CHAPTER 8

BATTLE DAMAGE REPAIR

Learning Objective: Recall the requirements and procedures for conducting battle damage analysis and repair.

To repair battle damage, you must possess extensive knowledge of the available damage control equipment and materials. At the same time, you must be able to expeditiously analyze and determine the appropriate corrective actions needed.

Should your ship sustain a damaging hit, the damage must be investigated immediately. Precise reports from investigators that are forwarded in an expeditious manner are critical. These reports allow key damage control personnel to form a concise picture as to the extent of the damage. This process results in a determination of what actions are required to localize and overcome the casualty.

DAMAGE CONTROL EQUIPMENT AND MATERIALS

Learning Objective: Identify the various types of damage control equipment and material and recall the maintenance and inventory requirements for each.

The equipment and materials required to make repairs to battle damage vary according to the nature of the damage. Since several types of damage can occur aboard ship, you must know how to use a wide variety of equipment and materials. The Allowance Equipage List has several repair locker inventory lists for various types of ships. A typical repair locker will usually contain some or most of the following equipment, depending upon the ship's allowance:

18 oxygen breathing apparatus (OBA). Twelve canisters for each OBA and six held in reserve

- Fire-fighter's protective gloves
- Flashlights
- Sealed-beam lights
- Battle lanterns
- Extension lights
- Sounding tapes
- Helmets
- Life jackets
- Hand tools
- Electrical tools
- Chain hoist
- Screw and hydraulic jacks
- Manila line
- Forcible entry tools
- X40J cable and jack boxes
- Oxygen indicator
- Combustible gas indicator (explosimeter)
- Four gas analyzers
- Supplied air respirator with self-contained breathing apparatus (SAR/SCBA)
- Portable Exothermic Cutting Unit (PECU)
- Electrical kits
- Rubber boots
- Rubber gloves
- Spare electrical cable
- Steel wedges
- Hose and pipe flanges
- Shoring kit and shoring batten
- Plugging kit
- Pipe-patching kit (soft patches)
- Blower sleeves
- Prefabricated patches (wood and steel)
- Sound-powered phones
- Basket strainer
- Submersible pump
- Gas masks
- Chemical, Biological, and Radiological (CBR) defense protective clothing
- CBR defense detection equipment and markers

- Decontamination equipment
- Fire rakes and ladders
- Nozzles and extra fire hose
- In-line foam eductor

NOTE

On ships that have subgroups, some of this equipment is stowed in the unit lockers.

Additional damage control equipment is dispersed throughout the ship in designated areas. This equipment includes the following:

- Portable gasoline-driven fire pumps (P 100 FIRE PUMP) and hoses
- Fire hose
- Nozzles
- Applicators
- Aqueous film-forming foam (AFFF) cans
- CO_2 extinguishers
- Dry-chemical extinguishers
- Portable blowers
- Submersible pumps
- Eductors
- Shoring kit
- Shoring materials
- Plate patches
- Battle lanterns
- Casualty power cables

RELIABILITY OF DAMAGE CONTROL EQUIPMENT

The damage control organization cannot function without an adequate supply of damage control equipment. As a Damage Controlman, you will help to ensure that all damage control equipment is available and in good condition. Frequent inspections are required according to Planned Maintenance System (PMS) guidelines. These inspections ensure that all damage control equipment, tools, and materials on your ship's allowance list are actually on board. Compare the ship's allowance list with an accurate and up-to-date inventory list of onboard damage control equipment. Check to see that all damage control equipment is stowed or installed in its designated location and that it is readily accessible. Emergencies can be handled much more effectively if the equipment is available and if you do not have to waste time looking for it. The equipment assigned to each repair locker should be identified in such a way that each of the items can be returned to that repair locker after they have been used. A simple color code marking system can be used. All tools and equipment that belong to a certain repair locker should be marked with a striped band or a spot of identifying color of that repair locker.

Damage control equipment should NEVER be used for any purpose other than damage control. Damage control equipment is located throughout the ship, and some people are tempted to use it just because it is handy. This must NOT be allowed. All hands are responsible for damage control and must realize that their lives may literally depend upon the ready availability and condition of damage control equipment in an emergency.

DAMAGE CONTROL KITS

At each repair locker a number of repair kits are made up and stowed in canvas bags. These kits are kept ready to be taken to the scene of damage. The kits should be constructed and packaged so they will fit through the smallest watertight scuttle on your ship. These kits are commonly called plugging kits, pipe-patching kits, and shoring kits.

All damage control kits and repair locker equipment must be inventoried according to PMS requirements after each use. Each damage control kit should have a list of contents attached to the carrying strap. This list makes it relatively simple to inventory the contents of the kit. Any equipment or material found missing during the inventory should be replaced as soon as possible. Your ship's Coordinated Shipboard Allowance List (COSAL) shows the amount of each item that is allowed for the ship. A stencil on the outside of the bag should identify each damage control kit.

Extra plugging and pipe-patching kits are made up for the engineering spaces. These extra kits are inventoried and maintained by the personnel assigned to the engineering spaces.

PATCHING MATERIALS

A number of materials are available to plug and patch holes and to cover and secure patches. Some of

the materials commonly used for these purposes are listed below.

Plugging and Patching Materials

Plugging and patching materials include wooden plugs and wedges, wooden shoring, prefabricated wooden box patches in various sizes, rags, pillows, mattresses, blankets, kapok life jackets, metal plate, folding metal plate patches, flexible sheet metal patches, prefabricated steel box patches, bucket patches, and welded steel patches.

Securing Materials

Securing materials include assorted hook bolts, manila line, wire rope, chain, machine bolts, angle clips for welding, and shoring. Backup materials include mess tables, metal joiner doors, buckets, plywood or lumber, sheet metal, and metal plate.

Gasket Materials

Gasket materials include sheet and strip rubber, leather, canvas, rags, and oakum.

REVIEW QUESTIONS

Q1. What document provides several repair locker inventory lists for various types of ships?

1. Table of Allowance List (TOAL)
2. Allowance Equipage List (AEL)
3. Damage Control Equipment List (DCEL)
4. Master Repair Locker List (MRLL)

Q2. On a Navy ship, what personnel are responsible for damage control?

1. All hands
2. Damage control parties only
3. Damage control supervisors only
4. Damage control assistants and damage control team leaders only

Q3. After each use, all damage control kits and repair locker equipment must be inventoried to meet what requirements?

1. PQS
2. PMS
3. NAVSEA
4. OPNAV

HULL REPAIRS

Learning Objective: Recall factors that affect underwater repairs and the procedures used for plugging and patching holes in the hull of a ship.

Any rupture, break, or hole in the ship's outer hull plating, particularly below the waterline, can allow seawater to enter the ship. If flooding continues uncontrolled, the ship will sink.

When the underwater hull is pierced, there are only two possible courses of action. They are as follows:

1. Plug the holes or openings.
2. Establish and maintain flooding boundaries within the ship to prevent further progress of the flooding.

Dewatering can be effective only after these two measures have been taken.

The one very important thing to remember about flooding is that a ship can sink just as easily from a series of small and insignificant looking holes, as it can from one large and more dramatic looking hole. The natural tendency is to attack the obvious damage first and to overlook the smaller holes in the hull and in interior bulkheads. You may waste hours trying to patch large holes in already flooded compartments. Meanwhile, you disregard the smaller holes through which progressive flooding is taking place. In many cases, it would be better to concentrate on the smaller holes. As a rule, the really large holes in the underwater hull cannot be repaired until the ship is dry-docked.

All holes in the hull, large or small, should be plugged completely as soon as possible. As an interim measure, all holes should be partially plugged if they cannot be completely plugged. Even a partial plug can substantially reduce danger of sinking by dramatically reducing the amount of water entering the ship.

Holes in the hull that are at or just above the waterline should be given immediate attention. Holes in this location may not appear to be dangerous but they are. As the ship rolls or loses buoyancy, the holes become submerged and allow water to enter at a level that is dangerously high above the ship's center of gravity. These holes must be plugged at once. Give the holes at the waterline or on the low side priority (if the ship is listing), and then plug the higher holes.

The same methods and materials used to repair holes above the waterline are also used, for the most part, in the repair of underwater holes. The repair of

underwater holes tends to be more difficult. Therefore, any Damage Controlman who can repair underwater damage must certainly be able to repair similar damage above the waterline. For this reason, most of the discussion in this chapter will deal with the repair of underwater damage.

FACTORS AFFECTING UNDERWATER REPAIRS

The primary factors that make it difficult to repair underwater holes are as follows:

1. The pressure exerted by the water
2. The relative inaccessibility of the damage

The difficulties caused by water pressure are often exaggerated. Actually, a hole 7 feet below the waterline is only subjected to a water pressure of about 3 pounds per square inch.

Figure 8-1 shows the flooding effect of unplugged holes and of the same holes after inserting simple plugs. The volumes of flooding water are given in gallons per minute. The number of electric submersible pumps required to handle the flooding is also shown. It should be obvious that prompt plugging of holes is desirable. It can save the ship, it releases pumps for use elsewhere, and it saves wear and tear on the pumps that are in use. Note that the pump capacities used are considerably under the rated capacity, usually 200 gpm. However, if the pump strainers get clogged with debris, the actual capacities may be much less than the rated capacity.

The greatest difficulty in repairing underwater damage is usually the inaccessibility of the damage. If

