a forward mast, the TC flag is flown from the outboard halyard on the port yardarm unless it interferes with signal flag communications.

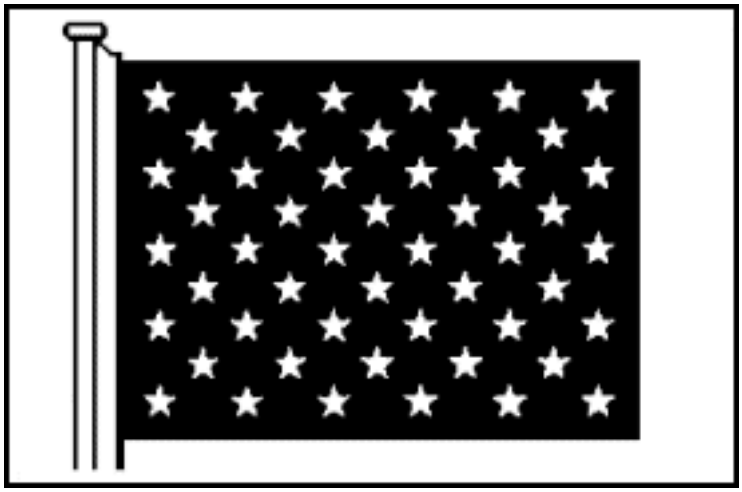


Figure 2-3. Union Jack

Figure 2-4. TC Flag

DRESSING AND FULL DRESSING SHIP

2-21. Ships may be either dressed or full dressed during our national holidays or while in a foreign port during that nation's holidays. Dressing a ship, in honor of a person or event, consists of displaying flags and pennants on various halyards and stays. Usually the port or terminal commander specifies whether to dress or full dress the vessels. The latter is usually ordered when ceremonies are held at the port or terminal. In determining whether to dress or full dress vessels while in foreign ports, masters may be governed by the actions of the foreign nationals.

2-22. Dressing ship is much less elaborate than full dressing. The national ensign is displayed at each masthead when a vessel is dressed. If the masts are all the same height, the ensigns at the mastheads must all be the same size. The largest ensign on board must be hoisted at the flagstaff and a union jack of corresponding size raised on the jack staff. If the occasion is one honoring a foreign nation, that nation's ensign is displayed at the main mast instead of the US ensign. The US ensign must be hoisted on the main mast and other mastheads during all US celebrations.

2-23. The same procedure with the ensigns is followed when a ship is full dressed. A rainbow of the international code flags is also arranged as follows:

- From the jack staff to the fore masthead.
- Between the fore and main mastheads.
- From the main masthead to the flagstaff.

If possible, all Army vessels should have their flags on the rainbow dressing lines in the same order. The flag order starts at the foot of the jack staff and extends to the foot of the flagstaff. This sequence should be repeated if one set of flags does not complete the rainbow. A ship is usually left dressed from 0800 to sunset during these celebrations. Dressing ship is never done when underway. If a ship enters port after 0800 or leaves before sunset on a dress occasion, she dresses or full dresses, as the occasion may be, upon anchoring and undresses upon getting underway.

SALUTES

2-24. Army personnel, whether officer or enlisted, salute the national ensign when boarding a vessel and salute the mate on watch. When leaving the vessel, they give the two salutes in reverse order. The mate on watch returns salutes given him. This courtesy is required only when a vessel flies both the national ensign and union jack.

DECK WATCHES

2-25. At sea, the day is divided into watches of 4 hours each (0000 to 0400, 0400 to 0800, 0800 to 1200, 1200 to 1600, 1600 to 2000, and 2000 to 2400). The 1600 to 2000 watch is sometimes divided into two watches (1600 to 1800 and 1800 to 2000). These are called "dog watches." Changing the watch at 1800 (dogging the watch) breaks the sequence, divides the evening recreational period, and allows the evening meal to be eaten without furnishing a relief section. Generally a late mess is held for the 0400 to 0800 watch. The watch is referred to according to location or type of duty, such as the gangway watch, towing watch, and bow lookout.

WATCH LIST AND QUARTERS LIST

2-26. The watch list specifies the hours and location for each crewman standing watch. Each crewman must check the watch list daily for the time and location of his duty. The quarters list specifies the compartment and location of each crewman’s berth. The watch list and quarters list are posted at any two of the following places aboard ship: crew’s quarters, passageways, crew’s mess, and wheelhouse.

WATCH DUTIES: CLASS A VESSELS

2-27. The dictionary describes the word "watch" (in nautical terms) as the periods of time into which the day aboard ship is divided and also during which a part of the crew is assigned to duty. The watches aboard Class A vessels are usually broken up into four-hour tours. The following guidelines describe how the watch routine function.

Relieving the Watch

2-28. Watches must be relieved 15 minutes before the hour. This allows time for the relief to receive instructions from the man on watch and permits the night relief to accustom his eyes to darkness. The quartermaster of the watch generally assigns watch stations. Once assigned, the relief reports directly to the soldier to be relieved and receives any instructions about the watch (such as targets being tracked and so forth). When he understands the instructions, he first requests permission to relieve the watch from the officer of the deck. Once permission is given, the relief will state loudly, "I relieve you," and then becomes completely responsible for the watch. The relieved watch then reports to the officer of the watch, informing him that he has been relieved. The watch relieving the helmsman follows this same procedure for relieving the off going watch. The helmsman in turn reports to the officer of the watch, informing him that he has been relieved and reporting the course on which the vessel was being steered when he was relieved.

Helm Watch

2-29. The helmsman may be a seaman or a quartermaster. He is responsible for the safe steering, either by compass or by terrestrial objects, as ordered by the master or watch officer. His tour of duty normally consists of a 2-hour watch at the helm. He must know the degree and full point markings of a compass card and the vessel handling characteristics at various engine speeds.

Lookout Watch

2-30. A crewman is stationed in the bow or bridge where he acts as a lookout, reporting anything he sees or hears to the bridge. This information includes ships, land, obstructions, lights, buoys, beacons, discolored water, reefs, fog signals, and anything that could pertain to the navigation of the vessel. When reporting, the lookout names the object and gives the direction to the target using the point system (Figure 2-5) for example, "lighthouse two points on the port bow." If the officer of the watch asks for further information on the object sighted, the lookout describes it as briefly and clearly as possible. When port and starboard lookouts are posted, each lookout keeps watch only on his side of the bridge. Each notes the running lights on his side and reports immediately if the lights are dim or go out. In general, the orders given to the lookout are as follows:

- Remain alert, giving your attention only to your own special duty.
- Remain at your station until you are relieved.
- Keep on your feet; do not sit or lounge.
- Do not talk to others except as required by your duty.
- Speak loudly and distinctly when making a report.
- Repeat a report until it is acknowledged by the officer of the deck.
- When stationed, be sure that you understand your duties.
- Report everything, even if it was reported on the previous watch.

Towing Watch

2-31. Aboard a tug, a member of the deck department is detailed to a towing watch. Normally stationed on the after section of the towing vessel, the crew member:

- Observes how the tow is riding (Figure 2-6) and reports any unusual conditions to the bridge.
- Checks and makes adjustments as required to the towing engine, towing cable chafing gear, and bridles.
- Reports equipment failures immediately to the bridge.

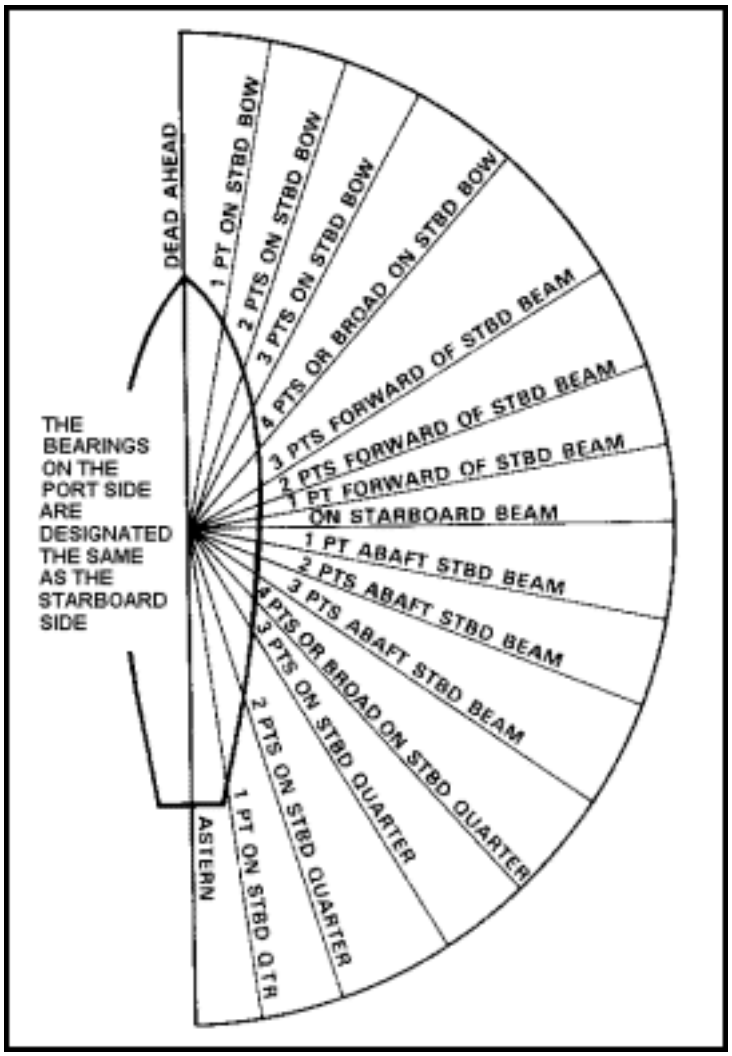


Figure 2-5. Point System

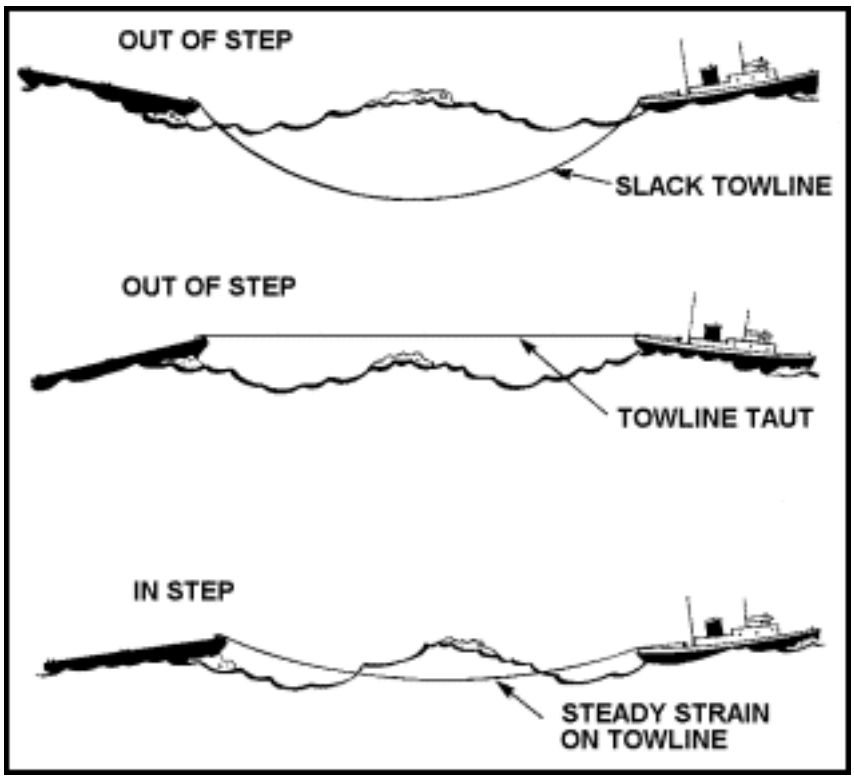


Figure 2-6. Tow Riding In/Out of Step

STANDING NIGHT WATCH

2-32. Night watches are the most critical periods of responsibility for the lookout. Knowing how to stand night watches is necessary to ensure the safety of the vessel. During a night watch, the officer of the watch frequently enters the chart room or other lighted areas. He depends primarily on the lookout to spot objects.

Eye Reaction at Night

2-33. Night vision differs from day vision to a much greater extent than is generally realized. Eyes respond slowly in the dark, picking out a moving object more easily than a stationary object. An object can more readily be seen at night by looking a little to the right or left of it rather than at it directly.

Dark Adaptation

2-34. Developing the ability to see and to recognize distant objects at night is known as "dark adaptation." To compensate for the slower eye reaction at night, the lookout should scan the sky and sea slowly because he may not notice an object until he has looked near it several times. Since an object cannot always be located at night by looking straight at it, the lookout should look above the object. Moving the head from side to side will give an object the appearance of movement, making it easier to locate. To learn to see things at night requires considerable and continual practice.

RULES FOR DEVELOPING AND MAINTAINING DARK ADAPTATION

2-35. A competent night lookout should do the following:

- Take advantage of the 10-minute interval before the hour of his watch to adjust his eyes to darkness.
- Use only a dim red light when a light is necessary.
- Look out of the corner of the eyes when scanning the horizon.
- Scan the region under observation slowly and regularly.
- Wear red dark adaptation goggles that permit vision without disturbing dark adaptation if it is necessary to enter a lighted place.
- Avoid looking at instrument panels, even if they are illuminated by a red light.
- Use light binoculars if available.
- Keep optical equipment clean.
- Refrain from looking at an object already spotted and reported.
- Keep in good physical condition. Fatigue, alcohol, and tobacco reduce dark adaptation.

ANCHOR WATCH AND FIRE WATCH

2-36. A member of the deck crew is detailed as anchor watch and fire watch when the vessel is at anchor or moored. He performs the following:

- Frequently checks the lead and strain on the anchor cable.
- Sounds the fog bell when fog closes in and notifies the watch officer of the weather condition.
- Checks the position of the vessel by taking compass bearings of known objects and checks the drift lead.
- Notifies the watch officer when there is a change in bearings or a strain on the drift lead (which indicates the vessel may be dragging anchor).
- Checks for fire and fire hazards; sounds the alarm in case of fire.

GANGWAY WATCH IN PORT

2-37. A member of the deck department is detailed as security or gangway watch in port to assist the watch officer in maintaining the security of the ship. The crew member on watch takes a position near the gangway to prevent unauthorized persons and contraband from coming aboard. He is also responsible for:

- Tending the mooring lines and gangway during the rise or fall of the tide.
- Keeping the gangway log, that is, recording the activities of the watch, such as noting persons coming aboard or going ashore, the weather, and other information designated by the officer of the watch.
- Notifying the watch officer in case of emergency.
- Maintaining discipline aboard ship and notifying the watch officer of any disorder or unusual circumstances.
- Inspecting the vessel periodically for evidence of fire hazards.

WATCH DUTIES: CLASS B VESSELS

2-38. DA regulations require small craft certification of operating personnel for class B vessels. On these vessels, the duties of the watch consist of performing all the duties and responsibilities of a coxswain or seaman while in command or on duty. The watch (not to exceed a 12-hour shift) on a class B vessel lasts for the duration of the task assigned the vessel.

WATCH DUTIES: CLASS C VESSELS

2-39. Watch duties consist of carrying out all the duties and responsibilities necessary for the safe operation and maintenance of the vessel and its machinery. The general duties assigned are comparable to similar positions on class A or B vessels, although modified to meet the requirements of the assigned mission.

WATCH DUTIES: FLOATING CRANES

2-40. The crane master assigns personnel under his command to watches consistent with the requirement for the operation, maintenance, and security of the crane. Detailed watch standing procedures are developed by the crane master into a SOP and posted for the guidance of the crew.

WATCH DUTIES: NONPROPELLED BARGES

2-41. When nonpropelled barges, other than cranes, are being used, the tug master or propulsion-unit operator are responsible in ensuring that proper security measures are initiated for all the equipment in his charge. When not engaged in operations, security watches for such equipment are provided from personnel in the nonpropelled floating-equipment pool (barge pool). Crewmen assigned to nonpropelled liquid or dry cargo barges help to maintain this equipment and handle lines when the barge is moved.

LOGBOOKS

2-42. Deck and engine department logbooks are maintained according to AR 56-9. The logbooks provide a permanent legal record of the operations and conditions of the vessel and the status of its cargo, crew, and/or passengers.

POLICY

2-43. All occurrences of importance, interest, or historical value concerning the crew, passengers, operation, and safety of Army watercraft will be recorded daily, by watches, in three types of deck logbooks.

The Deck Department Log (DA Form 4640)

2-44. This log is required for use on class A and class B vessels.

The Deck and Engine Log (DA Form 5273)

2-45. This log is required for use on all class B vessels. DA Form 5273 may also be used on the deck or liquid barge, design BG 231B, and the refrigerator barges (BR 7010 and BR 7016).

The Engine Department Log (DA Form 4993)

2-46. This log is required on class A and class C-1 vessels.

2-47. Logbooks will be prepared according to instructions in AR 56-9. Logbooks and other pertinent records must be preserved for use in claims against the US for damage caused by an Army watercraft and for affirmative claim by the US for damage to Army property caused by other vessels or floating objects. Requirements for preserving deck and engine logs as well as other records are in AR 27-series regulations.

2-48. HQDA (DAJAZA) will be notified when a log (or any portion of the log) is to be used in litigation or is to be withheld for any other legal proceedings. When no longer required for the legal proceedings, the log will be returned to the installation having command over the Army watercraft that was involved.

2-49. Commanders having assigned watercraft will periodically review log requirements to ensure that logs are maintained according to provisions in AR 56-9. Amphibians and watercraft under 30 feet do not require maintenance of logs; provided adequate records are maintained by the unit.

MAINTENANCE AND RETENTION OF LOGBOOKS

2-50. The ship’s deck log will be presented to the master or coxswain each day. Should any inaccuracies or omissions be noticed, the master or coxswain will have the necessary corrections made. After corrections have been made, they will approve the log by signing the page. After the log has been approved, no change or addition will be made without the by the master's or coxswain's permission or direction. The mate, on whose watch the matter under consideration occurred, must make any change or addition. When the master or coxswain calls attention to an inaccuracy or omission, the mate will not decline to make a change in or an addition to, the log unless he believes the proposed change or addition to be incorrect. He will, if required, explain in writing to the master or coxswain his reason for the change or addition. The master or coxswain may then make any appropriate remarks concerning the inaccuracy or omission, entering them at the bottom of the page of the log over his own signature.

2-51. When a correction is necessary, a single line will be drawn through the original entry (in red ink) so that the entry remains legible. The correct entry will then be made clearly and legibly. Corrections will be initialed by the person making the original entry and also initialed by the master or coxswain.

2-52. Entries will also be made of all drills and inspections prescribed in CFR 46, paragraph 97.35-1. These entries will be made or underlined in red ink.

2-53. For RCs, nondrill dates will be noted in the log, together with the vessel location, and annotated "nonduty days." Logs will be made available to the area maintenance support activity personnel for entries when applicable.

2-54. Night order books are used aboard class A vessels where sea watches are maintained on a 24-hour basis. Each day the master reviews, updates, and prepares the general standing orders, special orders, and specific instructions for the night watches. Each mate coming on watch must read and sign the night order book.

2-55. Bell logbooks (Figure 2-7) will be maintained on every vessel except those capable of complete engine control and operation from the pilothouse. The time and all changes in engine speed and/or direction must be recorded. Vessels with pilot-house control are also included when using the bell system.

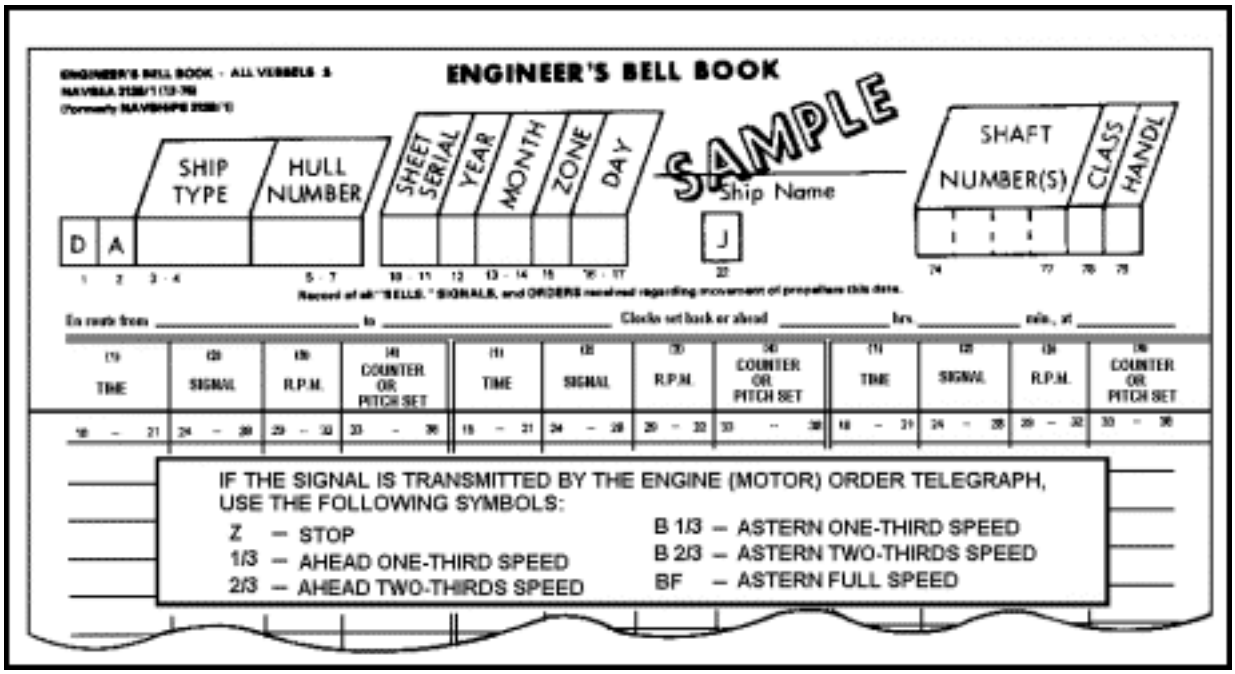


Figure 2-7. Engineer's Bell Book

2-56. A logbook will be retained for 5 years as the onboard record of the deck and engine departments. At the end of this period, it will be destroyed according to the AR 25-series of regulations.

OIL RECORD BOOK

2-57. In addition to required deck and engine logs, class A and class B vessels will maintain a record of ballasting or cleaning of bunker fuel tanks and disposal of oily residues from bunker fuel tanks. Other exceptional discharges of oil will also be recorded. All masters, coxswains, and chief engineers of class A, B, and C-1 vessels and assigned crews will comply with oil pollution regulations cited in this paragraph. Oil record books will also be kept for 5 years.

MODIFICATION OF LOGBOOKS

2-58. Make changes to individual log sheets by drawing ruled lines in ink and then making appropriate entries on them. Changes are required for floating cranes to show the number and weight of heavy lifts made, as well as any other entries appropriate to the type of service in which employed.

COMMUNICATION LOGBOOK

2-59. The vessel master or coxswain will ensure that the following logs are maintained.

Bridge-to-Bridge (VHF-FM)

2-60. For vessels equipped with bridge-to-bridge VHF-FM radio/telephone, this record may be kept on the logbook. Each page shall be dated and identified by the vessel name or number. The log of the bridge-to-bridge station (channel 13, 156-650 MHz) shall include, as a minimum, the following entries:

- All radio/telephone distress and alarm signals, all communications transmitted or intercepted, and any information heard which might be of importance to maritime safety. Text should be as complete as possible, including the time, frequencies used, and position of vessel in distress.
- The times when watch is begun, interrupted, and ended.
- A daily entry concerning the operating condition of the radio.

Military Tactical Communications

2-61. For vessels equipped with military tactical communication capability, records and procedures shall be according to existing Army regulations.

High Frequency and Low Frequency Communications

2-62. On vessels equipped with HF or LF communication ability, a record of the following shall be kept as a minimum:

- Name of the operator on watch. The entry "On Watch" is made by the operator going to watch. The entry "Off Watch" is made when an operator is relieved or the station is closed down. The operator’s signature must accompany both entries.
- All calls and replies to calls, the call sign of station called, the time that traffic is handled, and the frequency and mode used. The time that traffic is handled shall be noted as "Time In" to note when a communication begins and "Time Out" to note when a communication is completed. Times shall be suffixed for the applicable time zone.
- Cases of unlawful interference and failure of equipment.
- The full text of distress, urgent, and safety messages.
- Results of tests of autoalarm receivers, including the times that the autoalarm is in operation.

RETENTION/DISPOSITION OF RADIO LOGS

2-63. Radio logs will be kept by calendar year. They will be kept for a period of 1 year after the last entry. Station logs involving communications, incident to or involved in distress, disaster, or accidents will be kept for a period of 3 years after the last entry is made.

SHIPBOARD SANITATION

2-64. Cleanliness and sanitary conditions are essential since personnel aboard ship live and work in restricted quarters. The health of each crew member is the concern of all aboard, as any infection or unhealthy habit can affect the overall health or efficiency of the crew.

SANITATION

2-65. High sanitary standards must be set to protect the crew from infection and illness. Conditions aboard ship should include:

- Adequate cleaning and laundry facilities.
- Adequate locker space for each member of the crew.
- Clean and orderly quarters.
- Recreation facilities separate from the crew's sleeping quarters.
- Adequate ventilation and temperature control in the crew's quarters.
- Enough storage space for refrigerated foods, dry storage, vegetables, and dairy products.
- Proper food handling and storage.
- A daily balanced diet for the crew.
- Rodent control. Rat guards should be used on the mooring lines and traps (if required) inside the vessel.
- Insect control. Cleanliness and the use of powders, insecticides, and fumigation.
- Water purification. Water will be chlorinated if there is any doubt of its purity.

PERSONAL HYGIENE

2-66. This is something that must be done by each crew member. Aboard ship, crew members can do this by:

- Wearing clean and dry clothing.
- Bathing at least once a day.
- Washing their hands after using the toilet facilities.
- Keeping their fingernails and toenails clean and clipped.
- Brushing their teeth after each meal or at least once a day.
- Getting the proper sleep and rest.
- Doing some type of physical exercise on a daily basis.

TAKING POTABLE WATER ABOARD SHIP

2-67. Using improper or careless procedures when taking potable water (water suitable for drinking) aboard ship can result in contaminated water being introduced into the drinking water system. The following describes the operational procedures that will be followed to provide for the safe and sanitary intake of water aboard ship.

Potable Water Hoses/Risers

2-68. Hoses will be labeled "POTABLE WATER ONLY" at 10-foot intervals and used only for that purpose. Potable water risers will be labeled "POTABLE WATER" and color- coded light blue. Also ensure the following:

- The end couplings of the hoses will be color-coded light blue.
- When not in use, potable water hoses will be rolled, coupled, or otherwise protected from contamination and stored.
- Hoses will be stored in a vermin-proof, closed locker specifically designated for potable water hose storage. Preferably, the locker will be located off the weather decks, installed 18 inches above the deck and labeled "POTABLE WATER HOSE."
- All risers will be equipped with screw caps and keeper chains.

Making the Ship-to Shore Potable Water Hose Connection

2-69. The following procedure will be used when making ship-to-shore potable water connections.

- Before making the potable water connection, disinfect the potable water risers on the vessel and the shore facility. Do this by preparing a chlorine solution and immersing or swabbing the risers with the solution.
- To disinfect the insides of the hoses, fill them with a chlorine solution and allow to stand for 2 minutes. To do this, elevate both ends of the hose, pour required amount of chlorine agent into one end, and fill remainder of hose with water.
- Open the valve on the shore supply and flush for 15 to 30 seconds to remove any debris which may be present in the piping.
- Connect the potable water hose to the shore facility riser. After disinfection of the vessel riser, the ship connection can be made and transfer of water initiated.

If during the transfer or connection procedures the hose is contaminated by hanging into or dropping into the harbor water, pumping operations will be stopped and the hoses disinfected.

NOTICE: All water supplied by public or private systems outside the US should be considered of doubtful quality. If doubt exists as to the quality of the water, medical authorities ashore should be requested to evaluate the source and provide recommendations to the vessel commander.

WATER POLLUTION CONTROL

2-70. The US government has passed many laws to protect our country’s natural resources starting with the River and Harbor Act of 1899 (which is still in use today) to the Federal Water Pollution Control Act of 1970 and later amendments. These federal laws are concerned with the dumping of sewage and garbage and oil pollution of our navigable waters.

POLICY FOR ARMY VESSELS

2-71. New Army vessels and older vessels going into the shipyard for overhaul and rehabilitation are now fitted with a filtering system and holding tanks. There will be no more overboard discharge of vessel-generated waste (sewage, laundry drains, galley waste, slop oil, and so on).

Vessels at Sea

2-72. When sailing in any waters, Army vessels will not discharge vessel-generated waste, throw garbage overboard, or create oil pollution.

Vessels in Port

2-73. When in port, Army vessels will discharge their holding tanks, slop oil, and sludge either into fixed shore disposal facilities or make arrangements with the shore authorities to bring alongside tank trucks or barges fitted for this task. Some ports have a disposal system where oil can be returned for reprocessing while others may provide only storage barrels. Make use of whatever is provided.

OIL POLLUTION

2-74. Any substance that will create a visible sheen on the surface of the water or create an emulsion on or below the surface will constitute as an oil spill. This may consist of only one cup of oil or oil product. Vessel personnel will not dump the following over the side:

- Soapy water.
- Galley water.
- Garbage.
- Paint, thinner, kerosene, or other oil-base products.
- Sanitary waste.

OIL TRANSFER PROCEDURES (INCLUDES TAKING ABOARD FUEL OIL)

2-75. Title 33, Code of Federal Regulations, Parts 154, 155, and 156, were written by the US Coast Guard based on the Federal Water Pollution Control Act. Their purpose is to prevent, as much as possible, any accidental oil spills.

2-76. Part 156 of the regulation concerns the actual oil transfer operations. The regulation states: "No person may transfer oil to or from a vessel unless--

- The vessel’s moorings are strong enough to hold in all expected weather conditions.
- Hoses or arms are long enough to allow the vessel to move at its mooring without strain on the hose or arm.
- Hoses are supported, so that couplings have no strain on them.
- All parts of the transfer system are lined up before beginning the transfer.
- All parts are blanked or shut off.
- The transfer system is connected to a fixed piping system on the receiving end.
- Overboard discharge or sea suction valves connected to the transfer system are sealed shut during oil transfer.
- Transfer hoses are in good shape--no cuts, slashes, or soft spots.
- Flange couplings are properly bolted.
- Discharge containment equipment (such as drip pans) are in place.
- Scuppers and drains are plugged.
- Communications are available between the vessel and facility.
- An emergency shutdown system is available.
- Enough people to do the job are on duty.
- The person in charge on the vessel is able to speak to the person in charge at the facility (translators must be available if there is a language difference).
- The person in charge on the vessel and the person in charge at the facility holds a meeting (to discuss the transfer operation) before starting the transfer.
- Both persons in charge agree to begin the transfer before it is started.

- Both persons in charge are present during the transfer.
- Required lighting is available at night.

2-77. Part 156 also describes what is meant by proper connections in oil transfer systems. The regulation states that the materials, in joints, must make a tight seal. If a coupling is a standard ANSI coupling, at least four bolts (one in every other hole) must be used. If it is not a standard ANSI coupling, a bolt must be used in each hole. Bolts must be of the same size in each coupling and be evenly tightened. Bolts must not be strained or deteriorated. Unless authorized by the Coast Guard, no quick-connect coupling may be used.

ACTION TO TAKE IN EVENT OF AN OIL SPILL

2-78. US Code, 40 CFR, 110.10 Notification, states that when an oil spill occurs, the person in charge of the vessel, an onshore facility, or an offshore facility must immediately notify the appropriate federal agency. The maximum fine for failing to report an oil spill is 1 year in prison and a fine of up to $10,000. When in a military port area, notify the harbor master immediately. The harbor master's office will in turn notify the US Coast Guard National Response Center. If finding an oil spill in an area outside of military control (within CONUS), notify the National Response Center on their TOLL FREE number 1-800-424-8802. Provide them with the following information:

- Identify yourself.
- Give the area of pollution.
- If possible, state how much and what type of pollution is involved.

Small oil spills, especially those with heavy oils, tend to be cumulative. This means that every time oil is spilled, it tends to join with oil already in the water and increases the problem.

DISCHARGE CONTAINMENT AND CLEANUP

2-79. When oil is accidentally discharged into water, there are two things that should be done after reporting the discharge. The oil should be contained or fenced in to prevent the slick from spreading. Containment is usually more desirable in the case of heavy oil spills. Because of possible dangers of fire from light oils, such as gasoline and kerosene, it is sometimes better not to contain these spills. The proper people who will consider all the problems involved must make the decision. As much oil as possible, must be removed from the water.

2-80. Since oil floats on water, much of it can be contained up to a point. However, weather conditions, tides, and currents can make it more difficult to contain the oil on the surface and can cause the oil and water to mix or emulsify. This also makes it harder to clean up.

2-81. The most common type of containment device is a boom. Booms are basically floating fences used to surround a patch of spilled oil. There are many types of booms, made of many different materials like wood, cork, or plastic. The simplest boom is a chain of logs or lumber. Some booms have skirts that hang down in the water and some are blown up with air like long balloons. Some are towed out to the area of the spill and others are permanently mounted in areas where oil is transferred. Oil can also be contained with a special system that allows a stream of air bubbles to escape from submerged permanent piping.

2-82. Removal of oil from water is done by different methods. Special suction equipment can be used to suck up the oil like a big vacuum cleaner. Skimmers (small boats that skim across the surface of the water to pick up the top layer of oil and water) are used in some places. Dockside or barge-mounted skimmers are also used to skim the surface oil.

ACCIDENT REPORTS

2-83. A report of the accident must be made immediately on DA Form 285 whenever an accident occurs during the loading or unloading of a vessel that results in bodily injury or damage to a vessel, cargo, or Army property. This is required whether the loading or unloading was being performed by DA personnel (military or civilian) or by contract stevedores. The report is prepared according to AR 27-20 and AR 385-40 and submitted according to AR 385-40. The military or civilian supervisor directly in charge of the work completes the report and forwards it to the commander of the installation or to someone designated by the commander to receive such reports. A copy of all written reports, DA Form 285, and any other information concerning an accident is forwarded to the Marine Safety Office, Fort Eustis, VA.

2-84. Whenever a vessel or any other floating equipment damages waterfront property owned or controlled by the Army, the property accountable officer of the pier, wharf, or other waterfront facility reports the damage on DA Form 285.

THE INITIAL REPORT

2-85. Any damage to a vessel or its cargo, any injury to personnel, or any damage to other vessels or property may be reportable. Whether it is reportable or not depends on the amount of the damage or injury. A collision estimated at $50.00 worth of damage might be worthy of a written report in one command, while in another command that collision estimate would require a log entry only. Your command should specify its limit concerning reportable accidents.

2-86. When the situation is under control and facts have been gathered, an initial report must be made and sent out. The following information should be included on the initial report if circumstances permit:

- Name and official number of the vessel involved.
- Nature of the accident (what, where, when, and how).
- Present location of the vessel.
- Names and addresses of persons injured (if available).
- Extent of damage to the vessel and its cargo.
- Name, official number, and ownership of any other vessels involved (if available).
- Salvage services being given or received. If an Army vessel is being salvaged, a statement is required as to whether or not the salvage is being performed under contract.
- A statement of whether or not the Army vessel is able to proceed and, if not, the length of delay expected.
- A statement of whether or not the damage can be repaired at sea, in the port, or waterway in which the vessel is located and how long before repairs will be completed.

This format is arbitrary and can be altered as desired by the local commander.

From Whom

2-87. The initial report should come from the vessel master or his next in command in the event of the master's injury or death. In the case of an unmanned vessel, the report will be made by the commander with custody of the vessel or having knowledge of the event.

To Whom

2-88. When the accident occurs at or near the home port, the report must be made to the port commander or his representative designated to receive such information. If the accident occurs away from the home port, the report is made according to the instructions of the home port commander and of the installation and command under whose immediate control the vessel is operating. If there are no such instructions, the report will be made to the commander or Army port having operational control of the vessel, who will in turn relay the message to the vessel's home port.

2-89. The report should be made as quickly as possible using the fastest means available. Radio, telephone, cable, Telex, and telegraph are just a few of the ways it can be sent.

THE WRITTEN REPORT

2-90. When an Army vessel is involved in an accident, a written report is due from the vessel master within 30 days following the accident. There is no DA printed form for the report, but what must be included is found in AR 385-40. Locally reproduced forms are available in some units.

2-91. An original and seven copies of the report must be made. If the accident occurs in or near the home port, the original and six copies must be sent to the vessel's home port commander or the person he designates for that purpose. If it occurs while the vessel is under the operational control of another command, it is sent to that command. If the vessel is operating overseas and a US Army port or installation is not available, the report should be sent to the nearest diplomatic or consular office with a request that all copies be forwarded to the commander of the vessel's home port.

2-92. A written accident report is not necessary under the following conditions:

- As a result of enemy or combat action while in a convoy under naval escort or during combat or landing operations. However, unescorted vessels do require reports even though the accident was the result of a combat action.
- As a result of damage while beaching during training exercises or normal ship-to-shore operations where damage can be expected because of the peculiarities of the operation. However, this is true only if there was damage to US government property, if there was no death or serious bodily injuries to personnel, and if first notice shows that the damage was not due to negligence or incompetence.

WHEN AN INVESTIGATION IS REQUIRED

2-93. Immediate responsibility for investigating an accident belongs to the commander of the port or other installation in whose jurisdiction or vicinity the accident occurred or to the commander of the first Army port of arrival of the vessel or its survivors. The investigating officer investigates the accident whenever any of the following circumstances exist:

- Government property has been lost, damaged, or destroyed that exceeds in the amount of $500; or circumstances indicate the existence of a claim in favor of the government.
- Property other than that owned by the government has been lost, damaged, or destroyed.
- The accident involved bodily injury causing disability for more than 3 days or death.
- Salvage service of a substantial nature has been given to an Army vessel or by the Army to any vessel.
- A claim has been made under the Army Maritime Claims Settlement Act, notice of intention to make such a claim has been given, or a claim under the Act is indicated.
- An investigation is in the interest of the government.

KEEPING EVIDENCE

2-94. All logbooks onboard an Army vessel, when a serious accident occurs, are to be carefully preserved aboard the vessel until the investigating officer gives instructions for their disposition. The master in charge at the time of the accident and his successors are required to preserve the logbooks. If it is necessary to retire a logbook before disposal instructions are received from the investigating officer, the master informs the person responsible for receiving the logbook of its status. This person then requests instructions from the investigating officer and retains the logbook until disposal instructions are received.

2-95. If it appears that breakdown or failure of machinery or equipment contributed to a serious accident involving an Army vessel, the malfunctioning and broken parts must be carefully marked for identification. The parts must be preserved aboard the vessel until the accident investigating officer gives instructions for their disposition.

2-96. The unit commander or the civilian supervisor must preserve all malfunctioning and broken parts if a breakdown or failure of machinery or equipment used in cargo handling appears to have caused or contributed to a serious accident in loading or discharging a vessel. He holds these parts until he receives disposal instructions from the investigating officer. If the physical evidence is private property or the property of another government agency, the commander or supervisor must ask the owner to give him the property or to preserve it for him.

2-97. When a civilian employee of the government or a government contractor is injured, all of that person’s current records (such as time sheets, time slips, and work sheets) will be held, pending instructions from the investigating officer.

THE INVESTIGATING OFFICER

2-98. The commander of each overseas command, terminal, or other installation under whose immediate control an Army vessel operates should designate by written order, a commissioned officer, a warrant officer, or a qualified civilian as the investigating officer of the command. The person appointed must be an officer or warrant officer of the Judge Advocate General’s Corps or a civilian experienced in conducting investigations, trained in maritime law, and familiar with vessel-operating standards and practices.

2-99. When such personnel are unavailable within the command, an officer, warrant officer, or civilian experienced in the marine field may be appointed to carry out the duties of investigating officer until a qualified person can be obtained. A civilian or warrant officer may not serve as an investigating officer or board member when the pertinent law or regulation requires that the investigating officer or board member be a commissioned officer.

2-100. The investigating officer investigates any accident involving damage to property, loss or destruction of property, or bodily injury or death. The officer's investigation covers all phases of the accident and its future bearing on the interests of the service, including the following:

- Possible claims against the government or in its favor.
- The line-of-duty status of military personnel.
- Survey matters.
- The necessity for special reports of fires, explosions, storms, and other serious occurrences.
- The question of whether the circumstances call for disciplinary action under Article 139 of the UCMJ.

THE SCOPE OF INVESTIGATION

2-101. The investigating officer, when planning his investigation, reviews the purpose of the investigation and the use to be made of his report. He makes sure that his investigation covers all pertinent aspects of the accident and that its scope is according to the nature and extent of the accident. The following guidelines should assist an officer in determining the scope of an investigation.

- When the accident involves government personnel or property only, the possibility of a claim may generally be disregarded.
- When government property is damaged by a General Agency Agreement vessel, a privately-operated Navy tanker, or any other government vessel covered by protection and indemnity liabilities insurance. The investigation should be extensive enough to develop a claim against the operator.
- Whenever government property is destroyed or damaged through the willful misconduct or gross negligence of government personnel, sufficient information should be developed to determine whether claims action should be taken against those personnel.

ACTIONS OF THE INVESTIGATING OFFICER

2-102. In investigating the accident and preparing a report, the investigating officer takes as many of the actions listed below that are pertinent and appropriate under the circumstances.

- Issues instructions on preserving evidence. That is, he determines whether broken parts of equipment or machinery that may have caused the accident or contributed to it are to be retained or disposed. If they are to be retained, he arranges for storage and safekeeping of all logbooks, records, time sheets, and so forth, necessary or desirable to have preserved for claims or litigation. He makes a note of this action in his report and keeps an additional record in the office of the staff judge advocate.
- Arranges a prompt survey of any damage sustained and of machinery parts, and so forth, that may have caused the accident or contributed to it by breakdown or failure to operate properly. When competent government personnel are not available to make the survey, commercial marine surveyors may be employed.
- Secures a signed statement, preferably sworn, from each person with knowledge of pertinent facts and circumstances. Getting such statements promptly is of the utmost importance in obtaining the accurate, uncolored evidence necessary for proper action on any claim. Statements of witnesses whose testimony is merely cumulative and not likely to be adverse to the interest of the government are not required.
- Prepares a list, giving names and addresses of all witnesses. The list is to be included in the report of accident and the report of claims officer.
- Reviews the report of accident. Considers all the information and evidence obtained from any previous inquiry or investigation of any aspect of the accident.
- Coordinates with any other DOD agency involved in the accident. Obtains copies of surveys and reports which that agency makes and avoids any unnecessary duplicate investigation.
- Conducts (fairly and impartially) any further investigation required to develop pertinent facts and information.
- Makes every effort to clear up disputed matters and to determine the facts of all pertinent issues.
- Prepares his report on DA Form 1208.

Chapter 3

Vessel Terms and Definitions

The watercraft operator must know and use the correct terms for following commands and instructions. He must also know the general layout of his vessel. Some terms, which are necessary to an understanding of structural and operational nomenclature, are not explained in this chapter. These terms are explained in their appropriate chapter or in the glossary. The terms used in this chapter are the same on all types and sizes of vessels.

NAUTICAL TERMINOLOGY

3-1. The floors of a ship are called decks, the walls are called bulkheads, and the stairs are called ladders. There are no halls or corridors in a ship, only passageways. There are no ceilings in a room, only the overhead in the compartment. Openings in the outside of the ship are ports, not windows. Entrances from one compartment to another are called doors. Openings from one deck to another are called hatches. The handles on the watertight hatch or door are called dogs.

3-2. When you close a door or watertight hatch, you secure it. If you close down the dogs on the door or hatch, you dog it down. You never scrub the floor or wash the walls, rather you swab the deck and scrub the bulkheads. When you get up to go to work, turn to. You never go downstairs, you lay below, and if you are going up from one deck to another, you lay topside. If you are going up the mast or into the rigging you are going aloft.

STRUCTURAL PARTS OF THE HULL

3-3. The hull (Figure 3-1) is the main body of the ship below the main outside deck. The hull consists of an outside covering (or skin) and an inside framework to which the skin is secured. The skin and framework are usually made of steel and secured by welding. However, there may still be some areas where rivets are used. The steel skin may also be called shell plating.

3-4. The main centerline structural part of the hull is the keel, which runs from the stem at the bow to the sternpost at the stern. The keel is the backbone of the ship. To the keel are fastened the frames, which run athwartship. These are the ribs of the ship and gives shape and strength to the hull. Deck beams and bulkheads support the decks and gives added strength to resist the pressure of the water on the sides of the hull.

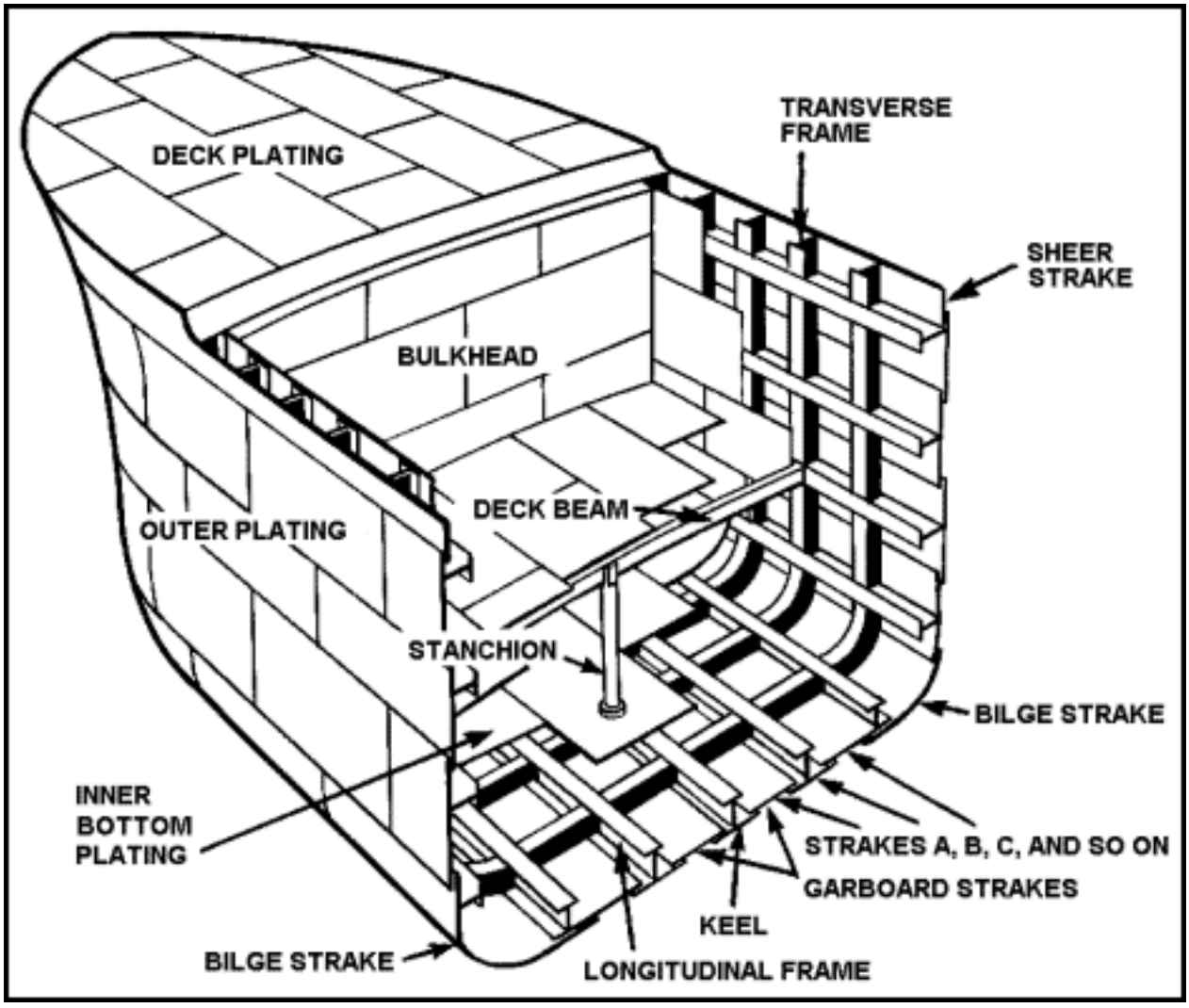


Figure 3-1. Construction of a Hull

SKIN

3-5. The skin, or shell plating, provides water-tightness. The plates, the principal strength members of a ship, have various thickness. The heaviest plates are put on amidships. The others are put on so that they taper toward both ends of the ship (from the keel toward the bilge and from the bilge toward the upper row of plates). Using plates of various thickness reduces the weight of the metal used and gives the vessel additional strength at its broadest part. The plates, put on in rows from bow to stern, are called strakes. They are lettered consecutively, beginning at the keel and going upward.

STRAKE NAMES

3-6. The bottom row of strakes on either side of the keel, are called garboard strakes. The strakes at the turn of the hull, running in the bilge, are bilge strakes. The strakes running between the garboard and bilge strakes are called bottom strakes and the topmost strakes of the hull are sheer strakes. The upper edge of the sheer strake is the gunwale.

BULKHEADS

3-7. The interior of the ship is divided by the bulkheads and decks into watertight compartments (Figure 3-2). A vessel could be made virtually unsinkable if it were divided into enough small compartments. However, too many compartments would interfere with the arrangement of mechanical equipment and the operation of the ship. Engine rooms must be large enough to accommodate bulky machinery. Cargo spaces must be large enough to hold large equipment and containers.

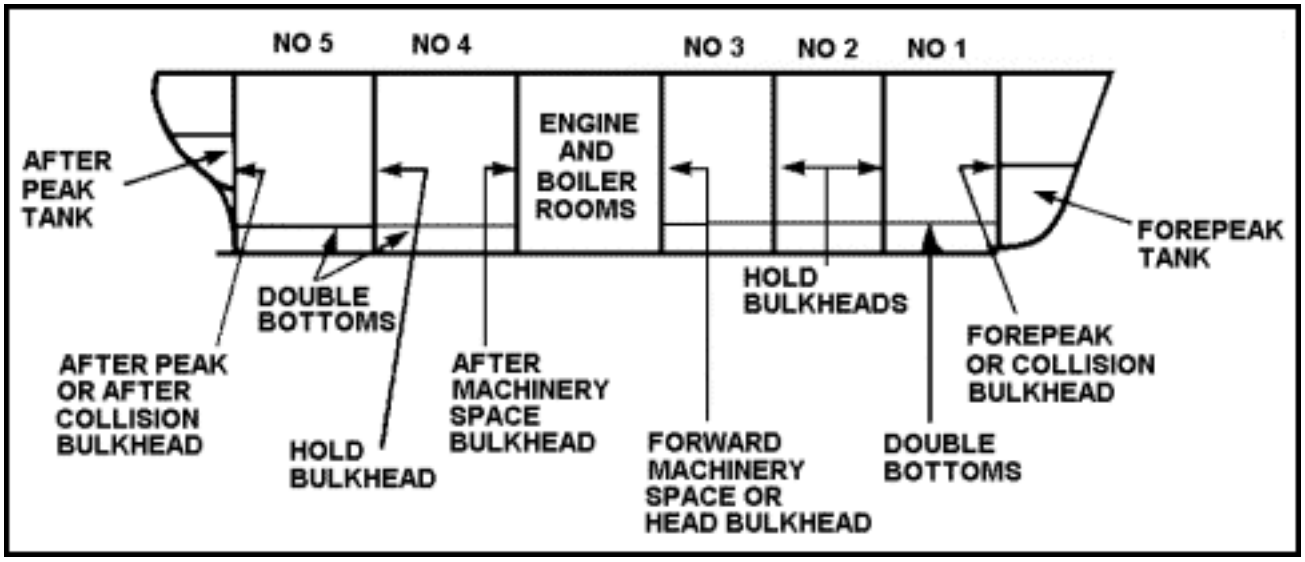


Figure 3-2. Bulkheads and Decks

ENGINE ROOM

3-8. The engine room is a separate compartment containing the propulsion machinery of the vessel. Depending on the size and type of propulsion machinery, other vessel machinery may be located there (such as generators, pumping systems, evaporators, and condensers for making fresh water). The propulsion unit for Army vessels is a diesel engine. The "shaft" or rod that transmits power from the engine to the propeller leads from the aft end of the engine to the propeller.

EXTERNAL PARTS OF THE HULL

3-9. Figure 3-3 shows the external parts of the hull. The waterline is the water-level line on the hull when afloat. The vertical distance from the waterline to the edge of the lowest outside deck is called the freeboard. The vertical distance from the waterline to the bottom of the keel is called the draft. The waterline, draft, and freeboard will change with the weight of the cargo and provisions carried by the ship. The draft of the ship is measured in feet and inches. Numbered scales are painted on the side of the ship at the bow and stern.

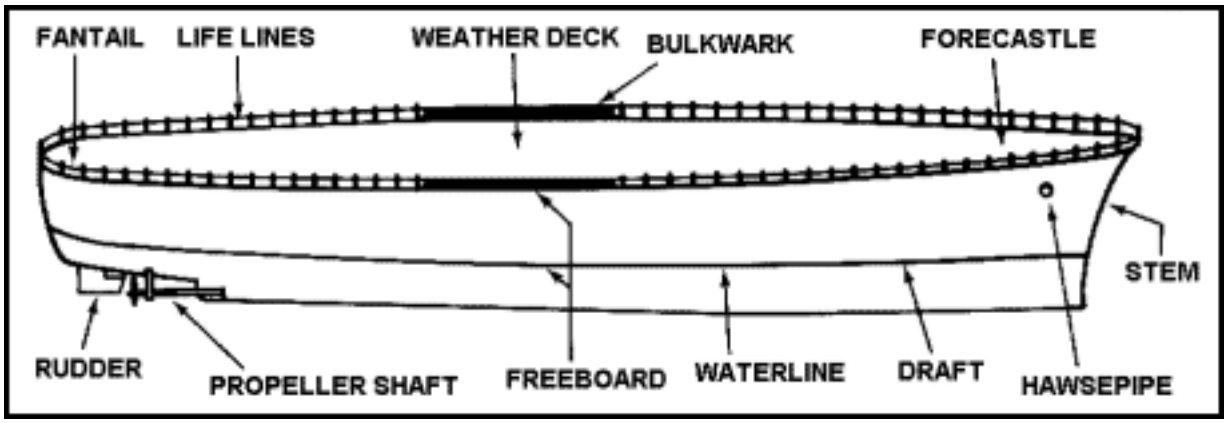


Figure 3-3. External Parts of the Hull

3-10. The relationship between the drafts at the bow and stern is the trim. When a ship is properly balanced fore and aft, she is in trim. When a ship is drawing more water forward than aft, she is down by the head. If the stern is too far down in the water, she is down by the stern. If the vessel is out of balance laterally or athwartship (leaning to one side) she has a list. She may be listing to starboard or listing to port. Both trim and list can be adjusted by shifting the weight of the cargo or transferring the ship's fuel and water from one tank to another in various parts of the hull.

3-11. The part of the bow structure above the waterline is the prow. The general area in the forward part of the ship is the forecastle. Along the edges of the weather deck from bow to stern are removable stanchions and light wire ropes, called life lines. Extensions of the shell plating above the deck are called bulwarks. The small drains on the deck are scuppers. The uppermost deck running from the bow to the stern is called the weather deck. The main deck area over the stern is called the fantail or poop deck. The flat part of the bottom of the ship is called the bilge. The curved section where the bottom meets the side is called the turn of the bilge.

3-12. Below the waterline are the propellers or screws which drive the ship through the water. The propellers are attached to and are turned by the propeller shafts. A ship with only one propeller is called a single-screw ship. Ships with two propellers are called twin-screw ships. On some ships (especially landing craft) there may be metal frames built around the propellers (called propeller guards) to protect them from damage. The rudder is used to steer the ship.

NAMES OF DECKS

3-13. The decks aboard ship (Figure 3-4) are the same as the floors in a house. The main deck is the first continuous watertight deck that runs from the bow to the stern. In many instances, the weather deck and the main deck may be one and the same. Any partial deck above the main deck is named according to its location on the ship. At the bow it is called a forecastle deck, amidships it is an upper deck, and at the stern it is called the poop deck. The term weather deck includes all parts of the forecastle, main, upper, and poop decks exposed to the weather. Any structure built above the weather deck is called superstructure.

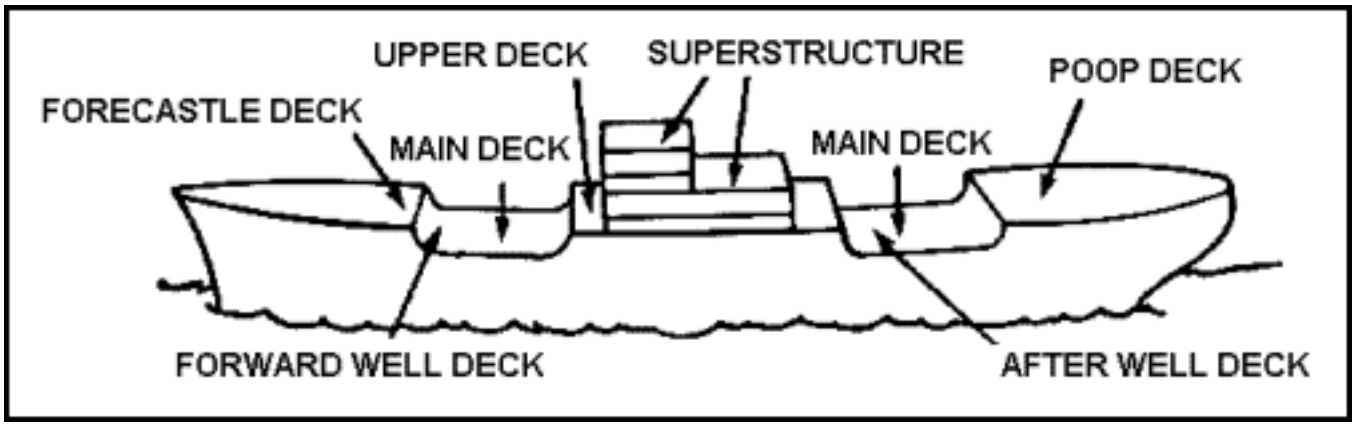


Figure 3-4. Weather Decks

SHIPBOARD DIRECTIONS AND LOCATIONS

3-14. You must be able to identify and locate stowage areas when involved in operations aboard ship. Refer to Figure 3-5 to locate the following:

Bow

3-15. The front end of the ship is the bow. When you move toward the bow, you are going forward, when the vessel is moving forward, it is going ahead. When facing toward the bow, the front-right side is the starboard bow and the front-left side is the port bow.

Amidships (Center)

3-16. The central or middle area of a ship is amidships. The right center side is the starboard beam and the left center side is the port beam.

Stern (Back)

3-17. The rear of a vessel is the stern. When you move in that direction you are going aft, when the ship moves in that direction it is going astern. When looking forward, the right-rear section is called the starboard quarter and the left-rear section is called the port quarter.

Other Terms of Location and Direction

3-18. The entire right side of a vessel from bow to stern is the starboard side and the left side is the port side. A line, or anything else, running parallel to the longitudinal axis or centerline of the vessel is said to be fore and aft and its counterpart, running from side to side, is athwartships.

3-19. From the centerline of the ship toward either port or starboard side is outboard and from either side toward the centerline is inboard. However, there is a variation in the use of outboard and inboard when a ship is on berth (moored to a pier). The side against the pier is referred to as being inboard; the side away from the pier as outboard.

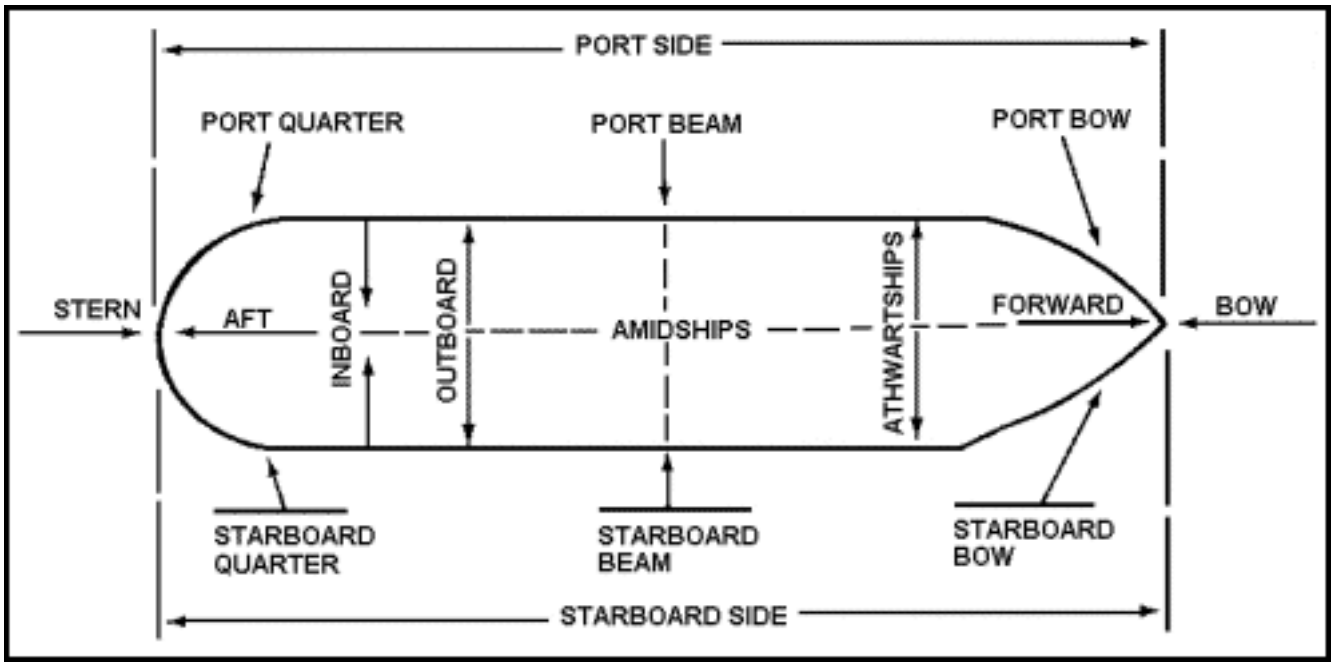


Figure 3-5. Locations and Directions Aboard Ship

SHIPBOARD MEASUREMENTS

3-20. A ship's size and capacity can be described in two ways--linear dimensions or tonnages. Each is completely different yet interrelated.

3-21. A ship's measurement is expressed in feet and inches--linear dimensions. A ship is a three dimensional structure having length, width, and depth (Figure 3-6).

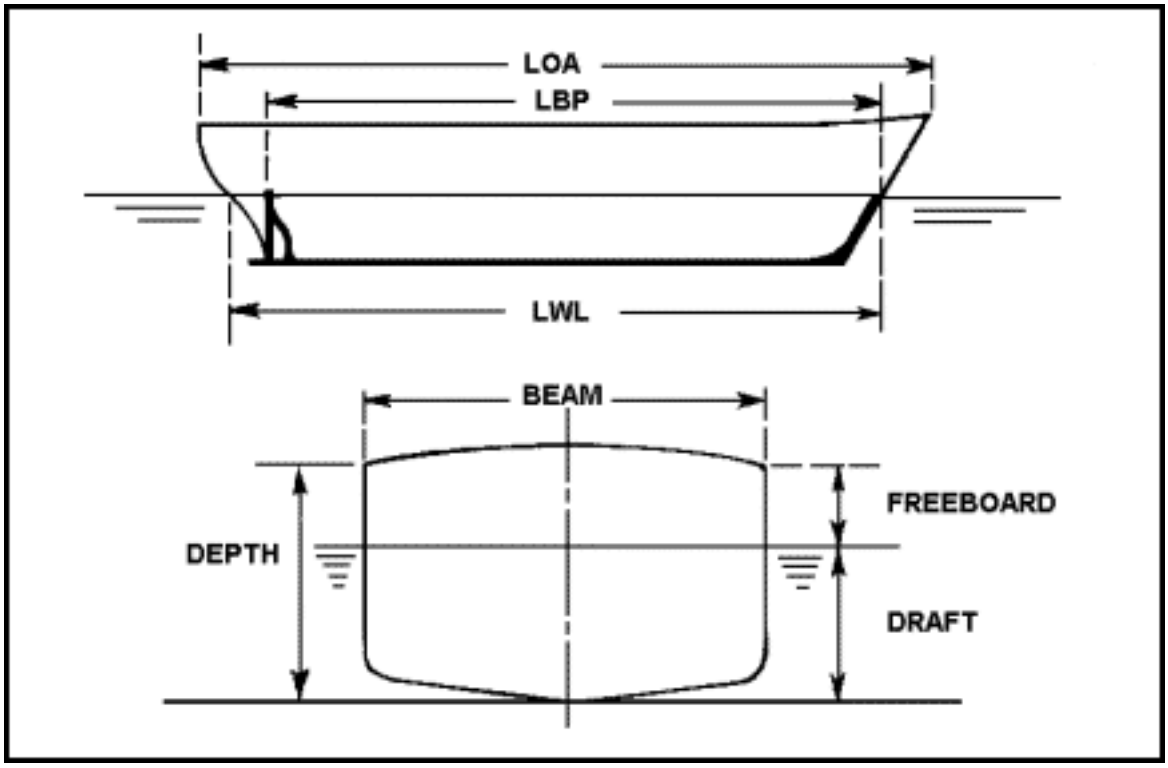


Figure 3-6. A Ship's Dimensions

LENGTH

3-22. A ship's length is measured in different ways for ship's officers, for architects and designers, and for registry. Terms used for technical or registry purposes include registered length, tonnage length, floodable length, and length by ABS rules. We mention these terms for familiarization only. The more commonly used length measurements -- length overall, length between perpendiculars, and length on load waterline are discussed as follows.

Length Overall

3-23. A ship's LOA is measured in feet and inches from the extreme forward end of the bow to the extreme aft end of the stern. The top portion of Figure 3-6 shows how the LOA is measured. Watercraft operators must be familiar with this and similar dimensions to safely maneuver the ship. The dimension is commonly found in lists of ship's data for each vessel.

Length Between Perpendiculars

3-24. A ship's length is sometimes given as LBP. It is measured in feet and inches from the forward surface of the stem, or main bow perpendicular member, to the after surface of the sternpost, or main stern perpendicular member. On some types of vessels this is, for all practical purposes, a waterline measurement.

Length on Load Waterline

3-25. A ship's LWL is an important dimension because length at the waterline is a key factor in the complex problem of speed, resistance, and friction. On vessels with a counter stern, the LWL and LBP can be the same or about the same. On a ship with a cruiser stern, the LWL is greater than the LBP, as shown in the top portion of Figure 3-6.

WIDTH

3-26. A ship's width or, more properly, a ship's breadth is expressed in a number of ways and, like length, for a number of reasons.

3-27. A ship's extreme breadth, commonly called beam, is measured in feet and inches from the most outboard point on one side to the most outboard point on the other at the widest point on the ship, as shown in the bottom portion of Figure 3-6. This dimension must include any projections on either side of the vessel. Like length overall, this measurement is important to a ship's officer in handling the vessel.

DEPTH

3-28. The depth of a vessel involves several very important vertical dimensions. They involve terms like freeboard, draft, draft marks, and load lines. The vessel's depth is measured vertically from the lowest point of the hull, ordinarily from the bottom of the keel, to the side of any deck that you may choose as a reference point. Therefore, it has to be stated in specific terms such as depth to upper deck amidships. It is impractical to measure depth in any other way, since it varies considerably from one point to another on many ships. For example, the depth is greater at the stern than amidships.

3-29. The term "depth" is where the measurement is taken from the bottom--from the keel upward. Ordinarily, if such a measurement were being made in a room of a building, taken from the floor to the ceiling, it would be called height.

Note: You must know a ship's draft or maximum allowable draft when selecting a berth for loading or discharging operations.

PROCEDURE FOR READING DRAFT MARKS

3-30. Draft marks are numbers marked on each side of the bow and stern of the vessel (Figure 3-7). Draft marks show the distance from the bottom of the keel to the waterline.

Figure 3-7. Draft Marks on Bow and Stern of Vessel

3-31. The draft numbers shown in Figure 3-8 are 6 inches high and 6 inches apart. The bottom of each number shows the foot draft mark.

Figure 3-8. Draft Numbers Showing Foot Draft Mark

3-32. Figure 3-9 shows four different draft readings.

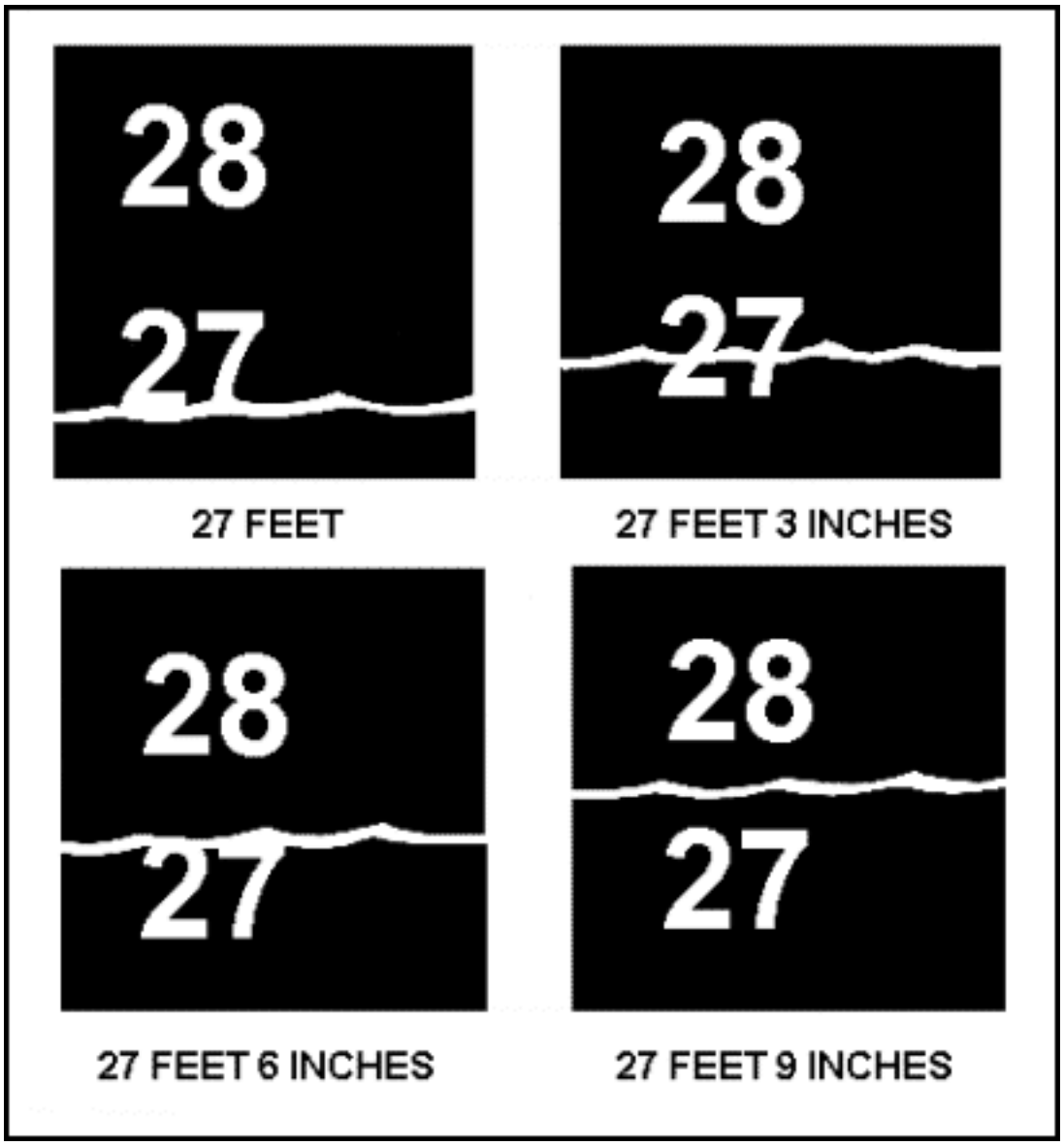


Figure 3-9. Various Draft Readings

WEIGHT TONNAGE TERMS

3-33. The word "ton" comes from the English "tun" meaning cask or barrel. To the English, it meant a wine barrel with a capacity of about 252 gallons. When Parliament imposed duties on the wine entering England in these barrels, the duty imposed on each tun eventually led to the use of tunnage in describing a ship’s capacity to carry such barrels. The original use of tun meant a barrel of a particular size, the space that such a barrel would occupy, and a ship’s capacity to carry a given number of such barrels. Tun was originally a figure for space--not weight. By law, Parliament fixed the tun at 252 gallons. Since this fixed tun weighed an average of 2,240 pounds, it brought into existence the weight term "long ton."

3-34. A long ton is used throughout the shipping business. It is not to be confused with the familiar ton of 2,000 pounds, the short ton, used so widely in the US in relation to so many things other than ships and shipping. The metric ton is 1,000 kilograms, the equivalent of 2,204.6 pounds. Tonnages throughout this manual refer to the long ton of 2,240 pounds.

CATEGORIES OF SHIP'S DECK GEAR

3-35. Watercraft operators must be familiar with ship’s gear. The term "ship’s gear" is used to describe that gear and equipment aboard ship that is used for cargo transfer activities and deck operations. Ship’s gear can be divided into four categories:

- Standing rigging.
- Running rigging.
- Deck fittings.
- Deck machinery.

STANDING RIGGING

3-36. Standing rigging gear (Figure 3-10) includes the rigging that supports masts or king posts. This gear includes the following:

Shrouds

3-37. These are heavy wire ropes that provide athwartship support for the mast or king posts. Two or more shrouds are used on either side of a mast or king post. They are secured to the outboard side of the deck or to the bulwark to provide maximum support.

Turnbuckles

3-38. These are internally threaded collars turning on two screws threaded in opposite directions. They are used to secure and to take up the slack in the shrouds and stays.

Stays and Backstays

3-39. These are heavy wires similar to shrouds. The difference is that they will lead in a forward or aft direction. They are found at the mast where the jumbo boom (heavy lift boom) is located. When they support the mast from a forward direction, they are called stays. When they support the mast from an aft (back) direction, they are called backstays.

RUNNING RIGGING

3-40. This gear includes the moving or movable parts that are used to hoist or operate gear (such as cargo runners, topping lifts, and guy tackles).

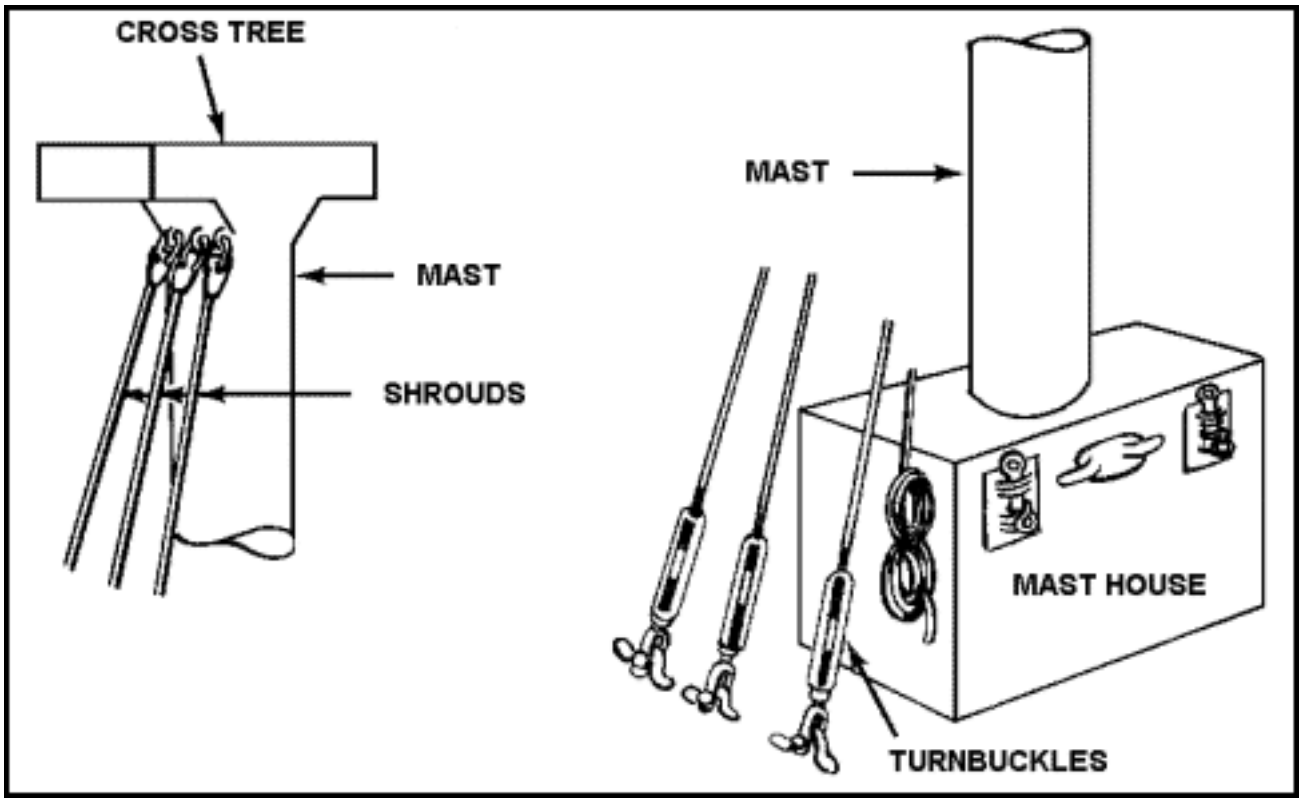


Figure 3-10. Standing Rigging Gear

DECK FITTINGS

3-41. These are the devices that are used to secure standing rigging, running rigging, and mooring lines. These devices (Figure 3-11) are described as follows:

Bitts

3-42. These are heavy metal bed plates with two iron or steel posts. They are used on ships for securing mooring or towing lines. Usually there is a set forward and after each chock.

Chocks

3-43. These are heavy fittings secured to the deck. Lines are passed through them to bollards on the pier. The types of chocks used are closed, open, roller, and double roller.

Cleats

3-44. These are metal fittings having two projecting horns. They are used for securing lines.

Pad Eyes

3-45. These are fixtures welded to a deck or bulkhead. They have an eye to which lines or tackle are fastened and are used for securing or handling cargo.

3-46. A bulwark is the wall around any deck exposed to the elements. This includes the weather deck, the poop deck, the fore deck, and any deck on the superstructure. On top of the bulwark is a flat rail (or plate) called the rail. Pad eyes and cleats are often welded to the rail.

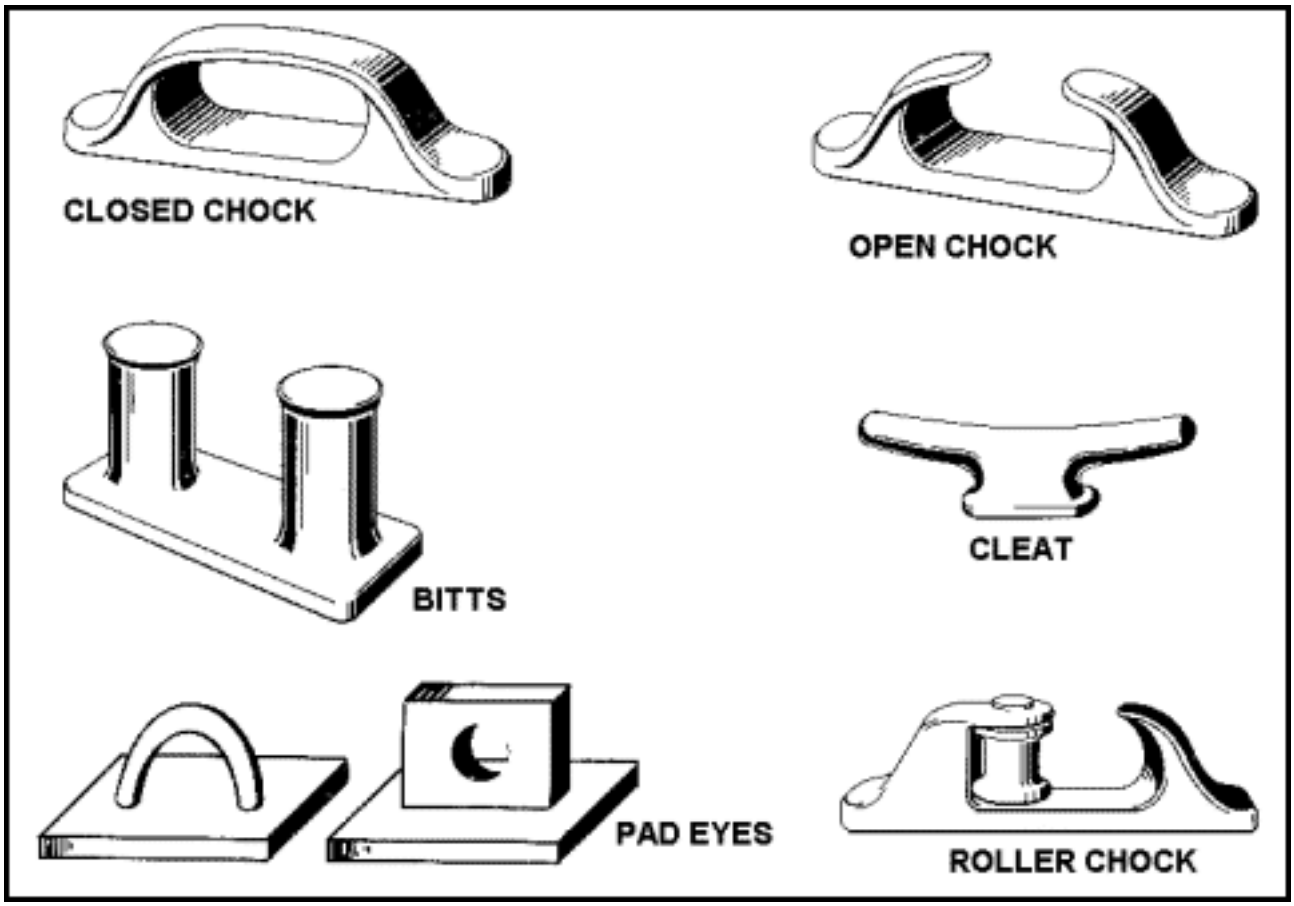


Figure 3-11. Deck Fittings

DECK MACHINERY

3-47. This includes the standard machinery that is found on the decks of Army watercraft. The size and shape of the deck machinery may vary depending upon type of vessel, but the operating principles remain the same.

Cargo Winches

3-48. These are power-driven machines used to lift, lower, or move cargo. Winches are classified according to their source of power. Electric winches are standard equipment on most vessels. An electric winch (Figure 3-12) has a steel base on which the winch drum, motor, gears, shafts, and brakes are mounted. The drum, which has cable wound on it, is usually smooth with flanged ends. It revolves on a horizontal axis and is driven through single or double reduction gears by an electric motor (usually direct current). A solenoid brake and a mechanical brake are fitted to the motor shaft. The winch is located on deck or on a deckhouse. The winch controls consist of a master controller or switchbox located on a pedestal at the end of the hatch square and a group of relays, contactors switches, and resistors located near the winch motor.

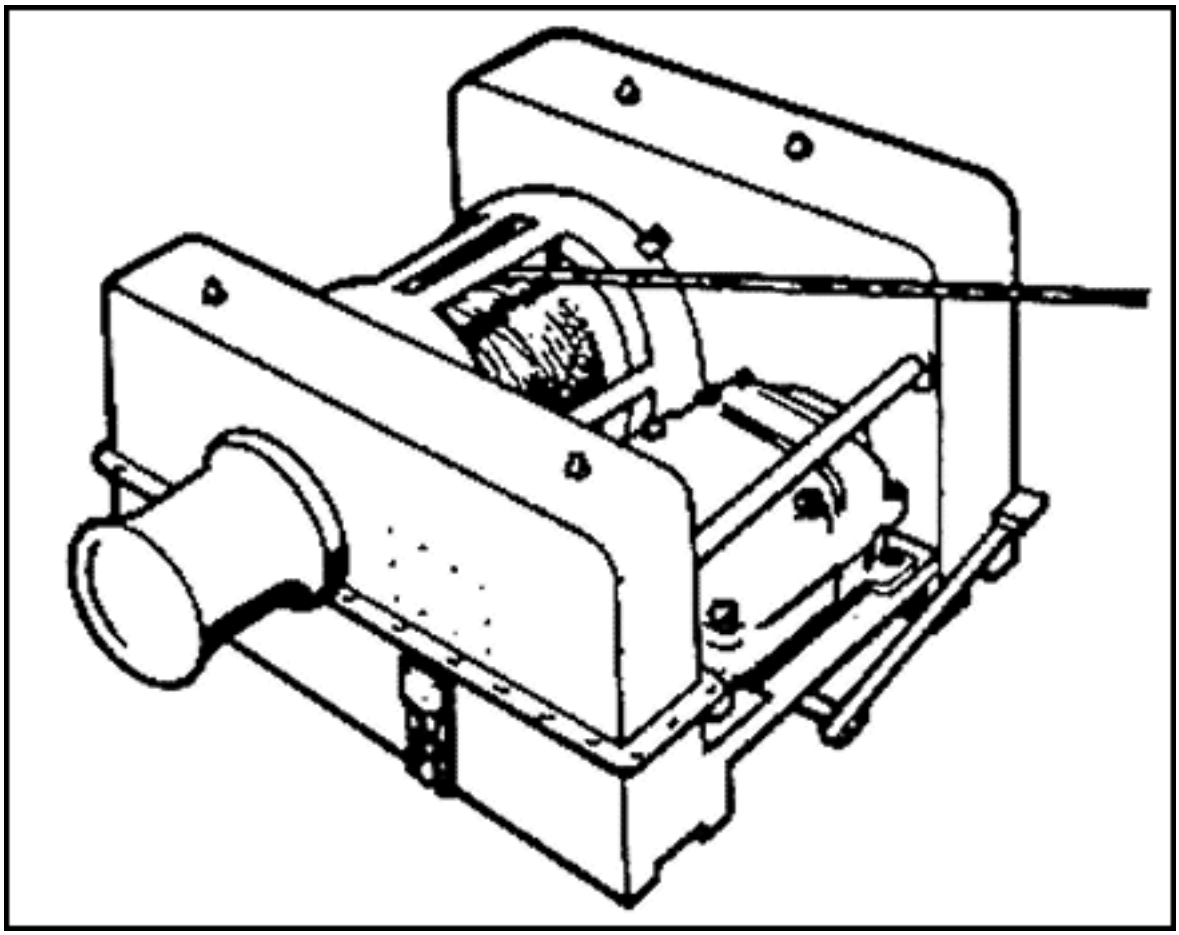


Figure 3-12. Electric Winch

Windlass

3-49. The windlass (Figure 3-13) is a special type of winch used to raise and lower the anchors and to handle the forward mooring lines. It consists of a wildcat (a steel casting in the form of a deeply grooved drum with projecting ribs [whelps]) used to grip the anchor chain, controls for connecting or disconnecting the wildcat from the engine, and a friction brake which can be set to stop the wildcat when disconnected. There are horizontal drums at each end of the windlass for warping.

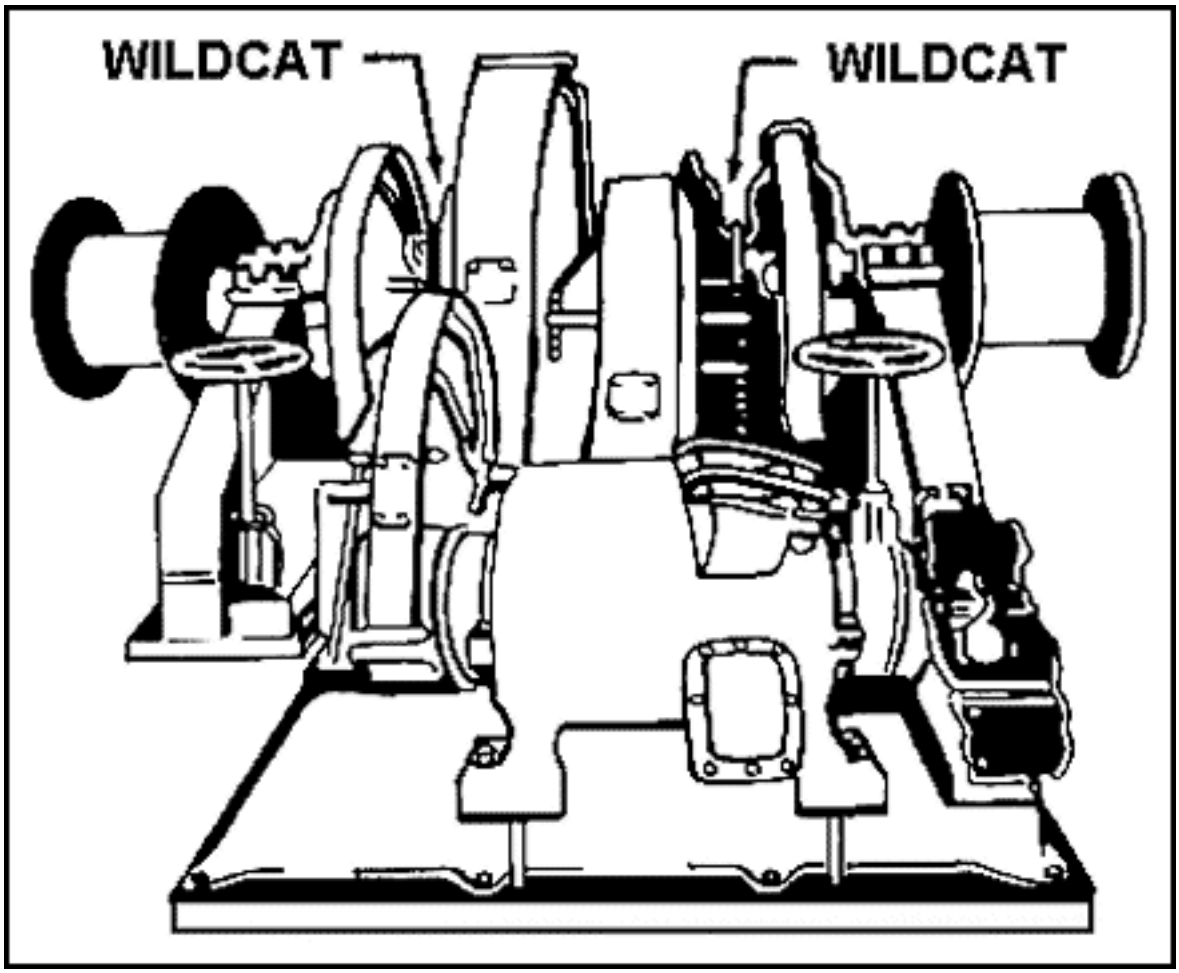


Figure 3-13. Windlass

Capstan

3-50. The capstan (Figure 3-14) is a vertically mounted winch head used aboard ship when mechanical power is required for raising anchor, lifting heavy weights, or for any similar work. It is a cast steel drum mounted on a vertical spindle with the largest diameters at top and bottom and the smallest in the middle to allow the rope around it to surge up or down as the number of turns are increased. The drum is fixed to the spindle by keys.

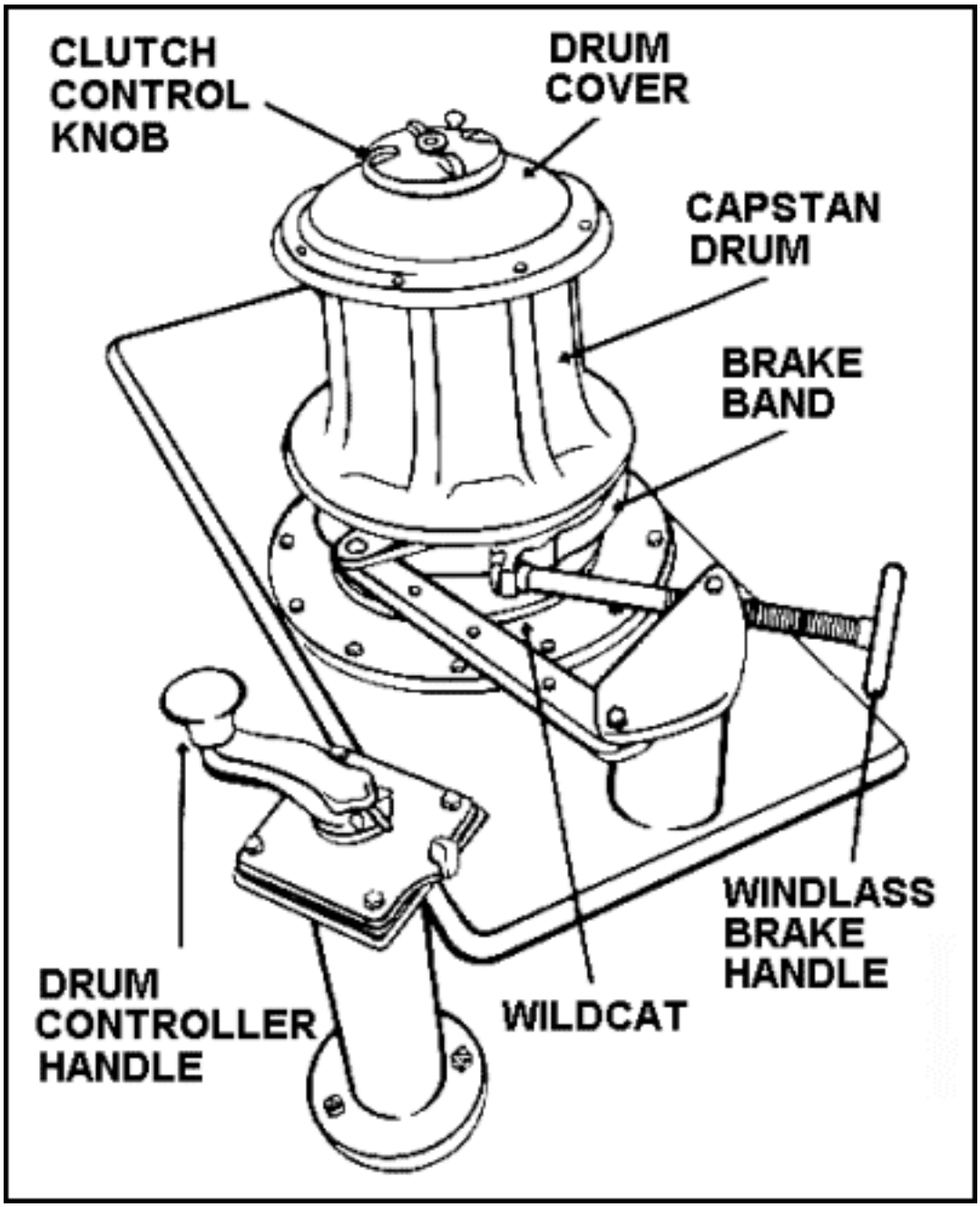


Figure 3-14. Capstan

Chapter 4

Small Boat Handling

Boat handling requires an understanding of the many variable and complex problems of seamanship. The basic principles involved in handling small boats are essentially the same as those used in handling larger craft.

FORCES AFFECTING BOAT HANDLING

4-1. Before attempting to handle a boat, it is important to understand the forces that affect a boat under various conditions. A watercraft operator who thoroughly understands these forces can use them to maneuver his boat. Therefore, he will not have to fall back on the often painful, trial-and-error method of learning boat handling. The following vessel characteristics influence the control of single-screw boats having right-hand propellers.

DESIGN OF THE VESSEL

4-2. The design of a ship includes the size and shape of the hull, draft, trim, weight, and amount of superstructure. Ships with shallow draft, low superstructure, and slim design normally handle more easily than ships with high superstructure, deep draft, and wide beam because they are less affected by wind and current and respond more rapidly to the rudder.

POWER

4-3. Each phase of motive force as it reacts on the vessel has its own peculiarities. No set of rules can be devised to cover all types. Every vessel has its own power characteristics, which the operator must learn to determine their effect upon handling of the vessel.

PROPELLER ACTION

4-4. A propeller draws its supply of water from every direction forward and around the blades, forcing it in a powerful stream toward the stern. This moving current which provides the power for propulsion is called "screw current." The water flowing into the propeller is called "suction screw current," that being ejected is called "discharge current." Figure 4-1 shows this water-pressure effect of the suction current vaporizing off the tips of the blades and spiraling back in a helical pattern. The factors that affect propeller action are:

Pitch

4-5. The pitch of a propeller (Figure 4-2) is the distance the propeller would advance in one revolution if the water was a solid medium.

Slip

4-6. The difference between the speed of the ship and the speed of the propeller is known as the "slip". Slip is caused by the yield of the water against the propeller thrust. In other words, it is the percentage of distance lost because water is a yielding substance.

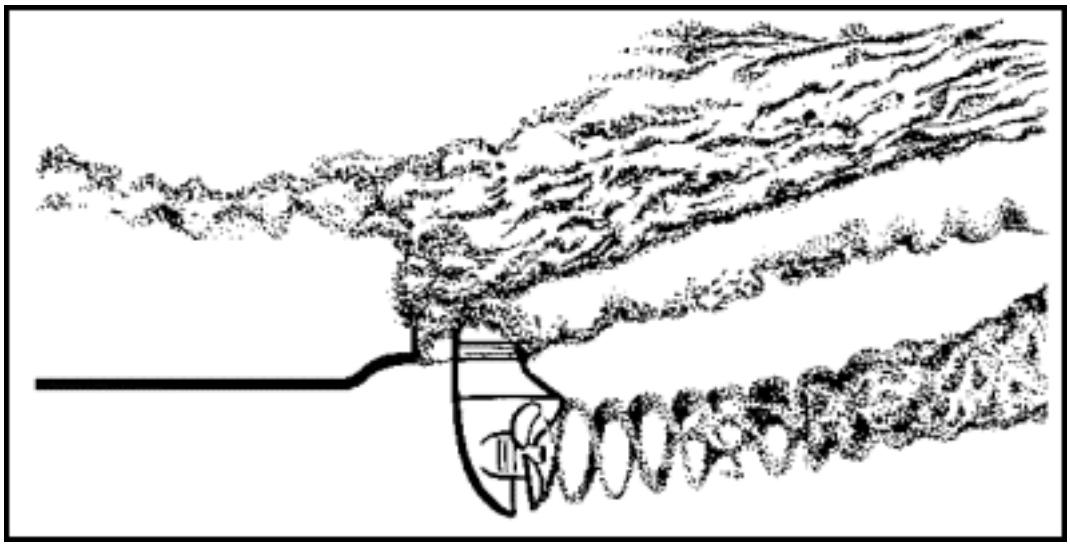


Figure 4-1. Propeller Action and Resulting Screw Action

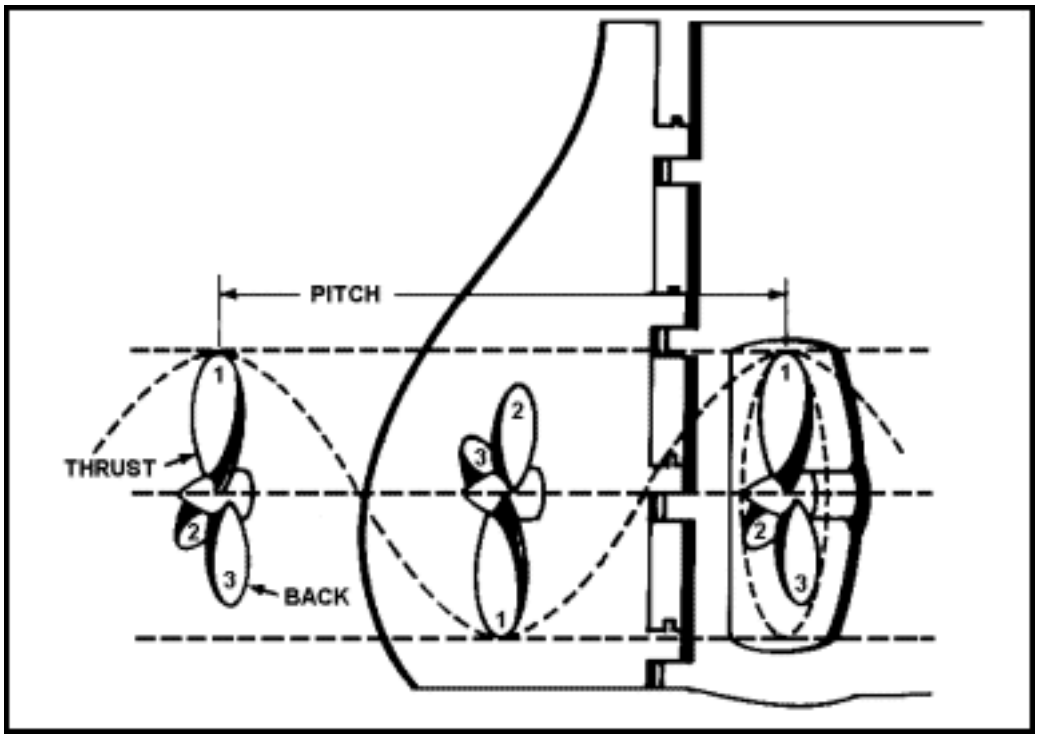


Figure 4-2. Propeller Pitch

Cavitation

4-7. When the blade-tip speed is excessive for the size and shape of the propeller, the vessel rides high in the water. There is also an unequal pressure on the lower and upper blade surfaces. This condition produces cavities or bubbles around the propeller known as "cavitation." The result is an increase in revolutions per minute without an equivalent increase in thrust. This results in loss of efficiency. When cavitation is fully developed, it limits a vessel's speed regardless of the available engine power.

Rudder Action

4-8. The rudder acts the same on a large vessel as on a small craft. The rudder is placed directly behind the propeller to use the powerful discharge current to turn the boat. Moving the rudder to the right deflects the discharge current to the right, which forces the stern to the left. This action is reversed when the left rudder is applied. At very slow propeller speed and with very little way on, there may not be enough control over a boat to maneuver it, especially if other forces are acting upon it at the same time. When this condition prevails, the propeller may be speeded up enough to give it a more powerful thrust against the rudder. Using sudden thrusts of power to kick (move) the stern in this manner is one of the fundamental principles of vessel handling. A vessel can often be turned in twice its length by kicking the stern.

OTHER FACTORS AFFECTING CONTROL

4-9. Wind, tidal, ocean currents (waves or sea), and depth of water must be considered when handling a vessel. Shallow water particularly affects deep draft vessels because of the cushion effect similar to that encountered when navigating in narrow channels.

STANDARD STEERING COMMANDS

4-10. There are some standard steering commands used to give orders to the helmsman. These are described below.

RIGHT RUDDER AND LEFT RUDDER

4-11. "Right rudder" or "left rudder" are orders given for the wheel to be turned to the right or left. When the wheel is turned to the right or left, the rudder and rudder angle indicator must turn to the same side; that is, they must not be rigged reversely.

COMMONLY USED COMMANDS

4-12. When a command is given to the helmsman, the first part of the order indicates the direction (right or left) for the helmsman to turn the wheel. The second part of the command states the amount of angle. The following are some commonly used steering commands.

- **"Right (or left) full rudder."** Full rudder designates a 30° rudder. When the rudder is turned past 30° (usually designated hard right or left), care must be exercised to avoid jamming it against the stops.
- **"Right (or left) 5° , 10° , 15° , and so on."** This indicates the angle, in degrees, that the rudder is to be offset.
- **"Right (or left) easy."** Usually indicates 2 or 3 degrees of rudder angle in the direction indicated. Some Masters may prefer 5 degrees of rudder angle for this command. This should be understood in the vessels SOP.
- **"Give her more rudder."** To increase the rudder angle already on when it is desired to turn the ship more rapidly in the direction in which she is already turning.
- **"Ease the rudder."** To decrease the rudder angle which is on. The order may also be: "Ease to (state number) degrees."
- **"Rudder amidships."** To place the rudder on the centerline.
- **"Meet her."** To check, but not stop, the swing by putting the rudder in the opposite direction. Usually this order is used when it is desired to keep the ship from swinging past her new course.
- **"Steady" or "steady as you go."** To steer the present course while the ship is swinging. The course should be noted at the time the order is given and the ship steadied on that course.
- **"Shift the rudder."** To change from right to left (or left to right) rudder. Usually given when a ship loses her headway and begins to gather sternway and it is desired to keep her turning in the same direction.
- **"Mind your rudder."** To steer more carefully or stand by for an order.
- **"Keep her so."** To steer the course just reported, following a request for that course.

REPEATING COMMANDS

4-13. To assure the watch officer that his orders have been correctly received, the helmsman must always repeat, word for word, any command received. As soon as the command has been executed, the helmsman must also report it to the watch officer. The watch officer confirms that the order is understood by replying, "Very well."

HANDLING CHARACTERISTICS OF SINGLE- AND TWIN-SCREW VESSELS

4-14. Characteristics or factors, such as the power, propeller, rudder, and design of a ship affect handling in various ways. For illustrating the effects of these factors, it will be assumed that the sea is calm, there is neither wind nor current, and the ship has a right-handed propeller.

HANDLING SINGLE-SCREW VESSELS

4-15. The single-screw vessel has only one propeller. The operation of this vessel is described below.

Vessel and Propeller Going Forward

4-16. With the ship and propeller going forward and the rudder amidships, the ship tends to move on a straight course. The sidewise pressure of the propeller is offset by the canting of the engine and shaft. When the rudder is put over (either to the right or left) the water through which the ship is moving strikes the rudder face, forcing the stern in the opposite direction. At the same time, discharge current strikes the rudder face and pushes the stern over farther. As a result of these forces, the bow moves in the direction in which the rudder has been thrown.

Vessel With Sternway, Propeller Backing

4-17. When backing, the sidewise pressure is opposite to that exerted when the ship is moving forward. The discharge current from the propeller reacts against the hull. This current is rotary; therefore, when the propeller is backing, the current strikes the hull high on the starboard side and low on the port side. This current exerts a greater force on the starboard side and tends to throw the stern of the vessel to port (Figure 4-3).

4-18. With rudder amidships, the vessel will back to port from the force of the sidewise pressure and the discharge current. When the rudder is put over to starboard (Figure 4-4), the action of the suction current against the face of the rudder will tend to throw the stern to starboard. Unless the ship is making sternway, this force will not be strong enough to overcome the effect of the sidewise pressure and the discharge current, and the stern will back to port.

4-19. When the rudder is put over to port (Figure 4-5), the force of the suction current on the face of the rudder intensifies the effect of the sidewise pressure of the propeller and the discharge current and will force the stern rapidly to port. Because of these forces, all right-handed, single-screw vessels tend to back to port.

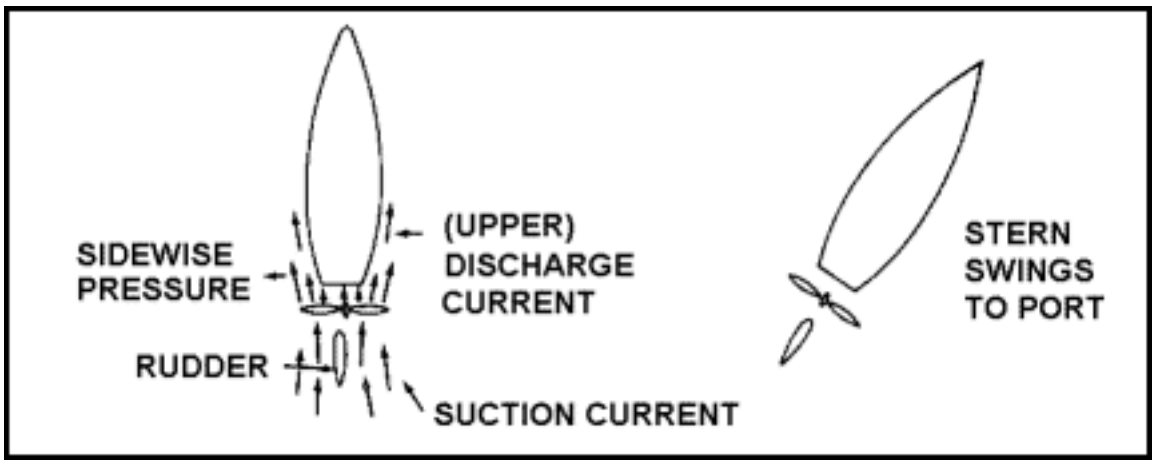


Figure 4-3. Vessel With Sternway, Propeller Backing, Rudder Amidships

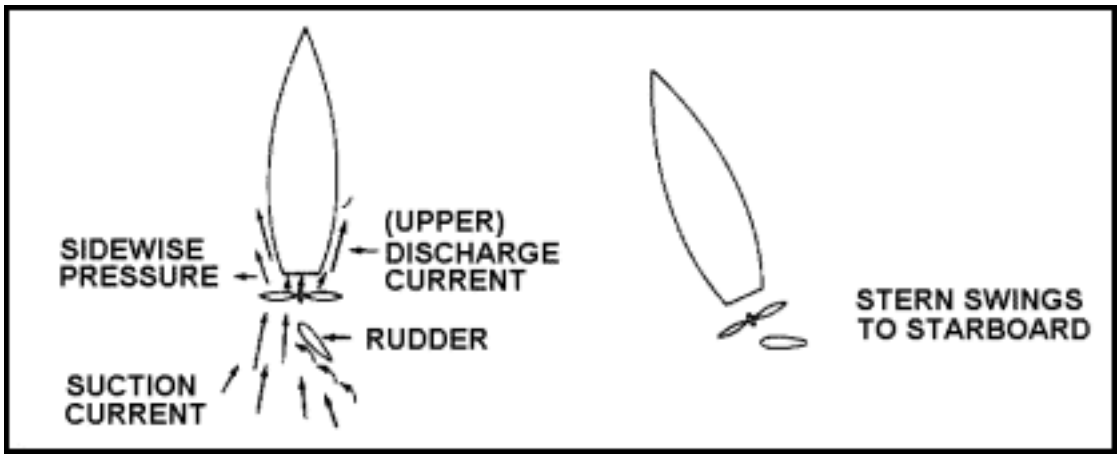


Figure 4-4. Vessel With Sternway, Propeller Backing, Rudder to Starboard

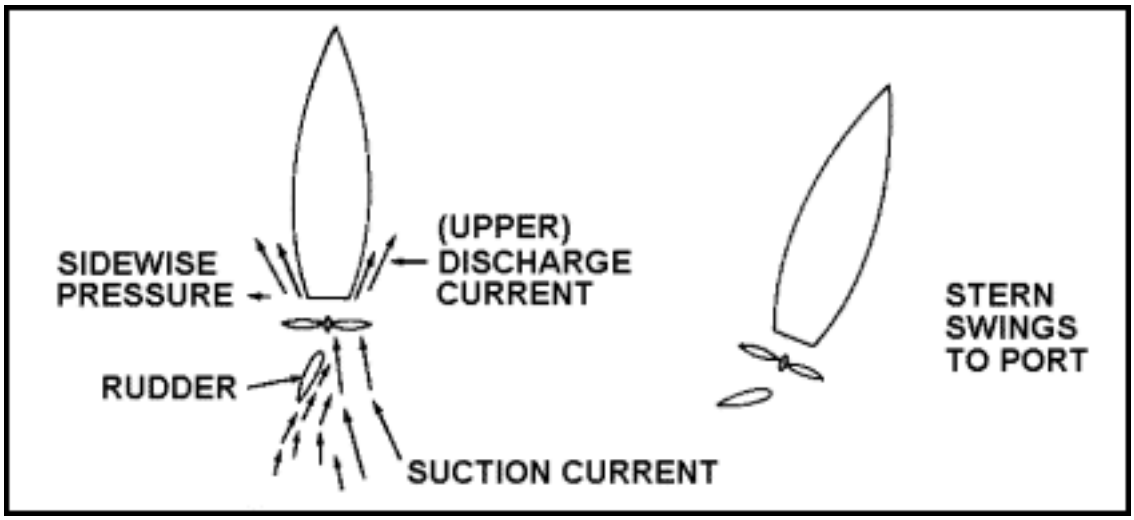


Figure 4-5. Vessel With Sternway, Propeller Backing, Rudder to Port

Vessel With Headway Propeller Backing

4-20. With the rudder amidships (Figure 4-6), the stern will go to port because the only active forces are the sidewise pressure of the propeller and the discharge current.

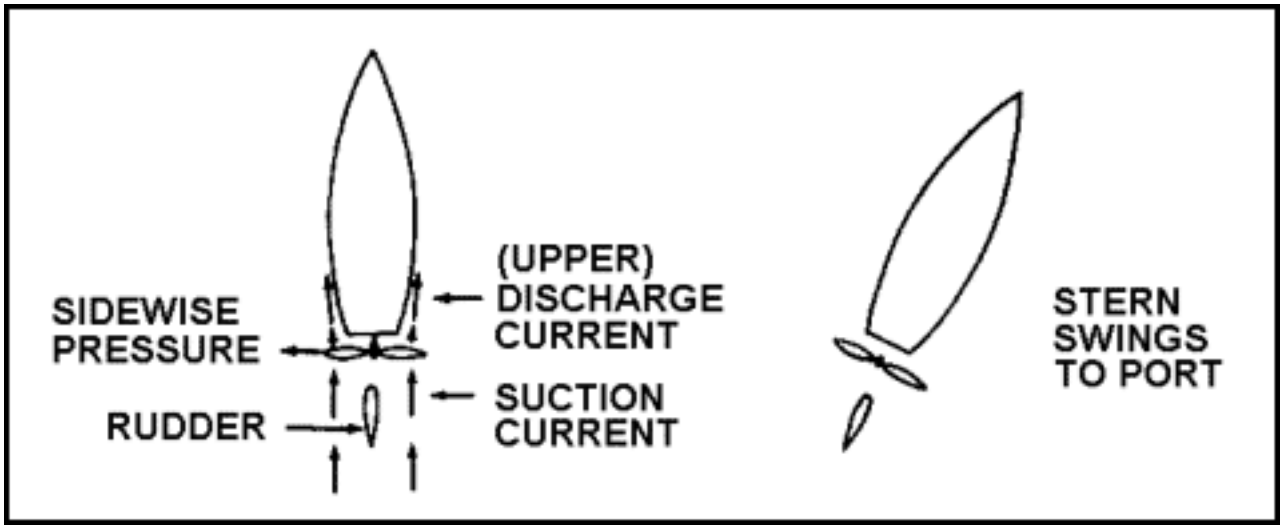


Figure 4-6. Vessel With Headway, Propeller Backing, Rudder Amidships

4-21. With the rudder to starboard (Figure 4-7), the stern rapidly goes to port but, as headway is lost and the vessel begins to go astern, the effect of the suction current on the face of the rudder slows the swing. However, since a single-screw vessel tends to back to port when moving astern, the stern will tend to port unless the vessel gathers considerable speed astern.

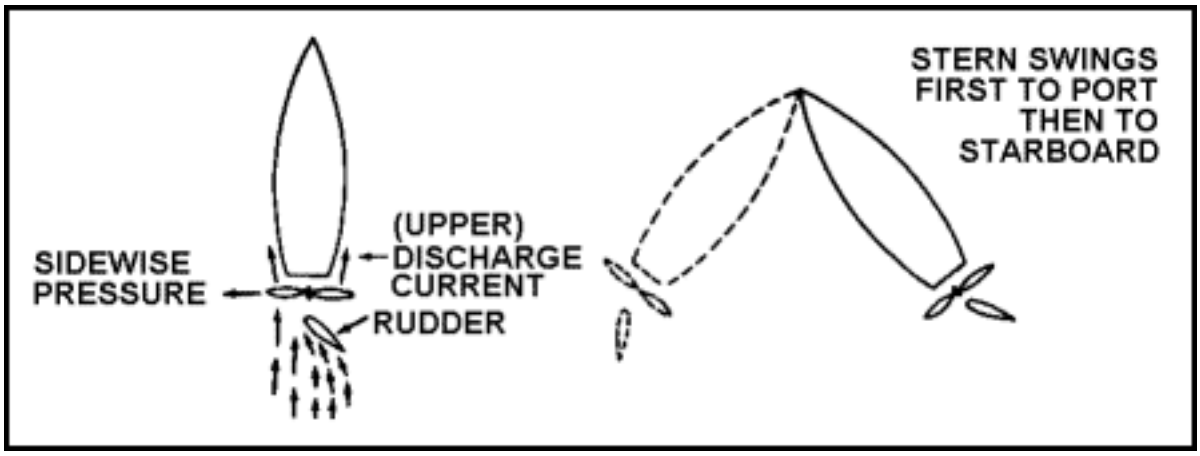


Figure 4-7. Vessel With Headway, Propeller Backing, Rudder to Starboard

4-22. With the rudder left (Figure 4-8), the normal steering tendency of the rudder will throw the stern to starboard. This starboard motion will occur when the vessel has considerable headway, but as headway is lost, the effect of the sidewise pressure of the propeller and the discharge current, in conjunction with increasing forces of the suction current against the face of the rudder, swings the stern rapidly to port.

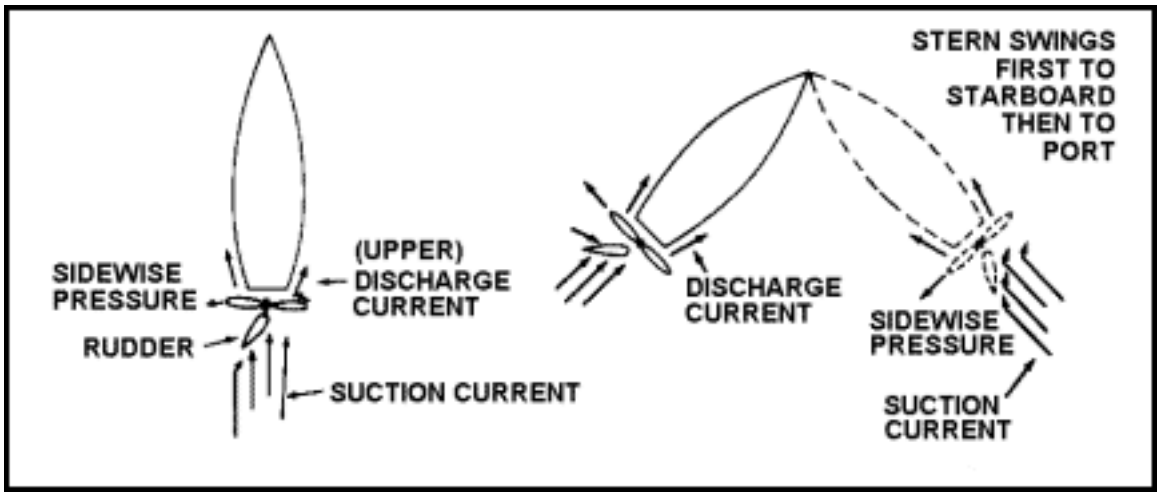


Figure 4-8. Vessel With Headway, Propeller Backing, Rudder Left

Vessel With Sternway, Propeller Going Ahead

4-23. In this situation, the sidewise pressure of the propeller and the discharge current are persistent factors and may offset each other. Therefore, if the rudder is amidships with no forces acting against it (Figure 4-9), the vessel will tend to follow a straight course.

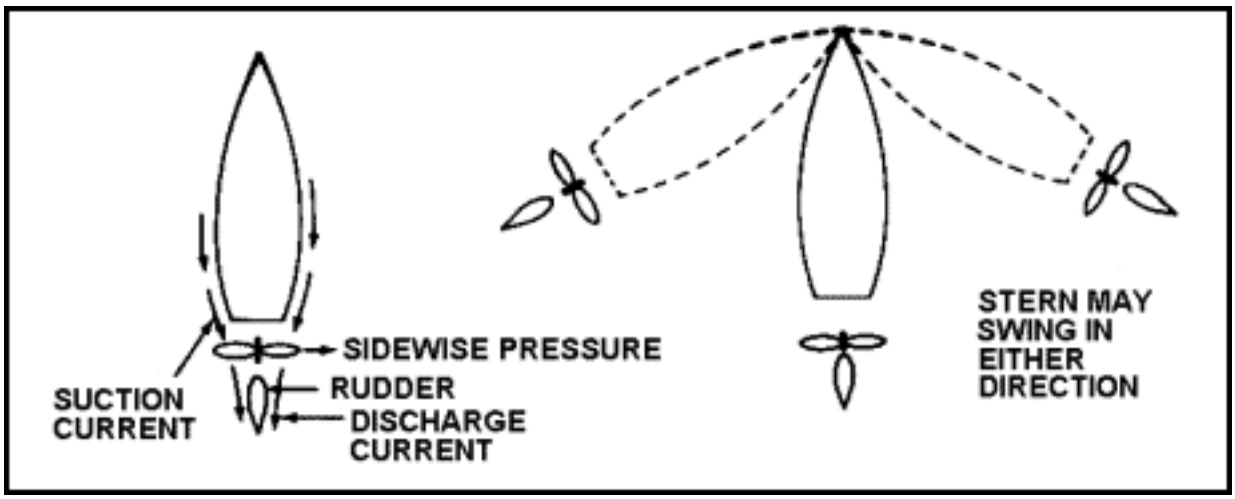


Figure 4-9. Vessel With Sternway, Propeller Going Ahead, Rudder Amidships

4-24. With the rudder to the right (Figure 4-10), the action of the water on the back face of the rudder as it moves astern will tend to throw the stern to the starboard. The action of the discharge current against the forward face of the rudder tends to throw the stern to port. Direction is determined by the stronger force. However, as the vessel loses sternway, the direct steering effect of the rudder takes over and the stern swings to port.

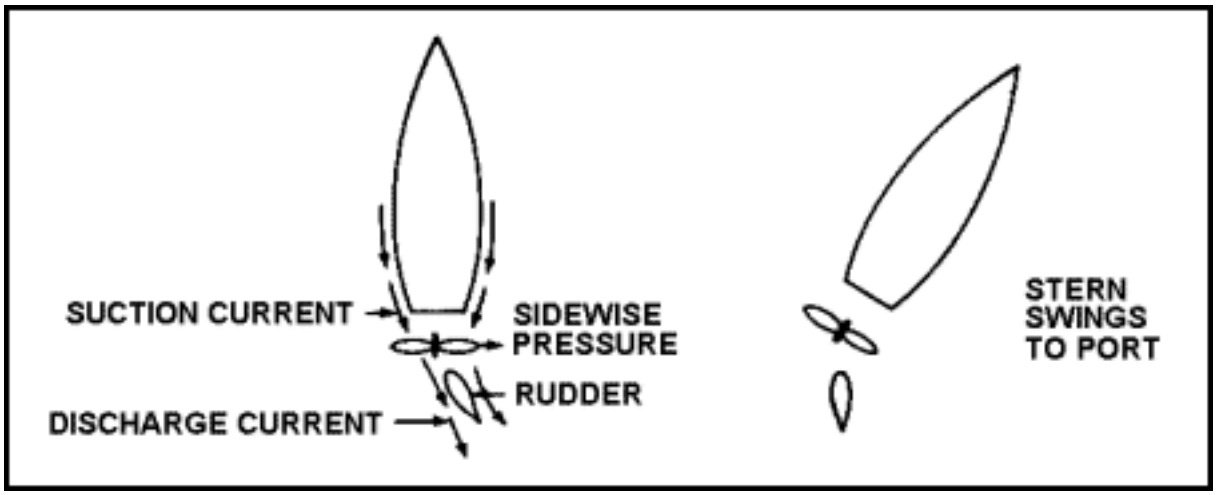


Figure 4-10. Vessel With Sternway, Propeller Going Ahead, Rudder to Right

4-25. With the rudder left (Figure 4-11), the action is the same as with the rudder right. In either case, the rudder action is determined by the strength of the forces, and as the rudder loses sternway, the direct steering effect of the rudder takes over and the stern swings rapidly to starboard.

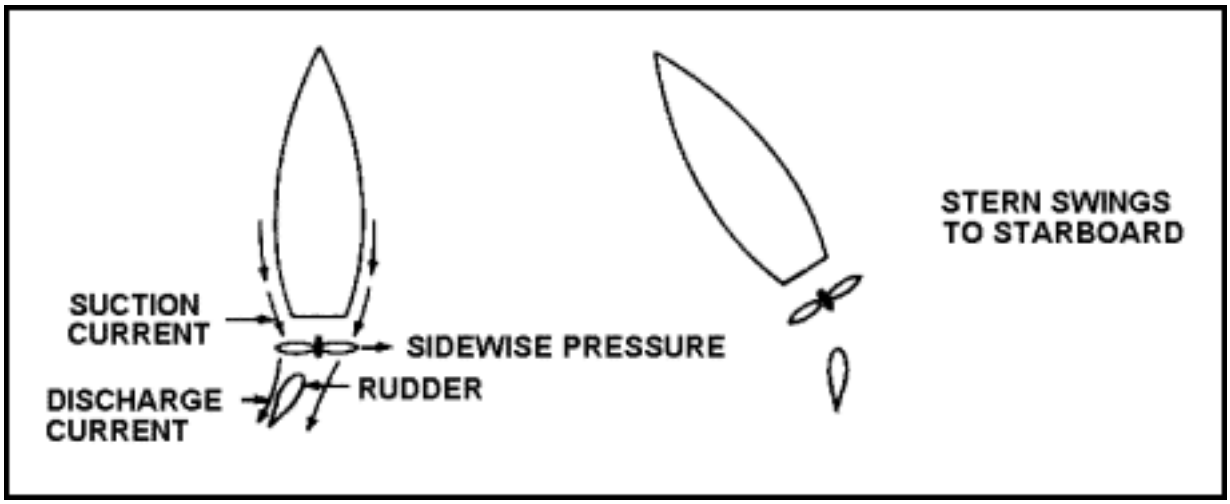


Figure 4-11. Vessel With Sternway, Propeller Going Ahead, Rudder to Left

HANDLING TWIN-SCREW VESSELS

4-26. The twin-screw vessel has two propellers -- one on each side of the centerline. These propellers are maneuvered by separate throttle controls. Generally the propellers are outturning; that is, the starboard propeller is right-handed and the port, left-handed. This balances the sidewise pressure of the propellers and makes it possible to keep the ship on a straight course with no rudder. Discounting outside influences, the twin-screw vessel backs with equal facility to port or starboard.

4-27. The various forces affecting the action of the single-screw ship are still present, but normally a twin-screw vessel is not affected by these forces as much as a single-screw vessel. This is because the forces from one screw balance the forces from the other screw.

4-28. One powerful force is the momentum of the ship, ahead or astern, acting through the center of gravity. When a twin-screw ship is going ahead and one screw is backed, two opposing forces are set in motion; namely, the force of the backing screw acting in one direction and the weight of the ship acting in the opposite direction. This is in addition to the forces from the action of the pressure on the rudder if it is put over. Other than this force and the turning action accomplished by one engine ahead and the other astern, the vessel handling characteristics of a twin-screw vessel are similar to those explained in the preceding paragraphs for the single-screw vessel.

TURNING IN A LIMITED SPACE

4-29. Single-screw vessels can be turned easily in restricted waters. To start the swing, the engine speed is set at full ahead and the rudder is put full right; then the engine is reversed to full astern until way is lost. When way is lost, the rudder is shifted; after sternway has started, the rudder is again shifted and the engine put full ahead. This procedure is repeated until the vessel is on the desired heading. This maneuver makes use of the tendency of right-handed propellers to back to port. In strong winds, it is wise to turn in such a way that the tendency to back into the wind can be used to increase the turn.

4-30. A twin-screw vessel with a single rudder can be turned by going ahead on one engine and astern on the other, using the rudder only when headway or sternway has been gained. When the vessel is fitted with twin rudders that are directly behind the propellers, the rudder is placed hard over in the direction of the turn before the maneuver is begun and one engine is backed at the speed necessary to prevent headway.

DOCKING AND UNDOCKING

4-31. In some ports, particularly on the East and Gulf Coasts, individuals frequently referred to as docking pilots or docking masters direct the docking and undocking of vessels. In most cases, these individuals are employees of tug boat companies.

MOORING LINES

4-32. The lines used to secure the ship to a wharf or to another ship are called "mooring lines." They must be as light as possible for easy handling and, at the same time, be strong enough to take considerable strain when coming alongside and holding a ship in place. Five- to six-inch nylon line is the customary material for mooring lines on freight supply and other large vessels. Figure 4-12 shows the locations and names of the lines. Lines should be neatly coiled or arranged to prevent fouling, to eliminate hazards, and to keep the working area clear.

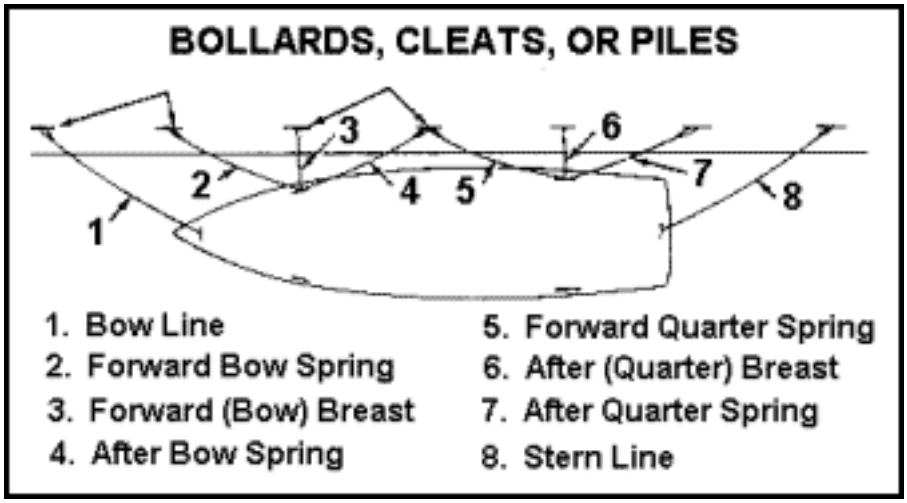


Figure 4-12. Names and Locations of Mooring Lines

4-33. The bow line and the stern line lead well up the wharf to reduce the fore and aft motion of the ship. Breast lines are run at right angles to the keel to prevent a ship from moving away from the wharf. Spring lines leading forward or aft prevent a vessel from moving aft or forward respectively. Two spring lines placed close together and leading in opposite directions act as a breast line from wharf to ship.

USING THE LINES

4-34. Lines assist in coming alongside or clearing a wharf. Before a ship comes alongside, the required lines with eye splices in the ends should be led outboard through the chocks, up and over the lifelines and/or rails. Heaving lines (light lines with weighted ends) are used on larger vessels to carry heavier lines to the wharf. With small boats, there is rarely any need to use a heaving line. Generally, a seaman can either step ashore with the mooring line or throw it the short distance required. Heaving lines should be made fast near the splice--not at the end of the bight where they may become jammed when the eye is placed over the bollard. Heaving lines should be passed ashore as soon as possible.

DIPPING THE EYE

4-35. If two bights or eye splices are to be placed over the same bollard, the second one must be led up through the eye of the first and then placed over the bollard. This makes it possible for either line to be cast off independently of the other and is called dipping the eye.

STOPPING OFF A MOORING LINE

4-36. When a mooring line is taut, it is stopped off with a stopper line (Figure 4-13). The stopper line is secured to the bitts and applied to the mooring line with a half hitch and three or four turns taken in a direction opposite to the one in which the hitch is taken. When the stopper takes the strain, the turns are thrown off the mooring line and it is made fast to the bitts.

DOCKING (SINGLE-SCREW VESSEL)

4-37. In securing alongside a wharf, attention must be paid to the tide. When securing at high water, enough slack must be left in the lines to ensure that at low tide they will not part, carry away bollards, or, in extreme cases, list the ship to a dangerous degree or capsize a small vessel.

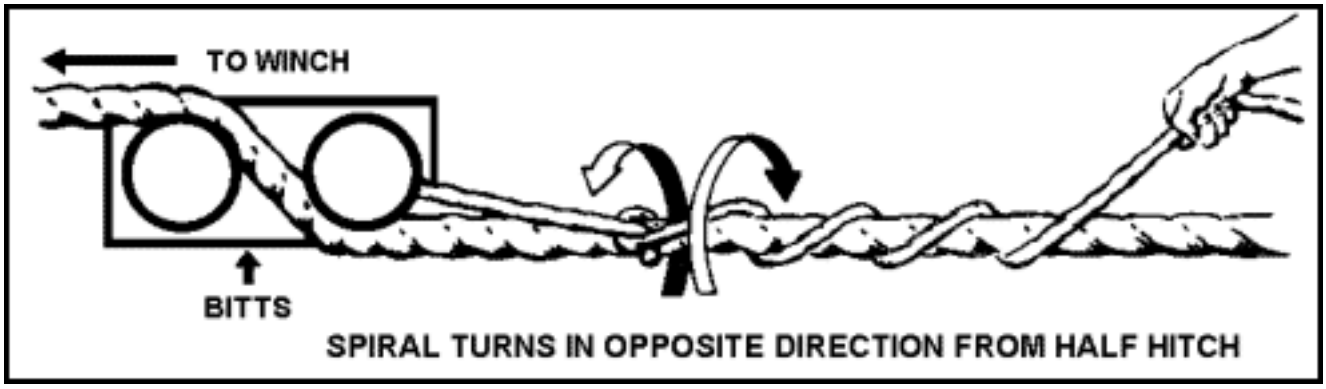


Figure 4-13. Stopping Off a Mooring Line

MAKING LANDINGS

4-38. Wharves and piers may be built on piles that allow a fairly free flow of water under them and in the slips between them. Their underwater construction may be solid, in which case there will be no current inside the slips, but eddies may whirl around them. Warehouses or other buildings may be built on piles, which vary the effect of the wind on the upper works of a vessel when making a landing.

4-39. Making a landing is more dangerous when the wind and current are at right angles to the wharf than when blowing or running along its face. In coming alongside, as in all ship handling, the wind and current should be observed and if possible, used as an advantage.

4-40. Making a landing usually involves backing down. For this reason, procedures for landing port-side-to differ from those for a starboard-side-to landing. Let us first consider a port-side-to landing.

Note: A coxswain should remember that boats do not always respond exactly as theory predicts and that there is no substitute for actual experience.

Port-Side-To Landing

4-41. Making a port-side-to landing (Figure 4-14) is easier than a starboard-side-to landing because of the factors already discussed. With no wind, tide, or current to contend with, the approach normally should be at an angle of about 20° with the pier. The boat should be headed for a spot slightly forward of the position where you intend to stop. Several feet from that point (to allow for advance), put your rudder to starboard-to, bring your boat parallel to the pier, and simultaneously begin backing. Quickly throw the bow line over. Then, with the line around a cleat to hold the bow in, you can back down until the stern is forced in against the pier.

4-42. If wind and current are setting the boat off the pier, make the approach at a greater angle and speed. The turn is made closer to the pier. In this situation, it is easier to get the stern alongside by using hard right rudder, kicking ahead, and using the bow line as a spring line. To allow the stern to swing in to the pier, the line must not be snubbed too short.

4-43. If wind or current is setting the boat down on the pier, make the approach at about the same angle as when being set off the pier. Speed should be about the same or slightly less than when there is no wind or current. The turn must begin farther from the pier because the advance is greater. In this circumstance, the stern can be brought alongside by either of the methods described, or the centerline of the boat can be brought parallel to the pier and the boat will drift down alongside.

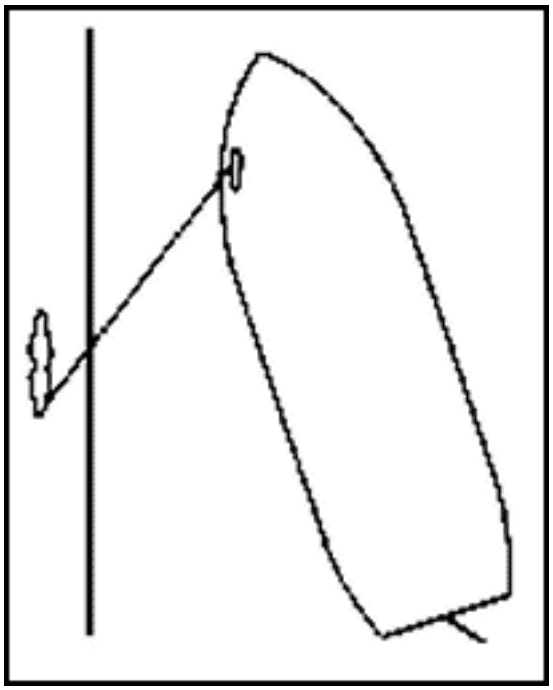


Figure 4-14. Port-Side-To Landing

Starboard-Side-To Landing

4-44. Making a starboard-side-to landing is a bit more difficult than a landing-to port. The angle of approach should always approximate that of a port-side-to landing. Speed however, should be slower to avoid having to back down fast to kill headway, with the resultant swing of the stern to port. Use a spring line when working the stern in alongside the pier. Get the line over, use hard left rudder, and kick ahead. If you cannot use a spring line, time your turn so that when alongside the spot where you intend to swing, your bow is swinging out and your stern is swinging in. When it looks as though the stern will make contact, back down; as you lose way, shift to hard right rudder.

MAKING USE OF THE CURRENT

4-45. If there is a fairly strong current from ahead, get the bow line to the pier, and the current will bring the boat alongside as shown in Figure 4-15 (View 1). If the current is from aft, the same result can be achieved by securing the boat with the stern fast as shown in Figure 4-15 (View 2). Care must be exercised during the approach because an oncoming following current decreases rudder efficiency, and steering may be slightly erratic.

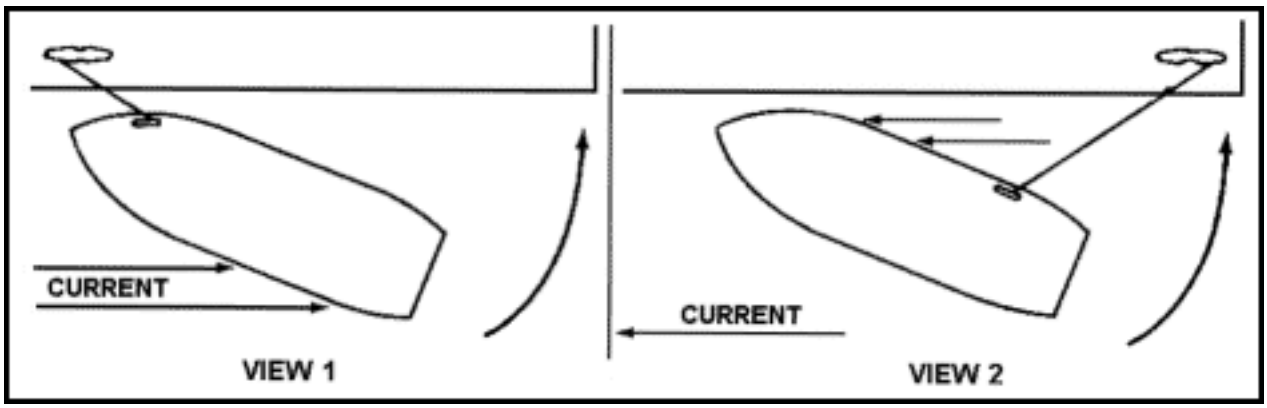


Figure 4-15. Making Use of the Current

TYING UP TO A PIER (HEAVY WEATHER PROCEDURES)

4-46. If heavy winds are forecast (less than 50 knots), make sure storm lines are out fore and aft and additional breast lines are set. The greatest damage to the ship will result from the ship banging against the pier or other nested ships. Make sure all lines are properly set and that adequate fenders are rigged between the ships nested alongside.

GETTING UNDERWAY FROM A PIER

4-47. As when coming alongside, procedures for getting underway depend upon which side of the pier the boat is located, as well as the state of current, wind, and so on.

Starboard-Side-To

4-48. The easiest way to get underway, when starboard-side-to a pier, is to cast off the stern first, hold the bow line, give the boat hard left rudder, and begin backing. When the stern is clear of the pier and any boat or other object astern, cast off the bow line and back out of the slip.

Port-Side-To

4-49. The easiest way to clear a port-side-to landing is to use the bow line as a spring line. Cast off the stern line, give the boat left full rudder, and kick ahead until the stern is well clear. Then cast off the spring line and back out of the slip.

HANDLING GROUNDED HARBOR CRAFT

4-50. Grounded vessels can cause physical damage to fragile reefs. The also pose serious pollution threats to the marine environment because fuel and waste oil tanks can be damaged as a result of grounding.

SURVEY THE SITUATION

4-51. If a vessel runs aground, an intelligent and careful estimate of the situation must be made before attempting to move the vessel. The following procedures should be observed:

- Notify unit HQ to send assistance; establish communication procedure; furnish a relief party; and provide for another vessel or vessels to take off fuel, water, stores, and/or cargo.
- Stop engines and inspect the double bottoms and bilges to find out the extent of leakage resulting from the initial impact of grounding.
- Take soundings around the entire vessel to determine the depth of the water and character of the bottom. Send out a boat to take soundings to determine if engines can be maneuvered.
- Inform the engineer about the condition of the bottom so that he may take precautions to protect the pumps, pipelines, and engine-cooling spaces from damage by sand and mud.
- Examine the hull to determine the extent of damage. If the shell has been pierced, IMMEDIATELY close watertight doors.
- Determine whether backing vessel off would be an advantage or would increase damage and whether or not pumps could control flooding compartments if the vessel were floated free.
- Study tide tables, sailing directions, and charts to determine the time of high tide and tidal current, depths, and type of bottom in the vicinity of the vessel's position. A leadsman should be stationed to take frequent soundings to note any change in tides. If it appears that some time will be required to ready the vessel for floating or to secure outside aid, weather reports should be obtained before planning action.

SALLYING

4-52. One of the first observations the master should make is whether the vessel is lively, that is, affected by the swells. If so, it may be possible to refloat her at once by sallying ship. Sallying a ship is accomplished by securing a line from another vessel at right angles to the keel and alternately pulling the vessel back and forth in an effort to free the bottom. At the same time, if the propellers are clear, the engines should be backed at full speed and, if another vessel is in the area, a line should be secured to the vessel to exert a pulling force.

FLOODING THE VESSEL

4-53. When the vessel is held fast and is in danger of being pounded by heavy seas, it may be best to flood the compartments with water to prevent the vessel from moving over the bottom and smashing the hull. The water can be pumped out later after the heavy seas have abated.

REMOVING BALLAST

4-54. The vessel may be lightened and its draft reduced by discharging some of its liquid ballast. This weight may be enough to decrease the draft and free the vessel. The tanks should not be emptied completely because a certain amount of fuel and water is needed to keep machinery running to deliver the vessel to safety. If the vessel is aground at the bow, the tanks should be pumped from bow to stern; if the stern is aground, the tanks should be pumped from stern to bow. You must keep in mind that intentional dumping of fuel is a criminal offense. If it is necessary to save the ship, a means of transferring the fuel to another vessel should be attempted.

KEDGING

4-55. When a vessel grounds on a bar or a river bank in quiet water and the engine either is of no assistance or cannot be used, the vessel may be cleared by kedging. Kedging consists of carrying out kedge anchors with sufficient scope and taking a strain on them. If in conjunction with any possible lightening or shifting, a steady strain often will work a vessel free. If the vessel has gone hard on a bar so that she is aground amidships, it is possible that the best means of freeing her may be to go ahead on the engines and shove full across the bar.

SHIFTING CARGO

4-56. If the vessel is not aground along the full length of her keel, all weight should be shifted to the part of the vessel still afloat. On a vessel aground by the bow, ballast, fuel, and water may be shifted to the aftermost tanks available and the cargo may be shifted from the forward to the after hatches. When there is no room in the after hatches, as much cargo as is deemed safe may be deck-loaded aft. Such shifting of weight and cargo should not be attempted if it would merely put the full length of the keel on the bottom. However, when there is enough depth (as there often is when grounded on a bar) such operations may be the quickest and simplest means of working free.

TOWING OFF

4-57. When a vessel is aground and the master is not sure that he can get it off quickly without damage or when a vessel strands on a beach in open surf, the aid of another vessel should be obtained immediately. The master of the assisting vessel must acquaint himself as fully as possible with the whole situation. This includes knowing the nature of the bottom, prevailing winds, current and tidal data, and any damage to grounded vessel (such as possibility of pierced hull or compartment). He must also confer with the master of the stranded vessel. Procedures are as follows:

In Quiet Seas

4-58. In quiet seas an assisting vessel may anchor to seaward with a good scope of cable. The lines should be secured to the stern of the stranded vessel and kept taut until the assisting vessel tails in as near the stranded vessel as wind and tide permit. The anchor windlass should be used with full power to keep these lines taut and pick up every inch of slack until the vessel is pulled off. Engines should be used and a good strain kept on anchor cable.

In Heavy Seas

4-59. If seas are heavy, it is often necessary to pass a light line (messenger line) between the assisting vessel and the stranded vessel. The messenger line is secured to one end of a heavy towing line and is hauled to the stranded vessel by pulling in the messenger line. During towing operations in heavy seas, oil should be poured on the water. This aids in preventing breakers and gives a smoother sea in which to operate. The oil should be poured so that the current and/or wind will cause it to spread over the area around and between the stranded and assisting vessels.

In Strong Current

4-60. The assisting vessel can use two anchors, but if they drag and the vessel is being set down on the beach, the lines should be cast off immediately. The vessel can then maneuver clear of difficulty, heave up anchors if necessary, and make a fresh attempt.

Towing Vessel--Not Anchored

4-61. When the towing vessel is not anchored, caution should be used to prevent grounding (Figure 4-16). A stern line must not be used, especially in a cross current or wind, as it would make the rudder useless.

4-62. It is best to secure a line to a bitt farther forward and then head the vessel slightly forward and across the current, gradually adding strain to the line and using it with the helm to pivot the towing vessel (Figure 4-17).

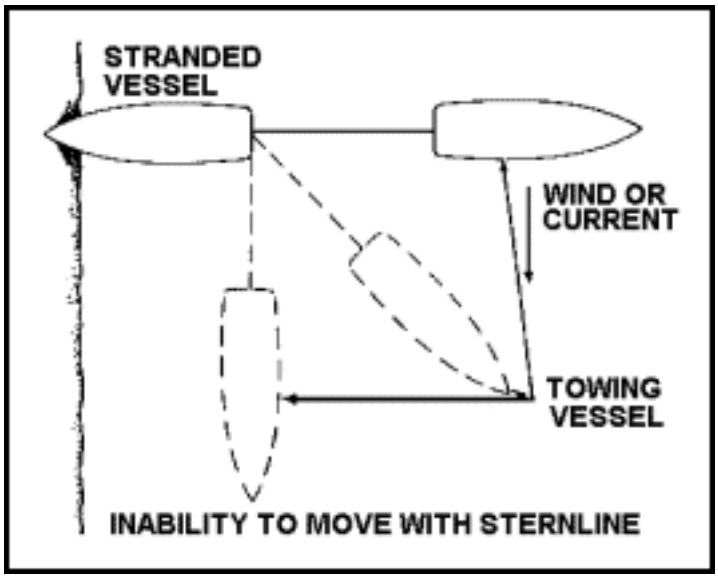


Figure 4-16. Maneuverability of Towing Vessel (Non Anchored)

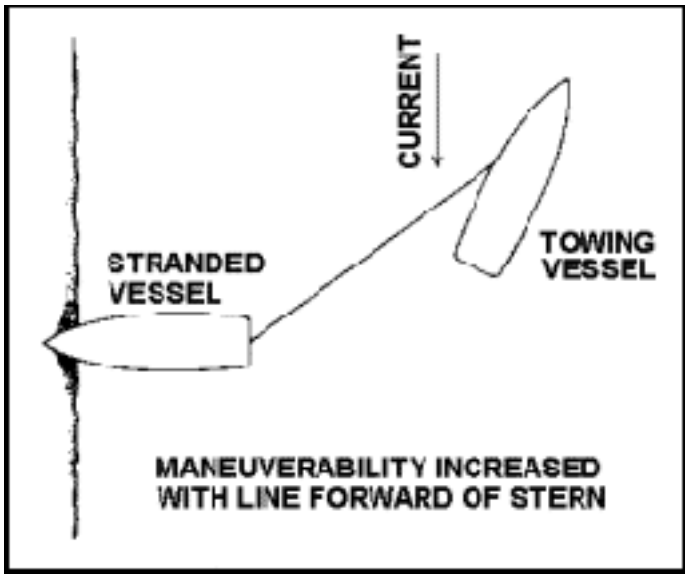


Figure 4-17. Maneuverability of Towing Vessel (With Secured Line)

Approaching Bow On

4-63. When the wind is offshore, it is possible for the towing vessel to approach bow on and pass a line forward (Figure 4-18). After taking the line in through a forward bow chock, the towing vessel can back her engines to pull off the stranded vessel, thereby saving time which would have been lost in maneuvering to take a line aft. However, pivoting power will be lost if the line is taken exactly at the bow. Instead, it should be taken through a chock a little farther aft. This procedure may assist in slowing the stranded vessel's stern and thereby causing it to break free.

4-64. A towing vessel which approaches bow on should come in a little to the windward, drift toward the stern of the stranded vessel, and receive the line in that position (Figure 4-19).

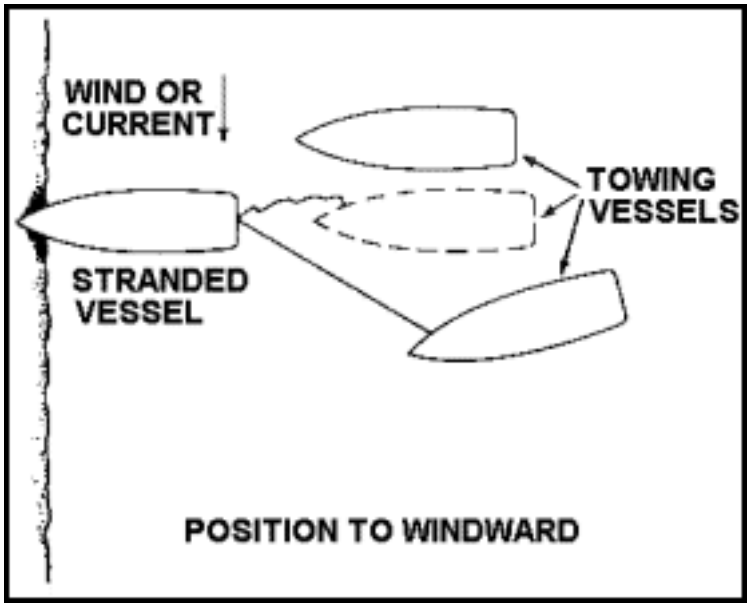


Figure 4-18. Receiving Line Forward

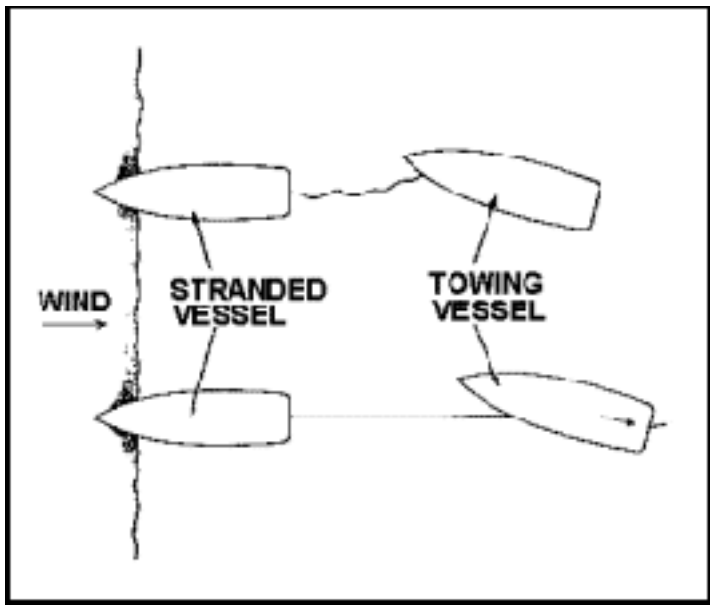


Figure 4-19. Towing Vessel Approaching Bow On

In Packed Sand

4-65. When a vessel is grounded by the bow on a sandy beach, sand will frequently become packed around the stern. Soundings taken by lead line will show the exact location of this sand. Water jets may be rigged over the side and connected to the fire mains. At the beginning of the high tide during which the vessel is to be pulled off, these pumps and jets should be started. The force of the water will create live sand, which will move away from the bottom and sides of the vessel.

For Jumping a Line

4-66. Small vessels may be pulled off the beach by a sudden pull under full power. This method is never used on heavy vessels, but is sometimes useful on smaller craft at high tide. The hawser must be securely fastened to towing bitts because no other part of the vessel will stand so great a strain. Care must be taken to keep the hawser away from the propellers and also that personnel stand clear of the hawser.

HEAVY WEATHER MEASURES

4-67. Since vessels vary in design and size and weather conditions vary in severity, so do the measures that need to be performed. The following are some measures you should know in heavy weather.

- Meet with the crew to explain the situation and reassure them. Make sure that they know what to do, and what not to do, when the extreme weather arrives. Explain such things as keeping low in the boat, not moving around excessively and not going out on deck unless necessary. Give them all an assignment to keep them occupied and keep their minds off the situation.
- Determine position of storm, wind direction, speed, and estimate time to your location.
- Secure all hatches and close all ports and windows to keep the water on the outside.
- Pump bilges dry (into holding tank) and repeat as required. This helps eliminate "free water affect." (Sloshing of water in the bilge as the boat rolls which can effect stability)
- Secure all loose gear above and below decks. Put away small items and lash down larger ones.
- Break out PFD's and foul weather gear.
- Ready emergency equipment that you may need such as hand pumps, bailers, first aid kit, sound signaling device, and so on.
- Get a good fix of your position and plot it on your chart. Make note of the time, your heading, and speed.
- Make plans to alter course to sheltered waters if possible.
- Continue to listen to the VHF radio for updates to severe forecasts.
- Review abandon ship procedures.
- Make sure the life raft is ready to be deployed.
- Make sure emergency food and water are in the life raft.
- Rig jack lines and/or life lines. Require anyone who must go on deck to wear a safety harness.
- Make ready your sea anchor or drogue if needed.
- Turn on navigation lights.
- Keep away from metal objects.
- Change to a full fuel tank if possible.
- Keep a sharp lookout for floating debris and other boats.
- If you have a choice, do not operate the boat from the flybridge.

STANDARD PRECAUTIONS

4-68. Before a vessel leaves port and passes the sea buoy, standard precautions are taken to make her secure. All booms are lowered and stowed, movable gear on deck is lashed down, and covers are placed over machinery that may be damaged by saltwater. When a vessel enters a storm area, a check should be made to see that these standard precautions have been taken. Extra lashings should be added where needed to avoid damage to gear or cargo. Hatch coverings should be checked and the battens secured. Ventilators should be trimmed away from the wind and spray or taken down entirely and plugs or tarpaulins should be fitted over the openings. Boat gripes should be inspected and tightened. Watertight doors should be closed securely and dogged, skylights battened, deadlights closed, and, if necessary, lifelines rigged.

Securing Cargo and Gear

4-69. When stowing or supervising the stowing of cargo, keep in mind that the vessel will be at sea and the cargo will be subjected to the forces constantly generated by the roll and pitch of the vessel. A stiff roll or continuous pitching has an element of impact that tends to loosen cargo. Once the stowage has become loose, it creates an impact of its own. After the damage is done, it is usually too late and too dangerous to attempt to correct. Gear used to handle cargo should always be stowed securely. Booms should be cradled and bolted and guys and pendants should be coiled and lashed. There should be no loose lines on deck while at sea because they jeopardize life and property.

Protection of Deck Cargo

4-70. The chief advantage of deck cargo is that it is always visible and can be easily checked. All deck cargo should be well lashed and secured. In foul weather, turnbuckles should be tightened and tarpaulins rigged. When they sweep the deck, waves exert an immense hydraulic force, which the deck cargo must withstand.

USE OF OIL AND SEA ANCHOR

4-71. Each oil and sea anchor must be of the type specified by the manufacturer and must be fitted with a shock resistant hawser. They may also be fitted with a tripping line. One anchor must be permanently attached to a vessel in such a way that, when the vessel is waterborne, it will cause the vessel to lie oriented to the wind in the most stable manner. A second oil and sea anchor must be stowed in the vessel as a spare. Military and passenger vessels must have the permanently attached oil or sea anchor arranged to deploy automatically when the vessel floats free. The oil or sea anchor for a rescue boat must be of the type specified by the rescue boat manufacturer, and must have a hawser of adequate strength that is at least 10 meters (33 feet) long.

Oil

4-72. The adherence of water to air allows strong winds to build up one large wave at the expense of others. These waves are dangerous to vessels because of their size, speed, and the amount of water they can deposit on deck. This liaison between water and air can be reduced by spreading oil over a large area of water to decrease the formation of giant waves and deaden the cresting motion of all waves. Preferably, an animal or vegetable oil should be spread windward of the vessel at the rate of approximately 2 gallons an hour. Too much oil is a fire hazard, especially if there is a possibility that boats may be launched. A canvas bag stuffed with oakum, cotton, or waste, soaked with oil, and hung over the side will spread oil slowly and safely.

Sea Anchor

4-73. Before it becomes impossible to steam either with or against the seas, the vessel must be hove to, that is, headed so she will take the seas most comfortably. It must be remembered that each vessel will heave to in a manner dependent on her design and trim. Some vessels will lay their quarters into the wind and others, their bows. The master, bearing in mind that the most comfortable and safe position for a vessel is with a small angle to the seas, should estimate what position his vessel will assume when lying powerless. Steaming slowly ahead or astern, depending on whether the vessel is laying its bow or quarters into the wind and whether the storm is of average strength, will preserve the desired angle. However, if the storm is so violent that the vessel is unable to proceed at all, a sea anchor may be rigged.

4-74. A sea anchor (Figure 4-20) is used to create a drag through the water and hold either the bow or the stern into the sea. Small vessels carry a sea anchor, which is a canvas bag to be dropped over the bow or stern and secured with a heavy line. Large vessels can improvise a sea anchor by rigging one from hatch covers or other available material. Oil (to calm the seas) may be used in conjunction with the anchor.

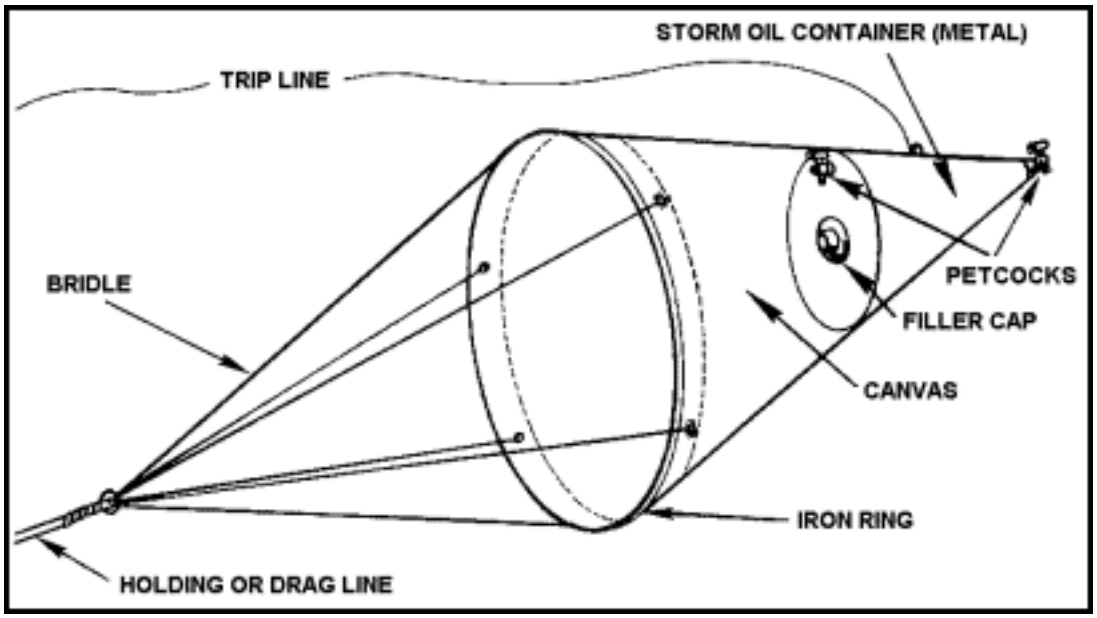


Figure 4-20. Sea Anchor

Search

Chapter 5

Charts and Publications

The mariner must be able to identify and describe the following:

- Basic charts used aboard ship.
- Chart numbers.
- Correct charts.
- Basic navigation publications.
- Agencies that are responsible for updating, publishing, and issuing charts and publications.

The mariner must also be able to interpret chart numbers, use basic navigation publications, and know how to requisition charts and publications.

THE EARTH AND ITS COORDINATES

5-1. This paragraph describes the earth and its basic reference lines which are required for locating a geographical position in terms of latitude and longitude. It also tells how to measure distance and direction. You need to know this information to be able to solve problems in navigation.

TERRESTRIAL SPHERE

5-2. The earth is called the terrestrial sphere (Figure 5-1). Although it is a little flattened at the poles instead of being perfectly spherical, this irregularity is disregarded here for simplicity. Reference points for location of objects on earth, with two exceptions, have been established by general agreement among maritime nations. The two exceptions are the North and South Poles, located at the ends of the axis on which the earth rotates. Imaginary lines (an infinite number of them) running through the poles and around the earth are called meridians (these divide the earth into sections).

5-3. If you start at the North Pole and travel along a meridian exactly halfway to the South Pole, you will then be on the equator (an imaginary line running around the earth). The equator bisects every meridian and divides the earth in half. The half the North Pole is located is called the Northern Hemisphere and the half the South Pole is located is called the Southern Hemisphere.

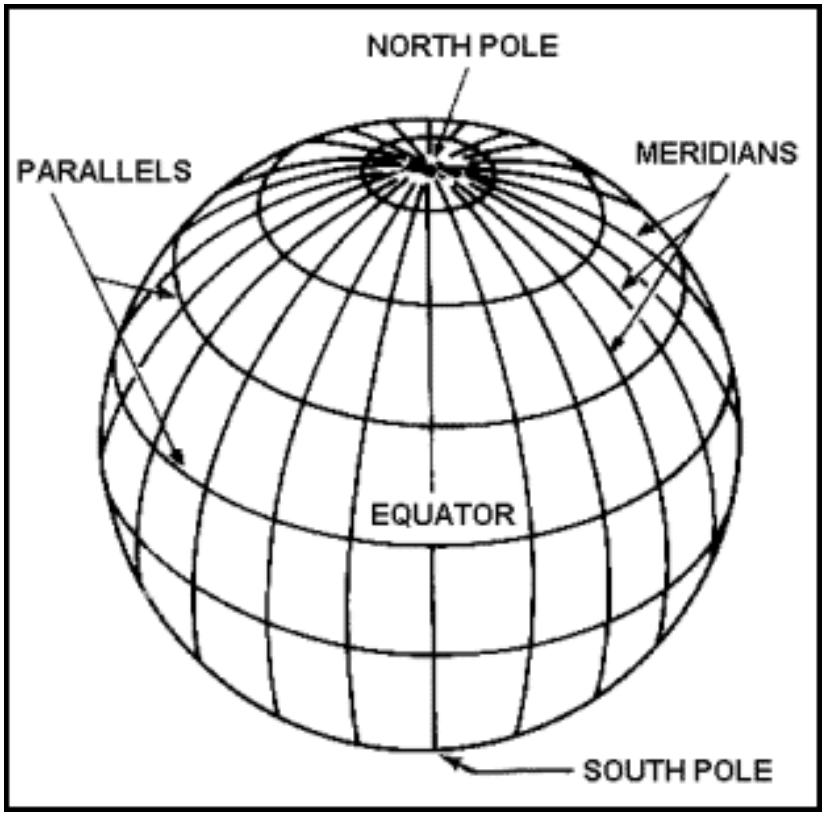


Figure 5-1. Terrestrial Sphere

CIRCULAR MEASUREMENT

5-4. You must know something about how distances are measured along the circumference of a circle. Measurement along a meridian, which is a great circle, is expressed in terms of degrees of arc. These degrees of arc may be transformed into linear measurement expressed in nautical miles. The best example of circular measurements in degrees of arc is the compass card. Whatever the size of the card, its circumference is always 360° . Each degree contains 60 minutes (‘), and each minute has 60 seconds ("). The nautical mile, by arbitrary international agreement, is now taken as 6,076.11549 feet or exactly 1,852 meters. The nautical mile is about one-seventh again as long as the statute mile.

MERIDIANS AND PARALLELS

5-5. In developing a system for locating points on the terrestrial sphere, there are a series of meridians running through the poles of the earth and a single line called the equator, running around the earth at right angles to its axis. These reference lines can be seen in Figure 5-2. The equator divides each meridian and the earth itself into two exact halves.

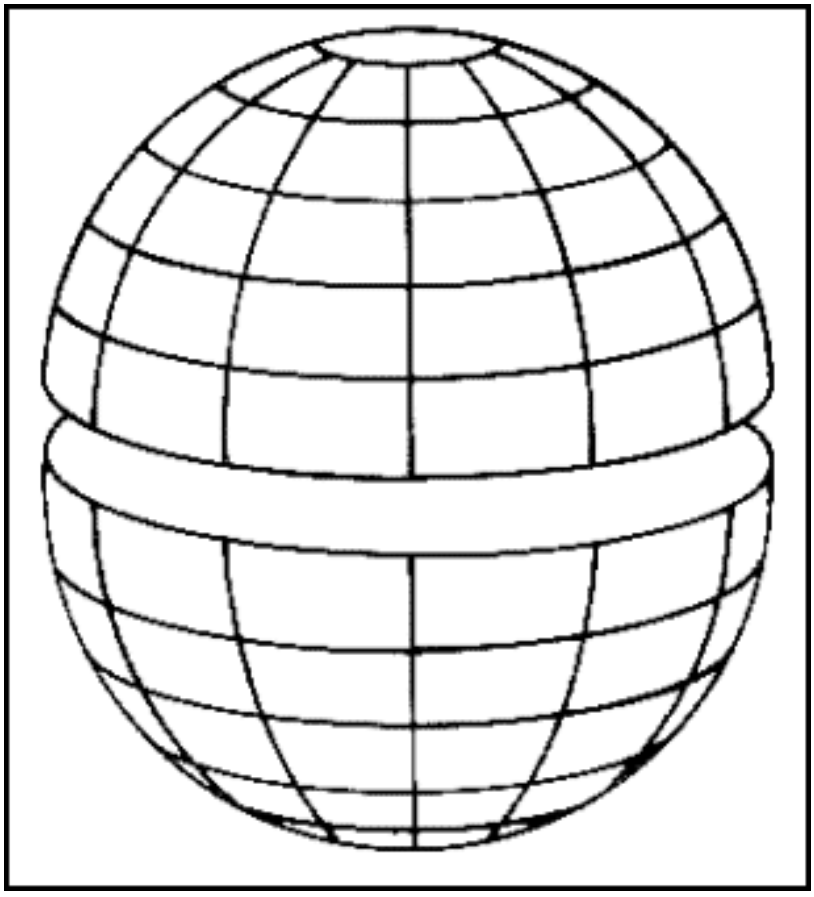


Figure 5-2. Equator

5-6. There is a meridian (360 of them) for each degree around the earth's rim. A starting point for numbering these meridians was required, and most of the maritime countries decided that the starting point should be the meridian passing through the Royal Observatory at Greenwich, England. The Greenwich meridian is therefore number 0; meridians run from that meridian east and west to the 180th, on the opposite side of the earth from Greenwich. The complete circle formed by the 0 and the 180th meridians, the prime meridian, like the equator, divides the earth into two exact halves, the Eastern and the Western Hemispheres (Figure 5-3). Meridians run true north and south.

5-7. If you cut a globe of the world in half exactly along the equator and then lay the top portion on a flat surface, the flat edge appears as a straight line. This top portion (now as a semicircle) contains 180° of arc, 90° from the equator to the pole on either side.

5-8. Beginning with the equator, you see lines that appear to be parallel to it, one for each of the 90° of arc from the equator to the North Pole. The planes forming these lines on the earth's surface are actually parallel to each other, and for this reason they are called parallels. If you shift your eye to a point just above the pole, you can see that they are actually circles, growing increasingly smaller as they get farther from the equator and nearer the poles. Remember that no matter how small a circle is, it still contains 360° . However, the distance represented by each degree becomes less as the parallel circles get smaller.

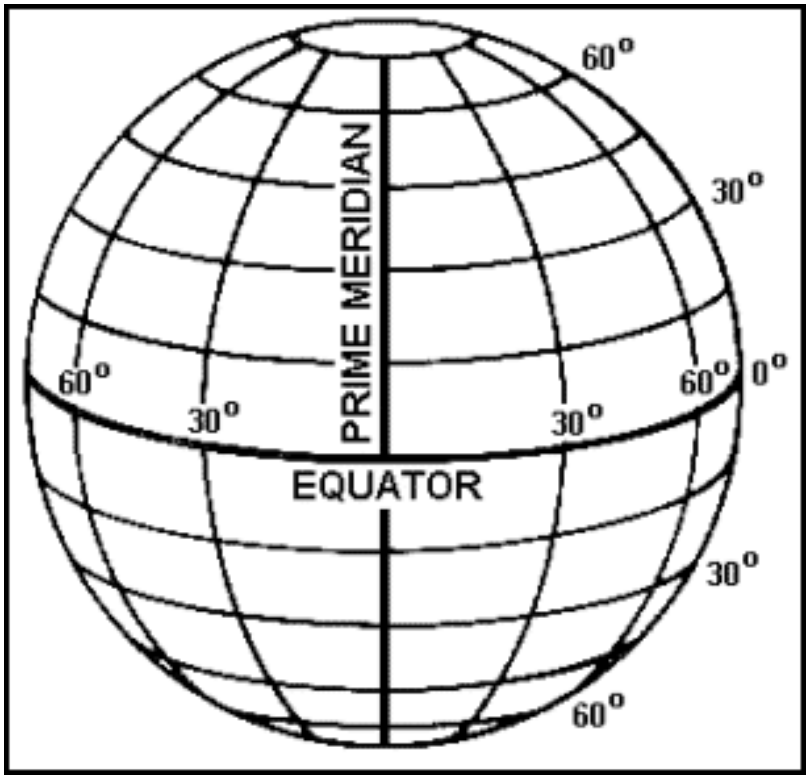


Figure 5-3. Prime Meridian

5-9. Do not think that there are only 360 meridians and 180 parallels. There is a meridian or parallel for every one of the 21,600 minutes around the complete circle of the earth's sphere.

5-10. The parallels and meridians are imaginary, but there is a limit to the capacity of our instruments. We seldom break down a measurement along a meridian or parallel to a value smaller than that of one second.

GREAT CIRCLE

5-11. A great circle is any circle whose plane passes through the center of the earth or any other sphere. The plane separates the sphere into two equal imaginary parts.

5-12. Suppose you have a perfect sphere of soft rubber through which you can pass a flat sheet of thin metal. If you shove the metal sheet through the sphere so as to cut it exactly in half, you have passed it through the center (see Figure 5-4). The circumference of the flat side of each half becomes a great circle whose circumference is the same size as the circumference of the sphere itself.

5-13. However, if you shove the flat metal through the sphere so that it does not pass through its center, the circumference of the flat side of each part is smaller than the outside circumference of the sphere.

5.14. In both examples cited, the flat sheet represents the plane of the circle the sheet makes when it cuts the sphere. If you were to cut the earth on a similar plane, no matter how it is spliced, if the plane passes through the earth's center, the cut off circle is a great circle. If the plane passes through the earth away from the center, the circle it cuts is a smaller circle.

5-15. The equator is a circle whose plane passes through the earth's center. Therefore, the equator is a great circle, and it is the only parallel that is a great circle. The other parallels N and S of the equator are all smaller circles whose planes do not pass through the earth's center. All meridians, on the other hand, pass through the poles, and all their planes must therefore pass through the earth's center. Therefore, every meridian is a great circle.

5-16. Do not think that a great circle must be either a meridian or a parallel. A great circle is any circle around the earth whose plane passes through the earth's center, no matter in what direction the plane passes. The practical significance of the great circle in navigation is that it is the shortest distance between two points on the earth along the great circle passing through those points.

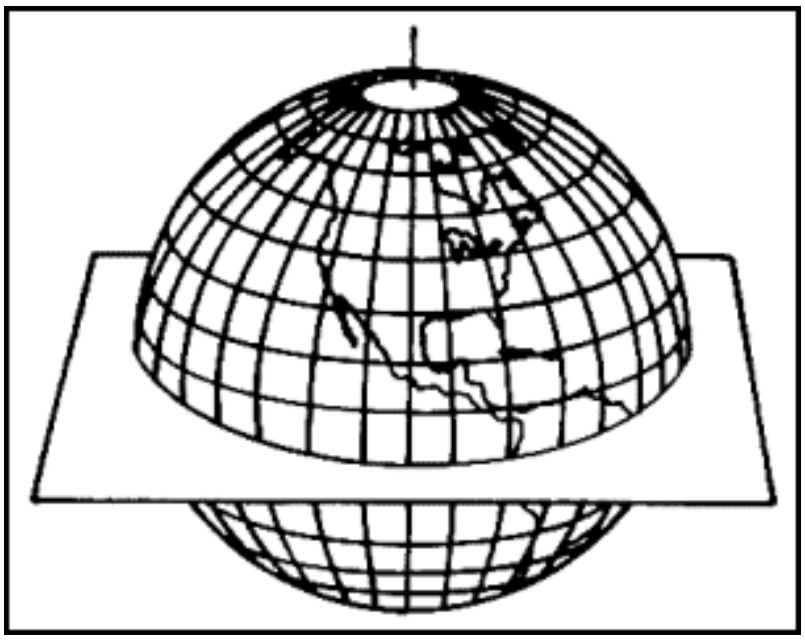


Figure 5-4. Great Circle Equator

LATITUDE AND LONGITUDE

5-17. Now we have a network of meridians and parallels all the way around the globe. Every spot on the earth is located at the point of intersection between a meridian and a parallel. Every point's location is described in terms of the following:

- Latitude (in degrees, minutes, and seconds of arc north [N] or south [S] of the equator, measured along the point's meridian).
- Longitude (in degrees, minutes, and seconds of arc east [E] or west [W] of 0 meridian, measured along the point's parallel).

Longitude is always from 0° to 180° E or W. Latitude is never greater than 90° N or S. Zero latitude is the equator. If you are at latitude 90° N, you are at the North Pole, and whichever way you look is south.

MEASURING DISTANCE

5-18. The nautical mile is almost equal to 1' of arc on the equator. This is about 1 1/7 statute or land miles. The equator is a great circle. So, if 1' of arc on the equator is 1 nautical mile, 1' of arc on any great circle must also be 1 nautical mile. All great circles are the same length.

5-19. This means that on any chart, the meridians may be used as a distance scale. All meridians are great circles; 1’ of latitude along any meridian equals 1 nautical mile. However, when it comes to parallels, 1’ equals 1 mile only on the equator, the only parallel that is a great circle. To put it another way, 1’ of longitude equals 1 mile only on the equator.

SPEED

5-20. The word "knots" is a seagoing speed term meaning nautical miles per hour. It is incorrect to say "knots per hour" except when referring to acceleration.

DIRECTION

5-21. Nautical direction is usually measured from true north on the observer’s meridian.

5-22. On the old-fashioned compass card (Figure 5-5), direction was indicated by points. There were 32 major points around the card, each of which had a name: N, N by E, NNE, NE by N, NE, and so on. Each point was subdivided into quarter points, a point equaled 11.25 degrees of arc. The system of naming these divisions toward or away from the points themselves was complicated and difficult to remember. You will still find the system used in our Rules of the Road. Referring to the arc of a light for example, the light may be seen from ahead to "two points abaft the beam."

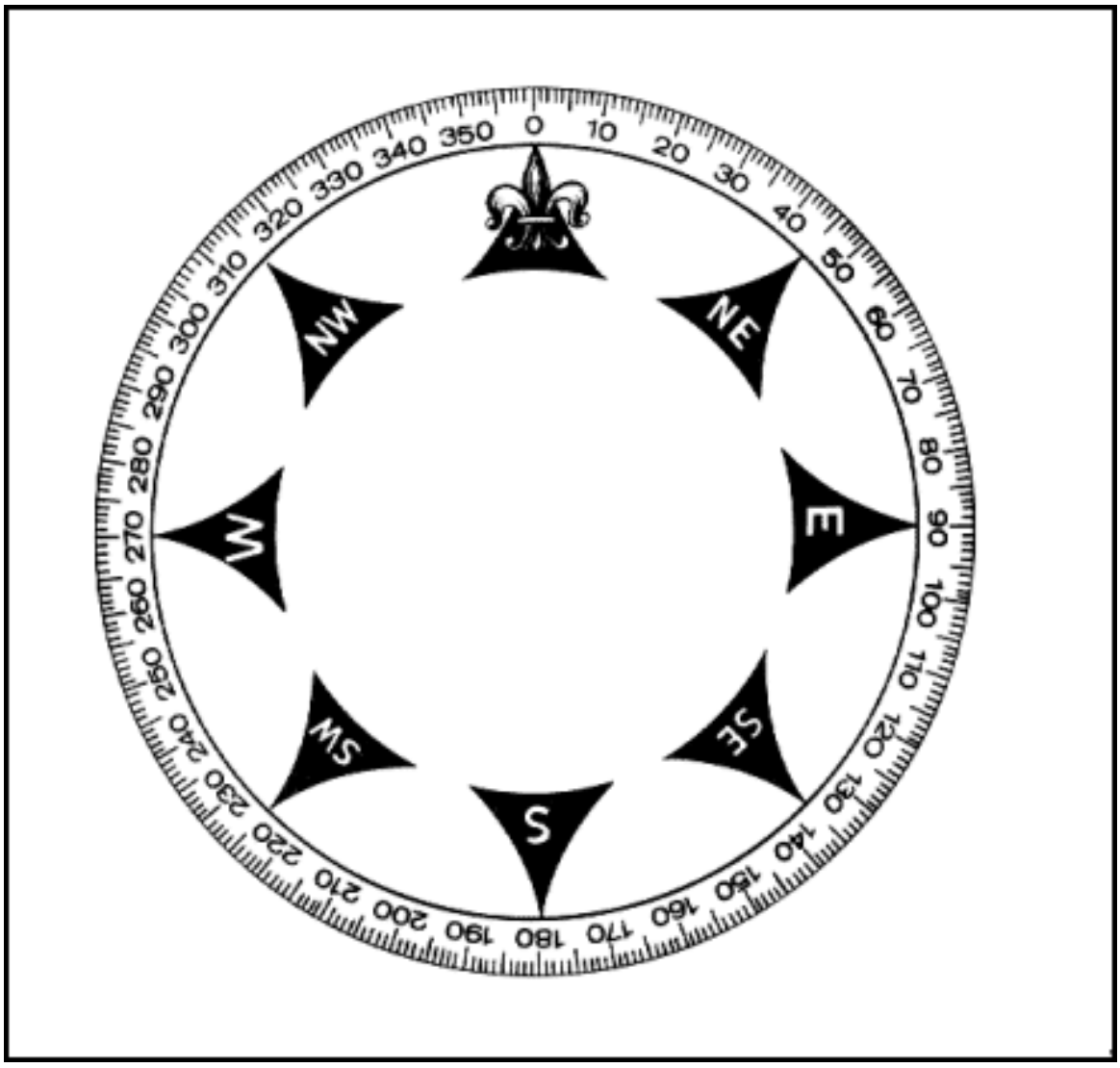


Figure 5-5. Compass Card

5-23. Navigators have long since adopted the system of circular measurement (360° of arc) as a more convenient means of indicating direction than the ancient system of points.

5-24. Direction in modern navigation is always given in degrees and measured clockwise from true north or 000° T. A course or bearing is always expressed in three figures, regardless of whether three digits are necessary (for example, it is not 45° , but 045°). Seldom is it possible to consider compass direction to a value smaller than the 10th of a degree even though each degree of direction contains 60 minutes of 60 seconds each. It is almost impossible to read a compass bearing or heading closer than a quarter of a degree.

5-25. A ***true bearing*** is the direction of an object from the observer measured clockwise from true north.

5-26. A ***relative bearing*** is the direction of an object from the observer measured clockwise from the ship's head, as indicated by the lubber's line in the binnacle, pelorus, or gyro repeater.

Note: There will be times when you will find it necessary to convert from true to relative bearings and vice versa. This relationship is shown in Figure 5-6. Notice that dead ahead is 000° , dead astern is 180° , and the starboard and port midpoints (beams) are 090° and 270° , respectively.

5-27. The ***reciprocal*** of any bearing is its opposite; that is, the point of degree on the opposite side of the compass card from the bearing (for example, the reciprocal of 180° is 000° and vice versa). When you obtain a bearing on an object, the bearing from the object to you is the reciprocal of the bearing from you to the object. To find the reciprocal of any bearing expressed in degrees simply add 180° to the bearing. If the bearing is 050° , for instance, its reciprocal is 050° plus 180° or 230° . If your bearing is greater than 180° , subtract 180° .

THE MERCATOR CHART

5-28. There is a difference between the terms "map" and "chart." A map shows land areas. It also shows the physical features of the land, cities, towns, roads, political boundaries, and other geographic information. A chart, specifically a nautical chart, shows primarily areas of navigable waters. It also shows coastlines and harbors, depths of water, aids to navigation, channels, and obstructions. A chart provides a means of describing position in terms of latitude and longitude.

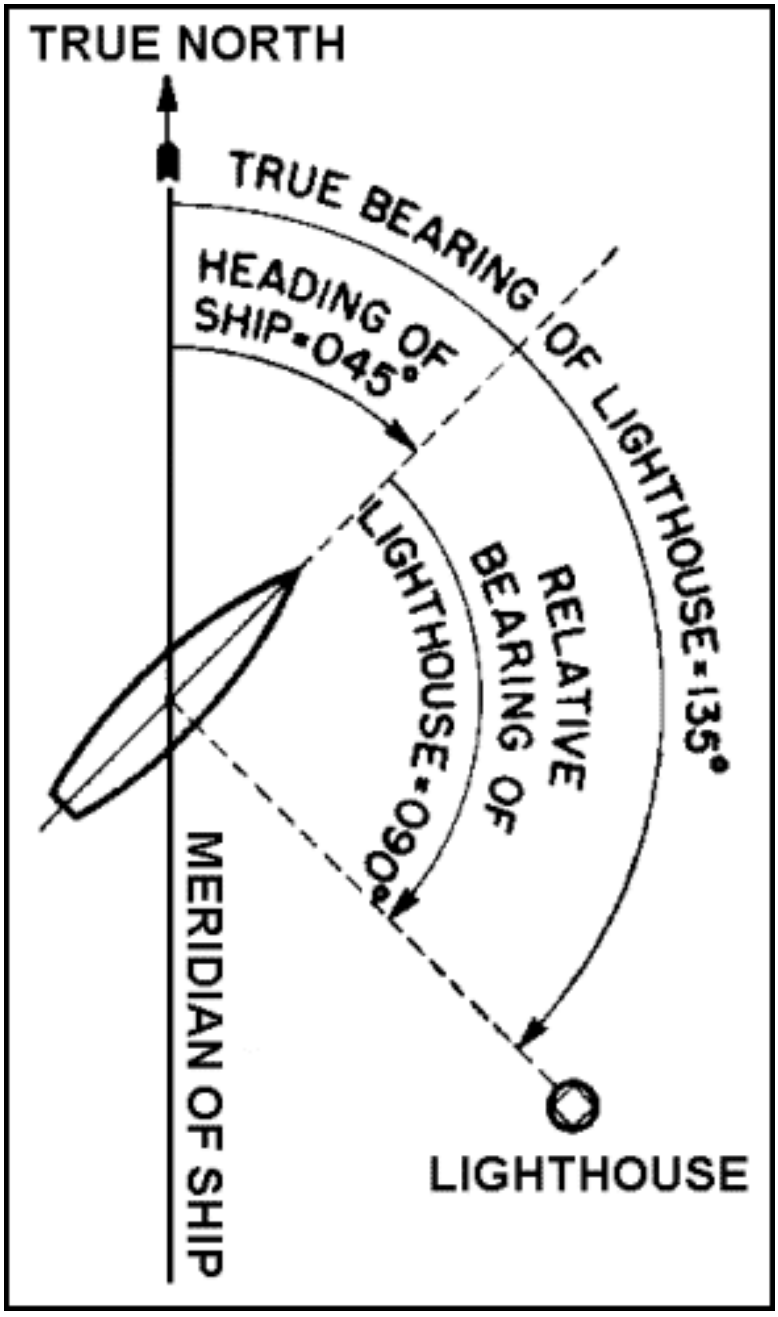


Figure 5-6. True and Relative Bearings

5-29. Gerhardus Mercator developed a method of making a world chart based upon the cylindrical projection. This type of chart (Figure 5-7) is projected by first placing a cylinder around a sphere representing the earth, tangent to the equator (see Figure 5-8). Planes are passed through the meridians and projected to the cylinder upon which they appear to be parallel lines. Lines are then drawn from the center of the earth to the cylinder passing through the parallels; this locates the parallels on the cylinder. The cylinder is then cut lengthwise and flattened out. The resulting graticule (the network of lines of latitude and longitude upon which a map is drawn) is shown in Figure 5-9.

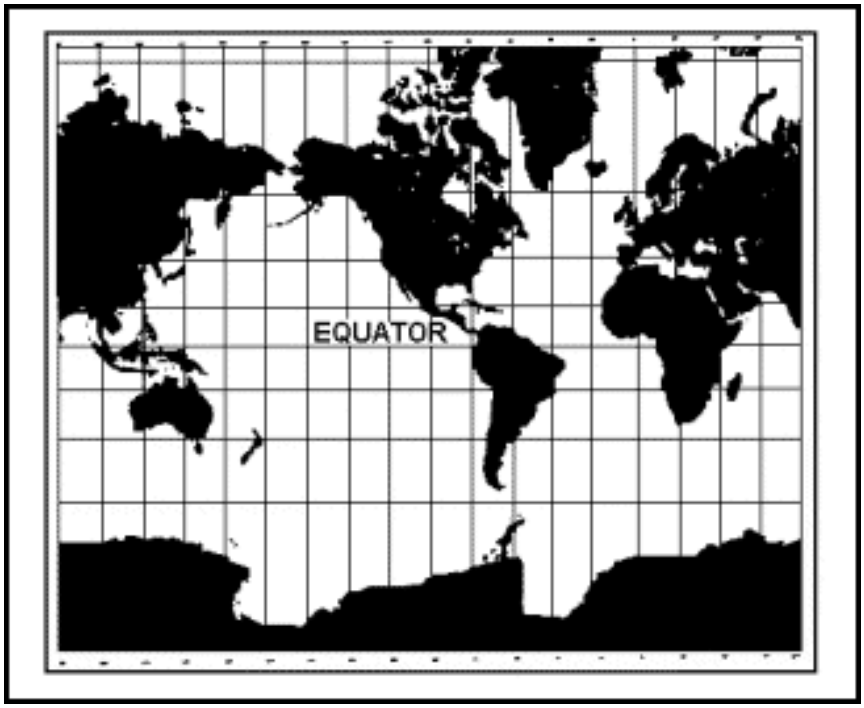


Figure 5-7. Mercator Chart of the World

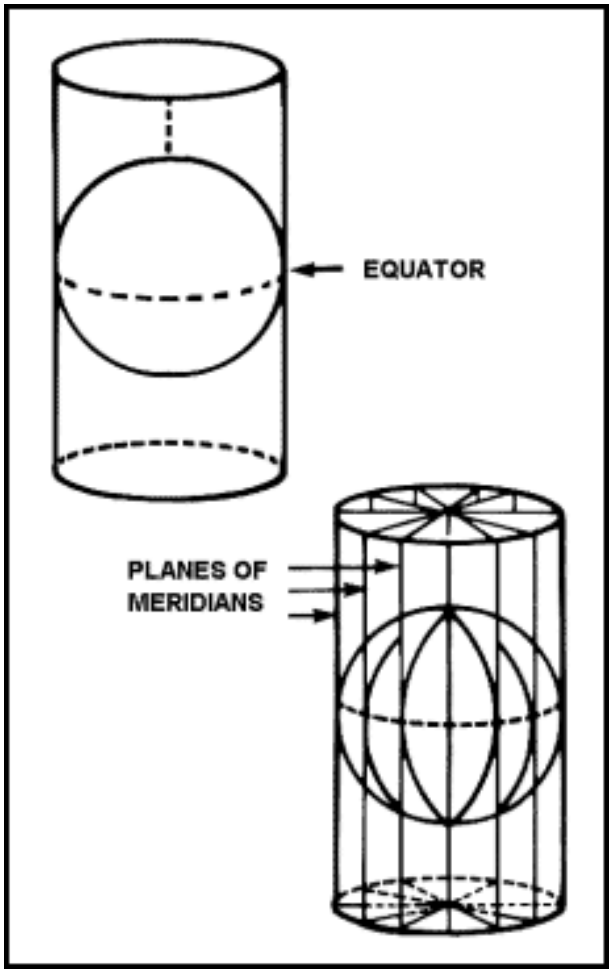


Figure 5-8. Mercator Projection

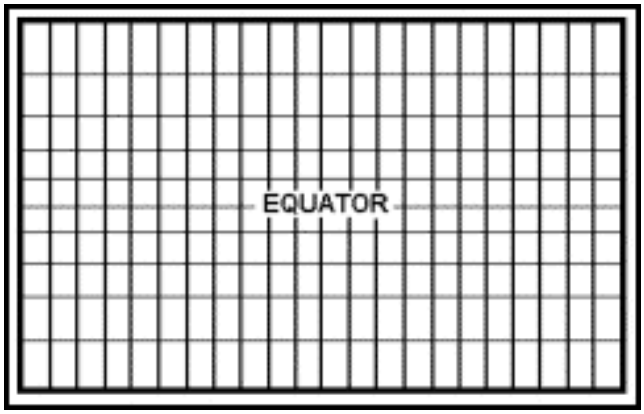


Figure 5-9. Meridians and Parallels

5-30. In the Mercator projection, parallels are spaced by mathematical formulas. In fact, meridians and parallels are expanded as the latitude increases toward the poles. A Mercator projection based on tangency with the equator cannot include the poles.

MEASURING DIRECTION ON A MERCATOR CHART

5-31. The advantage of a Mercator chart (Figure 5-7) is that it is a conformal chart. The appearance of meridians on a Mercator projection as parallel straight lines is one of the most valuable features of this type of projection. It makes it possible to plot a course as a straight line, called a rhumb line (Figure 5-10). A rhumb line cuts every meridian at the same angle. It is also a line with the same bearing throughout. Although it does not represent the shortest distance between the points it connects, this fact is not important unless very large distances are involved.

MEASURING DISTANCE ON A MERCATOR CHART

5-32. The disadvantage of a Mercator chart is the distortion at high latitudes. On earth, the meridians actually converge at the poles, while on the Mercator chart they remain parallel. For practical purposes, 1° of latitude everywhere on the earth's surface may be considered to be equal to 60 nautical miles in length; 1° of longitude will vary with the latitude. At the equator, 1° of longitude is equal to 60 nautical miles and zero at the poles (60' equal 1°). Since 1 minute of latitude is equal to 1 nautical mile everywhere, it is the latitude scale that must be used for measuring distance, never the longitude scale.

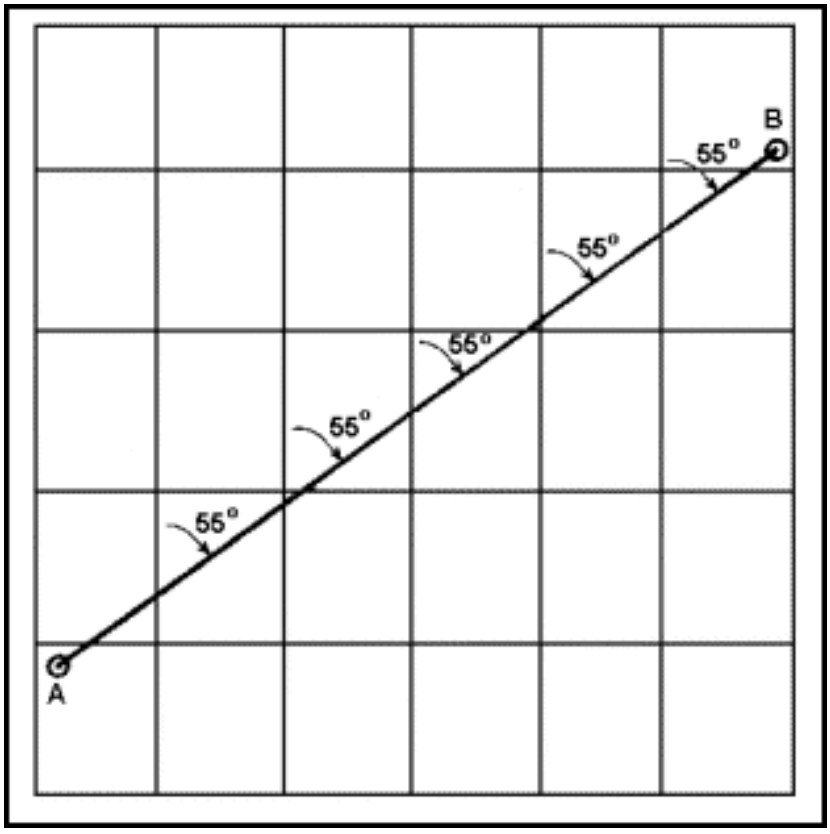


Figure 5-10. Rhumb Line

5-33. When measuring distance over a large area, set the dividers to a convenient scale at the mid-latitude between the two points of measurement. Then step off the distance (Figure 5-11).

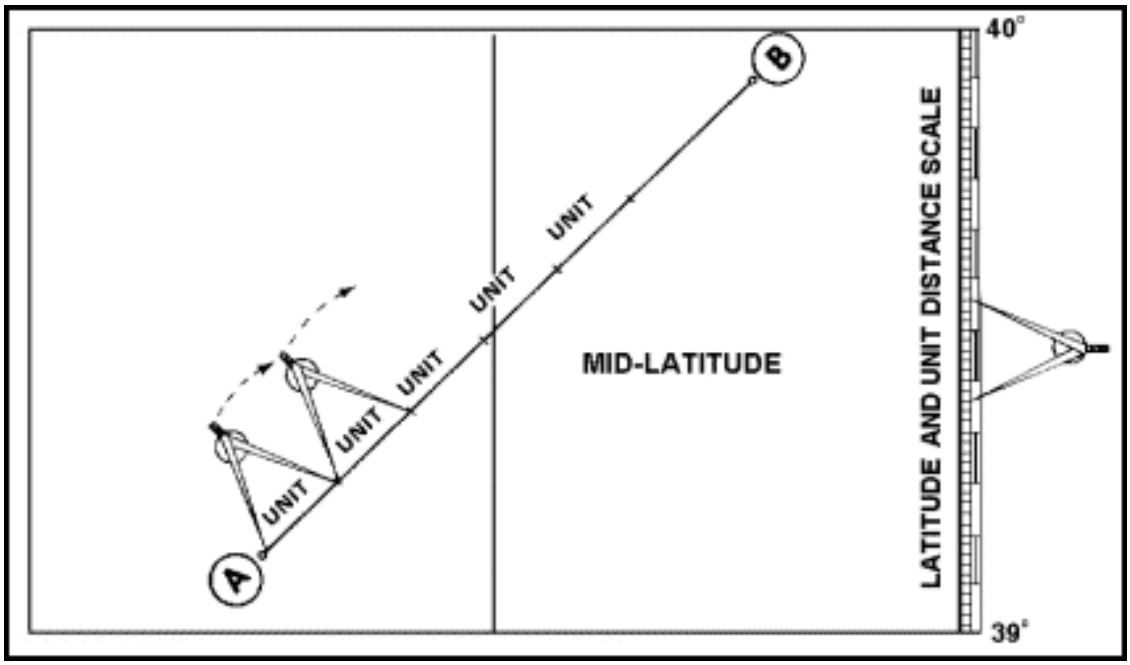


Figure 5-11. Measuring Distance

Plotting Position on the Chart

5-34. A position is usually expressed in units of latitude and longitude, generally to the nearest 0’.1. It may also be expressed as bearing and distance from a known position, such as a landmark or aid to navigation.

5-35. You can plot the latitude and longitude of a position on a Mercator chart by using a triangle or straight edge and a pair of dividers. For example, the position of "Point X" is latitude 57° 09’ N and longitude 63° 44’ W. This may be plotted as shown in Figure 5-12 and as described as follows:

A. Use the dividers to measure off the latitude. Put one leg of the dividers on the closest parallel (57° N) and the other on 09’. The spread of the dividers equals the difference of latitude.

B. Transfer the dividers to the meridian nearest to the desired position to be plotted (65° W), and mark the latitude on the meridian.

C. Place a straight edge through this point parallel to the parallel of latitude. (Lay the straight edge in the direction of the plot.)

D. Set one leg of the dividers on 65° on the longitude scale and the other leg on 64° 44’ W (a spread of 16’).

E. Without changing the spread of the dividers; lay off this distance along the straight, from 65° toward the desired position.

F. Draw a dot, then circle and label the dot.

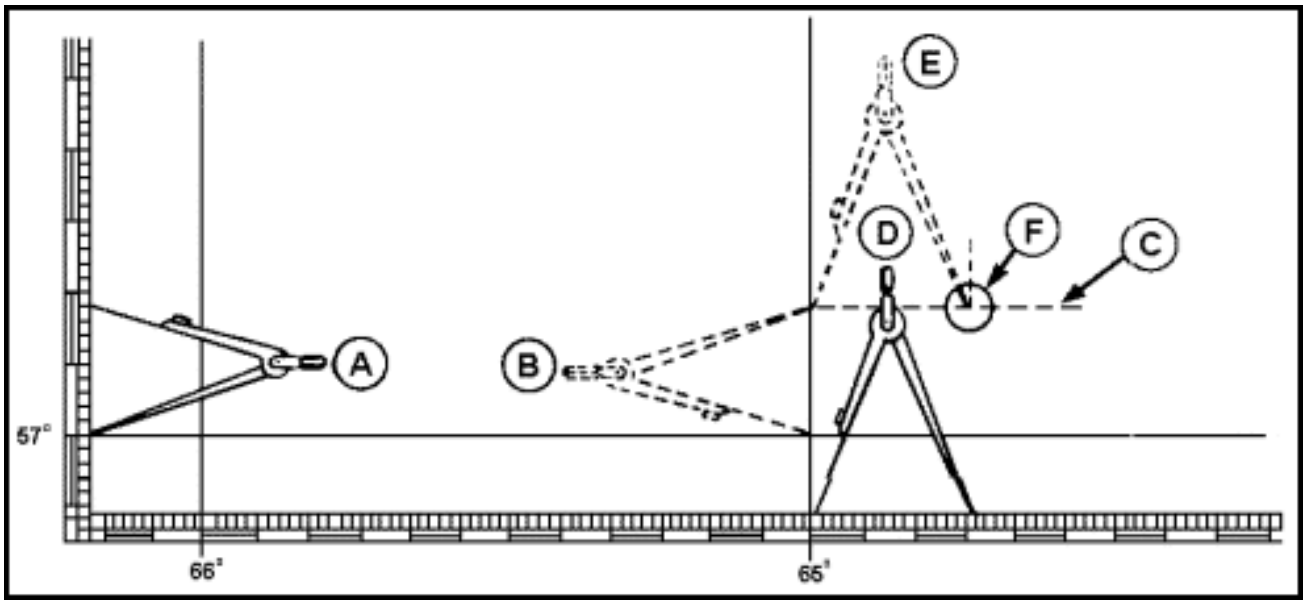


Figure 5-12. Plotting a Position

Reverse Situation

5-36. Determine the latitude and longitude of a specific position as shown in Figure 5-13 and as described as follows:

A. Place the point of one leg of the dividers on the position, swing the other point in an arc, and adjust the spread of the leg until it is at right angles to and touches a parallel of latitude.

