# UNDERWATER SHIP HUSBANDRY MANUALS

# CHAPTER 16
# COFFERDAMS
# S0600-AA-PRO-160

**Revision 0, 1 February 1996**
**Revision 0, Change H, 15 November 2011**



CLICK HERE TO ENTER TABLE OF CONTENTS

# NAVSEA TECHNICAL MANUAL CERTIFICATION SHEET

NAVSEA 9086/11 (8/88)

| TM Identification Number<br>S0600-AA-PRO-160 | Publication Date<br>15 November 2011 |
|---|---|

Change No. H Revision No. 0 Volume No. ___ Part No. ___
Book No. S0600-AA-PRO-160 Chapter No. 16 Other No. ___
TM Specification. ___

Title: Underwater Ship Husbandry Manual, Chapter 16, Cofferdams

FOR CHANGES AND REVISIONS: (Indicate "NA" if item not applicable)

Purpose of Change/Revision:
Change paragraph 16-7.5 to incorporate new NAVSEA drawing reference

TM/Change/Revision Numbers Superseded: NA
TMDER/ACN Numbers Incorporated: N32253-11-NL01
Ship or Equipment Alteration/Field Change (FC)/Engineering Change (EC) Numbers Incorporated: NA

CERTIFICATION STATEMENT

This is to certify that responsible NAVSEA activities have reviewed the basic technical manual ( x ), revision ( ), or change ( x ) for acquisition compliance, technical coverage, and printing quality. This form is for internal NAVSEA management use only, and does not imply contractual approval or acceptance of the technical manual by the Government, nor relieve the contractor of any responsibility for delivering the technical manual in accordance with the contract requirements.

NAVSEA SIGNATURES

| Activity | Name | Signature | Organization | Code | Date |
|---|---|---|---|---|---|
| Acquisition | W. Reid | REID.WILLIAM.HOWARD.1047663225 Digitally signed by REID.WILLIAM.HOWARD.1047663225 DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USN, cn=REID.WILLIAM.HOWARD.1047663225 Date: 2011.11.03 07:55:42 -04'00' | NAVSEA | 00C5 | |
| Technical | S. Posey | POSEY.SCOTT.E.1038505773 Digitally signed by POSEY.SCOTT.E.1038505773 DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USN, cn=POSEY.SCOTT.E.1038505773 Date: 2011.11.02 10:12:40 -04'00' | NAVSEA | 00C51 | |
| Printing Release | | | | | |

**CHAPTER 16**
**COFFERDAMS**

## TABLE OF CONTENTS

## LIST OF APPENDICES

# LIST OF ILLUSTRATIONS



# LIST OF TABLES

# Record of Change
# ACN / FORMAL

| Change NO. | Title and / or Brief Description |
|---|---|
| A | Change to paragraph 16-3.4<br>Change to paragraph 16-3.4.2<br>Change to paragraph 16-3.4.2.1<br>Change to paragraph 16-3.6<br>Change to paragraph 16-3.7<br>Change to paragraph 16-3.8, added CAUTION<br>Change to paragraph 16-3.9<br>Change to paragraph 16-3.12<br>Change to paragraph 16-3.13<br>Change to paragraph 16-4.5<br>Change to paragraph 16-4.7<br>Change to paragraph 16-4.7.1<br>Change to paragraph 16-4.7.1.1<br>Change to paragraph 16-4.7.1.2<br>Change to paragraph 16-4.7.1.3<br>Change to paragraph 16-4.7.1.4<br>Change to paragraph 16-4.7.1.5<br>Change to paragraph 16-4.7.1.7<br>Change to paragraph 16-4.7.1.8<br>Change to paragraph 16-5.2<br>Change to paragraph 16-5.2.1<br>Change to paragraph 16-5.2.2<br>Change to paragraph 16-5.2.3, added CAUTION<br>Change to paragraph 16-5.2.4<br>Change to paragraph 16-5.2.5<br>Change to paragraph 16-5.2.6<br>Change to paragraph 16-5.2.7<br>Change to paragraph 16-5.2.8<br>Change to paragraph 16-5.2.9<br>Change to paragraph 16-5.2.10<br>Change to paragraph 16-5.2.11<br>Change to paragraph 16-5.2.13<br>Change to paragraph 16-5.2.14<br>Change to paragraph 16-5.2.15<br>Change to paragraph 16-5.2.16<br>Change to paragraph 16-5.2.17<br>Change to paragraph 16-5.2.18 |

| | |
|---|---|
| | Change to paragraph 16-5.2.19 through 16-5.2.20<br>Change to paragraph 16-5.2.21<br>Change to paragraph 16-5.3<br>Change to paragraph 16-5.3.1<br>Change to paragraph 16-5.3.3<br>Change to paragraph 16-5.3.4<br>Change to paragraph 16-5.3.5<br>Change to paragraph 16-5.4<br>Change to paragraph 16-5.5<br>Change to paragraph 16-6.8<br>Change to paragraph 16-6.8.1<br>Change to paragraph 16-7.6<br>Change to paragraph 16-7.6.2<br>Change to paragraph 16-7.6.3<br>Change to paragraph 16-7.6.4<br>Change to paragraph 16-7.6.5<br>Change to paragraph 16-7.6.6<br>Change to paragraph 16-7.6.7<br>Change to paragraph 16-7.7<br>Change to paragraph 16-7.7.1<br>Change to paragraph 16-7.9<br>Change to paragraph 16-7.9.2<br>Change to paragraph 16-8.4<br>Change to paragraph 16-8.4.3<br>Change to paragraph 16-8.4.4<br>Change to paragraph 16-9.1<br>Change to paragraph 16-9.1.1, added CAUTION<br>Change to paragraph 16-9.1.1.1<br>Change to paragraph 16-9.1.1.2<br>Change to paragraph 16-9.1.1.3<br>Change to paragraph 16-9.2<br>Change to paragraph 16-9.2.3<br>Change to paragraph 16-9.2.3.4<br>Change to paragraph 16-9.3<br>Change to paragraph 16-9.3.1<br>Change to paragraph 16-9.3.2<br>Updated Appendix A<br>Added new Appendix B<br>Added new Appendix C<br>Added new Appendix D<br>Added new Appendix E<br>Added new Appendix F<br>Added new Appendix G |

| | |
|---|---|
| B | Changed Appendix C, item 3 to permit use of 3/8" diameter J-Bolts<br>Changed Appendix F, Added Note 5 to permit use of 3/8" diameter J-Bolts |
| C | Changed paragraphs 16-1.4 through 16-1.8, 16-2.1.3.1, 16-3.6, 16-3.8, 16-4.7.1.3 through 16-4.7.1.10, 16-5.2.9, 16-5.2.11, 16-5.2.21, 16-6.6.10, 16-6.6.11, 16-7.6.4, 16-7.6.5, 16-7.6.7, 16-8.3.2, and 16-9.2.3.2.<br>Added Section 10 and Table 16-9. |
| D | Changed paragraphs 16-5.2.14, 16-5.2.18,<br>items 1, 19, and 22 of Appendix D and<br>item 1 of Appendix G.<br>Added paragraphs 16-5.2.18.1 and 16-5.2.18.2. |
| E | Changed paragraphs 16-4.7.1.1, 16-4.7.1.2, 16-4.7.1.5, 16-5.2.1, 16-5.2.2, 16-5.2.10, and 16-5.2.18.2.<br>Revised Appendix G. |
| F | Changed paragraph 6 of Appendix A to include a commercial source for Bintsuke. |
| G | Changed Section 16-7.6, Requirements |
| H | Paragraph 16-7.5 – Replaced NAVSEA drawing 6618843 with NAVSEA drawing 6699055 and changed item numbers to correspond. |

# CHAPTER 16

# COFFERDAMS

# SAFETY SUMMARY

## GENERAL SAFETY PRECAUTIONS

The following general safety precautions supplement the specific Warnings and Cautions throughout this chapter. These general precautions are related to cofferdams. They are precautions that must be understood and applied before and during work on cofferdams. In addition to the following precautions, personnel must be familiar with and observe safety precautions set forth in the following publications.

**a.** Navy Safety Precautions for Forces Afloat, OPNAV 5100 Series

**b.** Naval Ships' Technical Manual (NSTM)

**c.** Technical/Operating manuals for equipment

**d.** NAVSEA 0944-LP-001-9010, **U.S. Navy Diving Manual, Volume I**

### Do Not Repair or Adjust Alone

Do not repair or adjust energized equipment alone. The presence of a qualified individual capable of rendering aid is required. Always protect against grounding hazards and make adjustments with one hand free and clear of equipment. Be aware that even after equipment has been de-energized, dangerous electrical hazards can exist due to capacitors retaining electrical charges. Circuits shall be grounded and capacitors discharged.

### Test Equipment

Make certain electrical test equipment is in good condition and personnel are familiar with its safe operation. Handheld equipment must be grounded, if possible, to prevent shock injury. Because some types of equipment cannot be grounded, avoid holding them.

## Equipment in Motion

Remain clear of equipment in motion. A safety watch will be posted if the equipment requires adjustment while in motion. The safety watch shall have a full view of operations and immediate access to controls which are capable of stopping equipment. If at any time the masker belt appears to be moving out of control, stop equipment immediately.

## Limit Switches and Interlocks

Limit switches and interlocks are provided to protect personnel and equipment. They should not be overridden or modified except by an authorized person. Do not depend solely upon limit switches for protection. Disconnect power at the power distribution source before adjusting limit switches if possible.

## First Aid

Attend to all injuries, however slight, by obtaining first aid or medical attention immediately.

## Resuscitation

Personnel working with or near high voltage shall be familiar with approved resuscitation methods. Begin resuscitation immediately if someone is injured and stops breathing. A delay could cost the victim's life. Resuscitation procedures shall be posted where electrical hazards exist.

## Minimizing Relative Motion

Relative motion is the movement of two or more objects in relation to each other. This poses unique hazards to divers. A common example is a nest of ships swaying and bouncing against each other due to wind and wave action. This motion would easily crush a diver caught between the two ships. To reduce the hazards of relative motion and to simplify the task, suspend the work platform and rigging from fittings on the ship.

## Tool Control

It is essential to ensure that all tools and materials brought to the jobsite are accounted for and removed at the completion of the job. Tools and material inadvertently left at the jobsite can generate unacceptable noise and possibly severe damage to shipboard components. Locally generated work packages shall ensure that a general tool and material log sheet is prepared and maintained during all UWSH operations.

## WARNINGS AND CAUTIONS

Specific Warnings and Cautions appearing in this chapter are summarized below for emphasis and review.

***WARNINGS***

***If an internal blank has been installed, the integrity of the plug must be re-established prior to removal of the blank. Repair personnel must not assume a positive seal.***

***Each repair activity must ensure that their specific procedure for Bintsuke production has been approved in accordance with local environmental and occupational safety and health regulations.***

***CAUTIONS***

CHANGE A ***The flat and box patch designs provided have adequate strength and gasket loading area for application over the opening sizes identified in each design. Prior to application on a specific hull opening attachment and rigging plans must be developedfor the specific ship and hull opening.***

***For Submarines: Ship's Commanding Officer permission is required prior to breaking loose fasteners to confirm patch or plug seal. Installed patch or plug must have a tether attached and run to the surface. Topside end of***

***tether must be labeled "Hull Fitting (Noun Name) Installed".***

***Do not completely remove fasteners, as it may be necessary to retighten them should unexpected leakage occur. Note that, under certain conditions, all water may not be removed between the cofferdam and inboard component, especially in the cases of horizontal piping. When working these types of piping, be prepared to handle water draining from the piping when the outboard sea valve flange is loosened.***

***The old Underwater Work Techniques Manual suggested the use of tapered mechanical plugs. These plugs are unreliable and tend to dislodge during the tightening process. They are not authorized for UWSH applications.***

***Do not use cheater bars when tightening the plug.***

***Use caution when performing this procedure. Depending on the type and size of the affected system, a large amount of residual water may be trapped within the piping. It may take a long time to drain all the trapped water and confirm seal integrity.***

***Never dewater the chamber completely. This will cause air to exhaust out the bottom of the chamber and create a rocking effect. The rocking can cause the rigging to slack and break the seal, thereby flooding the chamber.***

# CHAPTER 16 COFFERDAMS

## SECTION 1 - INTRODUCTION

**16-1.1 Purpose.** This chapter provides maintenance activities with the minimum design, fabrication, and installation requirements for the use of cofferdams on U.S. Navy ships and submarines during waterborne maintenance and repair operations.

**16-1.2 Scope.** Underwater Ship Husbandry (UWSH) requires standardization of practices to ensure consistently safe and cost-effective operations. This chapter provides approved NAVSEA policy and requirements for the design, fabrication, and use of cofferdams on U.S. Navy ships and submarines. Specifically, this chapter provides: maintenance planners with a broad view of the function and use of cofferdams in underwater ship maintenance and repair; diving personnel with the requirements for the safe installation of cofferdams; designers with fabrication requirements for common size flat and box patch cofferdams; and ship's force or repair personnel with the interior space requirements during cofferdam operations.

**16-1.3** Cofferdams are defined as: any plug, patch, or dry chamber installed externally to the hull of a ship or submarine at or below the waterline in order to secure or dewater an area or system to enable shipboard or diver personnel to conduct maintenance or repairs to the hull or system. They can be as simple as a wooden plug inserted into a round opening or as complex as a dry chamber for a shaft coating repair.

**16-1.4** This chapter is divided into ten major topic sections: introduction, general information, operations planning, plugs, patches, dry chambers, stern tube seals, templating, cofferdam design, and compliance and performance standards for contractor cofferdam work.

**16-1.5 Applicability.** All personnel involved with the design, selection, fabrication, installation, and removal of cofferdams on U.S. Navy ships and submarines must be familiar with the appropriate sections of this chapter. This includes not only the engineers responsible for the design of the cofferdam and the divers responsible for the installation, but the ship fitters responsible for fabricating the devices, the ship's force responsible for tag-outs, the repair personnel responsible for removing systems that have been blanked off, and the riggers who will assist in properly placing and removing the cofferdam.

**16-1.6 Training.** All divers (Navy and Contractor) shall be trained in the fundamental cofferdam knowledge identified in Appendix E prior to cofferdam installation tasking. Regional Maintenance Centers shall be responsible for approval of contract diver organization training plans and execution.

**16-1.7 Background.** There have been recent (circa 1994) casualties during UWSH operations, including flooding of aircraft carriers and submarines. These casualties have prompted a new emphasis on cofferdam engineering and installation practices, leading to the development of this chapter to the Underwater Ship Husbandry Manual.

**16-1.8 General Safety Precautions.** Section 6 “Safety Precautions” of Chapter 2 “General Information and Safety Precautions” of the Underwater Ship Husbandry Manual describes the safety precautions to be observed during UWSH operations.

## SECTION 2 - GENERAL INFORMATION

### 16-2.1 Basic Types of Cofferdams.

**16-2.1.1 Plugs.** The simplest blanks used in UWSH operations are plugs. There are two types of plugs used in UWSH applications, the wooden damage control (DC) plug and the expandable mechanical plug. Plugs can be used to seal round hull penetrations that have no screens or bars to use as attachment points. Examples of these kinds of penetrations include pump discharge piping, blow-down piping, and dead lights. See Figure 16-1.

### 16-2.1.2 Patches.

**16-2.1.2.1 Flat Patch.** The simplest form of a patch is one made out of a single plate of metal or wood. As the name implies, this form of patch lies flat on the hull when it is secured in place.

**16-2.1.2.2** The unit is sized and shaped to rest flat and uniformly against the surrounding hull surface, thereby blanking off the hull opening. If the area to be covered is contoured, accurate templating is necessary to properly shape the unit during fabrication, depending on the stiffness of the material and curvature of the hull area. Because of its configuration, a flat patch is effective only if the hull surface is reasonably fair and free of any projections, distortions, or fittings. As the size and load carrying requirements increase, flat patches are often reinforced with stiffeners. Figure 16-2 illustrates a typical installed flat patch.

**16-2.1.2.3 Box Patch.** The box patch is essentially a flat patch with sides, with the open side of the box facing the hull. It mates to and seals against the hull surface through a flange and gasket along its open side. Sealing a main circulating pump or fire pump sea chest to allow maintenance to be performed from inside the ship is a typical box patch application. It can be constructed to cover any projections or fittings near the opening to be enclosed. If the area to be covered is contoured, then accurate templating is necessary to properly shape the unit during fabrication. Figure 16-3 illustrates a typical installed box patch.

**16-2.1.3 Dry Chambers.** There are two common types of dry chambers used in UWSH work: open bottom and open top. Open bottom cofferdams allow divers direct access to a particular hull area, system, or opening. The flange sides of the chamber secure and seal against the hull, acting as an airtight boundary. Dry chamber use considerations typically include items such as diver work space for rigging or welding and ventilation for welding or epoxy cure. Open top dry chambers are similar in design but allow surface access to the work area.

**16-2.1.3.1** Several Navy shipyards have designed and built various large unique application surface access dry chambers. These dry chambers allow work to be performed by topside workers below the waterline. Design of the larger units normally requires sophisticated design techniques not addressed in Section 9 of this chapter. However, NAVSEA 00C5 has collected many such designs and cofferdams from closing shipyards and will act as the focal point for identifying available units. Figures 16-4 and 16-5 illustrate typical dry chambers.

**16-2.1.4 Stern Tube Seals.** Stern tube seals are used to dewater the stern tube to allow maintenance, repair or replacement of the packing gland or Syntron seal. Often stern tube repairs only require the resurfacing of internal face seals which are inboard of the boot seal. Special blanking plates (dummy seat, see Section 7, Stern Tube Seals) are available which are installed after the face seals are removed. The blanking plates provide double-valve protection when combined with the inflated boot seal. In this case, diver-installed external stern tube seals are not required. Shaft seals may be a single device or a composite system. Surface ship shafts are sealed either by wrapping, a specialized box patch, or a mechanical shaft seal. The cooling ports are normally closed off with small flat patches or plugs. Submarine shafts are normally sealed using a mechanical shaft seal.

## SECTION 3 - OPERATIONS PLANNING

**16-3.1** Operations planning involves the assessment and assignment of resources necessary to accomplish a task. While each cofferdam task possesses its own unique aspects, the requirements of the planning process are identical. The following sections present a listing, in the typical order of occurrence, of the requirements for UWSH cofferdam work. For cofferdam tasks this assessment should be viewed as impacting three resource areas: technical, personnel, and organizational.

**16-3.2 Task Assignment.** The identification of the work required on the affected system, i.e., blanking cofferdam or dry chamber, is accomplished by a thorough review of the tasking documentation which may include 2-Kilo, Automated Work Request (AWR), and message information. These documents may assist the planner by providing reference to specific drawing numbers and technical manuals that are required to plan cofferdam work.

**16-3.3 Retrieve Drawings.** A thorough review of applicable drawings is required to properly plan and select the type and size of device to accomplish the repair. The use of these drawings will provide the planner with the required information such as location, details, interference, and curvature of the work area:

**(1)** System Component/Specific Drawings

**(2)** Docking Plans

**(3)** Shell Plating

**(4)** Lines Drawings

**16-3.4 Ship Check.** A ship check is required to establish liaison with the ship's Engineering Officer, Main Propulsion Assistant, and respective work centers. This allows the planner to retrieve information on conditions that may exist with the system being worked on or associated systems that could affect the installation and success of the cofferdam. The planner shall conduct a thorough internal inspection of the repair area for material condition and interference. An external inspection is required to determine accessibility to the repair area, positioning of the ship, and the availability of work area. The following are the minimum checks required during a ship check.

**16-3.4.1 External**

**16-3.4.1.1** Ship's position:

**(1)** Free access from pier;

**(2)** Requirement to work from boat or platform; and

**(3)** Clearance to maneuver craft.

**16-3.4.2 Internal**

**16-3.4.2.1** Double-valve or single-valve protection. A primary concern of UWSH cofferdam operations is double-valve protection. Double-valve protection is defined as maintaining any two of the following boundaries simultaneously:

**(1)** A ship's sea chest closure valve;

**(2)** An internal sealing blank installed immediately after the internal piping or watertight boundary is opened;

**(3)** An external cofferdam, patch, or plug.

Internal sealing blanks are preferred over external cofferdams.

Anytime there are less then two of the above boundaries in place, the ship and repair activity must accept the additional requirements associated with single valve protection. This includes the brief periods of time between opening the piping and installing an internal sealing blank and between removing the internal blank and replacing the repaired component.

Double external cofferdams (a cofferdam over another cofferdam) are not required or recommended.

**16-3.4.2.2** Condition of isolation valves.

**16-3.4.2.3** Hull plating and piping material condition around repair area.

**16-3.4.2.4** Special conditions (other shipboard interference, fuel or other tanks).

**16-3.4.2.5** Liaison with the Chief Engineer (CHENG) to discuss associated systems:

**(1)** Condition of cross connect valves associated with failed valve or component to be removed;

**(2)** Determine if additional blank required;

**(3)** Develop emergency operations plan for flooding; and

**(4)** Watch standers, monitors and alarms.

**16-3.4.2.6** Internal and external communications.

**16-3.4.3 Tag-Out.**

**(1)** Specific to the system being worked.

**(2)** All affected systems or cross connects.

**16-3.5 Identify Support.** To prevent scheduling conflicts, support required to accomplish the repair must be identified early in the planning stage. The services of several activities may be required simultaneously, such as a crane from public work center and a YD from port operations. Proper planning and scheduling will prevent unnecessary delays. The following are some typical support services that may be required for the installation of a cofferdam.

**16-3.5.1 Hardware and Craft Assets.**

**(1)** Camels

**(2)** Tugs

**(3)** Cranes

**(4)** Barge or Craft

**16-3.5.2 Personnel Support**

**(1)** Engineering and Technical

**(2)** Fabrication Services

CHANGE C CHANGE A **16-3.6 Inspection Dive.** Except for repetitive routine tasks, an inspection dive is required whenever a cofferdam is to be installed. There are certain steps that must be considered to perform an inspection dive for the use of a cofferdam such as confirm correct system, cleaning, templating, and planning for rigging. The type of cofferdam used will determine the details of the inspection.

CHANGE A **16-3.7 Select and Inspect Cofferdam.** The requirement of the cofferdam selection process is to provide an engineering approved cofferdam that will ensure and maintain watertight integrity. Engineering documentation for every cofferdam must be on file with the installing activity and accessible for review by installation personnel. It must also provide a means of being held firmly and securely against the hull in the event of a loss of differential pressure. All patches must be secured such that they can not rotate or move out of alignment with the hull opening. The following are the minimum considerations for the selection and inspection process:

**(1)** Type of Cofferdam to be Used

**(2)** Check Inventory for Availability, Suitability

**(3)** Decision to Build, Borrow, Modify

**(a)** Modify or reconfigure as appropriate, to build seal

CHANGE A **(b)** Inspect in accordance with the Appendix C Patch and Plug Inspection Checksheet

CHANGE C CHANGE A **16-3.8 Engineering Evaluation.** All cofferdams used for UWSH must meet the engineering design criteria of Section 9. Section 9 of this chapter also provides flat and box patch designs that meet this requirement and cover over 80 percent of U.S. Navy hull openings. Included are: material type and thickness criteria for unstiffened flat patches and the NAVSEA Standard Cofferdam drawing.

> CHANGE A ***Caution***
>
> ***The flat and box patch designs provided have adequate strength and gasket loading area for application over the opening sizes identified in each design. Prior to application on a specific hull opening attachment and rigging plans must be developed for the specific ship and hull opening.***

CHANGE C The engineering evaluation of any cofferdam selected must address:

CHANGE A **(1)** Design and Materials- Verification of compliance with predesigned patches of Section 9 or design in accordance with the requirements of section 9.

CHANGE A **(2)** Design of Stiffeners (if required).

CHANGE A **(3)** Gasket design - including consideration of loaded gasket area to consider allowable gasket compression values of Section 9.

CHANGE A **(4)** Use of Fasteners.

**(5)** Consideration of attachment locations for dewatering eductor and external vent line (if no internal vent line is available in the sea chest). Both eductor and external vent line attachment points must have closure valves.

**(6)** Rigging and attachment to include consideration of rigging loads.

**(7)** Unique inspection criteria - not included in the Appendix C Patch and Plug Inspection Checksheet but considered important by the designers to include for the specific cofferdam design.

### 16-3.9 Dewatering Methods or Concerns

**(1)** Eductor size

**(2)** Eductor location

**(3)** External vent line size, required if an internal vent line is unavailable

**(4)** Closure valves for suction side of eductor.

**(5)** Cofferdam attachment point of external vent line.

**(6)** Air supply and vent line size (dry chambers)

**16-3.10 Templating.** Except for flat hull surfaces, templating is the process to pattern hull shape data (hull contour) for use in forming the sealing surface of cofferdams. The requirement is to achieve acceptable leakage of the cofferdam without the continuous use of dewatering equipment. Successful templating requires trained personnel using properly designed equipment.

**16-3.11 Fabrication or Modification of the Blank or Seal.** All fabrication, modification, or repair of a cofferdam must be done in accordance with an approved engineering design specification. Engineering design criteria is specified in Section 9.

**16-3.12 Rigging Plan and Assembly.** A rigging plan is required for installation of a cofferdam. When planned properly, it ensures the safety of personnel and equipment and the successful installation of the cofferdam. The rigging plan includes the installation or attachment method and the selection of safe working loads for rigging components. The rigging plan must identify the following:

**(1)** Lifting Requirements

**(2)** Securing and Attachment Requirements - to include consideration of rigging loading requirements as discussed in Section 9.

**(3)** Manufacturer and Weight Testing Requirements (Lifting Straps, Padeyes, Wire)

**16-3.13 Installation Confirmation.** Dive Supervisors shall confirm all installations are proper and complete by signing the Appendix D Patch and Plug Installation Checksheet. All installation checksheets shall remain on file at the installation activity while the cofferdam is installed on a vessel.

## SECTION 4 - PLUGS

**16-4.1** Though plugs are the most basic, simplest form of sealing devices, the proper use and selection is critical to safe, successful UWSH operations. Two types of plugs, wooden damage control (DC) and mechanical expandable, are commonly used for UWSH. Of the two types, mechanical expandable plugs are preferred since they provide a reliable positive seal, are reusable, and are easy to install and remove.

**16-4.2** DC plugs have been used for salvage and UWSH for years; however, their safe use for UWSH requires special consideration. The diver must always ensure that the DC plug is completely seated and sealed (i.e., Bintsuke sealing DC plug to hull) before checking for leakage. (See Appendix A for Bintsuke recipe).

**16-4.3** Mechanical expandable rubber plugs provide a simple and reliable means of sealing any small round hull opening. They are easy to install and remove and will remain securely in place when correctly installed. The expansion of the plug, rather than a differential pressure, secures the plug in place and forms the seal.

**16-4.4** Typical uses for plugs are sealing uncovered discharges and dead lights. Suctions are normally covered with a grating or screen that prevents the use of plugs for routine blanking. There may be instances, however, where an individual suction within a sea chest requires blanking while leaving the other systems operational. In such cases, it is necessary to remove the screen or grate and use a plug to blank only the desired system.

**16-4.5** The installation of a tag line from the plug to the surface will greatly assist in relocating the plug for removal. Further, a highly visible tag line alerts other diving activities (hull cleaning) and outside traffic, such as tugboats, pusher boats, or other craft of the plug's existence when coming alongside. The tag line also alerts shipboard personnel to avoid mooring camels or ship waste offload barges in the vicinity of the plug. This is especially important when the plug is installed on the vertical sides of the hull (above the bilge keel or turn of the bilge). Some activities prefer use of hull bellybands to tag lines since bellybands can help to secure the plug in addition to locating the plug.

**16-4.6** For plugs installed on the flat bottom of a hull, a tag line from the plug to a C-clamp secured on the bilge keel will assist the diver in relocating the plug, but will not interfere or obstruct traffic alongside.

### 16-4.7 Requirements.

#### 16-4.7.1 General.

**16-4.7.1.1** Repair personnel shall install a replacement component or an internal sealing blank with a gasket immediately after the damaged component is removed. Immediate installation of an internal sealing blank in combination with a closed sea chest valve meets the double-valve protection requirement without a diver installed plug, provided that the ship's Commanding Officer or his designated representative understands that there is only single valve protection during the brief period occurring between the time the repair component is removed and the internal sealing blank is installed and between the time the internal sealing blank is removed and the repaired component is replaced. Prior to removal of the internal sealing blank for replacement of the repaired component the blank fasteners shall be loosened and the seal cracked to check for leakage.

**16-4.7.1.2** If a sea chest closure valve is being worked or can not be secured, a diver installed plug in combination with an internal sealing blank with a gasket installed immediately after the damaged component is removed meets the double-valve protection requirement provided that the ship's Commanding Officer or his designated representative understands that there is only single valve protection during the brief period occurring between the time the repair component is removed and the internal sealing blank is installed and between the time the internal sealing blank is removed and the repaired component is replaced. Prior to removal of the internal sealing blank for replacement of the repaired component the blank fasteners shall be loosened and the seal cracked to check for leakage.

**16-4.7.1.3** A Formal Work Package (FWP), including the Patch and Plug Inspection Checksheet (Appendix C) and the Patch and Plug Installation Checksheet (Appendix D) that has been approved by the repair activity and ship's Commanding Officer or his designated representative shall be followed when any diver installed plug serves as the primary or secondary barrier to the sea.

CHANGE C CHANGE A **16-4.7.1.4** Prior to installation of a plug, ship's Commanding Officer or his designated representative shall be notified of the location of the plug and level of protection provided (single or double-valve protection).

CHANGE C CHANGE A CHANGE E **16-4.7.1.5** Emergency plan (flooding) - Whenever single valve protection is in place, the repair activity shall include in their written notification to the ship a specific plan for immediate installation of a replacement piping component or internal sealing blank as discussed in 16-4.7.1.1 or 16-4.7.1.2 to restore double-valve protection. The ship shall calculate the worst case possible scenario for flooding and provide a plan of action and additional emergency dewatering equipment as required. Except for the brief period of single valve protection provided for in 16-4.7.1.1 or 16-4.7.1.2, the equipment shall be rigged in place and operationally ready prior to commencing work and for the entire time single valve protection is in place.

CHANGE C CHANGE A **16-4.7.1.6** Prior to installation, all plugs shall be visually inspected in accordance with the Patch and Plug Inspection checksheet (Appendix C). The dive supervisor shall sign off the Patch and Plug Inspection Checksheet approving the inspection. The Patch and Plug Inspection checksheet shall remain on file at the installing activity while the device is installed on a vessel. Any deficiencies found during inspection must be corrected, repaired, or replaced, prior to each use.

CHANGE C **16-4.7.1.7** All components and subsystems of the affected system must be identified and tagged-out using an approved tag-out procedure.

CHANGE C CHANGE A **16-4.7.1.8** Zero leak rate seal shall be confirmed at the internal repair area prior to complete removal of piping connection fasteners. If a repair activity is unable to achieve a zero leak rate and all efforts are exhausted, a leak rate acceptable to personnel performing internal repair work and ship's damage control personnel must be established. The established leak rate must be confirmed at the internal repair area prior to complete removal of piping connection fasteners. Regular assessment (measurement) of the plug's leakage to ensure leakage is maintained at or below the acceptable leak rate is required.