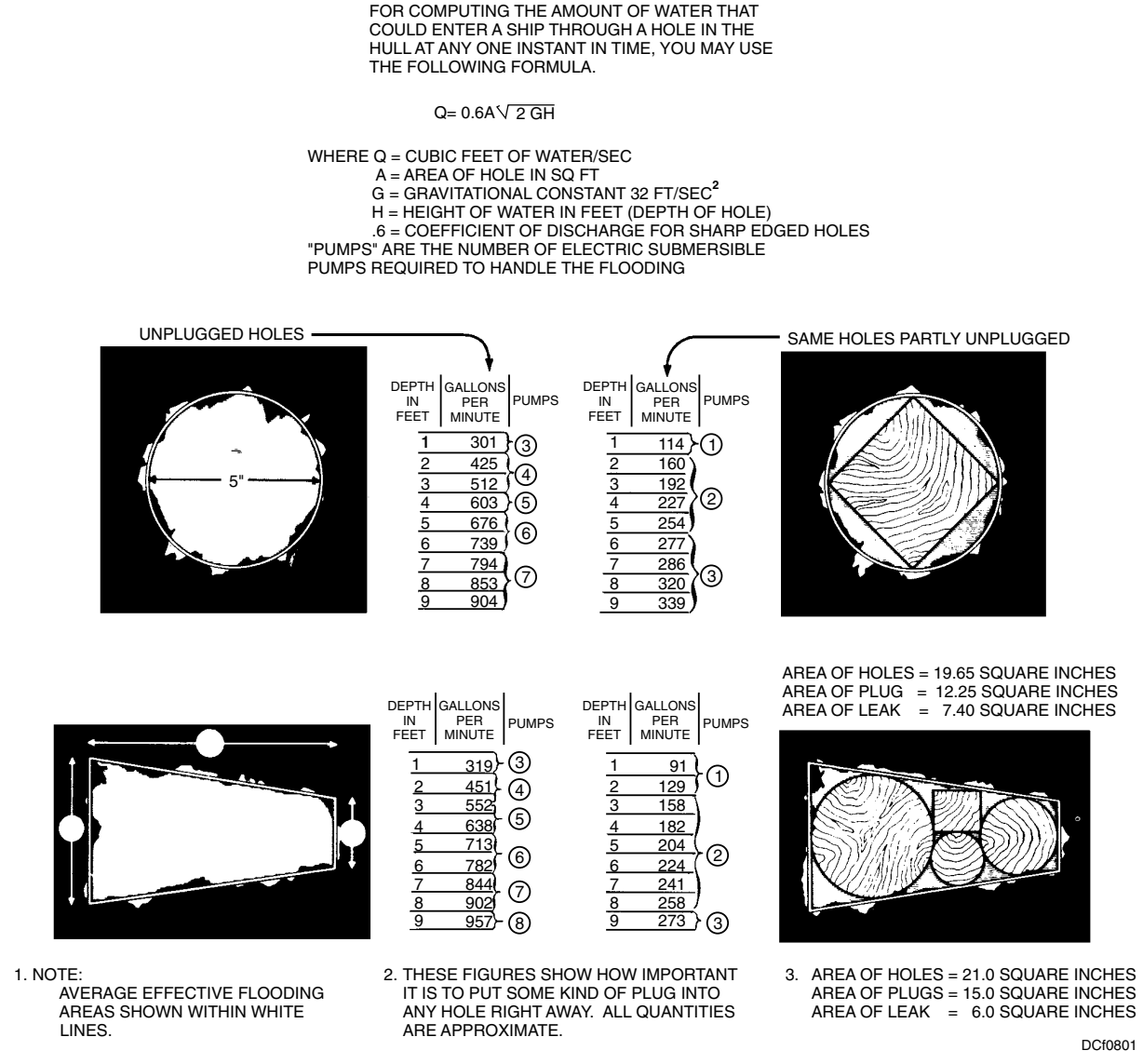

Figure 8-1. Flooding effect comparison; unplugged holes vs. partially plugged holes.

an inboard compartment is flooded, other compartments will flood if you open doors or hatches to get to the actual area of damage. The repair work may be hampered by tangled wreckage in the water, the absence of light, and the difficulties of trying to keep buoyant repair materials submerged.

PLUGGING AND PATCHING HOLES

The procedures discussed here for plugging and patching holes are intended for emergency use. They are temporary repairs that can be done to keep the ship afloat while it is in action. In most cases, they do not call for elaborate tools or equipment. They involve principles that can be applied when using wooden plugs, prefabricated patches, or other readily available materials.

The two general methods of making temporary repairs to a hole in the hull are as follows:

1. Put something in it.
2. Put something over it.

In either case, the patches will reduce the area through which water can enter the ship or through which water can pass from one compartment to another.

Plugging

The simplest method of stopping up a fairly small hole is to insert some kind of plug. Plugs made of softwood, such as yellow pine or fir, are quite effective for plugging holes up to about 3 inches by 3 inches in size. Sometimes you may use these plugs to plug larger holes as well.

The items in a plugging kit are as follows:

- A canvas bag with a carrying strap approximately 30 inches deep and 12 inches in diameter
- Softwood plugs; a minimum of 10 plugs in various sizes from 1 inch to 10 inches in diameter
- Five pounds of oakum or rags
- One hatchet
- One cold chisel
- One metal caulking iron
- Wedges made of softwood; a minimum of eight wedges, 2 inches by 4 inches and 12 inches long
- One maul or sledge
- One hammer; a minimum 2 pounds in weight
- One crosscut handsaw for cutting wood

The plugs and wedges may be used individually if they fit the hole. Often however, it is best to use a combination of conical, square-ended, and wedge-shaped plugs to make a better fit in the hole. One such combination of plugs is shown in figure 8-2.

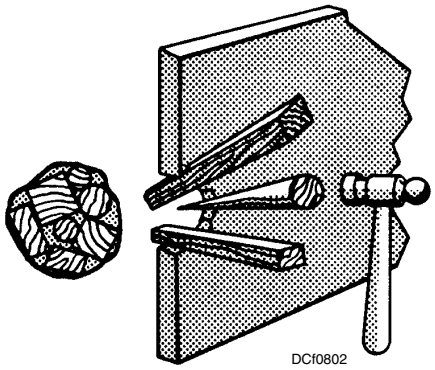

Figure 8-2. Combination of plugs used to plug a hole.

It is best to wrap each plug with lightweight cloth before inserting it. The cloth tends to keep the plugs in place and fills in some of the gaps between the plugs. In most cases, plugs will not make a watertight fit. However, you can substantially reduce the rate of leakage by using the plugs and then caulking the remaining leaks with rags, oakum, and smaller wedges. Square-ended plugs tend to hold better than conical plugs in holes located in plating that is one-fourth of an inch or less in thickness.

Most wooden plugs are inserted from the inside of the ship. When plugging a hole in this manner, you must contend with the metal edges that are protruding inward. You normally will not have this problem when plugging a hole from the outside of the ship. However, plugs on the outside of the ship cannot be tended easily nor will they hold very well over an extended period of time. If it is necessary to insert the plugs from the outside of the hull, fit the inboard ends of the plugs with screw eyes. A line running from each screw eye and secured to a solid structural member inside the ship will help to keep the plug in place.

Patching

Box patches are effective for use over holes that have jagged edges projecting inboard. View A of figure 8-3 shows a typical metal box patch; view B

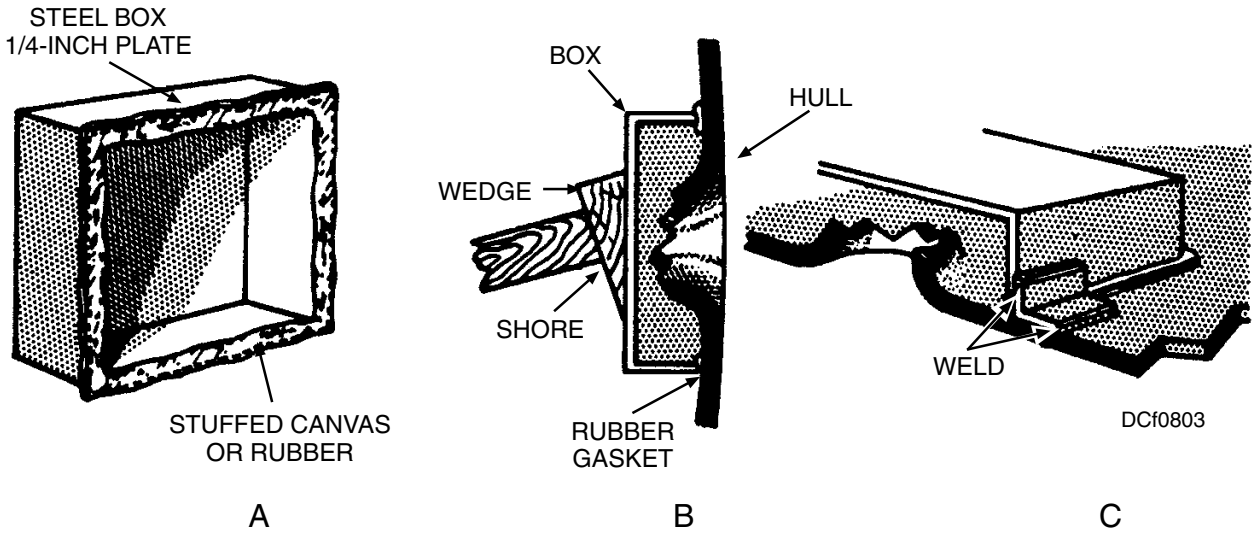

Figure 8-3. Application of a box patch.

shows a metal box patch held in place by shoring; and view C shows a metal box patch welded in place over a hole that has jagged edges.

A hinged patch is designed for use over relatively small holes. This patch has no vertical support to hold it in place. Figure 8-4 shows a hinged plate patch before, during, and after installation.

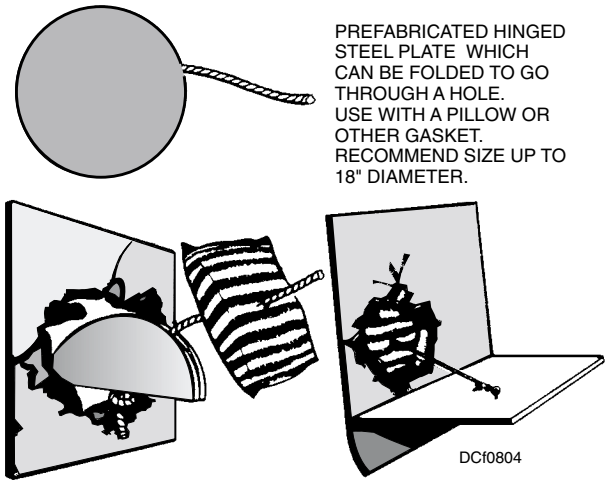

Figure 8-4. Application of a hinged plate patch.

A hook bolt is a long bolt that is usually fabricated from round steel stock. Hook bolts come in a variety of diameters and shapes. The head is shaped so that the bolt can be hooked to the plating through which the head has been inserted. Figure 8-5 shows T-shaped, L-shaped, and J-shaped hook bolts and how the hook bolts are used to apply a patch. The long shanks are threaded and are provided with nuts and washers. Wood (or sometimes steel) strongbacks are used with hook bolts.

To use a hook bolt, insert the head end of the bolt through the hole in the hull. Rotate or adjust the bolt until it cannot be pulled back through the hole. Slide a pad or gasket that is backed by a plank or strongback over the bolt. Secure the patch by tightening the nut. Generally, these bolts are used in pairs. Hook bolts can be used with a variety of patches and in various combinations.

The folding T-shaped hook bolt (figs. 8-6 and 8-7) has a hinge where the shank joins the crosspiece. This bolt can be folded and inserted through a small hole. When the bolt is pulled back, the crosspiece catches on the hull plating. By using this bolt, a crewmember standing inside the ship can put a patch on either the inside or the outside of the ship. By using a retaining line on the bolt, a strongback and a pillow can be threaded over the line and the entire patch folded and placed through the hole. When the line is hauled in, the patch fits against the ship. The patch can be re-adjusted to give a tighter fit. It is also possible to push the pillow and plate over the shank inside the ship to make an inside patch. Nuts and washers are provided to hold and tighten a patch; often large wing nuts are used. Figure 8-6 shows one way in which a folding T-shaped hook bolt can be used to secure a patch.