B. Without changing the spread of the dividers, transfer the dividers to the latitude scale. Put one leg on the reference parallel, put the other leg in the direction of the plot, and read the latitude of the fix at the other point.

5-37. A similar procedure is used in steps **C** and **D**, measuring from the position to a meridian of longitude. This will give the longitude of the position.

Note: Care must be taken in each case to lay off the distance of latitude and longitude in the right direction from the reference parallel or meridian.

5-38. Several variations of these procedures may suggest themselves. That method which seems most natural and is least likely to result in error should be used.

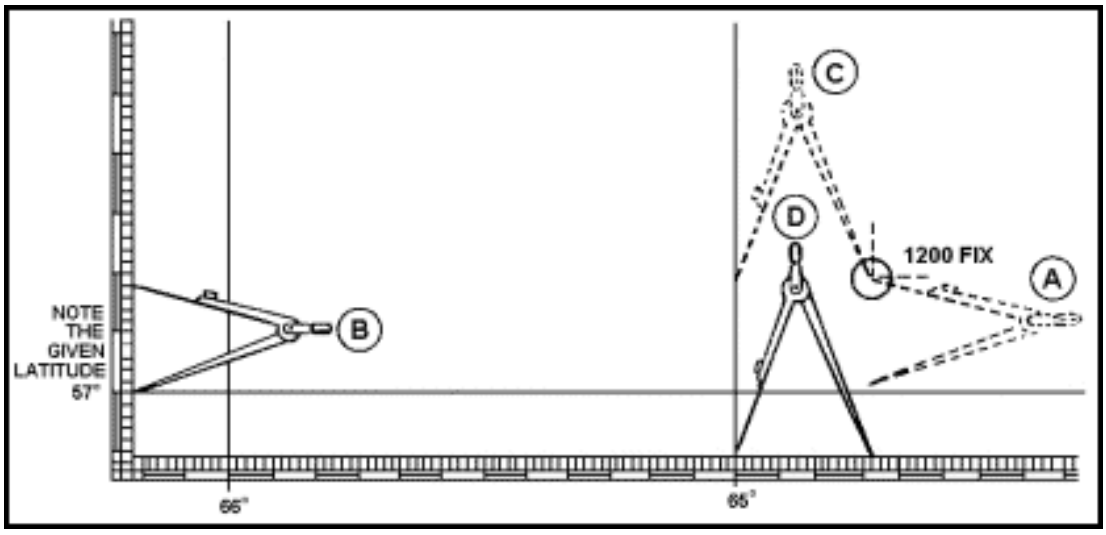


Figure 5-13. Determining Latitude and Longitude

SCALE OF CHARTS

5-39. The scale of a chart refers to a measure of distance, not area. A chart covering a large area is called a small-scale chart (Figure 5-14), and a chart covering a small area is called a large-scale chart (Figure 5-15). Scales may vary from 1:40,000, which are for special charts of inland waters and inland waterways, to 1:600,000, which are the sailing charts. The scales can vary from about 1:2,500 to about 1:5,000,000.

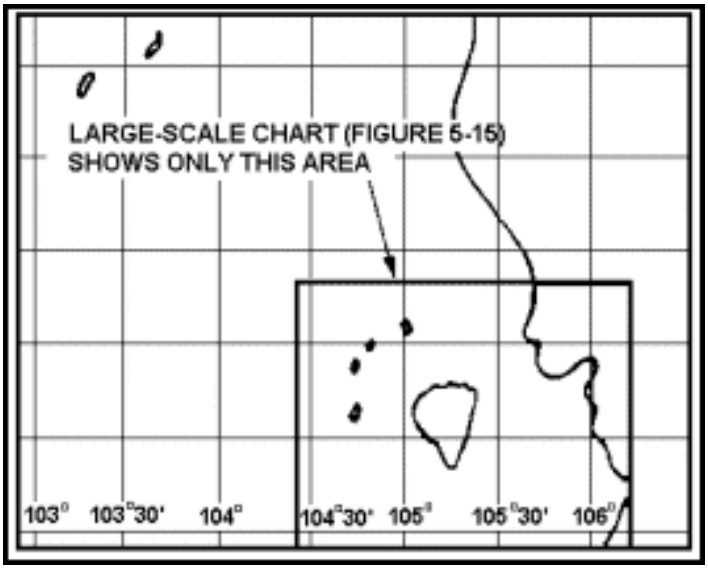


Figure 5-14. Small-scale Chart

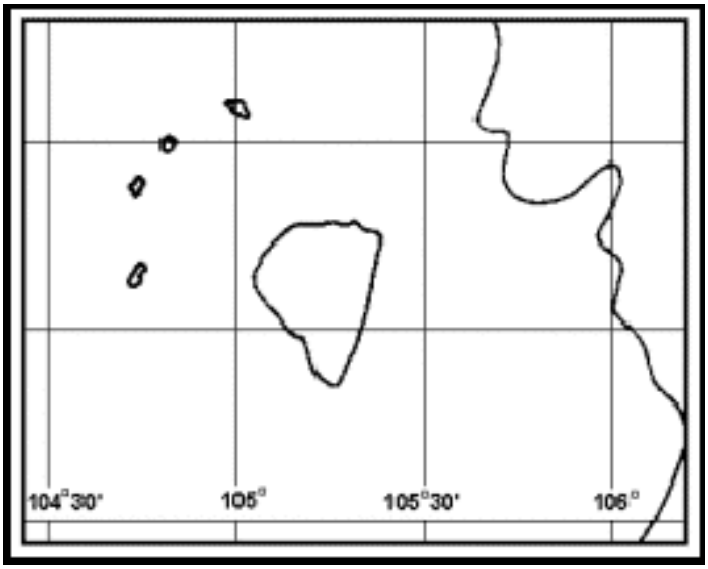


Figure 5-15. Large-scale Chart

5-40. Charts published by National Ocean Survey, which is under the National Oceanic and Atmospheric Administration, Department of Commerce, are classified into series according to their scale.

Sailing Charts - Scale 1:600,000 and Smaller

5-41. These charts are used when approaching the coast from the open ocean or for sailing between distant coastwise ports.

General Charts - Scale 1:150,000 to 1:600,000

5-42. These charts are used for coastwise navigation outside of outlying reefs, yet where the vessel will be within sight of land or aids to navigation and where piloting techniques are used.

Coast Charts - Scale 1:50,000 to 1:150,000

5-43. These charts are used for inshore navigation, entering large bays and harbors, and navigating large inland waterways.

Harbor Charts - Scale Larger Than 1:50,000

5-44. These charts are used in harbors, anchorage areas, and smaller inland waterways.

Small-Craft Charts - Scale 1:40,000 and Larger

5-45. These small-craft charts are strip charts of inland waters to include the intracoastal waterway.

5-46. Charts published by the Defense Mapping Agency Hydrographic and Topographic Center are classified into two categories: Approach Charts - charts of 1:150,000 and less and General Charts - roughly 1:150,000 and larger.

5-47. Good seamanship requires that you use the largest scale chart available for study of your proposed voyage, even though you may use smaller scale charts for doing your plotting.

BASIC INFORMATION SHOWN ON CHART

5-48. The chart's legend will show the title of the chart which describes the waters covered; type of projection used; the scale; unit of measurement used for water depths (feet, fathoms, or meters); and the datum plane for the soundings (Figure 5-16).

5-49. Also on the chart (where space is available) other useful information can be listed. This information could include the meanings to special abbreviations, cautions, special markings, and any other information that may be of value to the mariners. Boxes and notes may be printed in the margins or on the face of the chart at locations where it will not block out other navigational information.

EDITIONS AND REVISIONS

5-50. The edition number and the date of the last revision will always appear in the lower, left-hand corner of the chart along with the chart number (Figure 5-17).

COLOR AND LETTERING

5-51. Land areas are shown in a buff or yellowish color. On DMAHTC charts, land areas are shown in a gray tint. Shallow or shoal waters are shown in blue, and deep water areas are shown in white. Areas that may be submerged at some tidal stage, such as sandbars, mud flats, and marshes are shown in green. The color "magneta" is used for most information listed on the chart because it is easier to read under red nightlights.

5-52. By knowing the type of lettering being used, you can more easily and quickly interpret the type of information being presented.

Upright or Roman Lettering

5-53. Identifies features that are dry at highwater.

Slanting or Italic Lettering

5-54. Identifies submerged or floating hydrographic features (this does not include sounding figures, showing depth).

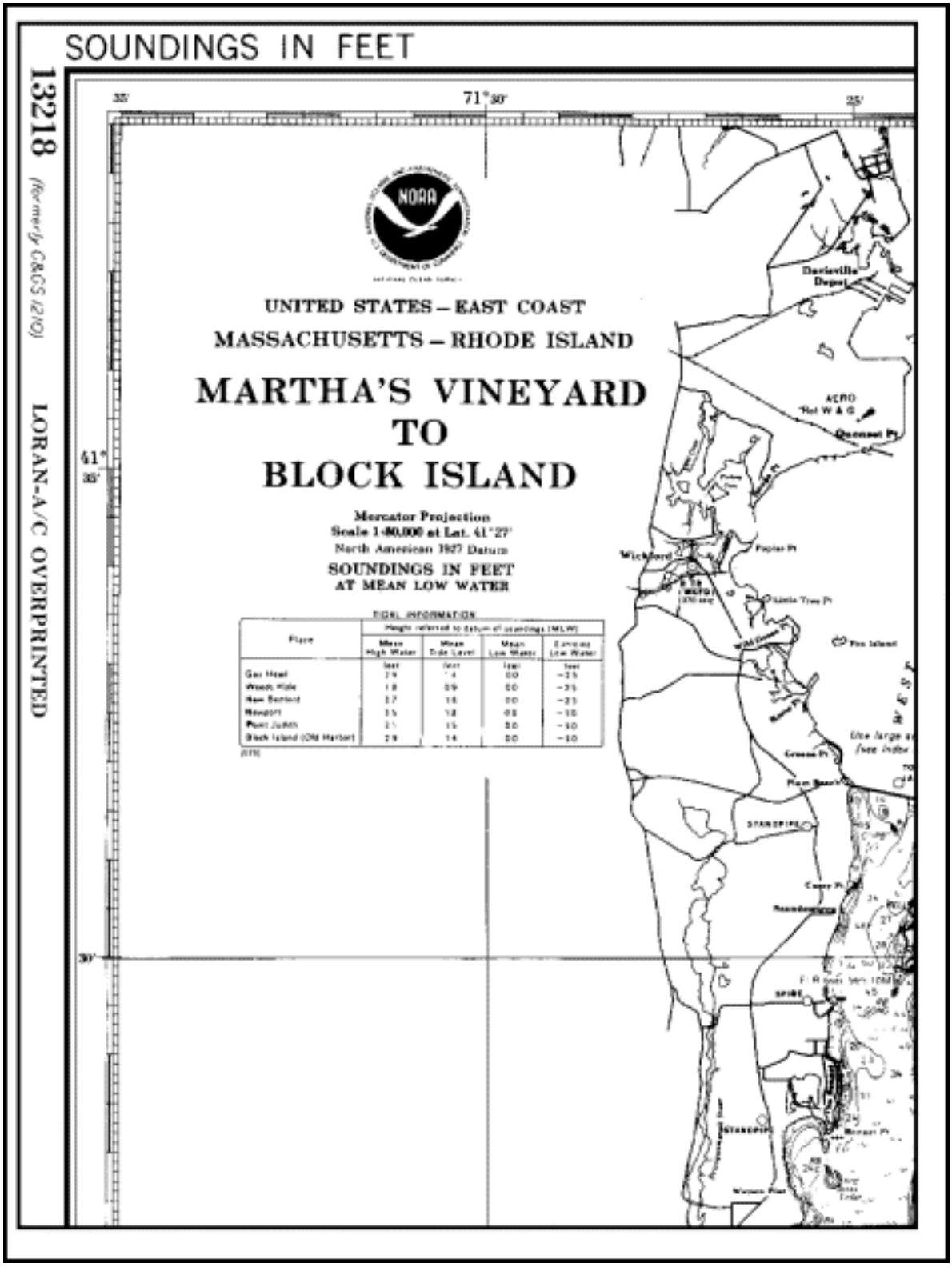


Figure 5-16. Chart Legend

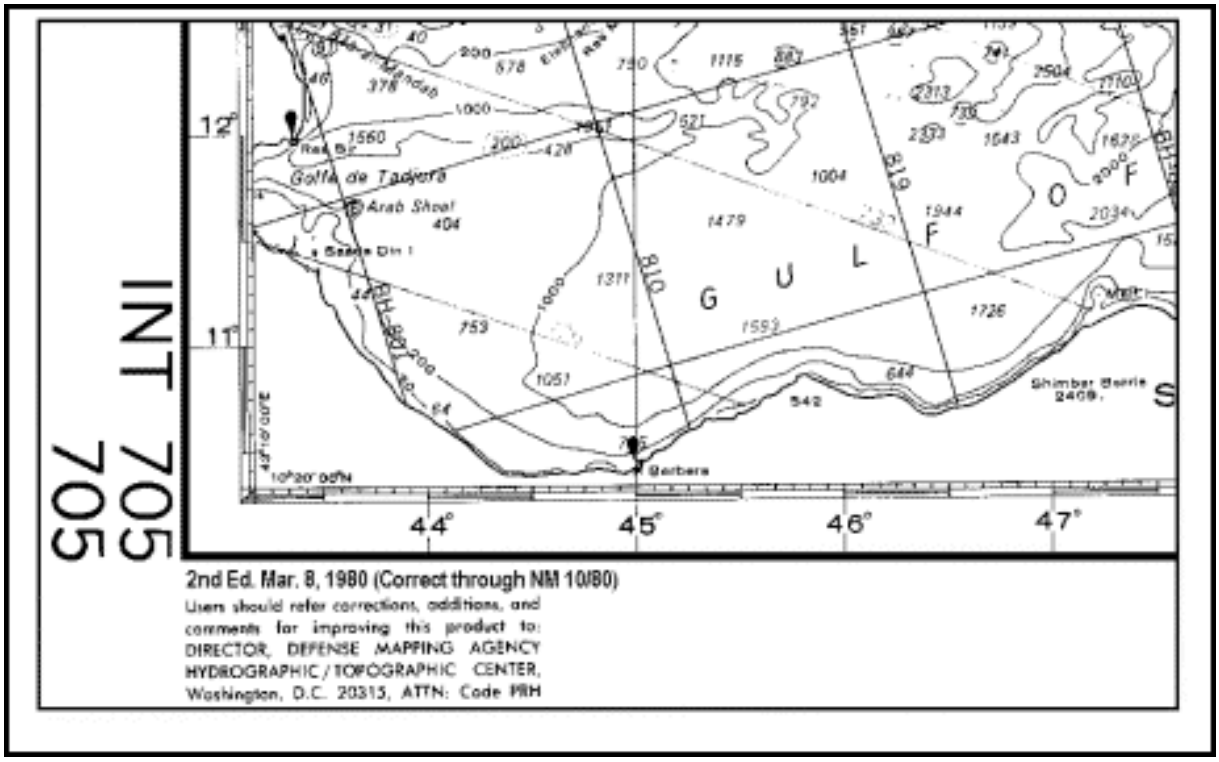


Figure 5-17. Edition Number on Chart

DEPTH

5-55. Depth is shown on a chart by many small printed figures, indicating the depth of water at that point in either feet or fathoms. A few charts may mix these units, using feet in the shallower areas and fathoms offshore in deeper waters.

5-56. Some of the newer charts being published by DMAHTC, and to a lesser extent by NOAA, will have soundings and land measurements shown in meters. Therefore, always check the legend of the chart to be sure of the units used for measurement.

CHART SYMBOLS AND ABBREVIATIONS

5-57. There are many symbols and abbreviations used on charts (see Appendix A for nautical chart symbols and abbreviations). These symbols and abbreviations are a type of graphic shorthand to tell you the physical characteristics of the area and the details of the available aids to navigation. Depending on the series or scale of chart used; these symbols and abbreviations are standardized, but are subject to some variation. On large-scale charts, the characteristics of lights are shown (see Table 5-1).

Table 5-1. Characteristics of Lights

CHARACTERISTICS	EXAMPLE	MEANING

Character	Gp F1	group flashing
Color	R	red
Period	(2) 10 sec	two flashes every 10 seconds
Height	160 ft	160 feet
Range	19M	19 nautical miles
Number	"6"	light number 6

Note: The chart legend for this light would appear as follows: Gp F1 R(2) 10 sec 160 ft 19 M "6".

UNITED STATES NAUTICAL CHART NUMBERING SYSTEM

5-58. The United States Nautical Chart Numbering System applies to all nautical charts produced by the DMAHTC and NOAA. The chart numbering system provides a simple method of identifying each chart by number. This number shows, in general, the geographical region and scale range in which the chart falls. Charts numbered with one to five digits are shown in Table 5-2.

Table 5-2. Chart Numbering System (One to Five Digits)

CATEGORY	NUMBER OF DIGITS	NATURAL SCALE
1	ONE (1-9)	No scale involved
2	TWO (10-99)	1:9,000,001 and smaller
3	THREE (100-999)	1:2,000,001 to 1:9,000,000
4	FOUR (5,000-9,999)	Nonnavigational type
5	FIVE (11,000-99,999)	1:2,000,000 and larger

5-59. From the list indicating number of digits and associated scale, four categories of charts exist. Each category contains clues to the location and scale range of the chart.

Charts With One-Digit Numbers

5-60. These charts have no scale and include charts showing nautical chart symbols and abbreviations, national flags and ensigns, and international flags and pennants with Morse symbols.

Charts With Two- and Three-Digit Numbers

5-61. These are general charts, based on the nine "ocean basin" concept (see Figure 5-18).

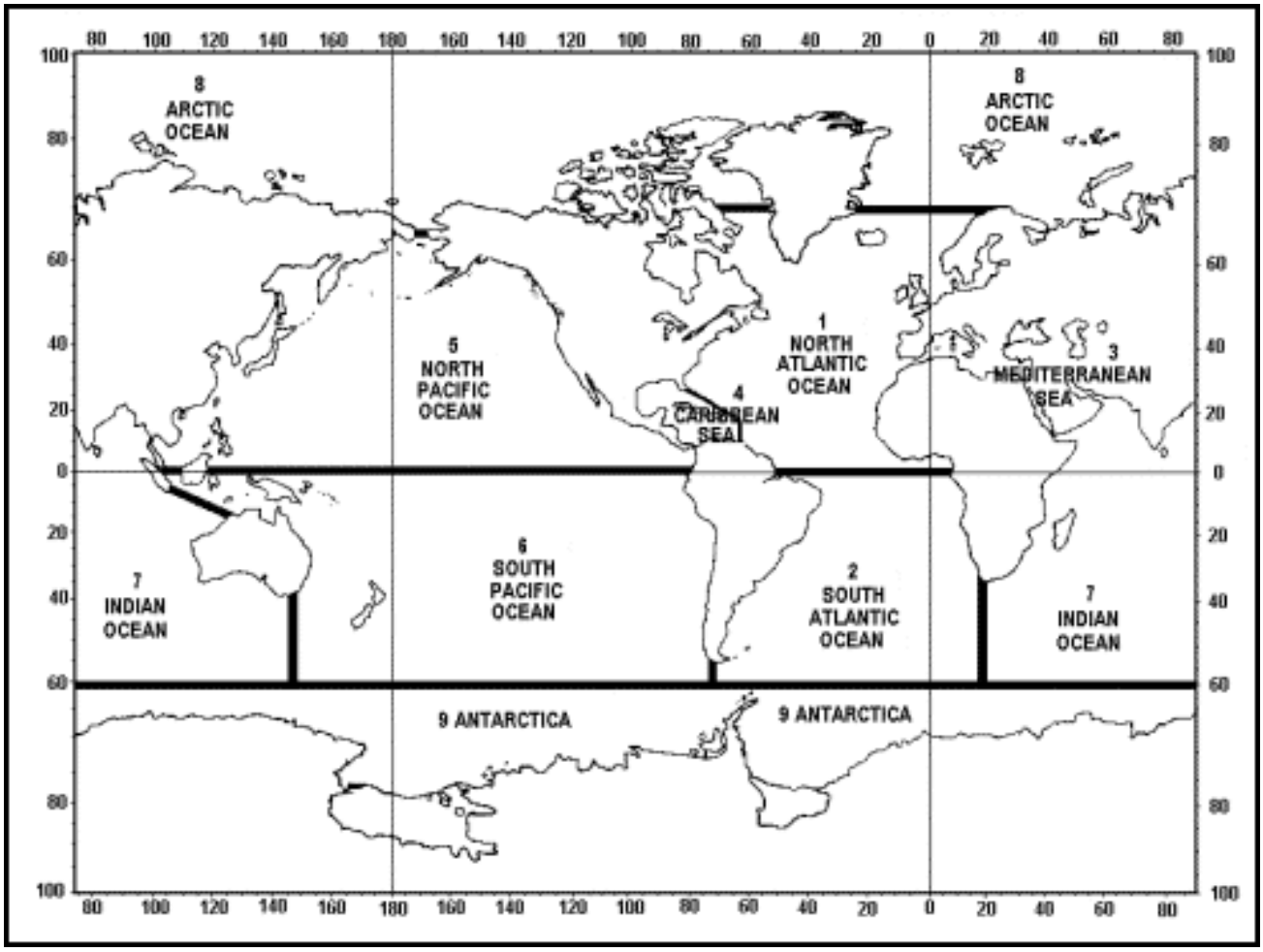


Figure 5-18. World Ocean Basins Area

5-62. The first digit in the category denotes the ocean basin which the chart covers. Two-digit numbers (10-99) are used for charts with a scale of 1:9,000,001 and smaller. The three-digit numbers (100-999) indicate charts with a scale between 1:2,000,001 and 1:9,000,000. An exception to the scale concept is the series of position plotting sheets, which have a scale larger than 1:2,000,000. These plotting sheets have been included in the three-digit number category because they cover ocean basins of 360° of longitude. Since the Mediterranean (basin 3), the Caribbean (basin 4), and the Indian Ocean (basin 7), for example, are small in size, an exception to the ocean basin concept exists. There is no chart smaller in scale than 1:9,000,000 in these areas. The two-digit numbers 30 to 49 and 70 to 79 are used for special world charts that cannot have the first digit indicating an ocean basin, such as the Magnetic Inclination or Dip, chart (30); Magnetic Variation, chart (42); and the Standard Time Zone Chart of the World, chart (76).

Nonnavigational Charts With Four-Digit Numbers

5-63. These are special-purpose chart series such as chart 5006, Chart of the World, Longitude 172° W to 15° E; and chart 5090, Maneuvering Board.

Charts With Five-Digit Numbers

5-64. Since the charts in this category have a scale range of 1:2,000,000 and larger, the "ocean basin" concept loses significance, so another system was adopted, based on the world now divided into nine regions as shown in Table 5-3.

Table 5-3. World Regions

REGIONS	GENERAL AREA
1	UNITED STATES AND CANADA
2	CENTRAL AND SOUTH AMERICA AND ANTARCTICA
3	WESTERN EUROPE, ICELAND, GREENLAND, AND THE ARCTIC
4	SCANDINAVIA, BALTIC, AND RUSSIA
5	WEST AFRICA AND THE MEDITERRANEAN
6	INDIAN OCEAN
7	AUSTRALIA, INDONESIA, AND NEW ZEALAND
8	OCEANIA
9	EAST AFRICA

5-65. The five-digit category contains all the large-scale charts of the world. These are the primary nautical charts. The first of the five digits indicates the region in which the chart is depicted, the second digit indicates a geographical subregion within the region, and the last three digits identify the geographical order of the chart within the subregion.

CARE OF CHARTS

5-66. Charts are one of the most important aids to the navigator, and they must be treated as such. Charts should be kept dry and clean.

5-67. Permanent chart corrections should be made in ink so that they cannot be erased. All other lines and markings should be made in pencil so that they can be erased. To avoid confusion, lines drawn on a chart should be drawn no longer than necessary and they should be labeled. After you have finished using the chart, all lines should be erased. The chart should be inspected for damage and stored flat with the least amount of folding.

5-68. Charts are stored in a drawer or kept in a portfolio. They should be properly indexed so that any desired chart can be found when needed.

CHART PORTFOLIOS

5-69. The chart portfolio system divides the world into 52 geographical areas. This system assigns a two-digit designator that represents a portfolio number to each area (see Figure 5-19).

5-70. An "A" and/or "B" prefix is also used. The "A" series of portfolios contain all the general charts and the principal harbor and approach charts for each of the 52 geographical areas. The "B" series of charts supplement the "A" coverage. To determine the chart portfolio number, locate the DMA stock number in the lower right-hand corner of the chart. Figure 5-20, shows the system used to establish the portfolio and sequence of chart numbers within the portfolio. The last three digits of the chart number show the chart number within the subarea.

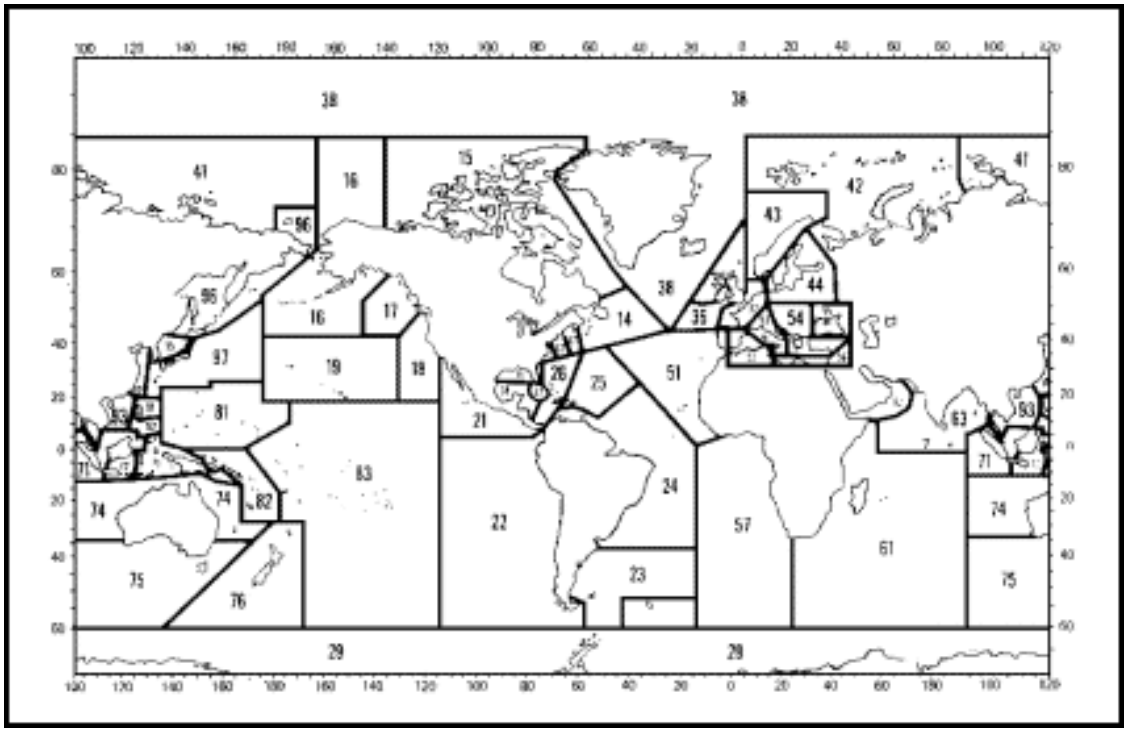


Figure 5-19. World Subregions

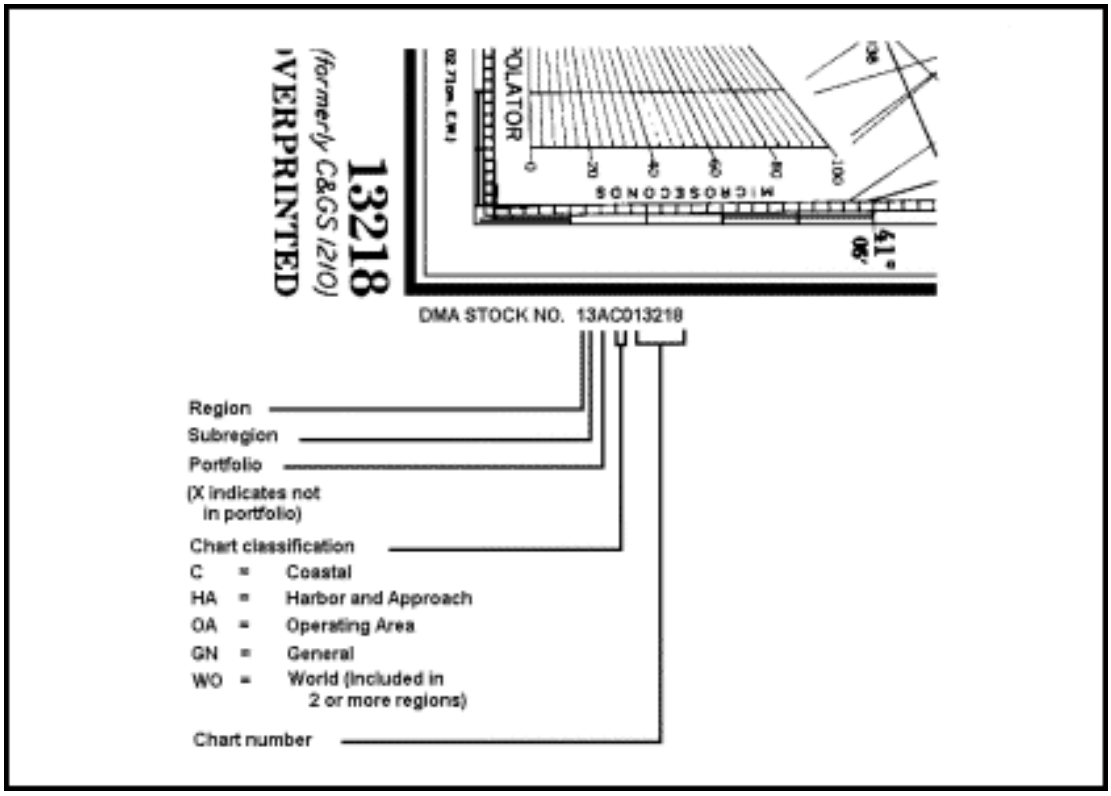


Figure 5-20. Lower Right-Hand Corner of Chart

CORRECTING A CHART

5-71. The date printed on the lower left-hand corner of the chart (Figure 5-21) is the date of the latest Notice to Mariners used to update the chart. After this date, the responsibility for updating the chart belongs to the user. The weekly Notice to Mariners will list corrections to be posted on charts as they occur.

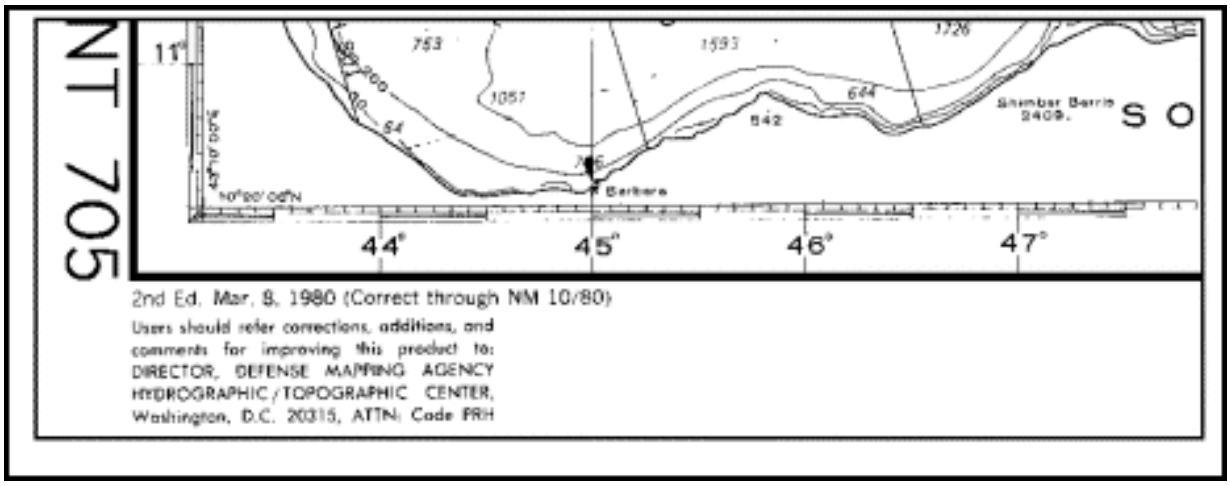


Figure 5-21. Lower Left-hand Corner of Chart

5-72. The weekly Notice to Mariners presents corrective information affecting charts as well as Coast Pilots, Sailing Directions, fleet guides, catalogs of nautical charts, light lists (USCG and DMAHTC), radio navigational aids, and other publications as may from time to time require updating.

5-73. Chart corrections are listed numerically by chart number, beginning with the lowest and progressing through all charts affected. Each correction pertains to a particular chart and that chart only. Related charts, if any, have their own corrections which, in turn, pertain to a single chart only.

5-74. The following paragraphs and the example in Figure 5-22 explains the individual elements of a typical correction.

5-75. A correction preceded by an asterisk (*) indicates it is based on original US source information, the letter "T" indicates it is temporary, and the letter "P" indicates it is preliminary.

5-76. Courses and bearings are given in degrees clockwise from 000º true. Bearings of light sectors are toward the light.

5-77. The visibility of lights is usually the distance that a light can be seen in clear weather and is expressed in nautical miles. Visibilities listed are values received from foreign sources. The visibility of lights maintained by the USCG is given as "nominal range."

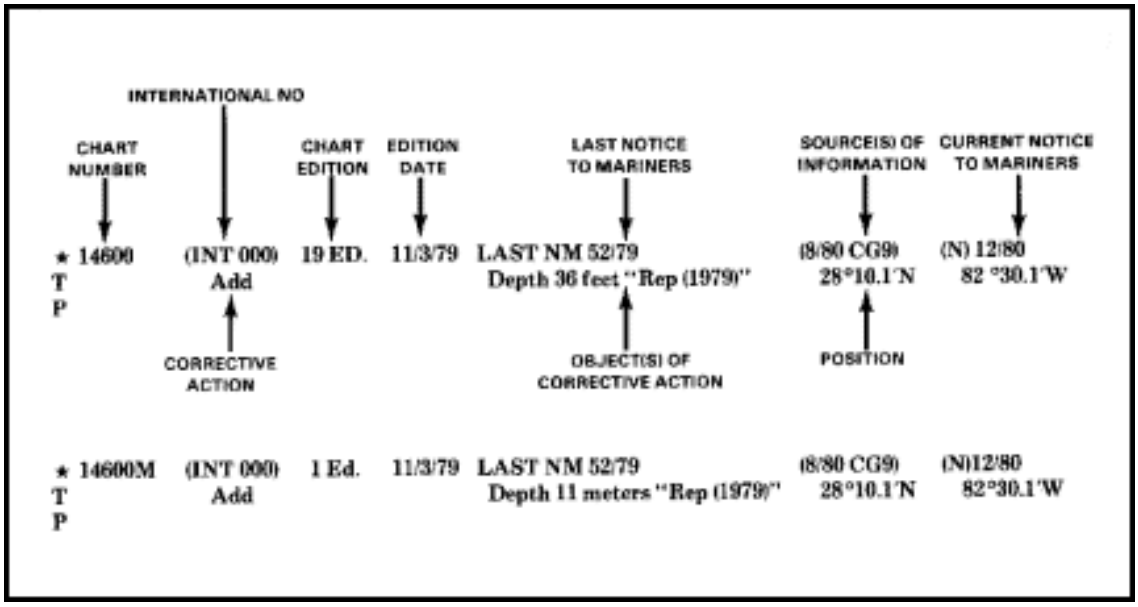


Figure 5-22. Explanation of Format

CHART/PUBLICATION CORRECTION RECORD CARD

5-78. Before changing any chart, you should go through the Chart/Pub Correction Record (DMAHC-8660/9) cards (Figure 5-23) and remove those affected by that particular notice. After withdrawing the cards corresponding to the number entered on the chart correction list, you are ready to enter the necessary data on the cards. Prepare a card for each chart/publication by inserting the following information:

- Chart/publication number.
- Portfolio.
- Edition number/date.
- Classification.
- Title of chart/publication (if title is too long, use an abbreviated descriptive title).

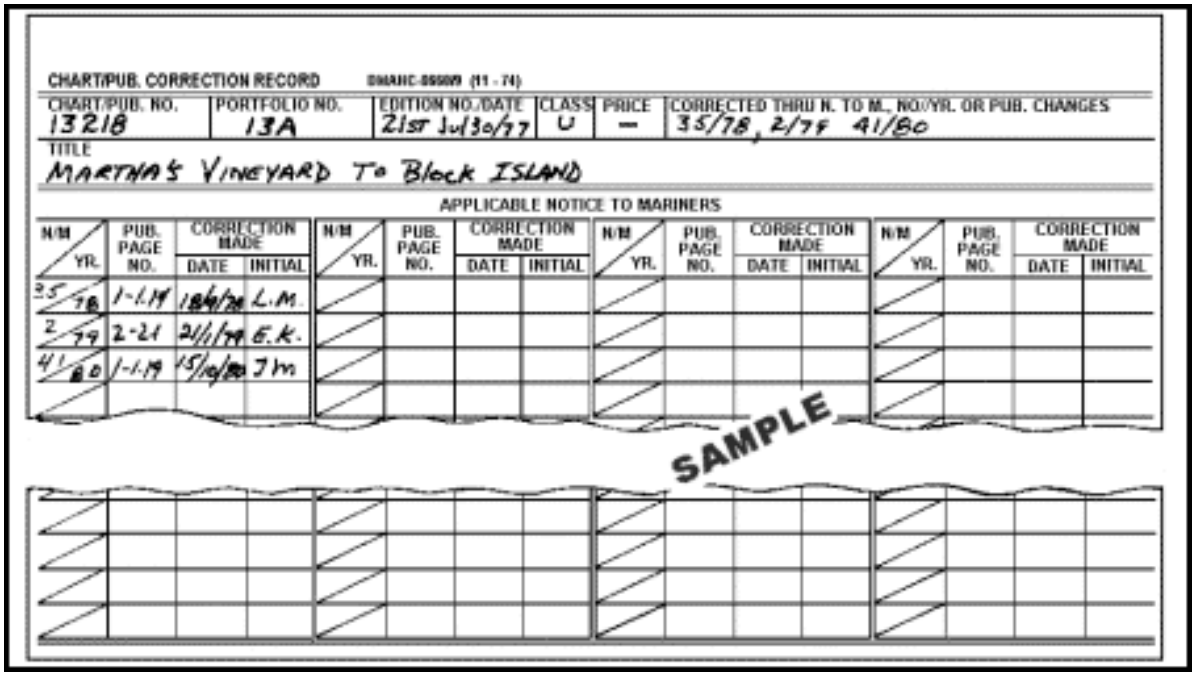


Figure 5-23. Chart/Pub Correction Record (DMAHC-86609)

STEPS FOR UPDATING RECORD CARD

5-79. Perform the following when updating the record card.

- Review section I of the current Notice to Mariners and determine which charts on board are to be corrected.
- Get the chart/publication correction record card for each chart to be corrected.
- Make corrections in ink on chart.
- Post chart/publication correction record card, date, and initial.
- Make notation on lower left-hand side of chart, showing date of correction and Notice to Mariners number.

5-80. Each chart on board will have a chart correction card on file. With the chart correction card system, only the charts in current use in the operating area of your ship must be kept up-to-date at all times. Corrections are not made to other charts until the charts are needed. If a chart is not corrected, a notation is made on the card. The entry gives the Notice to Mariners number and page number. When a chart is corrected, the date and the initials of the person who corrected the chart are entered in the prescribed spaces on the card.

5-81. The weekly Notice to Mariners features a new format for presenting corrective information affecting charts, Sailing Directions, and US Coast Pilots. In section I, chart corrections are listed by chart number, beginning with the lowest and progressing in sequence through each chart affected. The chart corrections are followed by publication corrections, which are also listed in numerical sequence. Since each correction pertains to a single chart or publication, the action specified applies to that particular chart or publication only. Related charts and publications, if any, are listed separately.

Note: In correcting charts that have accumulated many corrections, it is more practical to make the latest correction first and work backwards. The reason for this is because late corrections may cancel or alter earlier corrections.

5-82. Upon receipt of a new chart and/or a new edition, a new card should be made so that the card will show only those corrections (including temporary changes) which have been published since the date to which the chart was corrected by the DMAHTC. Temporary changes are not incorporated in new editions of charts and must be carried forward from old editions. Consult Notice to Mariners 13, 26, 39, and 52 for outstanding temporary corrections. At the end of each quarter, the DMAHTC will include in the Notice to Mariners a chart correction list for that quarter containing all effective Notice to Mariners corrections to charts. The list for Navy Notice to Mariners corrections will be published annually. These lists should be checked against the cards to make sure that all corrections have been entered.

CHART CORRECTION TECHNIQUES

5-83. The first step in correcting a chart is usually to erase that part of the charted information that will be changed. Lay the chart on a smooth area. Erase in a back and forth motion with an abrasive eraser (this should remove most of the ink). To preserve the quality of the paper's surface, remove the remainder of the ink with a nonabrasive eraser. Most typewriter erasers are very abrasive and general erasers are mildly abrasive. A sharp penknife or razor blade can be a valuable tool in the hands of an experienced draftsman, but poor handling of a knife can quickly ruin a chart. Rubbing an erased surface with an ivory or bone burnishing tool, or even the thumbnail, may improve its inking qualities. The ink from a conventional lettering or drafting pen tends to feather to a degree, depending on the condition of the erased surface. Normally, a ballpoint pen with a fine point, feathers less and reduces the possibility of ink smears. Another advantage of the ballpoint pen is the variety of colored inks available. Although black is the principal color used in chart correction work, other colors such as green, purple, magenta, or blue may be occasionally needed.

5-84. Corrections in writing should be kept clear of water areas as much as possible, unless the objects referred to are on the water. When inserting written corrections, care must be taken not to obliterate any of the information already on the chart. When "notes" are to be inserted (such as cautionary, tidal, and so forth), they should be written in a convenient but conspicuous place, where they will not interfere with any other details.

5-85. The year and number of every Notice to Mariners from which corrections have been made are to be entered in ink at the lower left-hand corner of the charts (for example, "1968-6, 9, 18"). Temporary changes should be made in pencil.

REQUISITIONING PROCEDURES FOR CHARTS

5-86. DMAHTC is responsible for providing navigational charts and publications to the DOD and civilian users. The DMA requisitioning requirements are designed primarily for DOD activities as a means of simplifying the control of inventories and to reduce order processing time.

GENERAL

5-87. The requisitioning procedures outlined below are an integral part of the DADMS and cover requisitions by both DOD and non-DOD activities. DOD activities authorized to request DMA products must obtain a DOD activity address designator code through their respective service or agency.

REQUISITION FORMS

5-88. Use any one of the following forms, which are shown in Appendix B, when ordering DMA products:

- DD Form l73/1.
- DD Form 1348.
- DD Form 1348M.
- SF 344.

DOD activities should use any one of the above forms that best fit their individual needs.

Note: Use SF 344 to requisition items not identified in DMA publications (1-N-A and 1-N-L) or items where the stock number is not known. When used in this manner, the item description may be written across the entire line or lines under requisition data without regard to columnar headings. Such data as the quantity, serial number, supplementary address, and signal and advice codes will be entered directly below the item description in the appropriate blocks.

PREPARATION OF REQUISITIONS

5-89. Requisition documents (DD Form 173/1, DD Form 1348, DD Form 1348M, and SF 344) will be prepared as shown in Appendix B.

REQUISITIONING OF NAUTICAL CHART PORTFOLIOS

5-90. To preclude the submission of many requisition documents when an entire nautical chart portfolio is desired, the requestor may prepare a single requisition identifying the portfolio in the first five positions of the stock number followed by the word "ALL" in the next three positions. The DADMS will generate a requisition for each nautical chart included in the portfolio applying the basic requisition information to each item including document number and quantity requested. Validation, status, manifesting, and issue will be accomplished on a line item basis. Requisitions of this type can be submitted only to the DDCP, DMA Office, Pacific, and DMA ODS branch offices. Examples of portfolios include the following:

- **Standard Nautical Chart Portfolios**:
  - Portfolio 11A--order as 11AXXALL.
  - Portfolio 37B--order as 37BXXALL.
  - Portfolio 97A--order as 97AXXALL.

Note: This same sequencing will be used in requisitioning any of the designated nautical chart portfolios included in this catalog.

- **World Portfolios**:
  - Portfolio WOA--General Charts of the Atlantic--order as WOAXXALL.
  - Portfolio WOP--General Charts of the Pacific--order as WOPXXALL.
  - Portfolio WOB--General Charts of the World--order as WOBXXALL.

SUBMISSION OF REQUISITIONS DOD ACTIVITIES

5-91. All DOD activities will submit requisitions for DMA products by AUTODIN, message, or mail to the designated source of supply.

Method of Transmitting Requisitions

5-92. DOD activities having punch card facilities will submit the DD Form 1348M to the designated supply source. Those DOD activities having transceiver facilities may transceive the DD Form 1348M via the AUTODIN. The DD Form 1348M may be mailed if AUTODIN is not readily available.

5-93. Those activities that do not have punch card equipment or transceiver facilities may use DD Form 1348 or SF 344. These forms will be mailed to the designated supply source. Requisitions forwarded by mail will be identified by the word "MILSTRIP" printed in the lower left corner of the envelope.

5-94. Message requisitions are acceptable from authorized requisitioners, provided that they are in the format shown. The term "MILSTRIP REQUISITION" will precede the text of the message.

5-95. Telephone requests from DOD activities are acceptable when the urgency of the requirement dictates. When the telephone is used, the requester will contact the DDCP, overseas depot, DMA field office, or other issuing activity, as appropriate, and provide pertinent data. The issuing activity will record the data on a machinable requisition document and complete processing of the telephone request. Telephone requests from non-DOD activities must be confirmed by letter or message, as such deliveries normally involve reimbursements.

Designated Supply Source

5-96. The mail and message address, routing identifier, and telephone number of the designated source of supply for nautical products is as follows:

DMA Office of Distribution Services
ATTN: DDCP
Washington, DC 20315

Message Address:

DMAODS WASHINGTON, DCC//DDCP//
Routing Identifier: HM8
DODAAD: HM0028
Telephone: DSN 287-2495 or 287-2496
COML: (202) 227-2495/227-2496

PUBLICATIONS

5-97. Every ship must carry the charts and publications required for its safe operation. These include the COMDTINST M16672.2C (Navigation Rules -- International-Inland), all charts applicable for the vessel's navigational area of operation, and all TMs, FMs, and ARs that apply to the class of vessel. The following discusses the various publications and the agencies responsible for publishing them.

THE NATIONAL OCEAN SURVEY

5-98. This agency is charged with the survey of the coast, harbors, and tidal estuaries of the US and its insular possessions and is a part of the National Oceanic and Atmospheric Administration, Department of Commerce. It is responsible for issuing the following publications.

United States Coast Pilot

5-99. The United States Coast Pilot publication consists of nine volumes. These volumes include the following:

- **ATLANTIC COAST**
  - Eastport to Cape Cod.
  - Cape Cod to Sandy Hook.
  - Sandy Hook to Cape Henry.
  - Cape Henry to Key West.
  - Gulf of Mexico, Puerto Rico, and Virgin Islands.
- **GREAT LAKES**
- **PACIFIC COAST**
  - California, Oregon, Washington, and Hawaii.
  - Alaska-Dixon Entrance to Cape Spencer.
  - Alaska-Cape Spencer to Beaufort Sea.

Coast Pilot

5-100. Coast Pilot, besides its standard information on US ports and waterways, contains the following:

- Descriptions of ports and harbors.
- Pilot information.
- Quarantine and marine hospital information.
- Coast Guard stations.
- Radio services, distances, and bearings.
- Time signals.
- Atmospheric pressure, temperature, and wind tables.
- Rules of the road.
- Instructions in case of shipwreck.
- General harbor regulations.

Tide Tables

5-101. These are published each year for various parts of the world and are published in four volumes. Each volume consists of the following:

- TABLE 1. A list of reference stations for which the tide has been predicted. The time and heights of high and low tides are tabulated for each day of the year for each of these reference stations.
- TABLE 2. A list of subordinate stations for which the tidal differences have been predicted with respect to a reference station having nearly the same tidal cycle.
- TABLE 3. A convenient means of interpolation which allows for the characteristics of the tidal cycle. While TABLES 1 and 2 provide times and heights of high and low tides, the state of the tide may be desired for a given time in between.
- TABLE 4. A sunrise-sunset table at 5-day intervals for various latitudes.
- TABLE 5. A table that provides an adjustment to change the local mean time from table 4 to zone or standard time.
- TABLE 6 (two volumes only). A table that gives the zone time of moonrise and moonset for each day of the year at selected places.

Tidal Current Tables

5-102. These tables are prepared annually in two volumes for various areas to provide predictions of the state of the current. Each volume consists of the following tables:

- TABLE 1. A list of reference stations in geographical sequence for which the current has been predicted.
- TABLE 2. A list of subordinate stations for which the difference between local current and current at a reference station has been predicted. Above the groups of subordinate stations, the appropriate reference station is listed.
- TABLE 3. A table that provides a means of interpolation for the state of the current at any time between tabulated times.
- TABLE 4. A table that gives the number of minutes that the current does not exceed the stated amounts for various maximum speeds.
- TABLE 5 (Atlantic Coast of North America only). A table that gives information on rotary tidal currents.

Tidal Current Charts

5-103. The tidal current tables are supplemented by 11 sets of tidal current charts. These charts present a comprehensive view of the hourly speed and direction of the current in 11 bodies of water. These bodies of water include the following:

- Boston Harbor.
- Narragansett Bay to Nantucket Sound.
- Narragansett Bay.
- Long Island Sound and Block Island Sound.
- New York Harbor.
- Delaware Bay and River.
- Upper Chesapeake Bay.
- Charleston Harbor.
- San Francisco Bay.
- Puget Sound (northern part).
- Puget Sound (southern part).

They also provide a means for determining the speed and direction of the current at various localities throughout these bodies of water.

Chart Catalogs

5-104. NOS publishes four catalogs. Each catalog covers the following areas:

- Catalog No. 1. The waters of the Atlantic and gulf coasts, including Puerto Rico and the Virgin Islands.
- Catalog No. 2. The Pacific coast, including Hawaii, and Pacific islands such as Guam and Samoa.
- Catalog No. 3. The Alaskan waters, including the Aleutian islands.
- Catalog No. 4. The Great Lakes and the adjacent waterways.

Each catalog contains several small-scale outline charts with lines showing the limits of each nautical chart in that region.

DEFENSE MAPPING AGENCY HYDROGRAPHIC AND TOPOGRAPHIC CENTER PUBLICATIONS

5-105. The identification of charts, publications, and other products of DMAHTC is based on a numbering system of one to five digits without a prefix. The number will be based on the scale and on the basis of region and subregion.

5-106. Publications will continue to carry the "HO" prefix until they are reprinted by DMAHTC. At that time, DMAHTC will assign a number and give the prefix "pub."

Portfolio Chart List

5-107. The portfolio chart list (Pub No. 1-PCL) is a publication furnished by the DMAHTC to United States ships. It is issued in two volumes: one for the Atlantic side of the world and one for the Pacific side. This publication contains a complete list of charts, by portfolio, arranged according to their numbers.

5-108. The portfolio chart list is intended as a guide for selecting and storing nautical charts aboard ship. It also provides a ready reference to the grouping, by geographical sequence, of the charts in the various portfolios. Most of the necessary information concerning charts, such as chart number, edition number and date, and title required by a mariner in establishing a chart correction card system, is included within this publication.

Index of Nautical Charts and Publications

5-109. Nautical charts and publications may be found indexed in one of the catalogs shown in Table 5-4. These catalogs provide additional information of interest to the navigator that may not be found in Pub No. 1-PCL.

5-110. Suppose you are to sail from Norfolk, Virginia to Sao Luis, Brazil, in South America. For general planning and for sailing the open sea between the two ports, you would refer to Pub No. 1-N-A to find the appropriate small-scale charts, Sailing Directions, light lists, any charts needed for Loran navigation, and position plotting sheets. For the large-scale charts needed when you navigate in ports, channels, and so forth, you would refer to REGION 2.

Note: Additions and changes to the catalogs may be obtained from the Notice to Mariners.

5-111. Only the latest editions of charts are issued. All charts issued by the depots will be corrected through NM 26/75, after which corrections will no longer be applied. All charts are corrected as of the print date shown in the lower left-hand corner of the chart. Corrections affecting charts after the issue date are published in the weekly Notice to Mariners received by all ships.

Pub 9 - American Practical Navigator (Volumes I and II)

5-112. This is commonly referred to as "Bowditch." This is an extensive text on piloting, celestial navigation, and other nautical matters. Volume II contains tables, data, equations, and instructions needed to perform navigational calculations (see extract in Appendix C).

List of Lights - Pub 111A and 111B, 112 through 116

5-113. These publications contain detailed information on the location and characteristics of every light in the world not located in the United States or possessions. Brief descriptions of lighthouses and fog signals are included. List of Lights is published in seven volumes, and it is corrected through Notice to Mariners.

Sailing Directions

5-114. The Sailing Directions provide the same type of information as the Coast Pilots, except the Sailing Directions pertain to foreign coasts and coastal waters. Typical information includes the following:

- Pilotage.
- Appearance of coastline (mountains, landmarks, visible foliage, and so forth).
- Navigational aids in general.
- Local weather conditions.
- Tides and currents.
- Local rules of the road, if any.
- Bridges -- type and clearance.
- Anchorage facilities.
- Repair facilities.
- Availability of fuel and provisions.
- Transportation service ashore.
- Local industries.

Note: Under a new concept begun in 1971, the 70 volumes of existing Sailing Directions are being replaced by 43 publications--namely 35 new graphic sailing directions (en route) and 8 new sailing directions (planning guide).

Pub 102 (HO 102) - International Code of Signals

5-115. This publication includes both general procedures that apply to all forms of signaling and the specific rules for signaling by flags, blinking light, sound, radio, and radio telephone.

Pub 117A-B - Radio Navigational Aids

5-116. These two volumes are based on geographic location and contain information such as:

- Time and frequency of hydrographic broadcasts.
- Radio time signals.
- Distress traffic.
- Radio beacons.
- Direction-finding stations.
- Loran coverage and stations.
- Radio regulations for territorial waters.

Notice to Mariners

5-117. The DMAHTC publications mentioned so far are published at more or less widely separated intervals. As a result, provisions must be made for keeping mariners informed of changes in hydrographic conditions as soon as possible after they occur.

5-118. The principal medium for distributing corrections to charts, light lists, and other DMAHTC publications is Notice to Mariners. One or more copies are distributed to each vessel. Each notice is divided into three sections:

- Section I, chart corrections.
- Section II, light list corrections.
- Section III, broadcast warnings and miscellaneous information.

A sample page is shown in Figure 5-24.

Table 5-4. Index of Nautical Charts and Publications

CATALOG NUMBER	CONTENTS
Pub 1-N-A	General information on the catalogs, graphics showing regions covered by Lists of Lights and Sailing Directions, a listing of Loran and Omega charts and plotting display charts, and instructions and forms for ordering charts and publications.
Pub 1-N-L	Complete numerical listing of charts issued by DMA Hydrographic and Topographic Center. Standard terminology for the DMA Hydrographic and Topographic Center and National Ocean Survey charts. Instructions and forms for ordering charts and publications.
Pub 1-N, REGION 1	United States and Canada.
Pub 1-N, REGION 2	Central and South America and Antarctica.
Pub 1-N, REGION 3	Western Europe, Iceland, Greenland, and the Arctic.
Pub 1-N, REGION 4	Scandinavia, Baltic, and Russia.
Pub 1-N, REGION 5	West Africa and the Mediterranean.
Pub 1-N, REGION 6	Indian Ocean.
Pub 1-N, REGION 7	Australia, Indonesia, and New Zealand.
Pub 1-N, REGION 8	Oceania.
Pub 1-N, REGION 9	East Africa.

SECTION 1

11460	(1112)	20 Ed.	11/1/75	LAST NM 5/77	(2/77CG7)	7/77
		Add		Wreck (PA)	27°40'N	79°53'W
11480	(1111)	19 Ed.	12/13/75	LAST NM 3/77	(2/77CG7)	7/77
		Change		Characteristic of buoy "2NE" (32°30.8'N 80°08.1'W) to F1 4 sec and relocate to	32°30'46"N	80°08/25"W
11481	9 Ed.	5/29/76	LAST NM N6/77		(2/77CG7)	7/77
		Change		Characteristic of buoy "2NE" (32°30.8'N 80°08.1'W) to F1 4 sec and relocate to	32°30'46"N	80°08/25"W
11483	2 Ed.	5/29/76	LAST NM N6/77		(2/77CG7)	7/77
		Change		Characteristic of buoy "2NE" (32°30.8'N 80°08.1'W) to F1 4 sec and relocate to	32°30'46"N	80°08/25"W
11498	9 Ed.	4/17/76	LAST NM N45/76		(2/77CG7)	7/77
		Change		Characteristic of buoy "2NE" (32°30.8'N 80°08.1'W) to F1 4 sec and relocate to	32°30'46"N	80°08/25"W
17368	1 Ed.	8/21/76	LAST NM 2/77		(1/77CG17)	7/77
		Add		(Plan Security Bay) Designation "1" to light	56°52'26"N	134°22'20"W
18640	(5502)	14 Ed.	8/21/76	LAST NM 44/76	(53/76CG12)	7/77
		Change		RBn to 320 kHz.	38°57.4'N	123°44.4'W
18649	(5532)	43 Ed.	12/27/75	LAST NM 3/77	(53/76CG12)	7/77
		Add		Light F1 5 sec BELL (Priv Maintd) Note: Exhibited only during Foggy weather	37°48'490.5"N	122°24'43.7"W
18650	(5535)	32 Ed.	7/3/76	LAST NM 49/76	(53/76CG12)	7/77
		Add		Light F1 5 sec BELL (Priv Maintd) Note: Exhibited only during Foggy weather	37°48'40.5"N	122-24'43.7"W

The weekly **Notice to Mariners (Worldwide Coverage)** is prepared jointly by the Defense Mapping Agency Hydropgraphic Center, the U.S. Coast Guard, and the National Ocean Survey. It is published weekly by the Defense Mapping Agency Hydrographic Center.

Figure 5-24. Sample Page From Notice To Mariners

Summary of Corrections

5-119. Every six months, DMAHTC publishes a Summary of Corrections, in two volumes. Volume I covers the Atlantic, Arctic, and Mediterranean areas. Volume II covers the Pacific and Indian Oceans and the Antarctic. These volumes cover the full list of all changes to charts, Coast Pilots, and Sailing Directions.

Pilot Charts

5-120. These are small-scale charts of large areas. They are of little use in actual piloting but are still valuable to navigators. They present, in graphic form, a complete review of the hydrographic, navigational, and meteorological situation in a given area. Included is information concerning the following:

- Average winds, tides, currents, and barometer readings.
- Frequency of storms, calms, or fog.
- Possibility of the presence of ice, wrecks, or other dangers.
- Location of ocean station vessels.

Lines of equal magnetic variations are given for each full degree of variation. Indicated also are the shortest and safest routes between principal ports.

5-121. Pilot charts of the North Atlantic Ocean and North Pacific Ocean are issued monthly by the DMAHTC. Other pilot charts are published in atlas form for the Northern North Atlantic Ocean, South Atlantic Ocean and Central American Waters, and the South Pacific Indian Oceans.

COAST GUARD PUBLICATIONS

5-122. The USCG prepares one major publication, marine safety manuals, and also extracts from CFRs.

List of Lights and Other Marine Aids

5-123. This publication is often referred to as the "light list" and comes in five volumes.

- **Volume I.** Atlantic Coast--St. Croix River, Maine to Little River, South Carolina.
- **Volume II**. Atlantic Coast--Little River, South Carolina to Rio Grande, Texas.
- **Volume III.** Pacific Coast and Pacific Islands.
- **Volume IV.** Great Lakes.
- **Volume V.** Mississippi River System.

5-124. The light list describes the lighthouses, lesser lights, buoys, and day beacons maintained in all navigable waters of the United States by the USCG and various private agencies. The information shown will include the following:

- The official name of the aid.
- Characteristics of its lights, sounds, and radio signals.
- Its structural appearance and position.
- Any other important information.

The List of Lights is published about every 12 months, and any corrections or changes are posted in the Notice to Mariners.

Navigation Rules

5-125. This is the law for all mariners operating in either inland or international waters. Commandant Instructions M16672.2C is published and issued by the USCG. It is an extract from the Code of Federal Regulations, Title 33, Navigation and Navigable Waters.

Chapter 6

Dead Reckoning and Piloting Techniques

Navigation is defined as the art and science of safely directing the movement of a vessel from one position to another. Navigation is divided into four subdivisions: dead reckoning; piloting; celestial; and electronic. This chapter only covers dead reckoning and piloting navigation (along with their instruments and navigation aids).

THE MAGNETIC COMPASS

6-1. The magnetic compass is one of the oldest items of navigational equipment. It gets its source of power from the earth’s magnetic field. Despite the rising importance and great convenience of the gyrocompass, the magnetic compass still retains its importance because of its simplicity and reliability. The magnetic compass will remain operative even when a ship is subjected to the following:

- Electrical power failure.
- Fire.
- Collision.
- Grounding.
- Other hazards.

MAGNETISM

6-2. To fully understand the operation of the magnetic compass, it is necessary to know something about magnets themselves. A magnet is a body that has the property of attracting iron and producing a magnetic field around itself.

6-3. Magnetism that is present only when the material is under the influence of an external field is called "induced magnetism." Residual magnetism is the magnetism remaining after the magnetizing force is removed. Permanent magnetism is the magnetism remaining for long periods without appreciable reduction unless the material is subjected to a demagnetizing force. Such materials are lodestone and magnetic oxide of iron, which in their natural state possess this property. The earth itself has similar properties and may be considered a gigantic magnet.

6-4. Every magnet has a north pole and a south pole. If a single magnet is cut in half, each half becomes a magnet with a north pole and a south pole. If two magnets are brought close together, their unlike poles will attract and their like poles repel. Therefore, a north pole attracts a south pole but repels another north pole. This law of magnetism has meaning as you learn how the magnets in a ship’s magnetic compass conform to this law in relation to the earth’s magnetic field or to the ship’s own magnetic properties.

THE EARTH'S MAGNETIC FIELD

6-5. The earth, like all other magnets, has a magnetic north pole and magnetic south pole. The magnetic north pole is located at an approximate latitude and longitude of 74° N and 101° W. The magnetic south pole is located at an approximate latitude and longitude of 68° S and 144° E. These magnetic poles are distinguished from the true North Pole, latitude of 90° N and the true South Pole, latitude of 90° S (see Figure 6-1).

6-6. The magnetic lines of force that connect the magnetic poles are called "magnetic meridians." These meridians are not great circles. Because of the irregular distribution of magnetic material in the earth, the meridians are irregular, and the planes of the magnetic meridians do not pass through the center of the earth. Approximately midway between the magnetic poles is a line called the "magnetic equator." The magnetic equator is an irregular arc, varying in latitude from 15° S in South America to 20° S in Africa.

6-7. Colors have been assigned to avoid confusion when speaking of the action of poles. The earth's north magnetic pole is designated as "blue" and the south magnetic pole is designated as "red." A law of magnetism states that "unlike poles" attract each other while "like poles" repel. Therefore, the north-seeking pole of a magnet is attracted to the earth's north magnetic pole and is "red" while the south-seeking pole is attracted by the earth's south magnetic pole and is "blue."

6-8. The earth's magnetism undergoes changes. These changes consist of the following:

Diurnal Changes

6-9. These are daily changes which are caused by the movement of the magnetic poles in an orbit having a diameter of about 50 miles.

Annual Changes

6-10. These simply represent the yearly permanent changes in the earth's magnetic field.

Secular Changes

6-11. These are changes which occur over a period of years.

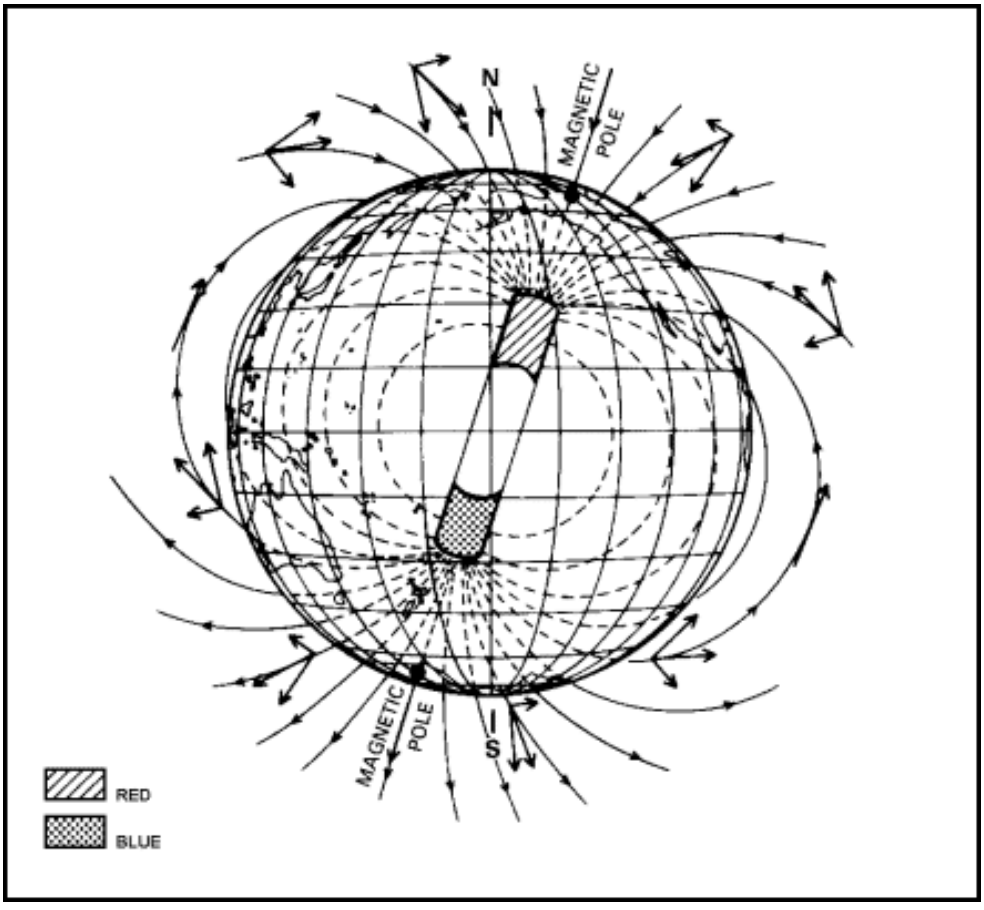


Figure 6-1. Earth's Magnetic Field

COMPASS DESIGNATION

6-12. The magnetic compass onboard ship may be classified or named according to its location or use. The magnetic compass located in a position favorable for taking bearings and used in navigation is called the standard compass. The magnetic compass at the steering station (used normally for steering or as a standby when the steering gyro repeater fails) is called the steering compass. Direction from either of these instruments must be labeled as "per standard compass" or "per steering compass" for identification.

MAGNETIC COMPASS NOMENCLATURE

6-13. The following components make up a standard 7 1/2-inch Navy compass (Figure 6-2). The (7 1/2 inches refers to the diameter of the compass.

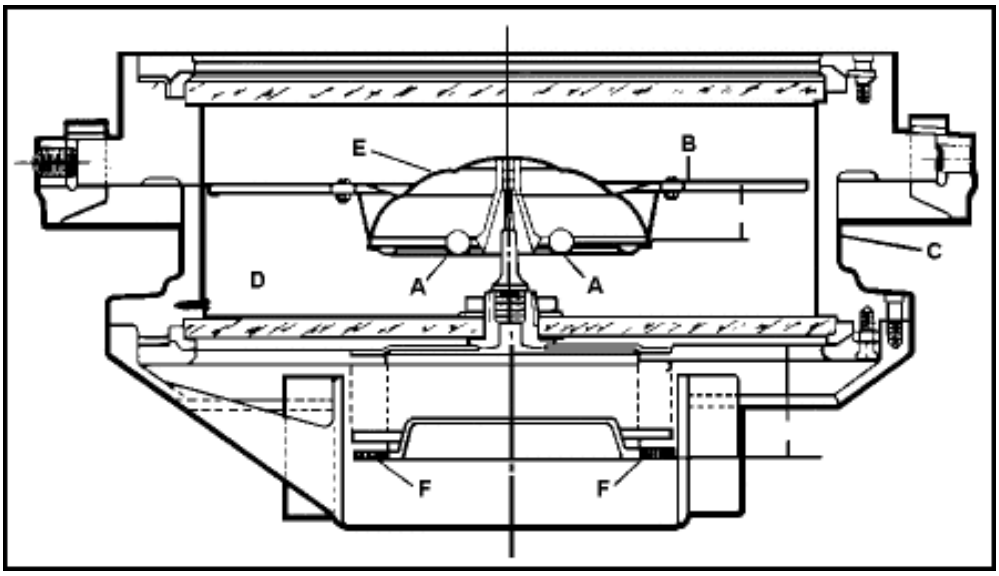


Figure 6-2. Components of the 7 1/2-inch Navy Compass

Magnets (A)

6-14. These are four (two in older compasses) cylindrical bundles of magnetic steel wire or bar magnets which are attached to the compass card to supply directive force. Some newer compasses have a circular magnet made of a metallic alloy.

Compass Card (B)

6-15. This is an aluminum disc, graduated in degrees from 0° to 360° . It also shows cardinal and intercardinal points. North is usually indicated by the fleur de lis figure in addition to the cardinal point. Being attached to the magnets, the compass card provides a means of reading direction.

Compass Bowl (C)

6-16. This is a bowl-shaped container of nonmagnetic material (brass) which serves to contain the magnetic elements, a reference mark, and the fluid. Part of the bottom may be transparent (glass) to permit light to shine upward against the compass card.

Fluid (D)

6-17. This is liquid surrounding the magnetic element. According to Archimedes principle of buoyancy, a reduction of weight results in a reduction of friction, making possible closer alignment of the compass needle with the magnetic meridian. Any friction present will tend to prevent complete alignment with the magnetic meridian. Today’s compasses contain a highly refined petroleum distillate similar to Varsol, which increases stability and efficiency and neither freezes nor becomes viscous at low temperatures.

Float (E)

6-18. This is an aluminum, air-filled chamber in the center of the compass card. This further reduces weight and friction at the pivot point.

Expansion Bellows (F)

6-19. This is an arrangement in the bottom of the compass bowl. This operates to keep the compass bowl completely filled with liquid, allowing for temperature changes. A filling screw facilitates addition of liquid, which may become necessary notwithstanding the expansion bellows.

Lubber Line

6-20. This is a reference mark on the inside of the compass bowl. It is aligned with the ship’s fore and aft axis or keel line of the ship. The lubber line is a reference for the reading of direction from the compass card. The reading of the compass card on the lubber line at any time is the "ship’s heading."

Gimbals

6-21. This is a metal ring on two pivots in which the compass bowl is placed. The compass is also on two pivots which permits it to tilt freely in any direction and remain almost horizontal in spite of the ship's motion. The compass rests on the binnacle. An important concept is that regardless of the movement of the ship, the compass card remains fixed (unless some magnetic material is introduced to cause additional deviation from the magnetic meridian). The ship, the compass bowl, and the lubber line move around the compass card. To the observer witnessing this relative motion, it appears that the compass card moves.

LIMITATIONS OF THE MAGNETIC COMPASS

6-22. The following characteristics of the magnetic compass limit its direction-finding ability:

- Sensitive to any magnetic disturbance.
- Useless at the magnetic poles and is sluggish and unreliable in areas near the poles.
- Deviation (explained later) changes as a ship's magnetic properties change. The magnetic properties also change with changes in the ship's structure or magnetic cargo.
- Deviation changes with heading. The ship as well as the earth may be considered as a magnet. The effect of the ship's magnetism upon the compass changes with the heading.
- Does not point to true north.
-

COMPASS ERROR

6-23. Compass error, defined as the angular difference between the compass direction and the corresponding true direction, may be easily computed since it is the algebraic sum of variation and deviation (Figure 6-3). Compass error must be applied to the compass direction to get true direction and must be applied to true direction, with a reversal of the sign, to arrive at compass direction.

6-24. Variation is found recorded within the compass rose or direction reference of the chart in use. Deviation is found by consulting the deviation card that provides the deviation for each 15° of magnetic heading.

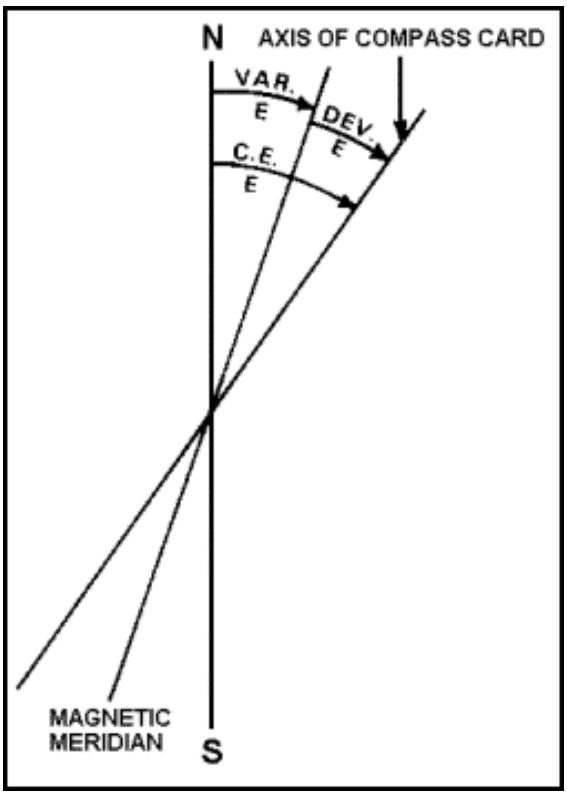


Figure 6-3. Compass Error

VARIATION

6-25. Because the magnetic north pole and the true North Pole are not located at the same point, the magnetic compass does not seek true north. The magnetic compass aligns itself with the magnetic meridian. The angular difference between the magnetic meridian and the true meridian is called "variation" because it varies at different points on the earth's surface (Figure 6-4). Even in the same locality it usually does not remain constant, but increases or decreases annually at a certain known rate.

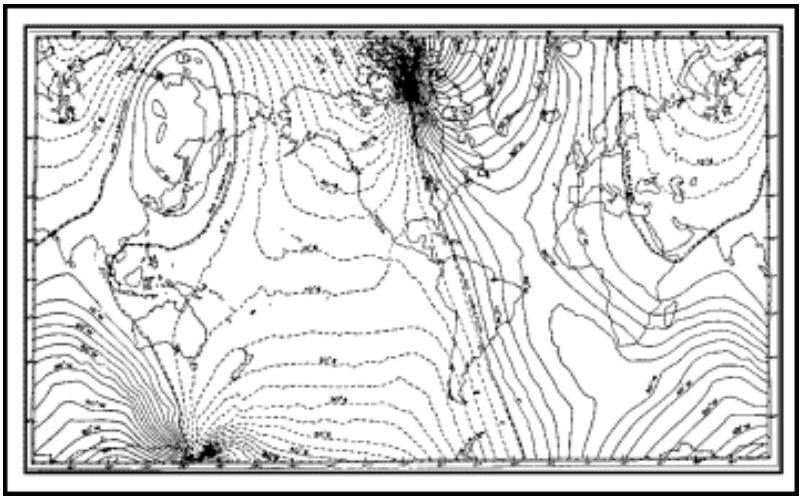


Figure 6-4. Magnetic Variation

6-26. The variation for any given locality, together with the amount of annual increase or decrease, is shown on the compass rose of the chart for that particular locality. The "compass rose" (Figure 6-5) indicates that in 1964 there was a 14° 45' westerly variation in that area, increasing 2' annually. To find the amount of variation in this specific locality, determine how many years have elapsed since 1964, multiply that number by the amount of annual increase, and add that sum to the variation in 1964. You add it in this example, because it is an annual increase. If it were decreasing, you would subtract it. Variation normally is rounded off to the nearest 0.5° .

6-27. Variation remains the same for any heading of the ship at a given locality. No matter which direction the ship is heading, the magnetic compass, if affected by variation only, points steadily in the general direction of the magnetic north pole. Remember, always use the compass rose that is closest to the area in which you are located.

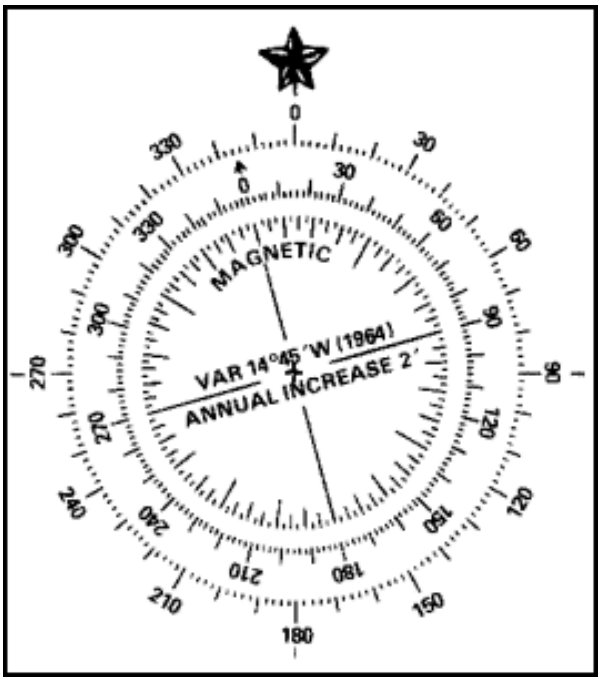


Figure 6-5. Compass Rose

DEVIATION

6-28. The magnetic properties of a ship cause deviation in the magnetic compass. Ship magnetism is of two types:

- **Permanent.** Magnetism in steel or hard iron that acts as a permanent magnet.
- **Induced.** Magnetism of soft iron, which is only temporary and is constantly changing depending upon ship's heading and latitude.

METHODS OF DETERMINING DEVIATION

6-29. The most convenient method of determining deviation, and the one most commonly used, is to check the compass on each 15º heading against a properly functioning gyrocompass. Because the ship must be on a magnetic heading when determining deviation, gyro error and local variation must be applied to each gyro heading.

6-30. It is a simple process to station personnel at each magnetic compass and have them record the amount of deviation for each compass upon signal from an observer at the gyrocompass or repeaters.

- **Compare with a magnetic compass of known deviation.** This method is similar to comparison with a gyrocompass except that it is not necessary to know the local variation. This method is used frequently by ships not equipped with gyrocompasses.
- **Determine deviation of the magnetic compass by a range.** Figure 6-6 shows how to determine deviation of the compass by a range.

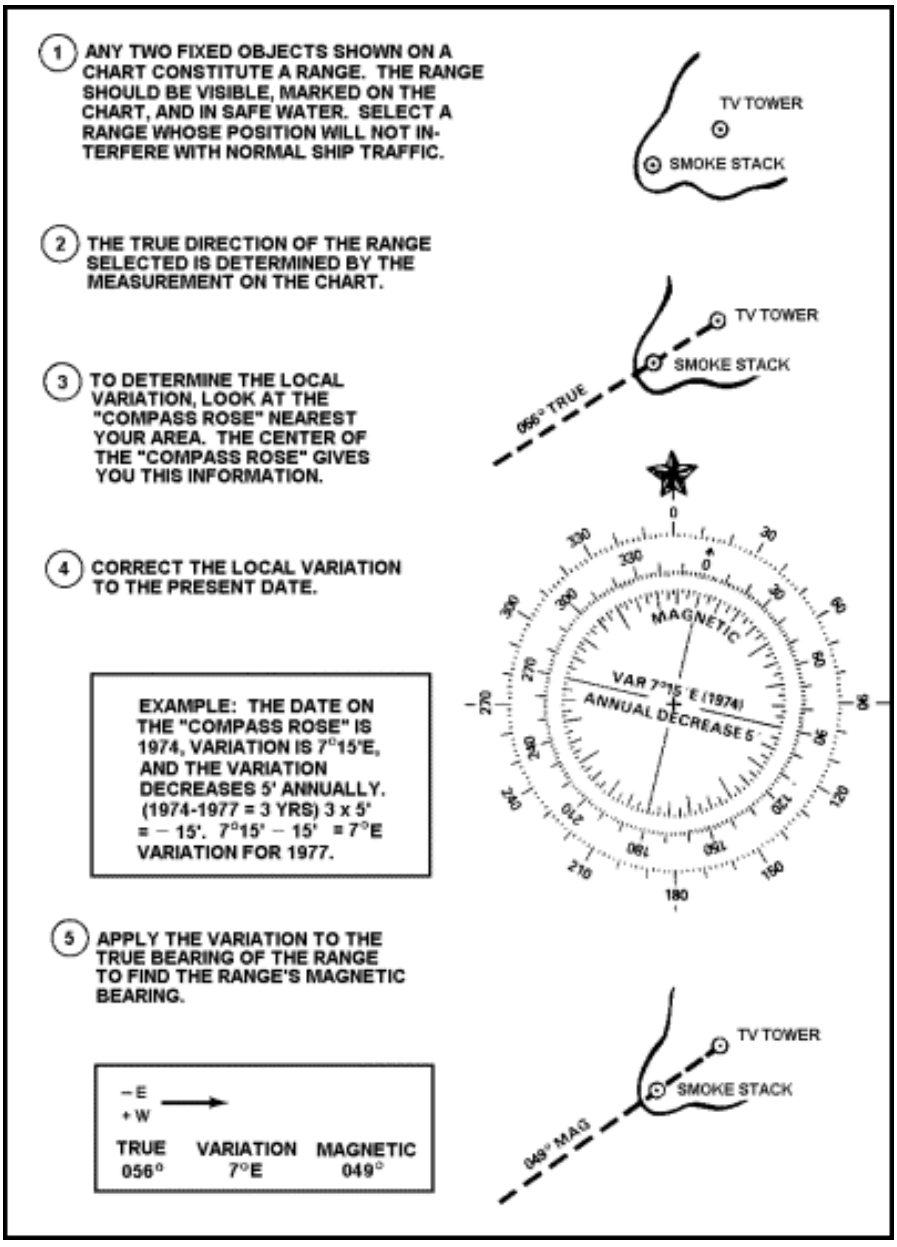
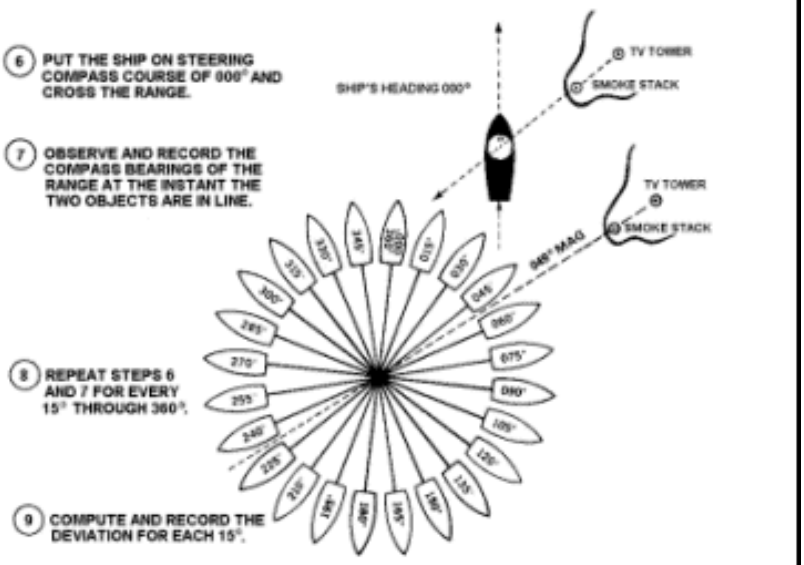


Figure 6-6. How to Determine Deviation of the Compass by a Range



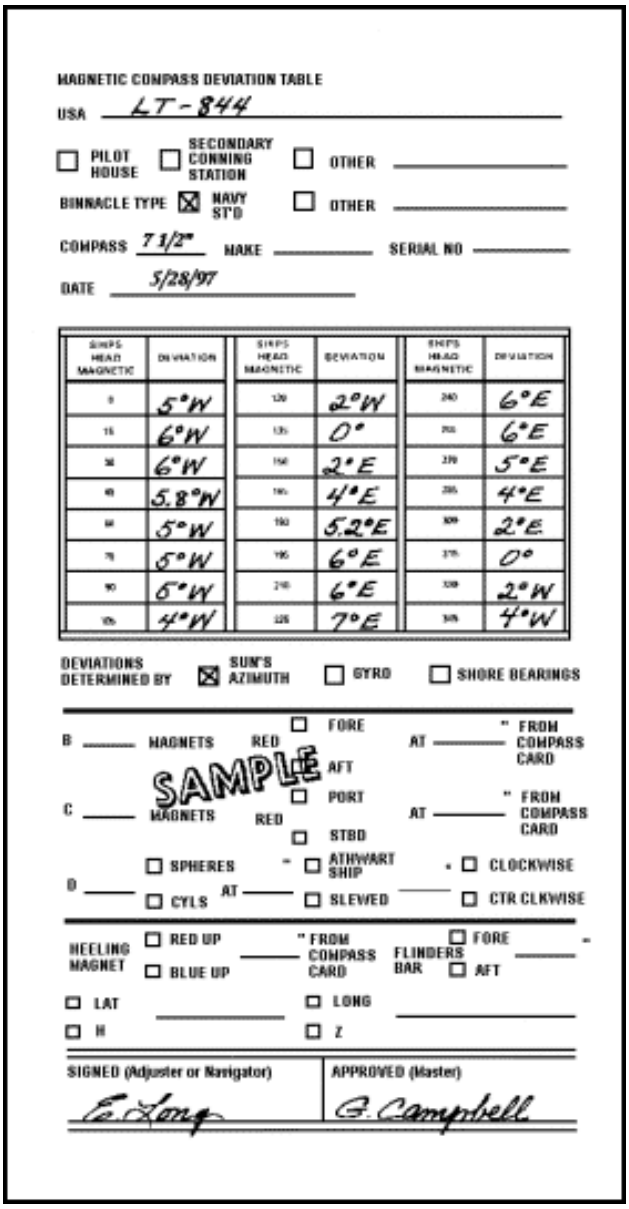
SHIP'S HEAD	TRUE DIRECTION RANGE	VARIATION	MAGNETIC HEADING RANGE	COMPASS BEARING OF RANGE	DEVIATION
000°	056°	7° E	049°	053°	4° W
015°				053°	4° W
030°				052°5	3°5 W
045°				052°2	3°2 W
060°				052°	3°0 W
075°				051°2	2°5 W
090°				051°	2°0 W
105°				050°8	1°8 W
120°				050°2	1°2 W
135°				049°8	0°8 W
150°				049°5	0°5 W
165°				047°5	1°5 E
180°				047°	2°0 E
195°				046°5	2°5 E
210°				046°	3°0 E
225°				045°5	3°5 E
240°				045°	4°0 E
255°				046°5	3°5 E
270°				046°	3°0 E
285°				047°	2°0 E
300°				047°5	1°5 E
315°				048°	1°0 E
330°				048°5	0°5 E
345°				050°	1°0 W

Figure 6-6. How to Determine Deviation of the Compass by a Range (continued)

RECORDING DEVIATION

6-31. Deviation is not the same on every heading. Therefore, the deviation that exists on the various headings must be recorded so the correction for compass error will be known. Use a process called "swinging ship" to determine and record the deviation your ship is headed through every 15° of the compass. The ship is steadied on each 15° . The navigator usually is stationed at the standard compass and ship's personnel are stationed at the other magnetic compasses. As the ship steadies upon one of the 15° increments of the compass and the compasses settle down, the navigator gives the signal to record the deviation on that heading. When the process of swing ship is completed and the deviation for the 24 headings recorded, the deviations are transferred to a deviation card as shown (Figure 6-7).

6-32. The deviation card contains important information that is necessary for future compass adjustment as well as for computing compass error.



MAGNETIC COMPASS DEVIATION TABLE

USA LT-844

☐ PILOT HOUSE ☐ SECONDARY CONNING STATION ☐ OTHER _____

BINNACLE TYPE ☒ NAVY ST'D ☐ OTHER _____

COMPASS 7 1/2" MAKE _____ SERIAL NO _____

DATE 5/28/97

SHIPS HEAD MAGNETIC	DEVIATION	SHIPS HEAD MAGNETIC	DEVIATION	SHIPS HEAD MAGNETIC	DEVIATION
0	5°W	120	2°W	240	6°E
15	6°W	135	0°	255	6°E
30	6°W	150	2°E	270	5°E
45	5.8°W	165	4°E	285	4°E
60	5°W	180	5.2°E	300	2°E
75	5°W	195	6°E	315	0°
90	5°W	210	6°E	330	2°W
105	4°W	225	7°E	345	4°W

DEVIATIONS DETERMINED BY ☒ SUN'S AZIMUTH ☐ GYRO ☐ SHORE BEARINGS

B _____ MAGNETS RED ☐ FORE ☐ AFT AT _____ " FROM COMPASS CARD

SAMPLE

C _____ MAGNETS RED ☐ PORT ☐ STBD AT _____ " FROM COMPASS CARD

D _____ ☐ SPHERES ☐ CYLS AT _____ " ☐ ATHWART SHIP ☐ SLEWED _____ ° ☐ CLOCKWISE ☐ CTR CLKWISE

HEELING MAGNET ☐ RED UP ☐ BLUE UP _____ " FROM COMPASS CARD FLINDERS BAR ☐ FORE ☐ AFT _____

☐ LAT _____ ☐ LONG _____

☐ H ☐ Z

SIGNED (Adjuster or Navigator)	APPROVED (Master)
E. Long	G. Campbell

Figure 6-7. Sample Deviation Card

6-33. Before a final recording is posted on the deviation card, a simple graph is made to plot the recorded deviations (Figure 6-8). This graph will quickly show if the deviation found for each of the 24 headings is consistent. When each of the deviations is plotted on the graph, a line connecting the points should form a smooth curve. Do not expect all points to be on the smooth curve, but they should be close. If you find one heading way off (2° -1 or 3°), go back and check the deviation on that heading again.

6-34. To compute the deviation on any magnetic heading not given in the table, it is necessary to interpolate between the two nearest recorded readings. If the deviations recorded on each 15° heading do not vary by more than 1/2° from the adjacent readings, you may use the deviation for the heading nearest the one you are checking.

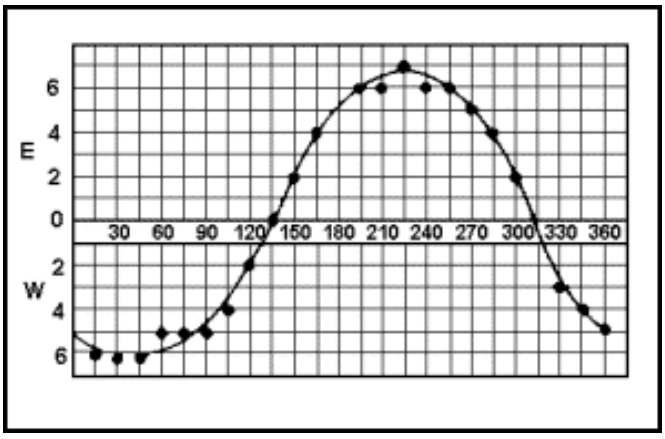


Figure 6-8. Deviation Graph

CORRECTING COMPASS ERROR

6-35. Variation and deviation combined constitute "magnetic compass error." The course on which you want the ship to make good is the true course, selected from the compass between two points on a chart. Knowing the true course, it is necessary for you to find the compass course that you must steer to make good that true course. Compass course is found by applying the compass error, in terms of variation and deviation, to the true course.

6-36. Your problem could be the other way around. Suppose you have a bearing taken by magnetic compass. Plotting true bearings on the chart is preferable to plotting magnetic compass bearings. Therefore, you must apply variation and deviation to the compass bearing to obtain the true bearing.

6-37. Changing from true course to compass course, or vice versa, may be accomplished more easily by means of this handy ditty: Can Dead Men Vote Twice? Write each word of the ditty in column form, then opposite each word set down what it represents, as shown in Table 6-1.

Table 6-1. Word Ditty

Can	***Compass***
Dead	***Deviation***
Men	***Magnetic***
Vote	***Variation***
Twice	***True***

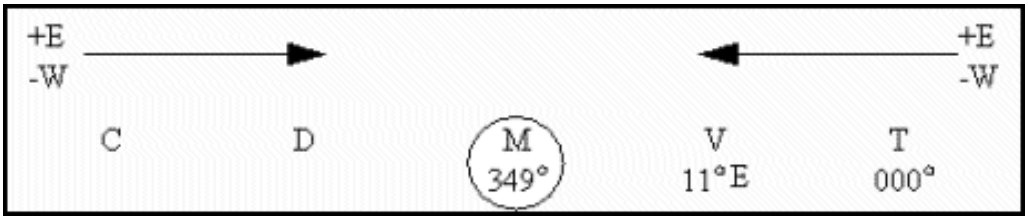
6-38. The problem will always be either (knowing the true course) to work up the line to the compass course, or (knowing the compass course) to work down the line to the true course. Going up the line, or changing from true to compass, is called "uncorrecting." Coming down the line, or changing from compass to true, is called "correcting." Remember this rule: When correcting, ADD easterly and SUBTRACT westerly error. When uncorrecting, SUBTRACT easterly and ADD westerly error. All compass errors, whether due to variation or deviation, are either easterly or westerly. There are no northerly or southerly errors.

6-39. Now work a problem. Suppose the true course is 000° and you want to know the course to steer by magnetic compass. You are uncorrecting. Write the initial letters of each word of the ditty in a line as follows:

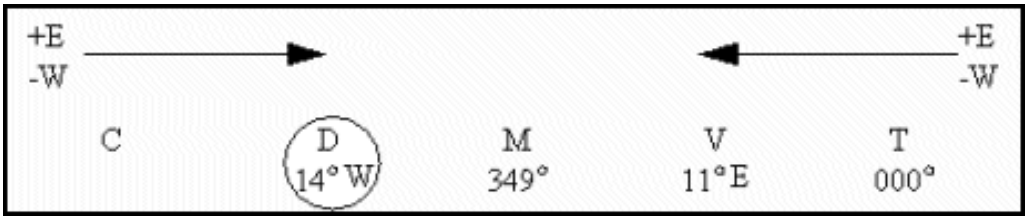
6-40. You already know what T is, so write it down as follows:

6-41. Do the following if the chart shows a variation of 11° E.

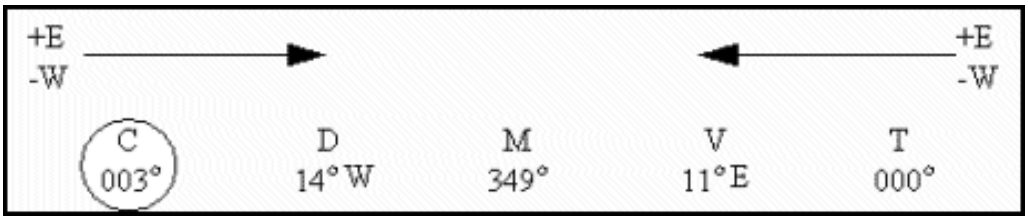
6-42. When uncorrecting, remember that you subtract easterly and add westerly errors. The 11° is an easterly variation so subtract it from 360° to get a magnetic course of 349° . Write that down as follows:



6-43. Sometimes you need to know a magnetic heading or bearing. If that were all you were looking for in this example, you could stop right here. However, you want to go on and find the compass course. Let us say the deviation table shows a deviation of 14° W for a 349° heading. Write that down as follows:



6-44. When uncorrecting, you add westerly error, so add 14° to 349° and get 003° . Now you have the following:



Note: Therefore, in order to head 000° true, you must steer 003° by this particular magnetic compass.

6-45. Note in the sample problem that the easterly variation and westerly deviation almost canceled each other, leaving an error of only 3° W. If you do not want to go through the correction process in detail, you can find the algebraic sum of the errors beforehand. This advance preparation is accomplished by subtracting the lesser from the greater, if they are unlike, or adding them if they are alike. Then you can apply the result directly to either T or C, depending on whether you are correcting or uncorrecting.

6-46. We were uncorrecting this time--changing from true to compass. We could have used the same method to change from compass to true. Remember, when correcting, add easterly and subtract westerly errors.

PILOTING INSTRUMENTS

6-47. In determining position and safely conducting a ship from one position to another, the navigator uses a variety of piloting instruments. The correct use of these instruments and the ability to interpret properly the information obtained from these instruments require skill and experience.

6-48. Piloting instruments must be capable of considerable accuracy. One of the best known navigational instruments is the magnetic compass, which is used for the measurement of direction. Aside from the compass, piloting equipment falls under the following categories:

- Bearing-taking devices.
- Speed-measuring devices (includes distance and time).
- Depth-measuring devices.
- Plotting instruments.
- Miscellaneous instruments.

BEARING-TAKING DEVICES

6-49. Instruments used for taking bearings consist of a azimuth circle, telescopic alidade, and pelorus (or dumb compass).

Azimuth Circle

6-50. This is a nonmagnetic metal ring (Figure 6-9). It is sized to fit a 7 1/2-inch compass bowl or a gyro repeater. The inner lip is marked in degrees from 0° to 360° counterclockwise for measuring relative bearings. The azimuth circle is fitted with two sighting vanes. The forward or far vane has a vertical wire and the after or near vane has a peep sight. Two finger lugs are used to position the instrument while aligning the vanes. A hinged reflector vane mounted at the base and beyond the forward vane is used for reflecting stars and planets when observing azimuths. Beneath the forward vane are mounted a reflecting mirror and the extended vertical wire.

6-51. This lets the mate read the bearing or azimuth from the reflected portion of the compass card. For taking azimuths of the sun, an additional reflecting mirror and housing are mounted on the ring, each midway between the forward and after vanes. The sun’s rays are reflected by the mirror to the housing, where a vertical slit admits a line of light. This admitted light passes through a 45º reflecting prism and is projected on the compass card from which the azimuth is directly read. In observing both bearings and azimuths, two attached spirit levels are used to level the instrument. An azimuth circle without the housing and spare mirror is called a bearing circle.

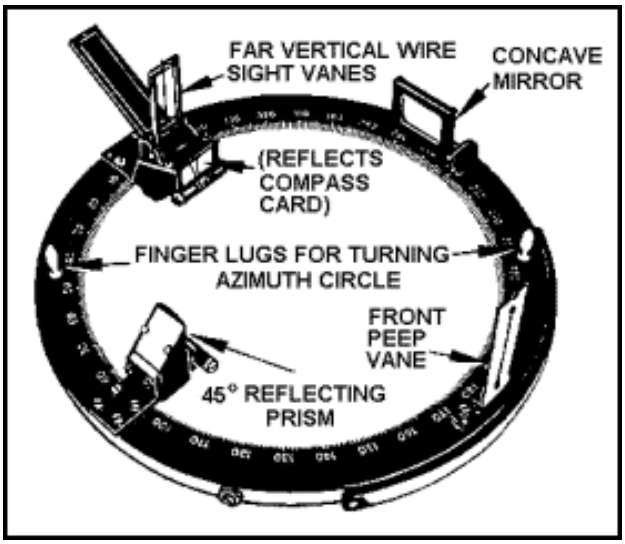


Figure 6-9. Azimuth Circle

Telescopic Alidade

6-52. This is similar to a bearing circle, only it has a telescope attached to the metal ring instead of the forward and after sight vanes (Figure 6-10). The magnifying power of the telescope lens makes distant objects appear more visible to the observer. When looking through the telescope, the bearing may be read, since the appropriate part of the compass card is reflected by a prism in the lower part of the field of vision. When a ship is yawing badly, it is easy to lose sight of an object using the telescopic alidade because the field of vision is very limited.

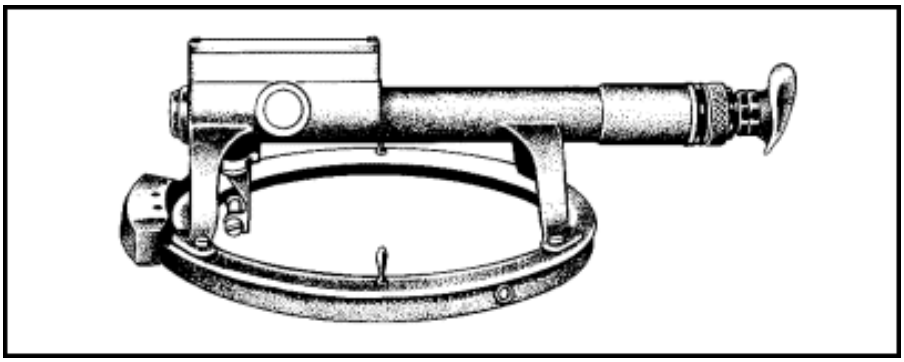


Figure 6-10. Telescopic Alidade

Pelorus (Dumb Compass)

6-53. In a ship without gyro installation, a pelorus or "dumb compass" (Figure 6-11) is located on either bridge wing, from which bearings may be taken on objects visible from the ship. The gyro repeaters has replaced the pelorus on all gyro-equipped ships.

6-54. The pelorus consists of a nonmagnetic metal ring mounted in gimbals on a pelorus stand. The inner lip of the ring is graduated through 360° . The 000° mark corresponds to the ship’s lubber line.

6-55. Inside the ring is a dumb compass card. The card can be rotated so as to bring any heading on the lubber line. A pair of sighting vanes, mounted on the card, are aimed at the object whose bearing is desired.

6-56. If the dumb compass card is set to the ship's true course, the bearing by pelorus will be a true bearing, provided the ship is exactly on course at the instant the bearing is taken. This synchronization seldom happens, however, and it is customary for the person taking the bearing to yell out "Mark!" the instant he takes it and simultaneously clamps the sighting vanes. The steersman notes the compass heading when he hears "Mark". If the ship was on the true heading, the bearing obtained was a true bearing. If she was off course, a correction equal to the amount she was off must be applied to the bearing. If the course was by magnetic compass, the bearing by pelorus must still be converted from compass to true.

6-57. Relative bearings are taken by pelorus merely by setting the dumb compass card's 000° heading to the lubber line.

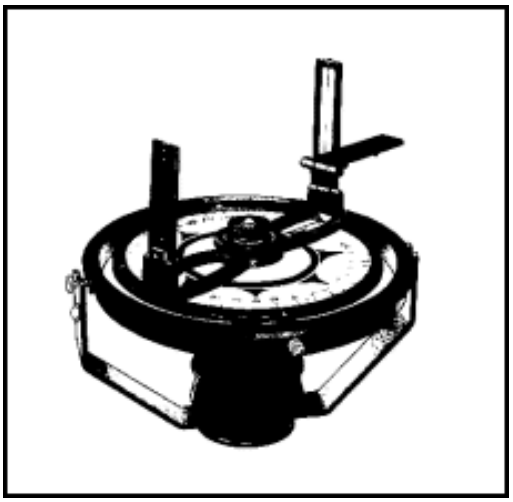


Figure 6-11. Pelorus

SPEED-MEASURING DEVICES

6-58. Speed can be determined indirectly by means of distance and time or it can be measured directly. All instruments in common use for measuring speed determine the rate of motion through the water.

6-59. An engine room counter counts off the number of revolutions the propeller shaft turns. When the unit of time is known, speed can be determined. Pitch is the distance that a given propeller would advance in one complete revolution if it were working against a solid. The difference between the pitch and the actual distance advanced through water is known as slip, expressed as a percentile. Therefore, if a propeller has a pitch of 10 feet and turns 200 revolutions per minute, it advances 2,000 feet per minute, which is equivalent to 19.75 knots. Assuming this propeller has a slip of 18 percent, the ship's speed is reduced by this amount. This is known as positive slip. So, instead of 19.75 knots, the speed is only 19.75 X 0.82 = 16.2 knots.

DEPTH-MEASURING DEVICES

6-60. Depth-measuring devices may be classified as mechanical or electronic. The mechanical type is represented by the hand lead. The most common example of an electronic type is the fathometer.

Hand Lead

6-61. The hand lead line (Figure 6-12) is the oldest and most reliable depth-finding device for shallow depths. It consists of a lead weight (7 to 14 pounds) attached to a 20-fathom line marked as follows:

2 fm	**2 strips of leather**
3 fm	**3 strips of leather**
5 fm	**white rag**
7 fm	**red rag**

10 fm	**leather with hole**
13 fm	**same as 3 fm**
15 fm	**same as 5 fm**
17 fm	**same as 7 fm**
20 fm	**line with two knots**

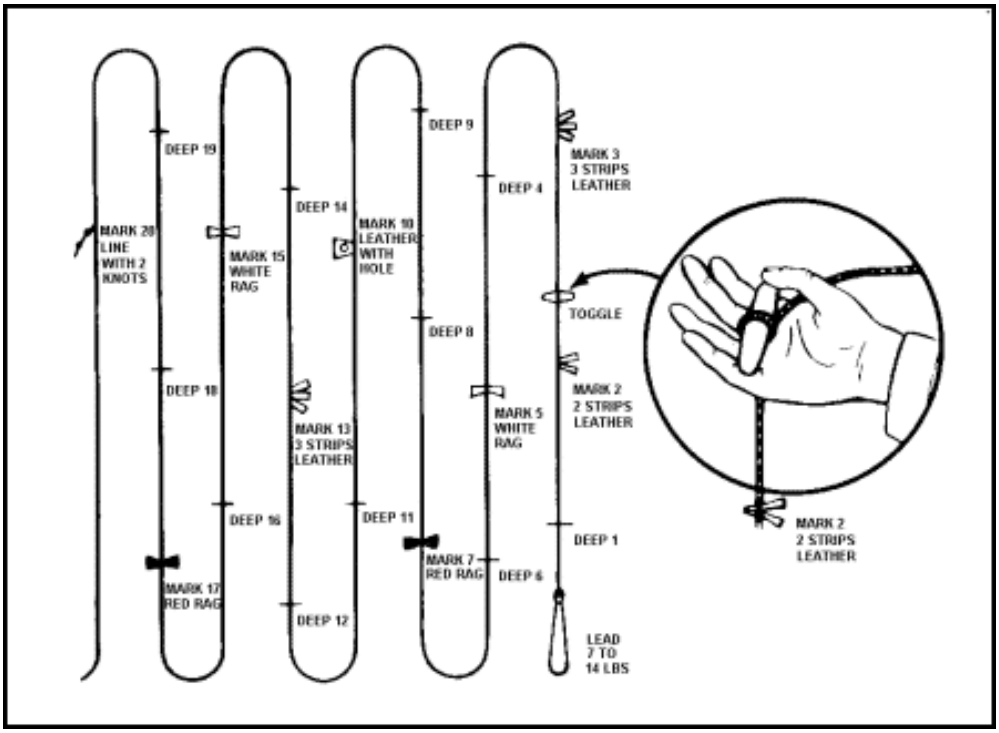


Figure 6-12. Hand Lead Line

6-62. Swing the hand lead in a pendulum motion to produce momentum for two complete turns. Then let it go to allow the lead to sink ahead of the chains (station on ship from which soundings are taken). The leadsmen call out depths referring to definite markings as "by the mark . . ." and other depth values as "by the deep . . ." Phraseology for fractions are "and a half," "and a quarter," or "a quarter less" as appropriate; for example, "and a half five" (5 1/2 fm) or "a quarter less four" (3 3/4 fm). The lead line should be measured and marked when wet. A hollow indentation in the end of the lead permits "arming". Arming is the application of tallow or other sticky substance to the lead in order to sample the bottom to determine the type of bottom you are over.

Type Fathometer or Echo Sounder

6-63. This is an electronic device that emits a sound signal and measures the time between the emission of the signal and the return of the echo. Since the signal must travel to the bottom and return, the depth is half the distance traveled, considering the average speed of sound waves in water to be 800 fathoms (4,800 feet) per second. When using the fathometer, remember that the fathometer sends the signal from the keel. All depths shown on the fathometer are depths under the keel. The actual depth is equal to the sum of the depth under the keel and the draft of the ship. Fathometers are usually found on category A-3 vessels.

PLOTTING INSTRUMENTS

6-64. The most basic of plotting instruments is the pencil, preferably a No. 2 or No. 3 pencil. Keep all lines short, and print legibly and lightly for easy erasure. Art gum erasers are normally used for erasure since art gum is less destructive to chart surfaces than India red rubber erasers.

Navigator's Kit

6-65. This kit contains a drawing compass, dividers, and screwdriver (for adjusting points), all essential navigation instruments. Dividers are used to measure distance and the drawing compass is useful for constructing circles and arcs such as circular LOPs and arcs of visibility (Figure 6-13).

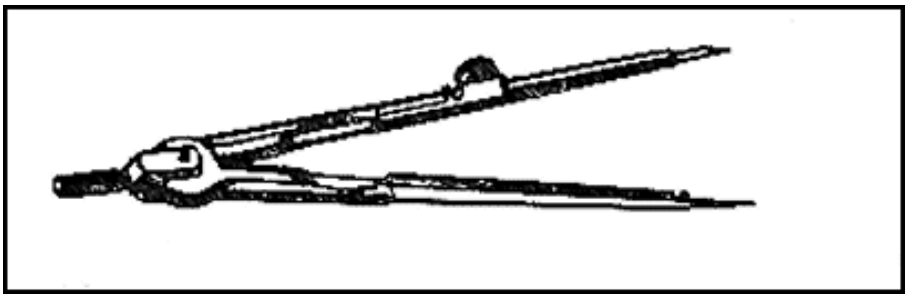


Figure 6-13. Divider/Drawing Compass

Parallel Rules

6-66. These are simple devices for plotting direction. The rules consist of two parallel bars with parallel cross braces of equal length which form equal opposite angles (Figure 6-14). The rules are laid on the compass rose (direction reference of a chart) with the leading edge aligning the center of the rose and the desired direction on the periphery of the rose. Holding first one bar and moving the second, then holding the second and moving the first, parallel motion is ensured. Lines representing direction may be plotted as desired upon the chart.

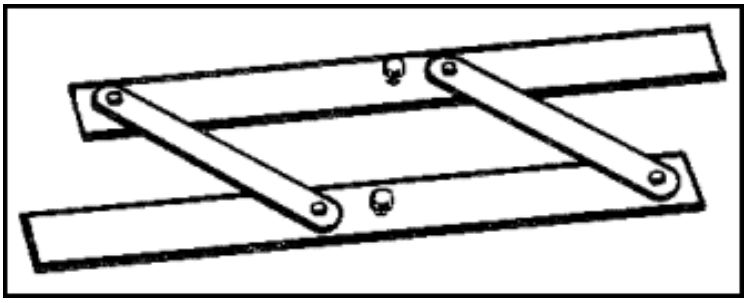


Figure 6-14. Parallel Rules

Triangles

6-67. A pair of plastic triangles can also be used for transferring a direction from one part of a chart to another, although not for great distances (Figure 6-15). The two triangles need not be similar in size or shape. The two hypotenuses (longest sides) are placed together, and one of the other sides of one triangle is lined up with the course or bearing line or with the desired direction at the compass rose. The other triangle is held firmly in place as a base, and the first one is slid along in contact with it, carrying the specified line to a new position while maintaining its direction. If necessary, the triangles may be alternately held and slid for moving somewhat greater distances. Two right triangles may be used in conjunction with a compass rose as a means for plotting direction.

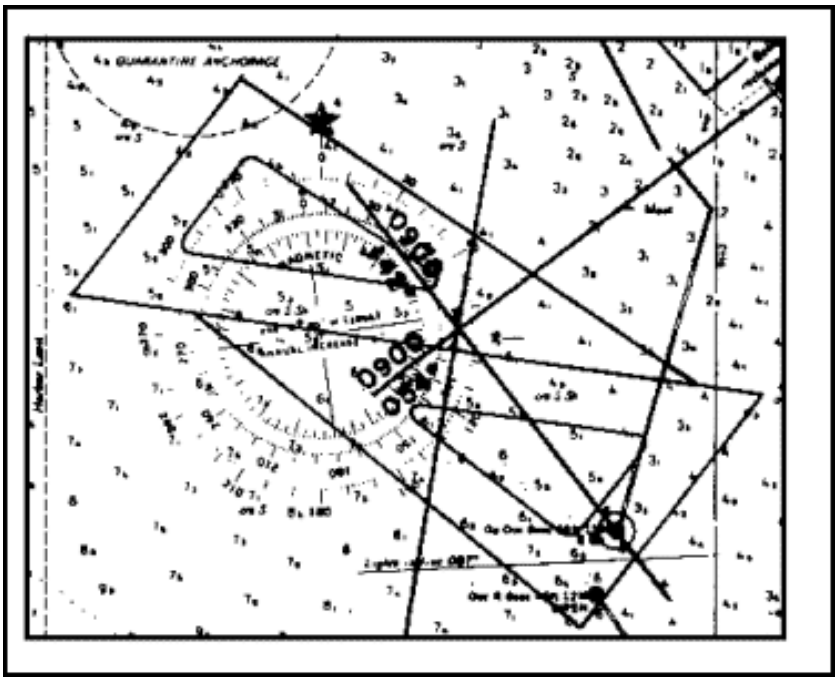


Figure 6-15. Triangles

Drafting Machine or Parallel Motion Protractor

6-68. This plotting device is anchored to the chart table and consists of two links and a drafting arm (Figure 6-16). An elbow between the two links permits unrestricted movement. Between the outboard link and the drafting arm, a metal disc is graduated as a protractor. It permits orientation of the protractor with the chart. A setscrew, usually on the inner edge, is loosened when in use to permit movement of the drafting arm in any given direction. Tighten the setscrew before plotting. The advantage of the drafting machine over other plotting instruments is speed.

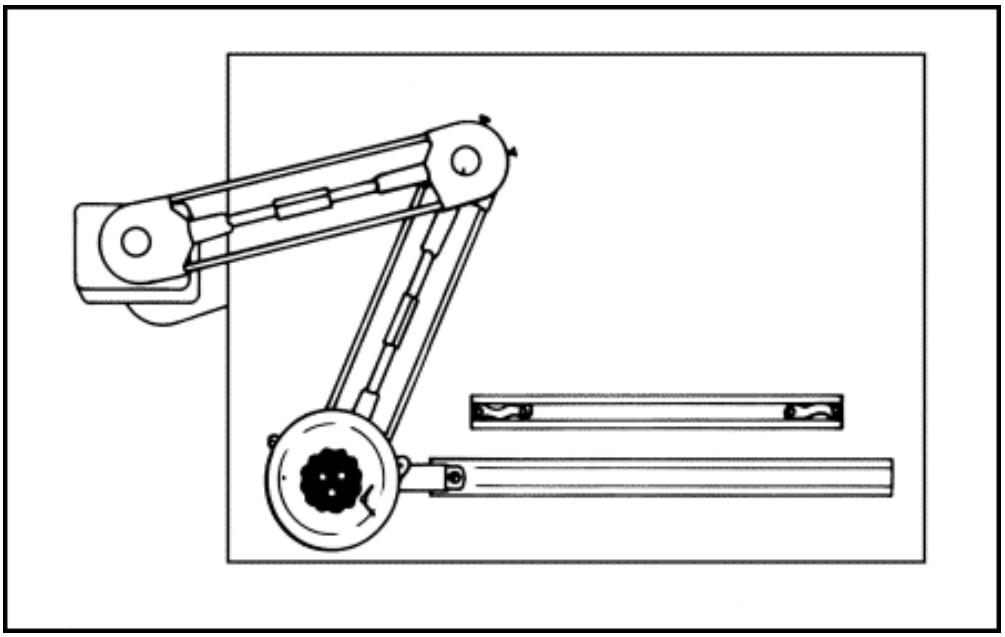


Figure 6-16. Drafting Machine

MISCELLANEOUS INSTRUMENTS

6-69. The following are essential to have aboard ship. Ensure that the are in good working order.

Binoculars

6-70. In selecting a pair of binoculars, keep in mind that increased power and magnification results in a narrowing field of view. A set of 7 X 50 binoculars is recommended for marine use. The "7" indicates the power of magnification and the "50" indicates the diameter of the front lens in millimeters. Minor adjustment to one eyepiece permits separate focusing for each eye. The glass lenses are usually coated to reduce the glare. Additional filters are available for further glare reduction. Binoculars must be handled with care and properly stowed when not in use. The lenses should be cleaned often, using only lens paper to prevent damage to the polished surfaces.

Flashlight

6-71. In selecting a flashlight, ensure that it is water resistant and that it is designed to withstand shocks and also seals out moisture. The case should be made of non-slip rubber. A red plastic disc should be inserted in the lighted end to provide a red light for sustaining your night vision or to prevent unnecessarily lighting up the bridge at night.

AIDS TO NAVIGATION

6-72. Aids to navigation are put at various points along the coasts and navigable waterways as markers and guides to help mariners determine their position. They also serve to warn of hidden dangers and assist in making landfall when approaching from the high seas. They also provide a continuous chain of charted marks, showing improved channels and assisting in coastal piloting.

6-73. Aids to navigation consist of lighthouses, light towers, minor lights, buoys, day beacons, and ranges. A ship cannot suspend piloting operations because of darkness. For this reason, aids to navigation are lighted whenever it is necessary and practical. Therefore, you must be knowledgeable of the light characteristics of the aids to navigation.

LIGHT CHARACTERISTICS

6-74. A light has distinctive characteristics which distinguish it from other lights or convey specific information. A light may show a distinctive sequence of light and dark intervals. A light may also display a distinctive color or color sequence.

Color of Lights

6-75. For all buoys in the lateral system having lights, the following system of color is used:

- **Green Lights.** Used only on those buoys marking the left-hand side of a channel returning from seaward (black, odd-numbered buoys) or on red-and-black, horizontally banded buoys having the topmost band painted black.
- **Red Lights.** Used only on those buoys marking the right-hand side of a channel when entering from sea (red, even-numbered buoys) or on red-and-black, horizontally banded buoys having a red topmost band.
- **White Lights.** May be used on either side of channels instead of red or green lights. White lights are frequently used where greater visibility is desired, such as at a change in the direction of the channel. No special significance is derived from a white light, the purpose of the buoy being indicated by its color, number, or its light phase characteristic.

Fixed, Flashing, and Occulting Lights

6-76. Some navigational lights are fixed, meaning that they burn steadily. Most important lights, however, go through repeated periods of systematic changes of light and darkness. It is this characteristic of a navigational light that is most valuable for identification purposes.

6-77. The following are the principal characteristics of lights on lighthouses. Lighted buoys have a few more special characteristics, which are mentioned later.

- **Flashing.** A single flash showing at regular intervals, the duration of light always being less than the duration of darkness.
- **Occulting.** A light totally eclipsed at regular intervals, the duration of light always being greater than the duration of darkness.
- **Fixed and Flashing.** A fixed light varied at regular intervals by groups of two or more flashes of greater brilliance. The group may, or may not, be preceded and followed by an eclipse.
- **Group Flashing.** Groups of two or more flashes showing at regular intervals.
- **Group Occulting.** A light with a group of two or more eclipses at regular intervals.
- **Equal Interval (Isophase).** A single flash with the duration of light equal to that of darkness.
- **Morse Code.** Light in which flashes of different durations are grouped to produce a Morse character or characters.
- **Alternating.** Rhythmic lights which exhibit different colors during each sequence.

VISIBILITY OF LIGHTS

6-78. The visibility of lights is measured by the specific distance, in nautical miles, a navigator can expect to see a lighthouse or beacon. In speaking of the visibility of a light, the following terms apply:

- **Geographic Range.** This is the maximum calculated distance at which the curvature of the earth permits a light to be seen from a height of eye of 15 feet above the water when the elevation of the light is taken above the height datum.
- **Luminous Range.** This is the maximum distance at which a light can be seen under present visibility conditions. This luminous range does not take into account of the elevation of the light, the observer's height of eye, the curvature of the earth, or interference from background lighting. The luminous range is determined from the known nominal luminous range (called the nominal range) and the present visibility conditions.
- **Nominal Range.** This is the maximum distance at which a light can be seen in clear weather as defined by the International Visibility Code (meteorological visibility of 10 nautical miles).
- **Computed Visibility.** This is determined for a particular light, taking into account its elevation, nominal range, height of eye of the observer, and the curvature of the earth.

COMPUTING THE VISIBILITY OF A LIGHT

6-79. The computed visibility will not exceed the light's nominal range (luminous range) or the computed range. Although, under certain atmospheric conditions, the loom of a powerful light may appear before the light itself is visible. The following examples illustrate the procedure for determining the visibility of a light.

Example 1: Determine the visibility of a light that is 90 feet above sea level for an observer with a height of eye of 50 feet.

Solution: From the DMAHTC List of Lights, determine the nominal range (20 miles) and the height of the light above water (90 feet).

Determine horizon distance from Table 6-2, and place in form shown below.

Height of eye of 50 feet	8.1 miles
Height of light above water, 90 feet	10.9 miles
Computed visibility	19.0 miles
Nominal range	20.0 miles

Answer: 19.0 miles

Example 2: Determine the visibility of another light that is 77 feet above sea level for an observer with height of eye of 37 feet.

Solution: From the DMAHTC List of Lights, determine the nominal range (10 miles) and the height of the light above water (77 feet). Determine horizon distance from Table 6-1, interpolating for 77 feet.

Height of eye of 37 feet	7.0 miles
Height of light above water, 77 feet	10.0 miles
Computed visibility	17.0 miles
Nominal range	10.0 miles

Answer: 10.0 miles

Table 6-2. Table of Distance of Visibility of Objects at Sea

The following table gives the approximate geographic range of visibility for an object that may be seen by an observer whose eye is sea level. Therefore, in practice, it is necessary to add to these a distance of visibility corresponding to the height of the observer's eye above sea level.

HEIGHT, FEET	NAUTICAL MILES	HEIGHT, FEET	NAUTICAL MILES	HEIGHT, FEET	NAUTICAL MILES	HEIGHT, FEET	NAUTICAL MILES	HEIGHT, FEET	NAUTICAL MILES
4	2.8	48	7.9	220	17.0	660	29.4	2,000	51.2
8	3.1	50	8.1	240	17.7	680	29.9	2,200	53.8
10	3.6	55	8.5	260	18.5	700	30.3	2,400	56.2
12	4.0	60	8.9	20	19.2	720	30.7	2,600	58.5
14	4.3	65	9.2	300	19.9	740	31.1	2,800	60.6
15	4.4	70	9.6	320	20.5	760	31.6	3,000	62.8
16	4.6	75	9.9	340	21.1	780	32.0	3,200	64.9
18	4.9	80	10.3	360	21.7	800	32.4	3,400	66.9
20	5.1	85	10.6	380	22.3	820	32.8	3,600	68.6
22	5.4	90	10.9	400	22.9	840	33.2	3,800	70.7
24	5.6	95	11.2	420	23.5	860	33.6	4,000	72.5
26	5.8	100	11.5	440	24.1	880	34.0	4,200	74.3
28	6.1	110	12.0	460	24.6	900	34.4	4,400	76.1
30	6.3	120	12.6	480	25.1	920	34.7	4,600	77.7
32	6.5	130	13.1	500	25.6	940	35.2	4,800	79.4
34	6.7	140	13.6	520	26.1	960	35.5	5,000	81.0
36	6.9	150	14.1	540	26.7	980	35.9	6,000	88.8
38	7.0	160	14.5	560	27.1	1,000	36.2	7,000	96.0
40	7.2	170	14.9	580	27.6	1,200	39.6	8,000	102.6

42	7.4	180	15.4	600	28.0	1,400	42.9	9,000	108.7
44	7.6	190	15-8	620	28.6	1,600	45.8	10,000	114.6
46	7.8	200	16.2	640	29.0	1,800	48.6		

LIGHTHOUSE AND LIGHT STRUCTURES

6-80. Lighthouses (Figure 6-17) are located on all coasts of the US, on the Great Lakes, and along many interior waterways. They are placed wherever a powerful light may be of assistance to navigators or wherever a danger requires a warning beacon of long-range visibility. Visibility of a powerful light increases with height. Therefore, the principal purpose of a light structure is to increase the height of a light above sea level.

Note: It should also be remembered that a light placed at a great elevation is often obscured by clouds, mist, and fog than one near sea level.

6-81. A lighthouse may also contain fog-signaling and radio beacon equipment. Many lights formerly operated by keepers are now automatic. Lighthouses still staffed by keepers may also contain living quarters. When operating personnel are housed in separate buildings grouped around the tower, the group of buildings is called a light station.

6-82. Secondary, minor, and automatic lights are located in structures ranging from towers that resemble important seacoast lighthouses down to a small cluster of piles supporting a battery box and lens.

6-83. Solid colors, bands, stripes, and other color patterns are applied to lighthouses and light structures as an aid to identification. Minor structures sometimes are painted red or black, like channel buoys, to indicate the side of the channel on which they are located--red structures to the right, black to the left, returning seaward.

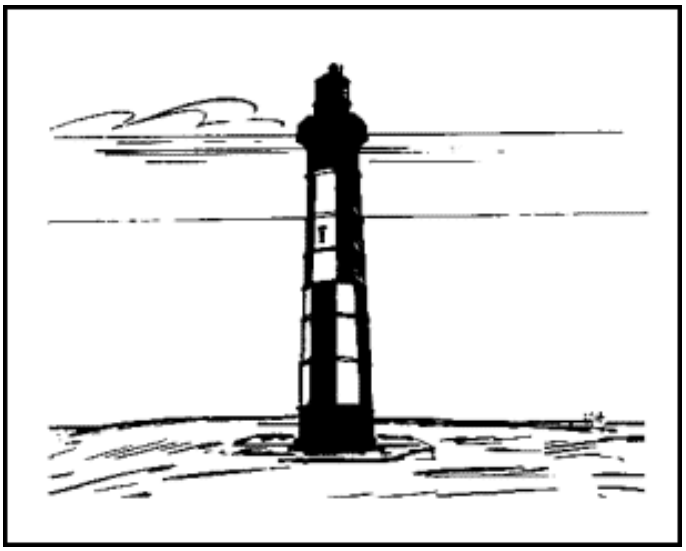


Figure 6-17. Lighthouse

OFFSHORE LIGHT TOWERS

6-84. A typical light tower (Figure 6-18) deckhouse is 60 feet above the water, 80 feet square, and supported by steel legs in pilings driven nearly 300 feet into the ocean bottom. The deckhouse accommodates living quarters and radio-beacon, communications, and oceanographic equipment. The top serves as a landing platform that will take the largest helicopters flown by the Coast Guard. On one corner of the deckhouse is a 32-foot radio tower supporting the radio-beacon antenna and a 3 1/2 million-candlepower light. At an elevation of 130 feet above the water it is visible for 18 miles. The construction details of other towers will vary slightly, but all are of the same general type.

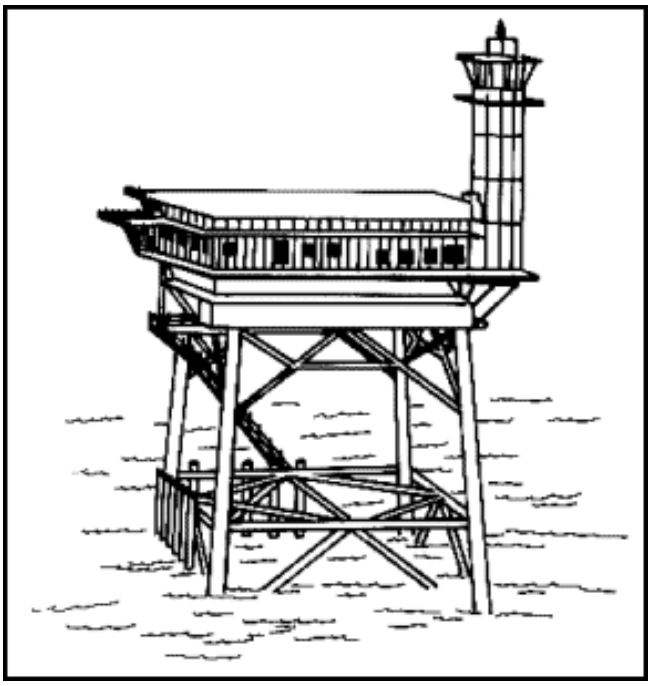


Figure 6-18. Light Tower

DANGER SECTORS

6-85. Sectors of red glass are placed in the lanterns of certain lighthouses to indicate an area in which a ship will be in danger of running on rocks, shoals, or some other hazard. The arcs over which the red light shows, are the danger sectors whose bearings usually appear on the chart (Figure 6-19). Although the light is red within the danger bearings, its other characteristics remain the same.

6-86. Sectors may be only a few degrees in width, marking an isolated obstruction, or they may be so wide that they extend from the direction of deep water to the beach. In most instances, red sectors indicate water to be avoided. A narrow green sector may signify a turning point or the best water across a shoal. Exact significance of each sector may be obtained from the chart.

6-87. All sector bearings are true bearings in degrees, running clockwise around the light as a center. As shown in Figure 6-19, the bearings of the red sector from the light are 135° to 178° . This sector is defined in the Light List in terms of bearings from the ship. These bearings are 315° to 358° , the reciprocals of the preceding bearings. The light shown in the diagram would be defined as follows: obscured from land to 315° , red thence to 358° , green thence to 050° , white thence to land.

6-88. On either side of the line of demarcation between colored and white sectors, there is always a small sector of undefined color because the edges of a sector cannot be cut off sharply in color. Under some atmospheric conditions, a white light itself may have a reddish appearance. Therefore, light sectors must not be relied upon entirely, but position must be verified repeatedly by bearings taken on the light itself or other fixed objects.

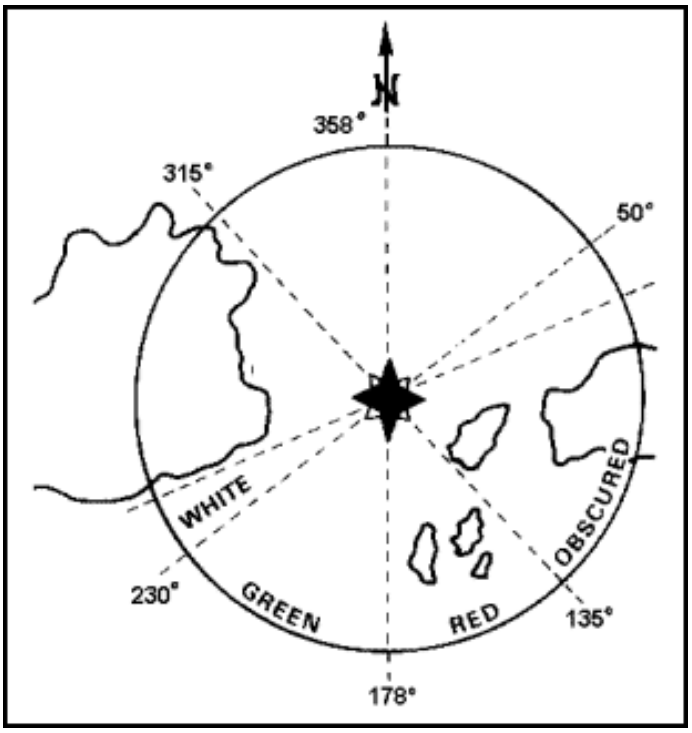


Figure 6-19. Light Sectors

BUOYS

6-89. Navigational buoys are moored floating markers. Place them so that they can guide ships in and out of channels, warn them away from hidden dangers, lead them to anchorage areas, and so forth. Buoys may be of various sizes and shapes (Figure 6-20). However, regardless of their shapes, their distinctive coloring is the chief indication of their purposes.

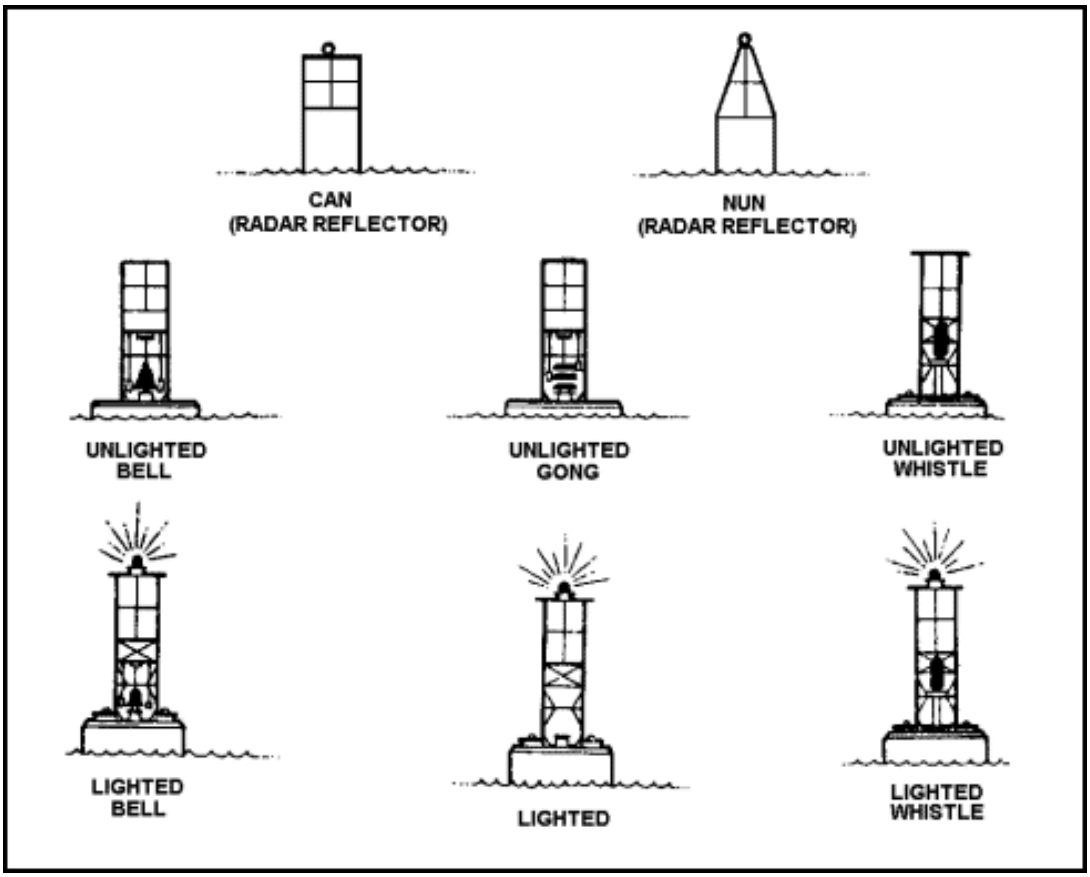


Figure 6-20. Types of Buoys

TYPES OF BUOYS

6-90. Although a buoy's type has no special navigational significance, it may help toward its identification from the description given in Table 6-3. The following are the principal types of buoys:

Spar Buoys

6-91. These are large logs, trimmed, shaped, and appropriately painted. Although the Coast Guard has now eliminated them, spar buoys may still be found in some foreign or private systems of aids.

Can and Nun Buoys

6-92. The shape of can buoys are cylindrical. The shape of nun buoys are conical.

Bell Buoys

6-93. These have flat tops, surmounted by a framework supporting a bell. Older bell buoys are sounded by the motion of the sea. Newer types are operated automatically by compressed gas or electricity.

Gong Buoys

6-94. These are similar to bell buoys except that they have a series of gongs, each with a different tone.

Whistle Buoys

6-95. These are similar to bell buoys except they carry a whistle sounded by the sea's motion or horns that are sounded at regular intervals by mechanical or electrical means.

Lighted Buoys

6-96. These carry batteries or gas tanks and are surmounted by a framework supporting a light. A description of the lights on lighted buoys is given later.

Combination Buoys

6-97. These are buoys in which a light and sound signal are combined, such as a lighted bell, gong, or whistle buoy.

COLORING OF BUOYS

6-98. In the US, red buoys mark the right side and black buoys mark the left side of the channel, coming from seaward. A great help in remembering this placement of buoys is the jingle "red right returning."

6-99. Normally red channel buoys are cone-shaped nun buoys, whereas black channel buoys are cylindrical can buoys. This situation probably is the only one in which a buoy's shape is of any significance, and even here the rule is not controlling. It is the color that counts. Sometimes red and black buoys are painted white on top, but this color scheme is merely to enable them to be located more easily at night.

Table 6-3. Buoy Characteristics

RETURNING FROM SEA*	COLOR	NUMBER	UNLIGHTED BUOY SHAPE	LIGHTS OR LIGHTED BUOYS	
				LIGHT COLOR	LIGHT PHASE CHARACTERISTIC
RIGHT SIDE OF CHANNEL	RED	EVEN	NUN	RED OR WHITE	FLASHING OR QUICK FLASHING
LEFT SIDE OF CHANNEL	BLACK	ODD	CAN	GREEN OR WHITE	FLASHING OR QUICK FLASHING
CHANNEL JUNCTION OR OBSTRUCTION	RED-AND-BLACK HORIZONTALLY BANDED**	NOT NUMBERED	NUN OR CAN**	RED, GREEN, OR WHITE	INTERRUPTED QUICK FLASHING
MIDCHANNEL OR FAIRWAY	BLACK-AND-WHITE VERTICALLY STRIPED	MAY BE LETTERED	NUN OR CAN	WHITE	MORSE CODE "A"

*OR ENTERING A HARBOR FROM A LARGER BODY OF WATER, SUCH AS A LAKE.
**PREFERRED CHANNEL IS INDICATED BY COLOR OF UPPERMOST BAND (SHAPE OF UNLIGHTED BUOY), COLOR OF LIGHT, IF ANY.

6-100. Red and black, horizontally banded buoys mark junctions in the channel, wrecks, or obstructions that may be passed on either side. If the topmost band is black, the preferred channel will be followed by keeping the buoy on the port (left) side. If the topmost band is red, the preferred channel will be followed by keeping the buoy on the starboard (right) side.

Note: When proceeding toward seaward, it may not be possible to pass on either side of these buoys, and the chart should always be consulted.

6-101. Black and white, vertically striped buoys mark the middle of a channel or fairway. Yellow buoys mark quarantine anchorages.

6-102. The foregoing conditions are practically all the colors on buoys that have a direct connection with navigation. Buoys painted all white have no special significance; they have uses not concerned with navigation, such as marking ordinary anchorage areas. Buoys with black and white horizontal stripes are used in some locations to mark fish trap areas. A white buoy with a green top usually means a dredging area.

NUMBERS ON BUOYS

6-103. The red buoys marking the right side of a channel bear even numbers, starting with the first buoy from seaward. This maritime situation is perhaps the only one in which anything to starboard has an even number. Black channel buoys, to the left of the channel coming from seaward, have odd numbers (Figure 6-21). Both the number and one or two letters appear on some channel buoys, for example, the Governor's Island (New York Harbor) West End Shoal Bell Buoy. Because it is the first buoy on the port side of the channel coming from seaward, it is painted black and carries the number 1. The letters "GI" are painted next to the 1.

6-104. Banded or striped buoys are not numbered, but some have letters for identification purposes. For example, the East Rockaway Inlet Bell Buoy (vertical black and white stripes) carries the letters "ER."

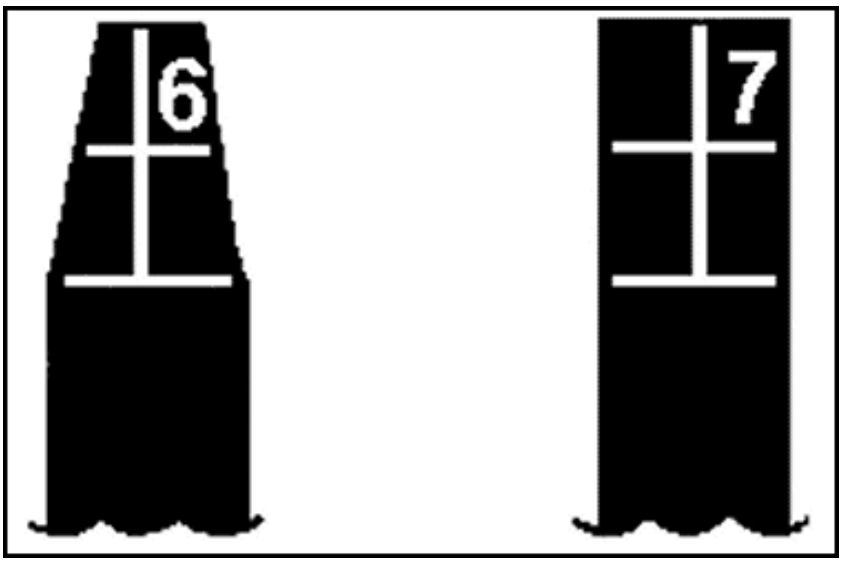


Figure 6-21. Numbered Buoys

LIGHTS ON BUOYS

6-105. Red lights are used only on red buoys or red and black horizontally banded buoys with the topmost band red. Green lights are only for black buoys or black and red horizontally-banded buoys with the topmost band black. When a brighter light is required, a white light frequently is substituted for either the green or the red light. White lights are the only lights used on the black and white, vertically striped buoys that mark the middle of a channel or fairway. Characteristics of lights on lighted buoys are as follows:

- **A Fixed (Steady) Light.** This light indicates a black or red channel buoy.
- **A Flashing Light.** This light which flashes at regular intervals (not more than 30 flashes per minute) may also indicate a black or red buoy or a special-purpose buoy.
- **A Quick-Flashing Light.** This light with no fewer than 60 flashes per minute, is also found on a black or red buoy, but it is used at a turning point or junction where special caution is required or to mark wrecks that can be passed only on one side.
- **An Interrupted, Quick-Flashing Light.** This light which has repeated series of quick flashes, separated by about 4-second dark intervals, indicates a red and black, horizontally banded obstruction buoy that can be passed on either side.
- **A Short-Long Flashing Light.** This light which flashes Morse code "A" (a short and a long flash, recurring at the rate of about 8 per minute) is placed on a black and white, vertically striped midchannel buoy and may be passed on either side. This will always be a white light.

DAY BEACONS

6-106. Unlighted aids to navigation (except unlighted buoys) are called "day beacons." A day beacon may consist of a single pile with a daymark on top of it, a spar supporting a cask, a slate or masonry tower, or any of several structures.

6-107. Day beacons, like lighthouses and light structures, usually are colored to distinguish them from their surroundings and make them easy to identify. Day beacons marking channels are colored and numbered like channel buoys. Many are fitted with reflectors that show the same colors a lighted buoy would show at night in the same position.

RANGES

6-108. Two day beacons, located some distance apart on a specific true bearing, constitute a "day beacon range." Two lights, similarly located, are a "lighted range." When a ship reaches a position where the two lights or beacons are seen exactly in line, she is "on the range" (Figure 6-22). Ranges are especially valuable for guiding ships along the approaches to or through narrow channels. Much steering through the Panama Canal is done on ranges.

6-109. Lights on ranges may show any of the three standard colors, and they may be fixed, flashing, or occulting. Most range lights appear to lose brilliance rapidly as a ship diverges from the range line of bearing.

6-110. When steering on a range, it is important to be sure the limit beyond which the range line of bearing cannot be followed safely. This information is available on the chart.

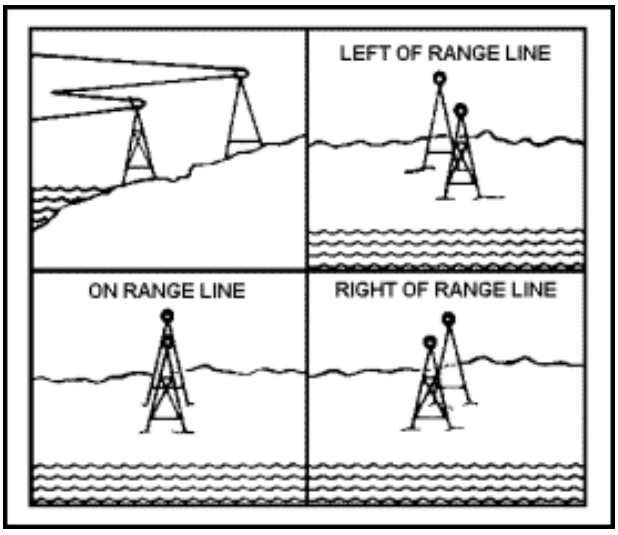


Figure 6-22. Range Lights

FOG SIGNALS

6-111. Most lighthouses have installed fog-signaling apparatus, ordinarily sounded by mechanical means. For identification purposes, each station has its own assigned number of blasts, recurring at specified intervals. A definite time is required for each station to sound its entire series of blasts, and this timing provides another means of identification.

6-112. The various types of apparatus produce a corresponding variance of pitch and tone. This gives your ear a chance to compare the sound of a station with its description in the Light List.

AIDS IN INTRACOASTAL WATERWAY

6-113. The Intracoastal Waterway is a channel through which light-draft vessels can navigate coastwise from the Chesapeake Bay almost to the Mexican border, remaining inside natural or artificial breakwaters for most of the trip. The following paragraphs describe special markings for the Intracoastal Waterway proper and for those portions of connecting or intersecting waterways that must be crossed or followed in navigating it.

6-114. Every buoy, day beacon, or light structure along the Intracoastal Waterway has part of its surface painted yellow, the distinctive coloring adopted for this waterway. Lighted buoys have a band or border of yellow somewhere.

6-115. As you proceed from the Chesapeake Bay toward Mexico, red buoys and day beacons are to the right and black buoys are to the left. As in other channels, red buoys have even numbers; black buoys, odd numbers. Because the numbers would increase excessively in such a long line of buoys, the buoys are numbered in groups of no more than 200. At certain natural dividing points, numbering begins again at 1.

6-116. Lights on buoys in the Intracoastal Waterway follow the standard system of red or white lights on red buoys and green or white lights on black buoys. Lights on lighted aids other than buoys also agree with the standard rules for lights on aids to navigation.

LATERAL BUOYAGE SYSTEM

6-117. In the lateral buoyage system used on all navigable waters of the US, the coloring, shape, and lighting of buoys indicate the direction of a danger relative to the course that should be followed. The color, shape, lights, and number of buoys in the lateral system as used by the US are determined relative to a direction from seaward. Some countries using the lateral system color their buoys and lights the direct opposite of the US color scheme. Before going into foreign waters, consult the Sailing Directions for an exact description of the aids to navigation in the particular locality.

6-118. In offshore channels, the lateral buoyage system prescribes the following markings and colorings for US waters:

- Proceeding in a southerly direction along the Atlantic coast.
- Proceeding in a northerly and westerly direction along the Gulf coast.
- Proceeding in a northerly direction along the Pacific coast is considered to be proceeding from seaward.

Accordingly, coastal buoys on the right, when proceeding in those directions, are red buoys with even numbers. On the Great Lakes, offshore buoys are colored and numbered from the outlet of each lake toward its upper end. The Intracoastal Waterway is marked from the North Atlantic states to the lower coast of Texas, regardless of the compass bearings of individual sections.

DEAD RECKONING

6-119. This is moving the vessel's position on a chart from a known position, using the course (or courses) steered and the speed (or speeds) through water (Figure 6-23). No allowance is made for wind, current, waves, and poor steering.

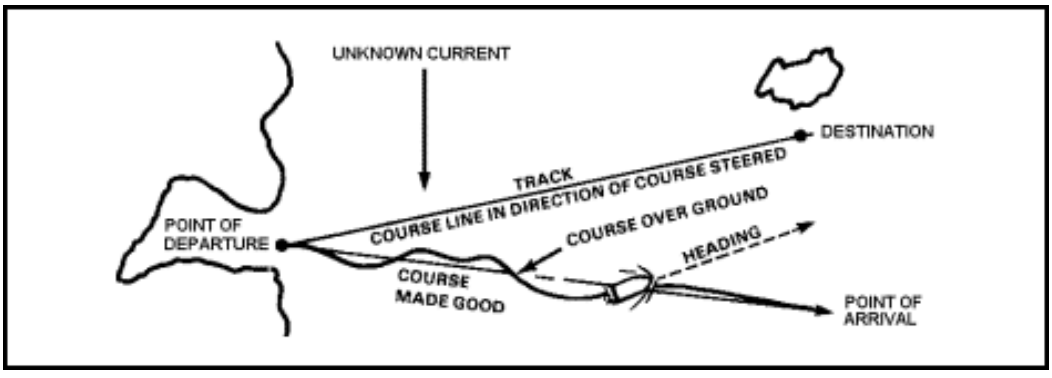


Figure 6-23. Course Line, Track, Course Over Ground, Course Made Good, and Heading

TERMS USED IN DEAD RECKONING

6-120. The following are some familiar terms used when using dead reckoning:

Heading

6-121. The horizontal direction in which the ship points or heads at any given second, expressed in angular units clockwise from 000° through 360° . The heading of the ship is also called ship's head. The heading is always changing as the ship swings or yaws across the course line due to the seas or steering error.

Course

6-122. As applied to marine navigation, the direction in which a vessel is to be steered or is being steered, and the direction of travel through the water. The course is measured from 000° clockwise from the reference direction to 360° . Course may be designated as true, magnetic, compass, or grid as determined by the reference direction.

DR Track Line

6-123. In marine navigation, the graphic representation of a ship's course normally used in the construction of a dead reckoning plot.

Speed

6-124. The ordered rate of travel of a ship through the water is normally expressed in knots. In some areas where distances are stated in statute miles, such as on the Great Lakes, speed units will be "miles per hour." Speed is used in conjunction with time to establish a distance run on each of the consecutive segments of a DR plot.

Fix

6-125. A position established at a specific time to a high degree of accuracy. It may be determined by any of a number of methods. A running fix is a position of lesser accuracy, based in part on present information and in part on information transferred from a prior time.

DR Position

6-126. A position determined by plotting a vector or series of consecutive vectors using only the true course and distance determined by speed through the water, without considering current.

Estimated Position

6-127. The more probable position of a ship, determined from incomplete data or data of questionable accuracy. In practical use, it is often the DR position modified by the best additional information available.

Dead Reckoning Plot

6-128. Commonly called DR plot. In marine navigation it is the graphical representation on the nautical chart of the line or series of lines, which are the vectors of the ordered true courses and distance run on these courses at the ordered speeds while proceeding from a fixed point. The DR plot originates at a fix or running fix; it is suitably labeled as to courses, speeds, and times of various dead reckoning positions, usually at hourly intervals or at times of change of course or speed. A DR plot properly represents courses and speeds that have been used. A similar plot may be made in advance for courses and speeds that are expected to be used.

Estimated Time of Departure

6-129. The estimate of the time of departure from a specified location according to a scheduled move to a new location.

PLOTTING A DR TRACK

6-130. The DR track (or DR track line) is the path or course the ship is expected to follow. It is plotted from a known position using courses and speeds through water. When plotting a DR track, no consideration is given for current and wind. Therefore, a path the ship actually follows may be quite different from the one plotted due to offsetting influences discussed later in this chapter.

6-131. There are three basic principles you must follow when plotting a DR track:

- A DR track is ALWAYS started from a known position.
- Only true courses are plotted.
- Only speed through water is used for determining distance traveled.

6-132. The purpose of the DR track is to show the navigator basically where he is planning to go, the rate of advance, and the ETA at various points along the way and at the final destination. After the DR track has been plotted, the navigator determines whether or not the basic track is clear of navigational hazards, as well as deciding what navigational aids are available and when they are visible. By examining the DR track, all elements of danger and surprise are eliminated for the voyage. If the navigator finds a DR track is going to lead into shoal waters or unnecessary danger, the DR track can be reevaluated in sufficient time to prevent any hazard to the ship.

6-133. When plotting the DR track, be sure that all DR tracks and distances are accurately measured. Neatness is essential to avoid confusion and error. Overlong lines and unnecessarily written information cause errors. Completeness of the DR track is necessary to show course, times, and positions. Standardization of labeling ensures neatness and clarity for any person using that plot.

LABELING DR TRACKS

6-134. The course is the intended horizontal direction of travel. This DR track starts from a known position and is plotted as follows:

6-135. Above and parallel to the course line, place a capital C and three digits to indicate the true course (C 007°). It is customary to label courses to the nearest whole degree. Under the course line and below the direction label, place a capital S and two digits for the speed. Since the course is given in degrees true and speed in knots, it is not necessary to indicate the units or reference direction.

6-136. DR positions are marked along the track line at specific time intervals depending upon where the ship is being navigated. In confined areas such as rivers and bays, DR plots can be plotted for every 15 minutes or half hour. Running along the coast in less restrictive waters, the DR plots can be put in every hour; and, when sailing great distances over open waters, they can be plotted every 4 hours. DR plots are put in wherever a course or speed change occurs. The standard symbols used are shown in Table 6-4. A new DR track is plotted from a well established fix. Even though an estimated position is shown, you do not begin a new DR track from this point.

6-137. Figure 6-24 shows the times of fixes, estimated positions, and the times of dead reckoning positions. Time of fixes and estimated positions are placed horizontally while the times of dead reckoning positions are placed other than horizontally.

FACTORS AFFECTING DR POSITIONS

6-138. A DR track is based on an assumption of making good an exact course and speed. There are many factors prevailing against the ship to prevent this. Some of these factors are poor steering and the inability to make good the plotted speed, current, and leeway.

6-139. Additional terms that must be understood in regards to dead reckoning include:

Current

6-140. This is the horizontal motion of water. The direction in which the water is moving is called the set and the velocity of the flow is called the drift.

Track

6-141. This is the intended horizontal direction of travel with respect to the earth, taking into consideration known or predicted offsetting effects such as current, wind, and seas.

Speed of Advance

6-142. This is the intended speed with respect to the earth, taking into consideration the effect of known or predicted current. SOA is also used to designate the average speed that must be made good to arrive at a destination at a specified time.

Set

6-143. This is the direction toward which the current is flowing. If the broader definition of "current" is used, the resultant direction is of all offsetting influences. Note carefully that the description of the set of a current is directly opposite from the naming of a wind--a westerly current sets toward the west, a westerly wind blows from the west.

Table 6-4. Standard Plotting Symbols

SYMBOL DESCRIPTIVE LABEL	MEANING

FIX	**AN ACCURATE POSITION DETERMINED WITHOUT REFERENCE TO ANY PREVIOUS POSITION. ESTABLISHED BY ELECTRONIC, VISUAL, OR CELESTIAL OBSERVATIONS.**
DR	**DEAD RECKONING POSITION. ADVANCED FROM A PREVIOUS KNOWN POSITION OR FIX. COURSE AND SPEED ARE RECKONED WITHOUT ALLOWANCE FOR WIND OR CURRENT.**
EP	**ESTIMATED POSITION. THE MOST PROBABLE POSITION OF A VESSEL, DETERMINED FROM DATA OF QUESTIONABLE ACCURACY, SUCH AS APPLYING ESTIMATED CURRENT AND WIND CORRECTIONS TO A DR POSITION.**

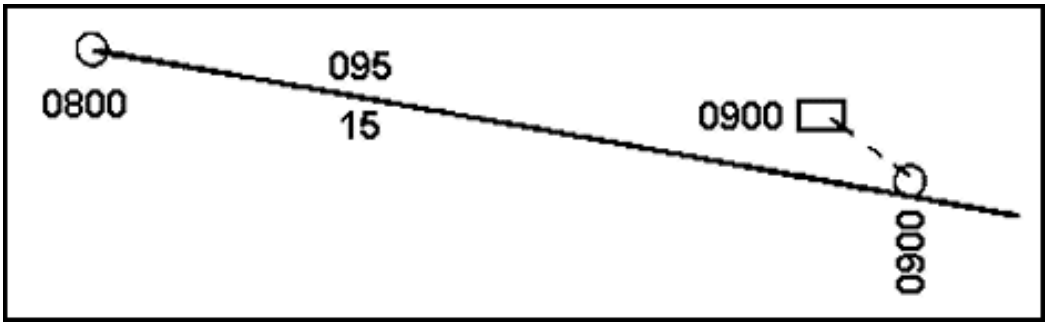


Figure 6-24. Labeling a DR Track

Drift

6-144. This is the speed of a current (or the speed of the resultant of all offsetting influences), usually stated in knots. However, some publications, notably pilot charts and atlases, express drift as nautical miles per day.

Course Made Good

6-145. CMG is the resultant direction from a given point of departure to a subsequent position. It is the direction of the net movement from one point to another, disregarding any intermediate course changes en route. This will differ from the track if the correct allowance for current was not made.

Speed Made Good

6-146. SMG is the net speed based on distance and time of passage directly from one point to another, disregarding any intermediate speed change. SMG is speed along the CMG.

Course Over The Ground

6-147. COG is the actual path of the vessel with respect to the earth. This may differ from CMG if there are intermediate course changes, steering inaccuracies, varying offsetting influences, and so forth. In current sailing triangles, CMG (not COG) is used.

Speed Over The Ground

6-148. SOG is the ship’s actual speed with respect to the earth along the COG. In current sailing, SMG (not SOG) is used.

6-149. In navigation, it is customary to use the word "current" to include all factors that introduce geographical error in dead reckoning. When a fix is obtained, one assumes that the current has set from the DR position at the same time as the fix and the drift equals the distance in miles between these two positions divided by the hours since the last fix. This is true, regardless of the number of changes of course and speed since the last fix.

6-150. If set and drift can be estimated, a better position is obtained by applying the correction to the DR position. This is referred to as an estimated position. If a current is setting in the same direction as the course of the ship or its reciprocal, the course made good is the same, only the speed changes. If course and set are in the same direction, the speeds are added. If in opposite directions, the smaller speed is subtracted from the larger. This is a common situation for ships encountering tidal currents when entering or leaving port.

6-151. For ships crossing a current, three current vector diagrams can be made giving the information needed to determine speed and courses to be steered. These diagrams can be made on scrap paper or an area on the plotting sheet away from the actual plot.

Example 1: Find course and speed made good through a current with ship's speed 10 knots, course 080° , current set 140° , and drift 2 knots (Figure 6-25).

Solution: From point A draw the line AB. This represents the course and speed (080° at 10 knots) in length.

From B draw in BC, the set and drift of the current, 140° at 2 knots. The direction and length of AC are the estimated course made good (089°) and speed made good (11.2 knots).

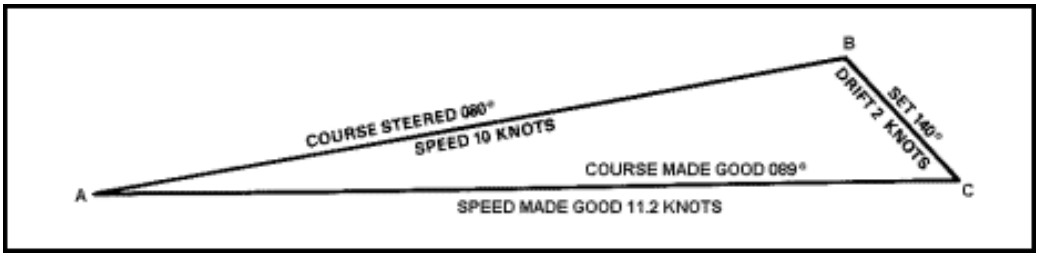


Figure 6-25. Find Course and Speed Made Good

Example 2: Determine the course to steer at a given speed to make good a desired course with this information: ship's speed 12 knots, the desired course 095° , the current's set 170° , and the drift 2.5 knots (Figure 6-26).

Solution: From point A draw course line AB extending in the direction of 095° (indefinite length).

From point A draw in the current line AC for the set 170° and drift 2.5 knots. Using C as a center, take the dividers, swing an arc of radius (ship's speed 12 knots) CD, intersecting the line AB at D. Measure the direction of line CD (083° .5). This is the course to steer. Measure the length of the line AD; 12.4 knots is the speed made good.

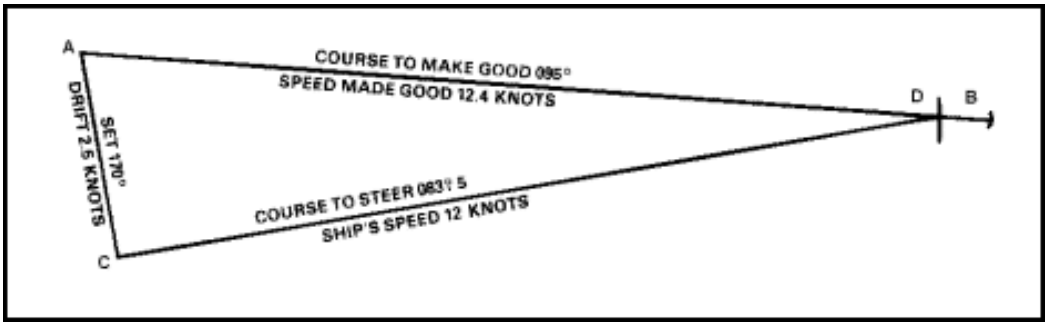


Figure 6-26. Find Course to Steer and Speed Made Good

Example 3: Determine what course and speed you must proceed in order to make a desired course and a desired speed good with this information: desired course 265° , desired speed to be made good 15 knots, current set of 185° , and a drift of 3 knots (Figure 6-27).

Solution: From A draw line AB in the direction to be made good (265°) and for a length equal to the speed to be made good (15 knots).

From A draw AC, the set and drift of the current, 185° and 3 knots.

Draw a line from C to B. The direction of this line is 276° ; this is the course to be steered. The length of the line equals the speed required (14.8 knots).

6-152. These current vectors can be made to any convenient scale and at any convenient place such as the center of the compass rose, unused area of the plotting sheet, a separate sheet of paper, or directly on the plot.

6-153. These current vectors can be made to any convenient scale and at any convenient place such as the center of the compass rose, unused area of the plotting sheet, a separate sheet of paper, or directly on the plot.

6-154. Leeway is the leeward motion of a vessel due to wind. It may be expressed as distance, speed, or angular difference between the course steered and the course made good through the water. The amount of leeway depends upon the speed and relative direction of the wind, type of vessel, exposed freeboard, trim, state of the sea, and depth of water. Leeway is most conveniently applied by adding its effect to that of the current and other elements introducing geographical error in the dead reckoning.

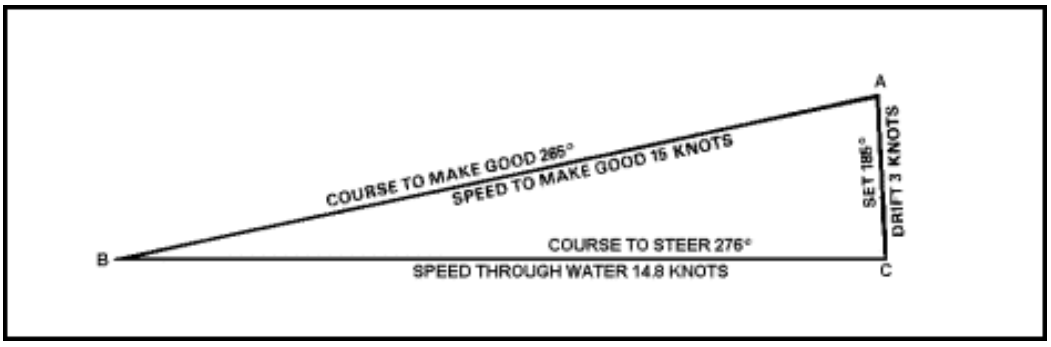


Figure 6-27. Course to Steer

TIME, SPEED, AND DISTANCE

6-155. All piloting and maneuvering solutions contain three factors: time, speed, and distance. When piloting you should be able to figure in your head any one of the three factors. The following are two simple methods that you can use.

The 3-Minute Rule

6-156. This is an excellent method for computing time, speed, and/or distance, when working in an area where short distances are involved or the times between measurements are close together. The 3-minute rule is: the distance, in yards, traveled by a ship in 3 minutes is equal to the speed of the ship multiplied by 100.

D = Distance traveled in yards in 3 minutes
S = Speed in knots

$$D = S \times 100$$

$$S = \frac{D}{100}$$

Example 1: A ship travels 1,500 yards in 3 minutes. What is the ship’s speed?

$$S = \frac{D}{100} = \frac{1,500}{100} = 15 \text{ knots}$$

Example 2: A ship's speed is 15 knots. How far will it travel in 3 minutes?

$$D = S \times 100 =$$
$$15 \times 100 = 1,500 \text{ yards}$$

When you have determined the distance traveled in 3 minutes, you can further determine the distance traveled in 1 minute by dividing the distance by 3.

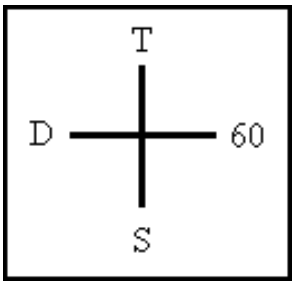
The 60-Minute Rule

6-157. This method for computing time, speed, or distance requires that you know two factors in order to determine the third:

$$D = \frac{T \times S}{60} \qquad T = \frac{D \times 60}{S}$$

$$S = \frac{D \times 60}{T}$$

As an aid, use this diagram:



1. Cover the unknown with your finger.
2. Multiply by the opposites on the diagram.
3. Divide by the remaining figure on the diagram for the answer.

Example 1: A ship travels 7 miles in 30 minutes. What is its speed?

Solution:

$$S = \frac{7 \times 60}{30} = \frac{420}{30} = 14 \text{ knots}$$

Example 2: A ship's speed is 15 knots. How far will it travel in 20 minutes?

Solution:

$$D = \frac{20 \times 15}{60} = \frac{300}{60} = 5 \text{ miles}$$

Example 3: A ship's speed is 8 knots. How long will it take for it to travel 6 miles?

Solution:

$$T = \frac{6 \times 60}{8} = \frac{360}{8} = 45 \text{ minutes}$$

PILOTING TECHNIQUES

6-158. Piloting is a method of determining position and directing the movements of a vessel by reference to landmarks, navigational aids, or soundings. Piloting is usually used as a primary means of navigation when entering or leaving port and in coastal navigation. In piloting, the navigator obtains warnings of danger, fixes the position frequently and accurately, and determines the proper course of immediate action.

LINES OF POSITION

6-159. An LOP is a line at some point of which a ship may be presumed to be on, as a result of observation or measurement (Figure 6-28). When piloting, LOPs are used to fix a ship's position. An LOP is determined with reference to a landmark, which must be correctly identified, and its position must be shown on the chart which is in use. There are three general types of LOPs: ranges, bearings including tangents, and distance arcs.

Note: An LOP should not be drawn through charted aids on the chart, because after a few erasures these symbols will become very difficult or impossible to see.

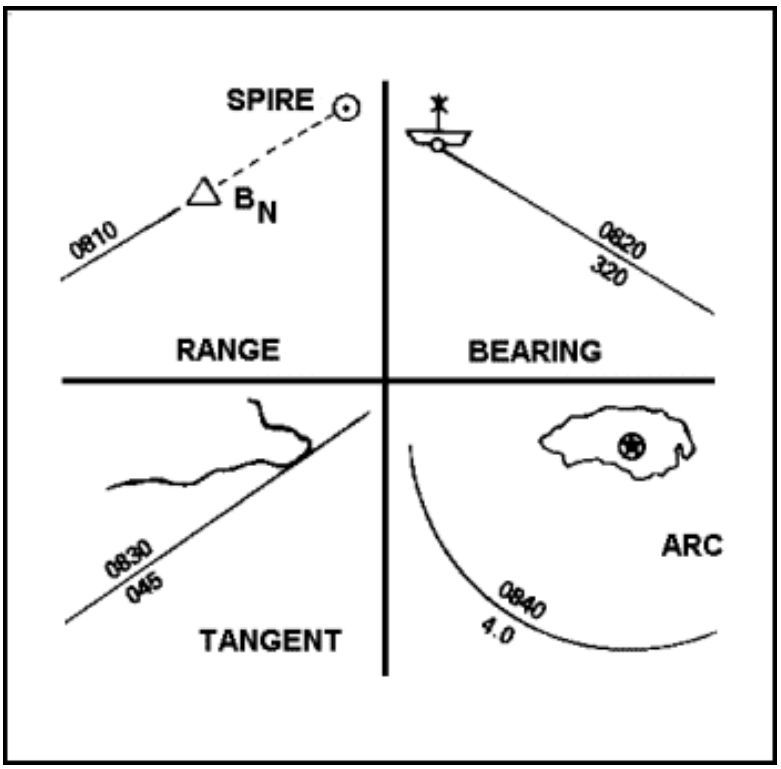


Figure 6-28. Lines of Position

6-160. A ship is on "range" when two landmarks are observed to be in line. This range is represented on a chart by means of a straight line which, if extended, would pass through the two related chart symbols. This line, labeled with the time expressed in four digits (above the line), is a fix of the ship's position. It should be noted that the word "range" in this context differs significantly from its use as a synonym of distance.

6-161. It is preferable to plot true bearings, although either true or magnetic bearings may be plotted. Therefore, when the relative bearing of a landmark is observed, it should be converted to true bearing or direction by the addition of the ship's true heading. Since a bearing indicates the direction of a terrestrial object from the observer, a LOP is plotted from the landmark in a reciprocal direction. For example, if a lighthouse bears 300° , the ship bears 120° from the lighthouse. A bearing LOP is labeled with the time expressed in four digits above the line and the bearing in three digits below the line (Figure 6-29).

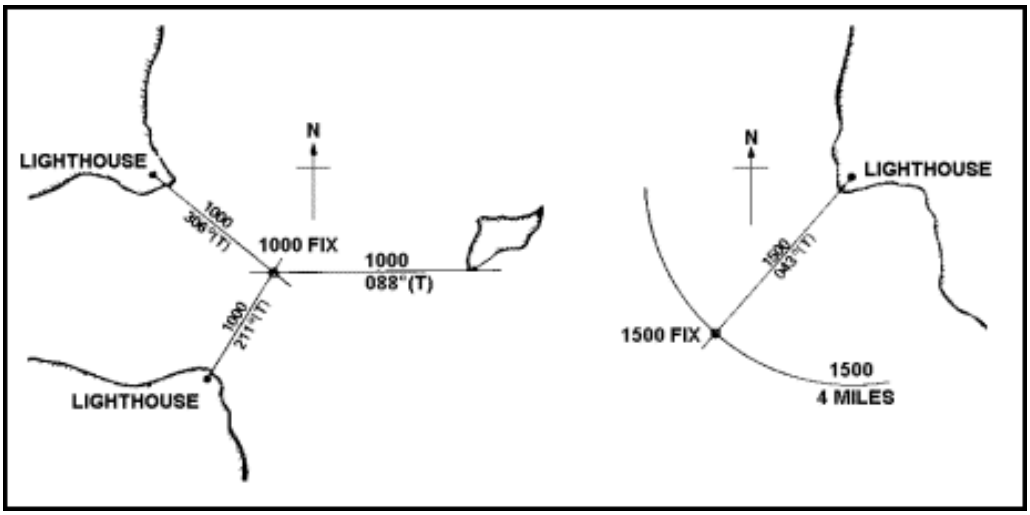


Figure 6-29. Plotting

6-162. A special type of bearing is the tangent. When a bearing is observed on the right-hand edge of a projection of land, the bearing is a right tangent. A bearing on the left-hand edge of a projection of land as viewed by the observer is a left tangent. A tangent provides an accurate LOP if the point of land is sufficiently abrupt to provide a definite point for measurement. It is inaccurate, for example, when the slope is so gradual that the point for measurement moves horizontally with the tide.

6-163. A distance arc is a circular LOP. When the distance from an observer to a landmark is known, the fix of the observer's position is a circle with the landmark as center having a radius equal to the distance. The entire circle need not be drawn, since in practice the navigator normally knows his position with sufficient accuracy as to require only the drawing of an arc of a circle. The arc is labeled with the time above expressed in four digits and the distance below in nautical miles (and tenths). The distance to a landmark may be measured using radar, the stadimeter, or the sextant in conjunction with TABLES 9 and 10 of the American Practical Navigator.

FIXES

6-164. A fix is defined as a point of intersection of two or more simultaneously obtained LOPs. The symbol for a fix is a small circle around the point of intersection. It is labeled with the time expressed in four digits. Fixes may be obtained using the following combinations of LOPs:

- A line of bearing or tangent and a distance arc.
- Two or more lines of bearing or tangents.
- Two or more distance arcs.
- Two or more ranges.
- A range and a line of bearing or tangent.
- A range and a distance arc.

Figure 6-30 shows how to take a fix using the azimuth circle.

6-165. Since two circles may intersect at two points, two distance arcs used to obtain a fix are not undesirable. The navigator in making his choice between two points of intersection may however, consider an approximate bearing, sounding, or his DR position. When a distance arc of one landmark and a bearing of another are used, the navigator may again be faced with the problem of choosing between two points of intersection at the same location.

SELECTING LANDMARKS

6-166. Three considerations in selecting landmarks or other aids for obtaining LOPs are:

- Angle of intersection.
- Number of objects.
- Permanency.

6-167. Two LOPs crossing at nearly right angles will result in a fix with a smaller amount of error than two LOPs separated by less than 30° . If there is a small compass error or a slight error is made in reading the bearings, the resulting discrepancy will be less in the case of the fix produced by widely separated LOPs than the fix from LOPs separated by only a few degrees.

6-168. If only two landmarks are used, any error in observation or identification may not be apparent. With three or more LOPs, each LOP acts as a check. If all intersect in a pinpoint or form a small triangle, you may generally rely on the fix. Where three LOPs are used, a spread of 60° would result in optimum accuracy.

6-169. When selecting landmarks or other aids, preference should be given to permanent structures such as lighthouses or other structural and natural features identifiable ashore or in shallow water. Buoys, while very convenient, are less permanent and may drift from their charted position because of weather and sea conditions or through maritime accident.

6-170. The navigator often has no choice of landmarks or their permanency, number, or spread. In such cases he must use whatever is available, no matter how undesirable. In the evaluation of his fix, the number of landmarks, their permanency, and their spread should receive consideration. When three LOPs cross forming a triangle, it is difficult to determine whether the triangle is the result of a compass error or an erroneous LOP. The plotting of four LOPs usually indicates if a LOP is in error.

THE RUNNING FIX

6-171. It is not always possible for the navigator to observe LOPs simultaneously. Sometimes only one landmark is available. The navigator may make frequent observations of the one landmark, or he may, after one observation, lose sight of the available landmark only to sight a new navigational aid. If the navigator is able to compute distances during these observations, he may easily establish his fix. If not, or if for any reason his data consists of LOPs obtained at different times, then he may establish a position that only partially takes into account the current. This position is the running fix, identified by the same symbol as the fix except that the time label is followed by the abbreviation "R. FIX." It is better than a DR position, but less desirable than a fix.

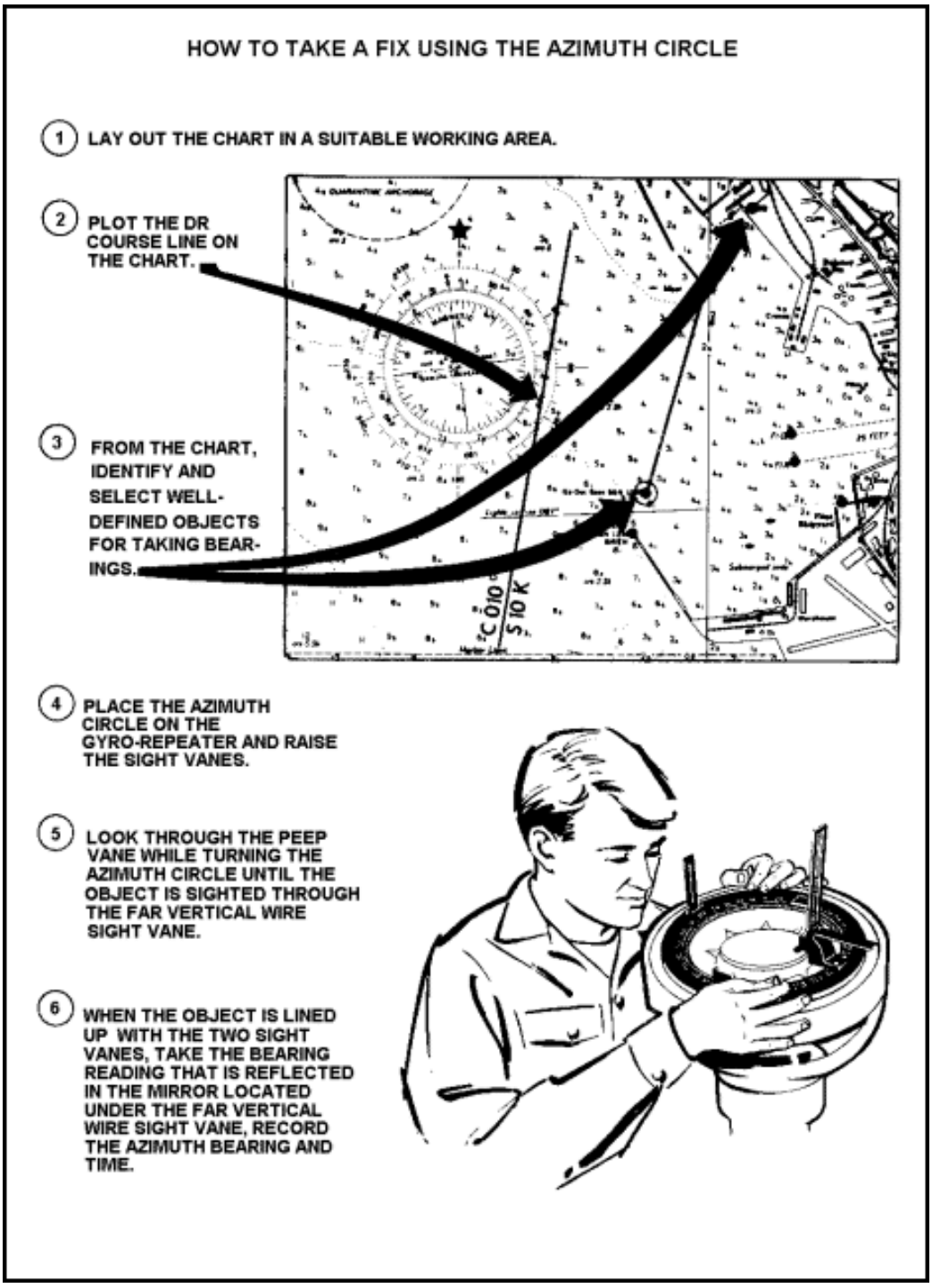


Figure 6-30. Taking a Fix Using the Azimuth Circle

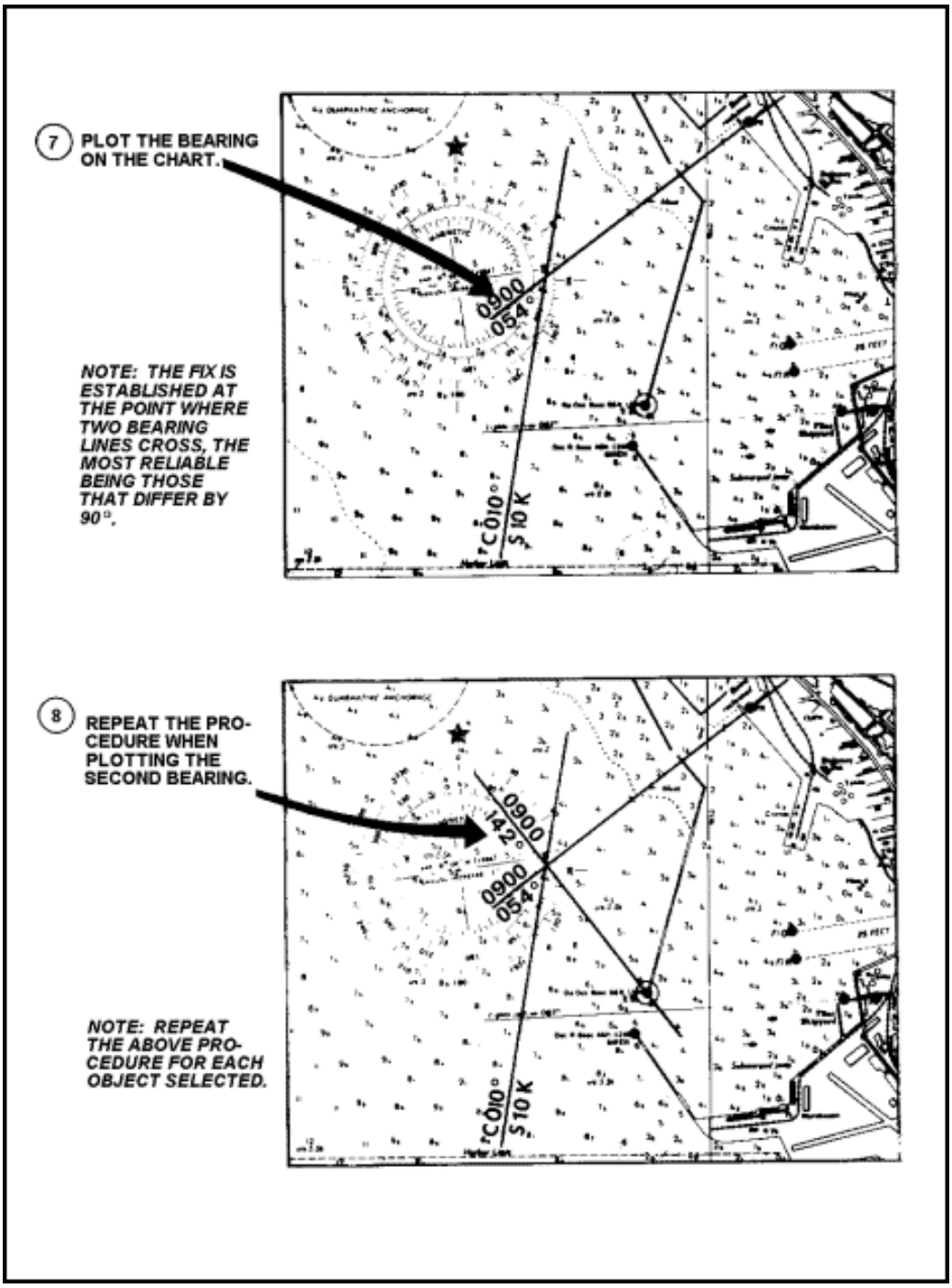


Figure 6-30. Taking a Fix Using the Azimuth Circle (continued)

6-172. A running fix is established by advancing the first LOP in the direction of travel of the ship (the course), a distance equal to the nautical miles the ship should have traveled during the interval between the time of the first LOP and the time of the second LOP. The point of intersection of the first LOP as advanced and the second LOP is the running fix. The advanced LOP is labeled with the times of the two LOPs separated by a dash and the direction, above and below the line respectively (Figure 6-31).

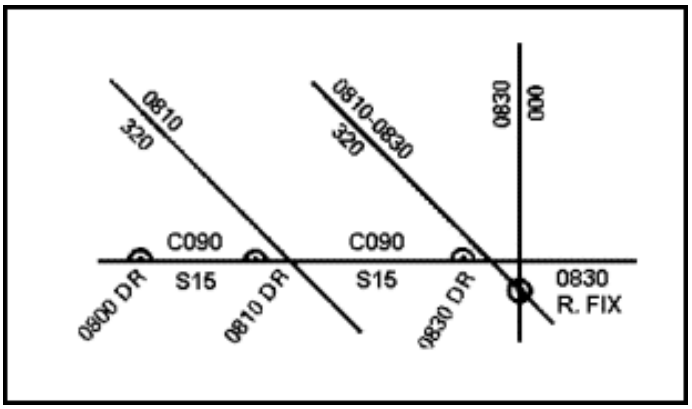


Figure 6-31. Bearing LOP Advanced

6-173. Use one of the following methods if the ship changes course and/or speed between observations:

Perpendicular Method

6-174. After two LOPs are obtained, plot DR positions corresponding to the lines of the LOPs. Drop a perpendicular from the earlier DR to the earlier LOP. At the second DR, make a line having the same direction and length as the first perpendicular. At the end of the latter line, make a line parallel to the original LOP (this is the advanced LOP). The intersection of this advanced LOP and the last observed LOP establishes the running fix. The following is the logic of the perpendicular method. The ship's speed and course generates the DR track line. If the advanced LOP lies with respect to the second DR position as it previously lay with respect to the old DR, then it has been advanced parallel to itself a distance and a direction consistent with the ship’s movement during the intervening time. A variation of this method is to construct, instead of a perpendicular, a line of any direction between the first DR and LOP. This line is then duplicated at the second DR and the LOP advance as before. In duplication, the line from the second DR must be the same length and direction as the line connecting the first DR and LOP (Figure 6-32).

Course Made Good Method

6-175. As in the perpendicular method, plot DR positions to match the time labels of the LOPs. Connect the DR positions. The connecting line represents the course and distance that the ship should have made good. Advance the first LOP a distance and direction corresponding to the line connecting the two DR positions (Figure 6-33).

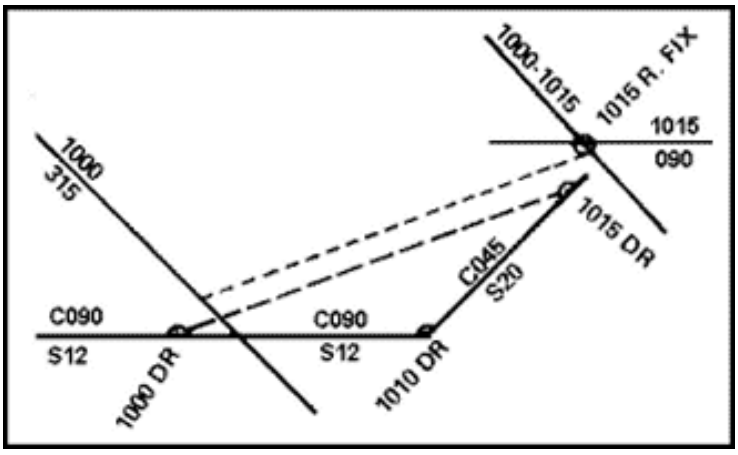


Figure 6-32. Perpendicular Method

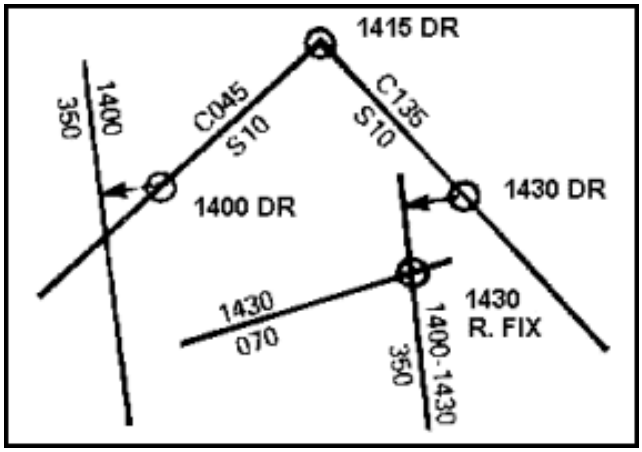


Figure 6-33. Course Made Good Method

RUNNING FIX CONSIDERATIONS

6-176. The running fix may be a well-determined position and is usually considered as such. For this reason the DR track is normally replotted using the running fix as a new point of origin.

6-177. However, a running fix does not fully account for current, and the displacement of the running fix from the DR is not a true indication of current. If a head current is expected, extra allowance should be made for clearance of dangers to be passed abeam, because the plot of running fixes based upon any single landmark near the beam will indicate the ship to be farther from that danger than it actually is. If a following current is experienced, then the opposite condition will exist. This occurs because the actual distance made good is less with a head current and greater with a following current than the distance the LOP is advanced based upon dead reckoning. A limitation of 30 minutes should be imposed on the elapsed time between LOPs in a running fix.

DANGER BEARINGS

6-178. It is possible to keep a ship in safe water without frequent fixes through the use of danger bearings. Figure 6-34 shows a shoal that presents a hazard to navigation, a prominent landmark at point A, and a ship proceeding along the coastline on course BC. To construct a danger bearing, line AX is drawn from point A tangent to the outer edge of the danger. If the bearing of point A remains greater than the danger bearing, the ship is in safe water, as with YA and ZA. The reverse is true when the danger is to port; the danger angle must remain greater than the angle to point A.

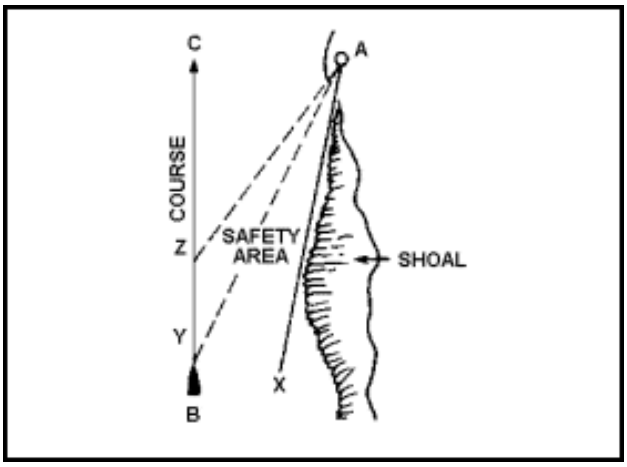


Figure 6-34. Danger Bearing

6-179. Wind or current could set the ship toward the shoal. However, even before a fix could be taken, this situation would be indicated by repeated bearings of point A.

DETERMINING POSITION BY SOUNDINGS

6-180. A position obtained by sounding is usually approximate. Accuracy of this type of position depends on the following:

- How completely and accurately depths are indicated on the chart.
- The irregularity of the depths.

It is impossible to obtain a position by soundings if the ship is located in an area where depth is uniform throughout. In practice, position by soundings ordinarily serves as a check on a fix taken by some other means.

6-181. Suppose you have only one spot on or near your DR track where water depth is 6 fathoms and the depth over the rest of the area for miles around is 20 fathoms. If you record 6 fathoms, you can be certain you are located at the one point where a 6-fathom depth was shown on the chart.

6-182. Piloting by soundings is not that simple. Figure 6-35 gives you an idea of the principle involved. What you really do is get a contour of the bottom you are passing over and try to match it up with a similar contour shown by the depth figures on the chart. One of the best methods is to proceed as follows:

6-183. Draw a straight line on a piece of transparent paper or plastic. Calculate how far apart your soundings will be, in other words, the length of the ship's run between soundings and mark off distances on the line to the scale of the chart. Alongside each mark representing a sounding, record the depth obtained at that sounding. The line represents the ship's course. The line of soundings recorded on the overlay should fit the depth marks on the chart somewhere near your DR track. If it makes an accurate fit, it probably is a close approximation of the course the ship is actually making good.

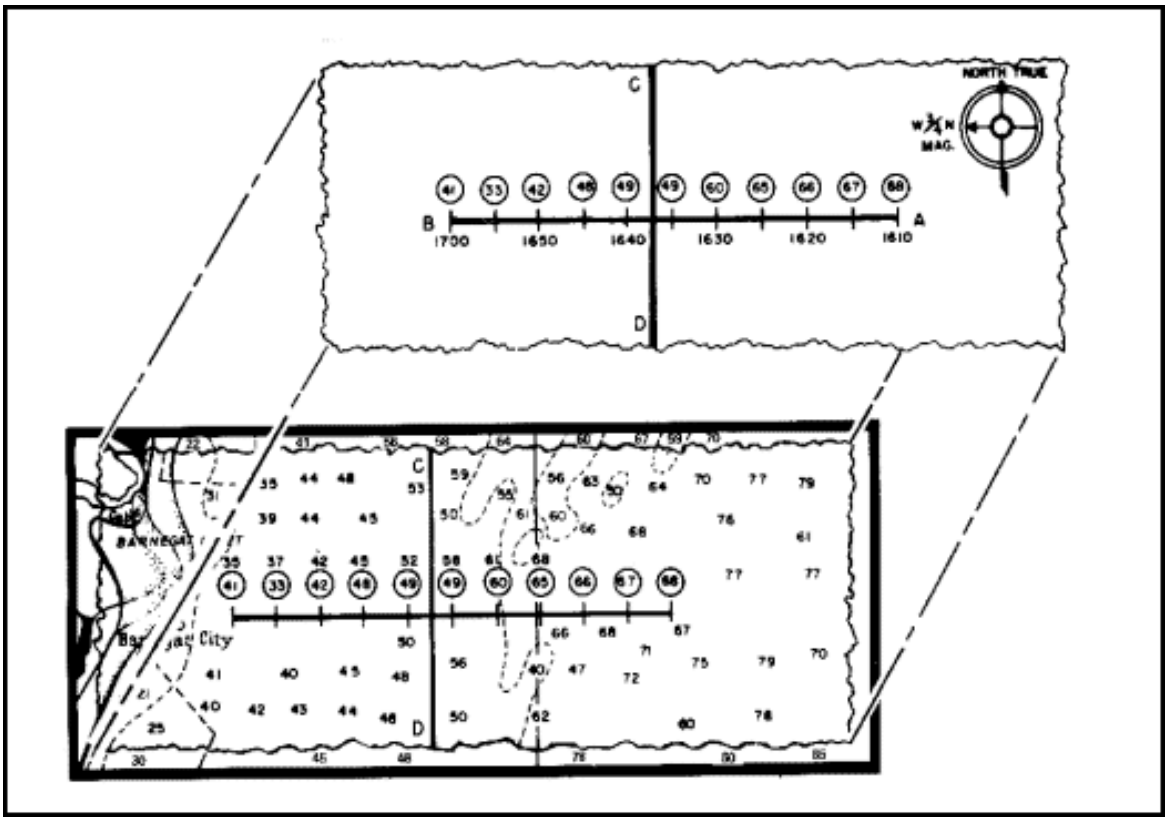


Figure 6-35. Line of Soundings

TWO BEARINGS OF A SINGLE OBJECT

6-184. A running fix can be obtained by using the mathematical relationships involved as shown in Figure 6-36. A ship is steaming past lighthouse D. At point A, a bearing of D is observed and expressed as degrees right or left of the course (a relative bearing if the ship is on course). At a later time at point B, a second bearing is taken of D and expressed the same as before. At point C, the lighthouse is broad on the beam. The angles at A, B, and C are known, as are the distances between these points. Trigonometry can be used to find the distance from D at any bearing. Distance and bearing provide fix.

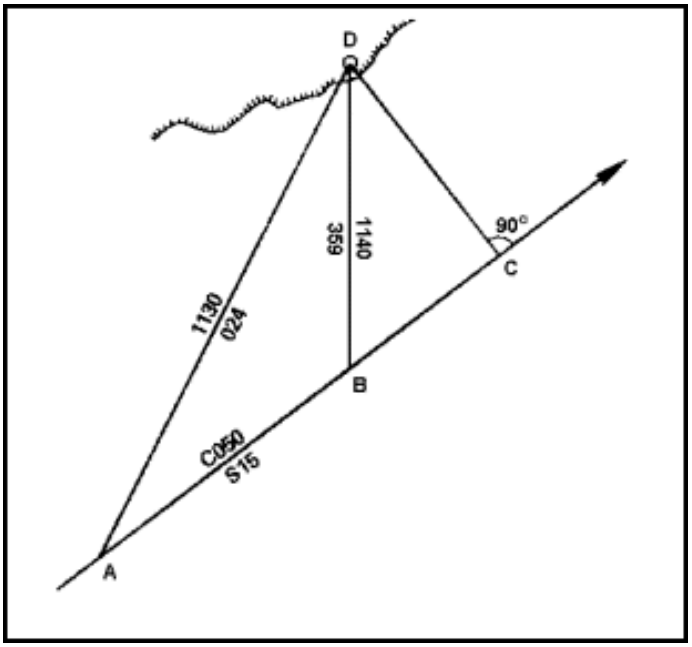


Figure 6-36. A Running Fix

6-185. A quick easy solution can be provided by using the extract of TABLE 7 from Pub. No. 9, American Practical Navigator (Vol. II) (Figure 6-37). To determine the distance of an object as a vessel steams past, observe two bearings of the object, note the time interval between the bearings, and determine the distance run. Determine the angular difference between the course and the first bearing and the angular difference between the course and the second bearing. Using the extract of TABLE 7, find the difference in degrees between the course and the first bearing going across the top of the table to that degree. Then go down that column until you come to the degrees of difference between the course and the second bearing. Multiply the distance run between bearings by the number in the first column to find the distance of the object at the time of the second bearing and then by the number in the second column to find the distance when you come abeam.

TABLE 7.

Distance of an Object by Two Bearings.

Difference between the course and second bearing.	Difference between the course and first bearing.													
	20°		22°		24°		26°		28°		30°		32°	
30°	1.97	0.98												
32	1.64	0.87	2.16	1.14										
34	1.41	0.79	1.80	1.01	2.34	1.31								
36	1.24	0.73	1.55	0.91	1.96	1.15	2.52	1.48						
38	1.11	0.68	1.36	0.84	1.68	1.04	2.11	1.30	2.70	1.66				
40	1.00	0.64	1.21	0.78	1.48	0.95	1.81	1.16	2.26	1.45	2.88	1.85		
42	0.91	0.61	1.10	0.73	1.32	0.88	1.59	1.96	1.94	1.30	2.40	1.61	3.05	2.04
44	0.84	0.58	1.00	0.69	1.19	0.83	1.42	0.98	1.70	1.18	2.07	1.44	2.55	1.77
46	0.78	0.56	0.92	0.66	1.09	0.78	1.28	0.92	1.52	1.09	1.81	1.30	2.19	1.58
48	0.73	0.54	0.85	0.64	1.00	0.74	1.17	0.87	1.37	1.02	1.62	1.20	1.92	1.43
50	0.68	0.52	0.80	0.61	0.93	0.71	1.08	0.83	1.25	0.96	1.46	1.12	1.71	1.31
52	0.65	0.51	0.75	0.59	0.87	0.68	1.00	0.79	1.15	0.91	1.33	1.05	1.55	1.22

Figure 6-37. Extract of Table 7 - Distance of an Object by Two Bearings

Note: The solution from TABLE 7, as with any of the "special cases," is accurate only if a steady course has been steered, the vessel has been unaffected by the current, and the speed used is the speed over the ground.

6-186. Applying the data from Figure 6-37, locate the difference between the course and the first bearing (angle B, A, and D in Figure 6-36) along the top of the table. Also locate the difference between the course and the second bearing (angle C, B, and D) at the left of the table. For each pair of angles listed, two numbers are given. To find the distance from the lighthouse at the time of the second bearing (B and D), multiply the distance run between A and B by the first number from the table. To find the distance off when you will be abeam (C and D), multiply the distance run between A and B by the second number in the table. If the distance between A and B is 1 mile, then the tabulated values are the distances sought. The tables are computed for even degrees. If a degree difference is an odd number, then you interpolate.

Example: Using the problem shown in Figure 6-36, the course is 050° , the speed is 15 knots, the first bearing of the lighthouse at 1130 was 024° , and the second bearing of the lighthouse at 1140 was 359° .

Required: The distance the ship was off at 1140 at the second bearing and the distance off when abeam.

Solution: The distance run between the first and second bearing:

$$D = \frac{ST}{60} = \frac{15 \times 10}{60} = \frac{150}{60} = 2.5 \text{ miles}$$

6-187. The difference between the course and the first bearing is 26° (050° – 024°). The difference between the course and the second bearing is 51° (050° + 360° – 359°). From TABLE 7 the two numbers (factors) are 1.04 and 0.81. This is found by interpolation between 50° and 52° for the second bearing.

6-188. Distance from lighthouse at second bearing:

1.04 X 2.5 = 2.6 miles.

6-189. Distance off lighthouse when abeam:

0.81 X 2.5 = 2.0 miles.

SPECIAL CASES

6-190. Certain combinations of angles provide a quick mental solution without the use of TABLE 7. These are referred to as special cases and include bow-and-beam bearings and doubling the angle on the bow.

