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NAVAL SHIPS' TECHNICAL MANUAL

CHAPTER 100

HULL STRUCTURES

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TABLE OF CONTENTS

TABLE OF CONTENTS - Continued

TABLE OF CONTENTS - Continued

TABLE OF CONTENTS - Continued

LIST OF TABLES

LIST OF ILLUSTRATIONS

NOTE

THIS CHAPTER HAS BEEN REFORMATTED FROM DOUBLE COLUMN TO SINGLE COLUMN TO SUPPORT THE NSTM DATABASE. THE CONTENT OF THIS CHAPTER HAS NOT BEEN CHANGED.

CHAPTER 100

HULL STRUCTURES

SECTION 1

GENERAL AND SAFETY PRECAUTIONS

100-1.1 SPECIFICATIONS FOR BUILDING SHIPS

100-1.1.1 Features considered in connection with structural design of most ships built under the cognizance of the Naval Sea Systems Command (NAVSEA) will be found in the ship construction drawings for that particular ship. Many amphibious and auxiliary ships, however, are built to American Bureau of Shipping Rules and/or Maritime Administration Specifications. For continuing safety of the ship, it is imperative that the structure be continually protected, maintained, and repaired.

100-1.2 HULL STRENGTH

100-1.2.1 This chapter contains information on measures required for maintaining the designed effectiveness of hulls of combatant and auxiliary ships. A discussion of features of hull strength built into a ship is contained in **NSTM Chapter 079, Volume 1, Damage Control, Stability and Buoyancy.** In general, replacement or modification of structure contributing to hull strength should follow ship construction drawings for the specific ship, insofar as practical.

100-1.3 HULL ALTERATIONS

100-1.3.1 GENERAL. In order to maintain stability, careful account must be taken of weights of hull alterations. See paragraph 100-2.4.1 through 100-2.4.1.2 and **NSTM Chapter 096, Weights and Stability** .

100-1.3.2 NOTCHES. In accomplishing repairs and alterations, care should be taken to avoid introducing notches (geometrical discontinuities) in the ship structure because such points of stress concentration form the starting point of fractures.

100-1.3.2.1 Serious notches are often caused by arcs striking on plating adjacent to a weld, or by leaving rough, burned edges on structure. Rounded corners must be provided in way of cuts in strength members. Corners of doublers, insert plates, clips, and pads must be rounded to avoid a notched effect. Discontinuities (such as slag inclusions, incomplete fusions, or undercuts in welds) also form the starting point of fractures.

100-1.3.2.2 Careful workmanship and inspection are necessary to prevent the introduction of such notches into the structure. Where structural members are notched out to allow passage through of frames, beams, or other shapes, corner radii shall be provided as specified in NAVSHIPS dwg 805-2460264.

100-1.3.3 MAINTAINING STRENGTH OF MEMBERS. It is undesirable and dangerous to cut holes in free flanges of bulkhead stiffeners or in lower flanges of deck beams because this affects the designed strength and safety of the ship.

100-1.3.3.1 General. Face plates, reinforcing angles, and free flanges of stiffeners must not be drilled or punched to attach gratings, platforms, foundations, or fittings. Where such attachments are necessary, holes must be located in the web of the stiffener near the neutral axis.

CAUTION

Welding (by any process) to the standing flange of aluminum deckhouse side stiffeners, beams, or girders is prohibited within the mid-third length of the span. Any necessary connections to these members in this area shall be to the web only, at a minimum distance of one inch from the flange.

100-1.3.3.1.1 When installing piping systems and electric leads under plated decks, wherever possible such leads should be run through any existing lightening holes in the webs of the deck beams rather than through new holes to be cut in the beams. If it is necessary to cut new holes in the webs of the deck beams to accommodate such leads or piping, sizes and spacing of the holes must not exceed specifications given in the construction drawings.

100-1.3.3.1.2 Holes shall not be cut in the lower flange of any deck beam, and only one horizontal row shall be cut in the web of any beam. Holes in deck beams shall not be located closer than three feet from stanchion or pillar attachments to the beams.

100-1.3.3.1.3 If it appears impractical to follow the foregoing specifications for holes in webs of deck beams, the proposed procedure for cutting of holes shall be referred to NAVSEA for approval. For reinforcement of openings in structure, other than protective plating, see **Design Data Sheet** (DDS) 100-1.

100-1.3.4 CUTTING HOLES. Holes or openings for any purpose whatsoever, except those shown or indicated by drawings or specifications, must not be cut in any watertight bulkhead, deck, or shell plating except where the local naval repair or overhaul activity finds such holes or openings to be necessary. In the case of a private repair or overhaul activity, this determination must be made by the cognizant Naval Inspector. If doubt exists as to the propriety of such cutting, and when time permits, the matter may be referred to NAVSEA.

100-1.3.4.1 In all such cases, when cutting a hole in any hull structure is indicated, consideration should be given to other possible means of accomplishing the desired result without cutting the hole.

100-1.3.4.1.1 In cutting and closing holes, the restrictions given in paragraphs100-2.7.1,100-2.7.1.1 and 100-3.6.1 apply.

100-1.3.4.1.2 For additional information on temporary openings and accesses for surface ships, see **NSTM Chapter 074, Volume 1, Welding and Allied Processes.**

100-1.3.5 WATERTIGHTNESS. The designed watertight subdivision of ships is of primary importance and must be maintained. No access or ventilation openings shall be permitted in main subdivision bulkheads below the damage control deck.

100-1.3.5.1 Wherever watertight construction is specified to a height which does not extend to the upper boundary of a bulkhead, vent ducts, wiring, and piping may be passed through the upper non-tight portion of bulkheads

using non-tight construction. The method of establishing watertightness level of main transverse bulkheads is discussed in **NSTM Chapter 079, Volume 1, Damage Control, Stability and Buoyancy.**

100-1.3.5.2 When installing piping, wiring, and similar systems, and when making repairs and alterations, it is important to ensure that the original watertightness of the space is preserved. In this connection, piercing of a watertight space with a piping system, or any other system which will permit flooding of the space from another space, will destroy the watertight subdivision unless positive means are provided in the installed systems to prevent such flooding.

100-1.3.5.3 **NSTM Chapter 096, Weights and Stability** gives instructions for tests and inspections to be made by ship's personnel to maintain watertight integrity.

100-1.3.5.4 Where pipes or voice tubes pierce watertight bulkheads or decks subject to deflection (see paragraph 100-2.2.1 the bulkhead or deck connection must be the standard type applicable to the particular condition so watertightness will not be affected at that point by deflection in the structure.

100-1.3.5.5 **NSTM Chapter 079, Volume 2, Damage Control, Practical Damage Control, and NSTM Chapter 079, Volume 4, Compartment Testing and Inspection,** give instructions to be followed to maintain tightness integrity and to conduct tests which must be made after alterations or repairs have been completed.

100-1.3.6 SHORING AFTER FLOODING. Main divisional bulkheads are designed, built, and tested to withstand the maximum water pressure likely to be placed upon them under probable flooding conditions. In event of flooding and damage to any of these bulkheads, it may be necessary to reinforce them temporarily by shoring. Instructions for shoring are contained in **NSTM Chapter 079, Volume 2, Damage Control, Practical Damage Control** .

100-1.4 REPORT OF STORM DAMAGE

100-1.4.1 In reporting storm damage to ships, the following information shall be submitted to NAVSEA on Report of **Storm Damage to Ships** (NAVSEA Report 9880-2) in triplicate:

a. Ship's position: Latitude and longitude

b. Time: Zone, time, and date

c. Wind: Force and direction

d. Sea: Height and direction of waves, and sea disturbance code (0 to 9)

e. Air temperature

f. Water temperature

g. Course: True

h. Speed: Knots

i. Average angle of roll: Upright to one side

j. Maximum angle of single roll: Upright to one side

k. Average period of roll: Port to starboard, or vice versa

l. Average total angle of pitch: Angle included between bow up and bow down position, or vice versa

m. Maximum total angle of single pitch: Angle included between bow up and bow down position, or vice versa

n. Average period of pitch: Bow up to bow down

o. Extent of yawing

p. Drafts: Forward and aft, using calculative marks (arabic numerals) if fitted

q. Loading: Longitudinal disposition of oil, water, cargo, or other heavy loads

r. Formation of ice

s. Statement of measures taken to prevent damage: Changes in course and speed, actions taken in securing gear, and so forth

t. Description of damage incurred: Location, size, and depth of buckles, extent of fractures, and so forth

NOTE

The starting point of fractures should be given, if known. The surfaces of most fractures have a herringbone pattern, the apexes of which point to the starting point of the fracture. Photographs of unusual or extensive damage should be included, if feasible.

100-1.5 EMERGENCY CRACK STOPPER

100-1.5.1 Emergency crack stopper procedure, as outlined in **NSTM Chapter 074, Volume 1, Welding and Allied Processes,** shall be used only in emergencies as a temporary device to stop progressive failure of ship's plates. The procedure is not intended to influence any other repair or overhaul procedure.

100-1.5.1.1 Strongbacks straddling the fractured area usually are used to relieve the imposed loading on the fractured area. They also help hold the structure in alignment until a survey is made to evaluate damage and a decision reached on the correct repairs to be made.

SECTION 2

SURFACE SHIPS

100-2.1 MAINTAINING TIGHTNESS

100-2.1.1 MISSILE MAGAZINE BLOWOUT HATCHES. Magazines on ships carrying missiles are vented by a trunk with a blowout hatch open to the weather. These hatches are designed to blow open at a fixed internal pressure. Areas in the way of the hatches should be clear so hatches can be opened readily. Hatches shall not be welded closed or have bars installed across the face thus preventing a complete opening.

100-2.1.2 BULKHEAD OPENINGS TO SHAFT ALLEY. Shaft alleys are usually vulnerable to flooding because of their length. Naval ships are not designed with access to these spaces through the after machinery bulkhead. On converted ships, such access must be blanked off or closed with welded plates. For tightness tests after alterations or repairs see **NSTM Chapter 079, Volume 4, Damage Control, Compartment Testing and Inspection.**

100-2.1.3 AIRTIGHT CLOSED FIREROOMS. Some older ships have closed firerooms in which a high air pressure can be maintained only if the fireroom is airtight. If a fireroom is not airtight, appreciable air leaks make it necessary to run blowers faster than otherwise necessary to maintain a given air pressure, thus causing a direct waste of power.

100-2.1.3.1 Minor air leaks that are not discovered except by air bubbles in water or other liquid over the leak, are difficult to avoid in light structural work, and the resultant waste of steam is negligible. All openings into the fireroom, such as doors, hatches, ventilators, and deadlights, must be fitted with tight gaskets, and firerooms should frequently be inspected for airtightness with blowers operating.

100-2.1.3.2 Procedures for inspection and maintenance of closures, as given in **NSTM Chapter 611, Fenders,** should be followed.

100-2.1.4 INSTALLATION OF BOW RAMP AND STERN GATE GASKETS. Molded gaskets, provided for watertightness of LST bow ramps and LSD and LPD stern gates, may be installed similarly to those shown on NAVSHIPS dwg LCU 1466-S1602-1207561, for LCU bow ramps. This would be in lieu of the flat bars and bolts shown on applicable drawings for the other types of craft.

100-2.1.4.1 When this method of installation is used, the following procedure must be adhered to:

1. Clean area between retainer strips and clean the strips to bare metal.
2. Remove all oil and grease with a suitable solvent or detergent.
3. Apply one coat of pre-treatment wash primer, Navy formula 117, to the cleaned area.
4. Apply one coat of adhesive, MIL-A-1154, to the cleaned area and to the gasket.
5. Install gasket and hold in place until adhesive sets.