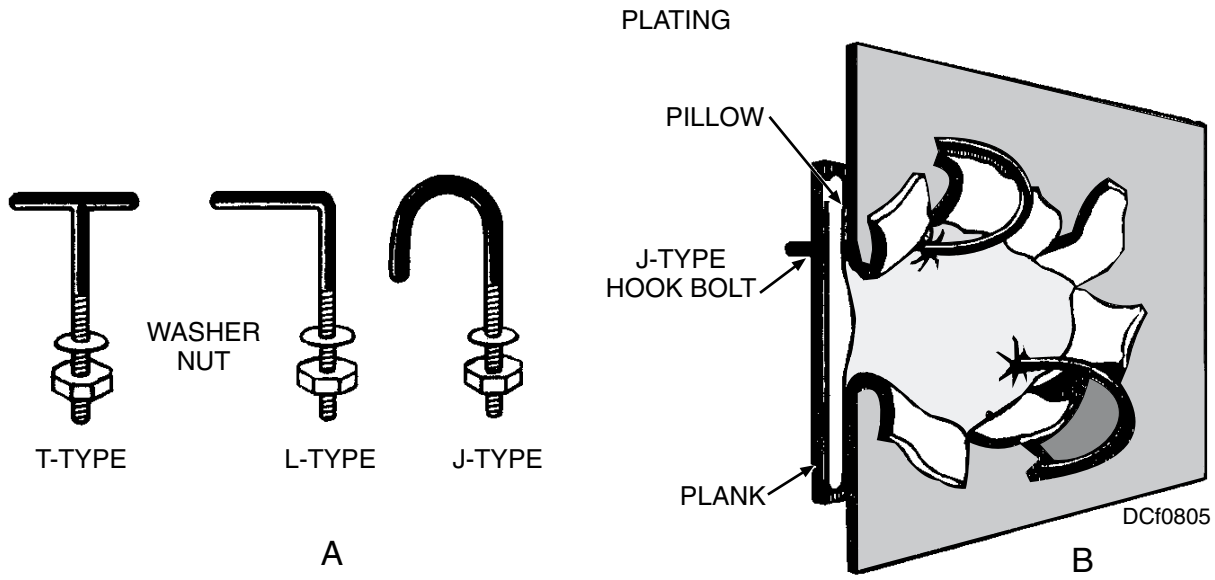

Figure 8-5. A. Types of hook bolts; B. Use of hook bolts in applying a patch.

Ordinary feather pillows have a tendency to ball up when they are wet and do not provide a uniform surface when used to patch holes. For this reason some ships may fabricate pillows made of canvas and oakum.

You will frequently find it necessary to improvise patches by using whatever material is handy. This calls for skill and a certain amount of imagination. Hinged or folding prefabricated patches are usually the easiest to use, and, in many cases, they are the most effective. But if they are not available, you will need to improvise patches.

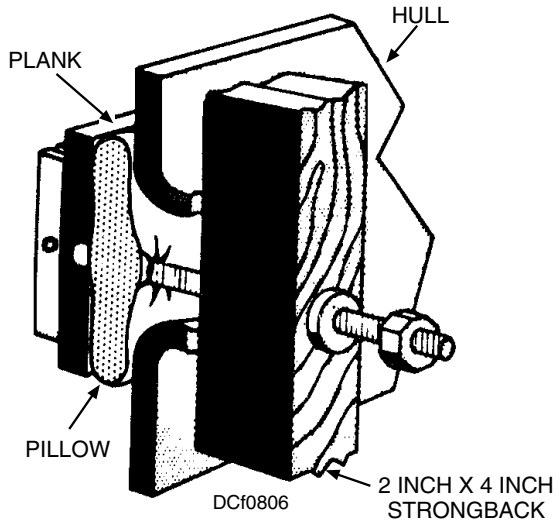

Figure 8-6. One method of installing a folding T patch.

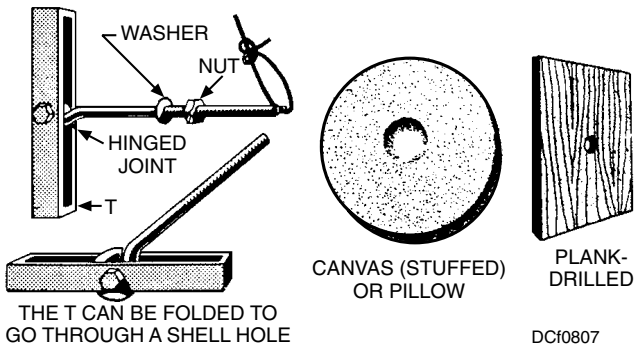

Figure 8-7. Materials used in assembling a folding T patch.

REVIEW QUESTIONS

Q4. What holes caused by battle damage should be given priority when plugging is needed?

1. All large holes
2. All small holes
3. Holes in the deck
4. Holes at the waterline or on the low side

Q5. The one very important thing to remember about flooding is that a ship can sink just as easily from a series of small and insignificant looking holes, as it can from one large and more dramatic looking hole.

1. True
2. False

Q6. Plugs made of softwood, such as yellow pine or fir, are quite effective for plugging holes up to what size?

1. 6 inches by 6 inches
2. 5 inches by 5 inches
3. 3 inches by 3 inches
4. 4 inches by 4 inches

Q7. It is best to wrap a plug with lightweight cloth before inserting it because the cloth keeps the plug in place and fills gaps between plugs.

1. True
2. False

Q8. What type of patches are effective for use over holes that have jagged edges projecting inboard?

1. Hinged
2. Folding T
3. Hook bolt
4. Box

SHORING

Learning Objective: Identify the various types of shoring materials and the general rules that govern their use.

Shoring is often used aboard ship to support ruptured decks, to strengthen weakened bulkheads and decks, to build up temporary decks and bulkheads against the sea, to support hatches and doors, and to provide support for equipment that has broken loose.

Knowing when to shore is a problem that cannot be solved by the application of any one set of rules. Sometimes the need for shoring is obvious. Examples are loose machinery or damaged hatches. However, dangerously weakened supports under guns or machinery may not be so readily noticed. Although shoring is sometimes done when it is not really necessary, the best general rule is this: "If in doubt, shore it."

SHORING MATERIALS

The basic materials required for shoring are as follows: shores, wedges, sholes, and strongbacks.

A **shore** is a portable beam.

A **wedge** is a block, triangular on the sides and rectangular on the butt end.

A **shole** is a flat block that may be placed under the end of a shore to distribute pressure.

A **strongback** is a bar or beam of wood or metal that is used to distribute pressure or to serve as an anchor for a patch. The strongback is often shorter than a shore.

Many other items are used in connection with shoring. They include wooden battens, claw hammers, mauls and sledges, handsaws, mattresses, pillows, axes, hatchets, wood clamps, chain falls, electric welding machines, oxyacetylene cutting outfits, cold chisels, wood chisels, nails, wooden plugs, packing sheets, turnbuckles, screw jacks, hydraulic jacks, bolts, nuts, and washers. The Coordinated Shipboard Allowance List (COSAL) lists the quantity of such gear that each ship should carry on board.

Shores

The best woods available for shores are Douglas fir and yellow pine. Hemlock and spruce may also be used. However, they are not as good because they are not as strong. Any wood used for shores should be straight grained and relatively free of knots and cracks. Green timbers are not as strong as cured timbers. If it is necessary to use a poor quality wood, use more shores than would be required for shores of a better quality wood. Shores authorized for shipboard use are treated with a fire-resisting chemical. They should NEVER be painted with an ordinary paint.

The length of a shore should never be more than 30 times its minimum thickness. Thus shores that have dimensions of 4 inches by 4 inches or 4 inches by 6 inches should not be any longer than 10 feet. A shore that is 6 inches by 6 inches should not be any longer than 15 feet. The shorter the shore is in relation to its thickness, the greater the weight it will support. Shores should normally be carried aboard ship in 16-foot and 18-foot lengths that can be cut to the required lengths when needed.

Wedges

Wedges should be of softwood, preferably fir or yellow pine. They should be cut with a coarse saw and left rough and unpainted. This allows the wedges to absorb water and hold better than if they are smoothed or painted. A few hardwood wedges should be kept on hand for special uses, since they resist crushing better. However, hardwood wedges cannot be used for all shoring because they have a tendency to work loose. When hardwood wedges are used, they must be checked frequently.

Wedges should be approximately the same width as the shores with which they are used. They may be made with various angles at the leading edge, but a blunt wedge will not hold as well as a sharp one. A wedge should be about six times as long as it is thick. Thus a wedge to be used with a shore that is 4 by 4 inches should be about 4 inches wide, 2 inches thick, and 12 inches long. Figure 8-8 shows some wedges and shows how they are used.

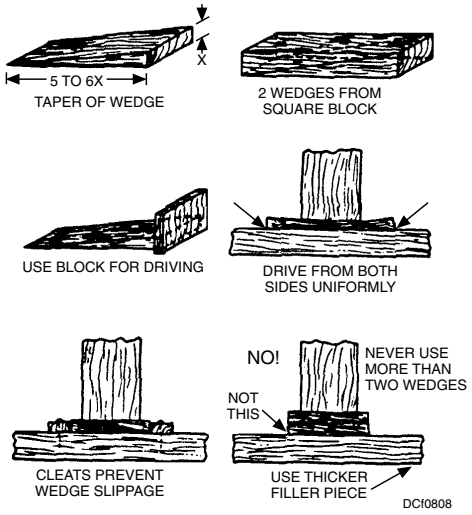

Figure 8-8. Wedges.

Sholes

Sholes should be made of Douglas fir or yellow pine planks that are at least 1 inch thick and 8 inches to 12 inches wide. Nailing cleats across two or more widths of planking can make wider sholes. A single plank may have to be cleated at the ends to keep it from splitting. Do not fabricate sholes in advance of the actual need for them; prefabricated sholes would probably not fit where they are needed. The use of a shole is shown in figure 8-9.

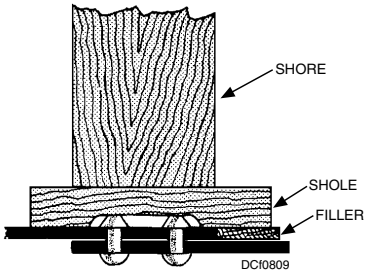

Figure 8-9. Use of a shole.

Strongbacks

All or part of an ordinary shore may be used to make a strongback. Shoring scraps should be kept for use as strongbacks and short shores. Heavy planks, steel bars, angle irons, and pipe can also be used as strongbacks (fig. 8-6).

Metal Shores

Several types of telescopic steel shores are used to make temporary repairs and some may be used for immediate repairs. The metal shores normally will have pins or locking devices and are fitted with a hinged shoe at each end. The pins or locking devices are used to adjust the length of the shore. The hinged shoe may be easily adjusted to any angle and then welded in place. The newer types of metal shores (fig. 8-10) are also fitted with screw jacks or swivel (ball-and-socket) bases.