Bow-and-Beam Bearings

6-191. When the bearing of an object diverges 45° from the ship's heading, it is said to be "broad on the bow." When the angle increases to 90° , it is said to be "on the beam." By noting the time of the first bearing and the time when the bearing is on the beam, you mentally compute the distance run. The distance run is equal to the distance off when abeam. The distance run equals the distance abeam because 45° and 90° angles provide a right triangle with equal sides. The advantage of the bow-and-beam bearing is the ease of solution (Figure 6-38).

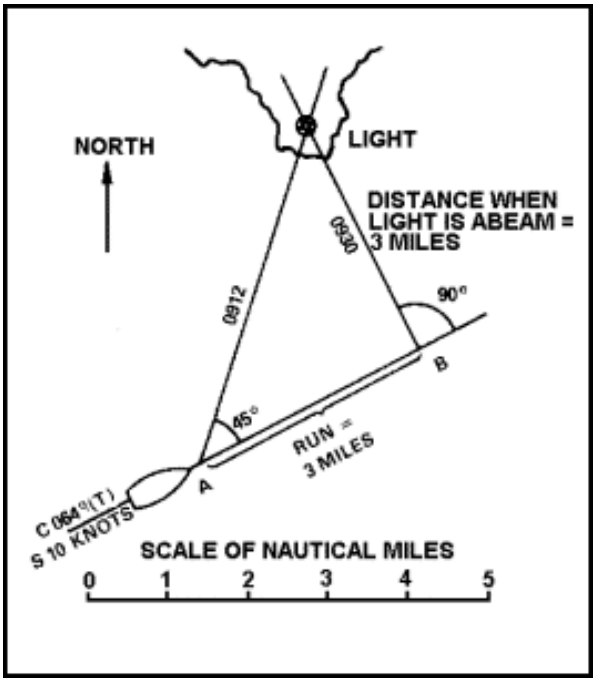


Figure 6-38. Bow and Beam Method

Doubling the Angle on the Bow

6-192. There are two special cases to remember: the 7/10 rule and the 7/8 rule.

- **The 7/10 rule.** If the first bearing is 22° .5 from the ship's heading and the second bearing is 45° on the bow, the distance the object will pass abeam is about 7/10 of the distance run between bearings.
- **The 7/8 rule.** If the angles are 30° and 60° , the distance of the object when abeam is about 7/8 of the distance run between bearings.

Two-Bearings-and-Run-Between

6-193. When there is only one object on which bearings can be taken, another method known as "two-bearings-and-run-between" is used. A bearing is taken of the object as the ship proceeds on its course. After the angle has changed by at least 30° , a second bearing is taken. This second bearing is taken before or after the object has passed abeam. The distance run is determined for the time that has elapsed between bearings (Figure 6-39).

6-194. Both bearings are plotted on the chart as shown in Figure 6-39. The dividers are opened to the distance run between the two bearings and are moved parallel to the course line until the points of the dividers fall on the bearing lines. The divider's points show the positions of the ship at the times of the first and second bearings. The accuracy of this procedure is dependent on the following factors:

- Estimation of ship's speed.
- Accuracy of steering between bearings.
- Current.
- Accuracy of the bearings themselves.

Accuracy of these factors at the time you are taking these bearings determines the reliability of the position. At best, it is still considered as an estimated position rather than a fix.

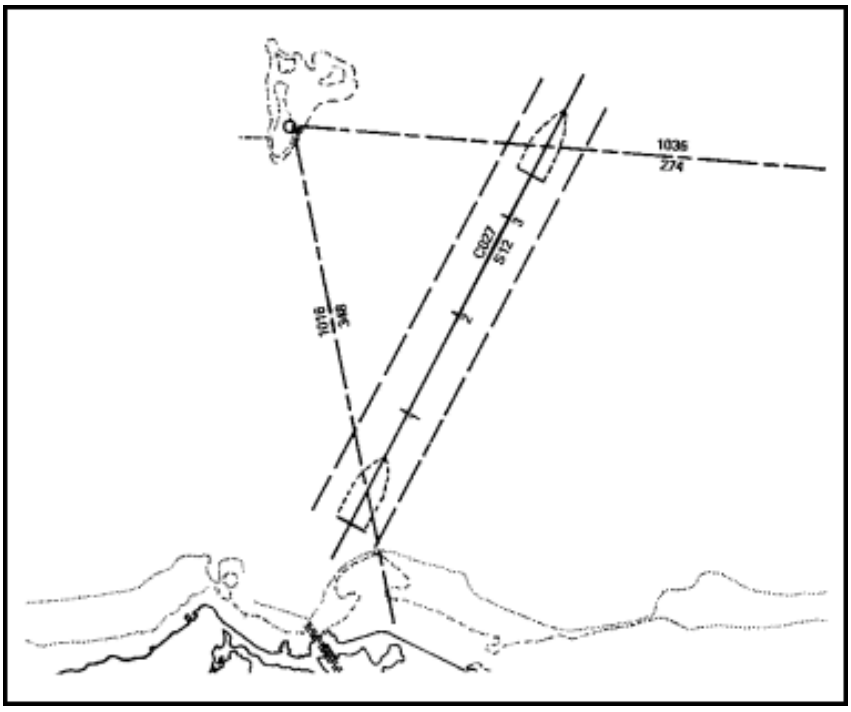


Figure 6-39. Two-Bearings-and-Run-Between

Chapter 7

Tides and Currents

The rise and fall of the tide is the primary cause of currents. Tides originate in the open oceans and seas, but they are noticeable and important only close to the shore. The effects of tides can be seen and felt along coastal beaches, in bays, and up rivers. The resulting current from the tide can have a major effect on the ship as far as steering and speed are concerned. Both the current and the tide are major factors to be considered when involved in any type of beach operation such as a LOTS operation. This chapter covers tides and currents and outlines the procedures for determining their state at any given time.

TIDES

7-1. The tide is the vertical rise and fall of the ocean level as a result of changes in the gravitational attraction between the earth, moon, and sun. It is a vertical motion only.

TIDAL EFFECTS

7-2. Current is the horizontal movement of the water from any cause. Tidal current is the flow of water from one point to another that results from a difference in tidal heights at these points. Besides the basic definitions given, there are certain tidal terms you must understand (see also Figure 7-1):

- **High Tide or High Water.** This is the highest level reached by the rising tide.
- **Low Tide or Low Water.** This is the lowest level reached by the tide going out.
- **Range of Tide.** This is the total difference in feet and inches between high water and low water.
- **Height of Tide.** At any specified time, this is the vertical measurement between the surface of the water and the reference plane (usually mean low water).
-
- Mean Sea Level. This is the average height of the surface of the sea for all stages of tide that is different only a little from half-tide level, which is the plane midway between mean high water and mean low water.

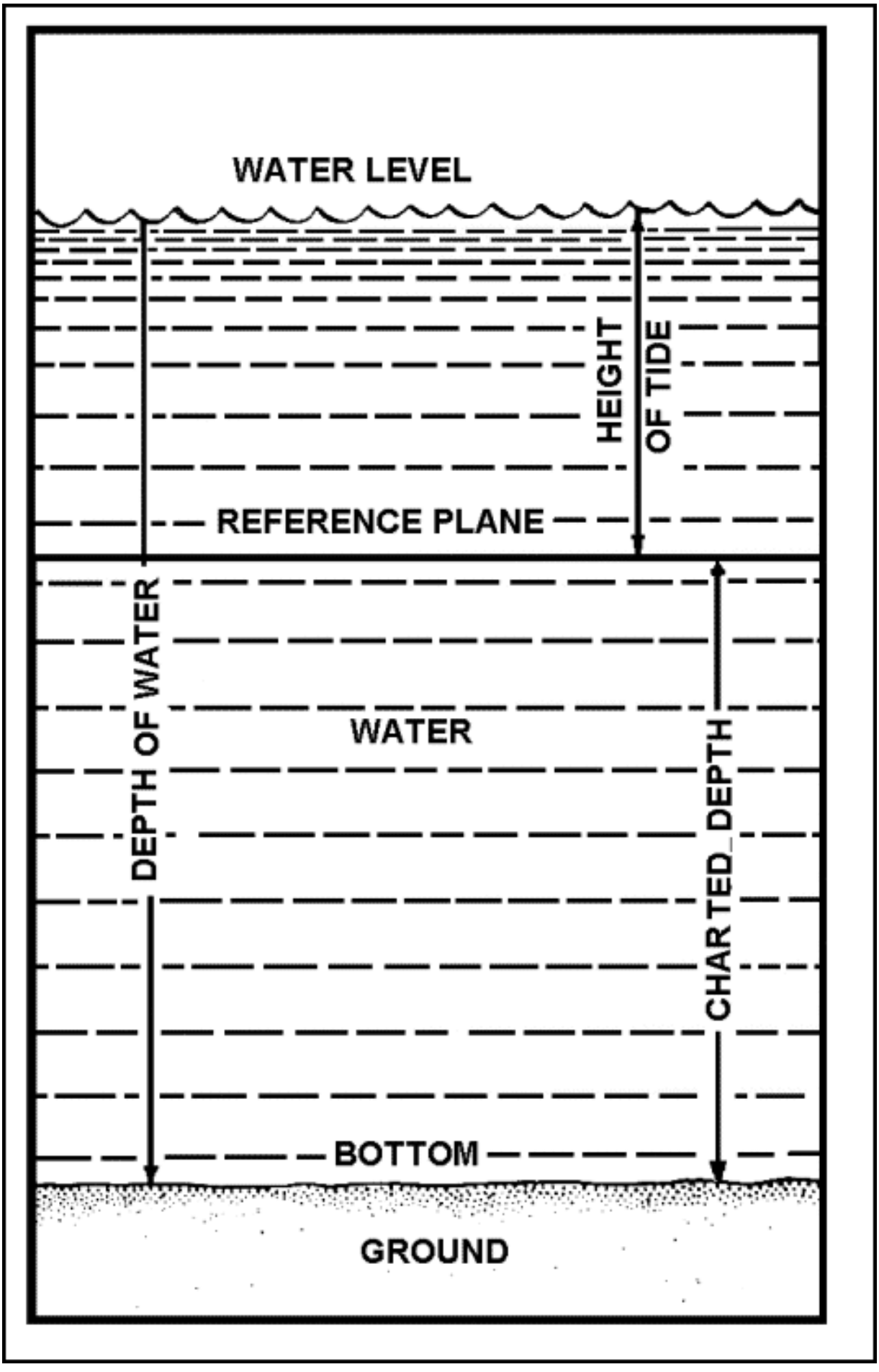


Figure 7-1. Terms Measuring Depths and Heights

TYPES OF TIDES

7-3. The following tides are named according to the characteristics of the tidal pattern occurring at that specific place (see also Figure 7-2):

- **Semidiurnal Tide.** For each tidal day there are two high waters almost equal in height and two low waters almost equal. This type of tide occurs most commonly along the east coast of the United States.
- **Diurnal Tide.** With this type of tide, only one high water and one low water occurs each tidal day. This type of tide is found in the Gulf of Mexico, the Java Sea, and the Gulf of Tonkin along the North Vietnam and China coasts.
- **Mixed Tide.** This type of tide is characterized by a large difference in the high water heights, low water heights, or in both. There are usually two high waters and two low waters each tidal day, but once in a while, the tide may become diurnal. This type of tide is most common on the west coast of the United States.

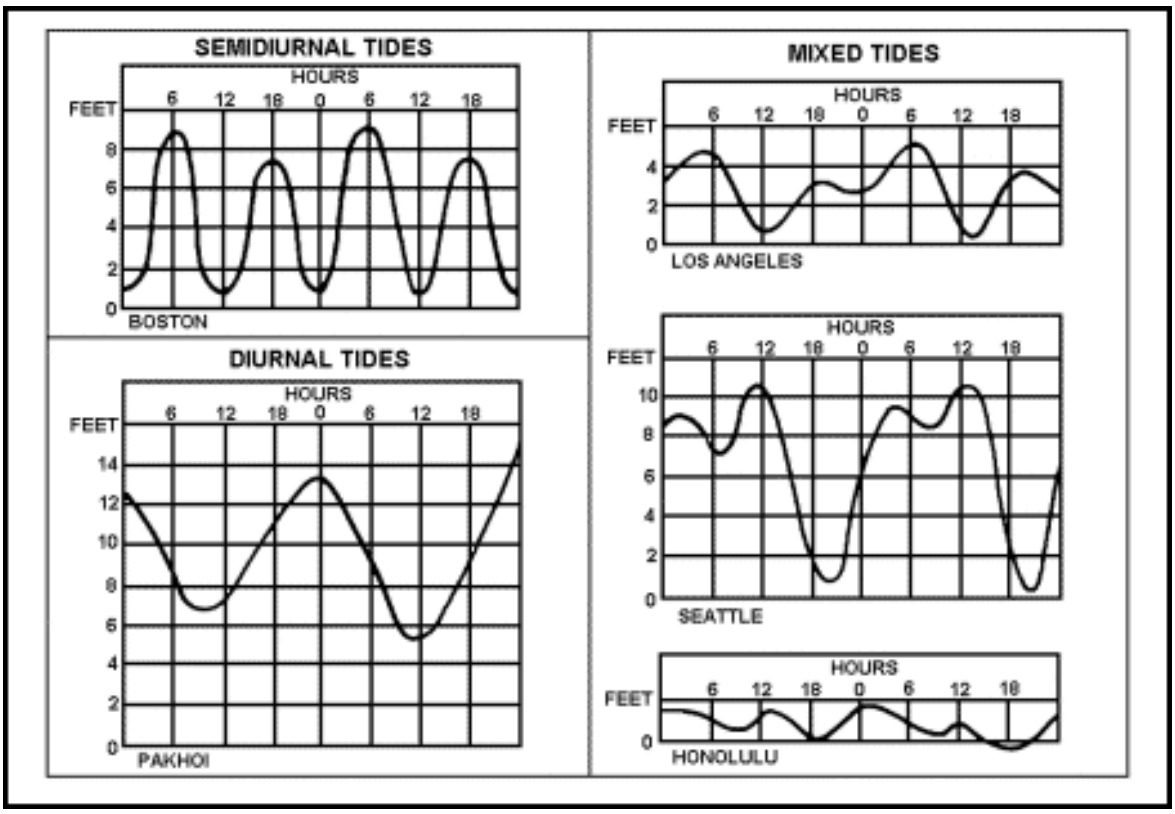


Figure 7-2. Tidal Patterns

TIDE TABLES

7-4. Predictions of tidal heights are published annually by the National Ocean Survey. Tide Tables are issued in four volumes:

- Europe and the West Coast of Africa (including the Mediterranean Sea).
- East Coast of North and South America (including Greenland).
- West Coast of North and South America (including the Hawaiian Islands).
- Central and Western Pacific Ocean and Indian Ocean.

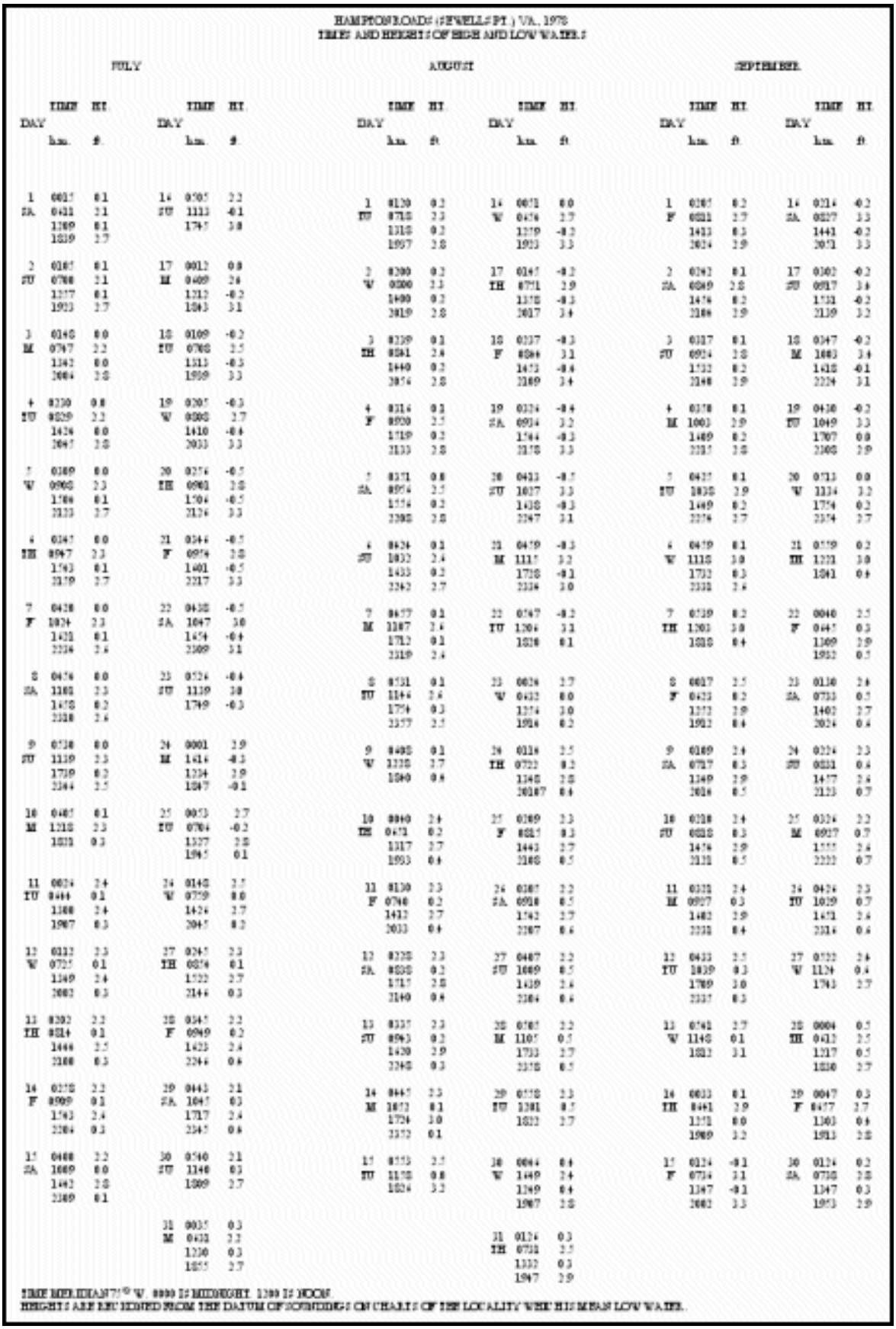
Together, the four volumes contain predictions for 196 reference ports and differences and other constants for about 6,000 stations. Each volume is arranged as follows:

- **TABLE 1.** Contains a complete list of the predicted times and heights of the tide for each day of the year at a number of places designated as reference stations.
- **TABLE 2.** Gives differences and ratios, which can be used to modify the tidal information for the reference stations to make it applicable to a relatively large number of subordinate stations (substations).
- **TABLE 3.** Provides information for use in finding the approximate height of the tide at any time between high water and low water.
- **TABLE 4.** Is a sunrise-sunset table at five-day intervals for various latitudes from 76° N to 60° S (40° S in one volume).
- **TABLE 5.** Provides an adjustment to convert the local mean time of TABLE 4 to zone or standard time.
- **TABLE 6 (two volumes only).** Gives the zone time of moonrise and moonset for each day of the year at certain selected places.

REFERENCE STATIONS

7-5. TABLE 1 (Figure 7-3), TABLE 2 (Figure 7-4), and TABLE 3 (Figure 7-5) are extracts from the Tide Tables, East Coast of North and South America, 1978.

7-6. TABLE 1 lists the time and height of the tide at each high water and low water in chronological order for each day of the year at a number of important points known as reference stations. There are 48 reference stations ranging from Argentina and Newfoundland to Punta Layola, Argentina.



HAMPTON ROADS (SEWELLS PT.) VA., 1978
TIMES AND HEIGHTS OF HIGH AND LOW WATERS

JULY

DAY	TIME hm.	HT ft.	DAY	TIME hm.	HT ft.
1 SA	0015 0431 1109 1819	0.1 2.1 0.1 2.7	14 SU	0705 1113 1747	2.2 -0.1 2.8
2 SU	0107 0708 1217 1913	0.1 2.1 0.1 2.7	17 M	0812 0409 1212 1843	0.8 2.6 -0.2 3.1
3 M	0148 0747 1242 2004	0.0 2.2 0.0 2.8	18 TU	0109 0705 1313 1959	-0.2 2.5 -0.3 3.3
4 TU	0230 0829 1424 2047	0.0 2.2 0.0 2.8	19 W	0207 0806 1410 2053	-0.3 2.7 -0.4 3.3
5 W	0309 0908 1504 2133	0.0 2.3 0.1 2.7	20 TH	0274 0901 1504 2124	-0.5 2.8 -0.5 3.3
6 TH	0347 0947 1543 2159	0.0 2.3 0.1 2.7	21 F	0344 0974 1601 2217	-0.5 2.8 -0.5 3.3
7 F	0428 1024 1621 2226	0.0 2.3 0.1 2.6	22 SA	0438 1047 1654 2309	-0.5 3.0 -0.4 3.1
8 SA	0476 1101 1658 2318	0.0 2.3 0.2 2.6	23 SU	0526 1139 1749	-0.4 3.0 -0.3
9 SU	0528 1139 1739 2344	0.0 2.3 0.2 2.5	24 M	0001 1616 1234 1847	2.9 -0.3 2.9 -0.1
10 M	0401 1210 1810	0.1 2.3 0.3	25 TU	0053 0704 1327 1945	2.7 -0.2 2.8 0.1
11 TU	0024 0444 1308 1907	2.4 0.1 2.4 0.3	26 W	0140 0759 1426 2045	2.5 0.0 2.7 0.2
12 W	0113 0725 1349 2002	2.3 0.1 2.4 0.3	27 TH	0247 0874 1522 2144	2.3 0.1 2.7 0.3
13 TH	0302 0914 1446 2108	2.2 0.1 2.5 0.3	28 F	0345 0949 1623 2244	2.2 0.2 2.4 0.4
14 F	0370 0959 1543 2204	2.2 0.1 2.4 0.3	29 SA	0443 1047 1717 2345	2.1 0.3 2.4 0.4
15 SA	0448 1039 1642 2249	2.2 0.0 2.5 0.1	30 SU	0540 1140 1809	2.1 0.3 2.7
			31 M	0035 0633 1230 1855	0.3 2.2 0.3 2.7

AUGUST

DAY	TIME hm.	HT ft.	DAY	TIME hm.	HT ft.
1 TU	0139 0715 1316 1937	0.2 2.3 0.2 2.8	14 W	0071 0476 1279 1903	0.0 2.7 -0.2 3.3
2 W	0200 0200 1400 2019	0.2 2.3 0.2 2.8	17 TH	0147 0771 1375 2017	-0.2 2.9 -0.3 3.4
3 TH	0229 0841 1440 2054	0.1 2.4 0.2 2.8	18 F	0227 0904 1473 2109	-0.3 3.1 -0.4 3.4
4 F	0314 0930 1519 2133	0.1 2.5 0.2 2.8	19 SA	0324 0914 1744 2176	-0.4 3.2 -0.3 3.3
5 SA	0371 0974 1554 2208	0.0 2.5 0.2 2.8	20 SU	0413 1017 1438 2247	-0.5 3.3 -0.3 3.1
6 SU	0426 1032 1633 2242	0.1 2.4 0.2 2.7	21 M	0479 1115 1716 2334	-0.3 3.2 -0.1 3.0
7 M	0457 1107 1712 2319	0.1 2.4 0.1 2.4	22 TU	0747 1206 1816	-0.2 3.2 0.1
8 TU	0531 1144 1754 2357	0.1 2.4 0.3 2.5	23 W	0826 0432 1274 1914	2.7 0.0 3.0 0.2
9 W	0405 1220 1840	0.1 2.7 0.4	24 TH	0116 0722 1340 20187	2.5 0.2 2.8 0.4
10 TH	0040 0472 1317 1953	2.4 0.2 2.7 0.4	25 F	0209 0821 1443 2108	2.3 0.3 2.7 0.5
11 F	0130 0740 1432 2033	2.3 0.2 2.7 0.4	26 SA	0307 0918 1742 2207	2.2 0.5 2.7 0.6
12 SA	0220 0830 1717 2140	2.3 0.2 2.8 0.4	27 SU	0407 1009 1439 2204	2.2 0.5 2.6 0.6
13 SU	0317 0943 1430 2240	2.3 0.2 2.9 0.3	28 M	0701 1107 1703 2315	2.2 0.5 2.7 0.5
14 M	0447 1052 1724 2332	2.3 0.1 3.0 0.1	29 TU	0110 1201 1822	2.3 0.5 2.7
15 TU	0553 1170 1824	2.5 0.0 3.2	30 W	0004 1449 1249 1907	0.4 2.4 0.4 2.8
			31 TH	0124 0721 1332 1947	0.3 2.5 0.3 2.9

SEPTEMBER

DAY	TIME hm.	HT ft.	DAY	TIME hm.	HT ft.
1 F	0205 0821 1423 2024	0.2 2.7 0.3 2.9	14 SA	0214 0827 1441 2051	-0.2 3.3 -0.2 3.3
2 SA	0242 0849 1476 2108	0.1 2.8 0.2 2.9	17 SU	0302 0917 1731 2139	-0.2 3.4 -0.2 3.2
3 SU	0317 0914 1532 2148	0.1 2.8 0.2 2.9	18 M	0347 1003 1418 2224	-0.2 3.4 -0.1 3.1
4 M	0378 1003 1489 2217	0.1 2.9 0.2 2.8	19 TU	0430 1049 1707 2308	-0.2 3.3 0.0 2.9
5 TU	0427 1038 1449 2276	0.1 2.9 0.2 2.7	20 W	0713 1114 1754 2374	0.0 3.2 0.2 2.7
6 W	0479 1115 1732 2333	0.1 3.0 0.3 2.6	21 TH	0759 1221 1841	0.2 3.0 0.4
7 TH	0529 1203 1810	0.2 3.0 0.4	22 F	0040 0847 1309 1952	2.5 0.3 2.9 0.5
8 F	0017 0623 1272 1912	2.5 0.2 2.9 0.4	23 SA	0130 0751 1402 2024	2.4 0.5 2.7 0.4
9 SA	0109 0727 1349 2016	2.4 0.3 2.9 0.5	24 SU	0224 0851 1477 2133	2.3 0.4 2.6 0.3
10 SU	0208 0828 1476 2121	2.4 0.3 2.9 0.5	25 M	0324 0917 1555 2222	2.2 0.7 2.4 0.7
11 M	0321 0927 1482 2231	2.4 0.3 2.9 0.4	26 TU	0424 1029 1651 2314	2.3 0.7 2.4 0.6
12 TU	0423 1039 1789 2337	2.5 0.3 3.0 0.3	27 W	0522 1124 1743	2.4 0.4 2.7
13 W	0741 1140 1822	2.7 0.1 3.1	28 TH	0004 0612 1217 1838	0.5 2.5 0.5 2.7
14 TH	0033 0641 1271 1909	0.1 2.9 0.0 3.2	29 F	0047 0647 1303 1913	0.3 2.7 0.4 2.8
15 F	0124 0734 1347 2002	-0.1 3.1 -0.1 3.3	30 SA	0124 0730 1347 1953	0.2 2.8 0.3 2.9

TIME USED (EASTERN) W. 0000 IS MIDNIGHT. 1200 IS NOON
HEIGHTS ARE REFERRED FROM THE DATUM OF SOUNDINGS ON CHARTS OF THE LOCALITY WHICH IS MEAN LOW WATER.

Figure 7-3. Extract of Table 1 - Times and Heights of High and Low Waters

TABLE 2.—TIDAL DIFFERENCES AND OTHER CONSTANTS

No.	PLACE	POSITION		DIFFERENCES				RANGES		Mean Tide Level
		Lat.	Long.	Time		Height		Mean	Spring	
				High water	Low water	High water	Low water			
		° ′	° ′	h. m.	h. m.	feet	feet	feet	feet	feet
	VIRGINIA—Continued									
	York River—Continued									
	Time meridian, 75° W	N.	W.	on HAMPTON ROADS, p. 88						
2324	Cheatham Annex	37 18	76 35	+0 39	+0 30	0.0	0.0	2.5	3.0	1.2
2325	Queen Creek (2 miles upstream)	37 18	76 39	+0 56	+0 54	-0.1	0.0	2.4	2.9	1.2
2327	Clay Bank	37 21	76 37	+0 46	+0 44	+0.3	0.0	2.8	3.4	1.4
2329	Almondsville	37 23	76 39	+0 55	+0 57	+0.3	0.0	2.8	3.3	1.4
2330	Roane Point	37 27	76 42	+1 38	+1 40	+0.3	0.0	2.8	3.4	1.4
2331	West Point	37 32	76 48	+2 03	+2 28	+0.3	0.0	2.8	3.4	1.4
	Mattaponi River									
2333	Walkerna	37 39	76 54	+3 25	+3 47	+0.9	0.0	3.4	3.9	1.7
2335	Walkertown	37 43	77 02	+4 22	+4 49	+1.4	0.0	3.9	4.5	1.9
	Pamunkey River									
2337	Sweet Hall Landing	37 34	76 54	+3 44	+4 01	-0.2	0.0	2.7	3.1	1.3
2339	Lester Manor	37 35	76 59	+4 36	+4 50	+0.3	0.0	2.8	3.2	1.4
2341	White House	37 35	77 01	+5 05	+5 19	+0.5	0.0	3.0	3.4	1.5
2343	Northbury	37 37	77 07	+5 54	+6 08	+0.8	0.0	3.3	3.8	1.6
	Chesapeake Bay, Western Shore - Con.									
2345	York Point, Poquoson River	37 10	76 24	-0 11	-0 04	-0.1	0.0	2.4	2.9	1.2
2347	Messick Point, Back River	37 06	76 19	-0 30	-0 10	-0.2	0.0	2.3	2.8	1.2
	Hampton Roads									
2349	Old Point Comfort	37 00	76 18	-0 11	-0 35	0.0	0.0	2.5	3.0	1.2
2351	Hampton River	37 01	76 20	-0 02	-0 12	+0.1	0.0	2.6	3.1	1.3
2353	HAMPTON ROADS (Sewells Pt.)	36 57	76 20	Daily predictions				2.5	3.0	1.2
2355	Lafayette River	36 54	76 18	+0 07	+0 15	+0.1	0.0	2.6	3.1	1.3
2357	Lafayette River, Granby St. Br	36 53	76 17	+0 22	+0 27	+0.2	0.0	2.7	3.2	1.3
	Elizabeth River									
2359	Craney Island	36 54	76 20	+0 09	-0 06	+0.1	0.0	2.6	3.1	1.3
2361	Port Norfolk, Western Branch	36 51	76 20	+0 13	+0 19	+0.1	0.0	2.6	3.1	1.3
2363	Norfolk	36 51	76 18	+0 14	+0 10	+0.3	0.0	2.8	3.4	1.4
2365	Portsmouth, Southern Branch	36 49	76 18	+0 16	+0 15	+0.3	0.0	2.8	3.4	1.4
	Nansemond River									
2367	Pig Point	36 55	76 26	+0 33	+0 30	+0.3	0.0	2.8	3.4	1.4
2369	Town Point	36 53	76 30	+0 29	+0 34	+0.5	0.0	3.0	3.6	1.5
2371	Hollidays Point (bridge)	36 50	76 33	+0 54	+1 12	+0.7	0.0	3.2	3.8	1.6
2373	Suffolk	36 44	76 35	+1 33	+1 25	+1.3	0.0	3.8	4.6	1.9
	James River									
2375	Chuckatuck Creek entrance	36 55	76 30	+0 41	+0 47	+0.3	0.0	2.8	3.4	1.4
2377	Newport News	36 58	76 26	+0 20	+0 18	+0.1	0.0	2.6	3.1	1.3
2379	Menchville	37 05	76 32	+0 54	+1 09	+0.1	0.0	2.6	3.1	1.3
2381	Smithfield, Pagan River	36 59	76 38	+1 25	+1 18	+0.3	0.0	2.8	3.4	1.4
2383	Burwell Bay	37 03	76 40	+1 14	+1 42	-0.1	0.0	2.4	2.9	1.2
2385	Mulberry Point	37 08	76 38	+1 56	+2 16	-0.1	0.0	2.4	2.9	1.2
2387	Hog Point	37 12	76 41	+2 11	+2 28	-0.4	0.0	2.1	2.5	1.0
2389	Jamestown Island	37 12	76 47	+2 5	+3 26	-0.5	0.0	2.0	2.4	1.0
2391	Dillard Wharf	37 12	76 52	+3 29	+4 05	-0.6	0.0	1.9	2.3	0.9
	Chickahominy River									
2393	Bridge at entrance	37 16	76 53	+3 54	+4 26	-0.6	0.0	1.9	2.3	0.9
2395	Wright Island Landing	37 21	76 52	+4 35	+4 53	-0.3	0.0	2.2	2.6	1.1
2397	Mount Airy	37 21	76 55	+5 01	+5 28	-0.3	0.0	2.2	2.6	1.1
2399	Lanexa	37 24	76 54	+5 31	+5 58	+0.1	0.0	2.6	3.1	1.3
2401	Claremont Wharf	37 14	76 57	+4 02	+4 38	-0.6	0.0	1.9	2.3	0.9
2403	Sturgeon Point	37 18	77 00	+4 28	+4 59	-0.4	0.0	2.1	2.5	1.0
2405	Windmill Point	37 18	77 06	+5 22	+5 46	-0.2	0.0	2.3	2.7	1.1
2407	Westover	37 19	77 09	+5 43	+6 07	-0.1	0.0	2.4	2.8	1.2
2409	Jordan Point	37 19	77 13	+6 07	+6 29	0.0	0.0	2.5	2.9	1.2
				on WASHINGTON, p. 84						
2411	City Point (Hopewell)	37 19	77 16	-4 55	-5 12	-0.3	0.0	2.6	3.0	1.3
2413	Petersburg, Appomattox River	37 14	77 24	-4 25	-4 00	0.0	0.0	2.9	3.3	1.4
2415	Bermuda Hundred	37 20	77 16	-4 50	-5 05	-0.3	0.0	2.6	3.0	1.3
2417	Haxall	37 22	77 15	-4 43	-4 52	-0.2	0.0	2.7	3.1	1.4
2419	Curles, 1 mile north of	37 24	77 18	-4 25	-4 26	-0.1	0.0	2.8	3.2	1.4

Figure 7-4. Extract of Table 2 - Tidal Differences and Other Constants

TABLE 3. – HEIGHT OF TIDE AT ANY TI ME

Duration of rise or fall, see footnote	Time from the nearest high water or lowwater															
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
4 00	0 08	0 16	0 24	0 32	0 40	0 48	0 56	1 04	1 12	1 20	1 28	1 36	1 44	1 52	2 00	
4 20	0 09	0 17	0 26	0 35	0 43	0 52	1 01	1 09	1 18	1 27	1 35	1 44	1 53	2 01	2 10	
4 40	0 09	0 19	0 28	0 37	0 47	0 56	1 05	1 15	1 24	1 33	1 43	1 52	2 01	2 11	2 20	
5 00	0 10	0 20	0 30	0 40	0 50	1 00	1 10	1 20	1 30	1 40	1 50	2 00	2 10	2 20	2 30	
5 20	0 11	0 21	0 32	0 43	0 53	1 04	1 15	1 25	1 36	1 47	1 57	2 08	2 19	2 29	2 40	
5 40	0 11	0 23	0 34	0 45	0 57	1 08	1 19	1 31	1 42	1 53	2 05	2 16	2 27	2 39	2 50	
6 00	0 12	0 24	0 36	0 48	1 00	1 12	1 24	1 36	1 48	2 00	2 12	2 24	2 36	2 48	3 00	
6 20	0 13	0 25	0 38	0 51	1 03	1 16	1 29	1 41	1 54	2 07	2 19	2 32	2 45	2 57	3 10	
6 40	0 13	0 27	0 40	0 53	1 07	1 20	1 33	1 47	2 00	2 13	2 27	2 40	2 53	3 07	3 20	
7 00	0 14	0 28	0 42	0 56	1 10	1 24	1 38	1 52	2 06	2 20	2 34	2 48	3 02	3 16	3 30	
7 20	0 15	0 29	0 44	0 59	1 13	1 28	1 43	1 57	2 12	2 27	2 41	2 56	3 11	3 25	3 40	
7 40	0 15	0 31	0 46	1 01	1 17	1 32	1 47	2 03	2 18	2 33	2 49	3 04	3 19	3 35	3 50	
8 00	0 16	0 32	0 48	1 04	1 20	1 36	1 52	2 08	2 24	2 40	2 56	3 12	3 28	3 44	4 00	
8 20	0 17	0 33	0 50	1 07	1 23	1 40	1 57	2 13	2 30	2 47	3 03	3 20	3 37	3 53	4 10	
8 40	0 17	0 35	0 52	1 09	1 27	1 44	2 01	2 19	2 36	2 53	3 11	3 28	3 45	4 03	4 20	
9 00	0 18	0 36	0 54	1 12	1 30	1 48	2 06	2 24	2 42	3 00	3 18	3 36	3 54	4 12	4 30	
9 20	0 19	0 37	0 56	1 15	1 33	1 52	2 11	2 29	2 48	3 07	3 25	3 44	4 03	4 21	4 40	
9 40	0 19	0 39	0 58	1 17	1 37	1 56	2 15	2 35	2 54	3 13	3 33	3 52	4 11	4 31	4 50	
10 00	0 20	0 40	1 00	1 20	1 40	2 00	2 20	2 40	3 00	3 20	3 40	4 00	4 20	4 40	5 00	
10 20	0 21	0 41	1 02	1 23	1 43	2 04	2 25	2 45	3 06	3 27	3 47	4 08	4 29	4 49	5 10	
10 40	0 21	0 43	1 04	1 25	1 47	2 08	2 29	2 51	3 12	3 33	3 55	4 16	4 37	4 59	5 20	

Range of tide, see footnote	Correction to height															
Ft	Ft	Ft	Ft	Ft	Ft	Ft	Ft	Ft	Ft	Ft	Ft	Ft	Ft	Ft	Ft	Ft
0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	
1.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.5	
1.5	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.3	0.4	0.4	0.5	0.6	0.7	0.8	
2.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	
2.5	0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.9	1.0	1.1	1.2	
3.0	0.0	0.0	0.1	0.1	0.2	0.3	0.4	0.5	0.6	0.8	0.9	1.0	1.2	1.3	1.5	
3.5	0.0	0.0	0.1	0.2	0.2	0.3	0.4	0.6	0.7	0.9	1.0	1.2	1.4	1.6	1.8	
4.0	0.0	0.0	0.1	0.2	0.3	0.4	0.5	0.7	0.8	1.0	1.2	1.4	1.6	1.8	2.0	
4.5	0.0	0.0	0.1	0.2	0.3	0.4	0.6	0.7	0.9	1.1	1.3	1.6	1.8	2.0	2.2	
5.0	0.0	0.1	0.1	0.2	0.3	0.5	0.6	0.8	1.0	1.2	1.5	1.7	2.0	2.2	2.5	
5.5	0.0	0.1	0.1	0.2	0.4	0.5	0.7	0.9	1.1	1.4	1.6	1.9	2.2	2.5	2.8	
6.0	0.0	0.1	0.1	0.3	0.4	0.6	0.8	1.0	1.2	1.5	1.8	2.1	2.4	2.7	3.0	
6.5	0.0	0.1	0.2	0.3	0.4	0.6	0.8	1.1	1.3	1.6	1.9	2.2	2.6	2.9	3.2	
7.0	0.0	0.1	0.2	0.3	0.5	0.7	0.9	1.2	1.4	1.8	2.1	2.4	2.8	3.1	3.5	
7.5	0.0	0.1	0.2	0.3	0.5	0.7	1.0	1.2	1.5	1.9	2.2	2.6	3.0	3.4	3.8	
8.0	0.0	0.1	0.2	0.3	0.5	0.8	1.0	1.3	1.6	2.0	2.4	2.8	3.2	3.6	4.0	
8.5	0.0	0.1	0.2	0.4	0.6	0.8	1.1	1.4	1.8	2.1	2.5	2.9	3.4	3.8	4.2	
9.0	0.0	0.1	0.2	0.4	0.6	0.9	1.2	1.5	1.9	2.2	2.7	3.1	3.6	4.0	4.5	
9.5	0.0	0.1	0.2	0.4	0.6	0.9	1.2	1.6	2.0	2.4	2.8	3.3	3.8	4.3	4.8	
10.0	0.0	0.1	0.2	0.4	0.7	1.0	1.3	1.7	2.1	2.5	3.0	3.5	4.0	4.5	5.0	
10.5	0.0	0.1	0.3	0.5	0.7	1.0	1.3	1.7	2.2	2.6	3.1	3.6	4.2	4.7	5.2	
11.0	0.0	0.1	0.3	0.5	0.7	1.1	1.4	1.8	2.3	2.8	3.3	3.8	4.4	4.9	5.5	
11.5	0.0	0.1	0.3	0.5	0.8	1.1	1.5	1.9	2.4	2.9	3.4	4.0	4.6	5.1	5.8	
12.0	0.0	0.1	0.3	0.5	0.8	1.1	1.5	2.0	2.5	3.0	3.6	4.1	4.8	5.4	6.0	
12.5	0.0	0.1	0.3	0.5	0.8	1.2	1.6	2.1	2.6	3.1	3.7	4.3	5.0	5.6	6.2	
13.0	0.0	0.1	0.3	0.6	0.9	1.2	1.7	2.2	2.7	3.2	3.9	4.5	5.1	5.8	6.5	
13.5	0.0	0.1	0.3	0.6	0.9	1.3	1.7	2.2	2.8	3.4	4.0	4.7	5.3	6.0	6.8	
14.0	0.0	0.2	0.3	0.6	0.9	1.3	1.8	2.3	2.9	3.5	4.2	4.8	5.5	6.3	7.0	
14.5	0.0	0.2	0.4	0.6	1.0	1.4	1.9	2.4	3.0	3.6	4.3	5.0	5.7	6.5	7.2	
15.0	0.0	0.2	0.4	0.6	1.0	1.4	1.9	2.5	3.1	3.8	4.4	5.2	5.9	6.7	7.5	
15.5	0.0	0.2	0.4	0.7	1.0	1.5	2.0	2.6	3.2	3.9	4.6	5.4	6.1	6.9	7.8	
16.0	0.0	0.2	0.4	0.7	1.1	1.5	2.1	2.6	3.3	4.0	4.7	5.5	6.3	7.2	8.0	
16.5	0.0	0.2	0.4	0.7	1.1	1.6	2.1	2.7	3.4	4.1	4.9	5.7	6.5	7.4	8.2	
17.0	0.0	0.2	0.4	0.7	1.1	1.6	2.2	2.8	3.5	4.2	5.0	5.9	6.7	7.6	8.5	
17.5	0.0	0.2	0.4	0.8	1.2	1.7	2.2	2.9	3.6	4.4	5.2	6.0	6.9	7.8	8.8	
18.0	0.0	0.2	0.4	0.8	1.2	1.7	2.3	3.0	3.7	4.5	5.3	6.2	7.1	8.1	9.0	
18.5	0.1	0.2	0.5	0.8	1.2	1.8	2.4	3.1	3.8	4.6	5.5	6.4	7.3	8.3	9.2	
19.0	0.1	0.2	0.5	0.8	1.3	1.8	2.4	3.1	3.9	4.8	5.6	6.6	7.5	8.5	9.5	
19.5	0.1	0.2	0.5	0.8	1.3	1.9	2.5	3.2	4.0	4.9	5.8	6.7	7.7	8.7	9.8	
20.0	0.1	0.2	0.5	0.9	1.3	1.9	2.6	3.3	4.1	5.0	5.9	6.9	7.9	9.0	10.0	

Obtain from the predictions the high water and low water, one of which is before and the other after the time for which the height is required. The difference between the times of occurrence of these tides is the duration of rise or fall, and the difference between the two heights is the range of tide for the above table. Find the difference between the nearest high or low water and the time for which the height is required.

Enter the table with the duration of rise or fall, printed in heavy-faced type, which most nearly agrees with the actual value, and on that horizontal line find the time from the nearest high or low water which agrees most nearly with the corresponding actual difference. The correction sought is in the column directly below, on the line with the range of tide.

When the nearest tide is high water, subtract the correction.

When the nearest tide is low water, add the correction.

Figure 7-5. Extract of Table 3 - Height of Tide At Any Time

7-7. All times stated in the tide tables are standard times, so adjustments are required for the use of daylight saving time or for any other differences from standard time. TABLE 1 is for the reference station of Hampton Roads for the months of July, August, and September. The time and heights of high and low water at the reference station are self-explanatory. Where no sign is given before the predicted height, the height is positive and is added to the depths given on the chart. If a minus (-) sign is in front of the height, then the number is subtracted from the charted depths.

7-8. While there is normally two high and two low tides for each date, they are, on an average, nearly an hour later each succeeding day. So there will be instances when a high or low tide may skip a calendar day, as indicated by a blank space in the tide tables (see 7, 13, 21, and 27 September).

SUBSTATIONS

7-9. These stations are listed in geographical order in TABLE 2 (Figure 7-4). Each substation is given a number, location, and position in latitude and longitude given to the nearest minute. Under the "differences" column, data are then given which are to be applied to the predictions at a stated reference station (the specific reference station is shown in bold type). If there is more than one reference station shown on a page of TABLE 2, make sure that you use the reference station printed above the substation listed. For Substation Number 2389, Jamestown Island, you will use the reference station on HAMPTON ROADS.

7-10. To determine the height of tide for a specific time other than those listed in TABLE 1 or computed using TABLE 2, see the extract of TABLE 3 (Figure 7-5). This table is easy to use and the instructions given below the table are explicit.

Note: The predictions of times of heights of tide are so influenced by local conditions that they are not exact enough to make meaningful any interpolation for a more precise value. For this reason, interpolation is not done when using TABLE 3.

PREDICTING THE HEIGHT OF TIDE

7-11. Use the tide tables to predict the height of tide at a specific spot for a particular time. As you calculate, write down the information as shown in Figure 7-6.

Example: The harbor master wants to know the height of tide off Jamestown Island, VA, at 1000 hours on 10 September 1978.

Solution:

- Write down the date and substation.
- Refer to Figure 7-7, and go down the alphabetical listing to find Jamestown Island, VA, and its index number (2389).
- Refer to Figure 7-8, and locate the substation by number. Locate and record the differences in times for high and low water and the difference in heights for high and low water (high water [+]2h54m, correction [-]0.5 ft; low water [+]3h26m, correction 0.0 ft).
- Refer to Figure 7-9, and write down the times for high and low water and their corrections (high water 0210, 2.4 ft and 1454, 2.9 ft; low water 0818, 0.3ft, and 2121, 0.5ft).
- Apply the corrections for the substation as given in Figure 7-8. Write down the corrected times and heights for high and low water for the substation opposite those for Hampton Roads (high water 0504, 1.9 ft and 1748, 2.4 ft; low water 1144, 0.3 ft and 0047 [9/11], 0.5 ft).

- Compute the duration of the rise or fall of the tide by determining the time difference between the time of the tide prior to the time for which the height is required and the time of the tide after.

Duration of the tide = 11h44m - 5h04m = 6h40m.

- Record the time.
- Find the difference between the nearest high or low water and the time for which the height is required. The time to the nearest tide (low water):

LW = 11h44m - 10h00m = 1h44m.

- Record this information.
- Determine the range of tide by subtracting the low water from the high water (1.9 - 0.3 = 1.6 ft) and record.
- In Figure 7-10, locate 6h40m under "duration of rise or fall" printed in bold face. Go across on the horizontal line to find the time from the nearest high or low water, which is the same or almost the same as the actual time difference. (In this case 1h41m is the actual time, so you will use 1h47m.)
- Come down this column into the "correction to height" column until you are on the line with the range of tide (1.6) or nearest range of tide (in this case 1.5), and the correction is 0.2. List this correction for computing tide.
- Apply the correction to determine the height of tide at a specific time.

Note: When the nearest tide is high water, subtract the correction. When the nearest tide is low water, add the correction.

- List the height of tide for 1000 hours on 10 September 1978.

Height of nearest tide	0.3 (low water)
Correction from Figure 7-10	+0.2
Height of Tide	0.5 feet

Note: This predicted correction of 0.5 feet would be added to the charted depth of the water around Jamestown Island. This predicted depth would be valid only for 1000 hours on 10 September 1978.

DATE: *10 September 1978*	TIME: *1000 hours*	
SUBSTATION: *Jamestown Island, VA (2389)*		
REFERENCE STATION: *Hampton Roads*		
HW TIME DIFFERENCE: *(+)2h54m*		
LW TIME DIFFERENCE: *(+)3h26m*		
DIFFERENCE IN HEIGHT OF HW: *(-)0.5 ft*		
DIFFERENCE IN HEIGHT OF LW: *0.0 ft*		
HAMPTON ROADS	JAMESTOWN ISLAND	
HW: *0210, 2.4 ft*	*0504, 1.9 ft*	
LW: *0818, 0.3 ft*	*1144, 0.3 ft*	
HW: *1454, 2.9 ft*	*1748, 2.4 ft*	
LW: *2121, 0.5 ft*	*(9/11) 0047, 0.5 ft*	
HEIGHT OF TIDE AT JAMESTOWN ISLAND AT 1000 HOURS ON 10 SEPTEMBER 1978:		
DURATION OF RISE OR FALL: *6h40m*	HEIGHT OF NEAREST TIDE: *0.3 ft*	
TIME TO NEAREST TIDE: *1h44m*	CORRECTION, TABLE 3: *0.2 ft*	
RANGE OF TIDE: *1.6 ft*	HEIGHT OF TIDE AT 1000h: *0.5 ft*	

Figure 7-6. Summary of Calculations for Computing Height of Tide

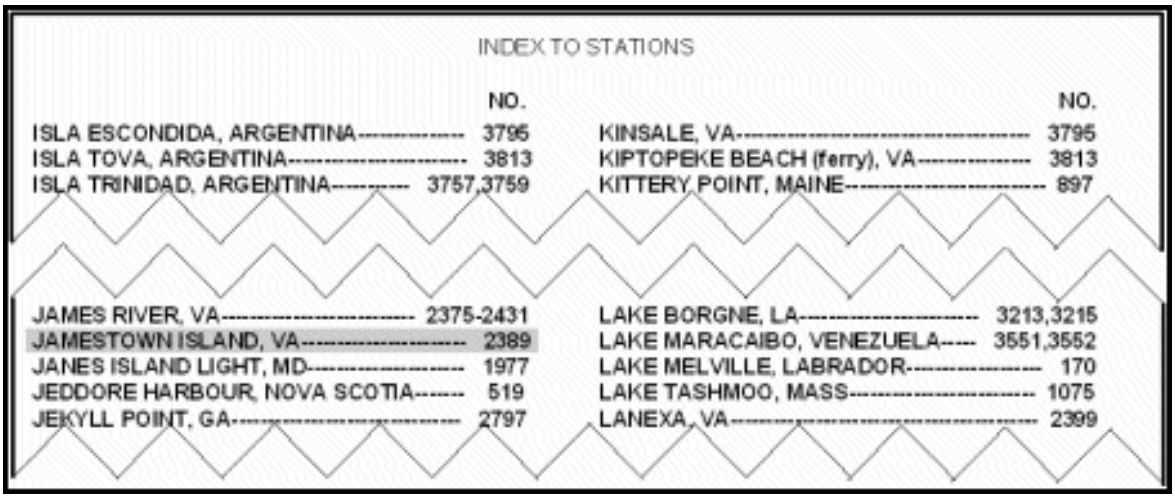


Figure 7-7. Extract of Index to Stations (Jamestown Island, VA)

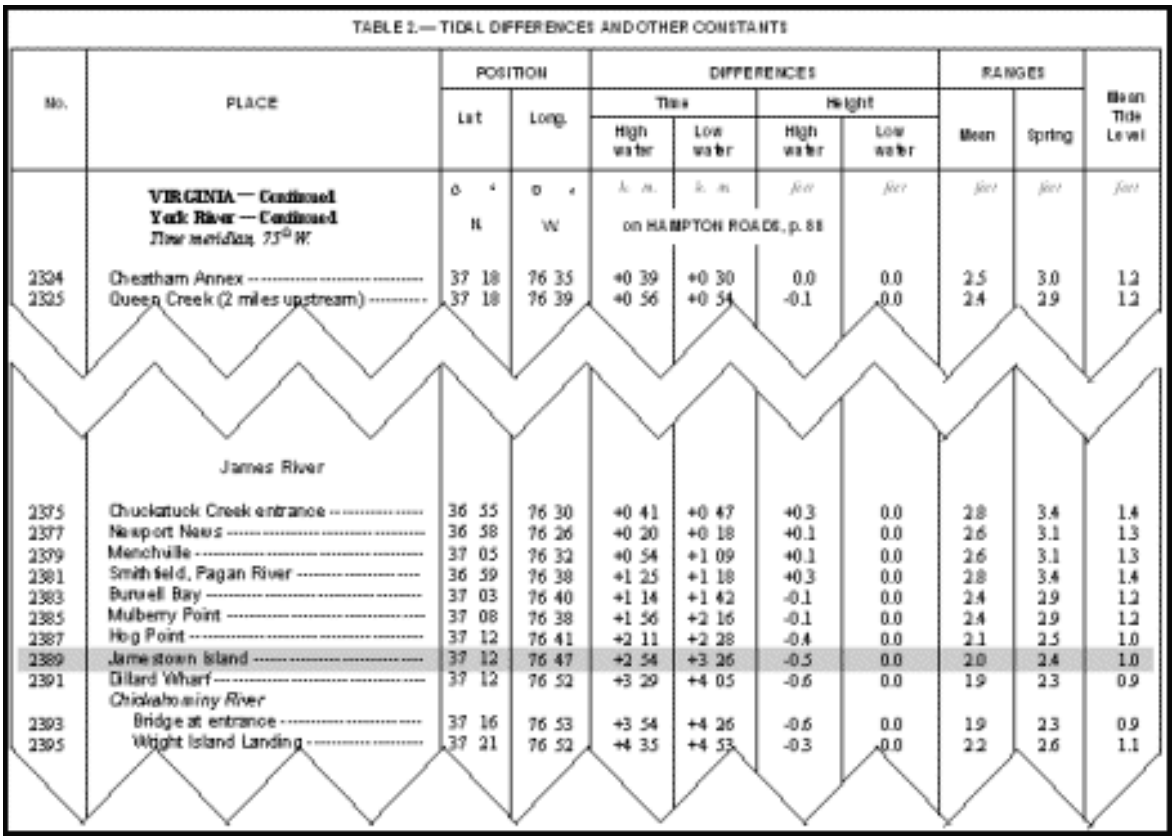
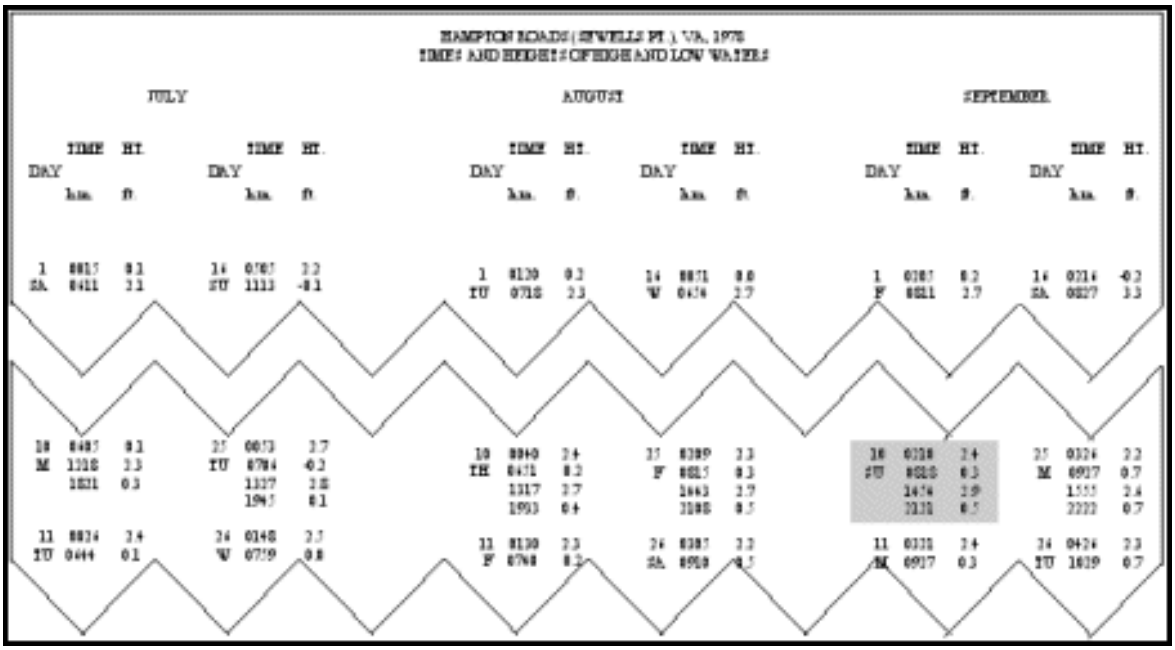


TABLE 2.— TIDAL DIFFERENCES AND OTHER CONSTANTS

No.	PLACE	POSITION Lat	POSITION Long.	DIFFERENCES Time High water	DIFFERENCES Time Low water	DIFFERENCES Height High water	DIFFERENCES Height Low water	RANGES Mean	RANGES Spring	Mean Tide Level
		° ′	° ′	h. m.	h. m.	feet	feet	feet	feet	feet
	VIRGINIA — Continued									
	York River — Continued									
	Time meridian, 75° W.	N.	W.	on HAMPTON ROADS, p. 88						
2324	Cheatham Annex	37 18	76 35	+0 39	+0 30	0.0	0.0	2.5	3.0	1.2
2325	Queen Creek (2 miles upstream)	37 18	76 39	+0 56	+0 54	-0.1	0.0	2.4	2.9	1.2
	James River									
2375	Chuckatuck Creek entrance	36 55	76 30	+0 41	+0 47	+0.3	0.0	2.8	3.4	1.4
2377	Newport News	36 58	76 26	+0 20	+0 18	+0.1	0.0	2.6	3.1	1.3
2379	Menchville	37 05	76 32	+0 54	+1 09	+0.1	0.0	2.6	3.1	1.3
2381	Smithfield, Pagan River	36 59	76 38	+1 25	+1 18	+0.3	0.0	2.8	3.4	1.4
2383	Burwell Bay	37 03	76 40	+1 14	+1 42	-0.1	0.0	2.4	2.9	1.2
2385	Mulberry Point	37 08	76 38	+1 56	+2 16	-0.1	0.0	2.4	2.9	1.2
2387	Hog Point	37 12	76 41	+2 11	+2 28	-0.4	0.0	2.1	2.5	1.0
2389	Jamestown Island	37 12	76 47	+2 54	+3 26	-0.5	0.0	2.0	2.4	1.0
2391	Dillard Wharf	37 12	76 52	+3 29	+4 05	-0.6	0.0	1.9	2.3	0.9
	Chickahominy River									
2393	Bridge at entrance	37 16	76 53	+3 54	+4 26	-0.6	0.0	1.9	2.3	0.9
2395	Wright Island Landing	37 21	76 52	+4 35	+4 53	-0.3	0.0	2.2	2.6	1.1

Figure 7-8. Extract of Table 2 - Tidal Differences and Other Constants



HAMPTON ROADS (SEWELLS PT.), VA, 1978
TIMES AND HEIGHTS OF HIGH AND LOW WATERS

JULY DAY	TIME h.m.	HT. ft.	JULY DAY	TIME h.m.	HT. ft.	AUGUST DAY	TIME h.m.	HT. ft.	AUGUST DAY	TIME h.m.	HT. ft.	SEPTEMBER DAY	TIME h.m.	HT. ft.	SEPTEMBER DAY	TIME h.m.	HT. ft.
1 SA	0015 0411	0.1 2.1	14 SU	0505 1113	2.2 -0.1	1 TU	0120 0718	0.2 2.3	14 W	0051 0454	0.0 2.7	1 F	0205 0811	0.2 2.7	14 SA	0214 0827	-0.2 3.3
10 M	0405 1218 1821	0.1 2.3 0.3	25 TU	0053 0704 1327 1945	2.7 -0.2 2.8 0.1	10 TH	0040 0451 1317 1933	2.4 0.2 2.7 0.4	25 F	0309 0815 1663 2108	2.3 0.3 2.7 0.5	10 SU	0210 0818 1454 2131	2.4 0.3 2.9 0.5	25 M	0326 0917 1555 2222	2.2 0.7 2.4 0.7
11 TU	0024 0444	2.4 0.1	26 W	0148 0759	2.5 0.0	11 F	0130 0760	2.3 0.2	26 SA	0305 0910	2.2 0.5	11 M	0321 0917	2.4 0.3	26 TU	0426 1019	2.3 0.7

Figure 7-9. Extract of Table 1 - Times and Heights of High and Low Waters

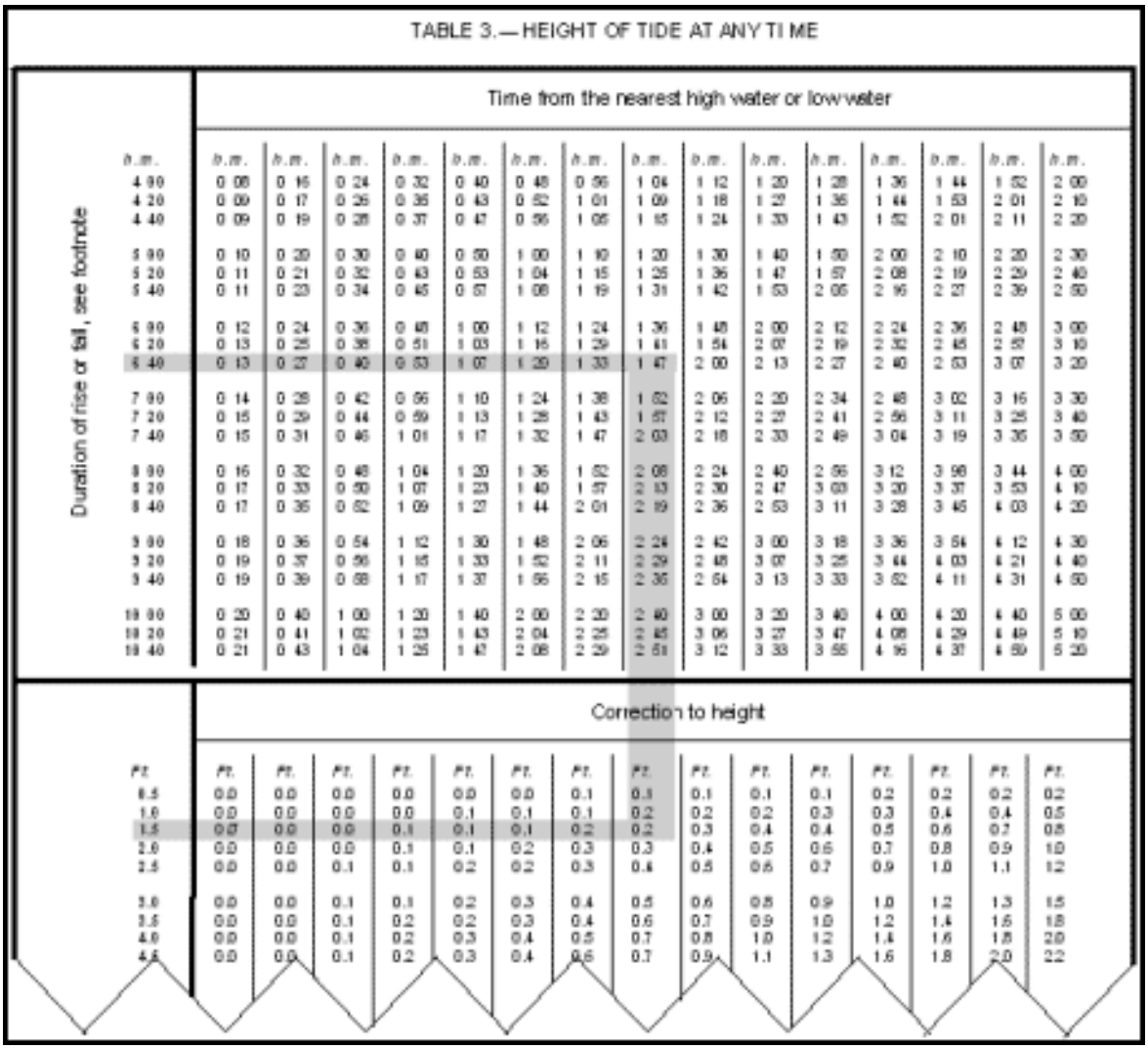


TABLE 3.—HEIGHT OF TIDE AT ANY TI ME

Time from the nearest high water or low water

Duration of rise or fall, see footnote	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
	4 00	0 08	0 16	0 24	0 32	0 40	0 48	0 56	1 04	1 12	1 20	1 28	1 36	1 44	1 52	2 00
	4 20	0 09	0 17	0 26	0 35	0 43	0 52	1 01	1 09	1 18	1 27	1 35	1 44	1 53	2 01	2 10
	4 40	0 09	0 19	0 28	0 37	0 47	0 56	1 05	1 15	1 24	1 33	1 43	1 52	2 01	2 11	2 20
	5 00	0 10	0 20	0 30	0 40	0 50	1 00	1 10	1 20	1 30	1 40	1 50	2 00	2 10	2 20	2 30
	5 20	0 11	0 21	0 32	0 43	0 53	1 04	1 15	1 25	1 36	1 47	1 57	2 08	2 19	2 29	2 40
	5 40	0 11	0 23	0 34	0 45	0 57	1 08	1 19	1 31	1 42	1 53	2 05	2 16	2 27	2 39	2 50
	6 00	0 12	0 24	0 36	0 48	1 00	1 12	1 24	1 36	1 48	2 00	2 12	2 24	2 36	2 48	3 00
	6 20	0 13	0 25	0 38	0 51	1 03	1 16	1 29	1 41	1 54	2 07	2 19	2 32	2 45	2 58	3 10
	6 40	0 13	0 27	0 40	0 53	1 07	1 20	1 33	1 47	2 00	2 13	2 27	2 40	2 53	3 07	3 20
	7 00	0 14	0 28	0 42	0 56	1 10	1 24	1 38	1 52	2 06	2 20	2 34	2 48	3 02	3 16	3 30
	7 20	0 15	0 29	0 44	0 59	1 13	1 28	1 43	1 57	2 12	2 27	2 41	2 56	3 11	3 25	3 40
	7 40	0 15	0 31	0 46	1 01	1 17	1 32	1 47	2 03	2 18	2 33	2 49	3 04	3 19	3 35	3 50
	8 00	0 16	0 32	0 48	1 04	1 20	1 36	1 52	2 08	2 24	2 40	2 56	3 12	3 28	3 44	4 00
	8 20	0 17	0 33	0 50	1 07	1 23	1 40	1 57	2 13	2 30	2 47	3 03	3 20	3 37	3 53	4 10
	8 40	0 17	0 35	0 52	1 09	1 27	1 44	2 01	2 19	2 36	2 53	3 11	3 28	3 45	4 03	4 20
	9 00	0 18	0 36	0 54	1 12	1 30	1 48	2 06	2 24	2 42	3 00	3 18	3 36	3 54	4 12	4 30
	9 20	0 19	0 37	0 56	1 15	1 33	1 52	2 11	2 29	2 48	3 07	3 25	3 44	4 03	4 21	4 40
	9 40	0 19	0 39	0 58	1 17	1 37	1 56	2 15	2 35	2 54	3 13	3 33	3 52	4 11	4 31	4 50
	10 00	0 20	0 40	1 00	1 20	1 40	2 00	2 20	2 40	3 00	3 20	3 40	4 00	4 20	4 40	5 00
	10 20	0 21	0 41	1 02	1 23	1 43	2 04	2 25	2 45	3 06	3 27	3 47	4 08	4 29	4 49	5 10
	10 40	0 21	0 43	1 04	1 25	1 47	2 08	2 29	2 51	3 12	3 33	3 55	4 16	4 37	4 59	5 20

Correction to height

Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.
0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
1.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5
1.5	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.3	0.4	0.4	0.5	0.6	0.7	0.8	0.8
2.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.0
2.5	0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.9	1.0	1.1	1.2	
3.0	0.0	0.0	0.1	0.1	0.2	0.3	0.4	0.5	0.6	0.8	0.9	1.0	1.2	1.3	1.5	
3.5	0.0	0.0	0.1	0.2	0.2	0.3	0.4	0.6	0.7	0.9	1.0	1.2	1.4	1.6	1.8	
4.0	0.0	0.0	0.1	0.2	0.3	0.4	0.5	0.7	0.8	1.0	1.2	1.4	1.6	1.8	2.0	
4.5	0.0	0.0	0.1	0.2	0.3	0.4	0.6	0.7	0.9	1.1	1.3	1.6	1.8	2.0	2.2	

Figure 7-10. Extract of Table 3 - Height of Tide At Any Time

TIDAL CURRENTS

7-12. A tidal current is the periodic, alternating, horizontal response of the water to the tidal forces which causes the rise and fall of the tide. Tidal currents are so called to distinguish them from ocean or river currents.

7-13. The horizontal motions of water that reverses direction of flow during a tidal cycle are called flood current and ebb current. The flood current sets toward and the ebb current away from the coast, or the flood and ebb current set parallel to the coast in opposite directions. At each reversal of the current direction, there is a moment of no horizontal motion called slack water.

7-14. The time of a tidal current’s change of direction does not coincide with the time of changing tide. The change of direction of the current always lags the turning of the tide by an interval that varies according to the physical characteristics of the land around the body of tidewater. For instance, along a relatively straight coast with only shallow indentations, there is usually little difference between the time of high or low tide and the time of slack water. However, where a large bay connects with the ocean through a narrow channel, the tide and the current may be out of phase by as much as three hours. In such a situation, the current in the channel may be running at its greatest velocity at high or low water outside.

7-15. The navigator of a ship operating in tidewater must know the direction (called set) and velocity (called drift) of the tidal current his ship may encounter. This information is obtained from Tidal Current Tables.

TIDAL CURRENT TABLES

7-16. The Tidal Current Tables are also published annually by the National Ocean Survey. These tables are similar to the Tide Tables, but the coverage is not so extensive, being given in two volumes. Each volume is arranged as follows:

- **TABLE 1.** Contains a complete list of predicted times of maximum currents and slack, with the velocity (speed) of the maximum currents for a number of reference stations.
- **TABLE 2.** Gives differences, ratios, and other information related to a relatively large number of subordinate stations (substations).
- **TABLE 3.** Provides information for use in finding the speed of the current at any time between tabulated entries in TABLES 1 and 2.
- **TABLE 4.** Gives the number of minutes the current does not exceed stated amounts for various maximum speeds.
- **TABLE 5 (Atlantic Coast of North America only).** Gives information on rotary tidal currents.

PREDICTING THE SET AND DRIFT OF THE CURRENT

7-17. Let us predict the set and drift of the current at Jamestown Island, VA, for 1000 hours on the same day we predicted the height of tide. As you calculate, write down the information as shown in Figure 7-11.

DATE: *10 September 1978*		TIME: *1000 hours*		
SUBSTATION: *Jamestown Island, VA (3705)*				
REFERENCE STATION: *Chesapeake Bay Entrance*				
TIME DIFFERENCE:	*Slack Water: (+)2h00m*		FLOOD DIRECTION: *325°*	
	Maximum Current: (+)1h40m		EBB DIRECTION: *145°*	
VELOCITY RATIO:	*Maximum Flood: 1.1*			
	Maximum Ebb: 0.9			
CHESAPEAKE BAY ENTRANCE			JAMESTOWN ISLAND	
(9/09)	*2337*	*0*	*0137*	*0*
(10/10)	*0149*	*0.6F*	*0329*	*0.7F*
	0412	*0*	*0612*	*0*
	0822	*1.4E*	*1002*	*1.3E*
	1155	*0*	*1355*	*0*
	1440	*1.0F*	*1620*	*1.1F*
	1747	*0*	*1947*	*0*
	2125	*1.2E*	*2305*	*1.1E*
INTERVAL BETWEEN			FACTOR, TABLE 3:	*1.0*
SLACK AND DESIRED TIME: *3h48m*				
			VELOCITY:	*1.3 knots*
INTERVAL BETWEEN				
SLACK AND MAXIMUM CURRENT: *3h50m (ebb/flood)*			DIRECTION: *145°*	
MAXIMUM CURRENT: *1.3 knots*				

Figure 7-11. Summary of Calculations for Set and Drift of Current

Notes:
1. Time differences are applied to the times of slack and maximum current at the reference station in the same manner that time differences are applied when figuring tides. Application of the time difference to the tabulated time of flood and ebb current produces the time of the corresponding current at the substation. Find the maximum velocity at the substation by multiplying the maximum velocity at the reference station by the correct flood or ebb ratio.
2. Flood direction is the approximate true direction toward which the flood current flows. Ebb direction is usually close to the reciprocal of the flood direction. Average flood and ebb velocities are averages of all the flood and ebb currents.

- First look up Jamestown Island in Figure 7-12. Its number here is 3705.
- In Figure 7-13, find Substation 3705 (Jamestown Island). Notice near the top of the page that the Reference Station is "Chesapeake Bay Entrance" instead of "Hampton Roads (Sewell's Point)." You will also see that the time difference for slack water is (+)2h00m and for the maximum current, (+)1h40m. These time differences mean that when slack water or maximum current exists at the Chesapeake Bay Entrance, the same conditions will exist, 2h00m and 1h40m later respectively, at Jamestown Island.

INDEX TO STATIONS

	NO.		NO.
HULL †	630	LESTER MANOR	3835
HULL GUT †	595	LEWIS BAY	900
HUNNIWELL BAY	170	LEWIS ISLAND	5805
JAMES ISLAND, TANGIER SOUND	3950	LONG SHOAL	865
JAMES RIVER	3660-3755	LONGBOAT PASS	5680
JAMESTOWN ISLAND	3705	LORD DELAWARE BRIDGE	3815
JEKYLL CREEK	5290	LOVE POINT, CHESAPEAKE BAY	3390-3400
JENNINGS POINT	1587	LOVE POINT, CHESTER RIVER	4355
JOE ISLAND	5760	LOWE POINT	155
JOHNS ISLAND HIGHWAY BRIDGE	4985	LOWER COAL DOCK	1710
JOHNS PASS	5910	LOWER HELL GATE, KNUBBLE BAY	160
JOHNSON CREEK	5225	LOWER MACHODOC CREEK ENTRANCE	4060

Figure 7-12. Extract of Index to Stations (Jamestown Island)

TABLE 2.—CURRENT DIFFERENCES AND OTHER CONSTANTS

No.	PLACE	POSITION		TIME DIFFERENCES		VELOCITY RATIOS		MAXIMUM CURRENTS			
								Flood		Ebb	
		Lat.	Long.	Slack Water	Maximum current	Maximum flood	Maximum ebb	Direction (true)	Average velocity	Direction (true)	Average velocity
	JAMES RIVER—Continued	° ′ N.	° ′ W.	h. m.	h. m.			deg.	knots	deg.	knots
	Time meridian 75°W.			on CHESAPEAKE BAY ENTRANCE, p. 58							
3700	Hog Point	37 12	76 42	+1 50	+1 40	1.1	0.9	260	1.1	070	1.3
3705	Jamestown Island, Church Point	37 12	76 47	+2 00	+1 40	1.1	0.9	325	1.1	145	1.3
3710	Chickahominy River Bridge	37 16	76 52	+1 50	+1 35	1.3	0.8	330	1.3	155	1.2
3715	Claremont Landing	37 14	76 57	+3 05	+2 55	1.5	1.0	290	1.5	135	1.5

Figure 7-13. Extract of Table 2 - Current Differences and Other Constants

7-18. The flood velocity ratio is 1.1 and the ebb velocity ratio is 0.9. Before selecting the correct ratio, you must determine whether the current is ebbing or flooding at 1000.

7-19. Under the maximum currents columns you will find the flood direction to be 325° and the ebb 145° (the reciprocal). The average flood velocity is 1.1 knots and the average ebb velocity is 1.3 knots.

- Write down these values for your calculations:

Time differences -- (+)2h00m for slack water, (+)1h40m for maximum current. Velocity ratios -- 1.1 for maximum flood, 0.9 for maximum ebb. Directin of current -- 325° for flood, 145° for ebb.

- In Figure 7-14 you will find the time of slack water and maximum current for 10 September 1978.
- Write down all the current conditions for the Reference Station (Chesapeake Bay Entrance) and the calculated values for the Jamestown Island substation.
- Note that the maximum current at Jamestown Island occurs at 1002 with a velocity of 1.3 knots (E). Therefore the current is ebbing, and its direction or set is 145° .
- Determine the interval between slack water and the desired time (1000):

10h00m desired time -0.6h12m time of slack water 3h48m interval

- Determine the interval between slack water and maximum current:

10h02m time of maximum current -0.6h12m time of slack water 3h50m interval

- In Figure 7-15, locate value nearest to 3h48m under "interval between slack and desired time," locate value nearest to 3h50m under "interval between slack and maximum current."
- Apply the factor of 1.0 to the value for maximum ebb velocity: predicted velocity of current = 1.0 X 1.3 = 1.3 knots.

What is the direction or set? You know that the current is ebbing at this time, and the ebb direction is 145° , which is the set.

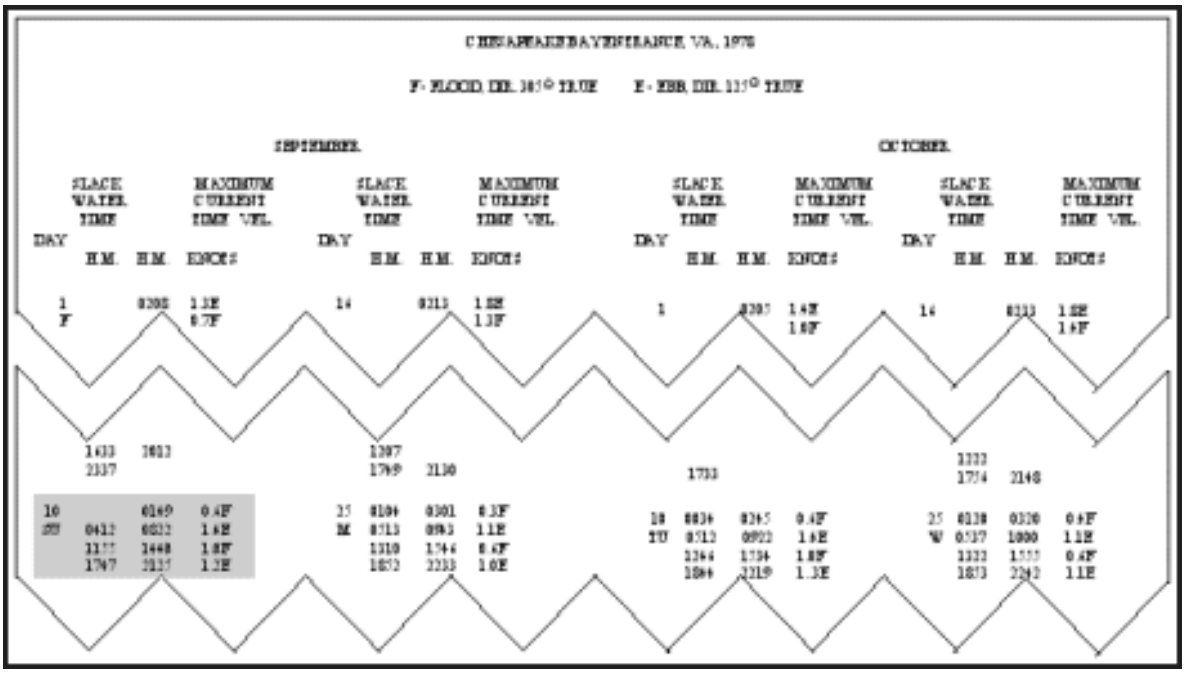


Figure 7-14. Extract of Table 1 - Daily Current Predictions

TABLE 3.— VELOCITY OF CURRENT AT ANY TI ME

TABLE A

Interval between slack and desired time	Interval between slack and maximum current													
	h.m. 1 20	h.m. 1 40	h.m. 2 00	h.m. 2 20	h.m. 2 40	h.m. 3 00	h.m. 3 20	h.m. 3 40	h.m. 4 00	h.m. 4 20	h.m. 4 40	h.m. 5 00	h.m. 5 20	h.m. 5 40
h.m.	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.
0 20	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0 40	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2
1 00	0.9	0.8	0.7	0.6	0.6	0.5	0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.3
1 20	1.0	1.0	0.9	0.8	0.7	0.6	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.4
1 40	—	1.0	1.0	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.5	0.4
2 00	—	—	1.0	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.6	0.5
2 20	—	—	—	1.0	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.7	0.6	0.6
2 40	—	—	—	—	1.0	1.0	1.0	0.9	0.9	0.9	0.8	0.7	0.7	0.7
3 00	—	—	—	—	—	1.0	1.0	1.0	0.9	0.9	0.8	0.8	0.8	0.7
3 20	—	—	—	—	—	—	1.0	1.0	1.0	0.9	0.9	0.9	0.8	0.8
3 40	—	—	—	—	—	—	—	1.0	1.0	1.0	0.9	0.9	0.9	0.9
4 00	—	—	—	—	—	—	—	—	1.0	1.0	1.0	1.0	0.9	0.9
4 20	—	—	—	—	—	—	—	—	—	1.0	1.0	1.0	1.0	0.9
4 40	—	—	—	—	—	—	—	—	—	—	1.0	1.0	1.0	1.0
5 00	—	—	—	—	—	—	—	—	—	—	—	1.0	1.0	1.0
5 20	—	—	—	—	—	—	—	—	—	—	—	—	1.0	1.0
5 40	—	—	—	—	—	—	—	—	—	—	—	—	—	1.0

Figure 7-15. Extract of Table 3 - Velocity of Current At Any Time

Chapter 8

Weather

Several times a day, ships receive weather reports for coastal areas and predictions for periods of 12, 24, and 36 hours. These predictions are based on reports from ships and weather stations around the world and from satellites. However, ships not in the general area for receiving weather predictions must do their own predicting from data obtained by limited means. You must know something about the use of a few of the weather instruments. To understand their value, you must also know something about the basic elements of the weather, clouds, and cloud formations; and how these cloud formations can be used as an indicator of oncoming weather conditions.

WEATHER INSTRUMENTS

8-1. Weather conditions such as air temperature and humidity, wind direction, and velocity are measured by a variety of instruments. This chapter describes how to use and how to interpret readings from some typical instruments.

THERMOMETERS

8-2. A thermometer is an instrument for measuring temperature. It is a glass tube of small bore in which either alcohol or mercury expands and contracts with the rise and fall of the temperature of the surrounding air.

8-3. Most thermometers are mercury-filled and almost all of them use the Fahrenheit scale, in which the freezing point of water is 32° and boiling point is 212° . However, temperature in meteorology sometimes is expressed according to the Celsius (formerly centigrade) scale in which the freezing point of water is 0° and boiling point is 100° (Figure 8-1).

8-4. You might be required to convert a Fahrenheit reading to Celsius or vice versa. Since 32° F is equivalent to 0° C, to change a Fahrenheit reading to Celsius you first subtract 32° and then multiply the remainder by 5/9. Say you want to change 41° F to Celsius. Subtracting 32° from 41° gives you 9° . Multiplying 9° by 5/9 gives you 45/9, or 5° C.

$$°C = 5/9\ (°F - 32) \qquad °F = 9/5\ (°C + 32)$$

Example:

$$°C = 5/9\ (41° - 32°) = 5/9\ (9°)\ \frac{45°}{9} = 5°$$

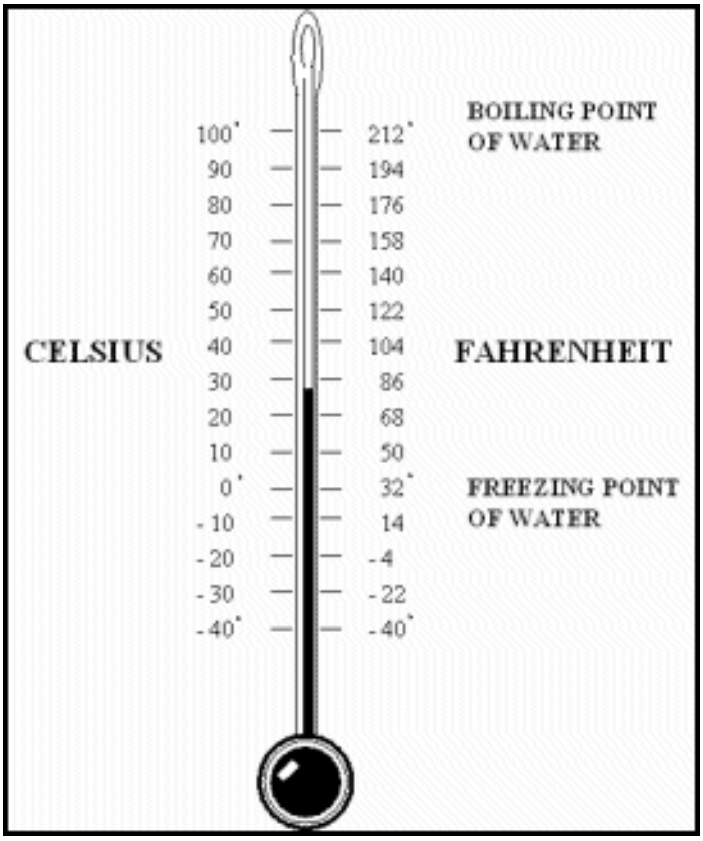


Figure 8-1. Celsius and Fahrenheit Scales

8-5. To change from Celsius to Fahrenheit, simply reverse the procedure. First multiply the Celsius temperature by 9/5, then add 32° . In the previous example, to change 5° C back to Fahrenheit, you first multiply it by 9/5, which gives you 45/5 or 9° . Adding 32° gives you 41° F.

8-6. When reading a thermometer, DO NOT touch the lower part of the glass which contains the alcohol or mercury. The heat from your body will cause the liquid to rise in the tube. Your eyes should be on a level with the top of the column to get an accurate reading. You will notice that the top of the column is curved. On a mercury thermometer, the reading is taken at the top of the curve. On an alcohol thermometer, the reading is taken at the bottom of the curve.

BAROMETERS

8-7. Many do not consider air as having weight. However, under normal conditions, a column of air (1-inch by 1-inch) extending to the top of the atmosphere weighs 14.7 pounds. "Normal conditions" means at sea level with the temperature at 59° F and the air charged with a certain amount of water vapor. We do not refer to this as the weight of air, but as atmospheric pressure, which (in our system of weights and measures) is measured in pounds per square inch. Barometers are instruments for measuring atmospheric pressure.

ANEROID BAROMETER

8-8. The type of barometer used aboard ship is the aneroid (Figure 8-2). The term "aneroid" means without fluid. A barometer of this type contains a metal cylinder from which much of the air has been removed. Outside pressure will make the thin metal ends expand and contract. By means of linkages, this motion is magnified and transmitted to a pointer that shows the pressure on a scale on the face of the instrument. Scales are marked in inches and hundredths of inches. Some instruments also have a millibar scale. Millibars are units of pressure (of the metric system) rather than units of length (Figure 8-3). An aneroid barometer is unaffected by temperature, so readings need not be corrected for changes in temperature.

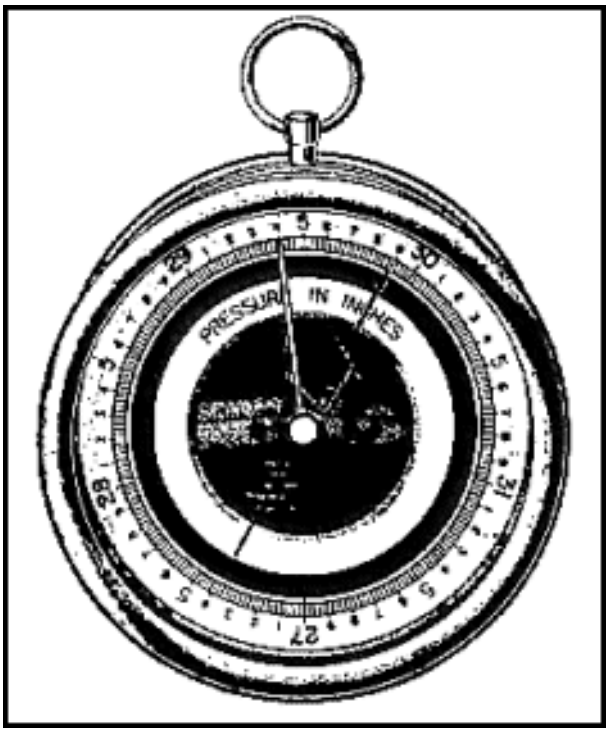


Figure 8-2. Aneroid Barometer

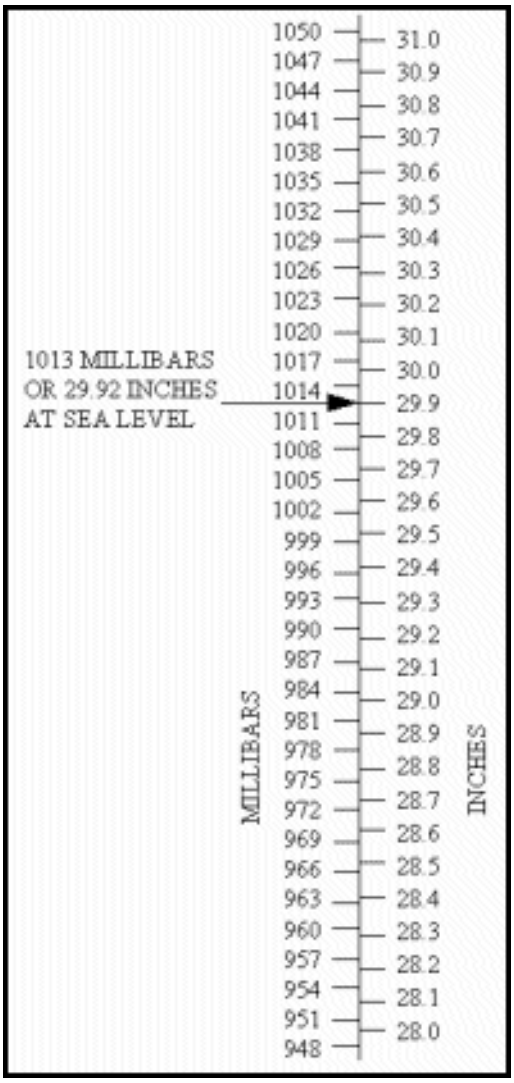


Figure 8-3. Inches and Millibars

USING BAROMETERS IN FORECASTING WEATHER

8-9. Barometer readings, along with those of the thermometer and psychrometer, can be used to make short-range forecasts of local weather. A single observation, however, is meaningless, and the actual readings are unimportant. Direction and the rate of change are important. You must note whether the change was rapid or gradual or, if the readings are steady, the length of time the condition has existed.

8-10. Each day there is a normal rise and fall of the pressure, with the highs occurring about 1000 and 2200 and the lows coming about 0400 and 1600. The average change during these periods is about 0.05 inches, or 0.01 inches per hour. These daily changes, called diurnal changes, must not be overlooked when considering the amount of change in readings. For example, assume the pressure drops from 30.15 inches to 30.07 inches. At first glance, the amount of drop would seem to be considerable, but, if the normal diurnal drop of 0.05 inches is subtracted from this, the 0.03 inches remaining is insignificant for a 6-hour period. If the same drop of 0.08 inches had occurred between 0400 and 1000, when the barometer normally rises about 0.05 inches, the drop would have to be considered significant.

8-11. A set of averages is useful in forecasting weather and for middle latitudes. A reading of 29.50 inches is considered low, 30.00 inches is high.

8-12. The violence and speed of an approaching storm is indicated by the rate and amount of fall of the barometer. When local weather conditions remain unchanged and the barometric pressure drops, a distant storm is raging. If the average fall per hour is from 0.02 to 0.06 inches, the distance from the center of the storm is roughly 250 to 150 miles. If the fall is 0.06 to 0.08 inches or 0.12 to 0.15 inches, the distance is about 150 to 100 miles or 80 to 50 miles, respectively.

8-13. Some general rules that will help when using the barometer are listed below.

- A falling barometer usually forecasts foul weather with winds from the east quadrants. Fair and clearing weather is usually forecast by winds shifting to west quadrants with a rising barometer.
- When the wind sets in from points between south and southeast and the barometer falls steadily, a storm is approaching from the west or northwest. The center of the storm will pass near or north of the observer within 12 to 24 hours, and the wind will shift to the northwest by way of south and southwest.
- When the wind sets in from points between east and northeast and the barometer falls steadily, a storm is approaching from the south or southwest. The storm center will pass near or to the south of the observer within 12 to 24 hours, and the wind will shift to northwest by way of north. The rate and amount of the fall of the barometer will indicate the speed and intensity of the storm's approach. Table 8-1 furnishes a ready means of forecasting weather from wind-barometer data. It is an excellent guide, based on the wind and barometric readings, for predicting weather in your immediate area of operation.

Table 8-1. Weather Forecasting Table

WIND DIRECTION	BAROMETER READING AT SEA LEVEL	CHARACTER OF WEATHER
SW to NW	30.10 to 30.20 and steady. (1019.3 to 1022.7 millibars)	Fair with slight temperature changes for 1 or 2 days.
SW to NW	30.10 to 30.20 and rising rapidly. (1019.3 to 1022.7 millibars)	Fair followed within 2 days by rain.
SW to NW	30.20 and above and stationary. (1022.7 millibars)	Continued fair with no decided temperature change.
SW to NW	30.20 and above and falling slowly. (1022.7 millibars)	Slowly rising temperature and fair for 2 days.
S to SE	30.10 to 30.20 and falling slowly. (1019.3 to 1022.7 millibars)	Rain within 24 hours.
S to SE	30.10 to 30.20 and falling rapidly. (1019.3 to 1022.7 millibars)	Wind increasing in force; rain within 12 to 24 hours.
SE to NE	30.10 to 30.20 and falling slowly. (1019.3 to 1022.7 millibars)	Rain in 12 to 18 hours.

SE to NE	30.10 to 30.20 and falling rapidly. (1019.3 to 1022.7 millibars)	Increasing wind and rain within12 hours.
E to NE	30.10 and above and falling slowly. (1019.3 millibars)	In summer with light winds, rain may not fall for several days. In winter, rain in 24 hours.
E to NE	30.10 and above and falling rapidly. (1019.3 millibars)	In summer, rain probably in 12 hours. In winter, rain or snow with increasing winds will often set in when the barometer begins to fall and the wind sets in from the NE.
SE to NE	30.00 or below and falling slowly. (1015.9 millibars)	Rain will continue 1 or 2 days.
SE to NE	30.00 or below and falling rapidly. (1015.9 millibars)	Rain with high winds, followed within 36 hours by clearing and, in winter, colder temperatures.
S to SW	30.00 or below and rising slowly. (1015.9 millibars)	Clearing within a few hours and fair for several days.
S to E	29,80 or below and falling rapidly. (1009.1 millibars)	Sever storm imminent, followed within 24 hours by clearing and, in winter, colder temperatures.
E to N	29.80 or below and falling rapidly. (1009.1 millibars)	Severe NE gale and heavy rain; in winter, heavy snow followed by a cold wave.
Going to W	29.80 or below and rising rapidly. (1009.1 millibars)	Clearing and colder.

HYGROMETER AND PSYCHROMETER

8-14. Another factor that plays an important part in our weather is humidity. Humidity is the amount of water vapor (water in a gaseous state) in the air. Any given volume of atmosphere at a given temperature can hold only a certain amount of water vapor. If more and more water vapor is added to the air, the saturation point eventually will be reached and some of the water vapor will condense, or become liquid. The condensation takes the form of fog cloud, dew, rain, or other precipitation. Relative humidity is the ratio of the amount of water vapor in the air to the total amount that the air can hold at the saturation point, or 100 percent humidity.

8-15. The warmer the air is the more water vapor it will hold. Therefore, cooling a volume of air will reduce its capacity to hold water vapor. If the cooling is continued, the dew point (the temperature at which moisture suspended in the atmosphere will begin to form dew will be reached, and the water vapor will condense and form clouds, dew, or fog. Readings taken from a psychrometer are used to compute relative humidity and dew point.

8-16. There are two types of instruments used aboard ship to determine relative humidity and the dew point. These two instruments look different, and a different method is used to get a reading, but both instruments will give you the same results.

8-17. A hygrometer consists of two thermometers mounted vertically in a ventilated case or box (Figure 8-4). One thermometer, known as the dry bulb, has a mercury bulb exposed directly to the air. The other thermometer, known as the wet bulb, has a bulb covered with muslin. The muslin is stretched tightly around the bulb and kept moist by a wick immersed in a small cup filled with water. The wick consists of a few threads of lamp cotton long enough to allow 2 or 3 inches of it to be coiled in the cup. The muslin is kept thoroughly moist, but not dripping, at all times.

8-18. A sling psychrometer also consists of two thermometers (Figure 8-5). They are mounted together on a single strip of material and fitted with a swivel link and handle.

8-19. One thermometer is mounted a little lower than the other and has its bulb covered with muslin. When the muslin covering is thoroughly moistened and the thermometer well ventilated, evaporation will cool the bulb of the thermometer causing it to show a lower reading than the other thermometer. With the sling psychrometer, twirling the thermometers by using the handle and swivel link causes ventilation. The uncovered thermometer shows the dry-bulb temperature reading and the muslin-covered thermometer shows the wetbulb temperature reading.

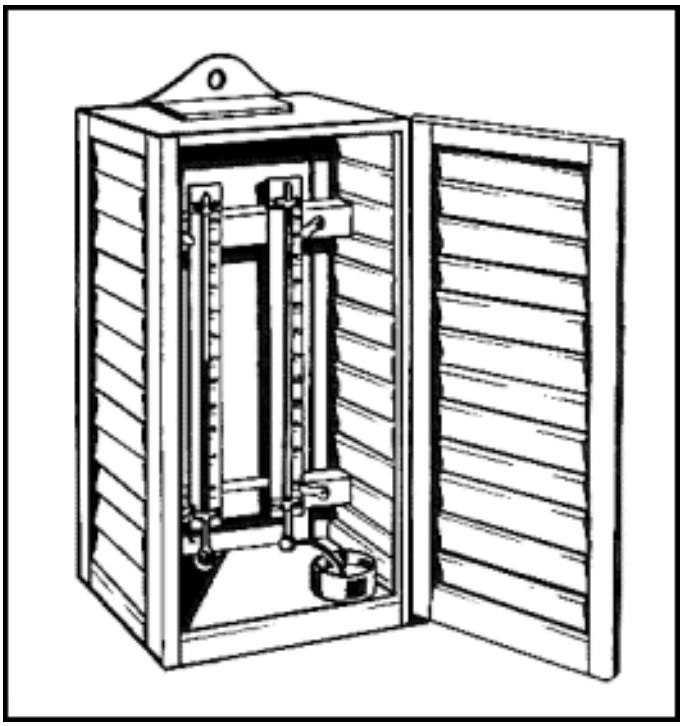


Figure 8-4. Hygrometer

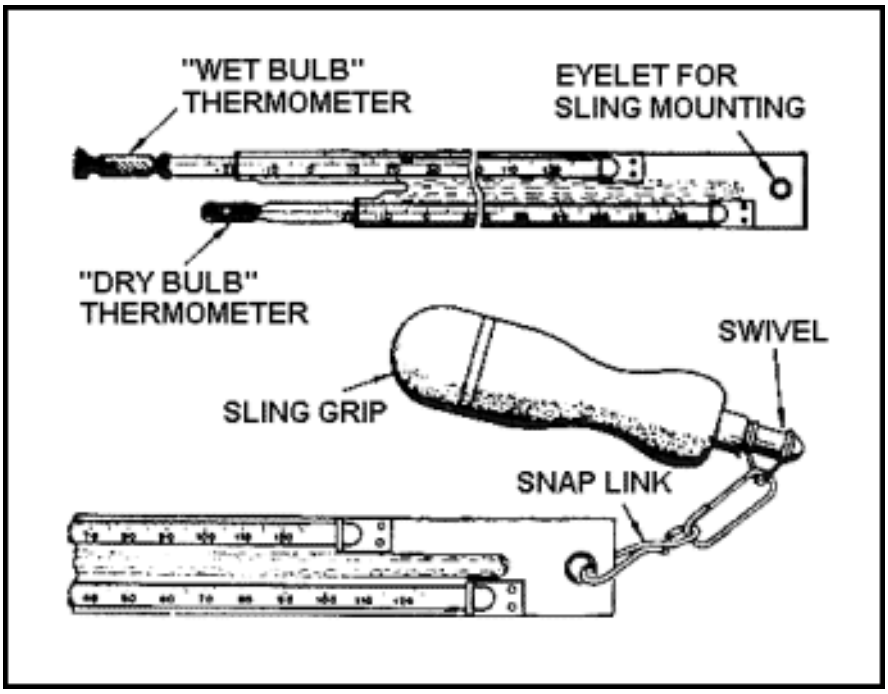


Figure 8-5. Sling Psychrometer

8-20. The dry-bulb thermometer records the temperature of the free air. The wet-bulb thermometer records what is known as the temperature of evaporation, which is always less than the temperature of free air.

Note*:* The difference between the temperature readings of the dry-bulb and the wet-bulb shows how close the air is to a state of saturation.

8-21. When the wet- and dry-bulb temperatures are known, the relative humidity of the atmosphere may be found by referring to Table 8-2 for determining relative humidity. The table may be readily understood by reviewing the following example.

8-22. Assume the temperature of the air (dry-bulb) is 60° and the temperature of evaporation (wet-bulb) is 56° ; the difference is 4° . Look in the column headed "Temperatures of the air;" find 60° and follow the same horizontal line across to the column headed "4° ." Here the figure "78" will be found. This means that the air is 78 percent saturated with water vapor. The amount of water vapor present in the atmosphere is 78 percent of the total amount it could carry at the given temperature (60°). The total amount or saturation is represented by 100 percent. Any increase in the amount of vapor beyond this point would show in the form of mist or rain. The relative humidity over the ocean’s surface is generally about 90 percent; it is even higher in the doldrums. Due to this increased moisture, the relative humidity at sea is normally higher than that cited in the above example.

8-23. The dew point spread is the number of degrees between the actual temperature (dry-bulb) and the dew point. Use Table 8-3, to find the temperature at which dew will begin to form. Example: The dry-bulb temperature is 60° and the wet-bulb reads 56° , the spread between the dry-bulb and wet-bulb reading is 4° . Using the table, read down for the value of 4° and across to the columns for 60° and you find a value of 7. This 7° tells you that there is a 7° dew point spread. This 7° spread is subtracted from the dry-bulb temperature of 60° , and that tells you that 53° is the dew point temperature.

Table 8-2. Determining Relative Humidity

TEMPERATURE OF THE AIR, DRY-BULB (THERMOMETER)	DIFFERENCE BETWEEN DRY-BULB AND WET-BULB READINGS (PERCENT)									
	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°
24	87	75	62	50	38	26				
26	88	76	65	53	42	30				
28	89	78	67	56	45	34	24			
30	90	79	68	58	48	38	28			
32	90	80	70	61	51	41	32	23		
34	90	81	72	63	53	44	35	27		
36	91	82	73	64	55	47	38	30	22	
38	92	83	75	66	57	59	42	34	26	
40	92	84	76	68	59	52	44	37	30	22
42	92	84	77	69	61	54	47	40	33	26
44	92	85	78	70	63	56	49	43	36	29
46	93	85	79	72	65	58	51	45	38	32
48	93	86	79	73	66	58	51	45	38	32
50	93	87	80	74	67	61	55	49	43	37
52	94	87	81	75	69	63	57	51	46	40
54	94	88	82	76	70	64	59	53	48	42
56	94	88	82	77	71	65	60	55	50	44
58	94	89	83	78	72	67	61	56	51	46
60	94	89	84	78	73	68	63	58	53	48
62	95	89	84	79	74	69	64	59	54	50
64	95	90	85	79	74	70	65	60	56	51
66	95	90	85	80	75	71	66	61	57	53
68	95	90	85	81	76	71	67	63	58	54
70	95	90	86	81	77	72	68	64	60	55

72	95	91	86	82	77	73	69	65	61	57
74	95	91	86	82	78	74	70	66	62	58
76	95	91	87	82	78	74	70	66	63	59
78	96	91	87	83	79	75	71	67	63	60
80	96	92	87	83	79	75	72	68	64	61
82	96	92	88	84	80	76	72	69	65	62
84	96	92	88	84	80	77	73	69	66	63
86	96	92	88	84	81	77	73	70	67	63
88	96	92	88	85	81	77	74	71	67	64
90	96	92	88	85	81	78	74	71	68	65

Table 8-3. Air Temperature: Dew Point Spread Table

Note*:* All figures are in degrees Fahrenheit at 30-inch pressure.

DIFFERENCE DRY-BULB MINUS WET-BULB	**AIR TEMPERATURE SHOWN BY DRY-BULB THERMOMETER**												
	35°	**40°**	**45°**	**50°**	**55°**	**60°**	**65°**	**70°**	**75°**	**80°**	**85°**	**90°**	**95°**
1	2	2	2	2	2	2	2	1	1	1	1	1	1
2	5	5	4	4	4	3	3	3	3	3	3	3	2
3	7	7	7	6	5	5	5	4	4	4	4	4	4
4	10	10	9	8	7	7	6	6	6	6	5	5	5
5	14	12	11	10	10	9	8	8	7	7	7	7	6
6	18	15	14	13	12	11	10	9	9	8	8	8	8
7	22	19	17	16	14	13	12	11	11	10	10	9	9
8	28	22	20	18	17	15	14	13	12	12	11	11	10
9	35	27	23	21	19	17	16	15	14	13	13	12	12

10		33	27	24	22	20	18	17	16	15	14	14	13
11		40	32	28	25	22	290	19	18	17	16	15	15
12			38	32	28	25	23	21	20	18	17	17	16
13			45	37	31	28	25	23	21	20	19	18	17
14				42	35	31	28	26	24	22	21	20	19
15				50	40	35	31	28	26	24	23	21	21

ANEMOMETER

8-24. A wind vane indicates the direction of wind. An anemometer (Figure 8-6) measures the force or speed of the wind. Aboard ship the two instruments usually are mounted together. They automatically transmit wind force and direction to indicators. These indicators are located at such places as the navigation bridge and the harbor master's office.

8-25. When a ship is moving, the indicators show apparent wind, which is a combination of true wind and ship's speed. Direction is measured in degrees from the bow of the ship and speed is measured in knots.

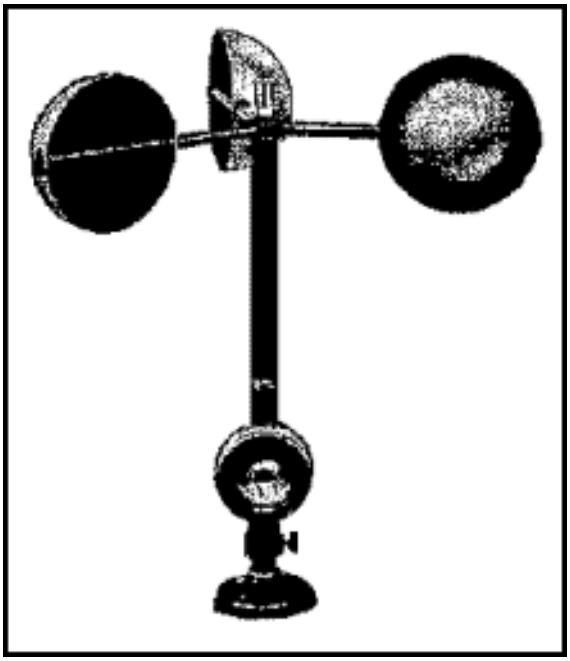


Figure 8-6. Anemometer

TRUE AND APPARENT WIND

8-26. A watercraft operator aboard a ship moving through still air will experience apparent wind, which is from dead ahead and has an apparent force equal to the ship's speed.

Note*:* Apparent wind, as measured from a moving ship, is the force and the relative direction from which the wind blows.

8-27. If the actual or true wind is 0, and the speed of the ship is 10 knots, the apparent wind from dead ahead is 10 knots. If the true wind is from dead ahead at 15 knots, and the ship's speed is 10 knots, the apparent wind is 15 + 10 = 25 knots from dead ahead. If the ship makes a 180º turn, the apparent wind is 15 - 10 = 5 knots from dead astern.

8-28. Wind vanes and anemometers measure only apparent wind. There is always the problem of converting apparent wind to true wind. There is more than one method of making a wind vector to find the true direction and true speed of the wind. The maneuvering board lends itself well to finding speed and direction of the true wind (Figure 8-7).

Note: You are always in the center of the maneuvering board.

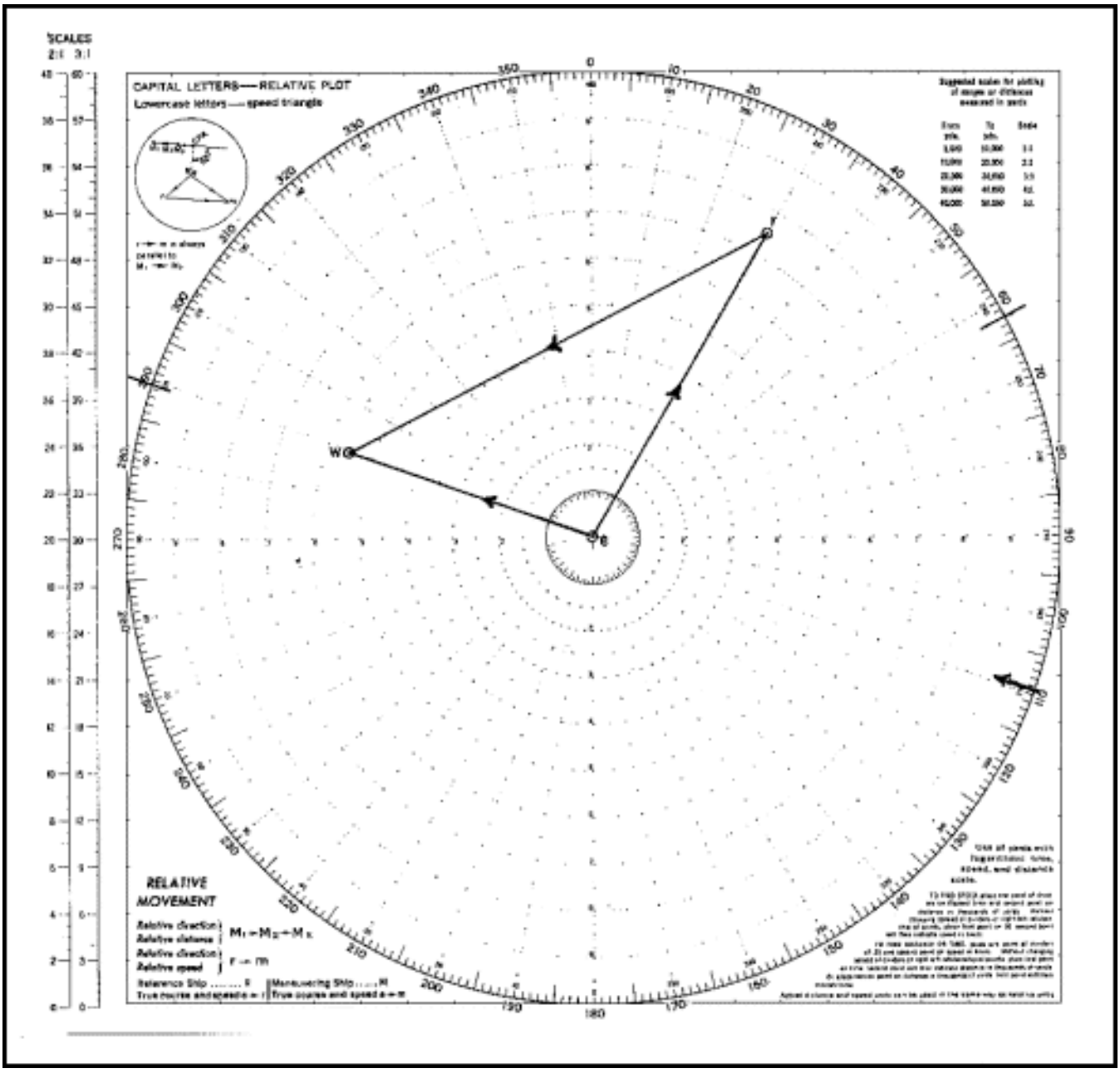


Figure 8-7. Maneuvering Board With Wind Vector

Example: Your ship is on a course of 030° , speed 15 knots. The apparent wind is from 062° , speed 20 knots.

Required: Direction and speed of the true wind.

Solution:

1. Draw the ship's true course and speed line on the plotting sheet from the center of the board in the direction of the ship's course (030°). The length of the line equals the ship's speed (15 knots) (use the 2:1 scale).

2. Label the center of the plotting sheet "e" for the ship's true course, and "r" at the end of the ship's speed line. (This line "er" is one side of the wind vector.)

3. Using parallel rules, measure the direction from which the apparent wind is blowing (062°).

4. Move this line to the tip of the ship's course and speed line "r".

5. Draw a line from "r" in the direction the apparent wind is blowing. The length of this line is equal to the speed of the apparent wind (20 knots).

6. Label the end of this line "w." (This line "rw" is the second side of the wind vector.)

7. Draw a line from the center of the maneuvering board "e" to point "w." (This line "ew" is the third side of the wind vector.)

8. Measure from "e" to "w" to find the true direction of the wind.

9. Measure the distance from "e" to "w" to find the true speed of the wind.

Solution: Direction of the true wind is from 109.5° ; speed of the true wind is 10.8 knots.

Note*:* Measure wind from the direction it is blowing.

CLOUDS

8-29. Clouds consist of condensation of water vapor and are a direct expression of the physical changes taking place in the atmosphere. They play an important part in weather forecasting.

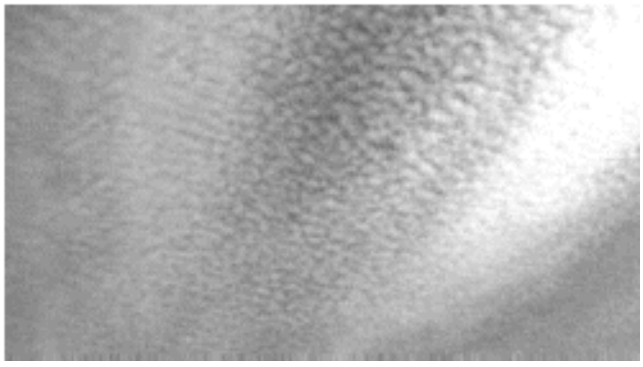
CLOUD TYPES

8-30. The cloud classifications adopted by the World Meteorological Organization are used universally. There are ten cloud types, each of which may have several variations (Figure 8-8). The ten types are grouped, according to the height of their bases above the surface of the earth, into three families.

DESCRIPTION **- CIRRUS CLOUDS ARE DETACHED CLOUDS THAT HAVE A DELICATE AND STRINGY APPEARANCE (GENERALLY WHITE, WITHOUT SHADING). THEY APPEAR IN THE MOST VARIED FORMS (SUCH AS ISOLATED TUFTS, LINES DRAWN ACROSS THE SKY, BRANCHING FEATHERLIKE PLUMES, AND CURVED LINES ENDING IN TUFTS). CIRRUS CLOUDS ARE COMPOSED OF ICE CRYSTALS; HENCE, THEIR TRANSPARENT CHARACTER DEPENDS UPON THE DEGREE OF**

SEPARATION OF THE CRYSTALS. BEFORE SUNRISE AND AFTER SUNSET, CIRRUS CLOUDS MAY STILL BE BRIGHT YELLOW OR RED. BEING HIGH-ALTITUDE CLOUDS, THEY LIGHT UP BEFORE LOWER CLOUDS AND FADE OUT MUCH LATER.

INDICATION **- CIRRUS CLOUDS OFTEN INDICATE THE DIRECTION IN WHICH A STORM IS LOCATED. WHEN THESE CLOUDS ARE SCATTERED, THEY WILL ONLY INDICATE THAT BAD WEATHER IS A GREAT DISTANCE AWAY.**



DESCRIPTION **- CIRROCUMULUS CLOUDS (COMMONLY CALLED MACKEREL SKY) LOOK LIKE RIPPLED SAND OR LIKE CIRRUS CLOUDS CONTAINING GLOBULAR MASSES OF COTTON, USUALLY WITHOUT SHADOWS.**

INDICATION **- CIRROCUMULUS CLOUDS ARE AN INDICATION THAT A STORM IS PROBABLY APPROACHING.**

DESCRIPTION **- CIRROSTRATUS CLOUDS ARE A THIN, WHITISH VEIL WHICH DOES NOT BLUR THE OUTLINES OF THE SUN OR MOON, BUT GIVES RISE TO HALOS (COLORED OR WHITISH RINGS AND AREAS AROUND THE SUN OR MOON). THE COLORED HALOS APPEAR REDDISH ON THE INSIDE EDGES. THIS HALO PHENOMENON, WHICH IS NEARLY ALWAYS PRODUCED IN A LAYER OF CIRROSTRATUS CLOUDS, DISTINGUISHES THEM FROM STRATUS CLOUDS (A MILKY VEIL OF FOG) AND ALTOSTRATUS CLOUDS.**

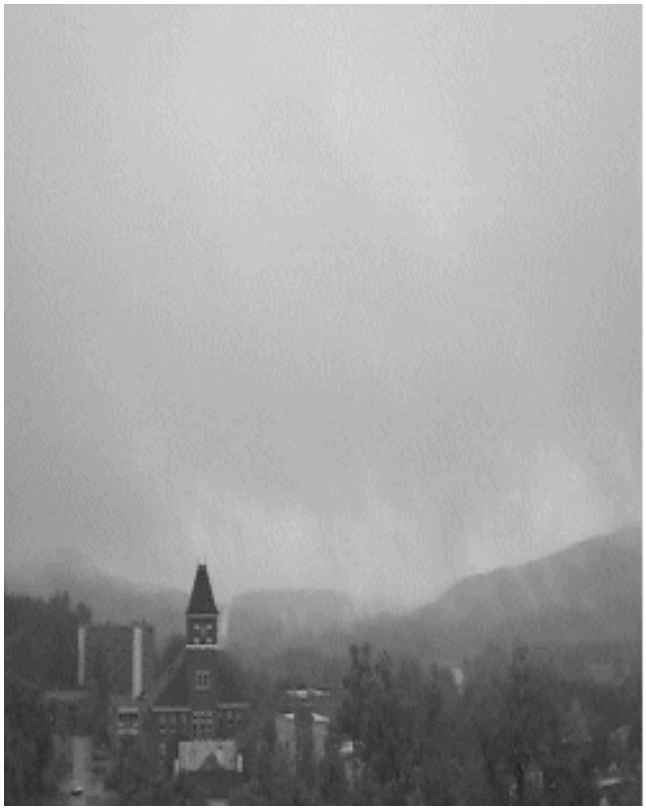
INDICATION **- THE APPEARANCE OF CIRROSTRATUS CLOUDS IS A GOOD INDICATION OF RAIN DUE TO THE APPROACHING OF A WARM FRONT OR OCCLUDED FRONT.**

DESCRIPTION **- ALTOCUMULUS CLOUDS ARE A LAYER (OR PATCHES) OF CLOUDS COMPOSED OF FLATTENED GLOBULAR MASSES, THE SMALLEST ELEMENTS OF THE REGULARLY ARRANGED LAYER BEING FAIRLY SMALL AND THIN, WITH OR WITHOUT SHADING. THE BALLS OR PATCHES USUALLY ARE ARRANGED IN GROUPS, EITHER IN LINES OR WAVES. SOMETIMES A CORONA (SIMILAR TO A HALO, BUT WITH THE REDDISH COLOR ON THE OUTSIDE EDGE) MAY BE SEEN ON ALTOCUMULUS CLOUDS. THIS CLOUD FORM DIFFERS FROM THE CIRROCUMULUS BY GENERALLY HAVING LARGER MASSES, BY CASTING SHADOWS, AND BY HAVING NO CONNECTION WITH THE CIRRUS FORMS.**

INDICATION **- WHEN ALTOCUMULUS CLOUDS ARE FOLLOWED BY CIRROCUMULUS, A THUNDERSTORM IS NEARING.**

DESCRIPTION **- LOOKING LIKE A THICK CIRROSTRATUS, BUT WITHOUT HALO PHENOMENA, THE ALTOSTRATUS IS A FIBROUS VEIL OR SHEET, GRAY OR BLUISH IN COLOR. SOMETIMES THE SUN OR MOON IS OBSCURED COMPLETELY AND AT OTHER TIMES, THEY CAN BE VAGUELY SEEN AS THROUGH GROUND GLASS.**

INDICATION **- LIGHT RAIN OR HEAVY SNOW MAY FALL FROM A CLOUD LAYER THAT IS DEFINITELY ALTOSTRATUS.**



DESCRIPTION **- NIMBOSTRATUS CLOUDS ARE A DARK GRAY, AMORPHOUS (SHAPELESS) RAINY LAYER OF CLOUD. THEY USUALLY ARE NEARLY UNIFORM AND FEEBLY ILLUMINATED, SEEMINGLY FROM WITHIN. WHEN PRECIPITATION OCCURS, IT IS IN THE FORM OF CONTINUOUS RAIN OR SNOW, BUT NIMBOSTRATUS MAY OCCUR WITHOUT RAIN OR SNOW. OFTEN THERE IS PRECIPITATION THAT DOES NOT REACH THE GROUND, IN WHICH CASE THE BASE OF THE CLOUD USUALLY LOOKS WET BECAUSE OF THE TRAILING PRECIPITATION. IN MOST INSTANCES, THE NIMBOSTRATUS EVOLVES FROM AN ALTOSTRATUS, WHICH GROWS THICKER AND WHOSE BASE BECOMES LOWER UNTIL IT BECOMES A LAYER OF NIMBOSTRATUS. WHEN PRECIPITATION FALLS FOR A CONTINUED PERIOD OF TIME, THE BASE OF THE CLOUD MAY LOWER INTO THE LOW-CLOUD FAMILY RANGE.**

INDICATION **- THESE ARE TRUE RAIN CLOUDS. THESE CLOUDS ARE OF LITTLE HELP IN FORECASTING WEATHER SINCE THE BAD WEATHER IS ALREADY UPON YOU.**

DESCRIPTION **- STRATOCUMULUS CLOUDS ARE A LAYER (OR PATCHES) OF CLOUDS COMPOSED OF GLOBULAR MASSES OR ROLLS. THE SMALLEST OF THE REGULARLY ARRANGED ELEMENTS ARE FAIRLY LARGE. THEY ARE SOFT AND GRAY WITH DARK SPOTS.**

INDICATION **- UNDERNEATH STRATOCUMULUS WAVES OR ROLLS, STRONG WINDS OCCUR. UNDER THE THICK PARTS, STRONG UP-CURRENTS RISE. ABOVE THE CLOUD LAYER THE AIR IS SMOOTH, BUT IT IS TURBULENT BELOW AND WITHIN THE LAYER. THESE CLOUDS DO NOT, AS A RULE, PRODUCE ANYTHING BUT LIGHT RAIN OR SNOW.**

DESCRIPTION **- STRATUS CLOUDS ARE A LOW, UNIFORM LAYER OF CLOUDS, RESEMBLING FOG, BUT NOT RESTING ON THE GROUND. A VEIL OF STRATUS GIVES THE SKY A HAZY APPEARANCE.**

INDICATION **- USUALLY ONLY DRIZZLE IS ASSOCIATED WITH STRATUS. WHEN THERE IS NO PRECIPITATION, THE STRATUS CLOUD FORM APPEARS DRIER THAN OTHER SIMILAR FORMS, AND IT SHOWS SOME CONTRASTS AND SOME LIGHTER TRANSPARENT PARTS. THESE CLOUDS DO NOT SIGNIFY ANY POTENTIAL DANGER.**

DESCRIPTION **- CUMULUS CLOUDS ARE DENSE CLOUDS WITH VERTICAL DEVELOPMENT. THEIR UPPER SURFACES ARE DOME-SHAPED AND EXHIBIT ROUNDED PROJECTIONS AND THEIR BASES ARE NEARLY HORIZONTAL. FRACTOCUMULUS CLOUDS RESEMBLE RAGGED CUMULUS CLOUDS IN WHICH THE DIFFERENT PARTS SHOW CONSTANT CHANGE.**

INDICATION **- STRONG UPDRAFTS EXIST UNDER AND WITHIN ALL CUMULUS FORMATIONS. IN FACT, CUMULUS CLOUDS, LIKE OTHER FORMS OF VERTICALLY DEVELOPED CLOUDS, ARE CAUSED BY UPDRAFTS. THESE CLOUDS, WHEN DETACHED AND WITH LITTLE VERTICAL BUILDUP, ARE TERMED FAIR WEATHER CLOUDS.**

DESCRIPTION **- CUMULONIMBUS CLOUDS ARE HEAVY MASSES OF CLOUD, WITH TOWERING VERTICAL DEVELOPMENT, WHOSE CUMULIFORM SUMMITS RESEMBLE MOUNTAINS OR TOWERS. THEIR UPPER PARTS HAVE A FIBROUS TEXTURE AND OFTEN THEY SPREAD OUT IN THE SHAPE OF AN ANVIL.**

INDICATION **- CUMULONIMBUS CLOUDS ARE GENERALLY ASSOCIATED WITH SHOWERS OF RAIN OR SNOW. THEY SOMETIMES PRODUCE HAIL. THEY ARE ALSO OFTEN ASSOCIATED WITH THUNDERSTORMS. BAD WEATHER CAN BE EXPECTED IN THE IMMEDIATE AREA OF THESE CLOUDS.**

Figure 8-8. Basic Cloud Formations and Indications

CLOUD FORMS

8-31. The high-cloud family contains clouds with a mean level of 20,000 feet. These include:

- **Cirrus (Ci).** Thin featherlike clouds.
- **Cirrocumulus (Cc).** Regular groupings of small white rounded masses.
- **Cirrostratus (Cs).** Very thin, high sheet cloud, darker than cirrus.

The middle-cloud family contains clouds that have bases lying between 6,500 feet and 20,000 feet. They are:

- **Altocumulus (Ac).** Clouds that looks like the wool on the back of a sheep.
- **Altostratus (As).** Medium high, uniform sheet cloud.

8-32. The low-cloud family contains clouds with bases lying from 6,500 feet at the upper level down to near the earth's surface. The vertical extent of the cumulus and cumulonimbus is often so great that the tips may reach into the middle- and high-cloud family levels. The clouds in this family include:

- **Nimbostratus (Ns).** Low, shapeless, dark gray, rainy cloud layer.
- **Stratocumulus (Sc).** Globular masses or rolls.
- **Stratus (St).** Low, uniform sheet cloud.
- **Cumulus (Cu).** Dense, dome-shaped, puffy-looking clouds.
- **Cumulonimbus (Cb).** Cauliflower, towering clouds with cirrus veils on top.

8-33. Although you will never see all types of clouds at the same time, quite often you may see two or three layers of clouds of different types.

BASIC ELEMENTS OF WEATHER

8-34. Weather is the state of the earth's atmosphere with respect to temperature, humidity, precipitation, visibility, cloudiness, and other factors. All weather may be traced to the effect of the sun on the earth. Most changes in weather involve large-scale horizontal motion of air. Weather is of vital importance to the mariner. The wind and state of the sea affect dead reckoning and reduced visibility limits piloting. The state of the atmosphere affects electronic navigation and radio communication. If the skies are overcast, celestial observations are not available; and under certain conditions refraction and dip are disturbed. When wind was the primary motive power, knowledge of the areas of favorable winds was of great importance. Modern vessels are still affected considerably by wind and sea.

PREVAILING WINDS

8-35. Uneven heating of the earth’s surface cause differences in atmospheric pressure which, in turn, causes winds. As air is warmed, it expands and becomes less dense. When it cools, it contracts and becomes dense. This results in higher atmospheric pressure. Equatorial regions of the earth receive considerably more heat than the polar areas. This excess of heat at the equator is the basis of a definite world pattern. The prevailing winds of the regions of the world are described below (see Figure 8-9).

- **Doldrums.** The low pressure belt extending around the earth in the vicinity of the geographical equator. They shift slightly north or south with the seasons. They are characterized by light winds, cloudiness, afternoon thunderstorms and showers, and a depressing humidity.
- **Trade winds.** The relatively permanent winds on each side of the equatorial doldrums that blow from the northeast in the Northern Hemisphere and from the southeast in the Southern Hemisphere.

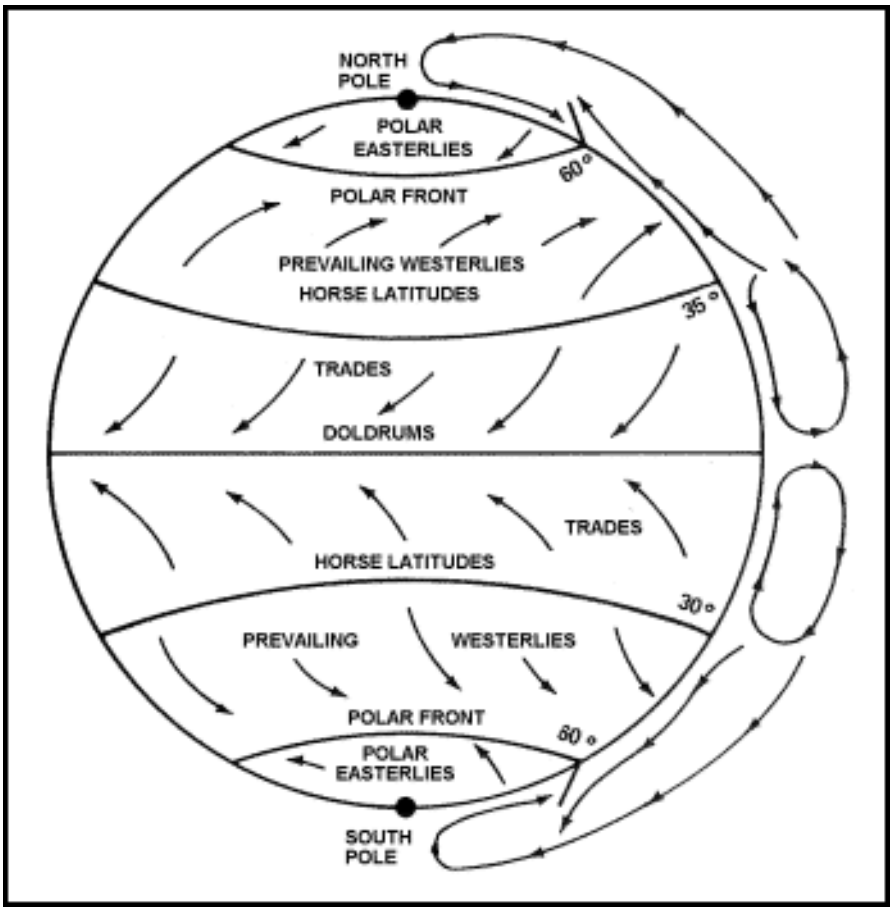


Figure 8-9. The General Pattern of World Winds

8-36. If the earth did not rotate, the trades would blow due north and south. But the Coriolis force, in a manner of speaking, draws these winds off their course to a westerly direction, causing the northerly winds to become the northeast trades, and the southerly winds, the southeast trades.

- **Horse latitudes.** These are zones of high atmospheric pressure on the poleward side of each trade wind where calms and variable winds prevail. The conditions are unlike those in the doldrums in that the air is fresh and clear and calms are not of long duration.
- **Prevailing westerlies.** The prevailing westerly winds (winds blowing from the west) are those on the poleward sides of the horse latitudes.

8-37. Air moving from the high-latitude sides of the same high-pressure belts toward the poles produces the prevailing westerlies. Here again the rotation of the earth causes the wind to deviate from the north-south direction. The deviation is opposite from that of the trades simply because these winds blow toward the poles while the trades blow toward the equator.

8-38. In the Southern Hemisphere, westerlies are persistent throughout the year and blow from nearly due west because the area is largely uninterrupted ocean. However, in the Northern Hemisphere, large land masses present frictional blocks and break up the continuity of the highs and lows. Therefore, northern westerlies vary considerably in strength and direction.

8-39. During the winter, well developed lows over the North Pacific and North Atlantic cause the storm weather with which you may be familiar.

8-40. In the Northern Hemisphere, the air masses of the converging polar northeasterlies do not mingle readily with the southwesterlies of the temperature zone where they meet. Instead, the cold mass underruns the warm air from the south. The surface between these two air masses is known as the polar front. (Action similar to this occurs in the Southern Hemisphere.) The average position of this irregular front is 60° north latitude. It is important to realize that the polar front shifts. For example, in the Northern Hemisphere, it may extend as far south as Florida and farther north than the 60th parallel.

8-41. The winds of the polar belt are generally less well known than the trades and the prevailing westerlies. Those who have taken part in any of the polar belt expeditions can attest to their strong and blustery winds. Because of the rotation of the earth, these intense, persistent winds are, respectively, northeasterlies and southeasterlies in the Northern and Southern Hemispheres.

LAND AND SEA BREEZES

8-42. The cause of land and sea breezes is by the alternating heating and cooling of coastal land and sea areas. The land, particularly in summer, is warmer than the sea by day and cooler than the sea by night. Therefore, there is a variation in atmospheric pressure over adjoining land and sea areas. This causes a system of littoral breezes which blow landward during the day and seaward during the night. These land and sea breezes usually penetrate to a distance of about 30 miles onshore and offshore, and extend to a height of a few hundred feet.

8-43. In the morning hours as the land warms, the sea breeze begins from 0900 to 1100. In the late afternoon, it dies away. In the evening, the land breeze springs up and blows gently out to sea until morning. In the tropics this process is repeated day after day with great regularity. In higher latitudes the land and sea breezes are often altered by winds of cyclonic origin. In many harbor areas or at the mouths of large river systems, these summer afternoon or evening breezes give rise to sudden squalls.

MONSOONS

8-44. Local conditions frequently interrupts the general pattern of belts of pressure and winds. One of the most pronounced and well known of these interruptions is the continental heating and cooling that produces monsoons.

8-45. When a sailor hears the word "monsoon," he naturally thinks of Asia, but monsoons affect all continents. However, the degree of influence varies from slight deflection of the winds over the smaller continents to absolute dominance in Asia where the pressure pattern is sufficiently distorted between winter and summer to produce opposite wind directions.

8-46. So vast is the summer low over Asia, that it completely dominates the Indian Ocean as far south as the Cape of Good Hope and east into the South Pacific. Its influence is felt even in the South Atlantic, from where winds blow across the Congo in Africa on into Asia.

8-47. Winds from the Indian Ocean, Australia, and the western part of the South Pacific cross the equator, heating and picking up water vapor as they go. Low air pressure causes the air to rise and rising air pressure, cools to the dew point. The result is heavy squalls, thunderstorms, and the torrential rainfall of the summer or wet monsoon.

8-48. Monsoons interrupt the normal pattern of the trades and prevailing westerlies. Just which direction the wind will blow in any area will depend, for the most part, on the direction of the low that influences that area. During the summer monsoon season is when most typhoons occur.

PRESSURE GRADIENT

8-49. Lines drawn through points on the earth having the same atmospheric pressure are known as isobars. These lines of equal pressure enclose areas of either high or low pressure. A pressure gradient is the space found between isobars (Figure 8-10). Pressure gradient indicates an increase or decrease in atmospheric pressure per unit distance between isobars.

8-50. Isobars are spaced closer in the eastern portion of the high-pressure area than in the western section. When isobars are close, the pressure gradient is said to be strong or steep; when they are far apart, it is called weak. Weather in strong or steep pressure gradients is normally subject to sudden changes with varying wind force and direction. In weak gradient areas, the weather changes are gradual and predictable.

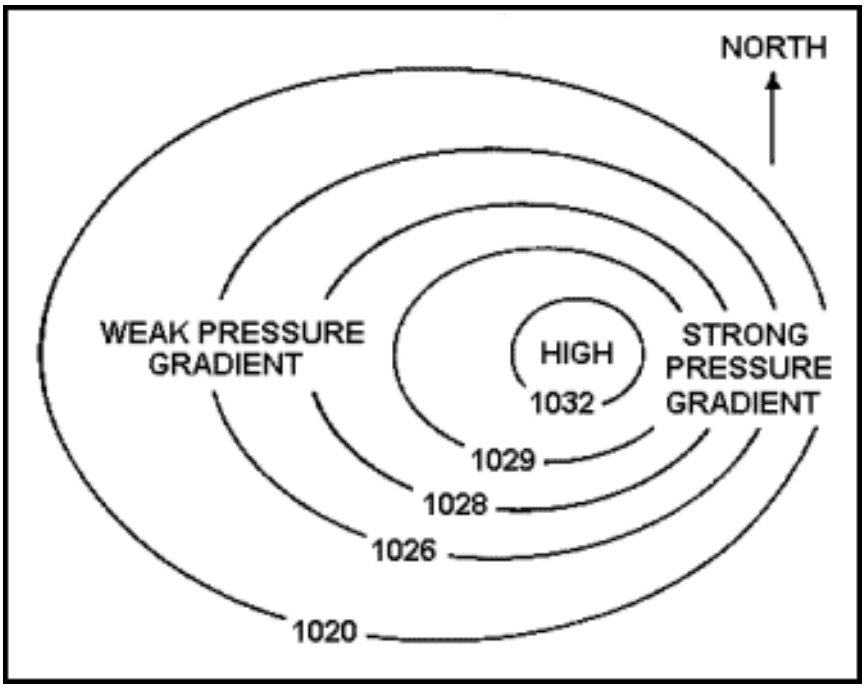


Figure 8-10. Pressure Gradients on a Weather Map

WIND VELOCITY AND DIRECTION

8-51. The pressure gradient determines the velocity of the wind. Strong gradients cause strong winds, while weak gradients result in gentle winds. When the pressure is about the same over a large area, the wind, if any, is slight. Wind direction depends mainly on the pressure gradient and the rotation of the earth. Wind direction is named by the direction from which it blows.

8-52. The direction and force of air flow over a long distance are diverted by the initial velocity generated by the rotation of the earth. This has no effect on our weather condition, except possibly on the movement of storms. Wind tends to blow parallel to isobars. For example, if a person is in the Northern Hemisphere facing away from the surface wind, the low pressure is toward their left and the high pressure is toward their right. If the person were in the Southern Hemisphere the effect would be the opposite.

TROPICAL CYCLONES

8-53. Near the equator lies a low-pressure belt where winds are either light and variable or nonexistent. There are frequent thunderstorms and squalls (rain falls in sheets). This belt of baffling winds and rain is called the doldrums and is the breeding place of the most violent of all storms--tropical cyclones.

8-54. In the Atlantic, tropical cyclones are known as hurricanes; in the Pacific, as typhoons; in Australia, as willy willies; and in the Philippines, as baguios. All are alike in character. The use of the term "hurricane" will apply to all of these systems.

8-55. Hurricanes are circular or elliptical whirling eddies of air up to 400 miles in diameter. Wind speeds reach as high as 150 or more knots near the center, but decrease toward the edges. In the Northern Hemisphere, the wind blows in a counterclockwise direction (Figure 8-11); in the Southern Hemisphere, it blows in a clockwise direction. Typical of these storms is a calm at the center or eye, which may be 5 to 40 miles in diameter. When the eye of a storm passes over an area, wind that has been violent decreases to a much lower speed and at times become calm and precipitation stops. When the eye has passed, the winds come from the opposite direction.

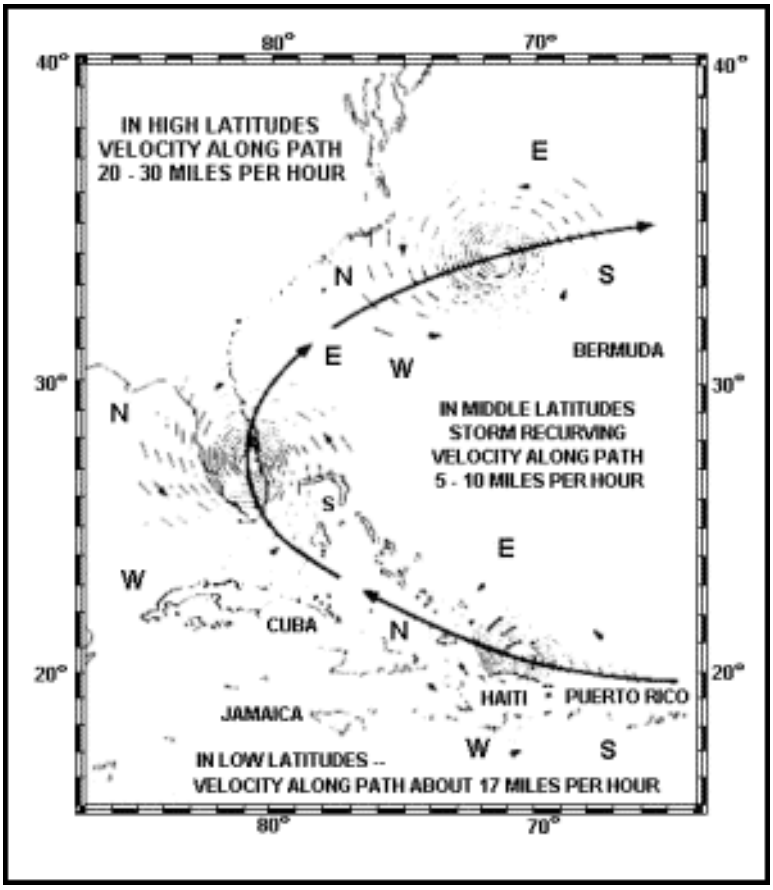


Figure 8-11. Hurricane Track in Northern Hemisphere

8-56. The actual cause of the formation of hurricanes is unknown. Soon after they form, they begin to move at speeds from 5 to 20 miles per hour. In the Northern Hemisphere, they generally follow a slightly curving path to the north and west until reaching the horse latitudes. The hurricanes then re-curve to the northeast, pick up speed over the surface, become less violent, and finally blow themselves out. In the Southern Hemisphere, the general path of hurricanes is first to the southwest and then they re-curve to the southeast. The life of a hurricane is about 10 days.

HURRICANE INDICATIONS

8-57. Hurricanes are usually preceded by a day of good visibility. Temperature and pressure are slightly higher than normal. Cirrus clouds appear. Wind changes direction and increases in force; sea swells increase their period. At night, the temperature is generally lower than normal. During the summer and fall in the Gulf of Mexico and the Caribbean Sea, the bearing of the storm is reliably indicated by the direction from which the swells come. In any other area this sign is unreliable.

8-58. In the tropics, a distinct drop in barometer pressure (diurnal change considered) of 0.10 inches signifies the approach of a hurricane. Anywhere else in the world, such a drop may indicate any type of storm.

8-59. Upon the approach of a hurricane, cirrostratus clouds replace the common at sunrise and sunset. As the storm draws closer, a bank of clouds appears on the horizon toward the storm. A light and gusty wind blows from your left as you face the storm center. The barometer continues to fall and at times is unsteady. Clouds darken and cover the entire sky. Wind increases and heavy seas develop.

DANGEROUS AND NAVIGABLE SEMICIRCLES

8-60. In the Northern Hemisphere, if you face the direction toward which a hurricane is moving, the portion of the storm on your right is the dangerous semicircle, the portion on your left is the navigable semicircle. In Figure 8-11 the arrows show the direction of the wind. It is apparent that a vessel in the dangerous semicircle would tend to be blown into the path of the storm. A vessel in the navigable semicircle would probably be blown to a position behind the storm. It is also clear that speed of the wind in the right semicircle would be greater as the speed of the storm over the surface would be added to the speed of the wind. In the left semicircle, speed of the storm would be subtracted from speed of the wind; therefore, wind and sea would be less violent.

8-61. Face the wind to locate the center of a storm, face the wind. The center lies about 113° to your right.

8-62. Buys Ballot’s law is useful in determining the direction of a storm. The law says that if you face the wind, the low-pressure area (the storm center) lies to your right. Actually it could be up to 130° to your right.

STORM WARNING SIGNALS

8-63. Whenever winds dangerous to navigation are forecast for an area, Navy and Coast Guard stations and yacht clubs hoist, in some conspicuous place, flags by day and lanterns at night to warn all seamen of the expected conditions. Figure 8-12 shows the types of signals and when to use each one.

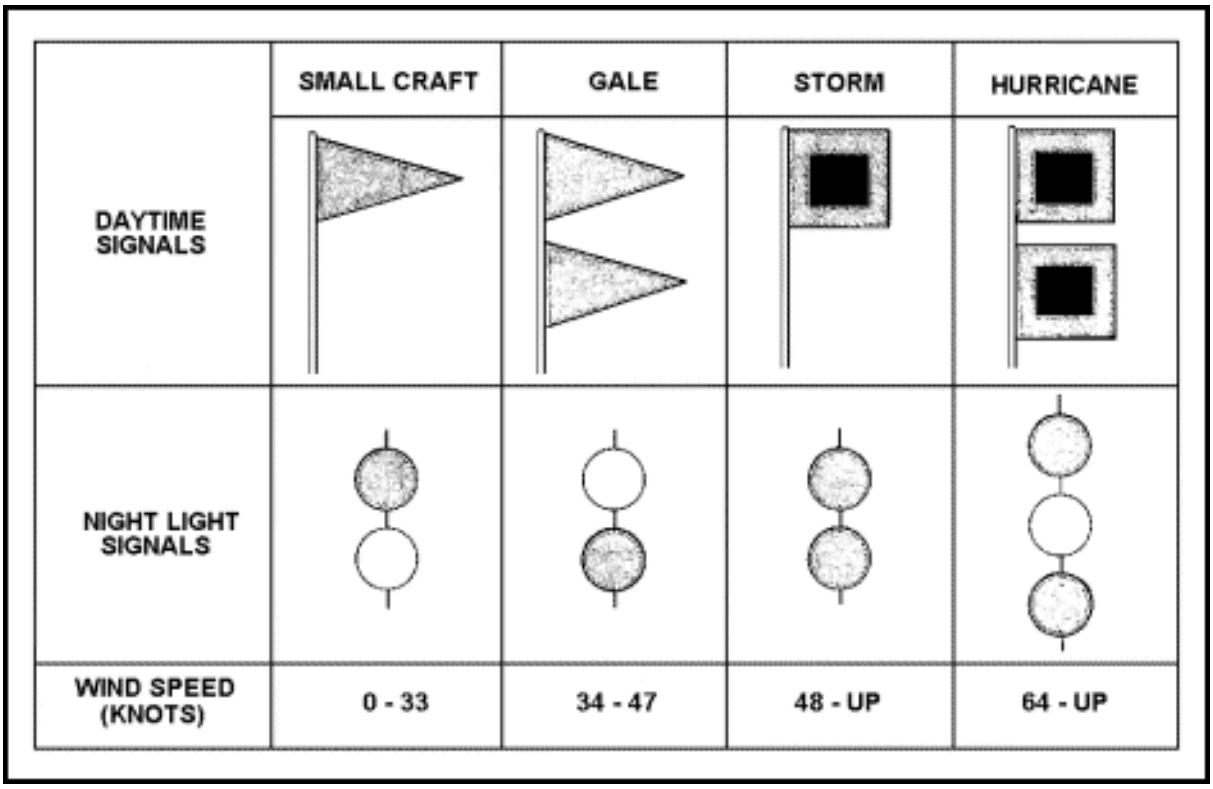


Figure 8-12. Storm Warning Signals

8-64. Watercraft operators should be aware of the significance of these signals. Even the small craft warning informs of conditions that are potentially dangerous to boats, including the relatively large ones used by the Navy.

8-65. Note that the definition of "storm" does not include an upper limit for wind unless the storm originated in the tropics, in which case the upper limit is 63 knots. Tropical storms with winds of greater speeds, of course, are hurricanes. Should no warnings be visible, you can estimate wind speeds by using the information contained in Table 8-4.

FOG

8-66. Fog, which may be defined as a cloud on the earth's surface, consists of water droplets or ice particles suspended in the air. It usually forms when the surface of the earth cools the air above to the dew point (Figure 8-13).

8-67. Radiation fog occurs at night. It only forms when the land cools; which in turn, cools the air above.

8-68. Advection fog occurs when warm air flows over a cool surface (for example, over a cool ocean current). Advection fog can form only in regions where marked temperature contrasts exist within a short distance of each other and only when the wind blows from the warm area toward the cold area.

BEAU-FORT NO.	KNOTS	DESCRIP-TIVE TERMS	EFFECT AT SEA	APPROX EQUIVALENT SEA DISTURBANCE SCALE IN OPEN SEA		
				CODE FIG	DESCRIP-TION	MEAN HT OF WAVES IN FEET
0	Less than 1	Calm	Sea like a mirror. Smoke rises vertically.	0	Calm (glassy)	1/2
1	1-3	Light air	Ripples with the appearance of scales are formed but without foam crests. Smoke drifts from stack.	1	Calm (rippled)	1/2
2	4-6	Light breeze	Small wavelets, still short but more pronounced; crests have a glassy appearance and do not break. Wind felt on face.	1		1
3	7-10	Gentle breeze	Large wavelets. Crests begin to break. Foam of glassy appearance. Perhaps scattered whitecaps. Wind extends light flag.	2	Smooth (wavelets)	2 1/2
4	11-16	Moderate breeze	Small waves, becoming longer; fairly frequent whitecaps. Wind raises dust, loose paper.	3	Slight	5
5	17-21	Fresh breeze	Moderate waves, taking a more pronounced long form; many whitecaps are formed (chance of some spray). Flag waves and snaps briskly.	4	Moderate	9
6	22-27	Strong breeze	Large waves begin to form; the white foam crests are more extensive everywhere (probably some spray). Whistling in rigging.	5	Rough	14
7	28-33	Moderate gale	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind. (Spray begins to be seen.) Inconvenient to walk into wind.	6	Very rough	19
8	34-40	Fresh gale	Moderately high waves of greater length; edges of crests break into spray. The foam is blown in well-marked streaks along the direction of the wind. Difficult to walk into wind.	7	High	25
9	41-47	Strong gale	High waves. Dense streaks of foam along the direction of wind. Sea begins to roll. Spray may affect visibility.	7		31
10	48-55	Whole gale	Very high waves with long overhanging crests. The resulting foam in great patches is blown in dense white streaks along the direction of the wind. On the whole, the surface of the sea takes a white appearance. The rolling of the sea becomes heavy and shocklike. Visibility is affected.	8	Very high	37
11	56-63	Storm	Exceptionally high waves. (Small and medium-sized ships might be for a long time lost to view behind waves.) The sea is completely covered with long white patches of foam lying along the direction of the wind. Everywhere the edges of the wave crests are blown in froth. Visibility affected.	9	Phenomenal	45 or more
12	Above 64	Hurricane	The air is filled with foam and spray. Sea completely white with driving spray; visibility very seriously affected.	9		

Table 8-4. Table of Beaufort Wind Scale and Correlative Sea Disturbance Scale

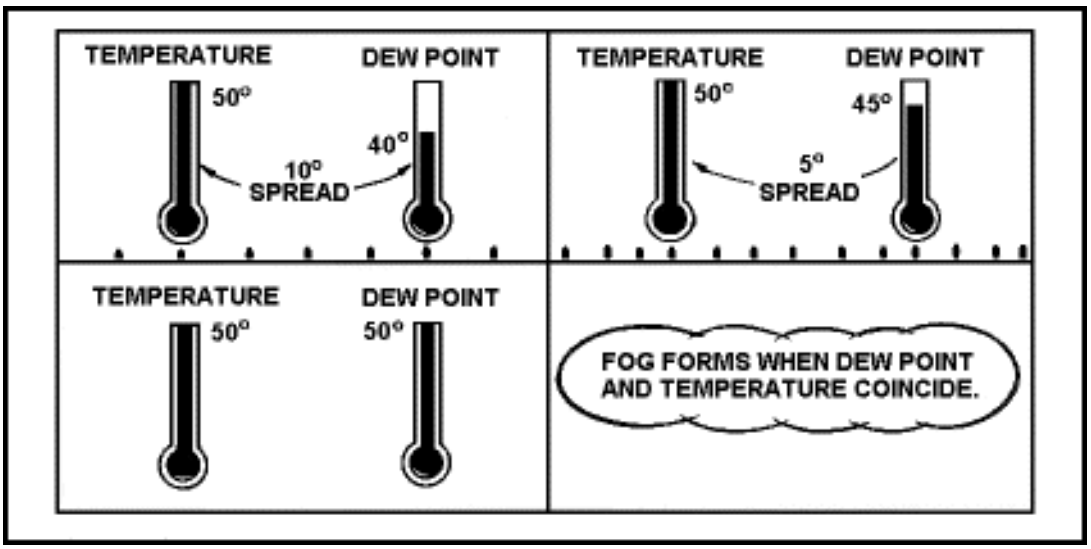


Figure 8-13. The Formation of Fog

8-69. Steam fog is a type of advection fog. It occurs when cool air blows over a warm surface. Evaporation from the warm surface easily saturates the cool air, causing fog, which rises from the surface like smoke.

8-70. Frontal fog occurs in the cold air mass of a front. As warm rain falls into the cold air, it evaporates, saturating the cool air and causing the fog. Although the cool air already is saturated, evaporation from the rain continues as long as the temperature of the raindrops is higher than the temperature of the air. Frontal fogs are rarely caused by cold fronts because they usually move so rapidly and have such narrow bands of precipitation. Warm fronts, on the other hand, cause deep and long-lasting fogs that are considered the worst type to encounter.

FRONTS

8-71. A front is the surface between warm and cold air masses. At times, air will lie over a vast cold or warm region long enough for the air to become fairly uniform in temperature and humidity. These air masses, in time, begin to move at varying rates of speed. Frequently, one air mass will meet or overtake another mass that is warmer or colder. These meetings are called fronts. When a cold air mass tends to underrun and displace a warm air mass, the front is called a cold front. When a warm air mass overrides or replaces a cold air mass, it is a warm front. Figure 8-14 shows a simplified cross-sectional diagram of cold and warm fronts.

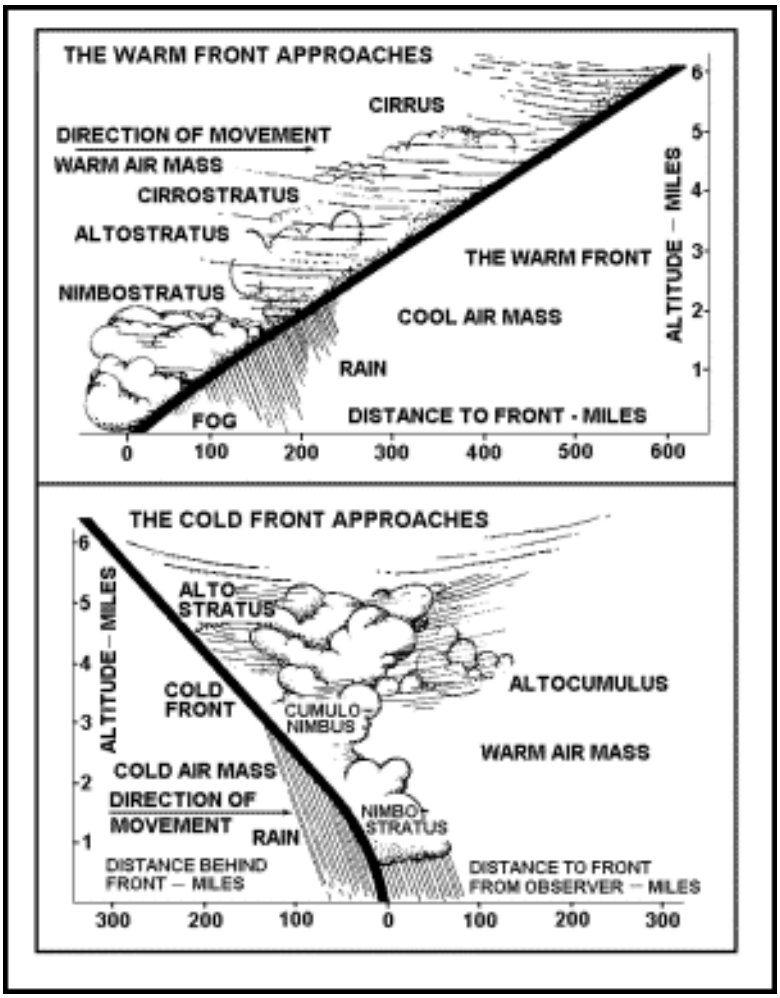


Figure 8-14. Characteristics of Warm and Cold Fronts

8-72. Sometimes a cold front will overtake a warm front, forming an occluded front or an occlusion. Two different occlusions are noted (depending on the temperature differences). If the overtaking cold air is warmer than the cold air ahead of the warm front, a warm-type occlusion is formed (Figure 8-15). If the overtaking cold air is colder than the other, a cold-type occlusion is formed (Figure 8-16).

8-73. There are three types of fronts: cold, warm, and occluded. An occluded front is a mingling of the first two fronts. All occluded fronts should be watched closely, because it is along these fronts that the most adverse weather conditions occur. When a ship passes through a front, a noticeable change in the weather may be seen. This is especially true when passing through a cold front, because a cold front is sometimes accompanied by a sudden shift in the wind and a hard squall from a westerly quarter.

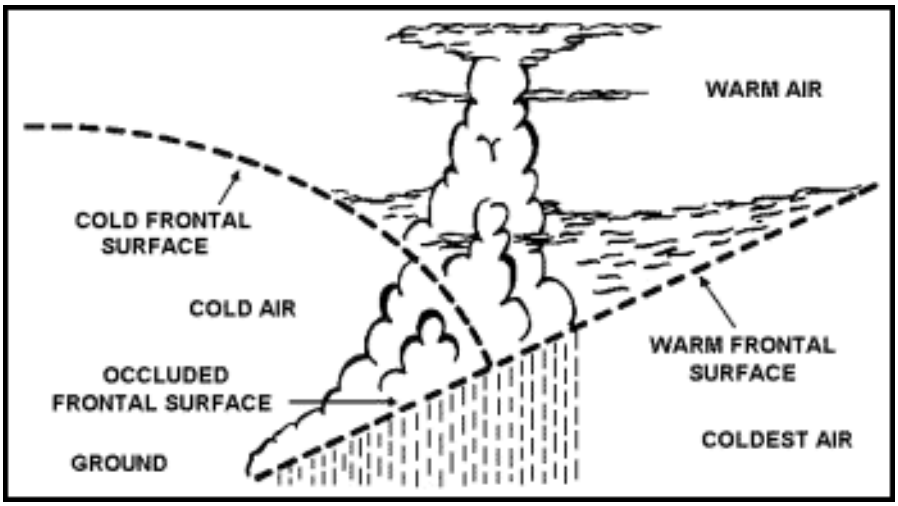


Figure 8-15. Warm-Front Occlusion

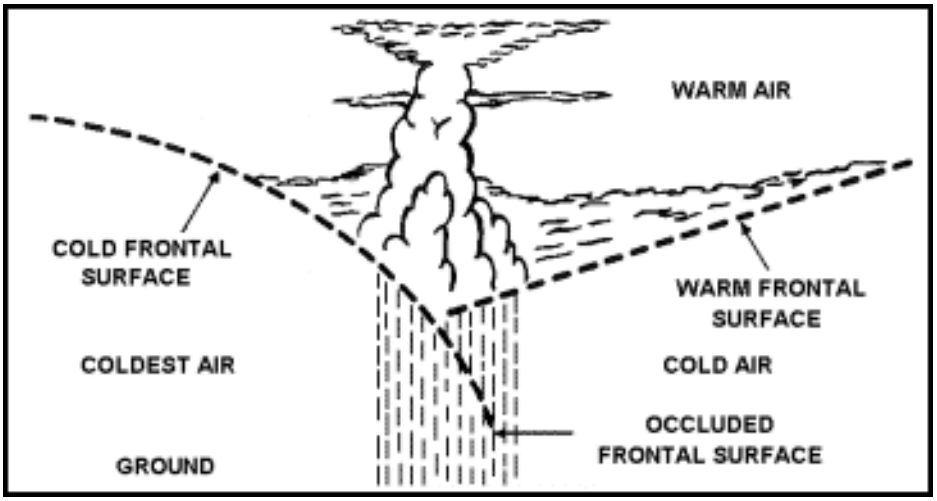


Figure 8-16. Cold-Front Occlusion

Chapter 9

Shipboard Communications

Ship-to-ship and ship-to-shore communications are vital for shipboard operations. These communications can be by radio, radiotelephone, flag hoists, and blinker lights. The watercraft operator and mate aboard ship must be thoroughly familiar with their communication equipment. Shipboard communications are essential in normal operations, distress situations, and/or sea-air rescue missions. This chapter covers communications by radiotelephone, blinker, flag hoists, and the international distress signals.

SHIPBOARD TACTICAL AND MARINE RADIOS

9-1. All Army vessels are equipped with some kind of radio which is easy to operate. This paragraph covers the most common radio sets used aboard Army vessels. Even though the nature of radio communications has changed rapidly in the last few years, you will find it is as easy to talk on the radio as it is on the telephone.

TACTICAL RADIOS

9-2. Tactical radios are those used to communicate with your higher HQ and with other Army vessels. You will have either the AN/VRC-46 or the AN/VRC-47 aboard your vessel.

9-3. The AN/VRC-46 (Figure 9-1) is an FM radio set providing two-way radiotelephone communications (sea-to-sea, air to-sea, or land-to-sea service) within the frequency range of 30 to 79.95 MHz. It has a transmitter power output of 35 watts and it weighs 85 pounds. It has an output power requirement of 10 amperes maximum at 25.5 volts DC.

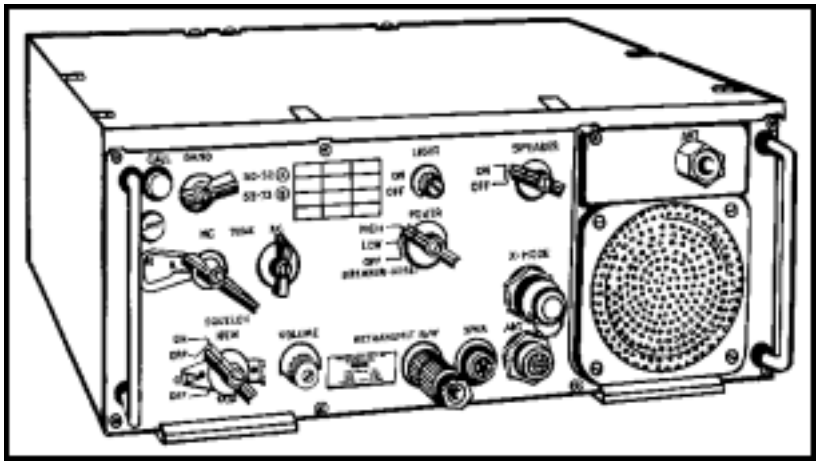


Figure 9-1. AN/VRC-46 Radio Set

9-4. The AN/VRC-47 (Figure 9-2) is an FM radio set providing two-way radiotelephone communications with Army land-based units, Army aircraft, and other Army vessels. It covers the frequency range of 30 to 79.95 MHz with a transmitter power output of 35 watts. It has an auxiliary receiver, which requires a separate antenna system, to monitor a frequency channel other than that normally used for operation. The total power input requirement is 10 amperes maximum at 25.5 volts DC. The set weighs about 105 pounds. The AN/VRC-47 is normally used only on command vessels or for certain special marine applications.

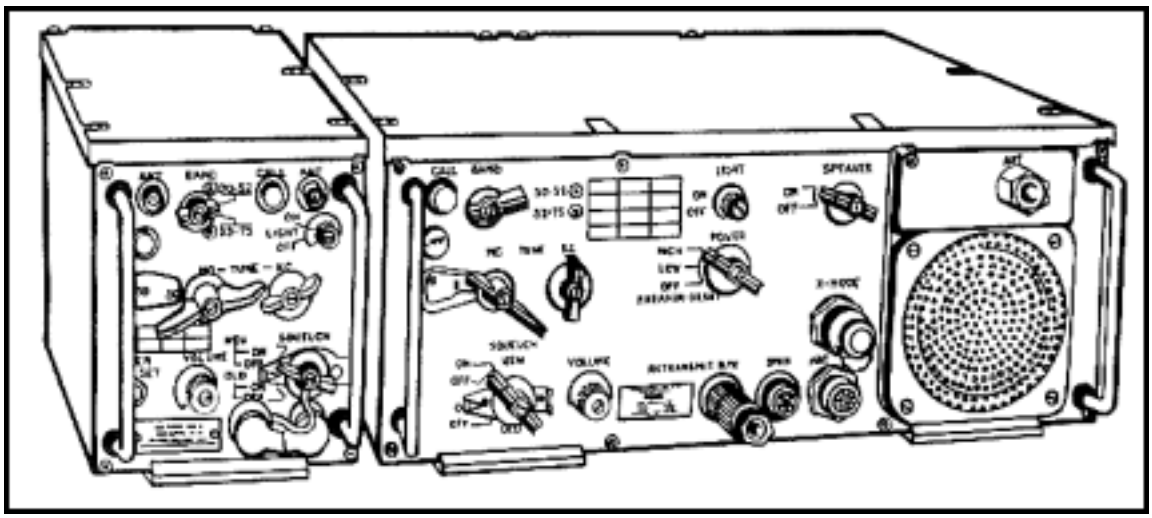


Figure 9-2. AN/VRC-47 Radio Set

MARINE RADIOS

9-5. Marine radio sets, often called "bridge-to-bridge" radiotelephones, are designed for vessel control and more informal communications. With them you can contact other vessels, even if they are not military, and receive civilian and Coast Guard emergency information. The requirement for carrying these radios is a US law and you cannot operate your vessel unless they work.

9-6. The DSC 500 (Figure 9-3) is a 25-watt (bridge-to-bridge) transceiver designed to communicate with other ships and shore-based radio stations. All international and United States VHF/FM marine channels in the frequency range of 156.025 to 163.775 MHz are accessible. The unit can also work 10 weather channels and 42 programmable channels. The DSC 500 has the following capabilities:

- Directory entry of 200 ship to ship stations.
- Directory entry of 50 coastal stations.
- Can store up to 100 call waiting events.
- Can store up to 50 group calls.
- Can distress log up to 20 calls.

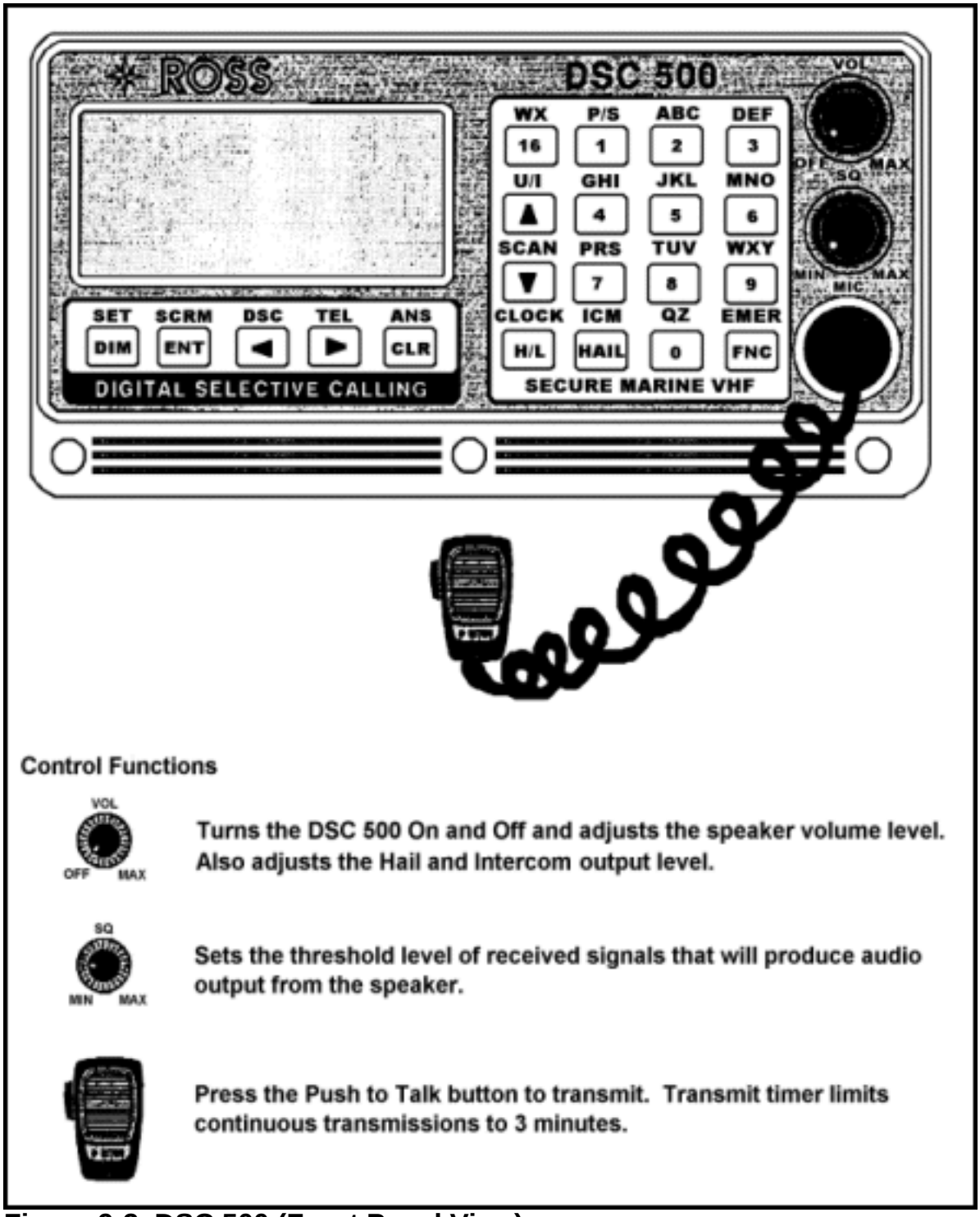


Figure 9-3. DSC 500 (Front Panel View)

The DSC is designed to cut down on excessive radio traffic and make radio calling more efficient. Typical Digital Selective Calling offers a better way of calling other vessels.

Channel 13 is to be used for bridge-to-bridge navigational purposes and it is monitored when underway. Channel 16 is the international calling and safety frequency (distress frequency).

9-7. If you connect your DSC to a navigation receiver (such as loran or GPS) your position can be given quickly to another vessel. Another vessel can request your position, in an emergency situation, through your radio.

Note*:* In order to provide the best fidelity at high volume settings, your DSC 500 uses a speaker with a strong magnet. If any rearranging of equipment in your wheelhouse becomes necessary, be sure to place the DSC 500 well away from your compass. Observe your compass during remounting to ensure that the radio is not effecting your compass heading. Remember that you will have to swing ship after any equipment in your wheelhouse is moved to determine the effects on your compass.

9-8. The AN/URC-92 (Figure 9-4) is a medium power, single sideband, high frequency, automatic tuned radio set able to transmit and receive upperside band, continuous wave, and amplitude modulation in the frequency range of 2.0 to 30.0 MHz. The set is capable of 100 watts of power output when transmitting SSB and compatible AM signals. The input power requirement is 115 volts AC, single phase, 60 Hz. This radio is for medium and long range communication with military and civilian stations with a range of 4,000 miles.

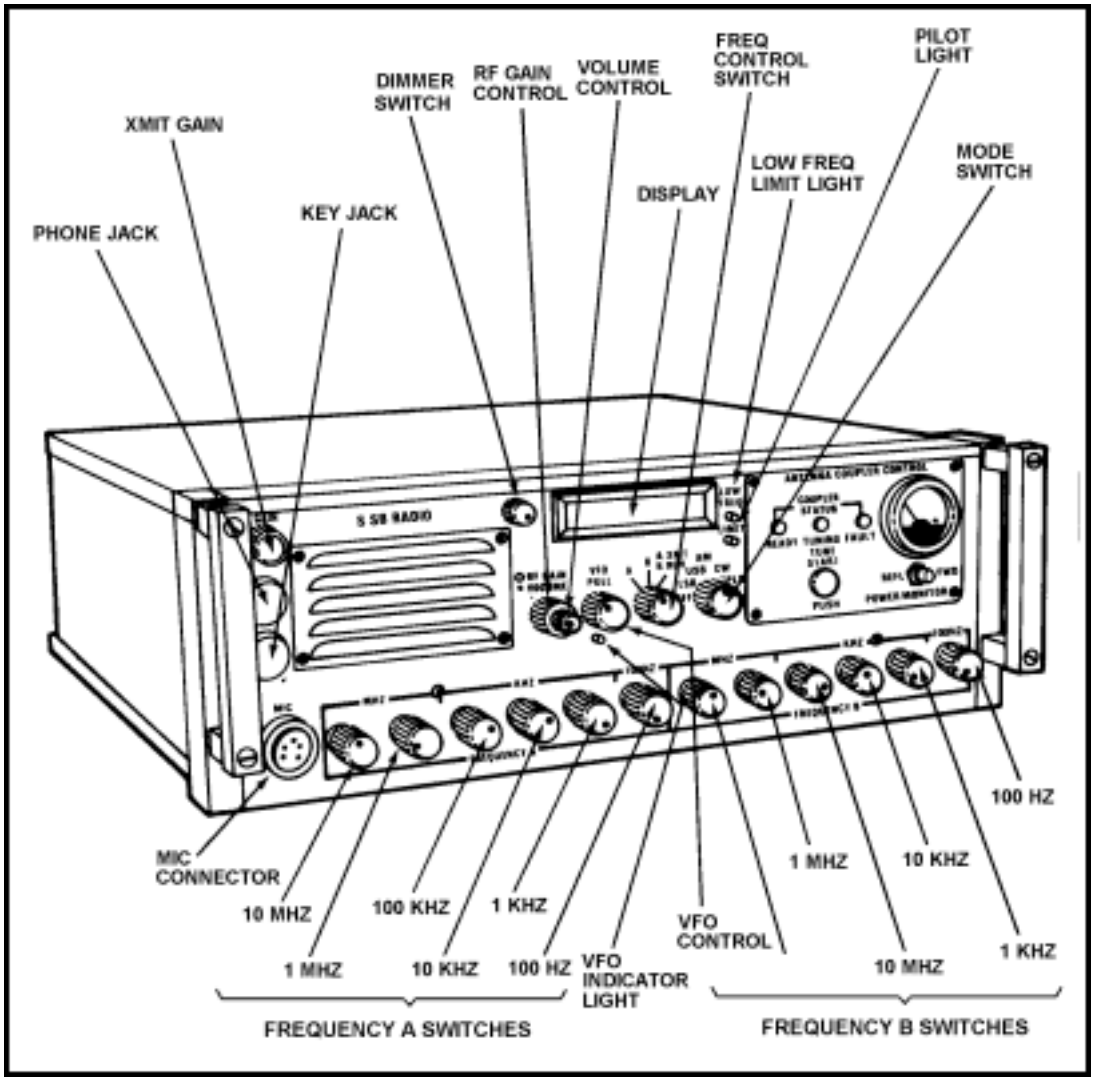


Figure 9-4. AN/URC-92

GLOBAL MARINE DISTRESS AND SAFETY SYSTEM

9-9. The GMDSS was developed by the maritime nations in the IMO. GMDSS was implemented on 1 February 1992 and has become mandatory for all new ships built after 1 February 1995. GMDSS should be installed on all ships by 1 February 1999 (unless this deadline is extended by the IMO). GMDSS is designed to ensure maximum coverage of safety communications for all passenger vessels and cargo vessels of 300 GT or more engaged in international voyages. The major reason for the GMDSS is to guarantee that complying vessels will be able to communicate at anytime (in case of distress or to exchange safety information) with a shore station or a ship. The GMDSS describes four sea areas based on the location and capability of shore-base communications facilities. These are described as follows:

Sea Area A1

9-10. An area within the coverage of at least one VHF coast station in which continuous DSC alerting is available (normally 20 to 30 NM).

Sea Area A2

9-11. An area, excluding Sea Area A1, within the coverage of at least one MF coast station in which continuous DSC alerting is available (normally within 150 NM).

Sea Area A3

9-12. An area, excluding Sea Areas A1 and A2, within the coverage of an Immarsat Satellite in which continuous alerting is available (normally everywhere on the globe except the polar regions).

Sea Area A4

9-13. An area outside Sea Areas A1, A2, and A3 which is in the polar regions.

9-14. GMDSS vessels carry the communications equipment appropriate to the Sea Area in which they are operating. GMDSS vessels also carry standard equipment that operates on the same frequencies and mode to ensure communication between other vessels.

HOW TO TALK ON A RADIO

9-15. It is important that you use the correct radio procedures when using the radio. Radio messages should be short and to the point. Speak slowly and distinctly and do not try to impress the other station with your knowledge of current slang terms or CB talk. Refer to FM 24-18 for complete radiotelephone transmitting instructions.

9-16. When talking on the bridge-to-bridge set (DSC 500), use plain language that can be understood. There are no requirements for special codes or words when using channel 13. Make sure the other person (whether civilian or military) can understand you. Speak clearly and use short sentences. The following practices are forbidden:

- Violation of radio silence.
- Unofficial conversation between operators.
- Transmitting on a directed net without permission (except flash and immediate traffic).
- Excessive tuning and testing.
- Transmitting the operator's personal sign or name.
- Unauthorized use of plain language.
- Use of other than authorized prowords.
- Unauthorized use of plain language in place of applicable prowords or

operating signals.
- Linkage or compromise of classified call signs and address groups by plain language disclosures or association with unclassified call signs.
- Profane, indecent, or obscene language.

9-17. BE ALERT while transmitting by radiotelephone. Release your PUSH TO TALK BUTTON occasionally (usually after each phrase or two) to allow another station to break in, if necessary, and to listen for a few seconds for possible distresses.

9-18. Keep the receiver gain (volume control) turned high enough to hear weak signals through static and other interference.

HOW TO CALL AND REPLY

9-19. The following are some important things to remember when calling or replying.

- Listen on the frequency before transmitting to make sure that you will not interfere with another transmitting station.
- Set your transmitter on the proper frequency.
- Speak clearly, in a normal voice, holding microphone about 1 to 3 inches from your lips.
- Reduce operating room noise level.
- Avoid excessive calling and unofficial transmissions. Transmit call signs only once when communication conditions are favorable and twice when unfavorable.

When a station called does not reply to a call sent three times at intervals of 2 minutes, the calling with cease and will not be renewed until after an interval of 15 minutes. However, if there is no reason to believe that harmful interference wil be caused to other communications in progress, the call sent three times at intervals of 2 minutes may be repeated after an interval of less than 15 minutes but not less than 3 minutes. The DSC 500 will do the calling for you automatically and let you know when called station answers. This will free up the operator for other bridge chores.

- End every transmission with either "OVER" or "OUT" (except when the sending operator wishes to pause a moment before continuing transmission). Use the proword "WAIT" in this instance. If you intend to pause for a longer period of time before resuming your transmission, use the proword "WAIT OUT". Never use OVER AND OUT together.

USEFUL OPERATING FREQUENCIES

9-20. The following are the most important frequencies that are available.

- **2182 kHz.** This is for international distress and calling voice frequency. It may be used for distress, urgent, and safety traffic. (Safety messages should be sent on 2670 kHz after a preliminary announcement on 2182 kHz.) Ship stations and shore stations will also establish initial contact on 2182 kHz and then shift to an appropriate working frequency for the passing of operational messages.
- **2670 kHz.** This is a Coast Guard frequency. Use by non-Coast Guard stations will be restricted to communications with the Coast Guard. This is a normal working frequency for communications with nongovernment vessels after initial contact on 2182 kHz. Group stations also use this frequency for Coast Guard safety information broadcasts.
- **2638 and 2738 kHz.** International ship-to-ship frequencies. Coast Guard ships may use these frequencies to communicate with non-Coast Guard ships. They are authorized for use by certain shore stations only for communicating with non-Coast Guard vessels that are in distress situations when no other common frequency is available.
- **3023.5 and 5680 kHz.** International SAR on-scene frequencies. Either of these frequencies may be used to conduct communications at the scene of an emergency or as the SAR control frequency.
- **156.3 MHz, Channel 6.** International VHF-FM ship-to-ship frequency (nationally used by maritime mobile stations for SAR communications at the scene of the SAR incident).
- **156.6 MHz, Channel 12.** Port operation's working frequency. Coast Guard use of this frequency shall be limited to shore station communications with non-Coast Guard ships involving port operations.
- **156.65 MHz, Channel 13.** Vessel bridge-to-bridge VHF-FM frequency for navigational purposes.
- **156. 7 MHz, Channel 14.** Second choice port operation's working frequency. Coast Guard use of this frequency will be limited to shore station communications with non-Coast Guard ships involving port operations.
- **l56.8 MHz, Channel 16.** International VHF-FM calling and safety frequency (nationally used also as a distress frequency). It may be used for calling or answering messages preceded by the distress, urgency, and safety signals.

Note: There are no restrictions on obtaining radio checks from Coast Guard Stations

on 156.8 MHz.

- **157.1 MHz.** Primary liaison frequency for communications between nongovernment vessels and Coast Guard vessels and coast stations. Also used by the Coast Guard for the national VHF-FM radiotelephone safety and distress system and the Coast Guard Marine Information Broadcast Frequency.
- **157.05 MHz, Channel 21; 157.15 MHz Channel 23.** Intra-Coast Guard VHF-FM working frequencies. These frequencies are authorized for communications between Coast Guard units engaged in maritime mobile operations and are common to all districts.
- **157.075 MHz, Channel 81.** Joint command, control, and surveillance frequency. Used by US and Canadian mobile units, that are operating according to Marine Pollution Contingency Plan for Spills of Oil and Other Noxious Substances. This frequency is also authorized for other Coast Guard maritime mobile command and control operations when not required for marine environmental purposes.
- **157.175 MHz, Channel 83.** Coast Guard command and control frequency when required. Coast Guard auxiliary operational and training frequency in the VHF band. This frequency can also be used by Coast Guard Reserve training units (on a not to interfere basis) to Coast Guard operations.

PHONETIC ALPHABET

9-21. You should be familiar with the standard international phonetic alphabet as shown in Table 9-1. It should be practiced and used for all transmissions. It is not a code; it is a means to better understanding of your radio transmission.

Table 9-1. Standard International Phonetic Alphabet

A -- ALFA	N -- NOVEMBER
B -- BRAVO	O -- OSCAR
C -- CHARLIE	P -- PAPA
D -- DELTA	Q -- QUEBEC
E -- ECHO	R -- ROMEO
F -- FOXTROT	S -- SIERRA

G -- GOLF	T -- TANGO
H -- HOTEL	U -- UNIFORM
I -- INDIA	V -- VICTOR
J -- JULIETT	W -- WISKEY
K -- KILO	X -- XRAY
L -- LIMA	Y -- YANKEE
M -- MIKE	Z -- ZULU

COMMUNICATIONS-ELECTRONICS OPERATION INSTRUCTIONS

9-22. This paragraph describes the CEOI and tells how to use it. The standing instruction, which explains how to use the CEOI, was published as a separate document called Communications-Electronics Standing Instruction. This instruction is provided to Army units in a two-part document. The first part (basic document) contains such items as the daily changing call signs, frequencies, suffixes, signs and countersigns, and pyrotechnic and smoke signals. The second part (supplement) contains handling instructions, general instructions, telephone switchboard designators, and other items that seldom change. A command simply combines these two documents in the field to make a complete CEOI. The CEOI now lists call signs using LNL combinations selected randomly by a computer.

9-23. Numbers are pronounced as shown in Table 9-2.

Table 9-2. Pronunciation of Numbers

NUMBER	SPOKEN	NUMBER	SPOKEN
0	ZERO	5	FI-YIV
1	WUN	6	SIX
2	TOO	7	SEVEN
3	THUR-REE	8	ATE
4	FO-WER	9	NINER

DESCRIPTION AND MAKEUP

9-24. All CEOIs are a standard size: 4 1/4 x 4 3/4 inches. This size fits into a soldier's field jacket pocket for easy handling. They reach the major commands in a complete package assembled in a "layered" configuration; that is, parts of the package that apply to subordinate units can be readily separated and distributed. The exact makeup of each CEOI package is determined by the using command. Each major command C-E officer is responsible for developing the initial information. He must promptly report all changes or required updates to the preparing agency so the computer can keep pace as the officer's organization, plans, and programs change.

9-25. Each CEOI is issued in editions containing 10 time periods. This helps reduce the impact of possible loss or compromise. Should loss or compromise occur, the command merely shifts to the next edition.

9-26. The "heart" of the CEOI is the capability to change call signs, suffixes, and frequencies at least every 24 hours. It does not remove from the tactical commander overall responsibility for content and management of his command's CEOI system.

RESPONSIBILITY

9-27. The commander of the unit for which the CEOI is prepared is the controlling authority of that CEOI. The C-E officer, acting for the commander, makes sure that the current CEOI is available to those who operate communications systems and that higher and adjacent organizations get copies.

9-28. All users must be familiar with the general and special instructions in the CEOI if effective and responsive communications are to be available. As mentioned earlier, your CEOI contains specific instructions for the operation of C-E equipment, systems, and facilities within your command. The command CEOI is the only authorized document from which subordinate elements will extract call signs and frequencies.

CONTENTS

9-29. The CEOI contains general and special operating instructions. With these instruments in the CEOI, each communications user has in one package all the guidance he needs to operate tactical communications effectively. All CEOIs are designed to meet the needs of the organization they support while retaining a standard format.

9-30. On the index pages of the CEOI, you will find the contents are listed and identified by item number. These numbers are consistent throughout the Army. These item numbers are very useful when you are communicating with someone else who holds the same CEOI you do.

SINGLE CHANNEL RADIO NETS

9-31. Field radio stations are grouped into nets according to the tactical situation. To control a net, one station, usually the one serving the highest echelon, is designated as the NCS. The authority of the NCS is absolute. The NCS opens and closes the net, grants or denies permission to enter the net, corrects errors in operating procedures, and maintains net discipline. The call sign assigned to the station controlling the net is the net call sign. For example, D5G28 is NCS of a division command net; D5G (with no suffix) is the net call sign.

9-32. Radio nets will normally be operated as free nets. In free nets, stations may exchange traffic without prior permission from the NCS. When traffic is heavy or when operators are inexperienced, the NCS may order a directed net. In this case, no station will transmit without first calling the NCS and requesting permission.

CALL SIGNS, SUFFIXES, AND FREQUENCIES

9-33. A call sign has two parts. The first part uses a random LNL combination, which is the basic call sign. The second part consists of two numbers (01 through 99) which make up the suffix. You can expand the suffix by adding a letter to identify a subelement (such as deputy or alternate). The last letter of the basic call sign is unique to the echelon at which the user operates. For example, in a battalion, no two stations would have the same last letter. The reason for this is that it permits an abbreviated call sign for routine use in a functioning net.

9-34. A complete call sign must be used any time a station enters or operates in a net in which it does not normally operate. A call sign must be used only during its effective time period. At no time will a new call sign be used on an old frequency. Likewise, an old call sign will not be used on a new frequency.

9-35. Call signs, suffixes, and frequencies are simultaneously changed daily throughout the organization or as directed by the commander. If you are suppose to change at an odd time, you will be informed through proper channels.

9-36. A frequency is assigned to a radio net for a stated period of time. The frequencies allocated to the command are assigned to designated nets by computer. This allows for nets to change frequencies at least once daily. It does not provide more frequencies but does allow better use of the frequency.

DISTRIBUTION AND REQUISITION OF THE CEOI

9-37. The automated CEOI is produced by the Director, National Security Agency, based upon requirements of the commander. It is shipped directly to the COMSEC custodian of each command. Distribution of the CEOI is limited to those units and individuals that must have them. The C-E officer makes these decisions. Subordinate C-E officers determine the distribution of CEOI items within their units and distribute the CEOI extracts required by their commands or units. C-E officers should refer to AR 25-1 for detailed information concerning requisitioning of CEOIs.

TRAINING AND OPERATIONAL/RESERVE EDITION

9-38. Holders of the CEOI will be issued two training editions and a minimum of 90 days of operational/reserve editions. The controlling authority keeps reserve editions of CEOI items to ensure rapid replacement. When reserve editions are issued, replacement editions must be obtained from NSA according to AR 25-1.

PHYSICAL SECURITY AND COMPROMISE

9-39. The CEOI is classified, if required, by its contents. Normally, operational and contingency CEOIs are classified CONFIDENTIAL. Administrative or training CEOIs are UNCLASSIFIED to make their handling easier. Those CEOIs classified CONFIDENTIAL or above must be given the physical security safeguards and requirements set forth in DOD 5200.1-R and AR 380-5.

9-40. The CEOI belongs to the organization for which it was produced. The commander is responsible for efficient and secure handling procedures. The commander is the recognized controlling authority and has the authority to use the unclassified call sign and frequency change programs for training purposes.

9-41. Additional physical constraints are necessary to lessen the possibility of unauthorized disclosure. The complete CEOI will not be taken forward of a battalion CP. No more than 10 days material is issued to the user at any time.

9-42. The individual in possession of a CEOI, or a portion thereof, is responsible for safeguarding its contents. A thorough understanding of handling procedures established by the unit, combined with good common judgment, will greatly assist in keeping the CEOI away from unauthorized personnel.

9-43. The CEOI, or any portion of it, is considered compromised when it is lost, captured, exposed to unauthorized personnel, or when the contents are so misused they endanger the security of communications systems.

NOTIFICATION OF COMPROMISE

9-44. Any individual having knowledge of a compromise, suspected compromise, or loss of a CEOI must advise the controlling authority immediately by the most expeditious secure means available. It is very important that this information be reported to the controlling authority so that the situation can be evaluated and contingency precautions implemented. A written report must be submitted within 48 hours after the initial report. The report should include complete details and circumstances of the compromise, suspected compromise, or loss.

TYPES OF CEOI

9-45. Two CEOIs are normally provided to a command in two versions. One is a training CEOI and the other is an operational reserve CEOI. Training versions are used when the command is not engaged against a hostile force. Two training editions are held by each command. These editions are unclassified and marked FOR OFFICIAL USE ONLY. They are recycled within the command until the copies are worn out. Replacement editions for training purposes may be requisitioned according to AR 25-1 when the material is worn out or when major organizational changes occur.

9-46. Operational/reserve CEOIs are held in reserve and will be implemented only when a unit becomes involved in operations against a hostile force or when instructed by the controlling authority. Operational/reserve CEOI material is classified at least CONFIDENTIAL. The NSA resupplies CEOI material, according to AR 25-1, as the operational editions are used. In situations where operational material is used routinely, resupply will be automatic. Otherwise, operational editions are resupplied only when the controlling authority requisitions them.

PRODUCTION OF THE CEOI

9-47. The Director, National Security Agency produces the CEOI. It is shipped to the COMSEC custodian of each command. Distribution is handled through armed forces courier service channels. Radio call signs, suffixes, and frequencies are assigned by automated techniques using data submitted by the using command. This procedure ensures that unique LNL call signs are provided for each tactical unit for which the CEOI is designed. To do this, the C-E officers of major commands furnish NSA specific input data according to AR 25-1. The input data required consists of the following:

- Organizations to be assigned call signs.
- Nets to be assigned frequencies. Nets requiring fixed frequencies and the list of frequencies must be furnished.
- All nets that share, or may possibly share, a common site, such as a command post or tactical operations center.
- All frequencies (in MHz) available to the command for assignment. Power restrictions imposed on the frequencies must also be indicated.

MANUAL PREPARATION

9-48. A CEOI may be manually prepared by a command when circumstances are such that an automated version is not available or must be updated. The manually prepared CEOI must follow the format of the automated CEOI and embody the principles of changing call signs, suffixes, and frequencies at least every 24 hours. This is done by first contacting the command's supporting US Army Intelligence and Security Command unit and asking for help. They have prepared, in conjunction with NSA, a call sign and suffix list plus standard nonchanging supplemental material for use by Army commands. The responsibility for manual CEOI preparation rests solely on the tactical command, which produces the manual system.

9-49. A sample of the computer-generated list of call signs, structured in time periods without unit designations, is shown in Figure 9-5.

(PROTECTIVE MARKINGS)
CALL SIGNS

(SHORT TITLE) 12

	01	02	03	04	05
	Y9X	J9J	T8U	Y2F	G8V
	R6A	G4M	O9F	E4U	K9R
	Q8B	Q1K	N6M	D8H	X5O
	F9N	W3A	A3B	S9G	B8E
	I4C	Q7N	U5K	N4O	A6S
	H3T	R9C	G0Y	Z9J	C5U
	W5R	Z5F	M4G	A1B	X7T
	D4J	K0B	C3Q	T5D	M2F
	C0D	S6D	U2R	F1I	A6Z
	H5E	W1L	B5H	K1A	M9P
	P4K	C5E	Q4P	A4R	H3C
	G0L	B1O	C5D	Y7S	Q9J
	G9F	P8T	O95	P0K	V9G
	X5I	A6P	O7N	G0C	L6B
	Q5O	Q8X	J5C	G9L	Z4H
	D5M	R0G	Q7Z	B4E	E8Q
	L5G	Z2H	U3T	X0M	K0L
	P6S	R5U	H8I	Y2X	V4A
	F6P	Q4I	N5E	H1Z	Q1I
	R1O	Y8O	W0V	N7N	G4D

F6P	Q4I	N5E	H1Z	Q1I	
R1Q	X8Q	W0V	N7N	G4D	
A6U	P3R	Q8J	L7O	Q2K	
R6V	A4Y	E8L	L8W	Y1M	
Q3W	N4V	D6W	J0P	Y7N	
R7Y	Y8S	C0O	O2T	P7W	
A7H	P9W	T5A	R7V	T2X	
B7Z	X2Z	I2X	F8Y	G2Y	
					12

Figure 9-5. Sample Computer-generated List of Call Signs

SIGNALING BY INTERNATIONAL CODE FLAGS

9-50. Use visual signals when your radio goes out or radio silence is ordered. Also use them when you need to get a message to that ship you are unloading or to the next boat in your convoy. Sending someone over in a boat is a possibility, but not usually a good idea. There are different types of visual signals. This paragraph will give you the basic information you will need to know about the international signal flags and flag hoist methods. Paragraphs 9-58 through 9-64 discusses flashing light signals and their application with Morse code. Although pyrotechnics (signal flares) are used less often, they are covered in another chapter.

FLAG HOISTS

9-51. Signaling by flag hoist is a method of communication in which a set of flags of different patterns and colors is used. The set consists of 26 alphabetic flags, 10 numeral pennants, 3 substitutes, and 1 answering pennant.

9-52. There are six single letter flag hoists that all crew members should immediately recognize (Figure 9-6). These signals warn the mariner of danger or are an urgent request for assistance. Any vessel seeing one of these signals will immediately take the proper action. Even though these six flags warn of danger, mariners should know all 26 signal flag hoist meanings from memory.

9-53. Except for proper names, the international signal alphabetical flags are used only to send messages by code. Each flag has a meaning by itself in addition to the alphabetical meaning. Each flag will also have a different meaning when used with another flag. For example, the "A" flag by itself means "I have a diver down; keep well clear at slow speed." If you hoist two flags that read "AC," it means "I am abandoning my vessel." Two and three letter signals are described in Pub. No. 102, International Code of Signals.

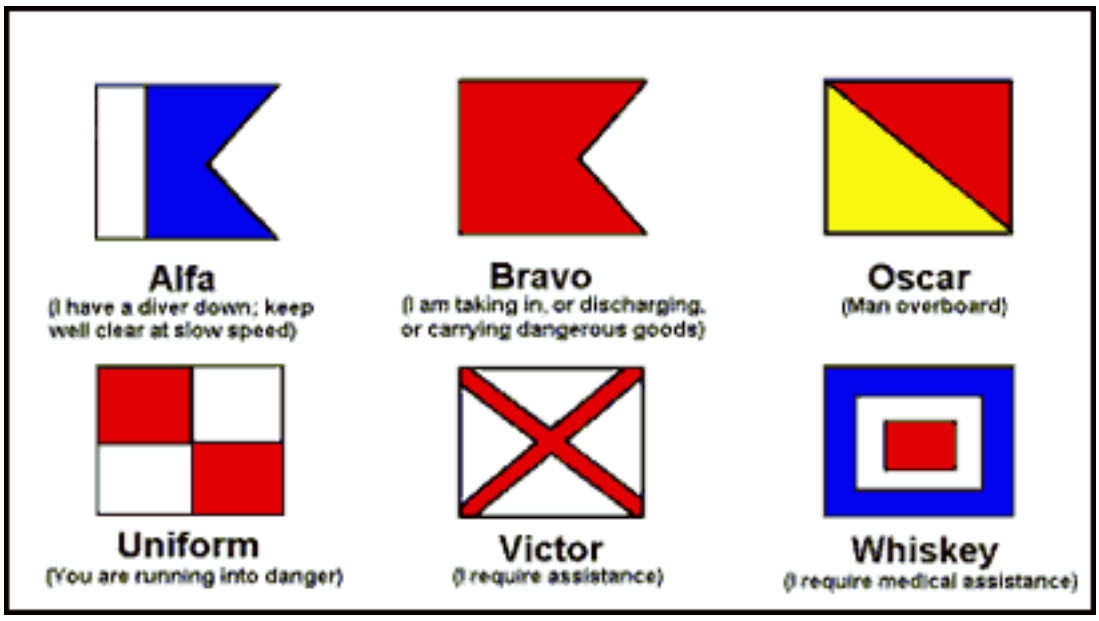


Figure 9-6. Urgent Code Flags

9-54. It is possible to communicate with several ships at one time if the flags are visible to all. Simple signals for towing and other activities may be worked out between vessel masters to make routine movements easier.

9-55. This method of signaling is slow and not suitable for the transmission of long messages. Flag hoists may be used only for short distances and cannot be seen in heavy weather or darkness.

USING THE FLAG HOIST SYSTEM

9-56. Do the following to use the flag hoist system:

- As transmitting vessel, hoist signals where they can best be seen by the receiving ship and make sure they blow out clear and are free from smoke.
- Fly each hoist or hoists until answered.

Note*:* A signal is superior to another when hoisted first or in time or position.

- When more than one signal is shown on the same halyard, separate each one from the other by tacklines. Always read from the top down.
- When several hoists are displayed at the same time, read in this order: masthead, triatic stay, starboard yardarm, and port yardarm.
- When more than one hoist is shown on the same yardarm, read from outboard to inboard (Figure 9-7).