CHANGE C CHANGE A **16-4.7.1.9** Dive supervisors shall complete and sign the Patch and Plug Installation Checksheet (Appendix D). The Patch and Plug Installation Checksheet shall remain on file at the installing activity while the plug is installed on a vessel.

CHANGE C **16-4.7.1.10** Divers shall not leave the dive station until double-valve protection is established, repairs are completed, or ship's Commanding Officer or his designated representative permission is granted.

**16-4.7.2 Mechanical Expandable Plugs.**

**16-4.7.2.1** The top plate or washer must have an outside diameter larger than the opening being sealed.

**16-4.7.2.2** The rubber sealing surface shall be untapered.

**16-4.7.2.3** The size range for each plug must be stamped on the end plate or on a permanent waterproof tag attached to the plug.

**16-4.7.2.4** The plug must have a seated pressure rating at least one and one half times the static pressure head it will seal.

**16-4.7.2.5** Due to the potential for galvanic corrosion, mechanical plugs with aluminum components are not authorized for use.

> ***CAUTION***
> ***The old Underwater Work Techniques Manual suggested the use of tapered mechanical plugs. These plugs are unreliable and tend to dislodge during the tightening process. They are not authorized for UWSH applications.***

**16-4.7.3 DC Plugs.**

**16-4.7.3.1** Plugs must be standard stock or equal.

**16-4.7.3.2** Plugs must be in good condition: no chips, gouges, or cracks.

**16-4.7.3.3** Use only bare plugs, not fabric or rubber wrapped.

**16-4.8 Mechanical Expandable Plugs.**

**16-4.8.1** Mechanical plugs for UWSH applications may be locally manufactured or bought commercially. Figure 16-6 illustrates the typical features of these plugs. Figure 16-7 and Table 16-1 provide size and construction details for locally manufactured mechanical plugs. Commercial plugs must meet the requirements of Section 16-4.7.2. Tables 16-2 and 16-3 list two manufacturers and recommended models.

**16-4.8.2 Preparation.** Using ship's drawings (Docking Plan), determine the diameter of the hull opening. All expandable rubber plugs have a limited range of the sizes of openings they will effectively seal. Select a plug that matches the diameter of the opening to be sealed. Commercially available mechanical expandable plugs are well suited to UWSH applications.

**16-4.8.3** Thoroughly inspect the condition of the plug. Disassemble the plug and examine all components for deterioration, corrosion, stripped threads, or any other obvious damage. If the material condition of any single component is questionable, either replace that component or the entire plug assembly, whichever is most appropriate.

**16-4.8.4** Establish a communications protocol with the on-site repair personnel. Direct communication is required to verify the integrity of the plug upon installation and prior to removal.

**16-4.8.5** All components and subsystems of the affected system must be identified and tagged-out using an approved tag-out procedure. Any increase in internal system pressure or movement of fluid in the piping could dislodge the plug. Consult all applicable drawings such as piping diagrams (tab books) and backup dewatering systems when planning the tag-out. Surface tag lines to the plug also should be clearly marked.

**16-4.8.6 Plug Installation.** Thoroughly clean the area of all fouling, rust, and debris. The plug must have a smooth clean surface to seal against. Use a wire brush, scraper or “greenie pad” to thoroughly clean the hull surface and opening of any fouling, cleaning at least as far into the opening as the plug will reach.

**16-4.8.7** Insert the plug into the hull penetration and verify that the backing plate is firmly seated against the hull prior to tightening. Do not over tighten and strip the threads of the compression assembly.

***CAUTION***
***Do not use cheater bars when tightening the plug.***

**16-4.8.8** Signal topside when the plug is securely in place.

**16-4.8.9** Have personnel inside the ship bleed off the pressure inside the piping to ensure a positive seal has been made. One method of accomplishing this is by opening a bleed valve installed in the system. Another method is to slowly loosen an internal flange. Only loosen the flange; do not completely remove any fasteners until a positive seal is established.

> ***CAUTION***
> ***Use caution when performing this procedure. Depending on the type and size of the affected system, a large amount of residual water may be trapped within the piping. It may take a long time to drain all the trapped water and confirm seal integrity.***

**16-4.8.10** Once the seal is confirmed, repair personnel may remove the item requiring repair. Repair personnel must be ready to internally blank the piping off or immediately return it to its original configuration, i.e., swap out a damaged item with a new or repaired one. The plug acts as one part and the installed blank acts as the other part of the required double-valve protection.

**16-4.8.11 Plug Removal.**

> ***WARNING***
> ***If an internal blank has been installed, the integrity of the plug must be re-established prior to removal of the blank. Repair personnel must not assume a positive seal.***

**16-4.8.12** When the system is restored to its original configuration by repair personnel, the diver loosens the plug's wing nut or T-handle to relax the plug and break the seal.

**16-4.8.13** After removal, the diver should remain at the work site, ready to reinstall the plug, until he receives verification that no leaks exist within the ship.

**16-4.8.14** After each use of a mechanical expandable plug, thoroughly inspect the condition of the plug. Disassemble and freshwater wash the plug and examine all of its components for deterioration, corrosion, stripped threads, or any other obvious damage. If the material condition of any single component is questionable, either replace that component or the entire plug assembly, whichever is most appropriate.

**16-4.9 Wooden DC Plugs.**

**16-4.9.1 Preparation.** Table 16-4 gives National Stock Numbers (NSN) and sizes for standard DC plugs. Table 16-5 gives the minimum and maximum size opening restrictions for standard plugs. Using Table 16-5, select the appropriate size DC plug for the opening. Plugs longer than 8 inches may need to be trimmed so that a maximum of 3 to 4 inches protrudes from the opening after installation. Excessively long plugs are harder to install and pose a greater risk of becoming fouled and dislodged.

**16-4.9.2** Thoroughly inspect the opening for fouling and corrosion; clean as required to obtain a smooth sealable surface.

**16-4.9.3 Installation.** Using a hammer, firmly seat the plug in the opening. Seal the plug to the hull with a sealing compound (e.g., Bintsuke) if required.

**16-4.9.4** Signal topside when the plug is securely in place.

**16-4-9.5.** Have personnel inside the ship bleed off the pressure inside the piping to ensure a positive seal has been made. One method of accomplishing this is by opening a bleed valve installed in the system. Another method is to slowly loosen an internal flange. Only loosen the flange; do not completely remove any fasteners until a positive seal is established.

***CAUTION***
***Use caution when performing this procedure. Depending on the type and size of the affected system, a large amount of residual water may be trapped within the piping. It may take a long time to drain all the trapped water and confirm seal integrity.***

**16-4.9.6** Once the seal is confirmed, repair personnel may remove the item requiring repair. Repair personnel must be ready to internally blank the piping off or immediately return it to its original configuration, i.e., swap out a damaged item with a new or repaired one. The plug acts as one part and the installed blank acts as the other part of the required double-valve protection.

**16-4.9.7 Removal.**

***WARNING***
***If an internal blank has been installed, the integrity***
***of the plug must be re-established prior to removal***
***of the blank. Repair personnel must not assume a positive seal.***

**16-4.9.8** When the system is restored to its original configuration by repair personnel, the diver loosens and removes the plug. Use a hammer to dislodge and loosen the plug by striking the side of the plug. If the plug is too firmly seated to dislodge by hammering alone, use a chisel to crush the seal area between the plug and the hull to assist in removal.

**16-4.9.9** After removal, the diver should remain at the work site ready to install a new plug until he receives verification that no leaks exist within the ship.

**16-4.9.10** Discard the DC plug if it is damaged.

## SECTION 5 - PATCHES

**16-5.1 General Information.** This section discusses the types and application of patches for use in Underwater Ship Husbandry. When properly planned and executed, they provide a safe and cost effective method to conduct repairs to a ship waterborne versus dry docking.

**16-5.1.1 Flat Patch.** The flat patch is constructed of metal or marine plywood. Figure 16-8 shows typical flat patch details. Depending on the size, it may be provided with stiffeners for strengthening and padeyes for lifting. The sealing surface is made by gluing a layer of sealing material to the mating side of the patch.

**16-5.1.2 Box Patch.** The box patch is basically a flat patch with four sides to allow the patch to stand-off from the hull, thus clearing obstructions and providing sufficient height to contour the sealing surface to match the hull curvature. Figure 16-9 shows typical box patch details. Box patches can have interchangeable sealing flanges. The design and fabrication of only a new sealing flange for different hull openings can save time and expense and reduce or eliminate additional engineering analysis.

**16-5.2 Requirements.** Patches, flat or box, used for UWSH maintenance and repair must meet the following minimum specific requirements to safely accomplish the task.

**16-5.2.1** Repair personnel shall install a replacement component or an internal sealing blank with a gasket immediately after the damaged component is removed. Immediate installation of an internal sealing blank in combination with a closed sea chest valve meets the double-valve protection requirement without a diver installed patch, provided that the ship's Commanding Officer or his designated representative has been notified per Appendix G and understands that there is only single valve protection during the brief period occurring between the time the repair component is removed and the internal sealing blank is installed and between the time the internal sealing blank is removed and the repaired component is replaced. Prior to removal of the internal sealing blank for replacement of the repaired component the blank fasteners shall be loosened and the seal cracked to check for leakage.

**16-5.2.2** If a sea chest closure valve is being worked or can not be secured, a diver installed patch in combination with an internal sealing blank with a gasket installed immediately after the damaged component is removed meets the double-valve protection requirement provided that the ship's Commanding Officer or his designated representative has been notified per Appendix G and understands that there is only single valve protection during the brief period occurring between the time the repair component is removed and the internal sealing blank is installed and between the time the internal sealing blank is removed and the repaired component is replaced. If no other internal vent exists, the internal sealing blank shall have a less then ½ inch diameter vent valve installed. The vent valve facilitates internal vent cofferdam monitoring per requirement 16-5.2.18. Prior to removal of the internal sealing blank for replacement of the repaired component no leakage shall be confirmed at the internal vent or blank vent valve.

**16-5.2.3** The design and fabrication must meet the requirements of Section 9 of this chapter. Design for sealing gasket and rigging loads discussed in Section 9 must be considered in addition to the patch structural design. Section 9 also provides standard flat and box patch designs that meet this requirement.

***CAUTION***

***The flat and box patch designs provided have adequate strength and gasket loading area for application over the opening sizes identified in each design. Prior to application on a specific hull opening attachment and rigging plans must be developed for the specific ship and hull opening.***

**16-5.2.4** Sea chest gratings and splitter bars can be considered in the sizing of flat patch material. To consider support from recessed grating or bars, they must be shimmed to flush with plywood or other suitable material.

**16-5.2.5** An uncompressed gasket sealing material thickness of 2 inches. Gasket material is specified in Section 9.

***NOTE***

***Existing NAVSEA approved (documented on a NAVSEA drawing) hydrostatic test blanks/ fittings designed to be bolted onto a flat flange and sealed with an O-ring or solid rubber gasket are not required to meet the gasket material or proportion requirements of 16-5.2.5. The specific gasket or O-ring requirements of the NAVSEA approved drawing shall be met.***

**16-5.2.6** The patch must be positively secured to the hull to prevent loss of the patch and rotation or movement of the patch out of proper alignment with the hull opening. The outer perimeter dimensions of the patch shall be marked on the hull prior to patch installation to ensure proper patch alignment with the hull opening. Marking on the hull shall not be by scribing into the hull paint system. Divers shall inspect the sea chest strainer bars for excessive deterioration, weld cracks and permanent deformation. Strainer bars shall be free of defects prior to cofferdam installation. If the strainer bars are bolted, verify that the fasteners are in good condition.

**16-5.2.7** All patches must have an installed data plate or engraved serial number which corresponds to supporting documentation. The repair activity having responsibility for patch installation shall maintain supporting documentation and maintenance records for verification while the device is in service. Supporting documentation shall include patch rated depth and maximum hull opening size, fabrication drawing, gasket requirements, eductor and vent line requirements, and patch specific hull opening attachment and alignment requirements.

**16-5.2.8** Prior to installation, all patches and attachment hardware (J-bolts, turnbuckles, etc.) shall be visually inspected in accordance with the Patch and Plug Inspection checksheet (Appendix C). The dive supervisor shall sign off the Patch and Plug Inspection checksheet approving the inspection. The Patch and Plug Inspection checksheet shall remain on file at the installing activity while the device is installed on a vessel. Any deficiencies found during inspection must be corrected, repaired, or replaced, prior to each use.

CHANGE C CHANGE A **16-5.2.9** Prior to installation of a patch, ship's Commanding Officer or his designated representative shall be notified in writing of the location of the patch and level of protection provided (single or double-valve).

CHANGE A CHANGE E **16-5.2.10** Emergency plan (flooding)- Whenever single valve protection is in place the repair activity shall include in their written notification to the ship a specific plan for immediate installation of a replacement piping component or internal sealing blank as discussed in 16-5.2.1 or 16-5.2.2 to restore double-valve protection. The ship shall calculate the worst case possible scenario for flooding and provide a plan of action and additional emergency dewatering equipment as required. Except for the brief period of single valve protection provided for in 16-5.2.1 or 16-5.2.2 the equipment shall be rigged in place and operationally ready prior to commencing work and for the entire time single valve protection is in place.

CHANGE C CHANGE A **16-5.2.11** A Formal Work Package (FWP), including the Patch and Plug Inspection Checksheet (Appendix C) and the Patch and Plug Installation checksheet (Appendix D) that has been approved by the repair activity and ship's Commanding Officer or his designated representative shall be followed when any diver installed patch serves as the primary or secondary barrier to the sea.

**16-5.2.12** All components and subsystems of the affected system must be identified and tagged-out using an approved tag-out procedure.

CHANGE A **16-5.2.13** All patches shall be sealed to the hull opening by a gasket compressed under differential pressure. Differential pressure is applied when the seachest covered by the patch is dewatered and brought to atmospheric pressure.

CHANGE D CHANGE A **16-5.2.14 Venting:** All patches shall be vented to atmospheric pressure by an internal seachest vent (steam blow down valve) or an external non-collapsible vent line installed directly on the patch and run to the surface. A vent line (internal or external) must be installed and open prior to operation of a dewatering eductor to ensure eductor suction will not draw the enclosed space pressure below atmospheric pressure and overload the patch. If the internal vent line is greater than or equal to ½ inch IPS, a temporary reducer shall be installed to make the opening less than ½ inch IPS. When using an internal vent, communications must be established between topside and internal space workers to ensure that the internal vent valve is open prior to eductor operation. All internal vents shall be caution tagged "External cofferdam vent valve. If water present or pressurized air released when opened, take action to confirm cofferdam adequacy". When an external vent line is used, it must be a non-collapsible hose. All patch pipe nipples used to attach external vent lines must have valves installed to secure the space when dewatering is complete.

**16-5.2.15 Dewatering:** All patches shall be dewatered by draining the seachest at an internal drain valve or piping connection or by use of an eductor installed directly on the patch. Eductors shall be secured after dewatering is complete. Eductors shall not be left running to maintain a differential pressure seal. All patch pipe nipples used to attach the suction side of dewatering eductors must have valves installed to secure the space when dewatering is complete.

**16-5.2.16 Retightening:** After sealing, a final check of all support rigging is necessary to verify integrity. Sealing the patch will compress the seal, causing slack in the rigging that was not present before dewatering. Readjust the rigging or tighten the J-bolt(s) as necessary to ensure a tight fit.

**16-5.2.17 Leakage:** Zero leak rate seal shall be confirmed at the internal repair area with dewatering equipment secured prior to complete removal of piping connection fasteners. If a repair activity is unable to achieve a zero leak rate after exhausting all efforts and the patch application has an internal vent, a leak rate with dewatering equipment secured acceptable to personnel performing internal repair work and ship's damage control personnel must be established. The established leak rate with dewatering equipment secured must be confirmed at the internal repair area prior to complete removal of piping connection fasteners. Regular assessment (measurement) of the patch leakage with dewatering equipment secured to ensure leakage is maintained at or below the acceptable leak rate is required. If a repair activity is unable to achieve a zero leak rate after exhausting all efforts and the patch application has an external vent, a departure must be processed.

**16-5.2.18 Monitoring:** The differential pressure seal on all patches (with dewatering equipment secured) shall be monitored during the time that the patches are actually providing single or double-valve protection for the seachest.

**16-5.2.18.1** For seachests and piping systems with internal means of venting, the location of the affected seachests and internal vents shall be reported to the ship's Chief Engineer per Appendix G. Internal vents shall be inspected for signs of leakage by ship's sounding and security detail on an interval not to exceed every seven days. The isolation valve for the internal vent shall be carefully opened during the inspection and the vent observed for the presence of water, or the release of pressurized air (indicating entry of water past the cofferdam seal causing the remaining air bubble to compress). The isolation valve for the internal vent may then be closed until the next inspection to avoid leakage between inspections from entering the bilge or, upon approval by the Ship, the isolation valve for the internal vent may be left continuously open to maintain cofferdam differential pressure.

**16-5.2.18.2** For seachests and piping systems with no means of internal venting, the patch shall be visually inspected by divers for reduced gasket compression indicating loss of seal on an interval not to exceed every seven days, or install a pressure gauge with one psi gauge resolution onto the surface end of an external vent line which has been extended to a location where ship's sounding and security detail can monitor the pressure gauge for a one psi(g) pressure increase, or install flood detection sensors on or inside the patch that will alarm in a continuously manned space if flooding occurs. NAVSEA Drawing 6698919, Wireless Alarm Flood Monitoring System, details a cofferdam patch alarm system.

CHANGE A ***NOTE***

***Existing NAVSEA approved (documented on a NAVSEA drawing) hydrostatic test blanks/ fittings designed to be bolted onto a flat flange and sealed with an o-ring or solid rubber gasket do not require monitoring after a zero leakage seal has been established and confirmed.***

CHANGE A **16-5.2.19** Dive supervisors shall complete and sign the Patch and Plug Installation Checksheet (Appendix D). The Patch and Plug Installation Checksheet shall remain on file at the installing activity while the patch is installed on a vessel.

CHANGE A **16-5.2.20** All divers (Navy and Contractor) shall be trained in the fundamental cofferdam knowledge identified in Appendix E prior to cofferdam installation tasking. Supervisor of Ship Building (SUPSHIP) activities shall be responsible for approval of contract diver organization training plans and execution.

CHANGE C CHANGE A **16-5.2.21** Divers shall not leave the dive station until double-valve protection is established, repairs are completed, or ship's Commanding Officer or his designated representative permission is granted.

CHANGE A **16-5.3 General Guidance - Preparation.**

CHANGE A **16-5.3.1** All patches (single or double-valve protection) should be scheduled for installation just prior to the requirement for internal work and seals confirmed immediately prior to commencing internal work.

**16-5.3.2 Selection.** The first reference drawing used when selecting a patch is the Docking Plan. The Docking Plan provides the underwater profile of the ship, the plan view of its hull, the exact location and size of the opening, the location of underwater appendages, and reference points and measurements to other openings and appendages. The “List of Hull Openings” on the Docking Plan provides drawing numbers applicable to each hull opening. These references are used to obtain details of openings, fittings, and appendages attached to the plating in the area of repair.

**16-5.3.3 Templating.** The requirements for templating can be found in Section 8. The additional time to template pays off in ease of installation and a watertight seal.

**16-5.3.4 Eductor Use.** Figure 16-10 shows a typical patch and eductor configuration. Figure 16-11 shows typical eductor and vent details. Venting during eductor use prevents rapid dynamic loading on the patch and drawing a vacuum, both of which will over stress the patch materials. Once the eductor is secured, the vent line provides an easy method for checking the cofferdam seal prior to breaking any internal connections. This can be accomplished by closing an installed stop valve on the surface end of the vent line after the patch has been dewatered, waiting a period of 30 minutes and opening the valve to check for pressure. If a discharge of air does not occur, an effective seal is indicated. This does not eliminate the requirement for verifying cofferdam seal from within the ship’s workspace as internal connections are broken. The eductor is used only for dewatering the void space of water retained in the system while establishing a differential pressure and not as a securing device or to compensate for an ineffective seal. Once a system is dewatered, eductors are secured to assess the performance of the patch. The sizing of the eductor should take into consideration the volume of water to be removed and the GPM rating of the eductor. The use of strain reliefs for the eductor water supply and patch vent lines should be incorporated into the rigging plan to prevent the weight of the hose from being carried by the patch. The eductor supply valve should be tagged, as appropriate, to clearly identify its condition.

**16-5.3.5 Rigging Plan.** The development of a rigging plan is important no matter how simple the task may seem. The type and size of the patch to be installed determines the extent of the rigging plan. The plan should identify the proper selection of equipment (safe working loads) to lift the device in air and water, secure it in place, and remove it after completion of the repair. The primary method of securing a patch to the hull is the attachment of J- bolts or hogging lines to permanent structures such as sea chest grates, splitter bars, or the main deck. When hull configuration limits the force applied by the hogging lines, the use of a stand-off should be considered to provide the sealing force required. (See Figure 16-12). Temporary devices, such as spiders, may be used as an aid to initial seating. However, an additional means of securing the patch to the hull, such as hogging lines, must also be used. If a NAVSEA-approved temporary securing device is used as a positive attachment, a hogging line is not required. Positive securing ensures the patch will stay on the hull in position if the differential pressure seal is lost. This will ensure the seal can quickly be re-established by the divers.

**16-5.4 General Guidance-Installation.**

**16-5.4.1 System Localization.** The first step to installing a patch is locating and confirming against the Docking Plan that the valve or system to be removed corresponds to the system being blanked. Localization may be accomplished by the use of locator lines suspended from known frames on deck. If the opening is below the bilge keel, the diver can follow the vertical butt welds to the corresponding strake. Another method of localization is to hammer on the valve or adjacent structure inside the ship. The diver then locates the opening by noise and vibration. Some systems are configured to allow connection of an air source (sea chest steam valve connection) which will allow a diver to follow the bubbles to the source. This method is helpful on large ships when there is poor visibility.

**16-5.4.2 Surface Preparation.** Removal of all fouling and corrosion from the immediate hull area is essential to achieve a positive seal. When using J-bolts to attach a patch to a sea chest grating or spreader bars, the patch should be centered over the opening. A paint stick or marker may be used to extend contour lines out from the opening for reference in positioning the patch.

### 16-5.5 General Guidance-Removal.

**16-5.5.1 Flood/Equalize.** Prior to flooding the patch for removal, establish communications with repair personnel inside the ship. Flooding can be accomplished by slowly opening a valve internal to the ship to equalize the pressure or by removing the vent line if installed. When it has been verified that of no leaks exist within the ship, the patch can be de-rigged and removed.

**16-5.5.2 Inspect and Refurbish.** After the patch has been removed and prior to placing back in stowage, an inspection should be performed as during the preparation phase to determine its condition and refurbish as necessary.

## SECTION 6 - DRY CHAMBERS

**16-6.1 General Information.** This section discusses the application of dry chambers and specific types available for use in Underwater Ship Husbandry. The installation of a dry chamber is a means of providing a dry envelope in which divers can work to accomplish specific requirements of a repair, or to maintain a minimum freeboard in cases of hull or system repairs at or near the waterline. Typical repairs requiring the use of dry chambers require that personnel are trained to accomplish the repair method and in some instances be certified in the procedure.

**16-6.2** Dry chambers typically are a four-sided open bottom or top cofferdam with a sealing surface to match the curvature of the hull. They may be constructed of metal or marine plywood with metal stiffeners. Dry chambers can have interchangeable sealing flanges. The design and fabrication of only a new sealing flange for different applications can save time and expense and reduce or eliminate additional engineering analysis. Figure 16-13 shows a typical dry chamber configuration.

**16-6.3** The attachment of a dry chamber to the hull or appendage is accomplished by the use of rigging designed to provide the required force to maintain a seal.

### 16-6.4 Typical Uses

**(1)** Weld repairs

**(a)** Hull plate replacement or repair

**(b)** Strut repair

**(c)** Protection sleeve replacement

**(d)** Sea chest installation

**(2)** Equipment and Sensor Change Out

**(a)** APU and SPM replacement

**(b)** ICCP system repair

**(3)** Shaft Coating Repair

### 16-6.5 Existing Designs

**(1) APU Replacement.** Underwater Ship Husbandry Manual Chapter 4 (S0600-AA-PRO-040) provides NAVSEA approved procedures for the underwater removal and replacement of Auxiliary Propulsion Units (APUs) in FFG 7 Class ships. These procedures provide detailed instructions for the dry chamber installation and removal, APU removal and replacement and electrical cable removal and replacement. Figure 16-14 shows an installed APU cofferdam.

**(2) SPM Replacement.** Underwater Ship Husbandry Manual Chapter 8 (S0600-AA-PRO-080) provides NAVSEA-approved procedures for the underwater removal and replacement of Secondary Propulsion Motors (SPMs). These procedures provide detailed instructions for the dry chamber installation and removal, SPM removal and replacement, and electrical cable removal and replacement.

**(3) Shaft Repair.** Underwater Ship Husbandry Manual Chapter 13 (S0600-AA-PRO-130) provides NAVSEA-approved procedures for the underwater propulsion shaft fiberglass coating repair. These procedures provide detailed instruction for the dry chamber installation and removal, shaft inspection, preparation, and repair.

**(4) DD 963, DD 993, and CG 47 Class Strut Repair.** Initially developed for the DD 963 Class for Prairie Air emitter system closure plate repair or replacement and weldment, NAVSEA Drawing 6698162, "Drawing Tree for Strut Overhead Habitat Assembly," outlines the required drawings and details to fabricate a dry chamber for either port/starboard struts and inboard or outboard configurations. NAVSEA drawing 6699502, "Drawing Tree Strut Arm Habitat Assembly," outlines the required drawings and details to fabricate a dry chamber for strut arms. These drawings do not cover repair procedures. Figure 16-15 shows the typical installation of the DD 963 strut repair cofferdams.

**(5) FFG 7 Class Hull Plate Weld Repair.** This open top dry chamber is an example of a typical cofferdam used for surface access dry welding for hull plate repair at or near the surface. (See Figure 16-5).

**16-6.6 Requirements.** All dry chambers used for UWSH maintenance and repair must meet the following minimum requirements to safely accomplish the task.

**16-6.6.1** The design and fabrication must meet the engineering requirements of Section 9. The design shall also include the attachment method to ensure sufficient force is applied to make and maintain a seal during the repair.

**16-6.6.2** A maximum uncompressed sealing material thickness of 2 inches.

**16-6.6.3** The dry chamber must be positively secured to a permanent hull structure or temporary welded padeyes.

**16-6.6.4** All dry chambers must have an installed data plate or engraved serial number that corresponds to the supporting documentation. The repair activity having cognizance or ownership of the dry chamber shall maintain original design and maintenance records for verification while the device is in service.

**16-6.6.5** Prior to installation of the dry chamber, the chamber and attachment hardware (J-bolts, turnbuckles, etc.) shall be visually inspected for cracks, corrosion, and deformation. Inspect all gasket material for damage, cleanliness, adhesive bond, and pliability. Any deficiencies must be corrected, repaired, or replaced, prior to each use.

**16-6.6.6** Dry chambers shall be provided with sufficient lighting to illuminate the chamber and work area.

**16-6.6.7** Dry chambers must have an air supply/vent system capable of meeting the requirements of NSTM S9086-CH-STM-030 Chapter 074, Volume 3 Gas Free Engineering, and the U.S. Navy Diving Manual, Volume 1, 0094-LP-001-9010, “Enclosed Space Diving,” if work involves the requirement for ventilation (welding, shaft laminate installation, etc.) or if divers plan to remove their UBA to perform work.

**16-6.6.8** Prior to commencing any work or repairs in the chamber the seal must be confirmed. With the dewatering system secured, the maximum leakage rate must not exceed 4 inches per hour rise in water level when the chamber is fully dewatered.

**16-6.6.9** The water level at the bottom of an open bottom dry chamber shall be continually monitored.

**16-6.6.10** When a dry chamber provides primary or secondary barrier to the sea a Formal Work Package (FWP) approved by the repair activities and ship's Commanding Officer or his designated representative shall be followed and ship's Commanding Officer or his designated representative shall be notified in writing of the level of protection provided (single or double valve).

**16-6.6.11** If surface piercing or open top underwater dry chamber sealed to a hull provides single valve protection (or possible single valve protection due to temporary hull integrity breach from welding or cutting operations) continuous 24 hour surveillance of the dry chamber seal by repair personnel in the surface piercing chamber or divers in the underwater open top dry chamber is required. Divers shall not leave the dive station until hull integrity is restored, repairs are complete, or the ship's Commanding Officer or his designated representative grants permission.

**16-6.7 Preparation.**

**16-6.7.1 References.** Since dry chambers are used for various types of repairs on appendages and hull plating, the use of the ship drawing index (SDI), which lists all applicable drawings to that particular ship, must be used to find the drawing applicable to the particular area to be worked. Drawings numbers are arranged in the SDI by functional group and they are numerically listed within these groups.

**16-6.7.2 Monitoring.** Monitoring for dry chamber work falls into two areas: the dry chamber requirements and the work re-quirements. For the dry chamber, when work is being performed by divers in the chamber, continuous monitoring of the water level and periodic checks outside the chamber shall be performed to assess the performance of the seal. Continuous monitoring is required to prevent flooding of the chamber. When divers are not at work, this may be accomplished by placing a DUCTS (Diver Underwater Color Television System) camera inside the chamber to view the waterline. The chamber may then be dewatered by topside personnel as required. Considerations for the work include: cure time, humidity, and temperature for epoxy and pre- and post-heat treatment for welding. Whenever welding is performed, and as appropriate, gas freeing and fire watches of the internal space opposite of the repair area are required.

**16-6.7.3 Templating.** The requirements for templating can be found in Section 8. The additional time to template pays off in ease of installation and an airtight seal.

**16-6.7.4 Inspection and Acceptance.** Prior to the installation of a dry chamber, a thorough inspection of its condition shall be performed. The user must perform a visual inspection of the lifting points, padeyes, welds, staging, air supply and vent line connections (if installed) for any signs of deformation, cracks, or bending which will require repair and testing before use, and possibly an engineering re-evaluation. Gasket material shall be inspected for complete adhesion to the flange and replaced when permanent indentations exist that may prevent the achievement of acceptable leakage. When a new dry chamber is fabricated, the design and fabrication drawings will provide initial testing and inspection requirements. The verification of testing to an approved dry chamber design shall be by means of an attached data plate or engraved serial number which corresponds to supporting documentation. The repair activity having cognizance or ownership of the dry chamber shall maintain records for verification while the device is in service.