100-2.2 DEFLECTION ALLOWANCE

100-2.2.1 GENERAL. Temporary or permanent deflections in ship structure can be caused by gun and missile blast, explosion, and water pressure. To minimize damage to the ship in these conditions, allowances must be made in installations of nonstructural members. Causes of deflections and allowances to be made are described in the following paragraphs.

100-2.2.2 PRECAUTIONS IN WAY OF GUN AND MISSILE BLAST. The nature of gun and missile blast is a sudden rise and fall of pressure, accompanied by movement of air. In the case of missile blast, a sudden rise and fall of temperature also occurs. These actions cause temporary deflection or, in some cases, permanent buckling of large flat areas, such as lockers. Consequently, nothing which cannot withstand this action should be rigidly or permanently attached to decks or bulkheads subject to blast.

100-2.2.2.1 Light joiner bulkheads, berth stanchions, and storeroom and ammunition stowage battens must be installed with slip joints to allow a movement of the deck (due to shock or explosion) of plus or minus two inches without stressing the nonstructural members.

100-2.2.3 PIPING AND OTHER SYSTEMS. Pipe hangers attached to decks or bulkheads subjected to gun or missile blast, or to deflection from shell impact, must be designed to permit an appreciable movement of structures without damage to the piping. Such provision particularly applies to systems supported from the underside of protective decks.

100-2.2.3.1 Important leads, pipes, or systems of transmission shall not be attached directly to protective decks unless specifically approved by NAVSEA.

100-2.2.4 PUMPS AND OTHER AUXILIARIES. Pumps, other auxiliaries, or moving parts (such as operating gear) which may be used in action must not be attached to decks, bulkheads, or other structure in such a manner that they may become disabled by deflection due to water pressure, mine or torpedo explosion, or gunfire.

100-2.2.4.1 In the case of ships of light construction, notably destroyers, difficulty has been experienced where auxiliaries were attached directly to the shell structure, owing to movement in the shell when bearing against docks or against other ships.

100-2.2.5 ACCESS TRUNKS. Access trunks are required to be constructed independently of armor bulkheads so that any damage to the bulkhead will not be transmitted to the trunk, thereby preventing its use.

100-2.2.6 HOLDING BULKHEAD CLEARANCES. Piping shall not be led through the plating of transverse bulkheads between the longitudinal holding bulkhead and the first stiffener of the transverse bulkhead. No attachments may be made to the holding bulkhead of a side protective system without special approval in each case by NAVSEA.

100-2.2.6.1 All main and auxiliary machinery installations, essential to the propulsion, fighting qualities, or watertight integrity of the ship, including their foundations, should be kept well inboard of the holding bulkhead. If possible, such installations should be clear of the arc formed by the bulkhead with a deflection of one-seventh of its height at mid-height. When this cannot be attained, a minimum clearance of two feet at mid-height and of one foot at inner bottom level should be maintained for the full length of the compartment. Clearances should be measured from the flange of the holding bulkhead stiffeners when these are mounted on the inboard side. Ammunition stowage fittings should be kept at least six inches clear of the holding bulkhead.

100-2.3 ORDNANCE FOUNDATIONS

100-2.3.1 GUN FOUNDATIONS. After gun firing, gun foundations shall be examined to determine whether any or all of the following adverse effects have occurred:

a. Loosening of hold-down bolt nuts

b. Elongation of hold-down bolts

c. Indication of excessive strain in foundation girders and connections, such as cracked paint or welds, or loose rivets

d. Indication of excessive strains on the stanchions and their connections

100-2.3.1.1 Any excessive vibration of gun foundations, which makes rapid firing of the guns either difficult or uncertain, shall be reported to NAVSEA on **Report of Equipment Failure** , Report Symbol 9120-1 (NAVSEA 3621).

100-2.3.1.2 No structural modifications in way of or affecting the structural strength and rigidity of ordnance foundations shall be undertaken without NAVSEA approval.

100-2.3.2 GUN DIRECTOR AND MISSILE LAUNCHER FOUNDATIONS. Gun director and missile launcher foundations shall be inspected periodically for alignment to determine the following:

a. Foundation structure has not been distorted.

b. Hold-down bolts have not loosened.

c. Bolt holes have not become elongated.

d. No excessive vibration exists.

100-2.3.2.1 Any defect noted shall be reported to NAVSEA on **Report of Equipment Failure** , Report Symbol 9120-1 (NAVSEA 3621).

100-2.3.3 TORPEDO TUBE FOUNDATIONS. Torpedo tube foundations shall be examined frequently to detect any weakness or loosening of connections.

100-2.4 WEIGHT CHANGES

100-2.4.1 Alterations involving change in ship's weight may prove detrimental to proper ship's functioning. No structure may be added to any surface ship, therefore, without prior approval of NAVSEA.

100-2.4.1.1 Requests for alterations involving a change in weight shall include:

a. Estimate of weight involved

b. Exact location (longitudinal, athwartship, and vertical) dimensioned from frame line, center line of ship, and height above base line

c. Proposed weight and moment compensation

100-2.4.1.2 Additional details on influence of weight and moment changes on ships are given in **NSTM Chapter 096, Weights and Stability.**

100-2.5 SHIPYARD STRUCTURAL EXAMINATION

100-2.5.1 GENERAL. When a ship is assigned availability for repairs, the repair activity shall make an inspection of the ship's structure when evidence of severe deterioration has been reported by the Commanding Officer. Repairs shall be based on criteria which have been established for such examinations. These criteria are described in the following paragraphs.

100-2.5.1.1 General Criteria. Strength members or portions of strength members, which have suffered a reduction in cross-sectional area of 25 percent or greater from their original, shall be cropped out and replaced. In cases where material deterioration is limited to small areas (less than two square feet), repairs may be accomplished by welding in lieu of replacement.

100-2.5.1.1.1 Scattered pits of depth at least 25 percent, but not greater than 45 percent, of original thickness may be repaired by welding. Repairs to restore thickness of existing structure by cladding or surfacing shall be accomplished by the metal arc welding process as set forth in **NSTM Chapter 074, Volume 1, Welding and Allied Processes.**

100-2.5.1.1.2 Where galvanized plating originally was installed, it must be replaced with galvanized plating, or coated, over abrasive blasted surfaces, with inorganic zinc type coating in accordance with MIL-P-23236, class 3 post-curing type.

100-2.5.1.2 Special Criteria. For certain ship classes, specific structural inspection and renewal criteria have been established. Check-off lists also have been prepared for some of these ship classes and are available from the cognizant planning yards and Type Commanders.

100-2.5.2 REPORTS. Where conditions requiring repairs are recurrent and of a similar nature, NAVSEA, the Type Commander, and the planning yard are to be notified. See **NSTM Chapter 997, Docking Instructions and Routine Work in Drydock** , which specifies that report form **SI and SWI Usage Summary** (NAVSEA 9070-1) shall be completed.

100-2.6 INSPECTION, TEST, AND REPAIR OF BULK FUEL CARRIER TANKS

100-2.6.1 GENERAL. Inspection of cargo oil, aviation fuel, and gasoline tanks in bulk fuel carriers, such as AO, AOG, YO, YON, YOG, and YOGN, presents problems peculiar to such ships because they are vulnerable to a type of corrosion not encountered in other ships.

100-2.6.1.1 The corrosive effect is brought about by the combination of seawater and impurities or additives in the fuel. This combination produces characteristic deterioration, depending on the fuel.

100-2.6.1.2 Clean fuels, such as gasoline and aviation fuel, seem to cause more rapid corrosion in the upper portion of the tanks. The greatest deterioration is likely to be found at hard spots, where beam brackets make up to bulkheads, deck, and shell, and about the centerline of individual bulkhead panels. Overall structural strength of the ship may be affected. Leakage into adjacent tanks results in contamination when split cargoes are carried.

100-2.6.1.3 Black fuels provide better preservation of the interior of the tanks than clean fuels, except in cases where the cargo has been, for example, a sulfur-bearing crude oil. The introduction of seawater into the tank, in ballasting or in butterworthing, however, permits the formation, in combination with the black oil residue, of corrosive agents. In this situation, the bottom plating is most likely to be attacked. The corrosion is not always of a general nature, but may be localized in deep pitted areas of several square inches.

100-2.6.1.4 To limit deterioration, the commercial practice is to shift from clean to black service, or vice versa, when deterioration approaches a predetermined limit.

100-2.6.1.5 Since both types of corrosion are random, it is not practical to prescribe inflexible rules for repair or replacement. Instructions given in the following paragraphs must be interpreted with good judgment. For example, although the standard for replacement of structure is deterioration of 25 percent or greater, extensive deterioration in deck or bottom shell plating, less than, but approaching 25 percent, may be more serious than a few locally pitted areas in which the loss is more than 25 percent. A sound structure must be maintained, but the cost of inspection and repair, including staging, cannot be neglected.

100-2.6.1.6 A hydrostatic test of each cargo tank and cofferdam, to a head of water to the top of the hatch coaming, must be conducted after approximately four years of service, and about every four years thereafter.

100-2.6.1.7 For AO, AOG, YO, YON, YOG, and YOGN, the following work shall be accomplished as a repair at the first overhaul availability after six years of service, and approximately every four years thereafter during regular overhaul availabilities:

1. Determine scantlings of structures bounding cargo gasoline and aviation fuel tanks by drill testing or with an electronic thickness-measuring instrument.
2. Replace all material which has suffered a reduction from its original thickness of 25 percent or greater.

NOTE

If electronic thickness measuring is used in lieu of drill testing, the decision to replace structure on the basis of the specified 25 percent reduction in thickness may be confirmed by a few drill tests. Scantling determinations of painted tank structure must not be accomplished unless the paint is deteriorated and there is evidence of severe corrosion of the structure.

3. Inspect all other cargo tanks.
4. Determine scantlings of deteriorated areas, if evidence of severe deterioration of structure is found.
5. Replace all material which shows a reduction from its original thickness of 25 percent or greater.
6. Safe-end all fractures, to effect permanent repairs, by drilling a 3/8-inch hole at each end.
7. Scale for at least three inches on each side of fracture.
8. Chip out fractures, creating V-groove, and weld using block or back-step techniques; make increments of not more than eight inches.
9. Peen, if necessary, to avoid cracking welds.
10. Conduct hydrostatic test of repaired tanks to a head of water to the top of the hatch coaming.

100-2.6.1.8 When conditions requiring repairs are recurrent and of a similar nature, NAVSEA, the Type Commander, and planning yard shall be informed.

100-2.6.2 REPAIR AND REPLACEMENT OF COUNTERSUNK RIVETS. Countersunk steel rivets shall be repaired or replaced when any one of the following conditions occurs:

a. When leaking

b. When head thickness has been reduced by 25 percent for plates up to 40.8 pounds

c. For plates 40.8 pounds or heavier, when head thickness has been reduced by 20 percent of the designed thickness of the thinnest plate in the joint

100-2.6.2.1 Head thickness reduction is to be measured from a place parallel to the plating in way of the joint.

100-2.6.2.2 Leaking rivets shall be recalked, redriven, repaired by welding, or replaced, as necessary.