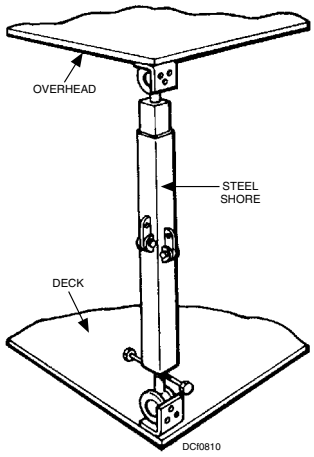

Figure 8-10. Steel shore supporting overhead deck or load.

The newer steel shores are available in two models as follows:

1. Model 3-5 is adjustable from a minimum of 3 feet, plus or minus 3 inches, to a maximum of 5 feet, plus or minus 3 inches. It will support a maximum vertical load of 20,000 pounds when closed to within 1 inch of the screw jack. It will support a maximum vertical load of 12,000 pounds when fully extended.

2. Model 6-11 is adjustable from a minimum of 6 feet, plus or minus 3 inches, to a maximum of 11 feet, plus or minus 3 inches. It will also support a maximum vertical load of 20,000 pounds when closed to within 1 inch of the screw jack. It will support a maximum vertical load of 6,000 pounds when fully extended.

These shores consist of two telescoping, square, steel tubes. Four spring-loaded locking devices, a swivel baseplate, and a screw jack are on the outer tube. A swivel baseplate is on one end of the inner tube. Each side of the shore has a spring-loaded locking device. Each locking device is on the same plane as the locking device on the opposite of it. However, there is a 2 1/4-inch offset of the adjacent locking devices.

The steel shores must be maintained in good operational condition. The tubes must slide easily, and the swivel joints must move freely. The threads of the screw jack must not have any paint on them. Both the swivel joints and the screw jack threads are to be clean and greased. All of the holes and slots are to be open and free of excess paint.

Steel wedges are more valuable for prying things apart than for actual shoring. Steel wedges may be used in conjunction with wooden wedges to take some of the wear and pressure off of the wooden wedges. Steel wedges can also be welded into place when making semipermanent repairs.

Steel sholes are better than wooden sholes for use under the ends of iron or metal pipe being used as a temporary stanchion because metal pipe can easily cut through wooden sholes.

Although steel bars, angle irons, and pipe can be used for strongbacks, their tendency to spring back and forth under variable loads must be considered. These materials can also be used for making semipermanent repairs when time is available.

SHORING KIT

Shoring kits are small enough to go through scuttles and other small openings. The items normally contained in a shoring kit are as follows:

- A canvas carrying bag that is approximately 30 inches deep and 12 inches in diameter
- One 10-pound sledge
- One 8-point crosscut handsaw
- One 10-foot metal tape rule
- One 50-foot metal tape rule
- One claw hammer
- One hatchet
- One 3/4-inch cold chisel
- One 1-inch wood chisel
- Eight adjustable clamps; four 6 inches and four 8 inches in nominal size
- One caulking hand tool
- One 24-inch carpenter's square
- One electric hand lantern
- Eight 2- by 4-inch softwood wedges
- One bag of nails; two pounds each of 20d and 30d common nails
- Five pounds of oakum or rags
- Five pounds of sand
- Several sections of shoring; 4 inches by 4 inches by 10 feet

MEASURING AND CUTTING SHORES

The most rapid and accurate way to measure a shore for cutting is to use an adjustable shoring batten similar to the one shown in figure 8-11. These battens can be made up from items carried aboard ship. Each repair party locker is required to have a shoring batten.

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. Lock the angle locking devices in place. Lay the batten along the shore. Mark and cut the timber to the proper length and angle. Shores should be cut one-half of an inch shorter than the measured length to allow space to install wedges.

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 in this way, as shown in figure 8-12, is as follows:

Step 1. Measure distance A from the center of the strongback to the deck. This distance is known as the "rise." Then measure distance B from the edge of the anchorage to the bulkhead. This distance is known as the "uncorrected run." Subtract the thickness of the strongback from measurement B. This distance is now known as the "corrected run."

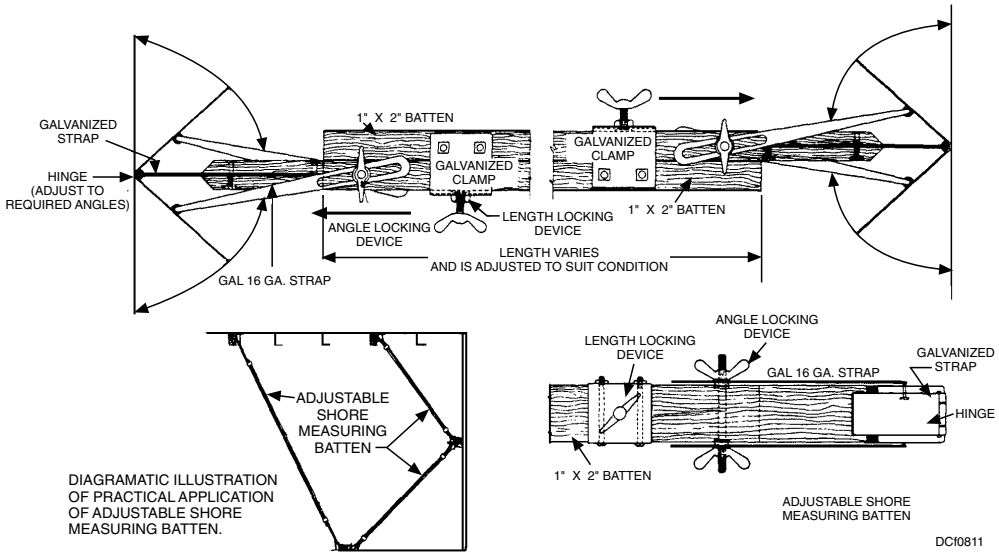

Figure 8-11. Shoring batten.

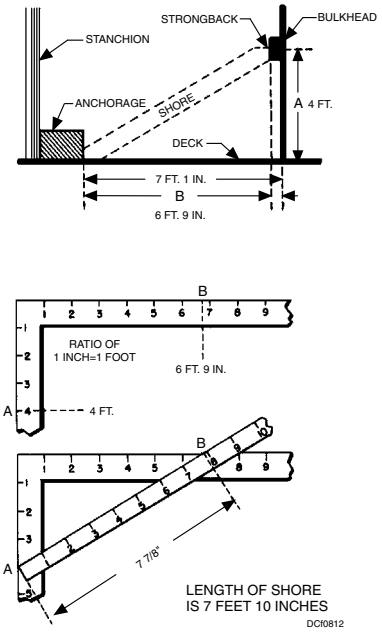

Figure 8-12. Measuring length of shore.

Step 2. Lay off the measurements A and B on a carpenter's square, using the ratio of 1 inch to 1 foot. Rule measurement is taken to the nearest one-sixteenth of an inch. To maintain the 1-inch to 1-foot ratio, use table 8-1.

Step 3. Measure the diagonal distance between A and B. In the example given in figure 8-13, this distance is 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.

Table 8-1. Actual Rule Measurement and Measurement on Carpenter's Square

ACTUAL RULE MEASUREMENT	MEASUREMENT ON CARPENTER'S SQUARE
3/4 inch	1/16 inch
1 1/2 inches	1/8 inch
2 1/4 inches	3/16 inch
3 inches	1/4 inch
3 3/4 inches	5/16 inch
4 1/2 inches	3/8 inch
5 1/4 inches	7/16 inch
6 inches	1/2 inch
6 3/4 inches	9/16 inch
7 1/2 inches	5/8 inch
8 1/4 inches	11/16 inch
9 inches	3/4 inch
9 3/4 inches	13/16 inch
10 1/2 inches	7/8 inch
11 1/4 inches	15/16 inch
12 inches	1 inch

Step 4. Subtract one-half because shores should be cut one-half of an inch shorter than the measured distance to allow for the required wedges. Thus 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 (fig. 8-13). Using the same measurements as in the previous example, proceed as follows:

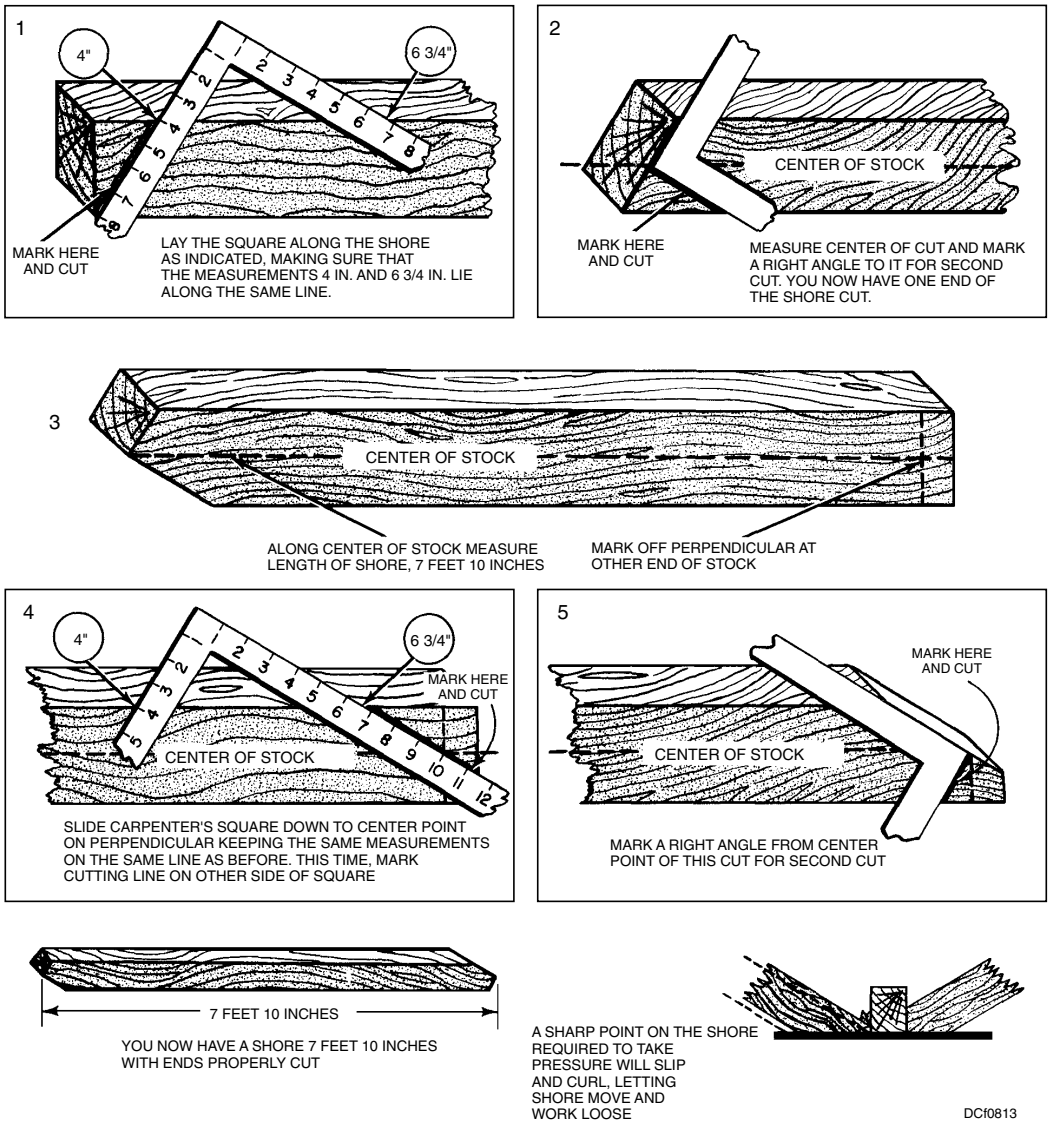

Figure 8-13. Cutting the angles of a shore.