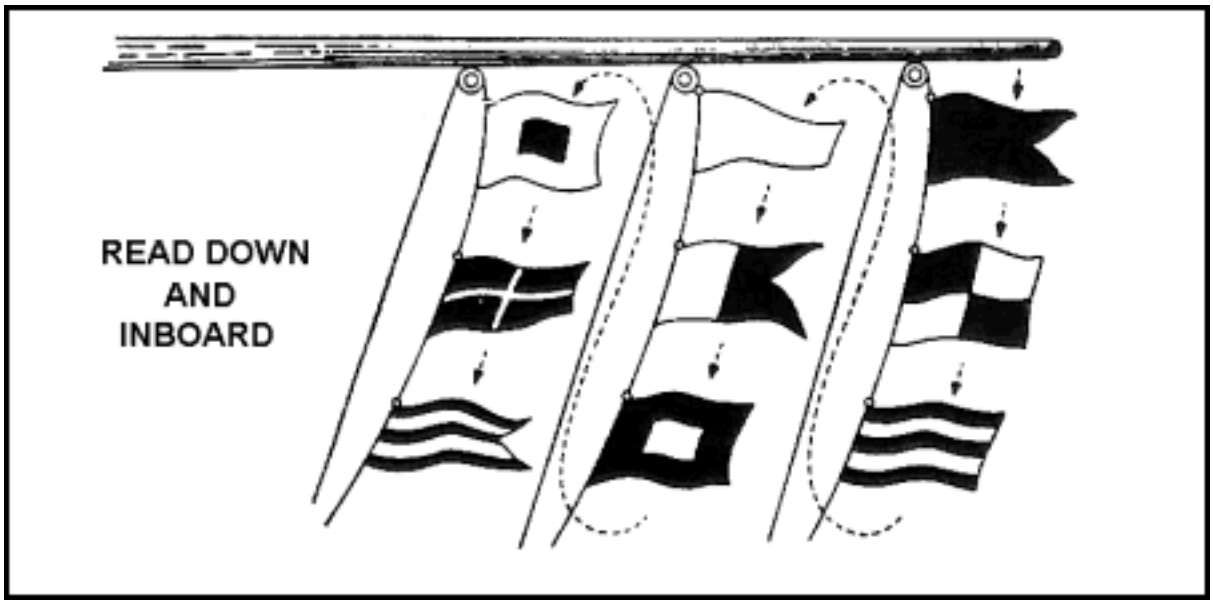


Figure 9-7. Order of Reading Flag Hoists on Yardarm

ANSWERING FLAG HOIST SIGNALS

9-57. Do the following to answer flag hoist signals:

- Hoist the answering pennant at the dip as soon as you see each hoist. As soon as you understand the signal, immediately close up the pennant.
- Lower the answering pennant to the dip as soon as the hoist is hauled down; close up again when the next signal is understood.
- Keep the answering pennant at the dip if you do not clearly see the message. If you can see but cannot understand the message, hoist "ZQ -- Your signal appears incorrectly coded. You should check and repeat the whole," or hoist "ZL -- Your signal has been received but not understood."

FLASHING LIGHT SIGNALS

9-58. Sending messages by flashing lights, using the Morse code, is one form of visual communication from ship-to-ship and from ship-to-shore. The flashing or blinker light has several advantages. It may be used when a radio is not available or when security prevents the use of radio. Brief messages may be sent with considerable speed. A portable flashing light is useful on small craft where size and construction prevent the installation of elaborate equipment.

9-59. There are certain disadvantages in the transmittal of messages by blinker light. This method is not very good for sending long messages because it is comparatively slow. Range is limited even under ideal conditions. Atmospheric and light factors may prevent its use.

INTERNATIONAL MORSE CODE

9-60. Morse code (Figure 9-8) is a system of signaling using a series of long and short light flashes or sounds. It is still the only way flashing lights can be used, and in that form is used on almost all Army vessels. All deck personnel should memorize Morse code.

THE BLINKER LIGHT

9-61. Blinker lights vary in size, shape, and power source, yet they all work the same way. One type of blinker, the Aldis Gun (Figure 9-9) consists of a tube closed at one end with a light inside. The light is turned on and off by a trigger-operated switch. The portable type blinker can get its electric power from either batteries or the ship's electrical system. The blinker lamp is fitted with a control knob that is used to dim or brighten the light.

A •—	N —•	1 •————
B —•••	O ———	2 ••———
C —•—•	P •——•	3 •••——
D —••	Q ——•—	4 ••••—
E •	R •—•	5 •••••
F ••—•	S •••	6 —••••
G ——•	T —	7 ——•••
H ••••	U ••—	8 ———••
I ••	V •••—	9 ————•
J •———	W •——	0 —————
K —•—	X —••—	
L •—••	Y —•——	
M ——	Z ——••	

Figure 9-8. International Morse Code

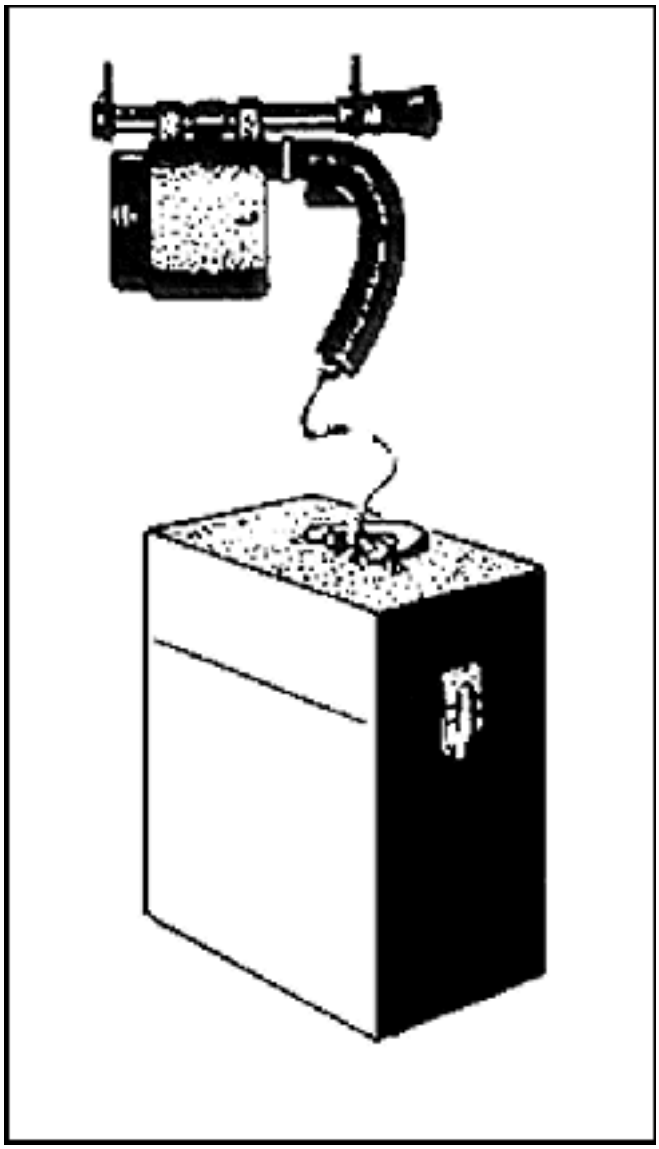


Figure 9-9. Aldis Gun

PROCEDURE SIGNS (PROSIGNS)

9-62. Prosigns are a form of visual communication shorthand. They give in brief form certain orders, requests, instructions, and other information that often comes up in visual communications. Figure 9-10 shows some of the more common ones that may be used. Those prosigns that are overscored are sent as one signal without a break between the letters.

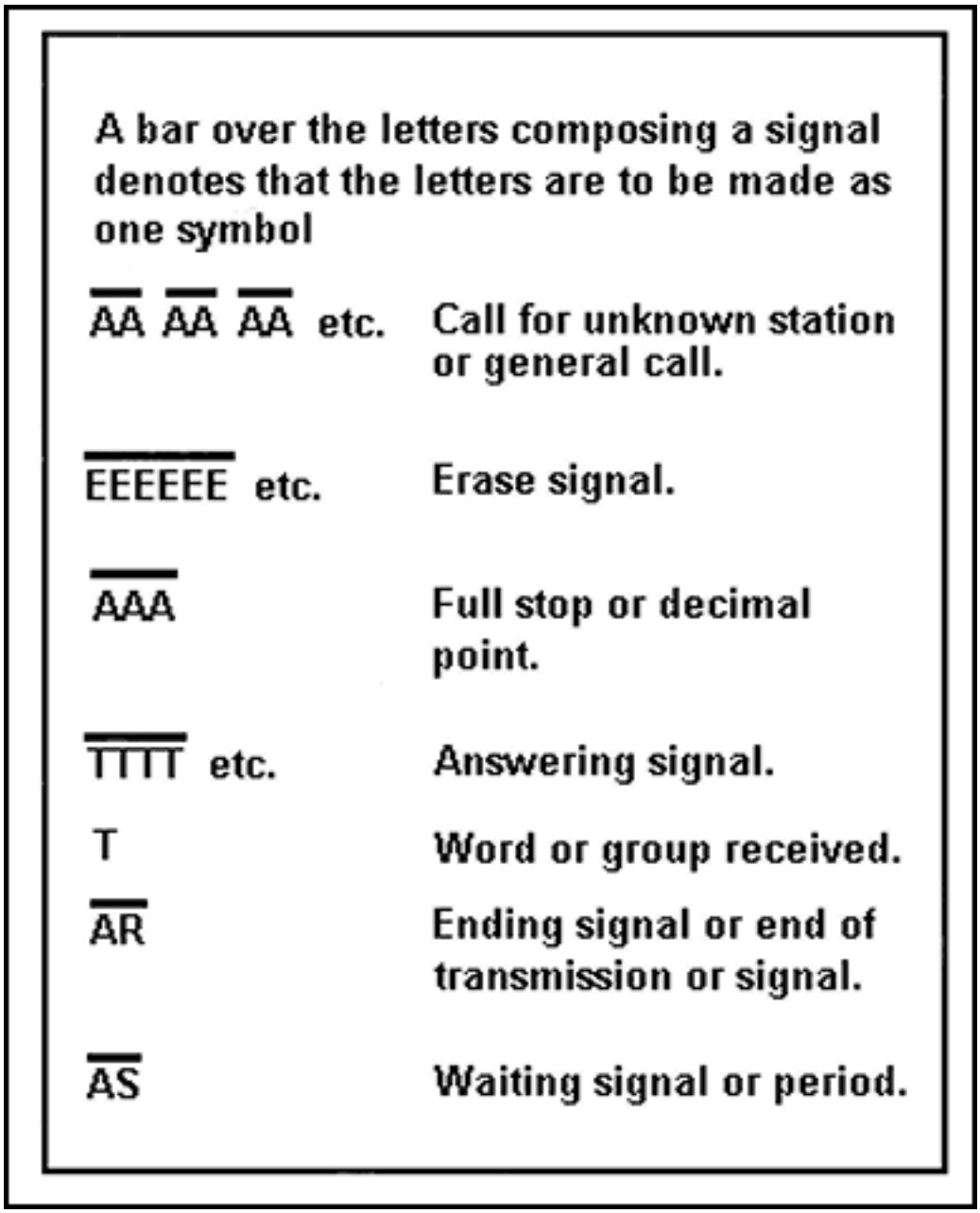


Figure 9-10. Procedure Signs

SENDING BY FLASHING LIGHT

9-63. The flashing light system uses the international Morse code. This is the dot-and-dash system. Most people do not use the term "dots and dashes." Instead they will say "dits and dahs;" the "dah" rhyming with "baa." It is much easier to learn the code by calling out the short flashes of light as "dits" and the longer light flashes as "dahs." When you hear the code called out in this manner, it makes for an easy rhythm. Figure 9-11 shows the desired spacing between dots and dashes for the simple message "we are here."
Note*:* The dots are one unit long and the dashes are about three units long. The space between the dots and dashes of a letter is one unit; between letters, three units; between words, seven units.

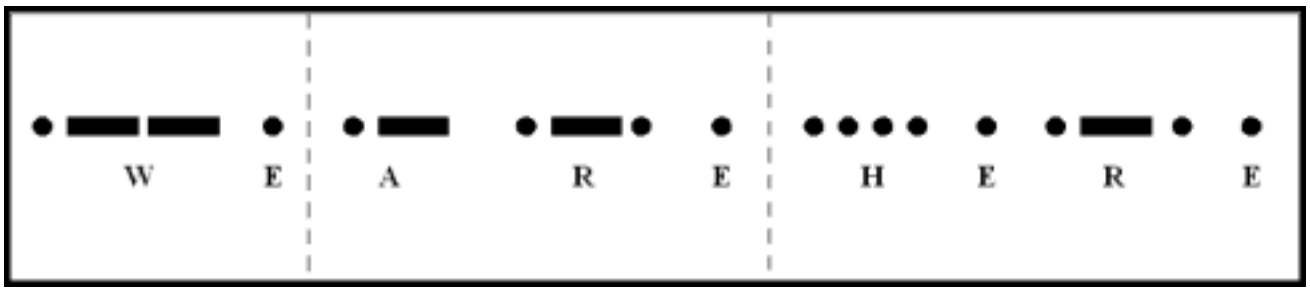


Figure 9-11. Spacing Used for Simple Message

HINTS FOR BETTER SIGNALING

9-64. The following are a few hints you can use when signaling:

- Never send blinker faster than you can receive.
- Have your message written out before you start to send.
- During daylight hours, aim the signal lamp directly at the receiving ship.
- At nighttime, aim the signal lamp at the water, just below the receiving ship's waterline. During times of darkness, you will NEVER aim the signal light onto the other ship's bridge.
- Look to one side when receiving blinker at night. DO NOT look directly at the light.
- Note*:* There are filters available that can be attached to the flashing light during hours of darkness. Then the light can be directed at the receiving station.
- Write each letter as soon as it is received. If you miss a letter, go to next letter. When the word is completed, you can go back and fill in the space. If you try to figure a letter in the middle of a word, you are apt to miss the next letter or letters being sent.

DISTRESS, URGENT, AND SPECIAL SIGNALS

9-65. Sailing can be hazardous. Even with today's modern electronic aids to navigation and worldwide radio and satellite communications systems, ships still sink. If you get into trouble, your greatest aid will be the distress signals you send out over the radio. International agreements and US laws have set up special frequencies that will be used for nothing but distress signals. There are also special message formats and key words to use if you are in trouble.

FREQUENCIES

9-66. Depending upon the type of radio you have, there are different frequencies to use for distress signals. Army FM tactical radios cannot be tuned to any of the frequencies. These frequencies are to be used FOR EMERGENCY CALLS ONLY. Once you have established contact, you will be told to change to another frequency to arrange any necessary rescue.

9-67. The most widely used emergency frequencies are 2182 kHz and 156.8 MHz on the marine radio (channel 16 on your URC-80). For vessels equipped with the longer range CW sets, 500 kilocycles has been established as the emergency frequency. Most vessels and shore stations with the capability will keep watch on the 500 KC frequency, so they can relay or respond immediately if an emergency arises.

9-68. The 500 KC frequency can also be used for safety and urgent advisory messages. An international silent period on this frequency has been established to enable any vessel in distress to have a clear channel for requesting help. The silent period is observed twice every hour, from 15 to 18 minutes after the hour and from 45 to 48 minutes after the hour. Do not make any calls during these periods unless distress, urgent, or safety matters are involved. If you are transmitting a routine call on 500 KC and notice that you are running into the silent period, transmit "AS" which means "Wait." When the silent period has ended, you may again resume transmission. In addition to being very careful not to transmit on 500 KC during the silent period, you should listen carefully on that frequency for distress messages. If you hear any station making illegal transmissions during the silent period, the nature of the transmission and the call sign of that station should be noted in your radio log.

DISTRESS PROCEDURES

9-69. The distress signal MAYDAY indicates that a ship or aircraft is threaten by grave or imminent danger and requests immediate assistance. The distress call has absolute priority over all other transmissions--and need not be addressed to any particular station. If you hear a distress call, immediately cease transmissions that might interfere with the distress traffic and continue to listen on the frequency over which the call was heard.

9-70. Distress transmissions are normally made on the distress frequencies 156.8 MHz (channel 16) or 2182 kHz. They may be handled over other frequencies if the need arises. A distress call consists of the following:

- Distress signal MAYDAY, spoken three times.
- The words THIS IS.
- Call sign of the distressed unit, spoken three times.

Example:

"MAYDAY, MAYDAY, MAYDAY
-- THIS IS -- LCM 2348, LCM
2348, LCM 2348."

9-71. Normally the distress message will immediately follow the call. Be prepared to copy all information heard. A distress message consists of the following:

- Distress signal MAYDAY.
- Distress unit's call sign. Particulars of position, nature of distress, type of assistance desired, unit's description, persons on board, and any information that might aid the rescue.

Example:

"MAYDAY--LCM TOO THUH-REE FO-WER ATE--MY POSITION IS TOO MILES WUN TOO SIX DEGREES TRUE FROM WINDY POINT -- I LOST MY POWER AND THE SEAS ARE GETTING ROUGH-- REQUEST COAST GUARD ASSISTANCE--I AM AN ARMY LANDING CRAFT--THUH-REE PERSONS ON BOARD--OVER."

Distress Message Repetition

9-72. The distress message, preceded by the distress call, should be repeated until you receive an answer. The repetitions should be preceded by the alarm signal whenever possible. If you receive no answer to a distress call on a distress frequency, the message may be retransmitted on any frequency available on which attention might be attracted.

Attracting Attention to a Distress Call

9-73. If you receive a distress call and are unable to make contact with the distressed unit, take all possible action to attract the attention of stations in a position to give assistance. Also pass along as much information concerning the call as possible.

Receipt of Distress Messages

9-74. When a distressed unit is in your vicinity, answer the message immediately. However, if the unit is some distance from you, pause a few moments to allow ships or stations nearer the scene to answer.

9-75. In areas where communications with one or more shore stations are practicable, ships should wait a short period of time to allow them to answer.

9-76. Receive distress messages in the following manner:

- The call sign of the unit in distress, spoken three times.
- The proword THIS IS.
- The call sign of the unit acknowledging receipt, spoken three times. The words RECEIVED MAYDAY.
- Request essential information needed to effect assistance. Obtain less important information in later transmission. Inform unit to stand by.
- The proword OVER.

9-77. If you receive distress traffic, you should do the following by the most rapid means:

- Forward distress information to the harbormaster or higher HQ.
- Set a continuous radio watch on frequencies of the distress unit.
- Maintain communications with the distressed signal.
- Maintain distress radio log.
- Keep higher HQ informed of new developments in the case.
- Place additional men (if available) on watch (if necessary).
- Obtain radio direction finder bearing of distressed unit if equipment and conditions permit.

VISUAL INTERNATIONAL DISTRESS SIGNALS

9-78. A vessel or seaplane that is in distress can use the following distress signals to tell other vessels or people ashore that help is needed. The vessel in distress may use more than one distress signal.

9-79. The distress signals are from the international regulations for preventing collisions at sea. The following signals are recognized by all maritime nations:

- Firing rockets or shells, which throw red stars once every minute.
- Constant sounding of any fog signal apparatus.
- Creating flames on the vessel (burning a tar barrel, oil barrel, and so on).
- Firing a gun or other explosive, once every minute.
- A piece of orange-colored canvas with either a black square and circle or other appropriate symbol for identification from the air.
- Firing a rocket parachute flare with a red light.
- A dye marker of any color.
- Hoisting the international signal flags which indicate "November Charlie." November: White and blue checkered flag. Charlie: horizontal striped (blue, white, red, white, blue) flag.
- Hoisting a square flag with a ball, or something that looks like a ball, above or below it.
- Standing on deck with arms outstretched to each side slowly and repeatedly raising and lowering arms.
- Igniting an orange smoke signal.

PRIORITY OF MESSAGES

9-80. There are several types of messages which are peculiar to marine communications and which you must be thoroughly familiar. By international agreement, the order of precedence for these messages are as follows:

- Distress call (including the autoalarm distress signal), distress messages, and distress traffic (SOS or MAYDAY).
- Urgent signals and messages (PAN).
- Safety signals and messages.
- Communications relative to radio direction-finding bearings.
- Communications about the navigation and safe movement of aircraft.
- Communications about the navigation, movements, and needs of ships, including weather observation messages for an official weather service.
- Government communications for which priority rights have been claimed.
- Service communications relating to the working of the radio-communication service or to communications previously transmitted.
- All other communications.

9-81. You should know this precedence, but you should remember that your primary responsibility is the proper handling of military traffic. If it does not interfere with the proper completion of your military mission, you may assist commercial stations (but only with the permission of the vessel master).
9-82. Except in cases of emergencies, operators aboard Army vessels are not authorized to transmit commercial or personal messages. Only official messages may be handled and they should be transmitted only through Government facilities. Under certain conditions, it may be necessary for you to send a message through a commercial station, especially if distress, urgent, or safety matters are involved. Commercial stations make no charge for handling such messages.

URGENT MESSAGES

9-83. The urgency signal PAN (pronounced PAHN) indicates that the station calling has an urgent message concerning the safety of a vessel, aircraft, or person on board or within sight. Send the signal and message on a distress frequency (156.8 MHz [channel 16] or 2182 kHz) or any other frequency that may be needed to get the required help.
9-84. The urgency signal has priority over all other communications except distress traffic. The message preceded by the urgency signal is usually addressed to a specific station. However, it may be addressed to ALL STATIONS.
9-85. If you hear the signal, listen on that frequency for at least 3 minutes. If nothing is heard following the urgency signal, you may resume normal communications. Do not interfere with urgent traffic. Normal work may continue on frequencies other than that on which the urgency signal was heard provided the message was not addressed to ALL STATIONS.
9-86. The urgent message should contain all details concerning the particular case and be in plain language form. If you receive an urgent message, deliver it by the

most rapid means to your next higher HQ or harbormaster.

CANCELLATION OF URGENT TRAFFIC

9-87. When the urgency signal has been sent before transmitting a message to ALL STATIONS, which calls for action by the stations receiving the message, the station responsible for its transmission will cancel it when action is no longer necessary. This message of cancellation shall likewise be addressed to ALL STATIONS.

SAFETY MESSAGES

9-88. The safety signal consists of the word SECURITE (pronounced SAY-CURE-E-TAY). It means that the station is about to send a message concerning the safety of navigation or it is giving important weather warnings. When you hear this message, inform your vessel master at once. The safety signal and call will be sent on the distress frequency or one of the frequencies that may be used in case of distress.

SAFETY CALL AND MESSAGE

9-89. The safety message will normally be sent on a working frequency, but an announcement to this effect will be made at the end of the silent period on the distress frequency.

Example: (Preliminary call on distress frequency).
"SECURITE SECURITE SECURITE--HELLO ALL STATIONS--THIS IS (Voice call sign twice) COAST GUARD MARINE INFORMATION BROADCAST (or) HURRICANE ADVISORY/STORM WARNING, and so forth, LISTEN (2670 kHz and/or Channel 22A) OUT."

9-90. When you hear the safety signal, listen to the safety message until you are satisfied that the message is of no concern to you. Do not make any transmission that will likely interfere with the message.

WEATHER BROADCASTS

9-91. Radio stations specializing in weather broadcasts are operated by the United States Weather Bureau. These stations have a limited range so the weather forecasts they send out are usually local weather. Your URC-80 has a special "W" channel for these weather broadcasts. As you move along the coast, you will find that the stations fade and are replaced with different ones. When overseas, you will have to rely upon local arrangements for weather forecasts, usually obtainable through your company operations section from the Battalion S2.

PUBLICATIONS

9-92. The following publications are needed for shipboard communications.

International Code of Signals (Pub. 102)

9-93. This publication lists all the internationally recognized signals, codes, distress signals, and rules to be employed by vessels at sea to communicate a variety of information relating to safety, distress, medical, and operational information. Each signal has a unique and complete meaning. This publication also contains the internationally recognized message formats and complete instructions for all the forms of communication. Pub. 102 is published in several different languages to make it easier to communicate with the crew of foreign vessels.

Radio Navigational Aids (Pub. 117)

9-94. This publication is a selected list of worldwide radio stations which perform services to the mariner. Though this publication is essentially a list of radio stations providing vital maritime communication and navigation services, it also contains information which explains the capabilities and limitations of the various systems.

EMERGENCY RADIOTELEPHONE PROCEDURES

9-95. If you are in distress, that is, if grave and imminent danger threaten you, transmit your emergency on the international distress frequencies: 2182 kHz and 156.8 MHz (channel 16).

9-96. If you are merely having difficulty (for example, engine trouble, steering failure, and so forth) and need help, the Coast Guard can be reached by calling on either of the two distress frequencies. The distress call sent by voice radio consists of the following:

- The distress signal MAYDAY spoken three times.
- The words "THIS IS" or the letters "DE," (spoken as DELTA ECHO in case of language difficulties) and your vessel's call signal and name.

9-97. If you are not in immediate danger, you will be shifted to a common working frequency for further communications. This keeps the distress channel open for other emergencies.

9-98. After you have made contact, speak slowly and clearly to avoid confusion and delays. Give the following additional information:

- Your vessel's position in latitude/longitude or true bearing and distance in nautical miles from a widely known geographical point. Avoid using local names that are known only in the immediate vicinity, as they can be confusing (for example, "buoy l9," or "the rocks").
- The nature of the distress or difficulty.
- The kind of help needed (for example, medical, air evacuation, damage control, and so forth).
- The number of persons aboard and the condition of any injured.
- The present seaworthiness of your vessel.
- A full description of your vessel including length, type, cabin, masts, power, color of hull, superstructure and trim.

9-99. The voice radio alarm signal, if available, should be transmitted for about 1 minute before the distress call. The voice radio alarm signal consists of two audiotones of different pitches transmitted alternately. 9-100. The radiotelegraph alarm signal is 12 dashes. Each dash is 4 seconds in duration with 1 second of silence between dashes. As in voice radio, the alarm signal comes before the SOS. 9-101. The purpose of these two alarms is to attract the attention of persons on watch and should be used to announce that a distress call or message is about to follow. Some Army and most commercial vessels are fitted with autoalarms. The autoalarm is placed in operation when the radio operator is not on watch while the ship is at sea. If the alarm is sounded, bells will ring on the bridge, in the radio room, and in the radio operator's cabin. This alarm responds to the alarm signals sent by a vessel in distress.

Chapter 10

Marine Emergencies

Fire, sinking, or injuries are constant dangers faced by crew members aboard ships at sea. The organization, training, and teamwork of the crew usually determine the difference between a marine emergency and a marine disaster. The emergency training that is given to the crew is the direct responsibility of the ship's master. This responsibility is the same for the coxswain on the LCM-8 as it is for the master of a category A-2 vessel. This chapter discusses the "how" and "what to do" during a shipboard emergency. Learn now--not during the emergency. Teamwork is essential for survival.

STATION BILL

10-1. The starting point for shipboard survival and survival training is the station bill. The station bill is a muster list that is required by federal regulations. It lists the emergency duty station and duty position for each crew member assigned aboard ship and also the signals for fire and abandon ship.

10-2. The station bill is prepared and signed by the ship's master. Each time a new master is assigned to the ship, one of his first responsibilities is to prepare a new station bill. When a new crew member is assigned aboard ship, the crew member will be assigned to a specific line and station bill number. When transferred, the crew member's name is removed from the station bill.

10-3. The ship's master is the only one who can sign the station bill. It is also his responsibility to keep it current. Copies of the station bill are posted in conspicuous places in the ship, such as the crew's quarters, crew's mess, and bridge.

FILLING IN A STATION BILL

10-4. The following information should be included on a station bill (see also Figure 10-1):

1. Vessel's name or number.
2. Date station bill was filled out.
3. "US Army" or "Name of company".
4. Master's signature.
5. A numerical listing for each man authorized aboard the vessel. The Master is listed as A, the Chief Mate is number one.
6. Crew rating and crew member's name. The crew rating is listed according to precedence in rating and department. If carried, the sequence for departments is deck, engine, radio, stewards, and medical.
7. Location and specific emergency duty to be performed by crew member.
8. Specific lifeboat assigned to crew member.
9. Specific location and task to be performed by crew member.

STATION BILL CARD

10-5. The crew member will also be issued an individual station bill card. This is usually posted next to the crew member's bunk. The card will list the crew member's station bill number, name and rating, fire and emergency station, lifeboat number, abandon ship, and boat station.

ASSIGNING EMERGENCY DUTIES

10-6. The emergency duties assigned to a particular crewman should, whenever possible, be similar to the normal work activity of that person. For instance, steward's department personnel should be assigned to assist passengers; deck department personnel should be assigned to run out hoses and lifeboats; and the engineering department should be assigned to run out hoses in the machinery space with which they are most familiar.

EMERGENCY SIGNALS

10-7. The signal for FIRE is a continuous blast on the ship's whistle or horn for not less than 10 seconds, supplemented by the continuous ringing of the general alarm bells for not less than 10 seconds.

10-8. The signal for ABANDON SHIP is more than six short blasts followed by one long blast on the ship's whistle supplemented by the same signal on the general alarm bells.

10-9. DISMISSAL from fire and emergency stations is signaled by three short blasts on the whistle or ship's horn supplemented by the same signal on the general alarm bells.

10-10. For man overboard, hail the bridge and pass the word "MAN OVERBOARD--PORT or STARBOARD SIDE."

10-11. Emergency signals, other than for FIRE and ABANDON SHIP will be determined by the ship's master. A special signal should be designated by the master to assemble the emergency squad. This signal should be one that will not be confused with the general alarm and navigational signals. Use coded signals to summon the emergency squad, so not to alarm passengers.

STATION BILL

1 LT-529 (Name of ship)

2 16 June 1997 (Date)

3 US Army (Name of company)

4 Karl V. St. John (Master's signature)

SIGNALS

FIRE AND EMERGENCY---Continuous blast of the whistle for a period of not less than 10 seconds supplemented by the continuous ringing of the general alarm bells for not less than 10 seconds.

ABANDON SHIP---More than 6 short blasts and 1 long blast on the whistle and the same signal on the general alarm bells.

MAN OVERBOARD---Hail and pass the word MAN OVERBOARD to the bridge.

DISMISSAL---Three FIRE and EMERGENCY stations, 3 short blasts on the whistle and 3 short rings on the general alarm bells.

WHERE WHISTLE SIGNALS ARE USED FOR HANDLING BOATS

LOWER boat---1 short blast on the whistle
STOP lowering boat---2 short blasts on the whistle
DISMISSAL from boat stations---3 short blasts on the whistle

ALL THE MEMBERS OF THE CREW MUST FAMILIARIZE THEMSELVES WITH THESE SIGNALS

INSTRUCTIONS

1. Entire crew shall familiarize themselves with the location and duties of their emergency stations immediately upon reporting on board.
2. Each crew member shall be provided with an individual muster/station bill card which must be memorized the special duties to perform.
3. Entire crew shall be instructed in the performance of their special duties and crew on watch will remain on watch on signal for emergency drill.
4. Every person participating in the abandon ship drill will be required to wear a life preserver and enter boat crew shall assemble at mustering or outboard rearing out boat.
5. Emergency squad will assemble with equipment immediately upon the emergency signal.
6. Steward's department will assemble and direct passengers, properly dressed and wearing life preservers, to embarkation stations.
7. Person discovering FIRE shall immediately notify the bridge by sounding the nearest alarm and fight the fire with available equipment.
8. Upon the FIRE and EMERGENCY signal fire doors are to be closed, all watertight and fire screen doors, port and starboard to be closed and all fans and blowers stopped. Fire hose to be laid out and outboard discharge valves closed as directed in the affected area.
9. Upon hearing the signal MAN OVERBOARD, the ship keeps overboard, stop engines and sound lookout on each side. Emergency boat crew consisting of all crewmen shall immediately clear the lee boat for launching.
10. During periods of low visibility, all watertight doors and ports below the bulkhead deck shall be closed, subject to ship master's orders.

5 No.	6 Rating/Name	7 Fire and emergency stations	8 Boat No.	9 Abandon ship and boat stations
A	Master CW2 St. John	On bridge in command of all operations	1	On bridge-in command
1	Ch Mate CW2 Jones	Assume of emergency-in charge	1	Boat deck-in charge of raft #1
2	2nd Mate CW2 Jones	Fore deck-in charge	2	Boat deck-in charge of raft #2
3	3rd Mate WO Gibbs	Main deck aft-in charge	2	Boat deck
4	Boatswain MC Walker	Emergency squad-leader	1	Boat deck-in charge of station detail
5	BM/QM SGT Myatt	On bridge-relieve John	1	Boat deck-provide general navy equipment
6	Lt SGT Brown	Emergency squad-provide pry and life line	2	Boat deck-provide emergency rations
7	AB SGT Veal	Fire station #4 - near lazaret	1	Boat deck-provide 24hr provisional flares
8	AB PFC Bush	Fire station #3 - near lazaret	2	Boat deck - assist with raft #2
9	AB PFC Nixon	Fire station #1 - near lazaret	2	Boat deck - assist with raft #2
10	AB PFC Reagan	Fire station #1 - open valve and near hose	1	Boat deck - assist with raft #1
11	Ord PFC McKinley	Fire station #2 - near lazaret	2	Boat deck - assist with raft #2
12	Ord Pvt Ryan	Emergency squad - provide bottle lantern	1	Boat deck - assist with raft #1
13	Ord Pvt Sinclair	Emergency squad	1	Boat deck - provide signal gun
14	CH ENG CW3 Washburn	Engine room - in charge	2	Boat deck
15	1st Asst CW2 Moon	Engine room - at fire and bilge pumps	2	Boat deck

SAMPLE

16	CH ENG CWO Wahlsen	Engine room - in charge	2	Boat deck
17	1st Asst CWO Moon	Engine room - at fire and bilge pumps	2	Boat deck
18	2nd Asst WO1 Bryant	Engine room - in charge of fixed CO2 system	2	Boat deck - provide flash light
19	3rd Asst WO1 Jensen	Engine room - secure blower and emergency steering	1	Boat deck - provide flash light
20	Bell Cl ISG Scribner	Secure Deftenand / stand by main / with board	1	Boat deck - provide bottle lantern
21	SL Cl ISG Taylor	Fixed CO2 - lead out hose	2	Boat deck - provide bottle lantern
22	Oiler ISG Jackson	Emergency squad - provide tool box	1	Boat deck - provide emergency rations
23	Oiler SFC Bowden	Secure water tight door to engine room	2	Boat deck - provide emergency rations
24	Oiler PFC Bray	Fire / ballast - open valve and man hose	2	Boat deck - provide emergency rations
25	Oiler PFC Johnson	Engine room - assist with fire pump	2	Boat deck - assist with fire #1
26	Oiler Pvt Lowe	Engine room - at telephone	2	Boat deck - provide emergency rations
27	Oiler Pvt Stock	Engine room - assist engine room personnel	2	Boat deck - assist with fire #2
28	SL EM ISG Speck	Radio room - prepare to send distress traffic	1	Boat deck - provide emergency radio
29	2nd EM SFC Sellers	Fire / ballast - open valve and man hose	1	Boat deck - provide emergency rations
30	1st Cook ISG Garrison	Secure galley - provide CIBA to emergency squad	2	Boat deck - provide emergency rations
31	2nd Cook SFC Moon	Close port and door on main deck	1	Boat deck - provide blanket package
32	3rd Cook PFC Black	Fire / ballast - open valve and man hose	2	Boat deck - provide blanket package
33	Medic ISG Cleary	Provide medical aid at emergency scene	1	Boat deck - provide medical kit
34	Passenger	Report to boat deck with life jacket		Boat deck - with life jacket

Figure 10-1. Sample of a Station Bill

EMERGENCY SQUAD

10-12. An emergency squad is a group of crew members selected by the master for their special training to deal with emergencies. The chief mate (assisted by the boatswain) is normally in command of the emergency squad. The rest of the squad should be made up of crewmen trained in the use of fire, emergency, and rescue equipment. Candidates for the emergency squad would be crew members who are highly knowledgeable in emergency procedures. A mustering location for the emergency squad should be included in the station bill. The mustering location could be on either wing of the bridge, at a designated position on the main deck, or wherever the master feels would be best. However, the chosen location should be one that the members of the squads can reach promptly--for example, in less than 2 minutes.

TRAINING

10-13. An emergency squad is a team. A team is a group of people brought together to accomplish a common goal. The word team brings to mind word coordination, cooperation, and training. Training is absolutely essential, since without it there can be little coordination or cooperation. Training consists basically of two parts and must be taught in the following order:

- A teaching-learning process in which the necessary knowledge is communicated to the trainee.
- Practice and demonstration of the necessary skills, using the proper equipment. As an example, fire drills are practice and demonstration sessions. They must come after crewmen have learned what to do; otherwise, they can serve no purpose except to reinforce bad habits.

10-14. Under an able and understanding leader, proper training will gradually produce coordination and cooperation among members of the emergency squad. After several practice sessions they will be operating as a team.

10-15. The master is responsible for all ship's functions, including those he assigns to subordinates. Although the master assigns the training of the emergency squad (and the rest of the crew) to his chief mate, he should review and approve the plans for proposed lessons and drills. These sessions are made more meaningful when the master personally observes them and then discusses them with those in charge.

10-16. The members of the emergency squad should attend periodic instructional sessions dealing with the variety of emergencies that could occur aboard ship. At each session, a problem could be presented, solutions discussed (until a satisfactory one is found), and the necessary tools and equipment should be handled for familiarity. Then the regularly scheduled fire drills would be demonstrations of efficiency rather than training sessions.

CREW FIRE FIGHTING TRAINING

10-17. The emergency squad may be called upon to deal with many emergencies, such as collision, man overboard, and a lost or damaged rudder. When the fire signal is sounded, all hands are involved. The station bill lists an assigned task and station for each member of the crew. Therefore, all crew members should receive some training in fire fighting.

ABANDON SHIP PROCEDURES

10-18. During all shipboard drills and emergency operations, crew members must wear their life jackets. It is one of the most important pieces of equipment for your survival in the water. It will hold you in the upright floating position without your having to swim. Another safety point during a drill or the real thing is to always wear a hat or some type of headgear to protect you from the elements.

DONNING THE LIFE JACKET

10-19. If you have time, put on extra clothing. Include an outer layer of wind and waterproof clothing fitted if possible with headcover and gloves. Then put on the life jacket in the following manner (see also Figure 10-2):

- Check the white tag on the lower back of the life jacket. This is the inside, and is worn next to your body.
- Put your arms through the holes.
- Pull the jacket up and around your shoulders.
- Put the neck straps through the D rings on each side of the jacket and tie them in a bowknot.
- Pull the chest strap and the waist straps tight, and then tie with bowknots.
- Take the slack out of the belly strap and snap it together.
- Reach down and back between your legs and grab the left-leg strap and pull it up between your legs.
- Put the end through the D rings and pull tight.
- Repeat the procedure for the right-leg straps.

Note*:* Practice putting on and securing your life jacket until you are able to don and secure it within 2 minutes.

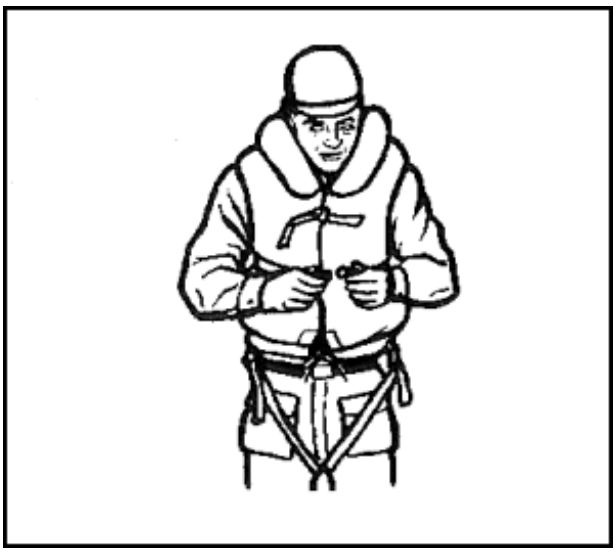


Figure 10-2. Donning Life Jacket

ENTERING WATER FROM A HEIGHT WEARING A LIFE JACKET

10-20. Make sure that your jacket is well secured. If it is not well secured, you could hurt your head when you jump. Then get down to a height of less than 30 feet if you can. Below 15 feet is ideal. If you jump from higher than 30 feet, you can hurt yourself (this depends on the height from which you jump and the angle at which your body hits the water). If worn, remove false teeth, eyeglasses, or contact lenses. Also remove any sharp objects from your pockets. Get in the jump position (see Figure 10-3) and do the following:

- Stand on the gunwale and check the water for debris.
- Check to see if the life jacket is tied and all the straps are secured.
- Hold your nose and cover your mouth with your left hand.
- Cross over your left hand with your right hand and hold the life jacket collar securely.
- Hold your elbows into your side as much as possible.
- Keep head and eyes straight ahead. Do not look down.
- Take one step out using either foot.
- Bring your trailing leg up behind your leading leg so that they cross at the ankles. This will protect you if you should land on any floating debris.

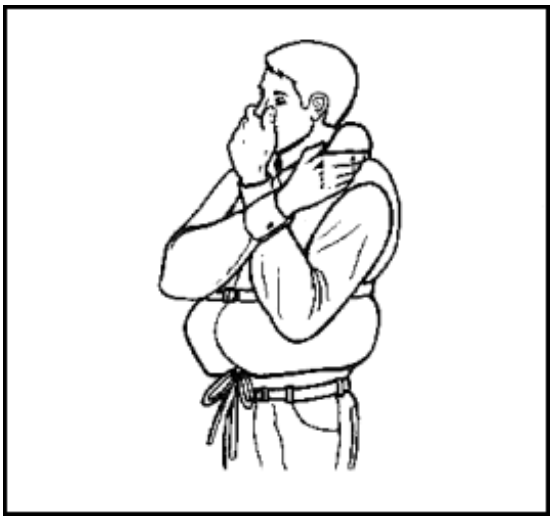


Figure 10-3. Jumping in Water

10-21. Get away from the ship once you are in the water. Swim as slowly as possible toward the survival craft. DO NOT swim or thrash about any more than you need to because of the following:

- You will lose your body heat.
- You will lose your strength. You will need all your strength to pull yourself up and into the survival craft.
- You should let your life jacket support you in the face-up position.

DROWNPROOFING

10-22. Drownproofing, also called water survival, is based on the natural buoyancy of the human body when the lungs are filled with air. It is intended to keep anyone alive in the water indefinitely, even a nonswimmer who is fully clothed. Drownproofing saves energy for the potential drowning victim. It is much easier to do the steps on drownproofing for long periods of time than to stay afloat by swimming. Each crew member should know drownproofing since it is an excellent way to stay afloat without a life preserver. This method can best be described in the following five steps.

- **Step 1--Resting Position.** The swimmer takes a deep breath and then sinks below the surface. The face is kept down with the back of the head even with the water surface (Figure 10-4). In this position, he will sink no deeper.
- **Step 2--Preparing to Exhale.** When ready for another breath (in about 6 to 10 seconds), maintaining the body and head position as shown in Figure 10-5, the swimmer slowly lifts the arms to about shoulder height. The legs slowly separate into a scissors-type kick.
- **Step 3--Exhalation.** The head of the swimmer is raised just high enough for the mouth to be out of the water (Figure 10-6). The swimmer now exhales through the nose, the mouth, or both. To give the swimmer bearing, the eyes should be open.
- **Step 4 --Inhalation.** As the head becomes vertical, the swimmer presses his arms downward and brings his legs together (Figure 10-7). The air is then inhaled through the mouth. The action of arms and legs should be done slowly.
- **Step 5--Return to Rest Position.** The swimmer relaxes his arms, and at the same time his legs move back to a dangling position. The swimmer's face goes back into the water and he "rests" once again (Figure 10-8). The cycle is then repeated.

While most persons can master drownproofing easily, skill is involved in breathing close to the water and instruction is necessary.

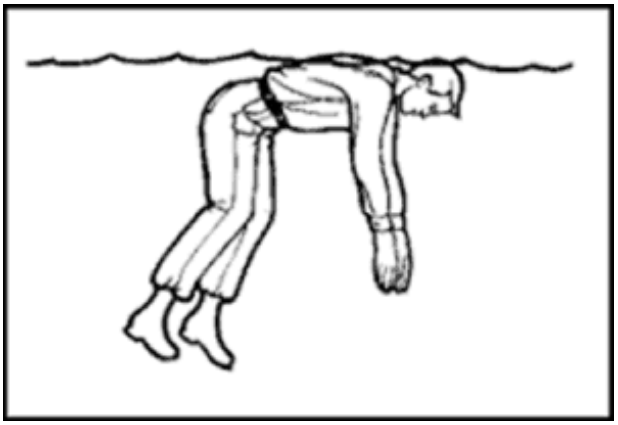


Figure 10-4. Resting Position

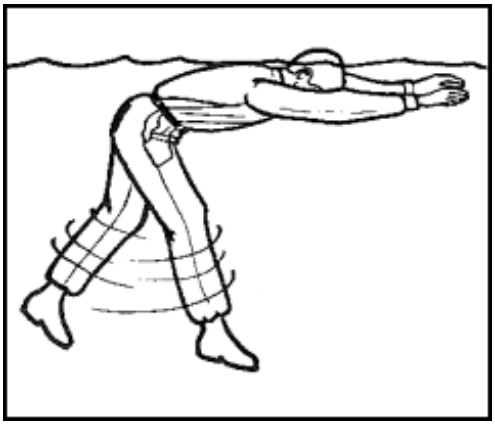


Figure 10-5. Preparing to Exhale

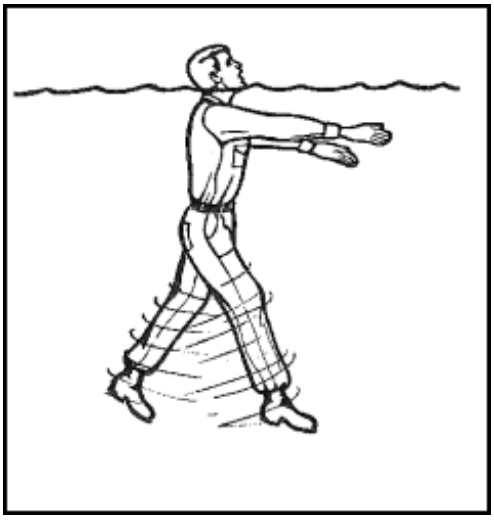


Figure 10-6. Exhalation

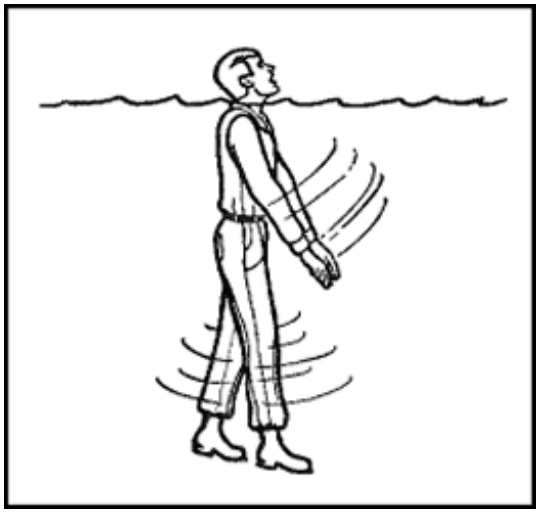


Figure 10-7. Inhalation

Figure 10-8. Return to Rest Position

TRAVEL STROKE

10-23. This stroke is used in a water survival situation when you are required to swim, while conserving as much energy as possible. Here is how it is done:

- Enter the water.
- Take a deep breath.
- Put your face in the water, arms at your side, feet together, and body horizontal.
- Prepare to breathe; move your hands up alongside of your body to a position in front of your forehead and palms down. At the same time, spread your legs in scissors fashion in preparation for a kick.
- Kick and exhale. Bring your feet together quickly and exhale through your nose and mouth. Raise your head slowly out of the water.
- Stroke and inhale. Stroke a heart-shaped stroke with your hands, then bring your hands back in front of your chest; at the same time, inhale through your mouth.
- Put your head back in the water and spread your legs for another kick.
- Kick and level. Extend your hands out in front and at the same time kick, bringing your feet together.
- Stroke and glide. With your elbows locked, sweep your hands to the side.
- Continue the glide until your feet start to drop or another breath is required.
- Repeat the process.

SWIMMING THROUGH THICK OIL FIRE

10-24. The most important thing to remember for your survival if you are forced to swim through a thick oil fire is to keep calm. The proper procedure for swimming through a thick oil fire is described in the following steps:

WARNING: NEVER WEAR A LIFE JACKET WHILE SWIMMING IN A THICK OIL FIRE.

- **Step 1.** Enter the water on the windward side of the vessel (windward is the direction from which the wind blows), feet first with one hand over the nose and mouth and the other hand covering the eyes.
- **Step 2.** Level out under the surface of the water and start swimming.
- **Step 3.** When you must breathe, surface in a straight up-and-down position with your hands extended above your head (Figure 10-9).
- **Step 4.** Exhale about 75 percent of the air in your lungs before breaking the surface.
- **Step 5.** As soon as your hands break the surface, start beating away the burning oil with a circular thrashing motion.
- **Step 6.** Fully inhale before submerging (Figure 10-10).
- **Step 7.** Continue swimming in this manner until you are clear of the burning oil (Figure 10-11).

Figure 10-9. Break the Surface

Figure 10-10. Fully Inhale

Figure 10-11. Swimming Through Thick Oil Fire

SWIMMING THROUGH A THIN OIL FIRE

10-25. The most important thing to remember for your survival if you are forced to swim through a thin oil fire is to keep calm. The proper procedure is shown in Figure 10-12, and described in the following steps:

WARNING: WEAR YOUR LIFE JACKET AT ALL TIMES WHILE SWIMMING THROUGH A GASOLINE OR THIN OIL FIRE. KEEP YOUR HEAD ABOVE WATER AT ALL TIMES.

- **Step 1.** Enter the water from the windward side of the vessel, feet first with one hand over the nose and mouth and the other hand covering the eyes.
- **Step 2.** Bring your hands up in front of your face, elbows extended with the palms halfway out of the water.
- **Step 3.** Push the water out in front and continue the stroke until your arms are straight out from the body.
- **Step 4.** Continue swimming until you are out of danger.

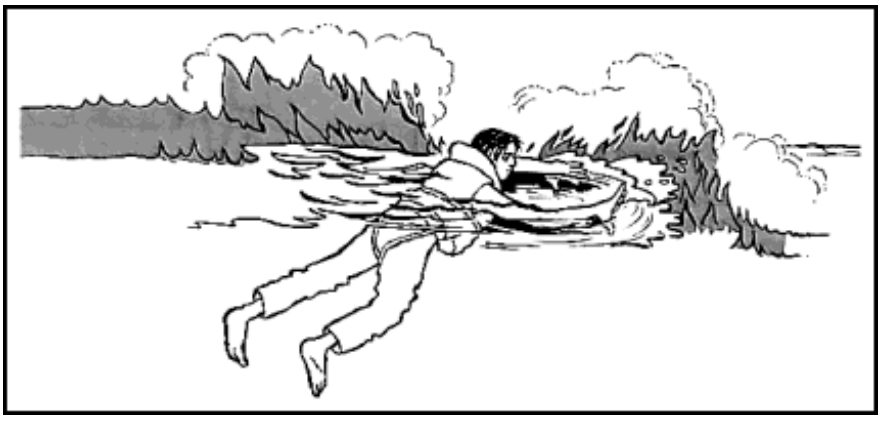


Figure 10-12. Swimming Through Thin Oil Fire

COLD WATER DROWNING

10-26. After reading the following, you and your crew, as would-be rescuers, should be more willing to attempt to revive a person who is supposedly "drowned."

10-27. Due to recent medical research, it has been discovered that the bodies of people "drowned" in cold water (below 70° F, 21° C) may go into a diving reflex. In this condition, the nervous system cuts off the flow of blood to all parts of the body except the brain and lungs. The heart slows so much that it cannot be heard without special instruments. The result is that a person can exist in seemingly a "dead" state for up to an hour, depending on the their age and the temperature of the water. The basic trigger that starts the diving reflex is cold water touching the face, specifically the area around the eyes and forehead.

10-28. However, the diving reflex does not always work. Studies show that the person's age combined with the temperature of the water are the main factors in deciding whether the reflex will start, and, if so, how long it will be effective. Its effectiveness is measured by how long it works before permanent brain damage begins.

10-29. The reflex is extremely active in youngsters. In infants and small children, it can be started by a water temperature of 65° F (18°C) and can, in theory, last for as long as an hour. As a person gets older, the water must be colder to start it and it is effective for a shorter time. The diving reflex may be one of those natural systems, which protects small children from their own inexperience.

10-30. A person's body weight also comes into play when the reflex is connected with hypothermia. Hypothermia simply means that the body temperature is below normal. However, when you take your temperature and it is 97.5°F instead of 98.6° F, it does not necessarily mean that you are a hypothermia victim. Hypothermia usually refers to the lowering of inside body temperature because of coldness outside the body such as cold water or a cold wind. Your arms and legs will become numb and you will lose the use of them if your body temperature gets down to about 93oF. When it reaches 80° to 86°F, you may lose consciousness; should it drop to about 79°to 77°F, it becomes fatal.

10-31. A person's weight is a factor when figuring how long it will take for all this to happen. Generally, the bigger a person is, the longer it takes for his body to lose heat because he has better insulation. Other factors that affect this heat loss are age, clothing, and physical activity.

10-32. It is the result of cold rather than the effect of drowning that begins the diving reflex. Hypothermia victims, even those not in cold water, often get some assistance from the reflex. In reaction to the cold, the vital body functions slow down to an almost unmeasurable level and thereby save body heat as well as oxygen. Again, this lengthens the time before serious brain damage begins. This extension can make the difference between whether or not a "drowned" person, or hypothermia victim, can be successfully rescued.

10-33. Tests during World War II revealed that a thin person in a flight suit and life jacket could survive up to 72 minutes in 40° F (5°C) water. However, he would be unconscious and apparently dead some time before that.

10-34. While this knowledge of the diving reflex may be consoling to a person drowning and going down for the final time, it is primarily important to his rescuers. Should your vessel be the first one on the scene of a cold water drowning, the things you and your crew do can determine whether the victim lives or dies.

10-35. Since you can never assume that medical assistance will be on the scene when a drowning victim is pulled from the water, his life may depend on you. The diving reflex stops as soon as the victim is taken out of the water. That means that you may have less than 4 minutes to get his blood flowing. Table 10-1, shows some DOs and DO NOTs to remember when reviving cold water drowning victims.

Table 10-1. Reviving Cold Weather Drowning Victims

DO	DO NOT

Start CPR immediately. This is a form of mouth-to-mouth resus-citation and external heart massage. Only a person that is qualified should attempt CPR. Check with your installation's hospital about available CPR training programs. Keep the victim warm with a light blanket or jacket, and so on, but do not waste necessary time on this. Keep giving CPR until medical assistants take over or until the victim revives.	Give the victim any alcoholic drink. Try to rewarm the victim with anything more than a light blanket, jacket, or so forth. Uncontrolled rewarming can cause severe injury.

FIRST AID FOR COLD WATER VICTIMS

10-36. Treatment will depend on the condition of the survivor and the facilities available. In more serious cases, where the victim is semiconscious or unconscious, contact should be made immediately with a ship or shore medical facility for detailed information on the care and handling of the victim. Administer the following first aid while waiting for medical instructions:

- After removing the victim from the cold water, gently transfer him to a warm environment. Rough handling of the victim can cause further harm.
- Remove his clothes only if it can be done with a minimum of movement of the victim's body. Do not massage him.
- Lay the victim in a face up and slightly head down position, unless vomiting occurs. This is important because a hypothermia victim has low blood pressure, and the head-down position ensures an adequate supply of blood to the brain.
- If available, administer warm, humidified oxygen by means of a face mask. The oxygen will not only assist victims if they are having difficulty breathing or have a low respiratory rate, but it will also provide core rewarming. Mouth-to-mouth resuscitation is always advisable if the victim is having problems breathing and no other form of assistance is available.

10-37. In some cases, you should rewarm the victim actively; in other cases, you should not rewarm him at all. Before deciding what to do, you need to know something about the following two different types of hypothermia.

Chronic, or Slow Onset Hypothermia

10-38. This type comes from being exposed (from a few hours to several days) to cold weather. Most chronic hypothermia cases develop in air temperatures of 30° to 50° F. The victim usually overestimates how long he can withstand the cold and fails to recognize the danger of being wet at such temperatures. A victim can get wet from sweat, rain, or from the splash and spray of water from working on the deck of a vessel. Because chronic hypothermia takes some time to develop, the victim may undergo dangerous fluid and biochemical changes. For these reasons, you do not want to rewarm the victim. As with a cold water drowning victim, victims of chronic hypothermia should be taken to a hospital as quickly as possible. REMEMBER, DO NOT REWARM A CHRONIC HYPOTHERMIA VICTIM!

Acute, or Rapid Onset Hypothermia

10-39. This type of hypothermia is different and is the result of immersion in cold water. Since water can withdraw heat from the body 25 or more times faster than air, we can estimate that in water temperatures of, 72° F and lower, the body cannot generate enough heat to offset heat loss to the water. Depending on water temperatures and body condition, acute hypothermia may begin to develop in as little as 10 to 15 minutes. Because of the rapid onset, acute hypothermia victims do not generally have time to develop dangerous chemical and fluid imbalances. Therefore, without delay, begin to REWARM ACUTE HYPOTHERMIA VICTIMS IMMEDIATELY. Even conscious hypothermia victims have died following apparently successful rescues when attempts at rewarming were delayed or were inadequate. Any of the following warming methods are recommended, preferably in the order given.

- Place the survivor in a hot shower or bath at 105° to 110°F or a temperature in which an observer can comfortably leave his arm. Keep the arms and legs out of the bath. If you are warming a victim in a shower, keep his limbs out of the spray to delay the return of blood circulation to the extremities since heating the limbs causes cold blood to flow from them to the body core. This further cools the core. Rather, direct the spray on the center of the back or the chest.

- Apply hot, wet towels or blankets at 115° F to the victim's head, neck, groin, chest, and abdomen. Again, do not attempt to warm his arms and legs.
- Apply your own body warmth by direct body-to-body contact with the victim. A blanket should then be wrapped around you and the victim to conserve the heat you are supplying. Unless he is in a warm environment, just wrapping a hypothermia victim in a blanket without a heat source is ineffective. This is because he is not generating sufficient heat to rewarm himself and the blanket insulates him from the warm environment.

10-40. Let us clear up something that may be confusing about rewarming cold water survival and drowning victims. Suppose a person has been in cold water (below 70°F) and was recovered within a 10- to 15-minute time span. Would you start first aid treatment as a chronic or acute hypothermia victim? You would treat this victim as a chronic hypothermia patient--you would not rewarm him. As in chronic hypothermia, the body could undergo dangerous biochemical changes.

COLD WATER SURVIVAL

10-41. The following will teach you how to improve your chances of survival in cold water. As mentioned before, body heat loss is a gradual process and the diving reflex provides some protection.

10-42. The loss of body heat is probably the greatest hazard to the survival of a person in cold water. Knowing what steps to take to help your body delay the damaging effects of cold stress will help you stay alive in the event of cold water exposure. Try protecting your head, neck, groin, and the sides of your chest. These are areas of rapid heat loss in cold water.

10-43. Locate and wear personal flotation equipment such as a life jacket. If you are not wearing it when you enter the water, put it on as soon as possible after entering the water. This is probably the single most important item of survival equipment. Survival in cold water is tough enough without having to contend with staying afloat. Learn how the flotation device is worn and used before an accident occurs.

10-44. Try to enter the water in a lifeboat or raft. This will avoid getting your insulation wet and lost of valuable body heat to the water. Abandoning a ship by means of a lifeboat or raft will greatly increase the chance for survival. This is better than jumping overboard and attempting to be rescued.

10-45. Wear several layers of clothing. If you are fortunate enough to stay dry and enter the water in a lifeboat or raft, the trapped air within your layers of clothing will provide excellent insulation. However, if you become wet in abandoning your ship, the layers of clothing, although wet, will slow down the rate of body heat loss.

10-46. If conditions prevent you from abandoning ship in a lifeboat and you must enter the water directly, try to cut down the shock of a sudden cold plunge in the water. Rather than jumping into the cold water, try to lower yourself gradually. A sudden plunge into cold water can cause rapid death as a result of the severe shock to your nervous system. It may also cause an uncontrollable rise in breathing rate resulting in an intake of water into the lungs. If jumping is necessary, try to hold your breath, pinch your nose, and avoid swallowing water during the plunge.

10-47. The body position you assume in the water is very important in conserving your body heat. Tests show that the best body position is one where you hold your knees up to your chest in a "doubled up" fashion with your arms tight against the side of your chest (Figure 10-13). This position reduces the exposure to the cold water of your groin and chest sides, both areas of high heat loss. Try to keep your head and neck out of the water.

10-48. Another heat conserving position is to huddle closely to one or two others afloat, making as much body contact as possible (Figure 10-14). You must be wearing a life jacket to be able to hold these positions in the water. You should also wear a life jacket in the lifeboat or life raft.

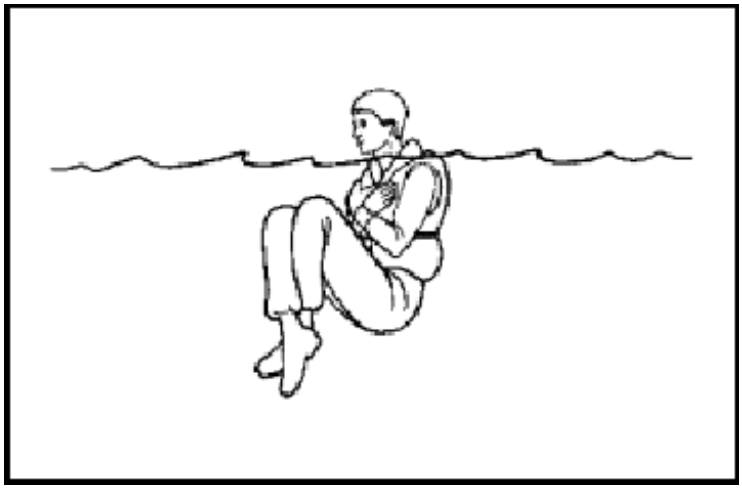


Figure 10-13. Double-up

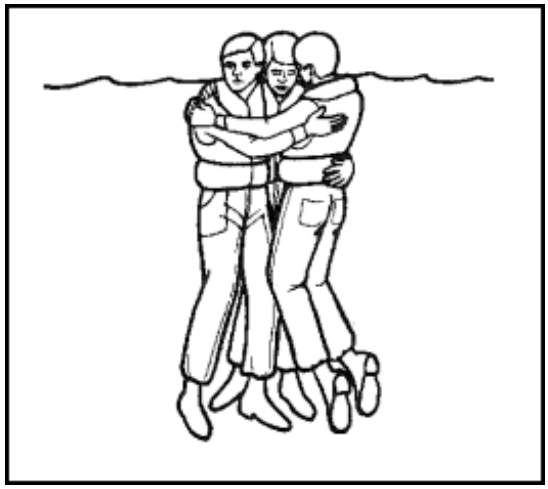


Figure 10-14. Buddy-up

10-49. Try to board a lifeboat, raft, or other floating platforms or objects, as soon as possible, in order to shorten immersion time. Remember that you lose body heat about 25 times faster in water than you do in air. Since the effectiveness of your insulation has been seriously reduced by water soaking, you must now try to shield yourself from wind to avoid a wind-chill effect (convective cooling). If you manage to climb aboard a lifeboat, shielding can be accomplished with the aid of a canvas cover, a tarpaulin, or an unused garment. Huddling close to the other occupants of the lifeboat or raft will also conserve body heat.

10-50. Keep a positive attitude about your survival and rescue. This will improve your chances of extending your survival time until you are rescued.

MAN OVERBOARD PROCEDURES

10-51. Immediately on seeing a crew member fall over the side, shout an alarm! Call out the words "Man overboard!" to personnel on the bridge. Be sure to include where on the vessel the person fell overboard. For example:

- On the right side of the vessel call out: "Man overboard, starboard side!"
- On the left side it would be: "Man overboard, port side,"
- At the front of the vessel it would be: "Man overboard at the bow!"
- At the rear it would be: "Man overboard at the stern!"

Action

10-52. Immediately after these vocal alarms are given, three things must happen at the same time:

- Get the stern away from the victim.
- Mark the spot.
- Post a lookout.

10-53. These things do not happen 1-2-3; they are done at the same time. That is why teamwork is a necessity. The first action of the person in charge of the vessel is to get the stern away from the victim. On a small craft it may be necessary to cut the throttle immediately and swing the stern away from the person in the water to avoid hitting him with the screws.

10-54. When the bridge watch hears the man overboard signal, the helmsman must be told immediately to put the rudder hard over to swing the stern away from the victim. If the victim falls overboard on the starboard side, the helmsman would turn the helm "hard right rudder." If the victim falls over on the port side, then naturally the helm will be put to "hard left rudder."

Mark the Spot

10-55. There are two procedures for marking the spot. One is used during hours of daylight the other is for hours of darkness. To mark the spot during daylight:

- Throw a life preserver or life ring immediately.
- Drop a smoke float.
- Get anything that floats into the water near the person that he can hang onto.

To mark the spot during darkness:

- Immediately throw a life preserver or buoy ring with water lights.
- Keep the vessel's searchlight trained on the victim.

Post a Lookout

10-56. Keep the victim in sight. It is easy to lose sight of the victim's position, especially in rough weather or at night. The person who saw the victim fall overboard usually makes the best lookout. It is also a good idea for the lookout to be posted on the forward part of the vessel for easier viewing.

Raise the Oscar Flag

10-57. The Oscar Flag is raised to let other vessels in the area know that you have a man overboard.

Pick up the Victim

10-58. If circumstances permit (such as if you are not limited by narrow channels or landfalls, and so forth), the Williamson turn, used by large vessels, has proven to be the preferred maneuver for picking up victims (Figure 10-15). To make the turn you must do the following:

- Put the rudder over to the side from which the victim fell. This action swings the stern away from that person.
- Hold the rudder hard over until the vessel begins to turn.
- Then steady her on a course about 60° off the original course.
- When the vessel heads on the new course, turn the rudder hard over to the opposite side until she is on a course 180° from the original course.
- Maintain the original speed until the vessel is steady on the reverse course.

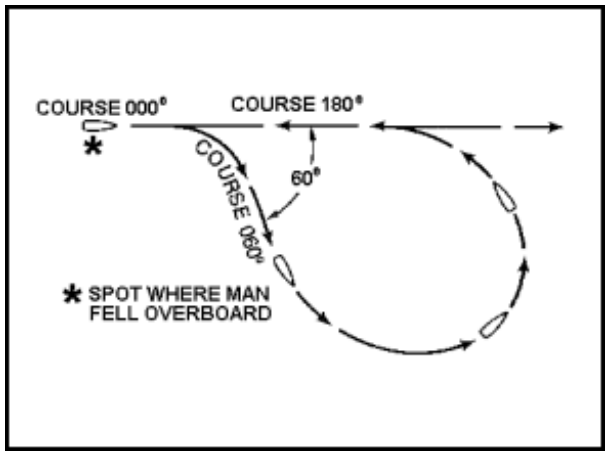


Figure 10-15. Williamson Turn

Other Maneuvers

10-59. On large vessels equipped with lifeboats, a lifeboat is lowered and the lifeboat crew maneuvers into position to rescue the victim. A small vessel, especially one with two screws, often is so maneuverable that it is simpler, safer, and quicker to maneuver the vessel back to the person in the water and throw them a line than to make the Williamson turn. For example, an LCM or LCU could make the pickup at the ramp. The vessel must turn around until its course has been reversed. At slow ahead, when it has been determined that the propellers will not endanger the person in the water, the vessel can be maneuvered toward them.

10-60. The vessel must approach slowly on the windward side of the victim. If the vessel is placed so that it shields the victim from the waves and the wind, the water around the victim will be calm. However, caution must be exercised to prevent the vessel from coming too close to the victim (Figure 10-16). Lines with life rings must be prepared so they can be thrown as soon as possible. The only time maneuvers of this type may be used at night are when weather conditions make launching a boat impossible.

10-61. When having man overboard drills, it is a good idea to identify all crew members who are good swimmers, and designate them for special emergency duty. When an overboard victim is unconscious, a good swimmer with life preservers and lifelines can jump in and help with the rescue. The first thing a man overboard should try to do is to get clear of the vessel, especially the stern, so that he does not get sucked under or hit by the screw.

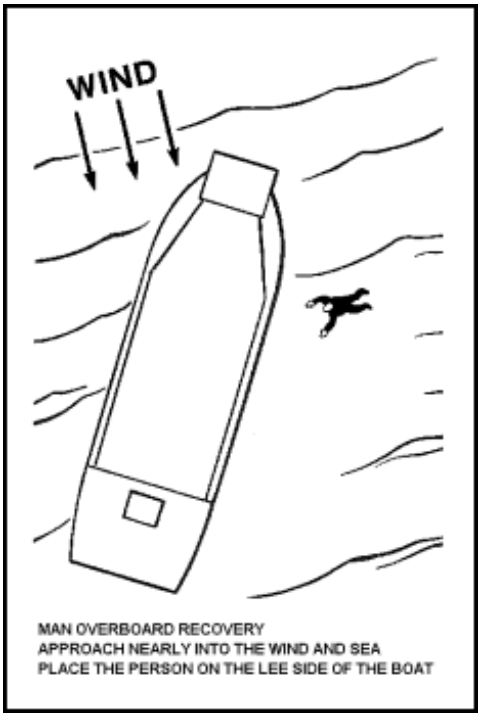


Figure 10-16. Bringing Ship Into Wind

10-62. The overboard victim should stay in the same general area where he fell, especially at night and in foul weather. Staying in the same general area will make it easier for the ship's lookouts to spot him since they will generally know where to look.

10-63. Victims of a fall overboard can help the ship's lookouts by:

- Making themselves more visible.
- Making themselves heard.

A victim can help to make himself more visible by waving his arms, a handkerchief, his T-shirt (if the water is not too cold) or any brightly colored object he might have been holding or wearing when he went overboard. If he was wearing a life preserver when he fell, and he does not need it to stay afloat, he can float the preserver alongside himself in the water. However, if the water is rough or if he is a poor swimmer, he should NEVER remove his preserver.

10-64. A victim can make themselves heard by the following:

- Shouting (if in hearing distance).
- Splashing the water (which can also improve his visibility).
- Sounding the whistle (if he was wearing a life preserver when he fell overboard).

10-65. Up to now, we have covered what to do if an overboard accident happens. Let us go over the different kinds of man overboard accidents, what causes them, and the things we can do to prevent them.

10-66. Most falls happen while a person is moving, standing, or leaning over the edge of a vessel. However, falls may occur from a wide range of causes which include, but are not limited to the following:

- Limited visibility caused by darkness, fog, or bad weather.
- A sharp turn or acceleration.
- A wave or wake striking the vessel.
- Sitting on a gunwale, the stern, or the bow.
- A slippery surface.

10-67. The following are some things you can do to prevent an overboard accident:

- Do not allow horseplay.
- Make sure everyone uses the handrails.
- Have everyone watch where he walks to avoid tripping.
- Make sure lifelines are rigged for crew members to use when working near the edge of the vessel.
- Do not allow anyone to sit on gunwales.

LIFE RAFTS

10-68. The inflatable life raft is as important a lifesaving device as the lifeboat. Shipboard drills with the inflatable life raft are not conducted because the raft container is sealed until ready for automatic or manual launching. Therefore, it is important to learn about the current design of rafts and keep informed of future design.

LIFE RAFT SIZE

10-69. Inflatable life rafts must be either Navy standard or Coast Guard approved. Life rafts have a range of sizes. Ships that do not make international voyages might have rafts that can hold 4 to 26 people. Ships that make international voyages might have rafts that can hold 6 to 25 people. The capacity (number of persons it will hold) of the life raft is marked on the container and the raft. The manufacturer's name is also shown on the container. An inflatable life raft (complete with case and equipment) does not weigh more than 400 pounds.

LIFE RAFT STOWAGE

10-70. Life rafts are kept in a cradle on an open deck (Figure 10-17). This is done so they can float free if the ship sinks before you can manually launch the raft.

10-71. The life raft container is strong, weathertight, and tamperproof. The raft container has small holes on the bottom for condensation drainage and air circulation. The container must be stowed with the words "THIS SIDE UP" on top to be sure the holes are on the bottom. Most containers are made of fiberglass.

10-72. The raft container is usually held together with packing bands, which break when the raft is inflated. A watertight gasket seals the two halves of the container together.

10-73. The container rests in a cradle. The cradle is permanently secured to the ship's deck. The container may be secured to the cradle with tiedown straps. A tiedown strap has a securing device called a hydrostatic release. A cleat provided near the cradle is used for tying the operating cord when launching manually.

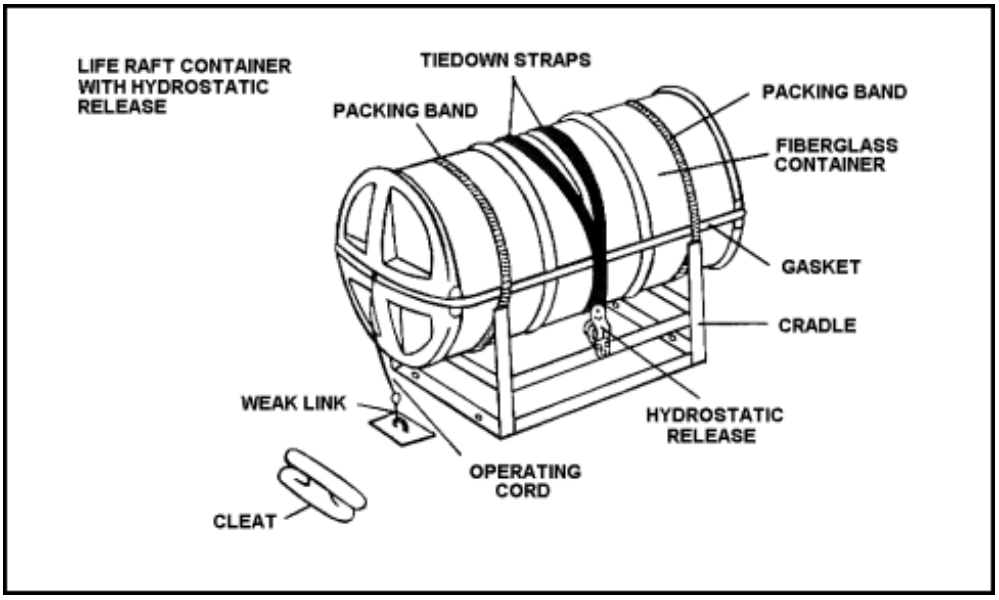


Figure 10-17. A Cradled Life Raft

LIFE RAFT DESIGN

10-74. Buoyancy tubes are located on the outer edge of the raft. They are made of thick nylon-reinforced rubber. The buoyancy tubes make the raft float. They are divided into at least two compartments. The raft is made to support its rated number of persons even if half the compartments in the buoyancy tubes are deflated.

Note*:* Inflatable life rafts may be designed to be round, oval, octagonal (eight-sided) or boat-shaped. Specific design may vary among manufacturers. A typical oval inflated life raft is shown in Figure 10-18.

10-75. Carbon dioxide is usually used to inflate the raft. The CO_2 cylinder (container) is on the bottom of the raft. It is activated by a sharp tug on the 100-foot long operating cord. The tug pulls the CO_2 tripping lanyard out of the CO_2 to enter the buoyancy tubes. The CO_2 can escape through leaks in the tubes. The gas is odorless, tasteless, and colorless, so you must watch for leaks. If you breathe air with a large amount of CO_2, you can suffocate, so always leave the curtains open if you know the tubes are leaking. Fix the leak as soon as possible.

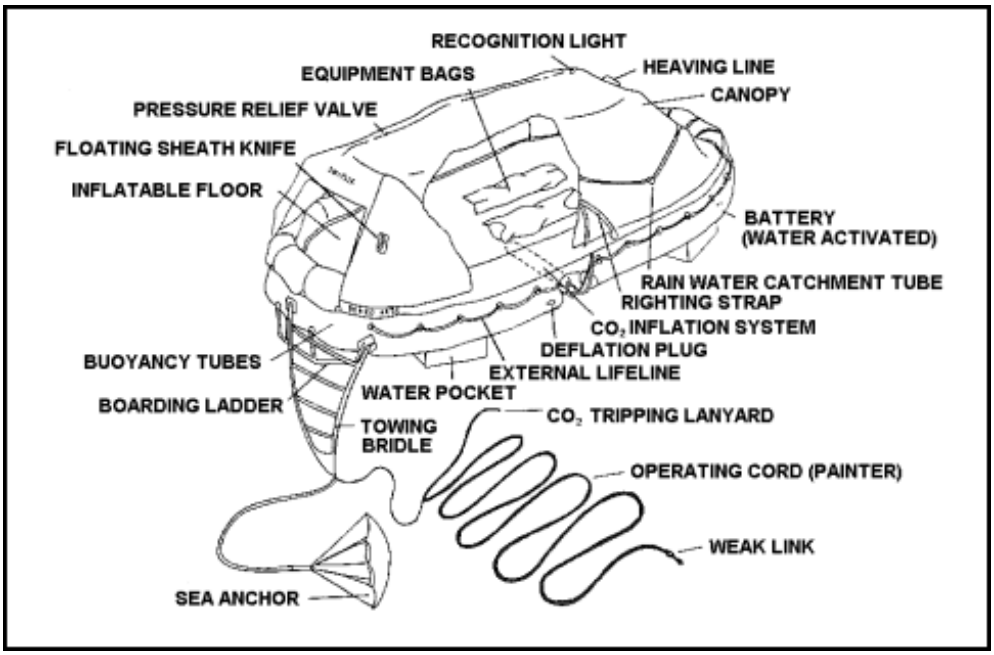


Figure 10-18. A Typical Oval Inflated Life Raft

10-76. Pressure relief valves are installed in most rafts. These valves are fitted in the tubes, so excess (extra) gas can automatically escape. It is normal for gas to escape right after the raft is inflated. You can tell it is escaping if there is a hissing sound coming from the valve. The sound will probably stop after a few minutes.

10-77. During the day, the rise in temperature might cause the gas to expand enough to activate the valves. At night, when the temperature drops, you may have to pump up the tubes with the inflation pumps because the air in the tubes might contract.

10-78. Sometimes, pressure relief valves do not work correctly. If gas continues to escape from the pressure relief valve, you can fix it with a safety valve plug from the repair kit. Then pump the tube back up. Deflation plugs are provided to deflate the raft after rescue.

10-79. The floor of the raft is also inflatable. In cold climates, the floor should be inflated with the inflating pump. This will insulate the occupants from the cold seawater. The floor should be left deflated in warm climates. This will allow the cooler seawater to cool the inside of the raft. If necessary, some inflatable floors can be removed and used for an extra emergency float.

10-80. A boarding ladder and towing bridle are fitted at each end of the raft. The two are usually combined. In addition to boarding and towing the raft, the raft can be hoisted aboard a ship by hooking onto one or both towing bridles. Lifelines are provided inside and outside the raft for survivors to steady themselves.

10-81. Two lights are installed on the canopy. These lights are automatically activated when the raft inflates. They are powered by either dry cells or water-activated batteries. The lights can operate for at least 12 hours. The external recognition light can be seen from 2 miles away. The other light is inside the canopy. Unscrewing the bulbs during the day will prolong battery life.

10-82. The canopy has two layers to insulate the inside from extreme temperatures. It erects (pops up) automatically as the arch tubes inflate. The canopy has tubes to collect rainwater. The canopy is colored Indian orange or some other bright color, which would stand out on a whitecapped sea.

10-83. Water pockets are located under the floor. They have holes in them to allow seawater to fill them up when the raft is launched. Water pockets have two purposes: to slow the drifting of the raft and to make the raft more stable (less likely to capsize).

10-84. The early designs of water pockets were simple, but did not always work well. In heavy seas or high winds, an empty or unevenly loaded raft with three or four small water pockets could easily capsize. Some inflatable life raft manufacturers have improved the basic stabilization design.

10-85. The Givens raft has a large stability chamber instead of the small water pockets. As the angle of the sea changes, the stability chamber adjusts the raft's center of gravity to compensate for the wave action. When the Givens raft reaches the crest of a wave, the raft bottom should not lose contact with the water, and should not be caught by the wind and capsize. The raft is not easily capsized in high winds with its minimum of 4,800 pounds of water ballast (on the four- to six-person raft). The stability chamber can be deballasted (emptied) so the raft can be towed.

MANUALLY LAUNCHING A LIFE RAFT

10-86. You are required to know how to manually launch a life raft. Do the following steps to successfully perform this task:

- **Step 1.** Pull open the hook at the hydrostatic release to release the tiedown straps.
- **Step 2.** Secure the operating cord (painter/lanyard) to the cleat. Make sure that the operating cord is free of tangles.
- **Step 3.** DO NOT REMOVE the bands around the container. They will automatically break open when the operating cord is pulled.
- **Step 4.** With two or more crew members, throw the life raft in its container overboard (Figure 10-19).
- **Step 5.** With the life raft and container in the water, pull on the operating cord (Figure 10-20). The bands on the container will break and the life raft will automatically inflate.
- **Step 6.** Leave the operating cord attached to the cleat aboard the ship.
- **Step 7.** Board the life raft as soon as possible (Figure 10-21).
- **Step 8.** Remove the knife from the pocket on the canopy.
- **Step 9.** Cut the operating cord to free the life raft from the sinking ship.
- **Step 10.** Read the survival manuals that are found inside the raft. These will give you complete instructions on what to do while you are in the life raft.

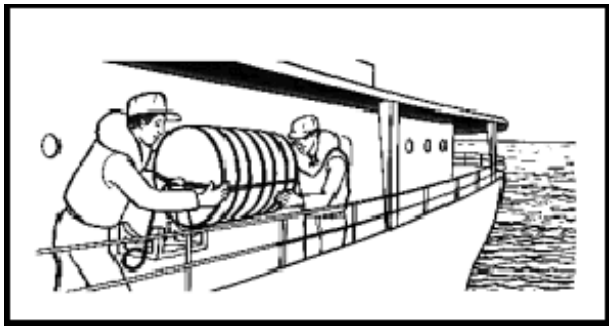


Figure 10-19. Throwing in Life Raft

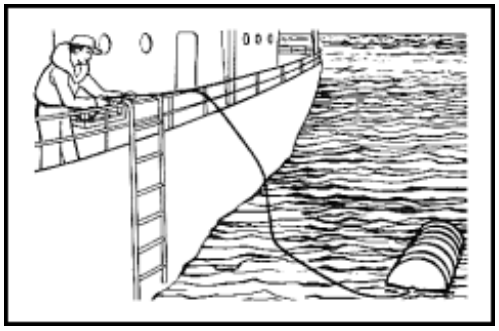


Figure 10-20. Yanking on the Operating Cord

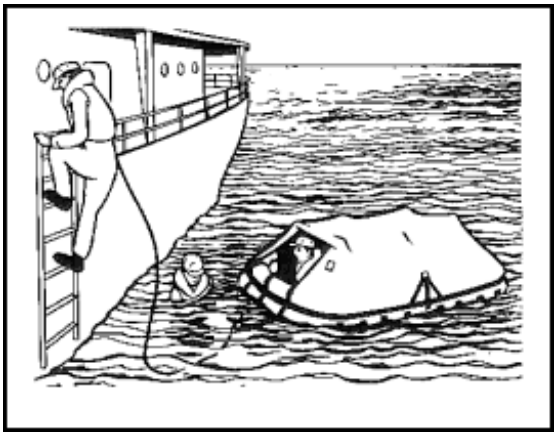


Figure 10-21. Boarding Life Raft

AUTOMATIC LAUNCHING OPERATION

10-87. After the ship sinks to a depth of 10 to 15 feet, the hydrostatic release will automatically release and free the life raft container. The container will rise to the surface (Figure 10-22). The pull of the sinking ship will cause the container bands to part and trigger the inflation of the life raft. The life raft will be completely inflated and ready for boarding within 30 seconds. The buoyancy of the life raft will cause the operating cord to part (Figure 10-23).

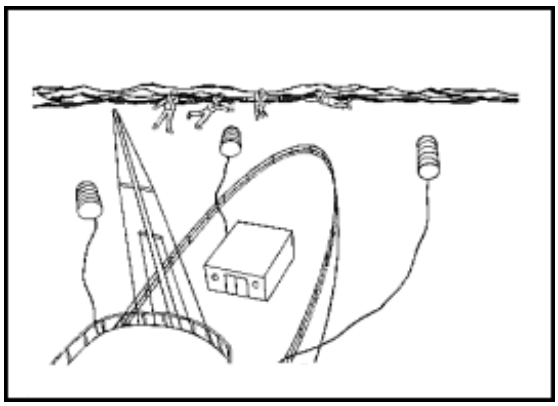


Figure 10-22. Containers Rises to Surface

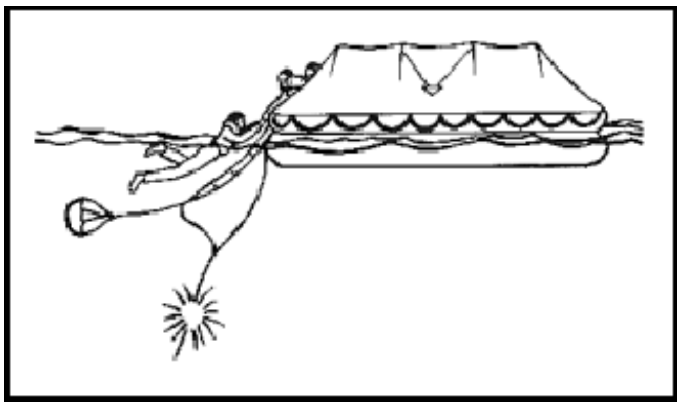


Figure 10-23. Operating Cord Parting

GETTING ABOARD THE LIFE RAFT

10-88. The life raft may be boarded by any one of these procedures:

- By climbing down a ladder.
- By jumping into the canopy (Figure 10-24).
- By entering from the ship or from the sea (Figure 10-25).

If you can, stay dry when getting off a vessel. Sometimes this is possible by climbing down a ladder, net, or line until you are within 4 feet of the raft. Then jump into the open canopy entrance. Land on the floor of the raft with the balls of your feet. (If you land with your heels first, you could fall backwards into the water.) Stretch out your arms and land with your chest against the inflated canopy arch. DO NOT jump onto the roof of the raft! People inside could be injured. 10-89. When boarding from the sea, place your feet on the boarding ladder. Reach inside the raft and grab the internal lifelines (if there are no external handholds provided). Pull yourself into the raft headfirst. Do not grab hold of the canopy to pull yourself because it tears easily.

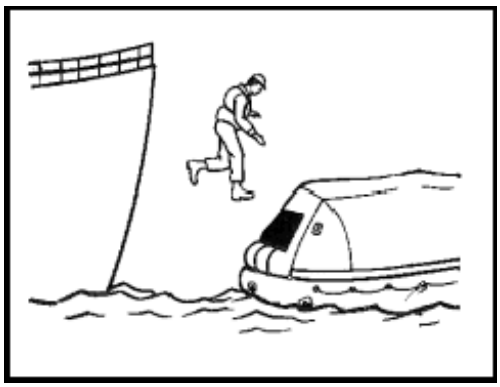


Figure 10-24. Jumping Into Canopy Opening

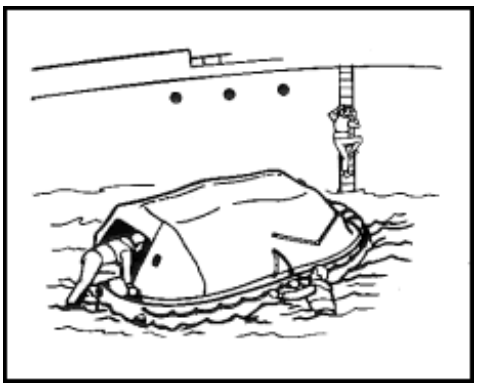


Figure 10-25. Boarding a Life Raft From the Sea

10-90. Two people can help an injured person board an inflatable life raft as shown in Figure 10-26 and doing the following:

- Place their outboard knees on the top of the buoyancy tube.
- Turn the injured person with his back toward them.
- Grab the injured person's life jacket with their inboard hands.
- With their outboard hands, grab the injured person's upper arms.
- Push the injured person slightly down into the water and, using his buoyancy to help them, spring him up and over into the life raft, back first.
- The two rescuers fall to either side on the raft's floor. This allows the injured person to fall between them.

Figure 10-26. Bringing Aboard an Injured Crewman

LIFE RAFT SURVIVAL EQUIPMENT

10-91. Inflatable life rafts are provided with equipment necessary for handling the life raft, surviving at sea, and alerting rescuers. The following list is for inflatable life rafts on ocean service ships. Ships on the lakes, bays, sounds, and rivers have considerably less equipment.

- **Heaving Line.** A buoyant heaving line, 100 feet long, that has a buoyant quoit (small floating ring) at one end. The other end is attached to the raft near the after entrance.
- **Instruction/Survival Manual.** A booklet printed on water-resistant material hanging in a clear envelope from one of the canopy arch tubes. The manual describes how to use the raft's equipment. It also contains internationally recognized distress signals and survival information.
- **Instruction Card.** A plastic card hangs from the inside canopy. The card shows immediate steps to be taken by survivors upon entering the raft.
- **Jackknife.** One jackknife is provided on rafts holding up to 12 persons. Two are required on larger rafts. The knife has a can opener. One of the knives is in a pocket near the forward entrance. It can be used to cut the painter. If the raft is provided with a floating sheath knife, it can replace the jackknife.
- **Paddles.** Two 4-foot long paddles are included.
- **Inflation/Dewatering Pump.** A pump is provided so survivors can keep the raft inflated. The pump can also be used to pump water out of the raft by switching the hose.
- **Sea Anchors.** Two sea anchors are provided. One sea anchor attaches to the outside of the raft and streams automatically when the raft is inflated. The other one acts as a spare. Each sea anchor has 50 feet of nylon line attached.
- **Bailers.** Two flexible bailers are provided on rafts carrying 13 or more people. One bailer is carried on smaller rafts.
- **Sponges.** Two cellulose sponges are provided.
- **First Aid Kit.** A kit containing first aid supplies is provided.
- **Flashlight.** A flashlight with three spare batteries and two spare bulbs is provided. The flashlight is Coast Guard-approved. It is waterproof and has a blinker button for signaling.
- **Signal Mirror and Whistle.** A mirror and whistle for signaling rescue units are provided.
- **Red Rocket Parachute Flares.** Two red rocket parachute flares are provided. They are approved for 3 years of service.
- **Hand-Held Red Flares.** Six hand-held red flares are provided. They are approved for 3 years of service.
- **Provisions.** One pound of hard bread or its approved nutritional equivalent is provided for each person. The food is packed in sealed cans.
- **Water.** One and one-half quarts of water are provided for each person. The water comes in sealed cans. The cans are approved for 5 years after packing. Some rafts may contain a desalting kit for each person. The contents of the kit can be mixed with saltwater to produce 1 pint of drinking water.
- **Can Openers.** Three can openers are provided.
- **Drinking Cup.** A flexible drinking cup marked in ounces is provided.
- **Fishing Tackle Kit.** A kit containing fishing tackle is provided.
- **Anti-seasickness Tablets.** Six anti-seasickness tablets are provided for each person.
- **Repair Kit.** A repair kit for repairing the buoyancy tubes is provided. The repair kit contains a roughing tool, five rubber tube patches (2-inch diameter), and cement. The cement is flammable. There must be no smoking while making repairs. The patches are used for patching small holes. Use patches only if the area around the hole can be kept dry while you are repairing the hole. Roughen the surface of the area that needs patching. Apply cement to both the patch and the area around the hole. Be sure the patch is 1 inch larger than the hole. Allow both to dry. Apply a second coat of cement to both. When both are tacky, press the patch on the hole. Do not completely inflate the raft until the patch has had 24 hours to dry.

PATCHING WITH SEALING CLAMPS

10-92. Six sealing clamps are also included in the kit for plugging large holes and any hole which cannot be kept dry enough to use cement. Use the following procedures:

- Loop the cord on the clamp around your wrist to prevent losing the clamp.
- Dip the clamp into the water. This makes the clamp slippery, so it can be inserted easily.
- Push the bottom plate through the hole (see Figure 10-27).

Note*:* If the hole is too small, carefully enlarge it so the clamp can be forced in.

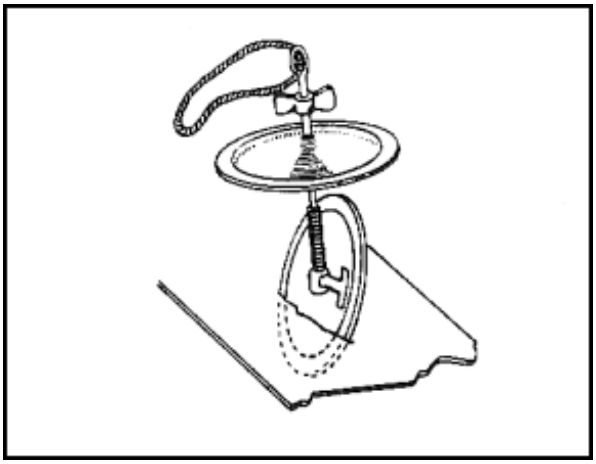


Figure 10-27. Pushing Bottom Plate Through Hole

- Pull the bottom clamp against the inner surface of the tube, and slide the top clamp over it (Figure 10-28).
- Adjust the clamp to completely cover the hole.
- Hold it in place and screw down the wing nut until it is tight (Figure 10-29).
- Break off the wire holding the cord.

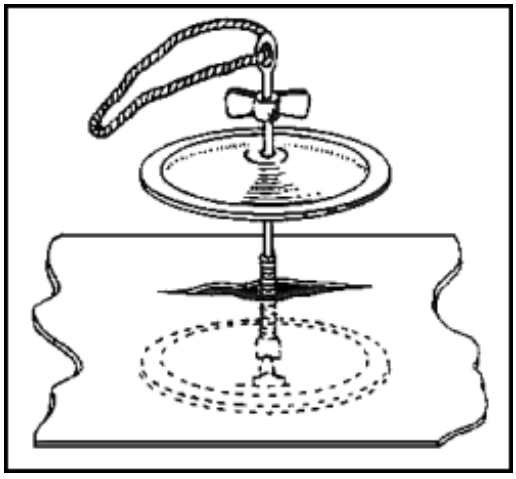


Figure 10-28. Sliding Top Clamp Over

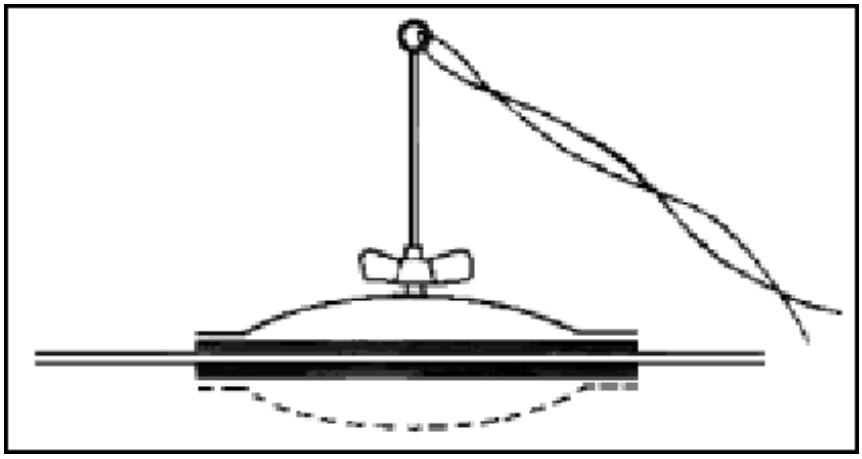


Figure 10-29. Tightening Wing

SIGNALING

10-93. The importance of a good lookout cannot be overstated. Remember, when in a life raft, you are so small and the sea is so big that it is very easy for a search ship or plane to overlook you. An alert lookout will make the difference in survival. Once you have sighted a rescue ship or aircraft, use the following to attract their attention:

- **Signaling mirrors.** Read the instructions for the particular kind of signaling mirror in your survival equipment. Do not wait until you see a rescue craft to use the signaling mirror. When the sun is shining, flash the mirror all around the horizon (Figure 10-30). An aircraft can spot the flash long before you would see the aircraft. The signaling mirror may save your life. Use it as long as the sun is shining.
- **Whistles.** In calm weather, your voice can be heard only a few undred yards away. If you keep screaming, you will become hoarse and lose your voice. A whistle, on the other hand, can be heard up to 4 miles away in favorable weather conditions. It can come in handy when you are floating in the water trying to attract the attention of nearby rescuers. A whistle can be used over and over again. It can be used in fog, at night, or during the day.
- **Pyrotechnics.** These are signals such as rockets, flares, and smoke. Instructions for operating various brands of pyrotechnics are written by the manufacturers. Once you are settled in your survival craft, read the instructions on each type of pyrotechnic so you will know how to use them when a ship or aircraft is

spotted. Keep the pyrotechnics close by for immediate use, so you can signal when necessary. Heed the following when using pyrotechnics:

- Be sure to fire the signals downwind on the lee side of the survival craft. When firing, hold them at a slight angle over the water. Pyrotechnics have burning particles that might fall, which may burn you or damage the raft.
- Only use smoke signals during the daytime. Smoke does not glow in the dark. Only use pyrotechnics when you can see a ship or plane. Do not waste smoke signals.
- Rockets should be used when a vessel is spotted far away on the horizon. A rocket will get the signal higher, where it can be seen from a greater distance.
- An aircraft directly overhead would be more likely to spot a hand flare than a flare covered with a parachute.
- **Emergency Position Indicating Radio Beacons.** Your ship may also have at least one EPIRB. There are different makes of EPIRBs. They all have the following things in common:
- EPIRBs float. They are stowed on the outside of the ship, so they will float free if the ship sinks.
- They are small (approximately 6 inches thick and 1 to 3 feet long).
- They transmit signals automatically on two international distress frequencies for military and civilian aircraft. These frequencies are 121.5 and 243 MHz.
- Most EPIRBs work on one-way automatic operation only and cannot be used for two-way communication.
- They transmit a continuous two-tone (hi/lo) signal.
- EPIRBs are easy to use.
- If your EPIRB is floated, tie it to the survival craft, so it will not drift away (Figure 10-31).

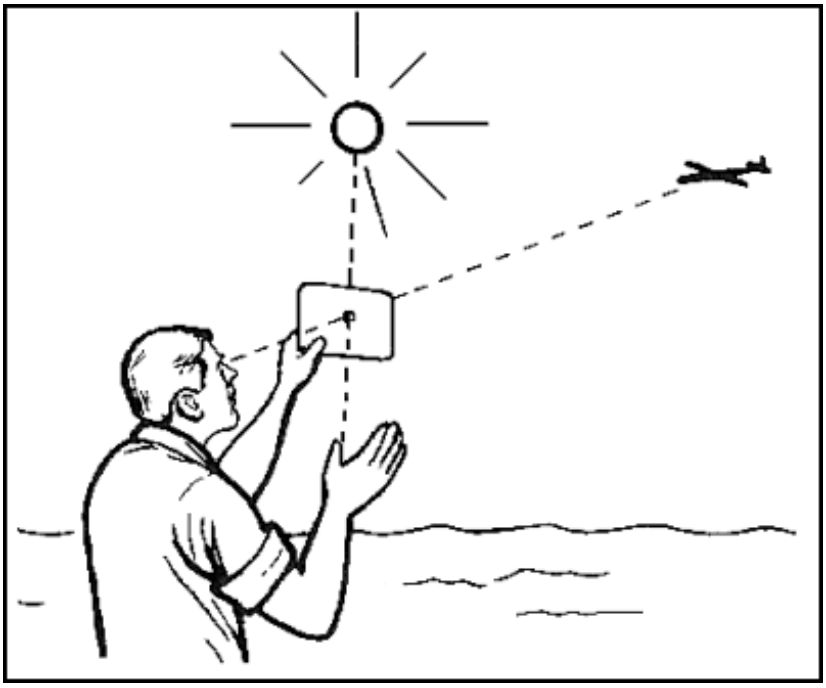


Figure 10-30. Signaling Mirror

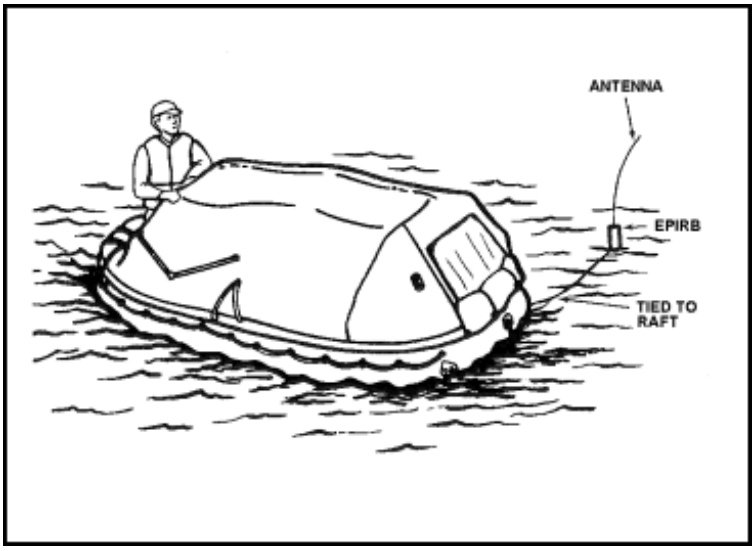


Figure 10-31. EPIRB Secured to a Life Raft

RIGHTING AN OVERTURNED LIFE RAFT

10-94. If a capsized raft can be righted (turned right side up) before the inverted (upside down) canopy fills with seawater, one person can easily right it using the following procedure:

- Swim to the side marked "RIGHT HERE." If it is not marked, go to the side where the CO_2 cylinder is located. Reach up and grab the righting strap. Start pulling yourself up onto the raft. It may help to kick your feet out as if swimming (Figure 10-32). If this does not work, try putting your feet or knees into the external lifelines to help you pull yourself up on the raft. Some rafts may right while you are climbing onto them. Others are more difficult to right.

Note: A righting strap is fitted on the underside of the raft to right the raft if it capsizes or inflates upside down. The righting strap runs the full width of the oval or round raft.

- Stand on the very edge, where the CO_2 cylinder is located. Lean back with all your weight while pulling on the righting strap (Figure 10-33).

If the canopy is clear of water, the raft will begin to follow you. If the raft is large, it will land on your head unless you bend your knees and spring backwards just as the raft begins to free fall (Figure 10-34). This should allow your head to clear the raft.

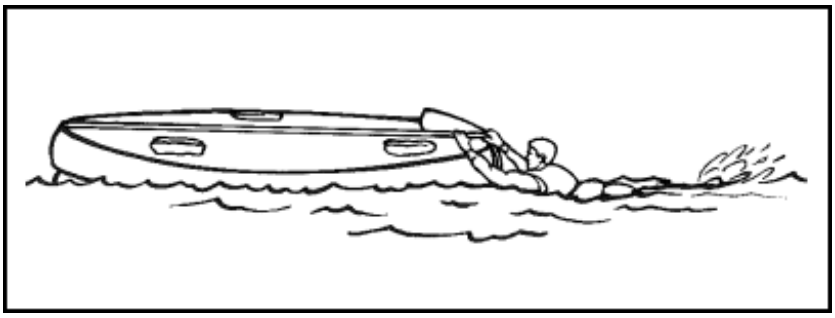


Figure 10-32. Getting Aboard an Overturned Life Raft

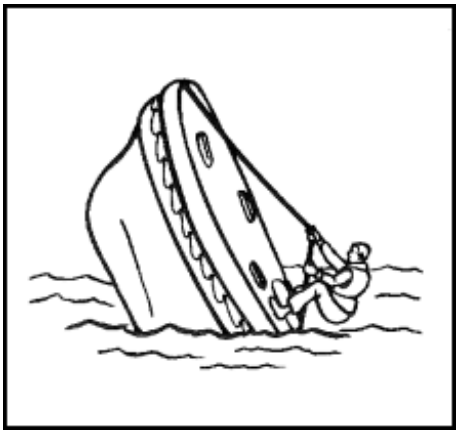


Figure 10-33. Standing On Edge

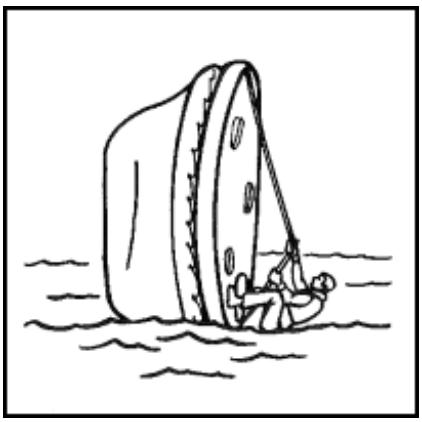


Figure 10-34. Knees Bent

10-95. Do not panic if the raft does land on top of you. Because the bottom of the raft is soft and flexible, you can create an air pocket by pushing your arms or head against the floor. This will give you a chance to catch a breath of air. Use your arms and swim face up to get out from underneath the raft. If you try to swim out face down, the raft may hang up on the back of your life preserver. If this happens, it will be difficult for you to get out from underneath the raft.

10-96. If one person cannot right a capsized raft, the canopy probably has filled with seawater that cannot escape. Try two persons pulling on the righting strap. If this does not work, then get several persons in the water on the opposite side of the raft (Figure 10-35). These persons should work the water out of the canopy by pushing up on the canopy while two people pull on the righting strap.

10-97. If the inverted canopy fills with seawater, the raft may be more difficult to right. Generally, round rafts have the righting strap parallel to the canopy openings. This allows the water to flow freely out of the raft while the raft is being righted.

10-98. If the raft is oval with the righting straps at right angles to the canopy openings, water tends to stay trapped in the canopy. It may take several persons to right this type of raft.

Note: Figure 10-36, shows the overhead views of round and oval rafts.

10-99. A single person may be able to right a waterlogged raft. He can try by pulling and walking the righting strap through his hands until the opposite side is pulled over. This takes a lot of strength and may be very hard to do. It might be done without climbing aboard the raft.

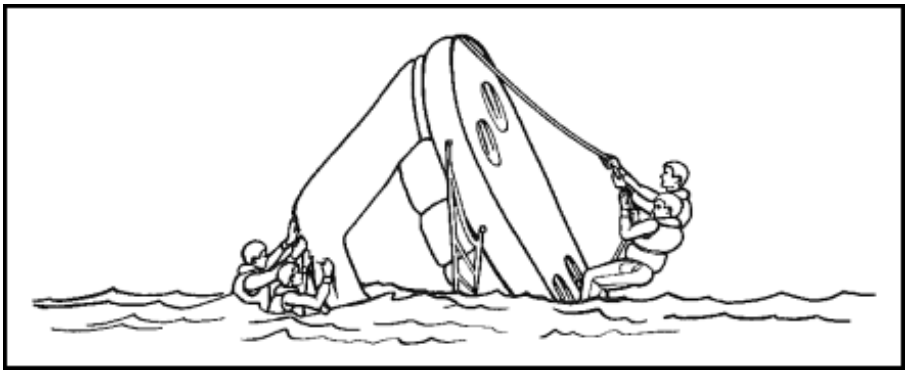


Figure 10-35. Several People Righting An Overturned Life Raft

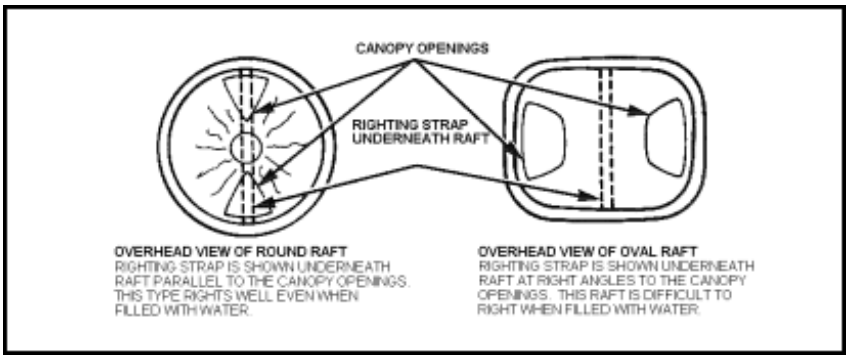


Figure 10-36. Overhead Views of Round and Oval Rafts

SURVIVAL ABOARD A LIFE RAFT

10-100. Life rafts are important in a marine emergency. The life raft is the primary means of escape in a shipboard emergency. Survival aboard a life raft starts with the proper launching and inflating of the life raft. Survival can also include how to correctly board the raft, avoiding hypothermia, how to right an upside down life-raft, know how to properly use safety equipment, anchoring the raft, plugging leaks, dealing with seasickness, establishing a chain of command, and rescue.

Preserve Body Fluids--Avoid Seasickness

10-101. Riding in a life raft is very uncomfortable. Your raft will be in constant motion even on a calm sea. A raft wiggles every time someone moves inside or the water moves underneath. You will be confined in a cramped and stuffy space. Even the most experienced seafarers tend to get seasick in a raft. Seasickness must be avoided if at all possible. It is a very miserable illness and can affect your will to survive.

10-102. If on hand, take a seasickness pill (if you can) before you abandon ship. If unable to take, take a seasickness pill found in the raft's supply kit as soon as all of your shipmates have been helped into the raft. The pills will keep you from vomiting. Vomiting empties your stomach of valuable fluids. You must preserve those body fluids. If you lose them, they will be difficult or even impossible to replace as long as you are in the raft. Remember how cramped your survival conditions may be. If one person vomits, others will probably do the same.

TAKE SEASICKNESS PILLS AS SOON AS YOU CAN!

Urinate Soon After Boarding

10-103. If you did not urinate within a few hours before boarding the survival craft, you should do so within 2 hours. The traumatic effects of a disaster at sea may make urination difficult. You could damage your bladder if you do not pass urine. There are two methods that might help you urinate:

- Have someone pour seawater slowly back and forth from cup to cup in front of you.
- Hang over the side with the water waist high. The cool water should help.

After several days with little drinking water, do not be alarmed if your urine appears dark and thick. Such a reaction to dehydration is normal.

Sit on a Life Jacket for Protection

10-104. In moderate seas, when there is no danger of the raft capsizing, you should take off and sit on your life jacket. The rubber raft constantly moving under you tends to wear your skin until soreness occurs. Your life jacket will provide a cushion that will prevent such soreness.

Cover Up

10-105. The dangers from exposure to cold are obvious, BUT do not forget the sun, wind, rain, and sea. The life raft comes with a built-in canopy to protect you. Do not cook yourself in the sun! Serious burns and loss of valuable body fluids could result from a sunburn. Wear light clothing or stay under the cover. 10-106. The following are some hot climate tips:

- If possible, keep a breeze blowing through the survival craft. Sometimes you can change the position of the sea anchor to increase ventilation (movement of air).
- Avoid sunburn.
- Reduce need for water by avoiding any extra exertion. If you exert yourself, you will sweat and use a lot of fluids.
- Keep the outside of the raft wet.
- Wet your clothing during the day with seawater.

Drinking Water

10-107. The normal, healthy body (at rest) can stay alive for over 40 days with no food and as little as 11 ounces (one ration can) of fresh water each day. As little as 2 or 3 ounces of drinking water each day can keep a person healthy for up to 10 days. Without fresh water, a person often becomes delirious in about 4 days and might die in 8 to 12 days.

No Water for First 24 Hours

10-108. Do not issue water during the first 24 hours unless you have an unlimited supply. The body is already full of water. If you drink more, it will probably be wasted in the form of urine. After 24 hours, your body will be drier and will absorb the water you drink, just like a dry sponge will hold water, but a wet sponge will not. If a survivor is injured, you may give him water during the first 24 hours. The survivor will need it to replace the fluid he lost through his bleeding or burns. Only give water if he is conscious.

10-109. After 24 hours, you may issue a full ration (1/3 of a 1-quart can) of water for each person. The ration should be divided into three equal parts. Drink one part at sunrise, one at midday, and one at sunset.

Rainwater

10-110. You may collect more water by catching rainwater. Some parts of the inflatable life raft canopy are designed to catch water. Rainwater catchment tubes will take the water into storage bags on the inside of the raft. The storage bags are in the raft's equipment container. Salt spray may dry on the canopy. The salt might be washed in with the first few ounces of rainwater. It might be very difficult to collect uncontaminated rainwater when the seas are rough and waves are constantly being blown onto the canopy.

10-111. The lookout should alert everyone when it rains. Use and fill all available containers with rainwater (such as equipment accessories bag, ration packs, and empty tin cans). After all of the containers have been filled, everyone should drink as much of the rainwater as they can.

Condensation

10-112. Water might condense on the inside canopy of the inflatable life raft. Use one of the cellulose sponges that is provided in the raft equipment to soak up the water. Squeeze the water out of the sponge to drink or store. Be sure to keep a sponge clean for this purpose.

Snow and Ice

10-113. In the Arctic Sea, you can collect "old saltwater ice." It is bluish in color with smooth, rounded corners. It is usually pure enough to eat or drink. Do not make the mistake of eating "salt ice." "Salt ice" is gray and milky. It should not be eaten.

10-114. Remember, ice and snow will tend to chill your stomach and reduce your body temperature. If you are on the verge of hypothermia, you should not eat ice or snow. Allow it to melt and get as warm as possible. Warm it in your mouth before swallowing.

Never Drink Seawater or Urine

10-115. Rain, ice, and condensation are good sources of water. Do not mix saltwater, urine, or animal fluid with fresh water to stretch your water supply. Drinking seawater will only worsen your thirst and increase water loss by drawing body fluids from the kidneys and intestines. The salt will go to the brain and cause delirium and convulsions. Drinking seawater and urine during a survival situation could cause madness and death.

Obtaining Food

10-116. Do not eat during the first 24 hours. After 24 hours, you may eat 4 ounces each day. In a life raft the food will last 5 days. You will have extra rations (food and water) if the boat or raft is not carrying its full number of passengers.

10-117. Do not eat food if you do not have water. Your body needs water for digesting food. Eating without drinking fresh water could cause death.

Getting Food From the Sea

10-118. The sea has many different forms of life. If you have enough fresh water, you will probably not starve to death. Remember that water is a MUST! Because fish and birds are rich in salt and protein, more water is needed to digest them. Do not eat food from the sea unless you have two or three times more water than your daily ration. DO NOT panic if you do not have enough water to drink with your seafood or if you cannot catch any seafood right away.

10-119. You probably abandoned ship with excess body fat. Your system will begin to use the fat if you do not eat. One pound of body fat will probably keep your system working at about the same rate as two meals. The rate at which body fat and protein are changed to heat and energy depends upon air temperature, your activity, and your mental state. You can live longer on your stored energy if you keep your mind and body relaxed. It also helps if you do not overwork yourself or expose your body to very hot or cold temperatures.

Fish

10-120. Most fish that are found in the open sea can be eaten. If they are found closer to shore they might be poisonous. The puffer, porcupine, and parrot fish are poisonous. They are fish that blow themselves out or have spines or bristles.

10-121. The flesh of fish caught in the open sea is good to eat whether cooked or raw. The heart, liver, and blood of fish are good to eat. Intestinal walls are edible, but the contents may be dangerous unless they are cooked. The stomachs of large fish may contain small fish partly digested, which are good to eat. Fish eyes also contain a lot of water.

10-122. You can catch fish by using the fishing kit provided with your equipment. Complete instructions are inside the kit. If you have lost your fishing kit, you could use the following methods to catch fish:

- By tying your knife to a paddle, oar, or boat hook, you may be able to spear large fish near the surface. Slash with your knife in schools of small fish.
- Fishhooks can be made from wood split from the lifeboat. This wood is notched and held together with thread from the equipment or unraveled from cloth (Figure 10-37).
- A jackknife can be made into a large fishhook. Wedge the blade open with a piece of wood and tie as shown in Figure 10-38.

10-123. Flying fish are probably the most available food. Many survivors have lived on them alone. Some may glide into or against your craft. At night, flying fish (and most other fish) are attracted by light. Shine your light on the side of your white craft or cloth and the flying fish will often glide toward the light and into the boat. Often, a bright moon shining on a white object will draw them.

10-124. If and when you catch more fish than you can eat, in order to drink, squeeze or chew out the juice of the flesh. Fish juice tastes much like the juice of raw oysters or clams. To squeeze it out, cut a piece of fish without bones or skin. Cut it into fine (tiny) pieces. Wrap it in a cloth with long ends. Have two people twist the ends as tight as possible. The juice will drip out. To chew it out, chew a small piece of fish in your mouth. Suck out the juice and swallow it. Spit out the remaining flesh.

10-125. Cut fish into thin, narrow strips and hang them out in the sun to dry. If it completely dried and kept dry, it will often stay good for several days. It may even taste better dried.

IMPORTANT!
Fish that are not cleaned may spoil in half a day.
Clean and immediately eat or dry your fish.

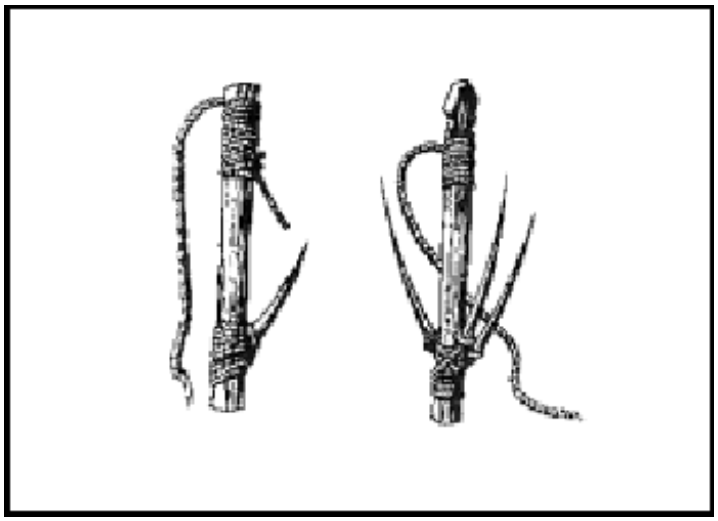


Figure 10-37. Fishhooks Made From Wood

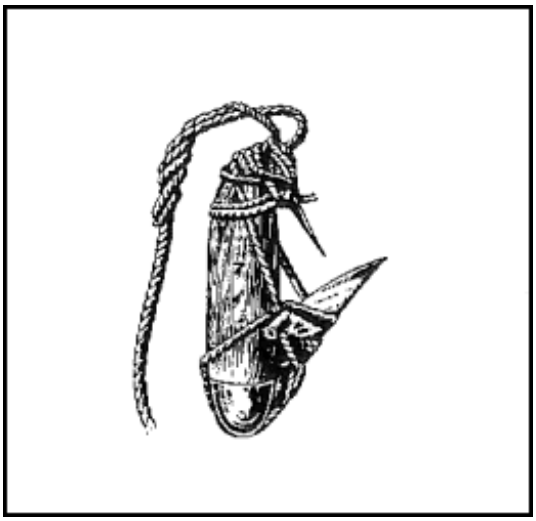


Figure 10-38. Fishhook Made From a Jackknife

Turtles

10-126. All of the meat, blood, and juice of a turtle are good. The best meat is found against the shell, under the backbone. Cut through the ribs to get to this meat. A hot sun brings a clear oil out of turtle fat in which you can dip your food.

CAUTION: A turtle can still bite and scratch even after you have cut off its head.

Seaweed

10-127. Raw seaweeds are tough and salty. They are difficult to digest. Eat them only if you have plenty of fresh water.

10-128. Small edible crabs, shrimp, and fish often live in the seaweed. Lift them out of the water slowly and carefully. Shake them over the survival craft. Get rid of the jellyfish and eat the remaining morsels.

Birds

10-129. All sea birds are nourishing and can be eaten. The blood and liver are also good to drink and eat. Try to catch birds that will sometimes land on you or on or in the survival craft.

10-130. Catch birds by dragging a baited fishhook behind the craft. Pull on the line after they have swallowed the hook. The hook catches the bird like a fish. Catch every bird you can. Use the feathers as fishing lures and the meat and guts for fish bait. Birds can also locate fish for you. When feeding, they usually follow schools of fish. This will give you an opportunity to get right up to the birds to catch them. Also, do not forget to catch the fish they are feeding on.

SEARCH AIR RESCUE

10-131. Upon receiving a signal from any source that a ship or aircraft is in distress, it is the responsibility of all vessels in the area to go to the site and give help to the ship, aircraft, or persons in distress. This signal can range from a ship that is sinking or on fire, a downed aircraft, man overboard, or serious illness or injury aboard ship.

TYPES OF DISTRESS SIGNALS

10-132. A ship at sea can be alerted to an emergency by the following:

- Radio or radiotelephone.
- Visual international distress signals.
- Aircraft.

HOW AIRCRAFT DIRECT SHIPS TO DISTRESS SCENE

10-133. These procedures are used by an aircraft to direct a ship toward another ship or aircraft in distress:

- The airplane circles over the ship at least once. Then the aircraft crosses the bow of the ship as close as possible. At a low altitude, the pilot opens and closes the throttle or changes the propeller pitch (Figure 10-39).
- Then the airplane will head in the direction that the ship is to follow in order to find the ship or aircraft in distress (Figure 10-40).
- If help is no longer required, the aircraft will return and fly, opening and closing the throttle or changing the propeller pitch, across the wake of the ship at a low altitude and as close astern as possible.

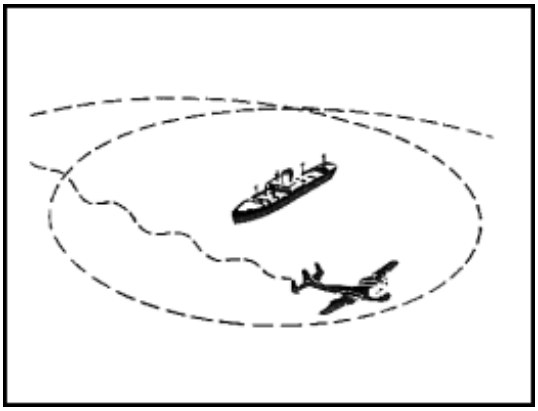


Figure 10-39. Aircraft Signal

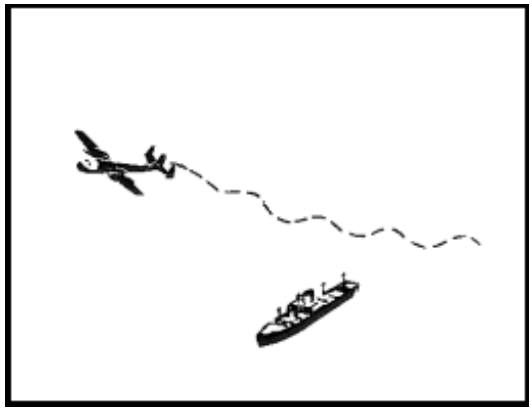


Figure 10-40. Aircraft Dismissal Signal

SURFACE SHIPS ACTION

10-134. Once your ship has been alerted to the distress situation, you will acknowledge the receipt of the message. You will also provide a continuous radio guard on 2182 kHz and/or channel 16 on the radiotelephone, and, if required, retransmit the distress message to the ships in the area.

10-135. The next step is to determine your exact position and the position of the vessel or aircraft in distress. If it is possible, you should communicate the following to the ship in distress:

- Your identity.
- Your position.
- Your speed and ETA.
- Your true bearing from the vessel.

Then the entire crew of your ship is to start preparing for the rescue as follows:

- Get heaving lines, ladders, and scramble nets rigged on both sides of the vessel.
- Prepare to receive survivors who may need medical assistance.
- Put lines over ship's side to assist any lifeboats or rafts that may secure alongside.

ASSISTING AN AIRCRAFT THAT MAY DITCH

10-136. Make a smoke signal if possible to show the pilot direction of surface wind. At night, show deck lights and shine the signal lamp straight up in the air. Do not shine it on the aircraft. You may blind the pilot. Try to make radiotelephone contact with the aircraft and give the following information:

- Wind direction and force.
- Direction, height, and length between the swells.
- Any other information the pilot may require.

Proceed alongside the aircraft as quickly as possible. The aircraft may break up as soon as it hits the water.

Note: Military aircraft are usually fitted with "ejection seats." Many times the crew will use their ejection seats rather than ditch with the aircraft.

10-137. When picking up survivors from a military aircraft, get the following information as soon as possible and, if necessary, pass the information to other rescue ships by radiotelephone:

- What was the time and date of the casualty?
- Did you bail out or was the aircraft ditched?
- If you bailed out, at what altitude?
- How many others did you see leave the aircraft by parachute?
- How many ditched with the aircraft?
- How many did you see leave the aircraft after ditching?
- How many survivors did you see in the water?

- What flotation gear did they have?
- What was the total number of persons aboard the aircraft before the accident?

PREPARATION FOR MEDICAL EVACUATION OF PERSONNEL FROM YOUR SHIP

10-138. If there is a serious injury aboard your ship, a helicopter may be used to remove the injured crew members. This may be a Coast Guard, Army, Navy, or Marine helicopter performing the rescue mission. The ship's master and crew should prepare for removing the crew member while waiting for the rescue helicopter. The following is a complete helicopter evacuation checkoff list. When requesting helicopter assistance:

- Give accurate position, time, speed, course, weather conditions, wind direction and velocity, voice and CW frequencies.
- If not already provided, give complete medical information, including whether or not the patient can walk.
- If you are beyond helicopter range, advise your diversion intentions so that a rendezvous point may be arranged.
- If there are any changes, advise immediately. Should the patient die prior to arrival of the helicopter, be sure to advise.

Remember that members of the flight crew are risking their lives attempting to help you. Make the following preparations prior to arrival of the helicopter:

- Provide continuous radio guard on 2182 kHz or specified VOICE frequency, if possible. The helicopter cannot operate CW.
- Select and clear the hoist area, preferably aft, with a minimum 50-foot radius. This must include securing loose gear, awnings, and antenna wires. Trice up running rigging and booms. If the hoist if aft, lower flagstaff.
- If hoist is at night, light up pickup area as well as possible. BE SURE YOU DO NOT SHINE ANY LIGHTS ON THE HELICOPTER. If there are obstructions in the vicinity, put a light on them so the pilot will be aware of their positions.
- Point searchlights vertically to aid in locating the ship, and secure them when helicopter is on scene.
- Advise location of pickup area BEFORE the helicopter arrives, so that the pilot may make his approach aft, amidships, or forward, as required.
- Arrange a set of hand signals among the crew who will assist. There will be a high noise level under the helicopter, making voice communication almost impossible.

HOIST OPERATIONS

10-139. Hoisting operations are used to rescue or evacuate personnel from a number of dangerous situations. The following are some guidelines to follow when using hoisting operations:

- If possible, move the patient to a position as close to the hoist area as his condition permits--TIME IS IMPORTANT.
- It may be necessary to move the patient by litter. Be prepared to do this as quickly as possible. Be sure patient is strapped in, face up, with life jacket, if his condition permits.
- Be sure patient is tagged to indicate what medication, if any, was administered, and when.
- Have patient's medical record and necessary papers in envelope or package ready for transfer WITH him.
- Change course so the ship rides as easily as possible with the wind on the bow, preferably on the port bow. Once established, maintain course and speed.
- Reduce speed, if necessary, to ease ship's motion; but maintain steerageway.
- If you do not have radio contact with rescue aircraft, when you are in all respects ready for the hoist, signal the aircraft with a "come on" by hand, or at night by flashlight.
- To avoid static shock, let basket or stretcher touch the deck before handling.
- If the aircraft drops the trail line, guide the basket or stretcher to deck with line. Keep line clear at all times.
- Place patient in basket, sitting with hands clear of sides, or in the litter as described above. Signal hoist operator when ready for hoist. Patient signals by nodding head if he is able. Deck personnel give thumbs up.

- If necessary to take litter away from hoist point, unhook hoist cable and keep free for aircraft to haul in. DO NOT SECURE CABLE TO VESSEL OR ATTEMPT TO MOVE STRETCHER WITHOUT UNHOOKING.
- When patient is strapped in stretcher, signal aircraft to lower cable, hook up, and signal hoist operator when ready to hoist. Steady stretcher from turning or swinging.
- If trail line is attached to basket or stretcher, use to steady. Keep feet clear of line.

HELICOPTER HOIST PROCEDURES

10-140. The wind developed by the helicopter rotor system can be over 70 knots. It is important to have all loose gear, on deck, securely tied down or stowed below decks. The rotor system could be destroyed if any loose objects are blown into the rotor during the hoist.

10-141. It is important to plan ahead because your voice cannot be heard over the noise made by the helicopter engine. Work out problems that may occur before the helicopter hovers overhead. Do not forget to wear your life jacket! 10-142. A helicopter might be used to rescue survivors or evacuate injured mariners by rescue basket, rescue sling, and stokes litter (Figure 10-41).

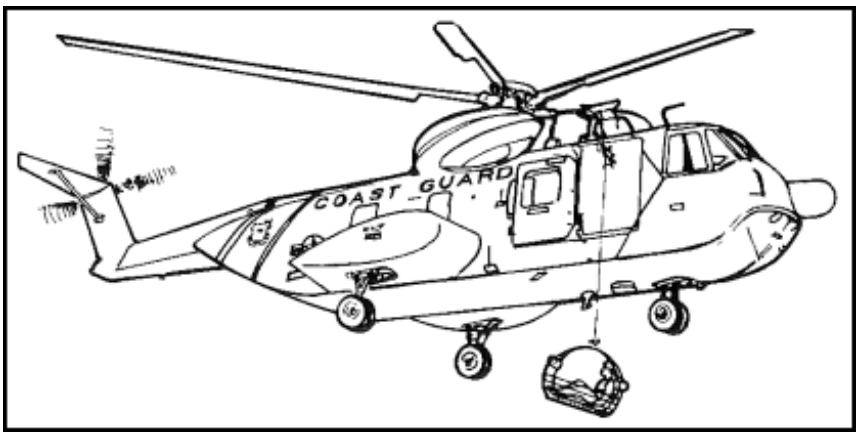


Figure 10-41. Rescue Basket Hoist

Rescue Basket

10-143. The US Coast Guard usually uses a rescue basket for survivors who can help themselves (Figure 10-42). The basket is very easy to use. Just climb into the basket after it touches the deck (to discharge static electricity), sit down, and keep hands and arms inside.

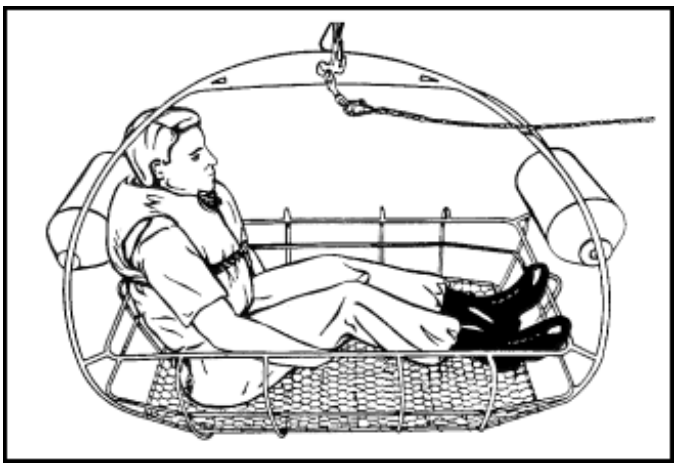


Figure 10-42. Rescue Basket

Rescue Sling

10-144. A rescue sling is carried on board helicopters. Rescue helicopters from other countries, use the sling more often than by the US Coast Guard. The rescue sling is just a padded loop that is placed over the body and underneath the armpits. The arms are held around the sling as shown in Figure 10-43.

Figure 10-43. Rescue Sling

Stokes Litter

10-145. This type of litter will usually be used to hoist those who have serious injuries or illnesses or who are unable to walk. To use the litter, it is necessary to get help from other crew members. The straps must be disconnected and spread out. The blankets must be removed. The patient should be put in the litter and covered with the blanket. The straps are then snugly fastened with the pad on top of the chest as shown in Figure 10-44.

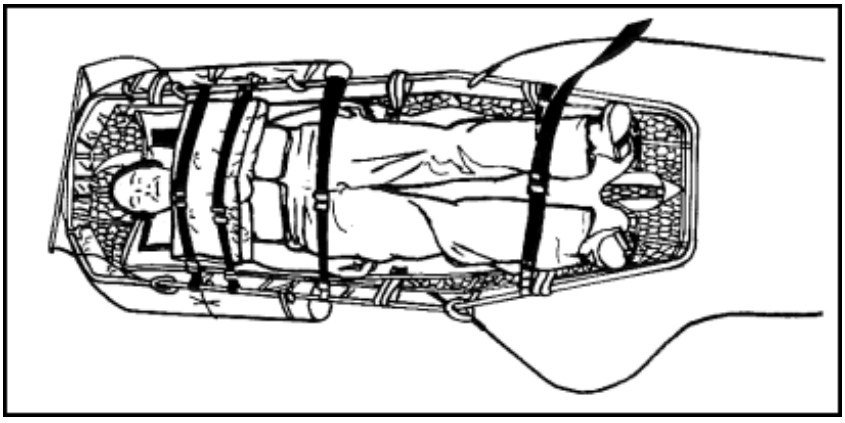


Figure 10-44. Stokes Litter

10-146. If the litter has to be taken below decks to the patient, it must be unhooked from the cable. This hook must not be attached to any part of the vessel. There is always a possibility that there may be an emergency aboard the helicopter itself. The helicopter may have to move unexpectedly. To decrease this type of danger, the pilot may hover off to one side of the vessel while waiting.

10-147. If a steadying line is attached to the basket, horse collar, or litter, it must be tended. This will stop the rescue device from swinging too much. It is very important that the rescue device touches the vessel before anyone touches it. As soon as the object being lowered touches the deck, static electricity (which builds up in the helicopter during flight) will be discharged. Never shine lights on the helicopter. It will blind the pilot.

Ready to Hoist

10-148. To signal the helicopter pilot that all is ready for hoisting, give him a thumbs-up signal, or if you are a patient, nod your head if you are able.

SHIPBOARD NBC DEFENSE

10-149. Much of your military training is dedicated to NBC training in a land combat situation and the protective measures to be taken for survival. This paragraph will discuss NBC countermeasures to be taken aboard ship for survival. Although a nuclear detonation is devastating, survival is possible, and aboard ship it is probable. Your survival will depend upon the actions taken before, during, and after the attack.

TYPES OF NUCLEAR BURSTS

10-150. The energy yield of a nuclear weapon is described in terms of the amount of TNT that would be required to release a similar amount of energy. A nuclear weapon capable of releasing an amount of energy equivalent to the energy released by 20,000 tons of TNT is said to be a 20-KT weapon. A nuclear weapon capable of releasing an amount of energy equivalent to the energy released by 1,000,000 tons of TNT is said to be a 1-MT weapon.

10-151. Weapon yields may range from a fraction of a KT to many MTs. Although a weapon's total yield is not significantly influenced by the environment about the burst point, the relative importance of weapon effects depends greatly on where the detonation takes place. The four types of bursts are high altitude, air, surface, and underwater.

10-152. Although the four types of bursts are defined below, there is actually no clear line of demarcation between them. Obviously, as the height of burst is decreased, the high altitude burst becomes an air burst, an air burst will become a surface burst, and so forth. The significant military effects associated with each type of burst follow.

High Altitude Burst

10-153. This explosion takes place at an altitude in excess of 100,000 feet. It produces airblast, thermal radiation, an EMP, initial nuclear radiation, and atmospheric ionization. At altitudes above 100,000 feet, the proportion of energy appearing as blast decreases markedly, while the proportion of radiation energy increases. Due to the low density of the atmosphere, the range of the initial nuclear radiation increases. In contrast to explosions below 50,000 feet, the attendant atmospheric ionization from bursts above 100,000 feet lasts for minutes to hours. The important consequences of high altitude bursts are the damage to weapons systems or satellites operating in the upper atmosphere or in space, and the effects on electromagnetic waves (communications and radar) relying on propagation through or near the region of the burst.

Air Burst

10-154. In this type of burst, the fireball does not contact the surface. An air burst produces airblast, thermal radiation (heat and light), EMP, and initial nuclear radiation (neutron and gamma rays) about the burst point. There will be no significant residual nuclear radiation (gamma and beta radiations from airborne or deposited radioactive material) except when rain or snow falls through the radioactive cloud.

Surface Burst

10-155. The fireball touches or intersects the surface. A surface burst produces airblast, thermal radiation, EMP, initial nuclear radiation around surface zero, and residual (transit and deposit) nuclear radiations around SZ and downwind from SZ. Transit radiation is produced by airborne radioactive material (base surge/fallout) and deposit radiation is produced by radioactive material (base surge/fallout) collection on exposed surfaces. Surface bursts over water will also produce underwater shock and surface water waves, but these effects will be of less importance. Over land, earth shock will be produced, but will not be an important effect at any significant distance from the burst point.

Underwater Burst

10-156. This burst occurs below the water surface. It produces underwater shock and a water plume, which then causes a base surge. Very shallow bursts may also produce airblast, initial nuclear radiation, fallout, and possibly some thermal radiation. These effects will be reduced in magnitude from those of a water surface burst and will become rapidly insignificant as the depth of burst is increased. The damage range due to shock is increased as depth of burst is increased. For a given weapon yield, greater hull and machinery damage will be produced by shock from an underwater burst than by airblast from an air or surface burst.

10-157. When a high yield weapon is detonated underwater in the deep waters adjacent to a continental shelf, large breaking waves may be generated by the upsurge along the shelf slope. These waves will appear on the shallow water side of the shelf edge. They are characterized by a long period with a sharp, possibly breaking, crest. They dissipate in amplitude as they progress toward the shore. Calculations and simulation experiments with the East Coast US continental shelf indicate that, in the near vicinity of the shelf edge (shallow water side only), these waves may be large enough to damage the largest combatant ships and swamp or capsize smaller ships. This shoaling phenomenon does not appear in deep water. Except in shoaling waters, water waves normally will not be a major hazard.

UNDERWATER SHOCK

10-158. Underwater shock is the shock wave produced in water by an explosion. The shock wave initially travels several times the speed of sound in water, but quickly slows down to sonic speed (about 5,000 feet per second). Underwater shock produces rapid accelerations that may result in equipment and machinery disarrangements, hull rupture, and/or personnel injuries. Both the directly transmitted shock wave and the shock wave reflected from the sea bottom can be damaging. An underwater explosion produces a shock wave similar to an air burst. Four factors determine whether the greater damage will be caused by the direct wave or the reflected wave:

- Distance from burst.
- Depth of burst.
- Depth of water.
- Bottom configuration and structure.

THERMAL RADIATION

10-159. Thermal radiation is the radiant energy (heat and light) emitted by the fireball. Thermal radiation travels at the speed of light and persists as long as the fireball is luminous. The duration of thermal radiation emission depends on weapon yield. It usually lasts less than 1 second for 1-KT yield and about 8 or 9 seconds for a 1-MT yield. Thermal radiation is effectively shielded by anything that will cast a shadow (opaque materials). Thermal radiation can produce combat ineffectiveness (that is, individuals unable to man battle stations) among exposed personnel by skin burns, flash blindness, or retinal burns.

10-160. Thermal radiation is modified by the height of burst, weapon yield, cloud cover, and terrain features. As height of burst is increased, the area of the earth's surface exposed to thermal radiation increases. This happens because there are fewer shadows from existing structures (such as vegetation, terrain features, and so forth).

10-161. As weapon yield increases, the range at which thermal radiation can cause skin burns and eye injuries to exposed individuals extends well beyond the range where blast and initial nuclear radiation are of significance. The rate at which thermal radiation is emitted from a high-yield weapon is slower than for a low-yield weapon. Therefore, the high-yield weapon must deliver more thermal energy to do an equivalent degree of damage because a target has more time to dissipate the heat being received.

NUCLEAR RADIATION

10-162. The four basic types of nuclear radiation given off during a nuclear explosion are alpha particles, beta particles, gamma rays, and neutrons.

- **Alpha particles.** These do not travel more than a few centimeters in air without being stopped. They cannot penetrate even a thin sheet of paper.
- **Beta particles.** These may travel several feet in the air, but they cannot penetrate a sheet of aluminum more than a few millimeters in thickness. Beta particles cannot penetrate the normal combat uniform.
- **Gamma rays.** These are a form of electromagnetic radiation, indistinguishable from X-rays.
- **Neutrons.** These are electrically neutral particles. Gamma rays and neutrons can travel comparable distances in the air, up to several hundred meters. Gamma rays and neutrons have the greatest penetrating power of all the forms of nuclear radiation, and their injurious effects on personnel are quite similar.

10-163. Nuclear radiation does not affect most materials in any visible manner. Therefore, the essential value of ships, vehicles, electronic equipment (except transistors), and other equipment is not impaired by radiation. However, radioactive contamination does pose a danger to operating personnel. The term CONTAMINATION is used to mean radioactive material that has been deposited in a location where it is not desired. All radioactive contamination gives off nuclear radiations.

INITIAL NUCLEAR RADIATION

10-164. Initial nuclear radiation is defined as the radiation (essentially neutrons and gamma rays) emitted by the fireball and the cloud during the first minute after detonation. Depending on weapon yield, all significant neutron radiation is emitted in less than 0.1 second, gamma radiation up to 20 or 30 seconds. The 1-minute time limit is set as the maximum time for the nuclear cloud to rise beyond the range in the air at which gamma radiation is a significant hazard. Initial nuclear radiation generally may not produce significant material damage, but will produce combat ineffectiveness.

NUCLEAR RADIATION INJURY

10-165. The radiological hazards described are those which might be of significance to the military effectiveness of marine personnel in combat operations. Injuries to personnel can result from exposure to sufficient quantities of either initial or residual radiation, or a combination of the two. Unlike injuries from other weapon effects, nuclear ionizing radiation injuries may not become evident immediately unless a high dose is received. All nuclear radiation, even in very small doses, has some harmful effect on the body and should be avoided whenever possible.

10-166. The biological injury to an individual from nuclear radiation depends on many factors. Some of these factors include the following:

- Radiation dose received.
- Partial or whole-body exposure (all radiation doses referred to are due to external whole-body exposures to penetrating radiation).
- Period over which the dose is received.
- Variations in the body's resistance to radiation injury including those due to physical condition, sex, and age.
- Previous radiation exposure.
- Presence or absence of other injuries.
- Periods of recuperation between periods of radiological exposure.

FALLOUT

10-167. Fallout, a major effect of a shallow underground and underwater burst, is the radioactive material that falls from the nuclear cloud and deposits on exposed surfaces. The fallout primarily consists of fission products (gamma and beta emitters) mixed with material vaporized by the fireball and drawn up into the nuclear cloud. Fallout, whether airborne or deposited, is a hazard because it emits gamma radiation that can penetrate ship structures, buildings, and aircraft. It can also cause radiation injury or death to personnel. Deposited fallout also presents a personnel contamination hazard.

10-168. The area of fallout is determined by the wind structure up to the top of the cloud. In complete calm, the fallout pattern is roughly circular. A constant wind direction leads to an elongation of the pattern. Complicated wind patterns (wind shear) as well as variations in wind pattern in time and space lead to complicated ground patterns. Fallout is difficult to predict accurately except under calm and very stable wind conditions.

10-169. Reduction in yield or changing the height/depth of burst to a point where the fireball does not intersect the ground will reduce fallout, as will complete containment of an underground burst.

10-170. Fallout landing on water will sink and will not constitute a hazard to ships passing through the area after fallout cessation. Fallout over a land area will remain on the surface and will be a hazard to personnel living in or passing through the area. In time, the fallout on a land surface will decay to an insignificant level.

PROTECTIVE SHIELDING

10-171. Protective shielding is one method of defense against nuclear radiation. The tremendous penetrating power of gamma rays makes it difficult to provide enough shielding to protect personnel from gamma rays. However, the structure of the ship provides some protection against them.

10-172. The main materials likely to provide shielding aboard a ship are steel plating, piping, machinery, water, fuel oil, and some types of wood. Shielding materials at storage facilities include concrete and earth.

10-173. The amount of shielding required to stop gamma rays is measured in half-value layer thickness or "half-thickness," for short. A half-thickness is defined as the amount of material necessary to cut down the amount of radiation to one half of its original value. The half-thickness value for each material is different. For example, a concrete shield about 6 inches thick or an earth shield about 7 1/2 inches thick will cut the gamma radiation in half. Suppose that you are standing at a plate where the gamma radiation is 400 roentgens. If you are behind a half-value layer thickness of some kind at the time, you will receive a dose of 200 roentgens. Now suppose you are standing behind two shields, each of which is a half-value layer. The 400 roentgens of gamma radiation is reduced to 200 roentgens by the first half-thickness and to 100 by the second half-thickness. With each additional half-thickness shield, you reduce the remaining gamma radiation by half. Remember that these thicknesses do not stop gamma radiation altogether; instead, they cut it in half. In a nuclear attack, one-half value layer of steel or concrete might be just enough of a shield to keep you from getting a lethal dose of gamma radiation.

10-174. The approximate half-thickness of some materials, listed in order of their effectiveness as shields against gamma radiation, are shown in Table 10-2.

Table 10-2. Materials Effectiveness Against Gamma Radiation

	INITIAL	RESIDUAL
Steel	1.5 inches	0.7 inches
Concrete	6.0 inches	2.2 inches
Earth	7.5 inches	3.3 inches
Water	13.0 inches	4.8 inches
Wood	23.0 inches	8.8 inches

PREVENTIVE MEASURES (BEFORE ATTACK)

10-175. Personnel should take preventive measures before an attack. The steps that are listed are not in a required sequence, they only list the things that should be performed. The situation at the time will determine the sequence.

- Notify all ship's masters and coxswains. They must take immediate charge of the situation aboard their vessel.
- Sound the NBC alarm.
- Shut all watertight doors, ports, and ventilation systems.
- Cease all cargo operations.
- Get away from the pier or beach, and put out to sea.
- Get all "soft" items off the decks, such as wood, hawsers, line, canvas, and so on.
- If the vessel is not equipped with a washdown system, rig the fire hoses for washdown.
- Commence washing the vessel down.
- Secure all loose gear inside the vessel.
- Have personnel don their protective clothing.
- Get personnel to take cover in interior of the vessel. Get them as far down below the centerline and in between the engines as possible.

Note: If the vessel is 1,000 yards or more from "ground zero," the crew should survive. With the crew below the waterline and in between the engines, the bulkheads, engines, ship's hull, and the water all provide a shield against radiation.

Personnel should also take the necessary actions against a nuclear attack. Table 10-3 shows the actions personnel should take during nuclear denotations.

Table 10-3. Recommended Personnel Action Against Nuclear Detonations

		WITH WARNING	NO WARNING
BURST TYPE	**TOPSIDE PERSONNEL**	**BELOW DECK PERSONNEL**	**TOPSIDE PERSONNEL**
Air	A	B	C
Surface	A	B	C
Underwater	B	B	

A –LIE PRONE AND HOLD ON TO SOLID SHIP STRUCTURE.

B – STAND WITH KNEES FLEXED AND HOLD ON TO SOLID SHIP STRUCTURE.

C – HANDS-TO-FACE EVASION.

PREVENTIVE MEASURES (DURING AN ATTACK)

10-176. Personnel should take preventive measures during an attack. The following are some precautions to take:

- DO NOT eat, drink, or smoke.
- Brace yourself and hold on to a secure object.
- Continue the washdown system for at least 1 hour.
- Keep all cuts or open wounds bandaged.
- At the sign of brightness, shut your eyes and turn your face away.

Note*:* When you are in an open topside area (where you can quickly drop to the deck) and you see the flash or see the sky light up, close your eyes and immediately raise your hands to cover your face. Meanwhile, drop to the deck as quickly as possible. Use your shoulder, not your hands, to break a fall. Curl up to present a minimum target. You may feel the heat from the detonation. Two to 5 seconds after the flash (depending on the weapon yield) or after the heat sensation is over, remove your hands from your face. Then immediately and firmly, grab a solid ship structure to prevent the airblast winds from blowing you overboard or against the ship's structure. You may suffer flash blindness for a period up to 30 minutes.

PROTECTIVE MEASURES (AFTER THE ATTACK)

10-177. Personnel should take preventive measures after an attack. The following are some precautions to take:

- Maintain maximum speed. Put the vessel on a course that is crosswind and away from the point of detonation.
- Continue the washdown for at least 1 hour.
- Do not eat, drink, or smoke.
- Check the interior of vessel for watertight integrity.
- Observe the fallout pattern and continue to leave the ventilation system shut off.
- If radiac instruments are on board ship, monitor interior of vessel, all open food, liquids, and cigarettes.
- Don protective clothing before going on deck.
- Commence vessel washdown.

RADIOLOGICAL DECONTAMINATION

10-178. This neither neutralizes nor destroys the contamination. Instead, it merely removes the contamination from one particular area and transfers it to an area in which it presents less of a hazard. At sea, dispose of radioactive material directly over the side.

10-179. Flushing with water, preferably water under high pressure, is the most practicable way of rapidly decontaminating topside surfaces. Aboard ship, a water washdown system is used to wash down all the exterior surfaces (from high to low and from bow to stern). The washdown system consists of piping and a series of nozzles that are specially designed to throw a large spray pattern on weather decks and other surfaces. Permanent washdown systems are being built into ships under construction or conversion. Interim washdown system kits are provided for ships already in service.

10-180. If the washdown system is turned on before the arrival of contamination, the system prevents heavy contamination of the ship by coating the weather surfaces with the flowing stream of water. The flowing stream of water carries away radioactive particles as they fall on the ship and keeps radioactive particles from settling into cracks and crevices.

10-181. If some areas of the ship become heavily contaminated before the washdown system is activated, it will probably be necessary to hose down such areas vigorously, using seawater under pressure. Hosing should proceed from higher to lower surfaces, from bow to stern, and, if possible, from the windward side to the lee side. Every possible precaution should be taken to see that contaminated water does not flow back over cleaned areas. Precautions must also be taken to see that contaminated water is not hosed into the interior of the ship through vents, doors, or hatches. The hose should be directed so that the water strikes the surface about 8 feet from the nozzle. The hose stream should sweep horizontally from side to side, moving lower on each sweep. The hosed areas should be overlapped somewhat on each sweep to ensure complete washing. The runoff should be directed into scuppers and deck drains as rapidly as possible to keep the contaminated water moving and to prevent pools of contaminated water from forming.

10-182. Hosing down will be most effective if it is done before metal or painted surfaces have dried after

contaminating material has been deposited. However, contamination that has been deposited despite washdown will also resist hosing alone. Vigorous scrubbing with deck brushes and detergents, followed by hosing, is required. Ships without washdown systems will initially decontaminate by hosing down with seawater as soon as the tactical situation permits.

CONTAMINATION MARKERS

10-183. Areas or objects that are contaminated by NBC attack must be clearly marked to warn personnel approaching the area of the existence of hazards. Contamination markers should outline dangerous areas and establish boundaries within which safety control must be exercised. Radiation hot spots--that is, areas having radiation intensities significantly greater than the general radiation level of the surrounding areas -- should be identified.

10-184. The standard NATO system for marking areas, that are contaminated by NBC attack, is used. Figure 10-45, shows these standard survey markers. Each marker is in the shape of a right triangle; one side of the triangle is about 11 1/2 inches long, and the other two sides are about 8 inches long. The markers may be made of wood, metal, plastic, or other rigid material.

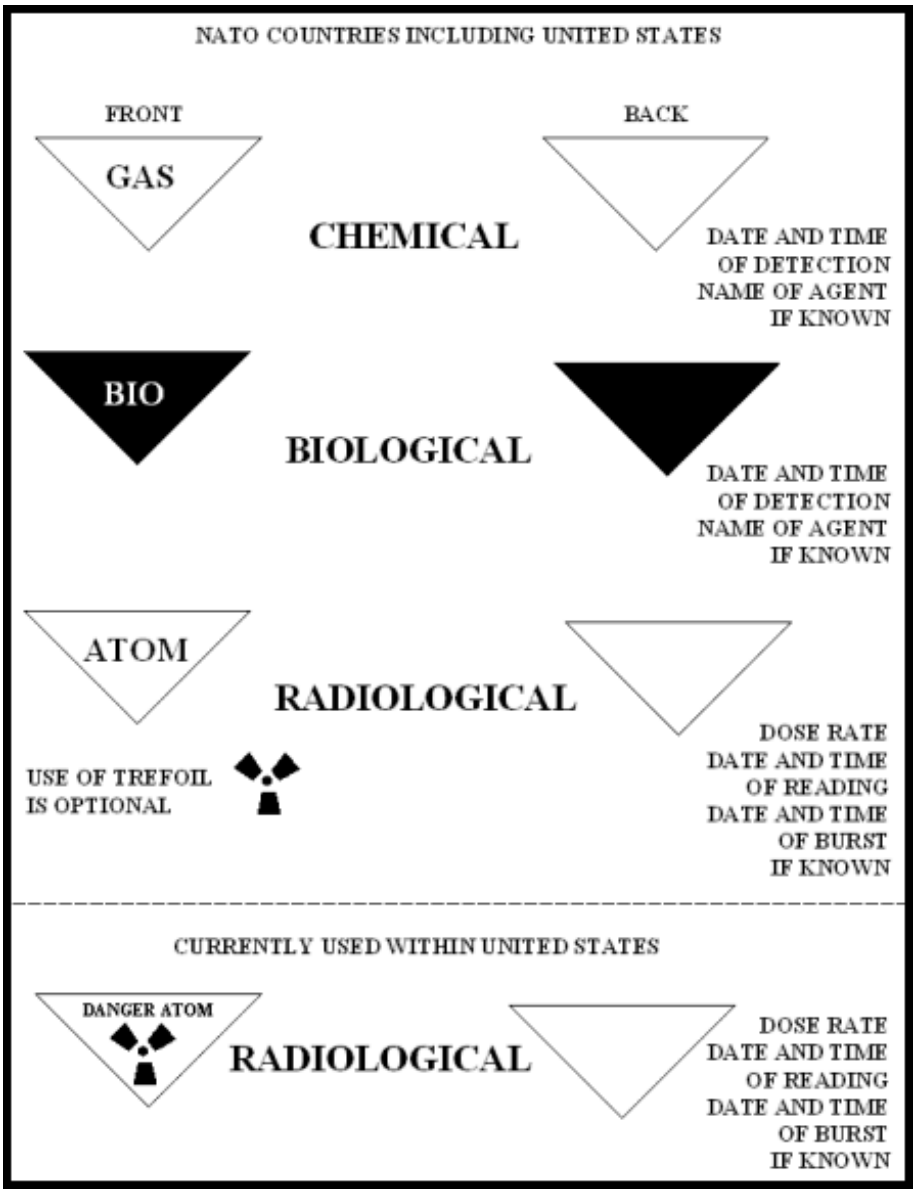


Figure 10-45. NATO NBC Markers

Chapter 11

Shipboard Fire Fighting

Fire aboard ship is a terrifying experience. It is a situation where the crew must work together as a team to survive. To do this you must know the type of fire you are fighting, select the right extinguishing agent, and know how to use the fire fighting equipment aboard ship to put out the fire. Once you understand what fire is, then you can take the proper actions for putting the fire out. This chapter covers the following:

- Definition of fire.
- Classes of fire.
- Effective agents to control and extinguish each class of fire.
- Types of fire fighting equipment.
- Different types of self-contained breathing apparatus.

CHEMISTRY OF FIRE

11-1. Oxidation is a chemical process in which a substance combines with oxygen. During this process, energy is given off, usually in the form of heat. Rusting iron and rotting wood are common examples of slow oxidation. Fire, or combustion, is rapid oxidation; the burning substance combines with oxygen at a very high rate. Energy is given off in the form of heat and light. Because this energy production is so rapid, we can feel the heat and see the light as flames.

THE START OF A FIRE

11-2. All matter exists in one of three states: solid, liquid, or gas (vapor). The atoms or molecules of a solid are packed closely together, and those of a liquid are packed loosely. The molecules of a vapor are not packed together at all; they are free to move about. In order for a substance to oxidize, its molecules must be pretty well surrounded by oxygen molecules. The molecules of solids and liquids are packed too tight to be surrounded by oxygen molecules. Therefore, only vapors can burn.

11-3. When a solid or liquid is heated, its molecules move about rapidly. If enough heat is applied, some molecules break away from the surface to form a vapor just above the surface. This vapor can now mix with oxygen. If there is enough heat to raise the vapor to its ignition temperature, and if there is enough oxygen present, the vapor will oxidize rapidly--it will start to burn.

BURNING

11-4. What we call burning is the rapid oxidation of millions of vapor molecules. The molecules oxidize by breaking apart into individual atoms and recombining with oxygen into new molecules. It is during the breaking-recombining process that energy is released as heat and light. 11-5. The heat that is released is radiant heat, which is pure energy. It is the same sort of energy that the sun radiates and that we feel as heat. It radiates, or travels, in all directions. Therefore, part of it moves back to the seat of the fire, to the "burning" solid or liquid (the fuel). 11-6. The heat that radiates back to the fuel is called radiation feedback (Figure 11-1). Part of this heat releases more vapor and part of it raises the vapor to the ignition temperature. At the same time, air is drawn into the area where the flames and vapor meet. The result is that there is an increase in flames as the newly formed vapor begins to burn.

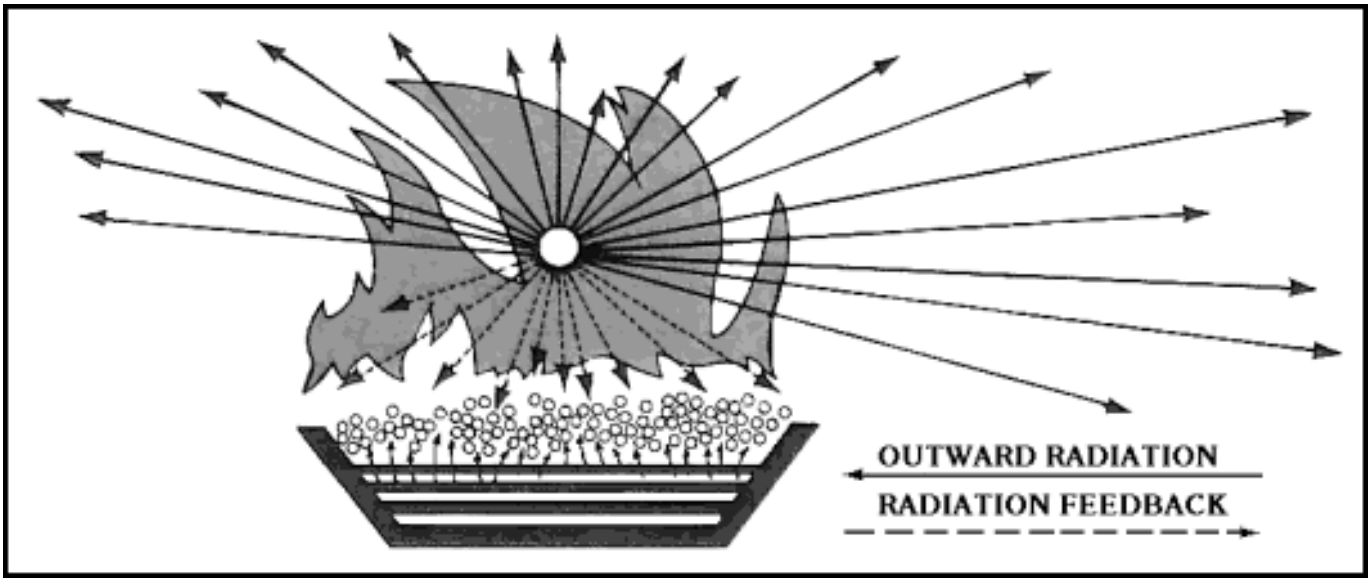


Figure 11-1. Radiation Feedback

THE FIRE TRIANGLE

11-7. The following are the three things that are required for combustion. Fuel (to vaporize and burn), oxygen (to combine with fuel vapor), and heat (to raise the temperature of the fuel vapor to its ignition temperature). The fire triangle illustrates these requirements (Figure 11-2). It also illustrates two important facts in preventing and extinguishing fires.

- If any side of the fire triangle is missing, a fire cannot start.
- If any side of the fire triangle is removed, the fire will go out.

A fire can be extinguished by destroying the fire triangle. If fuel, oxygen, or heat is removed, the fire will die out. If the chain reaction is broken, the resulting reduction in vapor and heat production will put out the fire. Additional cooling with water may be necessary where smoldering or reflash is possible.

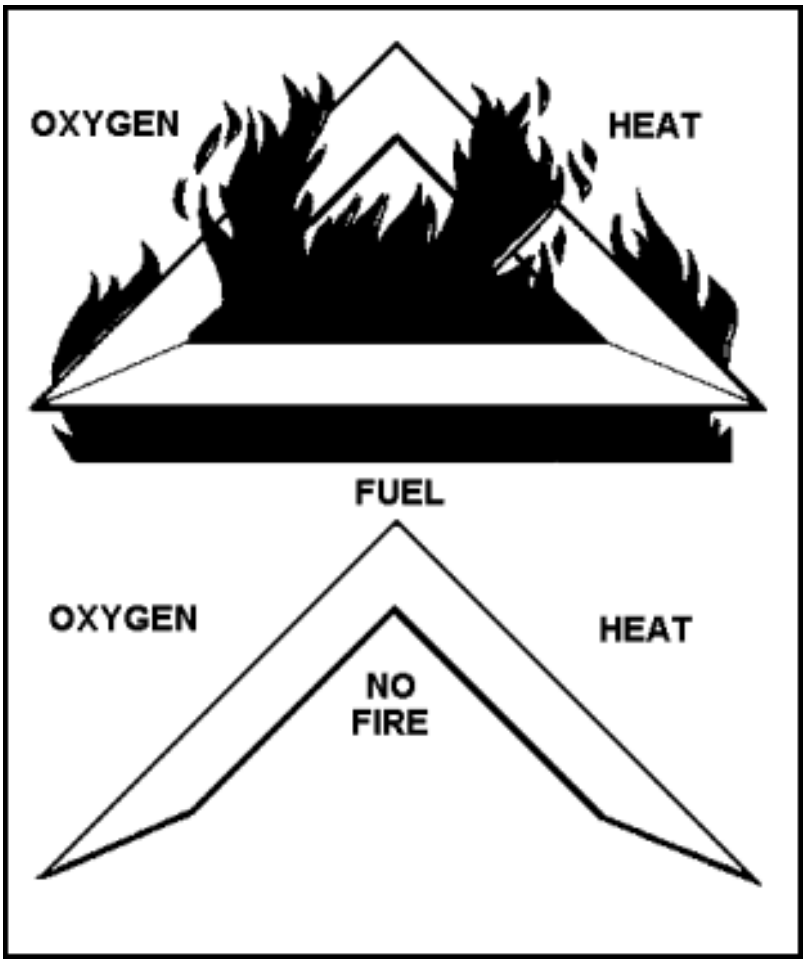


Figure 11-2. Fire Triangle With One Side Missing

FUELS AND FUEL CHARACTERISTICS

11-8. Fuels and fuel characteristics are important for the mariner to know so that they can identify what fire fighting agent should be used in fighting a fuel fire.

Solid Fuels

11-9. The most obvious solid fuels are wood, paper, and cloth. These can be found aboard ship as cordage, canvas, dunnage, furniture, plywood, wiping rags, and mattresses. The paint on bulkheads is also a solid fuel. Vessels may carry a wide variety of solid fuels as cargo (from baled materials and goods in cartons to loose materials, such as grain). Metals such as magnesium, sodium, and titanium are also solid fuels that may be carried as cargo.

Ignition Temperature

11-10. The ignition temperature of a substance (solid, liquid, or gas) is the lowest temperature at which sustained combustion will occur without the application of a spark or flame. Ignition temperatures vary among substances. For a given substance, the ignition temperature also varies with bulk, surface area, and other factors. The ignition temperatures of common combustible materials is between 149°C (300°F) and 538°C (1,000°F).

Liquid Fuels

11-11. The flammable liquids most commonly found aboard ship are bunker fuel, lubricating oil, diesel oil, kerosene, and oil-base paints and their solvents. Cargo may also include flammable liquids and liquified flammable gases.

Vaporization

11-12. Flammable liquids release vapor in much the same way as solid fuels. The rate of vapor release is greater for liquids than for solids, since liquids have less closely packed molecules. Liquids can also release vapor over a wide temperature range. Gasoline starts to give off vapor at -43°C (-45°F). This makes gasoline a continuous fire hazard; it produces flammable vapor at normal temperatures. Heating increases the rate of vapor release.

11-13. Heavier flammable liquids such as bunker oil and lubricating oil must be heated to release sufficient vapor for combustion. Lubricating oils can ignite at 204°C (400°F). A fire reaches this temperature rapidly, so that oils directly exposed to a fire will soon become involved. Once a light or heavy flammable liquid is burning, radiation feedback and the chain reaction quickly increases flame production.

11-14. The vapor produced by a flammable liquid is heavier than air. This makes the vapor very dangerous because it will seek low places, dissipate slowly, and travel to a distant source of ignition. For example, vapor escaping from a container can travel along a deck and down deck openings until it contacts a source of ignition (such as a spark from an electric motor). If the vapor is properly mixed with air, it will ignite and carry fire back to the leaky container. The result can be a severe explosion and fire.

Flash Point

11-15. The flash point of a liquid fuel is the temperature at which it gives off sufficient vapor to form an ignitable mixture near its surface. Sustained combustion takes place at a slightly higher temperature, referred to as the fire point of the liquid. The flash points and fire points (temperatures) of liquids are determined in controlled tests.

Gaseous Fuels

11-16. There are both natural and manufactured flammable gases. Those that may be found on board a vessel include acetylene, propane, and butanes.

Burning

11-17. Gaseous fuels are already in the required vapor state. Only the correct intermix with oxygen and sufficient heat are needed for ignition. Gases, like flammable liquids, always produce a visible flame; they do not smolder.

Explosive Range (Flammable Range)

11-18. A flammable gas or the flammable vapor of a liquid must mix with air in the proper proportion to make an ignitable mixture. The smallest percentage of a gas (or vapor) that will make an ignitable air-vapor mixture is called the lower explosive limit of the gas (or vapor). If there is less gas in the mixture, it is too lean to burn. The greatest percentage of a gas (or vapor) in an ignitable air-vapor mixture is called its upper explosive limit. If a mixture contains more gas than the UEL, it is too rich to burn. The range of percentages between the lower and upper explosive limits is called the explosive range of the gas or vapor.

OXYGEN

11-19. The oxygen side of the fire triangle refers to the oxygen content of the surrounding air. Ordinarily, a minimum concentration of 16 percent oxygen in the air is needed to support flaming combustion. However, smoldering combustion can take place in about 3 percent oxygen. Air normally contains about 21 percent oxygen, 78 percent nitrogen, and 1 percent other gases, principally argon.

HEAT

11-20. Heat is the third side of the fire triangle. When sufficient heat, fuel, and oxygen are available, the triangle is complete and fire can exist. Heat of ignition initiates the chemical reaction that is called combustion. It can come from the flame of a match, sparks caused by ferrous metals striking together, heat generated by friction, lightning, an oxyacetylene torch cutting or welding metal, an electric short circuit, an electric arc between conductors, or the overheating of an electric conductor or motor.

CLASSES OF FIRE

11-21. There are four types or classes of fires (labeled A through D) according to their fuels. However, some fuels are found in combinations, and electrical fires always involve some solid fuel. Therefore, for fire fighting purposes, there are actually six classes:

- Class A Fires (common flammable solid fuel).
- Class B Fires (flammable liquid or gaseous fuel).
- Combined Class A and Class B fires (solid fuel combined with liquid or gaseous fuel).
- Combined Class A and Class C fires (solid fuel combined with electrical equipment).
- Combined Class B and Class C fires (liquid or gaseous fuel combined with electrical equipment).
- Class D fires (combustible-metal fuel).

This list includes every known type of fire. Note that the environment of a fire, that is, where it occurs, does not affect its classification. For example, Class B fires are Class B fires whether they occur in an engine room or on a pier.

11-22. The main purpose of this classification scheme is to help crew members pick the best extinguishing agent. The choice of an extinguishing agent depends on the class of fire, the hazards involved, and the agents available. It is not enough to know that water is best for putting out a class. A fire because it cools, or that a dry chemical works well in knocking down the flames of a burning liquid. The extinguishing agent must be applied properly and sound fire fighting techniques must be used.

EXTINGUISHING AGENTS

11-23. An extinguishing agent is a substance that will put out a fire. Every extinguishing agent operates by attacking one or more sides of the fire triangle.

- Cooling. Reduces the temperature of the fuel below its ignition temperature. This is a direct attack on the heat side of the fire triangle (see Figure 11-3).
- Smothering. Separates the fuel from the oxygen. This can be considered as an attack on the edge of the fire triangle where the fuel and oxygen sides meet (see Figure 11-4).
- Oxygen dilution. Reduces the amount of available oxygen below that needed to sustain combustion. This is an attack on the oxygen side of the triangle (see Figure 11-5).

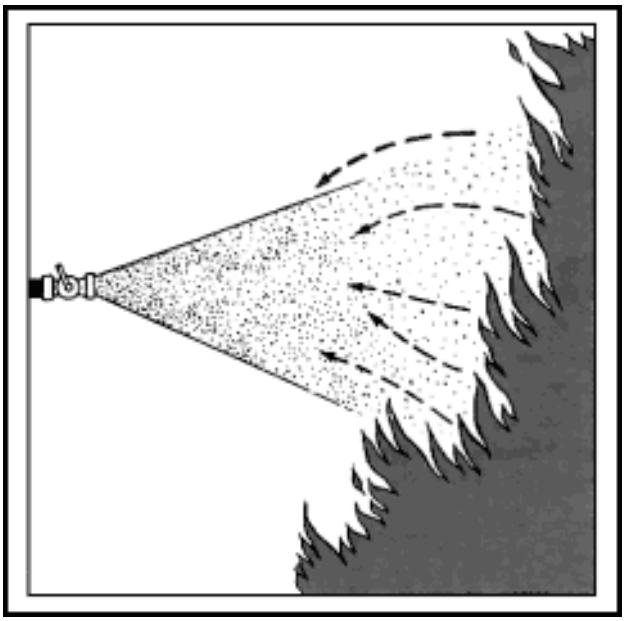


Figure 11-3. Effects of Cooling

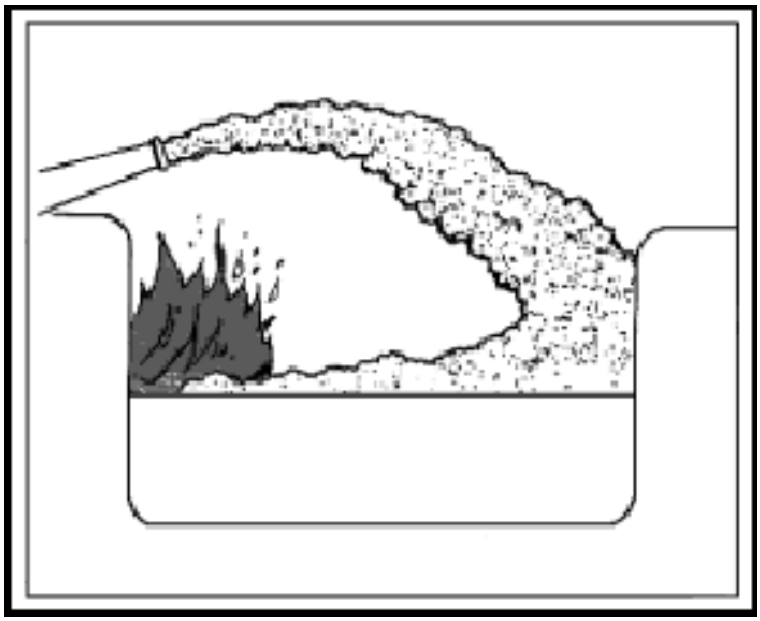


Figure 11-4. Effects of Smothering

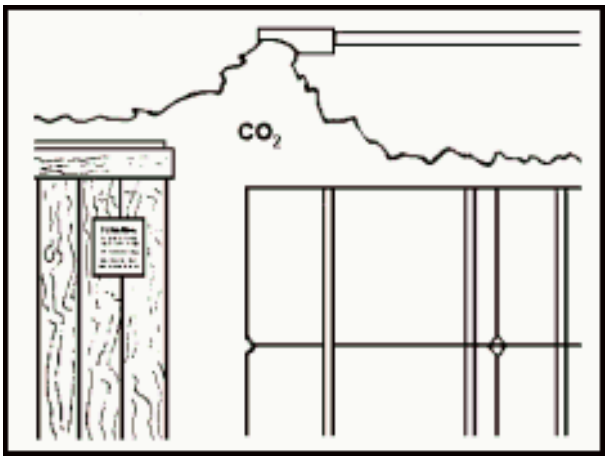


Figure 11-5. Effects of Oxygen Dilution

TYPES OF EXTINGUISHING AGENTS

11-24. Eight extinguishing agents are in common use. Each is applied to the fire as a liquid, gas, or solid, depending on its extinguishing action and physical properties. Some may be used on several types of fires, where others are more limited in use (see Table 11-1).

Table 11-1. The Eight Common Extinguishing Agents

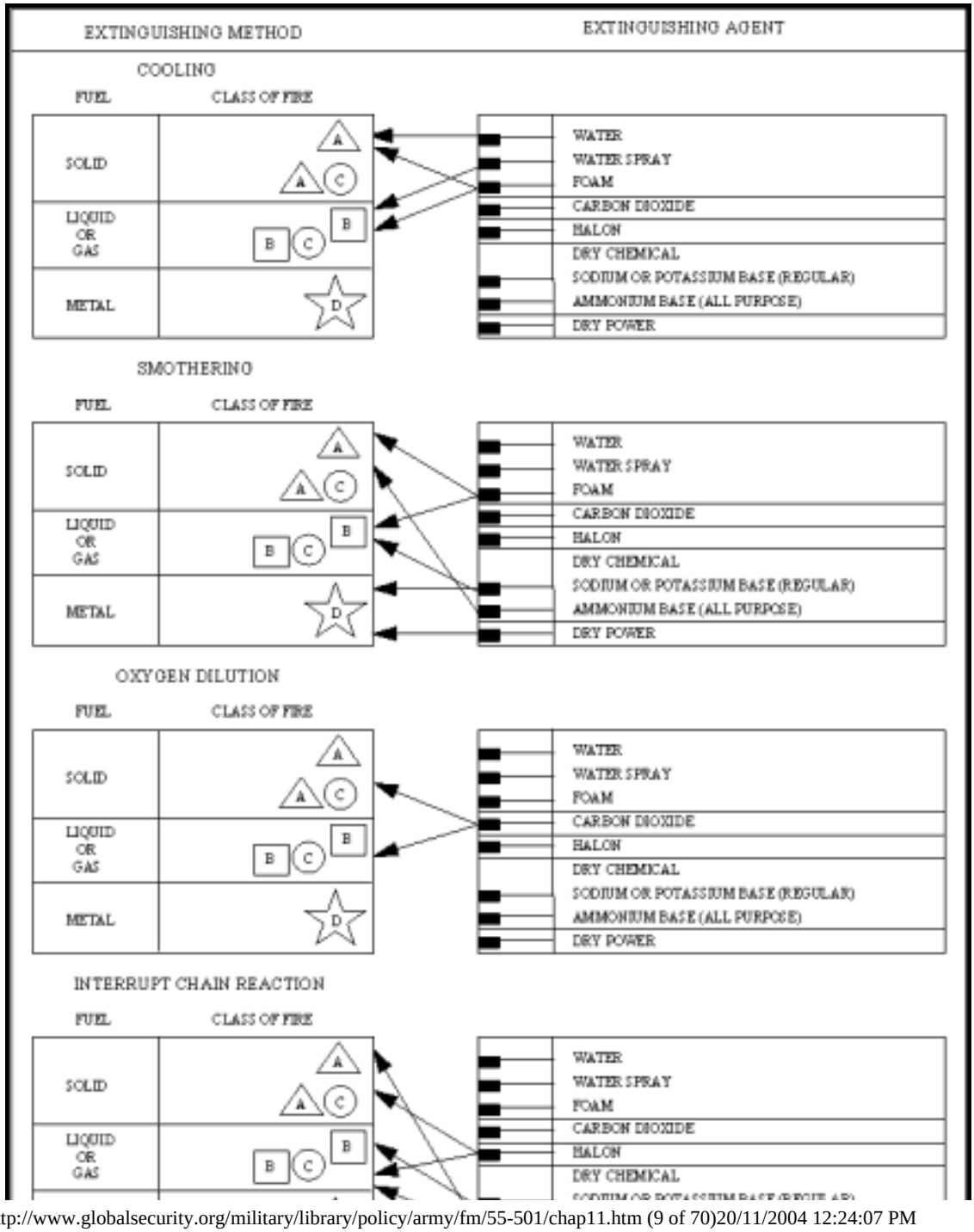
LIQUIDS
WATER SPRAY
FOAM
GASES
CARBON DIOXIDE (CO_2)
HALON 1301
SOLIDS (DRY CHEMICAL)
MONOAMMONIUM PHOSPHATE
BICARBONATE
POTASSIUM BICARBONATE
POTASSIUM CHLORIDE

EXTINGUISHING AGENTS FOR THE DIFFERENT CLASSES OF FIRE

11-25. It is necessary to use the most suitable type of extinguishing agent to put out a fire. Select an extinguishing agent that will do the task in the least amount of time, cause the least damage, and result in the least danger to crew members (Figure 11-6).

11-26. Class A fires involve common combustible solids such as wood, paper, cloth, and plastics and are most effectively extinguished by water, a cooling agent. Foam and dry chemical may also be used; they act mainly as smothering agents.

11-27. Class B fires involve oils, greases, gases, and other substances that give off large amounts of flammable vapors. A smothering agent is most effective. Water fog, dry chemical, foam, and carbon dioxide (CO_2) may be used. However, if the fire is being supplied with fuel by an open valve or a broken pipe, a valve on the supply side should be shut down. This may extinguish the fire or, at least, make extinguishing less difficult and allow the use of much less extinguishing agent.



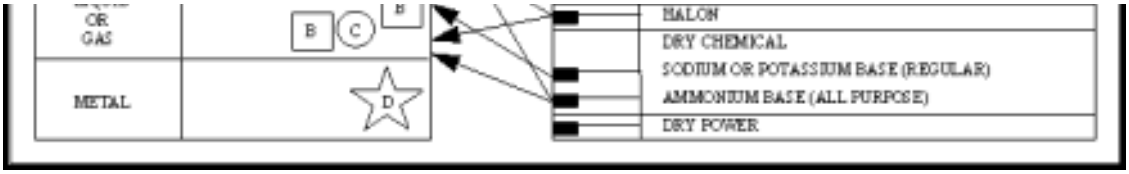


Figure 11-6. Actions of Extinguishing Agents on the Different Classes of Fire

11-28. In a gas fire, it is imperative to shut down the control valve before you extinguish the fire. If the fire were extinguished without shutting down the valve, flammable gas would continue to escape. The potential for an explosion, more dangerous than the fire, would then exist. It might be necessary to extinguish a gas fire before shutting down the fuel supply in order to save a life or to reach the control valve; however, these are the only exceptions.

11-29. Combined Class A and Class B fires involve both solid fuels and flammable liquids or gases. Water spray and foam may be used to smother these fires. These agents also have some cooling effect on the fire. Carbon dioxide has also been used to extinguish such fires in closed spaces.

11-30. Combined Class A and Class C fires involve energized electrical equipment and a non-conducting extinguishing agent must be used. Carbon dioxide, Halon, and dry chemical are the most efficient agents. Carbon dioxide dilutes the oxygen supply, while the others are chain-breaking agents.

11-31. Combined Class B and Class C fires involve flammable liquids or gases and electrical equipment. A nonconducting extinguishing agent is required, such as Halon or dry chemical acting as a chain breaker. They may also, in closed spaces, be extinguished with CO_2.

11-32. Class D fires involve combustible metals such as potassium, sodium and their alloys, magnesium, zinc, and powdered aluminum. They burn on the metal surface at a very high temperature and often with a brilliant flame. Water should not be used on Class D fires, as it may add to the intensity or cause the molten metal to splatter. This, in turn, can extend the fire and inflict painful and serious burns on those in the vicinity.

11-33. Fires in combustible metals are generally smothered and controlled with specialized agents known as dry powders. Dry powders are not the same as dry chemicals, although many people use the terms interchangeably. The agents are used on entirely different types of fires: dry powders are used only to extinguish combustible-metal fires. Dry chemicals may be used on other fires, but not on Class D fires.

WATER

11-34. Water is primarily a cooling agent. It absorbs heat and cools burning materials more effectively than any other of the commonly used extinguishing agents. Water has an important secondary effect. When it turns to steam, it converts from the liquid state to the gaseous (vapor) state. Seawater is just as effective in fighting first as fresh water.

Straight Streams

11-35. The straight stream, sometimes called the solid stream, is the oldest and most commonly used form of water for fire fighting.

Efficiency of Straight Streams

11-36. The distance that a straight stream travels before breaking up or dropping is called its reach. Reach is important when it is difficult to approach close to a fire. Actually, despite its name, a straight stream is not really straight. Like any projectile, it has two forces acting upon it. The velocity imparted by the nozzle gives it reach, either horizontally or at an upward angle, depending on how the nozzleman aims the nozzle. The other force, gravity, tends to pull the stream down, so the reach ends where the stream encounters the deck.

11-37. Probably less than 10 percent of the water from a straight stream actually absorbs heat from the fire. This is because only a small portion of the water surface actually comes in contact with the fire, and only water that contacts the fire absorbs heat.

Using Straight Streams

11-38. A straight stream should be directed into the seat of the fire. This is important; for the most cooling, the water must touch the material that is actually burning. A solid stream that is aimed at the flames is ineffective. The main use of solid streams is to break up the burning material and penetrate to the seat of a Class A fire.

Low-Velocity Fog Streams

11-39. Low-velocity fog streams are obtained by using an applicator along with a combination nozzle. Applicators are tubes or pipes that are angled at 60° or 90° at the water outlet end. They are stowed for use with the low-velocity head already in place on the pipe. Some heads are shaped somewhat like a pineapple, with tiny holes angled to cause minute streams to bounce off one another and create a mist. Some heads resemble a cage with a fluted arrow inside. The point of the arrow faces the opening in the applicator tubing. Water strikes the fluted arrow and then bounces in all directions, creating a fine mist.

11-40. For 1 1/2-inch nozzles, 4-foot, 60° angle and 10-foot, 90° angle applicators are approved for shipboard use. For 2 1/2-inch nozzles, 12-foot, 90° angle applicators are approved. Other lengths with different angles are sometimes found. The 4-foot applicator is intended for the 1 1/2-inch combination nozzles fitted in propulsion machinery spaces containing oil-fired boilers, internal combustion machinery, or fuel units.

11-41. Low-velocity fog streams are effective in combating Class B fires in spaces

where entry is difficult or impossible. Applicators can be poked into areas that cannot be reached with other types of nozzles (Figure 11-7). They are also used to provide a heat shield for fire fighters advancing with foam or high-velocity fog. Low-velocity fog can be used to extinguish small tank fires, especially where the mist from the applicator can cover the entire surface of the tank. However, other extinguishing agents, such as foam and carbon dioxide, are usually more effective.

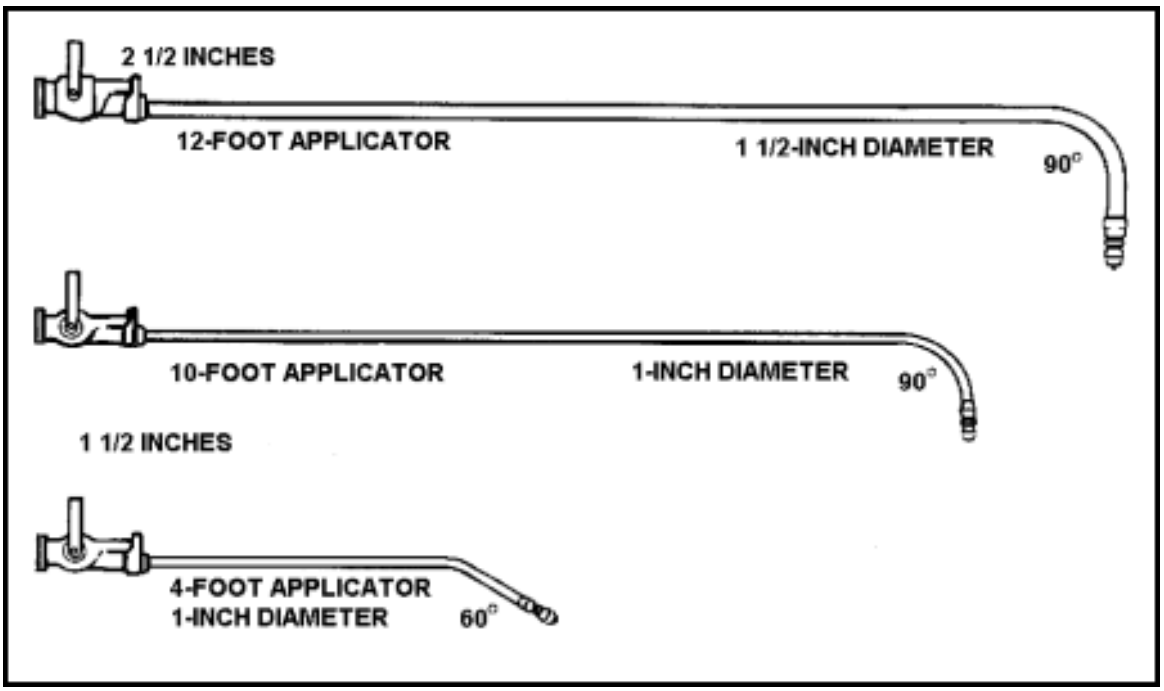


Figure 11-7. Low-Velocity Fog Applicators

Limitations of Fog Streams

11-42. Fog streams do not have the accuracy or reach of straight streams. Improperly used, they can cause injury to personnel, as in a blowback situation. While they can be effectively used on the surface of a deepseated fire, they are not as effective as solid streams in soaking through and reaching the heart of the fire.

11-43. In some instances, there may be an obstruction between the fire and the nozzleman. Then the stream can be bounced off a bulkhead or the overhead to get around the obstacle (Figure 11-8). This method can also be used to break a solid stream into a spray-type stream, which will absorb more heat. It is useful in cooling an extremely hot passageway that is keeping fire fighters from advancing toward the fire. A combination fog-solid nozzle could be opened to the fog position to achieve the same results.

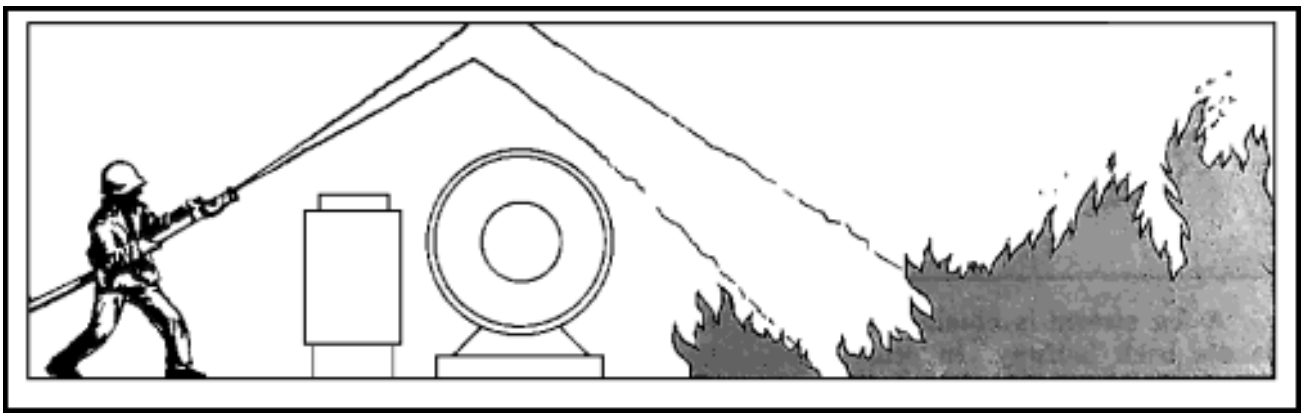


Figure 11-8. Bouncing a Straight Stream Off the Overhead

Fog Streams

11-44. The fog (or spray) nozzle breaks the water stream into small droplets. These droplets have a much larger total surface area than a solid stream. Therefore, a given volume of water in fog form will absorb much more heat than the same volume of water in a straight stream (Figure 11-9).

11-45. The greater heat absorption of fog streams is important where the use of water is limited. Less water need be applied to remove the same amount of heat from a fire. Also, more of the fog stream turns to steam when it hits the fire.

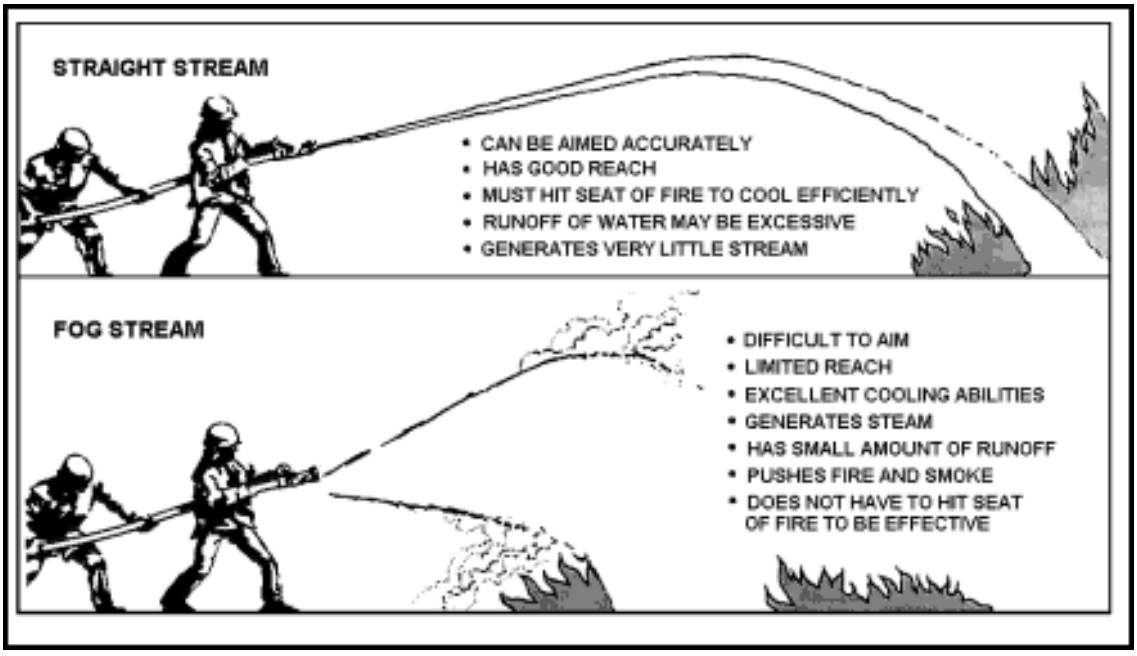


Figure 11-9. Advantages and Disadvantages of Straight and Fog Streams

Combination Nozzle Operation

11-46. Depending on the position of its handle, the combination nozzle will produce a straight stream or high-velocity fog stream. Combination nozzles are available for use with 1 1/2- and 2 1/2-inch hoses. Reducers can be used to attach a 1 1/2-inch nozzle to a 2 1/2-inch hose.

11-47. Create a straight stream by pulling the nozzle handle all the way back toward the operator (Figure 11-10). Create a fog stream by pulling the handle back halfway. In other words, the handle is perpendicular to the plane of the nozzle (Figure 11-11). Shut down the nozzle, from any opened position, by pushing the handle forward as far as it will go (Figure 11-12).

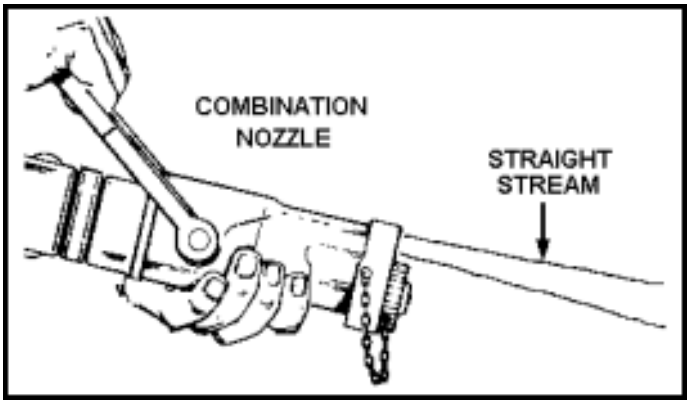


Figure 11-10. Creating a Straight Stream

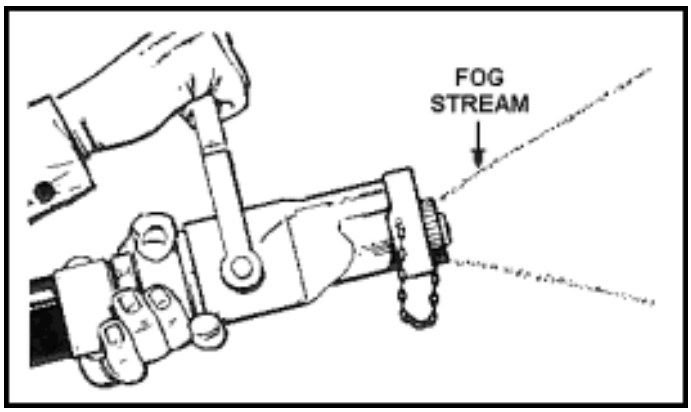


Figure 11-11. Creating a Fog Stream

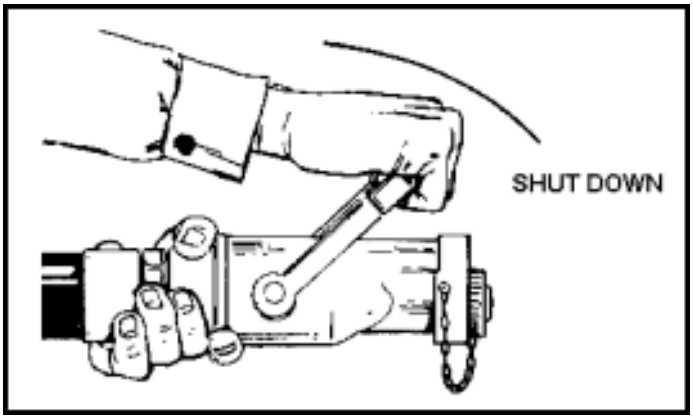


Figure 11-12. Shutting Down the Nozzle

11-48. The low-velocity fog applicator must be attached with the nozzle shut down. First, the high-velocity tip is removed. Then the straight end of the applicator is snapped into the fog outlet and locked with a quarter-turn. A low-velocity fog stream is obtained with the nozzle handle in the fog position (halfway back).

11-49. When any nozzle is to be used, the handle should be in the closed position until the water reaches the nozzle. The hose will bulge out, and the nozzleman will feel the weight of the water. Before pushing the handle to an open position, he should let the entrained air out of the nozzle. To do this, turn a bit sideways with the nozzle and slowly open it until a spatter of water comes out. Now the nozzle is directed at the target. The backup man closes up to the nozzleman and takes some of the weight of the hose and the back pressure from the nozzle. The nozzle is opened to the desired position, and the fire is attacked.

11-50. Straight and fog streams can be very effective against Class A fires in the hands of skilled operators. Fog streams can also be used effectively against Class B fires. However, it is important that crewmen have actual experience in directing these streams during drills. Applicators should also be broken out at drills so crewmen can get the feel of these devices.

FOAM

11-51. Foam is a blanket of bubbles that extinguishes fire, mainly by smothering. Mixing water and a foam-making agent (foam concentrate) produces bubbles. The result is called a foam solution. The various foam solutions are lighter than the lightest of flammable oils. Consequently, when applied to burning oils, they float on the surface of the oil (Figure 11-13).

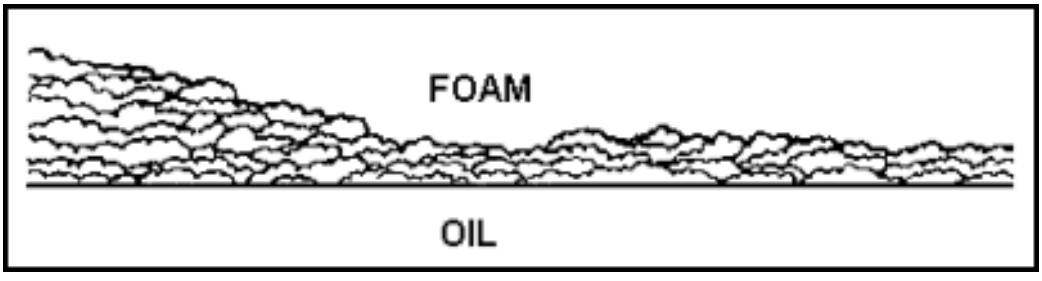


Figure 11-13. Foam

Extinguishing Effects of Foam

11-52. Fire-fighting foam is used to form a blanket on the surface of flaming liquids, including oils. The blanket of foam keeps flammable vapors from leaving the surface and keeps oxygen from reaching the fuel. Fire cannot exist when the fuel and oxygen are separated. The water in the foam also has a cooling effect, which gives foam its Class A extinguishing capability. 11-53. The ideal foam solution should flow freely enough to cover a surface rapidly, yet stick together enough to provide and maintain a vapor-tight blanket. The solution must retain enough water to provide a long-lasting seal. Rapid loss of water would cause the foam to dry out and break down (wither) from the high temperatures associated with fire. The foam should be light enough to float on flammable liquids, yet heavy enough to resist winds. 11-54. The quality of foam is generally defined in terms of its 25 percent drainage time, its expansion ratio, and its ability to withstand heat (burnback resistance). These qualities are influenced by:

- The chemical nature of the foam concentrates.
- The temperature and pressure of the water.
- The efficiency of the foam-making device.

11-55. Foams that lose their water rapidly are the most fluid. They flow around obstructions freely and spread quickly. Such foams would be useful in engine room or machinery space fires. They would be able to flow under and around machinery, floor plates, and other obstructions. The two basic types of foam are chemical and mechanical.

- **Chemical foam.** You can form *c*hemical foam by mixing an alkali (usually sodium bicarbonate) with an acid (usually aluminum sulfate) in water (Figure 11-14). When chemical foam was first introduced, these substances were stored in separate containers. They are now combined in a sealed, airtight container. A stabilizer is added to make the foam tenacious and long-lived. When these chemicals react, they form a foam or froth of bubbles filled with carbon dioxide gas. The carbon dioxide in the bubbles has little or no extinguishing value. Its only purpose is to inflate the bubbles. From 7 to 16 volumes of foam are produced for each volume of water.

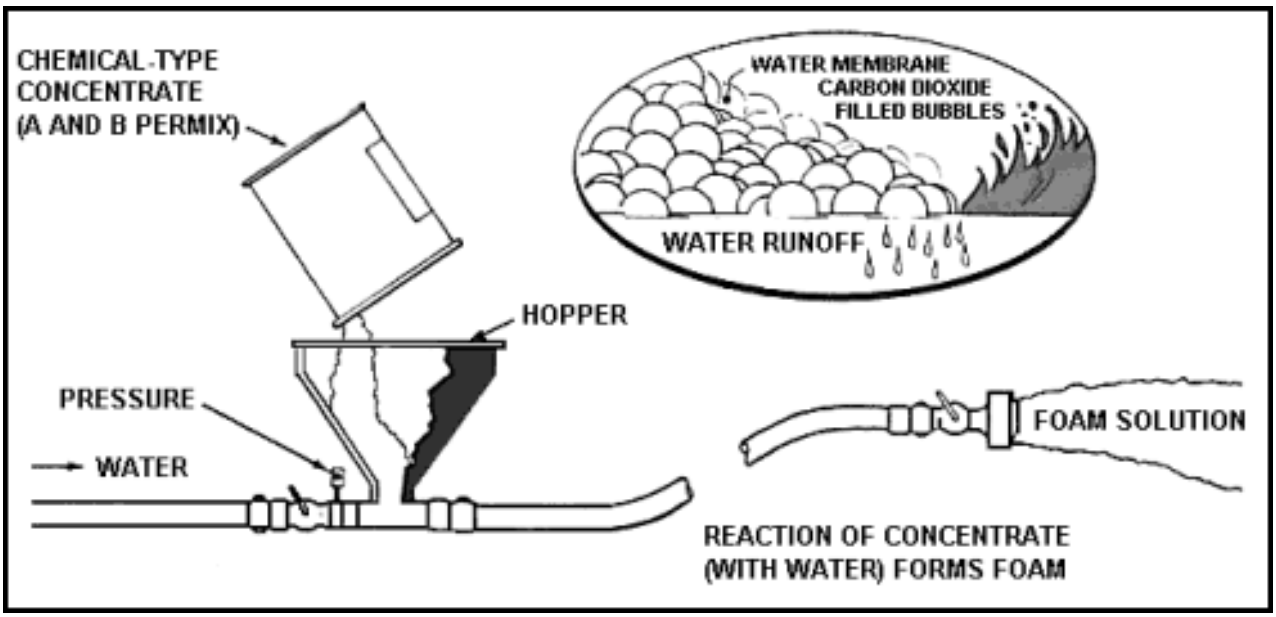


Figure 11-14. Production of Chemical Foam

- **Aqueous film-forming foam.** This foam was developed by the US Naval Research Laboratory to be used in a twinned system: a flammable liquid fire would be quickly knocked down with a dry chemical; then AFFF would be applied to prevent reignition. However, the AFFF proved more effective than expected, and it is now used without the dry chemical. AFFF controls the vaporization of flammable liquids by means of a water film that forms as the foam is applied. Like other foams, it cools and blankets. This double action gives a highly efficient, quick-acting foam cover for combustible-liquid spills. It has a low viscosity and spreads quickly over the burning material. Water draining from this type of foam has a low surface tension, so AFFF can be used on mixed Class A and Class B fires. The draining water penetrates and cools the Class A material, while the film blankets the Class B material. AFFF can be produced from freshwater or seawater. AFFF can be used with, before, or after dry chemicals. AFFF concentrates should not be mixed with the concentrates of other foams, although in foam form they may be applied to the same fire successfully.