**16-6.7.5 Dewatering and Ventilation Equipment.** The dewatering and ventilation equipment selected shall be capable of delivering the required amount of air for initial dewatering and ventilation of the chamber throughout the repair. The air supply requirements are determined by calculating the volume of the chamber and converting to standard cubic feet (scf) required for the operating depth. The air source (compressor or air banks) must be capable of meeting these requirements. The sizing of the air supply and exhaust hose shall be capable of meeting the ventilation flow requirements of NSTM 074, Volume 3. Air supply and exhaust hoses should be equipped with stop valves at the chamber for diver operation and at the surface for topside control during monitoring. The discharge side of the air supply in the chamber should be equipped with an air diffuser or deflector to prevent injury to personnel. Strain reliefs are recommended to support the weight of the hoses at the chamber and topside.

**16-6.7.6 Rigging Plan.** The development of a rigging plan is required during the engineering design phase to ensure sufficient lifting force is provided. The location and size of the dry chamber to be installed determines the extent of the rigging plan. The plan shall identify the proper selection of equipment (safe working loads) to lift the device in air and water to the job site, secure it in place, and remove it after completion of the repair.

### CHANGE A 16-6.8 Installation.

**16-6.8.1 Surface Preparation.** Removal of all fouling and corrosion from the sealing surface is required to achieve a positive seal. When using an existing dry chamber for a specific repair, marking the outline of the seal area on the hull with a paint stick or marker for reference in positioning the chamber will ease the installation.

**16-6.8.2 Open Bottom Dry Chamber Dewatering.** When the dry chamber has been installed, place a mark on the wall inside the chamber (grease pencil or paint stick) approximately 4 inches from the bottom. This will be the reference water level line. With the exhaust valve shut, open the air supply valve and dewater the chamber down to the mark and secure the air. Divers then inspect for excessive leakage and correct as necessary. In most cases, minor leaks will be present. Minor leaks are defined in terms of the rise in water level with the inlet and exhaust secured. A rise of not greater than 4 inches per hour is considered to be minor. Prior to commencing any work, a stable water line shall be established and confirmed. As divers and equipment enter and leave the chamber, the volume of air displaced will change. The divers will need to either add or exhaust air to maintain the water line.

***CAUTION***

***Never dewater the chamber completely. This will cause air to exhaust out the bottom of the chamber and create a rocking effect. The rocking can cause the rigging to slack and break the seal, thereby flooding the chamber.***

## SECTION 7 - STERN TUBE SEALS

**16-7.1 General Information.** This section provides the requirements for sealing shaft stern tubes externally to allow for removal and repair of internal shaft seals.

**16-7.2** Often stern tube repairs only require the resurfacing of internal face seals which are inboard of the boot seal. Special blanking plates (dummy seat) are available which are installed after the face seals are removed. The blanking plates provide double-valve protection when combined with the inflated boot seal. In this case, diver-installed external stern tube seals are not required.

**16-7.3** Figure 16-16 shows the internal stern tube seal configuration for a CG 47 Class ship. Figure 16-17 shows the "face insert," "seat," and "splash guard" removed and the dummy seat installed. Similar arrangements exist for other ship classes. Detailed installation procedures and fabrication drawings for dummy seats are available from

NAVSEA 00C5.

**16-7.4** There are two types of stern tube sealing methods commonly used on surface ships. The first method is the use of a special box patch which is templated to fit around and seal the propeller shaft, stern tube, and hull. The second method is the use of packing material to wrap and seal the opening between the propeller shaft and stern tube fairwater. The packing material wrap method is only practical for ships with an exposed, accessible stern tube fairing which can be wrapped with material. Inaccessible or recessed stern tube openings require the fabrication of a box patch. The design, templating, and fabrication of a box patch stern tube seal can be initially time consuming. However, ease of reapplication to all ships of the same class and a high degree of watertight integrity more than pay back the initial effort.

**16-7.5** Submarines typically use mechanical shaft seal devices installed around the shaft at the forward end of the mud tank. NAVSEA Drawing 6699055, SSN 688 Class Temporary Stern Tube Seals Assembly and Details, details a SSN 688 Class stern tube seal device. Modifying the design with a new inside and outside diameter at the seal ring (item 3) and the clamp ring (item 7) as applicable for other shaft sizes, would allow for application to other submarines or surface ships with exposed accessible stern tube fairings. A mechanical seal of this type is preferable to the wrapping method.

**16-7.6 Requirements.**

**16-7.6.1** Regardless of the sealing method used, the seal must be installed and secured to the propeller shaft, stern tube, and/or hull as applicable prior to any dewatering effort.

**16-7.6.2** The wrap method of stern tube sealing is not allowed unless the gap between the shaft and the aft end of the stern tube fairing is completely open and accessible over the entire circumference of the shaft. Hose type warps energized or inflated with water or any other medium require NAVSEA approval on a case basis after specific details of the particular application are provided.

**16-7.6.3** A stern tube box patch or a mechanical sealing device must meet all the requirements of Section 5, Patches, except as stated below.

**16-7.6.4** When eductors are used to dewater a stern tube cavity sealed by a mechanical sealing device or wrap type seal the eductor shall be positively secured to the hull to prevent loss.

**16-7.6.5** Emergency plan (flooding) - When the stern tube seal is providing the only barrier to the sea (single-valve protection), the repair activity shall notify the ship's Commanding Officer or his designated representative in writing. The ship shall calculate the worst case possible scenario for flooding and provide a plan of action and additional emergency dewatering equipment as required. The equipment shall be rigged in place and operationally ready prior to commencing work.

**16-7.6.6** When an exterior, diver-installed stern tube seal will serve as the only barrier to the sea or a secondary barrier to the sea, a Formal Work Package (FWP) that has been approved by the repair activity and ship's Commanding Officer or his designated representative must be followed.

**16-7.6.7** When the ship's stern tube will have single or double valve protection and either the diver installed temporary external stern tube seal or the internal inflatable boot require a dynamic continuous feed to maintain their individual seal a continuous watch stationed at the ship's internal leak path for the stern tube and an immediately available secondary power source for all continuous feed seals are required. Dynamic continuous feed for the external diver installed temporary stern tube seal is the need to continuously operate the de-watering eductor to maintain the seal. Dynamic continuous feed for the internal inflatable boot is the need for any continuous or regular supplementing of the inflatable boots internal pressure due to leakage.

**16-7.6.8** For a special box patch or mechanical sealing device type stern tube seal the leakage requirements shall be as defined in section 5, Patches. For a wrap type stern tube seal, a leak rate acceptable to personnel performing internal repair work and ship's damage control personnel must be established. The established leak rate must be confirmed at the internal repair area prior to disassembly of the internal seal. Regular assessment (measurement) of the stern tube seal leakage to ensure leakage is maintained at or below the acceptable leak rate is required. Wrapping type seals must provide an acceptable leak rate for a minimum of 30 minutes to confirm integrity prior to disassembly of internal seal. If dewatering equipment (eductor) is run continuously to establish an acceptable leak rate for a wrap type seal then personnel performing internal repair work and ship's Chief Engineer shall be informed in writing using Appendix G that continuous eductor operation is required to maintain the acceptable leak rate.

**16-7.6.9** Divers shall not leave the dive station until double- valve protection is established, repairs are completed, or ship's Commanding Officer or his designated representative permission is granted.

**16-7.7 Preparation.**

**16-7.7.1 Selection.** The first reference drawing used when selecting a stern tube sealing method (box patch, mechanical shaft seal, or wrap) is the shafting arrangement drawing. It gives the general measurement of the shaft and a general idea of the stern tube accessibility. The reference block of this drawing lists the detail drawings of the stern tube and stern tube fairwater, usually included in the “rope guard and fairwater” drawing. Careful review of the stern tube and stern tube fairwater drawings may show hull access plate locations that would not be obvious during an inspection dive. These areas would need to be sealed also.

**16-7.7.2 Monitoring.** Whenever a stern tube seal is installed, ship's force should have a thorough understanding of the location and protection it is providing. This allows shipboard watch standers to be fully aware of and monitor its condition during normal watch standing rounds.

**16-7.7.3 Templating.** When a repair activity makes a decision to develop a ship class box patch stern tube seal, accurate templating is the key to making an effective seal. The requirements for templating can be found in Section 8. NAVSEA Drawing 6697929, Shaft Repair Top Section Assembly, gives detailed procedures for templating the hull contour and shafting in the stern tube area using the NAVSEA contour tool (NAVSEA Drawing 6698079).

**16-7.7.4 Inspection.** Conduct an inspection dive of the entire stern tube area, including fairwater, shaft, and hull surface, prior to installation of a stern tube seal to assess cleaning required, configuration, or access issues that were not clear from the drawing review. The inspection dive will also locate additional cracks or openings, weld seams, or hull access plates not shown in the drawings that will need to be sealed. Box patch stern tube seals shall have a material inspection and verification of approved design prior to use in the same manner as for all patches. (See Section 5, Patches.)

**16-7.7.5 Rigging Plan.** Similar to all patches, a box patch stern tube seal requires a rigging and installation plan. An important aspect of stern tube box patches is fixed, closed, positive buoyancy tanks. Positive buoyancy ensures that the installing divers do not have to fight with excessive rigging loads at the same time they are trying to optimize the exact position of the patch for the best possible seal. Each time a stern tube box patch is used on a different ship of the same class the optimum position for best seal will be slightly different. A series of position adjustments and inspection swims of the entire sealing surface will eventually locate the optimum position for the patch. Trial and error adjustment of the patch buoyancy by adding or removing weight will optimize buoyancy at depth. If an eductor and vent line are used, strain reliefs should be provided to support the weight of hoses.

### 16-7.8 Installation

**16-7.8.1 Surface Preparation.** Remove all fouling and corrosion from the immediate hull area, shafting, and stern tube to achieve a positive seal. If possible, avoid sealing on damaged surfaces.

**16-7.8.2 Dewatering.** When the stern tube seal has been secured in place, rapidly drain the trapped water to establish a differential pressure and assess the performance of the seal. One common reason for failing to establish an initial differential pressure is draining the stern tube too slowly from inside the ship. To properly dewater, flow into the stern tube seal from the outside (minor leaks in the external seal caused by lack of differential pressure acting on the seal) must be overcome by flow out of the stern tube seal at the internal drain. Quickly opening the internal stern tube drain all the way should provide sufficient flow to obtain differential pressure on the external seal. A second reason for failing to get adequate drainage to achieve a differential pressure seal is a failure to secure the ship’s stern tube flushing or bearing cooling water supply. Sometimes an unsecured port to starboard cooling water cross-connect or a secured valve which is leaking-by frustrates all attempts to drain the system and achieve and confirm a seal.

**16-7.8.3** In some ship classes, a large amount of water is trapped in the stern tube by the external seal, so it may take 20 minutes or more to see reduction in the drainage flow as an indication the seal is working. In some cases, partial external dewatering can be used to reduce the volume of water drained to bilge. Inspection of the seal during the dewatering process will reveal problem areas with the seal.

**16-7.8.4** After dewatering, a final check of all support rigging must be made. Dewatering the stern tube will compress the seal, causing slack in the rigging that was not present before dewatering. Adjust as necessary to ensure a tight fit. If flat patches with T-bolts are used to seal dead lights, the wing nuts must be retightened because the differential pressure will compress and seal the patches more.

**16-7.9 Removal.**

**16-7.9.1 Flood/Equalize.** Flood the stern tube with internal stern tube flushing or bearing cooling water supply to equalize the external pressure. When no leaks are verified at the internal seal, the external seal may be removed.

**16-7.9.2 Inspect and Refurbish.** All stern tube sealing equipment should be inspected after use and refurbished as necessary to ensure it is ready for the next operation.

## SECTION 8 - TEMPLATING

**16-8.1 Introduction.** Templating is the process required to pattern hull shape data (hull contour) for use in forming the sealing surface of cofferdams. Except for flat hull surfaces, templating is required to achieve the goal of zero leakage. If done properly, templating is precise and time-consuming work; however, the time and effort expended up front in templating gives a pay back of quicker installations with good seals for blanks and habitats. Poor fit is the major result of poor templating procedures and the primary cause of rework. Rework may result in the removal, disassembly, re-templating, and modification of the cofferdam. This results in lost time, rescheduling of logistic support, and possible damage to and replacement of equipment. A poorly fitting cofferdam is a clear safety hazard to the diver, the ship or submarine, and interior workers. Templating and pattern fit checks must be repeated until a good fit and seal is obtained.

**16-8.2 Requirements.** Templating is required in underwater ship husbandry cofferdam applications when the repair activity can not define the hull contour to +/- 1 inch at the location of cofferdam installation using ship's drawings only. If templating is required, the specific requirements of the templating fixture are:

**16-8.2.1** Two-dimensional box structure allowing divers to perform one continuous template layout which matches the footprint of the cofferdam to be installed.

**16-8.2.2** One inch maximum deflection over longest assembled span.

**16-8.2.3** Neutral or positive buoyancy.

**16-8.2.4** Easy adjustment and securing of battens.

**16-8.2.5** Attached levels allowing divers to confirm proper horizontal and vertical attitude.

**16-8.2.6** All divers involved in the templating process must have prior training in the use of the templating fixture.

**16-8.2.7** A templating fixture similar to the simple, proven accurate NAVSEA Contour Template Fixture (NAVSEA Drawing 6698079), Figure 16-18, meets these requirements and can be locally manufactured.

**16-8.3 Process.**

**16-8.3.1 Review Drawings.** The ship's drawings are useful in helping to plan the templating process. They are used to determine location, position, and size of fixture; identify possible interference and location references; and estimate length of battens and set the initial fixture stand-off required. Interpretation of these drawings may require the assistance of or training by an engineer.

**16-8.3.2 Site Survey/Marking Location.** Clean, inspect, and mark the area to be templated. The hull surface must be completely clean of all fouling for the template fixture to produce an accurate measure of the hull contour. Inspect the area to be templated for any surface irregularities such as dents, bumps, or doubler plate installations. If possible, shift the eventual cofferdam location to avoid having to seal on hull surface irregularities. If the cofferdam location can not be shifted, mark the irregularities so special attention can be focused on detailed templating to avoid seal problems. Confirm that no interference exists for placement of the template fixture or the cofferdam. Consider the rigging plan for the cofferdam when selecting the final location for the cofferdam. Changing the footprint (sealing surface) of the cofferdam may simplify the rigging requirements. Use of the Diver Underwater Color Television System (DUCTS) to document the survey can provide all hands with a good understanding of the task. When the area has been surveyed, mark the hull to help with initial positioning of the template fixture. This ensures that the fixture is aligned with the intended position of the cofferdam sealing surface on the hull. Mark the hull with underwater paint sticks or grease pencils. Do not scribe into the paint on the hull, since this will cause hull plate corrosion.

**16-8.4 Template Installation.**

**16-8.4.1 Assemble Template Fixture.** To minimize handling, the templating device should be assembled as close as possible to the repair staging site. Prior to placing the templating device in the water, ensure that the templating rods and all moving parts move freely and are easy for the diver to set. Number all battens to help provide a means to record location of additional detailed measurements taken in problem areas. Set the position of the corner battens (stand-off) using the measurements taken from the drawing review. The minimum fixture to hull standoff distance (length of shortest batten extension) for the leveling process should be 4 inches.

**16-8.4.2 Position Fixture.** Before setting battens or taking any measurements, the templating fixture must be secured firmly in place. Any templating performed with a lively fixture will produce an inaccurate contour. Secure the fixture by using hogging lines. Compare the structural strength and weight of the fixture to the size of the equipment used in rigging. Most templating fixtures are lightweight and are designed to be neutral. The rigging must not distort the fixture. Therefore, use lightweight securing equipment. Lower the fixture to the work site and attach rigging to secure it in place. Make sure to align the fixture inside the markings from the survey. Level the fixture by observing the spirit levels attached to the fixture while adjusting the four corner battens of the fixture. Normally, the cofferdam should be installed level in the fore-aft and the port-starboard orientations. However, blanks mounted to the side of the ship's hull may only require leveling in the fore-aft orientation. For such blanks, the port and starboard ends of the template fixture should be offset by an equal amount to ensure a uniform hull contour is measured. Once the fixture is in position, mark all four corners to form reference points for the template. These reference marks are used to confirm that the template stays in position while adjusting the battens. Figure 16-19 illustrates the installation of the NAVSEA templating fixture for templating a shaft stern tube area of the hull.

**16-8.4.3 Adjust Battens.** Adjust, secure, and mark the remaining battens to match the hull contour. If there are irregularities in the hull which the battens do not accurately describe (i.e., irregularities are between the batten spacing), more detailed measurement of that area is required. Commercially available contour gauges or a straight edge and ruler provide detailed templating or measurements of small problem areas. (See Figure 16-20). Make a final inspection of the fixture, checking reference points to verify that the fixture did not move while adjusting the battens. Scribe the final position of each batten before sending the fixture to the surface.

**16-8.4.4 Mark Exact Location of Fixture on Hull.** Prior to removing the templating fixture from the hull, mark the outline on the hull along each of the battens. This outline approximates the centerline of the sealing surface. Extend the marks outward at the corners to compensate for half the width of the proposed sealing flange. These marks are critical for accurate positioning of the cofferdam. Incorrect positioning by as little as a few inches can negate all templating efforts. The hull should be marked without scribing or otherwise damaging the hull paint system.

**16-8.4.5 Retrieve Fixture.** Ensure that the rigging does not become fouled between the battens. To prevent distortion of the fixture, do not use excessive strain when retrieving it. Position the fixture on the pier, using standing blocks to provide sufficient height to prevent damage or movement of the battens. Keep the fixture level and stable to prevent distortion. Avoid unnecessary handling and movement of the fixture. Use the scribe mark on each batten to confirm that no movement has occurred.

**16-8.4.6 Make/Check Patterns.** Using ¼-inch plywood as pattern material, trace the hull curvature outline from the tops of the fixture battens. Cut the pattern along the hull contour, being sure to include any additional measurements or contours taken around irregularities or doubler plates. Make a pattern for each of the template fixture's four sides. Take each pattern down to its respective hull positions as marked on the hull before the template fixture was removed. Depending on the size of the pattern, more than one diver may be required. Test fit each pattern to the hull contour. Mark gaps, return to the surface for adjustment, and repeat contour verification until each pattern accurately represents the hull contour. There should not be any gaps larger than ½ inch. This will ensure that gasket material will provide an effective seal. Figure 16-21 illustrates making patterns for a shaft stern tube hull contour.

**16-8.4.7 Training/Practice.** Templating is a demanding skill. Like all skills, it requires training and practice to be perfected. While there are manuals explaining the techniques for templating, these manuals only give the basics. Merely reading about them will not give the diver the skills required to template properly. Practice and training are required. Since most UWSH work takes place in low visibility, on-the-job training is a less-than-ideal training environment. A ship in dry-dock provides an excellent opportunity as a training platform on which to practice. Other dry-land sources of training can be found on any structure with an irregular or regular contour, such as storage tanks, large drums, or work boats that have been hauled and blocked for maintenance.

## SECTION 9 - FLAT PATCH, BOX PATCH, AND DRY CHAMBER DESIGN

### 16-9.1 General Information

**16-9.1.1 NAVSEA Flat and Box Patch Designs.** The following designs allow divers to blank most existing Fleet hull openings without additional engineering support.

***CAUTION***

***The flat and box patch designs provided have adequate strength and gasket loading area for application over the opening sizes identified in each design. Prior to application on a specific hull opening attachment and rigging plans must be developed for the specific ship and hull opening.***

For blanking applications where the patches below do not work, the design criteria in Section 16-9.2 support unique patch design.

**16-9.1.1.1 Unstiffened Flat Patches.** Unstiffened flat patches applied over flush mounted or shimmed to flush gratings or splitter bars with maximum 5-inch spacing shall be minimum ¼-inch 5000 series aluminum, ¼-inch mild steel, or 1-inch marine grade plywood. Uncompressed gasket sealing material thickness shall be 2 inches. Submarine main ballast tank patches shall be minimum 1/8-inch 5000 series aluminum or 16 gauge stainless steel sheet.

**16-9.1.1.2 Stiffened Flat Patches for Large Unsupported Openings (Scoop Injections).** NAVSEA-approved standard stiffened flat patch designs are provided in NAVSEA Drawing 805-7370421. These patches will cover large unsupported (no grates or grates recessed too far to practically shim) openings such as some scoop injections.

**16-9.1.1.3 Box Patch for Discharge Openings with Protrusions.** NAVSEA approved standard box patch designs are provided in NAVSEA Drawing 805-7370421.

**16-9.2 Flat Patch, Box Patch, and Dry Chamber Design Requirements.**

**16-9.2.1 Introduction.** This specification provides experienced design engineers with criteria necessary for the design of cofferdams for use in Underwater Ship Husbandry.

**16-9.2.2 Applicability.** This design specification establishes a minimum standard for the design of any flat patch, box patch and dry chamber used for sealing, blanking or establishing a dry work environment on U.S. Navy ships and submarines for waterborne maintenance and repair actions. The criteria set forth in this specification are applicable to all new and existing flat and box patches and dry chambers.

**16-9.2.3 Design and Materials.**

**16-9.2.3.1 Steel Construction.** Flat patches, box patches, and dry chambers of steel construction shall meet the requirements of the American Institute of Steel Construction, Inc. as defined by the latest issue of the Manual of Steel Construction (Allowable Stress Design), reference 16-9.6.1.

***NOTE***

***Existing NAVSEA approved (documented on a NAVSEA drawing) hydrostatic test blanks/ fittings designed to be bolted onto a flat flange and sealed with an o-ring or solid rubber gasket are not required to meet the gasket material or proportion requirements of the specific NAVSEA approved design shall be met.***

**16-9.2.3.2 Aluminum Construction.** Flat patches, box patches, and dry chambers of aluminum construction shall meet the requirements of the American Aluminum Association, Inc. as described in the latest issue of the Specifications for Aluminum Structures, reference 16-9.6.2, using the basic allowable tensile stresses and factors of safety specified for Building and Similar Type Structures.

**16-9.2.3.3 Marine Grade Plywood Used as Sheathing.** Marine grade plywood can be used for sheathing in metal framed dry chamber or box patch structures or for unstiffened flat patches. Frame work of steel or aluminum must meet the criteria of Paragraph 16-9.2.3.1 or 16-9.2.3.2 above, as applicable. Marine grade plywood construction shall meet the requirements of the American Plywood Association, as described by the latest issue of the Plywood Design Specification, reference 16-9.6.3.

**16-9.2.3.4 Minimum Factors of Safety for Rigging, Lifting, Handling, and Securing Components.** The factors of safety listed in Table 16-6 shall apply to the design of all bolted or welded attachments and their supporting structure to the flat patch, box patch, or dry chamber. All cofferdam applications must have a basic rigging plan which defines the direction and magnitude of expected rigging loads for safe installation, use, and retrieval of the cofferdam. An example of an open bottom dry chamber rigging plan design is provided in Appendix B. J-bolt attachment devices shall meet the minimum requirements specified in Appendix F.

**16-9.2.3.5 Total Equivalent Design Head Loading.** Other than the weight of the patch or dry chamber and any live loads generated by the weight of personnel and equipment in a dry chamber, the primary loading of patches and dry chambers comes from hydrostatic (water pressure) and hydrodynamic (current) forces. The total equivalent design head (hd), expressed in feet of salt water (64 lb/ft3), is the summation of hydrostatic and hydrodynamic forces as follows:

$$h_d = h_s + h_m + h_c$$

where:

**$h_s$** = Design static head taken as the perpendicular distance (ft) from the design waterline to the point of interest for cofferdams. The design static head for open dry chambers is the height of each bulkhead in the dry chamber subject to hydrostatic pressure. For plating panels the point of interest shall be the supported edge of the panel that produces the largest value of hs. For stiffener design, the point of interest shall be the midspan of supported breadth and may be assumed to be uniform over the length of the stiffener.

**$h_m$** = Design head margin (ft) for eductor pressures and wave induced head variation. A value of 5 feet is recommended.

**$h_c$** = Design head allowance for hydrodynamic loading (current induced). A value of 0.3 feet is recommended.

**16-9.2.3.6 Selection of Plating Panels.**

**16-9.2.3.6.1 Steel and Aluminum Plating Panels.** The required plating thickness for aluminum and steel panels is based on simply supported panel edges, with the maximum bending stress occurring at the center of the plate, using the following expressions:

rectangular or square panel

$$t_r = \left(\frac{b}{42.1}\right)\sqrt{\beta\frac{h_d}{F_{cyw}}}$$

or

circular patch

$$t_r = \left(\frac{d}{75.7}\right)\sqrt{\frac{h_d}{F_{cyw}}}$$

where:

**$t_r$** = required thickness (in)

$\beta$ = factor based on ratio of longer to shorter panel dimensions (from Table 16-7 below)

**$h_d$** = total equivalent design head (ft)

**b** = shorter panel dimension (in)

**a** = longer panel dimension (in)

**$F_{cyw}$** = material welded compressive yield strength (ksi), use $F_y$ (see reference 16-9.6.1) for steel alloys; use $F_{cyw}$ (see reference 16-9.6.2) for aluminum alloys.

**d** = circular patch diameter (in)

**16-9.2.3.6.2 Marine Grade Plywood Sheathing Panels.** The minimum required thickness of marine grade plywood for use as sheathing panels or patch material is determined by Section 4.1 of reference 16-9.6.3, Plywood Design Specification. The following expressions is derived from the Plywood Design Specification and can be used for selection of the minimum thickness of marine grade plywood required:

$$KS = \frac{(h_d b^2)}{1758}$$

**$h_d$** = total equivalent design head (ft of water)

**b** = shorter panel dimension (in)

**KS** = Effective Section Modulus ($in^3/ft$). Use KS in Table 16-8 to select appropriate thickness ($t_p$) of marine grade plywood.

**16-9.2.3.6.3 Used as Sheathing in Stiffened Patches or Dry Chambers.** Where used as sheathing resisting hydrostatic loading in stiffened patches or dry chambers, the marine grade plywood shall not be used in a manner where tear-out forces are produced on fastener connections. The material shall be used only in a manner where hydrostatic loading results in bearing reactions along the perimeter of the sheathing panel. Fastener connections shall be limited to holding plywood panels to the framing and for maintaining watertight integrity.

**16-9.2.3.7 Design of Stiffeners.** All stiffener design shall meet the requirements of references 16-9.6.1 or 16-9.6.2 as applicable, except for wooden dry chamber hull interface seals which may be stiffened with wood planking or beams.

**16-9.3 Design Requirements for Seal Gaskets.**

**16-9.3.1 Gaskets for Sealing Between Cofferdam and Vessel Hull.**

**a. Acceptable Material.** All cofferdam to vessel hull seal gaskets shall be closed cell foam material. The closed cell foam material shall conform to ASTM D 1056-00 Type 2, Class B or C, Grade 1 or 2, for applications up to 35 feet seawater depth. ASTM D 1056-00 Type 2, Class B or C, Grade 2 material shall be used for applications deeper then 35 feet seawater. Grade 1 material has a 2-5 psi compression deflection and Grade 2 material has a 5-9 psi compression deflection.

**b. Gasket Proportions.** Gasket thickness shall be 2 inches in total uncompressed thickness. Gasket width shall be calculated as described in paragraph c (1) or (2) below. In no case shall gasket width be less than 3 inches. The 3-inch minimum width ensures a sufficient shape factor to develop the allowable gasket compression stated and ensures sufficient width to accomodate hull surface irregularities. Calculated gasket widths based on differential pressure loading (as discussed below) will normally result in widths exceeding 3 inches.

**c. Design Gasket Compression Loading.** The structure applying the gasket compression (normally the gasket flange) shall be suitably stiffened to avoid local bottoming across the gasket width. The allowable gasket compression values ($F_{gc}$) have been chosen to limit average compression of closed cell foam across the gasket width to no less than 3/8-inch compressed thickness under design loading. These values require accurate templating of the hull curvature to produce a suitable mating gasket flange and reasonably smooth hull contact areas.

**(1) Hydrostatic Force as Primary Compression Load.** Gasket area for flat patches, box patches, and open top dry chambers where hydrostatic pressure provides the primary gasket compression force shall be suitably apportioned to limit the allowable gasket compressive stress ($F_{gc}$) in the gasket material to 50 psi for 2-inch thick closed cell foam gasket material. The designer should first determine the total force (lb.) applied to the cofferdam by total equivalent design head (area enclosed by gasket x hd x density of seawater). The total force is then divided by $F_{gc}$(50 psi) to determine the total gasket area required. Depending on the cofferdam geometry (circular, square, or rectangular), set up the appropriate equations for gasket area to solve for the gasket width as a variable.

**(2) Rigging Force as Primary Compression Load.** For open bottom dry chambers where rigging force provides the primary compression load for sealing the gasket, designers must be concerned with determining the rigging forces required (in addition to the weight of the chamber) to establish an effective gasket seal. In most cases, exceeding the allowable gasket compressive stress ($F_{gc}$) stated above will not be a concern. The rigging force should be designed to provide a minimum gasket compression of 3.5 psi for gasket sealing. The designer should first select the gasket width. Then calculate the total gasket area based on the dry chamber geometry. The total gasket area multiplied by the minimum gasket compression (3.5 psi) determines the vertical force required to seal the gasket. The vertical force must be resolved into the magnitude and direction of rigging force based on the geometry of the dry chamber installed on the hull and the location of rigging attachment points. An example of an open bottom dry chamber rigging plan design is provided in Appendix B.

**d. Design Gasket Shear Loading.** Gaskets shall not be designed for shear loading to be applied.

### CHANGE A 16-9.3.2 Gaskets for Sealing Between Bulkheads or Interconnecting Flanges of a Bolt-Together Cofferdam.

CHANGE A **a. Acceptable Material.** Solid neoprene sheet (30-70 durometer) or closed cell foam material is required. The closed cell foam material shall be in conformance to ASTM D 1056-00 Type 2, Class B or C Grade 1 or 2, for applications in seawater depths up to 35 feet. Closed cell foam shall conform to ASTM 1056-00 Type 2, Class B or C, Grade 2 for applications deeper then 35 feet seawater. Grade 1 material has a 2-5 psi compression deflection and Grade 2 material has a 5-9 psi compression deflection.

**b. Gasket Proportions.** Gasket thickness shall be 1-inch maximum uncompressed thickness. The minimum clear width between the edges of fastener holes and the protected boundary shall not be less than 1/2 inch.

**c. Sealing Compression.** As a minimum, fasteners for interconnecting flange surfaces shall be apportioned to apply uniform compression to the sealing surfaces in sufficient quantity to maintain the required pressure seal. A minimum of 20 psi uniform compression is recommended.

**16-9.4 Use of Fasteners.** Fasteners used in flat patches, box patches, and dry chambers shall be either steel or stainless steel and must meet the requirements of the American Institute of Steel Construction, Inc. as defined in reference 16-9.6.1.

**16-9.5 General Design Guidance.**

**16-9.5.1 Deflection of Dry Chamber Walls.** For cases where the dry chamber seals to the hull and air is captured under the vessel, the deflection of the walls away from the hull sealing surface must be considered. Dry chamber walls can be designed so that they are under the minimum stresses allowed by the governing specification, but deflect under load so that they lose contact with the sealing surface. Even though the members of the wall are below the allowable stress, the deflection of the wall violates the chamber seal and the chamber suddenly floods. This failure mode must be considered during the design process to ensure that the chamber walls have sufficient stiffness to inhibit excessive deflection. The maximum deflection of the dry chamber sealing surface should be no larger than 1/4 inches.