Step 1. Lay the square along the shore, as shown in part 1 of figure 8-13, making sure that the measurements 4 inches and 6 3/4 inches lie along the same line. Cut the shore to this line.

Step 2. Measure the center of the cut and mark a right angle to it for the second cut. Saw to the line. You have now completed cutting one end of the shore.

Step 3. Along the center of the timber, measure the length of the shore (7 feet 10 inches) and mark off a perpendicular line at the other end of the shore.

Step 4. Slide the carpenter's square down to the center point on the perpendicular. Keep the same measurements on the same line as before in step 1. This time, mark the cutting line on the other side of the square.

Step 5. Mark a right angle from the center point of this cut for the second cut. Make your cuts. You now have a shore that is 7 feet 10 inches long with the ends properly cut to fit the measurements.

The proper cutting of shores is an important part of any shoring operation. Shores are usually cut with a hand-held circular saw. However, you may use an ordinary carpenter's handsaw. All repair party personnel should be instructed in the correct use of these tools. Shores that are poorly cut may cause a delay in completing the shoring job and may cause failure of the shoring structure. You will find that the wedges and shores will not fit properly if the shores are not cut correctly. Wet timbers are particularly hard to cut unless the proper methods of sawing are used. In cutting heavy shores, a lumberjack crosscut saw will save a good deal of time. Chisels, axes, and hatchets are also used to cut shores.

TRIMMING SHORES

Shores must be trimmed to fit the shoring structure. The trimming must be done in such a way as to prevent splitting or chipping of the shores. If shore A in figure 8-14 is to fit against a plane surface of shore B and if it must take a load in compression, the end of shore A must be cut square and perpendicular to its long axis.

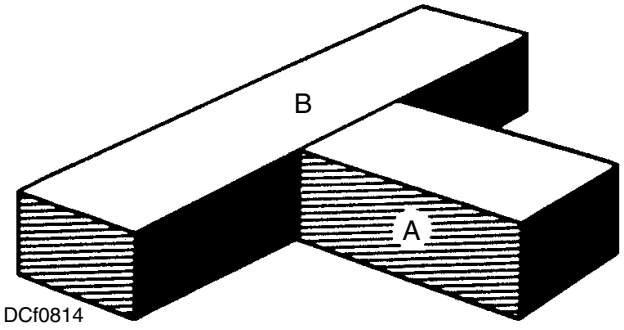

Figure 8-14. Trimming shore to shore.

A sharp point must never be used when a shore will be required to withstand pressure. A pointed end will slip and curl and allow the shore to work loose and move. Figure 8-15 shows the correct and incorrect ways to trim shores to present a flat surface at each pressure area.

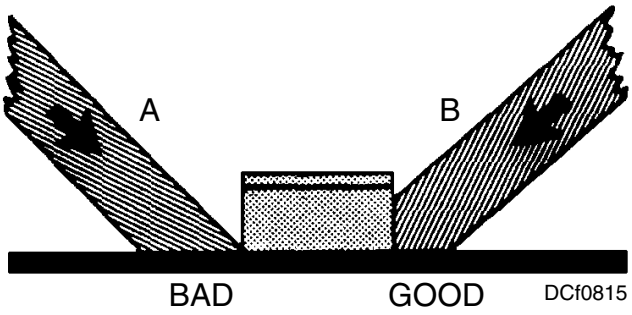

Figure 8-15. Trimming shore to deck.

Shores are sometimes notched at the end to fit against other shores. However, this method should not be used if you expect any great pressure. A safer method is to cut a socket in the side of one shore and fit the butt of the other shore into the socket. This method is shown in figure 8-16.

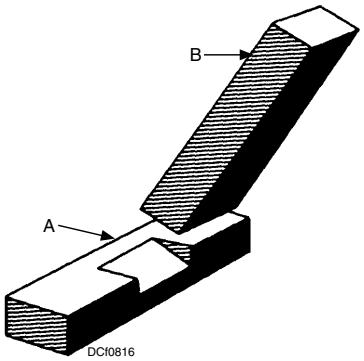

Figure 8-16. Socket cut in shore.

GENERAL SHORING RULES

Most shoring is done to support bulkheads that are endangered by structural damage or weakness caused by a hit or by the pressure of flooding water. The pressure on the bulkhead of a flooded compartment is tremendous. Expert shoring is required to hold such bulkheads in place. Some of the general rules to remember in connection with shoring bulkheads are as follows:

- Always allow a large margin of safety. Use MORE shores than you think you need, rather than fewer.
- Spread the pressure. Make full use of strength members by anchoring shores against beams, stringers, frames, stiffeners, stanchions, barbettes, and so forth. Place the legs of the shoring against the strongback at an angle of 45° or 90° if at all possible. Figure 8-17 shows the simplest and strongest shoring structure; figure 8-18 shows shoring angles.
- Do not attempt to force a warped, sprung, or bulged bulkhead back into place. Place the shoring so that it will hold the bulkhead in its warped or bulging position.
- When possible, strengthen the main shores with auxiliary shores.

The same general rules apply to shoring a hatch or a door. However, the entire hatch or door should be shored and the pressure should be spread over both the hatch cover or door and the supporting structure, as shown in figure 8-19. Remember that hatches and doors are the weakest part of the bulkhead or deck in which they are installed. Shoring doors and hatches may be complicated by the presence of scuttles and quick-acting handwheels. In the situation shown in figure 8-19, the shores are arranged in such a way as to

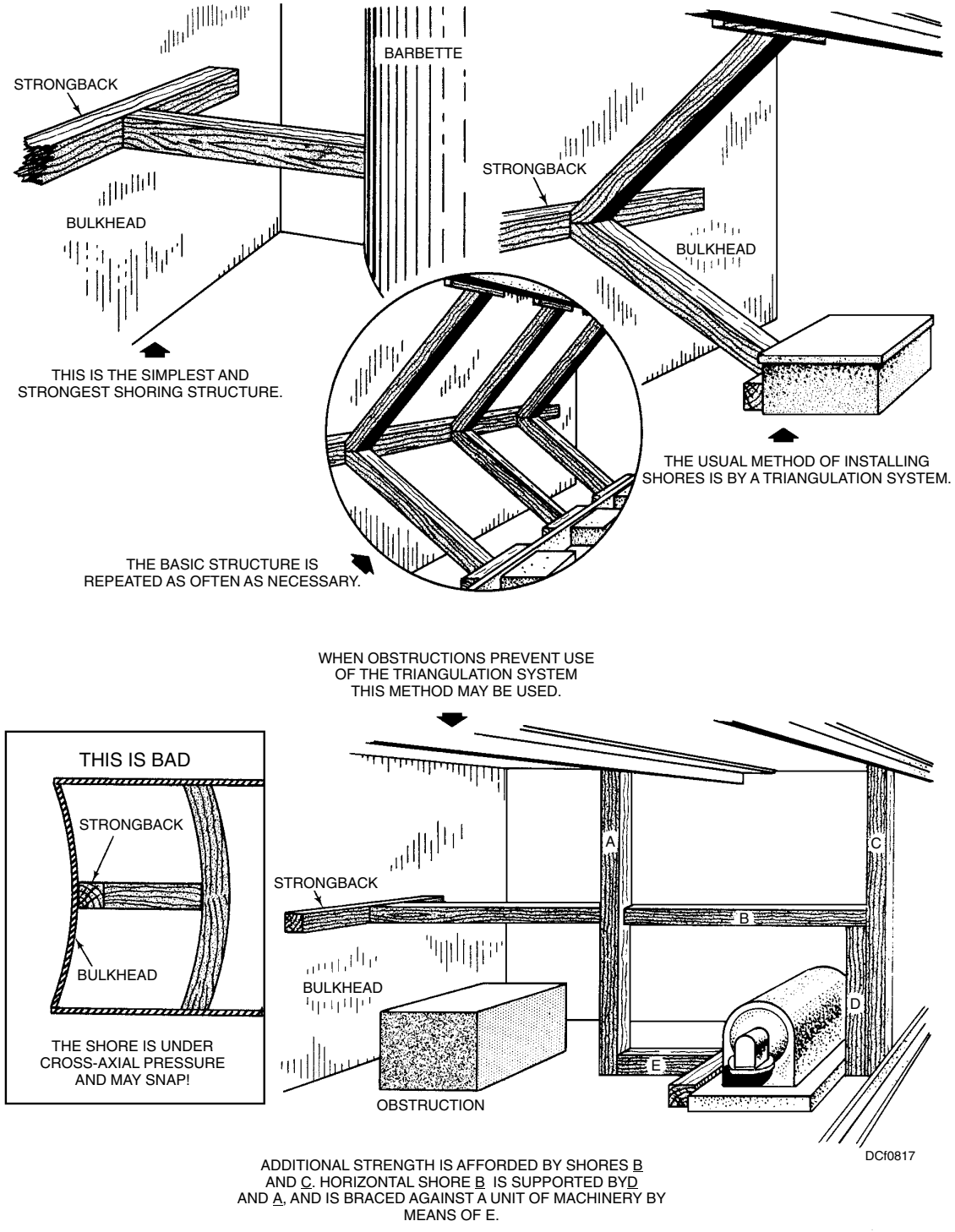

Figure 8-17. Shoring against horizontal pressure.

clear the handwheel. A basic rule is to put as many points of pressure on the closure as there are dogs on the closure.

The success of any shoring job depends largely on the way in which the timbers are wedged. As the shoring job progresses, check carefully to ensure that all of the wedges are exerting about the same amount of pressure on the member being shored. Use as few wedges as possible to obtain satisfactory results. Always drive the wedges in uniformly from both sides so that the shore end will not be forced out of position. Lock the wedges in place so that they will not work loose and cause the shoring to slip. Figure 8-20 shows one method of locking wedges in place.