100-2.6.2.3 Repairs to rivets by welding may be effected in accordance with applicable NAVSEA instructions, provided the depth of repair does not cause fusion between the plates in the joint. If fusion of the plates is likely to occur, rivets must be replaced in lieu of welding (see **NSTM Chapter 074, Volume 1, Welding and Allied Processes**).

100-2.6.3 STIFFENING OF BULKHEAD OPENINGS FOR DOORS EXPOSED TO BOARDING SEAS AND GUNBLAST. Difficulties are being experienced aboard older ships in maintaining structural doors and preventing leakage under blast loading or boarding seas. The door frame tends to rotate around the bulkhead stiffener, permitting the door to slip past the knife edge, causing leakage.

100-2.6.3.1 Structural nonballistic doors exposed to boarding seas or gunblast shall be inspected when leakage is noted or abnormal maintenance is required. Under such conditions, the bulkhead opening should be provided with vertical stiffeners installed at each side of the door opening, and as close to the opening as practical. A horizontal header should be fitted between the two vertical stiffeners above and as close to the door opening as practical. The door frame should be bracketed at each dog to the adjacent stiffeners.

100-2.7 CUTTING HOLES

100-2.7.1 Cutting temporary holes in shell plating to facilitate removal of sand after sandblasting the interior of tanks, or for shipping and reshipping machinery, is approved, providing it is done under careful control and subject to the following restrictions:

a. Holes are minimum necessary size.

b. No holes are cut in flat keel or bilge strakes.

c. No more than two holes are cut in each tank.

d. Holes are located between principal ship framing or bulkheads and cuts are at least three inches from any of these members.

e. Holes are cut with corners of minimum radius of three inches, or one-eighth of the transverse dimension of the cut, whichever is greater.

f. Plate blanks are properly crowned to provide for anticipated shrinkage.

g. Holes are closed and inspected in accordance with**NSTM Chapter 074, Volume 1, Welding and Allied Processes.**

100-2.7.1.1 The procedure for making multiple cuts for temporary access in both riveted and welded construction is also given in **NSTM Chapter 074, Volume 1, Welding and Allied Processes.**

100-2.8 PNEUMATIC TIRE LOADING ON DECKS

100-2.8.1 Wheel loads from aircraft and land vehicles are applied to the deck structure through pneumatic tires in two ways:

a. By air pressure acting on the inside of the tire casing

b. By compression due to the rigidity of the wheel rims when tire is bottomed out

100-2.8.1.1 DDS 130-1 provides guidance in structural design, and in allowable stresses, and gives examples. In the case of helicopter landing loads, recent service experience has shown these guidelines to be conservative when considering lightweight landing decks such as those on non-aviation type ships. Loads twice as great as those permitted by DDS 130-1 have been found to be acceptable.

100-2.8.1.2 For further guidance, Naval Ship Engineering Center (NAVSEC) should be consulted until revised design and analysis procedures are issued.

100-2.8.1.3 Deck structure in way of vehicle handling areas shall be inspected periodically for damage and wear. In addition, vehicle tie-down fittings shall be inspected and tested periodically in accordance with **NSTM Chapter 611, Fenders,** to ensure they will not fail under load and that the restrained vehicle will not come adrift.

100-2.9 HULL SHEATHING

100-2.9.1 TREATING WOOD HULLS. Pressure-treating lumber and timbers with creosote is the best known means for preventing shipworm attacks. This is not effective in preventing bottom fouling by various types of marine growth, even when the bottom is painted with an antifouling paint, however, because of the tendency of creosote to bleed through paint film.

100-2.9.1.1 Reports on unpainted pressure-treated exposure test panels show that after submergence in shipworm infested waters, lumber treated with ammoniacal copper arsenite (Federal Specification TT-W-549), or chromated copper arsenate (Federal Specification TT-W-550) has successfully resisted shipworm attack for a 12-month period.

100-2.9.1.2 Neither of these materials significantly affects the strength of wood nor harms the paint finish (when treating and drying are properly performed). Satisfactory operating service periods of 12 months may be expected (even for ships operating in waters severely infested with shipworms) when pressure-treated bottom or sheathing material is paint-finished in accordance with present practice, using antifouling paint, Navy formula 105 or 121, for the last two coats.

100-2.9.1.3 Commercial facilities are available for pressure treatment of lumber with any of these preservatives.

100-2.9.1.4 Preservative treatment should be in accordance with Federal Specification TT-W-571, except that minimum quantities of preservative are to be retained in the woods as follows:

a. Chromated copper arsenate: 1.5 pounds per cubic foot of wood

b. Ammoniacal copper arsenite: 1.5 pounds per cubic foot of wood

c. Creosote: 12 pounds per cubic foot of wood

100-2.9.1.5 In view of paintability and the lesser weight involved, either ammoniacal copper arsenite or chromated copper arsenate should be selected for all ship-shaped ships. For double-planked barges and similar heavy built slow-moving craft, creosote is preferred as the preservative for treatment of outer exposed parts. For heavy scantling craft of this type which are single-planked, sheathing about 1-1/16-inches thick, pressure-treated with creosote is preferable to treated hull planking.

100-2.9.1.6 Lumber which is pressure-treated with any of the foregoing preservatives is authorized for use as necessary by ship repair activities. To avoid added weight, damaged planks may be replaced with treated planking. Sheathing, however, shall not be installed in the following:

a. Motor torpedo boats (PTs)

b. Wooden landing craft (LCVPs, LCPLs, and LCPRs)

c. Aircraft rescue boats

d. Minesweeping boats (MSBs)

e. Small boats

NOTE

Small boats are defined as craft generally under 70 feet in length, which do not appear in the ships **Data Book** , are not formally commissioned, and are not specifically assigned a Commanding Officer by the Bureau of Naval Personnel (BUPERS).

100-2.9.2 REPAIRING SHIPWORM-INFESTED SHIPS. The following paragraphs discuss the most effective methods for repairing ships based for extended duty in waters severely infested with shipworms.

100-2.9.2.1 Double-Planked Ships. If large areas of double-planked ships (except barges and others with similarly built hulls) are severely damaged by widespread infestation of shipworms, replank outer course entirely (below 12 inches above the heavy-load line) with pressure-treated planking. This should be done after replacement of any damaged inner planking with nontreated material similar to that existing. Sheathing is not necessary in this case.

100-2.9.2.1.1 If damage is sporadic and confined to small areas, replace unsound planks with nontreated planking. With pressure-treated sheathing about 25/32-inch thick, sheath entire hull where weight, moment, and design considerations do not preclude installation below 12 inches above the heavy-load line. Where installation of sheathing is not practical, follow procedure included in note in paragraph 100-2.9.2.2.

100-2.9.2.2 Single-Planked Ships. In single-planked ships (except barges and other ships with similarly built hulls) replace or patch damaged area of unsound planks with nontreated planking. With pressure-treated sheathing about 1-1/16-inches thick, sheath entire hull (below 12 inches above the heavyload line).

NOTE

In cases of ships (either single-or double-planked) which experience trouble only in the vicinity of the waterline, due to the nature of their work, pressure-treated sheathing shall be fitted on a belt extending from stem to stern. In cases of ships which have only occasional shipworm damage of a minor nature, it is suggested that only the damaged planks be replaced with treated planking, and that no sheathing be installed.

100-2.9.2.3 Barges and Similarly-Built Ships. In all barges and similarly-built ships, with either single or double planking, replace unsound planks with nontreated planking and sheath entire hull (below 12 inches above the heavy-load line) with 1-1/16-inch sheathing. Pressure-treated creosote is suggested as first choice, with either one of the other two approved preservatives as second choice.

100-2.9.3 SHEATHING. Although application of sheathing to ship-shaped hulls presents certain problems not encountered when sheathing barges and lighters, it is practical for repair activities to make such installations without undue difficulty. YTBs and ANs have been completely sheathed and MSCs have received waterline sheathing. The following procedure has been found satisfactory in making such installations:

1. Scrape hull and clean thoroughly below 12 inches above the heavy-load line.

2. Test planking in accordance with paragraph 100-2.10.4.1.1.

NOTE

Replacement planking may be of untreated stock to conserve treated material for use on exposed surfaces, except as indicated in the note in paragraph 100-2.9.2.2. Fastenings of repair planking should be similar to those used in initial installation. Any loose planks should be refastened.

3. Harden all seams. Calk and apply seam compound to all seams in outer hull, as necessary, to ensure a tight hull.

4. Apply one priming coat of Navy formula 105 or 121 antifouling paint to all new repair material; then apply two coats to entire hull below 12 inches above the heavy-load line. Apply pretreatment formula 117 over wood known to have had preservative treatment prior to application of antifouling paint.

NOTE

The hull should be dry prior to application of paint. There should be a minimum of four hours between coats. Sheathing felt, also known as tarred felt or Irish felt (Federal Specification HH-R-595, type 30) in rolls or standard sheet size 32 by 40 inches and 26 or 30 pound weight, should be tacked on hull while the final coat of paint is still wet.

5. Apply sheathing after coating faying surfaces with two coats of antifouling paint, formula 105 or 121. (Permit no installation of unsound or loose knots.) Use butt joints spaced at least 24 inches apart in adjacent planks.

NOTE

All sheathing except that which is creosoted should be installed with space between strakes to allow for swelling. Creosoted sheathing should be fitted edge to edge. Secure 25/32-inch sheathing with 8d hot dip galvanized nails or equivalent flathead wood screws. Secure 1-1/16-inch sheathing with 10d hot dip galvanized nails or equivalent flathead wood screws. Use corrugated boat nails if available. Otherwise, use hot dip galvanized common boat or wire nails. In any case, fasteners should not protrude or show splits on inner surface of the hull.

6. Space nails to suit the use of at least six nails per square foot.

NOTE

Sheathing ends should be secured with nails spaced, at most, 2-1/2-inches center to center. For end fastenings only, prebore holes 3/4-inch from ends of a diameter 1/32-inch less than that of fastenings. Set in all nail heads at least 1/8-inch. All fastenings used in nonmagnetic minesweepers shall be fabricated from nonmagnetic material. Caulking of sheathing is not necessary where it is installed on a reasonably tight hull and where the edge distance between sheathing does not exceed the requirements of paragraph 100-2.9.3.1.

7. Prime all butts and seams of sheathing with one coat of antifouling paint, formula 105 or 121, prior to installation.
8. Prime all nail holes and surface cracks.
9. Fill all tracks and fasten holes with white lead putty or marine seam composition.
10. Finish paint exposed surface or sheathing in general accordance with established practice for finishing bottoms of wooden ships, using formula 117 and three coats of formula 105 or 121 bottom paint.

NOTE

When operating area is expected to include tropical or heavily fouling waters, the use of formula 121 is recommended.

100-2.9.3.1 Red oak and southern yellow pine are easily pressure-treated. Red oak and yellow pine have been used for minesweepers and on barges. Red oak sheathing should be installed with a strake spacing calculated from Figure 100-2-1. Southern yellow pine strake spacing also may be calculated from Figure 100-2-1 by applying a 10 percent reduction of the value for flat grain red oak material and an increase of 10 percent for vertical-grained pieces. Note that the seam width is the sum of the width increase for strakes on each side of the seam.

100-2.9.3.2 The extent of repairs with this material to any specific ship will be at the discretion of the repair activity concerned.