**16-9.5.2 Rigging Loads on Box Patches, Flat Patches, and Open Top Dry Chambers.** A cofferdam design package must include a rigging plan noting the direction and magnitude of expected loads through installation, use, and retrieval of the cofferdam. Rigging points and supporting structure should be designed with the factors of safety from Table 16-6. A value of 2.0 psi gasket compression is recommended to estimate rigging loads for sizing of wire rope and rigging hardware. Installation loads are determined in practice by observation of gasket compression and actual achieving of a seal. The 2.0 psi compression allows for initial gasket seating during installation so that patches or open top dry chambers can be dewatered and allow hydrostatic pressure to take effect. Side loading of padeyes should be avoided wherever possible. If side loading cannot be completely avoided, the predicted side loads must be considered in the padeye design.

**16-9.5.3 Buoyant Forces on Flat Patches, Box Patches, and Dry Chambers.** Buoyant forces can be significant forces in patches and dry chambers. Buoyant forces need to be resolved for the installation, use, and retrieval phases to ensure that rigging and structure is adequate for all loading circumstances. Buoyant forces are of particular concern in open top (topside access) dry chamber designs.

**16-9.5.4 Load Paths and Stiffener Location.** Framing members (stiffeners) should be properly supported along the boundaries of the patch or dry chamber such that all reaction load paths transmit loads directly to the hull.

**16-9.6 References.**

**16-9.6.1 Manual of Steel Construction (Allowable Stress Design)**

Available from:

American Institute of Steel Construction
One East Wacker Drive, Suite 3100
Chicago, Illinois 60601-2000
(312) 670-2400

**16-9.6.2 Specifications for Aluminum Structures**

Available from:

The Aluminum Association
1525 Wilson Boulevard, Suite 600
Arlington, VA 22209
(703) 358-2960
FAX (703) 358-2961

**16-9.6.3 Plywood Design Specification**

Available from:

American Plywood Association
P.O. Box 11700
Tacoma, Washington 98411-0700
(206) 565-6600

# CHANGE C SECTION 10 - COMPLIANCE AND PERFORMANCE STANDARDS FOR CONTRACTOR COFFERDAM WORK

## 16-10.1. SCOPE

**16-10.1.1 General.** This section serves as a compliance and performance standard which has been developed for contractors to perform cofferdam work in accordance with NAVSEA S0600-AA-PRO-160, U.S. Navy Underwater Ship Husbandry Manual, Chapter 16, Cofferdams. Contained within this section are the minimum requirements necessary for contractors to qualify for cofferdam design, selection, fabrication, installation, and removal operations. This section also provides training requirements that must be completed by employees of the diving contractor in order to be qualified to conduct cofferdam work.

**16-10.1.2 Purpose.** The aim of this section is to establish training and quality requirements for contractors that perform the scope of work outlined in this manual. In addition this document provides a checklist (Table 16-9) that can be used by Navy activities to audit diving contractors to ensure conformance to this document as well as related industry and regulatory standards. Recognizing that some compliance requirements are a reiteration of earlier sections of this manual, the focus throughout this section is to provide clear, concise guidance to the elements of the training and qualifications necessary to perform cofferdam design, selection, fabrication, installation, and removal.

**16-10.1.3 Responsibility.** In order to ensure that cofferdam operations are effective, coordination between the contractor, sub-contractors (if any) and ship's force is paramount. The bulk of the responsibility (design, selection, fabrication, installation, and removal) is under the purview of the prime contractor. Some of this responsibility may be delegated to sub-contractors. Although the prime contractor is charged with adherence to this standard, it does not abrogate the Commanding Officer's/Master's responsibility for the safety of ship. Ultimately it is the responsibility of the Lead Maintenance Activity (LMA) or Contracting Authority (e.g. Regional Maintenance Center) to ensure that all parties are in compliance with this document.

**16-10.1.4 Definitions:**

**16-10.1.4.1 Cofferdam:** Is defined in section 1, part 16-1.3, as "any plug, patch, or dry chamber installed externally to the hull of a ship or submarine at or below the waterline in order to secure or dewater an area or system to enable shipboard or diver personnel to conduct maintenance or repairs to the hull or system".

**16-10.1.4.2 Contractor:** In terms of this standard, contractor refers to the prime contractor (who typically is the repair activity) or their designated sub-contractor (who typically is the diving contractor, fabricator or design firm).

**16-10.1.4.3 Customer:** The U.S. Navy maintenance activity responsible for repair and maintenance of surface ships and submarines which requires contracted diving services is the ultimate Customer in terms of this standard. This typically is the Regional Maintenance Center (RMC).

**16-10.1.4 OQE:** Objective Quality Evidence. Any statement of fact, either qualitative or quantitative, pertaining to the quality of a product or services, based on observations, measurements, or tests that may be fully verified. Evidence will be expressed in terms of specific quality requirements or characteristics. These requirements/ characteristics are identified in drawings, specifications, and other documents that describe the item, process, or procedure.

## 16-10.2. COFFERDAM PROGRAM

**16-10.2.1 General Program Description.** For purposes of developing proficiency and expertise in cofferdam operations, each diving contractor shall have an established program that provides for a training plan; documents and tracks qualification of personnel; documentation and record management; equipment used for cofferdam operations; and operational protocol. The cofferdam program is to be documented and submitted to the applicable contracting authority (e.g. cognizant Regional Maintenance Center) for review and approval in accordance with 16-1.6. The program will serve as a qualifying document for the diving contractor. Once the conditions outlined in 16-10.2.2 through 16-10.2.6 of this section have been met (i.e. a diving contractor has demonstrated that its personnel have a developed proficiency in each performance task and records of this performance are current) the diving contractor will be considered qualified to perform cofferdam operations.

**16-10.2.2 Training Plan.** Each diving contractor's program shall have a developed training plan for topics that are required by Appendix E. Each plan shall present the required reading and study material, provide for an outline for classroom instruction, and provide a method for assessing employee knowledge.

**16-10.2.3 Personnel Qualification.** There are various categories of personnel that are typically involved in cofferdam operations. This section is limited to those personnel that are directly involved in the design, construction, installation and removal of cofferdams. Non-US and US contractors, working outside the USA, who cannot satisfy all or part of the personnel qualifications outlined in paragraphs 16-10.2.3.1- 16-10.2.3.3 may apply for dispensation to NAVSEA 00C5 by presenting documentary evidence of qualifications and experience which are considered by the contractor to be at least equivalent to the qualifications outlined in paragraphs 16-10.2.3.1 - 16-10.2.3.3. It will be the responsibility of NAVSEA 00C5 to decide if the documentary evidence is acceptable and to inform the contractor and applicable Navy contracting authority accordingly.

**16-10.2.3.1 Design personnel.** If a contractor elects to use a cofferdam design other than that provided by section 9, then it will be necessary to provide for design calculations and drawings of the cofferdam to be used. The responsible engineer approving the design shall be a Professional Engineer (PE) or a degreed engineer or naval architect from an accredited 4-yr university and registration as Fundamentals of Engineering (FE/EIT).

**16-10.2.3.2 Fabrication personnel.** Fabrication personnel qualifications are limited to those individuals that fabricate, perform repairs, maintenance or modifications to cofferdams by means of welding. These individuals shall be qualified to their company's approved welding procedure specifications in accordance with the appropriate fabrication standard (code). In most cases the governing fabrication code for a commercial fabricator will be the Structural Welding Code for steel or aluminum published by the American Welding Society (references 16-10.4.1 and 16-10.4.2). Also acceptable are welders that are qualified to their company's approved welding procedure specifications that are in accordance with the U.S. Navy's requirements listed in reference 16-10.4.3.

**16-10.2.3.3 Diving personnel.** At a minimum there are three individuals that make up a dive team to perform cofferdam installations and subsequent removals. The dive team is lead by a designated person in charge (dive supervisor) who has responsibility for the technical direction and safety of the divers, standby divers and tenders that make up the remainder of the dive team. The US Coast Guard and OSHA publish the federal regulations that govern diving operations (references 16-10.4.4 and 16-10.4.5). The minimum qualification common for all diving personnel are as follows:

**16-10.2.3.3.1** Initial diver training consists of successful completion of a certified commercial and/or military surface-supplied diving course. SCUBA diving certification does not meet this requirement. OQE can be either a certification card issued by the Association of Diving Contractors International (ADCI) plus a resume demonstrating a minimum of seven years commercial diving experience or a diploma / certificate from an ADCI recognized commercial or military training facility.

**16-10.2.3.3.2 Medical Qualification:** If an individual will be diving or in a standby diving mode, then a current medical physical screening with an endorsement for diving by the reviewing physician is required. Periodicity is every two years.

**16-10.2.3.3.3 CPR/First Aid:** All dive team personnel will complete and maintain CPR and First Aid certification through Red Cross or other certifying agency.

**16-10.2.3.3.4 Cofferdam Program Qualification:** Diving personnel shall be trained and tested in accordance with the company's training plan as outlined in section 16-10.2.2, and includes successfully accomplishing the following:

(a) Reading and discussing applicable references related to cofferdam installations aboard US Navy vessels;

(b) Perform operational procedures to demonstrate practical experience to include a minimum of six (6) satisfactory installation dives under the direction of
a qualified diver

**NOTE:**

Divers in training shall not perform cofferdam installations for single valve protection applications.

(c) Satisfactorily complete a cofferdam written examination with a minimum passing grade of 75% covering the minimum diver cofferdam training requirements located in Appendix E;

(d) Satisfactorily complete an interview with the company's Diving Supervisor or Manager.

**16-10.2.3.3.5 Maintenance of Qualifications:** Each diver qualified under 16-10.2.3.3.4shall perform a minimum of one cofferdam installation every six months to maintain qualification. Any diver who fails to perform one cofferdam installation in a six month period looses his qualification and must re-qualify in accordance with 16-10.2.3.3.4.

**16-10.2.4 Document and Record Management.** In order to demonstrate that qualification to this addendum has been met, specific OQE is required. This section presents the documents and records that are required for the initial qualification and maintenance of qualification necessary for cofferdam operations. These documents are to be submitted upon request to the applicable contracting authority (e.g. cognizant RMC). Retention of OQE related to this addendum shall be for two years after the completion of a resultant contract.

**16-10.2.4.1** A Training Plan shall be written and contain at a minimum an outline of discussion topics contained in section 16-10.2.2 above.

**16-10.2.4.2** Cofferdam Training and Qualification Record (i.e. Qual Card) shall be prepared and maintained for all diving personnel involved with cofferdam operations. The Training and Qualification Record shall contain the following information:

**16-10.2.4.2.1** Individuals name and job classification;

**16-10.2.4.2.2** Date and certificate or diploma number from ADCI recognized commercial (or military) dive school training plus each individual divers log dates confirming a minimum of 7 years commercial diver experience.

**16-10.2.4.2.3** Date of CPR and First Aid training

**16-10.2.4.2.4** Signatures and dates of supervisory personnel or cofferdam qualified personnel attesting that the candidate has demonstrated their knowledge for each specific area outline in the company's training plan;

**16-10.2.4.2.5** OQE demonstrating practical experience that the candidate has performed the six (6) cofferdam installations under the supervision of a qualified diver. This can be a dive record (dive sheet) that can be traceable back to the actual job/ application.

**NOTE:**

Divers in training shall not perform cofferdam installations for single valve protection applications.

**16-10.2.4.2.6** Examination results;

**16-10.2.4.2.7** Certification statement and signature from the company attesting that the individuals' qualification meets the requirements of this manual;

**16-10.2.4.2.8** OQE demonstrating that the qualified diver has performed a cofferdam installation within the past six months. This can be a dive record (dive sheet) that can be traceable back to the actual job/application.

**16-10.2.4.3** Personnel resumes shall be maintained for design engineers, welders and diving personnel. Additional OQE to support personnel qualifications include: performance qualification records for welders, CPR/First Aid certificates for diving personnel, engineering registration, and dive school diplomas/certificates.

**16-10.2.4.4** Process Control Procedure (PCP) shall be prepared in accordance with the requirements of reference 16-10.4.6 for each cofferdam operation. The PCP fulfills the requirement of the Formal Work Package (FWP) presented in section 16-4.7.1.3 (plugs), or 16-5.2.11 (patches), or 16-6.6.10 (dry chambers), or 16-7.6.6 (stern tube seals). As most cofferdam installations are unique it is expected that a separate PCP will be required for each individual cofferdam operation. A standardized PCP can be developed to address recurring operations (i.e. flat patches, eductor boxes, dry chambers, shaft wrap stern tube seals, plugs etc.). The minimum OQE for plug or patch PCP's will be the checklists contained in Appendices C and D.

**16-10.2.4.5** Cofferdam drawings and design calculations shall be made and documented for each cofferdam used. Cofferdam drawings shall be of sufficient detail to show weld details, material used and over all dimensions. Calculations shall be carried out in accordance with the guidance given in section 9.

**16-10.2.5 Equipment Used for Cofferdam Operations.** There is a variety of equipment used for cofferdam operations. This section lists only some of the equipment that can be audited by customers to verify that the contractor is performing the cofferdam operation in a safe and efficient manner.

**16-10.2.5.1 Diver Communication equipment.**

**16-10.2.5.2 Rigging equipment**. It is the responsibility of the contractor to inspect, test and verify that all rigging used for cofferdam operations is appropriately sized, meet the requirements of the rigging plan, and is in safe working condition. Also, the contractor shall have designed a rigging plan for each specific cofferdam installation.

**16-10.2.5.3 Cofferdam and attachment hardware.**

**16-10.2.6 Document and Drawing Requirements.** During the project evolutions, certain documentation must be reviewed and kept on hand at the operating site. Listed below are some of these documents that shall be on site during actual production work if applicable.

**16-10.2.6.1** Applicable system drawings;

**16-10.2.6.2** Automated Work Request;

**16-10.2.6.3** Docking plan drawing;

**16-10.2.6.4** Process Control Procedure or Formal Work Package

**16-10.2.6.5** UWSH Manual, Chapter 16: Cofferdams;

**16-10.2.6.6** Applicable forms (i.e. Appendices C and D for all plug or patch operations and Appendix G as required);

**16-10.2.6.7** Rigging plan;

**16-10.2.6.8** Cofferdam design package (16-10.2.4.5);

**16-10.2.6.9** Emergency flood plan;

**16-10.2.6.10** Diving contractor's Safe Practices Manual.

**16-10.3. COMPLIANCE CHECKLIST**

**16-10.3.1** Table 16-9 is an operational checklist that is organized in accordance with this section. Table 16-9 can be used as a guide for a diving contractor for putting together their company's initial cofferdam program. The table can also be used as a compliance matrix for external audits performed by Navy activities.

## 16-10.4 REFERENCES

**16-10.4.1** American Welding Society (AWS), Structural Welding Code - Steel, D1.1: 2004

**16-10.4.2** American Welding Society (AWS), Structural Welding Code - Aluminum, D1.2

**16-10.4.3** NAVSEA S9074-AQ-GIB-010/248, Requirements for Welding and Brazing Procedure and Performance Qualification

**16-10.4.4** Code of Federal Regulations (CFR), (2004). Occupational safety and health standards Part 29 - 1910.401-1910.441 Commercial Diving Operations

**16-10.4.5** Code of Federal Regulations (CFR), Ch-1 (10-1-89 Edition), Subchapter V, Part 197, Subpart B - 197.200 - 197.488 - Commercial Diving Operations

**16-10.4.6** NAVSEA Standard Item 009-09, Process Control Procedure

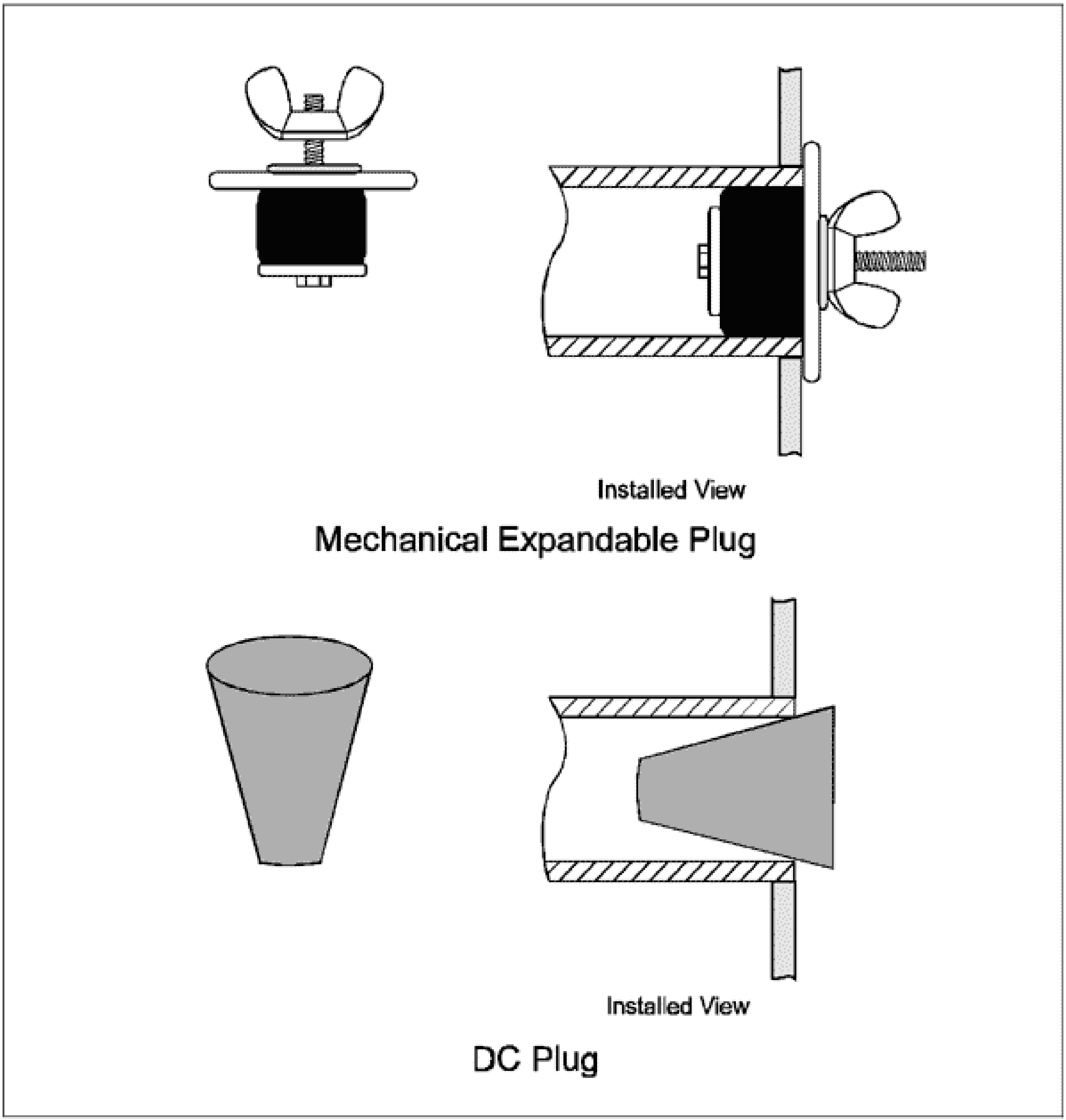



**Figure 16-1. DC and Mechanical Plugs.**

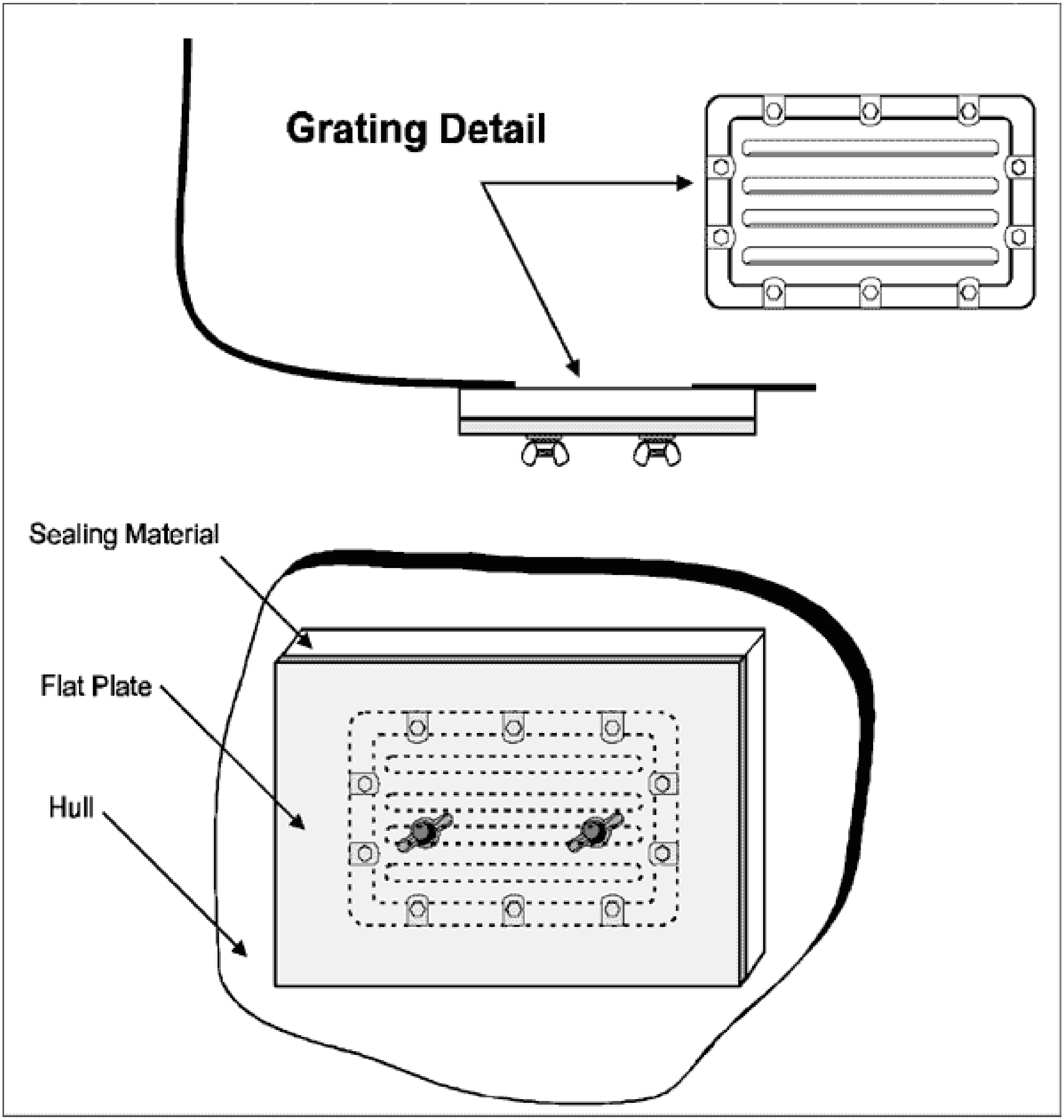



**Figure 16-2. Installed Flat Patch.**

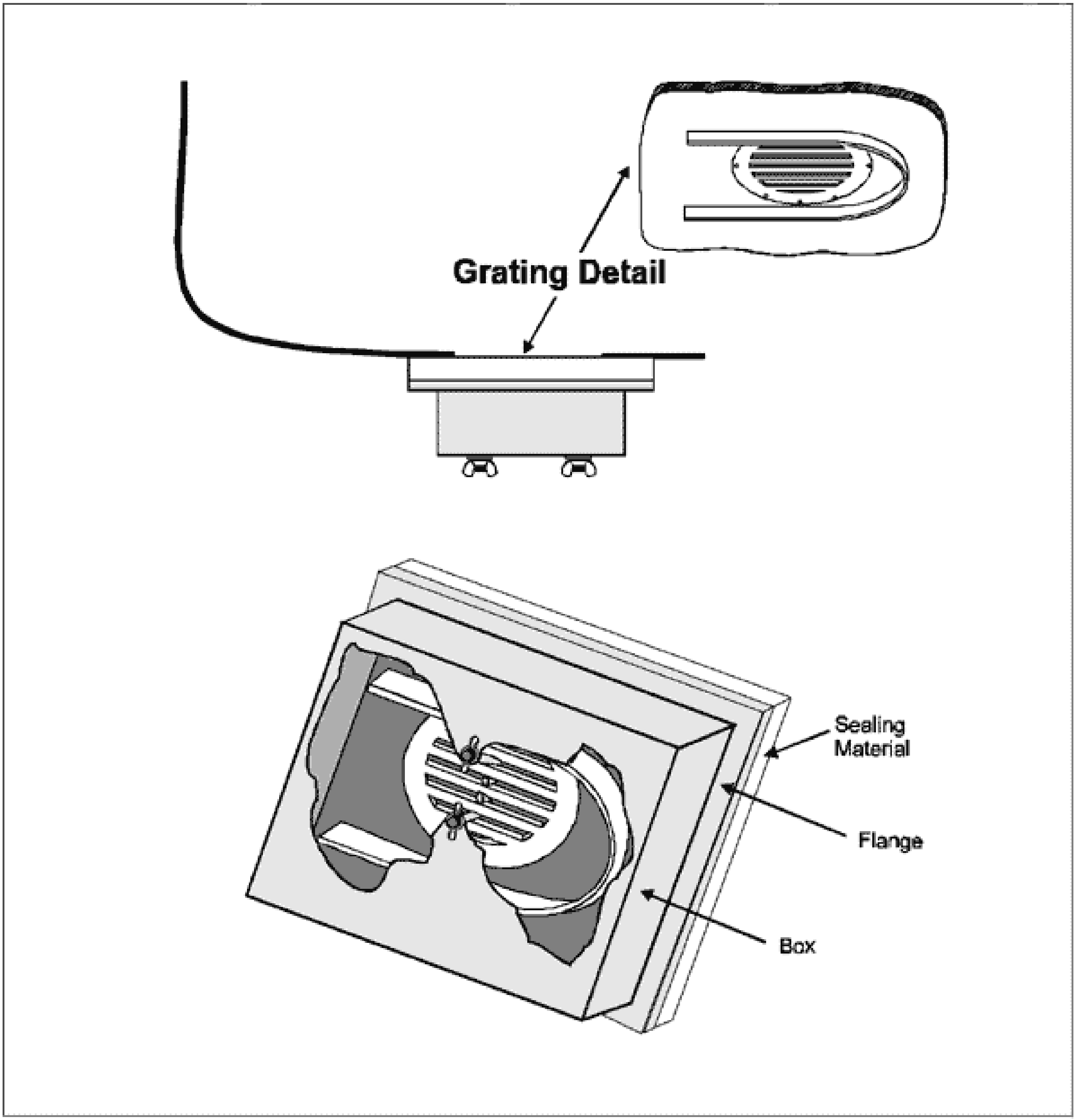



Figure 16-3. Installed Box Patch.

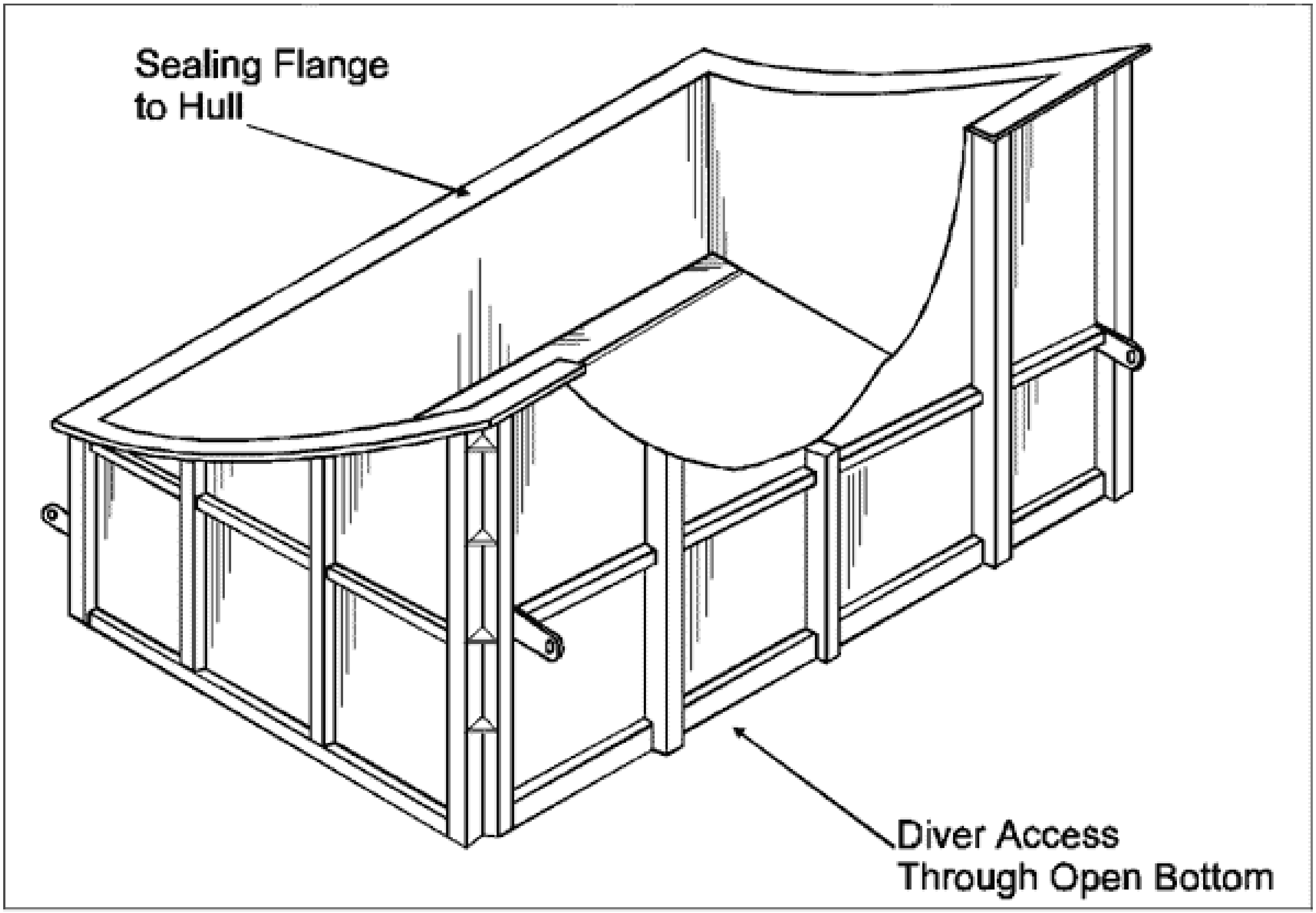



**Figure 16-4. Typical Open Bottom Dry Chamber - APU Cofferdam.**

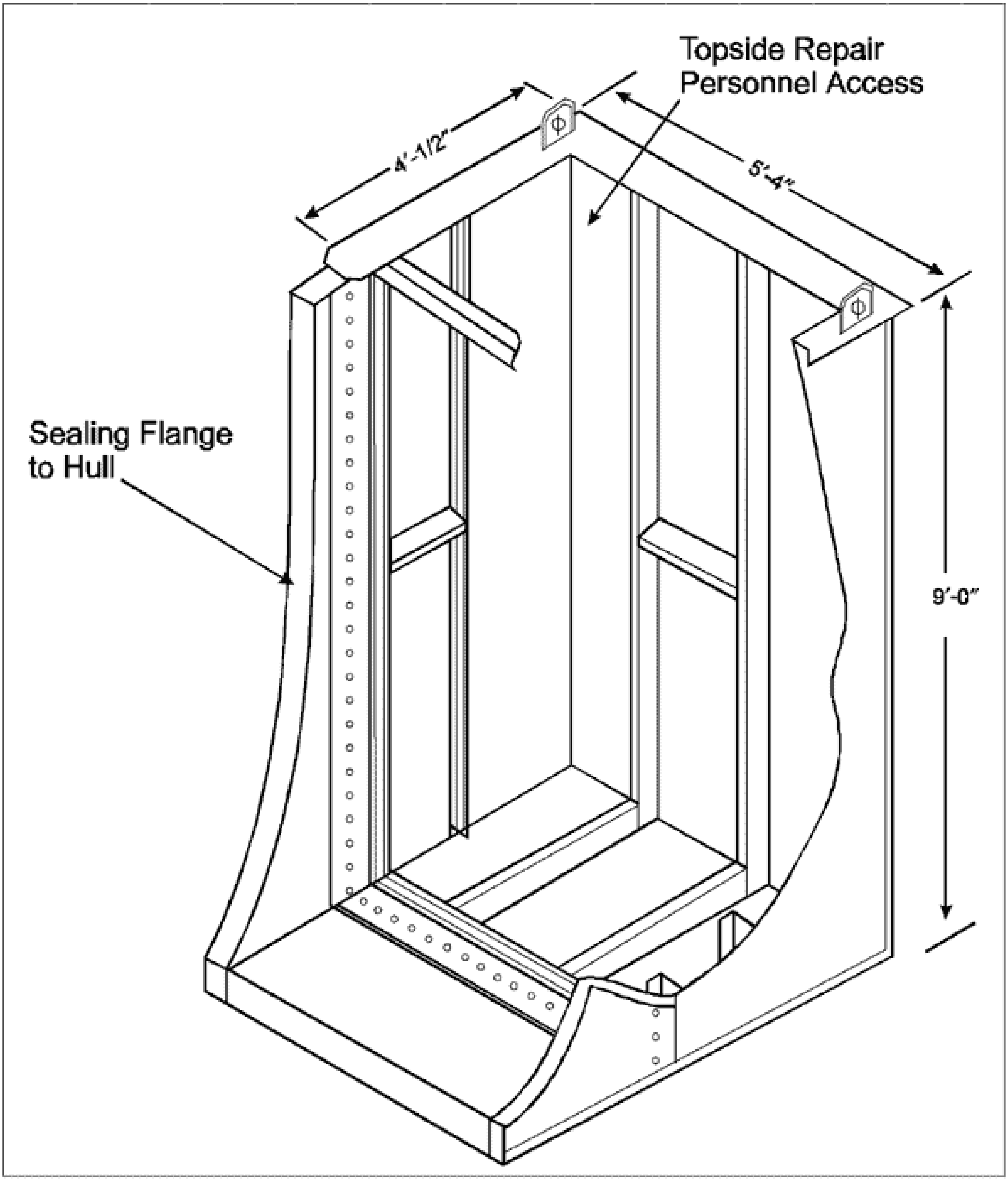



**Figure 16-5. Typical Open Top Dry Chamber - FFG 7 Hull Plate Weld Repair.**

# APPENDIX A

## MATERIAL REQUIREMENTS

**1. Gasket material ASTM D 1056-00 Type 2, Class B or C, Grade 1 or 2 for application up to 35 feet seawater depth or Grade 2 for application deeper then 35 feet seawater depth**

NSN 5640-00-237-4786 is a stock number for 1 inch thick Grade 1 material.