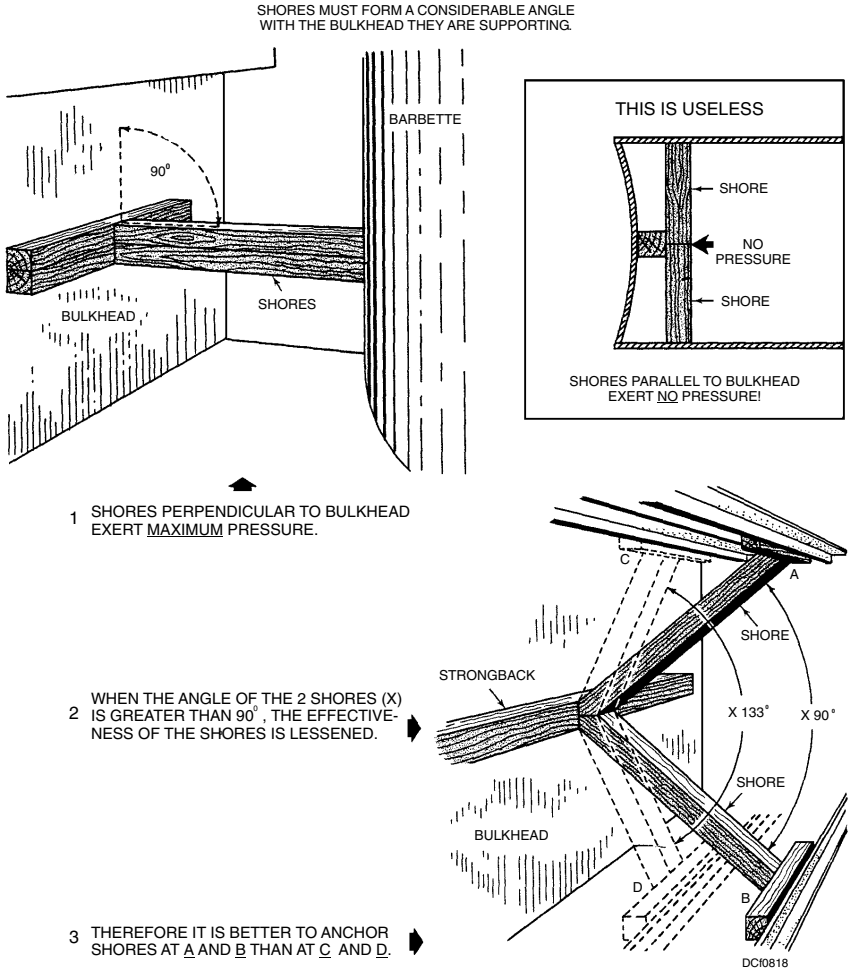

Figure 8-18. Shoring angles.

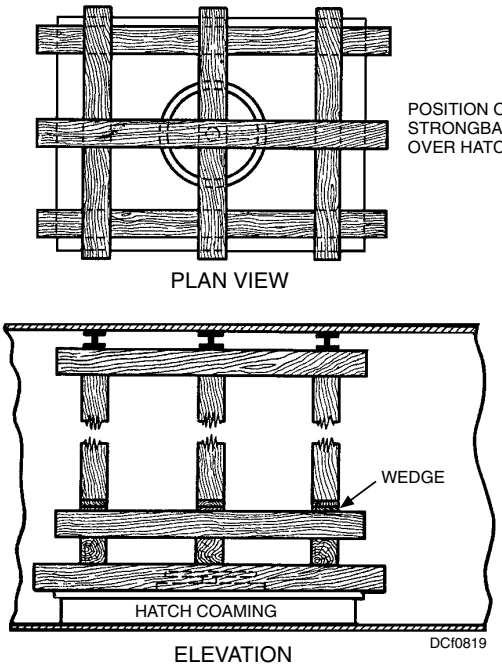

Figure 8-19. Shoring a hatch.

PRACTICE SHORING

If you are in charge of a shoring detail and if you have enough shores on board, it would be a good idea to give your shoring detail personnel some practice in shoring. As they put up the shoring, explain what they are doing right and what they are doing wrong and, in each case, why it is right or wrong. Ensure that they understand the principles of spreading the pressure, and why a shore in cross-axial pressure might snap. Be sure that they learn how to measure shores and how to cut them correctly before they actually do the cutting. If possible, obtain permission to put the shoring up in a compartment where it may be left for a few days. This will allow other personnel to inspect it and indirectly learn something about how to shore.

When doing practice shoring jobs, be careful not to cut the shores more than necessary. You will seldom have an oversupply of shores aboard ship. If you do not have spare shores for practice jobs, use strips and

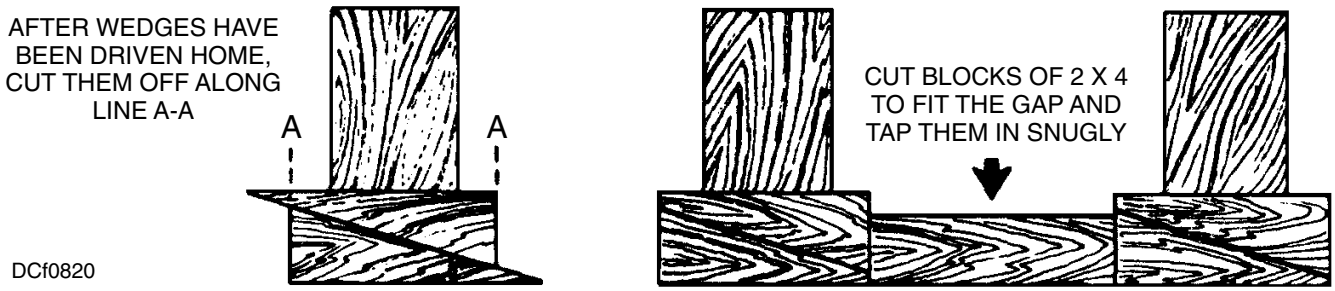

Figure 8-20. Locking wedges in place.

battens to build mock-ups and models to scale. Although models are not as effective for training as actual practice shoring jobs, they do have some training effect. An important advantage of models is that you can work out some rather elaborate shoring problems with them. Also, the models can be kept and used again and again for training purposes.

After the shoring practice has been completed (whether using a model or full-size shores), it is a good idea to have the shoring detail personnel discuss the job and make comments on the good and bad points of the shoring. Some of the questions to be brought up in this discussion include the following:

- Is the shoring job effective?
- Could it be made just as effective with fewer shores?
- Should more shores have been used?
- Is the shoring pressure correctly spread?
- Is the wedging done correctly?

This type of questioning and discussion can be effective as a device for making sure that everyone involved really understands the problems and principles of shoring.

REVIEW QUESTIONS

Q9. Which of the following woods are best to use for the construction of shores?

1. Walnut and pecan
2. Balsam and spruce
3. Douglas fir and yellow pine
4. Redwood and birch

Q10. A shore is a portable beam, a wedge is a block, triangular on the sides and rectangular on the butt end, and a shole is a flat block that may be placed under the end of a shore to distribute pressure.

1. True
2. False

Q11. A strongback is a bar or beam of wood or metal that is used to distribute pressure or to serve as an anchor for a patch. The strongback is often shorter than a shore.

1. True
2. False

Q12. What is the fully extended load for the model 6-11 steel adjustable shore?

1. 9,000
2. 8,000
3. 7,000
4. 6,000

Q13. A steel wedge is considered more valuable as a prying tool than for actual shoring.

1. True
2. False

Q14. The most rapid and accurate way to measure a shore for cutting is to use an adjustable shoring batten.

1. True
2. False

EMERGENCY ACCESS EQUIPMENT

Learning Objective: Recall the requirements and procedures for using emergency access equipment.

Earlier in this chapter, different types of damage control kits were mentioned that are used to control damage. But what equipment is available on the ship in case a space is inaccessible due to damaged doors, hatches, and scuttles? The answer is the Portable Hydraulic Access and Rescue System (PHARS) and the Portable Exothermic Cutting Unit (PECU).

PORTABLE HYDRAULIC ACCESS AND RESCUE SYSTEM (PHARS)

Already proven as a valuable piece of equipment by civilian fire departments, the Navy has approved the Portable Hydraulic Access and Rescue System (PHARS) for use as emergency damage control equipment. PHARS can be utilized in emergency access, personnel rescue, or fire-fighting operations involving spreading, cutting, pulling, and piercing light plate or sheet metal. There are several different types of these units available in the fleet. Each ship should have at least one PHARS kit.

The power unit for the PHARS houses a diesel engine designed to power the hydraulic pump used to pressurize the hose reel. The hose reel has 100 feet of hydraulic hose attached. This hose has a manifold used for attachments that include cutters, extension ram, and spreader.

Damage control personnel are required to know how to operate this equipment. They must also test it and maintain it by performing minor repairs and ensuring the equipment is properly lubricated. For detailed information, you should refer to the appropriate technical manuals and to the ship's Planned Maintenance System (PMS).

PORTABLE EXOTHERMIC CUTTING UNIT (PECU)

The Portable Exothermic Cutting Unit (PECU) is a valuable piece of damage control equipment that provides rapid access into areas of the ship where normal access is impaired. The PECU can be used for cutting into a deck to vent a compartment due to extreme temperatures from fire that prevents normal entry. The PECU can also be used for fire-fighting operations and to drain water from areas of the ship where the effects of accumulated water from fire-fighting operations may impair the ship's stability.

The PECU utilizes expendable cutting rods, which operate on the exothermic torch principle. This principle involves the use of oxygen, which is combined with fuel. In this case, the fuel is a steel tube. The exothermic cutting rod is ignited when the oxygen passing through the iron rod comes in contact with a spark generated from a 12-volt dc battery-powered igniter. Once ignited, the fuel rod will continue to burn until expended, provided the oxygen flow is maintained. Releasing the oxygen lever will extinguish the rod. A 12-volt battery is the maximum electrical power permitted because larger power sources will melt cables.

The exothermic torch can cut through most materials, including steel, aluminum, laminates, piping, and cables. The unit can operate with a cutting rod and torch handle underwater as well as in the air. Commercially available units may not provide the underwater cutting capability.

Holes cut in the ship's structure with the PECU should be circular and be no less than 6 inches nor more than 19 inches in diameter. Forming of corners that initiate or induce stress cracking must be avoided.

Damage control personnel are required to know how to operate this equipment. They must also test it and maintain it by performing minor repairs and ensuring the equipment is properly lubricated. For detailed information, you should refer to the appropriate technical manuals and to the ship's Planned Maintenance System (PMS).

WARNING

Do not cut piping that is pressurized, piping containing flammable fluids, or electrical cables that are energized.

The exothermic torch produces sparks and molten slag that can burn personnel, damage equipment, or ignite combustibles on both sides of the deck or bulkhead being cut.

When using the torch in weather, the operator and other personnel should position themselves upwind of the cut, and the cut should be started downwind of the planned hole so the molten slag, heat, and smoke formed by the torch or vented from the hole will blow clear of personnel. The access team should have smoke curtains; plugging, patching, and shoring materials; and fire-fighting equipment immediately available as applicable to the situation.