100-2.9.3.3 For additional information on wood hulls, refer to the NAVSEA publication entitled Wood: A Manual for Its Use as a Shipbuilding Material. This manual is divided into four volumes:

a. Volume I, NAVSEA 0900-LP-015-1010,**Basic Wood Technology Applicable to Shipbuilding**

b. Volume II, NAVSEA 0900-LP-015-1020, **Techniques and Practices Applicable to Shipbuilding**

c. Volume III, NAVSEA 0900-LP-015-1030, **Technical Data Applicable to Boat and Ship Design**

d. Volume IV, NAVSEA 0900-LP-015-1040, **Techniques Applicable to Boat and Ship Construction**

100-2.9.4 STEEL HULLS. Certain steel-hulled auxiliary ships utilize, as a fender, a layer of wood sheathing fore-and-aft, extending from about the sheer line to below the turn of the bilge. Most of these ships have a layer of 10-pound steel plate fastened to the outboard side of the sheathing to provide abrasion resistance and better load distribution; however, in some ships, this outer plate may not be used.

100-2.9.4.1 General. The use of untreated wood has resulted in decay and has necessitated frequent replacement of sheathing. To reduce maintenance costs, certain wood species, preservatives, and hull application procedures are recommended for repair or replacement of existing sheathing. Optimum penetration and retention of preservatives by the timbers is essential.

NOTE

Retention shall be calculated in pounds of creosote solution or dry salt per cubic foot of wood, based on the volume of the treated portion of the core boring. Penetration and retention shall be determined in accordance with the latest Boring and Assay Method as developed by the AWPA, and results shall be considered acceptable if 80 percent of the core borings meet requirements, and each core meets requirements by 80 percent.

100-2.9.4.1.1 Wood Species. Use Douglas fir or southern pine beams. Incise the Douglas fir timbers 3/8-inch to improve preservative penetration. Incising is not required for southern pine, although if faces are largely heartwood, incising is advisable.

100-2.9.4.1.2 Preservatives. Preservatives used are creosote solutions and water-borne salts. These are listed in Table 100-2-1 together with maximum retention of each preservative (given in pounds per cubic foot) and federal specification number of each (see paragraph 100-2.9.1.4 for minimum retention criteria).

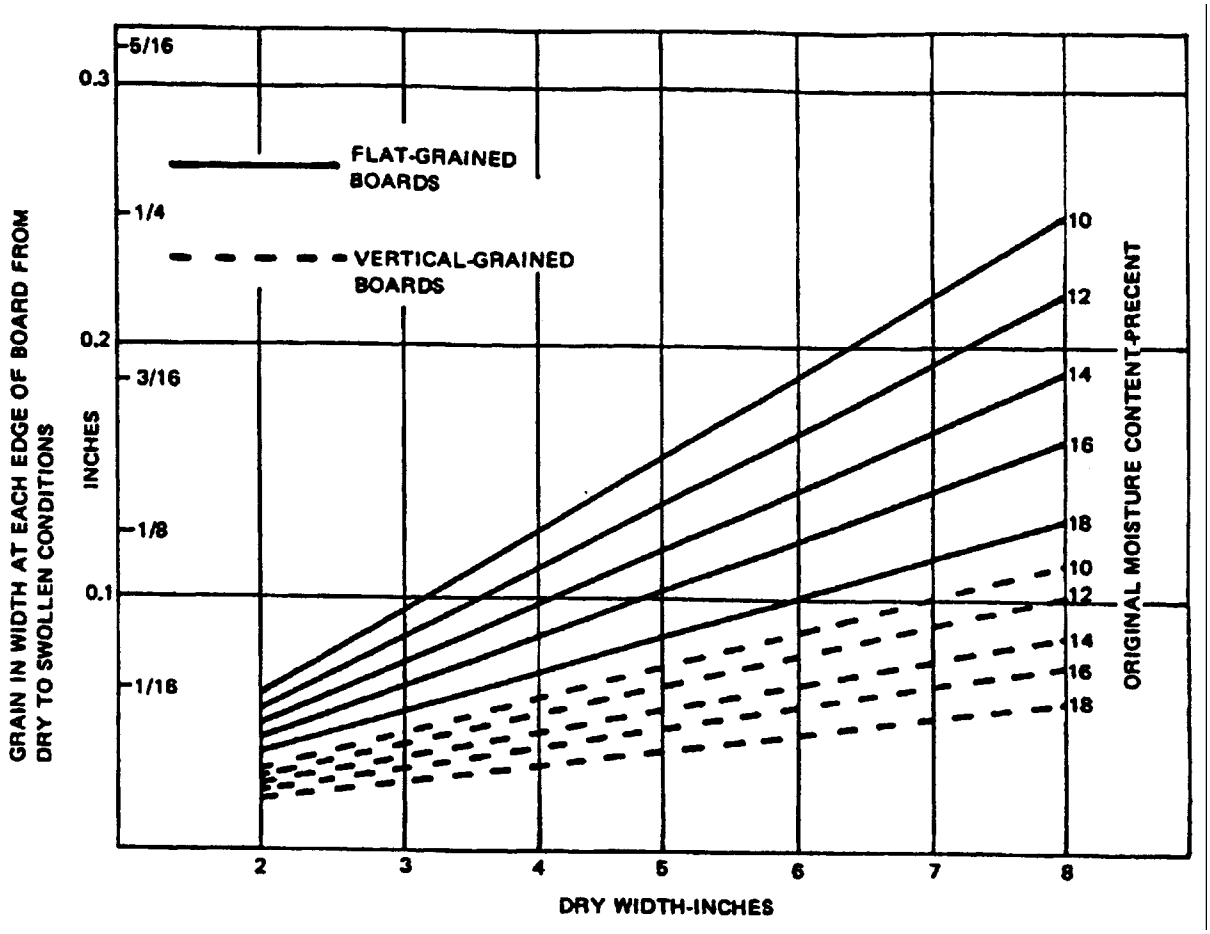


Figure 100-2-1 Increase in Width at Each Edge of Red Oak Sheathing From Dry to Wet Condition

Table 100-2-1 PRESERVATIVES AND RETENTION

Preservative	**Maximum Retention (lb/ft^3)**	**Material Spec.**
Creosote-Coaltar Solution	20.0	TT-C-650
Coal-Tar Creosote	20.0	TT-C-645
Ammoniacal Copper Arsenite (Chemonite)	1.50	TT-W-549
Chromated Copper Arsenate (Greensalt)	1.50	TT-W-550

100-2.9.4.1.3 Treatment. Timbers of ships using outboard steel plate should be treated with one of the creosote solutions specified in Table 100-2-1; timbers of ships without outboard steel plate should be treated with one of the water-borne salt preservatives.

100-2.9.4.1.3.1 Timbers shall be treated in conformance with Federal Specification TT-W-571, Table 100-2-1.

100-2.9.4.1.3.2 Fair, bore, cut, and shape sheathing to the fullest extent possible prior to treatment. If necessary to bore holes, cut to length, or shape surfaces after timber has been pressure-treated. The freshly exposed surfaces shall be further protected by a liberal brush coat of creosote on the creosoted timbers, or a four percent solution of one of the salts on salt-treated timbers.

100-2.9.4.1.3.3 Creosoted timbers require no further preparation.

100-2.9.4.1.3.4 Prior to installation, salt-treated timbers should be air or kiln-dried to a surface moisture content of 16 percent, to ensure paintability. One coat of Navy formula 105 or 121 antifouling paint shall be applied to the three sides of the wood sheathing that are away from the hull and extend into the boot topping area. Paint also should be applied below this area, if possible.

100-2.9.4.1.3.5 Two additional coats of Navy formula 105 or 121 paint shall be applied to the outside surface of the sheathing after installation. The sheathing above the boot top area should also be painted, using the same procedure as for wooden hull ships.

100-2.9.4.1.3.6 The steel hull and plate that comes in contact with the wood sheathing shall be coated with a hot melt corrosion preventive, MIL-C-11796, class 1 or 1A, to a thickness of 20 to 30 mils. Steel attaching studs shall be similarly coated. The coating material is applied at a temperature of about 200°F and will set as soon as it becomes cold.

100-2.9.4.1.3.7 Prior to application, the steel surfaces shall be well cleaned of rust, dirt, oil, and loose paint, preferably by abrasive blasting. Intact paint need not be removed.

100-2.9.4.1.4 Testing For Retention. Test creosote-treated wood by taking 20 borings from each charge. Ninety percent of the sapwood shall be penetrated without damage and with a minimum penetration of 1/2-inch on any face.

100-2.10 WOODEN SHIP DECAY PREVENTION AND REPAIR REQUIREMENTS

100-2.10.1 FUNDAMENTALS. Three fundamentals of decay prevention are:

a. The use of dry lumber and the use of any method to maintain the dryness of the lumber after installation.

b. The use of all heartwood lumber of a decay resistant species.

c. The use of wood preservative chemicals.

100-2.10.2 DETECTION OF DECAY. Decay in the hull structure is often concealed and occurs in those portions which are poorly ventilated and where fresh water has gained access. For the most part, these portions are confined to the stem and transom areas - the region directly beneath the coverboard - and the bilge region in hulls having tight platform decks. The headers beneath superstructures and filler blocks also warrant careful inspection, as does that portion of frame and plank near the waterline of hulls in freshwater service or storage. Beam ends, beam end connections, and the plywood used as decking and subdecking must be closely inspected.

100-2.10.3 RECOGNITION OF DECAY. Decay in hull structure usually is not recognizable by visible fungus growth except in joints between faying surfaces. There are, however, several other considerations which facilitate the recognition of decay.

a. Recognizable decay is most likely to be found near faying surfaces and joints.

b. If paint coatings are discolored or the wood surface is cupped, decay may be suspected.

c. Thoroughly decayed wood is brittle and breaks easily across the grain with a distinct brash fracture and may crumble into powder. Dry, sound wood breaks with difficulty, giving an uneven, splintering fracture. Wet, sound wood bends.

d. Sounding with a hammer will produce a dull sound in infected wood and provides a particularly useful test for internal decay in timbers.

e. A sharp ice pick or knife can be used to detect decayed wood by its ease in penetration and withdrawal. Also, in decayed wood, slivers turned up by a pick or knife point tend to break off short; in sound wood long splintering breaks are formed.

NOTE

When probing with an ice pick or knife it should be taken into account that wet wood is softer than dry wood.

f. The condition of large timbers is best determined by drilling with a 3/8-inch drill to two-thirds the depth of the timber. The ease with which the drill penetrates and the condition of the chips will indicate any advanced stage of decay of the timber.

g. In doubtful instances, where it is practical to do so, wood specimens can be submitted to a laboratory for positive determination.

h. Black stains spreading along the grain from ferrous metal fastenings usually are caused chemically rather than by decay fungi and affect the strength of the wood to a much smaller degree.

100-2.10.4 DECAY REPAIR ESTIMATES. Estimates for repairs should be based on a thorough examination of the most susceptible areas rather than a cursory examination of many areas selected at random.

100-2.10.4.1 Ships serving in seawater show markedly less decay repairs than those serving in fresh or brackish water. Ships which do not require decay repairs in seven or eight years will usually show little or no decay in ensuing years, providing the area of service is not radically changed. Those hulls having heavy sawed frames and tight ceilings in their construction are especially susceptible to decay. Before a decision is reached on how thorough an inspection should be performed, a review of the repair record should be made, and the type of construction and whether service has been in salt, fresh, or brackish water should be determined.