**2. Gasket adhesive (contact cement)**

NSN 8040-00-754-2685 or equivalent

**3. Hose for vent line or eductor discharge - 1196 RoyalFlex Heavy Duty Multi-Purpose Suction and Discharge Hose or equivalent.**

NSN 4720-01-087-2097 is 1.5 inch ID x 250 ft long

NSN 4720-01-136-3323 is 2 inch ID x 120 ft long

NSN 4720-01-322-9785 is 3 inch ID, variable length

Manufacturer:

Dana Corp/Boston Industrial Products Division
1621-T Vaden Blvd.
Brentwood, TN 37027
(615) 377-6700

**4. Jet pump (eductor) - Penberthy 1.5 inch, model LL (low head), bronze or equivalent**

Manufacturer:

Penberthy
320 Locust St.
Prophetstown, IL 61277
(815) 537-2311

**5. Sealing Putty - DUXSEAL or equivalent**

Manufacturer:

JM Clipper, Corp.
403 Industrial Drive
Nacogdoches, TX 75963
(409) 560-8900

## CHANGE F 6. Commercial Source and Recipe for Bintsuke

Commercial source for individually bagged and wrapped, ten-foot long coils of optimum, all-season recipe Bintsuke is:

Stevenson-Cooper, Inc.
1039 W. Venango Street
Philadelphia, PA 19160
Phone: (215) 223-2600
POC: Dennis L. Cooper, President

Many Navy dive lockers are familiar with a "homemade" sealing compound known as "Bintsuke." The compound is very effective for sealing. The compound has a summer and winter formula as follows:

| | **Summer** | **Winter** | **NSN** |
|---|---|---|---|
| Cooking oil | 5 gal | 5 gal | 8945-00-616-0081 |
| Rosin (Pitch) | 25 lb | 30 lb | 8030-00-275-1176 |
| Beeswax | 25 lb | 25 lb | 9160-00-253-1171 |
| Tallow | 2 lb | 3 lb | 9160-00-263-8757 |
| Paraffin | 2 lb | 2 lb | 9160-00-285-2044 |
| Cheesecloth | approximately 6 ft x 1 ft strips | | 8305-00-222-2423 |

***WARNING***
***Each Repair activity must ensure that their specific procedure for Bintsuke production has been approved in accordance with local environmental and occupational safety and health regulations.***

**Directions:** Heat cooking oil to boiling. Add rosin and wait until it melts completely. Add beeswax and tallow, stirring until they melt and mix completely. Let mixture cool to approximately 150° F. Add the paraffin and allow it to melt. Soak the cheesecloth strips in the mixture and allow the Bintsuke to cool. Twist or fold the Bintsuke-impregnated cheesecloth into the desired shape for storage. The compound will stiffen during storage but will become flexible when worked by hand.

**Safety Recommendations:** Produce only in an open-air environment with posted warning signs. Use the following minimum personnel protection equipment (PPE): NIOSH approved chemical safety glasses/goggles and face shields, coveralls with a full canvas or leather apron, steel-toed high top leather boots, impervious heat resistant gloves, and adequately sized readily accessible ABC type fire extinguisher.

CHANGE A

# APPENDIX B

# EXAMPLE OPEN BOTTOM DRY CHAMBER RIGGING CALCULATIONS

## APU RIGGING CALCULATIONS

**1.** This example demonstrates the resolution of the rigging forces applied to padeyes attached to an "I" beam bolted to the bottom of the APU cofferdam. There is assumed to be no out of plane load applied to the padeyes and the center of gravity is assumed to be equidistant from all padeyes.

**2.** Required gasket compression force for a 3.5 psi gasket compression (force needed to compress the gasket 25%): add the areas of all of the tops of the walls, multiplied by the gasket compression force. The gasket width is 6 in; inboard and outboard walls are 120 in long; forward and aft walls are 108.75 in long. For the purpose of this analysis, the length of the forward and aft walls will be used, not the slightly longer gasket length due to the curvature.

(2 x 108.75 in + 2 x 120 in) x 6 in x 3.5 psi = 9608 lb

**3.** The wet weight of the cofferdam is calculated below:

Weight of the cofferdam dry: 1435 lb

Weight of aluminum per cubic ft: 165 lb

Weight of salt water per cubic ft: 64 lb

$$\frac{64}{165} = 38.78\%$$

0.3878 x 1435 lb = 556.5 lb displaced by water

1435 lb - 556.5 lb = 878.5 lb wet weight of cofferdam when immersed in water.

**4.** The total force required to seat the cofferdam when immersed in water is equal to the displaced weight of the cofferdam plus the seating force required to seat the gasket against the hull of the ship.

> 9608 lb + 878.5 lb = 10,486.5 lb force required to seat the cofferdam against the bottom of the ship.

**5.** The load is equally divided between four padeyes; therefore:

$$\frac{10,487 \text{ (rounded up)}}{4} = 2622 \text{ lb per padeye vertical force to seat the cofferdam.}$$

**6.** The bottom of the cofferdam is 35.4 in (2.95 ft) BBL (below baseline) when installed on the ship. The ship's draft in the area of the cofferdam is 16 ft. Total depth to the bottom of the cofferdam is 18.95 ft.

**7.** When the cofferdam is blown down, the inside walls of the cofferdam will see the differential hydrostatic force between the top of the cofferdam and the bottom of the cofferdam. The outboard wall of the cofferdam is 78.3 in high. The inboard wall of the cofferdam is 35.4 in high. The height difference results in an unbalanced load on the cofferdam. The hydrostatic force exerted on the inboard wall will cancel an equal area of hydrostatic force on the outboard wall.

Therefore: 78.3 in - 35.4 in = 42.9 in of outboard wall that is seeing the differential pressure created by the hydrostatic pressure at the bottom of the cofferdam. (See Figure D-1).

**8.** To determine the pressure affecting the inside walls of the dewatered cofferdam, multiply the depth of water times 0.445 psi/ft.

0.445 psi/ft of sea water depth x 18.95 ft of sea water depth = 8.4 psi inside the cofferdam.

There is 42.9 in of cofferdam wall that is unbalanced by an equivalent area opposite side wall. To determine the hydrostatic pressure being exerted against the outside of the cofferdam, the average depth must be calculated for that area.

> Draft of ship: 16 ft to baseline

Cofferdam outboard wall extends 42.9 in (3.57 ft) ABL (above baseline).

$$\frac{3.57 \text{ ft}}{2} = 1.79 \text{ ft}$$

Average depth:16 ft - 1.79 ft = 14.2 ft (rounded)

0.445 psi/ft of seawater depth x 14.2 ft of seawater depth = 6.3 psi (rounded).

Pressure acting on the upper outboard wall = 8.4 psi - 6.3 psi = 2.1 psi differential.

Total force acting on the wall is equal to the height of the wall (in inches) multiplied by the length of the wall (in inches) multiplied by the pressure differential.

Height = 42.9 in

Length = 120 in

Pressure = 2.1 psi

42.9 in x 120 in x 2.1 psi = 10,811 lb (rounded)

**9.** There are now two forces acting against the cofferdam:

The seating force (10,487 lb).

The hydrostatic force trying to push the cofferdam to the surface (10,811 lb).

**10.** The rigging must be sized to contain the forces. The following method is used to determine the forces acting on the rigging:

Right triangles are formed with one side representing the path of the rigging. (See Figure D-2).

**11.** In triangle ABC, side AB is equal to one fourth of the force needed to seat the cofferdam or 2622 lb. In this example it is determined to be 38.6 in long (rounded). To determine the force per inch of length: 2622 lb/38.6 in = 67.9 lb/in.

To determine the loads in the remaining sides of the triangle, multiply their lengths by 67.9 lb/in.

Side AC = 59.6 in x 67.9 lb/in = 4047 lb

Side BC = 45.5 in x 67.9 lb/in = 3089 lb

Triangle $A_1$ $B_1$ $C_1$ is computed with the same method.

Side $B_1$ $C_1$ = 818 lb

Side $A_1$ $C_1$ = 2745 lb

Side $A_1$ $B_1$ = 2622 lb

The loads imposed on sides AC and $A_1$ $C_1$ will determine the size of the required rigging.

Side BC should counteract the force of side $B_1$ $C_1$ plus the hydrostatic force trying to push the cofferdam off the hull.

BC = 3089 lb fwd and 3089 lb aft (2 padeyes per side).

2 x 3089 lb = 6178 lb force

$B_1$ $C_1$ = 818 lb fwd and 818 lb aft (2 padeyes per side).

2 x 818 lb = 1636 lb

10,811 lb hydrostatic force acting against the outboard wall of the cofferdam.

10,811 lb + 1636 lb = 12,447 lb force

12,447 lb - 6178 lb = 6269 lb differential in the opposing rigging forces. Therefore the inboard rigging would have to be sized for the additional forces being applied.

$\frac{6269}{2} = 3135$ lb per inboard leg additional loading to prevent the cofferdam from moving.

This load is applied to line BC.

Add the above force to line BC (3089 + 3135 = 6224) and calculate for AC in the same manner as shown above.

Rigging loads for line AC is increased to 8151 lb

Rigging loads for line $A_1$ $C_1$ is 2745 lb

This is a conservative approach to resolving the forces acting on the rigging and assumes that the differential hydrostatic force is acting straight outboard against the wall of the cofferdam.

# APPENDIX C

# PATCH AND PLUG INSPECTION CHECKSHEET

**Dive Supervisor Instructions: Check each applicable item when complete and sign sheet when all items are complete. Items considered not applicable shall be marked "NA". Keep checksheet on file while patch or plug is installed on a vessel.**

_____ **1.** Confirm the engineering activity tasked with patch or plug design and selection or fabrication has provided the following:

**a.** _____ Identify scope of repairs to be accomplished in-hull, incidental inboard piping configuration and that internal piping blanks with gaskets are ready for installation.

**b.** _____ Obtain sea chest description/dimensions and location on underwater hull from Docking or Hull Penetration drawings. Information should include the following:

**1.** Docking plan number and rev. ________________________

**2.** Hull Opening Item# ________________________

**3.** Hull Opening Size ________________________

**4.** Dimensions and location of any protrusions from the hull which would interfere with patch installation________________________

**5.** Sea chest Location Port or Starboard (P/S) ________________________

**6.** Sea chest Distance off Frame________________________

**7.** Sea chest Distance off Ship's CL________________________

**8.** Height above keel of Hull Opening________________________

**9.** Plug, Box Patch or Flat Patch required________________________

**c.** ______ Determine means of positive attachment to the hull to prevent loss or movement out of alignment with the hull opening.

**d.** ______ Provide necessary supporting documentation (in accordance with NAVSEA S0600-AA-PRO-160, Underwater Ship Husbandry Manual, Chapter 16, Cofferdams, Section 5, Patches) referenced to the patchs' serial number.

**e.** ______ Confirm patch has gasket design (material and required load area), external vent line nipple (if no internal sea chest vent is available), eductor nipple, and rigging attachment points.

**f.** ______ Confirm that patch seal flange is shaped to match templated hull shape if required to achieve 100% contact between hull surface and patch sealing gasket.

_____ **2. Inspect assembled patch or plug.**
**Patch** - Divers verify that patch plating has no cracks, tears, or broken welds. Maximum allowable corrosion on any area of the patch is less than or equal to a reduction of 25% in member thickness, i.e 3/32" in depth for 3/8" plate. Sealing flanges must not have any corrosion or pitting which might interfere with achieving a final seal. Cracks and corrosion are to be repair welded if practical, or replace the patch. Air blast test repair welds. Air blast test consists of directing 90 PSI air hose on far side of welded area, applying soap solution to near side, and observing for bubbles indicating leakage. No leaks are allowed. Replace patch if criteria cannot be met.
**Plug** - Divers verify that that a DC Plug is free of chips, whittling or cracks. Surface is to be smooth to ensure tight seal. Mechanical expansion plugs shall have no damage and a freely operating mechanism.

CHANGE 8 _____ **3. Inspect patch J-Bolt(s).** Divers visually inspect verify that the J-Bolt is 5/8" diameter or greater. If the hull opening strainer or grating spacing precludes the use of 5/8 inch diameter J-bolts, then 3/8 inch diameter minimum may be used. Verify no cracks or deterioration. Verify that the J-hook bend is not straightening or deformed.

_____ **4. Inspect patch or plug sealing material.** Divers visually inspect to verify that 2" thick closed cell foam patch gasket is not brittle, cracked, torn, permanently compressed, or unglued. Replace if not acceptable. Divers inspect mechanical expandable plug sealing rubber to verify the plug's rubber is not brittle, cracked, torn or damaged. Replace if not acceptable.

_____ **5. Inspect piping penetration welds on patch.** Divers visually inspect all piping nipples welded to the patch plate to verify that attachment welds and piping are free of cracks, pitting, and distortion. Pipe welders repair weld any defects noted and retest in accordance with air blast test in step 2.

_____ **6. Inspect patch eductor.** Divers verify that the eductor is free of cracks, distortion, and damaged threads.

_____ **7. Divers inspect/test patch hoses.** The tests detailed below are required every three years or if visual inspection of the entire hose length prior to each use indicates any cracking or damage to the hose.

**a. Vent Hose:** Verify that hose is in good condition and free of cracks. Check for leaks by pressurizing to city water pressure (30 PSIG) minimum. Observe entire run of hose for leaks for 10 minutes (minimum). No leakage allowed. Replace if required.

**b. Eductor firemain supply hose (canvas), valves, and fittings:** Inspect hoses and fittings, verifying that they are in good condition and are free of cracks and other rejectable defects. Hoses, fittings, and adapters shall be hydrostatically tested to 250 +10, -0 PSIG for 10 minutes (minimum) prior to installation. No leakage allowed. Replace if required. Independent firemain hose hydrostatic pressure testing by divers is not required if ship's hoses are used.

**c. Hose test identification:** Tested hoses shall be marked to identify the last completed pressure test.

**Pre-Dive Inspection Complete:**

**Dive Supervisor (Print Name)**

**Dive Supervisor signature** **Date**

# APPENDIX D

# PATCH AND PLUG INSTALLATION CHECKSHEET

**Dive Supervisor Instructions: Check each applicable item when complete and sign sheet when all items are complete. Items considered not applicable shall be marked "NA". A brief explanation why any item is marked NA shall be provided. Keep checksheet on file while patch or plug is installed on a vessel.**

_____ **1.** Prior to installation of a plug or patch, ship's Commanding Officer or his designated representative shall be notified of the location of the plug and level of protection provided (single or double-valve protection).

_____ **2.** Divers schedule patch/plug installation in coordination with the lead onboard repair shop. Ensure required internal sealing blanks are ready.

_____ **3. For Submarines:** Ship's force must identify the hull opening location by use of a weighted line hung over the side at the correct frame location. Two independent divers must verify the correct hull opening is being patched or plugged by returning an onboard tapping signal.

_____ **4.** Divers clean the hull and inside of the seachest in way of the patch or plug sealing surfaces to provide a clean surface to maximize surface contact. A clean surface is a surface that results in 100% contact area around the entire perimeter between the patch gasket or plug and hull surfaces, based on visual inspection.

_____ **5.** After cleaning in way of the patch installation, mark the measured perimeter of the patch around the hull opening to ensure proper patch alignment during installation. Do not mark by scribing into the hull paint system.

_____ **6.** If patch J-Bolt(s) are to be attached to the sea chest internal strainer bars or grates, divers clean and visually inspect strainer bars for deterioration. If strainer bars or grates are bolted, verify that the fasteners are in good condition. Do not attach J-Bolt(s) to excessively deteriorated strainer bars or grates.

_____ **7.** Prior to installing the patch or plug to the hull, the Diving Supervisor shall contact the onboard mechanics performing internal repair work and inform them that the patch or plug is ready to be installed.

_____ **8. Patch:** Install and center the cofferdam over the sea chest hull opening. Divers to tighten the cofferdam over the sea chest with the J-bolt (s), which is hooked to a strainer bar or grate inside the sea chest. The wing nut shall be threaded until contacting the gasket and no slack exists. Then tighten the wing nut an additional full turn. Appendix F shows proper J-Bolt configuration. Visually inspect to ensure the patch gasket is against the hull on the entire perimeter of the patch. If the patch gasket is not against the hull on the entire perimeter then the patch is not properly templated to the hull shape in that location. Template the hull and modify the patch as required to achieve a proper fit. Attempt to shake the cofferdam assembly to ensure that it is tight and firmly in place.
**Plug:** Install and center the plug within the sea chest hull opening. Divers are to firmly seat the plug in the opening. Visually inspect to ensure the DC or mechanical plug is tight within the hull opening.

_____ **9.** Install belly bands (3/8" wire rope (minimum)) from the ship's hull, through patch padeye(s). Ensure patch bellyband standoffs (see figure 16-12 of UWSH Manual chapter 16) are used if required based on hull shape at the installation location. Secure the belly band wire ropes on both sides of each patch padeye, to eliminate side-to-side motion of the patch. Tension belly bands until visual inspection confirms patch gasket is against the hull over the entire patch perimeter. If under reasonable belly band tension the patch gasket is not contacting over the entire patch perimeter, then the patch is not properly templated to the hull shape at that location. Template the hull and modify the patch as required to achieve proper fit.

***NOTE***
***Belly bands are required only when splitter bars or grates are not available to secure the patch to the hull.***

_____ **10.** Run the external non-collapsible vent line hose from topside (open-ended to atmosphere) to the vent valve connection on the patch. Securely attach the topside end of the hose to the ship's shell or the diving barge as necessary to ensure that it stays open to the atmosphere. If the external vent is to be left in place to monitor patch seal, the topside end will need to be run to a location accessible by Ship's Force.

_____ **11.** Run the eductor supply hose (canvas) from the pierside shore seawater supply or the ship's riser to the eductor connection on the patch.

_____ **12.** Prior to operating the eductor, ensure the internal or external vent line is open. Open the eductor cutout valve on the patch nipple. Open the eductor actuating seawater supply valve to place the eductor in operation.

_____ **13.** The eductor shall be operated until the diver(s) observe "white water" coming from the eductor discharge. This indicates that the eductor is now pulling air. The entrained air bubbles in the eductor discharge fluid stream cause the appearance of "white water". Run the eductor for an additional 30 seconds to ensure that the interior of the patch is sufficiently evacuated and vented to atmospheric pressure.

_____ **14.** Topside personnel, in communication with the Diving Supervisor and other parties, listen and feel at the open ended vent hose or internal vent for evidence of air being pulled into the vent hose or internal vent.

_____ **15.** Shut the eductor cutout valve at the patch, then secure the seawater supply to the eductor. Divers tighten the J-bolt(s) or bellybands further if required to ensure no leakage past the J-bolt(s) hole, and to ensure a snug fit of the patch rigging.

_____ **16.** Divers check the patch or plug seal for tightness by releasing air bubbles around the perimeter of the patch or plug and around the J-bolt (s) holes. Observe the air bubbles to see if any are sucked into the sea chest at any point. Plug any leaks with sealing compound or tighten the J-bolt(s) to secure leakage at the bolt holes. Repeat the leak checks until no leakage is detected.

_____ **17.** Divers inform the lead Shop that the patch is sealed and vented to the atmosphere or plug is sealed. Divers observe the lead shop confirming patch or plug seal by opening an internal vent if possible or breaking loose the repair component sea-side flange fasteners.

**Caution**

***For Submarines: Ship's Commanding Officer permission is required prior to breaking loose fasteners to confirm patch or plug seal. Installed patch or plug must have a tether attached and run to the surface. Topside end of tether must be labeled "Hull Fitting (Noun Name) Installed".***

***Do not completely remove fasteners, as it may be necessary to retighten them should unexpected leakage occur. Note that, under certain conditions, all water may not be removed between the cofferdam and inboard component, especially in the cases of horizontal piping. When working these types of piping, be prepared to handle water draining from the piping when the outboard sea valve flange is loosened.***

**Caution**

***Use caution when performing this procedure. Depending on the type and size of the affected system, a large amount of residual water may be trapped within the piping. It may take a long time to drain all the trapped water and confirm seal integrity. Be prepared to handle water draining from the piping when the outboard repair component flange is loosened.***

_____ **18.** Divers confirm the watertight integrity of the patch or plug is evident at the internal repair site and any entrapped sea chest water has been drained. Zero leakage or an acceptable leak rate (as defined in the patch or plug requirements of UWSH Manual, Chapter 16) is required. The Lead shop shall complete disassembly of the component to be repaired.

CHANGED _____ **19.** Divers confirm that, immediately after removal of the repair component, the Lead shop installs a gasketed internal sealing blank with a less than ½ inch diameter vent valve. Blanks shall be danger tagged after installation to avoid accidental removal. The blank vent valve may be left shut when not temporarily opened by the ship's sounding and security detail for patch or plug seal monitoring or, upon approval by the Ship, the blank vent valve may be left continuously open to maintain cofferdam differential pressure.

_____ **20.** Divers shall confirm arrangements with ship's force to monitor diver installed patch or plug seal if required by and in accordance with the patch and plug requirements of UWSH Manual, Chapter 16.

_____ **21. Reassembly of Repair Components:** After component repairs are complete and ready for reassembly, re-assemble and re-establish communications with all parties for repair component replacement.

CHANGED _____ **22.** Divers confirm no leakage exists at the internal sealing blank vent valve. If leakage is observed, divers shall correct the seal.

_____ **23.** Divers confirm watertight integrity of the patch or plug at the internal repair site. Once leakage has been eliminated, lead shop mechanics disassemble the blank flange in the same manner as stated in Step 17.

_____ **24.** Divers confirm that reassembly of the components is complete.

_____ **25.** Without actuating eductor water supply, divers slowly crack open the eductor cutout valve on the patch or loosen the plug. This action will initiate controlled flooding of the sea chest.

_____ **26.** Check all disturbed mechanical joints for leakage. No leakage is allowed. If leakage occurs, divers are to actuate the eductor supply water and evacuate the patch to re-establish the patch seal or re-seat the plug. Lead Shop shall then correct the leakage by remaking the repaired component's flange(s) as necessary.

_____ **27.** Re-perform steps 25 and 26 until no leakage is noted. Divers confirm that zero leakage has been observed, and that the installation is satisfactory.

_____ **28.** Divers may remove the patch or plug. Inspect the interior of the sea chest prior to returning to the surface to ensure that no foreign objects or debris are present. Inform all involved parties that patch or plug removal is complete.

_____ **29.** Inspect all patch and plug hardware for obvious rejectable defects such as cracking, pitting or deformation. Repair defects or mark for future repair prior to re-use.

**Cofferdam Installation Complete:**

---

**Dive Supervisor (Print Name)**

---

**Dive Supervisor signature** **Date**

Provide 24 hour per day 7 day per week emergency contact name(s) and phone number(s) for the installing divers.

---

---

# APPENDIX E

# MINIMUM DIVER COFFERDAM TRAINING REQUIREMENTS

**Reference (a): NAVSEA S0600-AA-PRO-160, Underwater Ships Husbandry Manual, Chapter 16, Cofferdams.**

**1.** Prior to tasks to install underwater patches, plugs or cofferdams all Divers shall be able to answer the following questions in accordance with the requirements of reference (a):

**A.** What are the steps of this procedure?

**B.** What are the reasons for each step?

**C.** What control/coordination is required?

**D.** What means of communications are used?

**E.** What safety precautions must be observed?

**F.** What parameters/operating limits must be monitored?

**2.** Satisfactorily perform six installations under the direction of a qualified diver.

**Fundamental Knowledge Required:**

**1.** Describe and discuss the following:

**a.** Cofferdam [ref. a, sec 1]

**b.** DC Plug [ref. a, sec. 4]

**c.** Expandable Plugs [ref. a, sec. 4]

**d.** Flat Patch [ref. a, sec 5]

**e.** Box patch [ref. a, sec 5]

**f.** Eductors [ref. a, sec 5]

**g.** Shaft wrap [ref. a, sec 7]

**h.** Shaft seal Cofferdam [ref. a, sec 7]

**i.** Bintsuke [ref. a, app. a]

**2.** Describe a differential pressure seal on a cofferdam patch? [ref a, section 5]

**3.** When is a dewatering eductor secured? [ref a, sec 5]

**4.** What is templating and it's purpose? [ref a, sec 8]

**5.** What is the required cofferdam gasket material and the uncompressed thickness? [ref a, sec 5]

**6.** Describe the requirements of the Patch and Plug Inspection Checksheet? [ref a, app E]

**7.** Describe the requirements of the Patch and Plug Installation Checksheet? [ref a, app F]

# APPENDIX F

# J-BOLT MINIMUM REQUIREMENTS

| PIECE # | DESCRIPTION | STOCK No. | MATERIAL | QUANTITY REQUIRED |
|---|---|---|---|---|
| 1 | J-Bolt C/F $^5/_8$" Dia. Round Bar | 9Z9510-00-189-0581 | CRES 304 QQ-S-763 | 1 |
| 2 | Wing Nut C/F $^1/_2$" thk plate | 9Z9515-00-204-4573 | CRES 304 QQ-S-763 | 1 |
| 3 | Washer, J-Bolt C/F $^1/_4$" thk plate, 4" Dia. | 9Z9515-00-204-4578 | CRES 304 QQ-S-763 | 1 |
| 4 | Spacer, J-Bolt C/F 1' NPS pipe, 3" length | 9C4710-00-893-8627 | CRES 304 MIL-P-1144 | 1 |
| 5 | Gasket, rubber 1" thk closed cell foam 6" Dia. (See Note 1.) | | See Note 1 | 1 |

**Notes**

1. Made from closed cell foam ASTM D1056, (Type 2, Class B or C, Grade 2) with a compression/deflection ratio of 5-9 psi as manufactured by Rubberlite Inc., Part Number SCE-42, sheet size 2" x 42" x 72". Known source: Hampton Rubber, 4571 Village Avenue, Norfolk, VA, phone (757) 858-1900

2. All fabrication and welding to be in accordance with MIL-STD-1689 (SH).

3. Grind smooth all edges of the wing nut and washer to prevent hose shear.

4. "A" dimension of J-Bolt is 24, 36, or 48 inches.

5. If the hull opening strainer or grating spacing precludes the use of 5/8 inch diameter J-bolts, then 3/8 inch diameter minimum may be used.

# APPENDIX G

## REPORT OF SHIP'S RESPONSIBILITIES FOR PATCH INSTALLATIONS AND/OR SINGLE VALVE PROTECTION

Ref (a): NAVSEA S0600-AA-PRO-160, Underwater Ship Husbandry Manual, Chapter 16, Cofferdams.
*(Check applicable paragraphs.)*
**1.** ____ (INTERNAL MONITORING) In accordance with ref (a) paragraph 16-5.2.18: Monitoring, Ship's Chief Engineer is hereby notified that the following list of seachests have external patches installed and are internally vented:

______________________________ ______________________________
______________________________ ______________________________
______________________________ ______________________________
______________________________ ______________________________
______________________________ ______________________________

Internal vents shall be inspected for signs of leakage by ship's sounding and security detail on an interval not to exceed every seven days during the time that the patches are actually providing single or double-valve protection for the seachest. The isolation valve for the internal vent shall be carefully opened during the inspection and the vent observed for the presence of water, or the release of pressurized air (indicating entry of water past the cofferdam seal causing the remaining air bubble to compress). The isolation valve for the internal vent may then be closed until the next inspection to avoid leakage between inspections from entering the bilge or, upon approval by the Ship, the isolation valve for the internal vent may be left continuously open to maintain cofferdam differential pressure. If significant leakage is observed, take action to confirm external patch seal adequacy.