Advantages of Foam

11-56. In spite of its limitations, foam is quite effective in combating Class A and Class B fires. Many advantages of foam include the following:

- Very effective smothering agent. Also provides cooling as a secondary effect.
- Sets up a vapor barrier that prevents flammable vapors from rising. The surface of an exposed tank can be covered with foam to protect it from a fire in a neighboring tank.
- Some use on Class A fires because of its water content. AFFF is especially effective, as are certain types of wet-water foam. Wet-water foam is made from detergents; its water content quickly runs out and seeps into the burning material.
- Effective in blanketing oil spills. However, if the oil is running, an attempt should be made to shut down a valve if such action would stop the flow. If that is impossible, the flow should be dammed. Foam should be applied on the upstream side of the dam (to extinguish the fire) and on the downstream side (to place a protective cover over any oil that has seeped through).
- Most effective extinguishing agent for fires involving large tanks of flammable liquids.
- Made with freshwater or seawater and hard or soft water.
- Does not break down readily; it extinguishes fire progressively when applied at an adequate rate.
- Stays in place, covers, and absorbs heat from materials that could cause reignition.
- Uses water economically. Does not tax the ship's fire pumps.
- Concentrates are not heavy, and foam systems do not take up much space.

Limitations on the Use of Foam

11-57. Foams are effective extinguishing agents when used properly. However, some limitations on foam include the following:

- Because they are aqueous (water) solutions, they are electrically conductive and should not be used on live electrical equipment.
- Like water, foams should not be used on combustible-metal fires.
- Many must not be used with dry chemical extinguishing agents. AFFF is an exception to this rule and may be used in a joint attack with dry chemical.
- Sufficient foam must be on hand to make sure that the entire surface of the burning material can be covered. In addition, there must be enough foam to replace foam that is burned off and to seal breaks in the foam surface.

11-58. The premixed foam powder may be stored in cans and introduced into the water during firefighting operations. For this, a device called a foam hopper is used. The two chemicals may be premixed with water to form an aluminum sulfate solution and a sodium bicarbonate solution. The solutions are then stored in separate tanks until the foam is needed. At that time, the solutions are mixed to form the foam.

11-59. Many chemical foam systems, both aboard ship and in shore installations, are still in use. However, these systems are being phased out in favor of the newer

mechanical foam or, as it is sometimes called, air foam.

Mechanical (Air) Foam

11-60. Mechanical foam is produced by mixing a foam concentrate with water to produce a foam solution (Figure 11-15). The turbulent mixing of air and the foam solution produces bubbles. As the name air foam implies, the bubbles are filled with air. Aside from the workmanship and efficiency of the equipment, the degree of mixing determines the quality of the foam. The design of the equipment determines the quantity of foam produced.

11-61. There are several types of mechanical foams. They are similar in nature, but each has its own special fire-fighting capabilities. Mechanical foams are produced from proteins, detergents (which are synthetics), and surfactants. The surfactants are a large group of compounds that include detergents, wetting agents, and liquid soaps. Surfactants are used to produce aqueous film-forming foam, commonly referred to as AFFF.

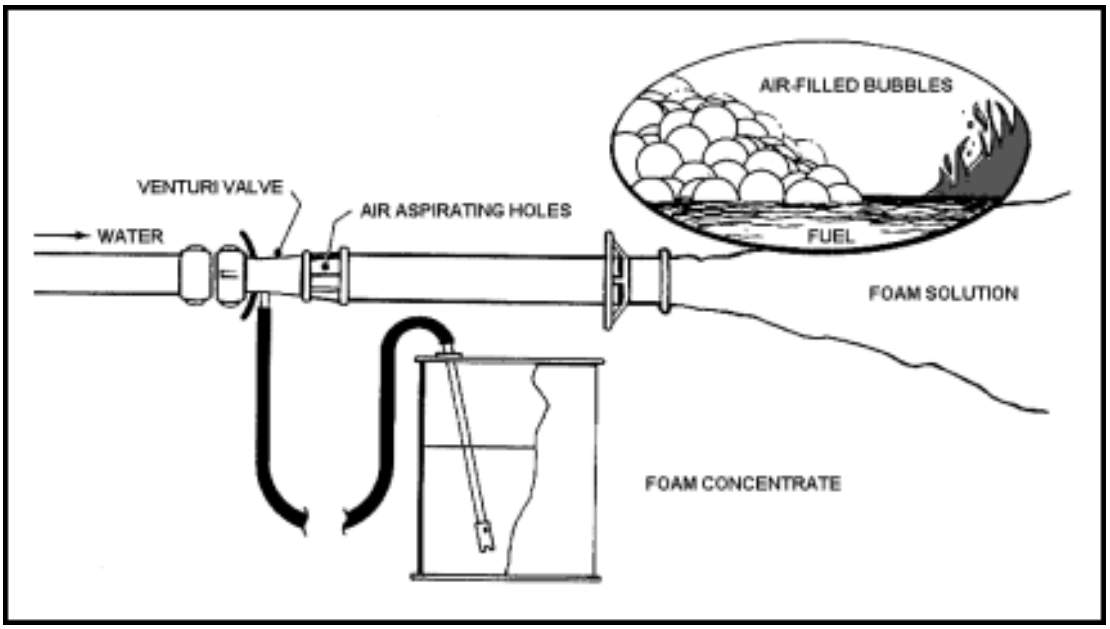


Figure 11-15. Production of Mechanical (Air) Foam

CARBON DIOXIDE

11-62. CO_2 extinguishing systems have, for a long time, been approved for ship installation as well as for industrial occupancies ashore. Aboard ship, carbon dioxide has been approved for cargo and tank compartments, spaces containing internal combustion or gas-turbine main propulsion machinery, and other spaces.

Extinguishing Properties of Carbon Dioxide

11-63. Carbon dioxide extinguishes fire mainly by smothering. It dilutes the air surrounding the fire until the oxygen content is too low to support combustion. For this reason, it is effective on Class B fires, where the main consideration is to keep the flammable vapors separated from oxygen in the air. CO_2 has a very limited cooling effect. It can be used on Class A fires in confined spaces, where the atmosphere may be diluted sufficiently to stop combustion. However, CO_2 extinguishing takes time. The concentration of carbon dioxide must be maintained until all the fire is out. Constraint and patience are needed.

11-64. Carbon dioxide is sometimes used to protect areas containing valuable articles. Unlike water and some other agents, carbon dioxide dissipates without leaving a residue. Since it does not conduct electricity, it can be used on live electrical equipment. However, fire fighters must maintain a reasonable distance when using a portable CO_2 extinguisher or a hose line from a semiportable system on high voltage gear.

Uses of Carbon Dioxide

11-65. Carbon dioxide is used primarily for Class B and Class C fires. It may also be used to knock down a Class A fire. It is particularly effective on fires involving:

- Flammable oils and greases.
- Electrical and electronic equipment, such as motors, generators, and navigational devices.
- Hazardous and semihazardous solid materials (such as some plastics, except those that contain their own oxygen [like nitrocellulose)].
- Machinery spaces, engine rooms, paint, and tool lockers.
- Cargo spaces which can be flooded with carbon dioxide.
- Galleys and other cooking areas, such as diet kitchens.
- Compartments containing high value cargo, delicate machinery, and other material that would be ruined or damaged by water or water-based extinguishing agents.
- Spaces where after-fire cleanup would be a problem.

Limitations on the Use of Carbon Dioxide

11-66. CO_2 portable extinguishers are used primarily for small electrical fires (Class C) and have limited effectiveness on Class B fires. Their use will be confined to Class B pool fires no greater than four square feet. Successful operation requires close approach due to the extinguisher's characteristics short range (4 to 6 feet).

- **Effectiveness.** CO_2 is not effective on substances that contain their own oxygen (oxidizing agents).
- **Outside use.** To be fully effective, the gas must be confined. For this reason, CO_2 is not as effective outside as it is in a confined space. This does not mean that it cannot be used outside.
- **Possibility of reignition.** Compared with water, carbon dioxide has a very limited cooling capacity. It may not cool the fuel below its ignition temperature and it is more likely than other extinguishing agents to allow reflash.
- **Hazards.** Although carbon dioxide is not poisonous to the human system, it is suffocating in the concentration necessary for extinguishment. A person exposed to this concentration would suffer dizziness and unconsciousness. Unless removed quickly to fresh air, the victim could die.

DRY CHEMICALS

11-67. Dry chemical extinguishing agents are chemicals in powder form. They should not be confused with dry powders, which are intended only for combustible metal fires.

Types of Chemical Extinguishing Agents

11-68. Five different types of dry chemical extinguishing agents are in use. Like other extinguishing agents, dry chemicals may be installed in a fixed system or in portable and semiportable extinguishers.

- **Sodium bicarbonate.** This is the original dry chemical extinguishing agent. It is generally referred to as regular dry chemical and is widely used because it is the most economical dry chemical agent. It is particularly effective on animal fats and vegetable oils because it chemically changes these substances into nonflammable soaps. Therefore, sodium bicarbonate is used extensively for galley range, hood, and duct fires. There is one possible problem with sodium bicarbonate: fire has been known to flash back over the surface of an oil fire when this agent is used.
- **Potassium bicarbonate (Purple-K).** Although usually used alone, this dry chemical was originally developed to be used with AFFF in a twinned system. It is most effective on liquid fuel fires in driving flames back and has a good reputation for eliminating flashback. It is more expensive than sodium bicarbonate.
- **Potassium chloride.** Potassium chloride was developed as a dry chemical that would be compatible with protein-type foams. Its extinguishing properties are about equal to those of potassium bicarbonate. One drawback is its tendency to cause corrosion after it has extinguished a fire.

- **Urea potassium bicarbonate.** This is a British development. It is not widely used because it is expensive.
- **Monoammonium phosphate (ABC, multipurpose).** Monoammonium phosphate is called a multipurpose dry chemical because it can be effective on Class A, Class B, and Class C fires. Ammonium salts interrupt the chain reaction of flaming combustion. The phosphate changes into metaphosphoric acid, a glassy fusible material, at fire temperatures. The acid covers solid surfaces with a fire retardant coating. Therefore, this agent can be used on fires involving ordinary combustible materials such as wood and paper, as well as on fires involving flammable oils, gases, and electrical equipment. However, it may only control, but not fully extinguish, a deep-seated fire.

Extinguishing Effects of Dry Chemicals

11-69. Dry chemical agents extinguish fire by cooling, smothering, shielding of radiant heat, and by breaking the combustion chain.

- **Cooling.** No dry chemical exhibits any great capacity for cooling. However, a small amount of cooling takes place simply because the dry chemical is at a lower temperature than the burning material.
- **Smothering.** When dry chemicals react with the heat and burning material, some carbon dioxide and water vapor are produced. These dilute the fuel vapors and the air surrounding the fire. The result is a limited smothering effect.
- **Shielding of radiant heat.** Dry chemicals produce an opaque cloud in the combustion area. This cloud reduces the amount of heat that is radiated back to the heart of the fire, that is, the opaque cloud absorbs some of the radiation feedback that is needed to sustain the fire.

Uses of Dry Chemicals

11-70. Monoammonium phosphate (ABC, multipurpose) dry chemical may, as its name implies, is used on Class A, Class B, and Class C fires and combinations of these. However, as noted above, ABC dry chemical may only control, but not extinguish, some deep-seated Class A fires and an auxiliary extinguishment method, such as a water hose line, is required. All dry chemical agents may be used to extinguish fires involving the following:

- Flammable oils and greases.
- Electrical equipment.
- Hoods, ducts, and cooking ranges in galleys and diet kitchens.
- The surfaces of baled textiles.
- Certain combustible solids such as pitch, naphthalene, and plastics (except those that contain their own oxygen).
- Machinery spaces, engine rooms, paint lockers, and tool lockers.

Dry chemical extinguishing agents are very effective on gas fires. However, gas flames

should not be extinguished until the supply of fuel has been shut down upstream of the fire.

Limitations on the Use of Dry Chemicals

11-71. The limitations on the use of dry chemicals are as follows:

- The discharge of large amounts of dry chemicals could affect people in the vicinity.
- Like other extinguishing agents that contain no water, dry chemicals are not effective on materials that contain their own oxygen.
- Dry chemicals may deposit an insulating coating on electronic or telephonic equipment, affecting the operation of the equipment.
- Dry chemicals are not effective on combustible metals such as magnesium, potassium, sodium, and their alloys, and in some cases may cause a violent reaction.
- Where moisture is present, a dry chemical agent may corrode or stain surfaces on which it settles.

WARNING
DRY CHEMICAL EXTINGUISHING AGENTS ARE CONSIDERED NONTOXIC, BUT THEY MAY HAVE IRRITATING EFFECTS WHEN BREATHED. FOR THIS REASON, A WARNING SIGNAL, SIMILAR TO THE ONE USED IN CARBON DIOXIDE SYSTEMS, SHOULD BE INSTALLED IN ANY SPACE THAT MIGHT BE TOTALLY FLOODED WITH DRY CHEMICALS. BREATHING APPARATUSES AND LIFELINES MUST ALSO BE AVAILABLE IN CASE CREWMEN MUST ENTER THE SPACE BEFORE IT IS ENTIRELY VENTILATED. TABLE 11-2 DESCRIBES THE SIGNALS THAT ARE USED BETWEEN THE OBA WEARER AND TENDER.

Table 11-2. Lifeline Signals Between OBA Wearer and Tender

	MEANING	
PULLS ON LINE	TENDER TO WEARER	WEARER TO TENDER
1	Are you all right?	I am all right.
2	Advance.	I am going ahead.
3	Back out.	Take up my slack.
4	Come out immediately.	Send help.

DRY POWDERS

11-72. Dry powders were developed to control and extinguish fires in combustible metals. These are Class D fires which involve the following metals:

- Magnesium.
- Potassium.
- Sodium and their alloys.
- Titanium.
- Zirconium.
- Powdered or fine aluminum.
- Some lesser known metals.

As mentioned earlier, dry chemicals and dry powders are not the same. Dry powders are the only extinguishing agents that can control and extinguish metal fires without causing violent reactions. Other extinguishing agents may accelerate or spread the fire, injure personnel, cause explosions, or create conditions more hazardous than the original fire. Dry powders act mainly by smothering, although some agents also provide cooling.

11-73. Two commercially available dry powders are composed mostly of graphite. The graphite cools the fire and creates a very heavy smoke that helps smother the fire. These agents are also effective on all the metals listed above. They are applied with a scoop or shovel.

11-74. Dry powder with a sodium chloride (salt) base is propelled from portable extinguishers by carbon dioxide and from large containers or fixed systems by nitrogen. The powder is directed over the burning metal. When it drops, it forms a crust on the metal and smothers the fire. Like the graphite types, it is effective on the combustible

metals mentioned above.

HALOGENATED EXTINGUISHING AGENTS (HALON)

11-75. Halogenated extinguishing agents are made up of carbon and one or more of the halogen elements: fluorine, chlorine, bromine, and iodine. Halon 1301 enters the fire area as a gas. Most authorities agree that the Halon acts as a chain breaker. However, it is not known whether it will slow the chain reaction, break it up, or cause some other reaction. Halon 1301 is stored and shipped as a liquid under pressure. When released in the protected area, it vaporizes to an odorless, colorless gas and is propelled to the fire by its storage pressure. Halon 1301 does not conduct electricity. The extinguishing properties of Halon 1301 allow its use on a number of different types of fire. These include:

- Fires in electrical equipment.
- Fires in engine rooms, machinery spaces, and other spaces involving flammable oils and greases.
- Class A fires in ordinary combustibles. However, if the fire is deep-seated, a longer soaking time may be needed or a standby hose line may be used to complete the extinguishment.
- Fires in areas where articles of high value may be stored and are damaged by the residue of other agents.
- Fires involving electronic computers and control rooms.

There are few limitations on the use of Halon agents. However, they are not suited for fighting fires in materials containing their own oxygen or combustible metals and hydrides.

WARNING

HALON 1301 MAY CAUSE DIZZINESS AND IMPAIRED COORDINATION IF INHALED. IF HALON 1301 IS TO BE USED FOR THE TOTAL FLOODING OF NORMALLY OCCUPIED SPACES, AN EVACUATION ALARM MUST BE PROVIDED. PERSONNEL SHOULD LEAVE THE AREA PROMPTLY ON HEARING THE ALARM. WHEN A HALON 1301 EXTINGUISHER IS USED, THOSE NOT DIRECTLY INVOLVED IN THE OPERATION SHOULD LEAVE THE AREA IMMEDIATELY. THE EXTINGUISHER OPERATOR SHOULD STEP AWAY AS SOON AS THE APPLIANCE IS DISCHARGED. THE AREA SHOULD BE VENTED WITH FRESH AIR BEFORE IT IS

REENTERED. IF IT IS NECESSARY TO REMAIN IN OR ENTER AN AREA WHERE HALON 1301 HAS BEEN DISCHARGED, A BREATHING APPARATUS AND LIFELINES SHOULD BE USED. THE ONLY VALID REASON FOR SUCH ENTRY WOULD BE TO SAVE A LIFE OR TO MAINTAIN CONTROL OF THE SHIP.

HEPTAFLUOROPROPANE (HFC227EA) OR FM-200

11-76. HFC227ea or FM-200 is a clear, odorless gas. It has been developed as a total compartment flooding system to replace Halon 1301. As good environmental stewards, the Army has decided on a program of removal of all Halon 1301 fixed firefighting systems aboard vessels. FM-200 will provide the same firefighting capabilities as Halon with a much less harmful effect on the environment. FM-200 is not an ozone-depleting chemical. It works in much the same manner as Halon. The same precautions for the use of Halon should be adhered to when using FM-200. FM-200 can potentiate the effects of adrenalin at concentrations greater than 9 percent. This chemical also produces hydrogen fluoride, a corrosive, when super heated.

PORTABLE FIRE EXTINGUISHERS

11-77. Portable extinguishers can be carried to the fire area for a fast attack. However, they contain a limited supply of extinguishing agent. The agent is quickly expelled from the extinguisher; in most cases, continuous application can be sustained for only a minute or less. For this reason, it is extremely important to back up the extinguisher with a hose line. If the extinguisher does not have the capacity to put the fire out completely, the hose line can be used to finish the job. A crewman who is using an extinguisher cannot advance a hose line at the same time, so the alarm must be sounded as soon as a fire is discovered to alert the ship's personnel to the situation.

11-78. There is a right way and many wrong ways to use a portable fire extinguisher. Crew members who have had little training with these appliances waste extinguishing agent through improper application. At the same time, untrained personnel tend to overestimate their extinguishing ability. Periodic training sessions, including practice with the types of extinguishers carried onboard, are the best insurance against inefficient use of this equipment. Extinguishers that are due to be discharged and inspected may be used in these training sessions.

CLASSES OF FIRE EXTINGUISHERS

11-79. Every portable extinguisher is classified in two ways, with one or more letters and with a numeral. The letter or letters indicate the classes of fires on which the extinguisher may be used. These letters correspond exactly to the four classes of fires. For example, Class A extinguishers may be used only on Class A fires--those involving common combustible materials. Class AB extinguishers may be used on fires involving wood or diesel oil or both.

11-80. The numeral indicates either the relative efficiency of the extinguisher or its size. This does not mean the size of fire on which to use the extinguisher; rather, the numeral indicates how well the extinguisher will fight a fire of its class.

11-81. The NFPA rates extinguisher efficiency with Arabic numerals. The UL tests extinguishers on controlled fires to determine their NFPA ratings. A rating such as 2A or 4A on an extinguisher would be an NFPA rating. (A 4A rating will extinguish twice as much Class A fire as a 2A rating; a 20B rating will extinguish four times as much Class B fire as a 5B rating.)

11-82. The Coast Guard uses Roman numerals to indicate the sizes of portable extinguishers. The numeral I indicates the smallest size and V the largest. A BIII Coast Guard rating indicates a medium-sized extinguisher suitable for fires involving flammable liquids and gases. The Coast Guard ratings of the different types of extinguishers are shown in Table 11-3.

Table 11-3. United States Coast Guard Extinguisher Classification Table

TYPE	SIZE	WATER (GALLONS)	FOAM (GALLONS)	DIOXIDE (POUNDS)	CHEMICAL (POUNDS)
A	II	2 1/2	2 1/2		
B	I		1 1/4	4	2
B	II		2 1/2	15	10
B	III		12	35	20
B	IV		20	50	30
B	V		40	100	50
C	I			4	2
C	II			15	10

TEST AND INSPECTION

11-83. Army fire regulations require masters or persons in charge to have portable and semiportable fire extinguishers and fixed fire-extinguishing systems tested and inspected "at least once in every 12 months." When tests are completed, a tag will be placed on each extinguisher, showing the date and the person who completed the tests.

GENERAL SAFETY RULES FOR PORTABLE EXTINGUISHERS

11-84. There are some general safety rules you should follow when using portable extinguishers. These are as follows:

- When you discover a fire, call out your discovery, sound the fire alarm, and summon help.
- Never pass the fire to get to an extinguisher. You can get trapped in a dead-end passageway.
- If you must enter a room or compartment to combat the fire, keep an escape path open. Never let the fire get between you and the door.
- If you enter a room or compartment and your attack with a portable extinguisher fails, get out immediately. Close the door to confine the fire and prepare to fight the fire while waiting for previously summoned help. Your knowledge of the situation will aid those responding.

WATER EXTINGUISHERS

11-85. Extinguishers that use water or a water solution, as the extinguishing agents, are suitable only for Class A fires. There are five types of water extinguishers, but only two are currently produced. In 1969, the manufacture of the inverting types of extinguishers (the soda-acid, foam, and cartridge-operated) was discontinued. However, since a large number of inverting extinguishers are still in use, they will be discussed along with the stored-pressure water extinguisher.

Soda-Acid Extinguisher

11-86. The soda-acid extinguisher (Figure 11-16) comes only in a 2 1/2-gallon size that carries an NFPA rating of 2A. It weighs about 30 pounds when charged, has a reach of 30 to 40 feet, and expends itself in about 55 seconds. The shell of the extinguisher is filled with a solution of 1 1/2 pounds of sodium bicarbonate in 2 1/2 gallons of water. The screw-on cap contains a cage that holds an 8-ounce bottle, half filled with sulphuric acid, in an upright position. A loose stopper in the top of the acid bottle prevents acid from splashing out before the extinguisher is to be used.

11-87. The extinguisher is carried to the fire by means of the top handle. At the fire, the extinguisher is inverted, the acid mixes with the sodium bicarbonate solution forming carbon dioxide gas, and the pressure of the CO_2 propels the water out through the nozzle. The stream must be directed at the seat of the fire and moved back and forth to hit as much of the fire as possible. The nozzle should be aimed at the fire until the entire

content of the extinguisher is discharged. Remember that water is available for less than a minute!

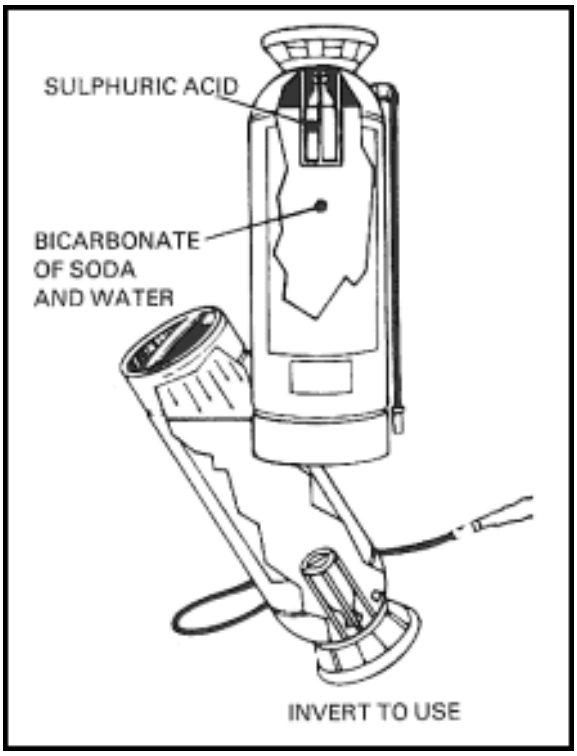


Figure 11-16. Water (Soda-Acid) Extinguisher

11-88. The extinguishing agent, sodium bicarbonate solution mixed with acid, is more corrosive than plain water. The operator should avoid getting the agent on his skin or in his eyes, as the acid could cause burning. Soda-acid extinguishers must also be carefully maintained. When the extinguisher is inverted, a pressure of 130 psi or more is generated. If the container is corroded or otherwise damaged, this pressure could be sufficient to burst the container.

Cartridge-Operated Water Extinguisher

11-89. The cartridge-operated water extinguisher (Figure 11-17) is similar in size and operation to the soda-acid extinguisher. The most common size is 2 1/2 gallons, with an NFPA rating of 2A. It has a range of 30 to 40 feet. The container is filled with water or an antifreeze solution. The screw-on cap contains a small cylinder of CO_2; when the cylinder is punctured, the gas provides the pressure to propel the extinguishing agent.

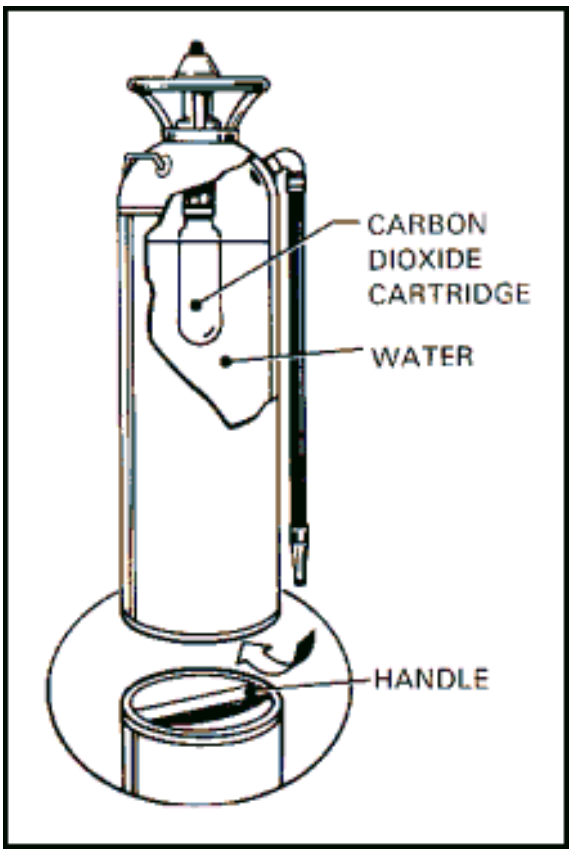


Figure 11-17. Cartridge-Operated Water Extinguisher

11-90. When using the extinguisher, it is first carried to the fire, then inverted and bumped against the deck (Figure 11-18, step 1). This ruptures the CO_2 cylinder and expels the water. The stream should be directed at the seat of the fire (Figure 11-18, step 2). The nozzle should be moved back and forth to quench as much of the burning material as possible in the short time available (Figure 11-18, step 3). The discharge time is less than 1 minute. The entire contents of the extinguisher must be discharged, since the flow cannot be shut off.

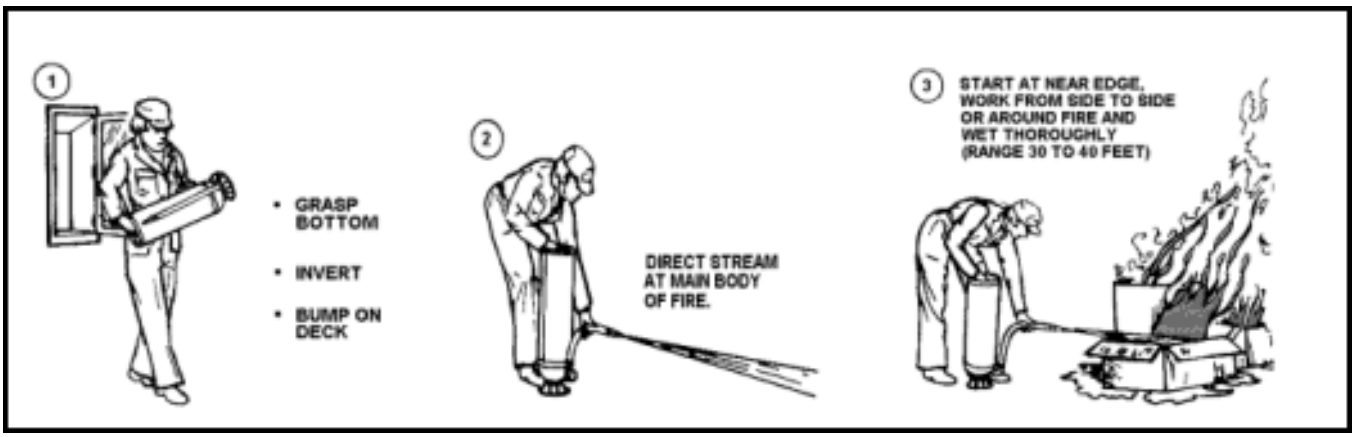


Figure 11-18. Using the Cartridge-Operated Extinguisher

11-91. As with the soda-acid extinguisher, the container is not subject to pressure until it is put to use. Any weakness in the container may not become apparent until the container fails.

Pin-Type Cartridge-Operated Extinguisher

11-92. A newer version of the cartridge-operated water extinguisher need not be inverted for use. Instead, you can pull the pin out of the cartridge with the extinguisher in an upright position. A lever is squeezed to discharge the extinguishing agent (water or antifreeze solution).

11-93. The cartridge is fitted with a pressure gauge. The gauge should be checked periodically to ensure that the cartridge pressure is within its operating range. Otherwise, maintenance is similar to that for the inverting-type cartridge extinguisher.

Stored-Pressure Water Extinguisher

11-94. The stored-pressure water extinguisher (Figure 11-19) is the most commonly used portable fire-fighting appliance. The 2 1/2-gallon size has an NFPA rating of 2A. It weighs about 30 pounds and has a horizontal range of 35 to 40 feet. In continuous operation, it will expend its water in about 55 seconds. However, it may be used intermittently to extend its operational time.

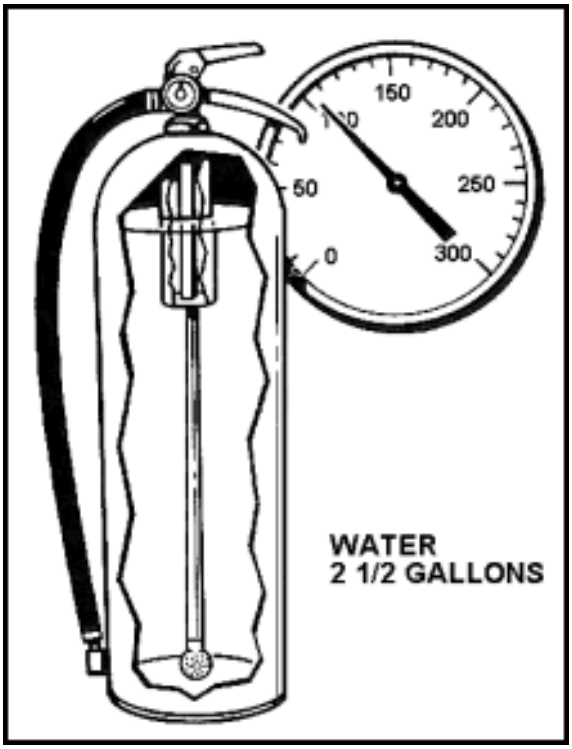


Figure 11-19. Stored-Pressure Water Extinguisher

11-95. The container is filled with water, or an antifreeze solution, to within about 6 inches of the top (most extinguishers have a fill mark stamped on the container). The screw-on cap holds a lever-operated discharge valve, a pressure gauge, and an automobile tire-type valve. The extinguisher is pressurized through the air valve, with either air or an inert gas, such as nitrogen. The normal charging pressure is about 100 psi. The gauge allows the pressure within the extinguisher to be checked at any time. Most gauges are color-coded to indicate normal and abnormal pressures.

11-96. The extinguisher is carried to the fire, and the ring pin or other safety device is removed. The operator aims the nozzle with one hand and squeezes the discharge lever with the other hand. The stream should be directed at the seat of the fire. It should be moved back and forth to make sure the burning material is completely covered. Short bursts can be used to conserve the limited supply of water.

11-97. As the flames are knocked down, the operator may move closer to the fire. By placing the tip of one finger over the nozzle, the operator can get a spray pattern that will cover a wider area.

FOAM EXTINGUISHERS

11-98. Foam extinguishers are similar in appearance to those discussed previously, but have a greater extinguishing capability. The most common size is 2 1/2 gallons, with an NFPA rating of 2A:4B. This indicates that the extinguisher may be used on both Class A and Class B fires. It has a range of about 30 to 40 feet and a discharge duration of slightly less than a minute.

11-99. The extinguisher is charged by filling it with two solutions that are kept separated (in the extinguisher) until ready to use. These solutions are commonly called the A and B solutions. Their designations have nothing to do with fire classifications.

11-100. The foam extinguisher is carried to the fire right side up and then inverted. This mixes the two solutions, producing a liquid foam and CO_2 gas. The CO_2 acts as the propellant and fills the foam bubbles. The liquid foam expands to about eight times its original volume. This means the 2 1/2-gallon extinguisher will produce 18 to 20 gallons of foam.

11-101. The foam should be applied gently on burning liquids. Do this by directing the stream in front of the fire and causing the foam to bounce back onto the fire. The stream may also be directed against the back wall of a tank or a structural member to allow the foam to run down and flow over the fire. Chemical foam is stiff and flows slowly. For this reason, the stream must be directed to the fire from several angles for complete coverage of the burning materials (see also Figure 11-20). For fires involving ordinary combustible materials, the foam may be applied in the same way, as a blanket, or the force of the stream may be used to get the foam into the seat of the fire.

11-102. Foam extinguishers are subject to freezing and cannot be stored in temperatures

below 4.4° C (40° F). Once activated, these extinguishers will expel their entire foam content; it should all be directed onto the fire. As with other pressurized extinguishers, the containers are subject to rupture when their contents are mixed. Maintenance consists mainly of annual discharging, inspection, cleaning, and recharging.

Figure 11-20. Operating a Foam Extinguisher on a Flammable Liquid Fire

CARBON DIOXIDE (CO_2) EXTINGUISHER

11-103. These are used primarily on Class B and Class C fires. The most common sizes of portable extinguishers contain from 5 to 20 pounds of CO_2, not including the weight of the relatively heavy shell. The CO_2 is mostly in the liquid state, at a pressure of 850 psi at 21° C (70° F). The 5-pound size is rated 5B:C and the 15-pound size has a rating of 10B:C. Depending on the size of the extinguisher, the range varies between 3 to 8 feet and the duration between 8 to 30 seconds.

11-104. Carry the extinguisher to the fire in an upright position. The short range of the CO_2 extinguisher means the operator must get fairly close to the fire. Place the extinguisher on the deck and remove the locking pin. The discharge is controlled either by opening a valve or by squeezing two handles together. The operator must grasp the hose handle and not the discharge horn (see Figure 11-21). The CO_2 expands and cools very quickly as it leaves the extinguisher. The horn gets cold enough to frost over and cause severe frostbite. When a CO_2 extinguisher is used in a confined space, the operator should guard against suffocation by wearing a breathing apparatus.

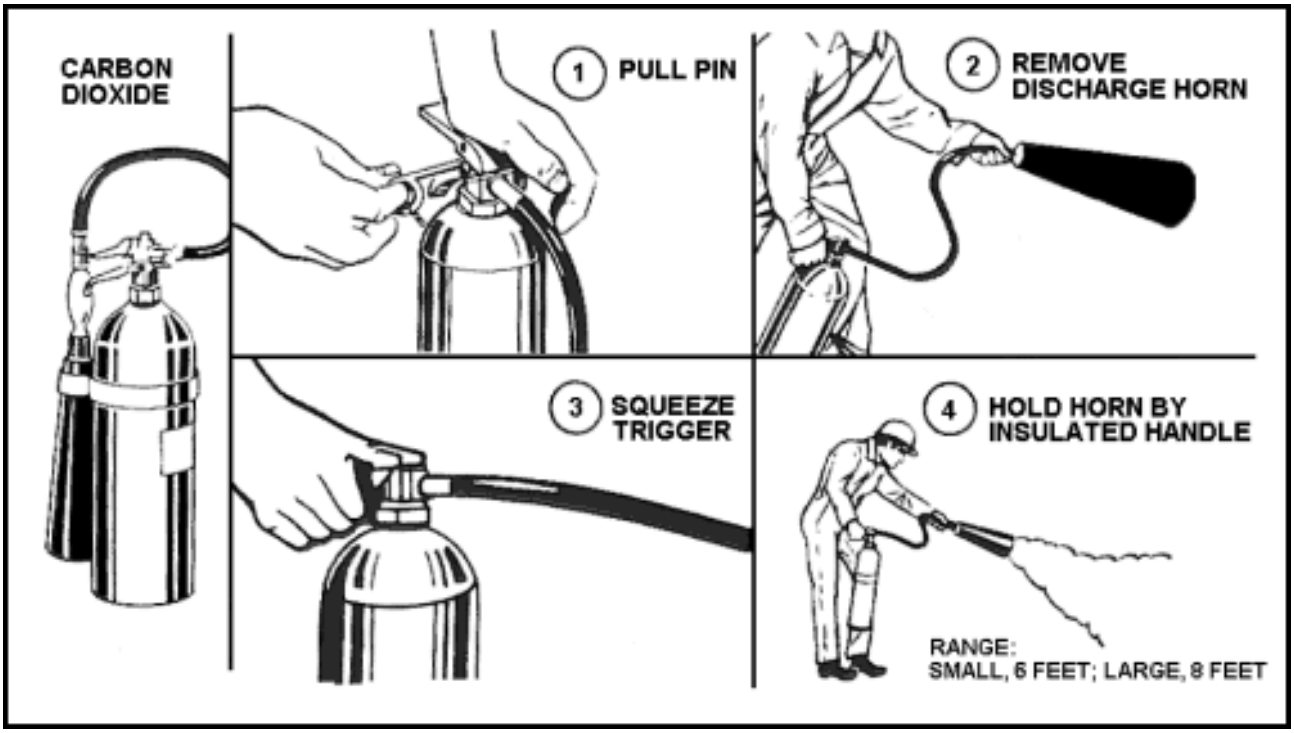


Figure 11-21. Procedure for Using the CO_2 Extinguisher

Class B Fires

11-105. The horn should be aimed first at the base of the fire nearest the operator. The discharge should be moved slowly back and forth across the fire. At the same time, the operator should move forward slowly. The result should be a "sweeping" of the flames off the burning surface, with some carbon dioxide "snow" left on the surface.

11-106. Whenever possible, a fire on a weather deck should be attacked from the windward side. This will allow the wind to blow the heat away from the operator and to carry the CO_2 to the fire. CO_2 extinguishers generally do not perform well in windy conditions. The blanket of CO_2 gas does not remain on the fire long enough to permit the fuel to cool down.

Class C Fires

11-107. The discharge should be aimed at the source of a fire that involves electrical equipment. The equipment should be de-energized as soon as possible to eliminate the chance of shock and the source of ignition.

Maintenance of CO_2 Extinguishers

11-108. Several times each year, CO_2 extinguishers should be examined for damage and to make sure that they are not empty. At annual inspection, these extinguishers should be weighed. The manufacturer should recharge any extinguisher that has lost more than 10 percent of its CO_2 weight. Recharge a CO_2 extinguisher after each use, even if it was only partly discharged.

DRY POWDER EXTINGUISHER

11-109. Dry powder (not dry chemical) is the only extinguishing agent that may be used on combustible metal (Class D) fires. The only dry power extinguisher (Figure 11-22) for Class D fires is a 30-pound cartridge-operated model that looks much like the cartridge-operated dry chemical extinguisher. One difference is that the Class D extinguisher has a range of only 6 to 8 feet. The extinguishing agent is sodium chloride, which forms a crust on the burning metal.

11-110. To operate, remove the nozzle from its retainer and press the puncture lever. This allows the propellant gas (CO_2 or nitrogen) to activate the extinguisher. The operator then aims the nozzle and squeezes the grips to apply the powder to the surface of the burning metal.

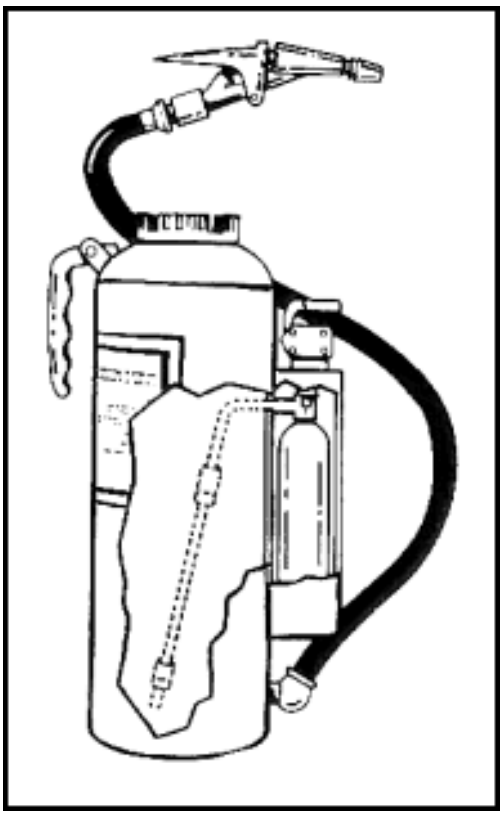


Figure 11-22. Dry Power Extinguisher

11-111. The operator should begin the application of dry powder about 6 to 8 feet from the fire. The squeeze grips may be adjusted for the desired rate of flow to build a thick layer of powder over the entire involved area. The operator must be careful not to break the crust that forms when the powder hits the fire (see also Figure 11-23).

Figure 11-23. Procedure for Operating the Dry Powder Extinguisher

11-112. A large amount of dry powder is sometimes needed to extinguish a very small amount of burning metal. A brown discoloration indicates a hot spot, where the layer of dry powder is too thin. An additional agent should be applied to the discolored areas. When the fire involves small metal chips, the agent should be applied as gently as possible so the force of the discharge does not scatter burning chips.

11-113. Class D dry powder also comes in a container, for application with a scoop or shovel. This agent should also be applied very gently. A thick layer of powder should be built up, and the operator should be careful not to break the crust that forms.

HALON EXTINGUISHERS

11-114. Halon 1301 (with an NFPA rating of 5 B:C) is available only in a 2 1/2-pound portable extinguisher. Its horizontal range is from 4 to 6 feet and its discharge time is 8 to 10 seconds. The extinguishing agent is pressurized in a lightweight steel or aluminum alloy shell. The cap contains the discharge control valve and discharge nozzle.

11-115. Carry the extinguisher to the fire and then remove the locking pin. Control the discharge by squeezing the control valve-carrying handle. Direct the Halon at the seat of a Class B fire and apply with a slow, side-to-side sweeping motion. It should be directed at the source of an electrical fire (see Figure 11-24).

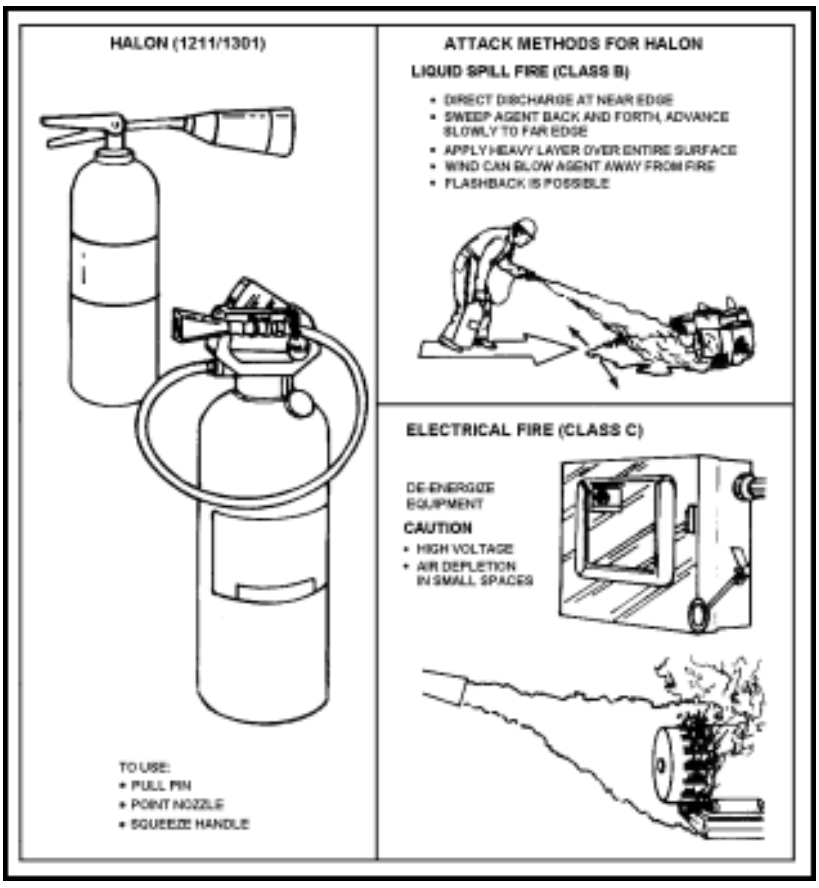


Figure 11-24. Operation of Halon Extinguishers

PURPLE-K EXTINGUISHER

11-116. PKP extinguishers are dry chemical extinguishers, provided primarily for use on Class B fires. PKP is nontoxic and is four times as effective as CO_2 for extinguishing fuel fires. PKP is effective on Class C fires, but do not use if CO_2 is available. Also, do not use on internal fires in gas turbines or jet engines because it leaves a residue that cannot be completely removed without disassembly of the engine.

11-117. The PKP extinguisher weighs about 18 pounds and uses CO_2 as the expellant gas. The extinguisher shell is not pressurized until it is to be used. Maximum range of the extinguisher is 20 feet from the nozzle and expellant will last for 18 to 20 seconds. Operating procedures (see also Figure 11-25) are as follows:

- Pull the locking pin from the seal cutter assembly.
- Sharply strike the puncture lever to cut the gas cartridge seal. The extinguisher is now charged and ready for use.
- Discharge the chemical in short bursts by squeezing the grip of the nozzle. Aim the discharge at the base of the flames and sweep it rapidly from side to side. If the fire's heat is intense, a short burst of powder into the air will provide a heat shield.
- When finished, invert the cylinder, squeeze the discharge lever, and tap the nozzle on the deck. This will release all the pressure and clear the hose and nozzle of powder. If not cleared, the PKP could cake and cause difficulty the next time the extinguisher is used.

11-118. PKP is an excellent fire-fighting agent, but its effects are temporary. It has no cooling effect and provides no protection against reflash of the fire. Therefore, it should always be backed up by foam. Use PKP sparingly in confined spaces, consistent with extinguishing the fire. An unnecessarily long discharge reduces visibility, makes breathing difficult, and causes coughing.

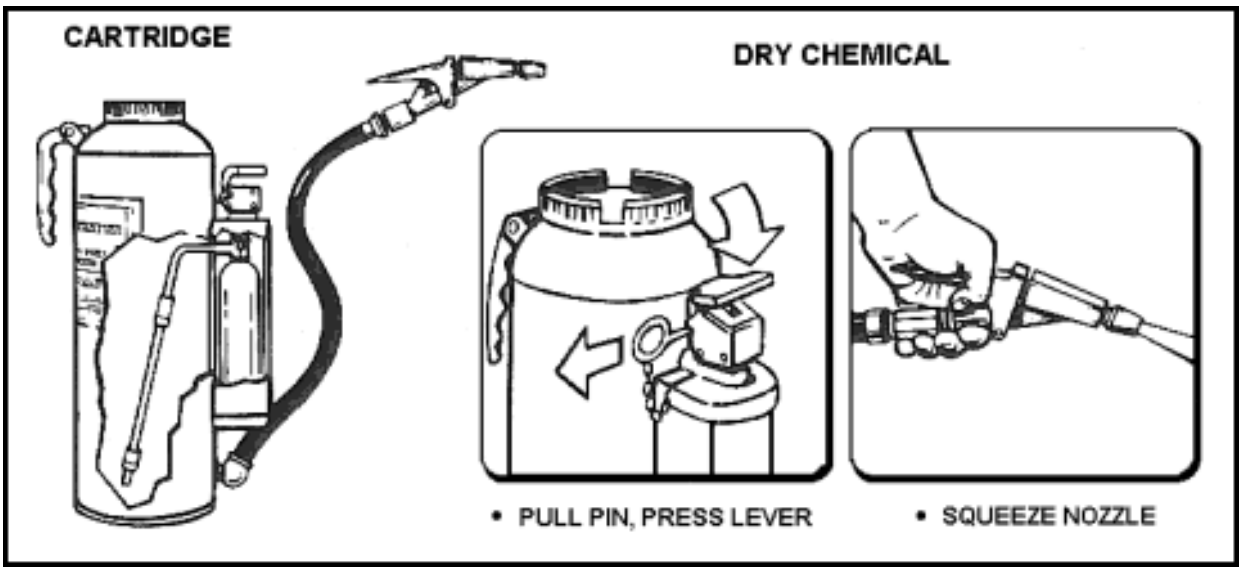


Figure 11-25. Operation of the PKP Extinguisher

PORTABLE FOAM SYSTEMS

11-119. A foam system using an in-line proportioner or a mechanical foam nozzle (with pickup tube) can be carried to various parts of the ship. The foam system is used with the ship's fire-main system. It is an efficient method for producing foam, but it requires more manpower than semiportable systems employing other extinguishing agents.

Mechanical Foam Nozzle With Pickup Tube

11-120. When using, attach the mechanical foam nozzle with pickup tube to a standard hose line from the fire-main system. It draws air in through an aspirating cage in its hose line end. At the same time it introduces mechanical foam concentrate into the water stream through a pickup tube. When the air and foam solution mix, foam is discharged from the nozzle.

11-121. One type of nozzle consists of a 21-inch length of flexible metal hose or asbestos-composition hose, 2 inches in diameter, with a solid metal outlet. A suction chamber and an air port in the hose line end form the aspirating cage. The pickup tube is a short piece of 5/8-inch metal pipe with a short piece of rubber hose on one end. It is used to draw up the contents of a 5-gallon container of foam concentrate. The pickup tube operates on suction created in the suction chamber of the nozzle.

Operation

11-122. The mechanical foam nozzle is screwed onto the fire hose and the pickup tube is screwed into the side port in the base of the nozzle. The metal pipe at the end of the pickup tube is inserted into the foam-concentrate container. When water pressure is applied to the hose, foam concentrate is drawn up to the nozzle where it mixes with the air and water. The resulting foam is applied in the usual manner. The mobility of the foam nozzle is improved if one fire fighter operates the nozzle while another follows with the concentrate container (see also Figure 11-26).

PORTABLE PUMPS

11-123. Portable pumps are a valuable adjunct to the installed pumps of a vessel. They may be used for fighting fires and for removing water from the ship (dewatering).

11-124. The P-250 pump (Figure 11-27) is a self-priming, 250 GPM, portable pump with a 2-cylinder, 2 cycle, 25-horsepower engine. Lubricate the pump by mixing 1/2 pint of 3064 (SAE 30) TEP oil to a gallon of 80- to 100-octane gasoline. Engine cooling is accomplished by pump discharge water passing through the engine.

11-125. This pump is designed for fire fighting and dewatering. The pump is equipped with a 3-inch male intake to which is fitted a 3-inch hard rubber suction hose (10 or 20 feet long) with a foot valve strainer. The discharge outlet is fitted with a 2 1/2-inch male thread to which a 2 1/2-inch hose or a trigate valve is attached. The trigate valve is equipped with a 1 1/2- to 2 1/2-inch thread reducer, making it possible to attach three 1 1/2-inch hoses or one 2 1/2-inch hose. With the reducer removed, a single 2 1/2-inch hose can be used for fire fighting or as the pressure hose for an eductor. The exhaust hose is a 2-inch hard rubber hose.

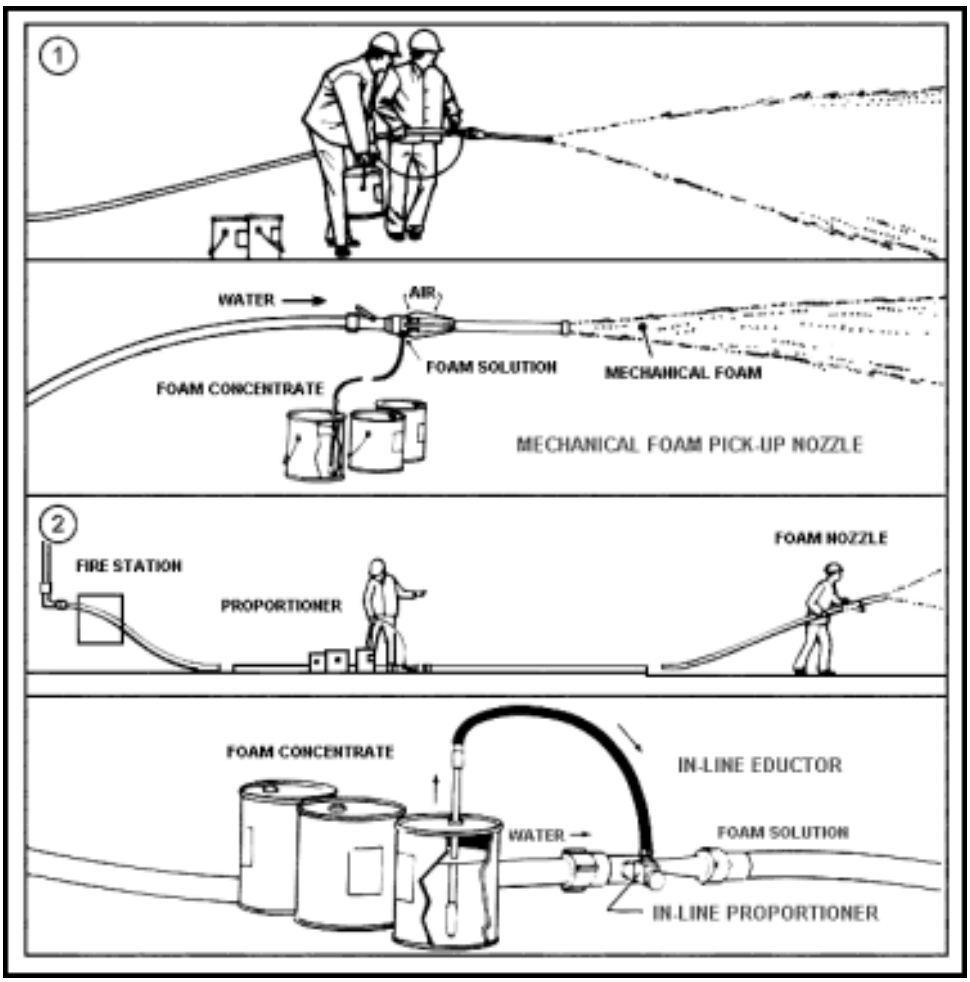


Figure 11-26. Using the Mechanical Foam Pick-Up Nozzle

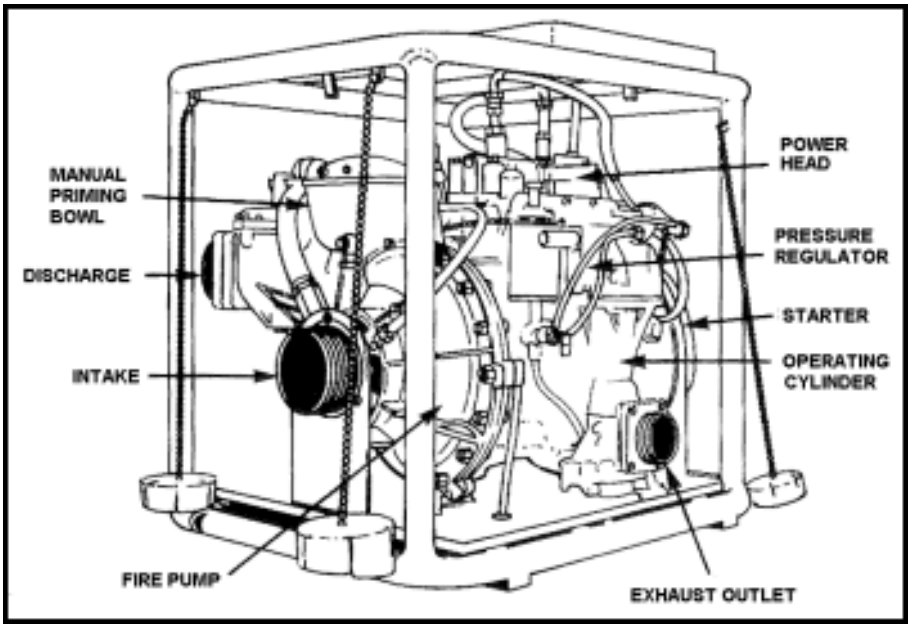


Figure 11-27. P-250 Pump

11-126. With the foot valve on the suction hose, the P-250 is self-primed by a special primer pump connected to the intake side of the fire pump. However, when the eductor is used or when the lift is greater than 16 to 20 feet, the fire pump must be primed by hand.

11-127. Depending on the amount of water used, delivery pressure may be adjusted within a range of 80 psi to 120 psi. Volume, of course, depends on the number and size of the nozzles.

11-128. Before securing, the portable pump should be flushed out with clean, fresh water. This is to remove salt and any other residue buildup, which may cause the pump to seize.

11-129. The following are the starting procedures for the P-250 pump:

- Remove the thread protector caps. There are three of them (discharge outlet, intake outlet, and exhaust outlet).
- Attach the suction hose to the intake outlet.
- Attach the "foot" to the other end of the suction hose.
- Put the "foot" end of the suction hose into the water.
- Attach the exhaust hose.
- Attach the discharge hose.
- If the suction lift is over 20 feet, unscrew and remove the cap to the manual priming bowl.

Note: If the suction lift is less than 20 feet, skip the next two steps and then continue.

- Fill the priming bowl with water.
- When the pump and priming bowl are full of water, replace the inlet cap on the priming bowl.
- Turn the OFF-START-RUN switch to the START position.
- Turn the speed control switch slightly in a clockwise direction.

Note: If the engine is cold, slightly turn the choke control in a clockwise direction.

- Push down on the START button when the engine is warm.

Note: If the starter engages, hold the START button down until the engine starts. If the starter does not engage, start the engine manually by pulling on the starter rope.

- Place the valve on the water discharge outlet to the OPEN position. If the pump has been manually primed, skip the next three steps and continue.
- If the pump has not been manually primed, make sure that the valve on the water discharge is in the CLOSED position.
- Push down, and hold down the primer push button until the water is discharged from the primer pump.
- Turn the valve on the water discharge to the OPEN position.
- When the pressure gauge reads 10 psi, release the primer button if you are

holding it down.

- Turn the OFF-START-RUN switch to the RUN position.
- Turn off the choke if it was used.

SEMIPORTABLE FIRE EXTINGUISHERS

11-130. A semiportable extinguisher is one way a hose can be run out to the fire. The other parts of the system are fixed in place, usually because they are too heavy to move.

11-131. The semiportable Halon Hose-Reel System (Figure 11-28) is very similar to the carbon dioxide system. This is used to combat Class B and Class C fires. Most semiportable systems use Halon 1301. The system consists of one or two pressurized cylinders containing the extinguishing agent, a hose line, and a nozzle with an ON-OFF control valve. The system is activated by operating a release mechanism at the top of the cylinder, similar to the CO_2 release device. If two cylinders are used, they are both opened when the pilot cylinder is activated. When the agent is released, it travels through the hose up to the nozzle. The hose is then run out to the fire, and the agent is applied as required.

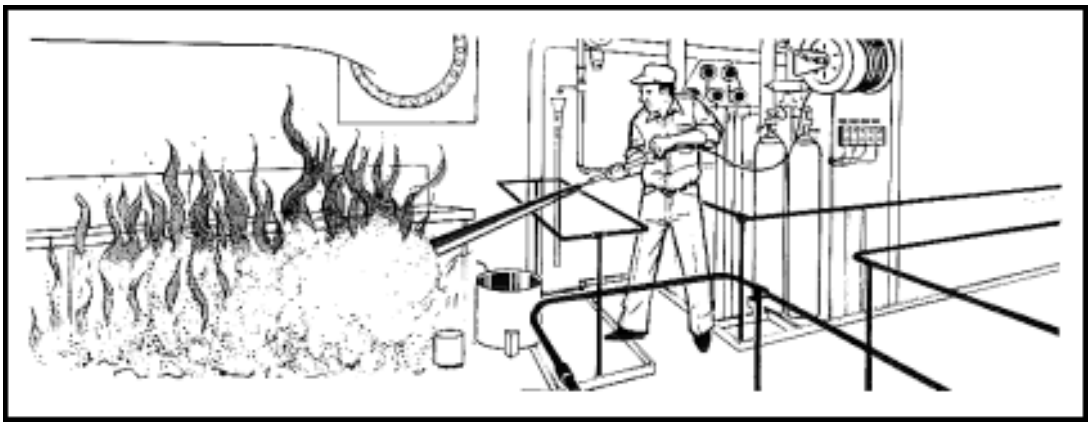


Figure 11-28. Operation of the Halon Hose-Reel System

FIXED FIRE STATIONS

11-132. The purpose of the fire-main system is to deliver water to the fire stations that are located throughout the ship. A fire station consists basically of a fire hydrant (water outlet) with valve and associated hose and nozzles. All required fire-fighting equipment must be kept in its proper place. Fire stations and hoses must be highly visible and easily put into service.

11-133. Crew members should try to protect all parts of the fire-main system and avoid unauthorized use of the system. Weekly visual inspection of fire stations should be a standard procedure to make sure that all required equipment is in its proper place. Hydrants located on weather decks may become corroded or encrusted with salt, causing their valves to freeze in position and become inoperable.

11-134. Different hydrants should be opened during succeeding weekly fire drills to make sure that water flows from each hydrant at least once every 2 months. This will reduce crusting and rust. When possible, flush out the fire-main system with fresh water to destroy any marine growth in the lines.

FIRE STATION LOCATIONS

11-135. Fire stations are located to ensure that the water streams from at least two hydrants will overlap. Fire hydrants shall be sufficient in number and so located that any part of the vessel, other than main machinery spaces, is accessible to persons onboard while the vessel is being navigated, and all cargo holds may be reached with at least two streams of water from separate outlets. At least one of these streams shall be from a single length of hose.

11-136. In main machinery spaces, all portions of such spaces will be capable of being reached by at least two streams of water, each of which shall be from a single length of hose and from separate outlets.

11-137. Fire stations are numbered. The term "Fire Station" and its number will be stenciled on the bulkhead in numerals at least 2 inches high.

HYDRANTS

11-138. The fire station hydrant has three major components: a control valve, the hose connection (1 1/2- or 2 1/2-inch) with appropriate threads, and a hose rack (Figure 11-29). Regulations require the following:

- Each fire hydrant outlet must have a valve that allows the hose to be removed while there is pressure in the fire-main system.
- The fire hydrant outlet may be in any position, from horizontal to pointing vertically downward. It should be positioned to lessen the kinking of the fire hose.
- The threads on the fire hydrant outlet must be National Standard fire hose coupling threads. These standard threads allow all approved hoses to be attached to the hydrant.
- A rack must be provided for the proper stowage of the fire hose. The hose must

be stowed in the open or where it is readily visible.

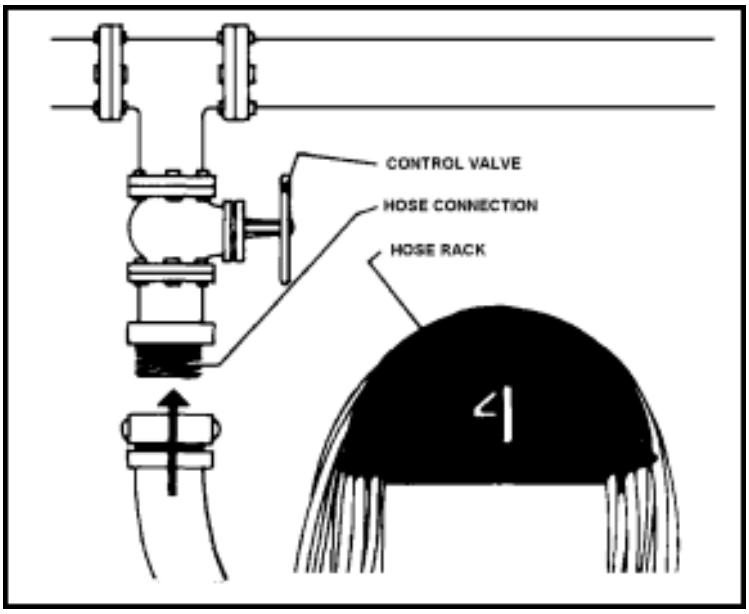


Figure 11-29. Three Components Of a Fire Station Hydrant

FIRE HOSES, NOZZLES, AND APPLIANCES

11-139. The efficiency of a fire station depends largely on the equipment stowed at the station and its condition. A single station should have the following equipment (see also Figure 11-30).

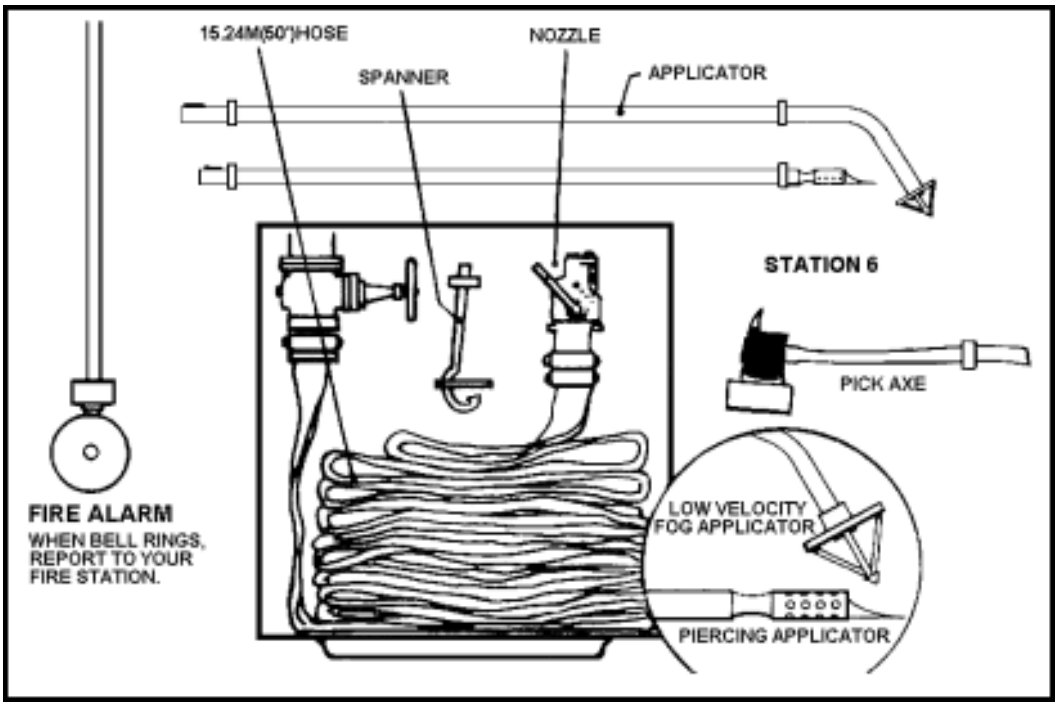


Figure 11-30. Shipboard Fire Station Equipment

Hoses

11-140. A single length of hose of the required size, type, and length is used. Use 2 1/2-inch diameter hose at weather deck locations and 1 1/2-inch diameter hose in enclosed areas. DO NOT use unlined hoses in machinery spaces. The hose couplings must be of brass, bronze, or a similar metal and be threaded with National Standard fire hose coupling threads. The hose must be 50 feet in length.

11-141. The fire hose with the nozzle attached must be connected to the hydrant at all times. However, when a hose is exposed to heavy weather on an open deck, it may be temporarily removed from the hydrant and stowed in a nearby accessible location. Temporarily move the fire hose if there is a possibility that it might be damaged during the handling of cargo. When the fire hose is removed, cover the exposed threads of the hydrant with a thin coating of grease and a protective screw cap. If a screw cap is not available, a heavy canvas, lashed over the threads, gives some protection.

Note: The fire hose may not be used for any purpose other than fire fighting, testing, and fire drills.

Racking and Stowing Hoses

11-142. Most shipboard racks for stowing hoses at fire stations require that the hose be faked. The procedure should include the following steps:

- Check the hose to make sure it is completely drained. A wet hose should not be racked.
- Check the female coupling for its gasket.
- Hook the female coupling to the male outlet of the hydrant. (The hose should always be connected to the hydrant.)
- Fake the hose so that the nozzle end can be run out to the fire.
- Attach the nozzle to the male end of the hose, making sure a gasket is in place.
- Place the nozzle in its holder or lay it on the hose so that it will not come adrift.

11-143. There are several different types of hose racks. One type consists of a half round plate, over which the hose is faked. A horizontal bar swings into position, holding the hose snug. Reels are used in engine rooms. They are also used for rubber hoses, such as those that are found on a semiportable CO_2 extinguisher.

Rolling Hose

11-144. After using the spare hose, it should be rolled and replaced in stowage. The hose must first be drained and dried. It should then be placed flat on the deck with the female coupling against the deck. The hose is next folded back on itself, so the male coupling is brought up to about 4 feet from the female coupling. The exposed thread of the male coupling should be layered between the hose when the roll is completed. Tie the roll with small stuff to keep it from losing its shape.

Nozzles and Applicators

11-145. Combination nozzles are quite rugged, but are still subject to damage. For example, the control handle can become stuck in the closed position, due to the corrosive action of seawater. Combination nozzles and applicators are often clogged by small pieces of dirt that enter and collect around openings. Periodic testing and maintenance will help detect and correct deficiencies.

11-146. The combination nozzle has a spring latch that allows the high-velocity tip to be released. The latch often freezes into position from misuse. During inspections and drills, the tip should be released and the applicator inserted into position for proper operation. The high-velocity tip should be attached to the nozzle by a substantial chain, so that it cannot be completely separated from the nozzle (see Figure 11-31).

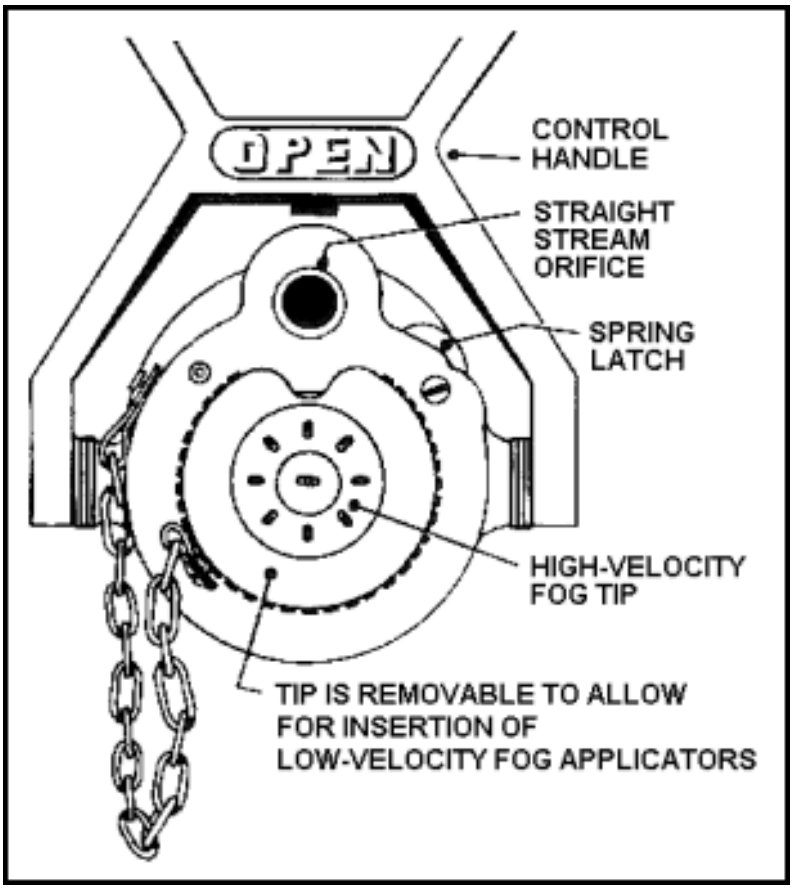


Figure 11-31. Outlet End of Combination Nozzle

11-147. Applicators are strong, but not strong enough to be used as crowbars, levers, or supports for lashing. If misused, the applicator can be crimped or bent along its length. The bayonet end can be damaged so that it cannot fit in the nozzle receptacle. Stow applicators in the proper clips at the fire station. Use applicators for fire fighting and training only. When stowed, applicator heads should be enclosed in sock-type covers to keep foreign matter out.

Appliances

11-148. A spanner wrench (Figure 11-32) is a special tool designed specifically for tightening or breaking apart fire-hose connections. The spanner should match the hose size and butt configuration. Hose-butt lug designs change over the years, making some spanner wrenches obsolete. When new hose is ordered, the available spanner wrenches must be compatible with the new hose couplings, or new spanner wrenches must also be ordered.

Note: Most hose connections can be made hand-tight and do not require excessive force.

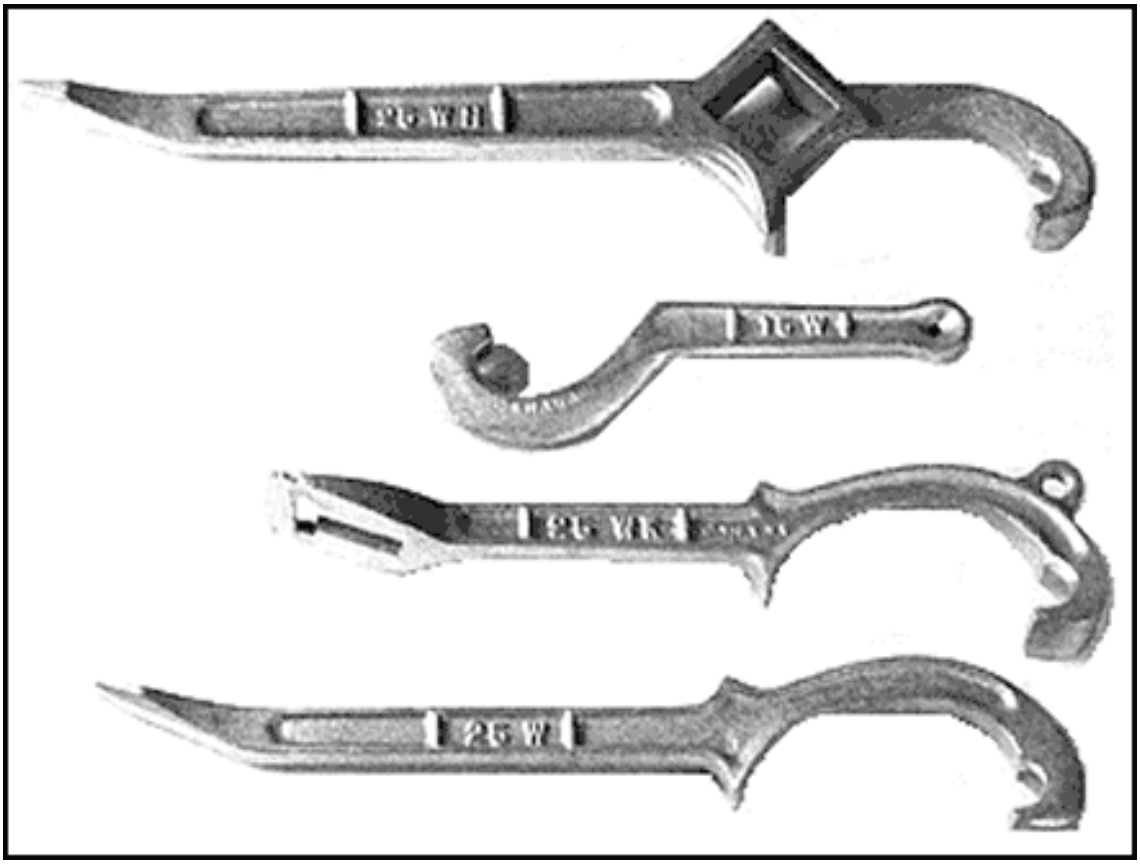


Figure 11-32. Spanner Wrenches

11-149. The pike head fire axe (Figure 11-33) is a multipurpose, portable, fire-fighting tool. The pike (pointed) end of the axe may easily be driven through light metal, including metal clad fire doors and some Class C bulkheads. It can be used to make openings quickly and to check for smoke or fire extension. It is also useful for tearing apart mattresses and upholstered furniture and for shattering heavy glass (including tempered glass) when necessary. The broad end of the axe can be used to pry open hinged doors, to remove paneling and sheathing to expose recesses and voids (avenues of fire travel), or to chock doors open.

11-150. Crew members must be cautious when using axes to force a door or break glass. They should wear gloves and other protective clothing, if available. A door should be forced only when necessary. The door should first be checked to see if it is unlocked. If locked, there may be time to obtain a key (especially if the fire is a minor one and lives are not in danger). Otherwise, if a door must be forced, it must be done without hesitation.

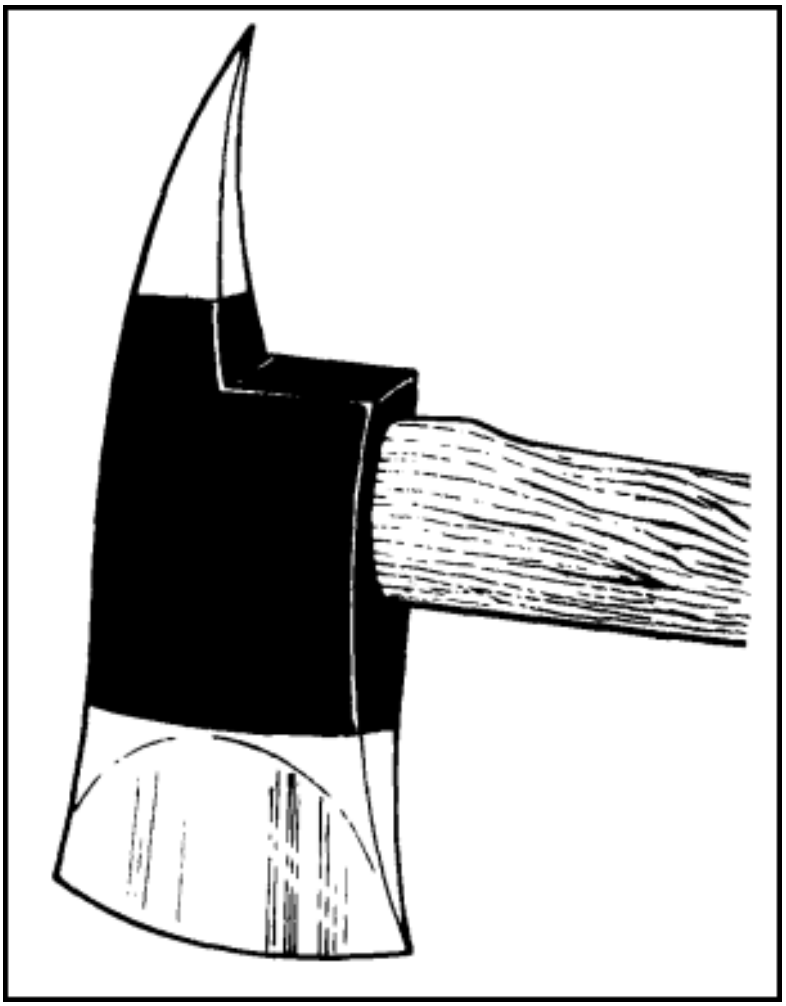


Figure 11-33. Pike Head Fire Axe

11-151. Inspect axes periodically. They should be sharpened, cleaned, or repaired as necessary. The blade and pike ends should be kept sharp and free of burrs. The handle should be tight in the axe head and free of splits and splinters. An occasional light oiling will keep the head from rusting.

SELF-CONTAINED BREATHING APPARATUS

11-152. Although the air encountered at a fire is hot, contaminated by smoke and toxic gases, and deficient in oxygen, crewmen must enter this hostile environment to fight the fire. Their problem is simple, direct, and urgent--they must breathe. The equipment discussed in this paragraph is designed to enable seamen to enter such a hostile environment with some degree of protection for the respiratory system.

11-153. A breathing apparatus is a device that provides the user with breathing protection. It includes a facepiece, body harness, and equipment that supplies air or oxygen. Breathing apparatuses are available in several types. Each type is effective, if used properly. Each one has certain advantages and disadvantages.

THE DEMAND UNIT

11-154. This type will provide air or oxygen from a supply carried by the user. Use the OBA in any atmosphere that contains, has contained, or is suspected of containing flammable or combustible liquids or gases. Never wear the OBA in a cofferdam or any compartment fouled by fuel oil.

THE STANDARD FACEPIECE

11-155. The facepiece is an assembly that fits onto the face of the person using the breathing apparatus. The facepiece forms a tight seal to the face and transmits air or oxygen to the user. The standard facepieces (Figure 11-34 and Figure 11-35) are shown with the breathing apparatus covered in this paragraph.

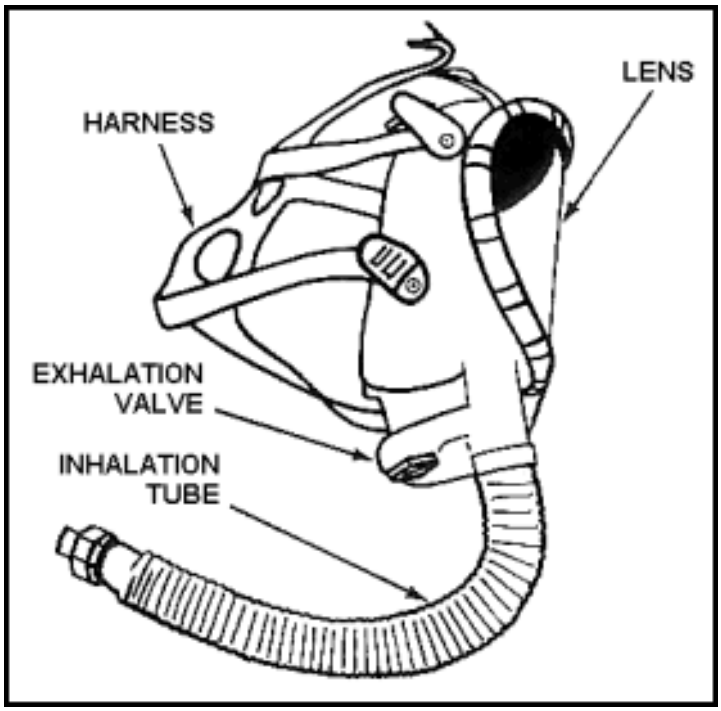


Figure 11-34. Single Hose Facepiece

Figure 11-35. Dual Hose Facepiece

Construction

11-156. The basic part of the facepiece is the mask. It is made of oil-resistant rubber, silicone, neoprene, or plastic resin. Most facepieces include a head harness with five or six adjustable straps, a flexible inhalation tube, an exhalation valve, and a wide-view lens. Some models also include a nose cup or a speaking diaphragm. The facepiece used with oxygen-generating equipment has an exhalation tube and an inhalation tube. Each tube has a mica disk-type valve for airflow control.

- Head harness. The head harness holds the facepiece in the proper position on the face, with just enough pressure to prevent leakage around the edge of the mask. Before stowing the facepiece, be sure all harness straps are fully extended, with the tab ends against the buckles. This helps ensure that the facepiece can be donned quickly in an emergency.
- Exhalation valve. The exhalation valve on a single hose facepiece (Figure 11-34) is a simple one-way valve. It consists of a thin disk of rubber, neoprene, or plastic resin, secured in the center of the facepiece. It may be contained in a hard plastic mount located at the front of the chin area. The exhalation valve, commonly referred to as the "flutter valve," releases exhaled breath from the facepiece.
- Flexible tubes. The flexible inhalation tube carries fresh air or oxygen to the facepiece. In the facepiece with dual hoses (Figure 11-35), the exhalation tube returns exhaled breath from the facepiece to the canister. The inhalation and exhalation valves controls airflow through these tubes. Like the facepiece, the flexible tubes are made of oil-resistant rubber, neoprene, or plastic resin. In use, the tubes must be kept free and unkinked for the proper flow of air. Avoid all unnecessary strain on these tubes. If they become tangled in any way, they must

be freed carefully. DO NOT pull them free.

- Lens. The facepiece may be supplied with dual lenses or a full-view single lens. In some cases, the single lens is available as an optional item at additional cost. The lens gives the wearer a wide range of vision. It is made of a plastic base resin and is attached to the mask with a removable frame or metal ring. Protect, as much as possible, the lens from scratches when in use or during handling and packing.
- Nose cup. The nose cup is an optional removable piece that fits into the exhalation valve. It is designed to reduce fogging of the lens.
- Speaking diaphragm. The speaking diaphragm projects the wearer's voice from the facepiece with little or no distortion. It is located directly in front of the wearer's mouth and is similar in appearance to the exhalation valve.
- Pressure relief valve. The facepieces used with canister- and cylinder-type breathing apparatus include a combination pressure relief and saliva valve. The valve is located in the cross-tube that connects the inhalation and exhalation tubes. It automatically relieves pressure within the facepiece. The wearer may also use the valve to get rid of saliva and to exhaust exhaled air to the outside by pressing a spring-loaded button.

Use and Maintenance

11-157. Donning, stowing, and maintaining the facepiece all affect its efficiency in use. For example, poorly stowed equipment is difficult to put on. Poorly maintained equipment could cause difficulties in achieving an uncontaminated atmosphere within the facepiece. Poorly donned equipment will simply not effectively protect the wearer.

Putting on the Facepiece

11-158. When the facepiece is put on properly, the chin straps are below the ears. The harness pad is at the back of the head, as close to the neck as possible. The side straps are above the ears. The mask portion is snug, but not tight. Two factors are important when the facepiece is to be put on.

- First, the wearer must obtain the proper seal by adjusting the harness.
- Second, time is precious when the breathing apparatus is needed; every second counts.

11-159. After much testing, the following method has proved to be the most effective for five-strap and six-strap facepieces. For the facepiece to be donned as recommended, the harness must be fully extended and pulled over the front of the lens. The tab end of each strap must be up against the buckle. If this was not done when the facepiece was stowed, it must precede the first step of the following donning procedure (see also Figure 11-36).

- Step 1. Hold the facepiece at the bottom with one hand. Place your chin in the pocket at the bottom of the mask, and fit the mask to your face.
- Step 2. Put your other hand between the mask and the harness. Your palm

should be on the lens, and your fingers and thumb should be fully extended and spread.

- Step 3. In one smooth motion, push the harness over the top of your head. Push with the back of your hand and your fingers. Keep your fingers spread and extended as the harness slips into place.
- Step 4. Tighten the chin straps by gently pulling them out and back. This places the harness pad at the back of the head close to the neck. For the proper fit and seal, tighten the straps from the bottom up.
- Step 5. Tighten the side straps as described in step 4.
- Step 6. Tighten the top straps last, again as described in step 4. When steps 4, 5, and 6 are completed in the proper order, the harness should fit tightly against the back of the head.
- Step 7. Test the facepiece for leakage as follows:
    - For demand-type breathing apparatus, block the end of the inhalation tube with the palm of your hand while trying to inhale. If the facepiece is properly fitted, it will collapse against your face.
    - For oxygen-generating or oxygen-rebreathing equipment, grasp both tubes while trying to inhale. Again, a properly fitted facepiece will collapse against your face.

Figure 11-36. Steps for Putting on the Facepiece

SELF-GENERATING (CANISTER) TYPE OBA

11-160. The self-generating, or canister, type OBA (Figure 11-37) is also a self-contained breathing apparatus. In this unit, the wearer's exhaled breath reacts with chemicals in a canister to produce oxygen. The wearer then breathes this oxygen.

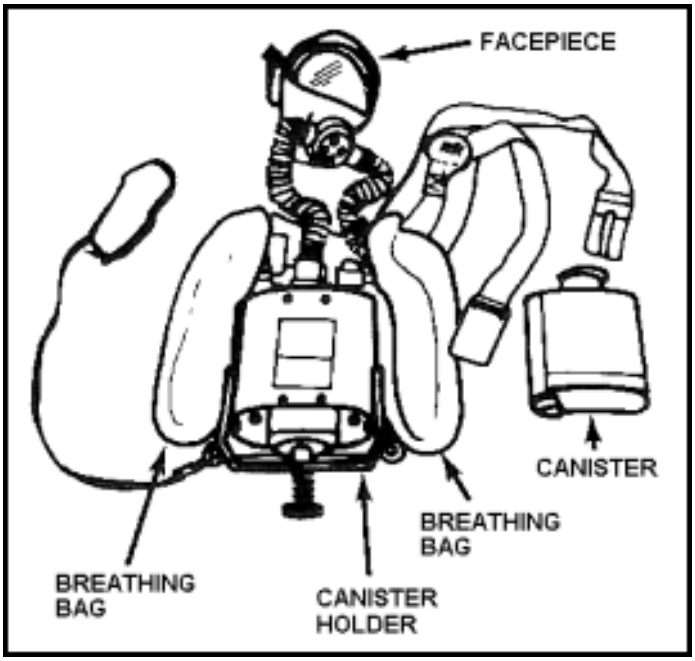


Figure 11-37. Canister Type OBA

Construction

11-161. The canister-type unit consists basically of five parts:

- Facepiece with an inhalation tube, an exhalation tube, and a pressure relief valve.
- Breathing bag.
- Canister holder and canister.
- Manual timer.
- Breastplate with attached body harness.

11-162. Store the unit in a suitcase-type container with room for three canisters. Complete operating instructions are displayed inside the cover of the case.

11-163. The canister contains chemicals that react with moisture in the wearer's exhaled breath to produce oxygen. These chemicals also absorb carbon dioxide from the exhaled breath. If the unit is used for a short time and then removed, a new canister

must be inserted before the next use. The chemicals in the canister continue to react even after the facepiece is removed and there is no accurate way of measuring the time left before the chemicals are used up. The breathing bag holds and cools the oxygen supplied by the canister and is made of reinforced neoprene.

11-164. The manual timer is set when the equipment is put into operation. It gives an audible alarm to warn the operator when the canister is nearly expended. The timer is no more than a clock; it does not indicate the condition of the canister. It should always be set to allow the wearer enough time to leave the contaminated area after the alarm sounds.

11-165. The body harness is a series of web straps that position and stabilize the apparatus. The breastplate holds the canister and protects the wearer from the heat generated by the unit.

Operating Cycle

11-166. Figure 11-38 shows the operating cycle of the canister-type unit. The wearer's exhaled breath [1] passes from the facepiece into the exhalation tube and then into the canister. The chemicals in the canister absorb moisture and carbon dioxide [2]. They produce oxygen, which passes from the canister to the breathing bag [3]. When the wearer inhales [4], the oxygen moves from the breathing bag to the facepiece [5] via the inhalation tube.

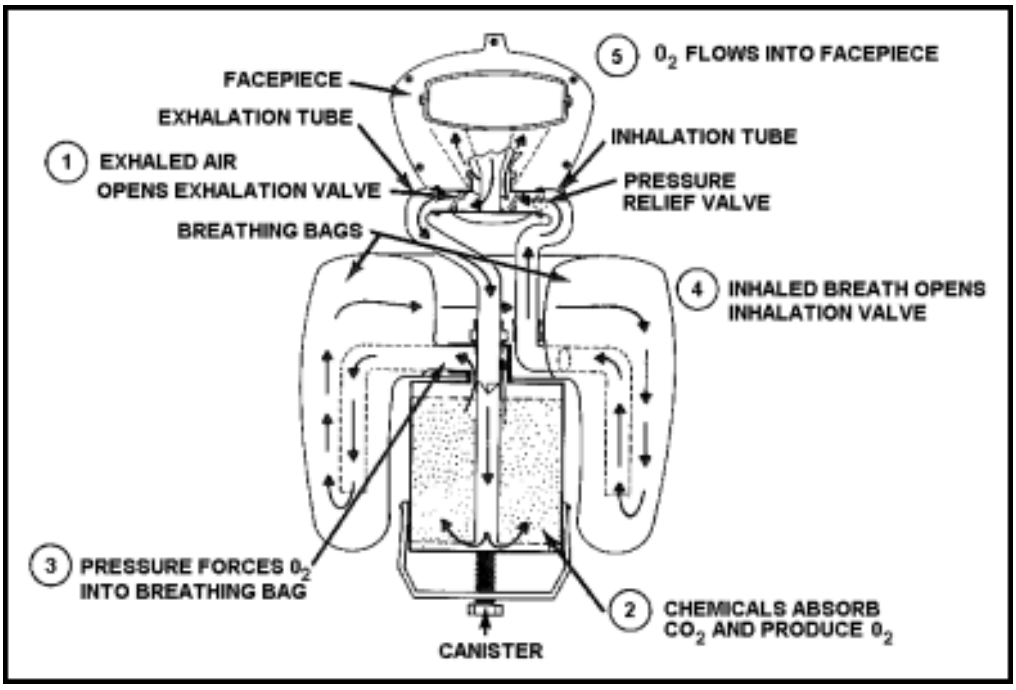


Figure 11-38. Sequence of Operating Cycle for OBA

Putting on the OBA

11-167. You can, without too much trouble, put on the OBA without assistance. Do the following steps to put on the OBA.

- Step 1. Grasp one shoulder strap in each hand and lift the harness over your head. This allows the equipment to rest on your chest while it is supported by the shoulder straps (Figure 11-39).
- Step 2. Reach around back to locate the side straps. Attach the side straps, one at a time, to the D-rings on the breastplate with the hooks provided. Then tighten the harness so it fits securely and comfortably (Figure 11-40).
- Step 3. Put the waist strap around your neck, attach the hooks at the D-ring, and tighten the strap (Figure 11-41).
- Step 4. Remove a canister from the carrying case. There are two types of canisters: self-start and manual-start (Figure 11-42). Steps 9 and 10 describe how to start each type of canister you are using.

Note: The self-start canister has a small metal box at the bottom.

- Step 5. Remove the protective cap from the top to expose a thin copper seal (Figure 11-43).
- Step 6. Swing the canister retaining bail forward and hold it with one hand. Now insert the canister in the holder, with the label facing outward, away from your body (Figure 11-44).
- Step 7. Swing the retaining bail down under the canister and tighten the retainer (a heavy screw with a pad and hand-wheel) by turning it clockwise. This secures the canister in the holder and forms a seal between the canister and the central casting. The point of the central casting punctures the copper seal (Figure 11-45).
- Step 8. Check the canister type to determine the correct starting action. Then don the facepiece as described in paragraph 11-158.
- Step 9. Start a self-start canister as follows. Locate the small triangular metal tab on the metal box at the bottom of the canister. Grasp the tab with the thumb and index finger of your right hand and pull it downward (Figure 11-46). The small metal box will come away from the canister, exposing a lanyard. Grasp the lanyard with your index finger and thumb and pull it straight out away from your body. Do not pull down on the lanyard. The correct action will activate the chemicals in the canister, filling the breathing bag with oxygen. If the lanyard breaks and does not activate the self-starter, use the manual-start procedure in step 10.
- Step 10. Start a manual-start canister in a safe, uncontaminated area by inserting one or two fingers under the facepiece and stretching it away from your face (Figure 11-47). With the other hand, grasp the inhalation and exhalation tubes and squeeze them tightly; then inhale. Now release the tubes, remove your fingers from under the mask, and exhale. Repeat this procedure several times to inflate the breathing bag. This will start the chemical action in the canister. Do not overinflate the breathing bag! It should be firm, but not rock hard.
- Step 11. Test the facepiece for leakage by squeezing the inhalation and exhalation tubes while inhaling (Figure 11-47). If the facepiece is properly fitted, it will collapse against your face.
- Step 12. Set the timer (Figure 11-48) by turning the knob clockwise. On older

units, the timer is set for 30 minutes. This allows the wearer 15 minutes to leave the contaminated area after the alarm sounds. On newer units, the timer may be set for 45 minutes or less. The control should be turned to the extreme clockwise position and then reset to the desired time interval. This ensures that the alarm will sound for a full 8 to 10 seconds.

Figure 11-39. Putting on the OBA, Step 1

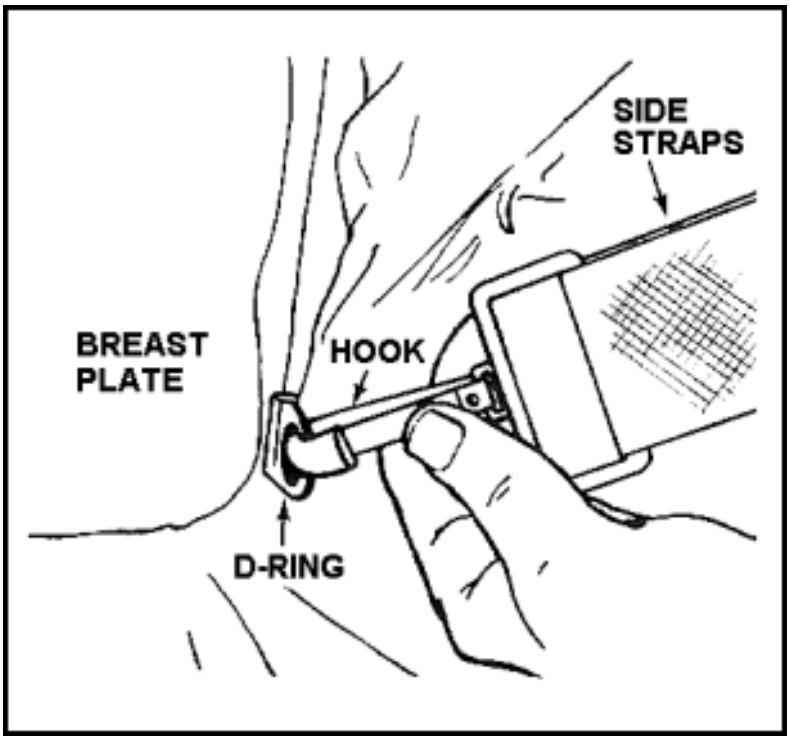


Figure 11-40. Putting on the OBA, Step 2

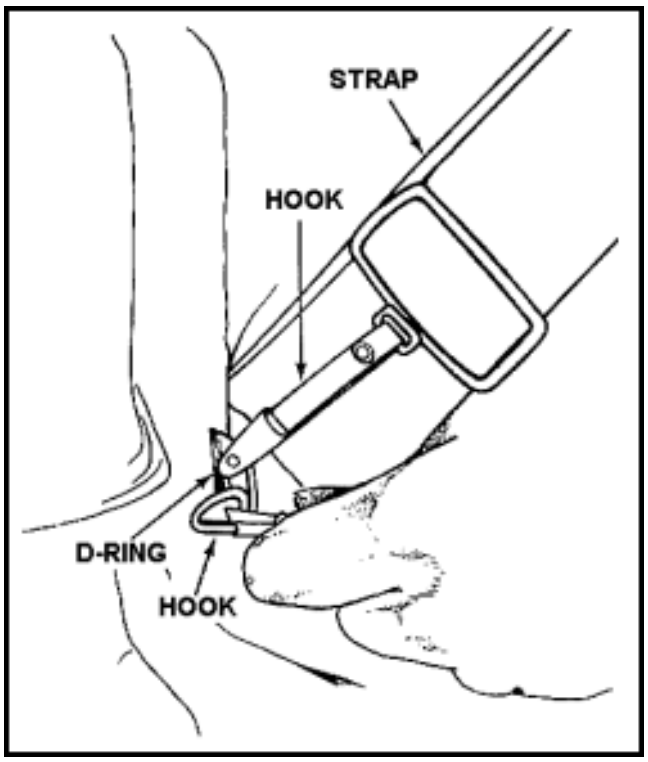


Figure 11-41. Putting on the OBA, Step 3

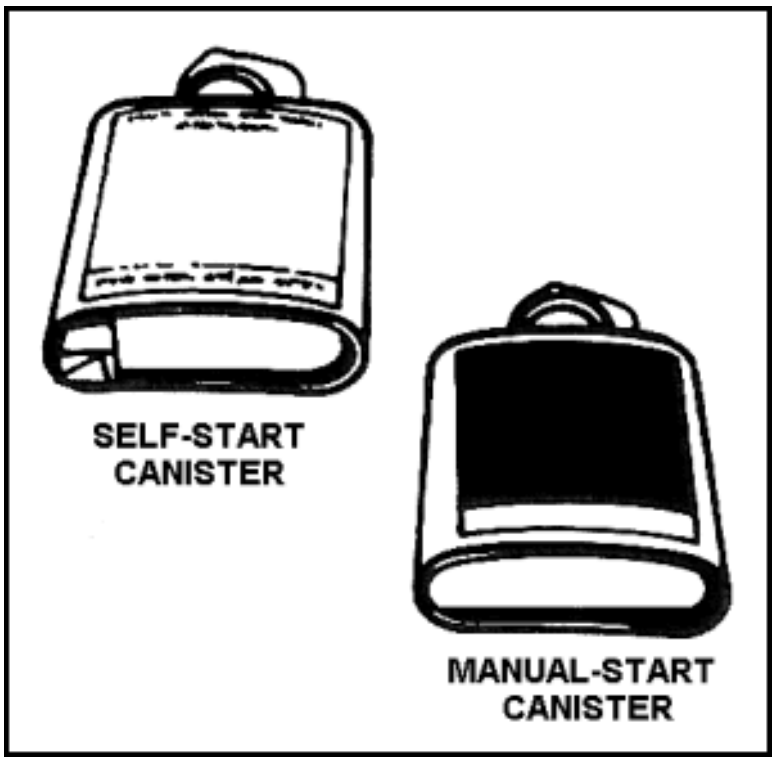


Figure 11-42. Putting on the OBA, Step 4

Figure 11-43. Putting on the OBA, Step 5

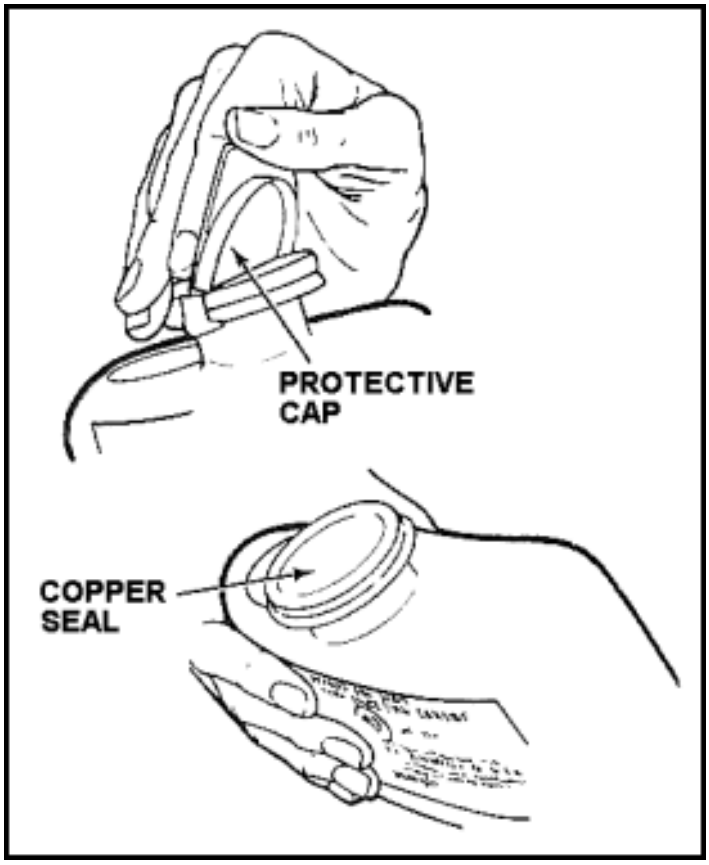


Figure 11-44. Putting on the OBA, Step 6

Figure 11-45. Putting on the OBA, Step 7

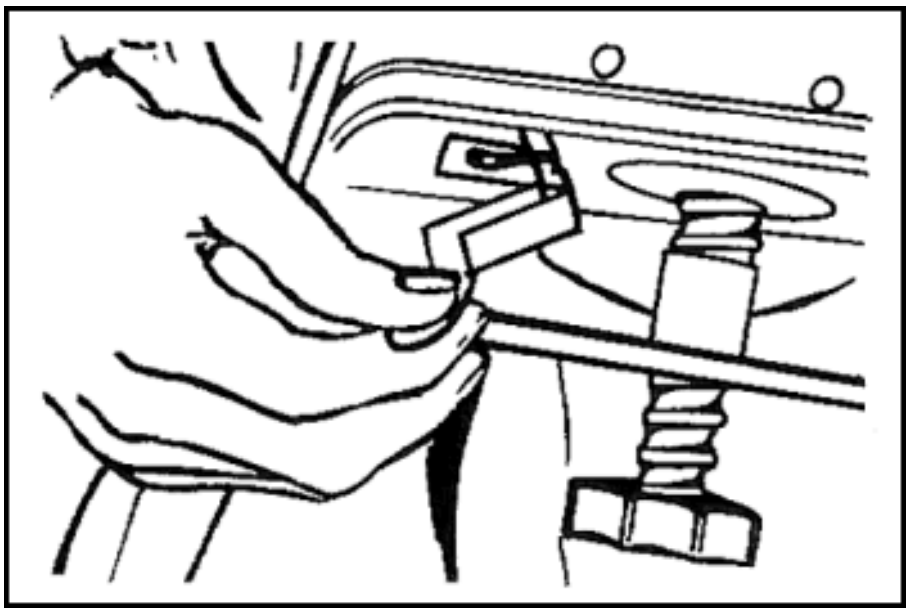


Figure 11-46. Putting on the OBA, Step 9

Figure 11-47. Putting on the OBA, Step 10 and 11

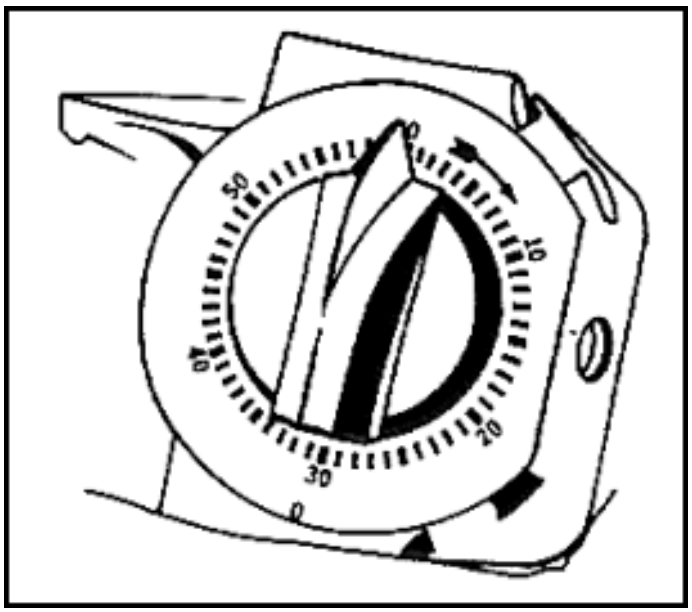


Figure 11-48. Putting on the OBA, Step 12

CAUTION: If the lenses fog up, any part of the unit malfunctions, or the wearer experiences any discomfort or difficulty in breathing, he must immediately retreat to safety. One cause of difficulty in breathing is an overinflated breathing bag. If the bag is overinflated, it will seem very hard. This problem can be corrected, in a safe area, by briefly depressing the button in the center of the relief valve. The bag should not be allowed to deflate completely during this process. If the bag becomes underinflated, the user must repeat step 10.

Removing the Canister

11-168. The removal and disposal of an expended canister are very hazardous operations that must be performed to avoid injury. The procedure (see also Figure 11-49) is as follows:

- Step 1. Spread your feet wide apart, and lean forward from the waist. (The chemical action that takes place in the canister generates sufficient heat to burn bare skin. For this reason, you must not touch the expended canister.)
- Step 2. Loosen the retaining screw by turning the handwheel counterclockwise.
- Step 3. Swing the retaining bail forward, and let the canister drop to the deck. It must not be tossed (or allowed to fall) into the bilge, or any place where oil, water, snow, ice, grease, or other contaminants can enter the hole in the copper seal. Organic material may cause a violent reaction. Water and substances containing water will cause a rapid chemical action in the canister, creating more pressure than can be released through the small neck opening. This pressure could cause an explosion that would produce flying fragments and injure anyone in the vicinity.
- Step 4. Puncture the expended canister several times, front and back, with the pike end of a fire axe (Figure 11-50).
- Step 5. Fill a pail with clean water, deep enough to completely submerge the canister. Gently drop the canister into the water. A violent chemical reaction will take place. However, the pressure cannot build up if the canister has been properly punctured, so there is no danger of an explosion.
- Step 6. After the boiling has stopped, the water (which is now caustic) and the canister must be discarded as a hazardous waste in accordance with unit, state, and federal regulations.

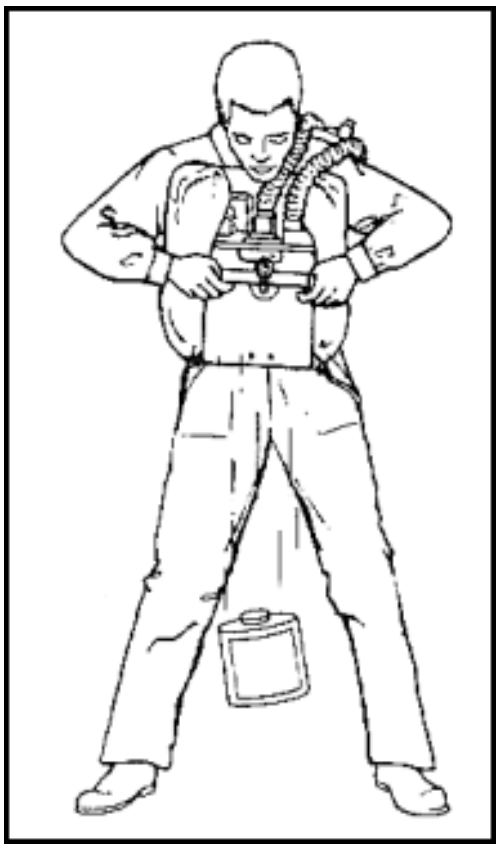


Figure 11-49. Removing the Canister

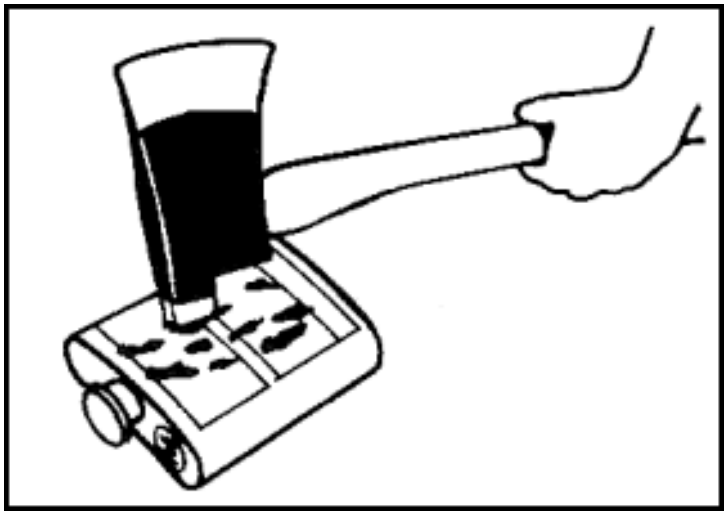


Figure 11-50. Puncturing the OBA Canister

Maintenance of Oxygen-Generating Apparatus

11-169. The oxygen-generating apparatus must be maintained carefully. The manufacturer or his representative must replace worn or damaged parts. Those who use the equipment should faithfully perform periodic inspections and after-use maintenance by using the following procedures:

- Clean the facepiece. Be especially careful to dry all the equipment thoroughly.
- Check the inhalation and exhalation valves periodically for corrosion and replace if necessary.
- Test the alarm bell to make sure it operates properly.
- Inspect the breathing bag for signs of damage and wear.
- Inspect the canister holder and retaining bail and screw for damage, wear, and proper operation. Check the central casting plunger that breaks the seal and seals the canister into the system. This plunger operates by moving in and out about one fourth of an inch. A spring holds the plunger out. When the canister is inserted and tightened down by the bail screw, the plunger is depressed against the spring. This action ensures a tight seal. If the plunger does not work properly, it must be repaired or replaced; it should never be lubricated.

Safety Precautions

11-170. Certain precautions must be taken when the oxygen-generating apparatus is used. The user must be careful not to damage the breathing bag on nails, broken glass, or other sharp objects. When it is necessary to operate the relief valve, he must do so carefully so as not to deflate the breathing bag too much.

11-171. The instructions on the canister must be followed. Foreign material, especially petroleum products, must be kept from entering an opened canister. The chemical in the canister must not come in contact with the skin.

11-172. The apparatus must not be stowed with a canister already inserted. After one use, regardless of how short, the canister must be discarded as described. For older units without the self-start action, three fresh canisters should always be kept in readiness, with their caps intact, in the storage case. For newer units with the self-start action, two fresh canisters may be kept in the case.

Advantages and Disadvantages of the OBA

11-173. The greatest advantage of the oxygen-generating apparatus is its staying time. The canister produces enough oxygen for comfortable breathing up to 45 minutes, and it is much lighter than other self-contained units. Therefore, it is advantageous for use in large contaminated spaces where ventilation may be difficult, where it is difficult to locate the fire or the source of contamination, and wherever an uninterrupted operating time of up to 45 minutes is needed.

11-174. The following are some disadvantages of the canister-type apparatus:

- About 2 minutes is required to start a manual-start canister and get the equipment into operation.
- If the relief valve is not operated properly, the breathing bag may lose its oxygen. The wearer must then return to an uncontaminated area to restart the unit.
- The bulkiness of the unit and its location on the wearer's chest may reduce maneuverability and the ability to work freely.
- The possibility of an explosion, because of the heat produced by the canister, if the canister is not properly disposed.
- If unit is not used properly, an explosive reaction can occur when petroleum products are introduced into the canister opening.
- The unit is not easily used for buddy breathing in rescue work.
- The apparatus cannot be used in an atmosphere that has contained or is suspected of containing flammable or combustible liquids or gases.
- When the alarm bell sounds, it rings once and stops. Due to noise or some other distraction, the wearer may not hear the alarm.

SELF-CONTAINED, DEMAND-TYPE BREATHING APPARATUS

11-175. The demand-type breathing apparatus is being used increasingly aboard ships. Its popularity stems from its convenience, the cool fresh air it supplies the user, the speed with which it can be put into service, and its versatility. The demand-type apparatus gets its name from the functioning of the regulator, which controls the flow of air to the facepiece. The regulator supplies air "on demand;" that is, it supplies the user with air when he needs it and in the amount his respiratory system requires. It therefore supplies different users with air at different rates, depending on their "demand."

Note: The newer model of the demand-type breathing apparatus is being supplied with a positive flow to the facepiece. The slight pressure in the facepiece prevents contaminated air from entering the facepiece and getting into the respiratory tract. This positive air pressure lessens the critical nature of the facepiece fit against the user's face.

11-176. The self contained, demand-type apparatus consists of four assemblies:

- Facepiece. The facepiece used is the standard full-face type discussed earlier in this chapter.
- Regulator. Air from the supply cylinder passes through the high-pressure hose and a preset pressure-reducing valve in the regulator. The admission valve is normally closed. However, when the user inhales, he produces a partial vacuum on one side of the admission valve. This opens the valve, allowing air to pass into the facepiece. The amount of air supplied depends on the amount of vacuum produced, which in turn depends on the user's air requirements. The regulator has a low-pressure alarm bell attached to the high-pressure hose. Older models of this regulator were equipped with a reserve valve. The reserve-valve lever is placed in the "start" position when the equipment is donned. When the cylinder pressure falls to about 500 psi, breathing becomes difficult, and the wearer must move the reserve lever to the "Reserve" position. This allows the wearer 4 to 5 minutes of reserve air with which to leave the contaminated area. An alarm bell kit can be installed on this older regulator model.
- Air cylinder. The air cylinder includes a pressure gauge and a control valve. On most cylinders, the threaded hose connection is a standard size. Cylinders are rated according to breathing duration, which depends on the size and pressure of the cylinder. There are four standard sizes. United States Coast Guard regulations require an air supply sufficient for at least 10 minutes of normal breathing. The IMCO code for tank ships requires a cylinder capacity of 1,200 psi (42 feet) of air. This should be enough to provide breathing protection for about 30 minutes.
- Backpack or sling pack. The backpack or sling pack and the harness are designed to hold the unit securely and comfortably on the wearer. They differ slightly according to the manufacturer, but all makes are donned in about the same way. However, backpack units are donned and stowed differently from sling-pack units.

BACKPACK UNIT

11-177. The backpack unit is the most commonly used demand-type breathing apparatus. Its air supply has a longer duration than that of the sling-pack unit.

Donning

11-178. When a backpack unit has been properly stowed in its carrying case, it can be donned by the user without assistance (Figure 11-51). The unit should be stowed with the tank down, backpack up, and harness straps fully extended.

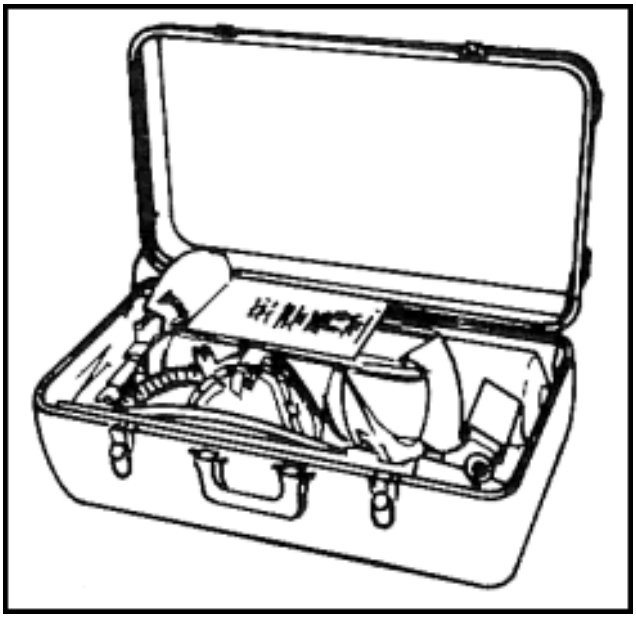


Figure 11-51. A Properly Stored Backpack Unit

11-179. The high-pressure air hose should be lying along the front of the case, with the regulator at the front right-hand corner. The harness take-up straps must be attached to the chest straps. One should be to the left of the regulator, and the other should be attached to the metal buckle on the right chest strap. The waist straps should be rolled or folded neatly between the backpack and the cylinder valve. The facepiece should be placed between the air cylinder and the high-pressure air hose.

11-180. When the unit has been stowed as described, it is donned in this way:

- Step 1. Take a crouched position at the right end of the open case. With one hand, grasp the cylinder valve handle and stand the cylinder and backpack on end. Check that the mainline valve (usually a yellow knob) is opened and locked in the open position. Check that the bypass valve (a red knob) is closed (Figure 11-52).
- Step 2. Check the cylinder gauge to be sure the cylinder is full. Then open the cylinder valve three turns. Now check the regulator gauge; it should read within 200 psi of the cylinder gauge. If the difference is more than 200 psi, assume the lower reading is correct. At the first opportunity, check the gauges for accuracy and make any necessary repairs (Figure 11-53).
- Step 3. Grasp the backpack with one hand on either side, making certain that the harness straps are resting on the backs of your hands or arms. From the crouched position, lift the unit over your head. Allow the harness to drop into

position over your arms (Figure 11-54).

- Step 4. After the harness has cleared your arms, lean forward, still in the crouched position. Lower the unit to your back. While still in this position, fasten the chest buckle (Figure 11-55).
- Step 5. Stand, but lean slightly forward to balance the cylinder on your back. Then grasp the two underarm adjusting strap tabs. Pull the tabs downward to adjust the straps (Figure 11-56). To get the equipment as high on your back as possible, bounce the cylinder by moving your back and legs; at the same time, pull the tabs to position the cylinder.
- Step 6. Locate both ends of the waist harness, hook the buckle, and tighten the strap. Once this is done, the equipment is secure and you may stand erect.
- Step 7. Remove the facepiece from the case, and don it as described earlier. The donning of the facepiece should be practiced and mastered before this equipment is used.
- Step 8. Insert the quick connect coupling of the inhalation tube at the regulator, and tighten it down (Figure 11-57). To conserve air, this step should be performed just before you enter the contaminated area.

Figure 11-52. Donning the Backpack Unit, Step 1

Figure 11-53. Donning the Backpack Unit, Step 2

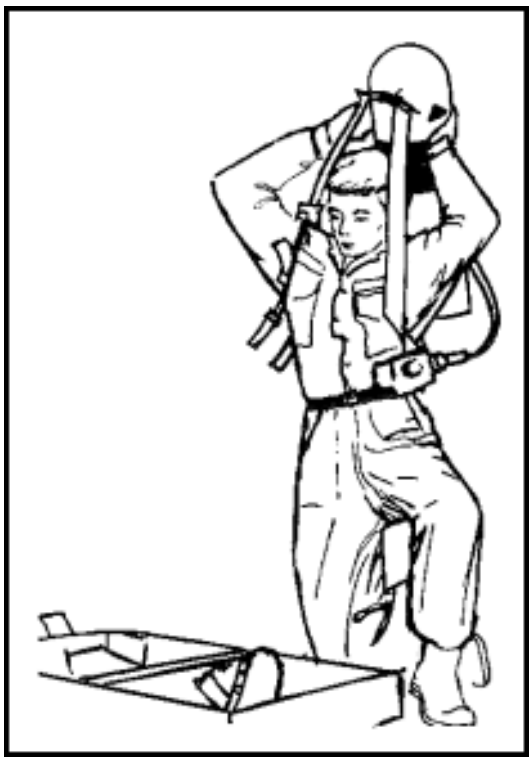


Figure 11-54. Donning the Backpack Unit, Step 3

Figure 11-55. Donning the Backpack Unit, Step 4

Figure 11-56. Donning the Backpack Unit, Step 5

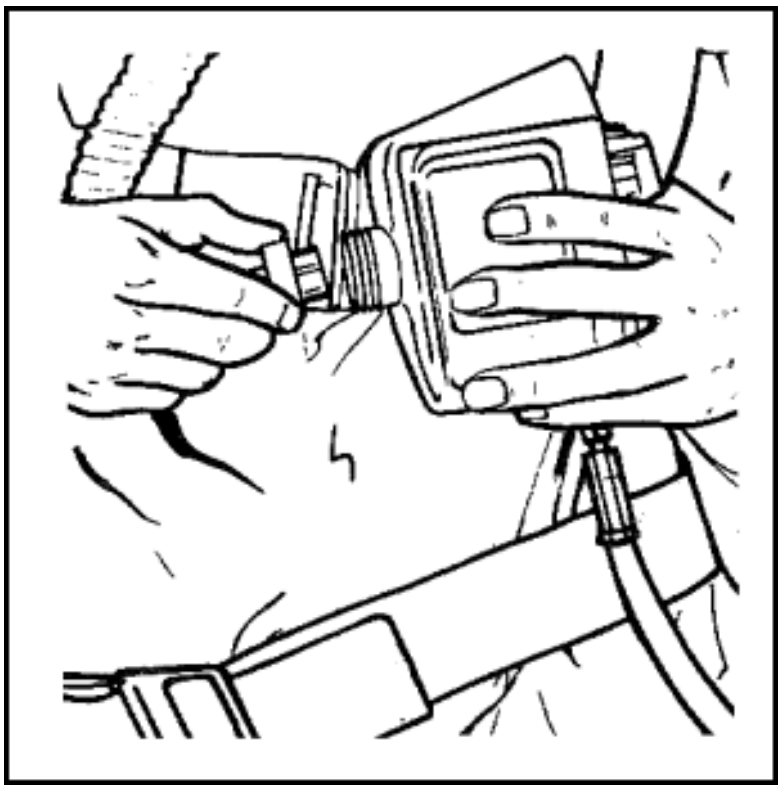


Figure 11-57. Donning the Backpack Unit, Step 8

Removal and Restowing

11-181. Remove the backpack unit as follows:

- Step 1. Disconnect the inhalation tube from the regulator.
- Step 2. With the tips of your fingers, release the self-locking buckles on the facepiece harness (2A). Remove the facepiece as described earlier (2B) (Figure 11-58).
- Step 3. Make sure the facepiece harness straps are fully extended. Pull the harness over the front of the facepiece and place the facepiece in the carrying case.
- Step 4. Unbuckle the backpack waist belt, and extend the belt fully.
- Step 5. With your thumb and index finger, release and hold the underarm strap buckles and extend them fully.
- Step 6. Disconnect the chest buckle.
- Step 7. With your left hand, get a firm grip on the body harness and the regulator at the point where they are attached. Slip your right arm out of the harness as if you were removing a vest (Figure 11-59).
- Step 8. Grasp the harness with your right hand, above and as close to the regulator as possible. Then remove the equipment from your left shoulder and arm (Figure 11-60). By removing the equipment this way, you will keep the regulator from striking nearby objects, which could damage it.
- Step 9. Close the valve on the air cylinder. Remove the air pressure from the regulator by cracking the bypass valve open momentarily.

The unit should be thoroughly cleaned, and the air cylinder should be replaced immediately with a full cylinder. However, it may be necessary to restow the equipment before it is cleaned and its cylinder is replaced. It should then be stowed in its case as described above. The case should be marked or tagged "Empty Cylinder. "

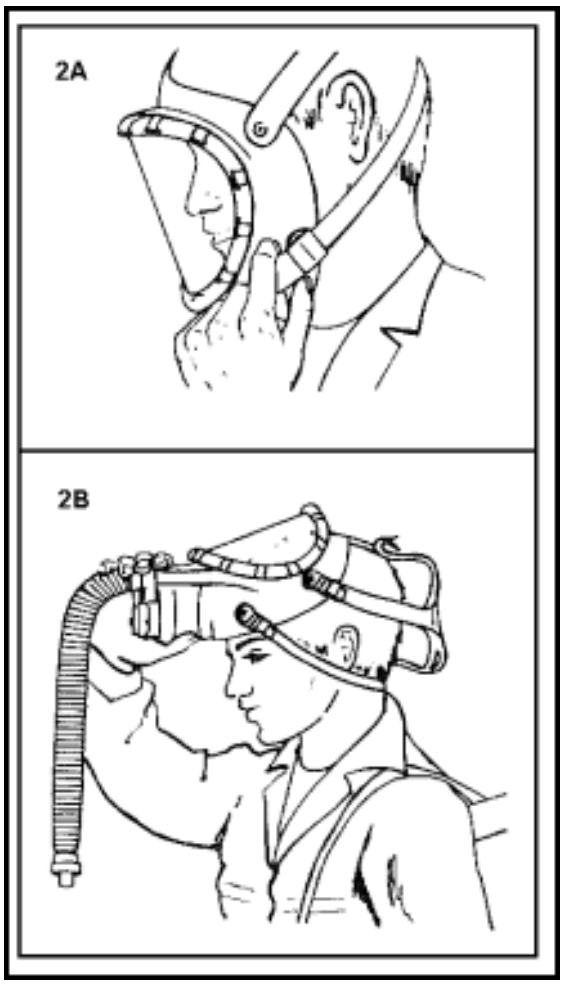


Figure 11-58. Removing and Restowing the BackpackUnit, Step 2

Figure 11-59. Removing and Restowing the BackpackUnit, Step 7

Figure 11-60. Removing and Restowing the Backpack Unit, Step 8

SLING-PACK UNIT

11-182. The sling-pack unit is generally stowed in a case. However, it is donned as follows no matter how it has been stowed:

- Step 1. Lay the facepiece aside, in a clean, dry place.
- Step 2. Grasp the shoulder strap with your right hand. The air cylinder should be to your left, and the regulator to your right.
- Step 3. In one motion, swing the unit onto your back while putting your left arm through the harness. Carry the shoulder strap over your head, and place it on your right shoulder (Figure 11-61).
- Step 4. Pull the strap to take up the slack (Figure 11-62).
- Step 5. Clip the waist straps together; tighten them by pulling the strap end to your right (Figure 11-63).
- Step 6. Don the facepiece as described previously.

Remove the sling-pack unit by reversing these steps. Clean the unit and replace the cylinder before the unit is stowed.

Figure 11-61. Donning the Sling-Pack Unit, Step 3

Figure 11-62. Donning the Sling-Pack Unit, Step 4

Figure 11-63. Donning the Sling-Pack Unit, Step 5

Search

Chapter 12

Marlinespike Seamanship

Marlinespike seamanship is a general term for the handling, knotting, whipping, splicing, and caring for fiber line and wire rope used aboard ship or in other marine operations. The knowledge and practical application of marlinespike seamanship principles and procedures are important to the crewman. A person who is truly dedicated to his work takes pride in the handling and caring of fiber line and wire rope to make operations safe and satisfactory. This chapter covers all of the phases of marlinespike seamanship required by the watercraft operator.

CARE AND USE OF FIBER LINE

12-1. One characteristic of a good watercraft operator is his ability to work with fiber line. To be able to do this, he must know the characteristics and properties of fiber line, how to handle and care for the line, and tie the basic knots, bends, and hitches.

MATERIALS FOR FIBER LINE

12-2. Fiber line is made of either vegetable or synthetic fibers. Vegetable fibers include manila, sisal, hemp, cotton, and flax. Synthetic fibers include nylon, Dacron, polyethylene, and polypropylene. Nylon is the primary synthetic fiber line used in the Army, so this text covers only nylon and none of the other synthetic fibers. These materials are described below.

Manila

12-3. Manila is a strong fiber that comes from the leaf stems of the abaca plant that is in the banana family. Varying in length from 4 to 15 feet in their natural state, the fibers have the length and quality to give manila rope relatively high elasticity, strength, and resistance to wear and deterioration. Most lines used in the Army are manila.

Sisal

12-4. Sisal is made from sisalana, a species of the agave plant. Although sisal is seldom used in the Army, it is covered here because it is a good substitute for manila. Sisal fibers are 2 to 4 feet long. Sisal withstands exposure to seawater very well.

Hemp

12-5. Hemp is a tall plant that has useful fibers for making rope and cloth. It was used extensively before manila was introduced. Now hemp's principal use is in fittings such as ratline and marline. Because hemp is absorbent, the fittings are invariably tarred to make them more water resistant. Uses of marline include lashings and whippings.

Nylon

12-6. Nylon is made from mineral products is waterproof, absorbs shocks, stretches, and resumes its original length. It also resists abrasion, decay, and fungus growth.

CONSTRUCTION OF FIBER LINE

12-7. Figure 12-1 shows how a fiber line is made by twisting fibers into yarns, yarns into strands, and strands into the finished line. The fibers are twisted from left to right to spin the yarn. The yarn is twisted from right to left to form the strands. The strands are then twisted from left to right to lay or form the line. Three-stranded nylon line is constructed in the same way as fiber line.

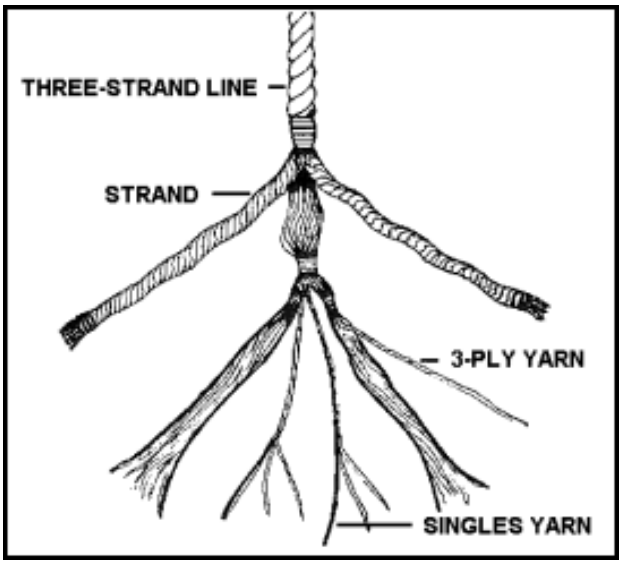


Figure 12-1. Fabrication of Fiber Line

SIZE OF LINE

12-8. Fiber line is measured, in inches, by its circumference. One exception is "small stuff". Small stuff has fiber line that is 1 3/4 inches or less in circumference. It also has three strands. The number of threads it contains determines its size. Small stuff will range in size from 6 to 21 threads. To determine the number of threads, count the number in one strand and then multiply it by three. Small stuff is used for lashing material and heaving lines.

12-9. Fiber line between 1 3/4 and 5 inches in circumference is referred to as line. Line over 5 inches in circumference is referred to as hawser. Hawsers are used for mooring and towing.

STRENGTH OF FIBER LINE

12-10. Manila is the standard line against which all other types of fiber line are measured. Implied in the measurement is that all the other lines have the same circumference as that of the manila line against which each is measured. With manila line having a strength of 100 percent, the strengths of the other lines are shown in Table 12-1.

Table 12-1. Line Strengths

TYPE LINE	STRENGTH
Manila	100 percent
Three-strand nylon	250 percent

2-in-1 braided nylon	300 percent
Sisal	80 percent

12-11. Nylon line is fast replacing natural fiber line for mooring and towing because of its strength and durability. With three-stranded nylon being 250 percent stronger than manila, size for size, it allows the use of smaller and lighter mooring and towing lines.

12-12. Three-stranded nylon line will stretch 30 to 35 percent under an average load or a load that does not exceed the safety factor for that size line. Three-stranded nylon line will stretch 40 percent without being damaged and draw back to its original length. The nylon line will part at 50 percent.

USEFUL FORMULAS

12-13. The manufacturer states the size and BS of its lines. If this information is available, use the manufacturer's figures for determining the strength of line. If this information is not available, then use the rule of thumb to compute the SWL and the BS. These rules of thumb give only approximate results (because of the constants that are used in the below formulas) but the error will be on the side of safety.

TYPE LINE	**CONSTANT**
Sisal	160
Manila	200
Three-strand nylon	500
2-in-1 braided nylon	600
With "C" meaning circumference in inches, the formula for SWL in pounds is:	
C^2 X constant for line = SWL	
Examples:	
3-inch sisal:	
3 X 3 X 160 = 9 X 160 = 1,440 pounds SWL	
3-inch manila:	
3 X 3 X 200 = 9 X 200 = 1,800 pounds SWL	
3-inch three-strand nylon:	

3 X 3 X 500 = 9 X 500 = 4,500 pounds SWL
3-inch 2-in-1 braided nylon:
3 X 3 X 600 = 9 X 600 = 5,400 pounds SWL
In marine operations, a safety factor of 5 is generally used. If you multiply this times the SWL you will find the BS of the fiber line. This is the amount of weight in pounds required to part the line. If you are given the BS of a line and divide it by the safety factor 5, you will find the SWL.
Note: The safety factor of 5 is valid when using new line or line that is in good condition. As line ages and wears out through use, the safety factor drops. Old line may have a safety factor of 3.
Example: Find the BS of 3-inch manila line:
Solution: C^2 X constant = SWL: 3 X 3 X 200 = 9 X 200 = 1,800 pounds
BS = SWL X SF = 1,800 X 5 = 9,000 pounds
Example: Find the SWL for a 6-inch hawser that has a BS of 36,000 pounds:
Solution:
SWL = $\frac{BS}{SF}$ = $\frac{36,000}{5}$ =7,200 pounds

12-14. Table 12-2 shows the SWL and BS of the various sizes of lines used on Army watercraft.

SIZE IN INCHES	MANILA		THREE-STRAND NYLON		2-IN-1 BRAIDED NYLON	
	SWL	BS	SWL	BS	SWL	BS
1	200	1,000	500	2,500	600	3,000
1 1/2	450	2,250	1,125	5,625	1,350	6,750
2	800	4,000	2,000	10,000	2,400	12,000
2 1/2	1,250	6,250	3,125	15,625	3,750	18,750
3	1,800	9,000	4,500	22,500	5,400	27,000
3 1/2	2,450	12,250	6,125	30,625	7,350	36,750
4	3,200	16,000	8,000	40,000	9,600	48,000
4 1/2	4,050	20,250	10,125	50,625	12,150	60,750
5	5,000	25,000	12,500	62,500	15,000	75,000
5 1/2	6,050	30,250	15,125	75,625	18,150	90,750
6	7,200	36,000	18,000	90,000	21,600	108,000
6 1/2	8,450	42,250	21,125	105,625	25,350	126,750
7	9,800	49,000	24,500	122,500	29,400	147,000
7 1/2	11,250	56,250	28,125	140,625	33,750	168,750
8	12,800	64,000	32,000	160,000	38,400	192,000
8 1/2	14,450	72,250	36,125	180,625	43,350	216,750

Table 12-2. Line Strength Table (Safety Factor of 5)

CORDAGE

12-15. In marine usage, cordage is a collective term that includes all cord, twine, line, and string made from twisted vegetable or synthetic fibers. Cord, string, and twine are loosely used to mean small line.

Cotton Twine

12-16. This is like the string found in homes. It is used for temporary whippings and should be run through beeswax before use.

Sail Twine

12-17. This is made of flax or of a better grade of cotton than that used in cotton twine. It is waxed during manufacture. Measured by the number of plies, it comes in three to seven plies. Like a yarn, a ply has a certain number of fibers. Sail twine is used for whippings.

Marline

12-18. This is tarred hemp. It is made of two yarns with fibers making up the yarns. Marline is used for whippings on lines 3 inches and larger.

Flax

12-19. This is braided. It is used for halyards or the lines for flags and pennants. Flax is stronger than cotton and lasts longer.

INSPECTION

12-20. The outside appearance of the line is not always a good indication of its internal condition. Therefore, it is necessary to inspect the inside as well as the outside. Overloading a line may cause it to break with possible damage to material and injury to personnel.

12-21. Inspect line carefully at regular intervals to determine its condition. Untwist the strands slightly to open the line so that you can examine the inside. Mildewed line has a musty odor and inside fibers have a dark, stained appearance. It is ordinarily easy to identify broken strands of yarn. Dirt and sawdust-like material inside the line means that it has been damaged. If the line has a core, it should not break away in small pieces. If it does, the line has been overstrained. If the line appears to be satisfactory in all respects, pull out two fibers and try to break them. Sound fibers should offer considerable resistance to breakage.

12-22. When any unsatisfactory conditions are found, destroy the line or cut it up in short pieces. Make sure that none of these pieces is long enough to permit its use in hoisting. This not only prevents the use of line for hoisting, but saves the short pieces for miscellaneous use such as lashings, whippings, and seizings.

UNCOILING NEW LINE

12-23. New line is coiled, bound, and wrapped in burlap as a protective covering. The burlap covering should not be opened until the line is to be used. To open, strip back the burlap wrapping and look inside the coil for the end of the line. It should be at the bottom of the coil. If it is not, turn the coil over so that the end will be at the bottom. Put your hand down through the center and grab the end of the line. Pull the end of the line up through the center of the coil. As the line comes up through the coil, it will unwind in a counterclockwise direction (Figure 12-2).

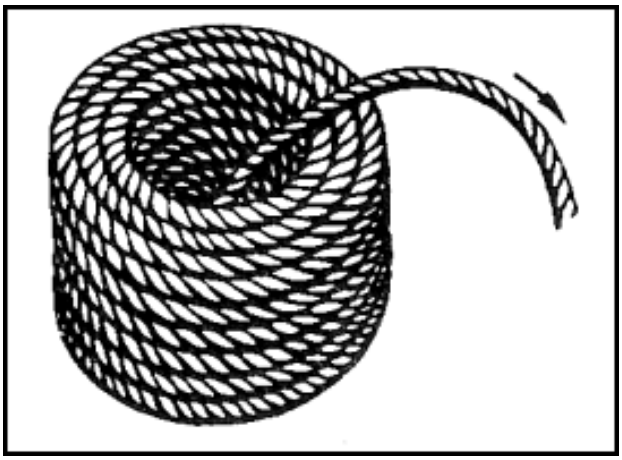


Figure 12-2. Opening View Coil Line

STOWING LINE

12-24. Hawsers and line must never be stowed when wet. After they are thoroughly dry and cleaned, they should be stowed in a dry, unheated, well-ventilated area or locker. Hawsers should be loosely coiled on wood grating or hung on wood pegs. Hawsers should never be stowed in contact with metal surfaces. Line can be coiled, flemished, or faked down.

12-25. Coiling down a line means laying it up in circles, roughly one on top of the other. Always coil down right-laid line right-handed or clockwise (Figure 12-3). When a line is coiled down, the top end is ready to run off. If you try the bottom end, the line will kink. If for some reason the bottom end must go first, it is necessary to turn over the coil to free it for running.

12-26. To flemish down a line, start with the bitter end and lay on the deck successive circles of the line. Always flemish down right-laid line clockwise, and left-laid counterclockwise. Figure 12-4 shows the bitter end is in the middle. Short lengths of a line, such as bitter ends of boat painters and guys, usually are flemished down.

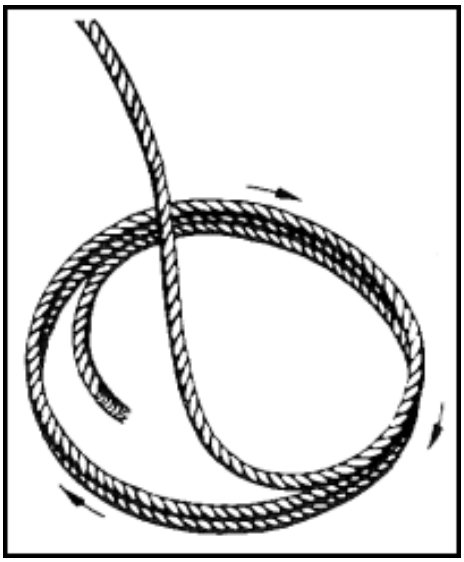


Figure 12-3. Coiling Line

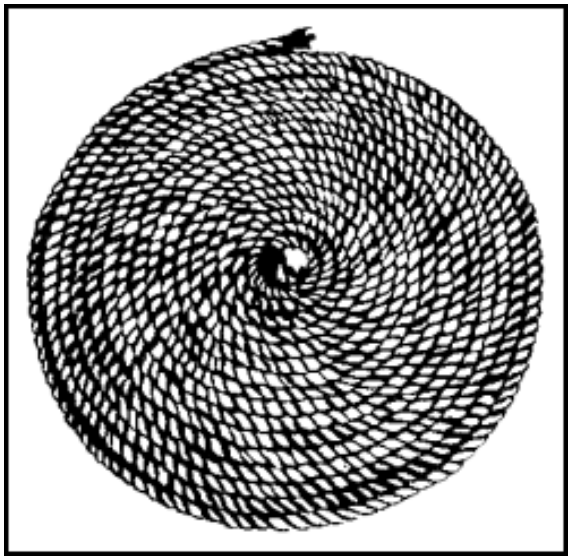


Figure 12-4. Flemishing Down a Line

Note: Nylon comes on reels. To uncoil it, place a reel on stands or jacks. Nylon is handled differently from natural fiber line. Coil three-strand nylon clockwise one week and counterclockwise the next week, because continuously coiling three-strand nylon line down one way tends to take the lay out of the strands. With 2-in-1 braided nylon line, simply put it in figure eights.

12-27. Faking down a line is laying it up the same way as in coiling down, except that it is laid out in long flat bights, one alongside the other, instead of in coils (Figure 12-5). The main advantage of working with line that is faked down is that it runs off easily.

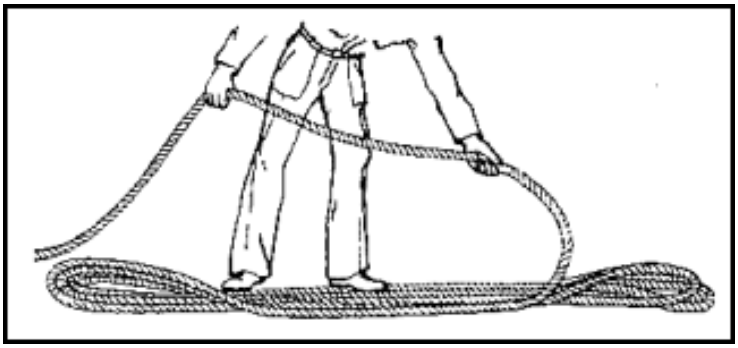


Figure 12-5. Faking Down a Line

WHIPPING A LINE

12-28. Never cut a line or leave the end of a line dangling loose without a whipping to prevent it from unlaying. A line without a whipping will unlay of its own accord. A frayed line is a painful sight to a good seaman. Whenever a line or hawser has to be cut, whippings should be put on first. Put one whipping on each side of the cut. To prevent fraying, a temporary or plain whipping can be put on with any type of cordage, even with rope yarn. Figure 12-6 shows one of several methods that can be used for putting a temporary whipping on a line.

12-29. Do the following to make a temporary whipping (see also Figure 12-6).

- **Step 1.** Lay the end of the whipping along the line and bind it down with three or four round turns.
- **Step 2.** Then lay the other end on the opposite way.

- **Step 3.** Bind it with a bight of the whipping.
- **Step 4.** Then take a couple more turns.
- **Step 5.** Take the bitter end of the whipping and pull it tight.

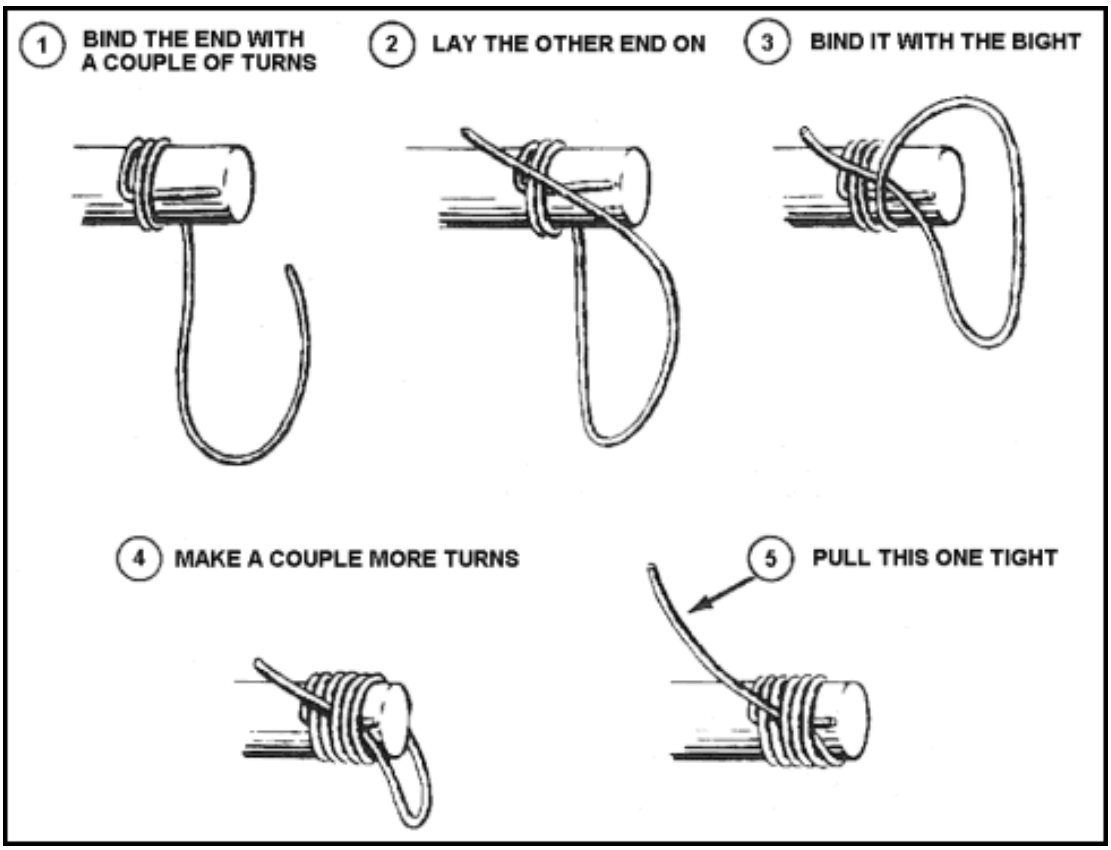


Figure 12-6. Plain or Temporary Whipping

12-30. As its name implies, a permanent whipping is put on to stay. One way to put on a permanent whipping is with a needle (Figure 12-7) and a sewing palm (Figure 12-8). Sewing palms are made for both right- and left-handed people. The width of the permanent whipping should equal the diameter of the line. Two whippings are recommended. The space between the two whippings should be six times the width of the first whipping.

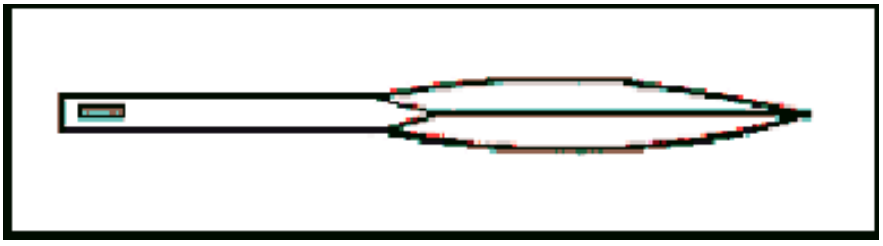


Figure 12-7. Short Spur Needle

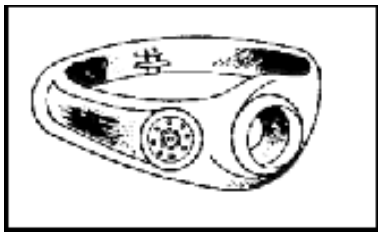


Figure 12-8. Sewing Palm for Rope Work

12-31. Do the following steps to make a permanent whipping (see also Figure 12-9).

Note: The needle is threaded with sail twine, doubled. Figure 12-9 also shows a single strand for clearness.

- **Step 1.** Push the needle through the middle of a strand so that it comes out between two strands on the other side.
- **Step 2.** Wind the turns toward the bitter end. The number of turns or the width of the whipping will depend on the diameter of the line.
- **Step 3.** Push the needle through the middle of a strand so that it comes out between two strands again.
- **Step 4.** Then go up and down between strands so as to put a cross-seizing between each pair of strands.
- **Step 5.** Pull each cross-seizing taut before taking the next one.
- **Step 6.** Have the thread come out through the middle of a strand the last time you push it through so that after you knot and cut the thread, the strand will hold the end of the twine.

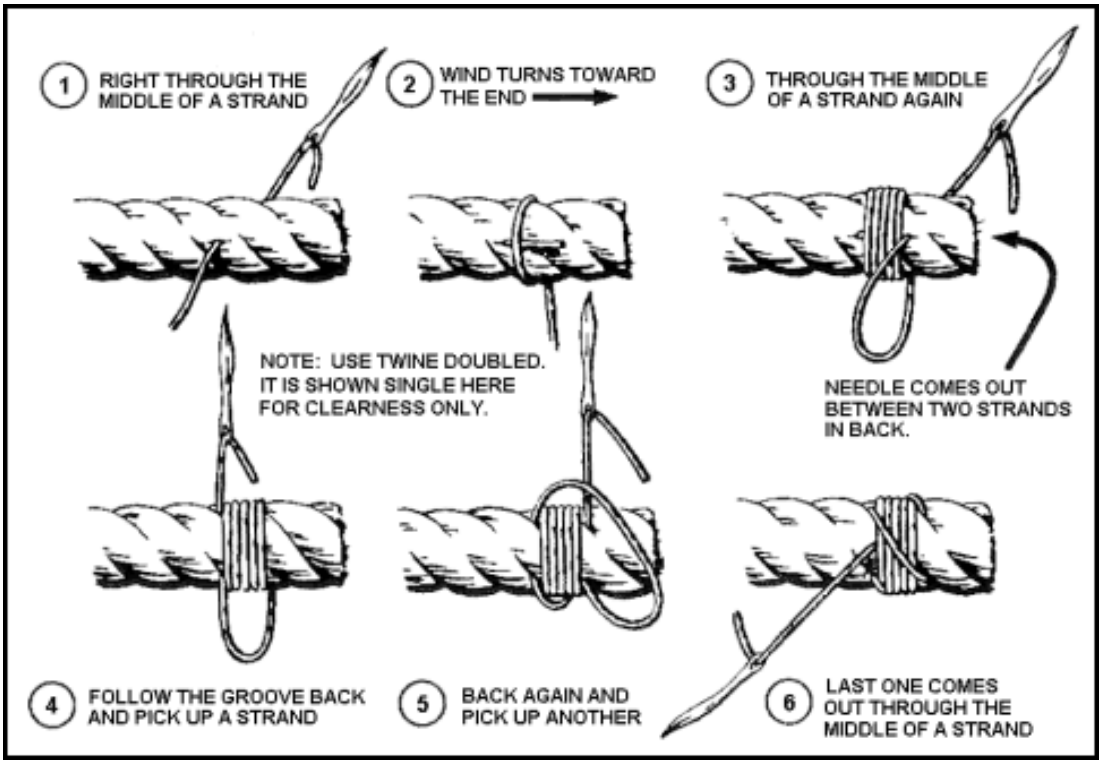


Figure 12-9. Making a Permanent Whipping

KNOTS, BENDS, AND HITCHES

12-32. A good knot must be easy to tie, hold without slipping, and be easy to untie. The choice of the best knot, bend, or hitch to use depends largely on the job it has to do (Figure 12-10). This FM explains why a given one is used and also gives the efficiency or strength of many of the knots, bends, and hitches. Always follow this rule: never tie a knot on which you are not willing to stake your life.

12-33. Each of the three terms--knot, bend, and hitch--has a specific definition. In a knot, a line is usually bent or tied to itself, forming an eye or a knob or securing a cord or line around an object, such as a package. In its noun form, a bend ordinarily is that used to join the ends of two lines together. In its verb form, bend means the act of joining; bent is the past tense of bend. A hitch differs from a knot and a bend in that it ordinarily is tied to a ring, around a spar or stanchion, or around another line. In other words, it is not merely tied back on itself to form an eye or to bend two lines together.

12-34. Tying a knot, bend, or hitch in a line weakens it because the fibers are bent sharply, causing the line to lose varying degrees of its efficiency or strength. A general rule to follow is to use a knot, bend, or hitch for temporary work and use a splice for permanent work because it retains more of the line's strength.

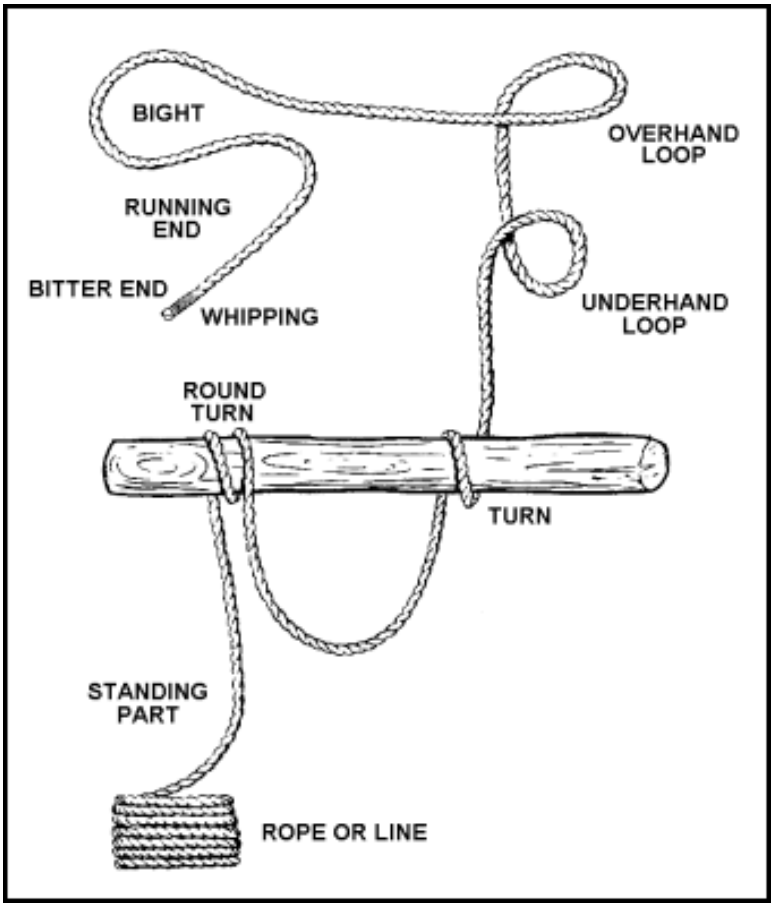


Figure 12-10. Elements of the Knot, Bend, and Hitch

OVERHAND KNOT

12-35. The overhand knot (Figure 12-11) is the basis for all knots. It is the simplest of all and the most commonly used. It may be used to prevent the end of a line from untwisting, to form a knot at the end of a line, or to be part of another knot. When tied to the end of a line, this knot will prevent it from running through a block, hole, or other knot.

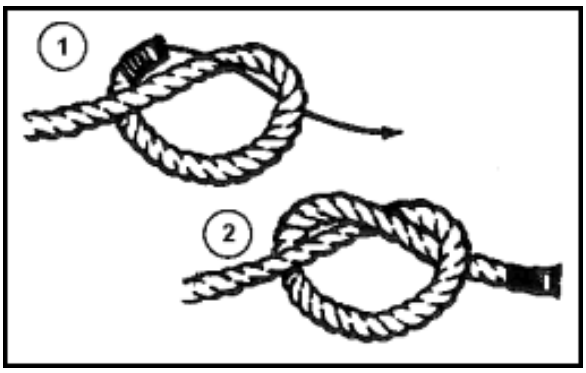


Figure 12-11. Overhand Knot

FIGURE EIGHT KNOT

12-36. The figure eight knot (Figure 12-12) is used to form a larger knot at the end of a line than would be formed by an overhand knot. It is used to prevent the end of the line from running through a block. It is an easy knot to tie.

12-37. To tie this knot, form an overhand loop in the line and pass the running end under the standing part, up the other side, and through the loop. Tighten the knot by pulling on the running end and the standing part.

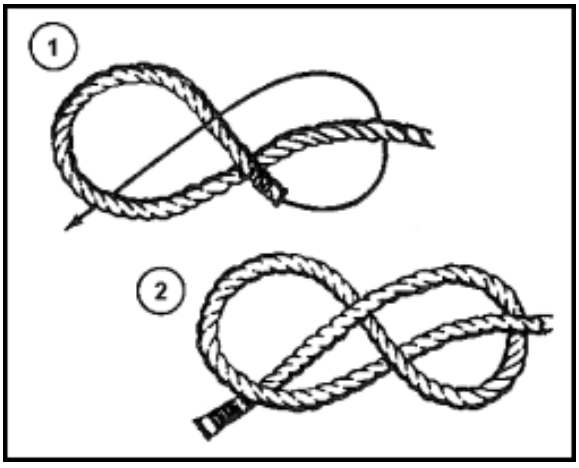


Figure 12-12. Figure Eight Knot

SQUARE KNOT

12-38. Use the square knot (Figure 12-13) to tie two lines of equal size together so that they will not slip. Figure 12-13 shows that for the square knot, the end and standing part of one line come out on the same side of the bight formed by the other line. This knot will not hold if the lines are wet or are of unequal sizes. It tightens under strain but can be untied by grasping the ends of the two bights and pulling the knot apart. Its strength is 45 percent.

12-39. To avoid a "granny" or a "fool's knot" which will slip, follow this procedure. Take the end in your right hand and say "over and under." Pass it over and under the part in your left hand as shown in Figure 12-13. With your right hand, take the end that was in your left hand. This time say to yourself "under and over." Pass it under and over the part in your left hand.

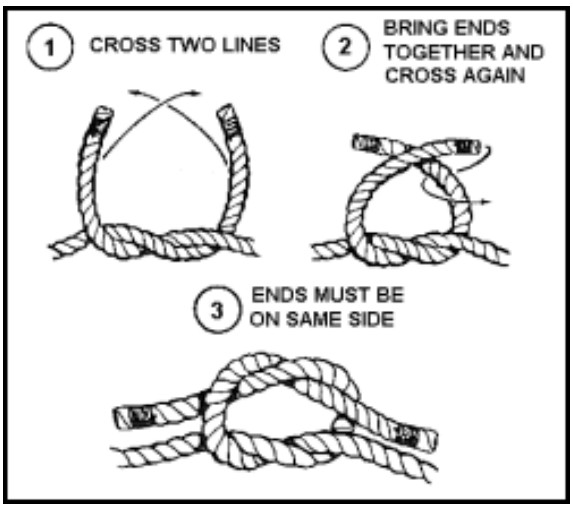


Figure 12-13. Square Knot

SHEET OR BECKET BEND

12-40. Use a single sheet or becket bend to tie two lines of unequal size together and to tie a line to an eye. Always use a double sheet or becket bend to tie the gantline to a boatswain's chair. The single sheet or becket bend will draw tight, but will loosen when the line is slackened. The single sheet or becket bend is stronger than the square knot, with a strength of 55 percent, and is more easily untied than the square knot.

12-41. To tie a single sheet or becket bend (Figure 12-14), take a bight in the larger of the two lines. Using the smaller of the two lines, put its end up through the bight. Then put it around the standing part of the larger line first because it will have the strain on it and then around the end of the larger line. Next put the end of the smaller line under its standing part. The strain on the standing part will hold the end. Notice in the double sheet or becket bend that the end of the smaller line goes under its standing part both times.

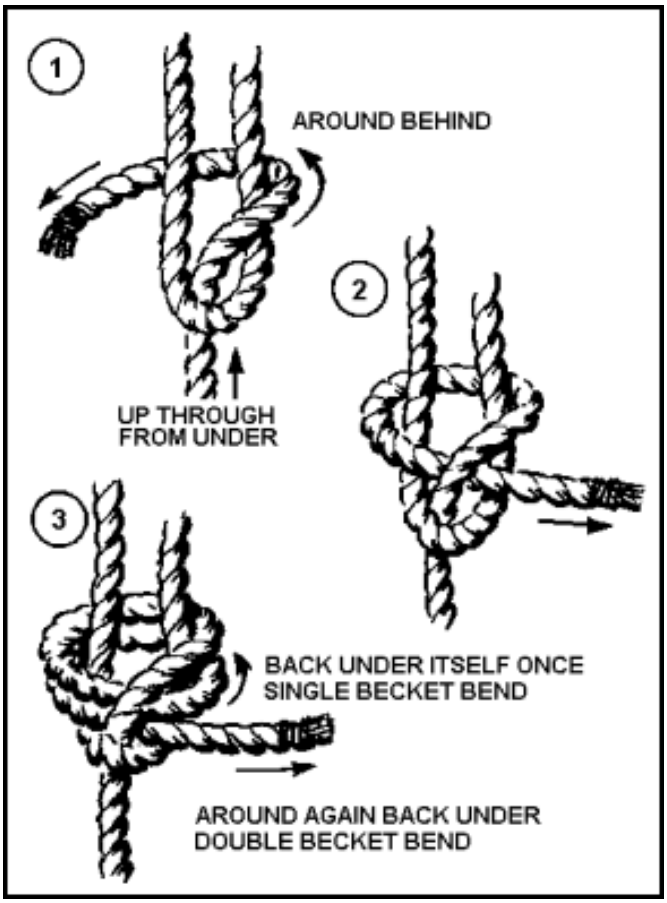


Figure 12-14. Tying the Single and Double Sheet or Becket Bend

BOWLINE

12-42. User the bowline to tie a temporary eye in the end of a line. A bowline neither slips nor jams and unties easily. An example of a temporary use is that of tying a heaving line or messenger to a hawser and throwing it to a pier where line handlers can pull the hawser to the pier, using the heaving line or messenger.

12-43. To tie a bowline (Figure 12-15), hold the standing part with your left hand and the running end with your right. Flip an overhand loop in the standing part, and hold the standing part and loop with the thumb and fingers of your left hand. Using your right hand, pass the running end up through the loop, under the standing part, and down through the loop. Its strength is 60 percent.

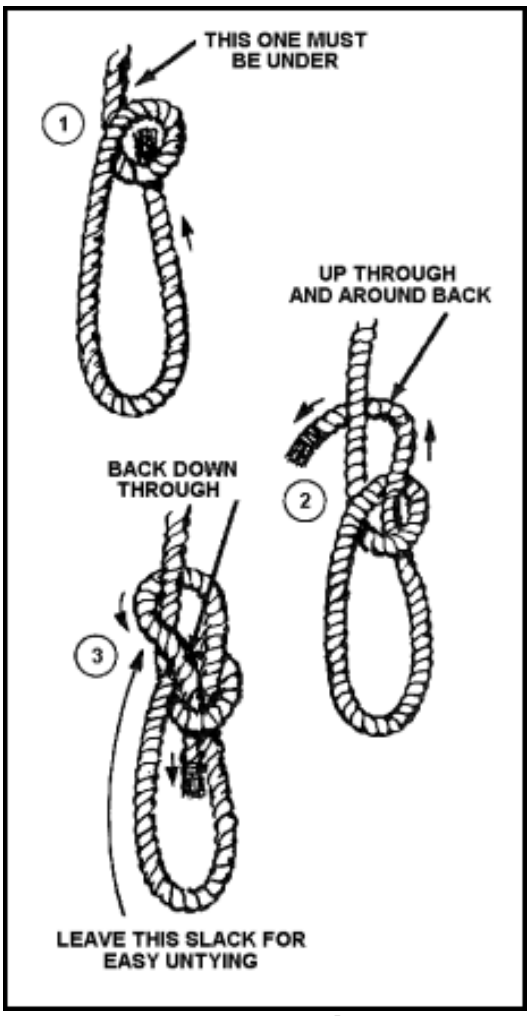


Figure 12-15. Tying a Bowline

BOWLINE ON A BIGHT

12-44. A bowline on a bight gives two loops instead of one, neither of which slips. It can be used for the same purpose as a boatswain's chair. It does not leave both hands free, but its twin, nonslipping loops form a comfortable seat. Use the bowline on a bight when:

- Strength (greater than a single bowline) is necessary.
- A loop is needed at some point in a line other than at the end.
- The end of a line is not accessible.

The bowline is easily untied and can be tied at the end of a line by doubling the line for a short section.

12-45. To tie a bowline on a bight (see Figure 12-16) double the line, form an overhand loop, and

put the end of the bight through the loop. Put your hand through the bight, take hold of the bight under the loop, and pull it through the first bight to tighten the knot.

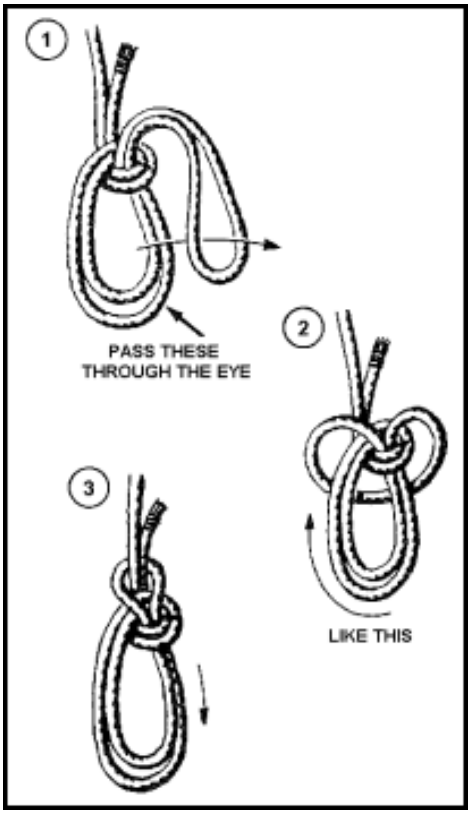


Figure 12-16. Typing a Bowline on a Bight

FRENCH BOWLINE

12-46. Use a French bowline as a sling for lifting an injured person. For this purpose, one loop is used as a seat and the other loop is put around the body under the arms, then the knot is drawn tight at the chest. Even an unconscious person can ride up safely in a properly secured French bowline, because his weight keeps the two loops tight so that he will not fall out. It follows, though, that it is necessary to take care not to allow the loop under his arms to catch on any projections. Also use the French bowline where a person is working alone and needs both hands free. The two loops of the knot can be adjusted to the required size. Figure 12-17 shows the step-by-step procedure for tying the French bowline.

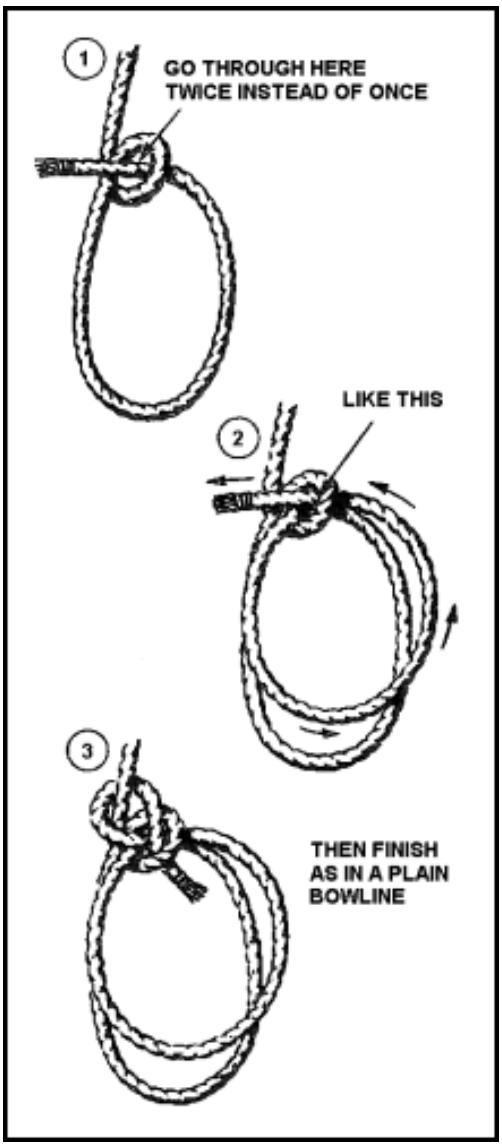


Figure 12-17. Typing a French Bowline

DOUBLE CARRICK BEND

12-47. A double carrick bend with its ends seized (Figure 12-18) is recommended for tying together two hawsers. Even after a heavy strain, it is easy to untie because it never draws up. Its strength is 56 percent. However, a double carrick will draw up if the ends are not seized.

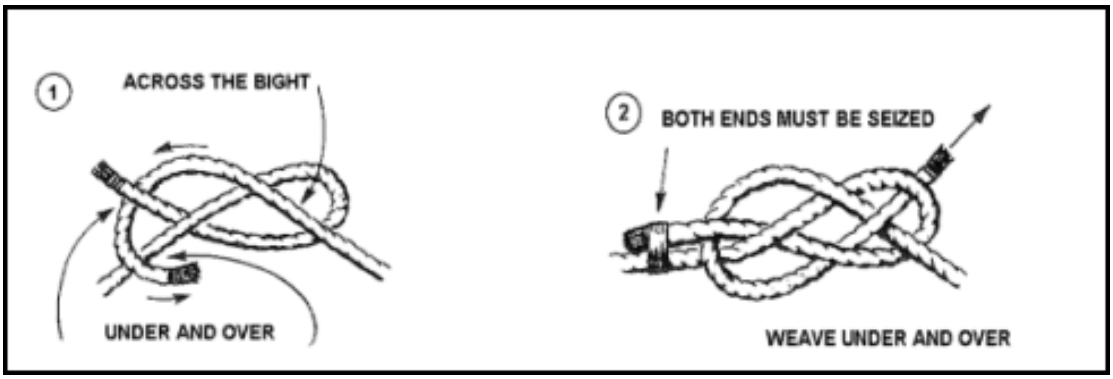


Figure 12-18. Tying the Double Carrick Bend

HALF HITCH

12-48. Use the half hitch to back up other knots, but tie with the short end of the line. Never tie two half hitches by themselves. Instead, take two round turns so that the strain will be on the line, not the hitches, and then tie the hitches (Figure 12-19).

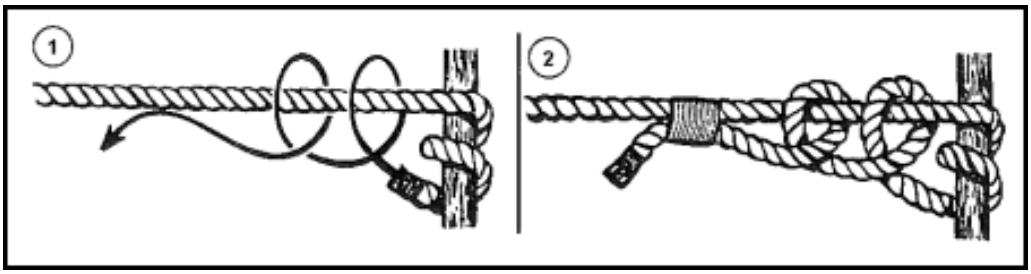


Figure 12-19. Half Hitch

CLOVE HITCH

12-49. The best knot for tying a line to a ring, a spar, or anything that is round is a clove hitch (Figure 12-20). It will not jam or pull out. Its strength is 55 to 60 percent.

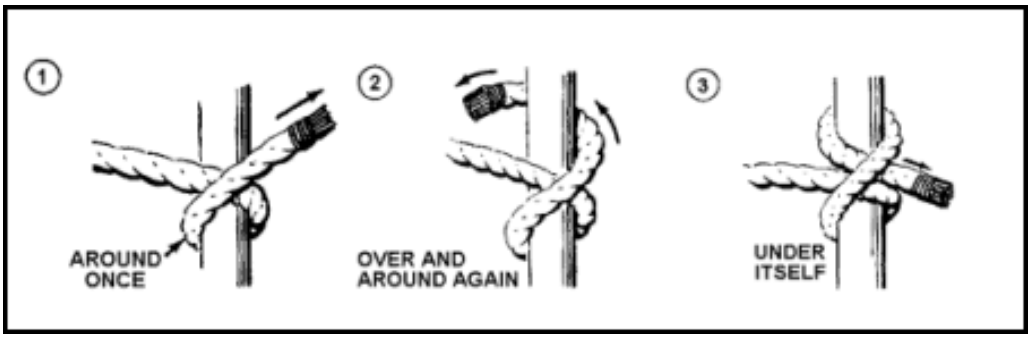


Figure 12-20. Clove Hitch

STOPPER HITCH

12-50. A possible defect of a clove hitch is that it can slide along the round object to which it is tied. To prevent this, use a stopper hitch (Figure 12-21), commonly called a rolling hitch.

12-51. When tying, make a turn around the line with the stopper (first view). Pull tight and take another turn. This one must cross the first turn and then pass between the first turn and the stopper (second view). This completes the stopper hitch itself, but it must be stopped off in one of two ways.

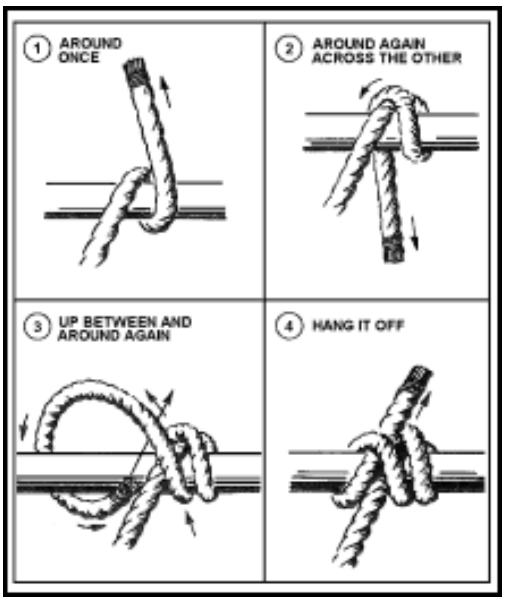


Figure 12-21. Stopper Hitch

12-52. You may make two or more turns with the lay of the line and then seize the stopper to the line with marline. Another method is to tie a half hitch directly above the rolling hitch (third view), and then take a couple of turns against the lay, and seize the stopper to the line.

STAGE HITCH

12-53. Use a stage hitch (Figure 12-22) for working over the side of a vessel. A stage hitch consists of a plank with a wooden horn attached at a right angle to the plank near each end to keep it away from the side.

12-54. Note that two parts of the line go under the plank. Therefore, the line supports the plank, as well as the horns. This gives more protection to persons working on the stage.

MONKEY FIST

12-55. The monkey fist (Figure 12-23) is tied at the end of a heaving line and a weight is put in it so that it can be thrown for a distance with some ease and accuracy. The monkey fist consists of three sets of turns taken at right angles to each other. For clarity, Figure 12-23 shows only three turns in each set; four turns per set are more likely to be used. To tie a monkey fist, start as in view 1, taking a set of turns around your hand. Then slip this set off your hand, hold it as shown in view 2, and pass the running end over your thumb and under and over the first set. Complete this set of turns. Put the last set around the second and through the first as shown in view 3. Note that the first turn of the last set locks the first two sets in place.

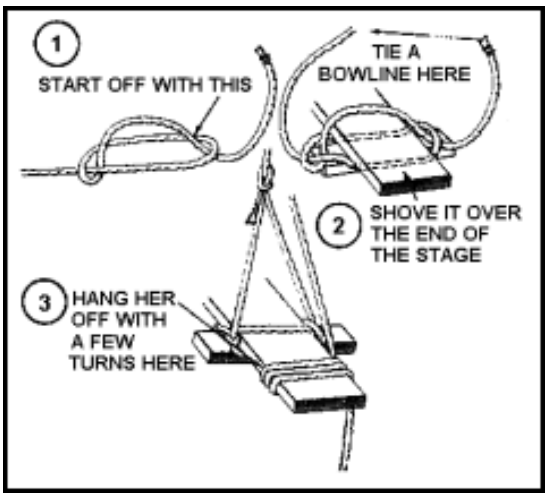


Figure 12-22. Stage Hitch

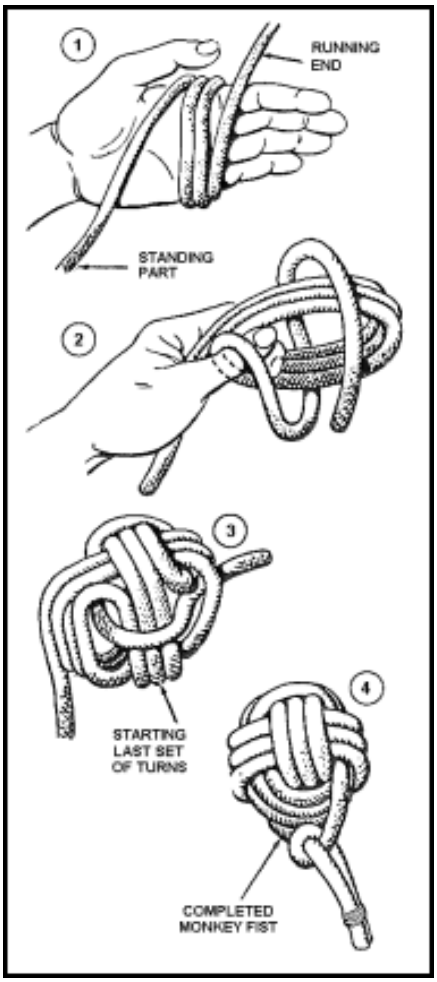


Figure 12-23. Monkey Fist

12-56. After completing the third set of turns, insert a 5- to 10-ounce weight in the monkey fist. Tighten the turns by working the slack back towards the standing part. In a properly tied monkey fist, the ends come out at opposite corners as shown in view 4. To complete the monkey fist, put a half hitch on the standing part with the running end and seize it to the standing part.

SPLICING THREE-STRAND FIBER LINE

12-57. Splicing is a method of permanently joining the ends of two lines or of bending-a line back on itself to form a permanent loop or an eye. If two lines are going to be spliced, strands on an end of each line are unlaid, and the strands are interwoven with those of the standing part of the line. Small stuff can be spliced without need of a fid. A fid is a tapering length of hickory or some other hard wood used in splicing larger lines. A knife is needed to cut off the ends of the strands. This paragraph explains and shows the back, short, and eye splices.

BACK SPLICE WITH A CROWN KNOT

12-58. Where the end of a fiber line is to be spliced to prevent unlaying and a slight enlargement of the end is not objectionable, use a back splice. This splice is usually done on small stuff. To make this splice, do the following:

- **Step 1.** Unlay six turns of the line (Figure 12-24).
- **Step 2.** To start the crown knot, form a bight with the left strand and lay the bitter end of the strand between the right and center strand. Then lay the center strand over the running end of the left strand. Take the right strand under the running end of the left strand, over the running end of the center strand, and back through the bight of the left strand. Then take all the slack out of the strands and gently pull the strands tight (Figure 12-25).
- **Step 3.** Start the left strand; go over one strand, tuck under the next one, and pull the strand tight (Figure 12-26).
- **Step 4.** Turn the line and tuck each strand. Three complete tucks are required for each strand (Figure 12-27).
- **Step 5.** Trim off the ends of the strands. Then lay the splice on the deck, put your foot on it, and roll it back and forth. This will tighten up and smooth out the splice.

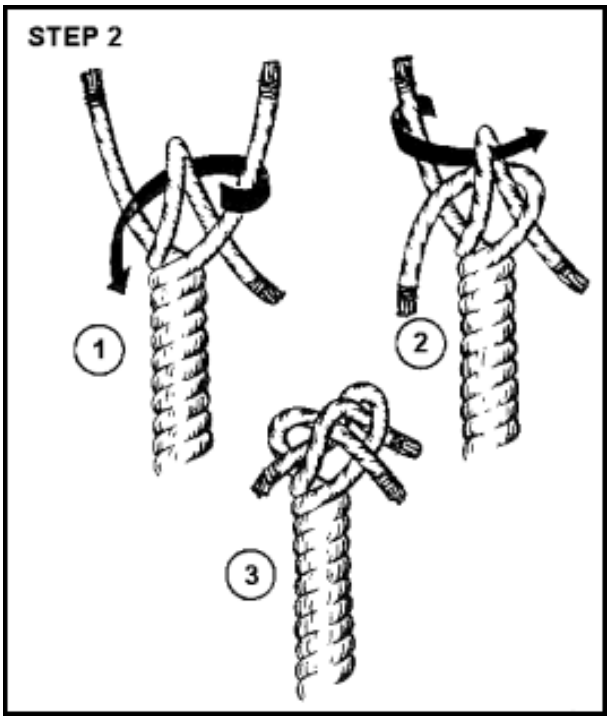


Figure 12-24. Making a Back Splice, Step 1

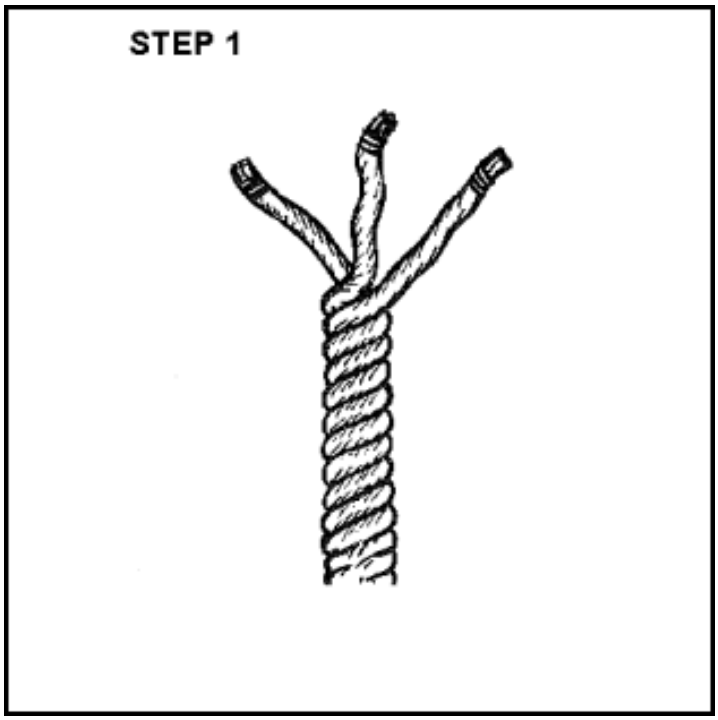


Figure 12-25. Making a Back Splice, Step 2

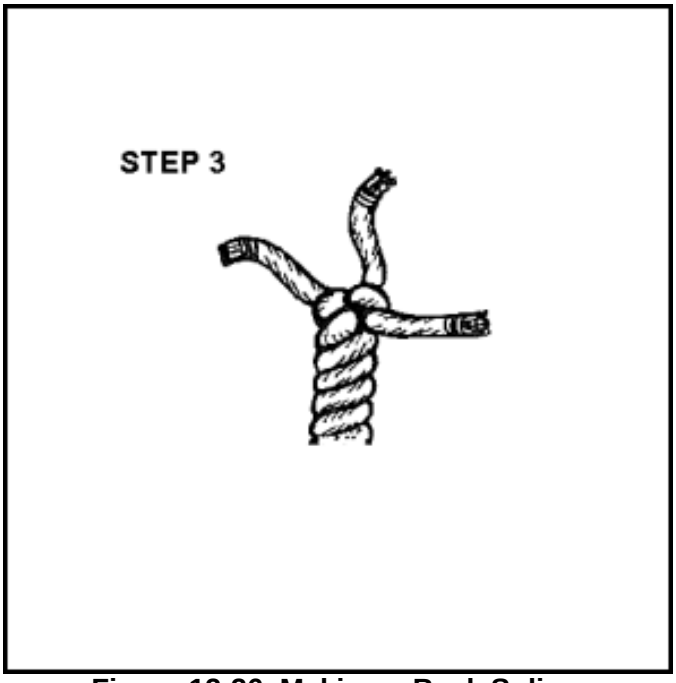


Figure 12-26. Making a Back Splice, Step 3

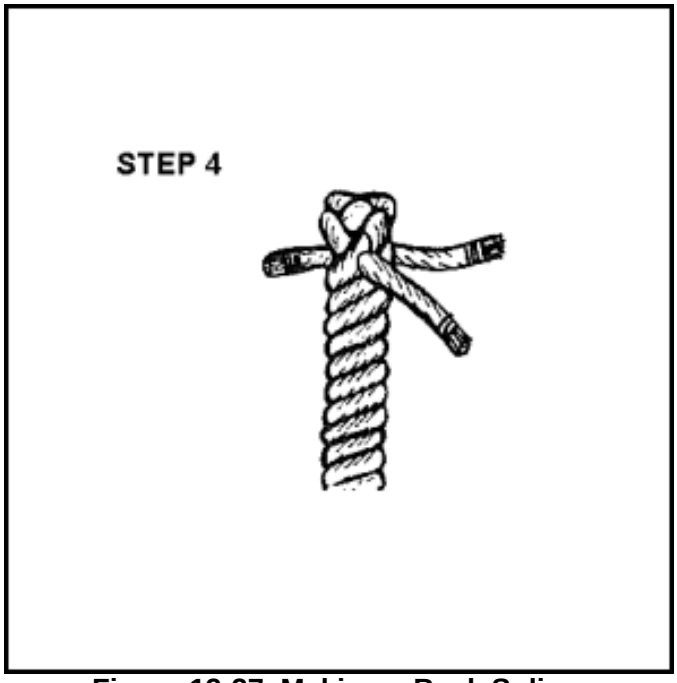


Figure 12-27. Making a Back Splice, Step 4

SHORT SPLICE

12-59. The short splice (Figure 12-28) is as strong as the rope of which it is made. However, the short splice will increase the diameter of the line at the splice and can be used only where this increase in diameter will not affect the operation. Use the short splice to repair damaged lines. The damaged parts of the line are cut out and the short splice rejoins the line. Only lines of the same size can be joined together using the short splice.

12-60. Do the following to make a short splice (see also Figure 12-28):

- **Step 1.** Untwist one end of each line five complete turns. Whip or tape each strand. Bring these strands tightly together so that each strand of one line alternates with a strand of the other line. Put a temporary whipping on the lines where they join to keep them from suddenly coming apart. Do this with small lines until you are skilled enough to hold them together while you tuck.
- **Step 2.** Starting with either line, tuck a round of strands in the other line. Then, using the strands of the other line, tuck a round in the first line. These first two rounds of tucks are expressed: "Tuck in one direction. Reverse and tuck in the other direction." When making a round of tucks, regardless of the direction, face where the lines are butted so to always tuck from right to left. Pull each strand as required to tighten the center of the splice.
- **Step 3.** Tuck two more rounds in each direction. After tucking in one direction and reversing and tucking in the other direction, pull the strands as required to strengthen the center of the splice. When finished with three rounds of tucks in each direction, cut off any excess length on the strands. To have a smoother splice, you may cut off one-third of the circumference of each strand before making the second round of tucks and another one-third cut before the third round.
- **Step 4.** When the splice is completed, cut off the excess strands as before. Lay the splice on the deck and roll it with your foot to smooth out and tighten the splice.

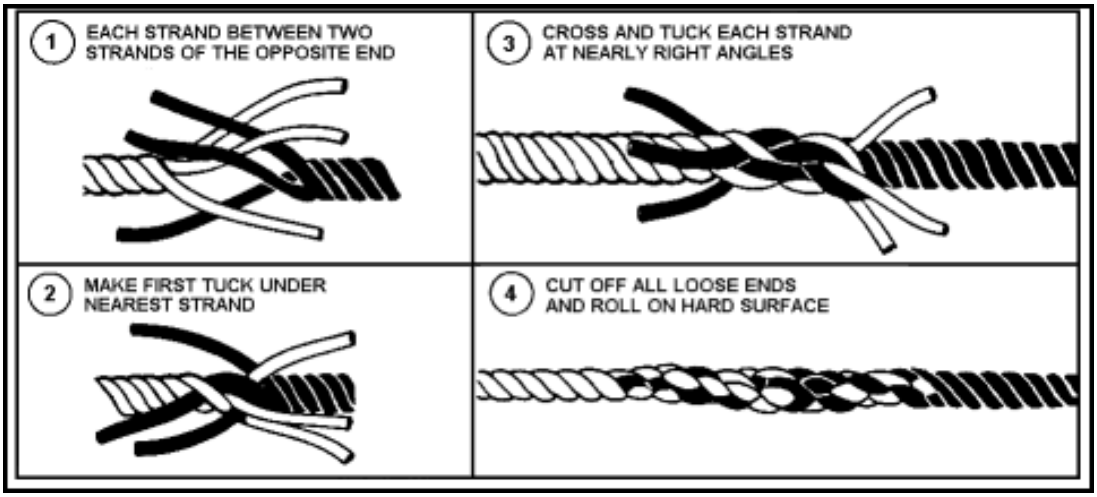


Figure 12-28. Making a Short Splice

EYE SPLICE

12-61. When a loop is to be permanent, put in the line with an eye splice, which has a strength of 90 to 95 percent. Compare this with the strength of a bowline of 60 percent.

12-62. Unlay (untwist) the strands four to five turns and splice them into the standing part of the line by tucking the unlaid strands from the ends into the standing part. Whip or tape the ends of the strands. An original round of tucks with two more complete rounds is enough because, if the line parts, it will likely part in the eye rather than in the splice. For this reason, three rounds are as effective as a greater number. Do the following to make an eye splice:

Note: Always whip or tape the ends of the strands before starting; otherwise they will unlay. Seize large lines at the point where unlaying stops to avoid trouble working with them. With up to 21 threads, you can open the strands in the standing part with your fingers. Use the fid for larger lines.

- **Step 1.** Figure 12-29 shows how to make the first two tucks. Separate the strands in the end and hold them up as shown. Place the three unlaid strands against the standing part where they will be tucked, forming an eye the size you need. Always tuck the middle strand facing you first. Put a reverse twist on the standing part so that you can raise the strand under which you will make the first tuck. Pick up the strand that you will tuck, and tuck it under the strand raised. Always tuck from right to left or with the lay of the line.
- **Step 2.** Be sure to keep the next strand on the side of the line that is towards you. Tuck that one next. Put it over the strand under which the first one is tucked, and tuck it under the next one (Figure 12-30).
- **Step 3.** Now turn the incomplete eye over as shown. Check the third strand to be sure that it has not unlaid more. If it has, twist it back to where it should be. Take the last strand and put it across the standing part, turn its end back toward you, put it under the strand over which the first tuck was made, and tuck it in a direction toward you. This results in the third tuck going to where the second came out and coming out where the first went in. After this round of tucks, there is a strand in each lay (Figure 12-31).

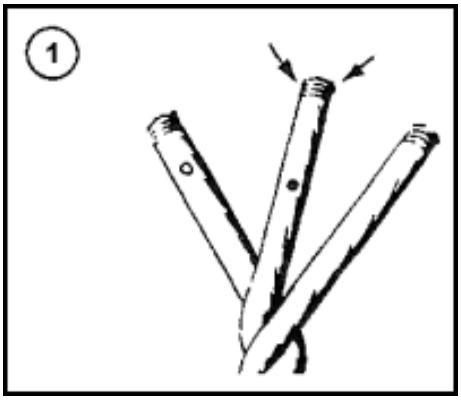


Figure 12-29. Selecting the Middle Strand

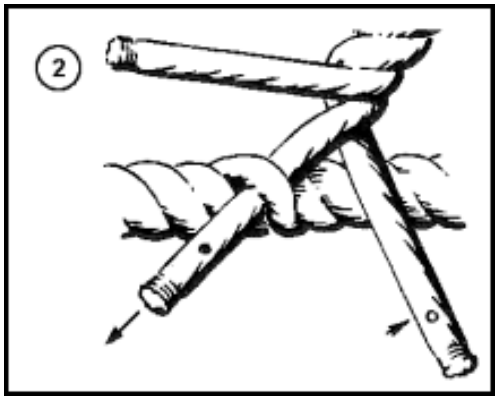


Figure 12-30. First Two Tucks in an Eye Splice

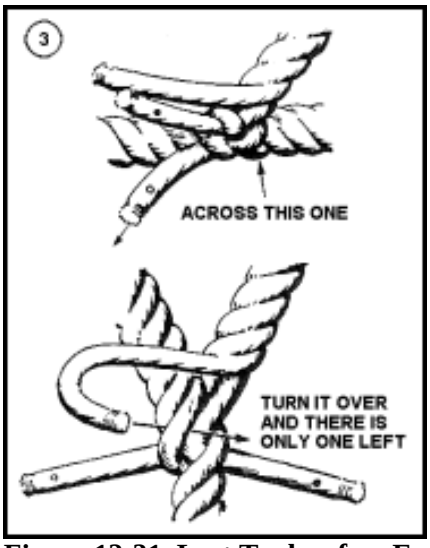


Figure 12-31. Last Tucks of an Eye Splice

12-63. Pull each of the three strands tucked backward at about a 45-degree angle to the eye to tighten the splice.

12-64. The first round of tucks is the key to making perfect eye splices. Starting with any strand, simply tuck each one over and under two more times. None of the last two rounds of tucks requires "over and back." However, always tuck from right to left. As required, pull the tucked strands away from the eye and twist the splice and line to tighten them.

12-65. After finishing the splice, bend the end of each strand back toward the splice and, using a knife, cut it off, up, and away, leaving a one-fourth inch tip.

CARE AND USE OF WIRE ROPE

12-66. Wire rope is made of steel (the core is likely to be fiber). The grades in descending order of strength are: extra improved plow, improved plow, plow, and mild plow steel. Of these four grades, the Army uses improved plow steel extensively and plow steel to a lesser extent. The manufacturer stamps the grade on the reel. Because you cannot tell the grade of wire rope by looking at it, always treat it as plow steel.

MAKEUP OF WIRE ROPE

12-67. The basic unit of wire rope is the individual wire. Wires are laid together to form strands. The number of wires in a strand varies according to the purpose for which the rope is intended. Strands are laid around a core to form the wire rope (Figure 12-32).

12-68. The core may be a wire, hemp, or polypropylene (a synthetic fiber. Use wire rope, with a wire as its core, where high temperatures would damage hemp and polypropylene. New wire rope is made with polypropylene as the core. The core is a foundation to keep the wire rope round, is a shock absorber when the wire rope contracts under strain, and is a reservoir or place where a portion of the lubricant is stored.

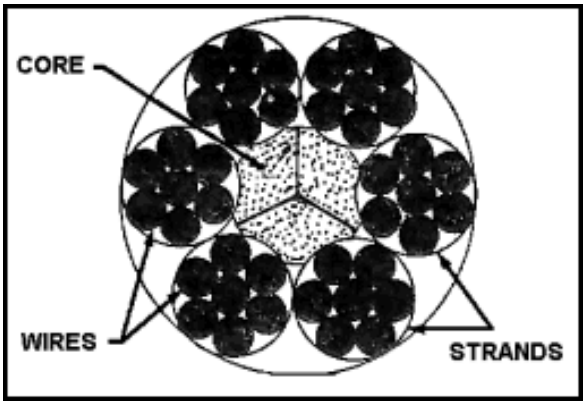


Figure 12-32. Makeup of Wire Rope

CLASSIFICATION

12-69. Wire rope is classified by the following:

- Number of strands.
- Number of wires per strand.
- Strand construction.
- Type of lay.

Strands and Wires

12-70. Standard wire rope has six strands. The present commercial classifications are not factually descriptive. Rather, they are groupings of wire ropes of similar weight, flexibility, and strength. Therefore, the 6 x 19 classification has 6 strands of wires per strand. The 6 x 37 classification has six strands and 37 wires in each strand. Figure 12-33 shows cross sections of four classifications. The smaller and more numerous the wires, the more flexible the rope, but the less resistant to external abrasion. Wire rope made up of a smaller number of larger wires is less flexible and more resistant to abrasion. All else being equal, two ropes of the same size have the same strength even though, for example, one is 6 x 19 and the other is 6 x 37.

Strand Construction

12-71. Wires and strands used in most wire rope are preformed. Preforming is a method of presetting the wires in the strands into the permanent corkscrew form they will have in the completed rope. As a result, preformed wire rope does not have the internal stresses found in non-preformed wire rope, does not untwist as readily as non-preformed wire rope, and is more flexible.

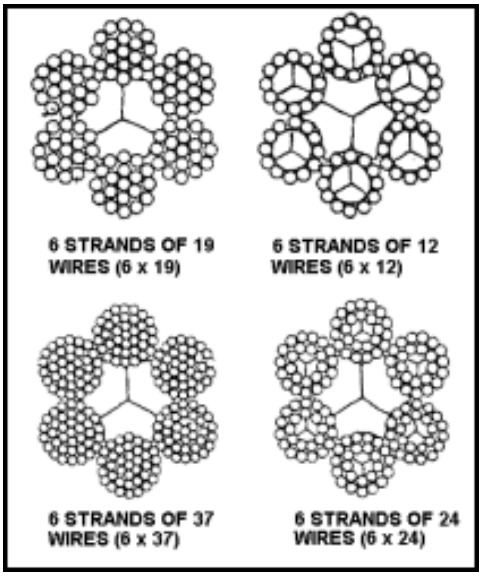


Figure 12-33. Strands and Wires

Types of Lay

12-72. Lay refers to the direction of winding of the wires in the strands and the strands in the rope. Both may be wound in the same direction or they may be wound in opposite directions.