100-2.10.4.1.1 Every four years, an inspection should be made of all areas described in paragraph100-2.10.2, by probing or sounding. If decay is suspected, the frameheads, beam ends, stem, planking, and other members should be bored as conditions indicate. Planking strakes selected for boring should be at, or a few inches above, the waterline in the stem-transom areas. Borings should be made about eight inches from the butted ends and should extend to the faying surfaces between inner and outer planking. If boring discloses other than localized infection, proceed as follows:

1. Pull and inspect a strake near the waterline, extending aft from the stem on one side of the hull and forward from the stern on the opposite side for approximately one-fourth the length of the hull in each case. If appreciable amounts of decay are found, repeat on the other side of the hull and continue removal as far toward midships as significant decay is found.

NOTE

In double-planked hulls, if inner plank is fore-and-aft, removal should include two strakes of outer and one of inner plank to permit direct examination of the frames. If inner plank is diagonal, remove strakes and probe, bore, or sound to determine the extent of decay of planks and frames. The stem should be bored just below the deck line and also below the platform deck.

2. The beam ends, end connections, and frameheads must also be examined by removal of the lock strake, planksheer, sheerstrake, or strake below the sheerstrake. The strake removed should extend aft from the stem on one side to the first watertight bulkhead.
3. All holes bored for inspection purposes must be plugged with seasoned dowels which have been soaked in preservative and allowed to dry. Dowels are cut 1/64-inch undersize and heavily coated with resorcinol glue prior to being driven the full depth of the drilled hole. Borings must never be so numerous or so located as to impair hull strength.
4. Record the details of inspections (see paragraph 100-2.10.10).

100-2.10.5 CORRECTIVE MEASURES. The following items must be considered when taking corrective action:

a. Addition of well placed ventilators or extension of the existing mechanical ventilation systems to unventilated compartments.
b. Alterations of tight platform decking, ceiling, or filler blocks to permit air circulation to the bilges and between bays at the framehead level. In compartments with ceiling removed, platform decks should terminate at the inboard faces of the frames and strakes of ceiling and 1/4-inch wire mesh employed to prevent trash accumulating in the bilge. In the event ceiling is removed to provide ventilation, swash boards must be installed in bilges to restrict motion of bilge water in way of critical areas such as machinery spaces.
c. Correction of any feature interfering with complete water run-off.
d. Removal of refrigerator compartment insulation which lies against the hull or deck plank.

NOTE

When the refrigerator compartment is rebuilt, the outer sheathing should extend no further than the inboard face of the frames. The outer sheathing at the top of the compartment should terminate at the lower face of the deck beams. The bottom sheathing should be raised about four inches off the platform deck and 16-gage wire mesh used to prevent trash accumulation and rat nesting beneath the compartment. Vapor barrier material, with all joints tightly sealed, should be installed on the outer face of all refrigerator compartment outer sheathing, if practical. If not, the vapor barrier material should be installed on the inner face of the outer sheathing. Installed sheathing should be class 1 or class 3 pressure-treated plywood.

e. Major changes in the design of a craft shall have prior NAVSEA approval.

100-2.10.6 REMOVAL AND REPLACEMENT OF DECAYED WOOD. The most important actions in the removal and replacement of decayed wood are finding and correcting the cause of decay (see paragraphs 100-2.10.2 and 100-2.10.5). In removing sections of wood, adding sister frames, or splicing, more end joints and

faying edges are created, providing additional places for moisture to collect. If the original cause of decay has not been eliminated, the chance for decay in the future will have been increased by the repair.

100-2.10.6.1 Extensively decayed wood members must be entirely removed. Where decay is localized, removal in the decayed member should be to a distance of approximately two feet along the grain and two inches across the grain beyond the point where decay is evident. The heartwood of decay resistant species, such as white oak, cypress, tropical American mahogany, Douglas fir, long leaf yellow pine, Port Orford cedar, northern or southern white cedar, and Alaska yellow cedar, are preferred for repair replacement. The selection of the wood should take into account the physical properties required of the member to be replaced. Sapwood in any species should be excluded if possible. When it is impossible to exclude all sapwood in the finished replacement member, the sapwood face or edge should not be at a faying surface. Red oak and the sapwood of white oak, Douglas fir, long leaf yellow pine, and mahogany may be used without limitation if pressure preservative treated. The sapwood of the other lumber species cannot be satisfactorily pressure-treated.

NOTE

Distinguishing red oak from white oak, and sapwood from heartwood is sometimes difficult. Information on visual and chemical methods for positive identification of oak heartwood and oak sapwood is available from NAVSEA upon request.

100-2.10.6.1.1 All replacement plywood must be in accordance with MIL-P-18066 for class 1 (Douglas fir), class 2 (mahogany), and class 3 (overlaid Douglas fir) panels. Overlaid panels are especially preferable for exterior components where checking or paint durability normally is a problem with conventional Douglas fir plywood.

100-2.10.6.1.2 The moisture content of all replacement lumber must be 13 ± 3 percent at the time of installation. The moisture content of all replacement plywood must be 10 ± 5 percent at the time of installation. Moisture content is measured in accordance with MIL-STD-1363.

100-2.10.7 PRESERVATIVE TREATMENT. Type A or type B preservative solutions, in accordance with MIL-W-18142, should be used for brush, dip, or soak treatments. The precautions listed in the specification must be observed at all times. Interior members should receive water-borne preservative treatment to preclude the fire hazard of oil-borne preservative.

100-2.10.7.1 All replacement lumber, except cedar and cypress heartwood and those items noted in paragraphs 100-2.10.7.1.1 and 100-2.10.7.1.2 must be soaked ten minutes in preservative after all boring, shaping, and fairing have been completed. Heartwood cypress and cedar require no treatment.

100-2.10.7.1.1 All plywood subject to a high decay hazard, such as that used for subdecking and refrigerator compartments or that showing decay upon repair, must be pressure-treated in accordance with MIL-P-19550. A small inventory of pressure-treated plywood should be maintained in general stores as a standard stock item for such purposes. All other plywood, except as noted in paragraph 100-2.10.7.1.2, must be soaked ten minutes in preservative solution.

100-2.10.7.1.2 All lumber and plywood surfaces receiving bright finish and those items not subject to decay, such as doors, tables, and cupboards, require no preservative treatment. Overlaid plywood should be brush-treated on the edges and ends provided that particular component does not warrant pressure-treatment. If any treated lum-

ber or plywood should require further cutting, boring, or fairing, the untreated surfaces thus exposed must be liberally brushed with preservative. Unpainted surfaces of original material exposed during repair are to be similarly treated. Retreatment of the outer hull up to the sheer line is not required after sanding or scraping except in the area directly beneath the guard rail.

100-2.10.7.1.3 All treatment surfaces should be allowed to dry thoroughly before painting. Drying normally requires 24 to 72 hours, depending on the treatment used and the weather conditions.

100-2.10.7.1.4 In barge repair, pressure-treated lumber should be used wherever possible. All lumber should be cut to final dimensions prior to treatment, if practical. Where cutting or boring is necessary after treatment, the exposed untreated portions must be heavily brushed with preservative. Pressure-treatment must be in accordance with applicable portions of Table 1 of Federal Specification TT-W-571. Southern yellow pine is preferred for pressure-treatment, but Douglas fir may be used. No sapwood restriction should be invoked in procurement documents when Douglas fir, southern pine, white oak, or red oak are to be pressure-treated, since the sapwood of these species is easily penetrated by the preservative chemical.

100-2.10.8 BEDDING COMPOUNDS. Fortified bedding compounds, as specified in MIL-S-19653, shall be used on frame and stem ends and beneath guard rails, moldings, and armor plate after initial preservative treatment. They shall also be used on faying surfaces where watertightness is desired, such as deck fittings, leveling pads, and butt blocks.

100-2.10.9 CANVAS COVERINGS. Where canvas is required, untreated number ten weight should be used. It should be laid in a heavy paint coat conforming to MIL-P-699, formula 20, and given a coat of canvas filler, followed by two coats of deck grey formula 20. Edges of canvas should be well covered and no portions should be subjected to sharp corners beneath moldings or elsewhere. Moldings should be screw fastened, properly angled, and bedded in MIL-S-19653 compound.

100-2.10.9.1 Tough, flexible polyurethane rubber overlay coatings are becoming more generally acceptable for protection of decks and cabin tops from wear and leakage. It is recommended that whenever canvas coverings are used, consideration be given to substituting a polyurethane covering. Materials and installation are detailed in **NSTM Chapter 634, Deck Coverings** .

100-2.10.10 REPORT FORMS. Upon completion of repairs, report form **SI and SWI Usage Summary** (NAVSEA 9070-1) must be completed as required in**NSTM Chapter 997, Docking Instructions and Routine Work in Drydock.** The details of decay inspection, made according to paragraphs 100-2.10.4 through 100-2.10.4.1.1, including the location of borings and strakes removed, must be included in the report for future reference.

100-2.10.11 FURTHER CONSIDERATIONS. During repair, all ventilators, doors, hatches, and drains should be opened to facilitate drying the hull. Floorboards should be removed or placed in an upright position and all scuppers, drains, and limbers freed of debris.

100-2.10.11.1 The use of forced air heaters within or near wooden ships or boats under repair is to be avoided. In some cases, however, use of heaters or blowers may be required to speed drying preparatory to painting or gluing. In these cases, excessive heat or air flow must not be used and frequent observations must be made to ensure that warping, checking, splitting, or other distortions do not occur. No undue fire hazard shall be tolerated.

100-2.10.11.1.1 Heavy, built-up coats of paint should be avoided. In all wooden ships, the area directly beneath the platform deck is left unpainted in new construction. This area, and any other found unpainted, should be brushed or sprayed with preservative and not painted during repair. Butt blocks should be fitted so a space remains between adjoining frame members to facilitate water runoff.

100-2.10.12 MAINTENANCE REQUIREMENTS. During active service:

1. Provide thorough ventilation.
2. Prevent fresh water leakage.
3. Keep ventilation terminals open.
4. Operate mechanical ventilation systems at all practical times.
5. Keep deck seams carefully caulked and maintained, especially in the coverboard area.
6. Open hatches and deck plates when weather permits, to supplement the air circulation provided by stationary or mechanical ventilators.
7. Remove wet dunnage in lockers and permit to dry.
8. Avoid washing down with fresh water.

NOTE

Seawater has some preservative value and should be used for washing down.

9. Use sponge or chamois lightly soaked in fresh water to remove salt accumulations from bright work, chrome fittings, and windows.
10. Inspect frequently to detect any leaks beneath the covering board and deckhouse areas.

100-2.10.12.1 Sanding of deck must be done carefully to prevent hollows or projections which will allow fresh water to accumulate; standing fresh water, even in small amounts, is particularly detrimental.

100-2.10.12.1.1 The considerations in paragraphs 100-2.10.12 and 100-2.10.12.1 are supplemental to those required in **NSTM Chapter 997, Docking Instructions and Routine Work in Drydock** , and in **NSTM Chapter 075, Threaded Fasteners.**

100-2.10.13 BOLT TIGHTENING. Frequently personnel on wooden ships are presented with the problem of tightening bolts due to shrinkage of wood, and to vibration and pounding in heavy seas. Ship's force shall tighten loose nuts or bolts, exercising due caution to prevent the head of washer from crushing the wood. Utilize the size wrenches for the indicated diameter of bolts (see Table 100-2-2); draw up on the bolts until firm.

Table 100-2-2 BOLT TIGHTENING WRENCH SIZES

Bolt Size (Diameter)	**Wrench (Approximate Length)**
3/8″ up to 1/2″	6″ to 7″
1/2″ up to 3/4″	7″ to 9″
3/4″ up to 1″	9″ to 12″

100-2.10.13.1 In the event that continual retightening results in failure of the wood fibers, larger outside diameter washers shall be utilized, where practical. The frequency of bolt tightening is established at the discretion of the Type Commander.