**2.** ____ (WRAP TYPE STERN TUBE SEAL) In accordance with ref (a) paragraph 16-7.6.8, Ship's Chief Engineer is hereby notified that a wrap type stern tube seal has been installed on # ___ shaft and an acceptable leak rate could not be established without continuous operation of an eductor. It is the ship's responsibility to maintain the acceptable leak rate by ensuring the eductor fire main supply line is continuously open.

Repair Activity________________________________________ Date______________

Chief Engineer ________________________________________ Date______________
(USS ___________)

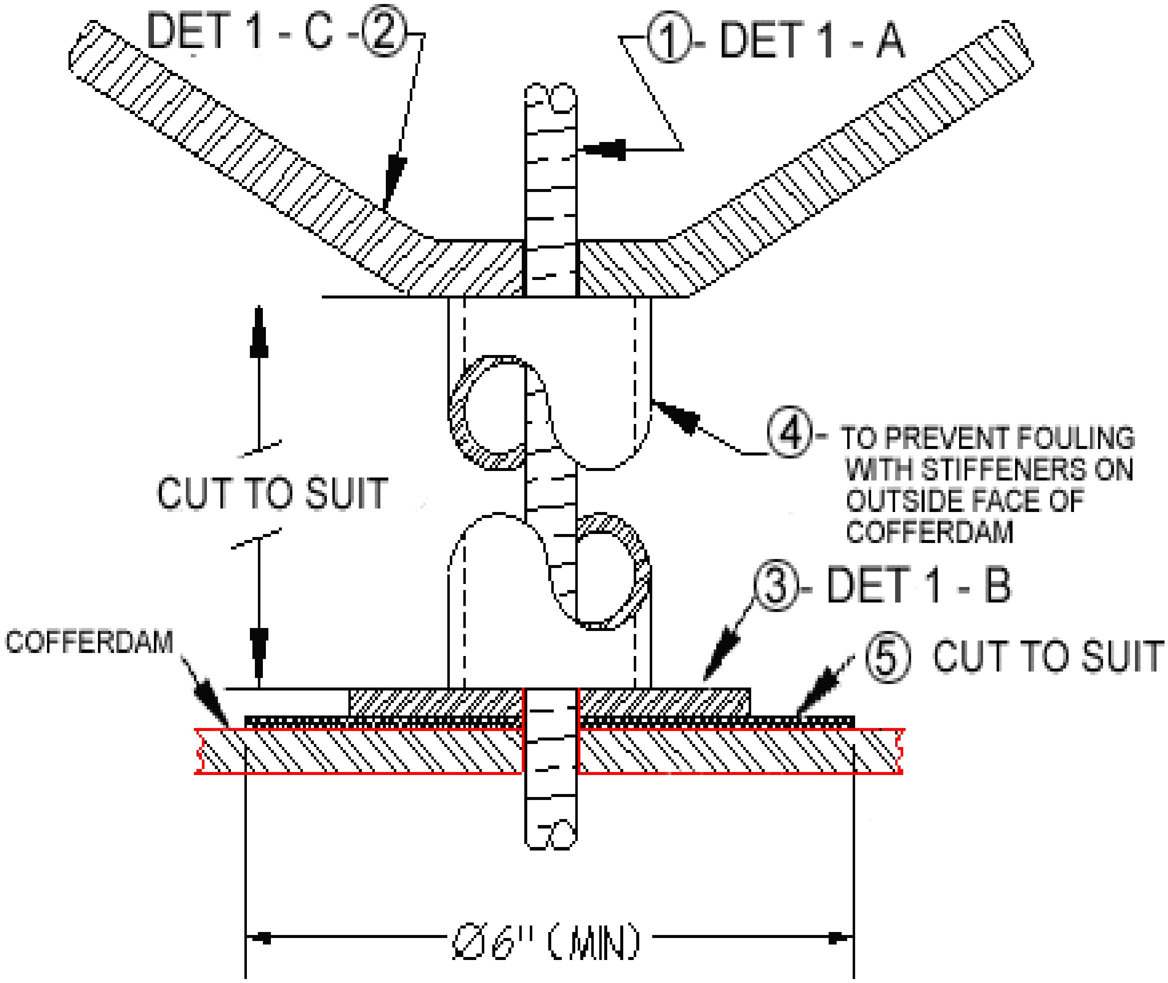
**3.** _____ (PATCH OR PLUG INSTALLED) The ship has been notified and is aware that the repairs to the following components will require installation of a patch or plug since the seachest valve is being worked or can not be secured. The patch or plug will provide the primary hull closure and an internal sealing blank will provide the second closure in accordance with ref (a) paragraph 16-4.7.1.2 or 16-5.2.2. Single valve protection will occur for brief periods during the removal of the component to be repaired/replaced and the installation of the internal sealing blank and the subsequent removal of the internal sealing blank and installation of the repaired/ replacement component. The repair activity has provided a specific plan for immediate installation of a replacement piping component or internal sealing blank to restore double-valve protection.
____________________________________________________________________________________________________
____________________________________________________________________________________________________
____________________________________________________________________________________________________
____________________________________________________________________________________________________

**4.** _____(NO PATCH OR PLUG INSTALLED) The ship has been notified and is aware that the repairs to the following components will not require installation of a patch or plug since the seachest valve will provide the primary hull closure and an internal sealing blank will provide the second closure in accordance with ref (a) paragraph 16-4.7.1.1 or 16-5.2.1. Single valve protection will occur for brief periods during the removal of the component to be repaired/replaced and the installation of the internal sealing blank and the subsequent removal of the internal sealing blank and installation of the repaired/replacement component. The repair activity has provided a specific plan for immediate installation of a replacement piping component or internal sealing blank to restore double-valve protection.

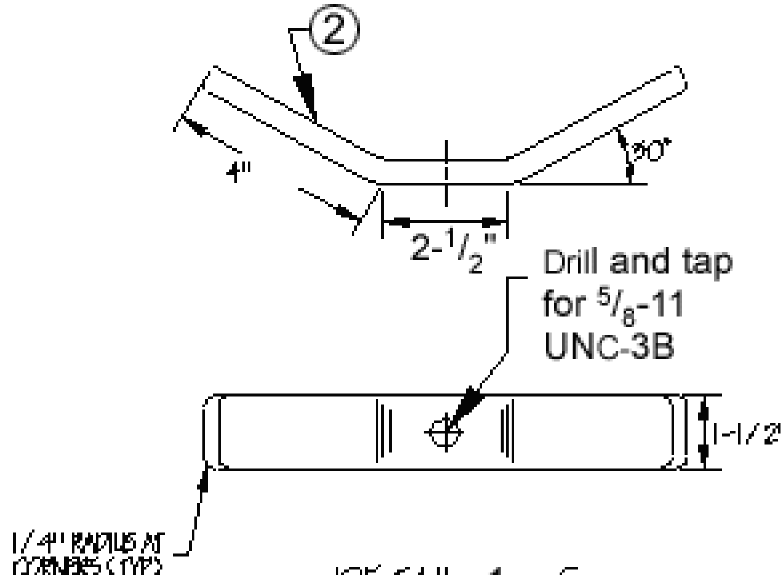
______________________________________________________________________________________________
______________________________________________________________________________________________
______________________________________________________________________________________________
______________________________________________________________________________________________

Repair Activity_______________________________________ Date______________

Chief Engineer _______________________________________ Date______________
(USS ___________)

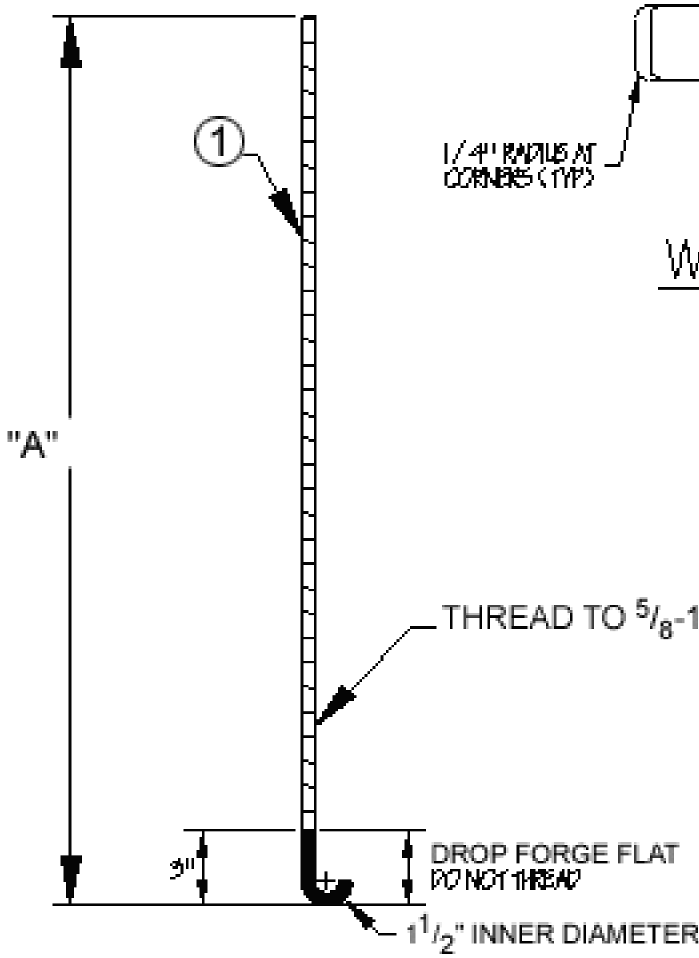



**J-HOOK ASSY, PARTIAL CUT-AWAY TYP INSTALLATION THROUGH COFFERDAM**




DETAIL 1 - C
WINGNUT FABRICATION


DETAIL 1 - B
J- BOLT GASKET WASHER FAB




DETAIL 1 - A
J- BOLT ANCHOR FAB

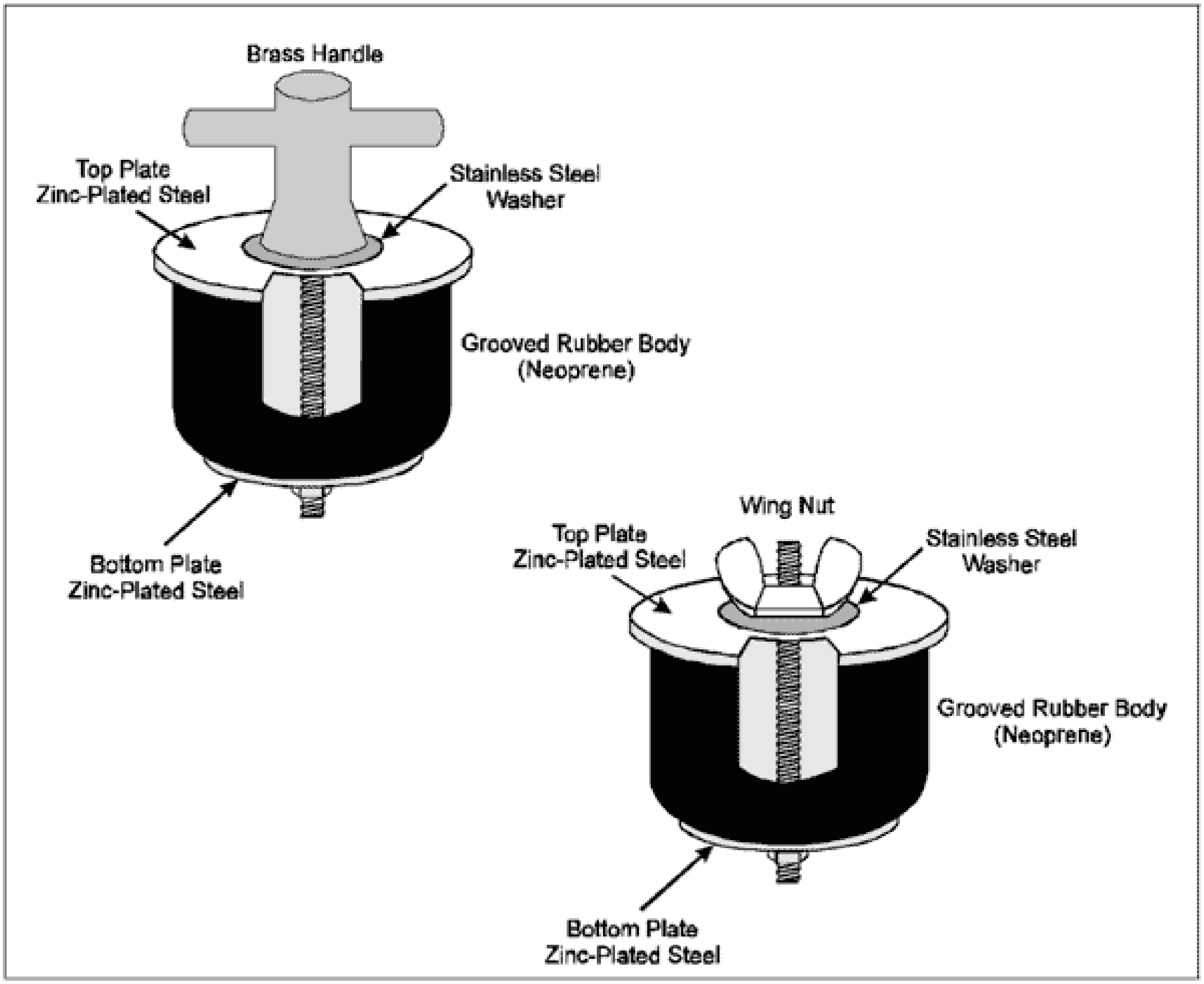
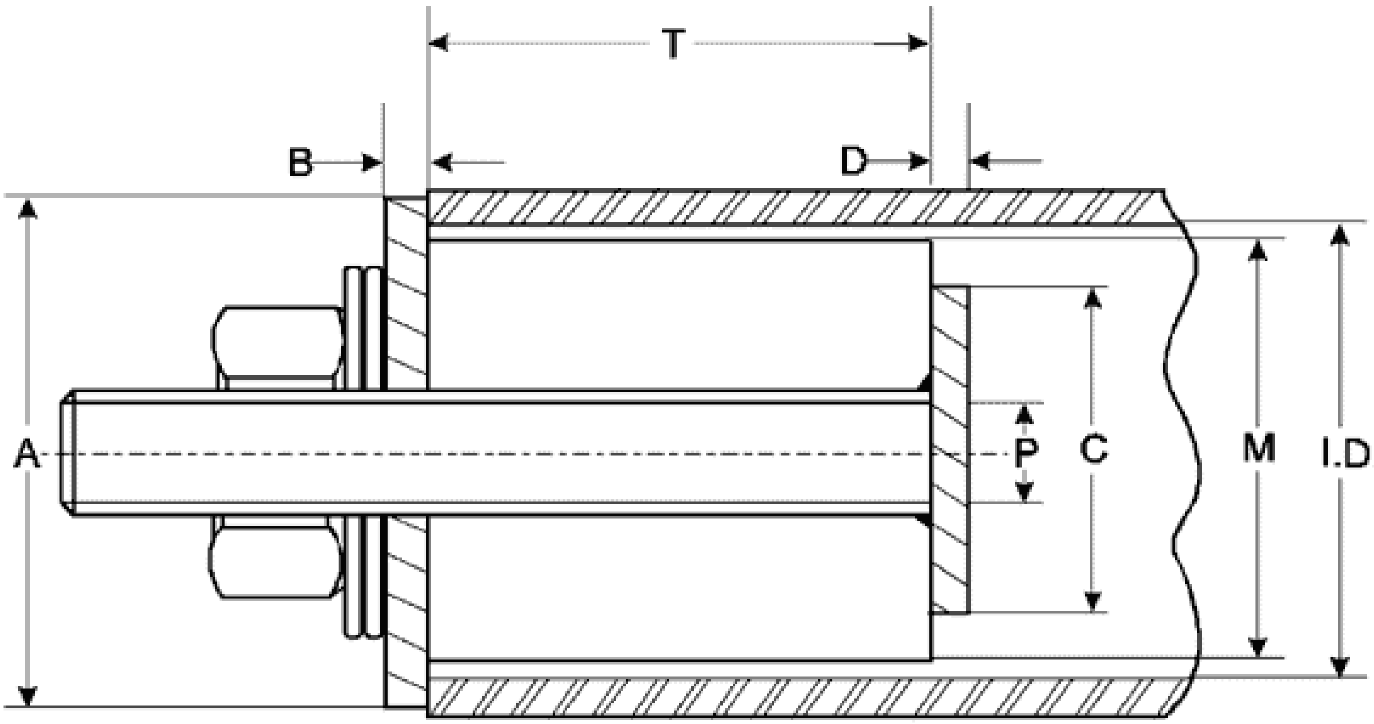



**Figure 16-6. Typical Commercial Plugs.**




Dimension P Indicates the Size of the Threaded Rod
The Pressure Plates Must be Properly Preserved or Made of Corrosion Resistant Steel
The Rubber is 30 Durometer Neoprene Sheet
The I.D. is the Internal Diameter of the Pipe Being Sealed
Assembly Requires a Lock Washer and a Flat Washer

**Figure 16-7. Locally Manufactured Mechanical Plug Details.**

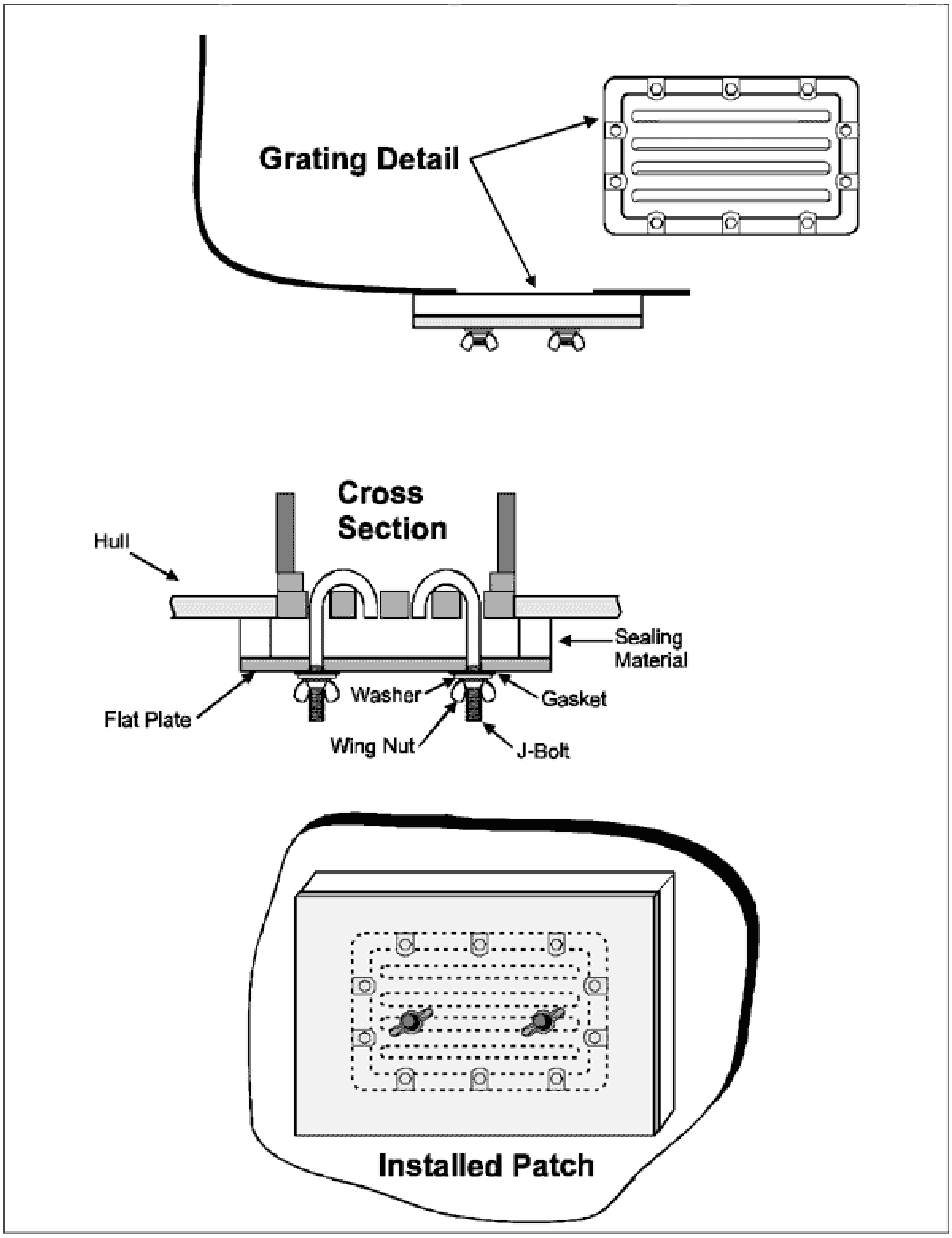



**Figure 16-8. Typical Flat Patch Details.**

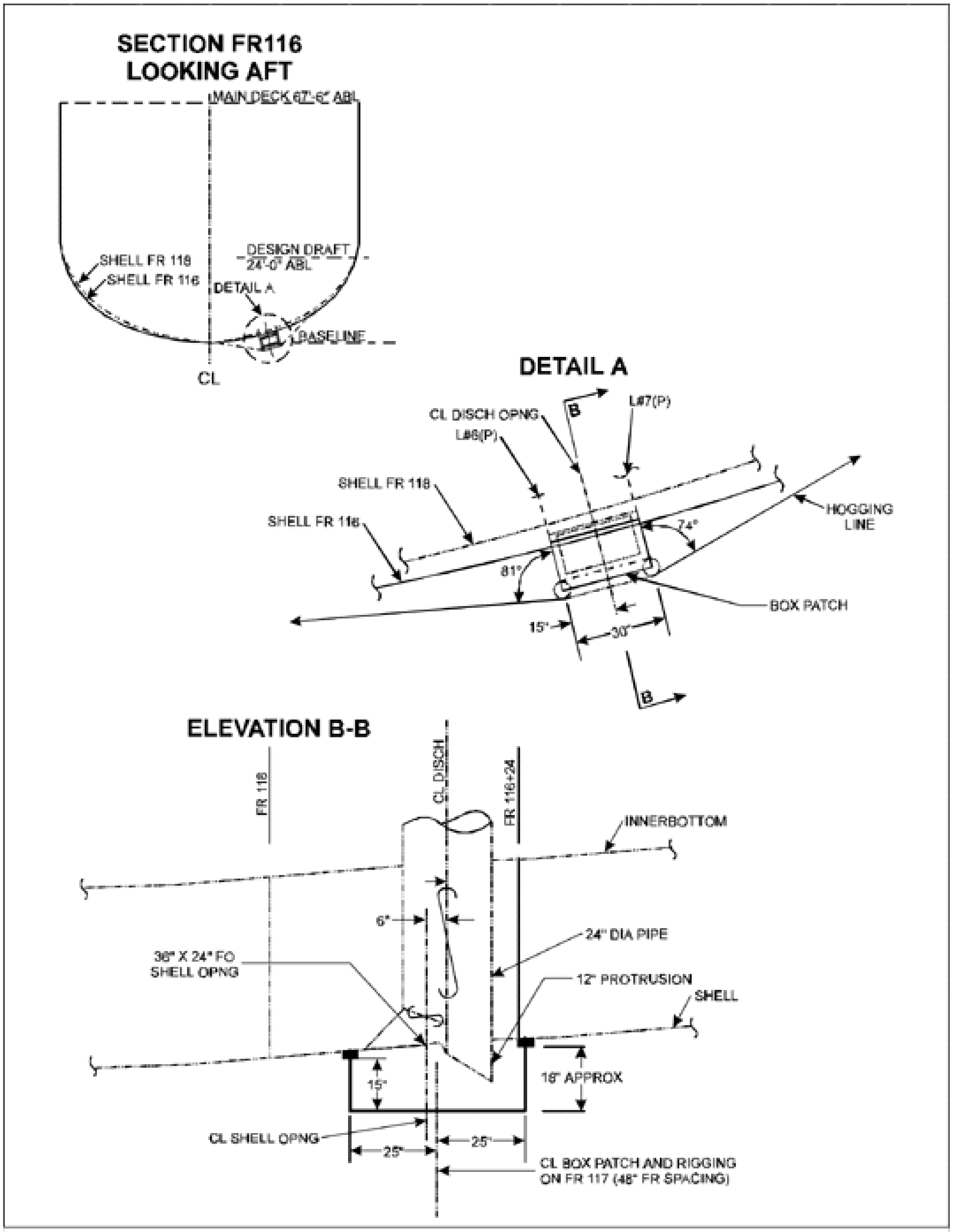
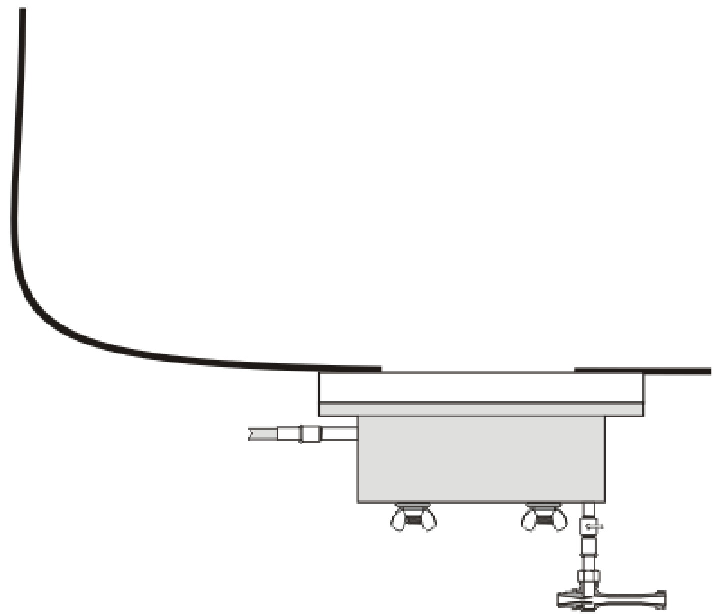



**Figure 16-9. AD 41 Main Discharge Cofferdam.**



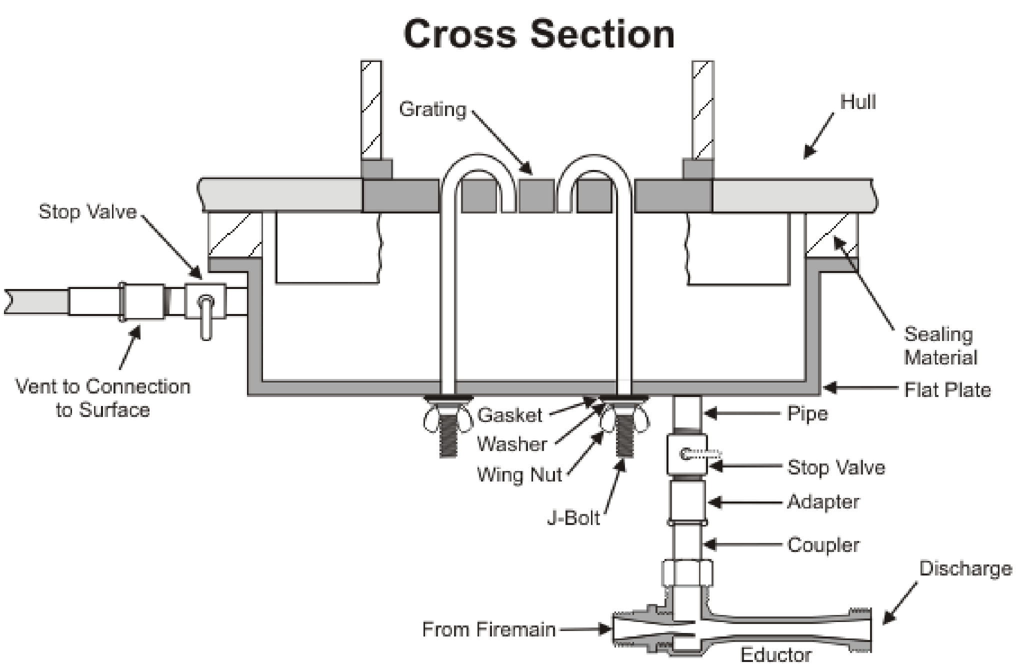



**Figure 16-10. Eductor Installed on a Box Patch**

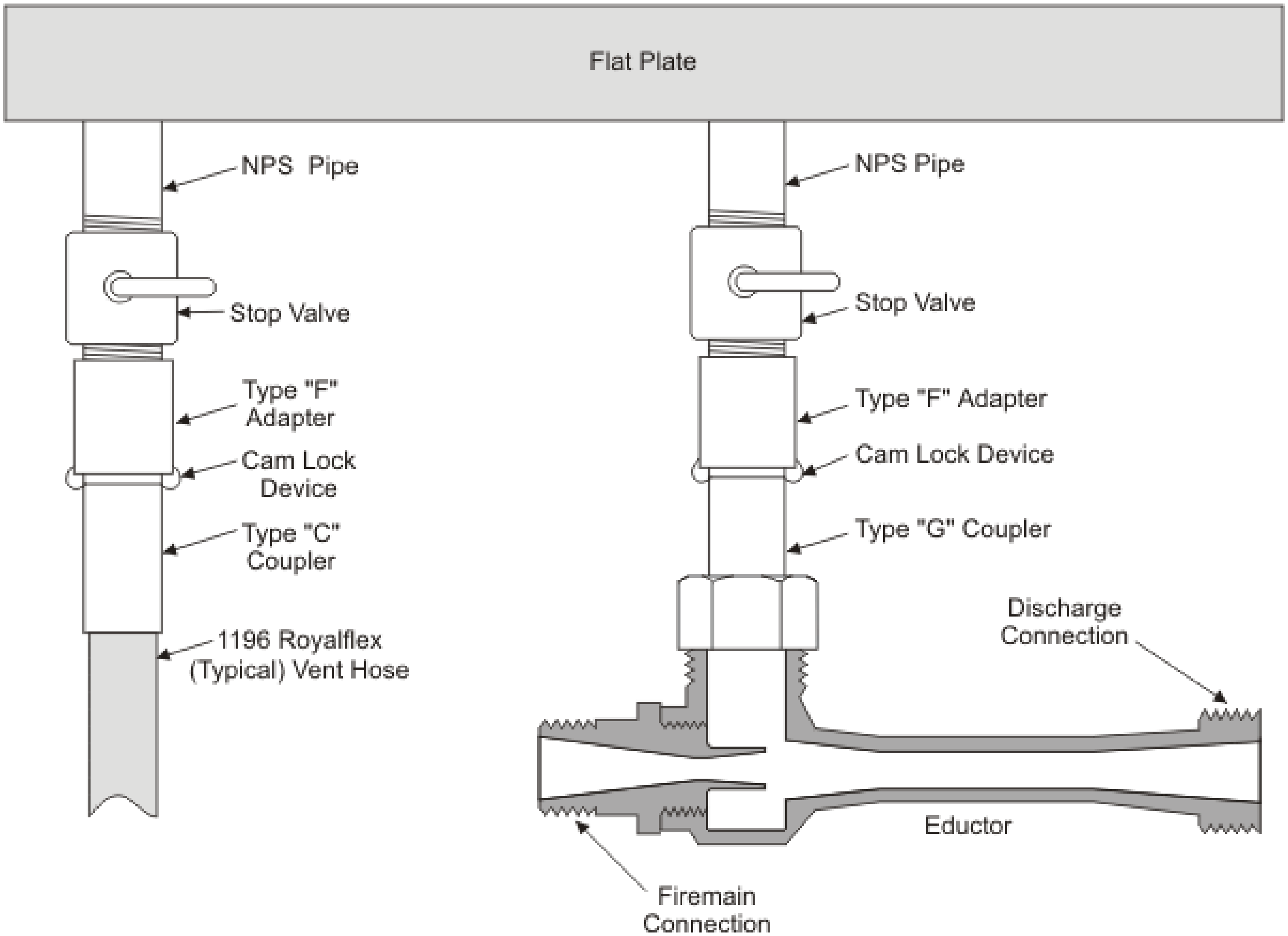



Figure 16-11. Eductor and Vent Configuration Details

> **NOTE**
> Additional eductor and vent part information is available on sheet 12 of NAVSEA drawing 805-7370421.