Operation of the PECU will generate a large fume plume. In some situations, it may be necessary to provide respiratory protection or emergency ventilation to the operator, or even for the operator to don an OBA. If an OBA is worn, it should be shielded from molten splatter. The equipment technical manual contains specific directions for maintenance, stowage, and cleaning of the PECU. These directions include the following:

- Keep the oxygen feed system clean (free of oil, grease, and dirt).
- Ensure the flash arrester is in place before use.
- Ensure the collet nut and washer are in good condition.
- Remove the fuel rod before storing the PECU.
- Never leave the torch unattended with the oxygen feed system pressurized or the ignition system energized.
- Remove all slag, dirt, and debris from the external surfaces before storing the PECU.

REVIEW QUESTIONS

Q15. Which of the following types of equipment are available on the ship in case a space is inaccessible due to damaged doors, hatches, and/or scuttles?

1. Drills and circle saws
2. Reciprocating saws and sheet metal shears
3. Acytelene torches and hammers
4. The Portable Hydraulic Access and Rescue System (PHARS) and the Portable Exothermic Cutting Unit (PECU)

Q16. PHARS can be utilized in emergency access, personnel rescue, or fire-fighting operations involving spreading, cutting, pulling, and piercing light plate or sheet metal.

1. True
2. False

Q17. The PECU utilizes expendable cutting rods, which operate on the exothermic torch principle.

1. True
2. False

EMERGENCY PIPE PATCHING

Learning Objective: Recall emergency pipe patching procedures.

Damaged piping systems are another source of flooding in compartments. The pipes may have small holes or cracks, or be totally severed. Normally, you will want to isolate the damage by securing the cutout valves on each side of the damaged section of piping. However, whether the piping may be secured, and the amount of time it can be secured, will depend on the service the system provides. A saltwater flushing line may stay secured until repairs can be made after vital repairs have been completed. However, you will need to make temporary repairs on some lines immediately to put the system back into service. Firemain piping, fuel oil lines, and chill water cooling lines to electronic spaces should be repaired as soon as possible.

Small holes in some piping may be temporarily repaired if you drill the hole out, thread it, and then insert a machine screw. Other holes will require a different means of patching. You may use a jubilee pipe patch, a soft patch, or a metallic pipe patch. The materials for all of these repairs are found in the pipe-patching kit.

Pipe-patching kits are available in the ship's repair lockers. Each kit contains the following items:

- A canvas bag approximately 30 inches deep and 12 inches in diameter
- Several small softwood plugs and wedges; enough to plug 24 inches of split
- Approximately 8 square feet of 1/8-inch rubber gasket
- Approximately 8 square feet of canvas
- One hundred and fifty feet of marlin
- Three pounds of oakum or rags
- One hacksaw with a minimum of six spare blades
- One hatchet or wood chisel
- One hammer; 2 pounds in weight
- A pair of scissors or a knife for cutting the materials
- A banding kit
- Jubilee pipe patches; a minimum of five in various sizes

JUBILEE PIPE PATCH

The jubilee pipe patch (fig. 8-21) is a modification of a commercial hose clamp. Periodically, you may purchase heavy-duty jubilee pipe patches through the supply system. However, if you cannot purchase them, you can manufacture them yourself.

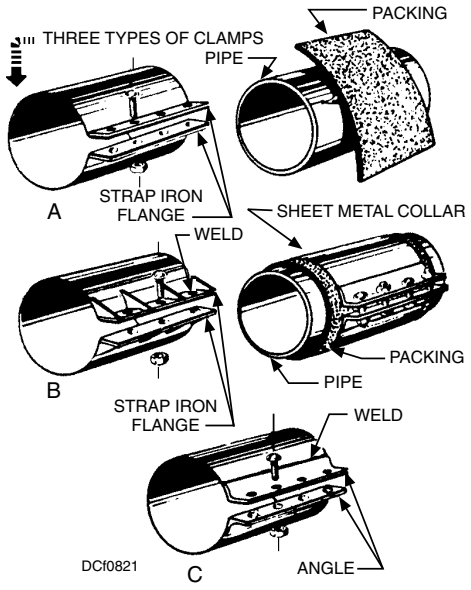

Figure 8-21. Jubilee pipe patches.

To manufacture a jubilee pipe patch, roll a piece of sheet metal into a cylinder. Bend a tab on each edge to form a flange. The flanges may be reinforced by welding on strips of scrap iron. Drill three to five holes through both flanges for the securing bolts. To keep the flange faces somewhat parallel when under pressure, weld small braces from the flanges to the back of the patch. Use a thick gauge sheet metal that will withstand pressure but can also be sprung open enough to be put over the pipe.

To use the jubilee pipe patch, put a piece of rubber or gasket material over the hole. It should be large enough to cover and overlap the damage at least 2 inches on all sides. Slip the jubilee pipe patch over the rubber or gasket material. Insert the bolts into the holes and secure them in place. The jubilee pipe patch can withstand 100 pounds of pressure.

SOFT PATCH

Small holes or cracks in low-pressure (150 psi) piping can often be repaired by applying a soft patch (fig. 8-22). When it is possible, reduce the area of the hole first by driving in softwood plugs and wedges as necessary. Do not drive the plugs and wedges in too far or else they will retard the flow of the fluids in the pipe. Once the plugs and wedges are in place, trim them off flush with the outside surface of the pipe. Cover the damaged area with a piece of rubber that will completely cover and extend about 2 inches past the damaged area on all sides. Use two tightly wound layers of marlin or wire to hold the rubber in place.

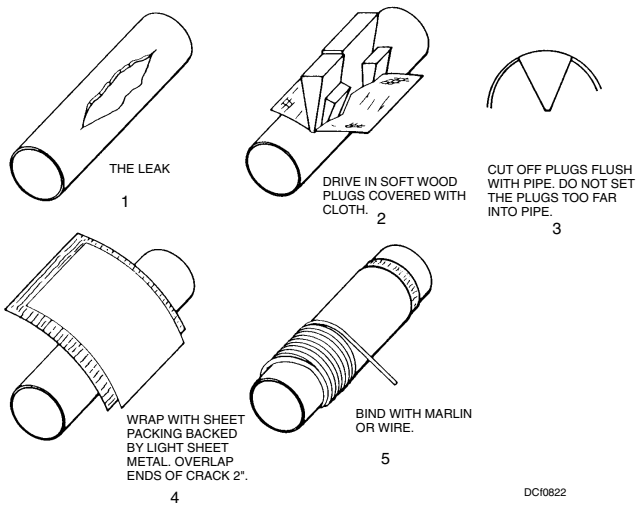

Figure 8-22. Soft patch on a low-pressure pipe line.

The soft patch can be modified or improved to suit the conditions at hand. Often it is advisable to use a curved piece of lightweight sheet metal between the rubber and the marline or wire. A coat of red lead on the face of the rubber will help and you can use marlin and oakum as a caulking material in the cracks.

The Emergency Water-Activated Repair Patch (EWARP) shown in figures 8-23 and 8-24 is a unique and easy to use pipe patch that can be used on many piping systems. The EWARP comes in a clear plastic package that includes a foil package containing the instant repair resin coated cloth and a pair rubber gloves. The patch comes in two different sizes; size 1 which is 3 inches by 9 feet and size 2 that is 4 inches by 15 feet. Maximum operating pressure is 150 psi. Normal operating temperature should not exceed 300 degrees Fahrenheit. The syntho-glass patch must be firmly wrapped around the damaged area extending several inches. If needed, the excess can be cut with a knife. The patch can also be sanded and painted. The EWARP is fully hardened in 30 minutes and complete function of the system can be resumed.

CAUTION

Do NOT use the Emergency Water-Activated Repair Patch (EWARP) on potable water inlet lines or fuel systems.

Figure 8-23. Emergency Water-Activated Repair Patch (EWARP).

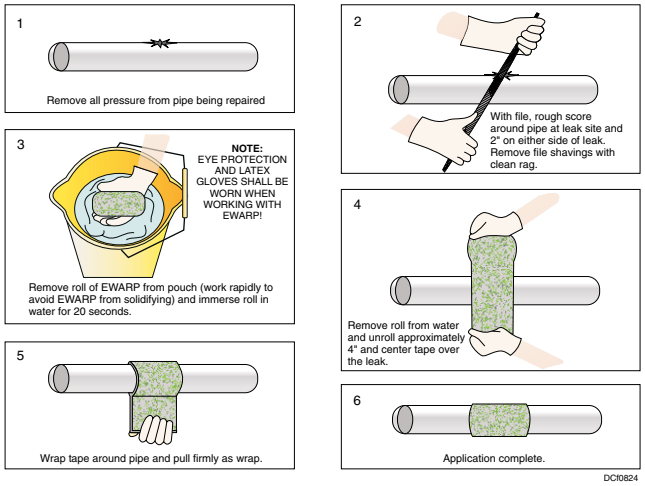

Figure 8-24. Steps for using EWARP.

REVIEW QUESTIONS

Q18. What is the maximum pounds of pressure a jubilee patch can resist?

1. 100 pounds
2. 125 pounds
3. 150 pounds
4. 175 pounds

Q19. What is the maximum pounds of pressure a soft patch can resist?

1. 500 pounds
2. 225 pounds
3. 150 pounds
4. 125 pounds

CASUALTY POWER SYSTEM

Learning Objective: Recall the purpose of the casualty power system and describe the components of the system.

The casualty power system (fig. 8-25) is one of the most important shipboard damage control systems. The system is a simple electrical distribution system. It is used to maintain a source of electrical power for the most vital machinery and equipment needed to keep the ship afloat or to get the ship out of a danger area. The casualty power system is intended to provide power during real emergencies only. It must NOT be used as a means of making temporary routine repairs.

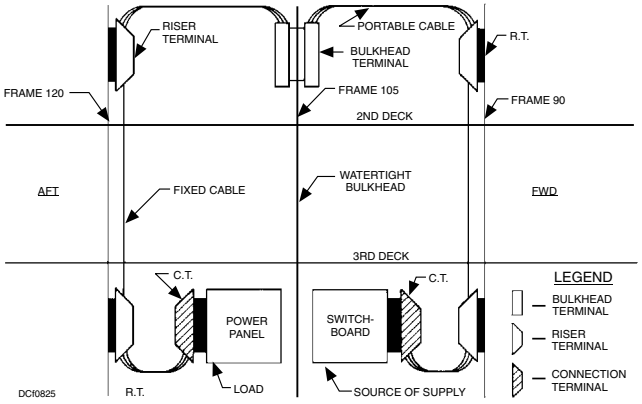

Figure 8-25. Casualty power run.