100-2.11 ALUMINUM

100-2.11.1 GENERAL CHARACTERISTICS. The best-known feature of aluminum is its light weight. Density of aluminum alloys ranges from 0.096 to 0.102 pounds per cubic inch, with a specific gravity of 2.7, in comparison to steel with a specific gravity of 7.85.

100-2.11.1.1 Aluminum alloys used in hull structures are confined to the aluminum magnesium series because these can be welded and provide welded strength, toughness, and corrosion resistance in a sea environment. The tensile strengths of alloys used range from 33 to 46 klb/in as minimum specification values. More important and controlling are their welded tensile yield strengths which only range from 14 to 26 klb/in as minimum design values.

100-2.11.1.2 Resistance to corrosion of the aluminum magnesium alloys in a sea environment is dependent on a thin oxide film that is highly resistant and protective. For aluminum to achieve its full corrosion resistance, some precautions in handling must be observed. Corrosion resistance and additional information on aluminum is discussed in **NSTM Chapter 583, Boats and Small Craft.**

100-2.11.1.3 Aluminum is generally regarded as a nonspark metal. Its nonmagnetic properties make it useful for applications requiring a material unaffected by an electromagnetic field and producing no magnetic effect.

100-2.11.2 SELECTIONS OF ALUMINUM ALLOYS. To facilitate selection of aluminum alloys, which can be a complex process, reference to the typical properties data of manufacturers' handbooks is helpful. In addition, refer to:

1. NAVSEA 0900-LP-029-9010, **A Guide For The Selection and Use of Aluminum Alloys For Structure of Ships of The United States Navy**
2. NAVSEA 0900-LP-000-1000, **Fabrication, Welding, and Inspection of Ship Hulls**
3. NAVSEA 0900-LP-014-5010, **Fabrication, Welding, and Inspection of Noncombatant Ship Hulls**

100-2.11.3 ALUMINUM SUBSTITUTE FOR STEEL (SUPERSTRUCTURE). The use of aluminum as a substitute for steel in superstructure deckhouses of ships is an accepted method for reduction of topside weight. Since aluminum cannot be welded directly to steel, it has been the practice to form a lap joint of the superstructure to the hull deck structure. This intersection is insulated and uses mechanical fasteners or rivets.

100-2.11.3.1 This type of joint, in addition to being difficult to maintain, is quite expensive and, in general, is less satisfactory than a welded joint. The joint shall be inspected for cracked plates or broken fasteners after operation in heavy seas, after high mechanical shock (such as firing guns), and periodically as experience indicates.

100-2.11.3.1.1 In recent years explosively-bonded and roll-bonded aluminum-to-steel bimetallic joints have been developed that offer a solution to the problems associated with the old fastener type joints. With these bonded bimetallic composites it is possible to form a joint between two dissimilar materials by welding the aluminum deckhouse to the aluminum portion of the couple, and the steel hull to the steel portion of the couple. The bonded bimetallic aluminum-to-steel composite material is procured to MIL-J-24445.

100-2.11.3.1.2 Use of explosively-bonded and roll-bonded joints is recommended when economic or material availability conditions for its use are more favorable than those for the fastener type joint.

100-2.11.4 INSTALLATION OF DECKHOUSE EXPANSION JOINTS. The following paragraphs, figures, and table provide guidance for installation of expansion joints of the cold-bonded type, with details indicating improved design.

100-2.11.4.1 General. Figure 100-2-2 is a guidance sketch for installation of expansion joints.

100-2.11.4.1.1 Alternative methods may be used where riveting of the expansion joint diaphragm plate, in other than new construction, involves removal of riveting interferences. Figure 100-2-3 is a guidance sketch showing an alternative installation method.

100-2.11.4.1.2 Application of synthetic rubber sheet (cold bond) for expansion joints requires knowledge of the characteristics and methods required for application. Materials used in such application are given in Table 100-2-3.

CAUTION

The thinner, rubber primer, and cement used are highly volatile and flammable. All precautions and safety measures pertaining to flammable materials, such as restrictions against smoking, welding, burning, or sparkproducing operations shall be enforced. Fighting the type of fire caused by neglect of safety precautions requires CO_2 type fire extinguishers.

NOTE

To ensure complete compatibility of each item in Table 100-2-3 with other components, all items shall be products of the same manufacturer. Materials shall not be applied when ambient temperature is below 40°F unless external heat is provided to reach this minimum temperature. (Heaters, if used, shall be explosion-proof type.) Except for items d and e, the materials in Table 100-2-3 have a short shelf-life. Procurement should not exceed a six-month supply.

100-2.11.4.1.3 Installations, modifications, or repairs of deckhouse expansion joints shall be accomplished as indicated in the following paragraphs.

100-2.11.4.2 For Ships Under Conversion. Where details of expansion joints have not been previously specified, supervisors are requested, subject to contractor acceptance, to issue no cost increase change orders for expansion joint installation in general accordance with Figure 100-2-2 and Figure 100-2-3 and Table 100-2-3.

100-2.11.4.3 For Ships In Service. Subject to approval and allocation of funds by the cognizant Type Commander, deckhouse expansion joints requiring major repair should be replaced in general accordance with Figure 100-2-2 and Figure 100-2-3 and Table 100-2-3. Repairs to cracked coamings should incorporate the features of the discontinuous coaming and diaphragm plate in general accordance with the figures. Where riveting interferences render this type of installation impractical, one of the following alternative methods may be used:

a. The diaphragm plate, of 10.2 #HY-80, approximately the same shape as shown on Figure 100-2-2, may be built-up or flanged into a channel shape, with about 1-1/2-inch flanges, and welded toe down to the deck. The fore-and-aft ends of the diaphragm plate are to be rounded and tapered to avoid abrupt ending. The void formed under the channel shall be coated or filled with rust preventive compound.

b. The diaphragm plate may be secured to the deck with welded studs, with a suitable waterstop gasket as specified in NAVSEA 0900-LP-000-1000, **Fabrication, Welding, and Inspection of Ship Hulls.**

100-2.11.4.4 Ships In Reserve Fleet. Action for reserve fleet ships should be similar to that described for ships in service.

100-2.11.5 SURFACE PREPARATION. Surfaces to which rubber sheet will be cemented shall be cleaned to bare metal, for a minimum width of two inches, by sandblasting, sanding, or wire brushing.

NOTE

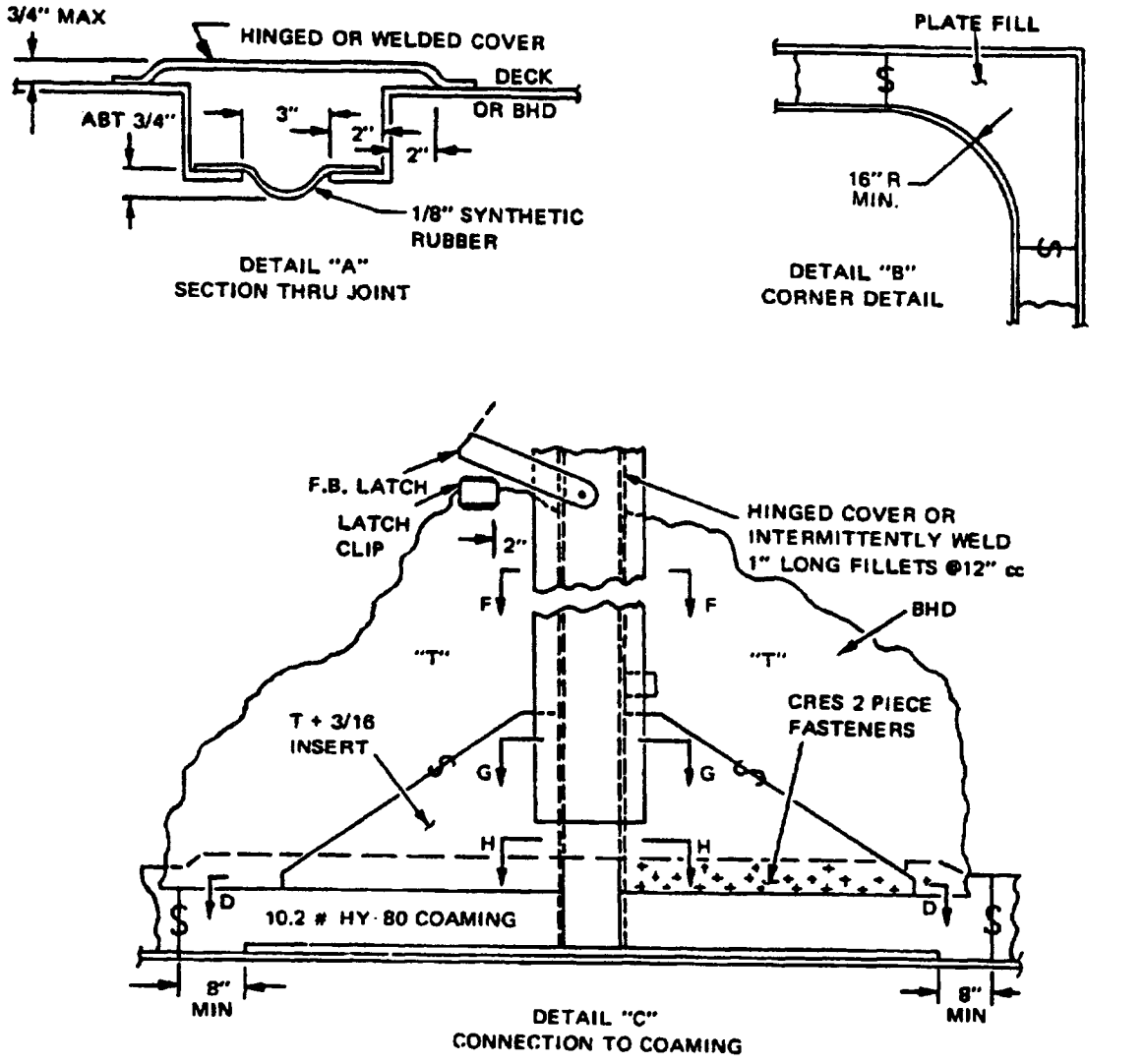
Do not burnish or polish surfaces.

100-2.11.5.1 General. Prepare work so bonding agent is applied to metal and synthetic rubber sheet at about the same time. The preparation procedure is described in paragraph100-2.11.5 and paragraphs 100-2.11.5.1.1 through 100-2.11.5.3.1.

100-2.11.5.1.1 Oil and grease shall be removed with suitable solvents (for example, methyl chloroform, NSN 6810-00-664-0387). When methyl chloroform, a toxic substance, is used in an enclosed area, ventilation must be provided. Safety information concerning the use of methyl chloroform is contained in **NSTM Chapter 670, Stowage, Handling and Disposal of Hazardous General Use Consumables.** Surfaces shall be thoroughly dry before applying primer cement.

100-2.11.5.2 Priming. Surfaces shall be treated with priming cement immediately after cleaning. Apply one coat by brush. Distribution must be even and coverage complete. Each coat of primer shall be allowed to dry for at least one hour. Primed surface must be thoroughly dry before application of the bonding cement. Renew primer if more than 24 hours elapses before application of the bonding cement. Any moisture or condensation must be removed with a clean dry cloth.