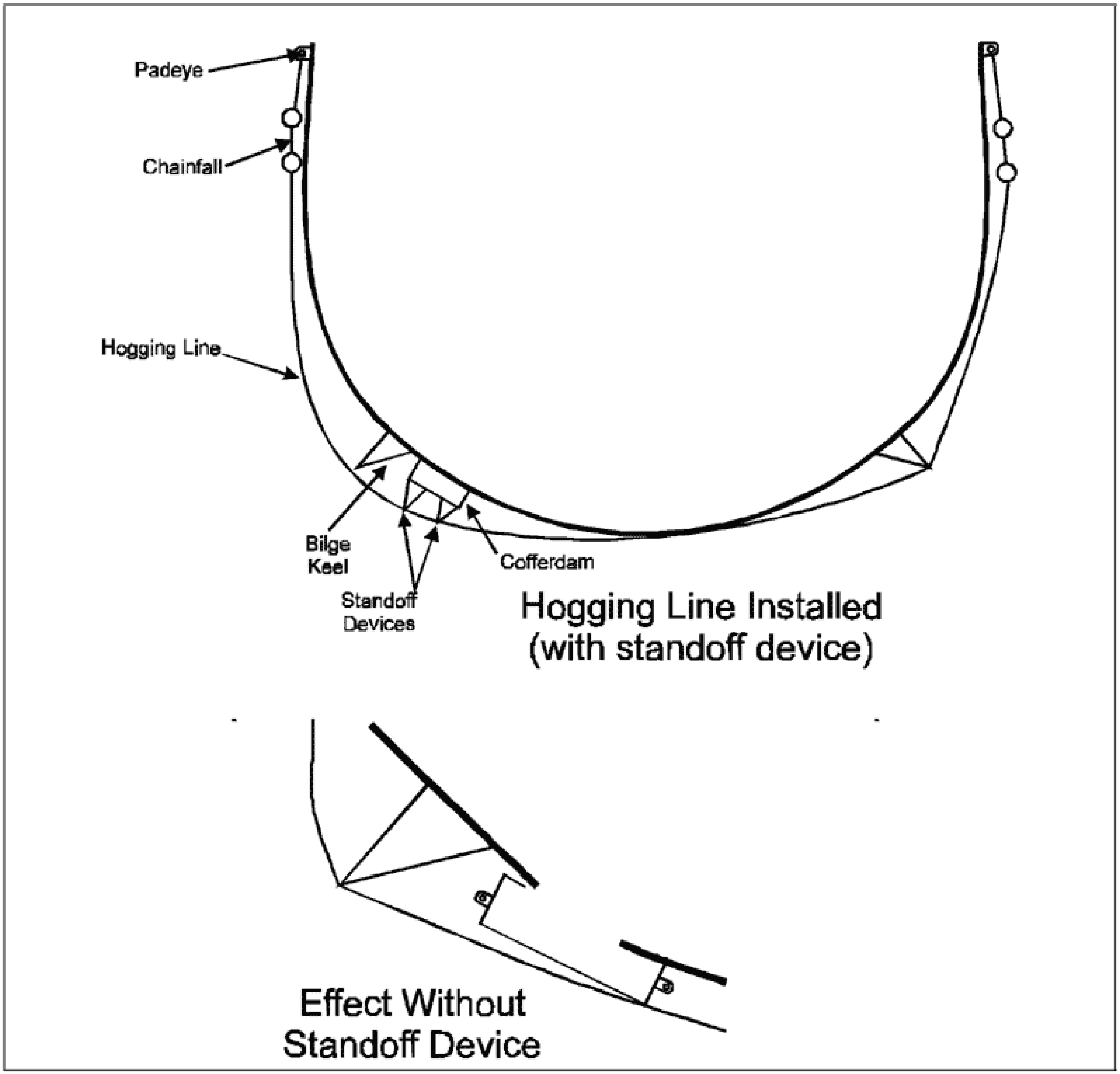



**Figure 16-12. Hogging Lines With and Without Standoffs.**

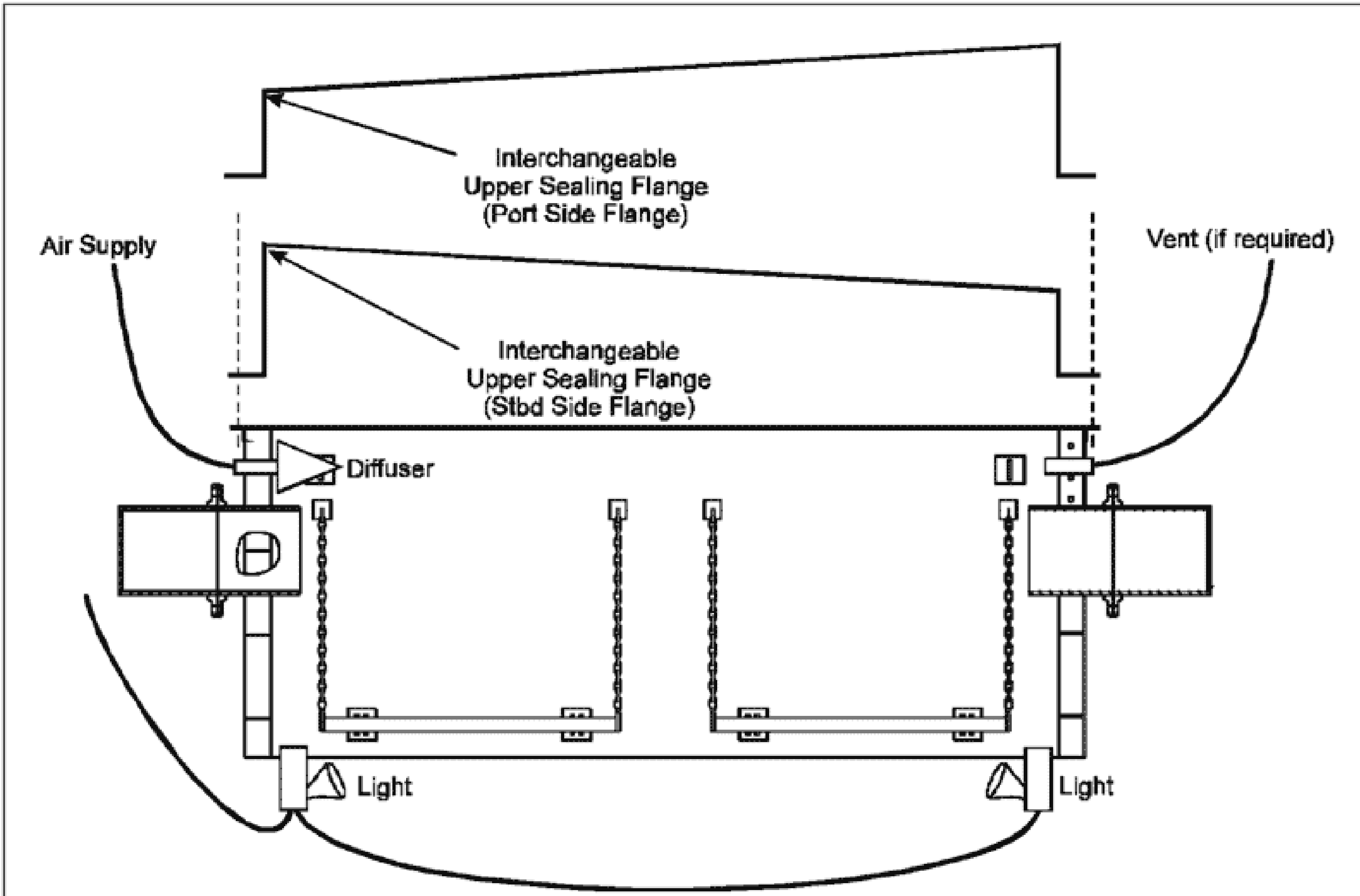



**Figure 16-13. Typical Dry Chamber Configurations.**

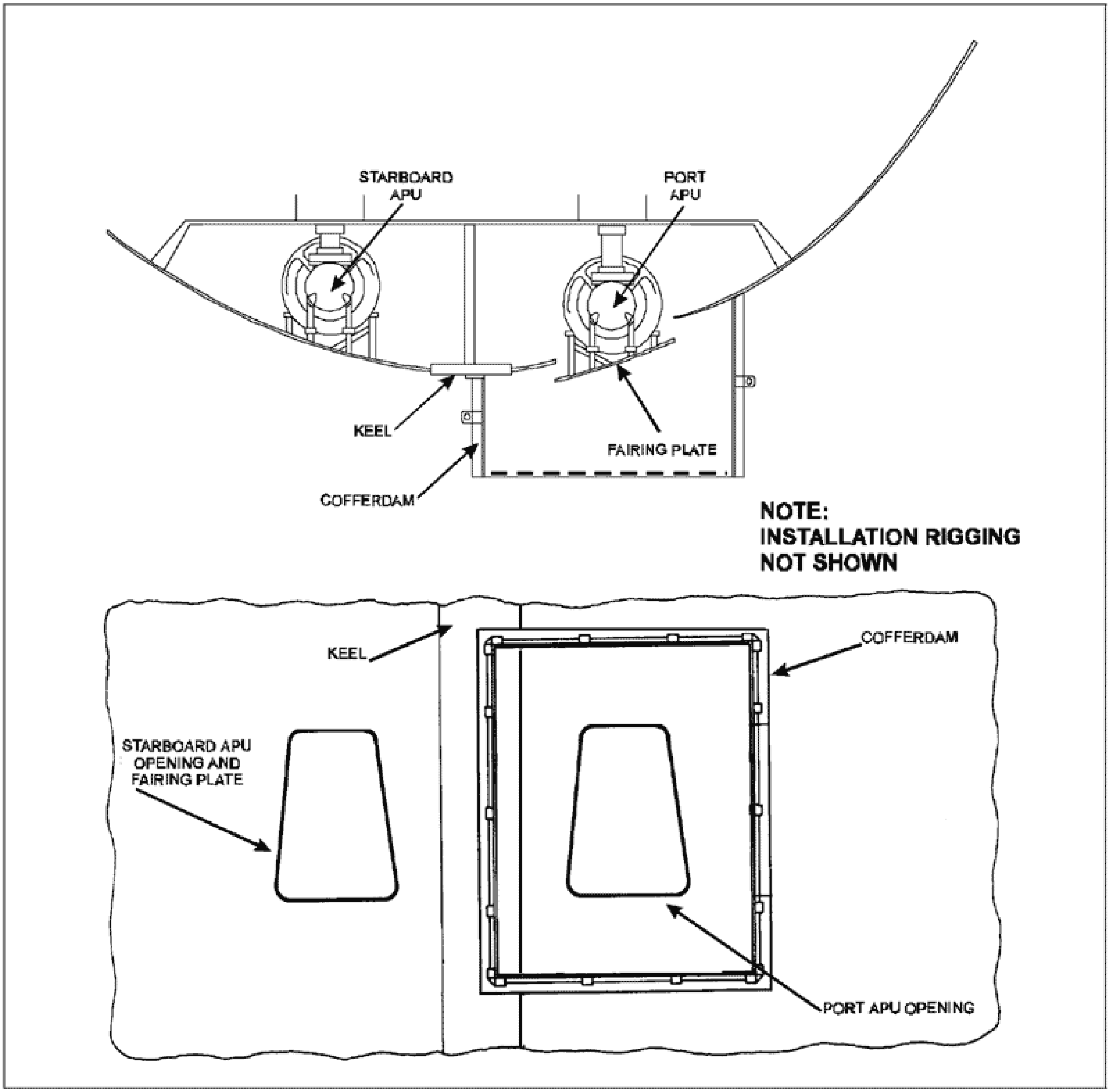



Figure 16-14. Installed APU Cofferdam.

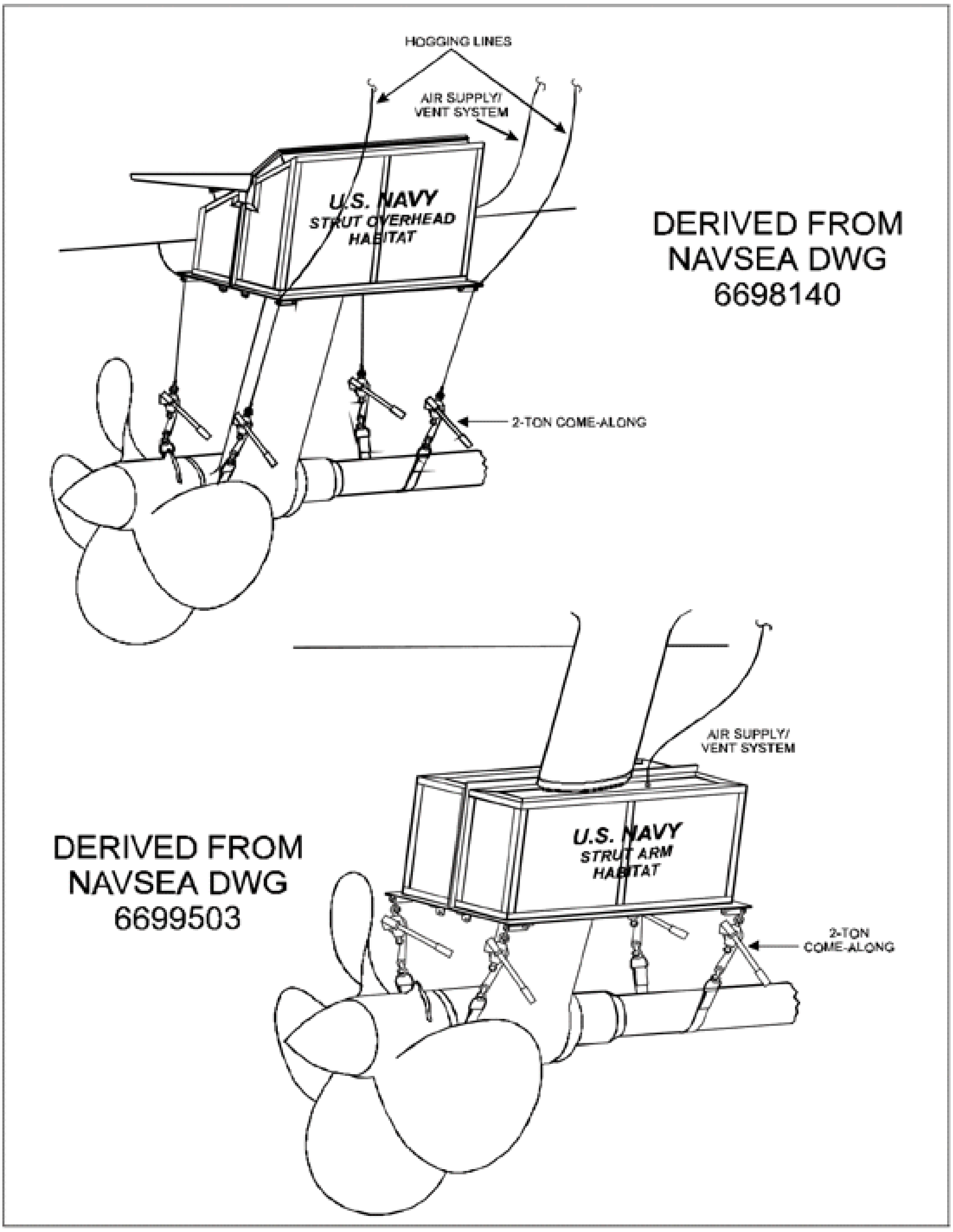



**Figure 16-15. DD 963 Strut Repair Cofferdams.**

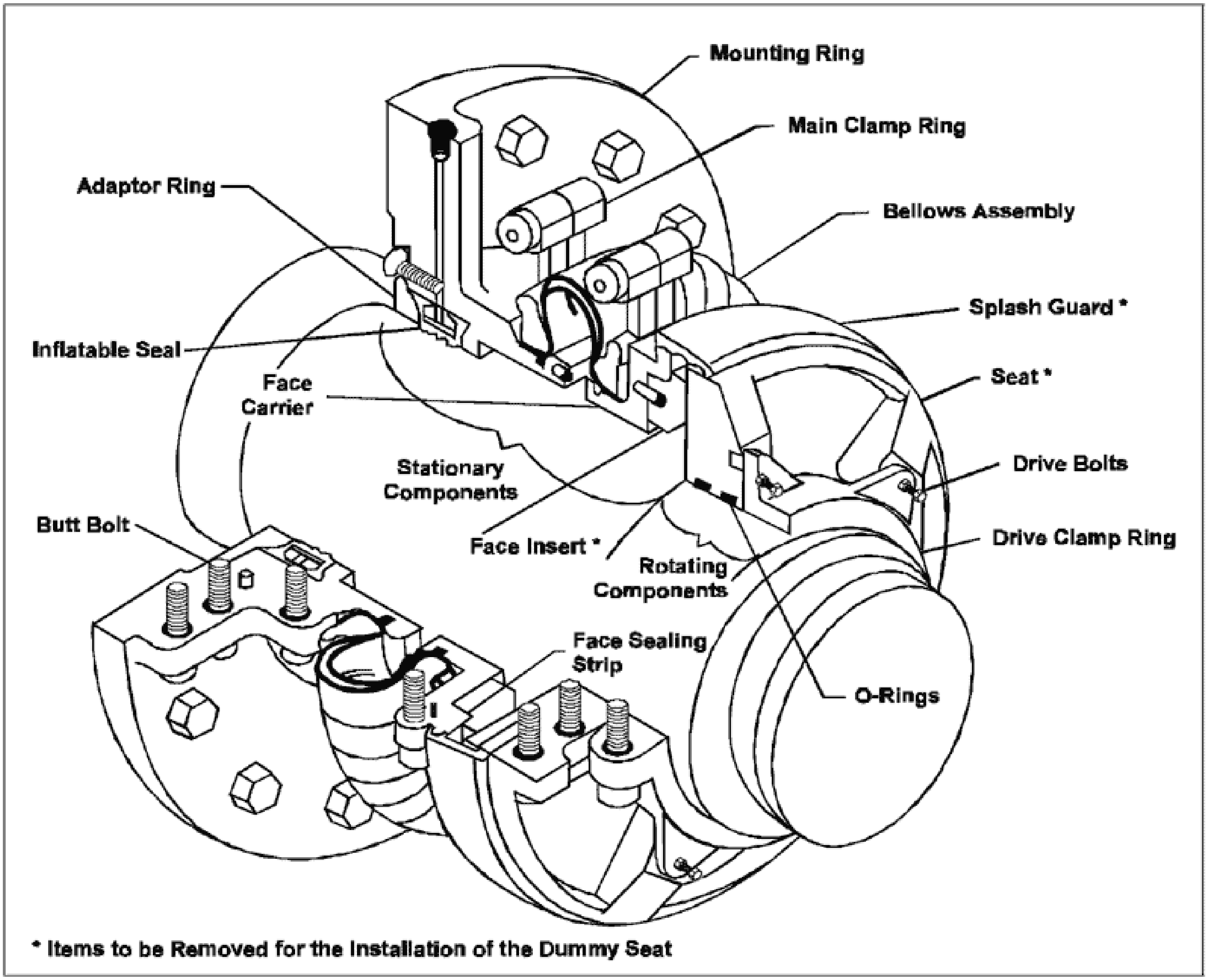



**Figure 16-16. CG 47 Stern Tube Seal Configuration.**

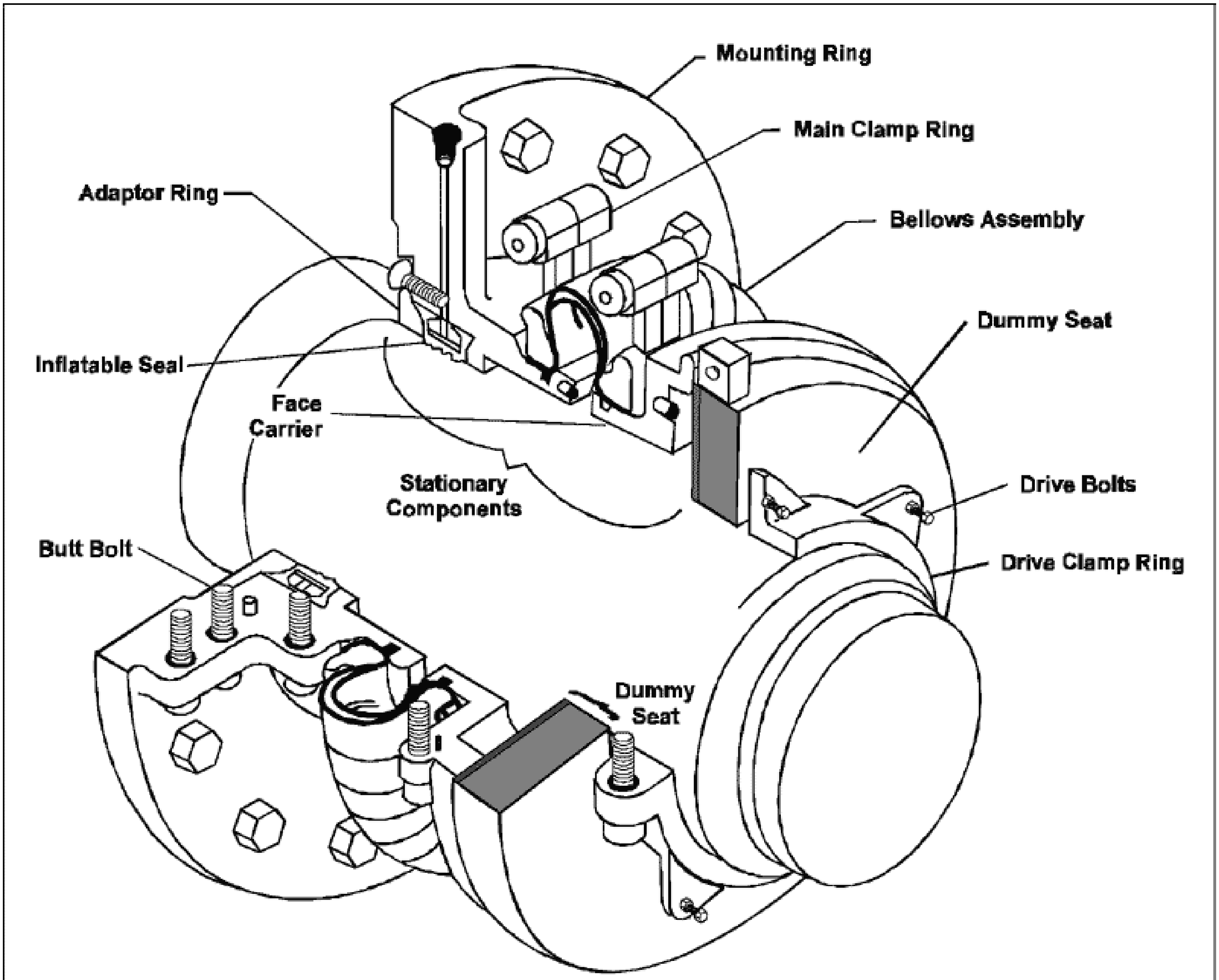



Figure 16-17. CG 47 Stern Tube Seal with Dummy Seat Installed.

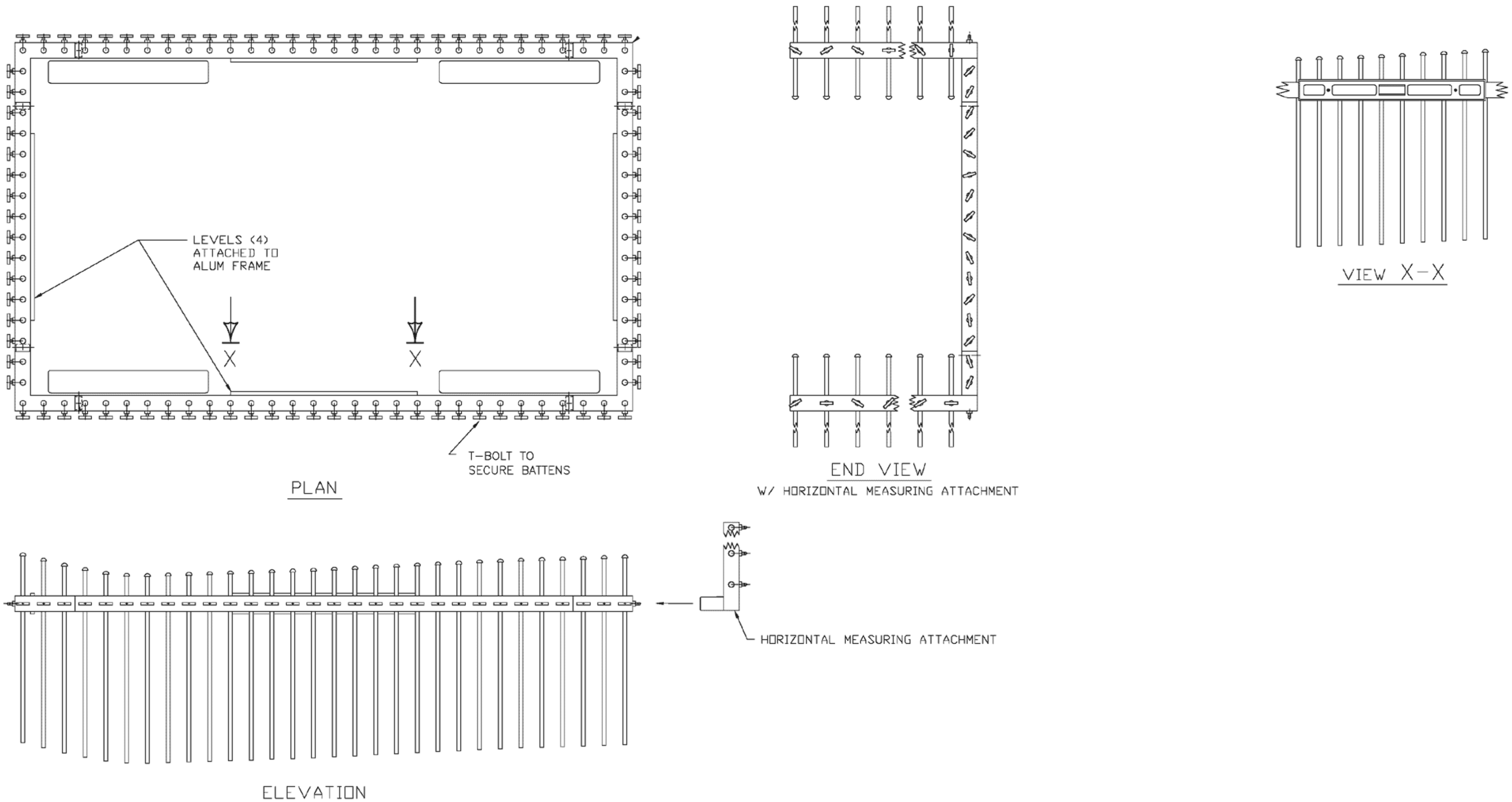



**Figure 16-18. NAVSEA Drawing 6698079 - Contour Template Fixture.**

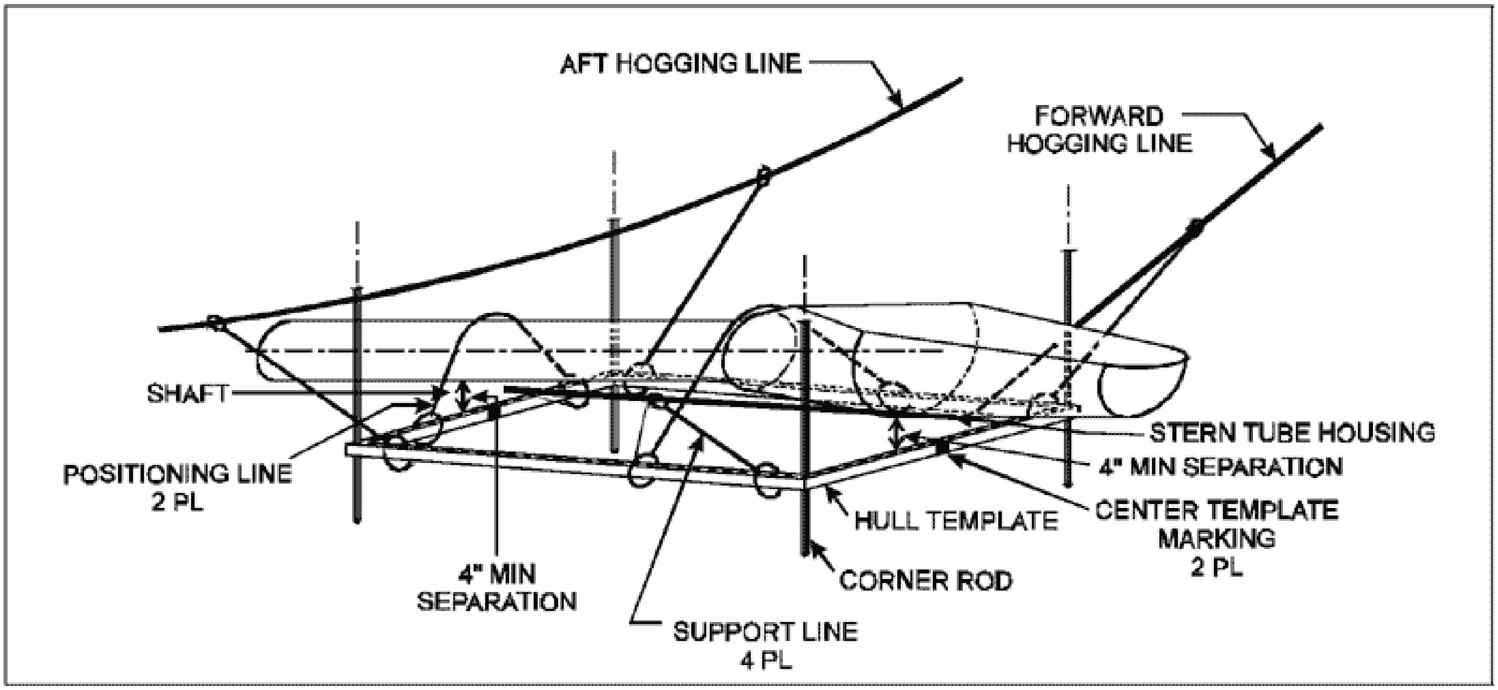
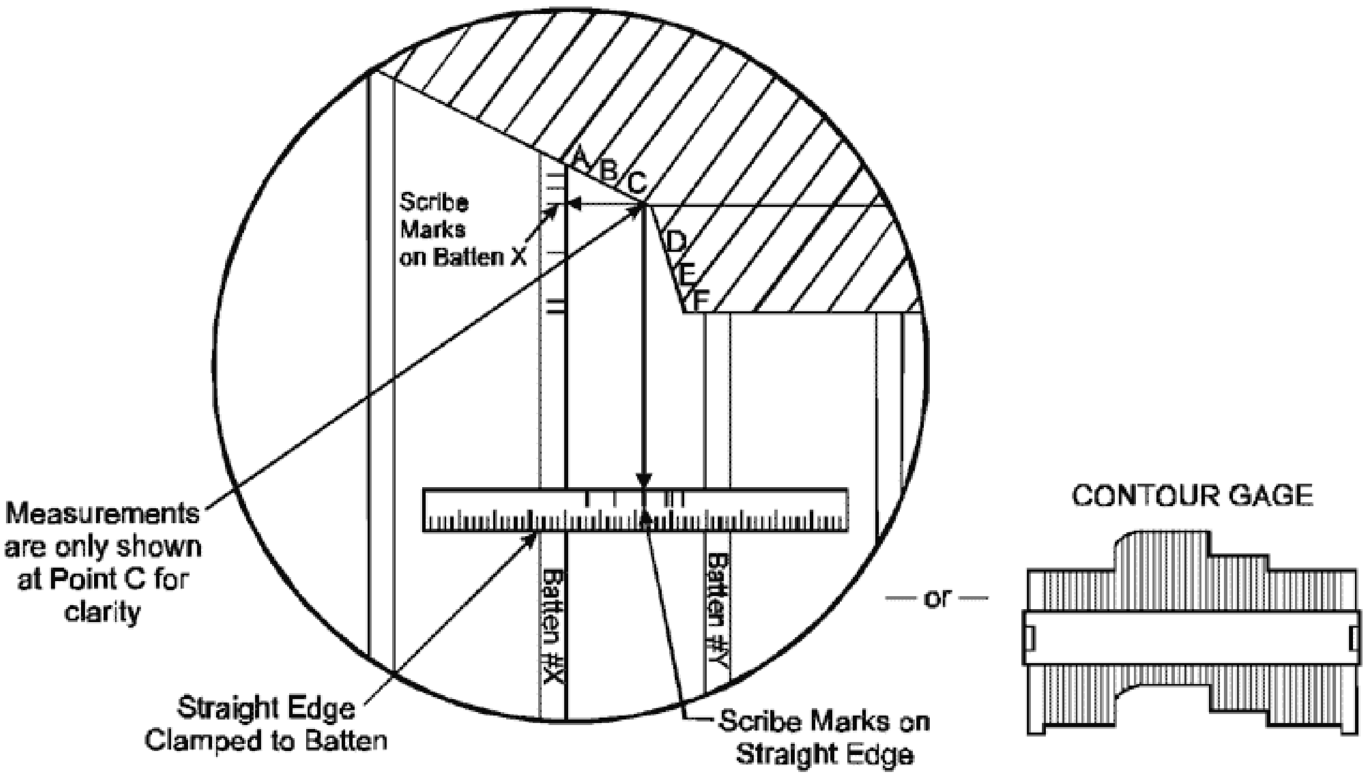



**Figure 16-19. Typical Template Fixture Installation.**




To get points A, B, C, D, E and F, between battens X and Y:

**Straight Edge and Ruler Process**

For each point:

1. Measure and record the horizontal distance from a scribe mark on batten X to the point on the hull.
2. Measure and record the vertical distance from a scribe mark on the straight edge to the point on the hull.
3. Repeat for all points.
4. Measure enough points to define the shape of the hull.

or

Determine shape using a contour gage. Gage must be referenced to the battens by scribe marks on the battens.