A casualty power system consists of the following items:

- Portable cables stowed in racks throughout the ship
- Bulkhead terminals for carrying the circuit through bulkheads without breaking the watertight integrity of the ship
- Risers between decks

- Casualty power connections at the source of supply

Portable casualty power cables are equipped with metal tags that indicate the length of the cable and the location of the cable stowage rack (fig. 8-26). Portable casualty power cables should be rigged only when required for use or when required for practice in rigging the casualty power system. At all other times, the cables should be stowed in the cable rack inicated on the cable tag.

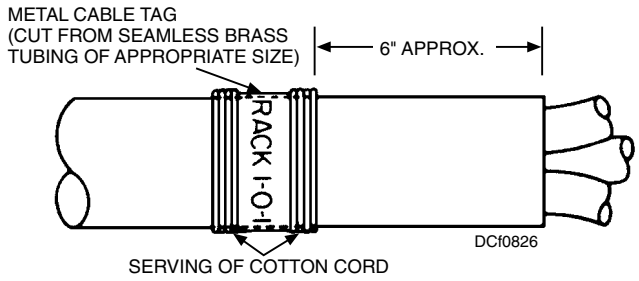

Figure 8-26. Portable casualty power cable tag.

When casualty power cables are rigged, the connections must always be made from the load to the supply to avoid handling energized cables. Portable signs saying DANGER—HIGH VOLTAGE must be posted at each connection and at 10-foot intervals along the length of the cable. The cables must be secured to the overhead, clear of the deck.

Sources of supply for casualty power use are provided at each ship's service and emergency switchboard. These consist of casualty power connection terminals on each switchboard; the terminals are connected to the bus bars through circuit breakers. Some ships also have small diesel-driven generators designated for casualty power use only. These generators are quite small and have very little control equipment.

Casualty power connection terminals are installed in power panels that feed equipment designed to receive casualty power. The casualty power connection terminals on the power panels may also be used as a source of supply to the casualty power system.

WARNING

All terminals on power panels are HOT. The normal supply to a panel must be shut OFF before the casualty power cable is connected to the terminals.

Machinery that can be supplied by the casualty power system includes steering gear, IC switchboards, fire pumps, and vital auxiliaries in firerooms and engine rooms.

The equipment and fixtures that make up an alternating current (ac) casualty power system include the following:

- Racks containing various lengths of portable thermoplastic covered or neoprene-covered cable. Each cable contains three leads or conductors (fig. 8-27). One lead is colored black, one is white, and one is red. This same color code is used in all three-wire power circuits throughout the electrical installations aboard ship.

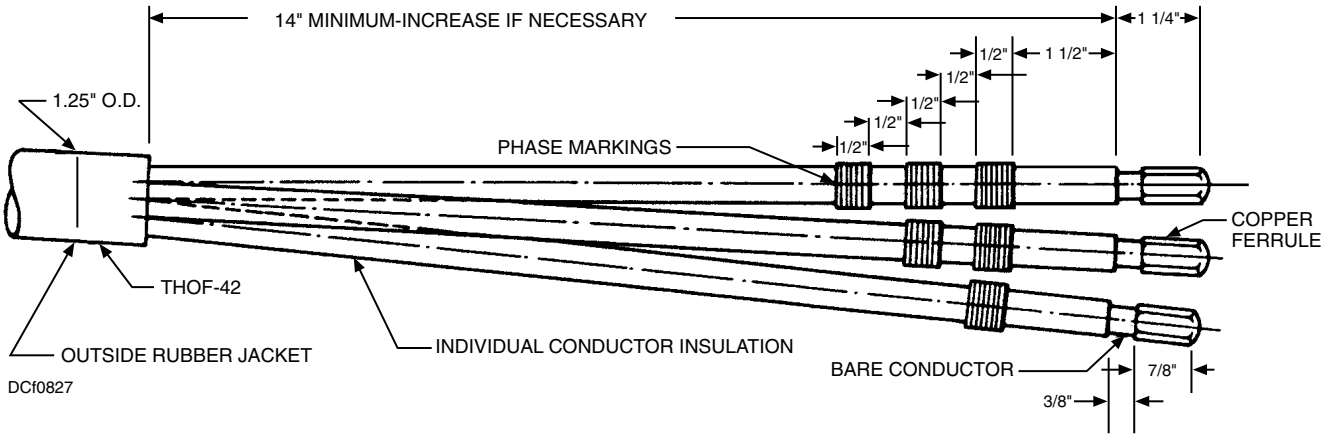

Figure 8-27. Portable casualty power, 450 volts, three-phase cable end.

- On small ships, bulkhead terminals provide for a single horizontal run of portable cable along the main deck, inside the superstructure. On large ships, there are generally terminals for two horizontal runs, one port and one starboard. These runs are located on the second deck. The terminals extend through the bulkhead and project from it on both sides. They do not impair the watertight integrity of the ship. The cable ends are inserted around the outer rim (or curved surface) of the terminal into the holes provided. There are three groups of three holes each. The face of the terminal also contains three groups of three holes each. The square-shanked insulated wrenches fit into these holes and are used to secure the cable in the terminal. Two of these wrenches are provided in a rack mounted on the bulkhead at each point where they are required. They must be kept in the rack at all times except when they are actually in use.

- Riser terminals are similar to bulkhead terminals. However, they are connected to other riser terminals by permanently installed armored cable to provide vertical runs. These riser terminals carry the casualty power from the generators to the main and the second deck levels.

- Portable switches are sometimes mounted on bulkheads near the cable racks. These are simply ON-OFF switches that are equipped with special holes for use with the portable cables.

The faces of the casualty power terminals of an ac system are marked A, B, and C, and the ends of the cables are colored black, white, and red, respectively. When connecting the cables to the terminals, connect the black lead to A, the white lead to B, and the red lead to C.

The color code is not sufficient for making proper connections in the dark or under other adverse conditions. Therefore, it is necessary to provide some means to identify each lead and its proper hole in the terminal by touch. This is accomplished by molded knobs in the A, B, and C portions of the terminals. There are one, two, or three knobs, respectively, in the A, B, and C portions of the terminals. Similarly, a piece of heavy twine is placed on the black lead of the portable cables, two pieces are placed on the white lead, and three pieces are placed on the red lead. Each of these servings of twine is about one-half of an inch wide.

NOTE

A new method of phase identification is similar to the old method, except that O rings and heat shrinkable tubing have been substituted for the cotton cord servings, as shown in figure 8-28.

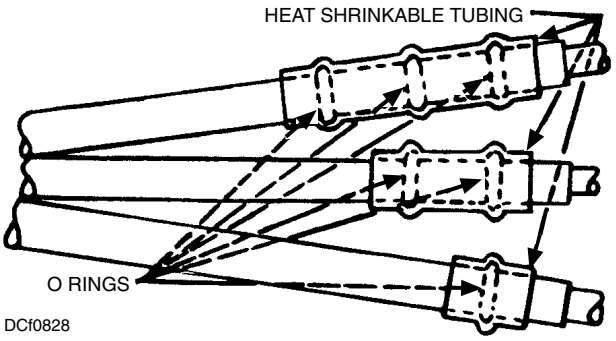

Figure 8-28. New method of cable identification.

Each lead and its corresponding position in the terminal can be identified by merely feeling the leads and matching the number of pieces of twine on each lead with the same number of raised knobs in the proper area of the terminal. In older ships, the casualty power fittings have identifying V-shaped notches in the outer edge of the fittings instead of the knobs.

When connecting a casualty power cable run, remember that you must ALWAYS connect from the load to the source of supply. This is to avoid working with live cables.

REVIEW QUESTIONS

Q20. When casualty power cables are rigged, the connections must always be made from the load to the supply to avoid handling energized cables.

1. True
2. False

Q21. Which of the following machinery can NOT be supplied by the casualty power system?

1. Steering gear
2. IC switchboards
3. Fire pumps
4. Main boiler plants

SUMMARY

When battle damage occurs, it must be repaired. In most cases, you will make a temporary repair until a permanent repair can be made. Shoring, plugging, and patching are your normal means of making the necessary temporary repairs. When the power source for certain vital equipment is discontinued, you will be required to supply power to the equipment by an alternate means, known as the casualty power system. Review the information presented to you in this chapter until you are familiar with it. If it is possible, you should put this knowledge into practical use with training aids such as a section of pipe that may be connected to a ship's fireplug. And always remember that you should not use expendable materials for training purposes until you have received permission from your work center supervisor or the damage control assistant (DCA).

REVIEW ANSWERS

A1. What document provides several repair locker inventory lists for various types of ships. **(2) The Allowance Equipage List**

A2. On a Navy ship, what personnel are responsible for damage control? **(1) All hands**

A3. After each use, all damage control kits and repair locker equipment must be inventoried to meet what requirements? **(2) PMS**

A4. What holes should be given priority when plugging is needed? **(4) Holes at the waterline or low side**

A5. The one very important thing to remember about flooding is that a ship can sink just as easily from a series of small and insignificant looking holes as it can from one large and more dramatic looking hole. **(1) True**

A6. Plugs made of softwood, such as yellow pine or fir, are quite effective for plugging holes up to what size? **(3) 3 inches by 3 inches**

A7. It is best to wrap a plug with lightweight cloth before inserting it because the cloth keeps the plug in place and fills gaps between plugs. **(1) True**

A8. What type of patches are effective for use over holes that have jagged edges projecting inboard? **(4) Box**

A9. Which of the following woods are best to use for the construction of shores? **(3) Douglas fir and yellow pine**

A10. A shore is a portable beam, a wedge is a block, triangular on the sides and rectangular on the butt end, and a shole is a flat block that may be placed under the end of a shore to distribute pressure. **(1) True**

A11. A strongback is a bar or beam of wood or metal that is used to distribute pressure or to serve as an anchor for a patch. The strongback is often shorter than a shore. **(1) True**

A12. What is the fully extended load for the model 6-11 steel adjustable shore? **(4) 6,000 pounds**

A13. A steel wedge is considered more valuable as a prying tool than for actual shoring. **(1) True**

A14. The most rapid and accurate way to measure a shore for cutting is to use an adjustable shoring batten. **(1) True**

A15. Which of the following types of equipment are available on the ship in case a space is inaccessible due to damaged doors, hatches, and/or scuttles? **(4) The Portable Hydraulic Access and Rescue System (PHARS) and the Portable Exothermic Cutting Unit (PECU)**

A16. PHARS can be utilized in emergency access, personnel rescue, or fire-fighting operations involving spreading, cutting, pulling, and piercing light plate or sheet metal. **(1) True**

A17. The PECU utilizes expendable cutting rods, which operate on the exothermic torch principle. **(1) True**

A18. What is the maximum pounds of pressure a jubilee patch can resist? **(1) 100 pounds**

A19. What is the maximum pounds of pressure a soft patch can resist? **(3) 150 pounds**

A20. When casualty power cables are rigged, the connections must always be made from the load to the supply to avoid handling energized cables. **(1) True**

A21. Which of the following machinery can NOT be supplied by the casualty power system? **(4) Main boiler plants**