12-73. In regular lay, the strands and wires are wound in opposite directions. Most common is the right, regular lay in which the strands are wound right and wires left. Use this lay in marine operations.

12-74. In Lang lay, the strands and wires are wound in the same direction. Use this type of wire rope on the blades of bulldozers and scrapers.

MEASUREMENT

12-75. Whatever its grade, wire rope is usually measured by its diameter. Figure 12-34 shows the correct and incorrect methods of measuring the diameter of wire rope. To measure wire rope correctly, place it in the caliper so that the outermost points of the strands will be touching the jaws of the caliper. Because of friction and tension, the diameter of used wire rope will be 1/64- to 1/8-inch less than when new.

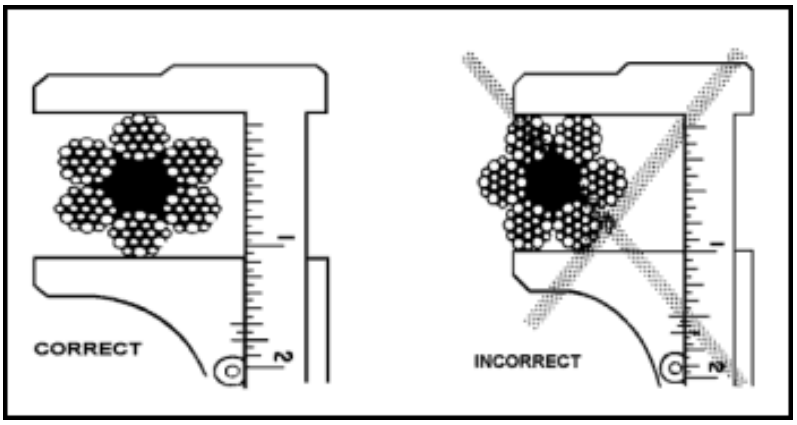


Figure 12-34. Measuring Wire Rope

SAFE WORK LOAD AND BREAKING STRENGTH

12-76. Useful formulas for determining the SWL of several grades of wire rope have constants not to be confused with safety factors. For example, the formula for the SWL in short tons (2,000 pounds) for extra improved plow steel wire rope is diameter squared times 10 or SWL = D^2 X 10.

12-77. To find the SWL of 1-inch, 6 X 19, extra improved plow steel wire rope:

SWL = D^2 X 10 = 1 X 1 X 10 = 10 STON

12-78. A figure relatively constant in marine operations, especially for new wire rope, is the safety factor. The safety factor is 5. Use the SF with the SWL to find the breaking strength or strain.

BS = SWL X 5 BS = 10 X 5 = 50 STON

12-79. The formulas for improved plow steel, plow steel, and mild plow steel (6 X 19 wire rope) are as follows:

- Improved plow steel.
  SWL = D^2 X 8 = STON
  BS = SWL X SF = STON

- Plow steel.
  SWL = D^2 X 7 = STON
  BS = SWL X SF = STON

- Mild plow steel.
  SWL = D^2 X 6 = STON
  BS = SWL X SF = STON

INSPECTION

12-80. Inspect wire ropes frequently and replace frayed, kinked, worn, or corroded ropes. How frequently rope should be inspected depends on the amount of its use. A rope used 1 or 2 hours a week requires less frequent inspection than one used 24 hours a day.

12-81. The common causes of wire rope failures are the following:

- Using rope of incorrect size, construction, or grade.
- Allowing rope to drag over obstacles.
- Operating over sheaves and drums of inadequate size.
- Overwinding or crosswinding on drums.
- Operating over sheaves and drums out of alignment.
- Permitting rope to jump sheaves.
- Subjecting rope to moisture or acid fumes.
- Permitting rope to untwist.
- Using kinked rope.

12-82. Carefully inspect weak points and points of greatest stress. Worn or weak spots show up as shiny flat spots on the wires. If the outer wires have been reduced in diameter by one-half, the wire rope is unsafe.

12-83. Broken wires also show where the greatest stress occurs. If individual wires are broken next to one another, unequal load distribution at this point will make the rope unsafe. These broken wires are called "fishhooks." To determine the extent of damage to the wire rope, slide your finger along one strand of wire for one complete turn, which is equal to the length of one wire rope lay. Count the number of "fishhooks." If you count eight or more "fishhooks," replace the wire rope immediately. Any time you find six to eight "fishhooks" with the measured area, you will consider the wire rope

unsafe and should have it replaced.

UNREELING

12-84. When removing wire rope from a reel or coil, be sure to rotate the reel or coil (Figure 12-35). If the reel is mounted, unwind the wire rope by holding the end and walking away from the reel. If a wire rope is in a small coil, stand the coil on end and roll it along the deck, barge, wharf, or ground. Be sure to remove any loops that may form, although the reason for rotating the reel or coil is to avoid loops.

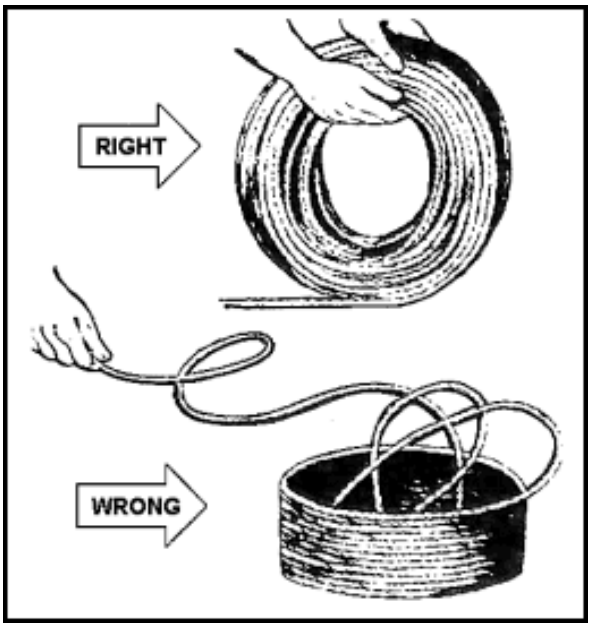


Figure 12-35. Uncoiling Wire Rope

SEIZING

12-85. Seize all wire rope before cutting. If the ends of the rope are not properly secured, the original balance of tension is disturbed and maximum service cannot be obtained because some strands carry a greater load than others. Use annealed wire for the seizings. Figure 12-36 shows the steps on how to seize wire rope. The turns of the annealed wire rope should be put on close and tight so that it will not be necessary to tighten them when the ends are being twisted together. It is well to twist the ends together at one end of the seizing so that the completed twist can be tapped into the groove between two strands where it is less likely to be knocked off.

12-86. There are three formulas for determining the number and length of seizings and the space between them. When a calculation results in a fraction, use the next larger whole number. The following formulas are based on a wire rope with three-fourths inch diameter:

12-87. The number of seizings required equals about three times the diameter of the rope. For example:

3 X 3/4 = 2 1/4 or 3 seizings

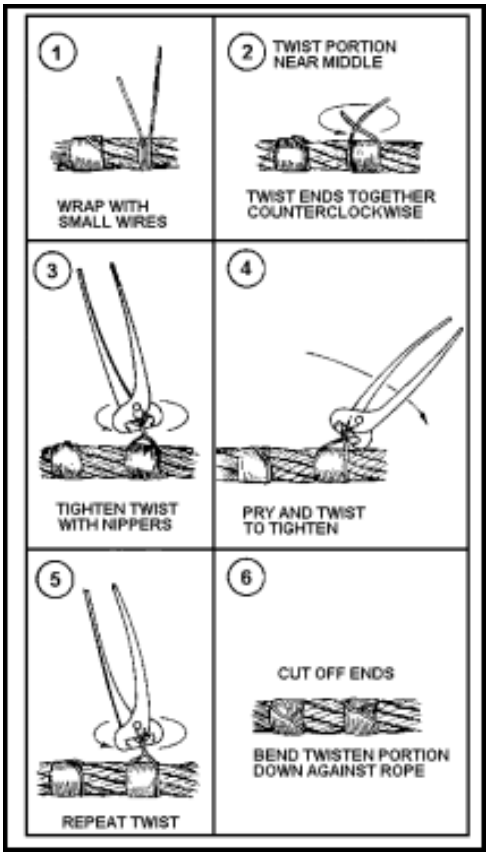


Figure 12-36. Seizing Wire Rope

12-88. Because the rope will be cut, six seizings are required so that there will be three on each rope end after the cut. The length of a seizing should be equal to the diameter of the rope. For example: 1 X 3/4 = 3/4 or 1 inch

12-89. The seizings should be spaced apart at a distance equal to twice the diameter. For example: 2 X 3/4 = 1 1/2 or 2 inches.

CUTTING

12-90. Wire rope may be cut with a wire rope cutter, a cold chisel, a hacksaw, bolt clippers, or an oxyacetylene cutting torch.

12-91. After seizing the wire rope, insert it into the cutter with the blade coming between the two central seizings. Close the locking device. Then, close the valve on the cutter and pump the handle to build up enough pressure to force the blade through the rope.

12-92. Use the bolt clippers on wire rope of fairly small diameter. However, the oxyacetylene torch can be used on wire of any diameter. Cutting with the hacksaw and cold chisel is slower than cutting with the other tools and equipment.

COILING

12-93. It may be necessary to take a length of wire rope from a reel and coil it down before using. Small loops or twists will form if the wire rope is coiled in a direction opposite to the lay. To avoid them, coil right lay wire rope clockwise and left lay counterclockwise. When a loop forms in the wire, put a back turn in as shown in Figure 12-37.

SIZE OF SHEAVES AND DRUMS

12-94. Two things happen when a wire rope is bent over a sheave or drum:

- Each wire is bent to conform to the curvature.
- The wires slide against each other longitudinally because the inside arc of the rope against the sheave or drum is shorter than the outside arc.

The smaller the diameter of the sheave or drum, the greater the bending and sliding. This bending and moving of wires should be kept to a minimum to reduce wear.

12-95. The minimum recommended sheave and drum diameter is 20 times the diameter of the rope. For example, determine the minimum sheave diameter for 6/8-inch rope:

20 X 5/8 = 12 1/2 inch sheave

If a 12 1/2-inch sheave is not on hand, use the next larger size. Never use a smaller size.

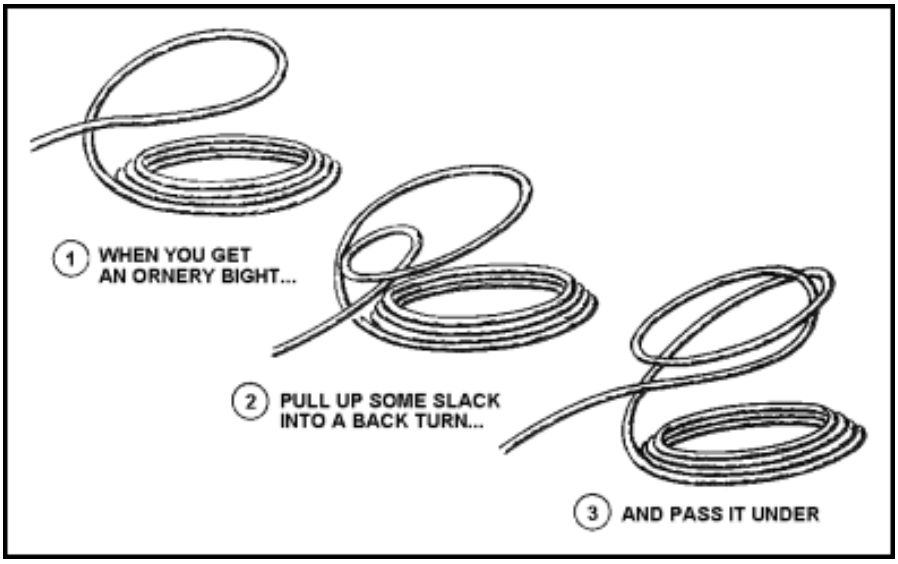


Figure 12-37. Putting a Back Turn in Wire Rope

LUBRICATION

12-96. Wire rope is lubricated when it is manufactured. The lubricant generally does not last throughout the life of the rope, which makes relubrication necessary. Crater "C" compound is recommended, but oil on hand may be used rather than delaying lubrication. Always lubricate as often as necessary. Heat Crater "C" compound before putting it on the wire rope. When lubricating, use a brush if one is on hand. If not, use a sponge or cloth, but look out for "fishhooks" or broken wires.

REVERSING ENDS

12-97. It is sometimes wise to reverse ends or cut back the ends to get more service from wire rope. Reversing ends is more satisfactory than just cutting ends because frequently the wear and fatigue on a rope are more severe at certain points than at others. Reversing distributes other, stronger parts of the rope to the points getting wear and fatigue. To reverse ends, remove the drum end and put it in the attachment. Then fasten the end taken from the attachment to the drum. Cutting back the ends has a similar effect, but there is not as much change involved. In reversing ends, cut off short lengths of both ends to remove the sections that have sustained the greatest local fatigue.

STORAGE

12-98. Wire rope should be coiled on a spool for storage. Attach a tag to the rope or spool to show its grade, size, and length. Store wire rope in a dry place to reduce corrosion. Do not store it with chemicals or where chemicals have been stored because both chemicals and their fumes might attack the metal. Always clean and lubricate wire rope before storing.

Continue Chapter 12

Chapter 13

Deck Maintenance

Vessel maintenance includes inspecting, cleaning, servicing, preserving, lubricating, and adjusting (as required). It can also require minor parts replacement within the capability of the crew. As a watercraft operator, you must take an active part in keeping your vessel at its peak operating condition. This is not an easy or simple task because you are constantly battling against the corrosive effects of salt water and salt air. The wind and sea also subject a vessel and its engines to strong stresses and strains. It takes day-by-day work and watchfulness to cope with all of these conditions. Maintenance never ceases. This chapter covers the procedures and tools to be used for preventive maintenance and the required maintenance aboard ship. It should be used as a guide for all watercraft personnel responsible for shipboard maintenance.

PREVENTIVE MAINTENANCE

13-1. These are the routine daily tasks that must be done aboard ship to prevent, or at least to hold back, the formation of rust or deterioration of the ship's equipment. The first and most important step in proper maintenance is to keep a vessel clean. This is necessary to good health and efficient operation.

DECKS

13-2. Wash and scrub decks often to prevent tracking dirt throughout the vessel. If it can be obtained, canvas or cocoa matting can be laid on the deck wherever people walk. Scuppers must be kept clean and open so water can flow overboard freely and not leak into spaces below.

TOPSIDES

13-3. Topsides and superstructure must be washed often, using fresh water when possible. A small amount of washing soda can be added to the wash water to help in the cleaning. Parts washed with soda and water must be given a final washdown with fresh water, if possible, or salt water.

INTERIOR

13-4. See that quarters are cleaned daily, giving close attention to dark corners and spaces blocked by lockers and other furnishings. Dirt collecting in these spaces results in unsanitary conditions where vermin can breed and rot can develop.

BILGES

13-5. The rounded parts of a vessel's bottom, known as the bilges, collect water, oil, fuel, trash, and so on. Keep them clean and well aired because dirty bilges are a fire hazard, produce disagreeable odors, and are harmful to vessels.

CARGO HOLDS

13-6. Keep cargo holds clean. Stow and secure excess dunnage. Trace and eliminate sources of fumes and odors.

HAND TOOLS AND THEIR USE

13-7. These tools must be cared for and used properly to get the most use from them. Safety in their use must also be stressed at all times.

HAND TOOLS

13-8. The following are the most commonly used hand tools found aboard ship:

- Chipping hammer.
- Wire brush.
- Hand scrapers.
- Portable electric grinder.
- Sandpaper.

The use of each of these tools is described below.

Chipping Hammer

13-9. Before letting anyone use this hammer, make sure they have been instructed on how to use only enough force to remove the paint. If a great deal of force is required to remove paint, the paint is still good and should not be chipped off. Feather the edges and paint.

Wire Brush

13-10. This is a handy tool for light work on rust or on light coats of paint. It is also used for brushing around weld spots. When the surface is pitted, use a steel wire brush to clean out the pits.

Hand Scrapers

13-11. These are more useful for removing rust and paint from small areas and from plating less than one-fourth inch thick, where it is impractical or impossible to use power tools.

Sandpaper

13-12. Sandpaper can be divided into two types of abrasive materials: natural and artificial. The flint and garnet grits of ordinary sandpaper are natural abrasives. Emery and corundum are also used in the production of some of the cheaper grades of abrasive sheets. Artificial abrasives have largely replaced natural abrasives for use on metal. The two principal artificial abrasives are silicon carbide and aluminum oxide.

13-13. The size of abrasive particles is indicated by code numbers ranging from 4 to 5/0 (or 00000). In garnet and artificial abrasives, 4 or 3 would be a very coarse abrasive (16-24 mesh); 2 1/2 to 1 1/2 would be coarse (30-40 mesh); 1 to 0 would be medium (50-80 mesh); and 2/0 to 5/0 would be fine (100-180 mesh). In flint paper or emery cloth, 3 to 1 would be coarse; 1 1/2 to 1/2 would be medium; and 0 to 3/0 would be fine. You will find sandpaper indispensable in cleaning corners. The usual procedure is to go over the surface first with a coarse sandpaper and polish it with one of the fine grades. Do not polish any more than final finish requirements dictate, however, as paint bonds best to clean surfaces which are rough enough to provide "mechanical tooth."

13-14. There is also a waterproof type of sandpaper. This usually consists of a better grade of garnet grit, bonded (made to stick on the paper) with a special resin. These sheets may then be used with water or oil for wet sanding. Ordinary sandpaper will disintegrate when used with liquids.

SHARPENING SCRAPERS AND CHIPPING HAMMERS

13-15. Like other tools, scrapers and chipping hammers gives the best service when they are kept in good condition. Normally, this involves little more than sharpening the scrapers and hammers.

13-16. The first step in sharpening a scraper is to square the end. Adjust the tool rest of the grinder so that it just clears the face of the wheel (see Figure 13-1 [views 1 and 2]). First, lay the scraper flat on the rest. Then, keeping the end of the scraper parallel with the shaft of the grinder, move the scraper back and forth across the face of the wheel. Grind across the entire width of the scraper. Use enough pressure to keep the wheel cutting out but not enough pressure to decrease its speed or overheat the metal. Keep a can of water handy while grinding and dip the scraper frequently into the water (this helps to prevent the scraper from overheating and drawing the temper from the metal). If the scraper has been chipped, grind away the edge until the chips disappear.

13-17. With the end squared, begin to sharpen the scraper. Hold it in such a way that the original bevel lies flat against the face of the wheel (Figure 13-1, view 3). If the construction of the tool rest is such as to support it, hold your forefinger against the tool rest to serve as a guide as you pass the scraper back and forth across the wheel (Figure 13-1, view 4).

13-18. Sharpening any tool in this manner causes the sharp edge to curl back or feather. The last step in sharpening is to remove the feathered edge. This may be done by lightly touching the flat side of the scraper to the side of the wheel, but a better method is to remove the feather with a file that has a fine surface.

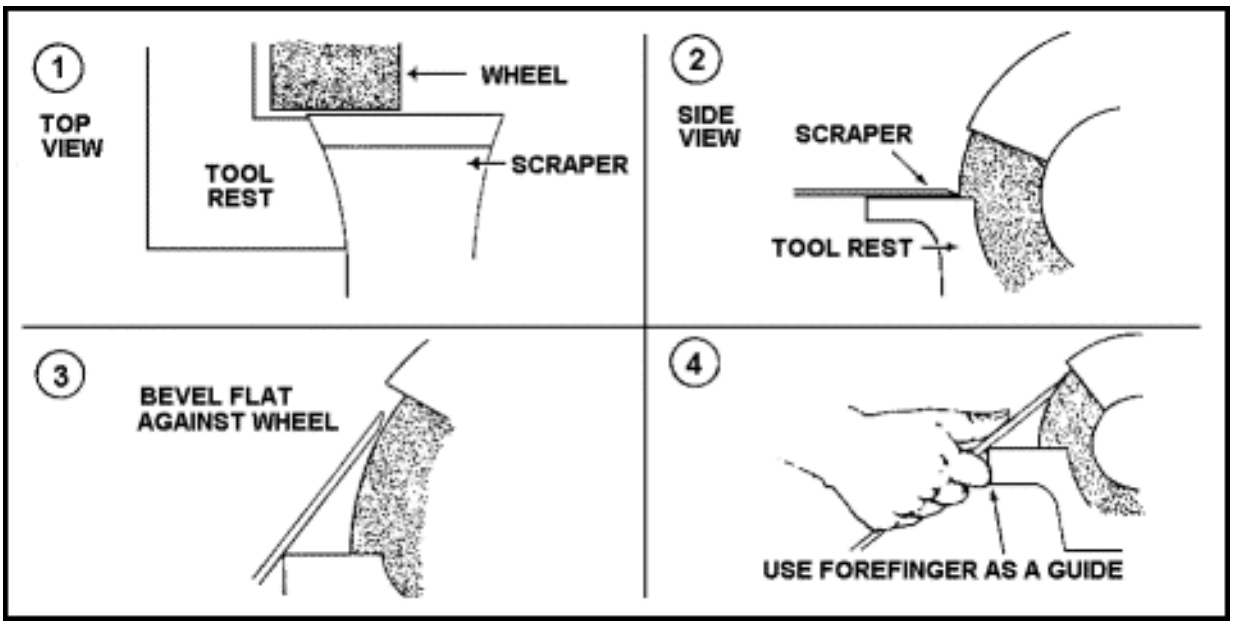


Figure 13-1. Sharpening the Scraper

13-19. A chipping hammer is not sharpened like a cutting tool but rather like the blade of an ice skate. First square the edge as described for scrapers. Then, as shown in Figure 13-2, grind away alternately on both bevels until the squared face is from one-sixteenth to one-eighth inch wide.

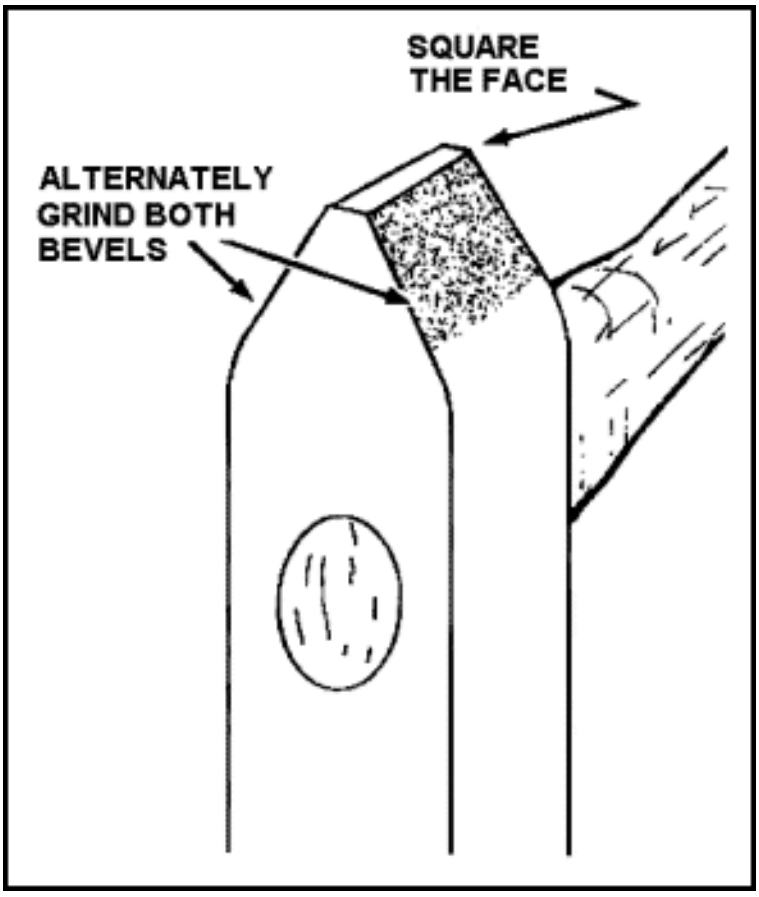


Figure 13-2. Sharpening a Chipping Hammer

POWER TOOLS

13-20. The most useful power tool for surface preparation is the portable grinder (Figure 13-3). This usually comes equipped with a grinding wheel. This brush can be replaced with either the rotary wheel wire brush or the rotary cup wire brush. Light-duty brushes are made of crimped wire and heavy-duty brushes are made of tufts of wire formed by twisting together several strands of wire.

13-21. Scaling may be done by either of the tools shown in Figure 13-4. A chisel about 8 inches long and 1 1/4 inches wide is used with the pneumatic hammer. The hammer is held so that the chisel strikes the surface at an angle of about 45 degrees. Great care must be taken not to dent the surface. Denting forms low and high areas. This can lead to early failure of the thin paint film deposited on the high points.

13-22. The rotary scaling and chipping tool, sometimes called a "jitterbug," is electrically powered and has a bundle of cutters or chippers mounted on either side. Use it by pushing it along the surface to be scaled and letting the rotating chippers do the work. Replacement bundles of cutters are available. Also available is a larger, heavier model of this tool, designed especially for scaling deck.

13-23. The electric disk sander is also a handy tool for surface preparation. Great care must be taken when using this machine. The disk should be moved smoothly and lightly over the surface. It should never be allowed to stay in one place too long because it will cut into the metal or wood.

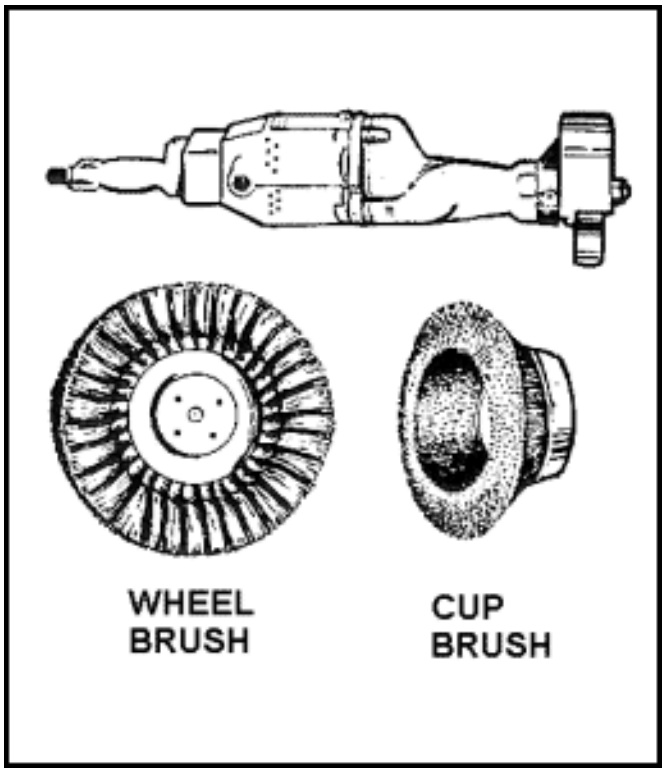


Figure 13-3. Electric Portable Grinder and Wire Brushes

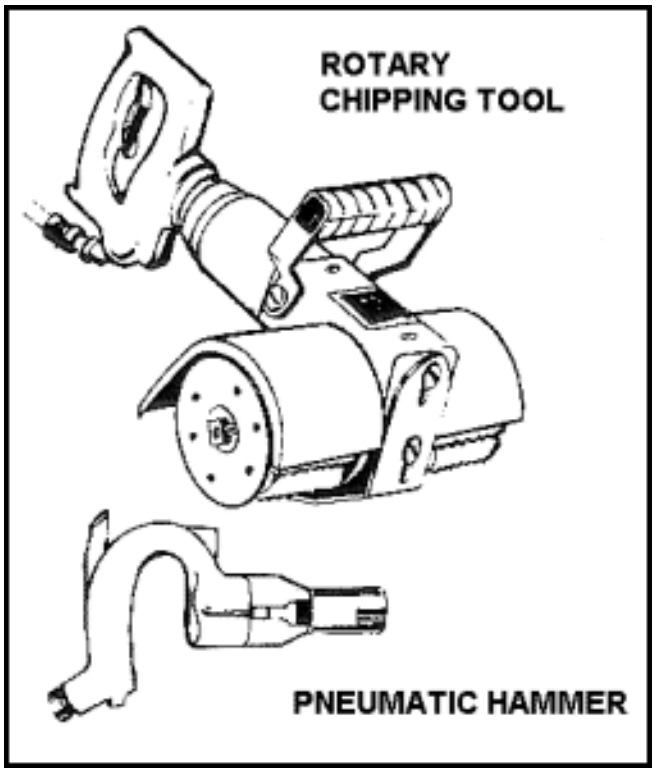


Figure 13-4. Power Scaling Tools

SAFETY PRECAUTIONS

13-24. Most electric tools are powered by 115-volt motors. Many people tend to regard 115 volts as not worthy of even moderate precautions. But make no mistake about it, 115 VOLTS CAN AND DOES KILL!

13-25. All electric power tools are of the three-wire, grounded type. However, the operator can still receive a shock if the insulation on the wires becomes defective due to age, abrasion, or defective repairs; the ground circuit is not complete; or the operator becomes grounded.

WARNING: NEVER ALLOW ANYONE TO OPERATE A POWER TOOL THAT IS NOT FUNCTIONING PROPERLY.

13-26. Always make sure that personnel wear goggles when using power tools. This is particularly important with wire brushes because strands of wire frequently break off and shoot through the air like tiny arrows, which can penetrate a person's skin with ease.

13-27. Insist that personnel give their full attention to the job and keep all parts of their bodies away from the working end of the tools. Keep nonessential personnel out of the area where power tools are in use. Always supervise work from behind the operators.

PAINTING

13-28. Paint is used primarily for preserving surfaces. It seals the pores of steel and helps to keep rust from forming. Paint also serves a variety of other purposes. It is valuable as an aid to cleanliness and sanitation because of its antiseptic properties and smooth, washable surface. Paint is also used to reflect, absorb, or redistribute light. For example, light-colored paint is used for the interior of the ship to distribute natural and artificial light to the best advantage. These same properties of reflection and absorption, incidentally, make camouflage painting possible.

COMPOSITION OF PAINT

13-29. Paint consists of four essential ingredients: pigment, vehicle, drier, and thinner. To make any paint, the pigment is ground into the vehicle and the drier is added. Thinner is then added to make the paint the proper consistency for use by brush, roller, or spray gun.

Pigment

13-30. The oldest of the opaque white pigments is white lead. White lead is no longer used in Army paint, although it is found in some commercial paints. It is made from acetic acid, carbon dioxide, and lead metal. The metal is corroded by the action of the other two ingredients until it becomes a fine, white powder. Linseed oil is usually added to this white lead to make a fine paste. It is then ready for use by the painter.

13-31. Another white pigment is zinc oxide. Zinc oxide, by itself, makes a film that is too hard and brittle to withstand the extreme changes of outdoor temperatures, which cause it to crack and scale off. Therefore, because of its very fine texture it is usually mixed with titanium dioxide and other pigments for exterior work.

13-32. Titanium dioxide and zinc oxide are now the principal white pigments in paints. Titanium dioxide is a white pigment with the highest known hiding power. Both titanium dioxide and zinc oxide are also considered "strengthening pigments" because they help increase the lasting quality of the paint in which they are used.

13-33. Paint extenders, or inert pigments, are chemically stable and do not affect the color or durability of the vehicle. Extenders are used to:

- Provide a less expensive base for certain kinds of colors.
- Decrease the amount of chemically active pigments in the paint.
- Reinforce the paint film.
- Limit spreading power and increase the thickness of the paint film.
- Make a good primer coat base for the finish coat.
- Help prevent settling or caking in the container.

Some of the more important extenders in common use are barium sulfate, calcium carbonate, whiting magnesium silicate or talc, and silica.

Vehicle

13-34. The vehicle, usually referred to as the base, is the liquid portion of a paint which acts as a binder and brushing medium for the pigment particles. It wets the surface to be painted, penetrating the pores and ensuring the adhesion of the film formed by the drying vehicle.

13-35. Until recently the base of most paints was an oil (such as linseed oil). Today few paints contain raw oils of any kind. Some have bases of processed oils in combination with synthetic resins; others have vinyl bases. Some fire-retardant paints have chlorinated alkyd bases; some high-performance paints have two-component epoxy or urethane bases. There are some that have water bases. Most oil-base vehicles dry partially by evaporation, partially by oxidation, and partially by polymerization. Polymerization is a process where two or more similar molecules combine chemically to form a larger molecule of a new substance. Older paints contained raw oils, had poorer physical properties when dry, and dried much slower than modern paints. For these reasons raw oils should never be added to paint. If the paint is thick and needs to be thinned, add some of the recommended thinner. Never add diesel oil, varnish, or other materials.

Drier

13-36. Certain metallic compounds, when mixed with oil, add to the drying properties of paint. These are called driers. A paint drier acts as a conveyor of oxygen, taking it from the air and adding it to the oil. This speeds the oxidation of the paint. Without the drier, absorption of oxygen would be too slow a process, and you would have to wait too long for the paint to dry.

Thinners

13-37. Thinners reduce the consistency of the paint to the proper degree for application by spraying or brushing. They also increase the penetration of the paint into the surface and reduces gloss. The vehicle will become diluted if too much thinner is used. As you will remember, the vehicle is the binder. So if it is diluted too much, the durability of the paint will be affected. In flat paints the proportion of oil to thinner is deliberately reduced so that the paint dries without gloss. The most common type of thinner is mineral spirits, but the proper type to use depends on the base of the paint.

MIXING PRECAUTIONS

13-38. Most paints you will be using will be ready-mixed. That is, when you draw them from the paint locker, they are ready for use. These paints have been carefully prepared to produce coatings that will be most satisfactory under the conditions in which the paints will be used.

13-39. Certain paints require mixing immediately before use. These are zinc-dust, water-tank paint, aluminum paint, and high-performance epoxy or urethane hull, tank, or nonskid deck paints (which contain more than one component). If the zinc-dust or aluminum paints were mixed and then stored, the heavier particles would settle to the bottom. The zinc-dust or aluminum paste should be added in exactly the quantity needed, and the paints should be stirred often during use. Multi-component epoxy or urethane paints have a limited "pot life" after mixing and will thicken or harden if not used within that time.

13-40. Aluminum and zinc-dust paints should always be freshly mixed just before use. If they are left standing any length of time after mixing, they lose the property of leafing. Leafing is the ability of the pigment to rise to the surface of the vehicle. In all cases, these paints should be used the same day as prepared. When kept in a sealed container, they have a tendency to become gaseous. The gases could rupture containers or blow the top off the can (presenting a danger to personnel). It could also result in a fire hazard as well as loss of the paint. So mix aluminum paint and zinc-dust paint only as needed, and use right away.

TYPES OF PAINT

13-41. There are many different kinds of paint. For example, you cannot use the same type of paint on the deck topside and on the bulkheads in the captain's cabin. There is a different paint made for almost every purpose. The following describes some of the most important paints.

Primers

13-42. Primers are paints specially prepared to adhere well to the surfaces for which they are mixed. A primer coat provides a good base for the finish coats of paint and, in the case of metal primers, includes chemicals that inhibit (hold in check) rust and other corrosion.

13-43. Two common primers used are red lead and zinc chromate. Red lead is a general purpose primer used on all metals except aluminum. Use zinc chromate on aluminum.

13-44. Always apply two primer coats on exterior, topside metal that has been stripped bare. Apply a third coat of the proper primer to the outside corners and edges. Allow at least 8 hours of drying time between coats.

Exterior Topside Paints

13-45. Properly primed, vertical surfaces above the upper limit of the boot topping area are painted with two coats of gray. In general, horizontal steel surfaces are painted with two coats of deck gray. Refer to TB 43-0144, "Painting of Watercraft," for the exact color for each surface.

Bottom Paints

13-46. Special paints have been developed for painting a ship's bottom. Because it is continuously underwater, the bottom is exposed to two dangers (corrosion and fouling). Either of these dangers could shorten the life of the ship if left unchecked. The part of the steel hull below the waterline would rust quickly from salt water if left unprotected. The steel hull could also become fouled with various types of marine growth. Two paint coverings that help overcome these problems are anticorrosive bottom paint and antifouling bottom paint.

Anticorrosive Paints

13-47. These types of paint do not protect against fouling. Anticorrosive and antifouling paints are always used together on underwater hulls of active ships. The anticorrosive always goes on first.

13-48. Vinyl and Formula 14N anticorrosive paints dry very quickly because the vehicles used evaporates rapidly. Because of this, you must apply anticorrosive with short, quick strokes and progress steadily over the area you are painting. Anticorrosive paint also contains heavy pigments that settle quickly. Because the beneficial effect of the paint depends largely on these pigments, you must stir the paint frequently.

Antifouling Paints

13-49. These types of paint will prevent the fouling of the ship's bottom that results in loss of speed and increased fuel consumption. It contains copper oxide, the chemical most effective in preventing the attachment and development of marine growth. Remember that antifouling goes over an anticorrosive. It should not come in contact with the steel plating of the ship because it may pit the surface. Be sure that the total thickness and required coats of anticorrosive paint have been applied before putting on antifouling paint.

Deck Paints

13-50. These types of paint are fairly standard. They do differ in color according to the compartment. For example, there is a dark green (interior), deck paint for decks in quarters and messrooms, a gray deck for decks in most other living and working spaces, and a dark red deck for machinery spaces and workshops. Exterior steel decks and other horizontal surfaces may be covered in several ways. One system requires two coats of red-lead-primer formula and two coats of exterior, gray deck paint. Where nonskid surfaces are required, nonskid decking material may be substituted.

Machinery Paints

13-51. The usual coating for the parts of machines (which may be painted) is a gray enamel called Formula 111. When painting machinery, it is important to know what not to paint. DO NOT paint the following:

- Start-stop mechanisms of electrical safety devices and control switchboards on machinery.
- Bell pulls, sheaves, annunciator chains, and other mechanical communication devices.
- Exposed composition metal parts of any machinery.
- Identification plates.
- Joint faces of gaskets and packing surfaces.
- Lubricating gear, such as oil holes, oil or greasecups, zerk fittings, lubricators, and surfaces in contact with lubricating oil.
- Lubricating oil reservoirs.
- Machined metal surfaces of reciprocating engines or pumps.
- Rods, gears, universal joints, and couplings of valve operating gear.
- Ground plates.
- Springs.
- Strainers.
- Threaded parts.
- Zinc.
- Working surfaces.
- Hose and applicator nozzles.
- Knife edges, rubber gaskets, dogs, drop bolts, wedges, and operating gear of watertight doors, hatches, and scuttles.
- Electrical contact points and insulators.
- Internal surfaces of ventilation ducts.

A special heat-resistant paint is available for application on objects that are subjected to high temperatures.

Aluminum Paints

13-52. These types of paint are composed of aluminum powder or paste and a varnish specially made for mixing purposes. The standard for practically all uses is 2 pounds of aluminum powder to 1 gallon of mixing varnish. Add the varnish gradually, increasing portions and stirring vigorously until a uniform mixture is obtained.

PAINT REMOVERS

13-53. There are three types of paint removers in general use:

- **Flammable.** Solvent type containing benzol, acetone, and amyl acetate.
- **Nonflammable.** Containing chlorinated hydrocarbons.
- **Waterbase.** Alkali type containing caustic materials.

Although all three are effective, their use aboard ship is limited because they are definitely hazardous. They must be used only in well-ventilated spaces, and all safety precautions, according to the type of remover in use, must be observed. Removers made to strip epoxy paints are extremely hazardous from both toxicity and skin-burning standpoints. Alkali paint removers must not be used on aluminum or galvanized surfaces.

13-54. Do the following regardless of the type of paint remover you use. Wet the surface with a smooth coat of the remover and let it soak in thoroughly until all paint or varnish is loosened. Then lift the paint off with a hand scraper.

13-55. Soon after the remover is spread on the object, a film forms on the surface of the remover. Do not disturb or break this film until you are ready to lift off the paint. If you break the film, the remover will lose some of its effectiveness. After the surface is cleaned, wet it again with the remover and wipe it off with a rag. Then thoroughly wash the surface, with paint thinner or soap and water.

WARNINGS:

NEVER USE PAINT REMOVERS AROUND AN OPEN FLAME BECAUSE SOME OF THEM CONTAIN FLAMMABLE INGREDIENTS. DO NOT USE THEM IN CONFINED SPACES SINCE SOME OF THEM HAVE DANGEROUS ANESTHETIC PROPERTIES. DO NOT USE PAINT AND VARNISH REMOVERS IF YOU HAVE OPEN CUTS OR SORES ON YOUR HANDS (UNLESS YOU ARE WEARING RUBBER GLOVES). AVOID LETTING THE REMOVER TOUCH YOUR SKIN (WATCH OUT PARTICULARLY FOR YOUR FACE, EYES, AND MOUTH). IF PAINT REMOVER TOUCHES THE SKIN AND BEGINS TO BURN, WASH IT OFF WITH COLD WATER IMMEDIATELY AND GET MEDICAL ASSISTANCE.

NEVER USE TURPENTINE, SPIRITS, OR OTHER THINNERS FOR CLEANING YOUR HANDS; THEY CAN BE ABSORBED THROUGH THE SKIN. GASOLINE IS ALSO DANGEROUS BECAUSE IT MAY CONTAIN LEAD. USE HAND SOAP AND WATER OR A COMMERCIAL HAND CLEANER. STUBBORN PAINT SPOTS USUALLY CAN BE REMOVED BY RUBBING WITH PETROLEUM JELLY. A LUBRICATING OIL OR DIESEL OIL CAN BE USED IF, IMMEDIATELY AFTER USE, YOU WASH YOUR HANDS THOROUGHLY WITH SOAP AND WATER.

PREPARATION OF METALLIC SURFACES (EXCEPT ALUMINUM AND GALVANIZED STEEL)

13-56. Where sandblasting methods are not practicable, manual methods may be used. The surface should be roughened first with roughing tools such as chipping hammers and scrapers. Care must be taken to prevent nicking, denting, or scratching of the surface when using these tools. Nicks, dents, and scratches provide ideal starting points for early failure of paint films. The low portion of such surface irregularities is difficult to clean and becomes a source of rust. On the sharp-edged, high points, only a thin film of paint will adhere causing early paint failure. Chipping hammers should never have a chisel-sharp edge. Thin plate (under three-sixteenth inch) should never be chipped, but should be scraped and wire brushed.

13-57. When the bulk of rust and old paint has been removed by roughing tools, finishing tools shall be used to complete the job. The main finishing tools are hand wire brushes, electric and pneumatic wire brushes, and sandpaper. The use of finishing tools without first using roughing tools results in a small amount of surface readied for painting or, with power wirebrushing, the "glazing" rather than removal of the rust and old paint. The hand scraper is used on small jobs, where power tools are impractical, and in crevices and corners. The hand wire brush is a useful tool for light rust and for brushing around welds and in places not accessible to the power wire brush. Sandpaper and sanding discs are used where a smooth, clean surface is desired. Where old paint is removed in spots, the edge of the remaining paint film should be sanded so that it tapers (feathers) down to the bare metal. This will give a smooth appearance to the new paint film. Steel wool should not be used as a substitute for sandpaper. Small steel particles can become embedded in the paint and form a source of rust. After the finishing operation is completed, sweep the surface to remove paint chips, dirt, and dust, and apply a liberal coat of primer.

PREPARATION OF ALUMINUM SURFACES

13-58. Sandblasting and wire-brushing aluminum surfaces are not recommended. Clean by brushing off dirt and dust and washing the surface with paint thinner. Then, wash with paint cleaner and water (soogee), rinsing with fresh water.

13-59. Defective paint coatings on outside painted surfaces should be removed with paint remover. The cleaned surface must then be washed with paint thinner, scrubbed with paint cleaner and water, and rinsed with fresh water.

13-60. Good paint on inside painted surfaces should not be removed. Flaking, scaling, or peeling patches may be removed with hand scrapers, being careful not to damage the aluminum surface. Dulling or rounding the corners of scrapers will help prevent nicking the aluminum. The edges of the good paint are faired with sandpaper. Do not sandpaper the aluminum surface. Wash the entire surface with paint thinner and again with paint cleaner and water and a fresh water rinse. Never use a chipping hammer or power tool on an aluminum surface.

PREPARATION OF GALVANIZED STEEL SURFACES

13-61. Heavy blast-cleaning of galvanized steel shall be avoided. Chipping hammers will not be used on galvanized surfaces. Old paint shall be removed by means of a hand scraper and wire brushes. Never use sandpaper on this surface.

13-62. After scraping and wire-brushing a galvanized surface, wipe the surface with paint thinner. As soon as the surface is dry, apply a liberal coat of primer.

SHIP BOTTOMS

13-63. The condition of the ship’s bottom has considerable effect on steaming performance. Before applying paint to the bottom, be sure that it has been cleaned carefully. A special problem is involved near the waterline where oil and grease often accumulate. Paint applied over grease will not adhere or dry, so you must remove all traces of grease with a solvent. Gasoline was formerly used for this purpose but recently kerosene solvent-emulsion cleaners have been developed. They are inexpensive and efficient and do not constitute as great a fire hazard as gasoline.

13-64. DO NOT REMOVE PAINT THAT STICKS AND IS FREE FROM FOULING. Remove blistered, flaked, or loose paint by sandblasting, hydroblasting, or hand cleaning. DO NOT touch paint that adheres firmly and gives protection to the bottom. Clean antifouling paint, which is over 2 years old, to its original color and apply two additional coats. Where paint is completely removed and the metal is bare, replace all coats of the bottom system.

PIPING SYSTEM

13-65. Remember that you must not mar the surface when cleaning piping systems. The ordinary procedure is to remove loose paint from the pipe with a scaling tool; then go over the pipe with a wire brush to remove all loose particles. When a big overhauling job is underway, at some shipyards the pipes may be taken out and sandblasted while other machinery is being moved.

13-66. One way the inside of a pipe is cleaned is with a tool called a vibrator. The vibrator has a long shank with a mallet-like head. The shank is inserted in the pipe and the vibration of the head removes scale and rust. Then an air hose is used to blow all the loose flakes out of the pipe.

ELECTRICAL EQUIPMENT

13-67. No attempt should be made to remove paint from electrical cables, fixtures, control enclosures, or switchboards. If you take the paint off a cable, you may injure the protective armor and watertight sheath directly beneath it. Damage to the sheath will allow moisture to enter and will result in grounding. Twisting or bending a cable to remove paint from it might destroy the watertightness of the packing in the bulkhead stuffing tubes.

13-68. When scraping paint, sandblasting, or painting near electrical equipment, be sure that the equipment is covered to protect it from paint, dust, or sand particles. After your work is finished, clean the electrical equipment thoroughly, using a vacuum cleaner if you have one. Remember that paint dust is full of abrasive and semiconducting particles, which can seriously damage electrical equipment.

CAUTION: Note the flash point listed on container labels and take adequate precautions. Apply only when electrical equipment in the same and adjacent compartments is de-energized and surfaces to be painted are in a cold-iron condition.

PAINT PREPARATION

13-69. No matter how high the quality, paint will give poor service if not thoroughly mixed before applying. When paint stands for long periods of time, the pigment settles to the bottom of the container, and the vehicle rises to the top. Naturally, the paint must be remixed before use. The best system for mixing is to pour off most of the vehicle and mix the remainder thoroughly. Then add a small amount of the liquid at a time, until the entire vehicle has been added and the paint is uniform. To make sure the paint is thoroughly mixed, pour the paint back and forth between two cans (Figure 13-5). This process is called "boxing" and ensures a smooth and even mixture.

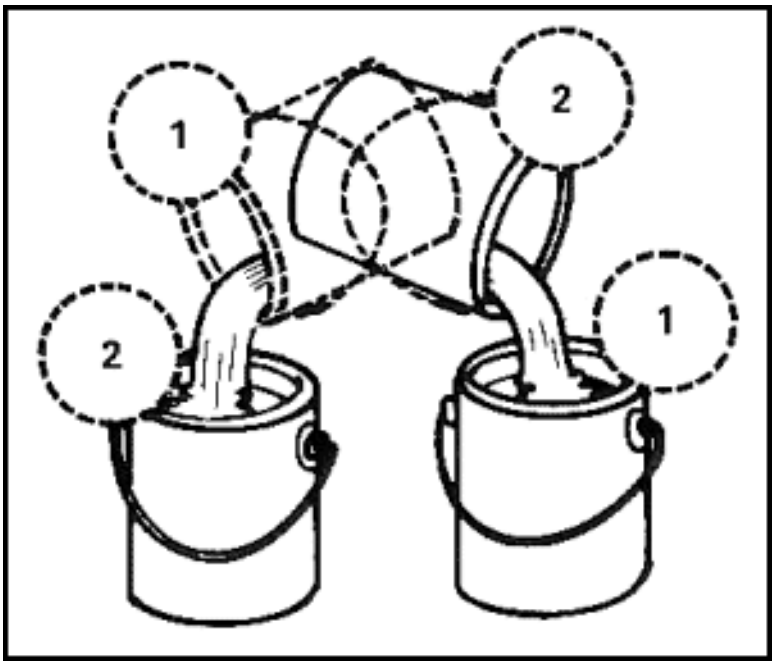


Figure 13-5. Steps in Boxing

13-70. Some of the newer paints require special mixing procedures, including induction times (waiting periods) before use. For epoxy or polyurethane paints, carefully follow the manufacturer’s instructions regarding mixing, induction time, and applying.

13-71. When opening a paint can, you may find that a "skin" has formed on the surface of the paint. This must be removed carefully and thrown away. All particles of pigment, dirt, and skin should be taken out by straining the paint through a wire screen or cheesecloth. Straining should be done after the paint has been mixed thoroughly.

Note: During storage, turn paint containers "bottoms up" periodically (at least once every 90 days) to reduce the labor involved in mixing paint.

PAINTING BY BRUSH

13-72. Smooth and even painting depends as much on good brush work as it does on good paint. There is a brush for almost every purpose, so be sure you use the right brush and keep it in the best condition. Table 13-1 lists the name and general use of the most frequently used brushes.

Table 13-1. Types and Uses of Brushes

TYPE	FOR USE ON
Flat paintbrush	Large surfaces
Oval sash and trim brush	Small surfaces
Fitch brush	Small surfaces
Oval varnish brush	Rough work
Flat varnish brush	Medium work
French bristle varnish brush	High-grade work
Lettering brush	Small surfaces
Painter's dusters	Cleaning work

13-73. The two most useful brushes are the flat brush and the oval sash and trim brush. A skillful painter using a flat brush can paint almost anything aboard ship. Flat brushes are wide and thick, carry a large quantity of paint, and provide a maximum of brushing action. Sash brushes are handy for painting small items and those hard-to-get places and for cutting in at corners. The most common used brushes aboard ship are shown in Figure 13-6.

13-74. Many of the brushes are made of horsehair and other natural bristles. More and more brushes are being made of synthetic bristles such as nylon. These brushes are much cheaper and provide comparable brushing action.

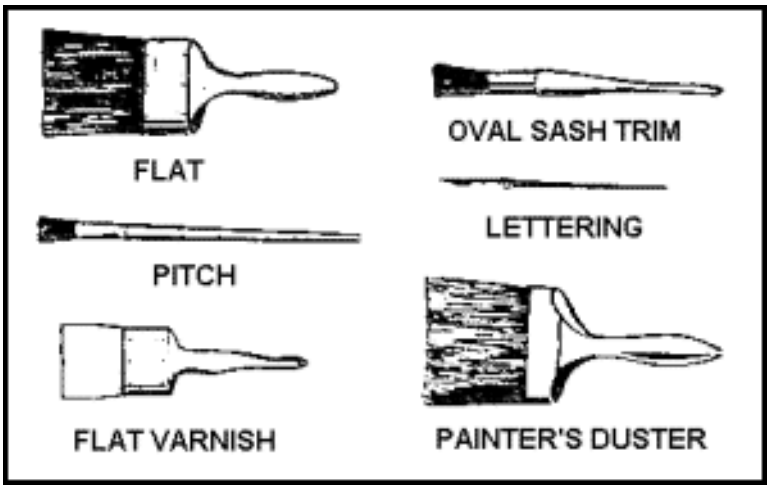


Figure 13-6. Types of Brushes

CARE OF BRUSHES

13-75. Brushes are only as good as the care given them. The best brush can be ruined very quickly if not properly treated. If you follow the suggestions given, your brushes will last longer and give better service.

13-76. When bristles of paintbrushes were set in wood, painters dampened the wood to cause it to swell and hold the bristles more tightly. However, almost all modern paintbrushes have bristles set in rubber or in some composition material. This means, of course, that wetting the end of the handle holding the bristle is useless. In fact, this practice will probably cause harm because it will tend to make the metal band (ferrule) rust faster. To make a new natural bristle brush more flexible and easier to clean, rinse it in paint thinner and soak it in boiled linseed oil for about 48 hours. Drain the oil from the brush before using. Wipe the bristles clean and wash them in a solvent or other oil remover. Synthetic bristle brushes do not require special treatment before use.

CARE AFTER USE

13-77. Every paint locker should have a container with divided compartments for stowing different types of brushes (that is, paint, varnish, shellac, and so on) for short periods of time. The container should have a tight cover and a means of hanging brushes so that the entire length of the bristles and the lower part of the ferrule are covered by the thinner or linseed oil. The bristles must not touch the bottom because they eventually will become distorted, making it impossible to turn out an acceptable job with them.

13-78. A simple brush keeper is shown in Figure 13-7. Drill a small hole through the brush handle and support the brush so that the ends of the bristles are allowed to soak in paint thinner or linseed oil. The keeper may be square or round, but it must have a tight lid to prevent evaporation and to avoid being a fire hazard.

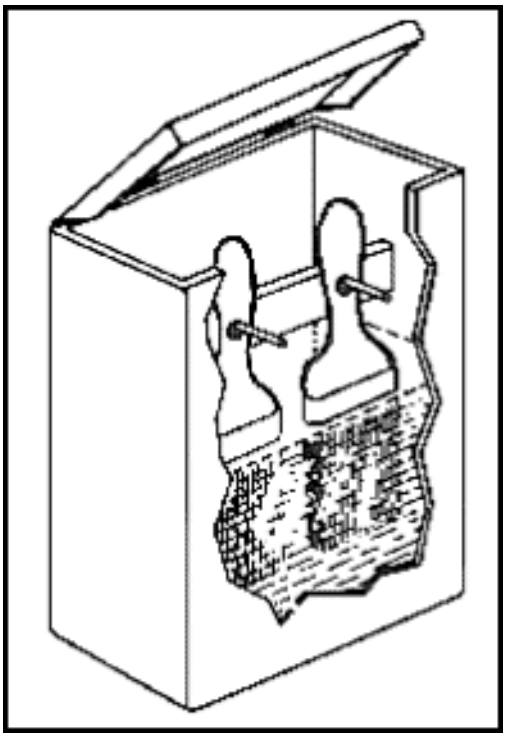


Figure 13-7. Small Brush Keeper

13-79. Brushes to be used the following day should be cleaned in the proper thinner and placed in the proper compartment of the container. Brushes to be used later should be cleaned in thinner, washed with soap (or detergent) and water, rinsed thoroughly in fresh water, and hung to dry. After drying, they should be wrapped in waxed paper and stowed flat. Brushes should not be left soaking in water; the water causes the bristles to separate into bunches, flare, and become bushy. The proper cleaners for brushes used with different finishes are shown in Table 13-2.

13-80. Remember that paint-soaked brushes should never be left in an open can of paint or exposed to the air. Good brushes are hard to get -- take care of them. Clean them immediately after use; then store them properly.

Table 13-2. Brush Cleaners for Different Finishes

TYPE	FOR USE ON
Flat paintbrush	Large surfaces
Oval sash and trim brush	Small surfaces
Fitch brush	Small surfaces
Oval varnish brush	Rough work
Flat varnish brush	Medium work
French bristle varnish brush	High-grade work
Lettering brush	Small surfaces
Painter's dusters	Cleaning work

HOW TO USE A BRUSH

13-81. There is an art to using a paintbrush properly. It is an art you will have to master if you are going to become a good painter. The following general hints will help you. Read them once to see how many mistakes you have been making. Then concentrate on each point separately until you are sure you have it mastered.

13-82. Hold the brush firmly, but lightly, in the position shown in Figure 13-8. Do not put your fingers on the bristles below the ferrule. Hold the brush in a way that will permit easy wrist and arm motion.

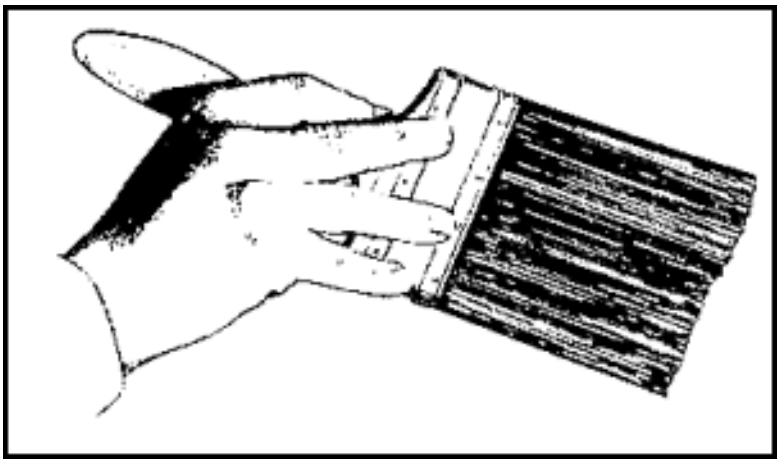


Figure 13-8. Correct Way to Hold a Brush

13-83. Do not try to paint with the narrow edge when using a flat brush. That will wear the corners down and spoil the shape and efficiency of the brush. When using an oval brush, do not let it turn in your hand. An oval brush that has been revolved too much will wear to a pointed shape and become useless. Do not poke oversized brushes into corners and around moldings. Such use will ruin a good brush by bending the bristles. Use a smaller brush that will fit into such spots.

13-84. Work the paint well into the brush before you start to paint. Hold the mixing paddle tightly over the rim of the bucket, dip the brush into the paint, and then wipe the brush clean across the edge of the paddle. Do this several times so you will be sure the brush is filled with paint.

13-85. Dip slightly less than half of the bristles into the can when applying paint. Slap the brush lightly against the side of the can, then apply it to the surface to be painted. To avoid paint from dripping off your brush, be careful not to overfill your brush.

13-86. Hold the brush at right angles to the surface being painted, with the ends of the brush just touching the surface. Lift the brush clear of the surface when starting the return stroke. If the brush is held obliquely and is not lifted, the painted surface will be uneven, showing laps and spots and a "daubed" appearance. A brush that is held at too great an angle will soon wear away at the ends.

PAINT APPLICATION

13-87. Use the "lay on" then "lay off" method to completely cover with paint (Figure 13-9). "Laying on" means applying the paint first in long, horizontal strokes. "Laying off" means crossing your first strokes by working up and down.

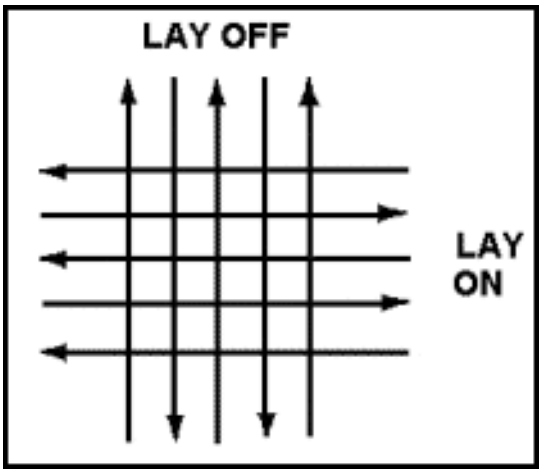


Figure 13-9. Laying On and Laying Off

13-88. The laying-on and laying-off method distributes the paint evenly over the complete surface with the least amount of paint. A good rule is to lay on across the shorter distance and lay off in longer direction. When painting bulkheads or any vertical surface, lay on in horizontal strokes, lay off in vertical strokes.

13-89. Always paint the overhead first and work from the far corner. By working the overhead first, you can keep the bulkhead free of drippings by wiping up as you go along.

13-90. When painting overhead surfaces, paint strokes on the ceiling panels should normally be laid fore-and-aft, and those on the beams, athwartships. But where panels contain many pipes running parallel with the beams, it is often difficult to lay off the ceiling panels fore-and-aft. In such cases, you will get better results by laying off the panels parallel with the beams.

13-91. To avoid brush marks when finishing a square, stroke toward the last square finished, gradually lifting the brush near the end of the stroke while the brush is still in motion. Every time the brush touches the painted surface at the start of a stroke, it leaves a mark. For this reason, never finish a square by brushing toward the unpainted area, but always end up by brushing back toward the area already painted.

13-92. When painting pipes, stanchions, narrow strips, beams, and angles, lay the paint on diagonally. Lay off along the long dimension (Figure 13-10).

13-93. Always carry a rag for wiping dripped or smeared paint.

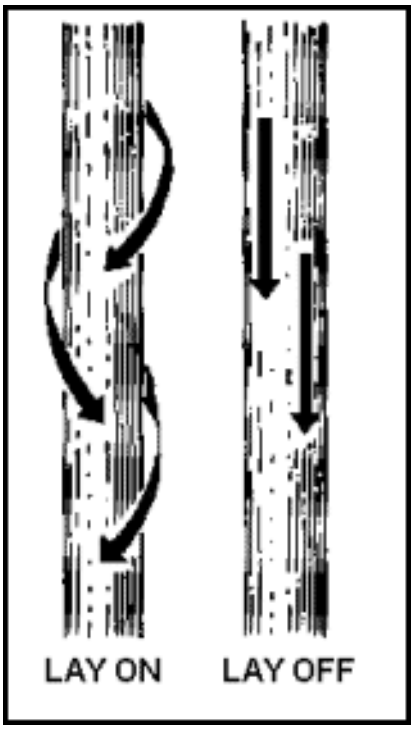


Figure 13-10. Painting Pipes and Stanchions

FILM THICKNESS

13-94. For interior painting, paint must be applied in the lightest possible coat that will cover the surface. Several reasons for this are:

- Heavy layers of paint constitute a fire hazard--the thicker the paint film, the more readily it will burn. Also, if paint is applied heavily, it is likely to entrap solvents and thinners that burn rapidly.
- Thick coats of paint tend to crack and peel. They are likely to be uneven and may show marks and scratches more readily than thin coats. Thick coats of paint do not penetrate as well as thin ones and do not dry as hard to a surface.

If an interior surface has already had a total of four coats of paint (including primer) or if the total thickness of the existing paint amounts to 0.005 inch, the old paint should be removed before adding any more paint.

WORKING CONDITIONS

13-95. Painting should not be attempted at a temperature below 32° F. In cold weather, moisture condenses on surfaces and the paint will not stick. The thinner also evaporates too slowly, increasing the drying time.

13-96. For best results, paint during warm weather (between 60° F and 80° F). In hotter weather, paint dries too rapidly and makes brushing and rolling difficult.

13-97. Humidity and ventilation are also important considerations. High humidity may cause condensation on the bulkheads and make painting difficult. To reduce humidity inside, you can increase the temperature or improve the ventilation. Proper ventilation is also necessary to carry off the solvents and to furnish oxygen so the paint will dry properly.

STRIPING

13-98. Striping can be a relatively easy job if you use masking tape. You can use either a brush or spray gun with masking tape. There are two basic methods to follow, depending on whether the surface to be striped has been finished.

Striping Method Number 1

13-99. If the surface is already painted and you do not want to do a complete repainting job, you can still add stripes without marring the finish. First decide on the position and width of the stripe; then apply masking tape to both sides of the stripe. Figure 13-11 shows how to apply the tape. It is a good idea to add a further protective covering on both sides, wide enough to prevent daubs or overspray from striking the rest of the surface. Placing newspapers or wrapping paper in the proper position before painting may also provide protection. The striping color is then sprayed or brushed on. When the paint has set, the masking tape is removed.

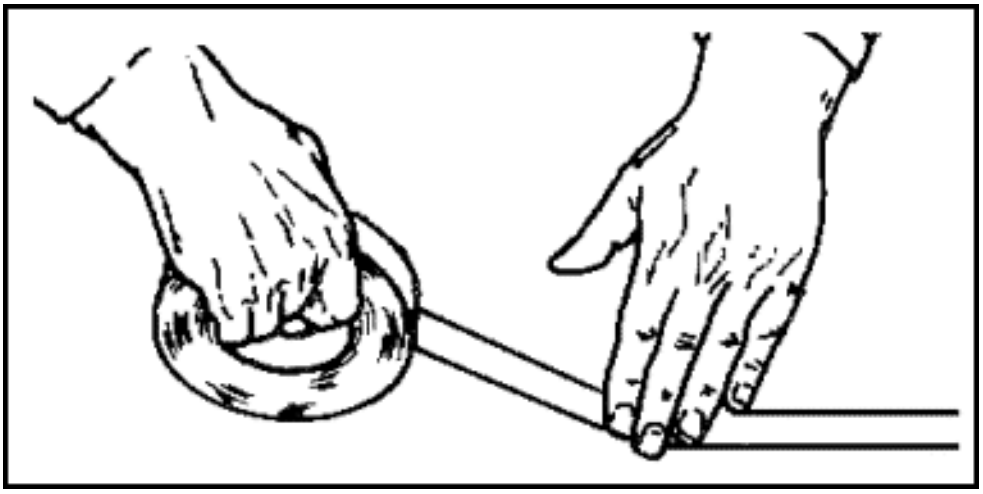


Figure 13-11. Applying Masking Tape

Striping Method Number 2

13-100. If the surface is unfinished, the process of striping is a little different. First decide on the position and width of the stripe; then spray or brush the color on, allowing the paint to overlap the edge of the stripe a little on both sides. Allow the striping color to dry thoroughly, then cover the exact area of the stripe with masking tape. Attach the tape firmly, but do not stretch it too much. Rub or roll it down to smooth out the wrinkles and make a tight, protective covering. Some painters recommend as the next step a light "fog" covering of the finishing material right over the tape. This will help to prevent the final coat of paint from sticking to the edges of the tape, cementing the tape to the surface. Now you are ready to spray or brush on the finishing coat. Do this right over the masking tape. When the surface coat has set, remove the tape to reveal a clean-cut stripe.

REMOVING MASKING TAPE

13-101. There is a trick to removing masking tape so it will not mar the surface. The right way is to pull the tape off somewhat diagonally and back upon itself. The wrong way is to pull the tape directly away from the surface at a right angle. Figure 13-12 shows the proper angle. Work slowly, with your hands moving close and parallel to the surface.

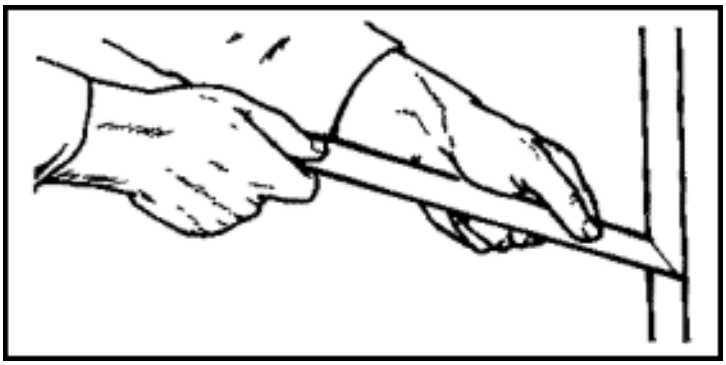


Figure 13-12. Removing Masking Tape

13-102. There may be a slight ridge along the edges of the stripe after you pull off the masking tape. If this is too noticeable, you can scrape it off after it has dried thoroughly and then rub it smooth with a rubbing compound.

STENCILS

13-103. All ships or boat companies should have adjustable stencil sets with locking edges. These sets are made of brass and include punctuation marks as well as the 26 letters of the alphabet and numerals from 0 through 9. The sets come in three sizes: 1/2 inch, 1 inch, and 2 inches. The edges of each piece are crimped allowing the use of a combination of letters, figures, and punctuation marks by slipping the edge of one piece into the edge of the adjoining piece.

13-104. Flat-ended brushes especially designed for stenciling are available, but an old toothbrush makes an acceptable substitute. Use the stencil paints available in general stores. After stenciling one surface, wipe off the back of the stencil before laying it on the next surface to be stenciled. Make sure the stencil does not slip while applying the paint. Stencils should be cleaned immediately after use--the brass ones with the proper thinner, the other type with only a clean soft rag.

CUTTING IN

13-105. A painter who has learned to "cut in" properly can do a job in less time than it takes another person to apply masking tape. Cutting in is not hard and anyone with a fairly steady hand can learn it in a short time. Suppose you have to cut in the angle between an overhead and a bulkhead. Start at one corner. Hold your brush at an angle of about 75 to 80 degrees from the bulkhead and about 10 degrees from the overhead. Run your brush along in fairly swift, long, smooth strokes. This is one job where working slowly will not produce better results. The slower your stroke, the wavier the line.

13-106. If there is no definite break, such as the angle between bulkheads and overheads or decks, you should draw a line to follow. You can do this either with a straightedge or by snapping a chalk line. To snap a chalk line, first mark a couple of reference points, one at each end where the line will be. Then chalk the line and stretch it taut between the reference points. Have somebody pull the center of the line about 6 inches out from the surface and let it snap back against the surface. This leaves a neat, straight line. Cut in as already described. You may want to paint up close to the line and then cut in, but usually it is best to cut in first and paint out from that line.

PAINT ROLLERS

13-107. The dip type of paint roller consists of a replaceable, knotted Dynel, plush fabric roller having a solvent-resistant paper core which rotates on the shaft of a corrosion-resistant steel frame.

13-108. Large areas, such as decks and ship's sides, free of rivets, bolts, cable, pipes, and so on, can be quickly covered with paint by using rollers. In order to get uniform coverage, always try to pick up the same amount of paint with your roller, and paint the same size area. A 7-inch roller filled with paint will cover about a square yard; a 9-inch roller, of course, will cover slightly more. Dip your roller in the paint at the lower end of the tray and roll it lightly toward the raised end. Repeat this process as necessary to fill the roller evenly. Then quickly apply it to the surface to be painted, using the same lay-on, lay-off technique used when brush painting. A moderate amount of pressure must be applied to the roller to ensure that the paint is worked into the surface. If pressure is not applied, the paint will not adhere and will peel off.

13-109. The fabric cylinder should be stripped from the core after use, cleaned in the solvent recommended for the paint used, washed in soap and water, rinsed thoroughly, and replaced on the core to dry. Combing the pile of the fabric while damp will prevent matting.

SPRAY GUNS AND THEIR USE

13-110. A spray gun is a precision tool in which paint is sprayed out through a nozzle by air pressure. The mixing area may be outside or inside the gun's spray cap.

CLASSES OF SPRAY GUNS

13-111. Spray guns are classed according to where the air and paint are mixed (external-mix, internal-mix), how the air is controlled (bleeder, nonbleeder), and how the paint is fed to the nozzle (suction-feed, pressure-feed).

External-Mix Spray Gun

13-112. In an external-mix gun, the air and paint are mixed outside and in front of the air cap as shown in Figure 13-13. This type of gun requires high air pressure, thereby using more cubic feet of air per minute than does an internal-mix gun. Atomization of the paint is extremely fine, however, and the size of the spray pattern can be controlled. There is no wear on the air nozzle. With different nozzles, an external-mix gun works with both suction and pressure feeds.

Internal-Mix Spray Gun

13-113. In an internal-mix gun, air and paint are mixed within the gun as shown in Figure 13-14. In this type of gun, atomization of the paint is coarse, and the spray pattern is fixed. This gun works only with a pressure-feed, but the pressure is lower and the amount of air used is less than for the external-mix gun. Because atomization of the paint is coarse, more paint is applied on each pass.

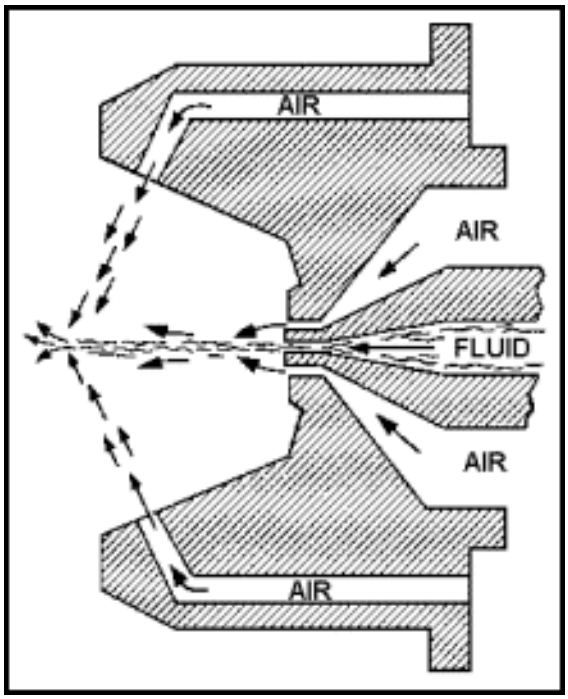


Figure 13-13. External-Mix Air Cap

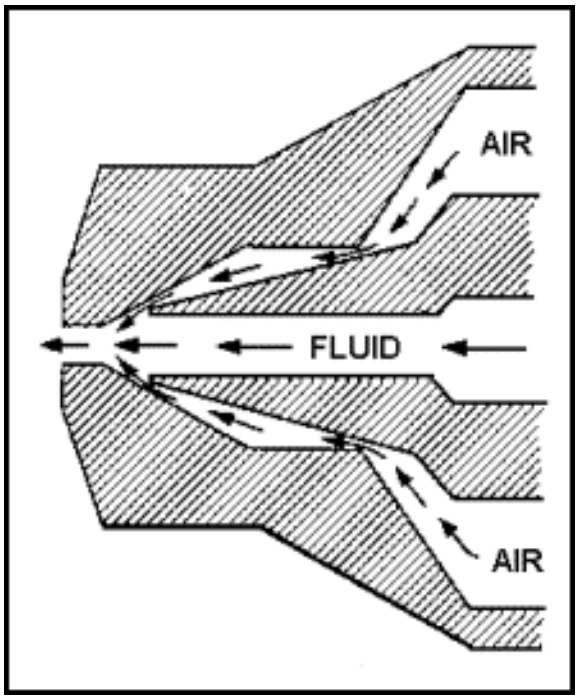


Figure 13-14. Internal-Mix Air Cap

Bleeder and Nonbleeder Spray Gun

13-114. The bleeder type of gun is one in which air is allowed to leak or bleed from some part of the gun to prevent air pressure from building up in the air hose. In this type of gun the trigger controls only the fluid. It is generally used with small, air-compressing outfits that have no pressure control on the air line.

13-115. The nonbleeder gun is equipped with an air valve that shuts off the air when the trigger is released. It is used with compressing outfits having a pressure-controlling device.

Suction Feed Spray Gun

13-116. In a suction-feed gun, the air cap is designed to draw the fluid from the container by suction (Figure 13-15) in somewhat the same way that an insect spray gun operates. The suction-feed spray gun is usually used with 1-quart (or smaller) containers.

Pressure-Feed Gun

13-117. A pressure-feed gun operates by air pressure (Figure 13-16) which forces the fluid from the container into the gun. This is the type used for large-scale painting.

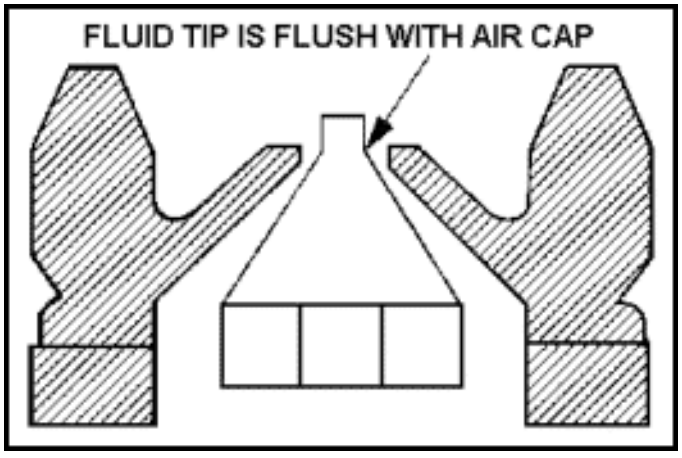


Figure 13-15. Suction-Feed Air Cap

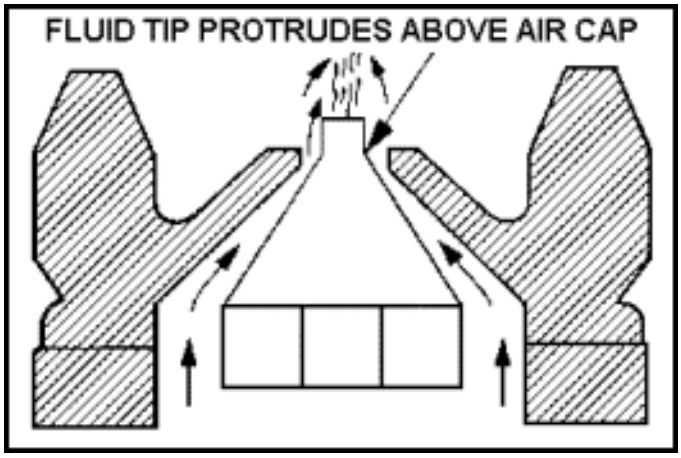


Figure 13-16. Pressure-Feed Air Cap

PARTS OF THE SPRAY GUN

13-118. The two main assemblies of the spray gun are the gun body assembly and the spray head assembly. Each of these assemblies is a collection of small parts, all of which are designed to do specific jobs.

13-119. Figure 13-17 shows the principal parts of the gun body assembly. The air valve controls the supply of air and is operated by the trigger. The spreader adjustment valve regulates the amount of air that is supplied to the spreader horn holes of the air cap. This will vary the paint pattern. It is fitted with a dial, which can be set to give the desired pattern. The fluid needle adjustment controls the amount of spray material that passes through the gun. The spray head locking bolt locks the gun body and the removable spray head together.

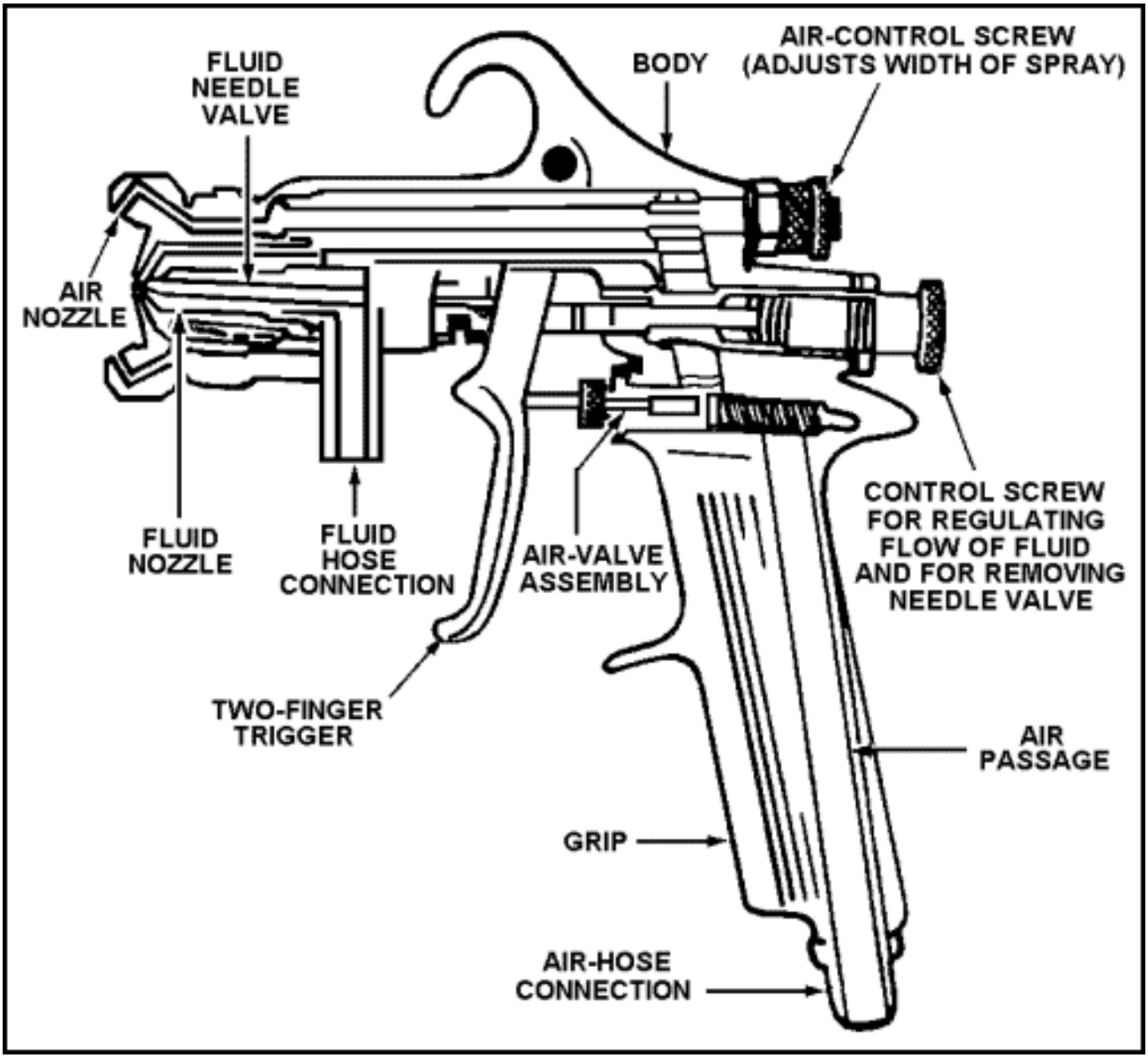


Figure 13-17. Cross-Section of a Spray Gun

13-120. Most guns are now fitted with a removable spray head assembly. This type has many advantages. The head can be cleaned more easily; the head can be quickly changed to use a new color or material; and, if damaged, the head alone can be replaced, using the old gun body.

13-121. The principal parts of the spray head assembly are the air cap, the fluid tip, fluid needle, and spray head barrel (Figure 13-18).

13-122. The fluid tip regulates the flow of the spray material into the air stream. The tip encloses the end of the fluid needle. The spray head barrel is the housing, which encloses the head mechanism.

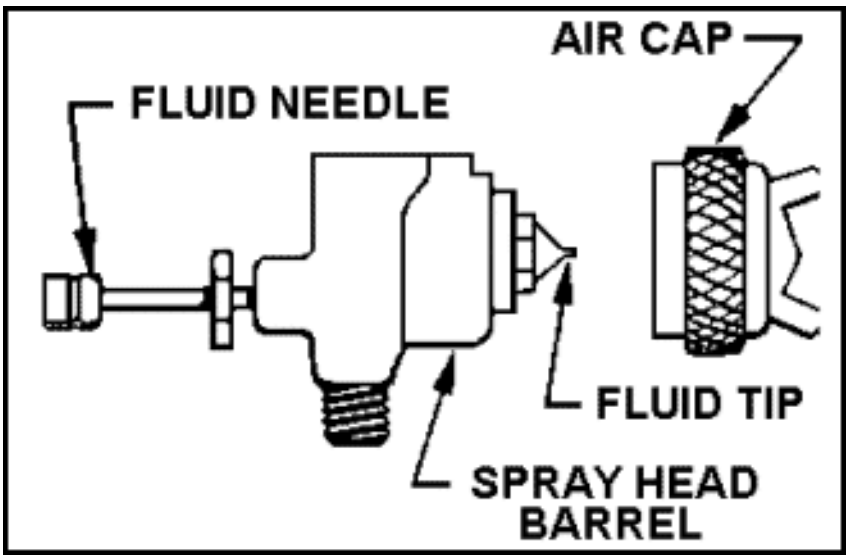


Figure 13-18. Principal Parts of the Spray Head

Containers

13-123. The cups or tanks, which hold the spray material before delivery to the gun, are called containers. The job to be done determines which one of several kinds of containers to use.

- Suction-feed cups are used for small quantities of lightweight and medium weight spray materials, such as lacquers.
- Gravity-feed cups are also small and are attached directly to the top or side of a gun. They normally are used only on artist's and decorator's guns or on small touch-up guns.
- Pressure-feed cups (Figure 13-19) are considered best for handling small quantities of enamels, plastics, or other heavy materials on jobs that need fine adjustments and speed of application.
- Pressure tanks are large containers with a capacity of 2 to 60 gallons. Figure 13-20 shows a common type of pressure tank. There are two general types, the regulator type and the type that uses the equalized pressure tank.

13-124. The equalized pressure tank is equipped only with a safety valve and a release valve. The regulator type is equipped with one or two regulators, a safety valve, release valve, and pressure gauge. It may also have one or two hand-operated or motor-operated agitators. If there is only one regulator, it regulates the fluid pressure in the tank only. If there are two regulators, one regulates the fluid pressure in the tank while the other regulates the air pressure from the container to the gun. Each regulator operates independently of the other.

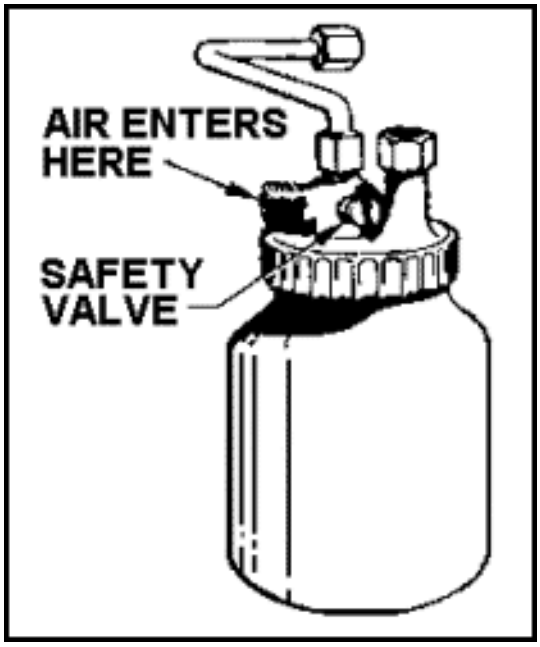


Figure 13-19. Pressure-Feed Cup

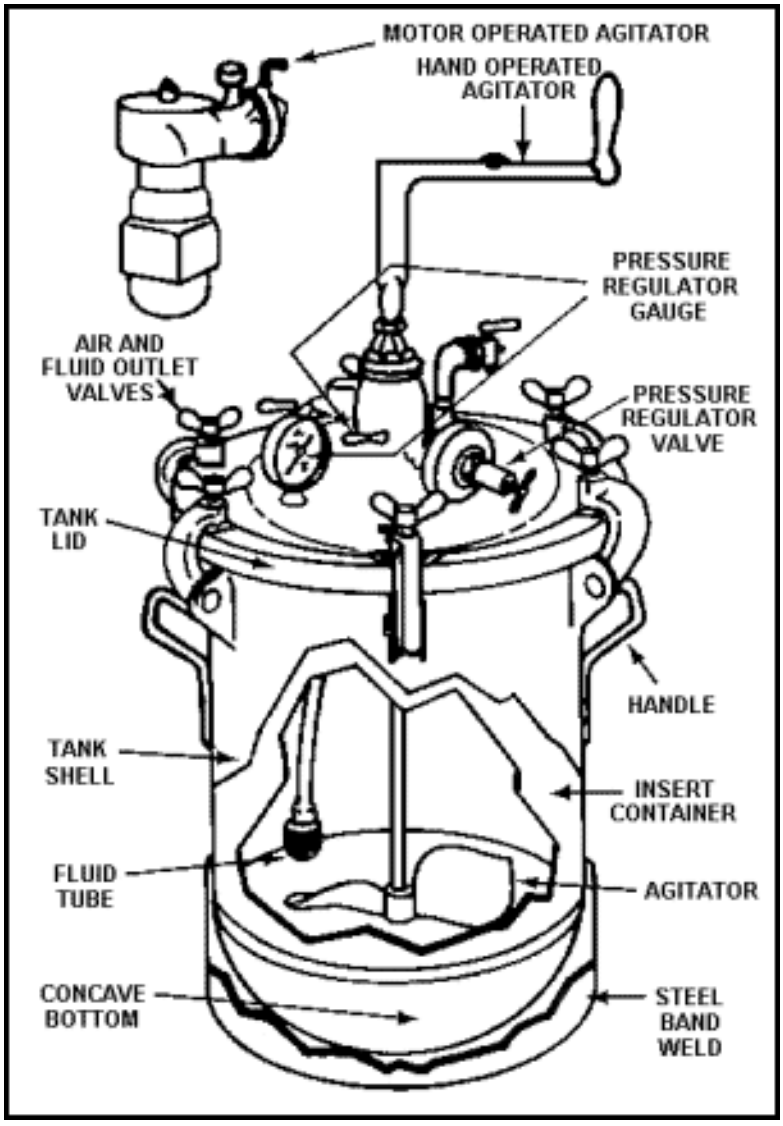


Figure 13-20. Pressure Tank

13-125. The pressure tank shown in Figure 13-20 is equipped with air outlets and fluid outlets. The fittings, pressure regulators, and gauges permit the use of more than one spray gun at the same time.

13-126. Sometimes, instead of pouring the material directly into the tank, you can put a separate container (called an insert container) into the tank. With this type of container it is possible to make quick changes of color or material without having to clean the tank. You can also mix your materials ahead of time and have them on hand.

Hose Lines

13-127. Spray gun hoses are of two varieties--one kind to handle air and another to handle liquids. Air hoses are usually made of braid-covered tubing, with either one-braid or two-braid construction. Fluid hoses are made of a special, solvent-resisting material.

AIR SUPPLY

13-128. Spray guns are operated by compressed air, which may be supplied by either portable or installed compressors. However, aboard ship, guns using pressure tanks are usually connected to the low-pressure ship’s service air line. Pressure on this line is usually from 100 to 125 psi, but this is cut down to spraying pressure at the tank by a pressure regulator valve.

13-129. The manufacturer's instructions for the operation of air compressors must be followed exactly. If you intend to use air from the low-pressure line for long periods, it is a good idea to inform the engineering officer of the watch.

13-130. To properly spray paint, the air should be dry and free from dust. All air, in varying amounts, contains moisture and dust and some means must be provided to remove both. An air transformer (Figure 13-21) is usually used to remove moisture and dust. The air transformer is also called an air separator or air regulator.

13-131. Air enters through an air inlet, passes through a series of baffles and a filter chamber, and then through a regulator diaphragm which adjusts the pressure. Normally, the transformer should be drained daily. If the weather is damp, it should be drained several times daily. You do this by turning a drain cock at the bottom. The packing and filtering material should also be changed at regular intervals.

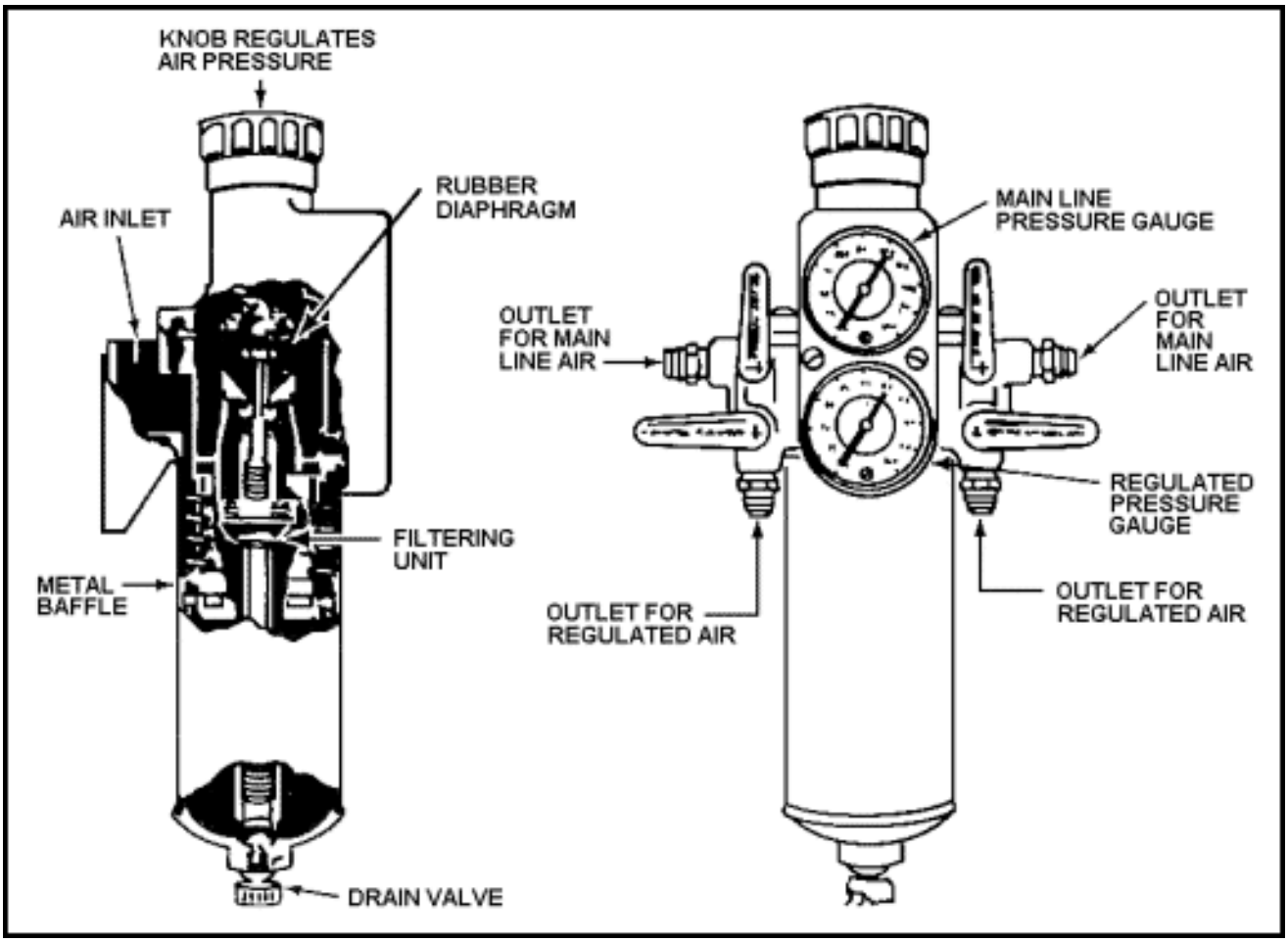


Figure 13-21. Air Transformer

OPERATION OF THE SPRAY GUN

13-132. Squeezing the trigger of the spray gun opens the air valve, admitting compressed air through the air inlet. The air passes through the gun body to the spray head. In the most common (external-mix) type of spray head, the air does not come in contact with the paint inside the gun, but is blown out through small holes drilled in the air cap. Paint is shot out of the nozzle in a thin jet, and the force of the air striking it breaks the jet into a fine spray. You can control this spray, making it into various patterns, by setting the air-control screw that regulates the spreader-adjustment valve. Turn the screw clockwise for a round spray. For a fan spray turn it counterclockwise. Turn the fluid-control screw clockwise to increase the flow. To obtain the same coverage over the wider area, the flow of paint must be increased as the width of the spray is increased. The handling of a spray gun is best learned by practice, but here are some tips.

13-133. Before starting to spray, check adjustments and operation of the gun by testing the spray on a surface similar to that which you intend to coat.

13-134. There are no set rules for spray gun pressure or for distance to hold the gun from the surface because pressure and distance vary considerably with the nozzle, the paint used, and the surface to be coated. The minimum pressure necessary to do the work is the most desirable, and the distance is normally from 6 to 10 inches.

13-135. Always keep the gun perpendicular to and at the same distance from the surface being painted (Figure 13-22). Start the stroke before squeezing the trigger, and release the trigger before completing the stroke (Figure 13-23). If the gun is not held perpendicular or is held too far away, part of the paint spray will evaporate and strike the surface in a nearly dry state. This is called "dusting." Failing to start the stroke before starting the spray or spraying to the end of the stroke will cause the paint to build up at the end of the stroke, and the paint will run or sag. Arching the stroke makes it impossible to deposit the paint in a uniform coat.

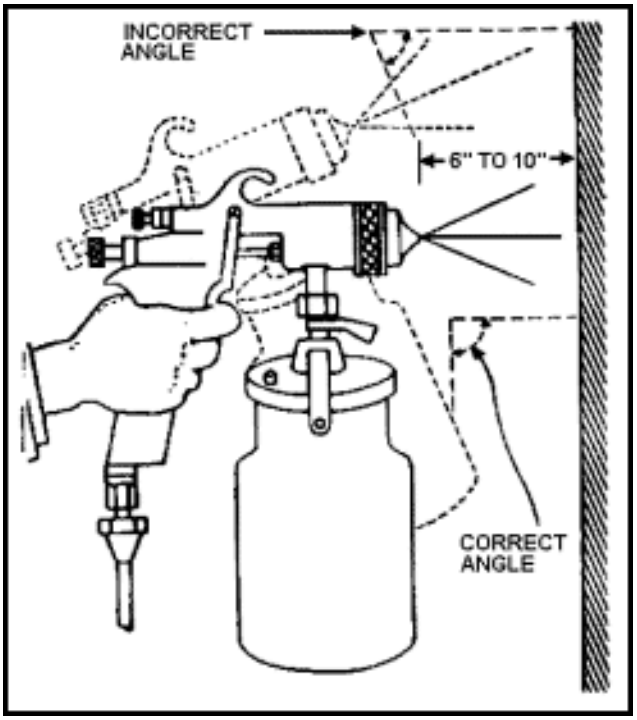


Figure 13-22. Hold Spray Gun Perpendicular to Surface

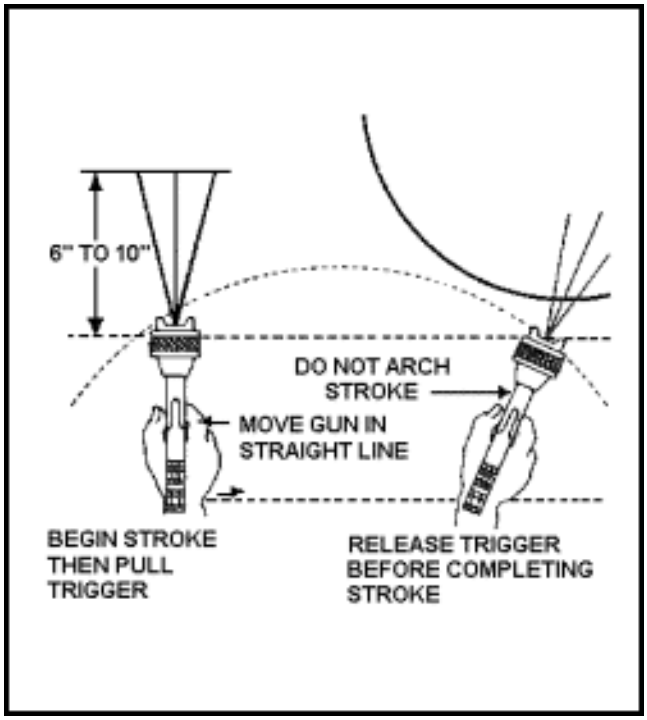


Figure 13-23. Proper Spray Gun Stroke

13-136. When spraying the inside and outside corners, stop 1 or 2 inches short of the corner. Do this on both sides, then turn your gun on its side and, starting at the top, spray downward, coating both sides at once (Figure 13-24).

13-137. If you are spraying a large area from which small parts and pieces protrude, first lightly coat those items. Then go over the whole surface.

13-138. For example, if you are painting a compartment, first spray the hatch coamings, door frames, rivets, exposed bolt heads, and all small items secured to the bulkheads. Then do the entire compartment. This eliminates a lot of touching up later.

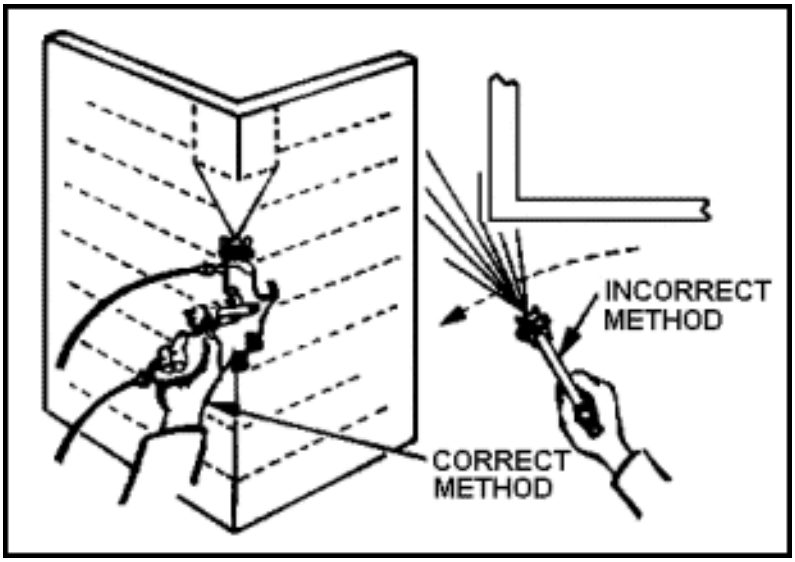


Figure 13-24. Correct and Incorrect Methods of Spraying Corners

COMMON SPRAYING DEFECTS

13-139. The most common defects in sprayed-painted coats are "orange peel," runs and sags, pinholes, blushing, peeling, and bleeding.

Orange Peel

13-140. This is a general term used to describe a painted surface that has dried with a pebble texture resembling an orange peel. This may be caused by using improper thinners, a spray which is not fine enough, holding the gun either too far or too close to the surface, improper mixing of the material, drafts, or low humidity.

Runs and Saps

13-141. These are usually the result of using material that is too thin. Sags result from too much material. Runs and sags can also be caused by allowing too big a lap in spraying strokes and by poor adjustment of the spray gun or pressure tank. Dirty or partially clogged passages for air or fluid will also cause uneven distribution.

Pinholes

13-142. These may be caused by the presence of water or excessive thinner in the paint or by too heavy of an application of quick drying paint. Either way, small bubbles form and break in drying, leaving small holes.

Blushing

13-143. This resembles a powdering of the paint. The cellulose material in the paint separates from its solvent and returns to its original powder form. Water is usually the cause of this, either moisture on the sprayed surface or excessive moisture in the air. When blushing occurs, you will have to remove the defective coating because the moisture is trapped within the material and will remain there unless the coating is removed.

Peeling

13-144. This is almost invariably due to carelessness in cleaning the surface. Before any spraying is attempted, the surface must be absolutely clean. Cheap spray materials sometimes will give poor adhesion, but you will not have this trouble if you always use standard paints.

Bleeding

13-145. This occurs when the color of a previous coat discolors the finish coat. Paint containing a strong aniline dye (synthetic organic dye) will do this when another color is sprayed over it.

CARE OF THE SPRAY GUN

13-146. Spray guns (as well as paint containers and hoses) must be cleaned thoroughly after they are used.

13-147. Figure 13-25 shows the steps in cleaning a pressure-feed gun. First, back up the fluid, needle-adjusting screw and release the pressure from the pressure tank by means of the release valve. Hold a cloth over the air cap and pull the trigger (this forces the spray material back into the tank). Now remove the fluid hose from the gun and run a solvent through the hose. There is a special hose cleaner made for this purpose. Dry out the tip and clean the tank. Soak the air cap in solvent. If the holes are clogged, use a toothpick to clean them. Put all clean parts back in place, and the gun is ready for use again.

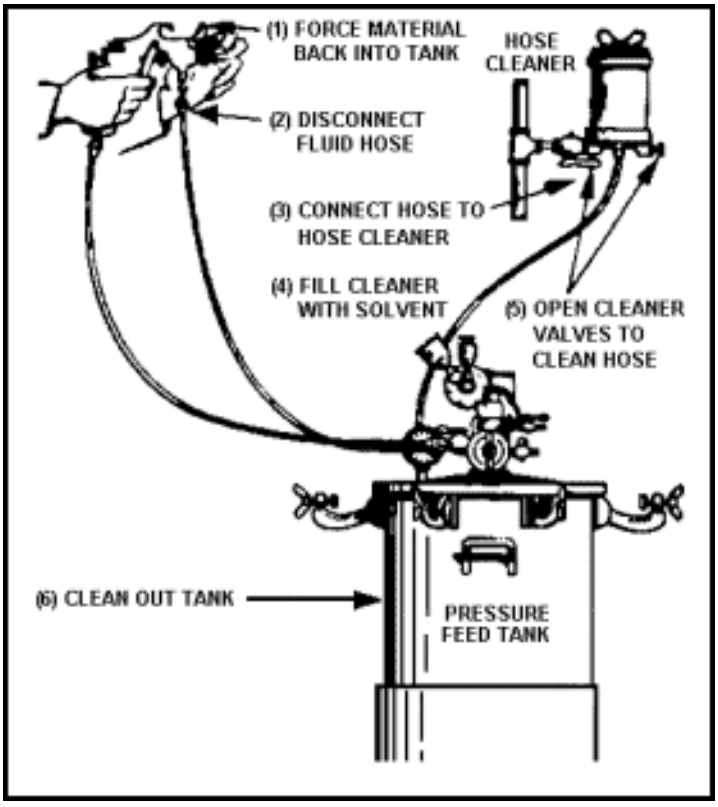


Figure 13-25. Steps in Cleaning a Pressure-Feed Gun

13-148. Figure 13-26 shows how to clean a container-type gun. First remove the container. Then hold a cloth over the air cap and pull the trigger. Empty the container and pour in a small quantity of solvent. Attach the container to the gun and spray in the usual way. This process cleans out all passageways. Clean the air cap by soaking it in a solvent and then replace it. Some spray gun troubles, their possible causes, and their remedies are listed in Table 13-3.

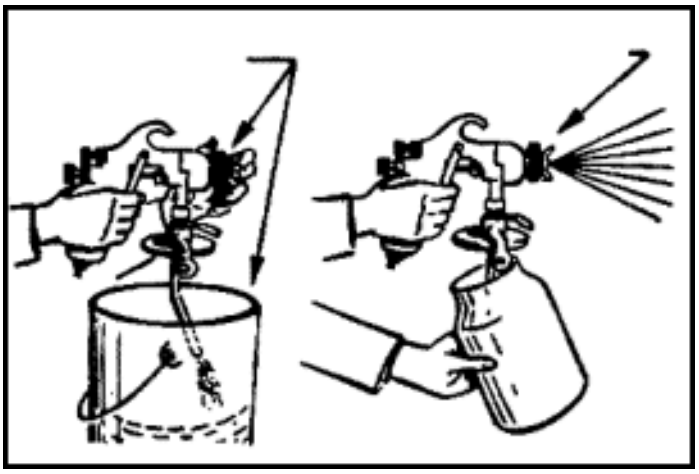


Figure 13-26. Steps in Cleaning a Container-Type Gun

Table 13-3. Spray Gun Troubleshooting Chart

TROUBLES	POSSIBLE CAUSES	REMEDIES
Air leaks from front of gun	Foreign matter on valve seat	Clean
	Worn or damaged valve seat	Replace
	Sticking valve stem	Lubricate
	Bent valve stem	Replace
	Packing nut loose	Adjust
Fluid leaks from front of gun	Worn or damaged fluid tip or needle	Replace
	Foreign matter in fluid tip	Clean
	Packing nut too tight	Adjust
	Wrong size needle	Replace
Jerky or fluttering spray (both suction- and pressure-feed)	Insufficient material in container	Refill
	Tipping container to excessive angle	Take greater care
	Obstructed fluid passageway	Clean
	Loose or cracked fluid tube	Tighten or replace
	Loose fluid tip or damaged tip seat	Tighten or replace
Jerky or fluttering spray (suction-feed only)	Too heavy a material	Change to pressure feed
	Clogged air vent in container lid	Clean
	Loose or damaged coupling nut or cup lid	Tighten or replace
	Fluid tube resting on bottom	Use proper fluid tube
Defective spray pattern	Air cap horn holes partially plugged	Rotate air cap one-half turn and spray another pattern.
	Dirt on air cap or fluid nozzle	If defect is inverted, fault is on/in air cap. If pattern is same, fault is on/in fluid nozzle. Clean proper part.

Lubrication of the Spray Gun

13-149. Your spray gun also needs a little lubrication. The fluid needle packing should be removed occasionally and softened with oil. The fluid needle spring should be coated with grease or petrolatum. Figure 13-27 shows the parts and the oil holes in which you occasionally should put a few drops of light oil.

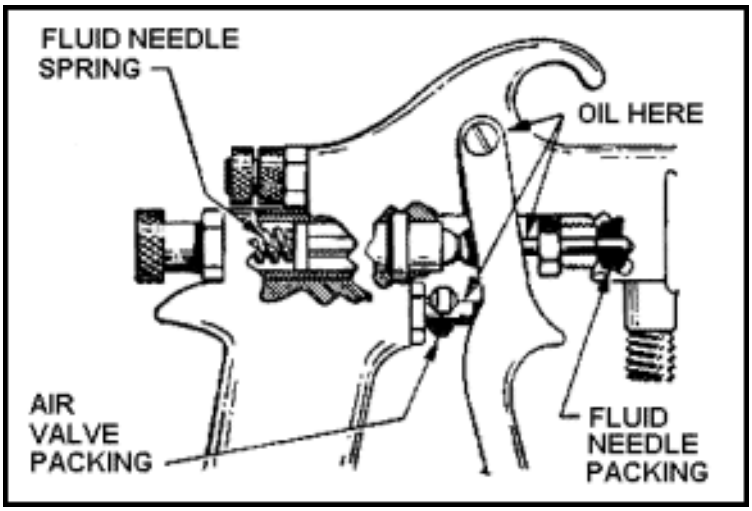


Figure 13-27. Lubrication Points of a Spray Gun

How to Remove the Spray Head

13-150. To clean, to repair, or to change paint color, you may have to change the spray head. First, remove the gun -from the air and fluid hose lines. Holding the gun in the left hand, pull the trigger all the way back and loosen the locking bolt with the wrench provided for the purpose. Push the trigger forward as far as possible and pull the spray head forward (Figure 13-28). To replace the head, push the trigger forward and insert the spray head. Then hold the trigger back and tighten the locking bolt.

What Not to Use in Your Spray Gun

13-151. As a general rule, paints, enamels, lacquers, synthetics, varnishes, and shellacs are suitable for spray work with ordinary equipment. Except in an emergency, material containing small gritty particles (such as alkaline coverings, rubber hose paints, plastics, and mastic paints) should never be used in standard equipment. They will damage the ordinary machines; therefore, use only the special outfits designated for use with those paints.

RESPIRATIORS

13-152. Spray painting breaks up the paint into a fine spray that releases fumes, pigment, and vehicle into the air. If you breathe them or otherwise absorb them into your body, these fumes and particles can cause injury. BE CAREFUL. Always wear a respirator when spraying or in the vicinity of spray work. Respirators are specially designed to give you maximum protection. Here are the most common types:

- The filter respirator (Figure 13-29) is equipped with filter pads. It can be used for spraying, grinding, or dust blowing when dust and fumes are not too severe. The cartridge respirator is designed for more severe conditions than those that can be met by a filter respirator. It uses a filter pad and a large purifying cartridge made of chemically treated charcoal.
- The dust respirator (Figure 13-30) is one of the most common types of respirators. It contains a replaceable cartridge and its light weight makes it easy to wear.
- The air supply respirator (Figure 13-31) provides you with complete protection when working in old, tank interiors, and other areas where no ventilation is possible. This type is supplied with fresh air through a compressed-air line, purified by a charcoal cartridge, and then fed to the breathing compartment of the respirator.
- The hood respirator (Figure 13-32) consists of a flameproof hood, a headgear of fiber with a metal eyepiece, and an air hose. The neck cloth at the bottom of the

hood ties snugly around your neck to prevent entrance of fouled air. The opening in front of the hood is the only outlet for the constant flow of air entering from a hose attached to the back of the hood. Foul air cannot enter because pressure inside is slightly greater than pressure outside. The generous opening permits maximum range of vision.

SAFETY PRECAUTIONS

13-153. The application of paints, varnishes, lacquers, enamels, wood bleaching liquids, and other flammable liquids by the spray process is more hazardous than brush or roller applications. This is due to the volume and concentration of fumes and particles as well as the production of a flammable residue and deposits, which are subject to spontaneous ignition. Health hazards from potentially harmful substances such as lead, benzol, and silica may also be present in paint-spraying operations.

13-154. To ensure immediate removal of vapors and paint dust from spraying operations, complete ventilation of the compartment is essential. A system balanced to supply fresh air as well as to exhaust vapors is recommended. Ordinarily the ventilation necessary for the health and comfort of the operators is also sufficient to remove flammable vapors.

13-155. Personnel using spray guns should wear clothing that fits tightly at the ankles, neck, and wrists. Approved respirators must be worn, and parts of the body not protected by clothing should be covered with petrolatum (Vaseline).

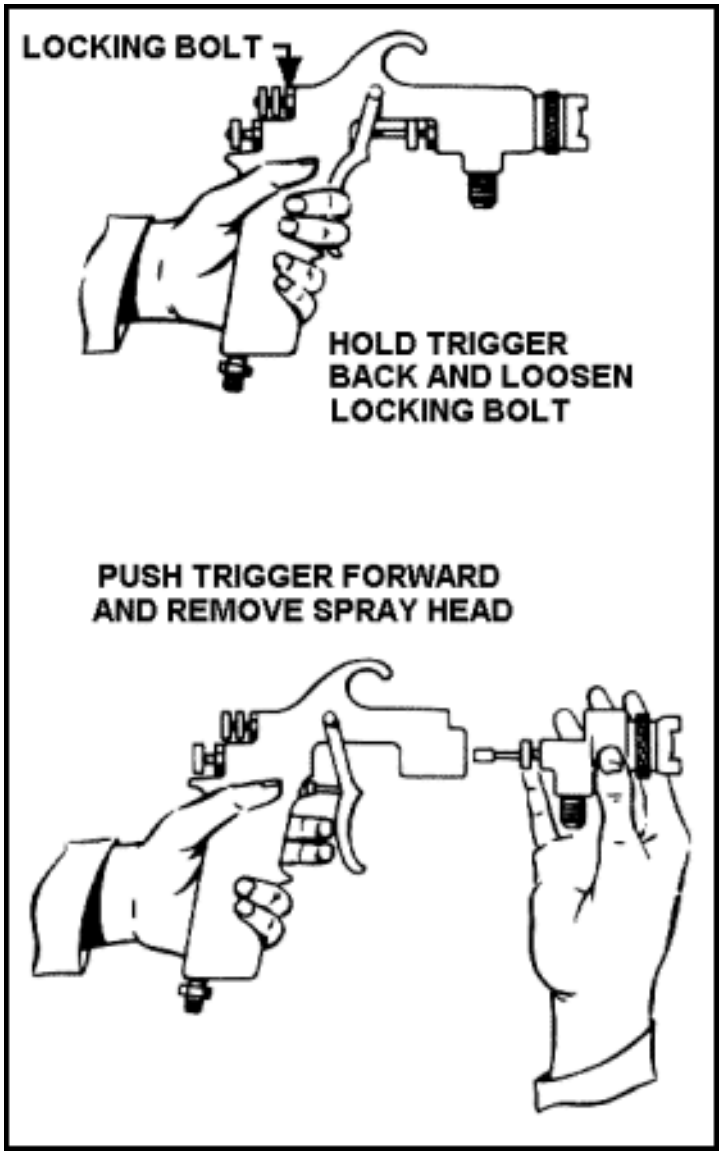


Figure 13-28. Removing the Spray Head

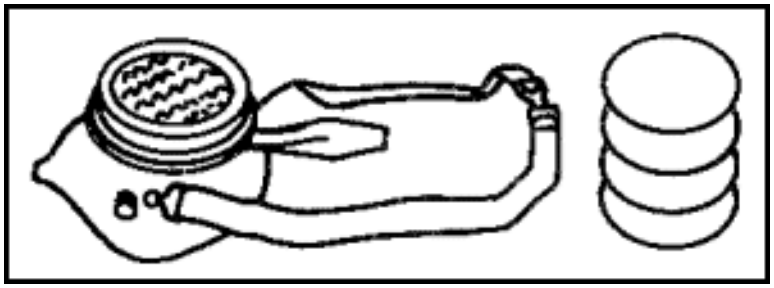


Figure 13-29. Filter Respirator

Figure 13-30. Dust Respirator

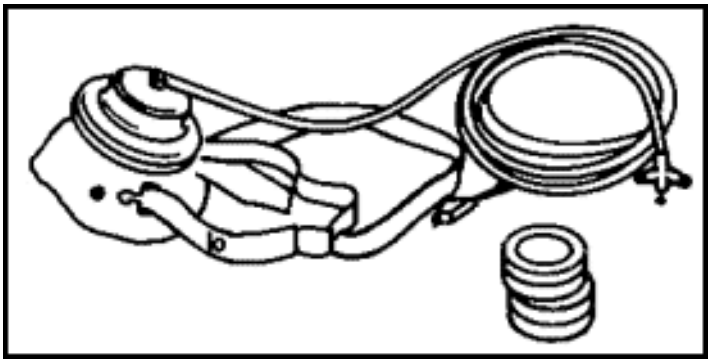


Figure 13-31. Air Supply Respirator

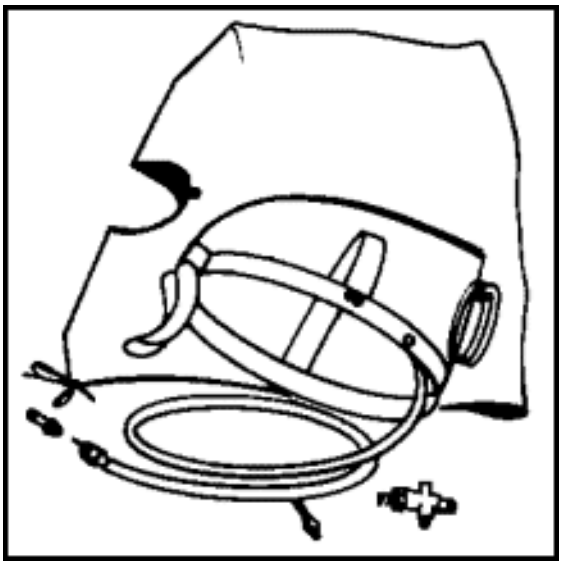


Figure 13-32. Hood Respirator

13-156. Smoking, open flames, welding, grounding of spray equipment, chipping, and other spark-producing operations are prohibited in compartments where spraying is in progress. Explosion-proof portable lights should be used. Care should be taken to ensure that wires do not become exposed from dragging and pulling. Bulbs must not be replaced in a compartment or tank being painted until flammable or explosive vapors have been removed.

ESTIMATING PAINT JOBS

13-157. To plan the work of your ship more competently and, particularly, to make the most effective use of your spray painting teams, you should develop the ability to estimate the number of man-hours and amount of paint required to do the ordinary, shipboard painting jobs.

13-158. It is difficult to list more than a few guidelines for estimating painting requirements. To lay down any hard and fast rules is impossible because of the many variables involved (type of compartment, skill of the team, type of paint to be used, and so on).

13-159. Keep notes on the jobs that your personnel perform. These records will help you with future estimations. Note such things as the number of square feet a gallon of each type of paint will cover when applied by different methods (see Table 13-4). Also how much time is required to ready the equipment for spraying, how many square feet of surface a team can paint in 1 hour, the number of gallons of paint required for each compartment, and so on.

Table 13-4. Paint Coverage per Gallon

1. ENAMEL – 400 FT2 (BRUSH)

2. ENAMEL – 500 FT2 (SPRAY)

3. HAZE GRAY – 500 FT2 (BRUSH)

4. HAZE GRAY – 500 FT2 (ROLLER)

5. GRAY DECK – 500 FT2 (BRUSH)

MAINTENANCE OF SHIP'S RIGGING AND DECK MACHINERY

13-160. Wire rope must be lubricated properly to ensure long life and safety. The internal parts of the wires move against each other wherever the rope passes over a sheave or winds on a drum. Each wire rotates around its own axis, and all wires slide against one another.

CLEANING AND SLUSHING STANDING RIGGING

13-161. A slush of specially prepared grease is used to prevent rust on standing rigging. It is very easy to handle and creates a minimal amount of drippings if applied sparingly. This is very important in regards to our protection of the environment. Remember that excessive use of cable lubricant will result in run off and eventual water pollution.

13-162. Galvanizing metal gives it a very thin coating of rustproof zinc. However, this coating eventually wears off in places, or the elements penetrate below it. Therefore, even though much standing rigging is galvanized, it should be slushed periodically.

13-163. The man going aloft should take a steel scraper and a wire brush to slush down standing rigging. Make sure that safety goggles and harness are worn. Any scale on the wire must be chipped or scraped off, and the wire brushed down, either to the bare metal or to a good hard coat of slush put on previously. New galvanized metal must be rubbed down with a rag soaked in vinegar before slush or paint is applied.

RUNNING RIGGING

13-164. A vessel’s running rigging consists of all the guys, tackles, whips, blocks, boat falls, and so on, used to control the motion of the ship’s movable gear or to handle cargo.

Blocks

13-165. Blocks on cargo davits and rescue boat davits must be periodically inspected and lubricated. Failure to do so could result in equipment failure at a critical time.

Slushing Down Running Rigging

13-166. Modern Army watercraft has very little, if any, running rigging. A thorough understanding of the care of this equipment is still necessary since it may be encountered. Wire in running rigging is protected from wear and the weather by being slushed at regular intervals with "Crater C" lubricant grease. On older break bulk type ships rigging was cared for from the boatswain’s chair, or the rigging may be unreeved and slushed while it is on deck. This slush is applied with a rag and it must be handled carefully to avoid getting spots on the deck, awnings, or paint work. The wire pendants or stationary supports on the ends of the tackles of cargo guys are also slushed because the pendants also need lubricated. Remember that excessive use of lubricant will result in deck run off that leads to water pollution.

WARNING: BEFORE SLUSHING ANY RUNNING RIGGING, BE SURE THE WINCH MOTOR IS DE-ENERGIZED.

SHACKLES AND TURNBUCKLES

13-167. Particular attention must be paid to protecting the threads of shackles and turnbuckles. They are the parts that will be eaten away first if not cared for properly. Turnbuckles should be opened out frequently, the threads should be brushed well, and the parts lubricated with graphite grease.

BOAT DAVITS

13-168. Boat davits should be inspected at least once a week. The regular lubrication of the mechanical components, as outlined in the individual manufacturer's manual, should be carried out.

13-169. The wire rope of the hoisting slings should be coated entirely with grease. As an alternative, grease may be applied only to those rope areas where salt water would form a pocket, adjacent to shackles, buttons, or clamps, and around the thimble.

WINCHES, CRANES, AND ANCHOR WINDLASSES

13-170. The maintenance and lubrication of heavy deck equipment (such as winches, cranes, and anchor windlasses) are performed by personnel of the engineering department. You need to keep in mind that you must work with this equipment. Therefore, for your own protection, you should assist as much as possible in the maintenance and lubrication of this equipment.

Chapter 14

Beaching and Retracting Operations

The term "landing craft" implies that the craft can safely land on a beach or shore. The most important phase of landing craft operations and the most severe test for the crew is beaching. Poor seamanship during beaching can risk life and property. The first task of the coxswain or master is to get past any obstructions that may be between deep water and the shore. The craft must be beached in a way that will not cause it to broach to and which will permit troops or cargo to be unloaded quickly and safely. A craft is broached to when it is thrown broadside to in heavy surf, heavy seas, or on a beach. After the craft is firmly on the beach, it must be retracted safely off the beach to be of further service to a unit. Like beaching, retracting from the beach requires skill in boat handling and seamanship.

RULES FOR LANDING OPERATIONS

14-1. During land operations, the landing craft coxswain or master must remember (even when he has the right of way) the importance of doing everything possible to avoid a collision. If there is immediate danger of a collision, his prime responsibility is to save the crew, passengers, cargo, and boat. Heavy surf, fog, smokescreens, and similar hazards met during landing operations call for special precautions and good judgment. Some general traffic rules for landing operations are as follows:

- Heavily loaded boats have right of way over lightly loaded or empty boats.
- Boats in tow have right of way over all boats.
- Retracting boats, which have their bows toward the beach and are in the surf zone, have right of way over empty or loaded boats.
- Boats, after clearing the surf zone, should keep clear of inbound craft. They should also make for the designated flank before continuing back to the transport.

SURF ACTION

14-2. To better understand this chapter, you should know what causes a surf and also the definitions of the terms. Definitions are as follows:

- **Breaker.** A single breaking wave.
- **Breaker line.** The outer limit of the surf.
- **Comber.** A wave on the point of breaking. A comber often has a thin line of white water on its crest.
- **Crest.** The top of a wave, breaker, or swell.
- **Foam crest.** The top of the foaming water that speeds toward the beach after the wave breaks.
- **Surf.** A number of breakers.
- **Surf zone.** The area between the first break in the swells and the shoreline.
- **Swell.** A broad, rolling movement of the surface of the water.
- **Trough.** The valley between waves.

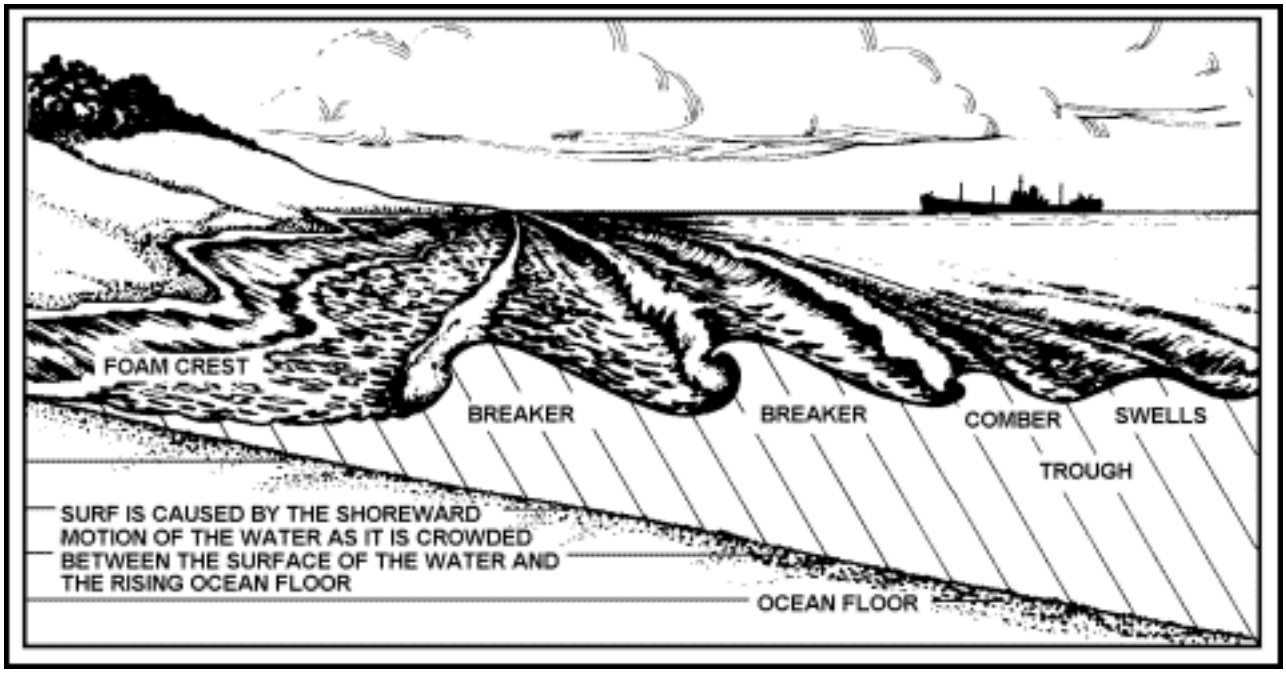


Figure 14-1. Cross Section of the Surf

14-3. Surf is caused by the swells as they move in toward the beach (Figure 14-1). As this movement approaches shore, it is confined between the rising ocean floor and the surface of the water. The more confined the water becomes, the more the crests peak up in the form of combers. Combers usually, but not always, form into breakers. A sandbar or reef between the outer surf (or breaker) line and the beach sometimes causes two (more or less) well-defined surf belts.

14-4. Breakers vary in size and sometimes may follow a sequence for a short interval (such as a large breaker following a certain number of smaller ones). There is no regularity to the pattern, so do not count on, for example, every seventh breaker being larger than the six preceding ones. However, the interval between breakers is fairly constant, tending to stay the same for several hours. Swells causing surf are created by winds far out to sea. The distance the swells travel from their origin, which may be several hundred miles, determines the interval between swells.

14-5. The important points to remember about surf are that you must not be lulled into expecting the surf to be consistent, you must respect it, and you must learn how to make it work for you while beaching and retracting.

PREPARING TO HIT THE BEACH

14-6. As stated earlier, the most important phase of landing craft operation and the severest test for the landing craft crew is beaching. Poor seamanship during this operation can jeopardize life and property. A number of important rules to be observed by the master or coxswain when hitting the beach are as follows:

- Check to see that all equipment and cargo are properly secured.
- Ensure that all personnel are wearing life jackets.
- Make sure that each crew member is in his place and ready for the run.
- Prior to entering the surf zone, check the ground swell and attempt to gauge the nature of the surf. Surf will appear only half as high as it actually is when looking from seaward to the beach. Therefore, what appears to be a 3-foot surf is actually a 6-foot surf.
- Cross the surf line at a right angle to the advancing waves (Figure 14-2). Waves are not always parallel to the beach.
- Approach the surf line at reduced speed and take each wave carefully. Pick out an object on the beach as a guide (range markers are desirable), select a stern wave of considerable size and, as the wave gets under the craft, increase speed to that of the wave, and ride in just behind the crest. If impossible to keep up, select another wave and repeat the process. However, be careful to ensure that the surf is kept perpendicular to the stern to prevent broaching to. Once inside the surf line, the course should not be changed, and the craft must be kept lined up with the object on the beach.
- If a bar stops the forward progress, reduce speed, wait for flotation, and proceed. If necessary to unload at the bar, check the depth of water prior to debarking troops or equipment. Do not debark troops or equipment into water too deep to ford.
- Hit the beach at the fastest speed possible. Keep the engines ahead, and use the rudders and engines to keep the craft on the beach.
- Constantly check the seawater strainers and discharge to prevent engine failure at this critical time. When the ramp is down, it will help keep the boat on the beach.

WARNING: DO NOT DROP THE RAMP WITHOUT FIRST CHECKING UNDERNEATH TO ENSURE THAT ALL IS CLEAR.

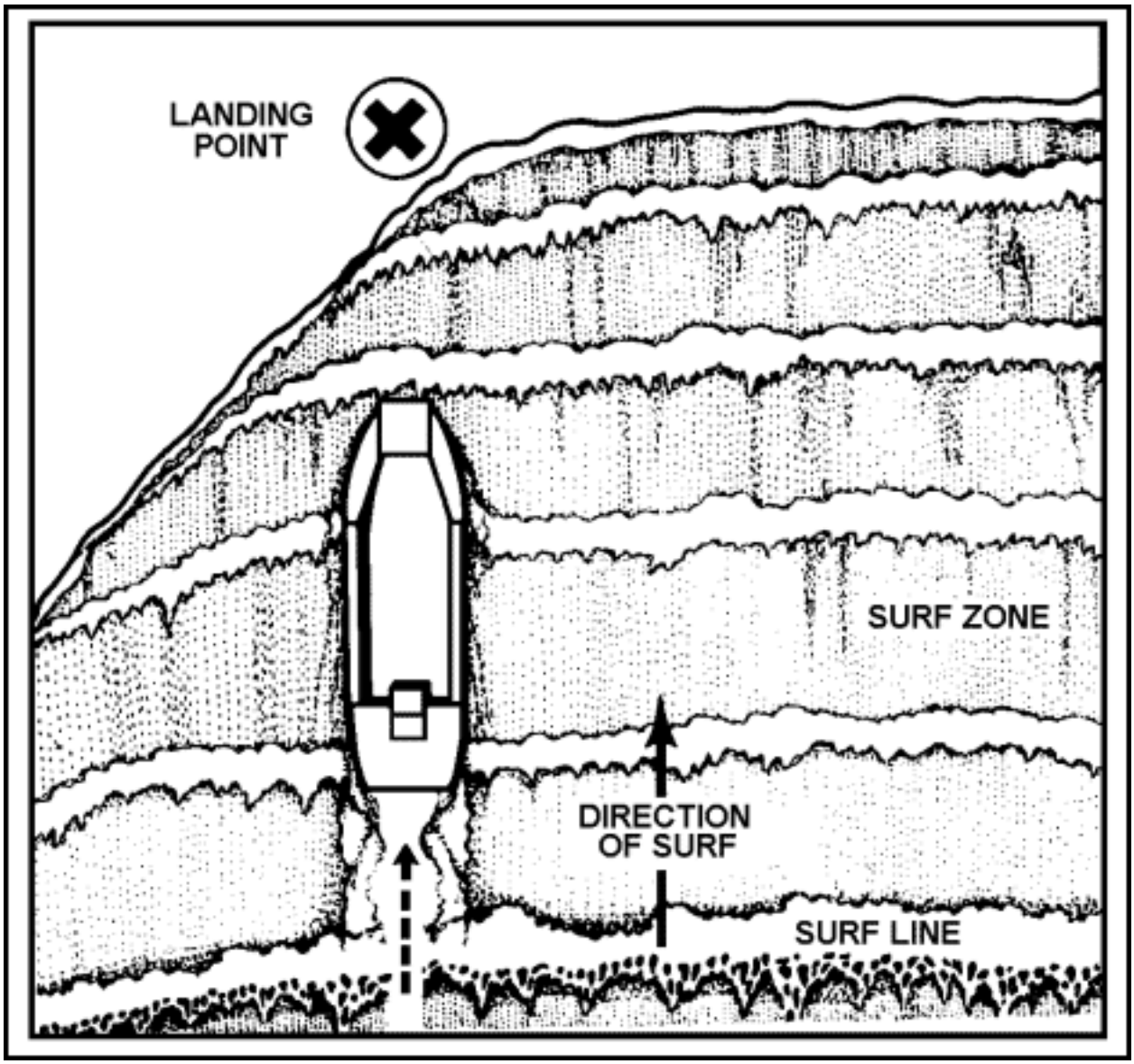


Figure 14-2. Crossing the Surf Line

BEACHING HAZARDS

14-7. There are a number of hazards that can be encountered. Be prepared to take the appropriate safety measures to safely maneuver your vessel.

SANDBARS

14-8. Sandbars encountered on the run to the beach should be hit by slowing down your craft. In many cases, the boat's momentum and the following wake will be sufficient to carry the craft over the obstruction. However, if the forward motion of the craft is stopped, the engines should be slowed immediately to idling speed. Then, when the stern wash comes under the craft, the engines are run at half throttle until the craft works free. If this method fails, it is still possible to get the craft over by use of the propeller streams. The starboard or port engine is reversed and set at half throttle, and the other engine is held at half ahead. The screw current from the reversed propeller will then wash the sand away from the side of the keel, cutting a small channel through the bar. If the freeing of one side is not enough to get the boat free, the engines can be shifted to dig the sand away from the other side of the keel. Turning the wheel from side to side helps to work the craft free. As soon as the boat becomes free and begins to move through the bar, both engines are put ahead until the craft is completely clear. In some cases, it is possible to work a boat clear by moving its cargo, combining the shift in trim with lift of the waves, to provide the necessary flotation. When the craft is free, it is run into the beach just behind the crest of a wave. As soon as the craft beaches, the engines are throttled down until the wash or a wave provides additional flotation, at which time the engines are accelerated to move the boat up on the beach. In a calm surf, the engines are slowed when about two boat lengths off the beach and then accelerated when the stern wash lifts the craft. The sudden stopping of the boat when it touches on a bar or beach can cause serious injury to personnel in closed spaces. All personnel aboard should therefore be kept out of the engine room during the last stages of the run.

REEFS

14-9. Two general types of reefs are fringing and barrier. Fringing reefs are attached to the land, while barrier reefs are separated from the land by a body of water called a lagoon. The problem of crossing a reef in a landing craft is largely a question of water depth. At high water, the minimum depth over a reef should be about equal to the tidal range. Under certain conditions, the rising and falling action of tidal waters usually cuts passageways through the reefs. Whenever possible, use the channels when approaching or clearing a beach.

SHELVING BEACHES

14-10. A shelving beach is one where the shore gradually slopes toward the sea. Where there is a long, shelving, sandy beach it may be necessary to run the craft a long way over the bottom to reach the beach. In this case, it is best to continue ahead by taking advantage of the waves for added flotation whenever possible to aid in carrying the craft onto the beach. When small sandbars are encountered, the craft can be freed by using the propeller streams as described earlier. If the craft cannot be freed by this method, lower the ramp and use a boat hook or sounding pole to check the depth of water immediately ahead. If shallow enough, one man should be sent in with a pole to test the depth all the way to the beach before troops or cargo are unloaded.

BROACHING TO

14-11. The most difficult task of the coxswain or master, in heavy weather, is to keep the craft from broaching to (or turning broadside to the sea or wind so as to risk capsizing). This occurs when the bow stops in still water and the stern is thrown around by the impact of the next wave. The same thing can happen, however, when the bow stops on the beach and the stern swings in toward the beach. In the first case, the craft probably will be thrown up on the beach before the coxswain can regain control. In the second case, the craft is already on the beach with the seas pounding it, and the boat may fill with water. In moderate surf, a broached landing craft sometimes can be freed under its own power. If the stern lies to port, it may be brought around by accelerating the port engine in reverse (causing the port screw current to wash sand from under the craft), and idling or accelerating the starboard engine ahead with the rudders hard left. The procedure is reversed if the stern lies to starboard. During this operation, the engine saltwater discharge lines must be visually checked to make sure the saltwater pumps are functioning properly.

14-12. The five measures listed below are designed to aid in avoiding situations that might cause broaching to.

- The coxswain or master must watch the seas carefully and maintain all possible headway during the run to the beach.
- Breaking seas must be kept dead astern and perpendicular to the craft at all times, even if it means hitting the beach at an angle.
- If the stern starts to swing, the engine opposite the swinging side should be accelerated and the wheel put over sharply in the direction of the swing.
- As incoming waves float the boat, the engines should be accelerated in forward gear to force the craft well upon the beach so that as much of the keel as possible is on the beach.
- The stern anchor on LCUs should be used as an antibroaching aid.
-

BEACHING PROCEDURES

14-13. During beaching operations, the operator must stand by the helm to hold the boat securely on the beach. This is true especially when the craft is on a steep beach with its stern partially afloat or while it is being loaded or unloaded. If the stern begins to swing around, the antibroaching procedure must be followed. In every case, the stern must be held directly into the seas or it will broach to immediately. The operator should apply forward throttle in varying amounts on each engine, depending on the particular situation, and also use the rudders as needed. The thrust of the propellers from a LCM will build up a sandbar in back of an average beach. On a steep beach, however, this problem will not occur because of the depth of the water at the stern.

14-14. The engines must get enough seawater for cooling while the craft is beached. If the engines show signs of overheating or if there is inadequate seawater discharge, the craft must be retracted sufficiently to allow the seawater suction pump to draw in more water.

14-15. The tides must be carefully checked during a prolonged stay on the beach and the craft moved in and out with the tide so that the stern stays in the water while the bow remains properly beached. In some localities, circumstances may require that the craft be beached prior to low tide and left resting on the bottom while the tide is out. In this case, the operator should select a position where the bottom is clear of rocks and obstructions.

CAUTION: Boats must never be left on the beach unattended or unwatched.

BEACHING AN LCU

14-16. When beaching an LCU, the crew should be alerted as to the intended beaching operations and crew members should be at their assigned stations. The following procedures should be used:

- Before entering the surf line, select a stationary object on the beach to help you establish your angle of approach.
- At all times, keep the LCU at right angles (90 degrees) to the surf line, even if it means hitting the beach at an angle.
- Begin the approach to the surf zone at a reduced speed.

RETRACTING AN LCU

14-17. The following procedure will be used when retracting an LCU:

- Have personnel at their assigned stations.
- Put the rudders amidships.
- Have the chief engineer start up the anchor windlass engine.
- Put the port, center, and starboard engines half speed astern to break the LCU free from the beach.
- Stop the engines once the LCU is free of the beach.

CAUTION: The chief engineer must keep up the speed of the anchor windlass to take up all the slack in the anchor cable. This will prevent the danger of the LCU overriding the anchor cable and fouling the propellers.

- If sandbars are encountered, put one engine half astern and the other half ahead. Alternate the outboard engines until a channel has been cut through the sandbar. The center engine on the 1466 class LCU is also put at half speed astern and is used to help the engine that is backing to cut a channel.
- House the anchor.

Note: The next step is accomplished after the anchor has been housed and the surf line has been cleared. The direction of turning will depend on the wind. Use the wind to your advantage.

- Put the rudders hard left, starboard engine full ahead and the port engine half astern. Reverse the procedure if turning to starboard.

Note: The turn is made at the crest of a wave as rapidly as possible and the turn is completed in the trough so that the LCU can meet the next sea head on.

CAUTION: Never turn in the surf zone. Boats retracting which have their bows toward the beach and are in the surf zone have the right of way over empty or loaded boats coming into the beach. Boats beyond the surf zone and leaving the beach will keep clear of inbound boats.

RETRACTING AN LCM

14-18. The procedures for retracting or backing the boat off the beach are generally the same for all landing craft except the LCU, in which case the stern anchor and winch are employed. Before retracting, the coxswain or master ensures that the rudders are not turned. All engines are backed down and used to steer until the craft is in deep enough water to permit proper rudder control. Landing craft are normally retracted at low speeds for control through the propellers. If bars are encountered during retracting operations, the procedure described earlier is partially reversed. One engine is backed down at half throttle and the other is put ahead about half speed, alternating until a channel has been cut through the bar. Both engines are then put in reverse and the boat is backed straight out. When completely clear of the surf line, the craft is turned to starboard by putting the starboard engine in reverse, the port engine in forward, and the wheel hard over right (this procedure is reversed when turning to port). The maneuver should be started on the crest of a wave and completed in the trough so that the craft will meet the next wave head on. When the breeze is fairly strong, the coxswain should use the wind to aid the start of the turn by letting the bow swing off to leeward. When putting about, the coxswain must make sure that the turn will leave the craft clear of incoming traffic. Turning in the surf zone must be avoided. When going against the waves, headway is maintained between waves but reduced somewhat when larger crests are encountered. This reduces the craft's resistance to the sea and allows it to ride over without danger of taking on excessive water.

CAUTION: The coxswain must make sure to pause a few seconds in neutral before engaging the opposite gear to allow the propeller time to stop turning. Failure to do so will result in transmission slippage plus an expensive and time-consuming repair job.

14-19. Retracting from a shelving beach in a bad surf poses special problems for the landing craft crew because, in most cases, the boat has been landed well up on the beach. The best solution is to rely on the seas and the power of the engines. By this method the engines are accelerated in reverse each time a wave washes under the stern and the process repeated until the craft works free. When completely cleared, the boat is turned seaward.

14-20. Retracting from steep beaches presents no special problems under normal conditions, but because of the depth of the water just off the beach the surf has a more direct and immediate effect on the operation in heavy weather. This situation calls for careful handling and rapid response in getting the craft off the beach.

SALVAGE PROCEDURES

14-21. Experienced salvage boat crews never lose sight of the fact that their main objective is to keep the beach clear for incoming waves of boats. They never become so involved in freeing a disabled boat that they impede the progress of other landing craft en route to the beach. On the other hand, salvage boat crews must free broached and stranded landing craft as quickly as possible for the safety of the crew of the disabled boat. For their part, the men in the operable boat must do all they can to keep the craft shipshape. The engines must be kept running at all costs. Once the engines fail, the landing craft is helpless, even if free from the beach.

14-22. In a light surf, the salvage boat may back in far enough to pass the towline to members of the crew of the stranded boat who wade out to receive it. Whenever possible, it is better for the salvage boat to remain outside the breaker line and let another inbound landing craft carry the towline to the beach, from which it may be passed to the stranded boat. Another possibility exists if the beach is flat and the surf is breaking well out. Under such conditions, the salvage boat may be beached and the line then passed to the disabled boat. But if the surf is breaking close in-shore or if the beach is steep, the salvage crew may approach the weather (windward) side of the broached boat and throw a heaving line so that the heavier towing line may be hauled aboard. Approaching from windward enables the heaving line to be thrown more effectively. The distance between the boats also decreases, as the salvage boat is set toward the stranded boat by the wind.

14-23. In a heavy surf it may be necessary to remain outside and use the line-throwing gun. At other times, it may be better seamanship to anchor the salvage boat by the bow outside the breakers and pay out the anchor line so the salvage boat drops astern close enough to pass a line to the helpless boat. The strain on the anchor line will hold the bow of the salvage boat to the sea. This procedure is generally undesirable, because it is difficult for the salvage crew to haul in the anchor line with sufficient speed when their boat begins to move seaward in the direction of the anchor.

14-24. Once the towline has been passed, the crews of both boats should keep in mind the following procedures (see also Figure 14-3):

- Both the salvage boat and the towline should be perpendicular to the waves.
- A bridle is always used when freeing an LCM.
- The towline must not foul the screws of either boat.
- A broached boat is never towed by one quarter. Such a tow would be both dangerous and inefficient.
- The salvage boat never attaches the towline to its own bow but, to maintain maneuverability, the towline must be secured well forward of the screws and rudder.
- After the salvage boat has moved out beyond the breaker line, a steady strain is put on the towline. Slack must be taken up smoothly. Do not use full throttle until all slack is removed. The stranded boat should come off the beach a few inches at a time as each sea raises her. The broached boat may not break free immediately, so a steady pull should be maintained until ordered otherwise.
- The coxswain of the disabled craft should keep it in forward gear. As the engines are gunned forward while a wave is receding, the discharge current blasts the sand away from the rudders and skegs. This prevents rudder damage and enables the boat to draw off the beach without digging into the sand. Likewise, keeping the engines in forward gear adds to the strain of the disabled craft. When the stern is broken free, the engines are reversed to assist the salvage boat. Once freed from the beach, the boat is towed clear of the surf.

The towline is cast off unless the tow is crippled.

14-25. The foregoing general rules serve only as examples of common procedures followed in typical situations. There are no hard-and-fast rules for salvaging. No two salvage jobs present exactly the same problems; each must be solved individually. The below are a few examples that illustrate procedures carried out in more unusual situations.

- When a boat is stranded and lying almost parallel to the beach, attaching the towline to the bow may be desirable. Sometimes the boat can be swung around with its stern serving as a pivot. In such cases, slip the towline under the bow, bring it up around on the shoreward side, and fasten it to a forward bitt or cleat. When freed, the boat is towed out to sea, bow first.
- On a steep beach, made treacherous by a heavy backwash and current, the best salvage approach may be for the salvage boat to beach at some distance from the stranded craft. The towline may then be carried across the beach by hand and secured. This method of passing the line lessens the danger of the heavy backwash carrying the towline into the screws of either or both boats.
- In the foregoing situation, if the salvage boat cannot draw near the shore, attach a light line to a life ring and let the life ring float in with the surf. The crew of the stranded craft can use the line to haul in the heavier towline.

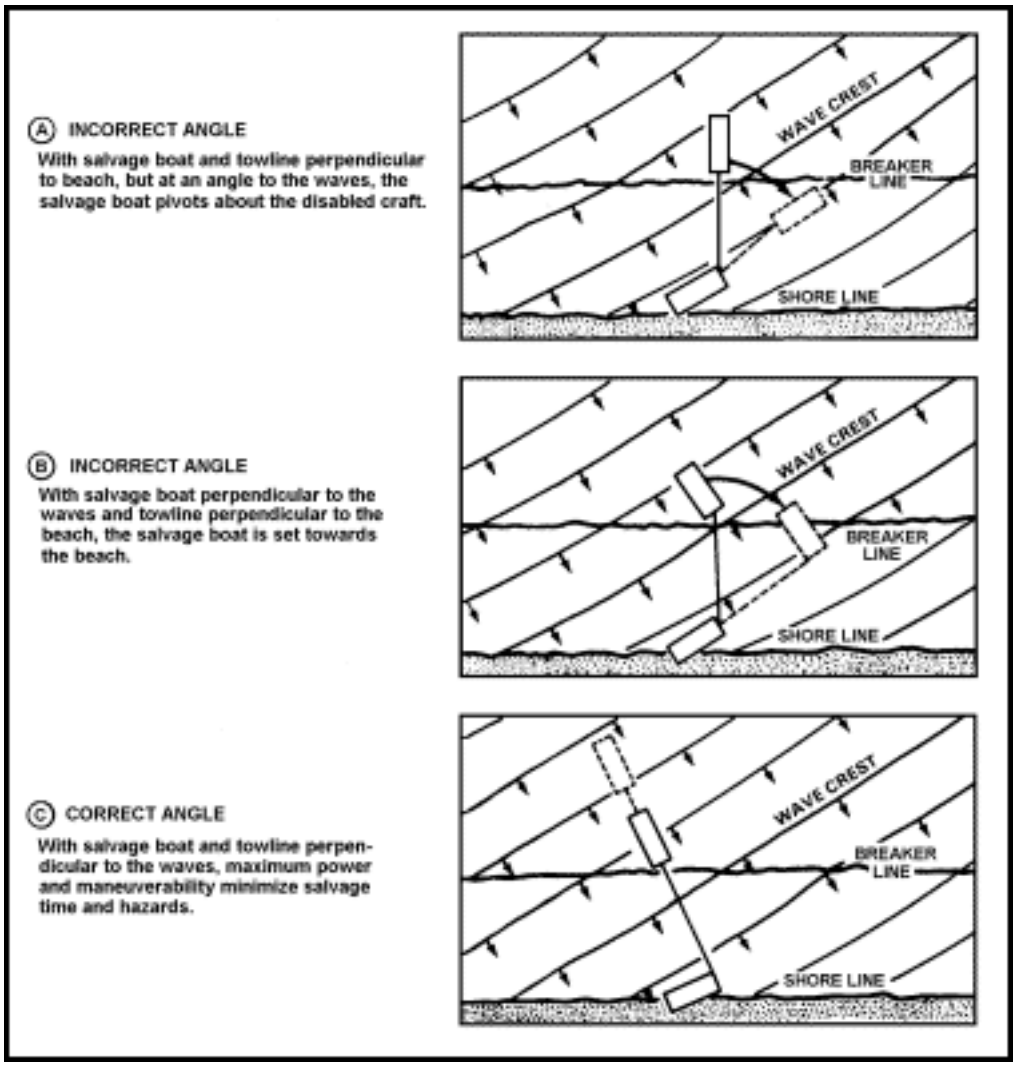


Figure 14-3. Correct and Incorrect Angles for Towing Broached Boat Clear of Beach

Chapter 15

Landing Craft Operations

Two principal types of landing craft operations are administrative and tactical. If the deployment is such that it is undesirable for watercraft units to move under their own power, various types of oceangoing vessels can transport them overseas.

ADMINISTRATIVE OPERATION

15-1. This type of operation is one during which no enemy interference or contact is anticipated. Emphasis is on economy; that is, maximum use of the transport capability. An overseas administrative move will be documented according to DOD Regulation 4500.32-R, Volumes 1 and 2.

TACTICAL OPERATION

15-2. This type of operation is different in that personnel, supplies, and equipment are loaded so that they may be unloaded easily and rapidly in accomplishing the tactical mission. Here, maximum use of the transport capability is secondary to successful accomplish the mission.

SECTION I - TACTICAL OPERATIONS

AMPHIBIOUS OPERATIONS

15-3. An amphibious operation is an attack launched from the sea by naval and landing forces embarked in ships or craft. This operation involves landing on a hostile shore to gain a lodgment area from which to carry out further combat operations ashore. The purpose is to obtain an advanced air or naval base area or to deny the use of seized positions to the enemy.

15-4. Loading plans for movement by ship are prepared based on the priority in which equipment and supplies will be needed upon landing. The priority is based on the equipment needed in the overall operation. When the far shore priority has been determined, the water transport unit commanders submit loading priority lists for their units to the HQ responsible for conducting the movement. The water transport unit commander is responsible for having the troops, equipment, and supplies available for loading when and where the higher HQ specifies. Landing craft may also be loaded along with personnel, vehicles, and unit equipment on naval transport vessels and conventional cargo ships for movement overseas.

LOADING FOR MOVEMENT OVERSEAS

15-5. The LCM-8 and LCU are usually transported aboard a heavy lift ship. When conventional ships are used, landing craft must be loaded or unloaded by cranes.

BOAT GROUPS

15-6. The boat group (under a boat group commander) is the basic naval organization of landing craft and amphibious vehicles. It is composed of the numbers and types of landing craft and amphibious vehicles required to land a particular troop unit (normally a battalion landing team). The boat group is organized into waves. Each wave will consist of the landing craft that will beach simultaneously.

15-7. Each landing craft is assigned to load troops or supplies from a certain ship. Troops load at debarkation stations marked by colored squares and numbers. Debarkation numbers run forward to aft, with odd numbers to starboard and even ones to port. The sequence of colors, also forward to aft, is red, white, blue, yellow, green, and black. At night, single-cell flashlights with appropriately colored lenses mark the debarkation stations.

CALLING BOATS ALONGSIDE

15-8. Flag hoists are used to call landing craft alongside naval amphibious cargo ships discharging cargo during tactical operations. These flag hoists are flown from either the main yardarm or from a special yardarm at the stern of the vessel being discharged.

DAY SIGNALS

15-9. Flag hoists flown from the starboard yardarm call boats to the starboard side. Hoists flown from the port yardarm call the landing craft to the port side (see Table 15-1).

NIGHT SIGNALS

15-10. At night, boats are called by three vertically aligned lights. These lights are coded as shown in Table 15-2.

Table 15-1. Day Signals

Top flag	Type of craft	
Papa	LCVP	
Lima	LCPL	
Six	LCM-6	
Eight	LCM-8	
Bottom flag	**Station number**	
(color)	(stbd)	(port)
Red	1	2
White	3	4
Blue	5	6
Yellow	7	8
Green	9	10
Black	11	12

Table 15-2. Night Signals

Top light	Side of Ship	
Green	Starboard	
Red	Port	
Center light	**Type of craft**	
Red	LCVP	
Amber	LCPL	
Blue	LCM-6	
Green	LCM-8	
Bottom light	**Station number**	
	(stbd)	**(port)**
Red	1	2
White	3	4
Blue	5	6
Yellow	7	8
Green	9	10
Black (no light)	11	12

LANDING CRAFT WAVES

15-11. Landing craft are formed into groups of six to eight boats. These groups of boats are called waves. The number of craft in each wave depends on the landing plan. The convoy commander is on the lead boat in the convoy. Control craft are stationed on the port and starboard flanks; salvage and maintenance boats are in the rear.

15-12. When a boat in a scheduled wave is loaded, it is given a paddle with two numbers on it--the first indicating the number of the wave, and the second, the boat's position in the wave.

15-13. After loading, a boat proceeds to the rendezvous area, falls in with its wave, and commences to circle slowly. The first wave of landing craft circles clockwise, and so on. Moving out of the rendezvous area, the boats proceed in a column and, when clear of the transport area, form into a wedge with odd-numbered boats to starboard and even-numbered boats to port of the boat carrying the wave commander. Before crossing the LOD, the boats are formed in line abreast. The distance between boats is usually 50 yards.

15-14. The coxswain of each craft should have sufficient charts and navigational aids aboard to enable him to travel alone in emergencies. The coxswain should be briefed on such details as follows:

- Approach and landmarks of the location.
- Currents and tides that prevail in that specific area.
- Suitability of the location for anchoring, depth of the water, and type of bottom.
- Facilities for procuring fuel, freshwater, and supplies.

TYPES OF FORMATIONS

15-15. Three basic reasons to run in formation are to keep in order and maintain contact and control between craft, facilitate landing large numbers of troops or amounts of supplies in a designated place of concentration, and present a difficult target for enemy fire. The following subparagraphs discuss four different types of formations.

THE CLOSED-V FORMATION

15-16. This formation enables craft to maintain closer contact than the straight column. The closed-V formation is used primarily in moving from the rendezvous area to the LOD. It is also the preliminary step in forming the open-V formation.

THE OPEN-V FORMATION

15-17. This formation is used primarily in assault beaching operations. It permits a large number of troops and supplies to be landed in one place with good control between craft and a minimum of vulnerability to air attack. In this formation, each craft is 50 yards astern and 100 yards abeam of the craft ahead.

THE LINE-ABREAST FORMATION

15-18. This formation is used during and after crossing the LOD. Such a formation is vulnerable to flanking shore fire and more difficult to control. The number of craft in a wave depends on the width of the beach. The craft are normally stationed 50 yards apart.

THE STRAIGHT COLUMN

15-19. This is a simple formation in which the craft operate in a straight line at intervals of 15 to 50 yards (depending on visibility). This formation is used when leaving the beach, when in a rendezvous area, or when operating in a noncombat situation.

LANDING CRAFT VISUAL SIGNALS

15-20. Special visual signals used in directing watercraft formations during both day and night are an absolute necessity in certain situations (Figure 15-1). Every watercraft operator should know how to send and receive signals. These signals must be given carefully and distinctly.

DAY SIGNALS

15-21. Hand and arm signals are used between landing craft by day when visibility permits. A signal flag may also be shown in the hand to permit recognition of the signal.

NIGHT SIGNALS

15-22. Two methods are used to transmit signals at night. Hand and arm signals are given using a flashlight equipped with a red lens, or a signal light may be used to transmit by Morse code signal the type of formation required. Arm and hand signals are used when radio silence is in effect and/or when a radio is inoperative. All crew members should know arm and hand signals. A receiving vessel should pass the signal to the vessel astern.

MANEUVERING SIGNALS

15-23. These signals (see Table 15-3) may be transmitted by signal flag or blinker.

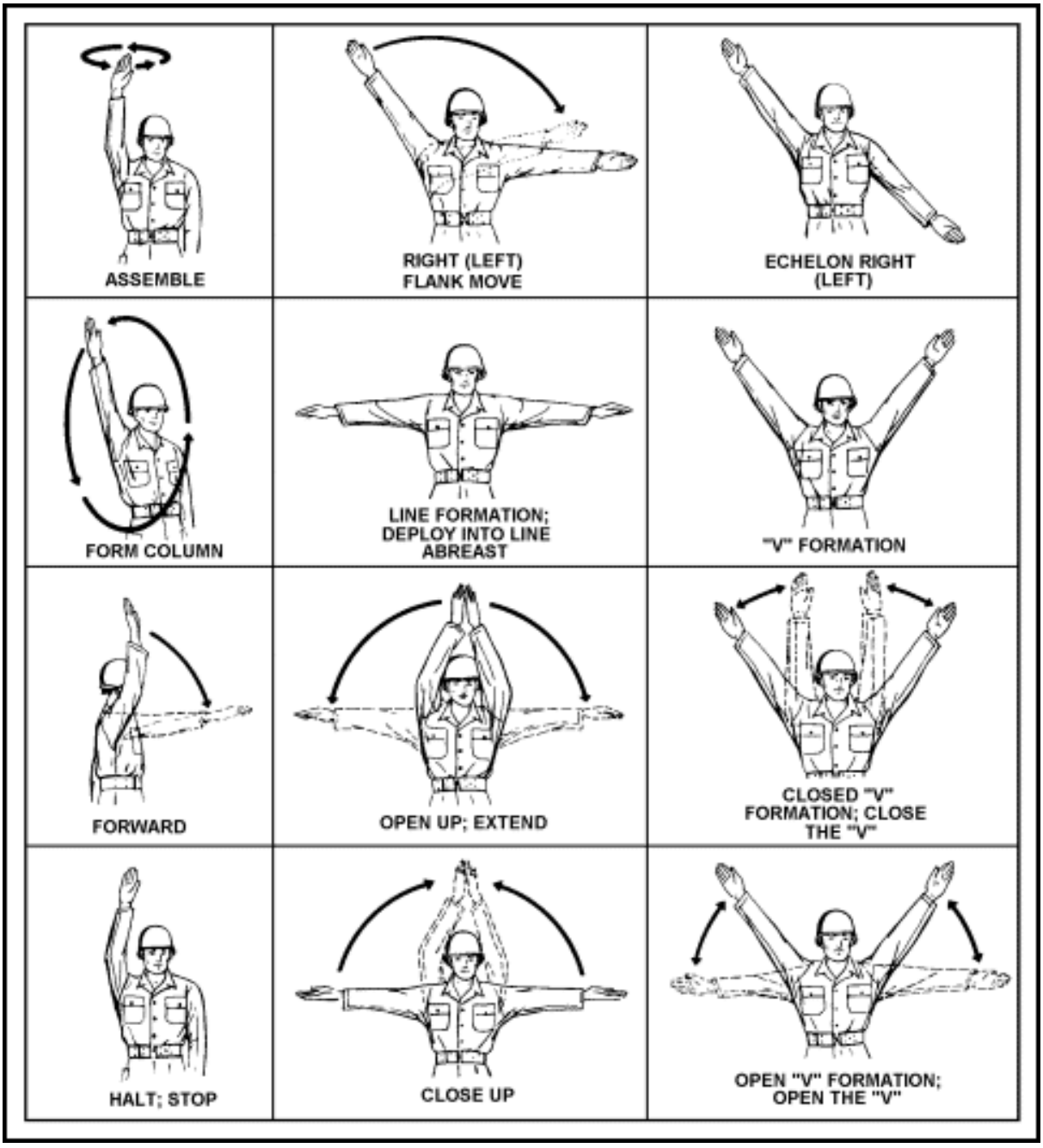


Figure 15-1. Arm and Hand Signals

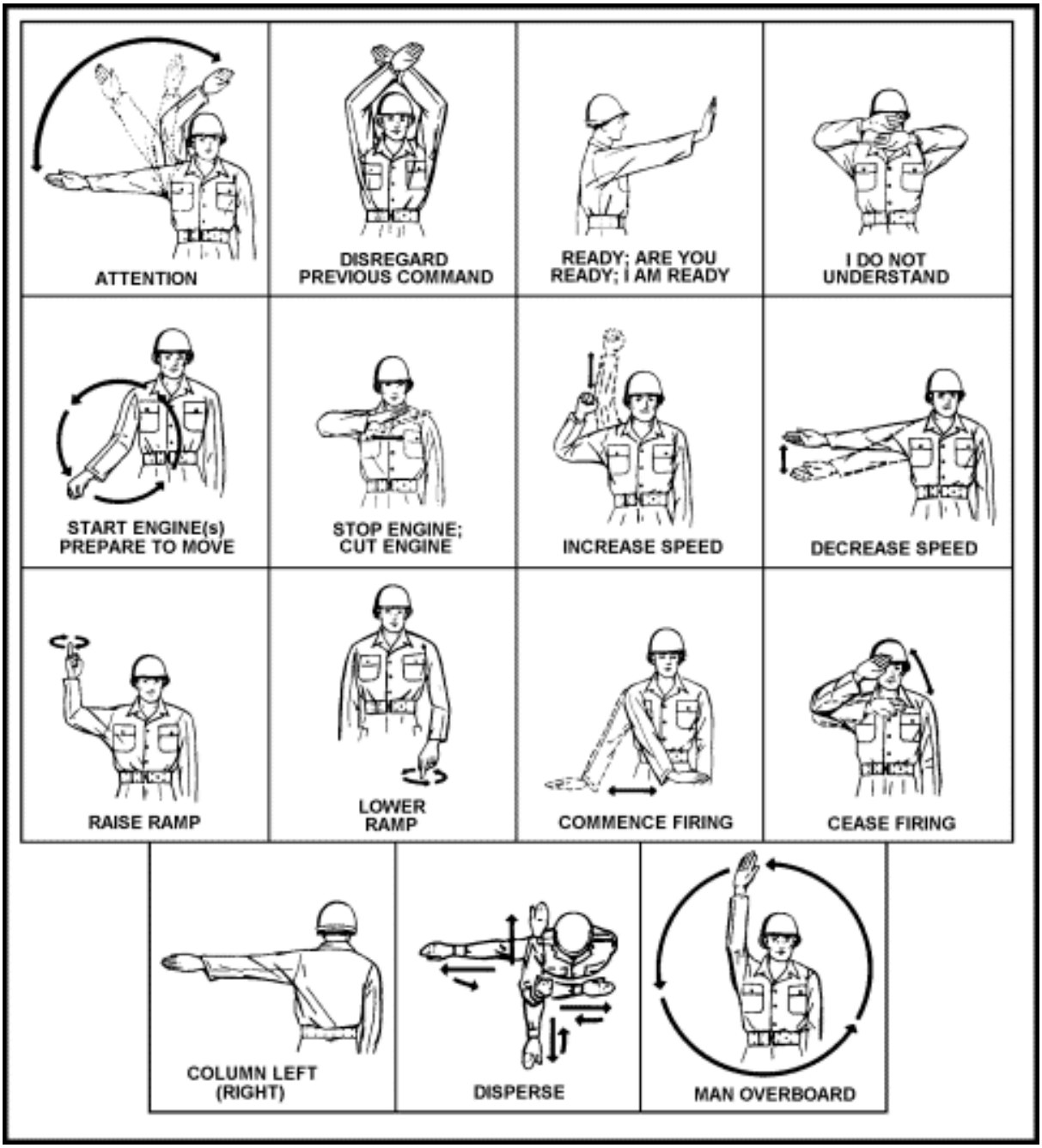


Figure 15-1. Arm and Hand Signals (continued)

Table 15-3. Maneuvering Signals

Command	Signal flag	Signal light
		(Morse code)
Attention	Mike	– –
Assemble in a column	Alpha	. –
Cease firing	Hotel	. . . .

Commence firing	X-Ray	– . . –
Execute	Echo	.
Forward	Foxtrot	. . – .
Increase speed	Kilo	– . –
Line abreast	Romeo	. – .
Man overboard	Oscar	---
Stop	Delta	– . .
V-formation	Uniform	. . –
Close the V-formation	Uniform/Tango	. . – /–
Open the V-formation	Uniform/Romeo	. . – /. – .

HYDROGRAPHIC AND BEACH MARKERS

15-24. The naval beach party is landed early in the assault. When they reach the beach, they proceed with their duties of marking channels and hazards to navigation.

Note: The US Navy Beach Master Unit is responsible for setting up and maintaining beach markers. These markers are used only during a tactical operation.

15-25. During the process of beach organization, debarkation points for various categories of supplies and equipment are selected on each beach where they best support the tactical plan. Shore party personnel erect beach markers and debarkation point as soon as possible after the initial assault of an amphibious landing. These debarkation markers along with lights for night operations are set up to indicate to the boat crews where the various types of cargo are to be landed.

15-26. Beaches under attack are given a color designation such as red beach, green beach, and so forth, and beach markers are constructed in corresponding colors. The center of a beach is marked by a large square of cloth with the color side facing seaward. The left flank of the beach, as seen from the sea, is denoted by a horizontal rectangle of the same color, while the right flank is marked by a vertical rectangle, also of the same color (see Figure 15-2).

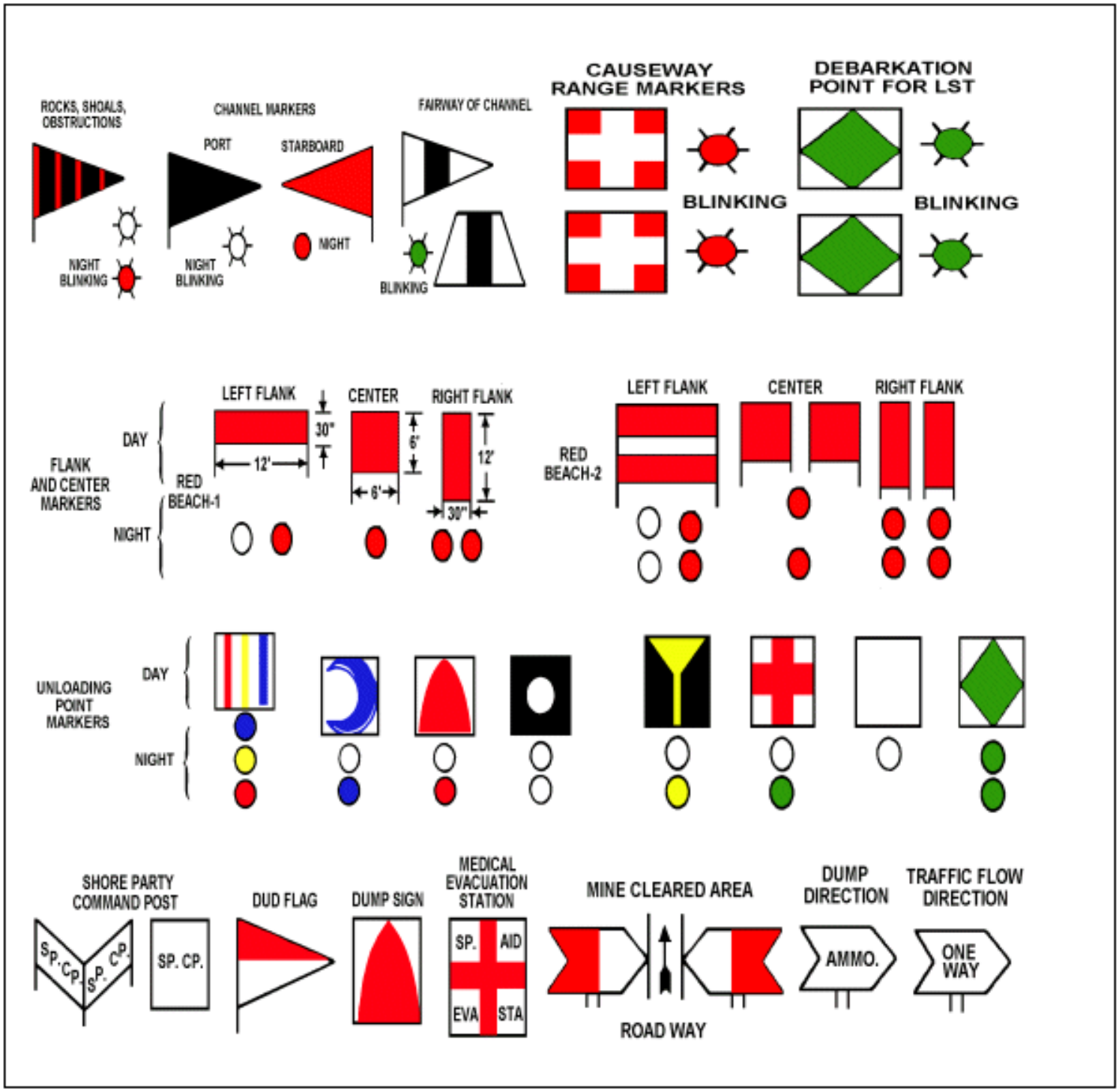


Figure 15-2. Hydrographic and Beach Markers and Signs as Seen from Seaward

GENERAL UNLOADING PHASE

15-27. During the general unloading phase, loaded boats do not maintain a formation on the trip to the beach, although several of them may be required to move as a unit. On the way to the beach, they must stop for orders at the primary control ship and at the boat group commander's boat.

15-28. The type of cargo in a boat is indicated by the color of special flags flown. These flags are described as follows:

- **Red flag.** Denotes bulk cargo, which needs manpower for unloading.
- **Yellow flag.** Shows the load is such that a prime mover is required.
- **Blue flag.** Denotes self-propelled cargo.
- **Red burgee.** Shows that the boat is a fuel boat.
- **Green flag.** Shows that a boat belongs to a floating dump.
- **Numeral flag.** May be flown under it to indicate the type of cargo carried.

SECTION II - LOGISTICS-OVER-THE-SHORE OPERATIONS

LOGISTIC OVER THE SHORE OPERATIONS

15-29. For information on Army Logistic Over the Shore Operations refer to FM 55-60.

CARGO DOCUMENTATION

15-30. To provide a record of cargo handled by each link in the loading and unloading chain, the coxswain or master will be given a DD Form 1384 for each unit of cargo loaded. The coxswain keeps one copy which is used for the log entry of tonnage hauled, gives the required number of copies to the cargo checker at the discharge point, and then delivers the required number of copies to the control officer. The exact number of copies and their distribution will be prescribed in the unit SOP. Detailed procedures for tallying cargo and the use of this form in accounting for cargo are discussed in DOD Regulation 4500.32-R, Volumes 1 and 2.

CARGO LOADING OPERATIONS

15-31. In a LOTS operation where you become involved in a resupply situation, accountability and condition of cargo are of utmost importance. When transporting cargo aboard landing craft, the crew must make certain that it is properly stowed and secured.

TIPS ON SECURING CARGO ABOARD LANDING CRAFT

15-32. When securing cargo aboard a landing craft, there a number of things that can be done to reduce the risk to the safety of the ship or the health or safety of any person on board.

- Properly load, stow, and secure all cargo.
- Properly pack and secure cargo within the containment.
- Correctly load and transport heavy cargo or cargo with abnormal physical dimensions to reduce the risk of damage to the ship's structure.
- Checking the strength of securing points and lashings.

DUNNAGE

15-33. Aboard landing craft, dunnage usually consists of 1- X 6-inch X random length lumber and timbers. Dunnage with dimensions of 4 inches X 4 inches X random length or larger is called timber. During cargo operations, dunnage is carried by all landing craft.

PALLETIZED CARGO

15-34. Dunnage is not required for palletized cargo; the pallets serve that purpose. Pallets can be loaded directly on deck.

MILVANs AND CONTAINERS WITHOUT CHASSIS

15-35. Lay a dunnage floor in a landing craft before MILVANs and containers without chassis are loaded. The bottom layer of dunnage should be laid athwartships to allow any water in the well deck to spill off into the bilge. If seas are heavy or considerable water is expected to come aboard, a second layer of dunnage is laid--this time, in a fore-and-aft direction. This will serve two purposes. First, it will protect the bottom of the containers from the water, and second, it will allow even distribution of weight over the deck of the landing craft. It will also protect the deck from being gouged and torn up in general. When loading MILVANs or containers without chassis, lashing is not required. Their weight and size will hold them in place.

MILVANs AND CONTAINERS ON CHASSIS

15-36. Dunnage should be laid only under the wheels and the front stands. The MILVAN or container and chassis must be lashed down. Four lashings are required--two forward and two aft.

CAUTION: Make sure that the MILVAN or container on chassis is loaded with the front (where the tractor connects with the chassis) facing the bow.

PECK AND HALE QUICK RELEASE

15-37. Several methods and types of lashings are used and in the system. The peck and hale quick release is only one of the systems used. This tie-down is used primarily for securing vehicles, but similar cables are incorporated into nets and used to secure cargo on deck. If such gear is unavailable, wire rope and turnbuckles can be used to prevent movement of the chassis.

WHEELED VEHICLES

15-38. These vehicles can be loaded directly on deck. ALWAYS LOAD THE VEHICLE WITH THE ENGINE OF THE VEHICLE FACING THE BOW. Then the vehicle can be driven straight off the landing craft. Once the vehicles are loaded and spotted on deck, make certain that the brakes are set, that vehicles are left in gear, that wheels are chocked, and that lashings are used to secure the vehicles to prevent them from shifting.

TRACKED VEHICLES

15-39. The same principles for securing wheeled vehicles are used when securing tracked vehicles. One exception that you must remember is that a double layer dunnage floor must be laid. When laying the dunnage floor, keep the cloverleafs or tie-down rings clear so that you will be able to tie down. For tanks and tracked vehicles of this size, use 8- X 8-inch or larger timbers for effective chocking.

POL IN DRUMS

15-40. Drums are stowed on their side in a fore-and-aft direction and stowed bilge-to-bilge. The drums are tiered in pyramid fashion and stowed no higher than three tiers. If only a few drums are to be loaded, then they are stowed in an upright position with their bungs up. They must be stowed on dunnage to prevent sparking and to reduce the possibility of shifting. Drums stowed in an upright position must be lashed in place.

WARNING: DO NOT ACCEPT ANY DRUMS THAT ARE LEAKING.

LOADING TROOPS

15-41. Before loading troops aboard landing craft, passenger lists must be prepared. Embarkation personnel should prepare these lists ahead of time. The passenger list should show the full name, grade, serial number, and unit of all troops to be loaded. At loading time, troops should be loaded in list order and at that time the accuracy of each entry verified. One copy should go to the embarkation officer loading the vessel, or if from a port area, to the harbor master, and one copy to the coxswain or master of the landing craft.

15-42. When taking troops aboard from either the pier or a troop ship, crew members on the landing craft should do the following:

- Make sure each passenger is wearing a life jacket.
- Assist passengers in boarding and getting into the well deck.
- If passengers are without life jackets when boarding, issue life jackets from the ship’s supply, if available.
- Take life jackets back from the passengers when they debark.

15-43. At all times, the vessel master or coxswain is responsible for the safety of passengers carried aboard the craft. Each crew member is responsible to the master or coxswain to help ensure the safety of the passengers.

Note: DO NOT allow passengers on the ramp, catwalks, upper decks, engine compartment, or in the crew’s quarters.

Chapter 16

Safety

Injuries and accidents can seriously hamper unit operations. Therefore, every precaution should be taken to avoid injuries and accidents. An effective safety program must be established to accomplish this goal.

RESPONSIBILITIES FOR SAFETY PROGRAM

16-1. Prevention of injuries and accidents must be the main goal of any unit commander. The safety program must be designed to impress unit personnel with the importance of constant vigilance in detecting potential hazards and promptly reducing or eliminating the hazard. The program must provide for training unit personnel in safe working practices peculiar to water transport operations. There should be a safety organization consisting of a unit safety officer and a safety committee. The safety committee should consist of platoon leaders and section chiefs responsible for supervising and coordinating all safety activities within the unit. This committee should meet at regular intervals to discuss measures for accidents, eliminating hazards, and improving safety practices. Further safety guidance is also given in FM 55-502.

COMMANDER

16-2. The unit commander is responsible for ensuring that all activities of the unit are conducted according to established safety rules. This includes determining causes of accidents and correcting situations to prevent recurring accidents. He must be aware of and enforce all safety regulations issued by higher HQ. When a deviation from an established safety rule is desired, the unit commander is responsible for requesting permission to deviate from the rule. This request, including full particulars and detailed plans and specifications, is submitted to the appropriate HQ. The unit commander must have his own safety rules and safety program. He cannot rely solely on programs of higher HQ to assure the safety of his personnel.

SUPERVISORS

16-3. Platoon leaders, section chiefs, and vessel masters daily directly supervise operating personnel. In their contacts with personnel on the job, they are in a position to personally witness the following:

- Daily working conditions.
- The potential hazards to which operating personnel are exposed.
- How effectively accident prevention measures are applied.

They should have frequent scheduled meetings to brief their personnel on safety procedures, ask for suggestions on improving safety practices, and publicize any newly adopted safety procedures. Such meetings should be held in the work area, and the agenda for such meetings should include the following:

- Overall job and the end result expected.
- Why, how, and when of the job and any ideas from the group concerning improvements of methods and procedures.
- Parts to be played by each man. The supervisor must make sure that each man understands his assignment.
- Existing and anticipated hazards and steps that should be taken to cope with these problems.
- Need for prompt reporting of all injuries, accidents or near accidents, and the importance of first aid when such action is required.
- Need for constant vigilance to detect and correct unsafe practices and conditions to prevent accidents and injuries.
- Need for conducting definite routine safety inspections.

INDIVIDUAL RESPONSIBILITY

16-4. All personnel should realize that safety rules have been established for their protection and welfare. They must follow all instructions and use all safeguards incident to the use of tools, machinery, equipment, and processes. Cooperation between and among vessel operators, engineers, platoon leaders, and section chiefs in developing and practicing safe working habits is essential to prevent injuries to personnel and damage to material and facilities. An effective unit commander will strive to assure that this spirit of cooperation prevails in the unit.

PRINCIPLES OF AN EFFECTIVE SAFETY PROGRAM

16-5. An effective safety program depends on proper application of the following principles of accident prevention.

CREATION OF ACTIVE INTEREST

16-6. The emphasis on safety in water transport units must be vigorous, continuous, and instilled by the unit commander. The best safety program in existence will soon deteriorate unless every person in the unit keeps actively interested and willingly participates in the program. Interest in safety should be maintained by appealing to the pride of all unit personnel, pointing out the responsibilities they have to themselves and to the unit. Any suggestions on improving safety operations should be carefully considered. The individual making the suggestion should be given credit if the idea is adopted or an explanation given if the suggestion is impractical. Supervisory personnel should develop an awareness of the effect of accidents on efficiency and productivity.

CORRECTIVE ACTION BASED ON FACTS

16-7. Pertinent facts surrounding each accident or injury should be reported. In addition to accidents, near accidents must also be reported along with all available information so that any hazards and unsafe procedures or conditions can be eliminated. Any procedure or condition, which might cause a threat to safety, should also be reported so that it can be corrected. Some individuals are accident-prone. If experience indicates that the same individual is repeatedly an accident victim, that person should be placed in an assignment where he is least likely to endanger himself or others.

SAFETY STANDING OPERATING PROCEDURE

16-8. Some of the elements that should be included in a water transport unit safety SOP are the designation of a safety officer and a safety committee. The SOP should also include their duties. It should also include emergency shipboard duties and procedures.

REPORTING ACCIDENTS

16-9. A definite procedure for reporting accidents should be included in the safety SOP. No matter how slight, the procedure should emphasize promptness and completeness in reporting all accidents or injuries (see AR 385-40 for details). It should also contain procedures for reporting marine casualties. The safety SOP should also provide instructions for determining the cause through investigation of all injuries and accidents and specify procedures for corrective action to prevent recurrence.

EMERGENCY SHIPBOARD DUTIES AND DRILLS

16-10. Landing craft operate under varied conditions and circumstances of climate, tide, current, and harbor limitations. Therefore, emergency procedures and shipboard drills must be included in the safety SOP so every crewman will be skilled in his duties to keep the craft afloat and prevent cargo from being damaged and fellow crewmen or passengers from injury or possible loss of life. The emergencies that would most commonly be considered are:

- Fire.
- Collision.
- Man overboard.
- Abandon ship.
- Handling grounded watercraft.
- Ground tackle and jury rigging.
- Chemical, biological, and radiological defense measures.

SPECIAL PRECAUTIONS

16-11. Most vessel operations, whether at the pier or beach or in the water, are hazardous. Water operations can be particularly dangerous due to adverse weather, operational task hazards, and enemy action. The vessel’s efficiency may also be seriously curtailed by carelessness of a crewman who permits dangerous conditions to exist or fails to repair faulty equipment. The following special precautionary steps should be taken to prevent accidents.

SHIPBOARD SAFETY

16-12. Most accidents aboard ship result from the following:

- Falls.
- Explosions.
- Falling objects.
- Faulty electrical equipment.
- Lack of protection for the eyes.

16-13. Safety rules that protect life and assure the safety of the vessel are of major importance to crewmen. During beaching operations, crew members must wear life jackets except when in the engine room or in the bridge house handling the wheel. They should be accomplished swimmers and qualified in lifesaving techniques. Anyone moving or standing on deck should watch his footing and be careful to avoid accidents. All lines on deck should be made up in such a manner that no one could get tangled in them or trip on them. Check the bilges regularly to make sure that the landing craft is not holed or taking on water through the hull connections. The presence of fuel or fuel fumes in bilges is also a sign of a potential fire hazard and must be checked immediately. When performing grinding, chipping, or scraping operations crewmen must wear clear, shatterproof safety goggles.

SAFETY CLOTHING

16-14. Crew members must wear safety-sole deck shoes because water and oil combined on a deck can be more slippery than ice. Any oil spilled must be cleaned up right away. When working around machinery, crew members will not wear loose clothing. Loose clothing may get caught in the machinery. If sleeves are to be rolled up while working on machinery, they will be rolled up at least to the elbow.

HANDLING LINES

16-15. Lines should be whipped with sailmakers whippings. Back splices and other end rope knots may cause severe injury if run through the hand quickly. When handling wire rope and mooring lines, gloves will be worn to protect the hands. The cargo decks will be kept clear of unnecessary lines.

POL PRODUCTS

16-16. Do not allow oil and grease spills to accumulate on decks. All spills should be wiped up as they occur. Bilges will be kept clean of oil and other POL products to reduce fire hazard. Use approved nonvolatile cleaning agents (not gasoline) for cleaning purposes. When fuel is being received on board; no bare lights, lighted cigarettes, or any electrical apparatus that has a tendency to spark should be permitted within 50 feet of an oil hose or fuel tank. Use only sparkproof tools to connect or disconnect fuel lines.

WARNING: NEVER ALLOW ANY SOLDIER TO ENTER A CONFINED SPACE THAT HAS NOT BEEN PROPERLY VENTILATED AND INSPECTED BY A QUALIFIED INDIVIDUAL TO ENSURE THAT THE ATMOSPHERE IS SAFE TO ENTER.

Ventilation

16-17. Closed compartments must be well ventilated to reduce rust, corrosion, and mold damage. Musty odors indicate a lack of ventilation. Shelves should be neat, orderly, clearly marked, and secured for sea to prevent objects from falling. Gasoline, oil, paint, and other flammables will be stored only in approved locations and in containers authorized for this purpose. Oxygen and acetylene bottles must be stored separately from other flammables.

Fire Fighting Equipment

16-18. Particular attention should be given to all the fire fighting and damage control gear aboard. The equipment must be serviceable and operational. The crew members must know the location and how to operate the equipment. Frequent inspections must be conducted to ensure that the equipment is operable.

Fire Prevention

16-19. Post "No Smoking" signs wherever potential fire hazards exist. Smoking will be permitted only in designated areas.

CARGO OPERATIONS

16-20. Special attention must be given to the proper loading, blocking, and securing of vehicles to be carried in landing craft. This is a responsibility of the vessel master. Cargo must be inspected prior to movement.

16-21. Dropping or toppling of loads onto a lighter deck is to be avoided. Doing so will invite damage to the cargo and the lighter and can cause personnel injuries. For safe handling, slings should be properly lashed on damaged or palletized cargo.

CAUTION: Be alert of bridle hooks, which may catch on your clothing or gear.

16-22. Personnel must be warned never to stand beneath a draft of cargo or get between the draft of cargo and a bulkhead or other cargo. They must also be warned never to pull a cargo draft into position as they might slip and fall beneath the draft. The draft is always pushed into place.

16-23. Crew members and terminal service personnel should watch for projections and loose banding of cargo, frayed wire, or cargo to be recoopered or rebanded before being loaded. Leaky drums will not be taken aboard as cargo.

SAFETY COLOR CODE MARKINGS AND SIGNS

16-24. All piping and fittings in the engineering spaces of watercraft will be coded and marked in accordance with TB 43-0144. Post a legend by all entrances to engineering spaces, indicating what each color represents. Red generally represents emergency equipment and systems (such as fire fighting). Flow directions are indicated by use of arrows.

Chapter 17

Shipboard Expedients (Emergencies)

Landing craft crews must be prepared to deal with a number of emergencies that usual arise during operations. Each landing craft is equipped with certain emergency gear. The coxswain or master is responsible for ensuring that each crew member is familiar with the location, function, and operation of all equipment. Crew members must be thoroughly familiar with all of the operating procedures to be followed in emergencies. Some of the more important emergencies are loss of power to the ramps, damaged steering cable, a broken quadrant, or the loss of a rudder or an engine. If the rudders are lost completely, the tiller is useless and it will be necessary to use a "jury" rudder.

Note: The LCM-8 is designed and constructed to sustain damage in any one of the 6-foot-long compartments and retain sufficient stability for safe operation. It can withstand damage in any two 6-foot-long compartments forward of the engine room and retain sufficient stability for limited operation. This is true, except in case of damage in the two most forward compartments while loaded to maximum safe operating draft. This condition will result in the LCM-8 sinking by the bow to such an extent that some water will enter the cargo well through the forward freeing pipes. In this condition, the craft has little, if any, theoretical stability. Should this combination of events occur, the craft should be handled slowly and carefully and beached as soon as possible. In case of damage to the engine room, the LCM-8 will develop excessive trim by the stern but will retain considerable stability. The stern will have some freeboard and the bow will rise quite high. In this condition, the operation of machinery will become impossible and assistance from other craft will be necessary. Damage to the lazarette will not have a serious effect on stability or maneuverability of the LCM-8.

EMERGENCY STEERING PROCEDURES, LCM-8

17-1. The helm unit and other valves control the direction and volume of flow of the hydraulic oil in the steering system. The helm unit directs the oil to one side or the other of the cylinders and limits the flow according to the speed at which the steering wheel is turned. In the event of pump failure, the helm unit will also act as a pump when turned manually. If for some reason there is a total loss of steering, you can rig for emergency steering using the emergency tiller. Do this by using the following procedure.

- **Step 1.** Remove the access plate from the deck over the rudder stock (Figure 17-1). There are two separate access plates. One is located on the starboard side and one is located on the port side just aft of the pilothouse. Either one can be used. The protective deck plate installed over the top of the rudder post should be loosened before all landing exercises so that the emergency tiller may be readily installed if necessary.
- **Step 2.** Remove the emergency tiller from the side of the pilothouse.
- **Step 3.** Insert the emergency tiller into the rudder stock (Figure 17-2).
- **Step 4.** Go into the lazarette and pull out the eye pins (Figure 17-3) to disconnect the hydraulic cylinder and the tie rod.
- **Step 5.** Use the emergency tiller to manually steer the LCM-8.

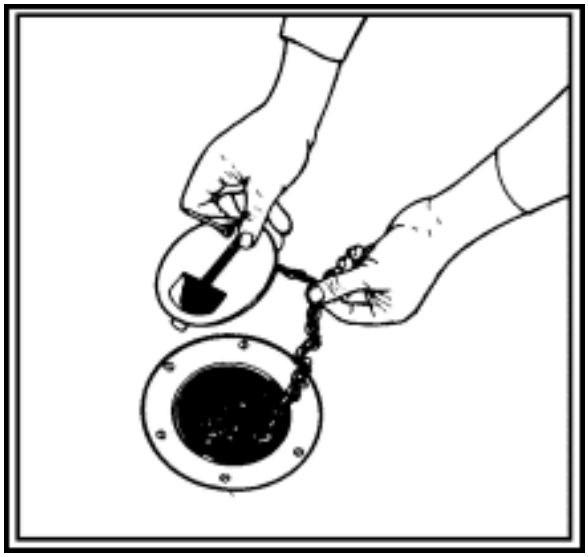


Figure 17-1. Access Plate

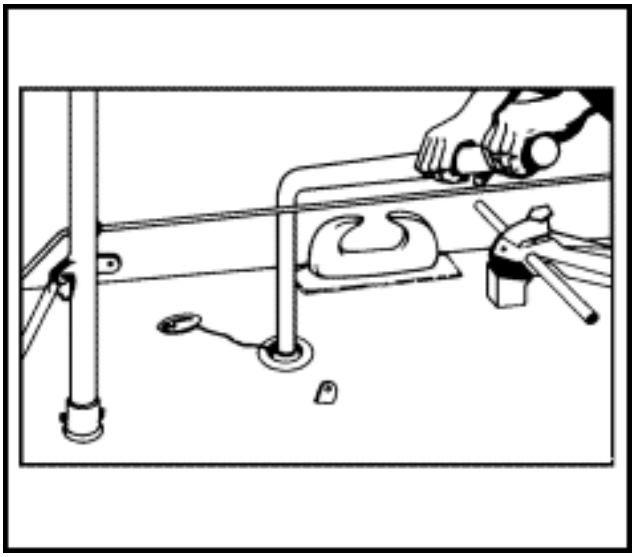


Figure 17-2. Inserting Emergency Tiller

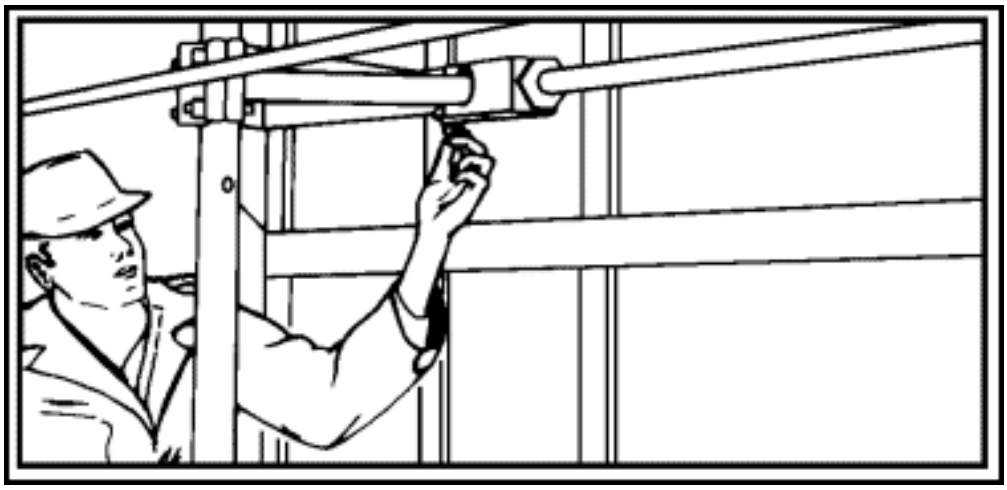


Figure 17-3. Pulling Out Eye Pin

17-2. It is important to grip the tiller tightly when backing because, if the boat starts to swing and the rudders are thrown hard over by the force of the water, the tiller will sweep across the after deck with force enough to knock a man overboard. In backing off a beach, particularly where bars are present, two members of the crew may be required to handle the tiller. Two important factors in connection with the use of this emergency rig are:

- First, it should always be handy and ready for use. It should not be lashed in place except with a slipknot, and it should be kept in the after section of the boat as near the rudder post as possible.
- Second, the method of steering with a tiller is exactly opposite from that of the wheel. To turn the boat to starboard, for instance, the tiller is put to port, and vice versa. This procedure is again reversed when backing up.

FIELD EXPEDIENT REPAIRS

17-3. Maintenance troubles may occur while the landing craft is being operated, where supplies and repair parts are not available, and normal corrections cannot be made. If so, expedient repairs may be used in emergencies. Equipment so repaired must be removed from operation as soon as possible and properly repaired before being placed in operation again.

17-4. GI soap can be used to plug burned-out overboard discharge elbows. The soap is placed thickly in the hole and wrapped with rags to prevent it from coming out. Sometimes a wooden plug covered with rags may be driven in the hole. Plugs made to fit outside exhaust holes may be driven in from the outside to prevent leaking. This will help to maintain watertight integrity while the boat is idle or untended.

17-5. A life jacket may be used for covering bad leaks in the hull. Cover the hole by using dunnage as shoring material and putting even pressure on the life jacket. Canvas floated under the hull and secured by line from the deck may slow or stop bottom leaks.

17-6. If a wrench is too large for a particular job, the blade of a screwdriver can be inserted between the nut and wrench to narrow the gap.

17-7. If the steering wheel is broken, a crescent wrench or a pipe wrench may be used to steer by fastening the wrench to the hub and using the handle of the wrench as a lever.

17-8. Heavy cloth or cardboard can be used to make emergency gaskets for the freshwater manifold, but they should be coated with heavy grease before installing.

17-9. Contaminated fuel can be controlled by letting the boat remain idle in a sheltered inlet or quiet water for a few minutes. Next, either drain off contaminated fuel from the bottom of the tank or use a long extension with a pump to take the contaminated fuel from the bottom of the fuel tanks.

17-10. Water may enter the boiler stack and drown the flame when an LCU is on the beach in heavy surf. A large, empty can (such as a 20-pound coffee can) placed over the stack will keep the water out.

Note: It is possible to steer an LCM with a damaged rudder by using the engines to reverse and/or varying the speed of the propellers. This method also applies to the LCU but should be employed only at low speed.

LCU 1600 EMERGENCY STEERING

17-11. Two or three crew members are required to set up and operate the emergency steering system on a 1600 class LCU. The procedures are as follows:

- **Step 1.** The stern ramp must be raised.
- **Step 2.** The deck access plug (Figure 17-4) is removed from over either the port or starboard rudder post.
- **Step 3.** The tiller is put through the deck hole and onto the square head of the rudder post (Figure 17-5).
- **Step 4.** The portable block davit (Figure 17-6) is installed in the pipe socket in the stern gate.
- **Step 5.** Two block-and-tackle rigs are hooked up, one to each side of the tiller arm and to the deck pad eyes. The hauling part of the line is led through the blocks secured on the portable block davit. The hauling parts of the lines are then led into the well deck (Figure 17-7).

Note: The block and tackle is stowed aft of the anchor winch compartment. The ramp bypass valve in the steering system is opened. Communications are maintained between the pilothouse and crew on deck by means of the sound-powered telephone.

Figure 17-4. Access Plug

Figure 17-5. Rudder Post

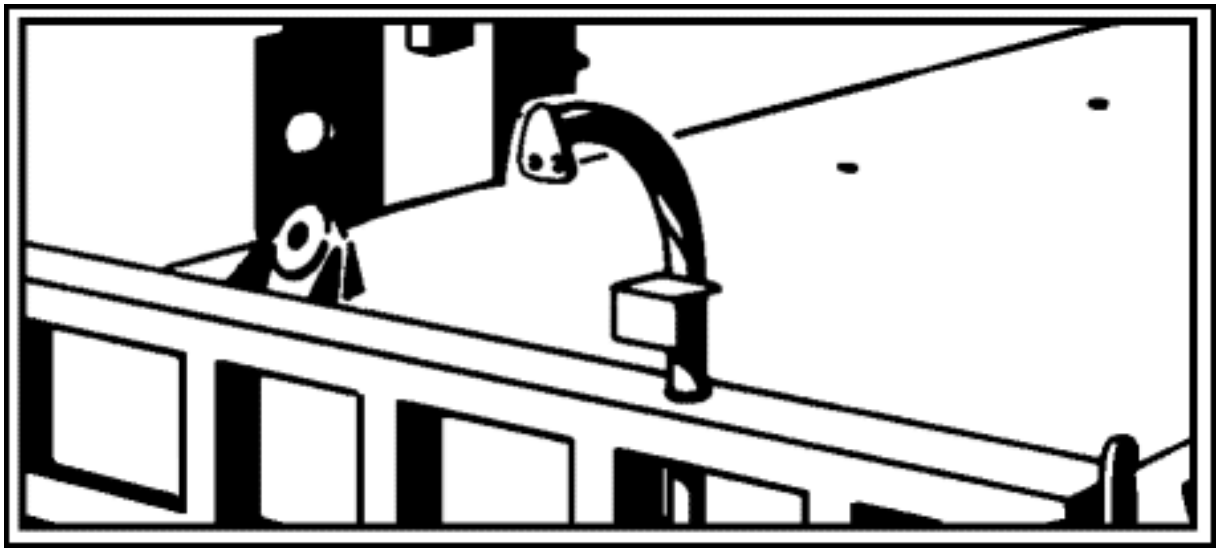


Figure 17-6. Portable Block Davit

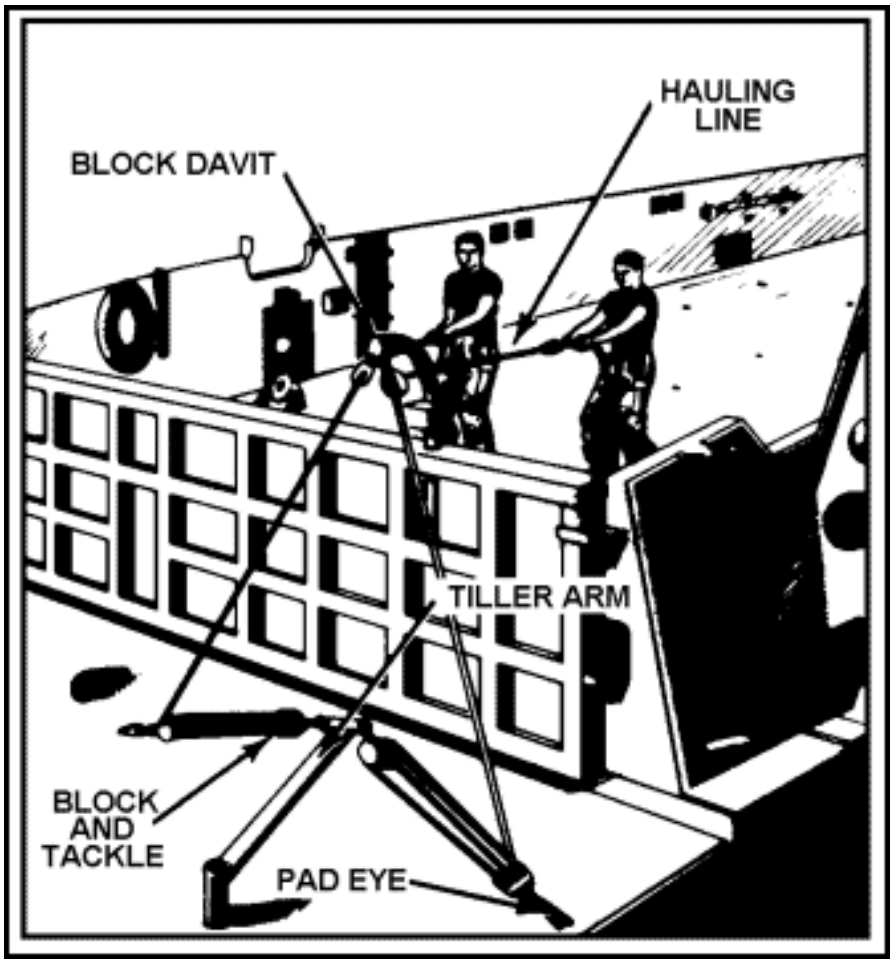


Figure 17-7. Rigging of Steering Gear

LOWERING THE RAMP ON AN LCM-8 WITHOUT POWER

17-12. The ramp hoisting arrangement (Figure 17-8) on an LCM-8 consists of a hoisting cable deadheaded to one side of the LCM, running through fairlead sheaves through the ramp, and to a winch on the opposite side. The systems for hull numbers 8500 through 8519, 8520 through 8560, and 8580 through 8618 are similar in operation, even though they do not have the same components. On hull numbers 8500 through 8519, the ramp winch is located on the port side, and on hull numbers 8520 through 8560 and 8580 through 8618 the ramp winch is on the starboard side.