**Figure 16-20. Template Small Irregular Area.**

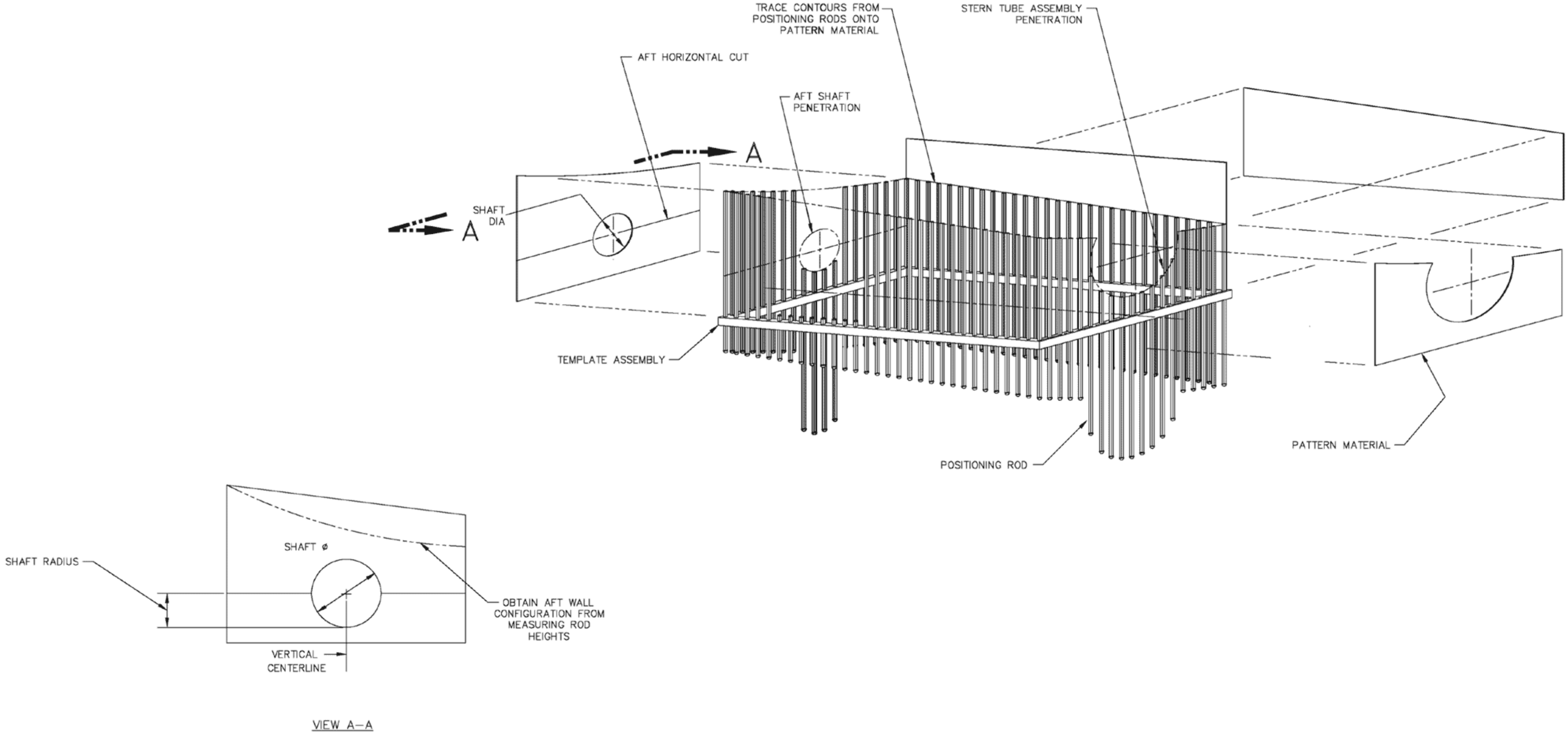



Figure 16-21. NAVSEA Drawing 6698079 - Pattern Making from Fixture.

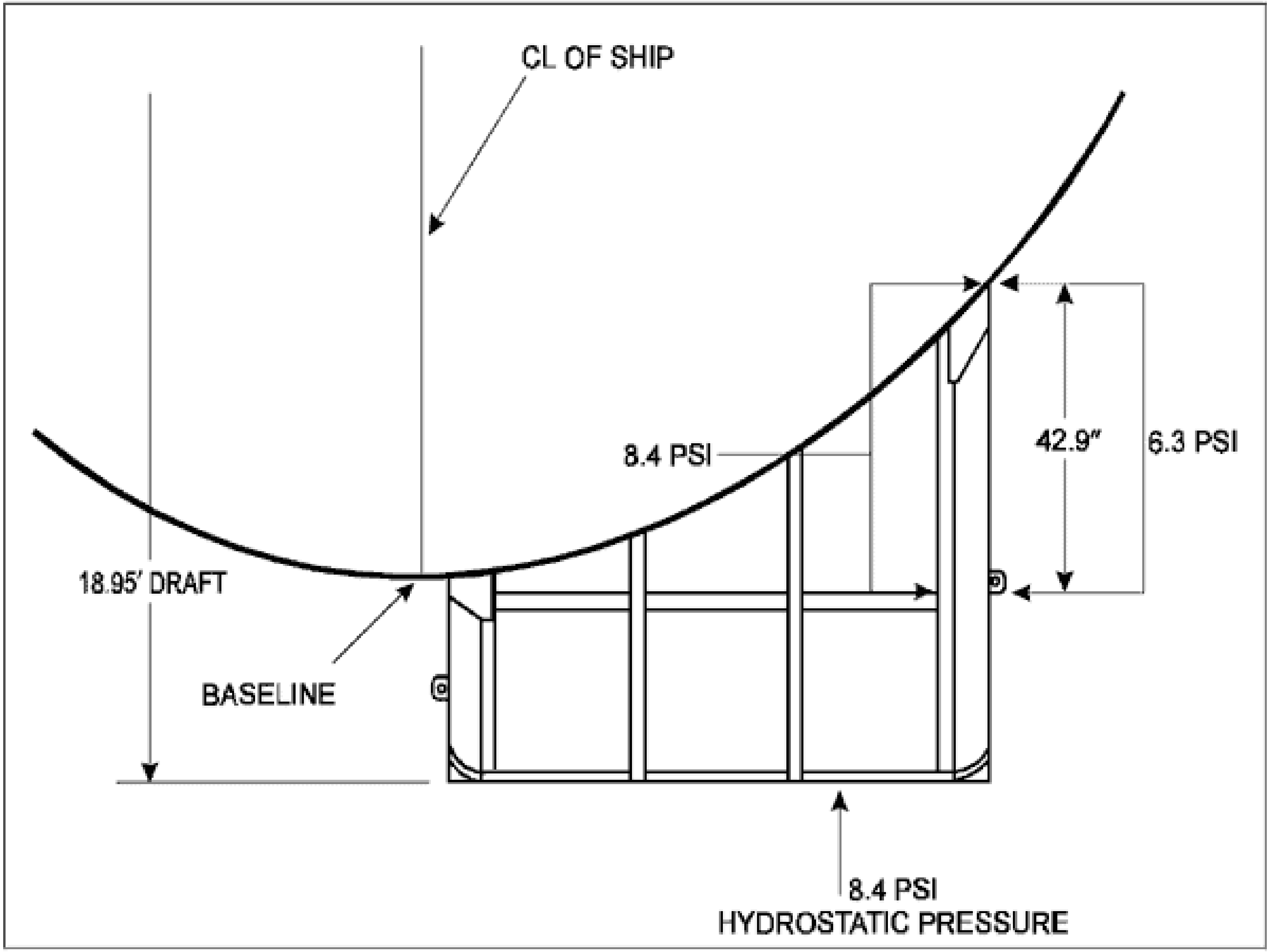



**Figure D-1. APU Load Diagram.**

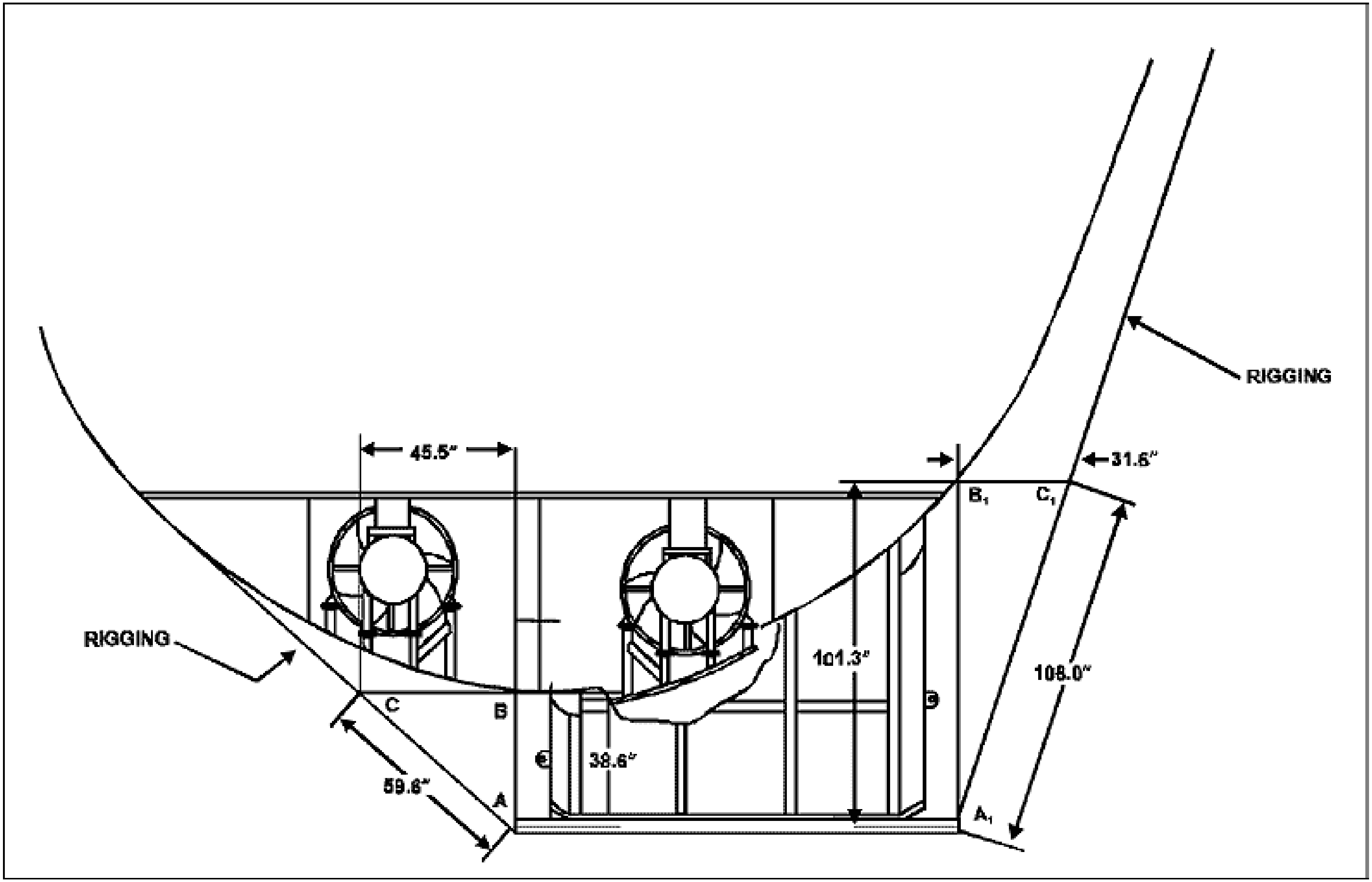



Figure D-2. APU Rigging Diagram.

## Table 16-1. Locally Manufactured Mechanical Plug Dimensions.

| Nominal Plug Size | Ship's Pipe Schedule | ID | M Dim | P Dim | T Dim | A Dim | B Dim | C Dim | D Dim |
|---|---|---|---|---|---|---|---|---|---|
| 1/2 | schd 40 | 0.622 | 19/32 | 13/64 | 5/8 | 27/32 | 16 ga | 3/8 | 16 ga |
| | schd 80 | 0.546 | 17/32 | 13/64 | 5/8 | 27/32 | 16 ga | 9/32 | 16 ga |
| 3/4 | schd 40 | 0.824 | 25/32 | 1/4 | 1 | 1-1/32 | 16 ga | 9/16 | 16 ga |
| | schd 80 | 0.742 | 23/32 | 1/4 | 1 | 1-1/32 | 16 ga | 1/2 | 16 ga |
| 1 | schd 40 | 1.049 | 1-1/32 | 1/4 | 1 | 1-5/16 | 16 ga | 25/32 | 16 ga |
| | schd 80 | 0.957 | 15/16 | 1/4 | 1 | 1-5/16 | 16 ga | 11/16 | 16 ga |
| 1-1/4 | schd 40 | 1.38 | 1-11/32 | 1/4 | 1 | 1-21/32 | 16 ga | 1-1/8 | 16 ga |
| | schd 80 | 1.278 | 1-1/4 | 1/4 | 1 | 1-21/32 | 16 ga | 1 | 16 ga |
| 1-1/2 | schd 40 | 1.61 | 1-19/32 | 7/16 | 1 | 1-29/32 | 16 ga | 1-11/32 | 16 ga |
| | schd 80 | 1.5 | 1-15/32 | 7/16 | 1 | 1-29/32 | 16 ga | 1-1/4 | 16 ga |
| 2 | schd 40 | 2.067 | 2-1/32 | 7/16 | 1 | 2-3/8 | 16 ga | 1-13/16 | 16 ga |
| | schd 80 | 1.939 | 1-29/32 | 7/16 | 1 | 2-3/8 | 16 ga | 1-11/16 | 16 ga |
| 2-1/2 | schd 40 | 2.469 | 2-7/16 | 7/16 | 1 | 2-7/8 | 16 ga | 2-7/32 | 16 ga |
| | schd 80 | 2.323 | 2-9/32 | 7/16 | 1 | 2-7/8 | 16 ga | 2-1/16 | 16 ga |
| 3 | schd 40 | 3.068 | 3-1/32 | 7/16 | 1 | 3-1/2 | 16 ga | 2-13/16 | 16 ga |
| | schd 80 | 2.9 | 2-7/8 | 7/16 | 1 | 3-1/2 | 16 ga | 2-5/8 | 16 ga |
| 4 | schd 40 | 4.026 | 4 | 7/16 | 1 | 4-1/2 | 16 ga | 3-3/4 | 16 ga |
| | schd 80 | 3.826 | 3-25/32 | 7/16 | 1 | 4-1/2 | 16 ga | 3-9/16 | 16 ga |
| 5 | schd 40 | 5.047 | 5 | 1/2 | 1 | 5-9/16 | 12 ga | 4-25/32 | 12 ga |
| | schd 80 | 4.813 | 4-25/32 | 1/2 | 1 | 5-9/16 | 12 ga | 4-9/16 | 12 ga |
| 6 | schd 40 | 6.065 | 6-1/16 | 1/2 | 1 | 6-5/8 | 12 ga | 5-13/16 | 12 ga |
| | schd 80 | 5.761 | 5-23/32 | 1/2 | 1 | 6-5/8 | 12 ga | 5-1/2 | 12 ga |

## Table 16-2. Mechanical Plugs Manufactured by Cherne Industries, Inc.
## 5700 Lincoln Drive
## Minneapolis, MN 55436
## (800) 843-7584

| End of Pipe Gripper Style | | Performance Rating | | | | |
|---|---|---|---|---|---|---|
| | | Size Usage Range | | Maximum Allowable Backpressure | | Approx. Product Weight (lbs.) |
| Part Number | Nominal Size | Minimum Diameter | Maximum Diameter | Air PSIG | Water FT. HD. | |
| 270-210 | 1.5" | 1.48" | 1.65" | 5 | 40 | 0.13 |
| 270-229 | 2" | 1.90" | 2.17" | 5 | 40 | 0.19 |
| 270-237 | 3" | 2.80" | 3.10" | 5 | 40 | 0.38 |
| 270-245 | 4" | 3.80" | 4.06" | 5 | 40 | 0.50 |
| 270-261 | 6" | 5.77" | 6.08" | 5 | 30 | 2.50 |

**Table 16-3. Mechanical Plugs**
**Manufactured by Shaw Aero Development, Incorporated**
**Naples, FL**
**(239) 304-1000**

| Opening I.D. and Length | Turn-Tite T-Handle Plug Stock Number | Hex Nut Plug Stock Number | Wing Nut Plug Stock Number |
|---|---|---|---|
| 1" x 1-5/16" | 52001 | 62001 | 72001 |
| 1-1/8" x 1-5/16" | 52001-1 | 62001-1 | 72001-1 |
| 1-1/4" x 1-5/16" | 52002 | 62002 | 72002 |
| 1-3/8" x 1-5/16" | 52002-1 | 62002-1 | 72002-1 |
| 1-1/2" x 1-5/16" | 52003 | 62003 | 72003 |
| 1-5/8" x 1-5/16" | 52003-1 | 62003-1 | 72003-1 |
| 1-3/4" x 1-5/16" | 52004 | 62004 | 72004 |
| 1-7/8" x 1-5/16" | 52004-1 | 62004-1 | 72004-1 |
| 2" x 1-5/16" | 52005 | 62005 | 72005 |
| 2-1/8" x 2" | 52005-1 | 62005-1 | 72005-1 |
| 2-1/4" x 2" | 52006 | 62006 | 72006 |
| 2-3/8" x 2" | 52006-1 | 62006-1 | 72006-1 |
| 2-1/2" x 2" | 52007 | 62007 | 72007 |
| 2-5/8" x 2" | 52007-1 | 62007-1 | 72007-1 |
| 2-3/4" x 2" | 52008 | 62008 | 72008 |
| 2-7/8" x 2" | 52008-1 | 62008-1 | 72008-1 |
| 3" x 2" | 52009 | 62009 | 72009 |
| 3-1/8" x 2" | 52009-1 | 62009-1 | 72009-1 |
| 3-1/4" x 2" | 52010 | 62010 | 72010 |
| 3-3/8" x 2" | 52010-1 | 62010-1 | 72010-1 |
| 3-1/2" x 2" | 52011 | 62011 | 72011 |
| 3-5/8" x 2" | 52011-1 | 62011-1 | 72011-1 |
| 3-3/4" x 2" | 52012 | 62012 | 72012 |
| 3-7/8" x 2" | 52012-1 | 62012-1 | 72012-1 |
| 4" x 2" | 52013 | 62013 | 72013 |
| 4-1/4" x 2-1/2" | 52014 | 62014 | 72014 |
| 4-1/2" x 2-1/2" | 52015 | 62015 | 72015 |
| 4-3/4" x 2-1/2" | 52016 | 62016 | 72016 |
| 5" x 2-1/2" | 52017 | 62017 | 72017 |
| 5-1/4" x 2-1/2" | 52018 | 62018 | 72018 |
| 5-1/2" x 2-1/2" | 52019 | 62019 | 72019 |
| 5-3/4" x 2-1/2" | 52020 | 62020 | 72020 |
| 6" x 2-1/2" | 52021 | 62021 | 72021 |
| 6-1/2" x 2-1/2" | 52023 | 62023 | 72023 |
| 7-1/4" x 2-1/2" | 52026 | 62026 | 72026 |
| 8" x 2-1/2" | 52029 | 62029 | 72029 |
| 9" x 2-1/2" | 52033 | 62033 | 72033 |
| 10" x 2-1/2" | 52037 | 62037 | 72037 |
| 13" x 2-1/2" | 52048 | 62048 | 72048 |

**Table 16-4. Wooden Plugs Available in the Navy Supply System.**

| Plug Size (max. dia. x min. dia. x length) | NSN |
|---|---|
| 1" x 0" x 3" | 5510-00-260-8953 |
| 2" x 0" x 4" | 5510-00-260-8958 |
| 3" x 0" x 8" | 5510-00-260-8962 |
| 5" x 1" x 10" | 5510-00-260-8966 |
| 7" x 3" x 10" | 5510-00-260-8969 |
| 8" x 4" x 10" | 5510-00-260-8973 |
| 10" x 7" x 12" | 5510-00-260-8949 |

**Table 16-5. Plug Size vs. Minimum and Maximum Opening Diameter.**

| Plug Size (max. dia. x min. dia. x length) | Minimum Opening Diameter | Maximum Opening Diameter |
|---|---|---|
| 1" x 0" x 3" | 1/2" | 3/4" |
| 2" x 0" x 4" | 3/4" | 1-1/2" |
| 3" x 0" x 8" | 5/8" | 2-3/8" |
| 5" x 1" x 10" | 1-7/8" | 4" |
| 7" x 3" x 10" | 3-1/2" | 6-1/4" |
| 8" x 4" x 10" | 4-1/2" | 7" |
| 10" x 7" x 12" | 7-1/4" | 9-1/2" |

**Table 16-6. Safety Factors for Rigging Components.**

| Description | Factor of Safety |
|---|---|
| Rated breaking strength of wire ropes, turnbuckles, eyebolts, shack-les, pins, etc.: | 5.0 |
| Fabricated padeyes, attachment components, attachment welds, etc.: | |
| On ultimate strength of material | 5.0 |
| On yield strength of material | 3.0 |

**Table 16-7. Panel Aspect Ratio Factor.**

| a/b | $\beta$ |
|---|---|
| 1.0 | 0.2874 |
| 1.2 | 0.3762 |
| 1.4 | 0.4530 |
| 1.6 | 0.5172 |
| 1.8 | 0.5688 |
| 2.0 | 0.6102 |
| 3.0 | 0.7134 |
| 4.0 | 0.7410 |
| 5.0 | 0.7476 |
| $\infty$ | 0.7500 |

**Table 16-8. Marine Grade Plywood Thickness ($t_p$) as Based upon Effective Section Modulus (KS)**

| KS< | $t_p$ |
|---|---|
| 0.123 | 1/2 |
| 0.199 | 19/32 |
| 0.238 | 5/8 |
| 0.338 | 23/32 |
| 0.418 | 3/4 |
| 0.569 | 7/8 |
| 0.827 | 1 |
| 0.955 | 1-1/8 |

## Table 16-9: Compliance Table for Section 10.

| SECTION REF | REQUIREMENT | COMPLIANCE | REMARKS |
|---|---|---|---|
| ***Section 16-10 to NAVSEA S0600-AA-PRO-160 UWSH Manual Chapter 16 – Cofferdams Compliance and Performance Standards for Contractor Cofferdam Work.*** | | | |
| General Program Requirements | | | |
| 16.10.2.1 | Does diving contractor have an established program that provides for a training plan; documents and track qualifications or personnel; documentation and records management; equipment used for cofferdam operations; and operational protocol? | | |
| Training Plan | | | |
| 16.10.2.2 | [Training Plan] Does contractor have a developed training plan for topics that are required by Appendix E of the UWSH Manual Chapter 16: Cofferdams | | |
| Personnel Qualifications | | | |
| 16.10.2.3.1 | [Design Personnel] Is the contractor's appointed engineer responsible for approving cofferdam design's and/or rigging plan's a Professional Engineer (PE) or a degreed engineer or naval architect from and accredited 4-yr university with registration as Fundamentals of Engineering (FE/EIT)? | | |
| 16.10.2.3.2 | [Fabrication personnel] Are the welder's who constructed the cofferdam qualified to their company's approved welding procedure specifications in accordance with the appropriate fabrication standard (code)? | | |
| 16.10.2.3.3.1 | [Diving Personnel] Do the divers have ADC I recognized commercial (or military) training and qualification plus a minimum 7 years commercial diving experience? | | |
| 16.10.2.3.3.2 | [Diving Personnel] Do divers have current medical physical screening? Note: Actual medical records shall not be released and therefore OQE shall be a signature from a company representative attesting to the fact that the individual(s) does in fact have a current medical physical clearance to dive. | | |
| 16.10.2.3.3.3 | [Diving Personnel] Do divers have current CPR and First Aid certification? | | |

| | | | |
|---|---|---|---|
| 16.10 .2.3.3.4 | [Diving Personnel] Have divers successfully passed the company's cofferdam program qualification? | | |
| Document and Record Management | | | |
| 16.10 .2.4.1 | Does the diving contractor have a written training plan containing at a minimum an outline of discussion topics contained in section 16.10 .2.2 ? | | |
| 16.10 .2.4.2 | Does the diving contractor have a Cofferdam Training and Qualification Record for all diving personnel involved with cofferdam operations? Does the Training and Qualification Record include the information provided in section 16.10 .2.4.2? | | |
| 16.10 .2.4.3 | Does the contractor have resumes with appropriate OQE for design engineers, welders and diving personnel? | | |
| 16.10 .2.4.4 | Is the Process Control Procedure prepared in accordance with the requirements of NAVSEA Standard Item 009-09? | | |
| 16.10 .2.4.5 | Does the cofferdam design and drawing package meet the requirements of 16.10.2.4.5? | | |
| Equipment Used for Cofferdam Operations | | | |
| 16.10 .2.5.1 | [Diving Mode] Is the diving contractor using surface-to diver communications equipment? | | |
| 16.10 .2.5.2 | [Rigging Equipment] Does rigging equipment match that in the rigging plan? Does the rigging equipment look to be in safe working condition? | | |
| Document and Drawing Requirements | | | |
| 16.10 .2.6.1 | Applicable ship system drawings available at job site? | | |
| 16.10 .2.6.2 | Automated Work Request, Work Authorization Form (WAF) or other document describing job to be completed available at job location? | | |

| | | | |
|---|---|---|---|
| 16.10.2.6.3 | Docking plan drawing of subject vessel at job location? | | |
| 16.10.2.6.4 | Approved PCP or FWP at job location? Is PCP or FWP being followed? | | |
| 16.10.2.6.5 | Latest revision of UWSH Manual Chapter 16, Cofferdams (NAVSEA S0600-AA-PRO-160), at job location? | | |
| 16.10.2.6.6 | Applicable forms contained in PCP to be completed as OQE at job site? Appendix C and D for all plug or patch operations. Appendix G as required. | | |
| 16.10.2.6.7 | Is rigging plan at job site and is diving crew adhering to plan? | | |
| 16.10.2.6.8 | Is the cofferdam design package available upon request of dive support personnel? | | |
| 16.10.2.6.9 | For single valve (boundary) protection cofferdam installations is the emergency flooding plan at job site? Is the emergency flooding plan being adhered to? | | |
| 16.10.2.6.10 | Does the diving contractor have a copy of their safe practices manual at job site? | | |