100-2.11.5.3 Preparation of Bonding Cement. The bonding cement and accelerator are packaged separately and are ready for use only after the accelerator has been added to the bonding cement. Instructions for use on the package indicate how much accelerator is required.



NOTES:

1. SYNTHETIC RUBBER TO BE COLD BONDED IN PLACE.
2. N.T. INTERIOR BHDS. TO BE PROVIDED WITH SLIP JOINTS IN LINE WITH EXPANSION JOINTS.
3. EXISTING DIAPHRAGM PLATES OF DIFFERENT CONFIGURATION MAY BE RETAINED.

Figure 100-2-2 Expansion Joints (Guidance Sketch)
(Sheet 1 of 2 Sheets)

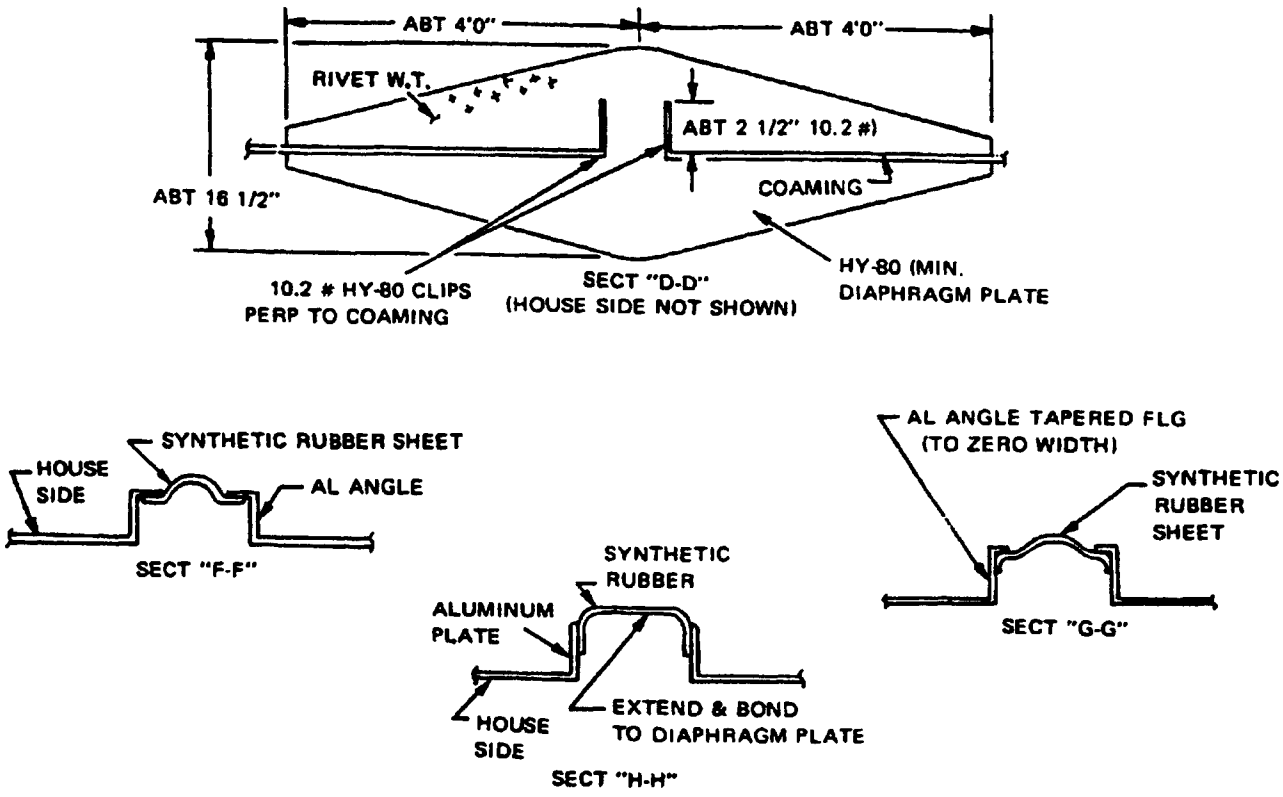
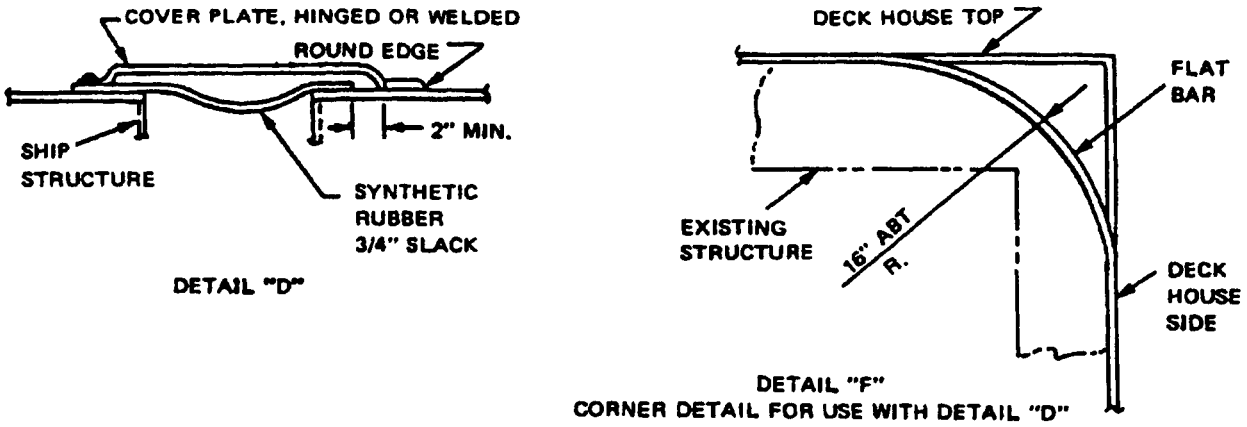


Figure 100-2-2 Expansion Joints (Guidance Sketch) (Sheet 2 of 2 Sheets)



NOTES:
1. SYNTHETIC RUBBER TO BE COLD BONDED IN PLACE.
2. PROVIDE HY-80 COAMING AND DIAPHRAGM PLATE, IN GENERAL ACCORDANCE WITH FIGURE 100-2, EXCEPT WHERE EXISTING.

Figure 100-2-3 Expansion Joints (Alternative Guidance Sketch)

Table 100-2-3 APPLICATION OF SYNTHETIC RUBBER SHEET (COLD BOND) FOR EXPANSION JOINTS

Material	Stock No.	Specification	Pkg.

Table 100-2-3 APPLICATION OF SYNTHETIC RUBBER

SHEET (COLD BOND) FOR EXPANSION JOINTS - Continued

a. Rubber priming cement	**9Q8030-00-291-0968**	**MIL-S-15058 type III**	**1 gal can**
b. Rubber troweling material with accelerator	9Q8030-00-290-5547	MIL-S-15058 type III	1 lb can
c. Rubber topcoat (bonding cement) with accelerator	9Q8030-00-291-0966	MIL-S-15058 type III	1 gal
d. Cleaner-Thinner	9Q8030-00-205-6870	MIL-S-15058 type III	1 gal
e. Synthetic rubber sheet (1/8″ x 36″)	9Z5330-00-291-5537	MIL-S-15058 type III	-

100-2.11.5.3.1 Thoroughly stir accelerator and add to bonding cement in proportions indicated. Stir mixture vigorously to obtain maximum dispersion and until it is streak-free. Then stir for an additional five minutes. Accelerated material will have a pot life of at least eight hours, at 75°F. Higher temperatures or high humidity will decrease the pot life.

100-2.11.6 APPLICATION OF ACCELERATED BONDING CEMENT TO METAL. Apply two brush or roller coats of accelerated bonding cement over primer. The first coat shall be allowed to dry for at least 30 minutes but not more than three hours, depending upon temperature conditions, before proceeding.

100-2.11.6.1 General. Allow the bonding cement to dry, so solvents evaporate completely before rubber sheet is pressed on. Drying time may vary depending upon ambient conditions. It is advisable to press on the sheet stock before curing has progressed too far. Experience has shown that two hours drying time under normal conditions of temperature and humidity gives the best results.

100-2.11.6.2 Joining Synthetic Rubber Sheets. When it is necessary to join one rubber sheet to another to obtain required length, sheets should be joined with a minimum lap of two inches. Roughen the two surfaces to be lapped by using a flex sanding wheel or an orbital portable sander (approximately 40 grit). Clean the roughened surfaces with a brush to remove loose rubber particles.

100-2.11.6.2.1 Clean the roughened surface with a clean lint-free rag moistened with the cleaner-thinner. Apply two coats of the accelerated bonding cement to both roughened surfaces. Before proceeding, the first coat shall be allowed to dry for at least 30 minutes, and the second coat at least 30 minutes but not more than 3 hours.

100-2.11.6.2.2 Join cemented surfaces by pressing them down with a device, known as a stitcher, which is a small roller with an attached handle. The stitcher applies pressure to the bond and also works trapped air into a local area, forming a bubble. Good workmanship will preclude trapping air but if an air bubble results, it may be reduced by inserting a hypodermic needle into the bubble at a 45 degree angle and allowing air to escape slowly by stitching around and over the blister. The puncture may be repaired by applying a coat of accelerated bonding cement.

100-2.11.6.2.3 Apply specified accelerated troweling compound along the lap joint exposed to the weather, to fair the surface.

100-2.11.6.3 Application of Accelerated Bonding Cement to Synthetic Rubber Sheet. Prepare surface of the rubber to be in contact with the metal (minimum width of two inches) and apply the cement as indicated in paragraphs 100-2.11.6.2 through 100-2.11.6.2.2.

100-2.11.6.4 Application of Synthetic Rubber Sheet to Metal. Apply the prepared rubber sheet to the metal by stitching as described in paragraph 100-2.11.6.2.2.

100-2.11.6.4.1 The joint of the rubber sheet and metal should be sealed by filling with the specified troweling material, accelerated in accordance with manufacturer's instruction.

100-2.11.7 REPAIRING SYNTHETIC RUBBER SHEET. Methods of repairing a synthetic rubber sheet are described in the following paragraphs.

100-2.11.7.1 Patching Punctures and Tears. The procedure for patching punctures and tears is as follows:

1. Roughen surface of rubber around puncture or tear with steel brush or buffing wheel. Clean roughened areas with a brush to remove loose rubber.
2. Wipe surface with cleaner-thinner.
3. Prepare rubber patch overlap about 1/2-inch around periphery of damage, and wipe with cleaner-thinner.
4. Apply two coats of accelerated bonding cement.
5. Apply patch and press to obtain good bonding.

100-2.11.7.2 Repairing Areas Where Rubber Sheet Has Lost Adhesion. The procedure for renewing adhesion is as follows:

1. Remove old cement by roughening the surfaces of the metal and rubber. Clean off loose particles with a brush. Wipe both surfaces with a clean lint-free rag moistened with the cleaner-thinner.
2. Apply two coats of primer to the metal surface.
3. Apply two coats of accelerated bonding cement to both the metal and rubber surfaces.
4. Apply the prepared rubber sheet to the metal by stitching.