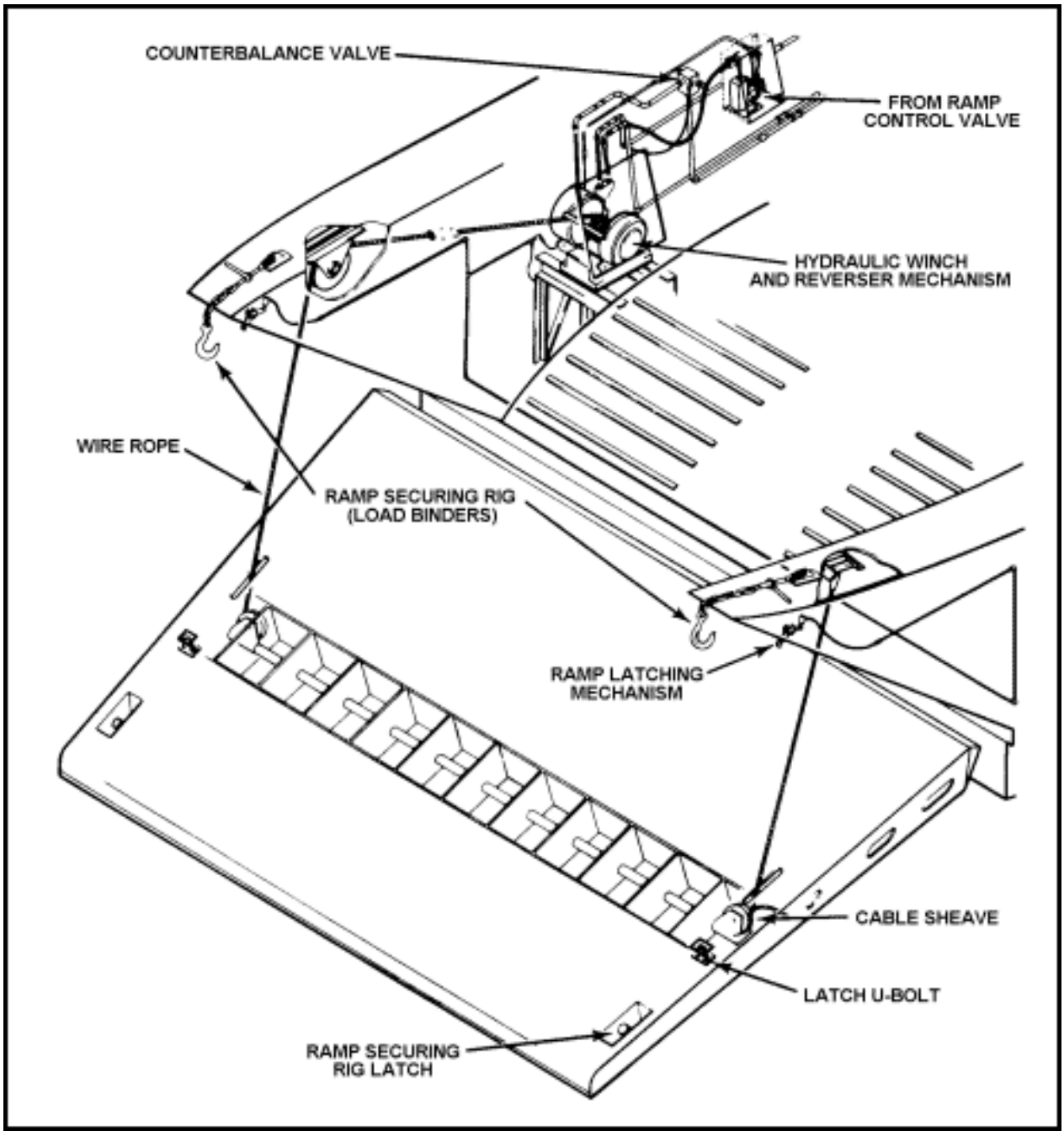


Figure 17-8. Ramp Assembly

HULL NUMBERS 8500 THROUGH 8519

17-13. Use a manual brake release system on a craft with these hull numbers when lowering the ramp in an emergency. Emergency ramp controls are located in the forward well deck on the port side. Ramp lowering procedures are as follows:

- **Step 1.** Disconnect the load binders (Figure 17-9).
- **Step 2.** Put the ramp hoist control valve lever in the neutral position (Figure 17-10).
- **Step 3.** Have the engineer disengage the ramp hoist pumps (located in the engine room).
- **Step 4.** Check to be sure that the area under the ramp is clear of personnel and obstructions.
- **Step 5.** At the emergency ramp control station, the ball valve is put in the open position. Pull the ball valve handle towards you.
- **Step 6.** Lift up on the manual brake release handle (Figure 17-11) to control the rate of speed that the ramp will fall.

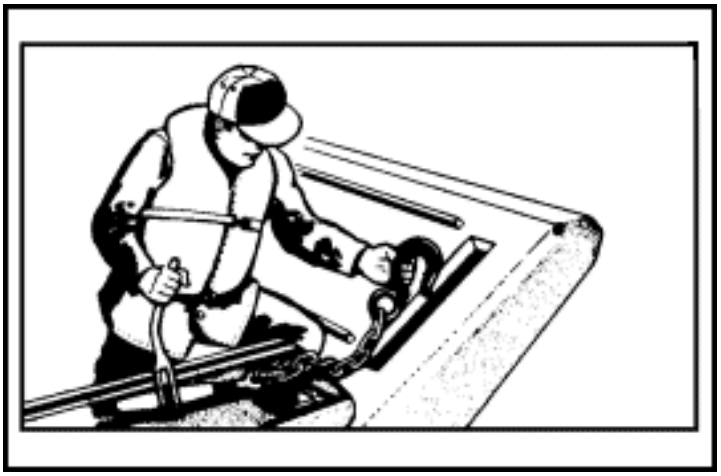


Figure 17-9. Disconnecting Load Binder

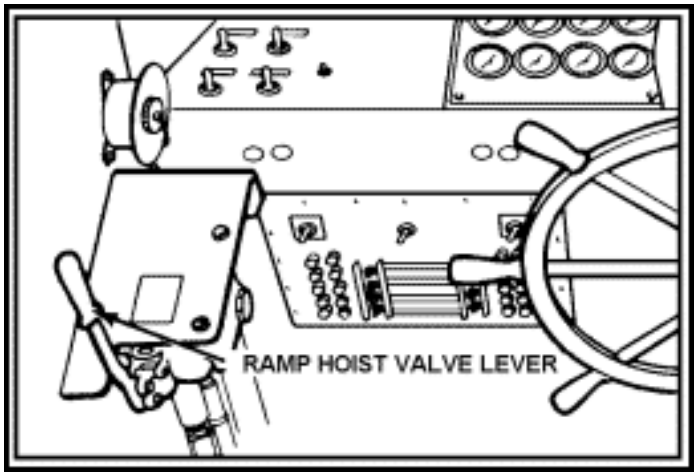


Figure 17-10. Ramp Hoist Valve Lever in Neutral Position

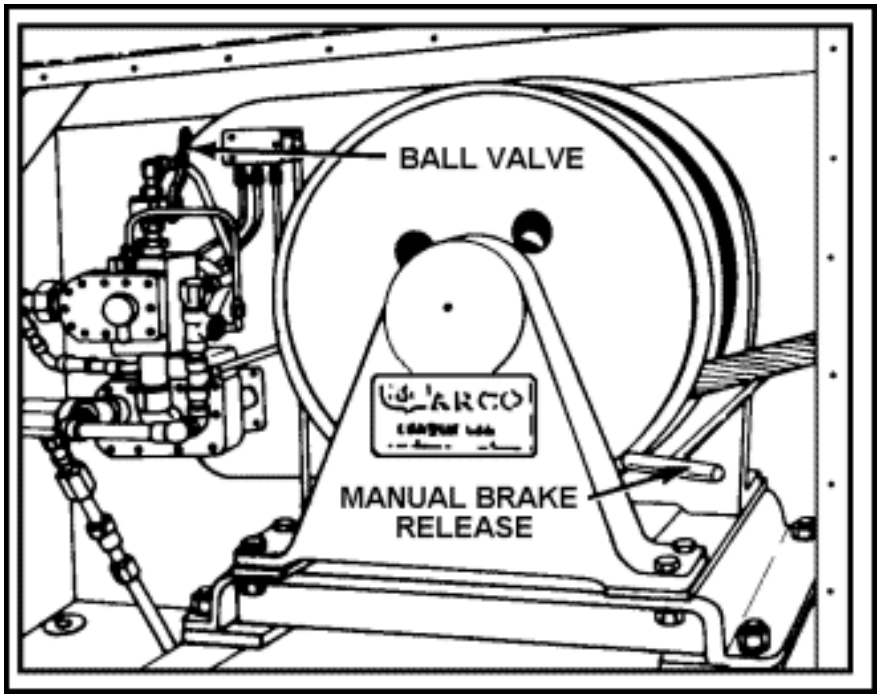


Figure 17-11. Manual Brake System

HULL NUMBERS 8520 THROUGH 8560 AND 8600 THROUGH 8618

17-14. Craft with these hull numbers use the hand-operated, hydraulic pump brake release system. Emergency ramp controls are located in the forward well deck on the starboard side.

HULL NUMBERS 8520 THROUGH 8539

17-15. To release the ramp on this craft with these hull numbers, use the following procedures:

- **Step 1.** Disconnect the load binders.
- **Step 2.** Put the ramp hoist control valve lever in the neutral position (see Figure 17-12).
- **Step 3.** Have the engineer disengage the ramp hoist pump located in the engine room.
- **Step 4.** Pump the hand pump to release the ramp.

Note: The speed that the ramp will fall is controlled by opening the ramp emergency release valve (Figure 17-13). To open, turn the handle to the left.

CAUTION: Periodically remove the plug to the oil filter hole. Oil level should be at the bottom level of the threads. If the oil level is low or there is no oil, the pump will not work. Refill if necessary, using only 2135 oil.

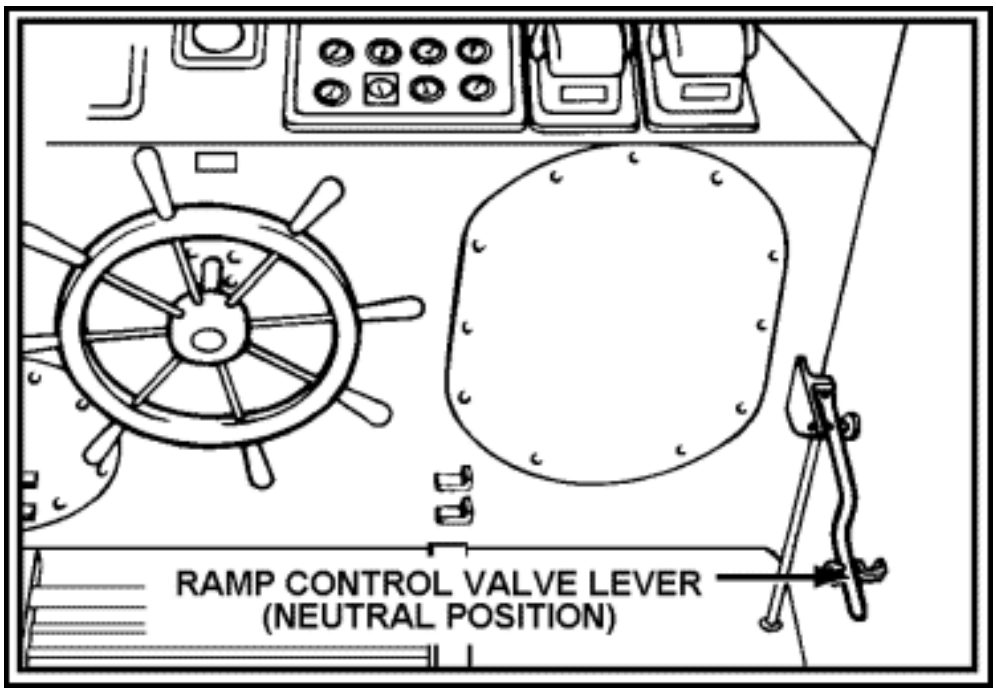


Figure 17-12. Ramp Control Valve Lever, Hull Numbers 8520 Through 8539

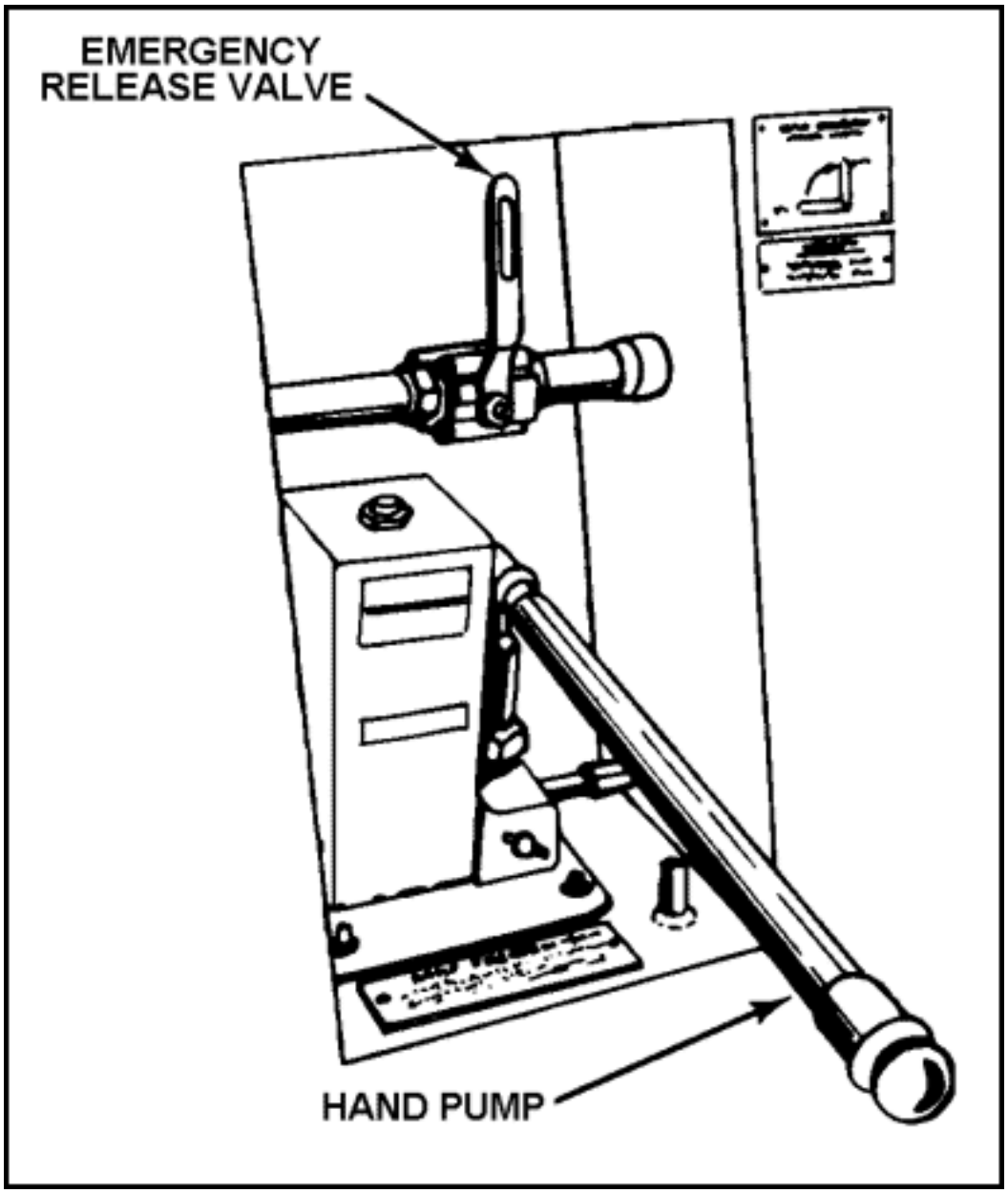


Figure 17-13. Ramp Hoist Control

HULL NUMBERS 8540 THROUGH 8560 AND 8580 THROUGH 8618

17-16. These landing craft use a different type of manual brake release system and emergency ramp release procedure. You must use the following procedures for these craft:

Note: Emergency ramp controls are located in the forward well deck on the starboard side (see Figure 17-14).

- **Step 1.** Disconnect the load binders.
- **Step 2.** Put the ramp hoist control valve lever in the neutral position.
- **Step 3.** Have the engineer disengage both hydraulic ramp pumps located in the engine room.
- **Step 4.** At the emergency ramp control, close the upper shutoff value by pulling the handle out toward you.
- **Step 5.** Open the lower hand pump shutoff valve by pushing it down.
- **Step 6.** Close the hand pump bypass valve by turning it all the way to the left.
- **Step 7.** Remove the hand pump handle and slip it on the lower hand pump.

Note: A hydraulically actuated mechanical latch is used to secure the ramp in the up position. The latch is unlocked during an emergency (no pressure in the ramp hydraulic system or the engines not operating) by applying pressure with the winch brake release hand pump. A selector valve located on the starboard side of the forward cargo well is used to select the type of hydraulic pressure required to activate the latch. By turning the selector to the emergency position, the hydraulic pressure originates at the hydraulic ramp system hand pump.

- **Step 8.** If necessary, put selector switch to emergency position.
- **Step 9.** Pump the hand pump until the brake releases and the ramp starts to lower.
- **Step 10.** Open the hand pump bypass valve to control the rate of lowering or to stop the lowering of the ramp.

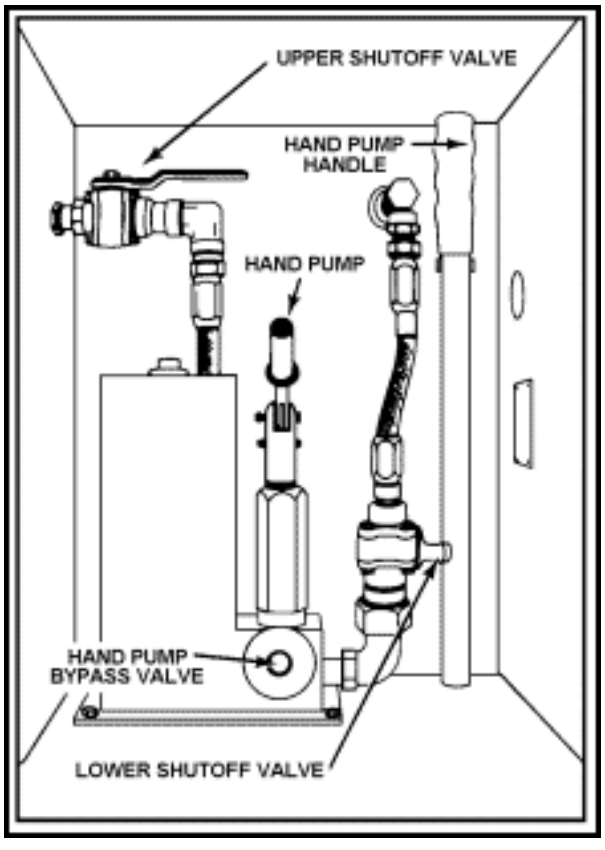


Figure 17-14. Emergency Ramp Controls

RAISING THE RAMP ON AN LCM-8 WITHOUT POWER

17-17. If the winch system fails or the ramp cable breaks, the ramp can still be raised by means of a ramp jacking lever (1 1/2-ton chain hoist). This ramp jacking lever is stowed in the lazarette. Procedures for raising the ramp are as follows:

Note: Every 90 days, the ramp jacking lever should be brought out on the deck and inspected for breaks, missing parts, and for rust on chain links. It should then be wiped down with an oily rag to give it a light coat of lubrication and restowed in the lazarette.

- **Step 1.** Bring the ramp jacking levers out from the lazarette and spread them out in the well deck to clear them for use.
- **Step 2.** Inspect the chain links to ensure that they are free of breaks and rust.
- **Step 3.** Hook the ramp jacking lever to the pad eye on the inboard side of the bulkhead on the main deck. This pad eye is located just aft of the load binder (Figure 17-15).
- **Step 4.** Shackle the long leg of the chain with the traveling block into the pad eye on the face of the ramp. If you have two ramp jacking levers, rig one on the port and one on the starboard side.
- **Step 5.** Take up on the chain hoists. A crew member is assigned to each chain hoist and they will take up on the chain hoist together and raise the ramp.
- **Step 6.** Once the ramp is up tight against the bulkhead, drop the load binder into the slot and secure the ramp in place (Figure 17-16).

BEACHING STERN FIRST

17-18. Because of leaks or breaking waves, a landing craft may occasionally take in more water in the engine room than its pumps can handle. Since replacing a rudder or propeller is easier than repairing engines damaged by submersion in saltwater, it is advisable to beach a craft stern first if a sandy beach is available and the surf is light. To beach the craft in this manner, the rudders are put amidships and the engines are backed down until the boat is a few feet off the beach. The clutches are then put in neutral to allow momentum and wave action to beach the craft. When it touches the beach, antibroaching lines are put out immediately and the engines are shut off.

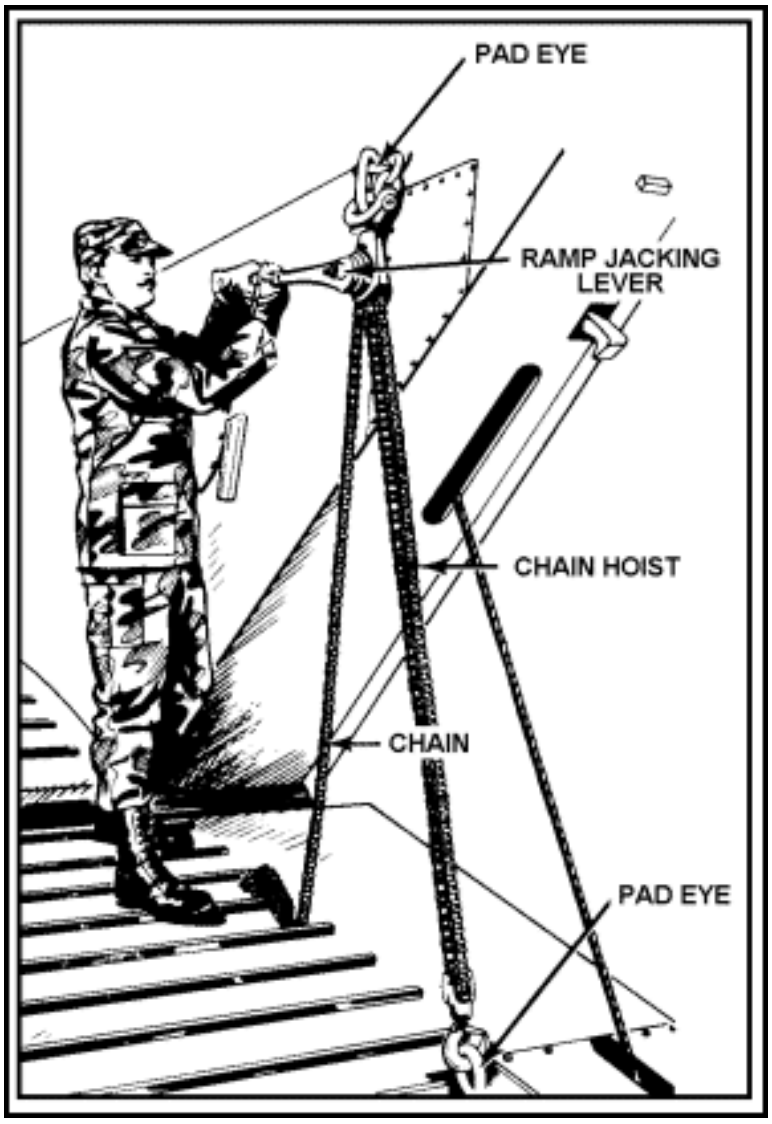


Figure 17-15. Securing Ramp Jacking Lever

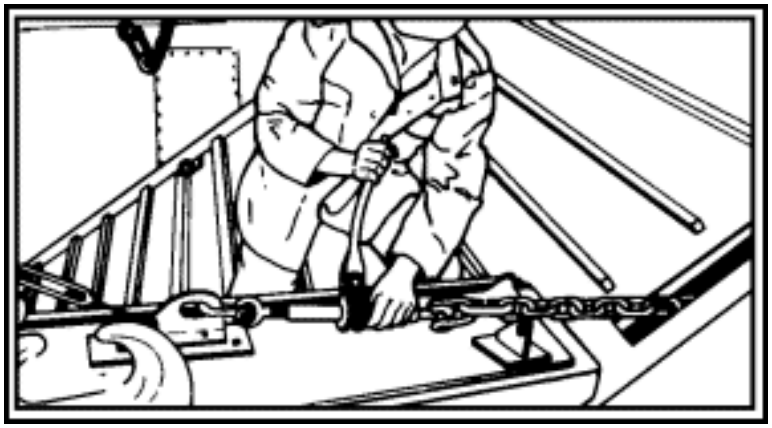


Figure 17-16. Securing the Ramp

UNDERWATER REPAIRS

17-19. To change propellers or do underwater work around the stern with no diver available, the vessel may be backed on the beach on high tide and a cofferdam built around the stern with sand and rock. A portion of the beach immediately under the stern of the vessel is dug away to obtain a working area. A bulldozer is helpful in this situation to launch vessels at high tide. However, if none is available, shovels or flat boards can be used to dig out the cofferdam to allow water to enter and float the vessel.

PROPELLER REMOVAL

17-20. Use the following procedures to remove a propeller (see also Figure 17-17):

- **Step 1.** Remove propeller nut and jam nut.
- **Step 2.** Remove propeller from shaft.

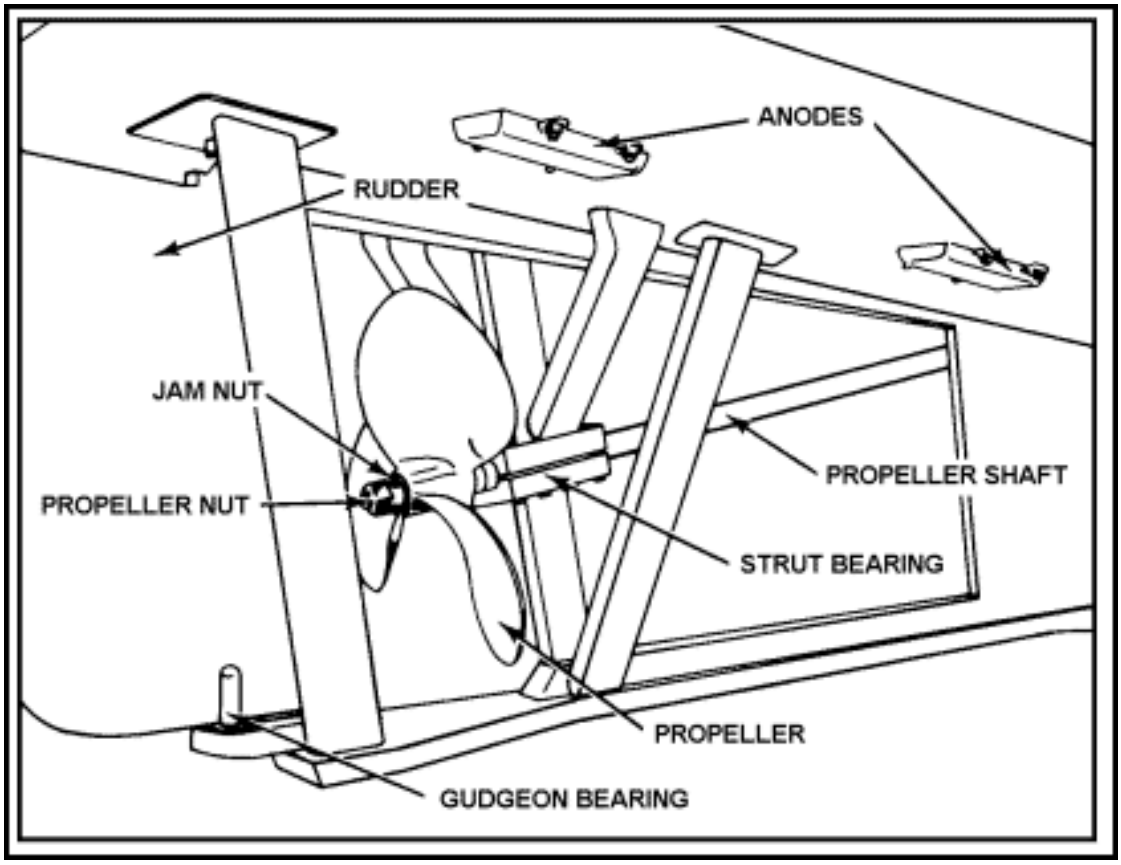


Figure 17-17. Propeller and Strut Assembly

PROPELLER INSTALLATION

17-21. Propeller is installed in reverse order of removal. A light coating of graphite and grease is applied to the shaft taper.

EXPEDIENT REPAIRS--TROUBLESHOOTING CHART

17-22. Table 17-1 shows some examples of expedient remedies for various types of problems that may be encountered in the operations of landing craft.

Table 17-1. Troubleshooting Chart

Problem	Trouble	Expedient Remedy
Emergency clutch engagement (LCM-8).	Transmission cannot be engaged hydraulically.	Engage emergency engagement bolts.
Loss of fuel.	Fuel line is cracked.	Tape cracked line and use until defective line can be replaced.
	Defective element (stopping flow of fuel).	Remove element and operate equipment until a new element can be installed.
Broken drive belts.	Alternator inoperative; bilge pump inoperative.	Replace drive belts.
Engine heats up.	Thermostat defective (closed).	Remove defective thermostat and operate unit until a serviceable thermostat can be installed.
Loss of lubricating oil.	Lubricating oil filter line broken.	Plug line and close filter return valve until oil line can be replaced.
Loss of electrical power.	Wire broken in electrical system.	Strip and splice ends of wire. Tape splice and continue operations until spliced line can be replaced.

FLOATING IN A TOWLINE

17-23. When a boat is disabled or broached on a beach and it is impossible to get a line to it by passing, one alternative is to float a line in. A life jacket, a life ring, or a piece of lumber may be used as a float, with a few hundred feet of light line secured to both the float and the regular towline. The towing boat must be positioned so that the current is flowing toward the disabled craft. The float is thrown overboard in the direction of the boat in distress and the line is payed out gradually as the float follows the current. No excess line is let out since the extra weight may impede the progress of the float. When the light line is taken aboard the disabled craft, the regular towline is payed out slowly until it can be hauled in and secured.

Chapter 18

Search and Rescue

Due to the nature of harbor craft operations (working in coastal waters, inland waters, and harbor areas) you are apt to become involved in a SAR operation. This chapter describes a limited SAR operation. This type of SAR occurs when a crewman is lost overboard, a small craft is lost, or when only your vessel is involved in the search.

PERSONAL SURVIVAL

18-1. With a man overboard, time is critical. All crew members must be fully aware of what is being done and how it is done. In the event you are the victim or whether it is one person or an entire crew, survival depends on three things: courage, training, and time. Courage, is your mental attitude - DO NOT GIVE UP! Do what you were trained to do to survive if you fall in the water. Time is of the essence. The ship's response to the situation is critical. Table 18-1 gives you an estimate of survival times in various water temperatures. This table is only a guideline to emphasize the need for fast action and not a means of setting an arbitrary limit on the search effort.

Table 18-1. Survival Times in the Water

Water temperature		**Survival time (Average duration)**
Centigrade	**Fahrenheit**	
Less than 2°	Less than 34°	Less than 45 minutes
2° to 4°	34° to 40°	Less than 90 minutes
4° to 10°	40° to 50°	Less than 3 hours

10° to 15°	50° to 59°	Less than 6 hours
15° to 20°	59° to 69°	Less than 12 hours
Greater than 20°	Greater than 70°	Indefinite (depends on physical condition)

COLD WATER SURVIVAL AND HYPOTHERMIA

18-2. Any time the sea temperature is below 70° F, the water is considered to be cold. To survive in cold water, two things must be prevented: drowning and hypothermia. Jumping into cold water will put a severe strain on your entire system. It can cause you to gasp for breath. If your head is below the surface of the water, you will drown.

18-3. By wearing a life jacket, you will keep you head above water. That is why the wearing of a life jacket is so essential during heavy weather operations, drills, or shipboard emergencies. The life jacket will take care of the first problem, which is drowning.

18-4. Hypothermia is defined as subnormal temperature of the body. In this case it is the lowering of the central body temperature. As the body temperature decreases it causes the person to become irrational, lose consciousness, and finally drown. To prevent hypothermia you must slow down the rate of "core" or central body cooling. Get out of the water as soon as possible. At all times keep your head up and as dry as possible. Your head is the greatest heat-loss area of your body. If you have a hat or cap on--keep it on.

18-5. When wearing a life jacket in cold water, you can protect the high heat-loss areas of your body. This includes the head, neck, sides, and groin. There are two ways to do this (see also Figure 18-1).

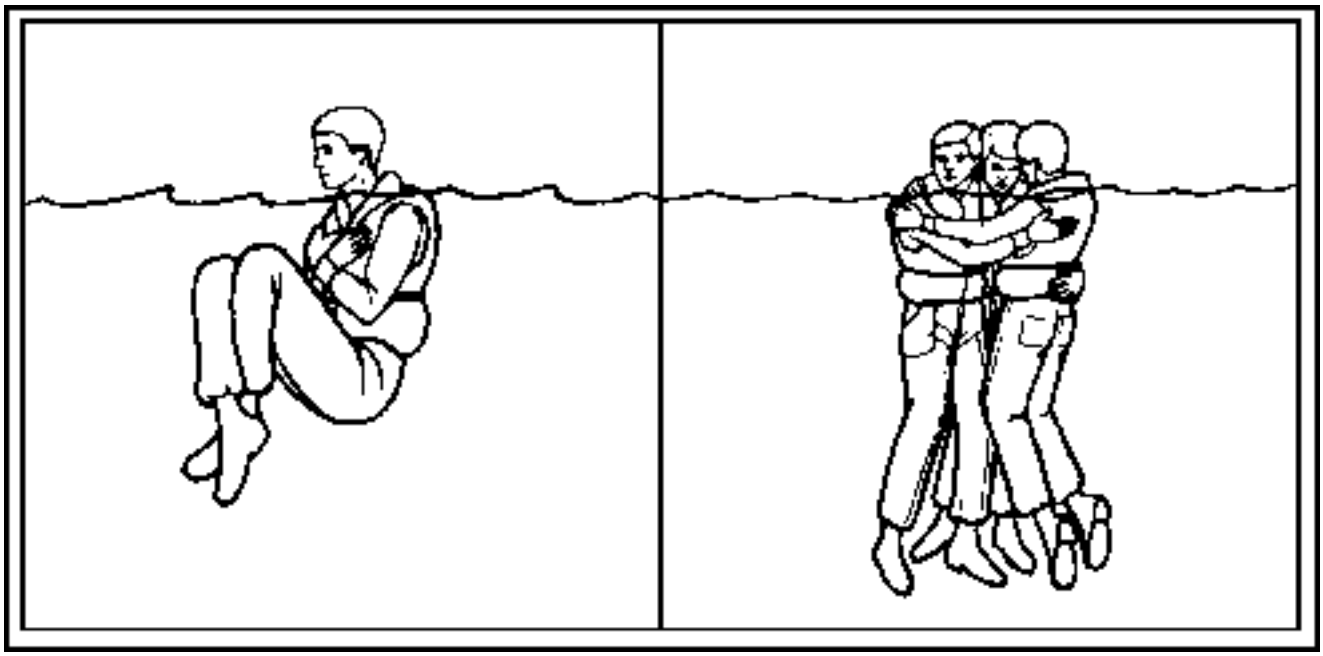


Figure 18-1. Retaining Body Heat

18-6. If you are alone, hold your upper arms against your sides with the wrists placed over your chest. Draw your legs up as close to your chest as you can and cross your ankles. If there are other persons in the water, group together. All of the people face one another with their chests and sides as close together as possible and their arms about one another. Either one of these actions will increase survival time up to 50 percent. However, even partial covering of the sides, neck, and groin will cut down the heat loss and extend the survival time.

WARNING: DO NOT EXERCISE OR SWIM - THIS WILL ONLY SPEED UP THE RATE OF BODY HEAT LOSS.

SECTOR SEARCH PATTERN FOR ONE SHIP

18-7. SAR covers many situations and many types of operations. This paragraph describes a sector search pattern for one ship (see also Figure 18-2). It is used when the position of the search target is known and within close limits, with a small probable area example. With a man overboard, the ship returns immediately to the datum; or, if the search target is once sighted and then lost, the ship heads for the datum.

18-8. All turns are 120 degrees to the starboard. Each leg of the pattern is approximately 2 miles. The search pattern will always start from the datum point. This pattern gives a very high probability of detection close to the datum point and spreads the search over the probable area quickly.

18-9. Upon completion of the search pattern, re-orient the pattern 30 degrees to the right and research a new pattern (see the dashed lines in Figure 18-2). This procedure can be repeated three or four times until either the victim is found or the search has been called off.

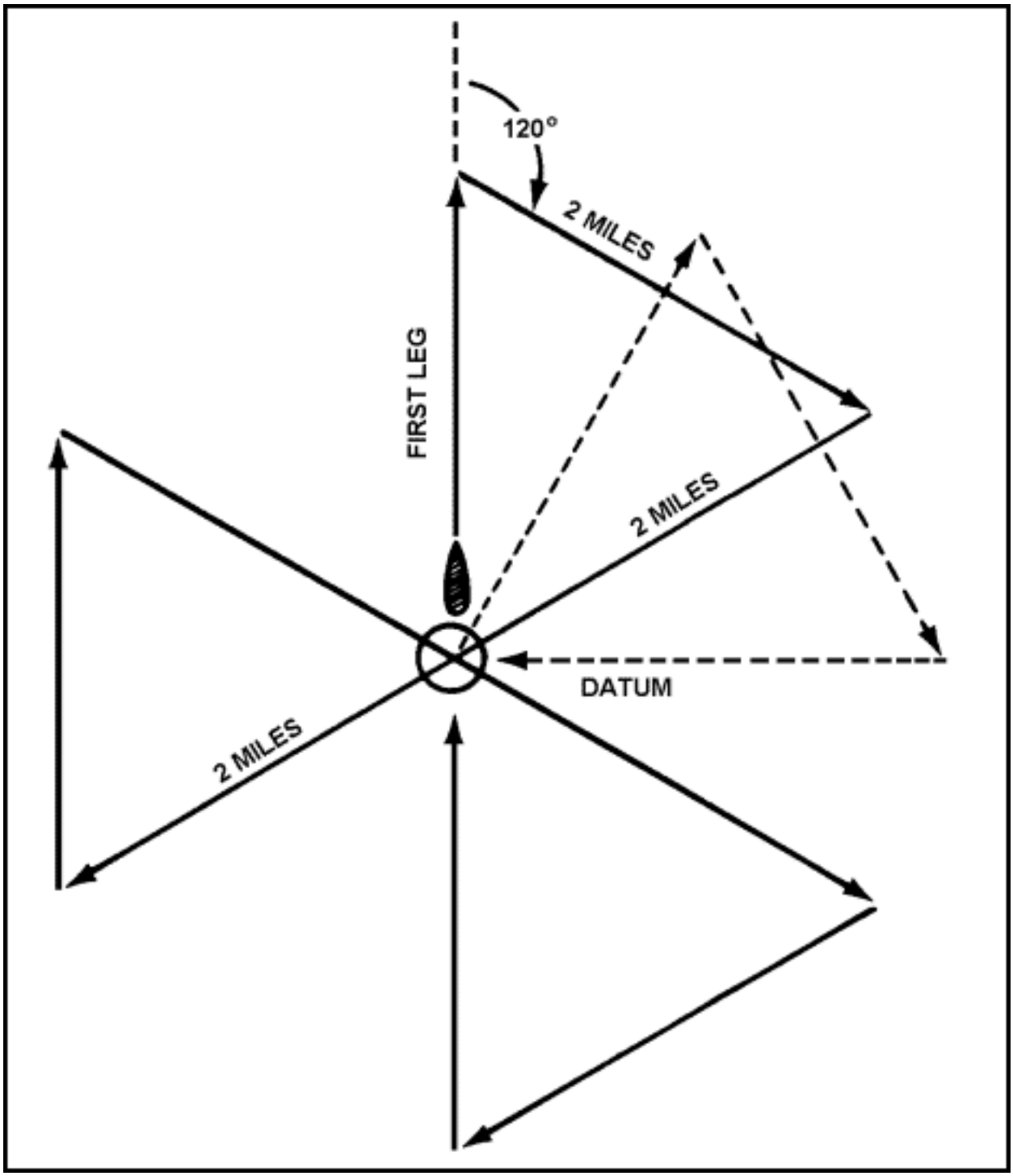


Figure 18-2. Sector Search Pattern--Ship

Chapter 19

Towing

Even though towing is a routine task for tugs, it is still one of the most dangerous operations Army mariners must perform. The practice of good seamanship is necessary to prevent endangering the crew, tug, or tow. The tug master is responsible for the entire operation, but the boatswain and leading seaman are responsible for preparing, making up, and rigging the tow. You should know how to make up a tow, the different types of tows, and how to assemble and rig for the different types of tows. This chapter is intended to improve your knowledge of these procedures.

TYPES OF TOWS

19-1. The use of tugs and their connection to the tows can vary. The following are some basic configurations:

- Single tug, single unit tow.
- Single tug, multiple unit tow.
- Multiple tug, single unit tow.

SINGLE TUG, SINGLE UNIT TOW

19-2. This consists of a tug and tow. Several methods are used in connecting the tug and tow. The single leg and bridle or stern tow is used for long distance towing in open waters. The alongside or hip tow is used where maximum control and maneuverability are required.

19-3. The single leg and bridle is made when the towing ship passes the towline, which is shackled to a flounder plate at the apex of the bridle. Each leg of the bridle consists of chain or wire rope passed through the bow chocks and secured on the tow's deck to padeyes or bitts.

19-4. Towing alongside (hip tow) is most often used in congested waters. Towing alongside offers excellent control; it is not recommended for the open ocean. For alongside towing, the tug generally secures to one side of the tow with her own stern abaft of the stern of the tow to increase the effect of her screw and rudder. The side chosen depends on how much the towing ship must maneuver with the tow.

SINGLE TUG, MULTIPLE UNIT TOW

19-5. This consists of one tug and several tows. The connection and makeup of the tows can vary. The following are the three versions used for towing astern:

- Christmas Tree rig (for long distance in open ocean towing).
- Honolulu rig (for short distance towing).
- Tandem rig (for congested waters where control is required).

MULTIPLE TUG, SINGLE UNIT TOW

19-6. It may be desirable to use more than one tug for only one tow. Greater power, increased towing speed, and better control may be obtained in a multiple tug tow. This type tow is generally used in towing large ships, deep-draft, large-displacement dry docks, or deep-draft barges.

Note: When a multiple tug, single unit tow is to be made up, the senior tug master is in charge and is responsible for the tow and its makeup.

DESCRIPTION OF TOWING EQUIPMENT

19-7. All deck crew members should know the basic terminology of towing gear, its function, and what to check for in safety and rigging procedures.

TOWLINES

19-8. Most of the towlines used today are made up of either nylon or one of the new synthetic polyester fiber lines. Based on size and weight, they provide great strength. If properly cared for, they will last for a long time. Usually wire rope and chain are used for deep sea tows. Nylon or synthetic fiber towlines are used in inland waters and coastal tows.

NAMES OF TOWLINES

19-9. Towlines may be called spring line or towing line, bowline or backing line, stern line or turning line, and bow breast line (see Figure 19-1).

STERN TOWLINES

19-10. The description given here is for typical towlines that are used for stern tows over long distances and in heavy weather. For a deep sea tow you may carry as much as 2,100 feet of 2- X 6- X 37-inch high-grade, galvanized plow steel, fiber-core wire rope. Wire rope is primarily used for long distance ocean tows. For short coastal or light displacement tows, you may carry 2,400 feet of 7- to 9-inch circumference nylon towline. Refer to Appendix D for the use, maintenance, precautions, and life expectancy of both wire and nylon towlines.

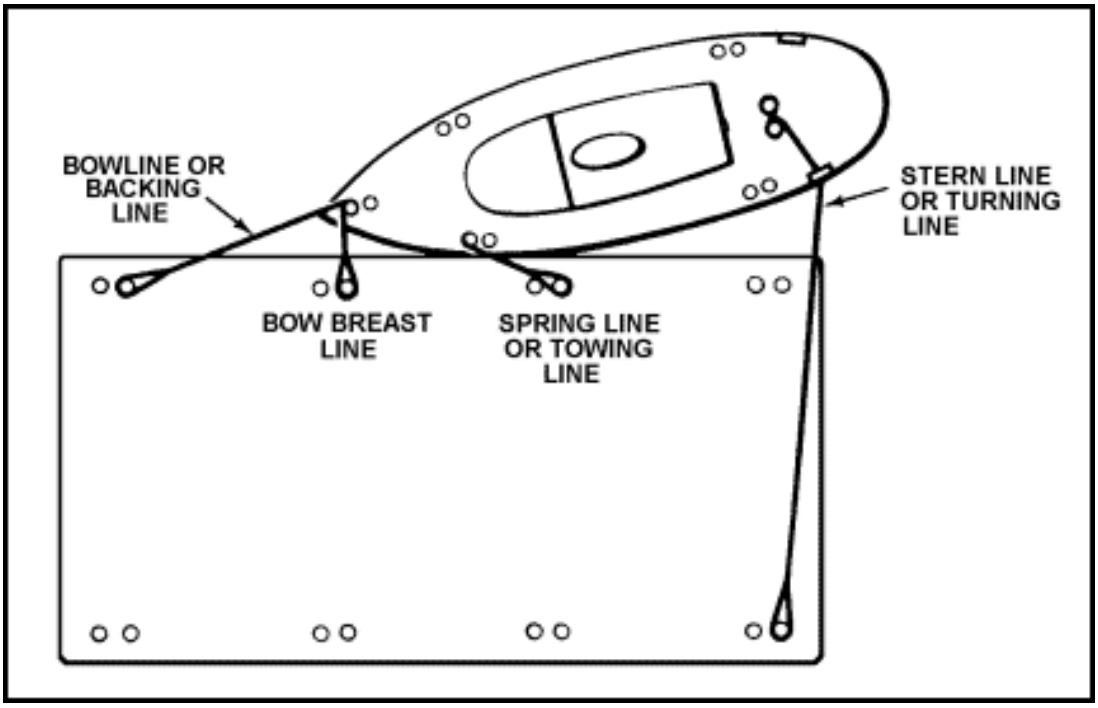


Figure 19-1. Display of Towlines

CAPSTAN

19-11. Power capstans are provided on the deck of a tug for taking a strain on line-towing hawsers. The capacity, characteristics, speed, and location vary from ship to ship.

Note: Towlines should never be made fast on the capstan or a cathead.

CHAFING GEAR

19-12. Chafing gear is used to prevent wear. It is additional protective material that is placed over and around a line or wire rope to protect it from damage through rubbing.

19-13. Old fire hose cut into 4- to 6-foot lengths and then split lengthwise makes excellent chafing gear. It is wrapped around the hawser or towing cable to protect it from wear due to constant rubbing (Figure 19-2). Chafing gear can be made up of the following:

- Old canvas and burlap wrapped around and secured to the towline at the point of chafing.
- Four- to six-foot lengths of old fire hose split and then wrapped and secured around the towlines.

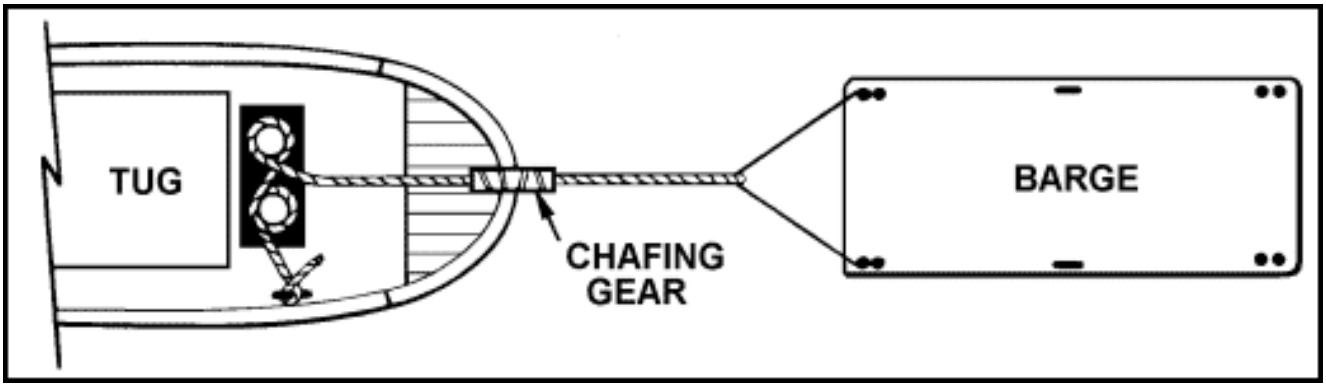


Figure 19-2. Chafing Gear

19-14. A towline chafing plate for wire rope is used for making an oversea tow. These chafing plates are 2 1/2 feet long.

FLOUNDER PLATE (BALE PLATE)

19-15. This is a triangular steel plate used as a central connecting point for the tows, bridles, and towline.

BRIDLES

19-16. Tows to be towed astern are to be fitted with bridles. Although chain is the preferred type of bridle, wire rope may also be used. One safety rule that must be followed when making up the bridles is that the length of each leg of the bridle must be at least one and one half times the width of the tow. For a barge with a beam of 50 feet, each bridle leg would be at least 75 feet long.

RETRIEVING LINE

19-17. This is a wire rope or fiber line that is connected to the flounder plate and usually led to the tow. The retrieving line should be longer than the distance from the tow to the flounder plate. This prevents it from taking any load. The legs of the bridle form two sides of an equilateral triangle. An imaginary line between the towing padeyes or bitts on the tow forms the triangle base.

PENDANTS

19-18. Made up of either wire or chain; pendants are used to connect the towline to the bale. A wire pendant is usually fitted with a "hard" splice on one end and a "soft" splice on the other.

PLATE SHACKLE

19-19. This type of shackle is preferred by personnel experienced in towing on the high seas because it will not work loose like a screw-pin shackle (Figure 19-3). However, for long tows, the threads of the shackle bolts should be peened over or the bolts welded in place.

HANDLING TOWLINES

19-20. Three ways can be used for making up when towing alongside or towing astern. When towing alongside, towlines can be made up as a single towline or the towline can be doubled up. The method used will depend on the situation.

SINGLE-LINE LEAD

19-21. When leading out a towline, lead it out between the towing bitts and make the eye fast to the bitt on the tow that is nearest to you. Then take in all the slack and secure the line with figure eight or round turns.

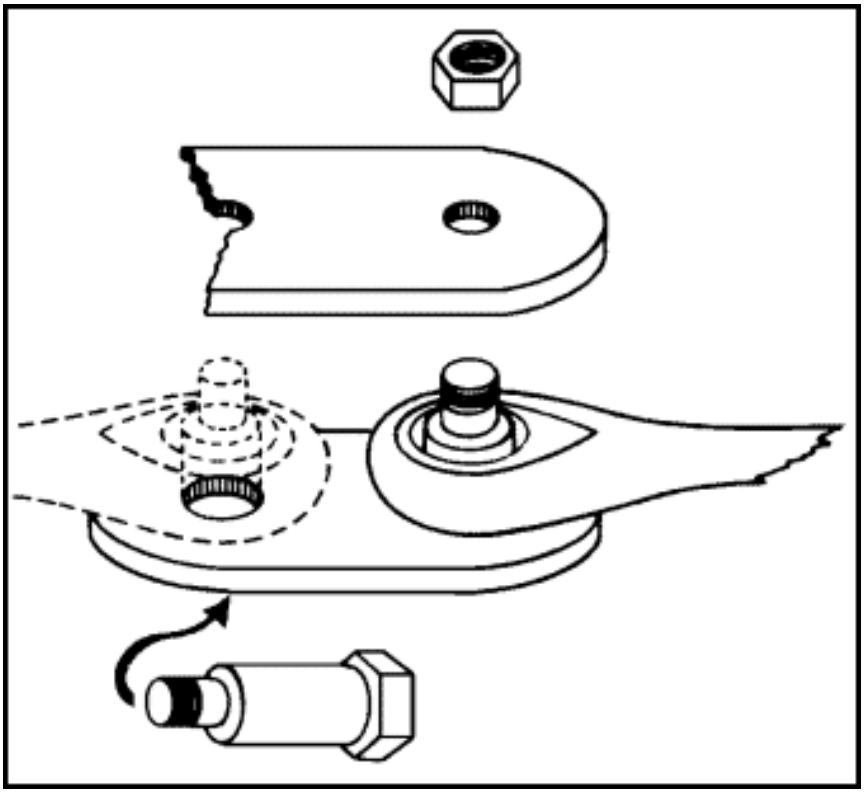


Figure 19-3. Small Plate Shackle

DOUBLING UP A TOWLINE

19-22. In this method (see also Figure 19-4) the eye splice of the towline is put over one of the bitts on the tug, and the bight of the line is then led around the bitt on the tow. The bitter end of the tow line is made up on the same bitt as the eye. The bitter end is lead from the outboard side, and one or two round turns are taken on the bitt, making a figure eight of the line on the bitts.

- Doubling the lines gives added strength.
- When releasing the tow, you slack off on the line, cast off the eye from the bitt on the tug, and take in the line. This eliminates the need of having to put an individual aboard the tow to release the line.

RIGGING A STERN TOWLINE

19-23. To rig a stern towline, the towing hawser should be faked out in the fantail of the tug (Figure 19-5). This will ensure that the hawser will pay out without becoming fouled. The eye of the hawser is led back over the top of the "H" bitt, over the shoulder of the horn, and back through the legs of the bitt (Figure 19-6). Then the hawser is payed out. When you get close to the point where you are going to secure the tow, take a full round turn and cross the line back onto itself. Then take two or three additional round turns before you figure eight the line on the bitts, and finish it off with two or three turns on the arm of the bitt.

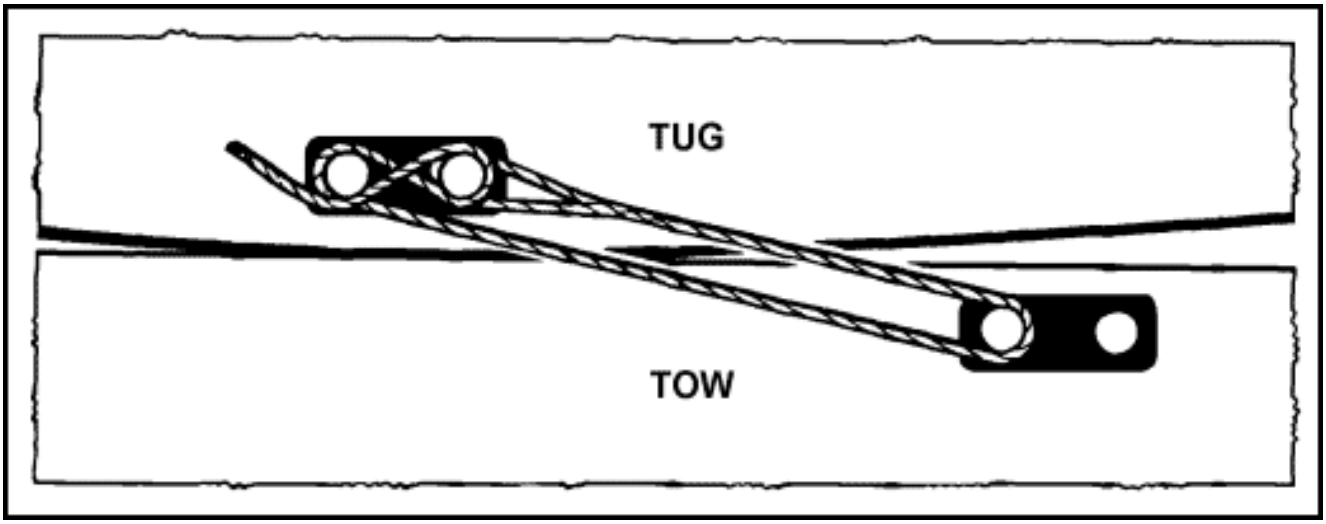


Figure 19-4. Doubling-Up Towlines

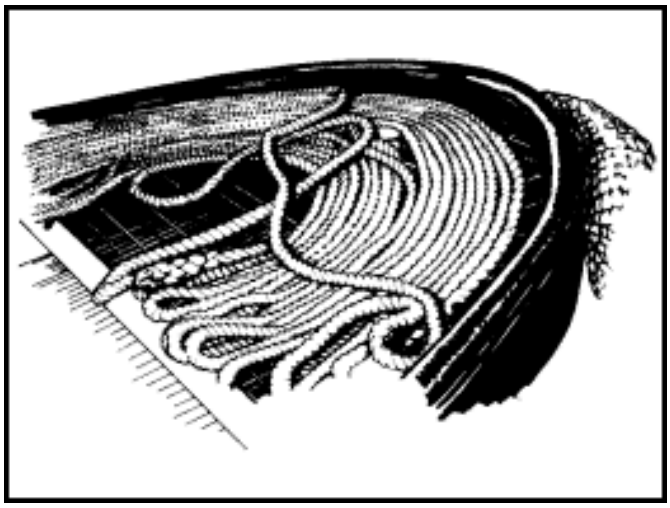


Figure 19-5. Hawser on Fantail

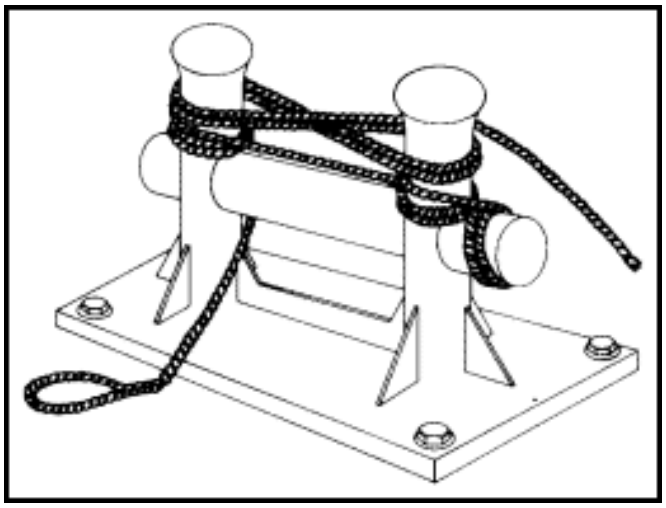


Figure 19-6. Leading the Hawser Over the "H" Bitt

WARNINGS:

1. ALWAYS FACE YOUR WORK.

2. NEVER STEP OVER A LINE LYING ON THE DECK. EITHER LIFT IT UP AND WALK UNDER IT, OR STEP ON TOP OF IT AND CROSS OVER. NEVER STRADDLE OR STEP IN THE BIGHT OF A LINE.

3. WHEN TOWLINES ARE COMING UNDER OR ARE UNDER A STRAIN, WORK FAST. GET THE TURNS OR FIGURE EIGHT ON AS QUICKLY AS POSSIBLE. WHEN SURGING OR SLACKING OFF ON A LINE THAT IS UNDER STRAIN, KEEP YOUR HANDS CLEAR OF THE BITTS.

4. KNOW WHERE THE FIRE AXE IS LOCATED.

TOWING ALONGSIDE (HIP TOW)

19-24. For tugs working inside harbors and for towing short distances or in confined areas where constant control is required, towing alongside or the hip tow is the preferred method. A hip tow can be made up on either the port or starboard side of the tug (see Figure 19-7). There are various ways of making up a hip tow; however, some standard requirements must be met.

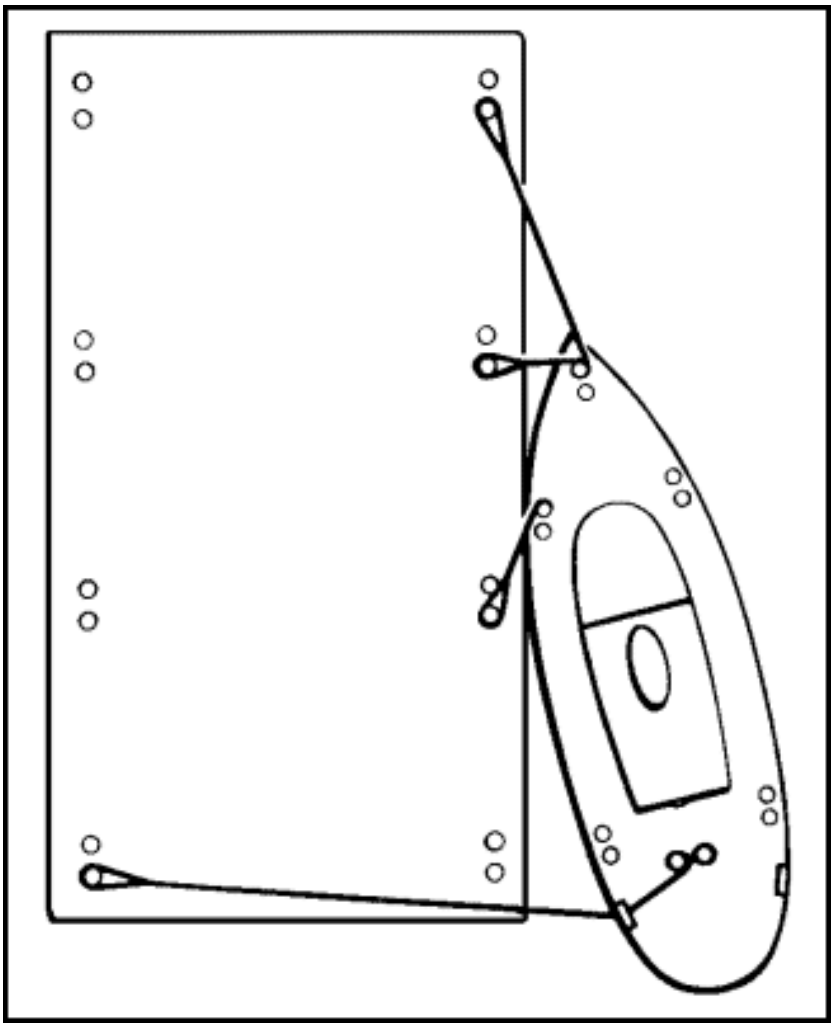


Figure 19-7. Making Up a Hip Tow

TOWLINES

19-25. Three lines should be used: the spring line, the bowline, and the stern line. For large or heavy tows, you may want to double up on the towlines and also use a bow breast line. Before the tug goes out to make up for a hip tow, the towing lines must be inspected and made ready. Inspect the lines for signs of severe chafing and the eyes and the eye splices for fraying or breaks. Check the towlines for wear and breaks. If you find a line damaged or one that you have doubts about, point it out to the boatswain or mate. When selecting the lines to be laid out, the usual procedure is that the best line is used for the spring line. This serves as the towline and takes the greatest strain. The second best line is used for the bowline, and the third best line is used for the stern line. The lines are then faked down (they are laid out so that they are free of kinks and obstructions). They can then be paid out rapidly when they are needed.

DETERMINING WHICH SIDE TO MAKE UP TO

19-26. The tug secures to one side of the tow with her own stern abaft of the stern of the tow. This will increase the effect of the tug's screw and rudder. The side chosen depends on how much the tug must maneuver with the tow.

19-27. If all turns are to be made with the tug's screw going ahead, she will be more favorably placed on the outboard side of the tow--the side away from the direction toward which the most turns are to be made.

19-28. If a sharp and difficult turn is to be made under headway, the tug should be on the side toward which the turn is to be made. Here she is properly placed for backing to assist the turn, because as she slows, the tow's bow will turn toward the side the tug is on.

19-29. If a turn is to be made under no headway, the tug is more efficient on the starboard side of the tow. When the tug backs to turn, the port send (side force) of her screw will combine with the drag of the tow to produce a turning effect greater than that which could be obtained with the tug on the port side.

19-30. The best position for a long back in a straight line is to have the tug on the port side. Then the drag of the tow tends to offset the port send of the backing screw.

SECURING THE TOWLINES

19-31. The towing line or spring line, usually a 6-inch (or larger) hawser, is led from the forward towing bitts on the tow side of the tug to the aft set of bitts on the tow. This line is secured first. Then the tug eases ahead with her bow turned in to take out all of the slack.

19-32. Next the bowline or backing line is paid out over the outboard side of the bow stem or king post and lead to a bitt on the forward end of the tow. Once the bowline is secured on the tow, all the slack is taken in and the bowline secured. This will bring the tug into proper position, slightly bow-in to the tow. When backing down, the bowline becomes the towline.

19-33. The stern line or turning line is lead from the tug's stern to the outboard side of the tow's stern. The purpose of this line is to keep the tug's stern from drifting out. The three lines, when properly secured and made taut, will make the tug and tow work as one unit.

Note: If for some reason the stern line cannot be fair led and secured to the outboard side of the tow, it is then secured to the inboard bitt on the stern of the tow.

19-34. A fourth line (optional), the bow breast line, can also be used for greater control when making up to a heavy tow. Check all the lines to ensure that they are as taut as possible. Perform this by easing the tug gently forward, then aft, to see that all the towlines are secure. The tug and the tow should be made up as a single unit.

CAUTIONS:

1. When securing these towlines, remember; NEVER secure the line so that it cannot be thrown off quickly and easily.

2. Areas of the harbor subject to wave action should be avoided whenever possible. The tug and tow seldom pitch in the same tempo. When both start pitching out of harmony, the lines take a heavy strain and may part. When equipped with a rudder the tow assists in steering. Size and loading of the tow may obstruct the view of the tug's conning officer. In that case, a lookout is stationed aboard the top who keeps the conning officer fully informed of activity and hazards in the blind area.

SHIFTING THE TOW TO THE OTHER SIDE

19-35. Occasionally it may be necessary to shift a tow from one side to the other. One method of doing this is shown in Figure 19-8.

TOWING TWO BARGES ALONGSIDE

19-36. Two barges may be towed alongside. Figure 19-9, shows the makeup for alongside tow.

TOWING ASTERN (INLAND WATERS)

19-37. There are many variations of a stern tow. Different towing materials are also required. Some factors that must be considered in planning for a stern tow are as follows:

- Whether the tow is being made in inland waters, bays, coastal waters, or overseas.
- Weather and sea conditions.
- Size and horsepower of the tug.
- Size of tow.
- Number of tows involved.

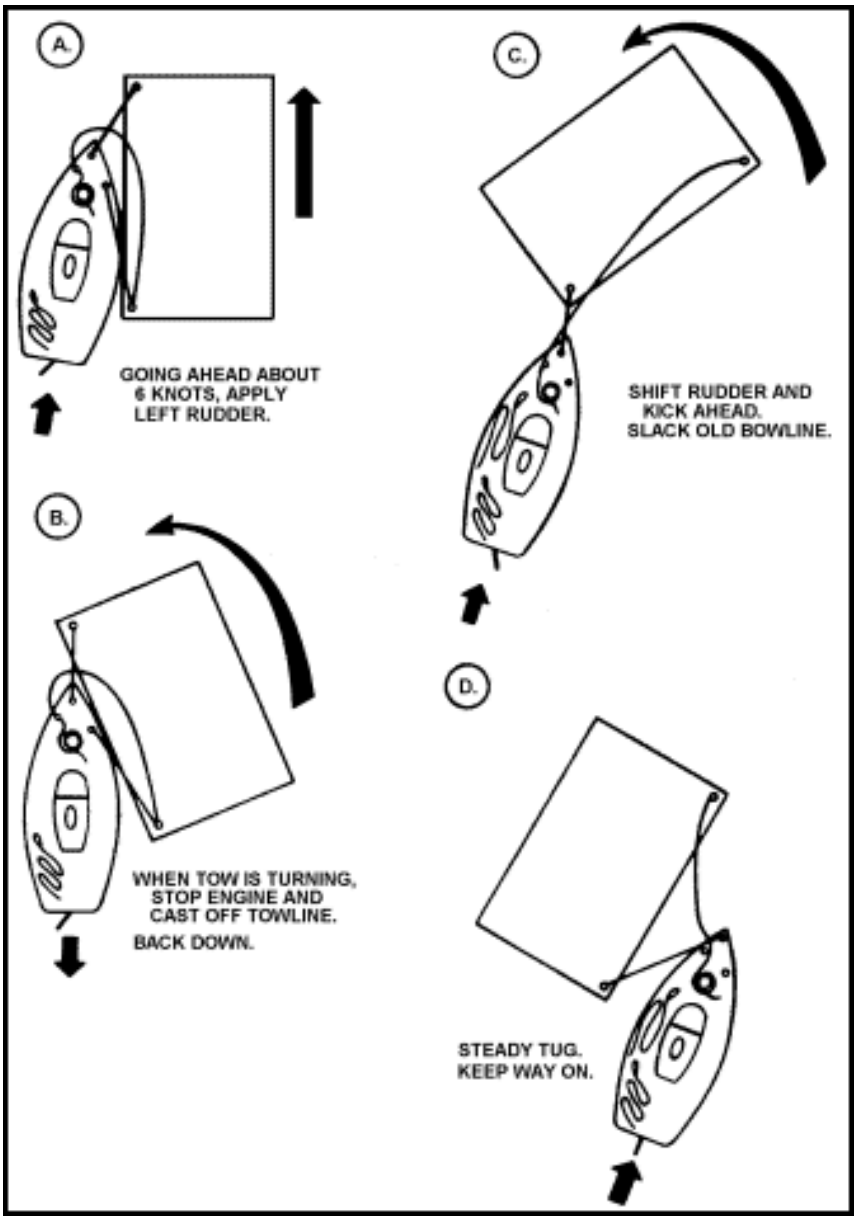


Figure 19-8. Shifting a Tow From One Side to the Other

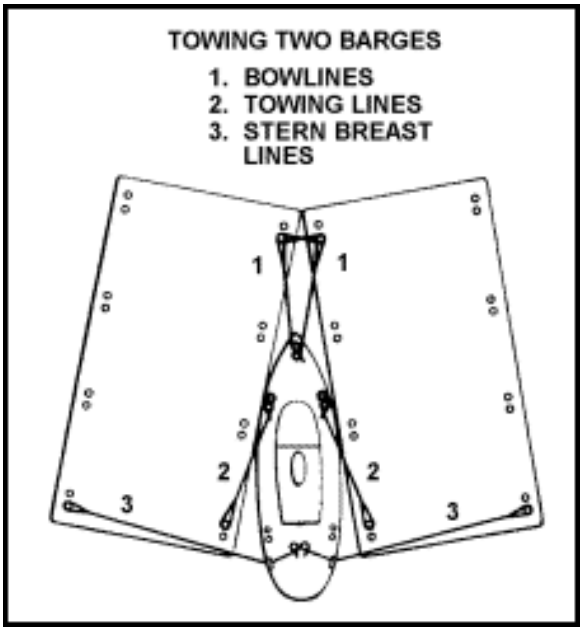


Figure 19-9. Towing Two Barges Alongside

SHIFTING THE TOW FROM ALONGSIDE TO ASTERN

19-38. Shifting usually is necessary when a tug is to tow a barge from port to port. The tow is taken alongside within the harbor and shifted astern outside. The shifting procedure is simple. The towing hawser is connected to the towing bridle before getting underway. Outside the harbor, the lines used for towing alongside are cast off, allowing the tow to drift away from the tug. Then, by slowly accelerating and carefully altering course and judiciously paying out the towing hawser, the tug gets underway with the tow and comes to the required course.

Note: When towing astern, you have limited control over the forward motion and turning of the tow. For this reason, stern tows are made in open waters. The longer the towline the less control you will have.

TOWING LINES

19-39. When towing in inland waters, the towing hawser is usually made up of nylon or other polyester line. For their size, the lines are lightweight and have tremendous strength. They are easy to handle. For inland waters, the length or scope of the stern towline is relatively short. Seldom will it ever be longer than 600 feet. The area in which you are towing and the master's desire determine the length.

19-40. Due to their relatively light weight, synthetic fiber towlines will float when they lie in the water. When a strain is taken on the line, it will rise up out of the water and stretch out. When using synthetic fiber towing lines there will be no catenary or dip in the towline. As the strain of the tow increases, the towline stretches out like a rubber band. As the line stretches, it will reduce its diameter by as much as 30 to 40 percent. Then the tow surges forward towing actually consists of pulling by jerks. Then the cycle starts over. The greatest danger in using synthetic fiber towlines is that if the line should part when under strain, it will snap back its full length like a bull whip. The force of the snapback is tremendous depending on the strain that the line was under at the time it parted. There is no set pattern on how the line will whip back. It may snap back directly on itself or it may whip from side to side. There is no way to tell what it will do. If you see a synthetic fiber line under strain parting or beginning to part--DO NOT RUN--just fall flat down on the deck.

TOWING ASTERN (OPEN SEA)

19-41. Deep-sea towing places many more requirements on the deck crew members of the tug. Now we are talking of much heavier towing gear, a variety of equipment, and the added requirements for assembling the towing gear.

Note: The tug master is responsible for determining the size and length of the towing gear to be used. The mate is responsible for obtaining this equipment. The boatswain and crew must be familiar with it and know how to assemble and rig for the different types of stern tows.

INSPECTION OF TOWING EQUIPMENT

19-42. Before assembling the towing rig, the mate and boatswain will inspect each item of equipment. If there is any doubt of its serviceability, REPLACE IT! If there is a question of size, for safety's sake, go to the next larger size. Remember, if anyone of these items fail you at sea, you stand the chance of losing the tow and even the life of a crew member.

SCOPE OF HAWSER

19-43. When underway, the tug and tow should be "in step"; that is, meeting and riding over the crests of waves at the same time (see Figure 19-10). Otherwise, the towline is alternately slack and taut, causing heavier than normal stresses. You can easily adjust the scope or length of the hawser when you have a towing machine. However, if you do not have the machine, it is almost impossible to make an adjustment. If you have the tow's anchor chain shackled to the hawser, you can let out or heave in the chain and hawser with the windlass.

19-44. The scope of a hawser should be long enough to provide a good catenary, but not to the extent of having the towline drag on the bottom if in shallow water. A catenary absorbs shocks. The scope of the hawser should be no less than 200 fathoms to provide a good shock-absorbing catenary when towing a large vessel. You should not put stress on a towline to the extent of lifting it out of the water, but you can increase the catenary by reducing the tug's speed.

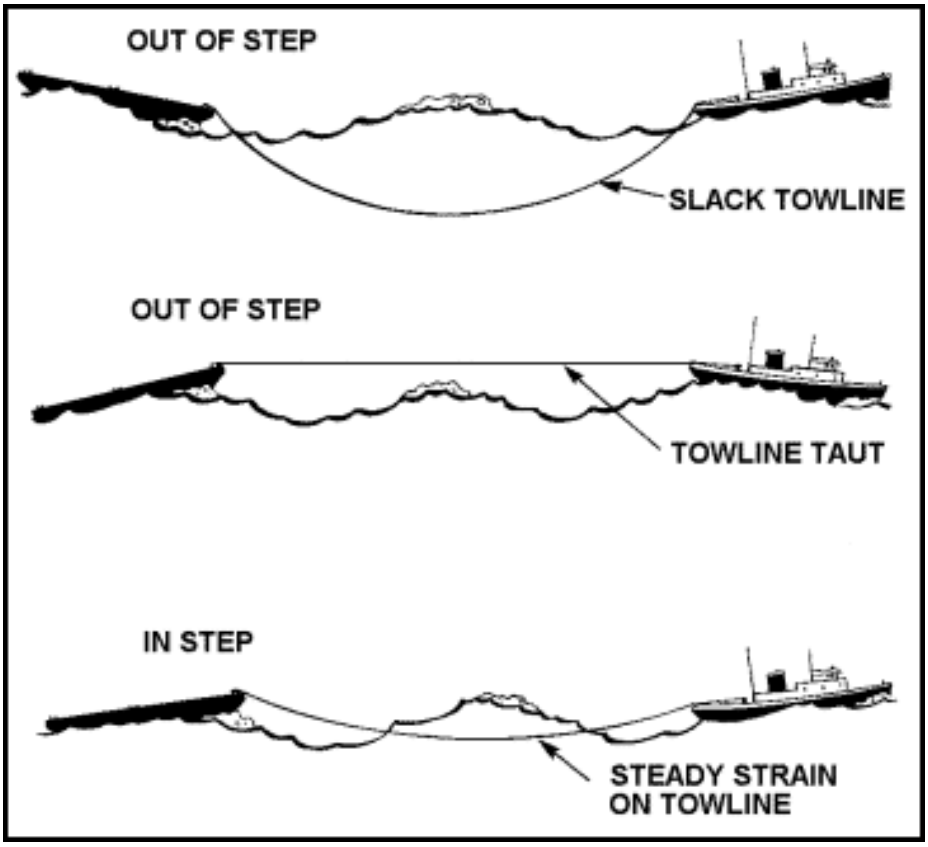


Figure 19-10. Keeping a Tow in Step

HAWSER WATCH

19-45. A hawser watch must be posted on the after deck to keep tow and gear under constant observation. Instruct the crew member, on watch, to immediately report the following:

- Too much tension is on the towline.
- The tow is not weathering properly.
- The bridles or other gear fail.

PREVENTIVE MAINTENANCE

19-46. The bos'n is responsible for maintaining the towing cable or line, bridles, and other gear efficiently at a minimum expense. Begin by having the cable or line properly wound and stowed. Then as rusted surfaces appear, have them scraped with wire brushes and then oiled. If the towline is a cable, oil it at least once a month. After each use, have it washed down with fresh water and then oiled. Greasing the rail at the stern reduces friction. Using chafing material at points where the cable contacts the tug, tow, and bitts reduces wear and tear.

19-47. In addition to chafing gear, continued monitoring of the towline's condition is necessary and important. Stern rollers and other fairleads must be properly lubricated and all possible points of line wear offered a fairlead. Canvas, hose, line, wood, or other materials should be used for chafing gear as required. Chafe must be eliminated or reduced on board the tow and the tug as much as possible. Continued paying out and retrieving of the towline can cause excessive chafing. Freshening the nip and lengthening or shortening the tow wire should be done every few hours in moderate weather and more often during heavy seas.

19-48. The towline must be checked periodically for a fairlead and chafing. Points of chafe must be protected. Appropriate lubrication and wearing surfaces should be placed so as to eliminate towline-to-hull contact.

TOWING IN TANDEM

19-49. When towing more than one barge astern, it is referred to as tandem towing. In a pure sense, tandem means one behind the other. Within the tandem rig are three other methods called the Honolulu rig, Christmas tree rig, and Modified Christmas Tree rig.

TANDEM RIG

19-50. In this method, the tug is connected to the first tow. The first tow connects to the second, and so on if additional units are towed (see Figure 19-11). The intermediate hawser, connecting the first tow to the second, must be streamed and allowed a proper catenary depth. The surging action must be eliminated between tug and first tow and between first tow and second tow.

HONOLULU RIG

19-51. In this method, the first tow is connected to the main tow wire. The second tow is connected, with an auxiliary tow wire, to the bitts on deck (see Figure 19-12). The Honolulu rig allows independent connection of the two tows. Disconnecting and control are readily workable.

CHRISTMAS TREE RIG

19-52. In this method, all of the barges tow from a single towing hawser (see Figure 19-13). This is done by means of pendants shackled to flounders (sometimes called bale or fishplates) inserted in the towing hawser.

MODIFIED CHRISTMAS TREE RIG

19-53. In the modified Christmas Tree rig, all of the tows are towed from a common flounder, but the last barge will tow as a separate unit (Figure 19-14).

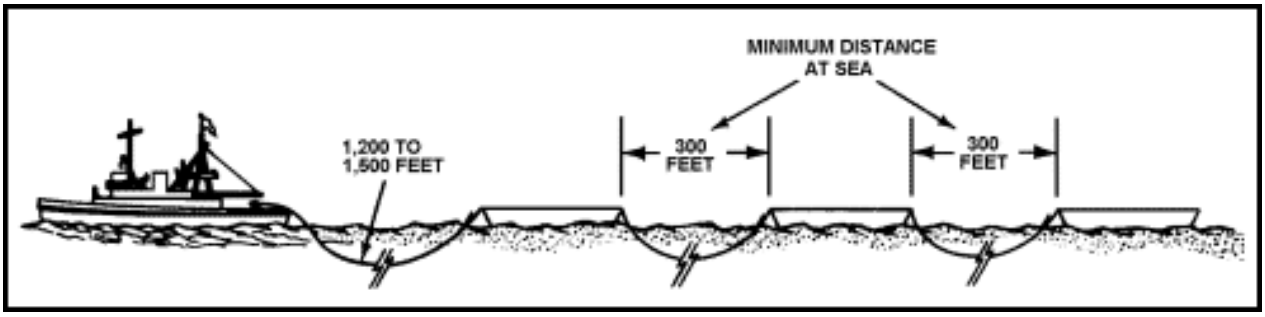


Figure 19-11. Tandem Rig

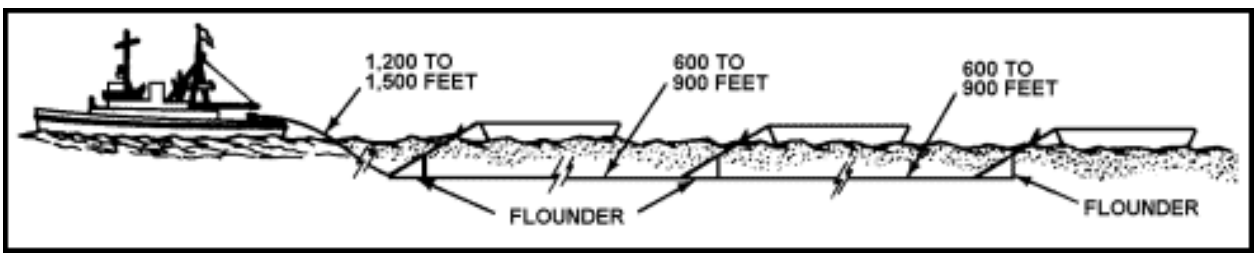


Figure 19-12. Honolulu Rig

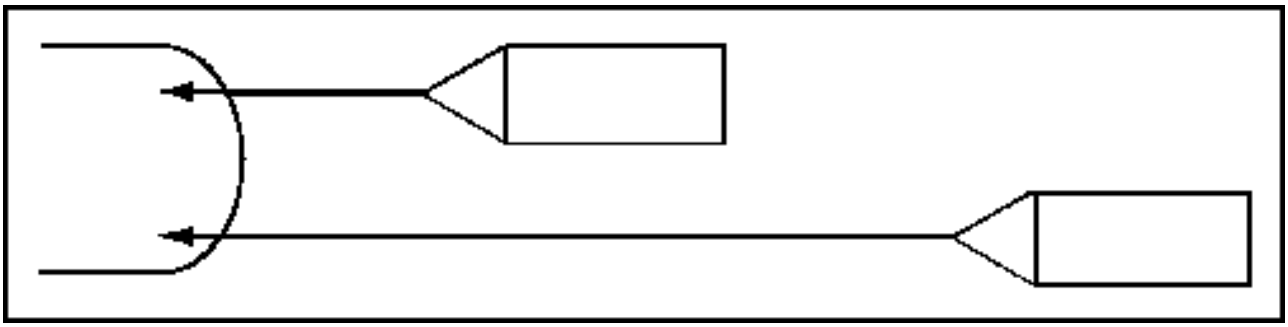


Figure 19-13. Christmas Tree Rig

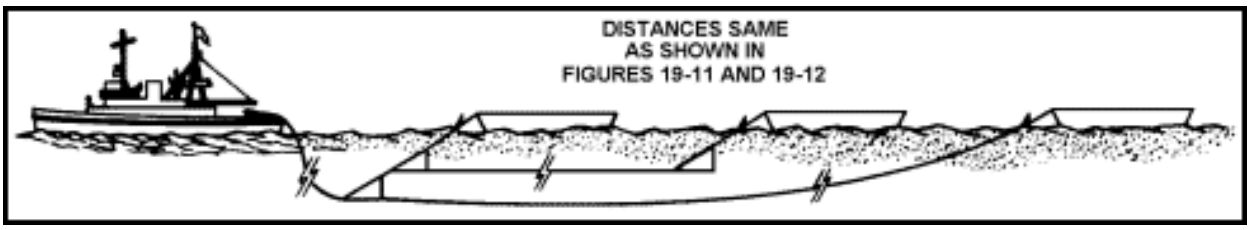


Figure 19-14. Modified Christmas Tree Rig

Note: Christmas Tree rigs are preferred for multiple tows. They are stronger and any one unit can be taken from the tow at anytime without disrupting the whole tow. The assistance of another tug is usually required to break up the Christmas Tree rig before entering port.

Chapter 20

Rigging (Seamanship)

This chapter describes the different types of blocks used in shipboard rigging and their nomenclature and maintenance. It also discusses the requirements for inspecting standing rigging. Also included are the formulas that are used to compute the safe working load and breaking strain for fiber, synthetic, and wire rope, hooks, shackles, and turnbuckles.

SECTION I - BLOCKS AND TACKLES

DESCRIPTION OF BLOCKS

20-1. A block consists of one or more pulleys or sheaves fitted in a wood or metal frame. Each block has one or more straps of steel or rope that strengthen the block and, in most cases, support the sheave pin. By inserting a hook or shackle in the strap, the block itself may be suspended or a load applied to the block. If the block has a becket to which the fall is spliced, the becket is also secured to the strap. A block with a rope led over the sheave is convenient in applying power by changing the direction of the pull. Used in conjunction with rope and another block, it becomes a tackle and increases the power applied on the hauling part (described later in this chapter).

DETERMINE THE SIZE OF BLOCK TO USE WITH FIBER LINE

20-2. The size of a block is found by measuring the length of the cheek of that block. The constant is 3 and the circumference of the line is the line size. The circumference of the line to be used will determine the size of the block needed. Blocks for fiber lines come in the following sizes: 4, 5, 6, 7, 8, 10, 12, and 14 inches.

Formula: LS X C = SB

Determine the size block to use for a 3 1/2-inch fiber line.

Example:

Line size to be used is 3 1/2 inches.

3 1/2 inches (LS) times a constant of 3.

3 1/2 X 3 = 10 1/2 inches

The closest sizes are 10-inch and 12-inch blocks. Go to the next larger size to select the 12-inch block. Blocks are designed for use with a certain size of rope. Therefore, they should never be used with rope of a larger size. Rope bent over a small sheave will be distorted, and any great strain applied will damage it and may even result in the rope wearing on the frame.

DETERMINE THE SIZE OF BLOCK TO USE WITH WIRE ROPE

20-3. It is impossible to give an absolute minimum size for wire rope sheaves because of the factors involved. However, experience has shown that the diameter of a sheave should be at least 20 times the diameter of the wire rope. An exception to this is a 6 X 37 wire and other flexible wire for which smaller sheaves can be used because of their greater flexibility. The construction of the wire rope has a great deal to do with determining the minimum diameter of sheaves to be used (Figure 20-1). The stiffer the wire rope, the larger the sheave diameter required.

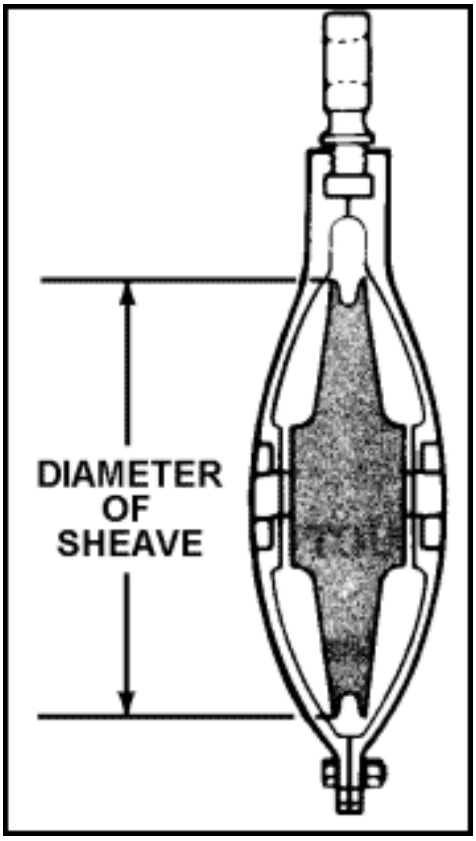


Figure 20-1. Wire Rope Block

COMMON CARGO BLOCKS

20-4. The three types of cargo blocks most frequently seen on ships are the diamond, oval, and roller bearing. Figure 20-2 shows the diamond block and roller bearing block. Each of these blocks are described below.

- **Diamond block.** A single-sheave diamond block is shown in Figure 20-2, but there may be many more, depending on the use of the block. Sheaves of this type of block are usually bushed with a high-grade bronze alloy, and the pins are equipped with grease fittings. Sheave bushings should be lubricated with hard graphite grease (such as Federal Specification VV-G-671, grade 0).
- **Oval Block.** Oval blocks are built to the same specifications as diamond blocks except that the cheeks are oval instead of diamond shaped. The most common use of these two blocks is for topping lifts of cargo booms.
- **Roller Bearing Block.** Head, heel, and many of the fairlead blocks are of the roller bearing type. These blocks have cast steel cheeks and sheaves. The sheaves are equipped with roller bearing assemblies. The pin is provided with a grease fitting. Roller bearing blocks are used where high-speed operation is essential.

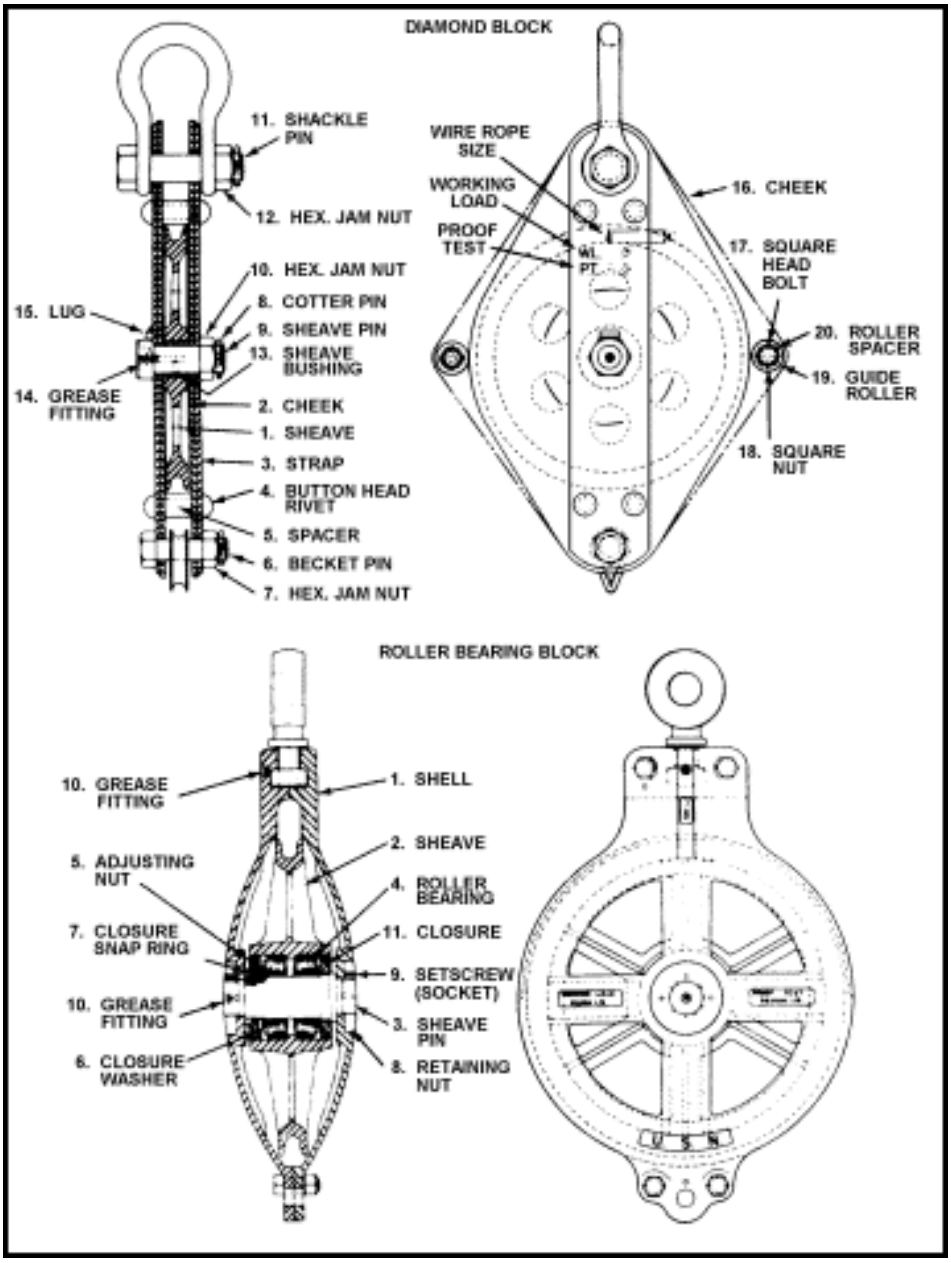


Figure 20-2. Common Cargo Blocks

NAMING A BLOCK

20-5. Regardless of type, a cargo block is usually named for its location in the cargo rig. The block at the head of the boom through which the whip runs is called the head block. The block at the foot, which fairleads the wire to the winch, is the heel block. A small single-sheave block in the middle of most booms is called the slack wire block because it prevents slack in a whip from hanging down in a bight. Blocks in the topping lift are upper and lower topping lift blocks. A fairlead block, called a check block, is permanently fixed by welding or bolting one cheek to a bulkhead, davit, and so on. Another fairlead block is a snatch block, which is cut at the swallow (the hole the line reeves through), hinged on one side, and fitted with a hasp on the other. This permits the block to be opened and clamped on a line rather than reeving the end of the line through. Tail blocks are single blocks usually used alone with a whip or as a runner.

Note: When ordering a block, five things must be specified: wood or metal, size, type rig (with or without becket), and number of sheaves.

TYPES OF RIGS

20-6. Blocks may be single, double, treble, and so on. That is, they may be fitted with one, two, three, or more sheaves, respectively. When used in a tackle, one of the blocks must be fitted with a becket to which one end of the line is spliced. When the hook, shackle, and swivel are fitted on the blocks they are called rigs. Figure 20-3 shows various types of rigs and fittings.

COMBINATIONS OF BLOCKS AND TACKLES

20-7. Tackles are designated in two ways. One is the number of sheaves in the blocks that are used to make the tackle, such as single whip, gun tackle, or twofold purchase. The other designation is according to the purpose for which the tackle is used, such as yard tackles, stay tackles, or fore-and-aft tackles. Only the most commonly used combinations found aboard ship are shown in Figure 20-4, and described as follows.

- **Single Whip.** Consists of one single-sheave block fixed to a support with a rope passing over the sheave.
- **Runner.** Consists of a single block, but the block is free to move. One end of the rope is secured to the support with the weight attached to the block.
- **Gun Tackle.** Consists of two single blocks. It takes its name from the use made of it in hauling muzzle-loading guns back into battery after the guns are fired and reloaded.
- **Luff Tackle (Jigger).** Consists of a double and a single block.
- **Twofold Purchase.** Consists of two double blocks.

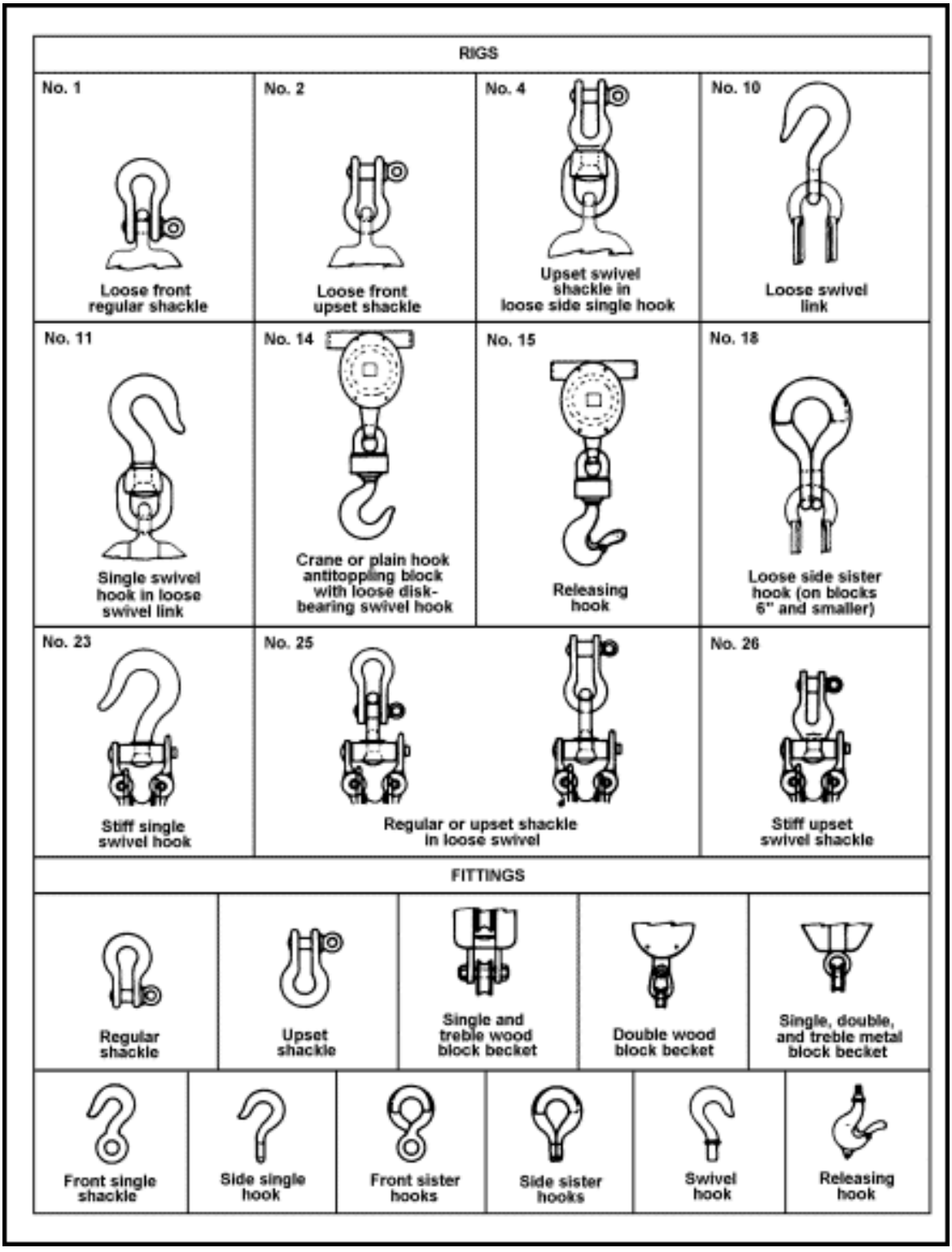


Figure 20-3. Various Rigs and Fittings

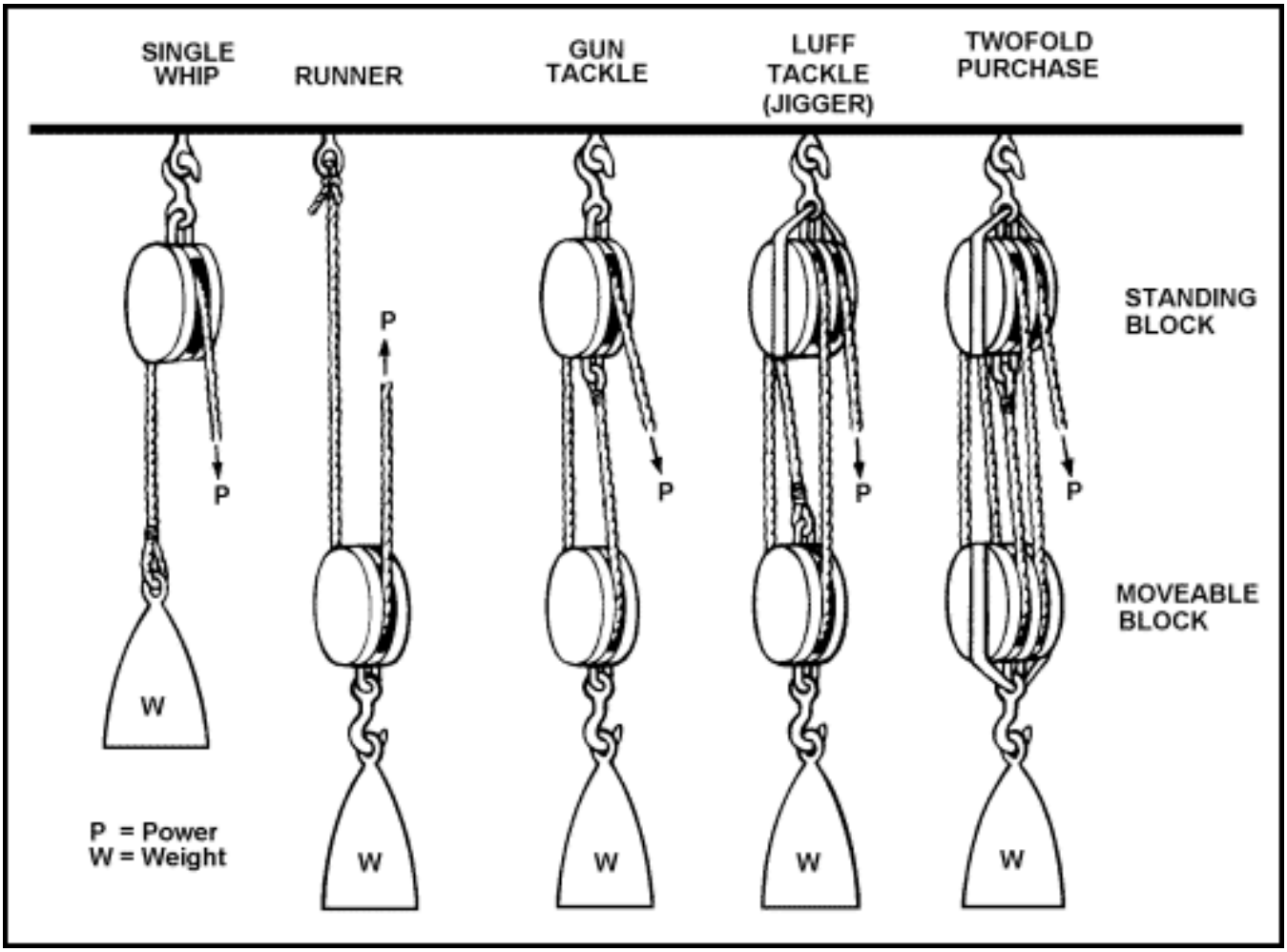


Figure 20-4. Blocks and Tackles

REEVING BLOCKS AND TACKLES

20-8. The preferred method of reeving multiple sheave blocks is referred to as the "right-angle method of reeving". With this method, one block (usually the head block) rests on the edge of its plates and cheeks, and the other block rests on its cheek. The sheaves are at right angles to each other (Figure 20-5). The advantages of using the right-angle method of reeving are that it reduces the chances of the rope chafing or of the blocks turning.

REEVING A DOUBLE LUFF TACKLE

20-9. A double luff tackle consists of a triple sheave and a double sheave block. The right-angle method of reeving is shown in Figure 20-6.

REEVING A THREEFOLD PURCHASE

20-10. The same method used to reeve a threefold purchase is used in reeving the double luff tackle (see Figure 20-7). After the line has been reeved through the last sheave, the final step is to make an eye-splice around the thimble and then bolt it into the becket.

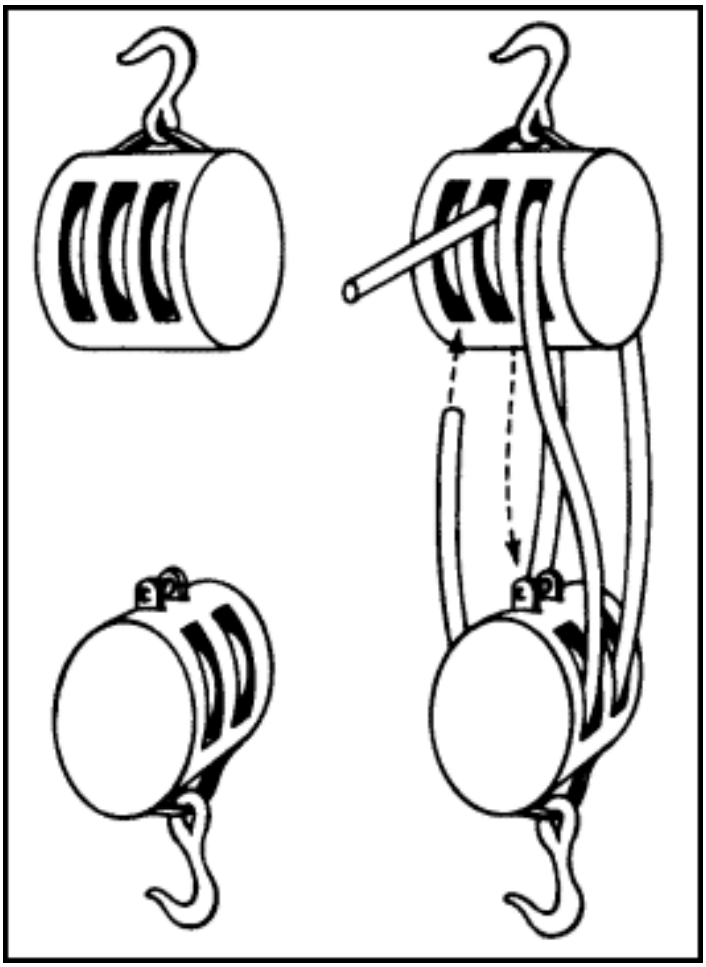
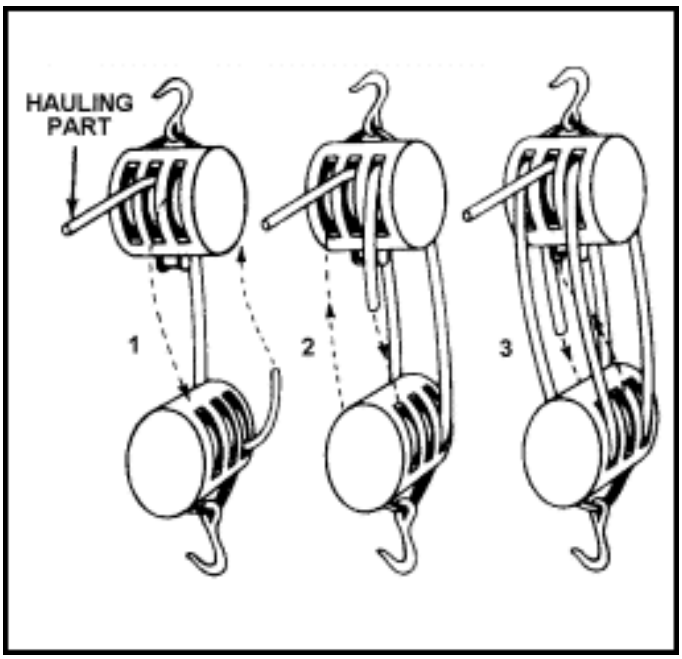


Figure 20-5. Blocks at Right Angles



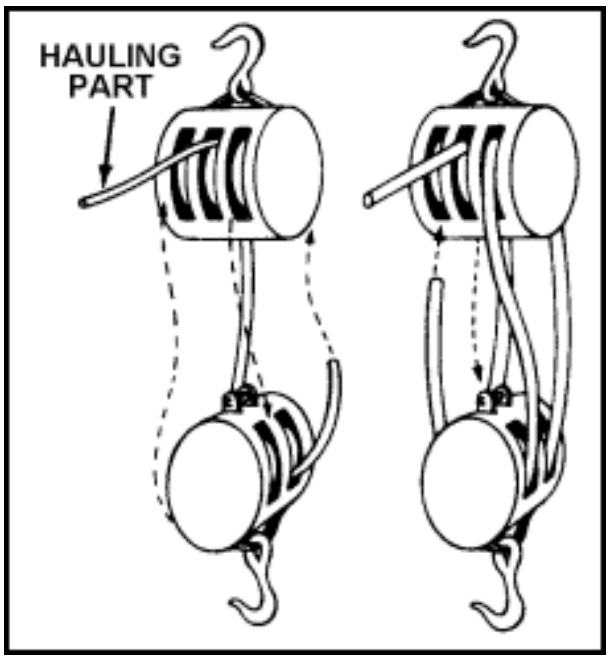


Figure 20-6. Reeving a Double Luff Tackle

Figure 20-7. Reeving a Threefold Purchase

DETERMINING THE MECHANICAL ADVANTAGES OF TACKLES

20-11. The mechanical advantage of a simple tackle is determined by counting the number of parts of the moving lines at the moveable block. The moveable block is the block that is attached to the weight to be moved (see Figure 20-8). Friction is not considered in the following example: If a load of 10 pounds requires 10 pounds to lift it, the mechanical advantage is 1. If a load of 40 pounds requires only 10 pounds of power to lift it, then the mechanical advantage is 4 to 1, or 4 units of weight lifted for each unit of power applied.

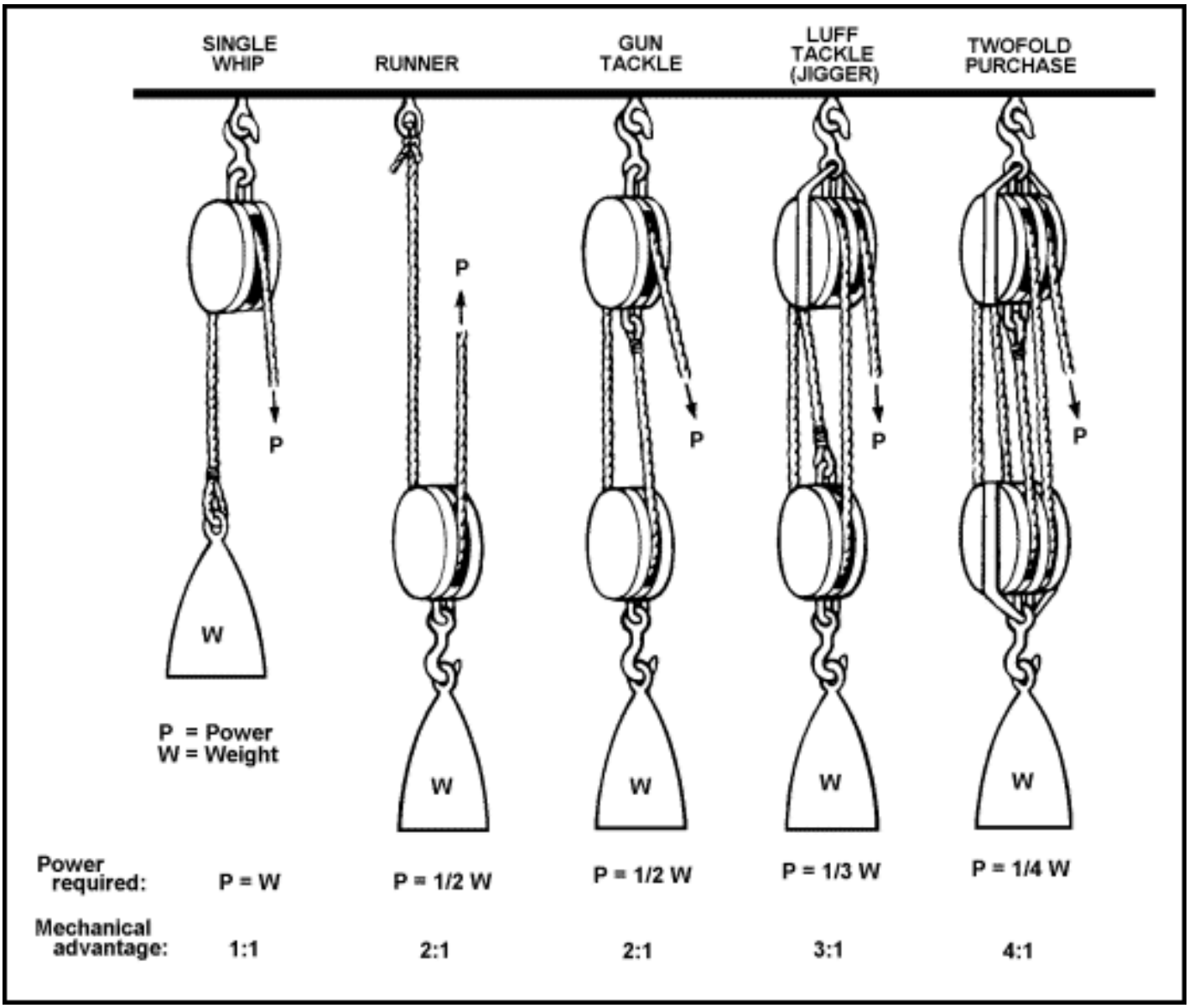


Figure 20-8. Mechanical Advantages of Tackles

SECTION II - COMPUTATIONS

COMPUTING FRICTION

20-12. A certain amount of the force applied to a tackle is lost through friction. Friction in a tackle is the rubbing of ropes against each other or against the frame or shell of a block, the passing of the ropes over the sheaves, and the rubbing of the pin against the sheaves. This loss in efficiency of the block and tackle must be added to the weight being lifted when determining the power required to lift a given load. Roughly 10 percent of the load must be added to the load for every sheave in the tackle. For example, what would be the loss of efficiency due to friction when picking up 500 pounds and using a twofold purchase?

Weight of load is 500 pounds.

10 percent of the weight of the load is 50 pounds.

With a twofold purchase there are four sheaves.

4 (sheaves) X 50 pounds (10 percent of weight) = 200 pounds loss in efficiency due to friction.

COMPUTING BREAKING STRENGTH AND SAFE WORKING LOAD

20-13. When working with line, it is essential that you do not overload it because doing so is dangerous and costly. An overloaded line may part and injure someone in the vicinity. Even if it does not part, its useful life is shortened every time it is overloaded. For these reasons, you need to know a line's breaking strength and safe working load.

20-14. The manufacturer's data gives the BS of a line, but to learn the line's SWL, you must apply an SF. An SF is a number by which the BS is divided to find the range in which it is safe and economical to operate the rope. Table 20-1 shows, even under the best of conditions, that the allowance for safety is considerable.

Table 20-1. Safety Factor of Line

Line	Working Conditions		
	Best	Average	Poor

Manila	5	10	15
Nylon Polyester	3	4	6
Polypropylene Polyethylene	5	6	8

USEFUL FORMULAS FOR LINES

20-15. When the manufacturer states the size and BS of its lines, use these figures for determining the strength of line. If this information is not available, then use the rule of thumb to compute the SWL and the breaking strength.

20-16. The following rules of thumb give only approximate results. However, the error will be on the side of safety because of the constants used in the formula.

Type of line	Constant
Sisal	160
Manila	200
Three-strand nylon	500
2-in-1 braided nylon	600

With "C" meaning circumference in inches, the formula for SWL in pounds is:

C^2 X constant for line = SWL

3-inch sisal:
3 X 3 X 160=
9 X 160 =
1,440 pounds SWL

3-inch manila:
3 X 3 X 200 =
9 X 200 =
1,800 pounds SWL

3-inch, three-strand nylon:
3 X 3 X 500=
9 X 500 =
4,500 pounds SWL

3-inch, 2-in-1 braided nylon:
3 X 3 x 600 =
9 X 600 =
5,400 pounds SWL

20-17. An SF of 5 is generally used in marine operations. Multiply this by the SWL to find the BS of a fiber line. This is the amount of weight in pounds required to part the line. If you are given the BS of a line, divide it by the safety factor 5 to find the SWL.

Note: The safety factor of 5 is valid when using new line or line that is in good condition. As line ages and wears through use, the safety factor drops. Old line may have a safety factor of 3.

SWL AND BS FOR WIRE ROPE

20-18. Useful formulas for determining the SWL of several grades of wire rope have constants not to be confused with safety factors. For example, the formula for the SWL in STONs (2,000 pounds) for extra improved plow steel wire rope is:

Diameter squared (D^2) times 10

or

$SWL = D^2 \times 10$

20-19. To find the SWL of 1-inch, 6 X 19, extra improved plow steel wire rope:

$SWL = D^2 \times 10$
$= 1 \times 1 \times 10$
= 10 STONs

20-20. A figure relatively constant in marine operations, especially for new wire rope, is the SF of 5. It is used with the SWL to find the breaking strength or strain:

BS = SWL X 5
= 10 X 5
= 50 STONs

20-21. The formulas for improved plow steel, plow steel, and mild plow steel (6 X 19 wire rope) are as follows:

Improved plow steel and plow steel:

SWL= D^2 X 7 = STONs

BS = SWL X SF = STONs

Mild plow steel:

SWL= D^2 X 6 = STONs

BS = SWL X SF = STONs

COMPUTING THE BREAKING STRENGTH OF A BLOCK AND TACKLE

20-22. Breaking strength determines the ultimate strength of the block and tackle. When computing the breaking strength of a block and tackle think of this as the load that your line should be expected to handle on a regular basis. Computing the correct breaking strength will safeguard expensive equipment and also protect the lives of personnel.

DETERMINING BREAKING STRESS

20-23. Perform the following steps to determine breaking stress.

- **Step 1.** Determine the friction for the block and tackle.
- **Step 2.** Determine the total weight to be lifted.
- **Step 3.** Determine the strain on the hauling part of the block and tackle.
- **Step 4.** Apply the breaking stress formula to compute the breaking stress of the block and tackle.

Note: The SF for the hauling part is always 5. The formula is SF X SHP = BS for the block and tackle.

- **Step 5.** Compare the breaking stress to the figures shown in the line strength table (see Table 20-2). The SWL of the line used should be greater than the computed BS for the block and tackle.

  Example:

  Determine the breaking strain for a twofold block and tackle that is going to be used to lift a 500-pound weight.

Determine the minimum size manila line that has an SWL capable of making the lift.

PROCEDURE

20-24. Friction is computed at 10 percent per sheave.

- **Step 1.** Determine the friction. For a block and tackle, 10 percent times the number of sheaves equals the percent of friction. Using a twofold purchase, there are four sheaves, giving a loss of efficiency of 40 percent.
- **Step 2.** Determine the total weight to be lifted. The original weight to be lifted is 500 pounds. There is a 40 percent loss of efficiency that must be added to that weight to be lifted (40 percent X 500 = 200 pounds). The formula for total weight is:

  W + F = TW

  500 + 200 = 700 pounds total weight to be lifted.

- **Step 3.** Determine the SHP. The mechanical advantage for a twofold purchase is 4.

Formula is:

TW ÷ MA = SHP

700 ÷ 4 = 175 pounds SHP

- **Step 4.** Compare the SHP to the line strength shown in Table 20-2. Select an SWL that exceeds the computed SHP for the block and tackle. You would use 1 1/2-inch manila line, which has an SWL of 450 pounds for making the lift.

Note: The information in Table 20-2 is computed in pounds for new line. For line that has been used, these figures will decrease. Old line may have only 60 percent of strength shown in pounds for a given size of line.

Table 20-2. Line Strength Table (Safety factor of 5)

Size in (inches)	Manila		Three-strand Nylon		2-in-1 Braided Nylon	
	SWL (pounds)	BS (pounds)	SWL (pounds)	BS (pounds)	SWL (pounds)	BS (pounds)
1	200	1,000	500	2,500	600	3,000
1 ½	450	2,250	1,125	5,625	1,350	6,750
2	800	4,000	2,000	10,000	2,400	12,000
2 ½	1,250	6,250	3,125	15,625	3,750	18,750
3	1,800	9,000	4,500	22,500	5,400	27,000
3 ½	2,450	12,250	6,125	30,625	7,350	36,750
4	3,200	16,000	8,000	40,000	9,600	48,000
4 ½	4,050	20,250	10,125	50,625	12,150	60,750
5	5,000	25,000	12,500	62,500	15,000	75,000
5 ½	6,050	30,250	15,125	75,625	18,150	90,750
6	7,200	36,000	18,000	90,000	21,600	100,800
6 ½	8,450	42,250	21,125	105,625	25,350	126,750
7	9,800	49,000	24,500	122,500	29,400	147,000
7 ½	11,250	56,250	28,125	140,625	33,750	168,750
8	12,800	64,000	32,000	160,000	38,400	192,000
8 ½	14,450	72,250	36,125	180,625	43,350	216,750

COMPUTING SAFE WORKING LOAD FOR HOOKS, SHACKLES, AND TURNBUCKLES

20-25. Calculated or predicted design loads are compared to a baseline strength in computing the safety factor for hooks, shackles, and turnbuckles. All hooks, shackles, and turnbuckles will be tested before being used.

COMPUTE THE SWL OF A HOOK

20-26. The diameter of a hook is measured where the inside of the hook starts its arc. The constant for a hook is 2/3.

Formula:

D^2 X C = SWL of hook in STONs

- **Step l.** Measure diameter of the hook to be used.
- **Step 2.** Use the constant of 2/3.
- **Step 3.** Apply the formula to determine the SWL of the hook in STONs.

Example:

Determine the SWL of a 3-inch hook.

D^2 X C = SWL in STONs

(D^2 = 3 X 3 = 9),(C = 2/3)

9 X 2/3 = 6 STONs SWL

COMPUTE THE SWL OF A SHACKLE

20-27. Measure the diameter of the shackle at its side. The constant for shackles is 3.

Formula:

D^2 X C = SWL in STONs

- **Step l.** Measure the diameter at the side of the shackle.
- **Step 2.** Use the constant of 3.
- **Step 3.** Apply the formula to determine the SWL in STONs for a shackle.

Example:

Determine the SWL of a shackle that has a diameter of 2 inches.

D^2 X C = SWL in STONs

(D^2 = 2 X 2 = 4), (C = 3)

4 X 3 = 12 STONs SWL

COMPUTE THE SWL OF A TURNBUCKLE

20-28. To determine the SWL for turnbuckles, measure the diameter of the threaded rod (Figure 20-9) and check the SWL in Table 20-3.

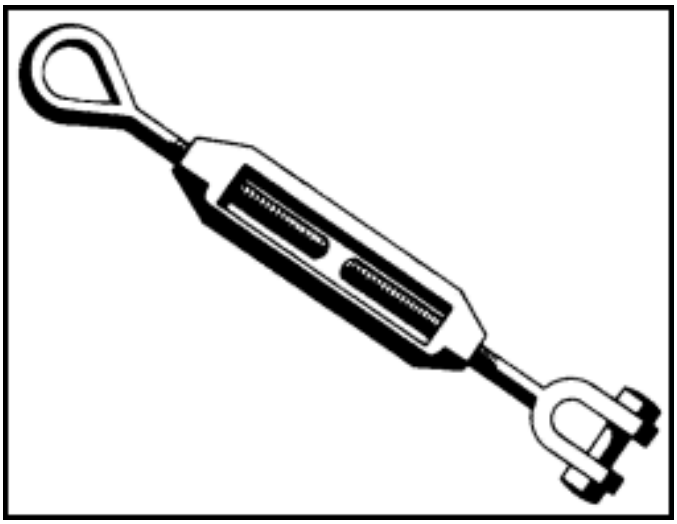


Figure 20-9. Threaded Rod on Turnbuckle

Table 20-3. Turnbuckle Rod SWL Table

Values in STONs (2,000 pounds)	
Rod diameter (in inches)	**SWL (in STONs)**
1/2	.9
5/8	1.5
7/8	2.2
1	3.1
1 1/8	5.1
1 1/4	6.6

SECTION III - BLOCK MAINTENANCE AND RIGGING

MAINTENANCE AND OVERHAUL OF BLOCKS

20-29. Blocks, like other equipment exposed to the elements, will become useless if they do not receive proper maintenance. The bearing and bushing will wear if they are not properly lubricated. The shells and accessories will deteriorate if they are not properly preserved. Maintenance for the fiber rope and the wire rope blocks is discussed as follows.

FIBER ROPE BLOCKS

20-30. These types of blocks should be disassembled periodically and inspected and lubricated. A mixture of white lead and tallow, or graphite and grease, should be used.

20-31. To disassemble a block, remove the becket bolt and becket, pry off the keeper, and drive out the pin. To loosen the strap in the frame, tap the bottom with a hammer. Then if you cannot pull it out by hand, insert a marlinespike in the U of the strap and drive it out by tapping on the marlinespike with the hammer. Figure 20-10 shows a disassembled block.

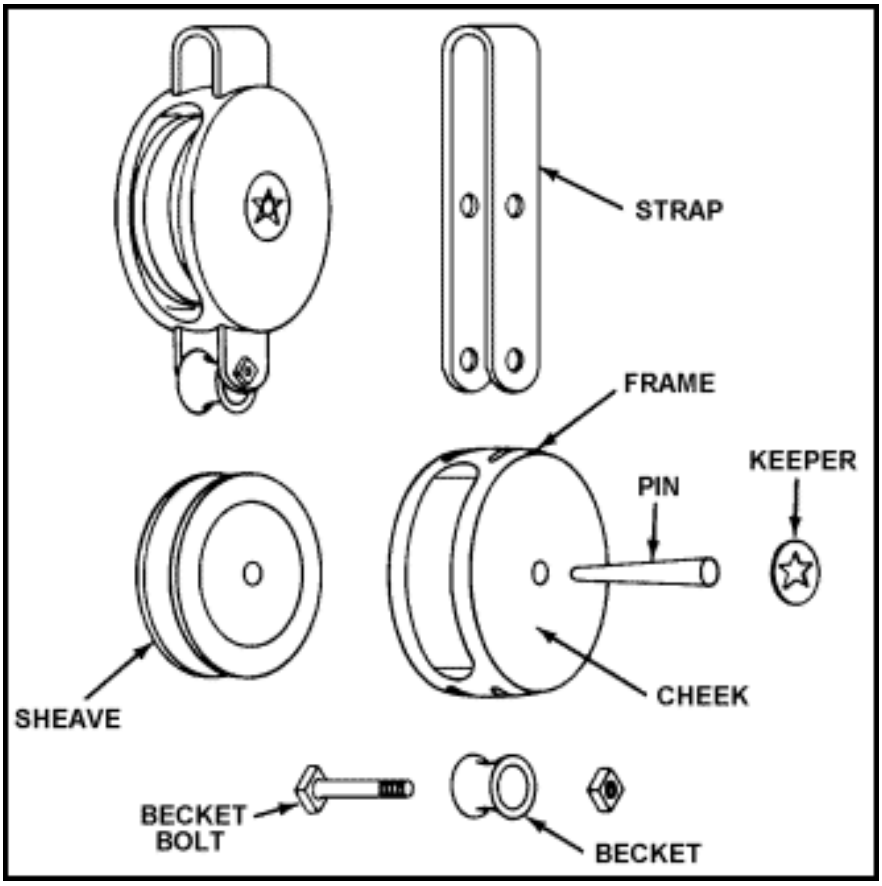


Figure 20-10. A Disassembled Block

20-32. Inspect the frame of the block for any cracks or splits and for any signs of the sheave wearing on the frame. If there are any worn spots on the inside of the frame, check the pin to see if it is bent. Check the hooks or shackles for any sign of distortion. A bent pin or a distorted hook or shackle is no longer is safe. Dropping a wooden block can split its frame. Never paint a wooden block because a coat of paint could hide a split. Instead, use clear shellac or varnish or several coats of linseed oil. Metal in constant use is subject to fatigue. Frequently and carefully inspect blocks in running rigging for any signs of distortion or wear. Immediately replace any doubtful block and, if the cost warrants, send it to a shipyard for testing.

20-33. Inspect and replace any suspected wooden blocks. Many parts for blocks are available separately--for example, rigs for wire rope blocks. Before replacing an entire block, consult the supply officer to see if you can get a replacement for any part that is defective.

WIRE ROPE BLOCKS

20-34. These types of blocks used in cargo handling rigs and others in continuous use should be disassembled frequently and inspected for wear. However, those used only occasionally seldom need to be disassembled if they are kept well lubricated. Two types of wire rope blocks are the diamond and oval blocks and the roller bearing block. Refer back to Figure 20-2, to do the following:

Diamond and Oval Blocks

20-35. To remove the sheave from a diamond or oval block, take out the cotter pin (8) and remove the hexagon nut (10) from the sheave pin (9). Drive out the sheave pin. For a diamond block it is necessary to loosen all bolts holding the cheeks together and to remove one before the sheave will slide out. With an oval block it is necessary only to loosen the bolts.

Roller Bearing Blocks

20-36. To disassemble a roller bearing block, loosen the setscrews (9) and remove the retaining nuts (8). Take out the bolts holding the shell together and remove the shell. Remove the closure snap rings (7), adjusting nut (5), closure washer (6), and closure (11). Now remove the pin, then the bearings from the sheave.

STANDING RIGGING

20-37. Standing rigging, usually of 6- X 19-inch galvanized, high-grade plow steel wire rope, is used to support the masts. The fore and aft supports are called stays and the supports running athwartships are shrouds. Stays and shrouds are set up at the lower end with turnbuckles. Vibration often causes turnbuckles to back off. To prevent this, keepers are installed on most turnbuckles in standing rigging. The effectiveness of shrouds and stays is reduced considerably if they are allowed to become slack. Inspect standing rigging periodically and tightened if necessary. Use the following procedure when considerable adjustments are required.

- Slacken all stays and shrouds so that no unbalanced forces are applied to the mast.
- Take up the slack as uniformly as possible until sag is substantially eliminated from all stays and shrouds, and turnbuckles are handtight. Measure the distances between the ends of the turnbuckle bolts.
- Tighten each turnbuckle so that it is shortened by a distance equal to l inch for each 60 feet of stay length.

Insulators should present clean surfaces. They should not be painted, tarred, varnished, or coated in any way. All electrical grounds on standing rigging should be inspected periodically for excessive deterioration at points of contact between different metals.

INSPECTIONS OF RIGGING

20-38. A weekly inspection of all booms and their rigging and associated fittings is conducted by the mate and boatswain. Whenever a boom is to be used for hoisting or lowering a load equal to its rated capacity, as shown on the heel of the boom, the chief mate should be notified. He will make a thorough inspection of the boom and its associated fittings and rigging before the lift is made. Whenever signs of deterioration are found, defective components should be replaced or renewed as soon as possible. If the inspection indicates a dangerous condition or weakness of any component, this should be reported without delay, and the boom in question should not be operated until it is repaired or replaced. Refer to FM 55-17 for more information on cargo rigging.

GROUNDING MASTS

20-39. Unless otherwise directed, mast shrouds should be grounded at the deck to prevent accumulation of static charges. One method of grounding shrouds is shown in Figure 20-11. Most electrical insulation and grounds on metallic standing rigging should be inspected periodically for deterioration at points of contact between dissimilar metals. When deterioration is evidenced, the connections should be thoroughly cleaned and replaced as required.

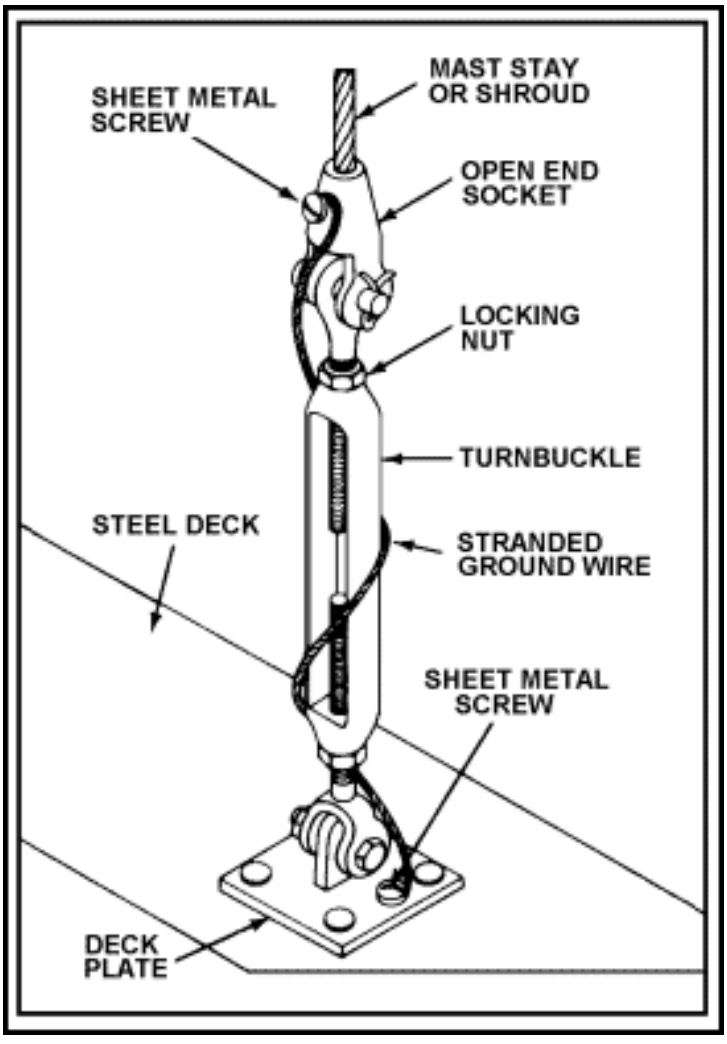


Figure 20-11. Grounding a Shroud

Chapter 21

Ground Tackle

Ground tackle consists of all the equipment used in anchoring. This includes the anchors, anchor cables or chain, connecting devices, and the anchor windlass. This chapter discusses these items and their nomenclature, maintenance, and use.

ANCHORS

21-1. An anchor works like a pickaxe. When the pick is driven into the ground, it takes a great deal of force to pull it loose with a straight pull on the handle. However, by lifting the handle, a leverage is obtained which breaks it free. In the same way, the anchor holds because the anchor chain or cable causes the pull on the anchor to be in line with its shank. When it is desired to break the anchor free, the chain is taken in and this lifts the shank of the anchor and gives the leverage needed to loosen the anchor's hold. The primary function of an anchor is to hold the ship against the current and wind. On landing craft, stern anchors are also used to prevent broaching on the beach and to assist in retracting from the beach.

NOMENCLATURE

21-2. The following describes the different parts of an anchor (see also Figure 21-1).

- **Ring (Shackle).** Device used to shackle the anchor chain to the shank of the anchor. The ring is secured to the top of the shank with a riveted pin.
- **Shank.** The long center part of the anchor running between the ring and the crown.
- **Crown.** The rounded lower section of the anchor to which the shank is secured. The shank is fitted to the crown with a pivot or ball-and-socket joint that allows a movement from 30º to 45º either way.
- **Arms.** The parts that extend from each side of the crown.
- **Throat.** The inner curved part of an arm where it joins the shank.
- **Fluke or palm.** The broad shield part of the anchor that extends upward from the arms.
- **Blade.** That part of the arm extending outward below the fluke.
- **Bill or pea.** Tip of the palm or fluke.

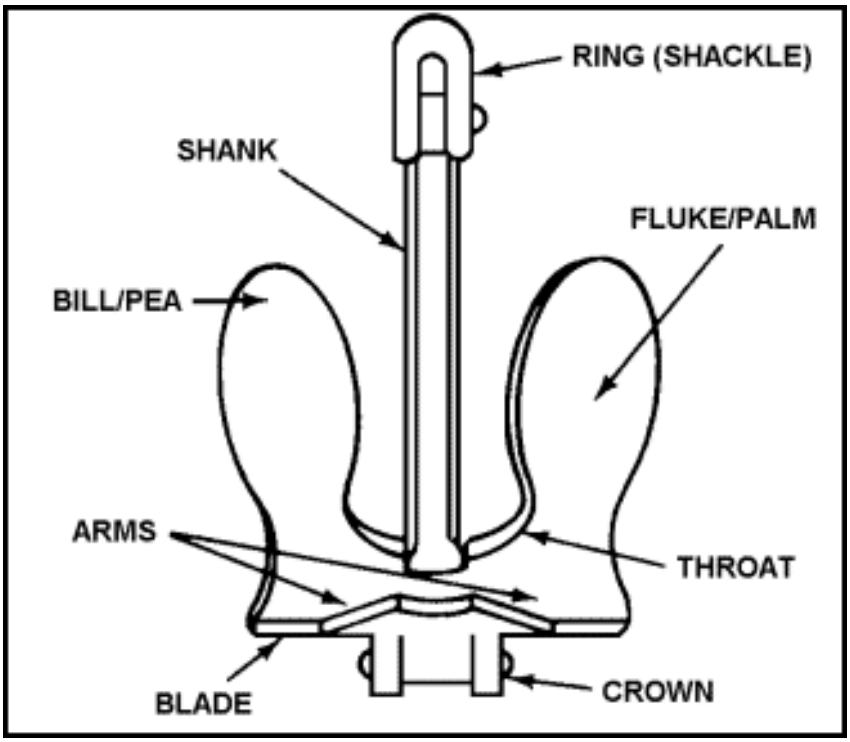


Figure 21-1. Nomenclature of an Anchor

TYPES

21-3. Three types of anchors used aboard Army vessels are the stockless, the lightweight, and the mushroom (see Figure 21-2).

Note: All vessels, 380 tons and over, must carry a spare bow anchor. Seagoing tugs must carry a kedge anchor.

ANCHOR CHAIN

21-4. Modern anchor chain is made of die-lock chain with studs. The size of the link is designated by its diameter, called wire diameter. The Federal Supply Catalog lists standard sizes from 3/4 inch to 4 3/4 inches. Wire diameter is measured at the end and a little above the centerline of the link. The length of a standard link is 6 times its diameter and width is 3.6 times its diameter. All links are studded; that is, a solid piece is forged in the center of the link. Studs prevent the chain from kinking and the links from pounding on adjacent links. They also further strengthen the chain up to 15 percent.

CHAIN NOMENCLATURE

21-5. A chain is made up of many parts besides links. A variety of equipment is required to use and maintain the chain.

Standard Shots

21-6. The lengths of chain that are connected to make up the ship’s anchor chains are called shots. A standard shot is 15 fathoms (90 feet) long.

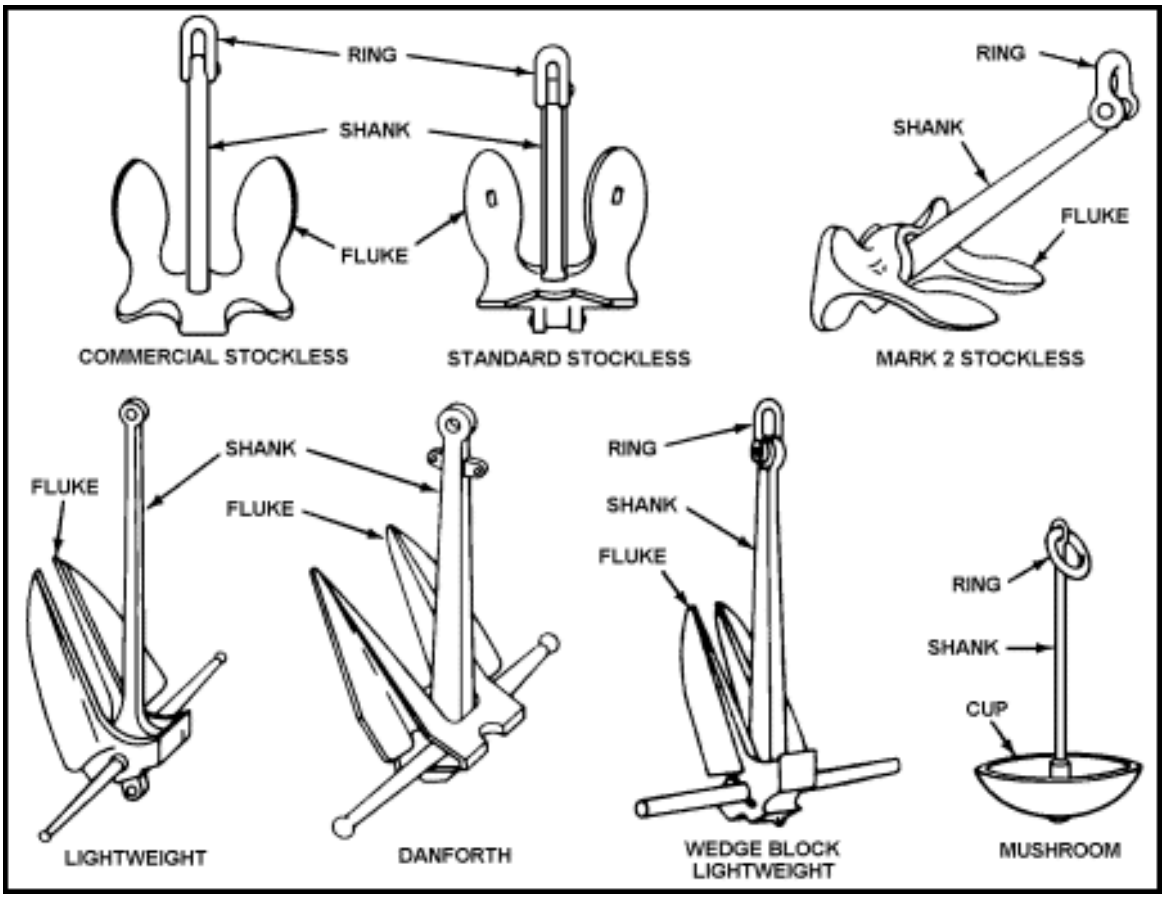


Figure 21-2. Types of Anchors

Detachable Links

21-7. Shots of anchor chain are joined by a detachable link. The detachable link (see Figure 21-3) consists of a C-shape link with two coupling plates which form one side and stud of the link. A taper pin holds the parts together and is locked in place at the large end by a lead plug. Detachable link parts are not interchangeable. Therefore, matching numbers are stamped on the C-link and on each coupling plate to ensure identification and proper assembly. You will save time and trouble when trying to match these parts if you disassemble only one link at a time and clean, slush, and reassemble it before disassembling another. When reassembling a detachable link, make sure the taper pin is seated securely. This is done by driving it in with a punch and hammer before inserting the lead plug over the large end of the pin. Detachable link toolbox sets contain tools, including spare taper pins and lock plugs, for assembling and disassembling links and detachable end links.

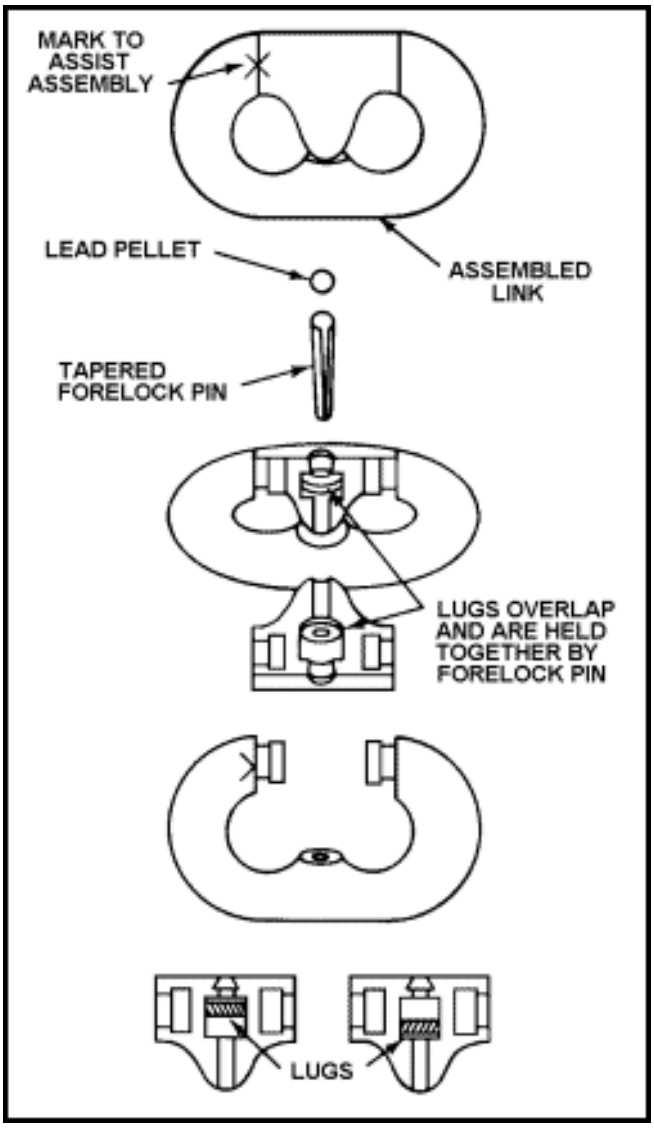


Figure 21-3. Detachable Link

Bending Shackles

21-8. Bending shackles are used to attach the anchor to the chain.

Note: The slush, a preservative and lubricant, is a mixture of 40 percent white lead and 60 percent tallow by volume. If the white lead/tallow mixture is not available, grease (MIL-G-23549A) may be substituted.

Chain Swivels

21-9. Furnished as part of the outboard swivel shot, chain swivels reduce kinking or twisting of the anchor chain.

Outboard Swivel Shots

21-10. Standard outboard swivel shots consist of detachable links, swivel, end link, and bending shackle. They are used on most vessels to attach the anchor chain to the anchor. These shots vary in length up to approximately 6 1/2 fathoms and are also termed bending shots. The taper pin in the detachable link, located in the outboard swivel shot, is additionally secured with a wire-locking clip.

MAKEUP OF AN ANCHOR CABLE

21-11. An anchor cable is an assembly of a number of individual units properly secured together (see Figure 21-4). These units are connected to the anchor by means of a swivel piece made up of shackles, swivels, and special links.

Note: Each shot of chain is joined together with a detachable link.

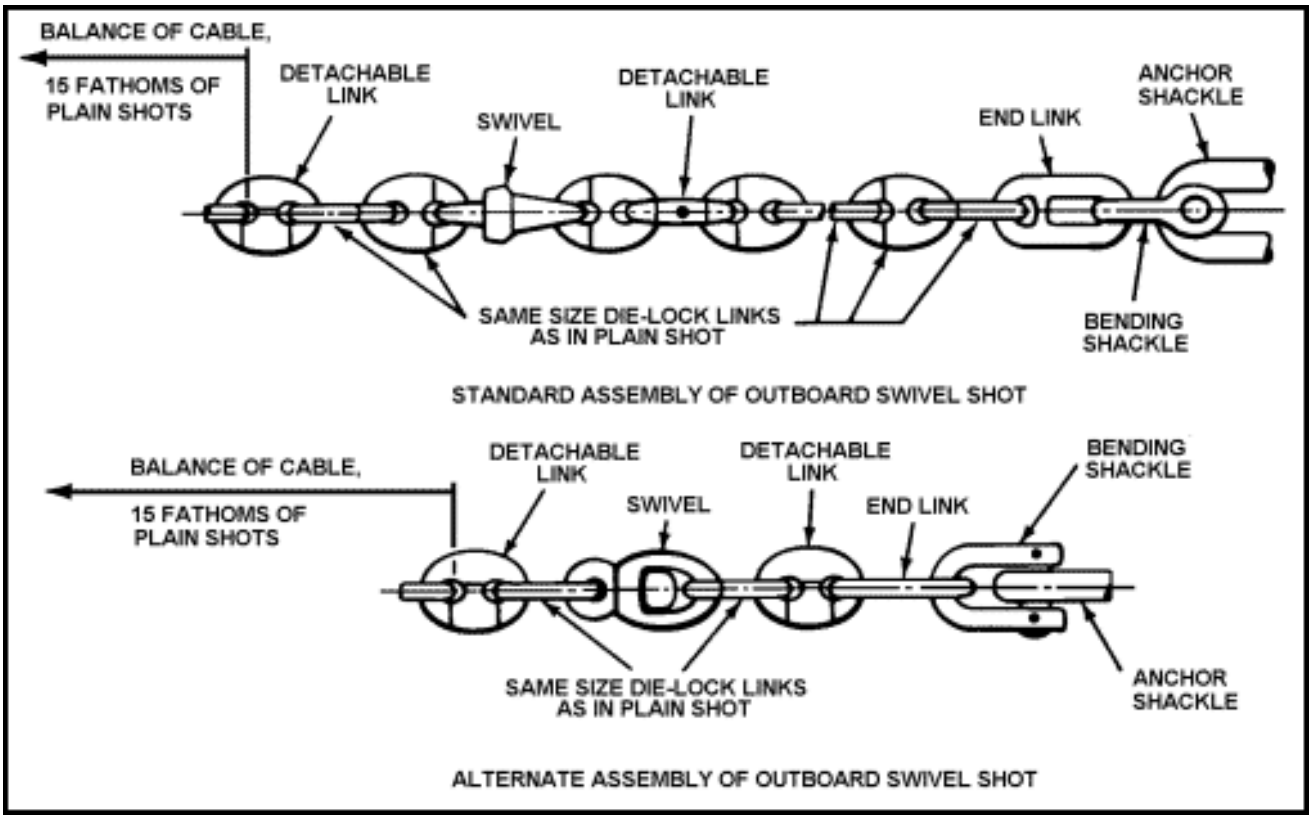


Figure 21-4. Connecting Anchor to Anchor Cable

MARKING THE ANCHOR CHAIN

21-12. For the safety of every ship, the ship's officers and the boatswain must know at all times the scope or how much anchor chain has been paid out. To make this information quickly available, a system of chain markings is used. Figure 21-5 shows the standard system for marking an anchor chain.

COLOR MARKINGS

21-13. The tools required for color marking an anchor chain are wire brush, paint brush, rags, and paint (red, white, blue, and yellow enamel paint).

- **15 fathoms (1 shot).** The detachable link IS painted red, and one link on each side is painted white.
- **30 fathoms (2 shots).** The detachable link is painted white, and two links on each side are painted white.
- **45 fathoms (3 shots).** The detachable link is painted blue, and three links on each side are painted white.
- **60 fathoms (4 shots).** The detachable link is painted red, and four links on each side are painted white.
- **75 fathoms (5 shots).** The detachable link is painted white, and five links on each side are painted white

Paint each link in the next to last shot yellow. The yellow alerts you that you are running out of chain. Paint each link in the last shot red.

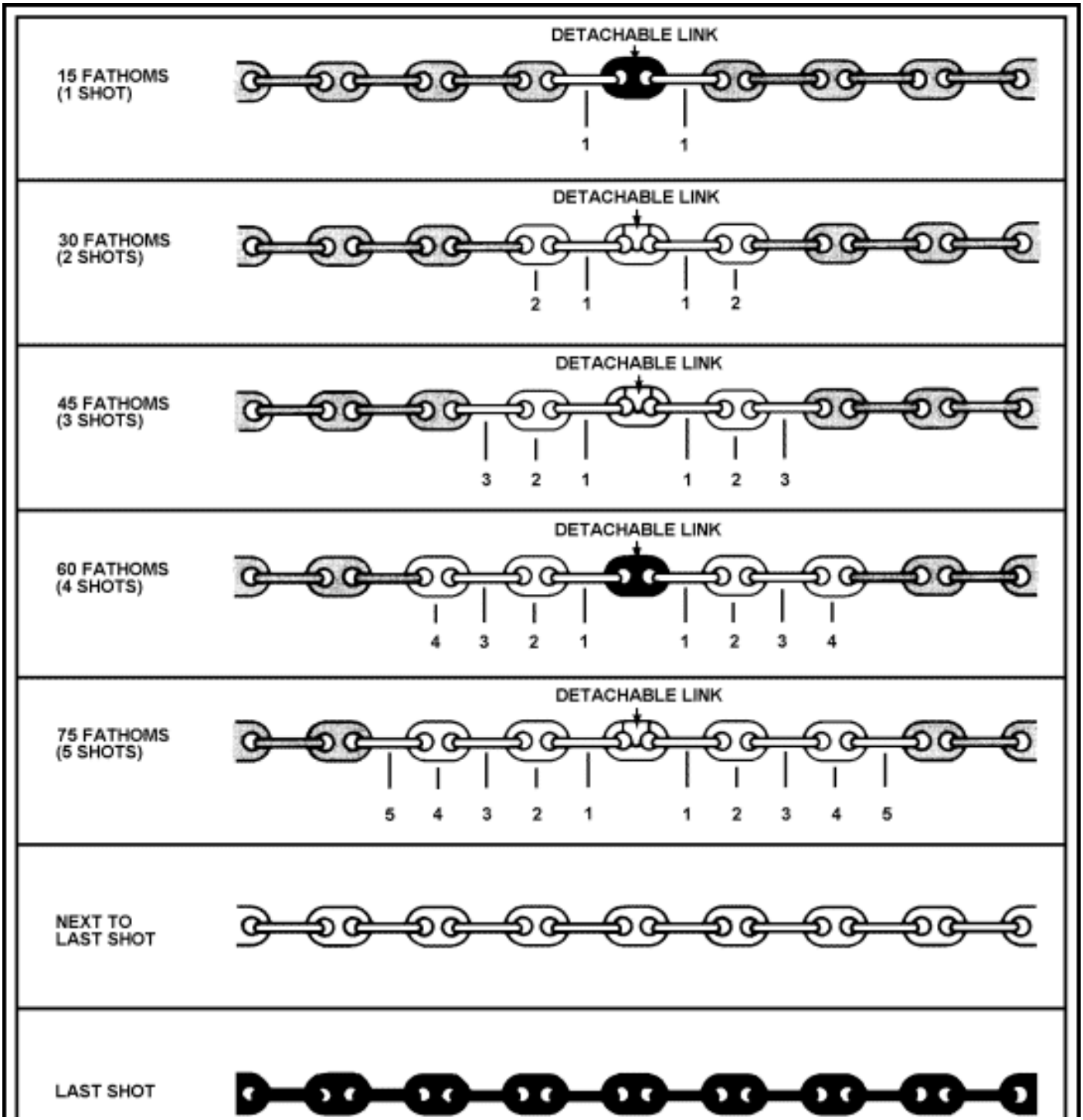
Note: 1 fathom = 6 feet. There are 15 fathoms (90 feet) in a shot of anchor chain.

Note: This method is used through the entire marking procedure alternating red, white, and blue for detachable links as appropriate.

WIRE MARKINGS

21-14. In addition to color markings, wire markings may also be used. The purpose of the wire marking is to let you count the shots by feel during blackout conditions or if the markings on the chain are worn off or rusted over.

- **lst shot.** One turn of wire on the first stud from each side of the detachable link.
- **2d shot.** Two turns of wire on the second stud from each side of the detachable link.
- **3d shot.** Three turns of wire on the third stud from each side of the detachable link.
- **4th shot.** Four turns of wire on the fourth stud on each side of the detachable link.
- **5th shot.** Five turns of wire on the fifth stud on each side of the detachable link.
- **6th shot.** Six turns of wire on the sixth stud on each side of the detachable link.



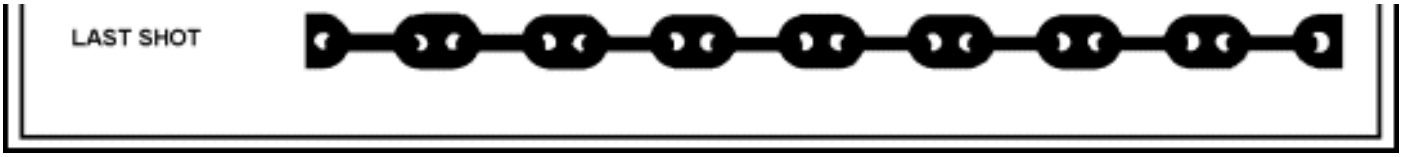


Figure 21-5. Standard Anchor Chain Markings

THE ANCHOR WINDLASS

21-15. The anchor windlass is installed on vessels primarily for handling and securing the anchor and anchor chain. Windlasses are provided with capstans or catheads, which are used for handling mooring lines when docking and undocking.

TYPES

21-16. There are two general types of windlasses installed aboard Army harbor craft. These are the horizontal shaft windlass (Figure 21-6) and the vertical shaft windlass (Figure 21-7).

Horizontal Shaft

21-17. This type of windlass is usually a self-contained unit with the windlass and windlass motor mounted on the same bedplate. It handles both the port and starboard anchors and is found aboard large vessels. Figure 21-8 shows the side view of this windlass.

Vertical Shaft

21-18. This type of windlass is found on tugs and barges. With the vertical shaft windlass, the power source is located below the deck with only the wildcat and capstan showing above the deck. The controller for the windlass is also above deck. This type of windlass can handle only one anchor.

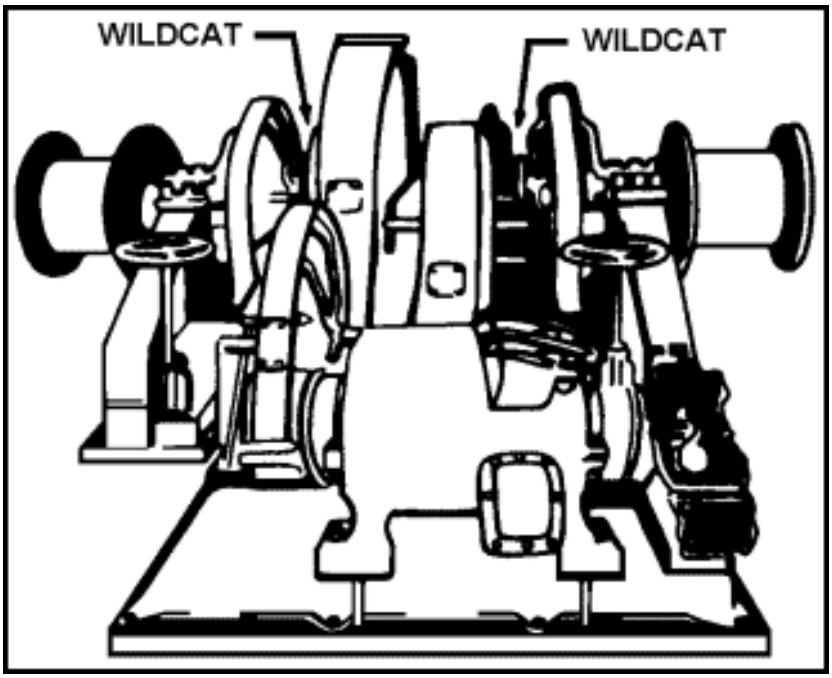


Figure 21-6. Horizontal Shaft Windlass

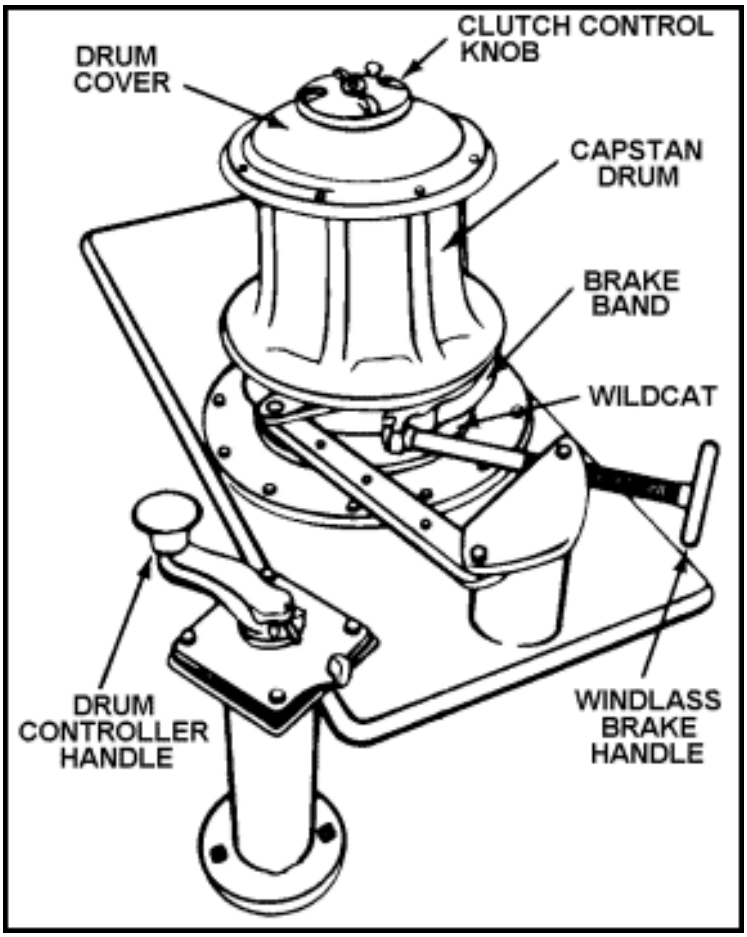


Figure 21-7. Vertical Shaft Windlass

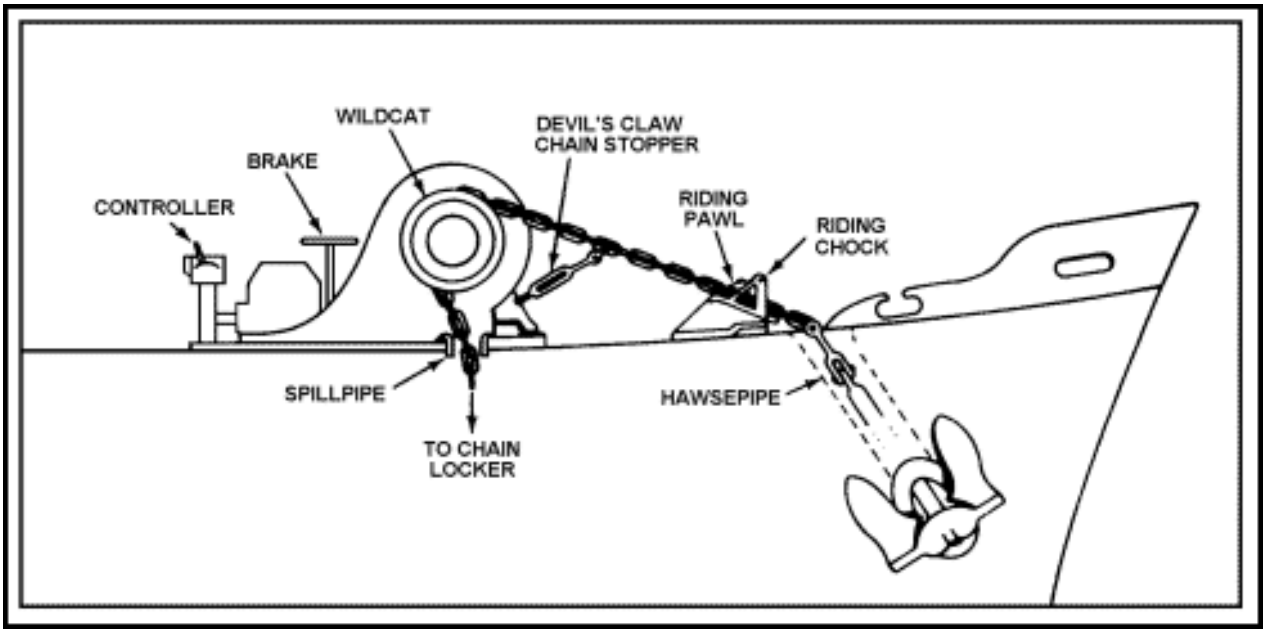


Figure 21-8. Side View of Horizontal Shaft Anchor Windlass

TERMINOLOGY

21-19. Although there is a difference in construction and appearance between the horizontal and the vertical shaft windlass, they do share a common terminology. Definitions of parts of equipment used in anchoring, starting at the anchor and working aft, are as follows:

- **Hawsepipe.** Openings in the eyes of forward part of the ship where the shank of the anchor is stowed.
- **Buckler plate.** A heavy steel plate that is "dogged down" by butterfly nuts when the vessel is at sea. The buckler plate covers the hawsepipe opening on deck and prevents water from rushing up the hawsepipe and spilling on deck.
- **Riding chock.** A metal fairlead for the anchor chain. It prevents the chain from fowling on deck and also holds the riding pawl.
- **Riding pawl.** A safety stopper, that works like a rocket on the links of the chain. It is lifted up to the "open" position when the anchor chain is run out. When heaving the chain in, the pawl is "closed" or dropped in the after side of the riding chock. The pawl bounces over the incoming chain. However, if an emergency occurs, such as the wildcat jumping out of gear, the pawl will catch on a link of the anchor chain and hold the chain and keep it from running out.
- **Chain stopper.** A turnbuckle inserted in a short section of chain with a pelican hook or a devil's claw attached to one end and a shackle on the other end. The stopper chain is screwed at the base of the windlass. In operation, the devil's claws are used when the vessel is setting out to sea. The claws are put on a link of the chain and the turnbuckle is set up, acting as a permanent stopper. On some ships, a pelican hook is used.
- **Wildcat.** A sprocketed wheel in the windlass with indentations for the links of the anchor chain. The wildcat, when engaged, either hauls in or pays out the anchor chain. When disengaged, the wildcat turns freely and the only control of the anchor chain is the friction brake.
- **Friction brake.** A band which bears on a flywheel. By tightening up on the band by means of the brake handle, the wildcat can be controlled.
- **Locking ring.** A device, with pigeon holes, into which a bar is placed to lock the wildcat to the hoisting gear of the engine. The locking ring is usually turned forward to disengage the wildcat and turned aft to engage it. On the capstan the wildcat is engaged or disengaged by turning the capstan barrel cover.

LETTING GO THE ANCHOR--GENERAL PROCEDURES

21-20. Certain procedures are required when preparing to let go the anchor. For this discussion, assume that the anchors are secured for sea with the spillpipes cemented in (see paragraph 21-29). This is a practice of good seamanship for ships operating at sea, where there are many days between ports or when heavy weather is expected.

WARNINGS:

1. ONLY CREW MEMBERS ON THE ANCHOR DETAIL WILL BE PERMITTED ON THE BOW.

2. CREW MEMBERS WILL NOT STAND BETWEEN THE CAPSTAN AND THE HAWSEPIPE WHEN LETTING GO THE ANCHOR.

Use the following procedures prior to entering port or when planning to use the anchor.

- Make sure the devil's claw assembly is taut.
- Engage the wildcat and release the brake.
- "Walk out" enough chains to break out the cement plugs in the spillpipes and free the chains.
- "Walk" the chain back to the original position.
- Clean area around the chain and anchor.
- Release the devil's claw or hooks.
- Put the riding pawls in the OPEN position.
- Make sure that the anchor is not frozen or jammed in the hawsepipe. The best way to do this is to "walk out" the anchor until it is clear of the hawsepipe.
- Having freed the anchor, set the brake tight and disengage the wildcat.
- The anchor is free.

Note: On vessels having two anchors, get both anchors ready.

OPERATING THE CAPSTAN ANCHOR WINDLASS

21-21. The Markey type VEV-16 anchor windlass (see Figure 21-9) with the single vertical capstan barrel, is the type described here. Although there are other types of vertical capstan barrel anchor windlasses in the system, their method of operation will, in most cases, be similar. The capstan barrel is keyed to the main shaft and is in continuous motion while the motor is running. The wildcat is driven off the capstan by two axial keys that may be engaged or disengaged by turning the capstan barrel cover (clutch) (see Figure 21-10). An inner drum, to which the capstan barrel cover is bolted, provides two axial cams that engage the two keys and moves them up or down as the barrel cover is turned. Indicator plates show key engagement and spring ball locks are provided to hold the shifter mechanism in either position.

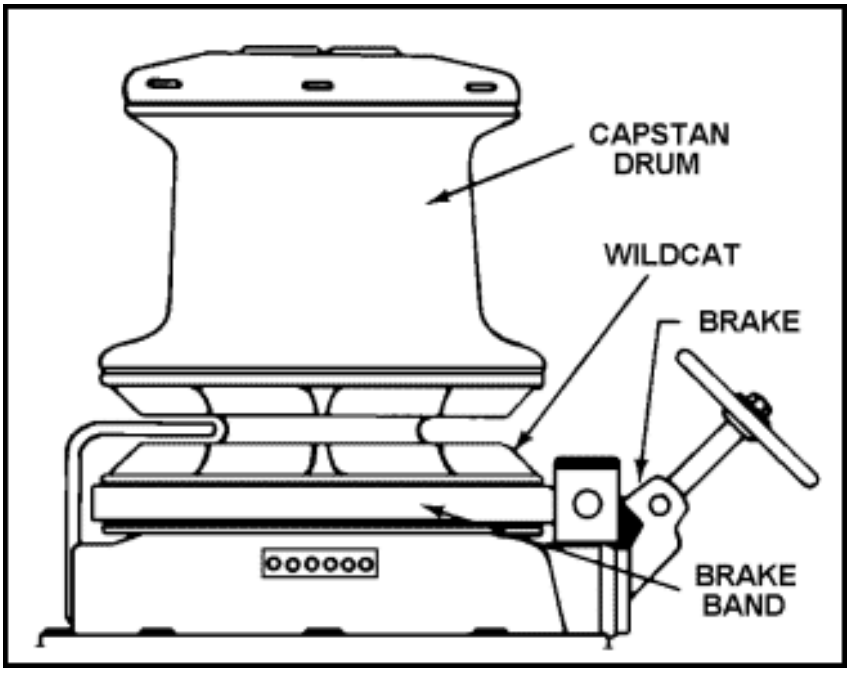


Figure 21-9. Capstan/Wildcat and Brake

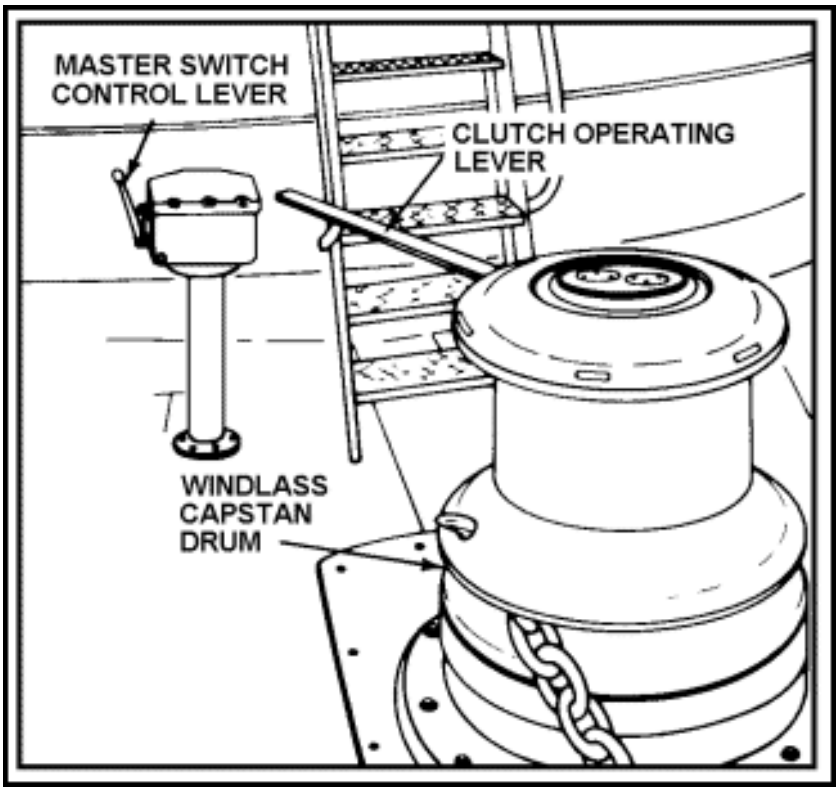


Figure 21-10. Turning the Drum Brake

DROPPING THE ANCHOR WITHOUT POWER

21-22. Use the following steps when dropping the anchor without power:

WARNING: SAFETY GOGGLES MUST BE WORN WHEN DROPPING THE ANCHOR WITHOUT POWER. THERE WILL BE A GREAT DEAL OF RUST, SPARKS, DIRT, AND DEBRIS FLYING ABOUT AS THE CHAIN RUNS OUT.

- Remove and stow the buckler plates.
- Make sure that the brake is on by fully turning the handwheel counterclockwise.
- Disengage the axial keys by turning the capstan barrel cover.
- Remove the chain stopper and open the riding pawl.
- Let go the anchor by releasing the brake (turning the handwheel clockwise). The anchor and chain will run freely when the brake is released. Use the brake to control the running speed of the chain.

WARNING: DO NOT ALLOW THE CHAIN TO RUN TOO SLOWLY. THE BRAKE, WHEN SLIPPING CONTINUOUSLY, WILL DEVELOP EXCESSIVE HEAT AND MAY BURN OUT. HOWEVER, THE CHAIN MUST NOT RUN SO FAST THAT IT WILL JUMP OUT OF THE WILDCAT.

Note: Once the anchor has hit the bottom and the strain is taken off the anchor chain, there should be a natural slowing down in the rate that the chain pays out.

- To stop lowering the anchor, turn the brake handwheel counterclockwise. This applies the brake.
- To secure, close the riding pawl and replace the chain stopper.

Notes:

1. As soon as the anchor hits bottom, during daylight hours, raise the anchor ball; during darkness turn on the anchor lights and shut off the navigation lights.

2. During daylight, after the ship is anchored, the union jack should be hoisted and flown from the jack staff. The national ensign should be shifted from the gaff to the flag staff at the stern.

RAISING THE ANCHOR

21-23. Use the following procedures to raise the anchor.

- Turn the stop switch lever of the controller to the ON position and check for power.

WARNING: WHENEVER THE CONTROLLER IS LEFT UNATTENDED, THE STOP SWITCH MUST BE PUT IN THE OFF POSITION.

- Check to see that the brake is on.
- Turn the capstan barrel cover to engage the two axial keys. This will put the wildcat in motion when the controller is operated.
- Put the controller handle in the hoist position and take a strain on the anchor chain, then stop.
- Drop the riding pawl.
- Release the chain stopper.
- Open the brake.
- Put the controller handle in the hoist position and raise the anchor. You will usually feel a "surge" or release of strain on the anchor chain when the anchor breaks free of the bottom.

Note: As the anchor chain is coming in, crew members should be stationed at the hawsepipe with a fire hose. The chain should be thoroughly washed down and freed of all mud, silt, and debris.

- House the anchor.
- Put on the brake.
- Replace the chain stopper.
- Disengage the axial keys by turning the capstan barrel cover.

Notes:

1. As soon as the anchor breaks free of the bottom, during daylight hours, drop the anchor ball. During darkness, switch off the anchor lights and turn on normal navigation lights.

2. Once the "anchor ball" is lowered, the ship is underway. The union jack is lowered and the national ensign is transferred to the gaff.

OPERATING THE HORIZONTAL ANCHOR WINDLASS

21-24. Anchor windlasses and their accompanying equipment vary in size and shape depending on the type and size ship on which they are used. However, the procedure for releasing the anchor remains the same.

LETTING GO THE ANCHOR

21-25. To let go the anchor do the following:

- Inspect the anchor windlass, anchor chain, hawsepipes, and anchor to see that they are free and clear for letting go the anchor.
- Make sure that the brake is set tight (Figure 21-11).
- Disengage the wildcat (Figure 21-12).
- Lift the locking ring key on the locking ring (Figure 21-13).
- Insert the anchor bar into the pigeonhole on the locking ring (Figure 21-14). The locking ring is then turned forward to disengage the wildcat.
- Wildcat is disengaged (Figure 21-15).
- Remove the chain stopper. The turnbuckle is secured at the base of the windlass.

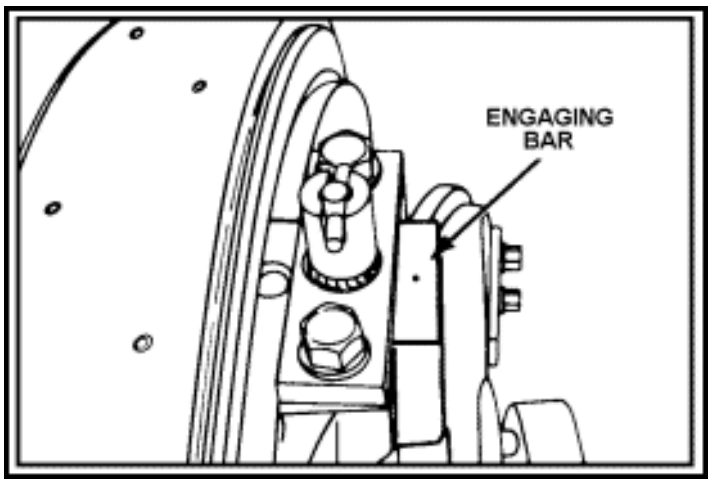


Figure 21-11. Setting Up Brake

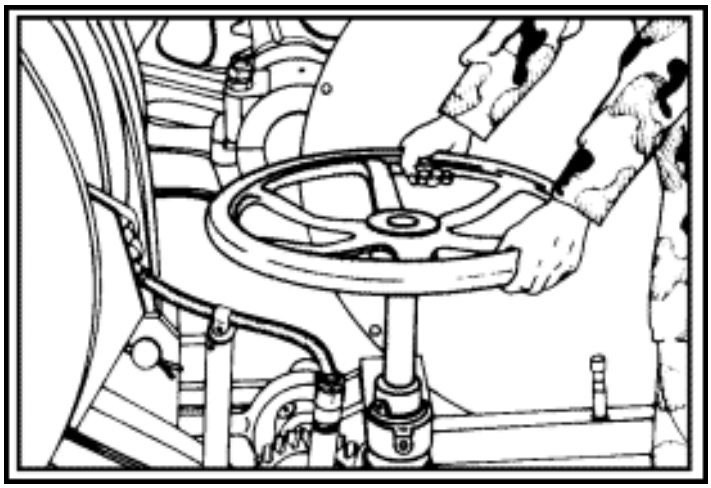


Figure 21-12. Wildcat Engaged

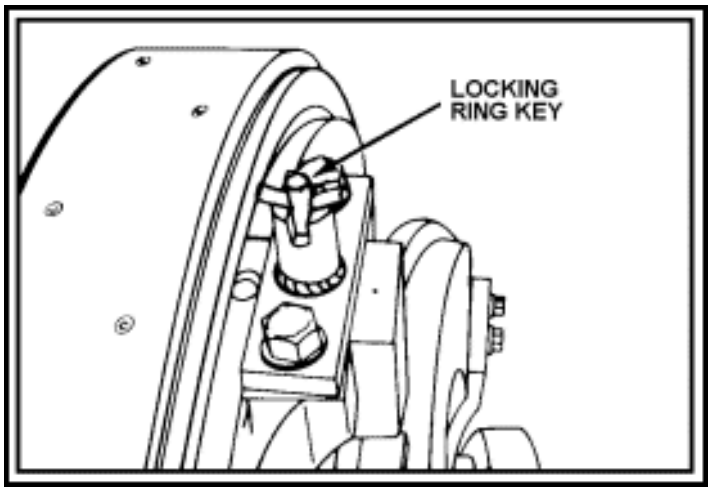


Figure 21-13. Lifting Locking Ring

Figure 21-14. Inserting Anchor Bar

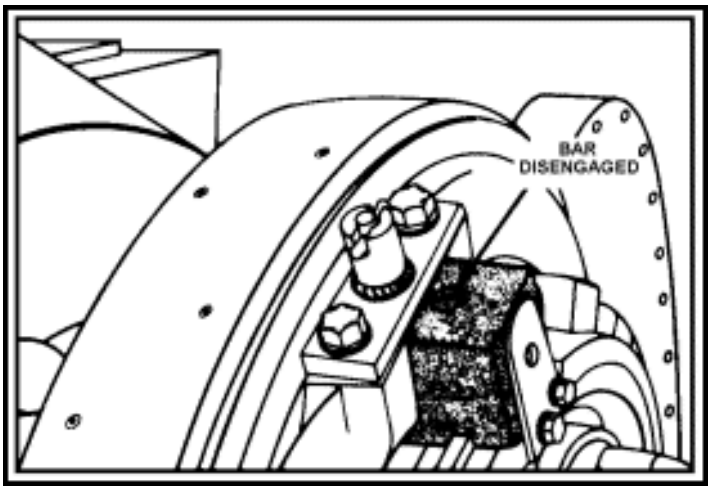


Figure 21-15. Wildcat Disengaged

21-26. The devil's claw is put on a link of the anchor chain, and the turnbuckle is set up, acting as a permanent stopper.

- Slack off anchor chain stopper (Figure 21-16).
- Take off the devil's claw (Figure 21-17).
- Lift open the riding pawl (Figure 21-18).
- On command from the bridge, let go the anchor by releasing the brake. Wear your safety goggles and keep your head turned to the side to protect your eyes from flying rust, sparks, and dirt from the anchor chain. Usually one can sense when the anchor hits the bottom--there is a noticeable slackening in speed of the chain paying out.
- Once the chain has hit bottom and slowed up in paying out, tighten the brake to where you can control the paying out of the chain.

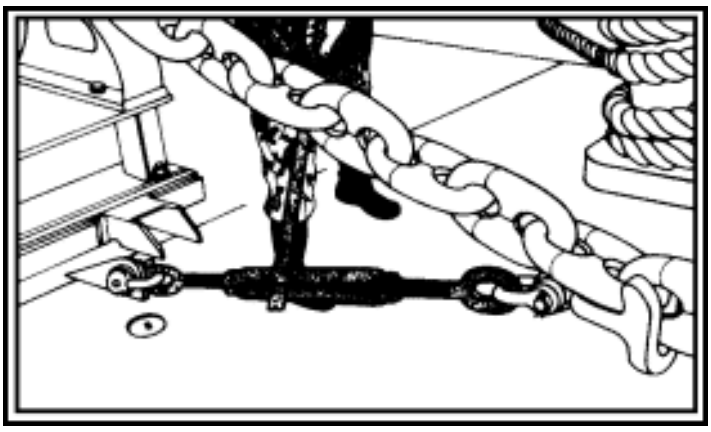


Figure 21-16. Slacking Off Chain Stopper

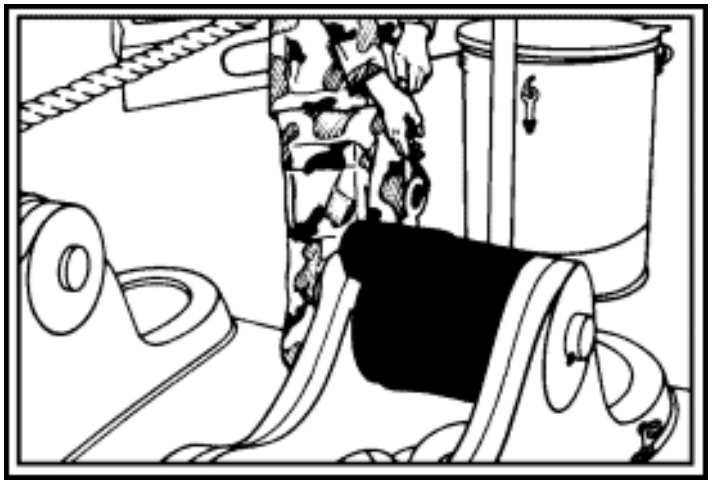


Figure 21-17. Removing the Devil's Claw

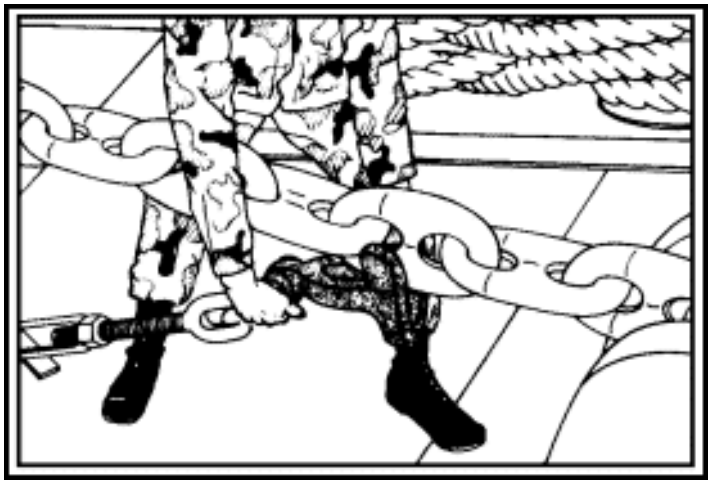


Figure 21-18. Opening Riding Pawl

Note: During daylight hours, as soon as the anchor hits the bottom, raise the anchor ball. Next, raise the union jack and shift the national ensign from the gaff to the flag staff. During hours of darkness or restricted visibility, as soon as the anchor hits the bottom, turn on the anchor lights and shut off the navigation lights.

- Secure the brake. Use the anchor bar or a "valve wrench" to set up on the brake (Figure 21-19).
- Replace the stopper. After the brake has been set up, then hook up the devil’s claw and secure the stopper (Figure 21-20). This will aid in holding the anchor and take some of the strain from the brake.
- Close the riding pawl (Figure 21-21).

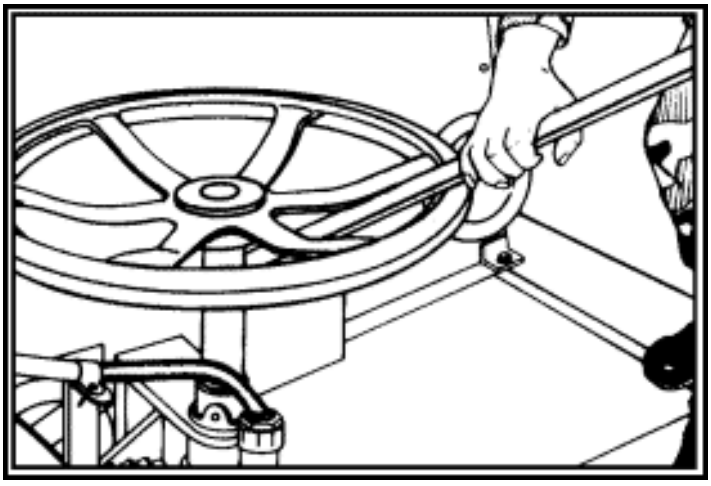


Figure 21-19. Setting Brake

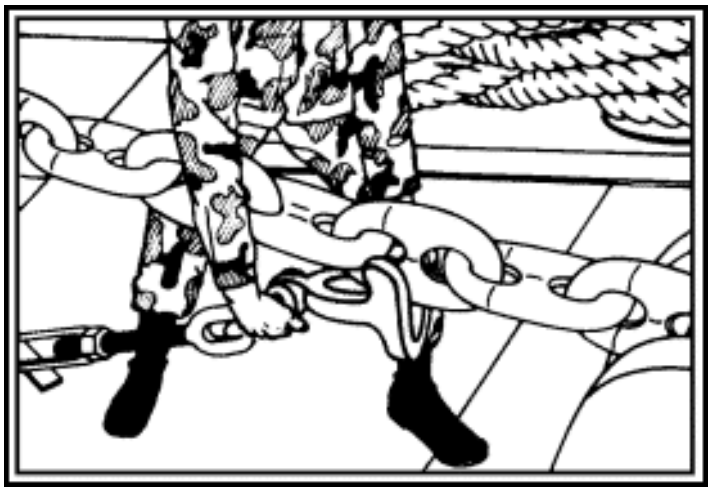


Figure 21-20. Securing Devil's Claw

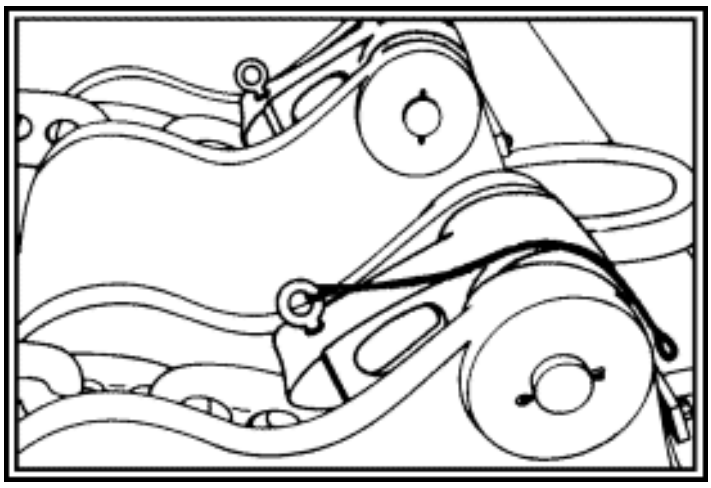


Figure 21-21. Closing Riding Pawl

RAISING THE ANCHOR

21-27. Use the following procedures when raising the anchor.

- Inspect the anchor windlass, chain, hawsepipe, and anchor to see that they are free and clear.
- Turn on the power switch and then push the control handle forward to the lower position (Figure 21-22). Put it in this position just long enough to hear the power turn on, then bring the control handle back to the stop position.
- Make sure that the brake is secured.
- Engage the wildcat.
- Lift locking ring key on locking ring (Figure 21-23).
- Using the anchor bar, turn the locking ring to engage the wildcat (Figure 21-24). Figure 21-25 shows the wildcat engaged.
- Remove the anchor chain stopper.
- Turn on the power and, using the windlass control, pull back on the handle. Take just enough strain to where you hear the engaging bar hit the spoke of the windlass, then stop.
- Release the brake. Slack off on the brake until it is free.
- Raise anchor on anchor windlass control.
- House the anchor.
- Put on the brake.
- Replace the chain stopper.
- Disengage the windlass.

Notes:

1. If the locking ring does not turn freely, go back to the control lever, push it forward and move locking ring forward about 1 inch. This will take the pressure off the engaging bar.

2. Crew members should be stationed at the hawsepipe with a fire hose. The chain should be thoroughly washed down and freed of all mud, silt, and debris as it is hauled in.

3. When the anchor breaks free of the bottom, during daylight hours, lower the anchor ball and the union jack; shift the national ensign back to the gaff. During hours of darkness, shut off anchor lights and turn on navigation lights.

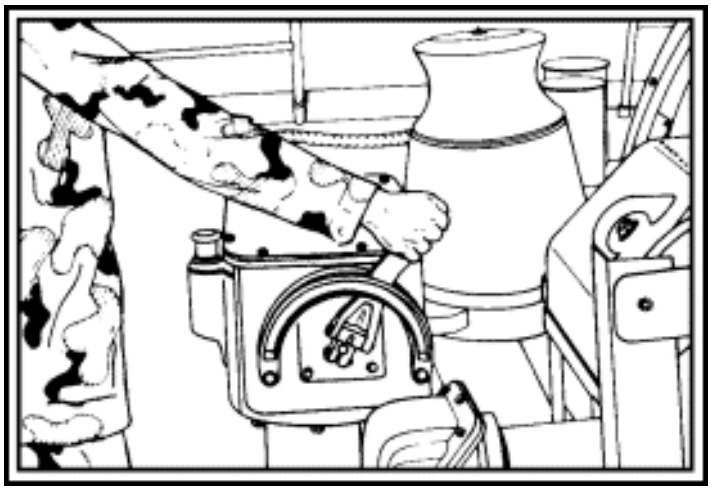


Figure 21-22. Checking Controller

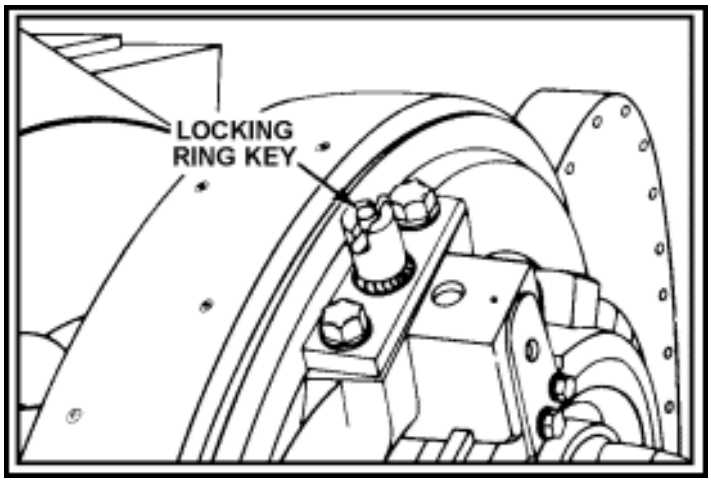


Figure 21-23. Lift Locking Ring Key

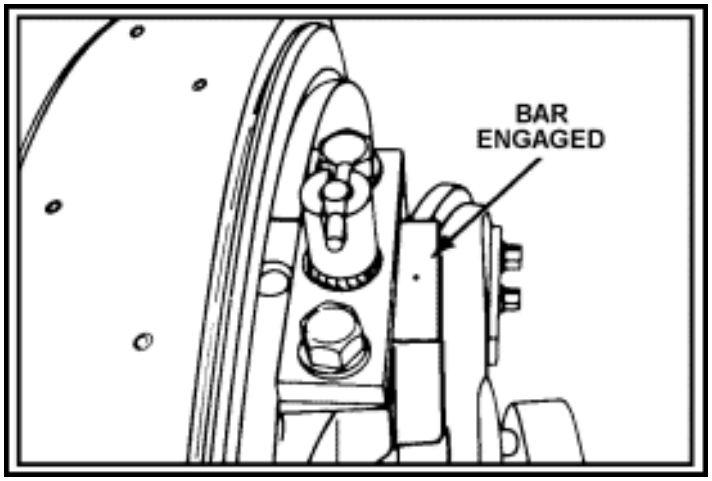


Figure 21-24. Engaging Wildcat

Figure 21-25. Wildcat Engaged

SEQUENCE OF WEIGHING ANCHOR

21-28. Figure 21-26 shows the seven stages of weighing anchor.

SECURING THE ANCHOR FOR SEA

21-29. When securing the anchor for sea; place small pieces of wood between the chain links, about 8 to 10 inches below the top of the spillpipe. Then on top of this, rags are stuffed. Mix up a pail of cement (50 percent cement, 50 percent sand) for each spillpipe. Pour it in on top.

21-30. It should fill right to the top of the spillpipe. The layer of cement should be at least 1-inch thick. To help it set up and dry, you can throw a handful of dry cement on top of the wet cement, this will absorb the excess water. Then cover the spillpipe with an old piece of canvas. This will help protect the cement plug and give it a chance to dry. Figure 21-27 shows a side view of a cemented spillpipe.

MAINTENANCE

21-31. The external maintenance of the anchor windlass and the periodic maintenance and checks of the anchor chain are the responsibility of the deck department.

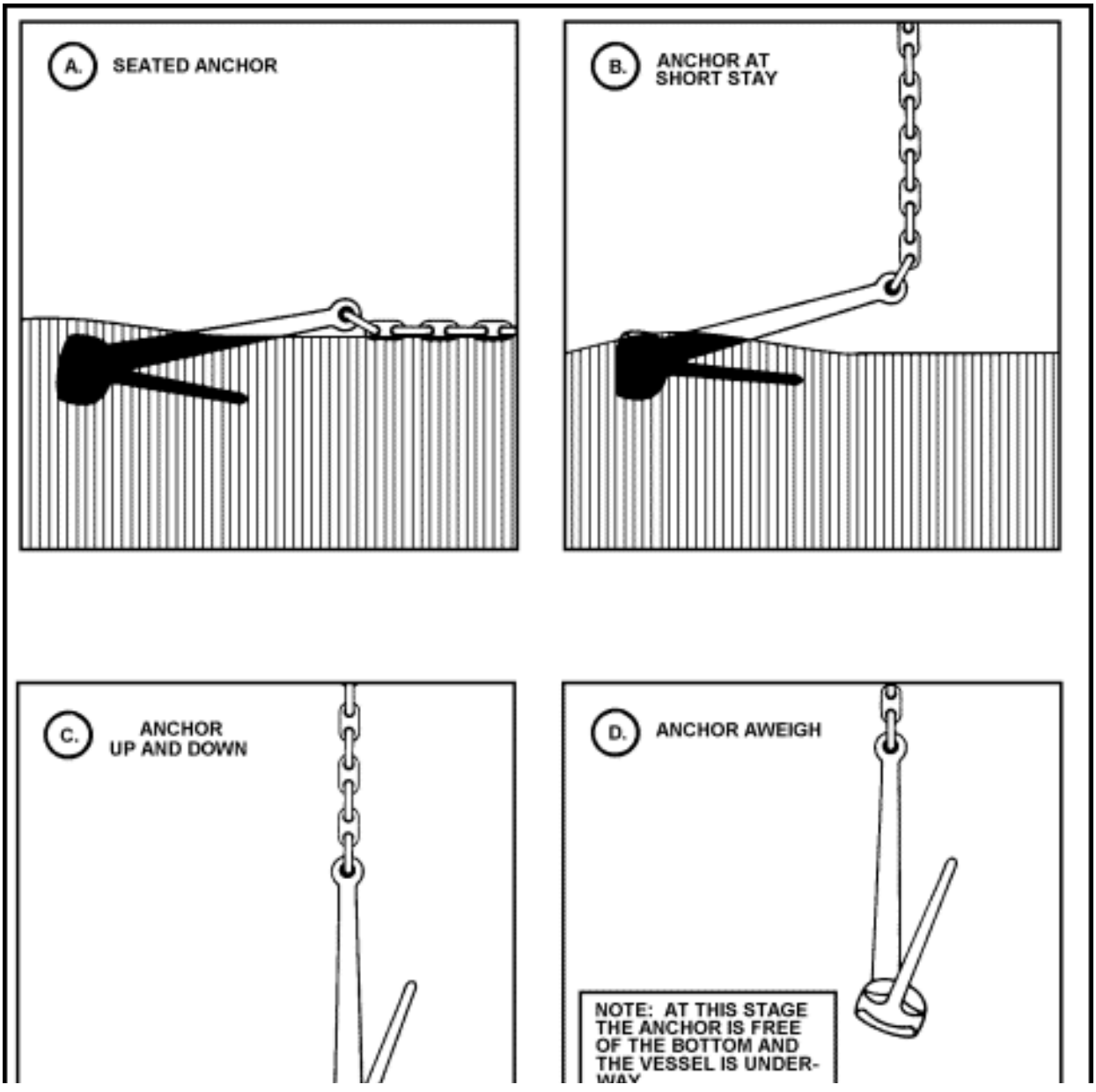
MAINTENANCE OF THE WINDLASS

21-32. Maintenance and adjustment of equipment should be continued during periods when it is not in use to prevent deterioration and to provide dependable operation. Inspect windlass weekly and operate as necessary to ensure that equipment is in proper condition.