100-2.11.7.3 Contents of Repair Kit. The repair kit used in this process contains the following items:

a. One roll of synthetic rubber sheet, 1/8″ by 36″ by 12'
b. One gallon cleaner-thinner
c. One quart priming cement
d. One quart bonding cement
e. One pound troweling material

100-2.12 CRANES AND BOOMS, AMMUNITION STOWAGE, AND TOWING GEAR

100-2.12.1 CRANES AND BOOMS - SHIPBOARD USE. **Cranes and booms** are installed on ships to handle equipment, cargo, and other heavy weights. Requirements for inspections, tests, and maintenance are given in **NSTM Chapter 573, Booms.** During inspection of cranes, booms, rigging, and associated fittings, special care shall be given to detecting any signs of weakness in the supporting structure; for example, cracks, distortion, excessive deflection, and deterioration such as corrosion.

100-2.12.2 AMMUNITION STOWAGE. Ship contract drawings show designated stowage for all ammunition on ship's allowance and the proper method of assembling various stowage fittings. These stowage fittings and the supporting structure shall be inspected periodically for damage which might impair strength.

100-2.12.3 TOWING GEAR. Each ship is furnished with a drawing showing how to rig for towing or being towed. (Towing information is included in **NSTM Chapter 582, Mooring and Towing.**) Periodic inspections should be conducted on towing fittings and support structure.

SECTION 3

SUBMARINES

100-3.1 DAMAGE TO EXTERNAL HULL

100-3.1.1 GENERAL. Attention is directed to possible damage to external ballast and fuel tanks of double-hull submarines by shocks and bumping which would not damage the external plating of single-hull submarines.

100-3.1.2 EXTERNAL BALLAST TANKS. The plating and construction of external tanks of doublehull submarines is considerably lighter than the plating and construction of external tanks of single-hull submarines. This fact should be borne in mind in deciding on the necessity for submarines to lie alongside a dock or ship in a seaway or currents. Due to the penetrating quality of fuel oil, considerable oil leakage in external fuel oil tanks will be caused by comparatively slight damage.

100-3.1.3 EQUALIZING PRESSURE IN EXTERNAL TANKS. In general, the external ballast tanks of double-hull submarines are designed to be subjected to relatively small differential pressure. It is necessary, therefore, when the submarine is submerged, to equalize the pressure inside these tanks with the external pressure. These tanks are in some cases fitted with flood valves opening inward, with the intent that these valves be kept open when the submarine is submerged.

100-3.1.3.1 It is also necessary when carrying reserve fuel in external ballast tanks to equalize the pressure in these tanks with the external pressure. If there are air pockets in the external tanks carrying fuel oil, failure to equalize the pressure before submerging may result in partial collapse of the external hull with consequent fuel oil leaks. Except in the case of variable fuel oil tanks, connections are provided by which, when submerging, full sea pressure can be applied in a routine manner to the external tanks carrying reserve fuel. In the case of variable fuel oil tanks it is not necessary to equalize the pressure since the tanks are built to withstand full submergence pressure.

100-3.2 SUBMERGENCE DEPTH

100-3.2.1 TEST DEPTH. The depth of submergence must be that specified in the contract or specifications under which the submarine is built, except where specifically reduced by the Force Commander.

100-3.2.1.1 All submergence depths must be measured to the axis of the submarine.

100-3.2.2 EXCEEDING TEST DEPTH. The specified test depth or the operating depth established by the Force Commander is considered to be the maximum safe depth for the submarine and normally should not be exceeded.

100-3.2.2.1 In every instance, when the specified limits to submergence are exceeded, a report in full of all attendant circumstances must be made to the Chief of Naval Operations via NAVSEA.

100-3.3 DEEP SUBMERGENCE TEST

100-3.3.1 GENERAL. Submarines shall be subjected to a deep submergence test before the preliminary or official trials, as applicable, after a conversion affecting hull strength, and at least once each year thereafter, while in commission. In addition, a similar test shall be conducted on an active submarine whenever it has undergone extensive work involving pressure hull openings or alterations which may materially affect the capability of the submarine to withstand external pressure.

100-3.3.1.1 When a deep submergence test of a submarine in commission is necessary, requiring special availability, NAVSEA will inform the Chief of Naval Operations so the necessary orders for conducting the test may be issued.

100-3.3.1.2 Deep submergence tests should always be conducted in water which is, as nearly as possible, of the desired test depth, and in the presence of an escort ship capable of communicating with the submarine undergoing test. A submarine rescue ship, fully equipped, manned, and ready for rescue operations, should be in attendance during these tests whenever practical. Deep submergence conducted for tactical reasons or to meet the requirement for annual tests requires no escort ship, unless the strength of the submarine is in question.

100-3.3.1.3 Submarines making deep submergence and all other kinds of test dives must always have their rescue chamber messenger buoys ready for use, if installed. Otherwise their marker buoys as well as their signal ejectors and specified signals must be ready for use.

100-3.3.2 INSTALLATION OF BATTENS AND STRAIN GAGES. Ordinarily, deflection and strain measurements will not be required during annual submergence tests. NAVSEA will arrange to obtain such measurements for each new class of submarines and when otherwise desired. When installation of battens is directed by NAVSEA, the shipyard must install, in each compartment, at least one vertical and one horizontal batten for measuring deflections.

100-3.3.2.1 The battens are to be placed where the greatest deflections are expected to occur and must be so rigged that they will interfere as little as possible with the operation of the submarine. They shall always be at least two frame spaces from a transverse bulkhead or partial bulkhead. A zero deflection reading shall be marked

on the battens before the dive is started; or, if a dial gage is used, the reading must be recorded and deflection observations shall be made and recorded at successive depths during descent, as specified by NAVSEA, down to and including the test submergence depth.

100-3.3.2.2 Readings of deflections shall also be observed and recorded upon returning to the surface, to determine whether any permanent sets have developed.

100-3.3.2.3 When installation of strain gages is directed by NAVSEA, these gages are to be located by personnel designated to supervise their installation. A NAVSEA representative and a representative of the naval shipyard or the Supervisor of Shipbuilding must be on board each submarine on which deflection and/or strain measurements are obtained.

100-3.3.3 TEST AT MAXIMUM DEPTH. If the depth is attained by running down, the rudder must be operated through its full arc, and the bow and stern planes must be operated as necessary to maintain depth. The aiming and drainage pumps must be operated, discharging to the sea. The main motors must be operated on the propellers to ascertain that no deflections sufficient to cause binding have occurred. Full sea pressure must be admitted to all torpedo tubes.

100-3.3.3.1 Safety and negative tanks must be vented inboard, or water must be pumped from them until they contain only atmospheric pressure. This test is to demonstrate the ability of these tanks to withstand external pressure.

100-3.3.3.2 The variable ballast tanks must contain only atmospheric pressure during the test. So that blowing of main ballast tanks can be accomplished quickly and safely at any time, it is desirable that main ballast flood valves be left open as is customary during submerged operation.

100-3.3.4 RECORD OF LEAKS. A careful record must be made of all leaks discovered while at successive test depths, so necessary corrective steps can be taken. If only minor leaks develop, they should be corrected by the submarine and tender forces whenever possible. A subsequent dive of at least 100 feet to the axis should be made to ascertain that leaks have been stopped.

100-3.3.4.1 If serious leaks or defects are discovered, the repair of which is beyond the capability of the submarine and tender forces, the submarine must return to the shipyard for work, as necessary, to place it in satisfactory operating condition.

100-3.3.4.2 The question of further tests must then be taken up with NAVSEA.

100-3.3.5 REPORT OF DEEP DIVES. A full report must be made upon complete submergence when:

a. Associated with builder’s trials and acceptance trials
b. Conducted after routine overhauls or activations and the dive indicates unusual conditions requiring significant additional shipyard work, or providing information useful in the overhaul of other ships
c. Depth is exceeded (see paragraph 100-3.2.2.1)

100-3.3.5.1 This report must state:

a. Time and place of test

b. That the required test depth was reached, and the manner in which this depth was measured

c. Method of submergence

d. Deflections noted

e. Permanent sets, if any

f. Locations of the battens, if installed

g. Leaks observed, together with steps taken to stop them

h. Whether or not all tests prescribed in paragraphs 100-3.3.3 and 100-3.3.3.1 were carried out during the dive

i. Whether or not machinery and material functioned satisfactorily during these tests

j. Any other circumstances or facts developed by the test which are indicative of the ship's condition, or which would be helpful on future tests, or in new design

100-3.3.5.2 The report must be forwarded promptly to NAVSEA via the Commander of the shipyard and Unit and Force Commanders for submarines in the fleet.

100-3.3.5.3 A similar report must be made of any other deep submergence on which excessive leaks or unusual material conditions occur; or of any scheduled deep submergence test on which, for any reason, the submarine does not attain the required test depth. No report is necessary of deep submergence conducted during tactical operations, or to meet the minimum annual test requirement unless one of these special circumstances occurs.

100-3.3.6 PRECAUTIONS. It is general practice to conduct deep submergence strength tests in water, as nearly as practicable, of the depth desired, to ensure that the submarine will not be inadvertently subjected to excessive pressure. Before conducting a test, a preliminary dive should be executed to check for satisfactory tightness. During the descent on the deep submergence test, the submarine must be leveled off at depths indicated in the test plan, to permit an examination of the hull. If excessive deflections or signs of local failure develop, the test must be discontinued immediately and the submarine brought to the surface. Deflections of about 1/4-inch are not unusual.

100-3.3.6.1 Fuel oil tanks located within the pressure hull must not be exposed to sea pressure during the deep submergence test. To avoid transmission of stresses to the tank tops due to deflections in the pressure hull, an inboard vent to each group of internal fuel oil tanks must be left open during the test.

100-3.4 PRESSURE TESTS

100-3.4.1 GENERAL. During each regular overhaul or as otherwise required, the shipyard shall test tanks and spaces in accordance with **NSTM Chapter 079, Volume 4, Damage Control, Compartment Testing and Inspection.**

100-3.5 STRUCTURE EXAMINATION BY SHIPYARD

100-3.5.1 GENERAL EXAMINATION. During each regular overhaul, the shipyard shall make a careful examination of the submarine. If compartment tests indicate that the ability of the submarine to withstand external pressure has been reduced, necessary repairs shall be accomplished prior to the submergence test. If repairs

necessary to restore required strength and tightness of the submarine are extensive or unusual in character, an immediate report giving full information about the conditions, must be made to NAVSEA, with copies to the Type Commander, the submarine, and the planning yard.

100-3.5.2 HULL INSPECTIONS. During each regular overhaul, or as otherwise specified, hull structural inspections, as applicable, shall be conducted. These inspection routines are delineated in **NSTM Chapter 091, Submarine Hull Inspection** . They are:

a. Hull surveillance inspections

b. Hull survey inspections

c. Ultrasonic sampling inspections

d. Ultrasonic monitoring inspections

100-3.6 CUTTING, FITTING, WELDING, INSPECTION, AND REPAIR

100-3.6.1 The cutting, fitting, welding, and inspection of patches, closure plates, and penetrations in submarines, as well as repair of cracked welds, shall be in accordance with **NSTM Chapter 074, Volume 1, Welding and Allied Processes.**

100-3.6.1.1 Repair of corroded plates and welds shall be accomplished in accordance with **NSTM Chapters 074, Volume 1, Welding and Allied Processes and 091, Submarine Hull Inspection** .

100-3.7 MINIMUM CORRODED SCANTLINGS

100-3.7.1 The minimum thickness of submarine structure is specified in **NSTM Chapter 091, Submarine Hull Inspection.**

REAR SECTION

NOTE

TECHNICAL MANUAL DEFICIENCY/EVALUATION EVALUATION REPORT (TMDER) Forms can be found at the bottom of the CD list of books. Click on the TMDER form to display the form.