21-33. Each wildcat is equipped with an externally contracting brake flat band operated by a handwheel. This brake can be used to hold the anchor and chain and to control the rate of descent. Inspect this brake regularly for wear, maladjustment, and defective parts. Consult the applicable windlass technical manual for detailed instructions for maintenance and adjustment of the brake. Failure of the wildcat brake can result in loss of the anchor and chain.

21-34. Lubrication instructions are provided in the applicable TM lubrication chart. These instructions should be followed as to grades of lubricant, frequency of application, and points of application.

21-35. If the windlass is not used frequently, it should be lubricated before each operation in accordance with the applicable TM. Rotation of the windlass by power during lubrication will distribute the lubricant evenly. The locking mechanism can be disengaged and the chain held by engaging the wildcat brake.



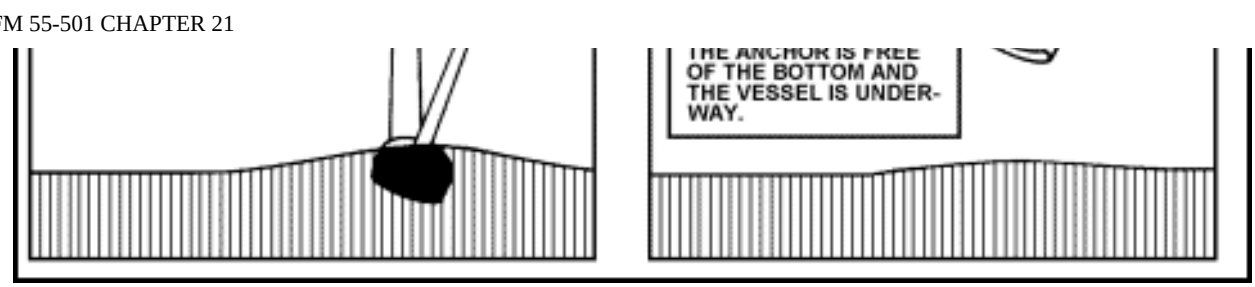


Figure 21-26. Sequence of Weighing Anchor

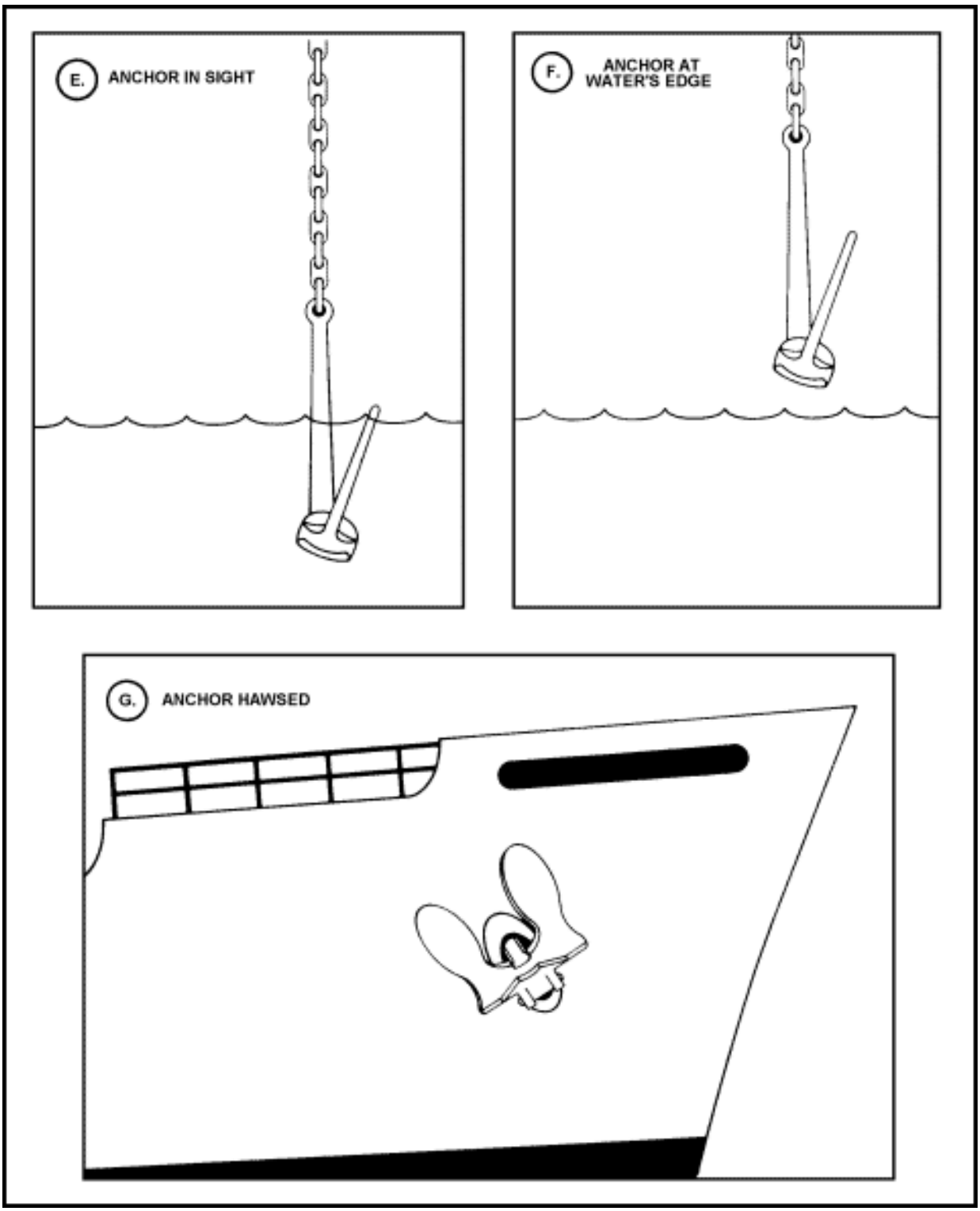


Figure 21-26. Sequence of Weighing Anchor (continued)

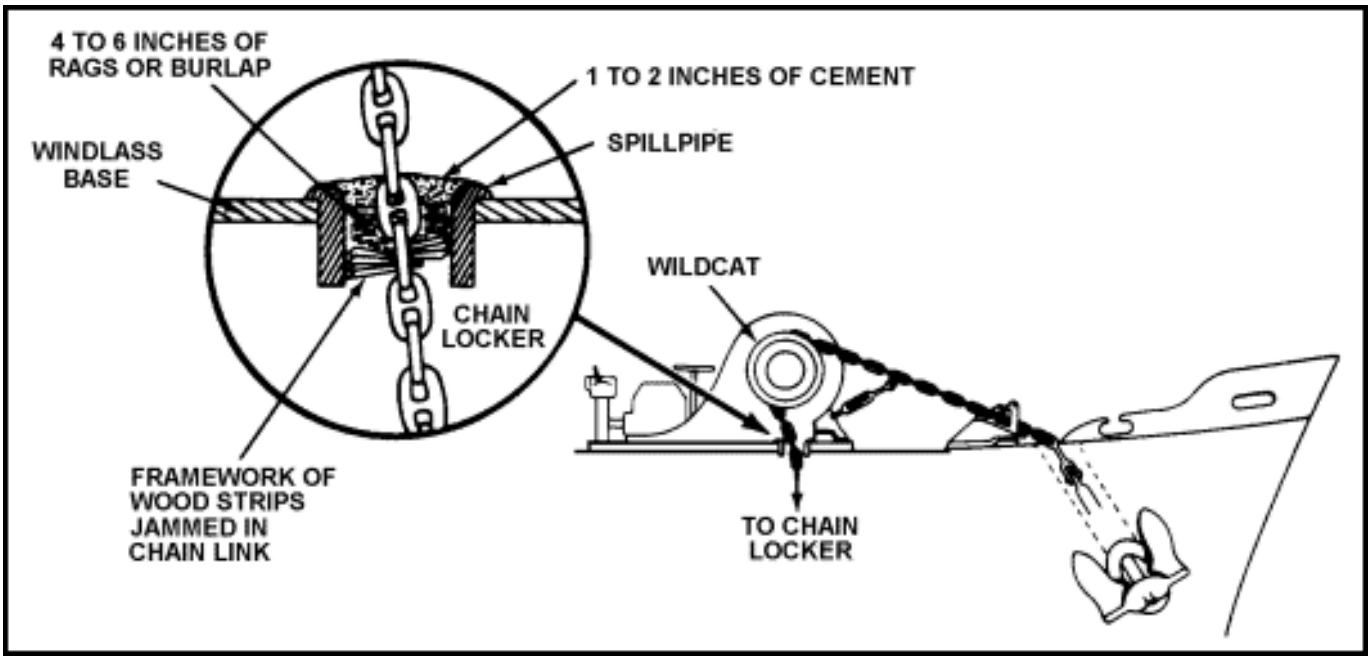


Figure 21-27. Side View of Cemented Spillpipe

21-36. After using the windlass, lubricate the equipment to prevent rusting and freezing of adjacent parts and to protect finished surfaces from corrosion.

21-37. Check the mounting frame to ensure that nuts and holddown bolts are tight.

21-38. Chip, scrape, preserve, and paint the frame, catheads, brake bands, and external parts of the brake band. Keep them free of rust.

MAINTENANCE OF THE ANCHOR CHAIN

21-39. Only minor maintenance can be performed on anchor chains. High-strength, welded chain and appendages can only be overhauled and heat-treated by shipyards meeting the requirements of the DOD.

Maintaining Chain Identification Marks

21-40. Each shot of anchor chain usually bears a serial number that is stamped, cut, or cast on the inner side of the end links at the time of manufacture. In the case of cast steel chain, this number is preceded by the letters C.S. If an end link is lost or removed from a shot, this identification number should be cut or stamped on the side of the new end link of the altered shot. The studs of forged-iron and forged-steel, fire-welded links have the wire diameter of the links imposed on the reverse side, with the opposite side indicated in raised letters. Cast steel and some types of high-strength, welded steel chain have these markings on the studs of alternate links only.

Restrictions as to Use of Chain Appendages

21-41. During makeup or repair, anchor chain appendages should be restricted to the purposes for which they are intended. The intended uses are obvious, but particular attention should be given to the uses of the detachable link.

Periodic Maintenance

21-42. Semiannually, all anchor chains of sizes up to and including 1 1/2 inches should be arranged on deck and examined throughout their length. If necessary, they should be scaled and cleaned of rust and foreign matter. Detachable links should be disassembled, examined for excessive wear or corrosion, and replaced as necessary. When the stock of detachable links is exhausted, new high-strength detachable links will replace the standard detachable links in sizes from 3/4 inch to 1 3/4 inches inclusive. These new links will have proof loads equal to the breaking load of the standard detachable links. Before reassembly, coat the new links with white lead. The detachable link, located in the outboard swivel shot, is fitted with a corrosion-resisting steel locking wire, which serves to hold the taper pin in position. Disassembly of this link requires the removal and probable destruction of the locking wire. A replacement wire of the same type should be carefully examined, put in order, and, if needed, coated with red-lead primer, Military Specification MIL-P-17545; zinc-chromate primer, Federal Specification TT-P-645; or Military Specification MIL-P-8585. This should be followed by one coat of black enamel, Military Specification MIL-P-15146. When facilities permit, the chain links should be preheated prior to both the primer and final coat of painting. A temperature of 250° F (121° C) is recommended, but a lower temperature of 150° F (66° C) will decrease the drying time. In cold weather, apply some heat to counteract the natural thickening of paint. This can be accomplished by using an immersion-type electric heater or a steam coil. When left standing for a considerable period, the turpentine substitute can evaporate to such an extent that it will cause thickening of the paint. The addition of solvent will remedy such a condition.

Note: Vessels which receive anchor chains that have been coated with either red-lead primer or zinc-chromate primer and black enamel or black-asphalt varnish should have this coating left intact and covered with one coat of black enamel, Military Specification MIL-P-15146.

Replacement of Worn Chain

21-43. Replace any part of the chain that has corroded or worn so that the mean diameter is reduced to 90 percent of its normal diameter. However, replace only if the diameters of the remaining links allow continued use. If it appears uneconomical to replace worn parts, the chain should be surveyed. If replacements are made, the new links, shackles, or parts should be heat-treated, proof-tested, and, in the case of wrought iron, heat-treated again. In each case a complete report should be made containing the following information:

- Material composition of the chain.
- Shot number.
- Length of each shot.
- Nature of work actually performed on the chain.
- Date of such work.
- Cost.

This report should reference the file number of the correspondence authorizing the work involved. This report should also include disposition of the chain after the heat treatment.

Chapter 22

Damage Control

Damage control is based on the premise that the safety and life of a ship depends on watertight integrity. This chapter describes some emergency procedures that can be used in the event the ship's hull has been punctured and watertight integrity has been lost. The procedures described are emergency measures taken by the damage control team to maintain watertight integrity of the ship in the event of accident, collision, or grounding.

DAMAGE CONTROL PROGRAM

22-1. If a ship’s hull is punctured, watertight integrity is lost. If enough water is allowed to enter the hull and is uncontrolled, the ship will sink. There is no such thing as a "little leak". Any size leak is a cause for alarm. Through damage control, this "leak" may be either stopped or reduced to a point where the ship’s pumps can control any excess water.

DAMAGE CONTROL TEAM

22-2. Along with other emergency duties (fire and lifeboat), certain crew members are also assigned to an emergency squad or damage control team. This team may consist of the chief officer, an engineer, bosun, and two or more seamen and enginemen. There should be sufficient skills among the team members to perform the tasks required in an emergency.

DAMAGE CONTROL KITS

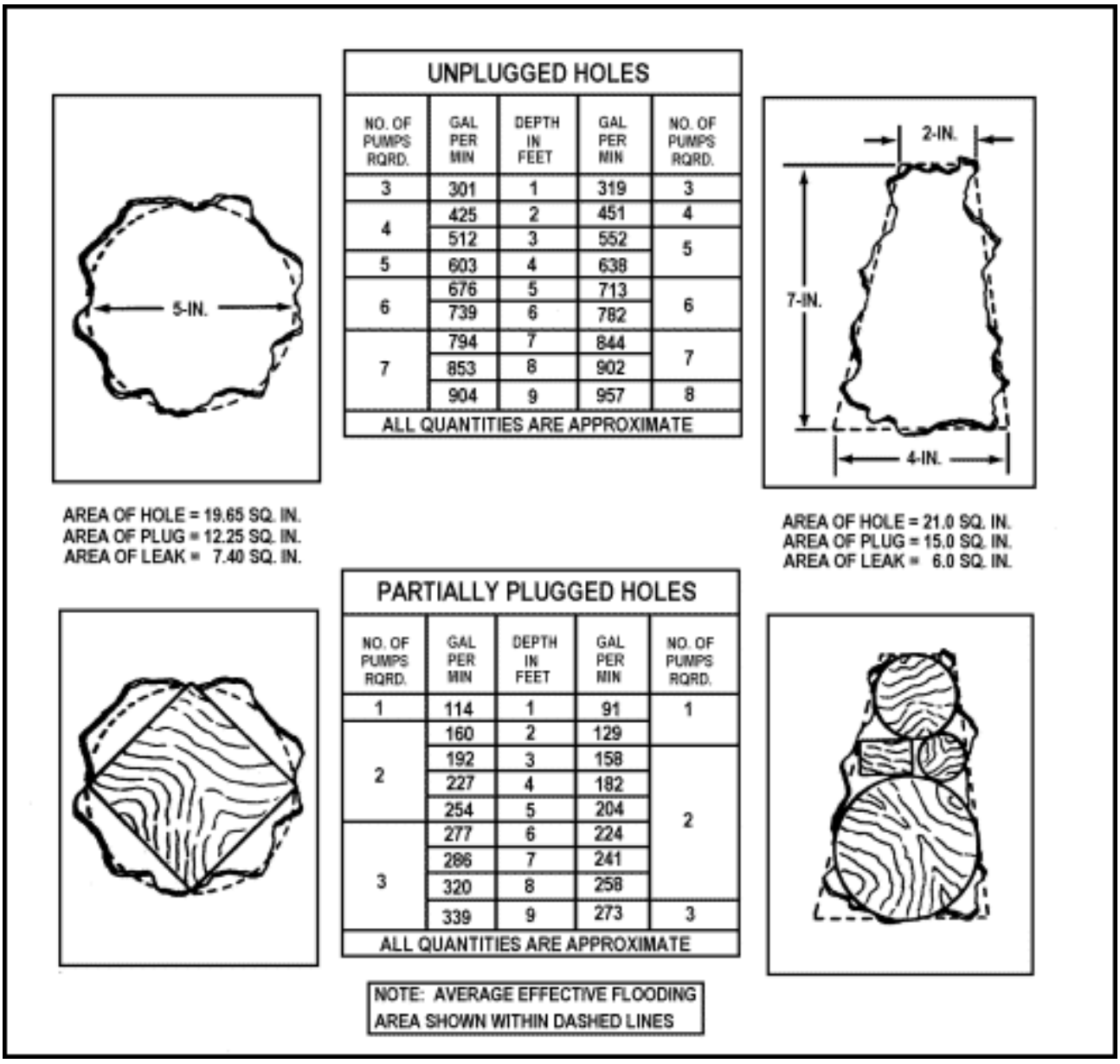
22-3. Army vessels are authorized to carry specified damage control kits. These damage control kit items should be set aside and used only for their intended purpose.

PURPOSE OF THE DAMAGE CONTROL TEAM

22-4. In the event of fire, collision, grounding, or hostilities, one of the damage control team’s missions is to assist in maintaining the watertight integrity of the ship. Many ships have been lost because no real effort was made to save them.

22-5. When plugging leaks, the ultimate aim is to stop the leak permanently. The amount of water entering a vessel through a hole varies directly with the area of the hole and with the square root of its depth. Realistically, if you can reduce the flow of water by more than 50 percent, it is a job well done. Also, the ship’s pumps should be able to handle whatever water is left. The values in Figure 22-1 show how important it is to put some kind of plug into any hole right away.

22-6. Damage control also consists of either shoring up decks that are weakened or strengthening bulkheads between flooded compartments. Although all damage control work is temporary, it must be strong enough to allow the ship to make it back to port safely.



UNPLUGGED HOLES

NO. OF PUMPS RQRD.	GAL PER MIN	DEPTH IN FEET	GAL PER MIN	NO. OF PUMPS RQRD.
3	301	1	319	3
4	425	2	451	4
	512	3	552	5
5	603	4	638	
6	676	5	713	6
	739	6	782	
7	794	7	844	7
	853	8	902	
	904	9	957	8

ALL QUANTITIES ARE APPROXIMATE

PARTIALLY PLUGGED HOLES

NO. OF PUMPS RQRD.	GAL PER MIN	DEPTH IN FEET	GAL PER MIN	NO. OF PUMPS RQRD.
1	114	1	91	1
2	160	2	129	
	192	3	158	2
	227	4	182	
	254	5	204	
3	277	6	224	
	286	7	241	
	320	8	258	
	339	9	273	3

ALL QUANTITIES ARE APPROXIMATE

Figure 22-1. Flooding Effect Comparison: Unpluggd Holes Versus Partially Plugged Holes

SHORING

22-7. The term "shoring" involves two phases:

- Stopping or reducing the inflow of water.
- Bracing or shoring up the damaged or weakened members of the ship’s structure by transferring and spreading the pressures to other portions of the ship.

Shoring also includes the processes of patching and plugging.

CLEARING THE DECKS

22-8. The first step in effective shoring is to clear the decks. Damage serious enough to produce a hole in the hull usually leaves wreckage scattered about the area. The damaged area should be cleared quickly to permit the damage control team to do a quick, adequate, and safe job.

22-9. Most loose wreckage can be removed by hand. At other times cutting and breaking are required. This requires the use of mauls, sledges, axes, heavy cold chisels, pinch bars, power drills, power chisels, and air hammers.

22-10. If fire accompanies the damage, burning bedding, stores, and supplies must be removed. A devil's claw (a homemade long-handled rake device) made of steel is handy for this purpose.

22-11. Shoring tools such as saws, 2-foot squares, hammers, and hatchets are stowed in the ship's damage control locker. Additional equipment may be devised, limited only by the ingenuity of the ship's crew.

SPEED

22-12. Step two in shoring is speed. Seconds count, especially if there is a hole below the waterline. Each member of the damage control team must be able to think fast and improvise shoring with whatever material is available. More than once; items such as life jackets, mattresses, pillows, and mess tables have proven to be satisfactory temporary shoring material.

PREPARATION

22-13. The third step is preparation. Only through regular drills can skills be developed that will enable each man to do a fast, effective shoring job under adverse conditions. A thorough training program should be established to train all crew members. Damage control lockers must be clean and orderly. All tools should be placed in secure mountings, yet be readily detachable.

SHORING PRINCIPLES

22-14. Observe the following basic principles when shoring damaged or weakened members of a ship's structure.

- Spread the pressure. Make full use of strength members by anchoring shores against beams, stringers, frames, stiffeners, and stanchions (see Figure 22-2). Place the legs of shoring against strongbacks at angles from 45° to 90° (see Figure 22-3).
- Plan shoring to hold the bulkhead as it is (see Figure 22-4). Do not attempt to force a warped, sprung, or bulged bulkhead back into place.
- Secure all shoring. Use nails and cleats to ensure that shoring will not work out of place.
- Inspect shoring periodically. The motion of the ship often can produce new stresses that will cause even carefully placed shoring to work free. Inspect all shoring regularly, particularly when the ship is underway.

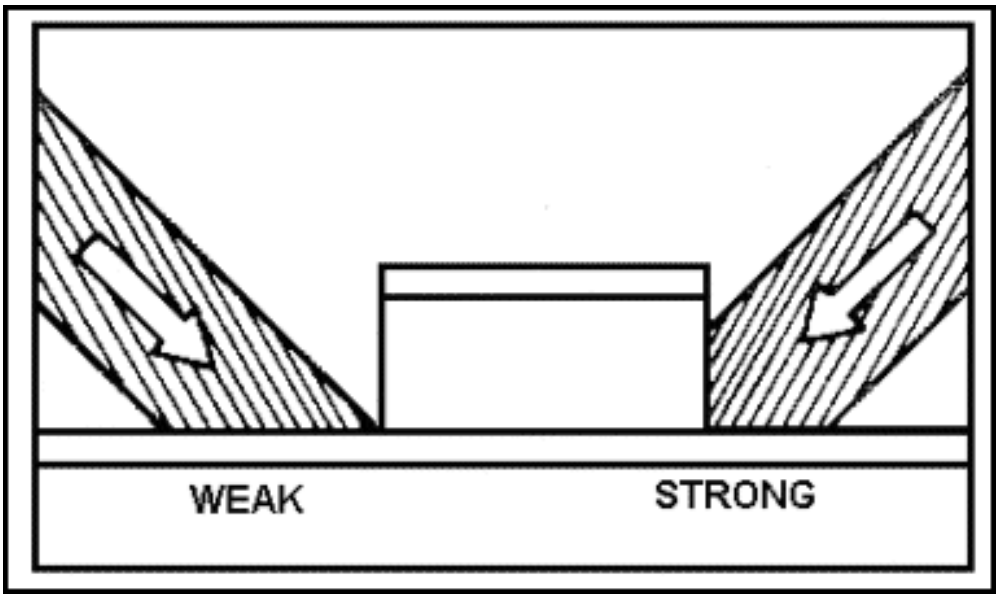


Figure 22-2. Anchoring Fit

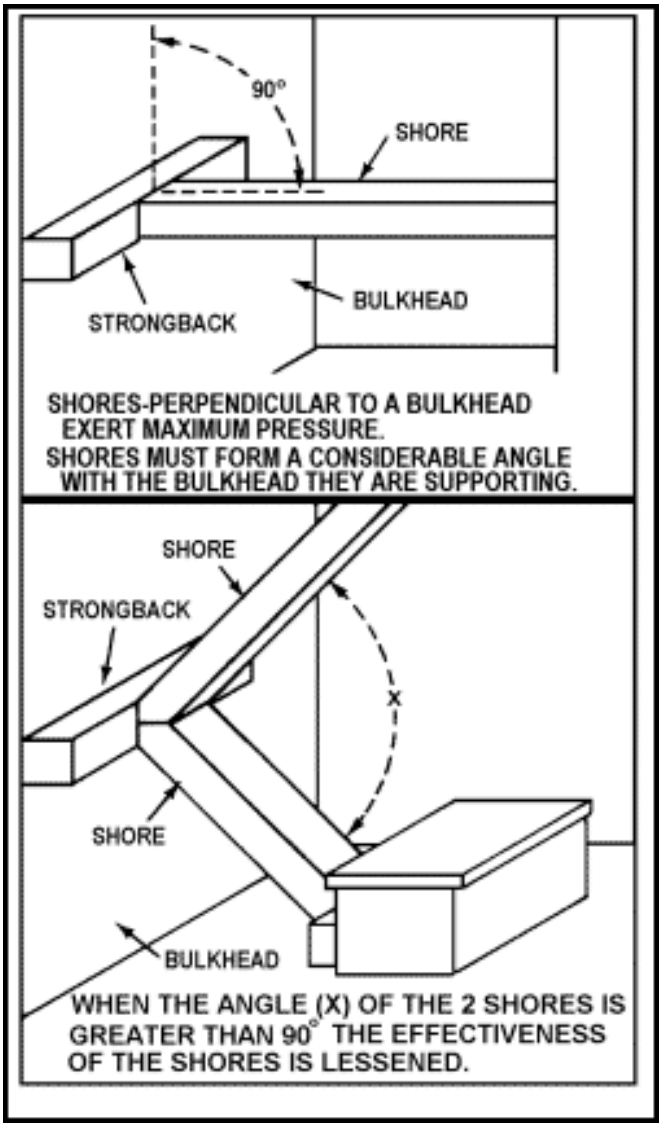


Figure 22-3. Correct Shoring Angles

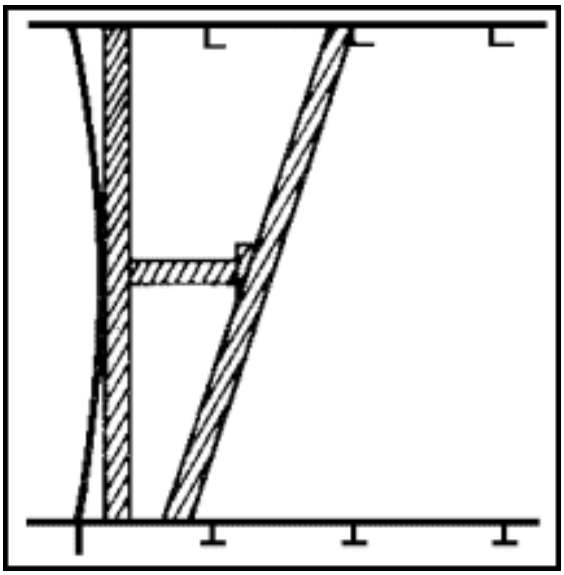


Figure 22-4. Shoring for Bulging Plate

BRACING

22-15. In addition to breaks and cracks in the hull, severe damage to a ship can impose stresses on bulkheads adjacent to the damaged area. The internal bulkheads of a ship are not designed to withstand a great amount of internal water pressure and must be immediately braced. It is unlikely that any two bracing jobs will ever be handled in the same manner, even among the same class ships. The location and extent of damage present individual problems to test the common sense and good judgment of the shoring party. Each case is different. The following fundamentals serve as a starting point.

22-16. Brace weakened or damaged bulkheads against decks, overhead beams, stanchions, and hatch coamings. It is important to allow a three-point distribution of pressure. At the same time it is equally important to avoid damage to flanges, stiffeners, and deck beams.

22-17. Place shores, so the pressure they receive produces direct compression. However, never place a shore deliberately below the point of compression so that bowing results. It is better to install several shores at close intervals because a bowed shore is dangerous to personnel and ship safety. When relatively long shores support heavy pressures, there is an even greater tendency of the shores to bow. Figure 22-5 shows shoring against horizontal pressure.

CAUTIONS:

1. Never use a shore that is longer than 30 times its minimum thickness. Therefore, the maximum length of a standard 4- by 4-inch shore must not exceed 10 feet (120 inches).

2. Sometimes it is impossible to foresee where new stresses will cause bowing. If a timber begins to bow, the pressure should be relieved immediately to prevent snapping. If there is danger of a shore jumping out as the ship works, the shore should be held in position with nails and cleats.

22-18. Secure the butt ends of shores against only undamaged members of the ship's structure such as hatches, stanchions, machinery foundations, frames, and coamings. Strongbacks may help distribute pressure on a bulkhead or deck. Each strongback must be supported with a number of shores placed to exert pressures perpendicular to the bulkhead.

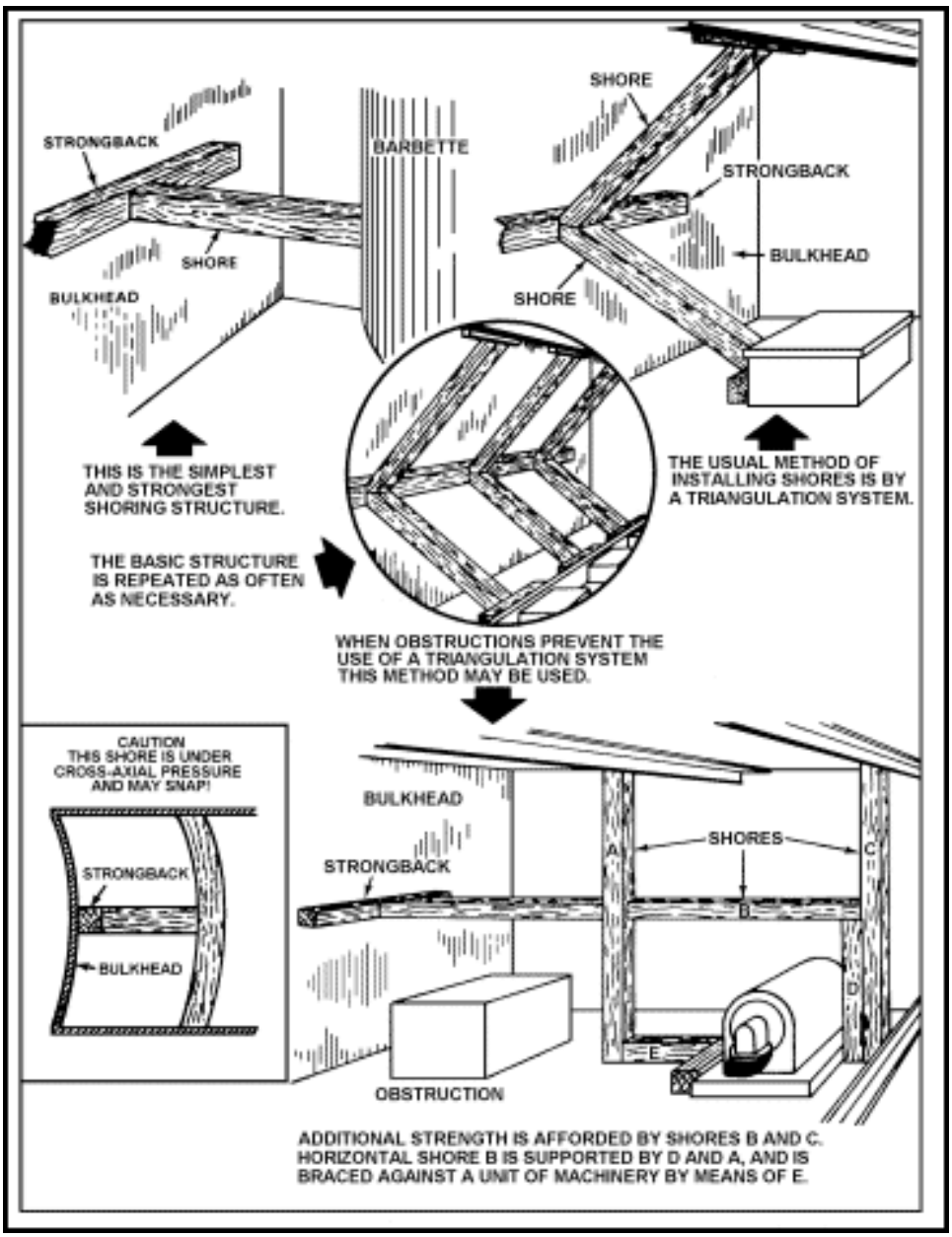


Figure 22-5. Shoring Against Horizontal Pressure

22-19. Use wedges to anchor and tighten shores in place. They should be driven in uniformly from both sides so the end of the shore will not be forced out of position (Figure 22-6). When the butt of a shore is anchored against a joint having protruding rivet heads, the shore is anchored with a shole (a plank or plate with pockets chiseled out for the rivet heads). This prevents the end of the shore from splitting. As the shoring job progresses, it must be checked carefully to ensure that all wedges are exerting the same amount of force on the member being shored in place. The desired force should be obtained by using as few wedges as possible.

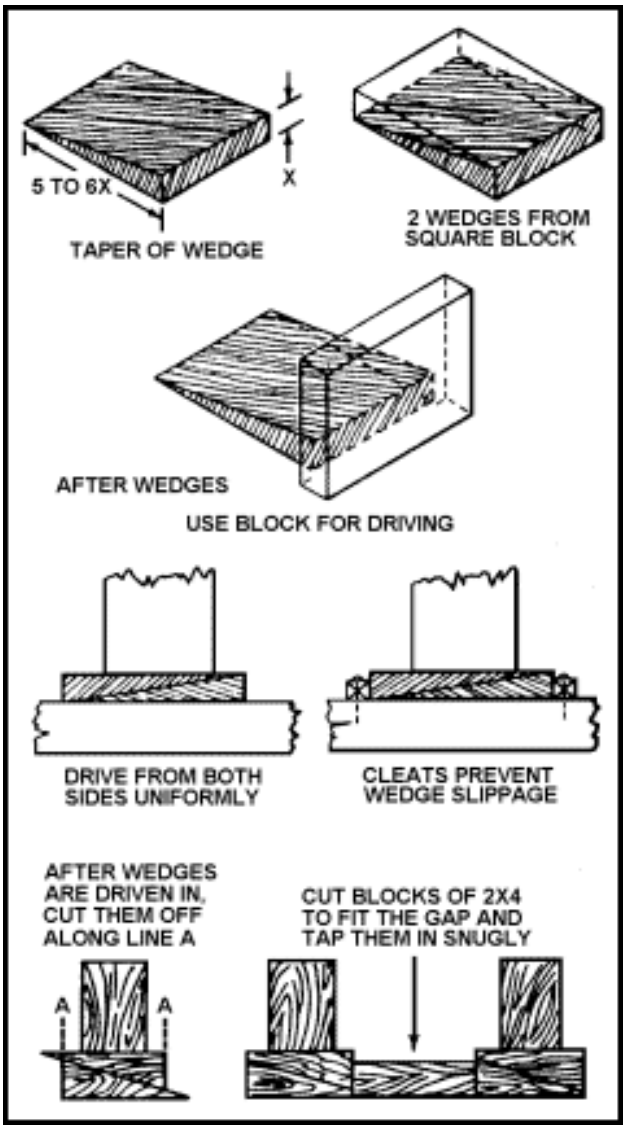


Figure 22-6. Driving Wedges

22-20. About half the shoring job is getting the right size shore. Practice in using the measuring batten will help in an actual emergency. The ends of the batten should be fitted firmly into the recesses selected for anchoring the timbers, and the exact measurement from each leg should be transferred carefully to the shoring. The most rapid and accurate way to measure shores for cutting is by using an adjustable shoring batten similar to the one shown in Figure 22-7. To use the shoring batten, extend it to the required length and lock it with the thumbscrews on the length locking device. Then measure the angles of cut by adjusting the hinged metal pieces at the ends of the batten and lock the angle locking device in place. Lay the batten along the shore. Mark and cut the timber to the proper length and angle. Shores should be cut 1/2 inch shorter than the measured length to allow space for wedges.

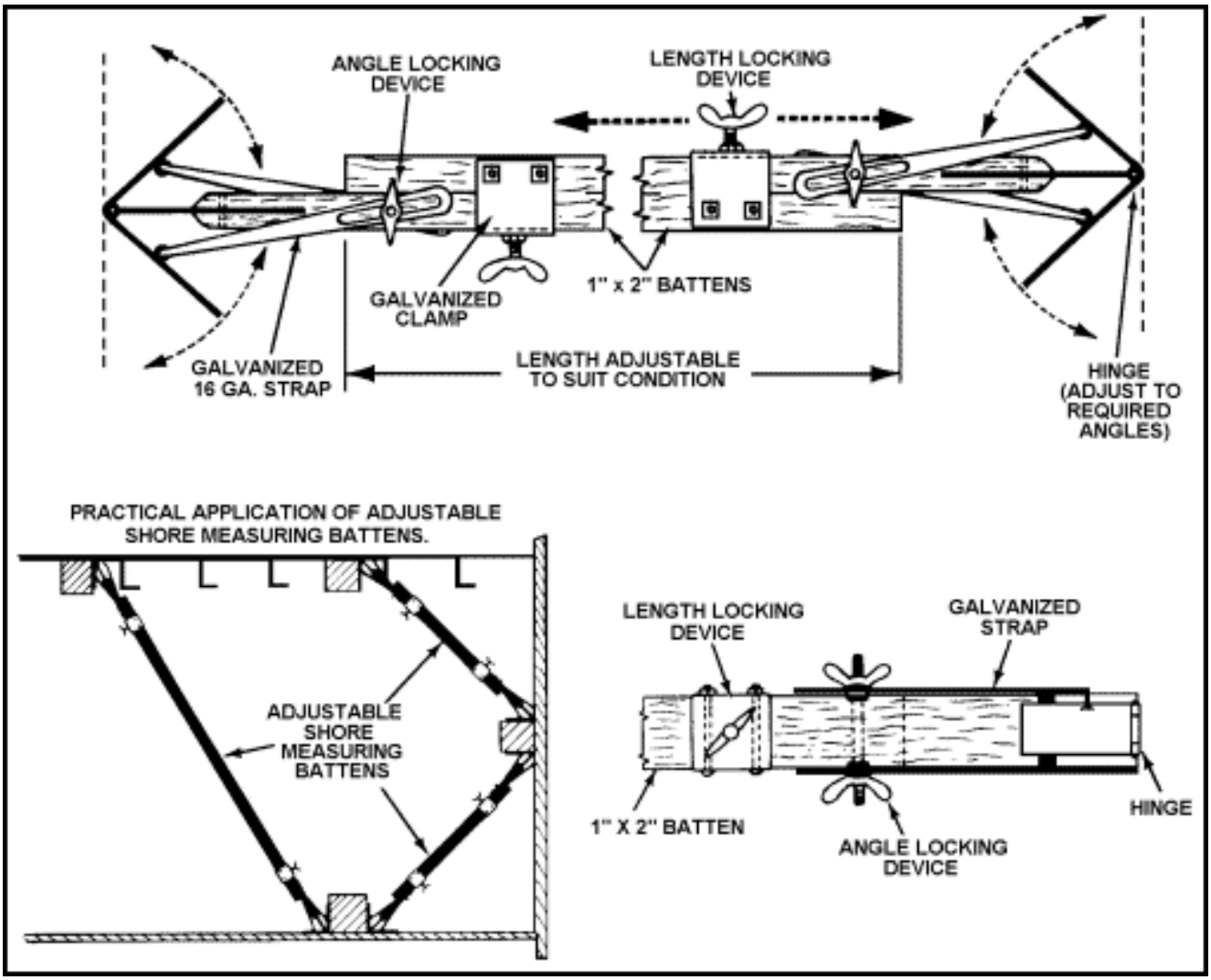


Figure 22-7. Adjustable Shore Measuring Batten

22-21. Shoring may be confined to one compartment of the ship. However, if the pressure on a deck or bulkhead is so great that the next deck or bulkhead anchorage cannot safely withstand the pressure, place the shoring in adjacent areas to distribute pressures (see Figure 22-8). The work of bracing often can be expedited by having chainfalls, blocks and tackles, and jacks available for use in moving heavy weights back into their original position. Dry sand can be sprinkled on oily decks as a safeguard against slipping.

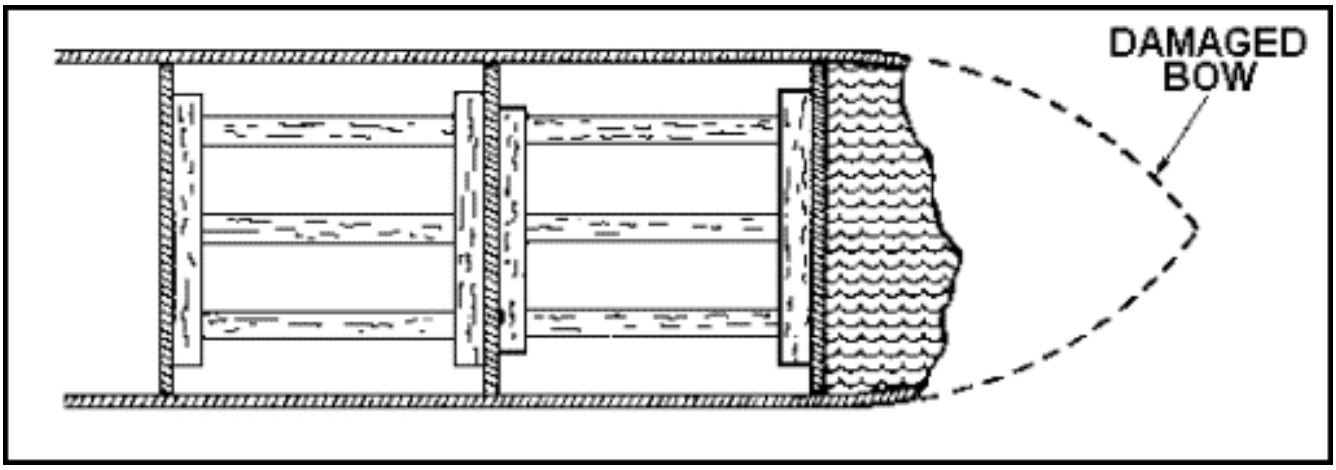


Figure 22-8. Shoring Spread to Adjacent Compartments

22-22. Most shoring is used to support bulkheads endangered by structural damage or weakness caused by concussion or by the pressure of floodwater. Shoring up a flooded compartment requires that particular attention be given to the heavier pressures existing at the lower sections of the bulkheads. These pressures increase with the height of water in the compartment. The area of greatest pressure can also move from one area to another due to pitching and rolling of the ship.

22-23. When a hatch or door is used to support shoring, the entire hatch cover or door should be shored over. Never place shoring ends and wedges directly against such openings, as they are the weakest parts of the bulkhead or deck. The pressure should be spread over the hatch or door and onto supporting structures.

22-24. Closely allied with shoring are the other basic damage control operations. Emergency lighting and lines for submersible pumps must be rigged. Ruptured fire mains and other liquid-carrying lines must be isolated or repaired. The entire operation must be attacked with determination and with an open mind to cope with conditions that never seem to parallel those in a reference book.

USE OF CARPENTER'S STEEL SQUARE IN SHORING

22-25. If a shoring batten is not available, measure the shores for length by using a folding rule or a steel tape and a carpenter’s square. The step-by-step procedure for measuring shores is as follows:

- Measure the distance A from the center of the strongback to the deck. Then measure the distance B from the edge of the anchorage to the bulkhead, subtracting the thickness of the strongback.
- Lay off the measurements A and B on a carpenter’s square, using the ratio 1 inch to 1 foot. Rule measurement is taken to the nearest 1/16 inch. To maintain the ratio of 1 inch to 1 foot, use the information in Table 22-1.
- Measure the diagonal distance between A and B. Figure 22-9 shows this distance as 7 7/8 inches. Because of the 1 inch to 1 foot ratio, the distance in feet would be 7 7/8 feet or 7 feet 10 1/2 inches.
- Subtract a 1/2 inch since shore should be cut 1/2 inch shorter than the measured distance. The final length of the shore should be 7 feet 10 inches.

The carpenter's square may also be used to measure the angles of cut and to mark the shore for cutting (see Figure 22-10).

Table 22-1. Ratio Conversion Table

Actual rule measurement	Measurement on carpenter's square
3/4 inch 1 1/2 inches 2 1/4 inches	1/16 inch 1/8 inch 3/16 inch
3 inches	1/4 inch
3 3/4 inches 4 1/2 inches 5 1/4 inches	5/16 inch 3/8 inch 7/16 inch
6 inches	1/2 inch
6 3/4 inches 7 1/2 inches 8 1/4 inches	9/16 inch 5/8 inch 11/16 inch
9 inches	3/4 inch
9 3/4 inches 10 1/2 inches 11 1/4 inches	13/16 inch 7/8 inch 15/16 inch
12 inches	1 inch

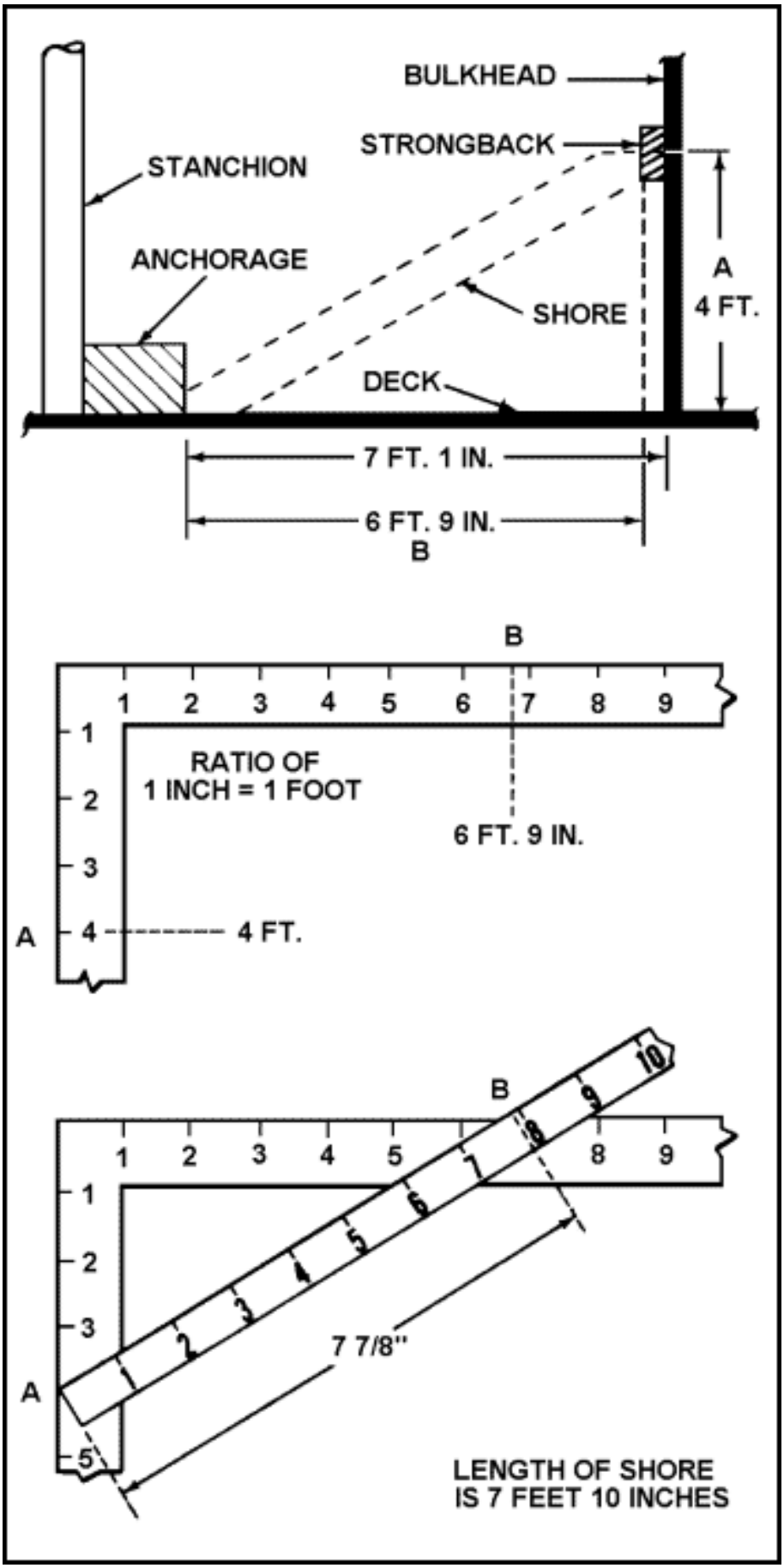


Figure 22-9. Measuring Length of Shore

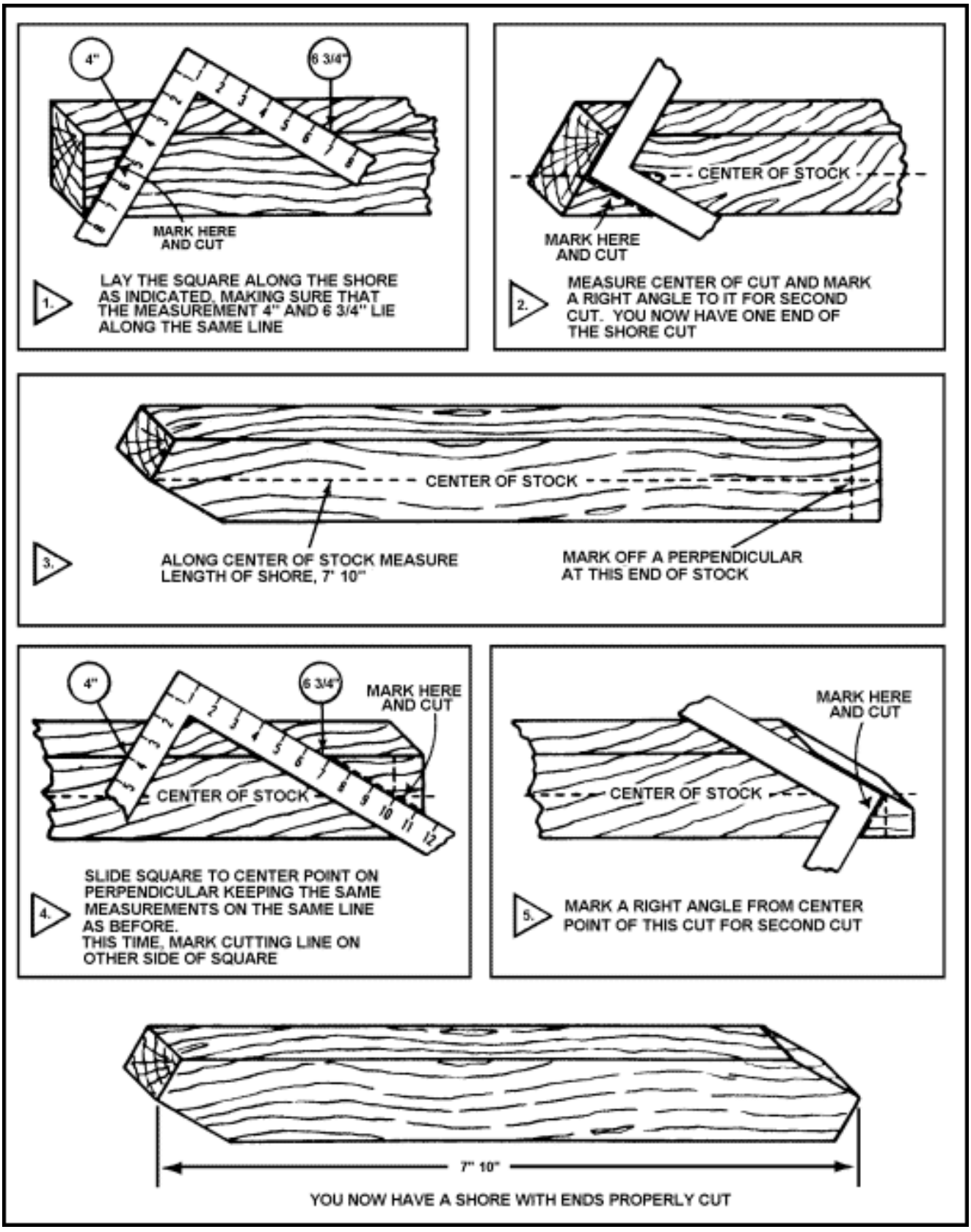


Figure 22-10. Cutting the Angles of a Shore

PLUGGING

22-26. Plugging is a technique used for filling small holes with a suitable material to stop the flow of water until permanent repairs can be made. Holes up to 6 inches in diameter can usually be plugged by driving in wooden plugs or wedges.

WOODEN PLUGS

22-27. Plugs made of bare, soft wood perform best because they soak up water, swell, and hold firmly in place.

- Painted wood does not swell, and should be used only in emergencies.
- Square-end plugs hold better than conical plugs.
- Additional sealing properties can be obtained by wrapping the plugs with cloth.
- Use "oakum" (a black sticky fibrous material made from old hemp) if carried aboard ship. Coat the plugs with oakum before putting them in the hole.

LEAD PLUGS

22-28. Plugs cut from sheet lead are effective in stopping leaks when a plate has pulled loose from its rivets. Often small leaks can be stopped by driving in lead slugs, strips, or plugs.

CRACKS

22-29. Cracks are dangerous because they may enlarge and spread. If time permits, drill a small hole at each end of the crack (see Figure 22-11). This will prevent it from cracking any further.

22-30. The drilled holes should be plugged with either machine or wood screws.

22-31. A flat piece of rubber or canvas backed up with a board should be laid across the crack and held in place with shoring (see Figure 22-12). This type of patch should be inspected frequently as it tends to shift and slip as the ship works.

PATCHING

22-32. Patching is used to cover larger holes with sections of improvised or prefabricated material. This FM only describes the procedures for applying a soft patch because in damage control you are only interested in stopping or controlling the inflow of water. The soft patch is for temporary repair only.

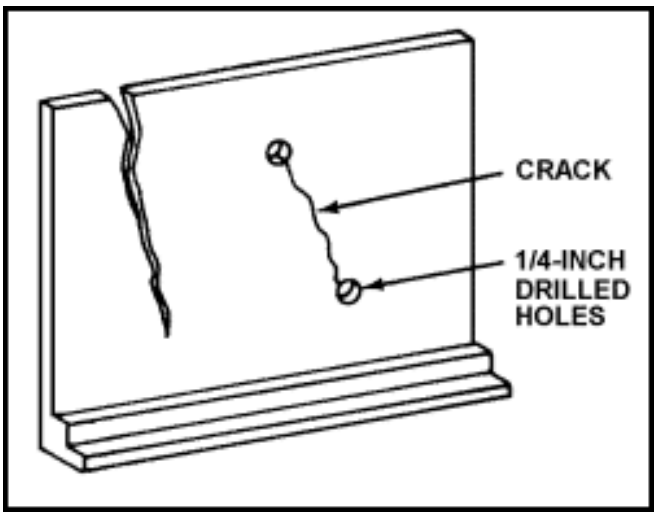


Figure 22-11. Cracks With Holes

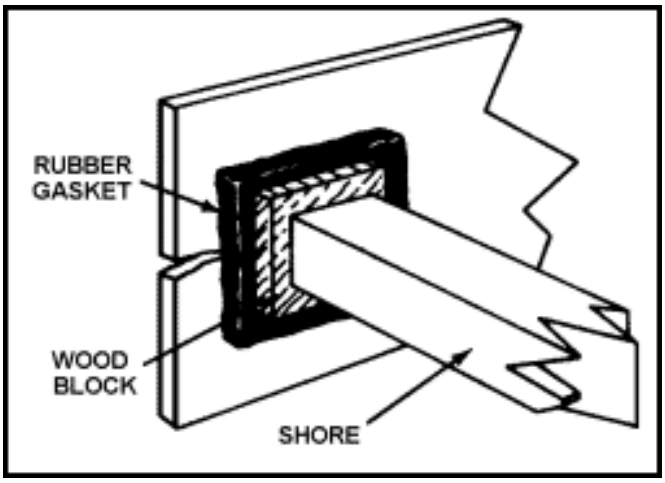


Figure 22-12. Shoring Over a Crack

PILLOWS, MATTRESSES, AND BLANKETS

22-33. Pillows, mattresses, and blankets can be rolled up and shoved into holes. They can be rolled around a wooden plug or a timber to increase their size and to provide rigidity. Such plugs cannot be relied upon, as they have a tendency to be torn out of the holes by action of the sea. This is an expedient to retard the flow of water entering the vessel until a more suitable patch can be applied. Figure 22-13 shows the use of mattresses installed inside and outside the hull as a patch. Placing mattresses inside will reduce the possibility of the patch being knocked away by the sea. If innerspring mattresses are used, at least two thicknesses of blanket should be used as a facing. Over a period of time, feather pillows are not as effective as folded blankets for patches. Feathers in the pillow get wet and tend to lump at one end.

HINGED PLATE PATCH

22-34. A variation of the plate patch is called a hinged plate patch (see Figure 22-14). This is a circular plate, 18 inches or less in diameter, cut in two, and so hinged that it can be folded and pushed through a hole from inside the vessel. The plate should be fitted with a gasket, such as a pillow, and also a line for securing to the vessel. Using water diving equipment, this patch can be applied over a submerged hole without going outside the vessel. This patch is for use over relatively small holes, as it has no vertical support to hold it in place.

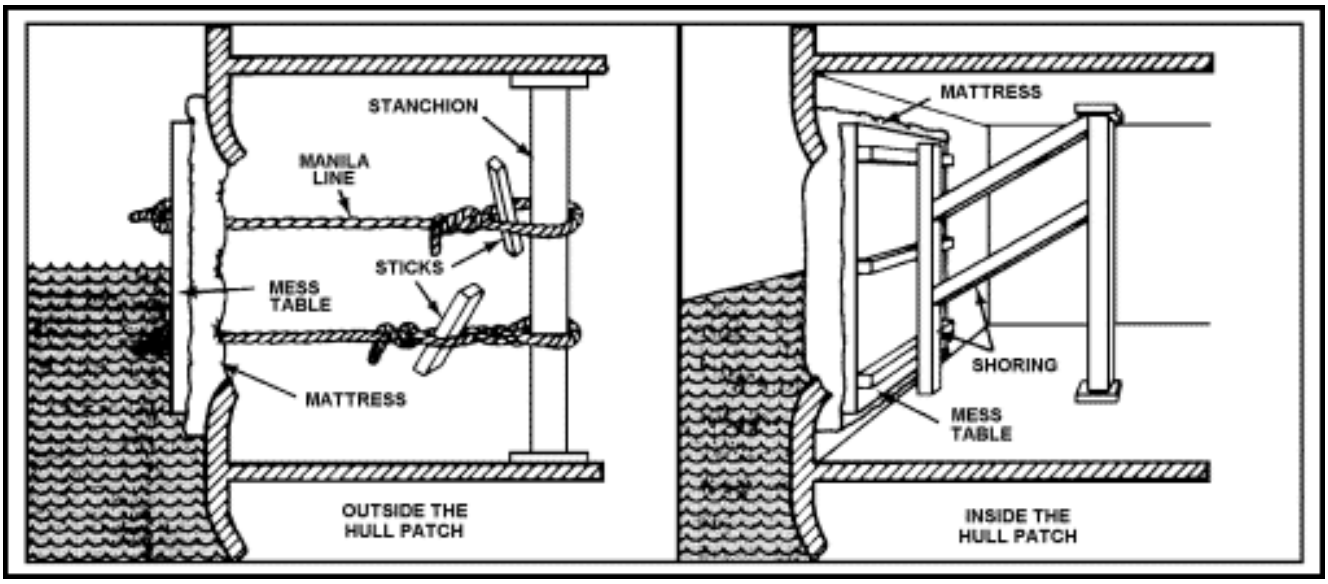


Figure 22-13. Example of Hull Patching Using a Mattress

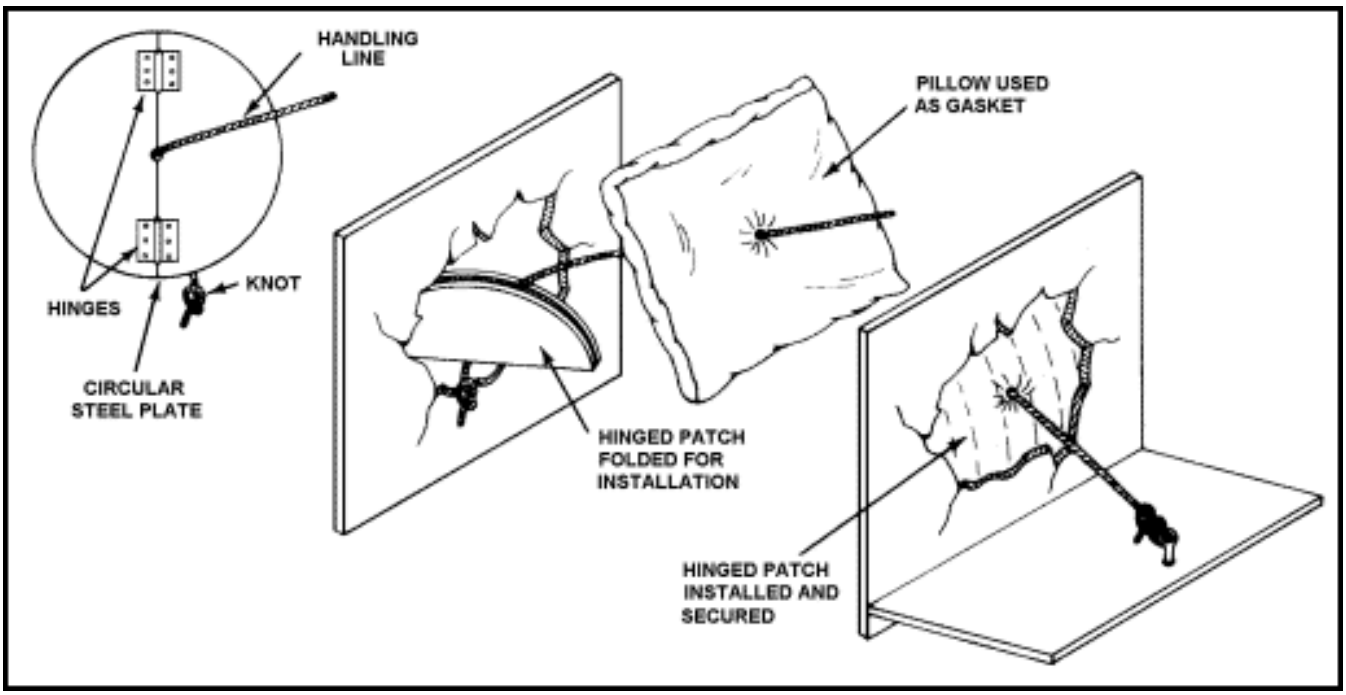


Figure 22-14. Hinged Plate Patch

BUCKET PATCH

22-35. An ordinary galvanized bucket can be used in a variety of ways to stop leaks. It can be pushed into a hole, bottom first, to form a metal plug, or it can be stuffed with rags and put over a hole. It can be held in place by shoring or by using a hook bolt.

USE OF A HOOK BOLT FOR SECURING PATCH

22-36. A hook bolt is a long bolt having the head end shaped so that the bolt can be hooked to plating through which it has been inserted. The common types are the T, J, and L (see Figure 22-15). The long shanks are threaded and provided with nuts and washers. Steel or wooden strongbacks are used with them. The bolt has no regular head. The head end of the bolt is inserted through a hole and the bolt rotated or adjusted until it cannot be pulled back through the hole. A pad or gasket, backed by a plank or strongback, is then slid over the bolt and the patch secured in place by taking up on the nut. It is generally necessary to use these bolts in pairs. Figure 22-16 shows an installed patch using two J-type hook bolts. Hook bolts can be used in combination with various patches such as the folding plate and the bucket. Figure 22-17 shows how to patch a hole using the folding T-type hook bolt.

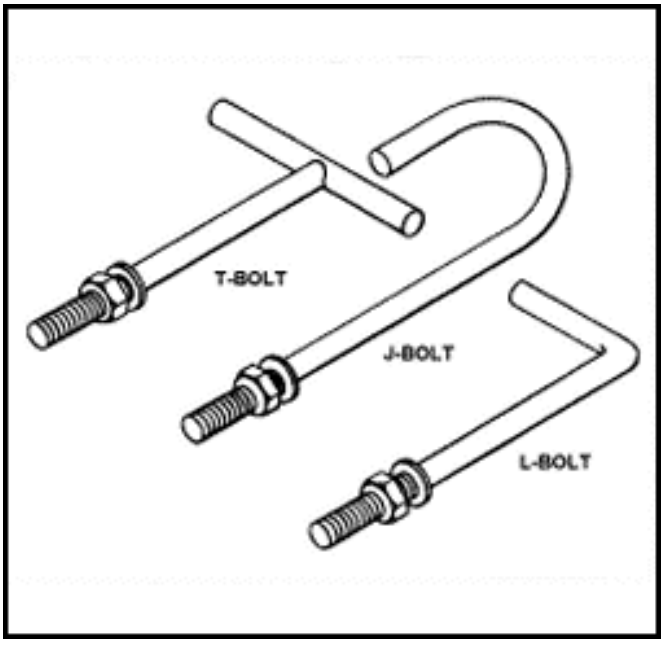


Figure 22-15. Types of Hook Bolts

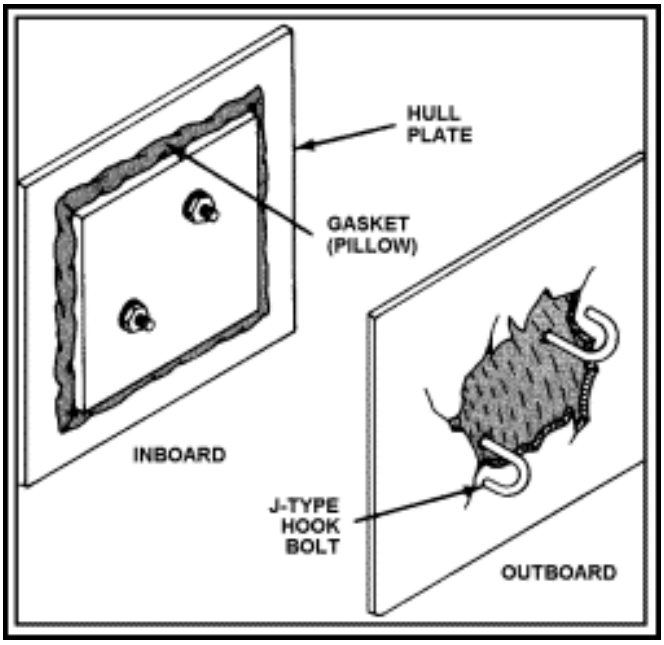


Figure 22-16. Patching Using Hook Bolts

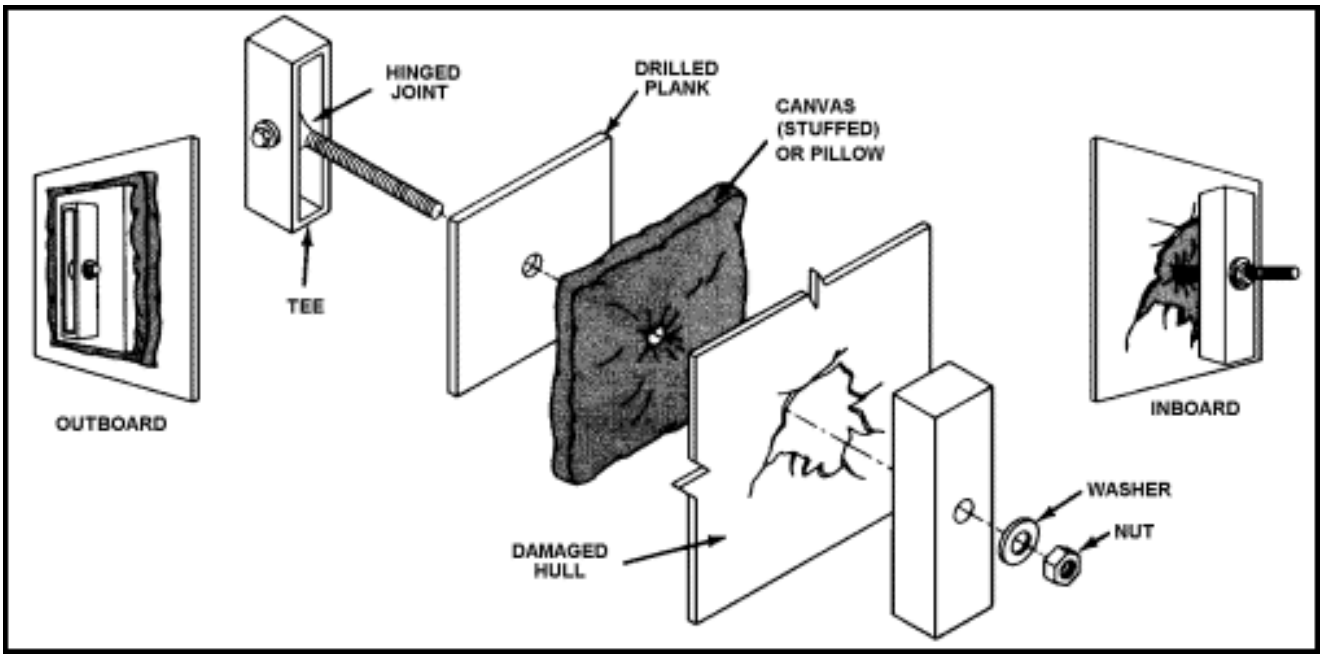


Figure 22-17. Patching Using the Folding T-type Hook Bolt

PIPE REPAIR

22-37. Piping system leaks usually accompanies any large hole in the hull. Soft patches can seal holes and cracks in low-pressure lines and water lines. Install a soft patch on a pipe as follows (see also Figure 22-18):

- Opening is plugged with soft wood plugs or wedges (the flow of water must not be retarded by driving an excessive amount of wood into the pipe).
- Trim plugs and wedges flush with the outside of the pipe.
- Wrap rubber sheeting over the damaged area and back it with light sheet metal held in place with bindings of wire or marline.

Stop minor pipe leaks with a jubilee patch (an adjustable strap with a flange on each edge). These can be made up as needed. The patch is shaped by bending sheet metal around a cylinder and turning out the flanges and then clamped in place (see Figure 22-19). The flanges may have to be reinforced as pressure increases (Figure 22-20).

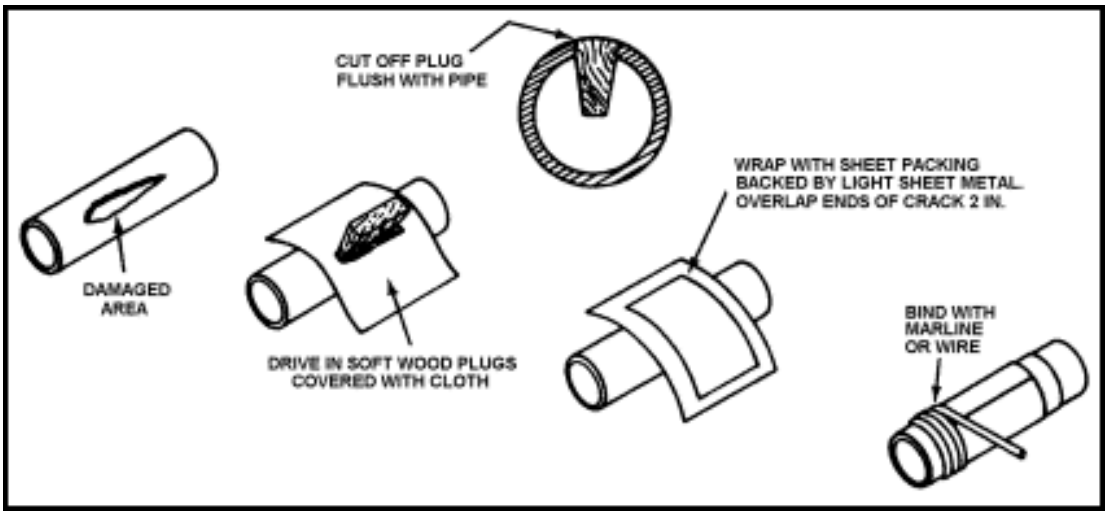


Figure 22-18. Installing a Soft Patch On a Pipe

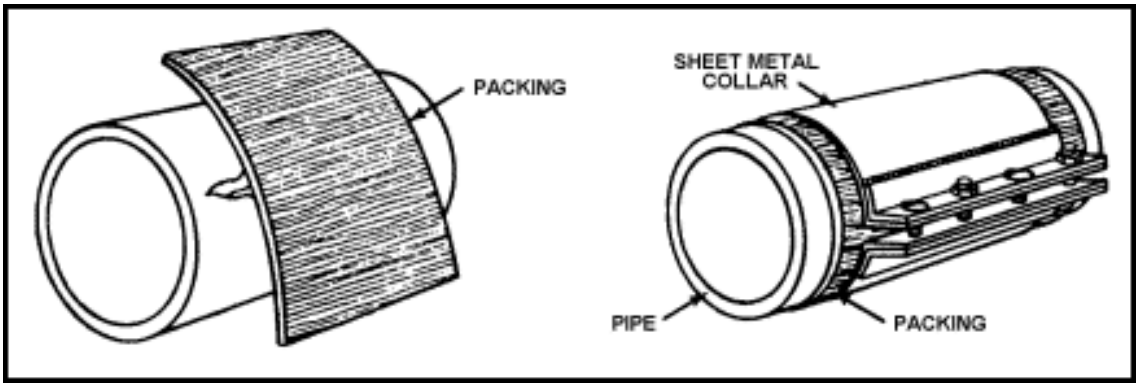


Figure 22-19. Jubilee Pipe Patches

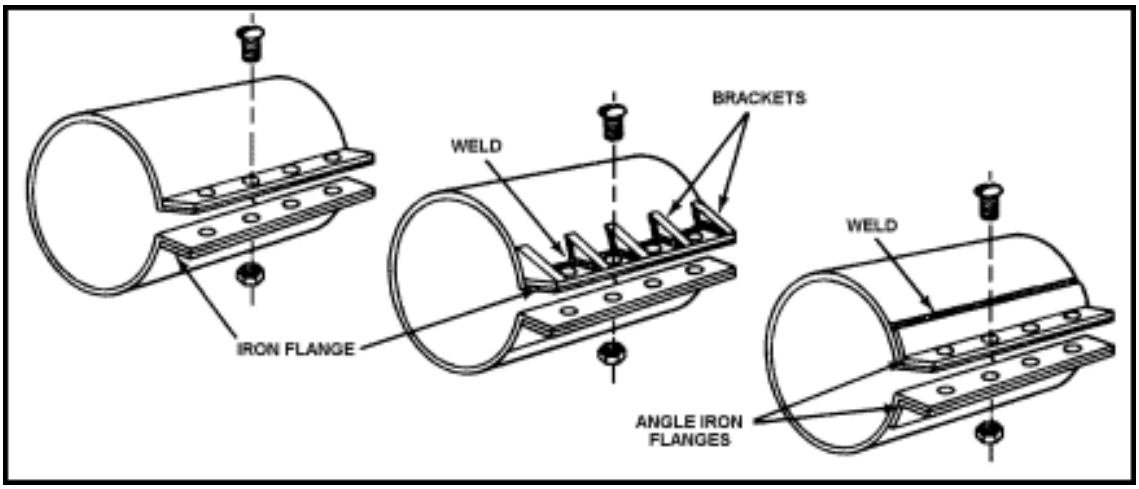


Figure 22-20. Three Types of Reinforced Clamps

EMERGENCY DAMAGE CONTROL METALLIC PIPE REPAIR KIT

22-38. Most water, fuel, and gas lines can be repaired and restored to the system within 30 minutes if the contents of the emergency damage control metallic pipe repair kit are applied properly. In addition to repair or patching of piping, certain materials, which may be used to patch small cracks and ruptures in flat metal surfaces, are included in the kit. Materials in the kit may be obtained separately through appropriate supply channels whenever a need arises to replace them. You do not need to obtain another completely new kit. A complete kit contains the following materials:

- Four cans epoxy, resin, 400 grams each.
- Four cans liquid hardener, 100 grams each.
- Four cans paste resin, 300 grams each.
- Four cans paste hardener, 75 grams each.
- One piece woven roving cloth 24" x 10 ".
- One piece void cover, 8" x 36".
- One piece polyvinyl chloride (PVC) film, 36" x 72".
- One chalk line, 1/8 pound.
- Four pairs of gloves.
- Two eyeshields.
- Four wooden spatulas.
- One sheet of emery cloth, 9" x 11".
- One instruction manual.

DESCRIPTION OF MATERIALS

22-39. The following describes the basic materials found in the kit. The discussion of factors related to plastics are given to help you gain a better understanding of the kit and its use.

Void Cover

22-40. The void cover is a resin-treated glass cloth that can be cut and formed to cover the damaged area. It is sufficiently rigid to give support to the patch.

Woven Roving Cloth

22-41. The woven roving cloth is made of a short-staple, glass fiber woven into a thick, fluffy cloth. During the application of a plastic patch this cloth is coated with the resin-hardener mixture and either wrapped around or placed over the damaged area. The glass cloth provides the main strength of the patch and also provides a means of applying the resin-hardener mixture.

Film (PVC)

22-42. The plastic film, referred to as PVC, is a thin transparent polyvinyl chloride material. It is used as a separating film for the flat patch to prevent the patch from sticking to the backup plate or other supports. In the pipe patch, it is used to cover the entire patch and retain the activated resin around the patch. Kraft wrapping paper may be used as a substitute if necessary.

Resins and Hardeners

22-43. The liquid and paste resins are of the epoxy type. The liquid and paste hardeners are chemical compounds used to harden the resins. The resins and the hardeners are packaged in premeasured amounts. For proper mixture and better results, mix the complete contents of the hardener in the smaller can with the complete contents of the resin in the larger can.

CAUTION: DO NOT mix hardener with resin until all preparations have been completed. DO NOT intermix liquid resin and paste hardener or paste resin and liquid hardener.

22-44. When the resins and the hardeners are mixed together, a chemical reaction occurs which causes the mixture to harden (liquid mixture, approximately 12 minutes; paste mixture, approximately 17 minutes). This reaction is exothermic, which means that heat is given off. For approximately 12 to 17 minutes the temperature increases gradually until it reaches 120° F to 135° F. At this point a sudden sharp rise in temperature is known as kick over. It is at this temperature that the resin-hardener mixture begins to solidify and change color from gray to light brown. The peak temperature (350° F) can be observed through the external change of the patch.

22-45. The resin-hardener mixture begins to cool slowly due to the poor thermal conductivity of the materials. After kick over, the mixture continues to harden and increase in strength. This process is referred to as curing. Approximately 30 minutes after kick over (the sharp rise in temperature) the patch is strong and hard and cool enough to use. Pressure should not be restored to the system until the patch has cured. The patch is considered sufficiently cured when the bare hand can be placed on it without discomfort from heat.

22-46. Several factors contribute to the control of kick over. The most important factor is the temperature. Both the initial temperature of the activated resin mixture and the temperature of the atmosphere, affect the kick over time. However, of these two temperatures, the initial temperature of the activated resin has the greater effect. When the temperature of the resin and the hardener prior to mixing is increased, the kick over time decreases. Conversely, when the temperature of the resin and hardener prior to mixing decreases, the kick over time increases.

22-47. Knowledge of controlling kick over is necessary since it corresponds to application of working time. This means that when the initial temperature of the mixture is 73° F, the patching material must be placed over the rupture within 12 minutes. Once the resin and the hardener are mixed together, the chemical reaction cannot be stopped. Therefore, the patch should be completely applied before kick over occurs.

22-48. Figure 22-21 shows the relationship of the kick over time of the resin temperature.

If you know the resin temperature at the time of mixing, you will be able to determine the amount of time available to apply the patch before kick over occurs. You can see that if the resin temperature is 80° (point A), the kick over will occur in less time than if the resin temperature were 60° (point B). The difference in resin temperatures represents an application working time of 9 minutes versus 18 minutes.

Note: If the initial resin temperature exceeds 80° F the temperature should be reduced by artificial means to 73° F prior to mixing. This lowering of the temperature allows for additional application working time.

MATERIALS REQUIRED FOR PIPE PATCH

22-49. Table 22-2 shows approximate quantities of materials required for pipe patches.

The top figure in the boxes shows quantities in the amount of resin and hardener mixture in grams. The second group of figures, immediately below, are the dimensions in inches of woven roving cloth.

ADVANTAGES OF THE PLASTIC PATCH

22-50. From the damage control viewpoint, the main advantages of the plastic patch are versatility, simplicity, effectiveness, speed of application, and durability. The plastic patch can be successfully applied to a variety of damaged surfaces (such as smooth edges or jagged protruding edges). Since the plastic has excellent adhesive qualities it can be readily applied to steel, cast iron, copper, copper-nickle, brass, bronze, and galvanized metals.

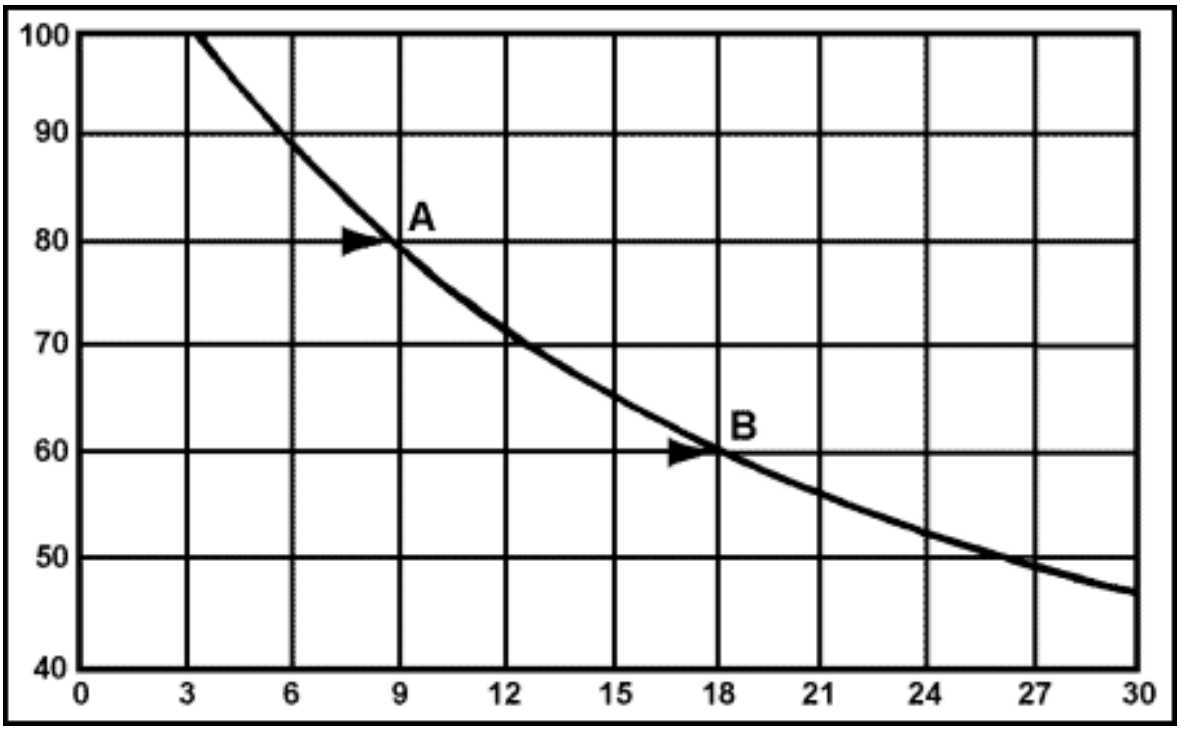


Figure 22-21. Resin Temperature Versus Kick Over Time Graph

22-51. The plastic materials and the plastic patch may be readily prepared and applied. By following the instructions outlined in the instruction manual included in the kit, a person with little or no experience can readily prepare the materials and apply a plastic patch. Applying a plastic patch is comparable to applying a battle dressing used in first aid. If the materials are properly prepared and the application procedures are duly followed, the plastic patch will be 100 percent effective. If leakage occurs through a plastic patch, it is likely that proper preparation and application procedures have not been followed.

22-52. The speed of application will vary somewhat with the size and type of rupture and also with local working conditions. When proper preparation procedures are followed, an inexperienced crew, who have had a minimum amount of teaching and training, can apply a simple patch to a 4-inch pipe in 10 minutes or less. The type and size of the structure to which the patch is applied do not materially affect the time involved in patching. However, some types of damage may require more initial preparation.

Table 22-2. Table of Approximate Quantities of Materials Required for Pipe Patches

Length of rupture (inches)	Size of pipe (inches)							
	1	1 1/2	2	2 1/2	3	4	5	6
1 / 2	200 8 x 12	290 8 x 18	400 8 x 25	500 8 x 31	500 8 x 37	770 8 x 48	960 8 x 60	1150 8 x 72
1	220 9 x 12	325 9 x 18	450 9 x 25	550 9 x 31	675 9 x 37	865 9 x 48	1080 9 x 60	1300 9 x 72
2	240 10 x 12	360 10 x 18	500 10 x 25	620 10 x 31	740 10 x 37	960 10 x 48	1200 10 x 60	1440 10 x 72
3	260 11 x 12	400 11 x 18	550 11 x 25	680 11 x 31	800 11 x 37	1050 11 x 48	1320 11 x 60	1585 11 x 72
4	290 12 x 12	435 12 x 18	600 12 x 25	750 12 x 31	890 12 x 37	1150 12 x 48	1440 12 x 60	1725 12 x 72
5	312 13 x 12	470 13 x 18	650 13 x 25	800 13 x 31	960 13 x 37	1250 13 x 48	1560 13 x 60	1875 13 x 72
6	336 14 x 12	500 14 x 18	700 14 x 25	875 14 x 31	1040 14 x 37	1350 14 x 48	1680 14 x 60	2020 14 x 72
7	360 15 x 12	540 15 x 18	750 15 x 25	925 15 x 31	1110 15 x 37	1450 15 x 48	1800 15 x 60	3160 15 x 72
8	385 16 x 12	575 16 x 18	800 16 x 25	1000 16 x 31	1185 16 x 37	1550 16 x 48	1920 16 x 60	2300 16 x 72
9	408 17 x 12	612 17 x 18	850 17 x 25	1054 17 x 31	1258 17 x 37	1632 17 x 48	2040 17 x 60	2448 17 x 72

APPLICATION OF PLASTIC PATCHES

22-53. When applying a plastic patch, you will see that as the individual patch materials are applied, the patch becomes progressively wider. Figure 22-22 shows the relative positions of the patch materials to one another.

22-54. The buildup in the patch length during application must be considered initially when determining the length of the patch to be applied. Where suitable, allow the patch to extend at least 4 to 5 inches on either side of the rupture.

22-55. In addition to the size of the rupture, the width of the patch may also depend on the location of the rupture in the pipe system. For example, an elbow rupture may require a wider patch than the same size rupture would require in a straight section of pipe.

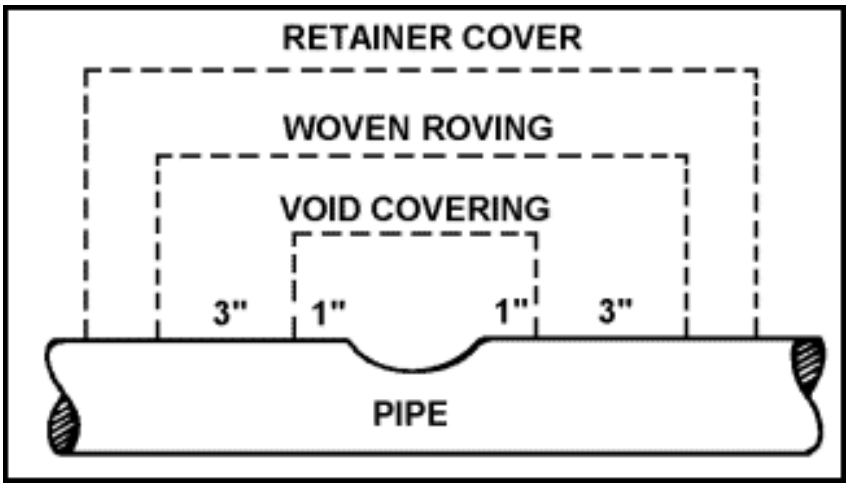


Figure 22-22. Relative Positions of Patch Materials

22-56. Certain specific preparations must be made prior to the actual application of the plastic patch. These are as follows:

- Secure or isolate the rupture area in the piping system.
- Remove all lagging.
- Clean the area around the rupture and remove all grease, oil, dirt, paint, and other foreign matter. If grease or oil is present, use an approved solvent such as ethyl chloroform. If this solvent is not available, scrape and wipe the surface until it is clean. When a clean surface is obtained, the surface may be further abraded for better adhesion. An abrasive cloth is furnished with the kit.
- Make sure that the entire pipe surface is dry.
- Where practical, simplify the rupture by bending or removing irregular projections. This may be accomplished by cutting or burning.

CAUTION: It is of the utmost importance that no explosive conditions exist prior to using spark-producing tools or burning equipment.

Determine the materials that will be required, such as the amount of woven roving cloth and the amount of resins and hardeners. For example, a 2-inch rupture in a 2-inch diameter pipe will require 500 grams of activated resin and a piece of woven roving cloth that is at least 25 inches long. Cut the woven roving cloth wide enough to extend at least 3 to 4 inches on either side of the rupture.

SIMPLE PIPE PATCH

22-57. The following are step-by-step procedures for applying the simple pipe patch.

- Put on eyeshields and gloves. Then open the liquid resin can and the liquid hardener can.
- Add hardener to the resin and mix thoroughly for approximately 2 minutes or until a uniform gray color is observed. (Note that the entire contents of the liquid hardener in the smaller can, is the correct proportion for mixing with the entire contents of the larger can of liquid resin.)
- Coat both sides of the void cover with the resin-hardener mixture and tie the void cover over the rupture with chalk line as shown in Figure 22-23, step A.
- Lay the woven roving cloth on a clean flat surface. Starting at one end of the cloth, pour on resin-hardener mixture and spread evenly over the entire surface of the cloth using the spatula provided in the kit. Only one side of the woven roving cloth needs to be impregnated. Be sure that the edges are well impregnated with the resin-hardener mixture.
- Center the woven roving cloth over the void cover with the impregnated side toward the pipe. Wrap it around the pipe not less than three turns and preferably not more than four turns (see Figure 22-23, step B).
- Wrap the PVC film around the entire patch making at least two complete turns. Tie the PVC film with the chalk line, starting from the center of the patch and working toward one end, making 1/2-inch spacing between spirals (see Figure 22-23, step C). Tie this end securely but do not sever the line. Make one spiral back to the center of the patch, then working to the opposite end, form the center of the patch. Make 1 1/2-inch spacing between spirals and again secure the line. After 30 to 40 minutes the patch should be sufficiently cured to restore the pipe to service.

Remember that for best results the temperature of the liquid resin and the liquid hardener should be approximately 70° F before mixing. The patch will cure in approximately one hour from the initial mixing time. After an hour, pressure may be restored to the piping system. In emergencies, if the temperature of the resins and the hardeners is below 50° F, applying external heat with hot-air heaters may accelerate kick over. However, the external heat must be applied gradually because excessive application of heat will cause the plastic patch to be extremely porous.

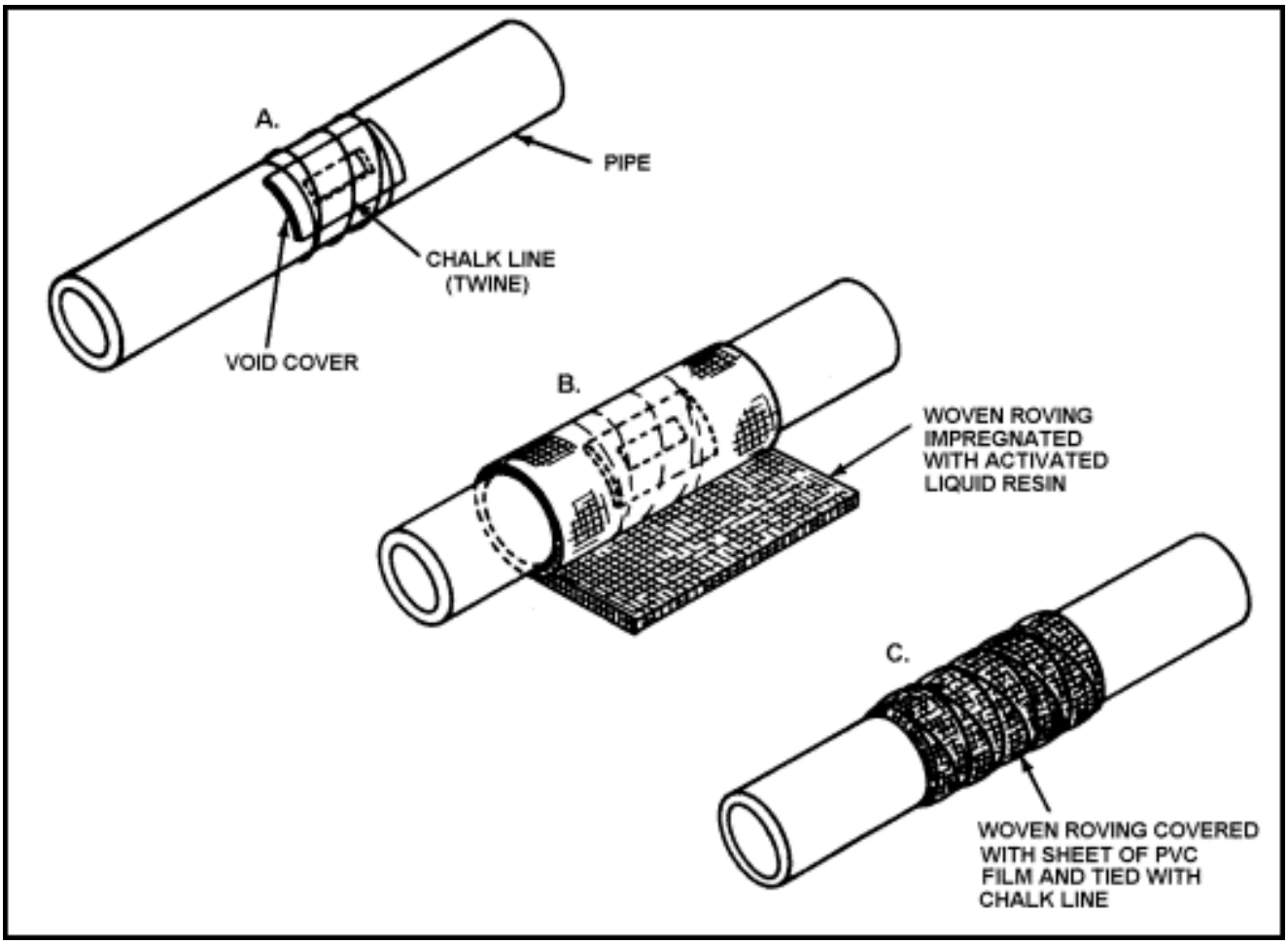


Figure 22-23. Simple Pipe Patch

Appendix A

Nautical Chart Symbols and Abbreviations

Army watercraft operators must be able to read and understand their charts rapidly and accurately. How much information they get from a chart will depend on how well they read the chart and interpret the various symbols and abbreviations. Even though there is little room on a chart, much information must be shown on a chart for the safe navigation of vessels. For this reason, symbols and abbreviations are used. Figure A-1 shows the contents page of Chart No. 1, Nautical Chart Symbols and Abbreviations. The symbols and abbreviations in this chart are approved for use on nautical charts and are used on charts published by the US. This chart is sold by National Ocean Service authorized sales agents or they can be found in many US ports and in some foreign ports. You can order copies of this chart from the National Ocean Service (Distribution Division) by writing to —

Distribution Division
National Ocean Service
6501 Lafayette Avenue
Riverdale, MD 20737-1199

Orders should be accompanied by a check or money order payable to NOAA, Department of Commerce or by providing Visa or MasterCard information. Remittance from outside the United States should be made either by an International Money Order or by a check in US funds drawn on a US bank. Chart catalogs, that include a listing of authorized sales agents, are free upon request.

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FAX: (301) 436-6829

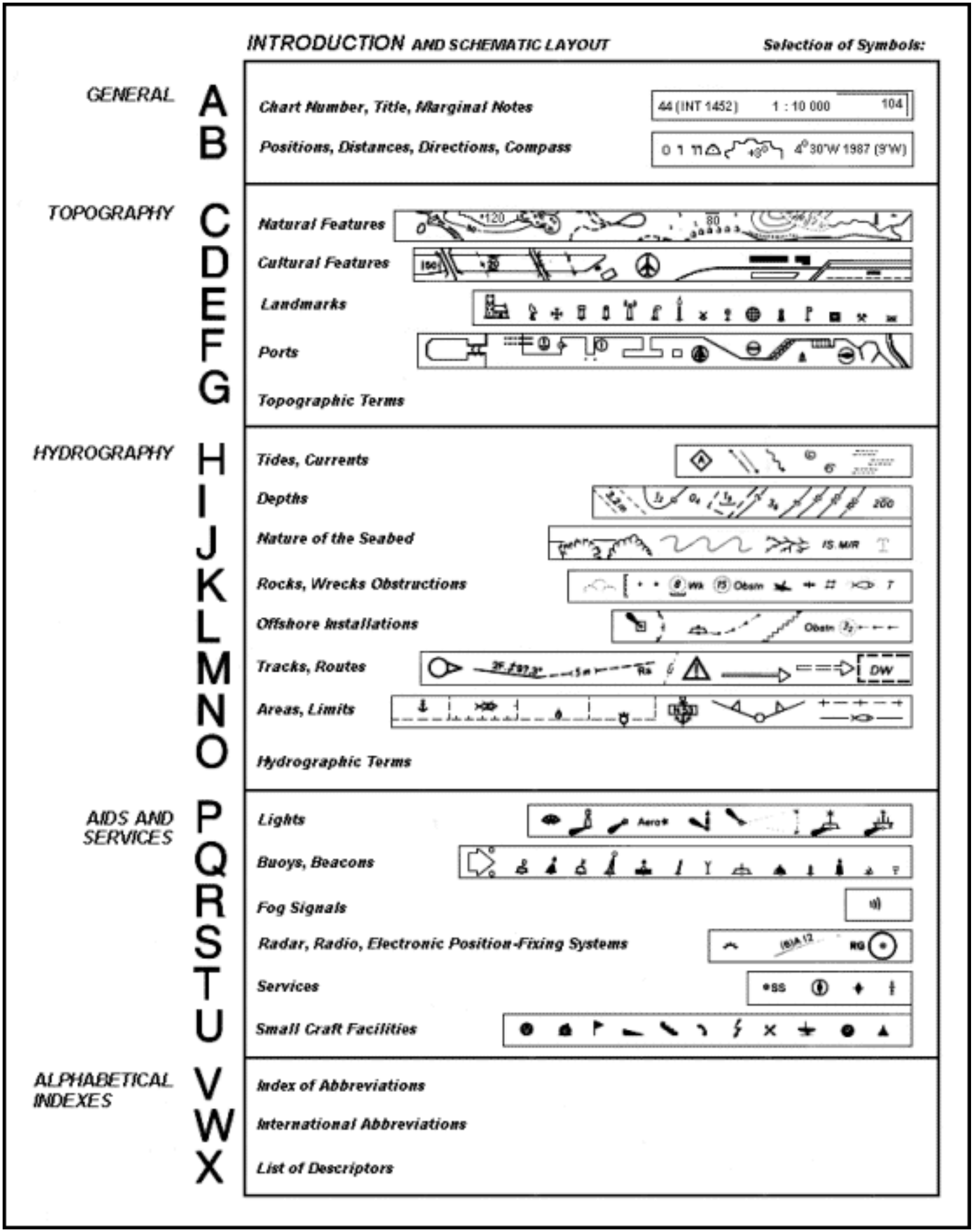


Figure A-1. Contents of Chart No. 1

Appendix B

Formats for Requisitioning Charts and Other Marine Products From the Defense Mapping Agency

This appendix contains sample copies (reduced to fit on page) of the forms that are needed when ordering DMA products. You may request these forms through appropriate distribution channels.

DD Form 1348M	DOD Single Line Item Requisition System Document (Mechanical)
DD Form 1348	DOD Single Line Item Requisition System Document (Manual)
DD Form 173/1	Joint Messageform
SF Form 344	Multiuse Standard Requisitioning/Issue System Document

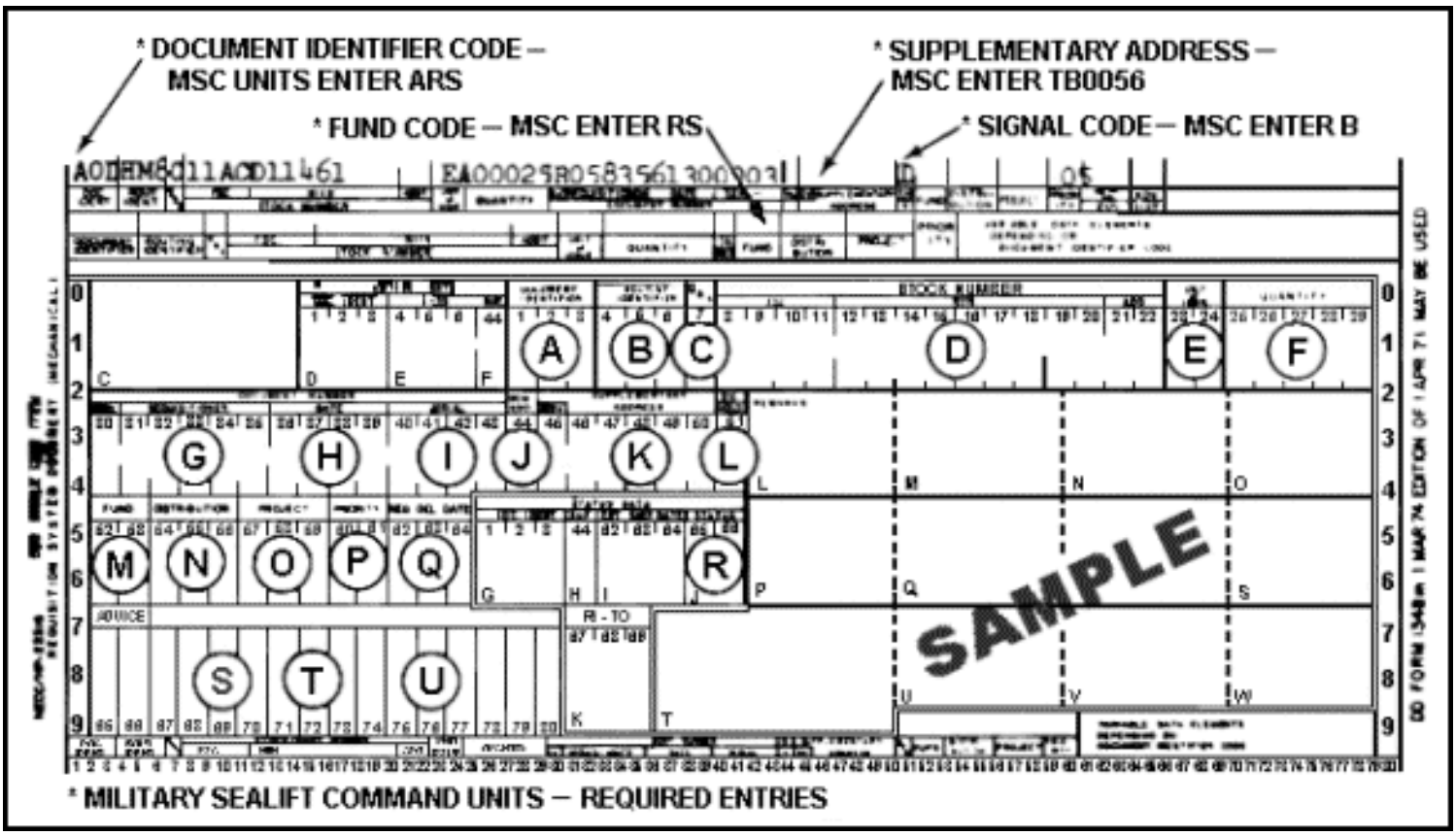


Figure B-1. DD Form 1348M—DOD Single Line Item Requisition System Document (Mechanical)

DATA FIELD	CARD COLUMN	EXPLANATION
A	1-3	Document Identifier Code AOD--CONUS Shipment A04--Overseas Shipment ARS--MSC Shipment
B	4-6	Routing Identifier Code of Chart Supply Source
C	7	Media & Status Code
D	8-22	Stock Number of Item Requested (leave unused columns blank)
E	23-24	Unit of Issue (EA)
F	25-29	Quantity Requested (fill all columns)
G	30-35	DoDAAD Address Code of Requisitioner
H	36-39	Julian Date of Requisition
I	40-43	Requisition Serial Number
J	44	leave blank

K	45-50	Supplementary Address/MSC will enter TB 0056
L	51	SignalCode/ MSC enter B
M	52-53	Fund Code/MSC enter Rs (other DoD leave blank)
N	54-56	leave blank
O	57-59	Project Code (optional)
P	60-61	Priority Designator (UMMIPS Code)
Q	62-64	Required Delivery Date (optional)
R	65-66	Advice Code
S	67-71	leave blank
T	72	"F" for Folded Stock or leave blank
U	73-80	leave blank

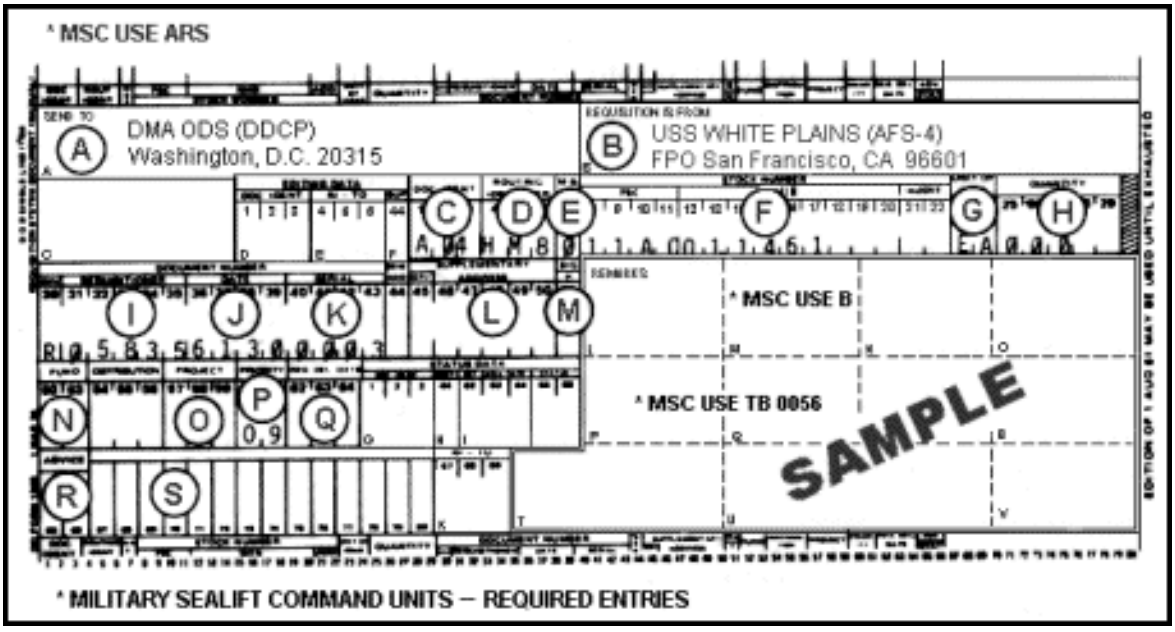
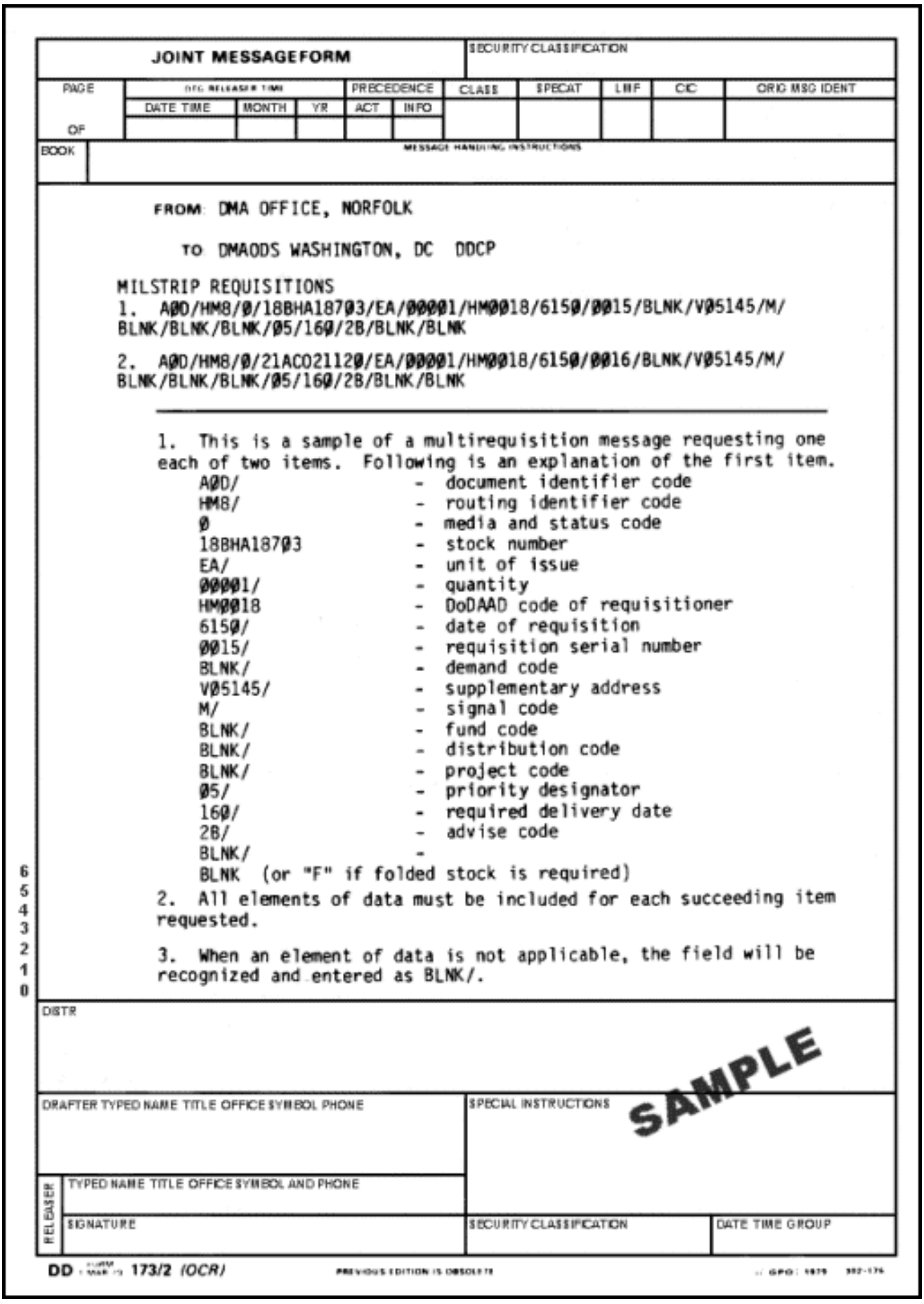


Figure B-2. DD Form 1348—DOD Single Line Item Requisition System Document (Manual)

DATA FIELD	CARD COLUMN	EXPLANATION
A		Mailing Address of Chart Supply Source
B		Requisitioner's Mailing Address

C	1-3	Document Identifier Code AOD--CONUS Shipment A04--Overseas Shipment ARS--MSC Shipment
D	4-6	Routing Identifier Code Chart Supply Source
E	7	Media & Status Code
F	8-22	Stock Number of Item Requested (leave unused columns blank)
G	23-24	Unit of Issue (EA)
H	25-29	Quantity Requested (fill all columns)
I	30-35	DoDAAD Address Code of Requisitioner
J	36-39	Julian Date of Requisition
K	40-43	Requisition Serial Number
L	45-50	Supplementary Address/MSC will enter TB 0056
M	51	Signal Code/MSC enter B
N	52-53	Fund Code/MSC enter RS (other DoD leave blank)
O	57-59	Project Code (Optional)
P	60-61	Priority Designator (UMMIPS Code)
Q	62-64	Required Delivery Date (optional)
R	65-66	Advice Code
S	70	"F" for Folded Stock or leave blank



JOINT MESSAGEFORM

SECURITY CLASSIFICATION

PAGE OF	DTG RELEASER TIME: DATE TIME	MONTH	YR	PRECEDENCE: ACT	INFO	CLASS	SPECAT	LMF	CIC	ORIG MSG IDENT

BOOK

MESSAGE HANDLING INSTRUCTIONS

FROM: DMA OFFICE, NORFOLK

TO: DMAODS WASHINGTON, DC DDCP

MILSTRIP REQUISITIONS

1. AØD/HM8/Ø/18BHA187Ø3/EA/ØØØØ1/HMØØ18/615Ø/ØØ15/BLNK/VØ5145/M/BLNK/BLNK/BLNK/Ø5/16Ø/2B/BLNK/BLNK

2. AØD/HM8/Ø/21ACO2112Ø/EA/ØØØØ1/HMØØ18/615Ø/ØØ16/BLNK/VØ5145/M/BLNK/BLNK/BLNK/Ø5/16Ø/2B/BLNK/BLNK

---

1. This is a sample of a multirequisition message requesting one each of two items. Following is an explanation of the first item.

AØD/	- document identifier code
HM8/	- routing identifier code
Ø	- media and status code
18BHA187Ø3	- stock number
EA/	- unit of issue
ØØØØ1/	- quantity
HMØØ18	- DoDAAD code of requisitioner
615Ø/	- date of requisition
ØØ15/	- requisition serial number
BLNK/	- demand code
VØ5145/	- supplementary address
M/	- signal code
BLNK/	- fund code
BLNK/	- distribution code
BLNK/	- project code
Ø5/	- priority designator
16Ø/	- required delivery date
2B/	- advise code
BLNK/	-
BLNK (or "F" if folded stock is required)	

2. All elements of data must be included for each succeeding item requested.

3. When an element of data is not applicable, the field will be recognized and entered as BLNK/.

6 5 4 3 2 1 0

DISTR

SAMPLE

DRAFTER TYPED NAME TITLE OFFICE SYMBOL PHONE

SPECIAL INSTRUCTIONS

RELEASER

TYPED NAME TITLE OFFICE SYMBOL AND PHONE

SIGNATURE

SECURITY CLASSIFICATION

DATE TIME GROUP

DD FORM 173/2 (OCR) PREVIOUS EDITION IS OBSOLETE GPO: 1979 302-175

Figure B-3. DD Form 173/1—Joint Messageform (MILSTRIP Requisition)

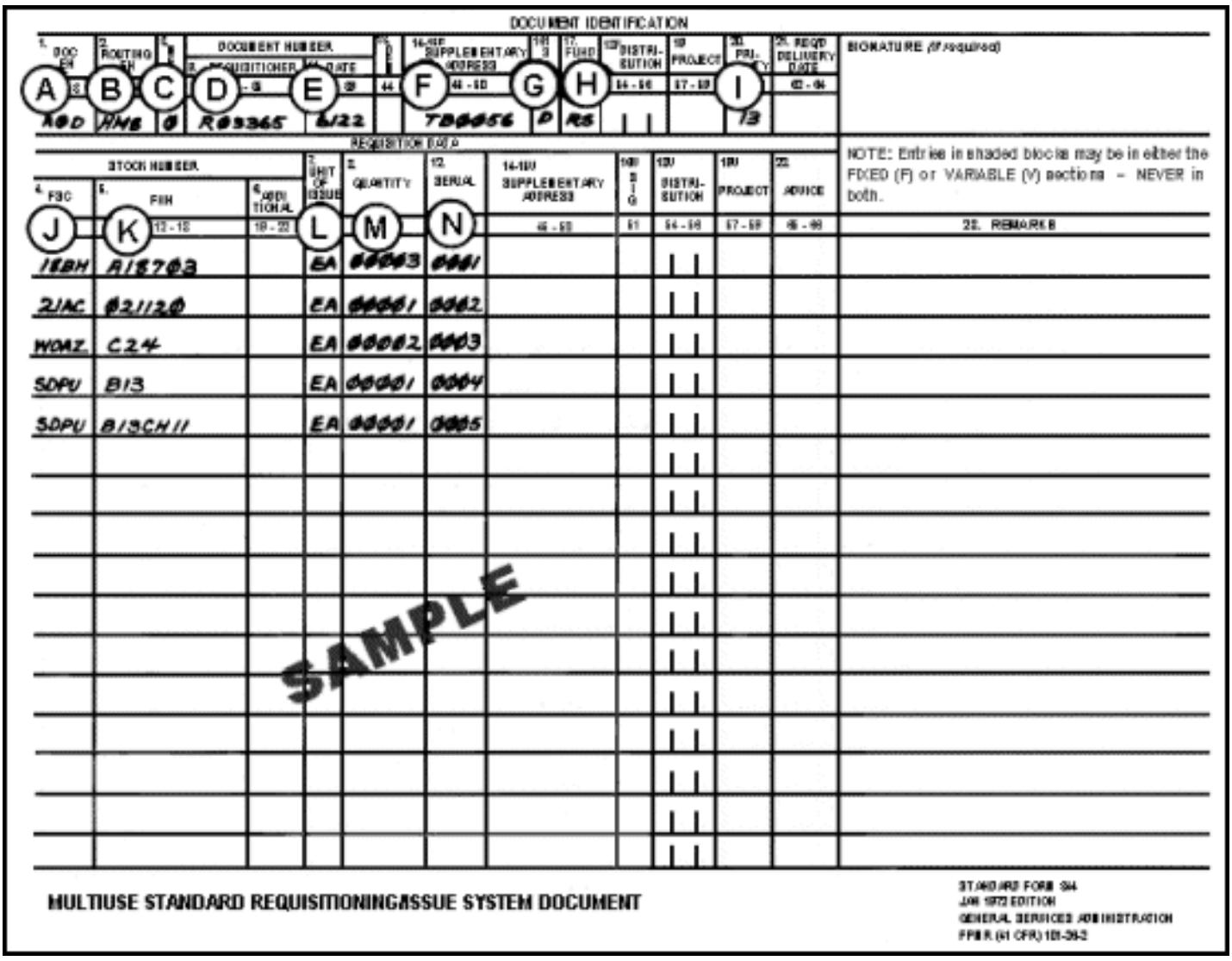


Figure B-4. SF Form 344— Multiuse Standard Requisitioning/Issue System Document

A. Document Identifier Code
   AOD--CONUS Shipment
   A04--Overseas Shipment
B. Routing Identifier Code of Chart Supply Source
C. Media & Status Code
D. DoDAAD Address Code of Requisitioner
E. Julian Date of Requisition
F. Supp Addee
G. Signal Code
H. Fund Code
I. Priority Designator in accordance with DoD Directive 4410.6 (UMMIPS Code)
J. Enter the first four digits of the five-digit series designator.
K. Enter last digit of the series designator and the balance of the stock number.
L. Unit of Issue (EA)
M. Quantity Requested
N. Requisition Serial Number

NOTE: This form will also be used to requisition any nautical products excluded from DADMS. Indicate complete mailing address where material is to be shipped and justification where required. Submit directly to:

DMA OFFICE OF DISTRIBUTION SERVICES
ATTN: DDCP
Washington, DC 20315

Search

Appendix C

Extract From American Practical Navigator, Volume II

The following is an extract (Table 7, Distance of an Object by Two Bearings) from Volume II of the American Practical Navigator.

TABLE 7.
Distance of an Object by Two Bearings.

Difference between the course and second bearing.	Difference between the course and first bearing.													
	20º		22º		24º		26º		28º		30º		32º	
30º	1.97	0.98												
32	1.64	0.87	2.16	1.14										
34	1.41	0.79	1.80	1.01	2.34	1.31								
36	1.24	0.73	1.55	0.91	1.96	1.15	2.52	1.48						
38	1.11	0.68	1.36	0.84	1.68	1.04	2.11	1.30	2.70	1.66				
40	1.00	0.64	1.21	0.78	1.48	0.95	1.81	1.16	2.26	1.45	2.88	1.85		
42	0.91	0.61	1.10	0.73	1.32	0.88	1.59	1.06	1.94	1.30	2.40	1.61	3.05	2.04
44	0.84	0.58	1.00	0.69	1.19	0.83	1.42	0.98	1.70	1.18	2.07	1.44	2.55	1.77
46	0.78	0.56	0.92	0.66	1.09	0.78	1.28	0.92	1.52	1.09	1.81	1.30	2.19	1.58
48	0.73	0.54	0.85	0.64	1.00	0.74	1.17	0.87	1.37	1.02	1.62	1.20	1.92	1.43
50	0.68	0.52	0.80	0.61	0.93	0.71	1.08	0.83	1.25	0.96	1.46	1.12	1.71	1.31
52	0.65	0.51	0.75	0.59	0.87	0.68	1.00	0.79	1.15	0.91	1.33	1.05	1.55	1.22
54	0.61	0.49	0.71	0.57	0.81	0.66	0.93	0.76	1.07	0.87	1.23	0.99	1.41	1.14
56	0.58	0.48	0.7	0.56	0.77	0.64	0.88	0.73	1.00	0.83	1.14	0.95	1.30	1.08

58	0.56	0.47	0.64	0.54	0.73	0.62	0.83	0.70	0.94	0.80	1.07	0.90	1.21	1.03
60	0.53	0.46	0.61	0.53	0.69	0.60	0.78	0.68	0.89	0.77	1.00	0.87	1.13	0.98
62	0.51	0.45	0.58	0.51	0.66	0.58	0.75	0.66	0.84	0.74	0.94	0.83	1.06	0.94
64	0.49	0.44	0.56	0.50	0.63	0.57	0.71	0.64	0.80	0.72	0.89	0.80	1.00	0.90
66	0.48	9.43	9.54	9.49	9.61	9.56	9.68	0.62	0.76	0.70	0.85	0.78	0.95	0.87
68	0.46	0.43	0.52	0.48	0.59	0.54	0.66	0.61	0.73	0.68	0.81	0.75	0.90	0.84
70	0.45	0.42	0.50	0.47	0.57	0.53	0.63	0.59	0.70	0.66	0.78	0.73	0.86	0.81
72	0.43	0.41	0.49	0.47	0.55	0.52	0.61	0.58	0.68	0.64	0.75	0.71	0.82	0.78
74	0.42	0.41	0.48	0.46	0.53	0.51	0.59	0.57	0.65	0.63	0.72	0.69	0.79	0.76
76	0.41	0.40	0.46	0.45	0.52	0.50	0.57	0.56	0.63	0.61	0.70	0.67	0.76	0.74
78	0.40	0.39	0.45	0.44	0.50	0.49	0.56	0.54	0.61	0.60	0.67	0.66	0.74	0.72
80	0.39	0.39	0.44	0.44	0.49	0.48	0.54	0.53	0.60	0.59	0.65	0.64	0.71	0.70
82	0.39	0.38	0.43	0.43	0.48	0.47	0.53	0.52	0.58	0.57	0.63	0.63	0.69	0.69
84	0.38	0.38	0.42	0.42	0.47	0.47	0.52	0.51	0.57	0.56	0.62	0.61	0.67	0.67
86	0.37	0.37	0.42	0.42	0.46	0.46	0.51	0.51	0.55	0.55	0.60	0.60	0.66	0.65
88	0.37	0.37	0.41	0.41	0.45	0.45	0.50	0.50	0.54	0.54	0.59	0.59	0.64	0.64
90	0.36	0.36	0.40	0.40	0.45	0.45	0.49	0.49	0.53	0.53	0.58	0.58	0.62	0.62
92	0.36	0.36	0.40	0.40	0.44	0.44	0.48	0.48	0.52	0.52	0.57	0.57	0.61	0.61
94	0.36	0.35	0.39	0.39	0.43	0.43	0.47	0.47	0.51	0.51	0.56	0.55	0.60	0.60
96	0.35	0.35	0.39	0.39	0.43	0.43	0.47	0.46	0.51	0.50	0.55	0.54	0.59	0.59
98	0.35	0.35	0.39	0.38	0.42	0.42	0.46	0.46	0.50	0.50	0.54	0.53	0.58	0.57
100	0.35	0.34	0.38	0.38	0.42	0.41	0.46	0.45	0.49	0.49	0.53	0.52	0.57	0.56
102	0.35	0.34	0.38	0.37	0.42	0.41	0.45	0.44	0.49	0.48	0.53	0.51	0.56	0.55
104	0.34	0.33	0.38	0.37	0.41	0.40	0.45	0.43	0.48	0.47	0.52	0.50	0.56	0.54
106	0.34	0.33	0.38	0.36	0.41	0.39	0.45	0.43	0.48	0.46	0.52	0.50	0.55	0.53
108	0.34	0.32	0.38	0.36	0.41	0.39	0.44	0.42	0.48	0.45	0.51	0.49	0.55	0.52
110	0.34	0.32	0.37	0.35	0.41	0.38	0.44	0.41	0.47	0.44	0.51	0.48	0.54	0.51
112	0.34	0.32	0.37	0.35	0.41	0.38	0.44	0.41	0.47	0.44	0.50	0.47	0.54	0.50
114	0.34	0.31	0.37	0.34	0.41	0.37	0.44	0.40	0.47	0.43	0.50	0.46	0.54	0.49
116	0.34	0.31	0.38	0.34	0.41	0.37	0.44	0.39	0.47	0.42	0.50	0.45	0.53	0.48
118	0.35	0.31	0.38	0.33	0.41	0.36	0.44	0.39	0.47	0.41	0.50	0.44	0.53	0.47
120	0.35	0.30	0.38	0.33	0.41	0.36	0.44	0.38	0.47	0.41	0.50	0.43	0.53	0.46

122	0.35	0.30	0.38	0.32	0.41	0.35	0.44	0.37	0.47	0.40	0.50	0.42	0.53	0.45
124	0.35	0.29	0.38	0.32	0.41	0.34	0.44	0.37	0.47	0.39	0.50	0.42	0.53	0.44
126	0.36	0.29	0.39	0.31	0.42	0.34	0.45	0.36	0.47	0.38	0.50	0.41	0.53	0.43
128	0.36	0.28	0.39	0.31	0.42	0.33	0.45	0.35	0.48	0.38	0.50	0.40	0.53	0.42
130	0.36	0.28	0.39	0.30	0.42	0.32	0.45	0.35	0.48	0.37	0.51	0.39	0.54	0.41
132	0.37	0.27	0.40	0.30	0.43	0.32	0.46	0.34	0.48	0.36	0.51	0.38	0.54	0.40
134	0.37	0.27	0.40	0.29	0.43	0.31	0.46	0.33	0.49	0.35	0.52	0.37	0.54	0.39
136	0.38	0.26	0.41	0.28	0.44	0.30	0.47	0.32	0.49	0.34	0.52	0.36	0.55	0.38
138	0.39	0.26	0.42	0.28	0.45	0.30	0.47	0.32	0.50	0.33	0.53	0.35	0.55	0.37
140	0.39	0.25	0.42	0.27	0.45	0.29	0.48	0.31	0.51	0.33	0.53	0.34	0.56	0.36
142	0.40	0.25	0.43	0.27	0.46	0.28	0.49	0.30	0.51	0.32	0.54	0.33	0.56	0.35
144	0.41	0.24	0.44	0.26	0.47	0.28	0.50	0.29	0.52	0.31	0.55	0.32	0.57	0.34
146	0.42	0.24	0.45	0.25	0.48	0.27	0.51	0.28	0.53	0.30	0.56	0.31	0.58	0.32
148	0.43	0.23	0.46	0.25	0.49	0.26	0.52	0.27	0.54	0.29	0.57	0.30	0.59	0.31
150	0.45	0.22	0.48	0.24	0.50	0.25	0.53	0.26	0.55	0.28	0.58	0.29	0.60	0.30
152	0.46	0.22	0.49	0.23	0.52	0.24	0.54	0.25	0.57	0.27	0.59	0.28	0.61	0.29
154	0.48	0.21	0.50	0.22	0.53	0.23	0.56	0.24	0.58	0.25	0.60	0.26	0.62	0.27
156	0.49	0.20	0.52	0.21	0.55	0.22	0.57	0.23	0.60	0.24	0.62	0.25	0.64	0.26
158	0.51	0.19	0.54	0.20	0.57	0.21	0.59	0.22	0.61	0.23	0.63	0.24	0.66	0.25
160	0.53	0.18	0.56	0.19	0.59	0.20	0.61	0.21	0.63	0.22	0.65	0.22	0.67	0.23

TABLE 7.
Distance of an Object by Two Bearings.

Difference between the course and second bearing.	Difference between the course and first bearing.													
	34º		36º		38º		40º		42º		44º		46º	

44º	3.22	2.24											
46	2.69	1.93	3.39	2.43									
48	2.31	1.72	2.83	2.10	3.55	2.63							
50	2.03	1.55	2.43	1.86	2.96	2.27	3.70	2.84					
52	1.81	1.43	2.13	1.68	2.54	2.01	3.09	2.44	3.85	3.05			
54	1.63	1.32	1.90	1.54	2.23	1.81	2.66	2.15	3.22	2.60	4.00	3.24	
56	1.49	1.24	1.72	1.42	1.99	1.65	2.33	1.93	2.77	2.29	3.34	2.77	4.14	3.43
58	1.37	1.17	1.57	1.33	1.80	1.53	2.98	1.76	2.43	2.06	2.87	2.44	3.46	2.93
60	1.28	1.10	1.45	1.25	1.64	1.42	1.88	1.63	2.17	1.88	2.52	2.18	2.97	2.57
62	1.19	1.05	1.34	1.18	1.51	1.34	1.72	1.52	1.96	1.73	2.25	1.98	2.61	2.30
64	1.12	1.01	1.25	1.13	1.40	1.26	1.58	1.42	1.79	1.61	2.03	1.83	2.33	2.09
66	1.06	0.96	1.18	1.07	1.31	1.20	1.47	1.34	1.65	1.51	1.85	1.9	2.10	1.92
68	1.00	0.93	1.11	1.03	1.23	1.14	1.37	1.27	1.53	1.42	1.71	1.58	1.92	1.78
70	0.95	0.89	1.05	0.99	1.16	1.09	1.29	1.21	1.43	1.34	1.58	1.49	1.77	1.66
72	0.91	0.86	1.00	0.95	1.10	1.05	1.21	1.15	1.34	1.27	1.48	1.41	1.64	1.56
74	0.87	0.84	0.95	0.92	1.05	1.01	1.15	1.10	1.26	1.21	1.39	1.34	1.53	1.47
76	0.84	0.81	0.91	0.89	1.00	0.97	1.09	1.06	1.20	1.16	1.31	1.27	1.44	1.40
78	0.80	0.79	0.88	0.86	0.96	0.94	1.04	1.02	1.14	1.11	1.24	1.22	1.36	1.33
80	0.78	0.77	0.85	0.83	0.92	0.91	1.00	0.98	1.09	1.07	1.18	1.16	1.28	1.27
82	0.75	0.75	0.82	0.81	0.89	0.88	0.96	0.95	1.04	1.03	1.13	1.12	1.22	1.21
84	0.73	0.73	0.79	0.79	0.86	0.85	0.93	0.92	1.00	0.99	1.08	1.07	1.17	1.16
86	0.71	0.71	0.77	0.77	0.83	0.83	0.89	0.89	0.96	0.96	1.04	1.04	1.12	1.12
88	0.69	0.69	0.75	0.75	0.80	0.80	0.86	0.86	0.93	0.93	1.00	1.00	1.08	1.07
90	0.67	0.67	0.73	0.73	0.78	0.78	0.84	0.84	0.90	0.90	0.97	0.97	1.04	1.04
92	0.66	0.66	0.71	0.71	0.76	0.76	0.82	0.82	0.87	0.87	0.93	0.93	1.00	1.00
94	0.65	0.64	0.69	0.69	0.74	0.74	0.79	0.79	0.85	0.85	0.91	0.90	0.97	0.97
96	0.63	0.63	0.68	0.67	0.73	0.72	0.78	0.77	0.83	0.82	0.88	0.88	0.94	0.93
98	0.62	0.62	0.67	0.66	0.71	0.70	0.76	0.75	0.81	0.80	0.86	0.85	0.91	0.90

100	0.61	0.60	0.65	0.64	0.70	0.69	0.74	0.73	0.79	0.78	0.84	0.83	0.89	0.88
102	0.60	0.59	0.64	0.63	0.68	0.67	0.73	0.71	0.77	0.76	0.82	0.80	0.87	0.85
104	0.60	0.58	0.63	0.61	0.67	0.65	0.72	0.69	0.76	0.74	0.80	0.78	0.85	0.82
106	0.59	0.57	0.63	0.60	0.68	0.64	0.70	0.68	0.74	0.72	0.79	0.76	0.83	0.80
108	0.58	0.55	0.62	0.59	0.66	0.62	0.69	0.66	0.73	0.70	0.77	0.74	0.81	0.77
110	0.58	0.54	0.61	0.57	0.65	0.61	0.68	0.64	0.72	0.68	0.76	0.71	0.80	0.75
112	0.57	0.53	0.61	0.56	0.64	0.59	0.68	0.63	0.71	0.66	0.75	0.69	0.79	0.73
114	0.57	0.52	0.60	0.55	0.63	0.58	0.67	0.61	0.70	0.64	0.74	0.68	0.78	0.71
116	0.56	0.51	0.60	0.54	0.63	0.57	0.66	0.60	0.70	0.63	0.73	0.66	0.77	0.69
118	0.56	0.50	0.59	0.52	0.63	0.55	0.66	0.58	0.69	0.61	0.72	0.64	0.76	0.67
120	0.56	0.49	0.59	0.51	0.62	0.54	0.65	0.57	0.68	0.59	0.72	0.62	0.75	0.65
122	0.56	0.47	0.59	0.50	0.62	0.53	0.65	0.55	0.68	0.58	0.71	0.60	0.74	0.63
124	0.56	0.46	0.59	0.49	0.62	0.51	0.65	0.54	0.68	0.56	0.71	0.58	0.74	0.61
126	0.56	0.45	0.59	0.48	0.62	0.50	0.64	0.52	0.67	0.54	0.70	0.57	0.73	0.59
128	0.56	0.44	0.59	0.46	0.62	0.49	0.64	0.51	0.67	0.53	0.70	0.55	0.73	0.57
130	0.56	0.43	0.59	0.45	0.62	0.47	0.64	0.49	0.67	0.51	0.70	0.53	0.72	0.55
132	0.56	0.42	0.59	0.44	0.62	0.46	0.64	0.48	0.67	0.50	0.70	0.52	0.72	0.54
134	0.57	0.41	0.59	0.43	0.62	0.45	0.64	0.46	0.67	0.48	0.69	0.50	0.72	0.52
136	0.57	0.40	0.60	0.41	0.62	0.43	0.65	0.45	0.67	0.47	0.70	0.48	0.72	0.50
138	0.58	0.39	0.60	0.40	0.63	0.42	0.65	0.43	0.67	0.45	0.70	0.47	0.72	0.48
140	0.58	0.37	0.61	0.39	0.63	0.40	0.65	0.42	0.68	0.43	0.70	0.45	0.72	0.46
142	0.59	0.36	0.61	0.38	0.63	0.39	0.66	0.41	0.68	0.42	0.70	0.43	0.72	0.45
144	0.60	0.35	0.62	0.36	0.64	0.38	0.66	0.39	0.68	0.40	0.71	0.41	0.73	0.43
146	0.60	0.34	0.63	0.35	0.65	0.36	0.67	0.37	0.69	0.39	0.71	0.40	0.73	0.41
148	0.61	0.32	0.63	0.34	0.66	0.35	0.68	0.36	0.70	0.37	0.72	0.38	0.74	0.39
150	0.62	0.31	0.64	0.32	0.66	0.33	0.68	0.34	0.70	0.35	0.72	0.36	0.74	0.37
152	0.63	0.30	0.65	0.31	0.67	0.32	0.69	0.33	0.71	0.33	0.73	0.34	0.75	0.35
154	0.65	0.28	0.67	0.29	0.68	0.30	0.70	0.31	0.72	0.32	0.74	0.32	0.76	0.33
156	0.66	0.27	0.68	0.28	0.70	0.28	0.72	0.29	0.73	0.30	0.75	0.30	0.77	0.31
158	0.67	0.25	0.69	0.26	0.71	0.27	0.73	0.27	0.74	0.28	0.76	0.28	0.78	0.29
160	0.69	0.24	0.71	0.24	0.73	0.25	0.74	0.25	0.76	0.26	0.77	0.26	0.79	0.27

TABLE 7.
Distance of an Object by Two Bearings.

Difference between the course and second bearing.	Difference between the course and first bearing.													
	48º		50º		52º		54º		56º		58º		60º	
58º	4.28	3.63												
60	3.57	3.10	4.41	3.82										
62	3.07	2.71	3.68	3.25	4.54	4.01								
64	2.70	2.42	3.17	2.85	3.79	3.41	4.66	4.19						
66	2.40	2.20	2.78	2.54	3.26	2.98	3.89	3.55	4.77	4.36				
68	2.17	2.01	2.48	2.30	2.86	2.65	3.34	3.10	3.99	3.71	4.88	4.53		
70	1.98	1.86	2.24	2.10	2.55	2.39	2.94	2.76	3.43	3.22	4.08	3.83	4.99	4.69
72	1.83	1.74	2.04	1.94	2.30	2.19	2.62	2.49	3.01	2.86	3.51	3.33	4.17	3.96
74	1.70	1.63	1.88	1.81	2.10	2.02	2.37	2.27	2.68	2.58	3.08	2.96	3.58	3.44
76	1.58	1.54	1.75	1.70	1.94	1.88	2.16	2.10	2.42	2.35	2.74	2.66	3.14	3.05
78	1.49	1.45	1.63	1.60	1.80	1.76	1.99	1.95	2.21	2.16	2.48	2.43	2.80	2.74

80	1.40	1.38	1.53	1.51	1.68	1.65	1.85	1.82	2.04	2.01	2.26	2.23	2.53	2.49
82	1.33	1.32	1.45	1.43	1.58	1.56	1.72	1.71	1.89	1.87	2.08	2.06	2.31	2.29
84	1.26	1.26	1.37	1.36	1.49	1.48	1.62	1.61	1.77	1.76	1.93	1.92	2.13	2.12
86	1.21	1.20	1.30	1.30	1.41	1.41	1.53	1.52	1.66	1.65	1.81	1.80	1.98	1.97
88	1.16	1.16	1.24	1.24	1.34	1.34	1.45	1.45	1.56	1.56	1.70	1.70	1.84	1.84
90	1.11	1.11	1.19	1.19	1.28	1.28	1.38	1.38	1.48	1.48	1.60	1.60	1.73	1.73
92	1.07	1.07	1.14	1.14	1.23	1.23	1.31	1.31	1.41	1.41	1.52	1.52	1.63	1.63
94	1.03	1.03	1.10	1.10	1.18	1.17	1.26	1.26	1.35	1.34	1.44	1.44	1.55	1.54
96	1.00	0.99	1.06	1.06	1.13	1.13	1.21	1.20	1.29	1.28	1.38	1.37	1.47	1.47
98	0.97	0.96	1.03	1.02	1.10	1.08	1.16	1.15	1.24	1.23	1.32	1.31	1.41	1.39
100	0.94	0.93	1.00	0.98	1.06	1.04	1.12	1.11	1.19	1.18	1.27	1.25	1.35	1.33
102	0.92	0.90	0.97	0.95	1.03	1.01	1.09	1.06	1.15	1.13	1.22	1.19	1.29	1.27
104	0.90	0.87	0.95	0.92	1.00	0.97	1.06	1.02	1.12	1.08	1.18	1.14	1.25	1.21
106	0.88	0.84	0.92	0.89	0.97	0.94	1.03	0.99	1.09	1.04	1.14	1.10	1.20	1.16
108	0.86	0.82	0.90	0.86	0.95	0.90	1.00	0.95	1.05	1.00	1.11	1.05	1.17	1.11
110	0.84	0.79	0.88	0.83	0.93	0.87	0.98	0.92	1.02	0.96	1.08	1.01	1.13	1.06
112	0.83	0.77	0.87	0.80	0.91	0.84	0.95	0.88	1.00	0.93	1.05	0.97	1.10	1.02
114	0.81	0.74	0.85	0.78	0.89	0.82	0.93	0.85	0.98	0.89	1.02	0.93	1.07	0.98
116	0.80	0.72	0.84	0.75	0.88	0.79	0.92	0.82	0.96	0.85	1.00	0.90	1.04	0.94
118	0.79	0.70	0.83	0.73	0.86	0.76	0.90	0.79	0.94	0.83	0.98	0.86	1.02	0.90
120	0.78	0.68	0.82	0.71	0.85	0.74	0.89	0.77	0.91	0.80	0.96	0.83	1.00	0.87
122	0.77	0.66	0.81	0.68	0.84	0.71	0.87	0.74	0.90	0.77	0.95	0.80	0.98	0.83
124	0.77	0.63	0.80	0.66	0.83	0.69	0.86	0.71	0.90	0.74	0.93	0.77	0.96	0.80
126	0.76	0.61	0.79	0.64	0.82	0.66	0.85	0.69	0.88	0.71	0.91	0.74	0.95	0.77
128	0.75	0.59	0.78	0.62	0.81	0.64	0.84	0.66	0.87	0.69	0.90	0.71	0.93	0.74
130	0.75	0.57	0.78	0.60	0.81	0.62	0.83	0.64	0.86	0.66	0.89	0.68	0.92	0.71
132	0.75	0.56	0.77	0.57	0.80	0.59	0.83	0.61	0.85	0.64	0.88	0.66	0.91	0.68
134	0.74	0.54	0.77	0.55	0.80	0.57	0.82	0.59	0.85	0.61	0.87	0.63	0.90	0.65
136	0.74	0.52	0.77	0.53	0.80	0.55	0.82	0.57	0.84	0.58	0.87	0.60	0.89	0.62
138	0.74	0.50	0.77	0.51	0.79	0.53	0.81	0.54	0.84	0.56	0.86	0.58	0.89	0.59
140	0.74	0.48	0.77	0.49	0.79	0.51	0.81	0.52	0.83	0.54	0.86	0.55	0.88	0.57
142	0.74	0.46	0.77	0.47	0.79	0.49	0.81	0.50	0.83	0.51	0.85	0.52	0.87	0.54

144	0.75	0.44	0.77	0.45	0.79	0.46	0.81	0.48	0.83	0.49	0.85	0.50	0.87	0.51
146	0.75	0.42	0.77	0.43	0.79	0.44	0.81	0.45	0.83	0.46	0.85	0.47	0.87	0.49
148	0.76	0.40	0.77	0.41	0.79	0.42	0.81	0.43	0.83	0.44	0.85	0.45	0.87	0.46
150	0.76	0.38	0.78	0.39	0.80	0.40	0.81	0.41	0.83	0.42	0.85	0.42	0.87	0.43
152	0.77	0.36	0.78	0.37	0.80	0.38	0.82	0.38	0.83	0.39	0.85	0.40	0.87	0.41
154	0.77	0.34	0.79	0.35	0.81	0.35	0.82	0.36	0.84	0.37	0.85	0.37	0.87	0.38
156	0.78	0.32	0.80	0.32	0.81	0.33	0.83	0.34	0.84	0.34	0.86	0.35	0.87	0.35
158	0.79	0.30	0.81	0.30	0.82	0.31	0.83	0.31	0.85	0.32	0.86	0.32	0.87	0.33
160	0.80	0.27	0.82	0.28	0.83	0.28	0.84	0.29	0.85	0.29	0.86	0.30	0.88	0.30

TABLE 7.
Distance of an Object by Two Bearings.

Difference between the course and second bearing.	Difference between the course and first bearing.															
	62º		64º		66º		68º		70º		72 º		74º		76º	

72º	5.08	4.84														
74	4.25	4.08	5.18	4.98												
76	3.65	3.54	4.32	4.19	5.26	5.10										
78	3.20	3.13	3.72	3.63	4.39	4.30	5.34	5.22								
80	2.86	2.81	3.26	3.21	3.78	3.72	4.46	4.39	5.41	5.33						
82	2.58	2.56	2.91	2.88	3.31	3.28	3.83	3.80	4.52	4.48	5.48	5.42				
84	2.36	2.34	2.63	2.61	2.96	2.94	3.36	3.35	3.88	3.86	4.57	4.55	5.54	5.51		
86	2.17	2.17	2.40	2.39	2.67	2.66	3.00	2.99	3.41	3.40	3.93	3.92	4.62	4.61	5.59	5.57
88	2.01	2.01	2.21	2.21	2.44	2.44	2.71	2.71	3.04	3.04	3.45	3.45	3.97	3.97	4.67	4.66
90	1.88	1.88	2.05	2.05	2.25	2.25	2.48	2.48	2.75	2.75	3.08	3.08	3.49	3.49	4.01	4.01
92	1.77	1.76	1.91	1.91	2.08	2.08	2.28	2.28	2.51	2.51	2.78	2.78	3.11	3.11	3.52	3.52
94	1.67	1.66	1.80	1.79	1.95	1.94	2.12	2.11	2.31	2.30	2.54	2.53	2.81	2.80	3.14	3.13
96	1.58	1.57	1.70	1.69	1.83	1.82	1.97	1.96	2.14	2.13	2.34	2.33	2.57	2.55	2.84	2.82
98	1.50	1.49	1.61	1.59	1.72	1.71	1.85	1.84	2.00	1.98	2.17	2.15	2.36	2.34	2.59	2.56
100	1.43	1.41	1.53	1.51	1.63	1.61	1.75	1.72	1.88	1.85	2.03	2.00	2.19	2.16	2.39	2.35
102	1.37	1.34	1.46	1.43	1.55	1.52	1.66	1.62	1.77	1.73	1.90	1.86	2.05	2.00	2.21	2.16
104	1.32	1.28	1.40	1.36	1.48	1.44	1.58	1.53	1.68	1.63	1.79	1.74	1.92	1.87	2.07	2.01
106	1.27	1.22	1.34	1.29	1.42	1.37	1.51	1.45	1.60	1.54	1.70	1.63	1.81	1.74	1.94	1.87
108	1.23	1.17	1.29	1.23	1.37	1.30	1.44	1.37	1.53	1.45	1.62	1.54	1.72	1.63	1.83	1.74
110	1.19	1.12	1.25	1.17	1.32	1.24	1.39	1.30	1.46	1.37	1.54	1.45	1.64	1.54	1.74	1.63
112	1.15	1.07	1.21	1.12	1.27	1.18	1.33	1.24	1.40	1.30	1.48	1.37	1.56	1.45	1.65	1.53
114	1.12	1.02	1.17	1.07	1.23	1.12	1.29	1.18	1.35	1.24	1.42	1.30	1.50	1.37	1.58	1.44
116	1.09	0.98	1.14	1.03	1.19	1.07	1.25	1.12	1.31	1.17	1.37	1.23	1.44	1.29	1.51	1.36

118	1.07	0.94	1.11	0.98	1.16	1.02	1.21	1.07	1.26	1.12	1.32	1.17	1.38	1.22	1.45	1.28
120	1.04	0.90	1.08	0.94	1.13	0.98	1.18	1.02	1.23	1.06	1.28	1.11	1.34	1.16	1.40	1.21
122	1.02	0.86	1.06	0.90	1.10	0.93	1.15	0.97	1.19	1.01	1.24	1.05	1.29	1.10	1.35	1.14
124	1.00	0.83	1.04	0.86	1.08	0.89	1.12	0.93	1.16	0.96	1.21	1.00	1.25	1.04	1.31	1.08
126	0.98	0.79	1.02	0.82	1.05	0.85	1.09	0.88	1.13	0.92	1.18	0.95	1.22	0.99	1.27	1.02
128	0.97	0.76	1.00	0.79	1.03	0.82	1.07	0.84	1.11	0.87	1.15	0.90	1.19	0.94	1.23	0.97
130	0.95	0.73	0.98	0.75	1.02	0.78	1.05	0.80	1.09	0.83	1.12	0.86	1.16	0.89	1.20	0.92
132	0.94	0.70	0.97	0.72	1.00	0.74	1.03	0.77	1.06	0.79	1.10	0.82	1.13	0.84	1.17	0.87
134	0.93	0.67	0.96	0.69	0.99	0.71	1.01	0.73	1.04	0.75	1.08	0.77	1.11	0.80	1.14	0.82
136	0.92	0.64	0.95	0.66	0.97	0.68	1.00	0.69	1.03	0.71	1.06	0.74	1.09	0.76	1.12	0.78
138	0.91	0.61	0.94	0.63	0.96	0.64	0.99	0.66	1.01	0.68	1.04	0.70	1.07	0.72	1.10	0.74
140	0.90	0.58	0.93	0.60	0.95	0.61	0.97	0.63	1.00	0.64	1.03	0.66	1.05	0.68	1.08	0.70
142	0.90	0.55	0.92	0.57	0.94	0.58	0.96	0.59	0.99	0.61	1.01	0.62	1.04	0.64	1.06	0.65
144	0.89	0.52	0.91	0.54	0.93	0.55	0.96	0.56	0.98	0.57	1.00	0.59	1.02	0.60	1.05	0.62
146	0.89	0.50	0.91	0.51	0.93	0.52	0.95	0.53	0.97	0.54	0.99	0.55	1.01	0.57	1.03	0.58
148	0.89	0.47	0.90	0.48	0.92	0.49	0.94	0.50	0.96	0.51	0.98	0.52	1.00	0.53	1.02	0.54
150	0.88	0.44	0.90	0.45	0.92	0.46	0.94	0.47	0.95	0.48	0.97	0.49	0.99	0.50	1.01	0.50
152	0.88	0.41	0.90	0.42	0.92	0.43	0.93	0.44	0.95	0.45	0.97	0.45	0.98	0.46	1.00	0.47
154	0.88	0.39	0.90	0.39	0.91	0.40	0.93	0.41	0.94	0.41	0.96	0.42	0.98	0.43	0.99	0.43
156	0.89	0.36	0.90	0.37	0.91	0.37	0.93	0.38	0.94	0.38	0.96	0.39	0.97	0.39	0.99	0.40
158	0.89	0.33	0.90	0.34	0.91	0.34	0.93	0.35	0.94	0.35	0.95	0.36	0.97	0.36	0.98	0.37
160	0.89	0.30	0.90	0.31	0.91	0.31	0.93	0.32	0.94	0.32	0.95	0.33	0.96	0.33	0.98	0.33

TABLE 7.
Distance of an Object by Two Bearings.

Difference between the course and second bearing.	Difference between the course and first bearing.															
	78º		80º		82º		84º		86º		88 º		90º		92º	

88º	5.63	5.63													
90	4.70	4.70	5.67	5.67											
92	4.04	4.04	4.74	4.74	5.70	5.70									
94	3.55	3.54	4.07	4.06	4.76	4.75	5.73	5.71							
96	3.17	3.15	3.57	3.55	4.09	4.07	4.78	4.76	5.74	5.71					
98	2.86	2.83	3.19	3.16	3.59	3.56	4.11	4.07	4.80	4.75	5.73	5.70			
100	2.61	2.57	2.88	2.84	3.20	3.16	3.61	3.55	4.12	4.06	4.81	4.73	5.76	5.67	
102	2.40	2.35	2.63	2.57	2.90	2.83	3.22	3.15	3.62	3.54	4.13	4.04	4.81	4.70	5.76	5.63
104	2.23	2.16	2.42	2.35	2.64	2.56	2.91	2.82	3.23	3.13	3.63	3.52	4.13	4.01	4.81	4.66
106	2.08	2.00	2.25	2.16	2.43	2.34	2.65	2.55	2.92	2.80	3.23	3.11	3.63	3.49	4.13	3.97
108	1.96	1.86	2.10	2.00	2.26	2.15	2.45	2.33	2.66	2.53	2.92	2.78	3.24	3.08	3.63	3.45
110	1.85	1.73	1.97	1.85	2.11	1.98	2.27	2.13	2.45	2.31	2.67	2.51	2.92	2.75	3.23	3.04
112	1.75	1.62	1.86	1.72	1.98	1.83	2.12	1.96	2.28	2.11	2.46	2.28	2.67	2.48	2.92	2.71
114	1.66	1.52	1.76	1.61	1.87	1.71	1.99	1.82	2.12	1.94	2.28	2.08	2.46	2.25	2.67	2.44
116	1.59	1.43	1.68	1.51	1.77	1.59	1.88	1.69	2.00	1.79	2.13	1.91	2.28	2.05	2.46	2.21
118	1.52	1.34	1.60	1.41	1.68	1.49	1.78	1.57	1.88	1.66	2.00	1.76	2.13	1.88	2.28	2.01
120	1.46	1.27	1.53	1.33	1.61	1.39	1.69	1.47	1.78	1.54	1.89	1.63	2.00	1.73	2.13	1.84
122	1.41	1.19	1.47	1.25	1.54	1.31	1.62	1.37	1.70	1.44	1.79	1.52	1.89	1.60	2.00	1.70
124	1.36	1.13	1.42	1.18	1.48	1.23	1.55	1.28	1.62	1.34	1.70	1.41	1.79	1.48	1.89	1.56
126	1.32	1.06	1.37	1.11	1.43	1.15	1.48	1.20	1.55	1.26	1.62	1.31	1.70	1.38	1.79	1.45
128	1.28	1.01	1.33	1.04	1.38	1.08	1.43	1.13	1.49	1.17	1.55	1.23	1.62	1.28	1.70	1.34
130	1.24	0.95	1.29	0.98	1.33	1.02	1.38	1.06	1.44	1.10	1.49	1.14	1.56	1.19	1.62	1.24
132	1.21	0.90	1.25	0.93	1.29	0.96	1.34	0.99	1.39	1.03	1.44	1.07	1.49	1.11	1.55	1.16
134	1.18	0.85	1.22	0.88	1.26	0.90	1.30	0.93	1.34	0.97	1.30	1.00	1.44	1.04	1.49	1.07
136	1.15	0.80	1.19	0.83	1.22	0.85	1.26	0.88	1.30	0.90	1.34	0.93	1.39	0.97	1.44	1.00
138	1.13	0.76	1.16	0.78	1.19	0.80	1.23	0.82	1.27	0.85	1.30	0.87	1.35	0.90	1.39	0.93
140	1.11	0.71	1.14	0.73	1.17	0.75	1.20	0.77	1.23	0.79	1.27	0.82	1.31	0.84	1.34	0.86
142	1.09	0.67	1.12	0.69	1.14	0.70	1.17	0.72	1.20	0.74	1.24	0.76	1.27	0.78	1.30	0.80
144	1.07	0.63	1.10	0.64	1.12	0.66	1.15	0.67	1.18	0.69	1.21	0.71	1.24	0.73	1.27	0.75
146	1.05	0.59	1.08	0.60	1.10	0.62	1.13	0.63	1.15	0.64	1.18	0.66	1.21	0.67	1.24	0.69
148	1.04	0.55	1.06	0.56	1.08	0.57	1.11	0.59	1.13	0.60	1.15	0.61	1.18	0.62	1.21	0.64

150	1.03	0.51	1.05	0.52	1.07	0.53	1.09	0.54	1.11	0.55	1.13	0.57	1.15	0.58	1.18	0.59
152	1.02	0.48	1.04	0.49	1.05	0.49	1.07	0.50	1.09	0.51	1.11	0.52	1.13	0.53	1.15	0.54
154	1.01	0.44	1.02	0.45	1.04	0.46	1.06	0.46	1.08	0.47	1.09	0.48	1.11	0.49	1.13	0.50
156	1.00	0.41	1.01	0.41	1.03	0.42	1.05	0.43	1.06	0.43	1.08	0.44	1.09	0.45	1.11	0.45
158	0.99	0.37	1.01	0.38	1.02	0.38	1.03	0.39	1.05	0.39	1.06	0.40	1.08	0.40	1.09	0.41
160	0.99	0.34	1.00	0.34	1.01	0.35	1.02	0.35	1.04	0.35	1.05	0.36	1.06	0.36	1.08	0.37
	94º		96º		98º		100º		102º		104 º		106º		108º	
104º	5.74	5.57														
106	4.80	4.61	5.78	5.51												
108	4.12	3.92	4.78	4.55	5.70	5.42										
110	3.62	3.40	4.11	3.86	4.76	4.48	5.67	5.33								
112	3.23	2.99	3.61	3.35	4.09	3.80	4.74	4.40	5.63	5.22						
114	2.92	2.66	3.22	2.94	3.59	3.28	4.07	3.72	4.70	4.30	5.59	5.10				
116	2.66	2.39	2.91	2.61	3.20	2.88	3.57	3.21	4.04	3.63	4.67	4.19	5.54	4.98		
118	2.45	2.17	2.65	2.34	2.90	2.56	3.19	2.81	3.55	3.13	4.01	3.54	4.62	4.08	5.48	4.84
120	2.28	1.97	2.45	2.12	2.64	2.29	2.88	2.49	3.17	2.74	3.52	3.05	3.97	3.44	4.57	3.96
122	2.12	1.80	2.27	1.92	2.43	2.06	2.63	2.23	2.86	2.43	3.14	2.66	3.49	2.96	3.93	3.33
124	2.00	1.65	2.12	1.76	2.26	1.87	2.42	2.01	2.61	2.16	2.84	2.35	3.11	2.58	3.45	2.86
126	1.88	1.52	1.99	1.61	2.11	1.71	2.25	1.82	2.40	1.95	2.59	2.10	2.81	2.27	3.08	2.49
128	1.78	1.41	1.88	1.48	1.98	1.56	2.10	1.65	2.23	1.76	2.39	1.88	2.57	2.02	2.78	2.19
130	1.70	1.30	1.78	1.36	1.87	1.43	1.97	1.51	2.08	1.60	2.21	1.70	2.36	1.81	2.54	1.94
132	1.62	1.20	1.69	1.26	1.77	1.32	1.86	1.38	1.96	1.45	2.07	1.54	2.19	1.63	2.34	1.74
134	1.55	1.12	1.62	1.16	1.68	1.21	1.76	1.27	1.85	1.33	1.94	1.40	2.05	1.47	2.17	1.56
136	1.49	1.04	1.55	1.07	1.61	1.12	1.68	1.16	1.75	1.22	1.83	1.27	1.92	1.34	2.03	1.41
138	1.44	0.96	1.49	0.99	1.54	1.03	1.60	1.07	1.66	1.11	1.74	1.16	1.81	1.21	1.90	1.27
140	1.39	0.89	1.43	0.92	1.48	0.95	1.53	0.98	1.59	1.02	1.65	1.06	1.72	1.10	1.79	1.15
142	1.34	0.83	1.38	0.85	1.43	0.88	1.47	0.91	1.52	0.94	1.58	0.97	1.64	1.01	1.70	1.05
144	1.30	0.77	1.34	0.79	1.38	0.81	1.42	0.83	1.46	0.86	1.51	0.89	1.56	0.92	1.62	0.95
146	1.27	0.71	1.30	0.73	1.33	0.75	1.37	0.77	1.41	0.79	1.45	0.81	1.50	0.84	1.54	0.86

148	1.23	0.65	1.26	0.67	1.29	0.69	1.33	0.70	1.36	0.72	1.40	0.74	1.44	0.76	1.48	0.78
150	1.20	0.60	1.23	0.61	1.26	0.63	1.29	0.64	1.32	0.66	1.35	0.67	1.38	0.69	1.42	0.71
152	1.18	0.55	1.20	0.56	1.22	0.57	1.25	0.59	1.28	0.60	1.31	0.61	1.34	0.63	1.37	0.64
154	1.15	0.50	1.17	0.51	1.19	0.52	1.22	0.53	1.24	0.54	1.27	0.56	1.29	0.57	1.32	0.58
156	1.13	0.46	1.15	0.47	1.17	0.47	1.19	0.48	1.21	0.49	1.23	0.50	1.25	0.51	1.28	0.52
158	1.11	0.42	1.13	0.42	1.14	0.43	1.16	0.44	1.18	0.44	1.20	0.45	1.22	0.46	1.24	0.47
160	1.09	0.37	1.11	0.38	1.12	0.38	1.14	0.39	1.15	0.39	1.17	0.40	1.19	0.41	1.21	0.41

TABLE 7.
Distance of an Object by Two Bearings.

Difference between the course and second bearing.	Difference between the course and first bearing.													
	110º		112º		114º		116º		118º		120º		122º	
120º	5.41	4.69												
122	4.52	3.83	5.34	4.53										
124	3.88	3.22	4.46	3.70	5.26	4.36								
126	3.41	2.76	3.83	3.10	4.39	3.55	5.18	4.19						
128	3.04	2.40	3.36	2.65	3.78	2.98	4.32	3.41	5.08	4.01				
130	2.75	2.10	3.00	2.30	3.31	2.54	3.72	2.85	4.25	3.25	4.99	3.82		
132	2.51	1.86	2.71	2.01	2.96	2.20	3.26	2.42	3.65	2.71	4.17	3.10	4.88	3.63
134	2.31	1.66	2.48	1.78	2.67	1.92	2.91	2.09	3.20	2.30	3.58	2.57	4.08	2.93
136	2.14	1.49	2.28	1.58	2.44	1.69	2.63	1.83	2.86	1.98	3.14	2.18	3.51	2.44
138	2.00	1.34	2.12	1.42	2.25	1.50	2.40	1.61	2.58	1.73	2.80	1.88	3.08	2.06
140	1.88	1.21	1.97	1.27	2.08	1.34	2.21	1.42	2.36	1.52	2.53	1.63	2.74	1.76
142	1.77	1.09	1.85	1.14	1.95	1.20	2.05	1.26	2.17	1.34	2.31	1.42	2.48	1.53
144	1.68	0.99	1.75	1.03	1.83	1.07	1.91	1.13	2.01	1.18	2.13	1.25	2.26	1.33
146	1.60	0.89	1.66	0.93	1.72	0.96	1.80	1.01	1.88	1.05	1.98	1.10	2.08	1.17
148	1.53	0.81	1.58	0.84	1.63	0.87	1.70	0.90	1.77	0.94	1.84	0.98	1.93	1.03
150	1.46	0.73	1.51	0.75	1.55	0.78	1.61	0.80	1.67	0.83	1.73	0.87	1.81	0.90

152	1.40	0.66	1.44	0.68	1.48	0.70	1.53	0.72	1.58	0.74	1.63	0.77	1.70	0.80
154	1.35	0.59	1.39	0.61	1.42	0.62	1.46	0.64	1.50	0.66	1.55	0.68	1.60	0.70
156	1.31	0.53	1.33	0.54	1.37	0.56	1.40	0.57	1.43	0.58	1.47	0.60	1.52	0.62
158	1.26	0.47	1.29	0.48	1.32	0.49	1.34	0.50	1.37	0.51	1.41	0.53	1.44	0.54
160	1.23	0.42	1.25	0.43	1.27	0.43	1.29	0.44	1.32	0.45	1.35	0.46	1.38	0.47
	124º		126º		128º		130º		132º		134 º		136º	
134º	4.77	3.43												
136	3.99	2.77	4.66	3.23										
138	3.43	2.29	3.89	2.60	4.54	3.04								
140	3.01	1.93	3.34	2.15	3.79	2.44	4.41	2.84						
142	2.68	1.65	2.94	1.81	3.26	2.01	3.66	2.27	4.28	2.63				
144	2.42	1.42	2.62	1.54	2.86	1.68	3.17	1.86	3.57	2.10	4.14	2.43		
146	2.21	1.24	2.37	1.32	2.55	1.43	2.78	1.55	3.07	1.72	3.46	1.93	4.00	2.24
148	2.04	1.08	2.16	1.14	2.30	1.22	2.48	1.31	2.70	1.43	2.97	1.58	3.34	1.77
150	1.89	0.95	1.99	0.99	2.10	1.05	2.24	1.12	2.40	1.20	2.61	1.30	2.87	1.44
152	1.77	0.83	1.85	0.87	1.94	0.91	2.04	0.96	2.17	1.02	2.33	1.09	2.52	1.18
154	1.66	0.73	1.72	0.76	1.80	0.79	1.88	0.83	1.98	0.87	2.10	0.92	2.25	0.99
156	1.56	0.64	1.62	0.66	1.68	0.68	1.75	0.71	1.83	0.74	1.92	0.78	2.03	0.83
158	1.48	0.56	1.53	0.57	1.58	0.59	1.63	0.61	1.70	0.64	1.77	0.66	1.85	0.69
160	1.41	0.48	1.45	0.49	1.49	0.51	1.53	0.52	1.58	0.54	1.64	0.56	1.71	0.58
	138º		140º		142º		144º		146º		148 º		150º	

148º	3.85	2.04												
150	3.22	1.61	3.70	1.85										
152	2.77	1.30	3.09	1.45	3.55	1.66								
154	2.43	1.06	2.66	1.16	2.96	1.30	3.28	1.48						
156	2.17	0.88	2.33	0.95	2.54	1.04	2.83	1.15	3.22	1.31				
158	1.96	0.73	2.08	0.78	2.23	0.84	2.43	0.91	2.69	1.01	3.05	1.14		
160	1.79	0.61	1.88	0.64	1.99	0.68	2.13	0.73	2.31	0.79	2.55	0.87	2.88	0.98

Appendix D

Wire And Nylon Towlines

A towline carries most of the load in a tug-and-tow operation. This appendix describes the use, maintenance, precautions, and life expectancy of wire and nylon towlines.

CARE OF WIRE ROPE TOWLINE

D-1. Wire rope towline is very expensive. It is important to keep it in excellent condition, protect it against excessive wear, and inspect it regularly.

LUBRICATION

D-2. Wire rope, like a machine, is made up of many moving parts. The steel fibers slide independently and must be protected by adequate lubrication against the effects of stress. Corrosion damage is also a danger. There is no way of estimating the exact loss of strength resulting from corrosion.

D-3. During manufacture, wire rope is thoroughly lubricated. However, this lubrication is lost during operation and must be renewed periodically and after each use. Use relatively fluid oil of light viscosity (such as linseed oil). If the oil is stiff, it must be heated. Apply the oil so that it penetrates through all the strands to the core. Apply the oil by swabbing, using a brush, or by pouring the oil on the rope.

D-4. If wire rope is to be stored for some time, lubricate it with a heavy oil (such as crude petroleum) to which a small amount of graphite has been added.

WINDING ON A DRUM

D-5. Ideally, only one layer of wire rope should be wound on a drum. Where this is impractical, the rope must be carefully wound so that each layer spools evenly over the preceding layer. The drum must be the correct size for the rope size.

DISTRIBUTION OF WEAR

D-6. A towline can be reversed occasionally to redistribute the wear, or one end can be cut. These are complicated operations because of the construction of wire rope. They must be done in a shipyard.

ACCELERATION

D-7. Suddenly applying a load to wire rope by rapid acceleration causes stress much greater than the weight or resistance of the tow. Avoid such strain on the rope by gradual acceleration.

STOWING

D-8. When not in use, stow wire rope in a dry place where there is no acid. Keep the outer layer lubricated.

BREAKING IN NEW ROPE

D-9. New wire rope is broken in by using it first with a light load or no load. A towline may be streamed aft before connecting to the tow. This procedure ensures a straight fairlead.

INSPECTION

D-10. Inspect the rope thoroughly as it is being wound after each use. Look for broken strands in the outer layer. When one-half the diameter of the fibers of the outer layer is worn away, the rope should be replaced. Worn wire rope is an indication of chafing. The cause of the chafing should be investigated. Ensure that the rope is properly lubricated and stored after use and inspection.

Note: Wire rope must not be thrown away; it is extremely expensive and in port can be cut into usable lengths for other purposes.

SPECIAL TREATMENT OF WIRE ROPE EXPOSED TO SEAWATER

D-11. After using a wire rope towline in seawater, wash it with freshwater and lubricate it with linseed oil. If the rope is to be submerged for a long time, saturate it with a heated preservative made of one part Stockholm tar to one part fresh slaked line, boiled.

MISUSE OF WIRE ROPE TOWLINES

D-12. It is extremely important that wire rope be used and maintained properly because of the great expense involved. It should not be subjected to any of the following common abuses:

- Chafing.
- Rope of incorrect size.
- Drum of inadequate size.
- Improper winding on drum.
- Improper or insufficient lubrication.
- Exposure to acid fumes.
- Lack of protection against moisture and saltwater.
- Kinks.
- Sudden acceleration.
- Touching the seabed.

Note: Simple shipboard action can prevent damage to wire rope. Adequate use of chafing gear, puddings, and fairleads; and timely change of nip will greatly increase the life of wire rope.

CARE OF NYLON TOWLINE

D-13. The tensile strength of nylon line is approximately twice that of manila line of equal size. It will stretch under strain and return to its normal length. Nylon line resists rot and mildew. If properly maintained, it should last five times longer as manila line.

ABRASION

D-14. Chafing gear should always be used at points of abrasion where there are sharp metal edges. If possible, ensure that all holding devices have smooth surfaces. If the yarn becomes abraded, cut away the chafed section and splice the ends.

D-15. Glazed areas may appear where the line has worked against bitts or chocks. These areas do not affect the strength of the line. When reeling in, ensure that thimble and connecting links do not chafe or cut hawers.

CLEANING

D-16. If nylon becomes oily or greasy, scrub it with freshwater and a paste-like mixture of granulated soap. For heavy accumulation of oil or grease, soak the line overnight in a 5 percent solution of a high alkaline detergent and freshwater (about 1 cup per gallon of water). Then scrub as directed above.

STRETCHING

D-17. Nylon line can stand repeated stretching. It thins out when under load and returns to normal if the stretch does not exceed 40 percent. Beyond that, the line may part. When the stretch becomes excessive, double the lines by passing the bight. This reduces the danger of snapback.

NEW HAWSERS

D-18. New cable-laid nylon hawers may be stiff. Tension the cables at 30 percent extension for 20 minutes.

D-19. When new lines are strained, they produce a sharp crackling sound. This is the result of readjustment of the line strands to stretching and should not be alarming.

D-20. To uncoil new line, unreel it as you would wire rope. Do not pull the end through the eye of the coil.

COILING AND WINDING

D-21. When not using a powered reel, coil the line in a different direction each time. This prevents unbalancing the lay.

STOWAGE

D-22. Stow nylon rope away from strong sunlight, heat, and strong chemicals. Cover the rope with tarpaulins. If the line is iced over, thaw it carefully and drain it before stowing.

USE OF NYLON WITH OTHER ROPE

D-23. When using sets of lines in parallel (for example, purchases), use nylon line with nylon line only, not with wire or manila. Other kinds of line must not be used on the same chock or bitt with nylon. Always use a nylon stopper with nylon towlines under load.

CHARACTERISTICS OF NYLON LINE UNDER LOAD

D-24. Plain-laid nylon hawsers may elongate around the bitts under load. Minimize by taking a turn under the horn and crossing the line on itself before taking more turns.

D-25. Sudden surges may occur when nylon hawsers are used on capstans for heavy towing or impact loading. Take six turns on the capstan. The standing part of the line is led to a set of bitts and figure eighted. This provides a back up and is a precaution against surges.

ALONGSIDE TOWING

D-26. Make up forward and backing towlines as closely as possible. Take up slack in the relaxed line while the other line is under load. It may be necessary to reverse the tug's engines slightly when easing pull. This counteracts the elasticity of the nylon and prevents snapback.

SPECIAL PRECAUTIONS

D-27. Snapback may occur after a 50 percent stretching. Ensure that personnel are away from the direct line of pull when applying heavy loads.

D-28. Nylon line around bitts may slip when eased out under heavy load because its coefficient of friction is below that of manila. This may cause injury to personnel who have not been thoroughly instructed in the peculiarities of nylon line. Take two or three turns on the bitt before figure eighting the line; this provides closer control. Stand well clear of the bitts.

Glossary

Abeam	directional term meaning at a right angle to the centerline or keel of a vessel.
ABS	American Bureau of Shipping
AFFF	aqueous film-forming foam
Aft or after	at, near, or toward the stern.
Aground	resting on the bottom (refers only to floating craft).
Aids to navigation	charted marks (such as buoys, beacons, lights, and electronic devices) to assist navigators.
Aloft	above the upper deck, as up in the rigging.
AM	amplitude modulated
Amidships	usually in the line of the keel, but sometimes halfway between bow and stern; often contracted to "midships."
Anchor	iron device so shaped as to grip the bottom and hold a vessel at her berth by the chain or rope attached.
Anchor buoy	a small buoy, usually painted a distinctive color, attached to an anchor by a light line and used to indicate the location of the anchor on the bottom.
Anemometer	instrument for measuring wind velocity.
Aneroid barometer	instrument used to measure atmospheric pressure.
ANSI	American National Standards Institute
AR	Army regulation

Arming	a piece of tallow or soap put in the cavity and over the bottom of a lead line.
Astern	behind the vessel; in the direction of the stern.
Athwartship	at right angles to the fore-and-aft line of a vessel; across the vessel in a direction at right angles to the keel.
ATTN	attention
AUTODIN	Automatic Digital Network
Backstay	SEE stay.
Bank	the side of a river channel, especially that part that usually rises above the water level. Also a shallow area of shifting sand, gravel, mud, and so forth (for example, a sandbank or mudbank).
Bar	a ridge or succession of ridges of sand or other substance, especially a formation extending across the mouth of a river or harbor or off a beach, and which may obstruct navigation.
Barrier reef	name given to reefs separated from the adjacent coast by a channel or lagoon.
Batten	long strip of wood or metal used for various purposes aboard ship.
Batten down	to close or make watertight, referring to hatches and cargo.
BC	barge cargo
BD	barge derrick
Beacon	a post or buoy placed over a shoal or bank to warn vessels of danger; also a signal mark on land.
Beam	the maximum width of a vessel, also called breadth.
Becket	loop of rope with a knot at one end to catch in an eye at the other.
Bend	a combination of turns and tucks by which a line is fastened to another one; to tie, as in securing a line to a cleat; to shackle a chain to an anchor; make fast.
Berth	a place for securing a vessel, either in the stream or alongside a wharf or other vessel.
BG	barge, liquid, nonpropelled
Bight	loop or double part of a rope; also, any part of a rope within the ends.

Bilge	the lowest interior position of a ship; the water that accumulates in the bilge is called bilge water.
Bilge pump	a pump used aboard vessels to remove accumulations of water in the bilge.
Binnacle	a compass stand made of nonmagnetic material, serving also to illuminate and protect the compass.
Bitter end	last end of a rope or inboard end of an anchor cable secured to a bitt.
Bitts	pair of heavy posts, set vertically in a deck or on a pier, to which mooring or towing lines are fastened.
Block	grooved pulley or sheave in a frame or shell provided with a hook, eye, or strap, by which it may be attached.
Boat hook	a wooden staff with a metal hook and prod at one end used for fending off or holding on when coming alongside a vessel or a wharf. It is also used for picking up small objects from the water.
Boom	spar having many uses, such as the boom for a sail, a boat boom, or a cargo boom.
Bow	the forward part of a vessel.
Bow anchors	two heavy anchors carried in the forward part of the vessel and ordinarily used in anchoring.
Bowline	a line leading from the bow of a vessel.
BR	barge, refrigerator
Breast line	a mooring line leading at an angle of about 90 ¡ from the fore-and-aft line of vessel to a wharf or another vessel.
Bridge	raised athwartships platform from which a vessel is steered and navigated.
Broaching to	to be thrown broadside to, in surf, heavy seas, or on the beach.
BS	breaking strain; breaking strength (in pounds)
Bulkhead	partition dividing the interior of a vessel into various compartments.
Bulwark	light plating or wooden extension of the hull above an exposed deck, furnishing protection against weather and loss of material or personnel.

Buoys	floating beacons, moored to the bottom, which by their shape and color convey valuable information as to position (such as channel, anchor, shoal, and rock).
C	celsius; circumference (in inches)
Capstan	vertical revolving drum, spool-shaped, used generally for heaving in towing or mooring lines.
Cathead	the outside spool on a winch.
CB	citizen's band
C.E.	compass error
C-E	communications-electronics
CEOI	Communications-Electronics Operation Instructions
CF	causeway ferry
CFR	Code of Federal Regulations
CG	Coast Guard
Chafe	to wear down by rubbing the surface of a line against a solid object.
Chafing gear	a guard of canvas, rope, or similar material placed around spars, lines, or rigging to prevent wear.
Chocks	round or oval holes in a vessel’s bulwark, sometimes fitted with rollers, through which hawsers and ropes are passed; also blocks of wood for supporting boats, weights, and so on.
Cleat	wood or metal fitting that has two projecting horns to which a line is secured.
CMG	course made good
CO_2	carbon dioxide
Coaming	sidewall of a hatch projecting above the deck around the perimeter of the hatch to prevent water from going below.
Cofferdam	a watertight structure fixed on the side of a vessel for making repairs below the waterline, sometimes constructed on the beach around a part of a vessel.
COG	course over ground

Collision bulkhead	partition in the forward part of a vessel, of sufficiently heavy material, to stand the great strain if the bow is damaged.
Collision mat	heavy square of canvas, roped and fitted with various lines, which can be hauled under the side to plug a leak or shell hole temporarily.
COMDINST	commandant instructions
COML	commercial
Compass error	influences which prevent the compass needle from pointing to the geographic North Pole.
Compass north	an imaginary point toward which the north end of the compass needle actually points; its direction varies with both variation and deviation.
Compass rose	a circle graduated in degrees, clockwise from 0 ¡ at the reference direction to 360 ¡ , and sometimes also marked to show compass points. Compass roses are placed at convenient locations on charts to ease measurement of direction.
COMSEC	communications security
Control ship	a ship to guide and act as a headquarters for the control of waterborne traffic.
CONUS	continental United States
Cordage	a general form for line of all kinds.
Coxswain	the enlisted person in charge of a small craft.
CP	command post
CPR	cardio-pulmonary resuscitation
Crane	derrick used aboard ship for swinging boats in and out, also for handling weights.
CW	carrier wave; continuous wave
D	diameter
DA	Department of the Army
DADMS	DMA automated distribution management system
DAJAZA	Department of the Army Judge Advocate

Danger angle	an angle (sighted from a vessel), between two charted objects, which if not exceeded will allow the craft to safely pass a known hazard.
Danger bearing	a bearing, to a charted object, which is used to ensure that a craft will safely pass a certain known hazard, usually used to determine the point where a change of course can be safely made.
Davits	small cranes on a vessel that are used to hoist and lower boats, especially lifeboats.
DC	direct current
D.C.	District of Columbia
DD	Department of Defense
DDCP	Department of Defense Control Point
Deadeye	wooden block through which holes are pierced to receive a lanyard which is used especially with shrouds and stays.
Deadlights	strong shutters that screw down upon air portholes and keep out water in heavy weather.
Dead reckoning	calculation of ship’s position kept by observing a vessel’s course and distance by the log.
DEV.	deviation
Deviation	angular difference at the vessel between the direction of magnetic north and compass north. An error of the compass caused by the magnetic influence of the iron and steel within the ship itself.
Diesel engine	type of internal-combustion engine in which air is compressed to a temperature sufficiently high to ignite fuel injected directly into the cylinder.
Distribute	delivery, piece by piece, in turn to members of a group.
DMA	Defense Mapping Agency
DMAHC	Defense Mapping Agency Hydrographic Center
DMAHTC	Defense Mapping Agency Hydrographic and Topographic Center
DOD	Department of Defense
Dogs	small, bent metal fittings used to secure watertight doors, hatch covers, manhole covers, and so on to close and fasten as tight as possible.

Double-bottom tanks	watertight tanks formed by placing steel plating a few feet above the skin or outer bottom for the purpose of protecting a vessel if the outer bottom is damaged; used to store oil, water, and so forth.
DR	dead reckoning
Draft	single load of cargo; also refers to the depth of water which a vessel requires to float freely; the depth of a vessel from the waterline to the keel; also a sling load of cargo.
DSC	Digital Selective Calling
DSN	Defense Switched Network
Dunnage	loose material placed on the bottom of the hold above the ballast; used to stow cargo.
E	east
Ebb current	tidal current flowing out to sea.
EMP	electromagnetic pulse
Engine room	compartment containing the propulsion machinery of a vessel.
Ensign	flag; the emblem of a vessel's nationality.
EP	estimated position
EPIRB	emergency position-indicating radio beacon
Equator	that great circle which lies midway between the poles.
Estimate	an opinion or judgment of the nature, character, or quality of something.
ETA	estimated time of arrival
Eye splice	loop spliced in the end of a line.
F	Fahrenheit; friction
Fairlead	fittings or devices used in preserving the direction of line, chain, or wire so that it may be delivered fairly, or on a straight lead, to the sheave, drum, and so on.
Fairway	the ship channel part of the river or harbor where the navigable channel for large vessels lies.

Faking down	to lay down rope in long or circular turns (coils) so that each turn of rope overlaps the next one underneath in such a way that the rope is clear for running.
Fall	by common usage, the entire length of rope used in a tackle such as (plural) boat falls and cargo falls.
Fantail	extreme after deck of a vessel; after section of the main deck; upper and round part of the stern.
Fast	secure; also, secure with a mooring line.
Fathom	a nautical measure equal to 6 feet; used as a measure of depth of water.
FC	floating causeway
Fenders	a device of canvas, wood, or rope used over the side to take the shock of contact between vessel and wharf or other vessel when alongside.
Fid	a tapering pin, usually of wood, used to open the strands of line for splicing.
Fire-main system	permanent fire-control installation for an entire vessel consisting of water pipes, plugs to which hoses are attached, pumps, valves, and controls.
Flagstaff	small vertical spar at the stern on which the ensign is hoisted while a vessel is at anchor.
Flood current	tidal current flowing in from the sea.
FM	field manual; frequency modulation
fm	fathom
Fore	parts of a vessel at or adjacent to the bow; also parts between the mid-ship section and stern.
Fore and aft	lengthwise of a ship.
Forecastle	the upper deck forward of the foremast and included in the bow area.
Forestay	SEE stay.
Foul	entangle or impede.
Frames	skeleton structure, or ribs, of a vessel.

Freeboard	distance from the waterline to the top of the main deck, measured amidships.
ft	feet
GA.	gauge
Gale	wind with a velocity of 34 to 48 knots.
Galley	a vessel’s kitchen.
Gangway	passageway or ladder up a ship’s side.
Gear	general term for a collection of spars, ropes, blocks, and equipment.
GI	government issue
GMDSS	Global Marine Distress and Safety System
GPM	gallons per minute
GPS	global positioning system
Gripes	metal fastenings for securing a boat in its cradle; canvas bands fitted with thimbles in their ends and passed from the davit heads over and under a boat for securing for sea.
Ground tackle	anchor gear.
GT	gross tons
Gunwale	the uppermost continuous strake in a vessel's side; the upper edge of a vessel's hull.
Guy	steadying rope used to support a spar in a horizontal or inclined position.
h	hour
Harbor master	officer charged with executing regulations respecting the use of a harbor.
Hard over	turning the wheel as far as possible in a given direction.
Hatch	opening in a deck giving access to cargo holds.
Hawsepipes	iron castings in a bow of a vessel through which anchor chains run.
Hawser	large line or rope such as mooring or towing line.
Headway	a vessel’s motion forward or ahead.

Heave to	to hold a vessel at sea without way; to check a vessel's way.
Heaving line	a light flexible line thrown to another vessel in order to allow a larger line or object to be transferred over.
Helm	the machine by which a vessel is steered.
HF	high frequency
Hitch	a tie for fastening by which a line is fastened to another object, either directly or around it, so that it will hold temporarily and can be readily undone.
Hold	space between the lowermost deck and the bottom of a vessel that is used for the stowage of ballast, cargo, and stores.
HQ	headquarters
HQDA	Headquarters, Department of the Army
HT	height
Hull	framework of a vessel, including all decks, but exclusive of masts, yards, riggings, and all outfit or equipment.
Hurricane	a cyclonic storm in the Western Hemisphere whose winds blow with a velocity of 64 knots or over.
Hz	hertz
IAW	in accordance with
IMCO	Inter-Governmental Maritime Consultative Organization
IMO	International Maritime Organization
in	inch(es)
Inboard	toward the centerline of a vessel; also the side next to a wharf or another vessel.
ISO	International Organization for Standardization
Jack staff	short, vertical flagpole at the bow of a ship from which the union jack is flown when a vessel is at anchor or moored.
Jury rig	a term applied to temporary structures, such as masts and rudders, used in an emergency.
Jury rudder	makeshift rudder used to steer a vessel when the rudder is damaged.

KC	kilocycles
Kedge	to move a vessel by carrying out a light anchor in a boat, dropping it overboard, and hauling the vessel up to it.
Keel	the timber or series of connected plates running from stem to sternpost on the bottom of the centerline of a vessel.
Keelson	timber or steel springer on top of the keel and used for strengthening a vessel's structure.
kHz	kilohertz
Knot	a unit of speed equal to 1 nautical mile per hour; also any tie or fastening formed with a line.
KT	kiloton
Lanyard	rope used to make anything fast, especially a short piece reeved through deadeyes, connecting shrouds, stays, and so on, to side of vessel.
LARC-LX	lighter, amphibious resupply cargo, 60-ton
LASH	lighter aboard ship
Latitude	angular distance north or south from the earth's equator measuring 0 ¡ at the equator and 90 ¡ at either pole.
Lazarette	a compartment used for storage purposes in the stern of a vessel.
LBP	length between perpendiculars
LCM	landing craft, mechanized
LCPL	landing craft, personnel, large
LCU	landing craft, utility
LCVP	Landing craft, vehicle, personnel
Lead line	weighted line with markings, which indicate the depth of water, also known as hand lead.
Leadsman	one who takes soundings or determines the depth of water by use of a lead line or hand lead.
Lee	the side opposite to that from which the wind blows.
Leeward	being in or facing the direction toward which the wind is blowing; (the lee side); being the side opposite the windward.

Left-hand propeller	when viewed from astern the propeller that turns counterclockwise while driving the boat ahead.
Left rudder	the movement of the rudder to the left of the centerline of the boat.
LF	low frequency
Lifeboat	small boat of wood, metal, or wood and metal placed aboard a vessel, with standard, prescribed equipment for use in emergencies.
Life lines	lines stretched fore and aft along the decks to give the crew safety against being washed overboard; lines thrown on board a wreck by a lifesaving crew; knotted lines secured to the span of lifeboat davits for hoisting and lowering ropes through to a man overboard.
Life jacket	an apparatus of buoyant material, usually kapok, designed to keep a person afloat.
Life raft	raft kept buoyant by cylindrical air chambers, designed to keep survivors of a disaster afloat for rescue.
Life ring	cork ring covered with canvas that is designed to support a person in water.
Line-throwing guns	guns used for lifesaving purposes that throw lines, attached to an eye in the shank of the projectile, from one vessel to another or to the shore; may be mounted or shoulder-type.
List	the inclination of a vessel to one side; as a list to port or a list to starboard.
LMSR	large, medium speed RO/RO
LNL	letter-number-letter
LOA	length overall
Locker	a chest, box, or compartment to stow things in.
LOD	line of departure
Logbook	book containing the official record of a vessel’s activities and other data relevant to its navigation, which furnishes a complete chronological history of the vessel; often called log.
LO/LO	lift on/lift off
Longitude	a position measured as so many degrees east or west of the prime meridian.

Lookout	person stationed above decks for observing and reporting objects seen.
LOP	line of position
LOTS	logistics over-the-shore
LS	line size
LSV	logistics support vessel
LT	large tug
Lubber line	a fine black line drawn on an enameled plate inside of the bowl of a magnetic compass, indicating the centerline (along the keel) of the ship.
LWL	load waterline
m	minute(s)
MA	mechanical advantage
MAG	magnetic
Magnetic compass	main navigational aid on a vessel.
Magnetic course	the angle between magnetic north and the intended track of the vessel over the bottom.
Magnetic north	the direction of the magnetic North Pole from the ship; the direction in which the compass needle points when not affected by deviations.
Main deck	first complete deck running the full length of a vessel.
Maneuver	to make a series of changes in direction and position for a specific purpose.
Marlinespike	an iron or steel pin that tapers to a sharp point used to splice wire rope.
MARPOL	marine pollution
Mast	long pole or spar rising from the keel through the decks, to sustain yards, booms, sails, and other rigging.
Maximum ebb	the greatest speed of an ebb current. The ebb is the tidal current moving away from land or down a tidal stream.
Maximum flood	the greatest speed of a flood current. The flood current is the tidal current moving toward land or up a tidal stream.

MAYDAY	general distress call.
MD	Maryland
Meridians of longitude	great circles of the earth which pass through both poles and are used to establish location in east-west direction.
Mess	group of persons eating together; the meal so taken; to supply with messes or to eat them.
Messenger	light line made fast to a hawser in order to heave the latter in.
Messenger line	a small line used to haul in a heavier line.
MF	maritime frequency
MHz	Megahertz
Midships	SEE amidships.
MILSTAMP	Military Standard Transportation and Movement Procedures
MILSTRIP	Military Standard Requisitioning and Issue Procedures
MILVAN	military-owned demountable container
Mix	to combine or blend into one mass; to combine with another.
Moored	lying with both anchors down; tied to a pier or anchor buoy; also to secure a vessel other than by anchoring with a single anchor.
Mooring lines	cables or ropes used to tie up a vessel.
MOS	military occupational specialty
MPH	miles per hour
MQB	Marine Qualification Board
MQO	marine qualification officer
MSR	main supply route
MT	megaton
N	north
NATO	North Atlantic Treaty Organization
NBC	nuclear, biological, chemical

NCO	noncommissioned officer
NCS	network control station
NE	northeast
NFPA	National Fire Protection Association
NM	nautical miles
NNE	north by northeast
No	number
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Survey
NSA	National Security Agency
NW	northwest
OBA	oxygen-breathing apparatus
ODS	Office of Distribution Services
Offshore wind	a wind blowing from the land.
Outboard	toward the side of a vessel in relation to the centerline or outside the vessel entirely; also, the side away from a wharf or vessel alongside.
Pad eye	metal eye permanently secured to a deck or bulkhead, to which lines and cables may be secured.
PAN	personal area network
Pass a line	to carry a line to or around something, or to reeve through and make fast.
Painter	line in the bow of a small boat for towing or making fast.
Pay out	to let out a line or cable secured on board.
Pelorus (dumb) compass	dummy compass used to take sightings, determining the vessel's relative position to another object.
Pennant	small flag of various forms flown on a vessel, in which the long narrow flag is flown at the masthead and the triangular one is flown as a signal; short rope on pendant.
PFD	personal floatation device

Pier	a wharf which projects into a harbor, with water and accommodations for berthing vessels on two or more sides of it.
PKP	purple-K
POL	petroleum, oils, and lubricants
Port side	the left side of a vessel looking forward, indicated by a red running light when underway at night; an opening in a vessel's side; a harbor for cargo operations.
Potable water	drinkable water, meeting standards set by the US Public Health Service.
Prow	that part of the bow of a ship above water.
psi	pounds per square inch
Psychrometer	a dry and a wet thermometer placed on one instrument used to determine relative humidity and dew point.
PT	pusher tug
Quarter	general area from the middle of a vessel to the extreme stern; also to proceed with the quarter to the wind or sea; to bring the sea or wind first on one quarter and then on the other.
R. Fix	running fix
Range lights	two white lights on the mast in the forward part of a vessel; the second range light is in line in back of and higher than the first one.
Rat guard	funnel-like protective device placed over hawsers or mooring lines to keep rats from getting aboard.
RC	reserve component
Reef	a ridge of rock or coral lying at or near the surface of the water which could pose a danger to vessels; also, in sailing vessels, to reduce the area of the sail.
Reeve	pass or thread a rope through a block.
Relative humidity	the percentage of water saturation of the air.
Relay	to wind a line around a belaying pin or cleat to make it secure or to stop it.
Rig	a vessel’s upper works; to fit out.

Rigging	the ropes of a ship; collective term for all the stays, shrouds, halyards, and lines that support a vessel's mast and booms and operate its movable parts; may be a "standing" or "running" rigging.
Right-hand propeller	when viewed from astern, the propeller that turns clockwise while driving the boat ahead.
Right rudder	the movement of the rudder to the right of the centerline of the boat.
RORO	roll on/roll off
R.P.M.	revolutions per minute
RRDF	RO/RO Discharge Facility
RSOI	Reception, Staging, Onward Movement and Integration
Rudder	flat structure hung vertically on the sternpost, just aft of the screw, and used to steer a vessel by offering resistance to the water when turned to an angle with the centerline.
Rudder amidships	the position of the rudder when it parallels the keel line of the vessel.
Rules of the road	the international and national regulations governing sailing of all vessels.
Running lights	all lights required to be shown during peacetime by a vessel that is under way.
S	south
SAR	search/air rescue
SB	size block
Scope	length of anchor chain or cable to which a vessel is riding.
Screw	propeller, located at a vessel's stern.
Screw current	the current caused by action of the propeller in water. It is discharged as a rotary current in the direction opposite to that of the vessel's movement.
Scuppers	small drains in a vessel's bulwark which are located near the deck.
Scuttle	to sink a vessel either by boring holes in her bottom or by opening her sea cocks; valves.
SE	southeast
Sea	disturbance of the ocean due to the wind (nautical sense).

Sea anchor	a device, normally a cone made out of canvas, which is put over (with a line attached) to reduce the vessel's speed over the water and to hold the bow or stern into the wind and sea. It is used when high wind and seas restrict the free navigation of vessels. Because of its construction, the sea anchor creates a drag in the water, thus reducing the speed of the vessel.
Sea buoy	last buoy before deep water that marks the channel to a harbor.
Sea cock	valve connecting with the outside sea water in the lower part of vessel which can be used to flood various parts.
Set	the direction in which a current flows; also, the direction in which a vessel is forced by the action of current or wind, or the combined force of both.
SF	safety factor; standard form
Shackle	U-shaped iron link with a removable pin that is used to make lines or blocks fast.
Shaft	rod transmitting power from a vessel’s engine to its propeller.
Shaft alley	watertight passage enclosing the shaft and its supporting bearings; also "shaft tunnel."
Sheave	a grooved wheel or pulley inside a block over which a line runs.
Sheer	a sudden change in course; also, the longitudinal upward curve of the deck of a vessel when viewed from the side.
SHP	strain on the hauling part
Shrouds	guy ropes or cables that support a mast by running athwartship from top of the mast to both sides of the vessel.
Skeg	wood or metal arm extending abaft the keel with a bearing at its after end. It supports the rudder and protects the propeller.
Skin	the inside or outside of a ship’s planking or plating.
SL	skill level
SMG	speed made good
Snatch block	block which can be opened on one side to receive a bight or rope.
SOA	speed of advance
SOG	speed over ground

SOP	standard operating procedure
SOS	save our ship
Soundings	depth of water surrounding a vessel which is determined by use of lead line or other equipment.
Span	piece of wire or rope fastened at each end to a fixture, such as a davit head.
Spar	pole, such as a mast or boom.
Splice	to join two ropes together by interweaving strands.
Spring line	a mooring line leading at an angle of about 45 ¡ from the fore-and-aft line of a vessel to a wharf or another vessel.
SSB	single side band
ST	small tug
Stadimeter	an instrument for measuring the distance to an object when the length or height of the object is known.
Stand	to maintain one’s position; to perform duties.
Starboard side	right side of a vessel looking forward; indicated by a green running light when underway at night.
Station bill	bill posted in the crew’s quarters and other conspicuous places listing the station of the crew at maneuvers and emergency drills; sometimes called muster roll.
Stay	a line or wire running fore and aft, used to support a mast, spar, or funnel; may be "forestay" or "backstay."
Stbd	starboard
Steerageway	slowest speed at which the rudder will act to change a vessel’s course.
Stem	the vertical or nearly vertical forward extension of the keel, to which the forward ends of the strakes are attached.
Stern	the after end (rear) of a vessel.
Stern line	a line leading from the stern of a vessel.
Sternpost	timber or steel bar extending from the keel to main deck at the stern of a vessel.

STON	short ton
Storm	a marked disturbance in the normal state of the atmosphere; also, a wind with a velocity of 55 to 65 knots.
Stow	to put away, to lock up for safekeeping in a proper place.
Strake	continuous line of plates running from bow to stern that contributes to a vessel's skin.
Stranded	of a vessel, run ashore.
Strongback	fore-and-aft spar extending from stem to stern on a lifeboat and serving as a raised spreader for a boat cover; also a strong bar placed across a hatch opening to hold hatch boards or covers.
Superstructure	any structure built above the top full deck.
Surf	the breaking swell or waves on a shore or shelving beach; breakers collectively.
Surf line	that point offshore, where waves and swells become breakers. The water area from this point to the beach is known as the surf zone.
Surge	the swell or heave of the sea; to slack off a line.
SW	southwest
Swell	the unbroken rise and fall of the sea surface persisting after the originating cause of the motion has ceased; a succession of long noncrested waves, as that continuing after a gale or other disturbance some distance away.
Swim	to propel oneself in water by natural means.
SWL	safe working load for a single part of a line.
SZ	surface zero
T	true north
TB	technical bulletin
Tackle	a combination of lines and blocks working together and giving a mechanical advantage to assist in lifting or moving.
Tail block	block having a rope about it and an end hanging several feet from it.
Tarpaulin	heavy, treated canvas used as a cover.
TC	Transportation Corps

Tidal current	the flow of water caused by the rise and fall of the tide.
Tiller	bar of iron or wood connected with the rudderhead and lead line, usually forward, in which the rudder is moved as desired by the tiller, and quadrant is the form of tiller most frequently used in modern vessels.
TM	technical manual
TNT	trinitrotoluene
Topside	above decks, such as on the weather deck or bridge.
Towing bitts or towing posts	vertical posts on a vessel to which towing or mooring lines are secured.
TRADOC	United States Army Training and Doctrine Command
Trim	difference in draft at the bow and stern of a vessel; manner in which a vessel floats on the water, whether on an even keel or down by the head or stern; shipshape. To adjust a vessel's position in the water by arranging ballast, cargo, and so on. To arrange for sailing; to assume, or cause a vessel to assume, a certain position, or trim, in the water.
Trough	the hollow between two wave crests or swells.
Turnbuckle	link threaded on both ends of a short bar that is used to pull objects together.
TW	total weight
UCMJ	Uniform Code of Military Justice
UEL	upper explosive limit
UL	Underwriter's Laboratories
Underway	a vessel is said to be underway when she is not anchored, moored, aground, or beached.
Union Jack	flag consisting of the blue star-studded field in the corner of the national ensign, flown at the jack staff by ships at anchor.
US	United States (of America)
USAML	United States Army Marine License
USCG	United States Coast Guard
VA	Virginia

VAR.	variation
Variation	angular difference at the vessel between the direction of true north and magnetic north.
Vehicle	liquid content which acts as a binding and drying agent in paint.
VHF	very high frequency
W	west; weight
Wake	a vessel's track or trail through the water.
Watch	period of time on duty, usually 4 hours in length; the officers and crew who tend the working of a vessel during the same watch.
Way	motion or progress through the water.
Weather	toward the point from which the wind blows; the side toward the wind; the windward.
Weather deck	deck having no overhead protection; uppermost deck.
Weigh	to raise the anchor off the bottom.
Wharf	projecting platform of timber, stone, or other material which extends into water deep enough for vessels to be accommodated alongside for loading or unloading.
Wheel	the instrument attached to the rudder by which a vessel is steered.
Whipping	the lashing of the end of a rope.
Winch	a piece of machinery, which operates a shaft, fitted with a drum or drums upon which lines or cables are wound to hoist or haul an object.
Windlass	apparatus in which horizontal or vertical drums or wheels are operated by means of a steam engine or motor for handling heavy anchor chains, hawsers, and so on.
Windward	toward the wind; being in or facing the direction from which the wind is blowing.
Wings	platforms on either side of the bridge.
WO	warrant officer
Yard	spar crossing a mast horizontally.

Yardarm	outer quarter of a horizontal spar attached to the mast athwartships, equipped with blocks for reeving signal halyards.
Yaw	to steer badly, zigzagging back and forth across the intended course of a boat; to go out of the line of course.

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