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19 June 1974
SUPERSEDING
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(See 6.4)

MILITARY SPECIFICATION

CONDENSERS, STEAM, NAVAL SHIPBOARD

This specification is approved for use by the Naval Ship Systems Command and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers steam condensers for Naval Shipboard applications.

1.2 Classification. Condensers shall be of the following types and classes as specified (see 6.1.1)

Type I - For main propulsion turbines or engines.
Type II - For turbines of steam turbo-generator sets.
Type III - For auxiliary steam turbines or steam reciprocating engines.
Type IV - For condensing gland leak-off or vent steam, including steam from ship's heating drain system vents; also for service as combined air ejector after condenser and gland leak-off condenser for a submarine application.
Class A - (Submarine application) - See table I.
Class B - (Surface ship application) - See table II.

2. APPLICABLE DOCUMENTS

2.1 The following documents of the issue in effect on date of invitation for bids or request for proposal, form a part of the specification to the extent specified herein.

SPECIFICATIONS

FEDERAL
QQ-C-465 - Copper-Aluminum Alloys (Aluminum Bronze) (Copper Alloy Numbers 606, 614, 630, and 642), Rod, Flat Products with Finished Edges (Flat Wire, Strip, and Bar), Shapes and Forgings.
QQ-N-281 - Nickel-Copper-Alloy Bar, Plate, Rod, Sheet, Strip, Wire, Forgings, and Structural and Special Shaped Sections.
QQ-N-286 - Nickel-Copper-Aluminum Alloy, Wrought.
TT-P-28 - Paint, Aluminum, Heat Resisting (1200°F).
TT-P-645 - Primer, Paint, Zinc-Chromate, Alkyd Type.
PPP-B-636 - Boxes, Shipping, Fiberboard.
PPP-B-1055 - Barrier Material, Waterproofed, Flexible.
PPP-B-40 - Packaging and Packing of Hand Tools.

MILITARY
MIL-C-104 - Crater, Wood; Lumber and Plywood Sheathed, Nailed and Bolted.
MIL-P-116 - Preservation, Methods of.
MIL-B-121 - Barrier Material, Greaseproofed, Waterproofed, Flexible.
MIL-B-131 - Barrier Material, Water Vaporproof, Flexible, Heat Sealable.
MIL-R-196 - Repair Parts for Internal Combusion Engines, Packaging of.
MIL-B-857 - Bolts, Nuts, and Studs.
MIL-S-901 - Shock Tests, H.I. (High-Impact); Shipboard Machinery, Equipment and Systems, Requirements for.
MIL-S-1222 - Studs, Continuous Thread (Bolt Studs): Nuts, Plain, Hexagon: and Steel Bars Round, High Temperature Service.
MIL-P-2863 - Packing, Preformed, Condenser-Tube (Symbol 1435).
MIL-G-5514 - Gland Design; Packings, Hydraulic, General Requirements for.
MIL-B-13239 - Barrier Material, Waterproofed, Flexible, All Temperatures.
MIL-T-15005 - Tubes, 70-30 and 90-10 Copper Nickel Alloy, Condenser and Heat Exchanger.
MIL-P-15024 - Plates, Tags, and Bands for Identification of Equipment.
MIL-P-15024/5 - Plates, Identification.
MIL-P-15137 - Provisioning Technical Documentation for Repair Parts for Electrical and Mechanical Equipment (Naval Shipboard Use).

MILITARY (Cont'd)

MIL-C-15726 - Copper-Nickel Alloy, Rod, Flat Products (Flat Wire, Strip, Sheet, Bar and Plate) and Forgings.
MIL-P-15742 - Plugs, Plastic (Heat-Exchanger-Tube).
MIL-E-15809 - Expander, Tube, Condenser and Heat Exchangers.
MIL-C-16173 - Corrosion Preventive Compound, Solvent Cutback, Cold Application.
MIL-T-16420 - Tube, 70-30 and 90-10 Copper-Nickel Alloy, Seamless and Welded.
MIL-I-17244 - Indicators, Temperature, Direct-Reading, Bimetallic, (3 and 5 Inch Dial).
MIL-A-17472 - Asbestos Sheet, Compressed (Gasket Material).
MIL-I-18997/1 - Indicators, Pressure, Circular Dial (3-1/2, 4-1/2 and 8-1/2 Inch Dial Sizes).
MIL-A-19521 - Anodes, Corrosion Preventive, Zinc, and Plugs, Zinc Anode Retaining; Design of and Installation in Shipboard Condensers and Heat Exchangers.
MIL-T-19646 - Thermometers, Remote Reading, Self-Indicating Dial, Gas Actuated.
MIL-I-20037 - Indicators, Sight, Liquid Level, Direct Reading, Reflex-Tubular Gage Glass.
MIL-C-20159 - Copper-Nickel Alloy (70-30 and 90-10): Castings.
MIL-F-21467 - Fittings, Flareless, Fluid Connection (Shipboard Use).
MIL-E-21562 - Electrodes and Rods - Welding, Bare, Nickel Alloy.
MIL-G-21610 - Gaskets, Heat Exchanger, Various Cross Section Rings, Synthetic Rubber.
MIL-E-22200/3 - Electrodes, Welding, Covered: Nickel Base Alloy; and Cobalt Base Alloy.
MIL-E-22200/4 - Electrodes, Welding, Covered, Copper-Nickel Alloy.
MIL-S-22473 - Sealing Locking, and Retaining Compounds; Single-Component.
MIL-S-23194 - Steel Forgings, Carbon and Low Alloy.
MIL-S-24113 - Steel Plates, Carbon Manganese - Heat Treated by Normalizing or Quenching and Tempering.
MIL-W-24270 - Wells for Temperature Indicators and Thermal Elements.
MIL-W-24270/3 - Well; Insertion Length - 4 Inches, Bore - 3/8 Inch, Connection-Socket Weld or Socket Brazed, 3/4 Inch IPS.
MIL-N-25027 - Nut, Self-Locking, 250°F., 450°F., and 800°F., 125 KSI FTU, 60 KSI FTU, and 30 KSI FTU.

STANDARDS

MILITARY

MIL-STD-22 - Welded Joint Design.
MIL-STD-129 - Marking for Shipment and Storage.
MIL-STD-167 - Mechanical Vibrations of Shipboard Equipment.
MIL-STD-271 - Nondestructive Testing Requirements for Metals.
MIL-STD-278 - Fabrication Welding and Inspection; and Casting Inspection and Repair for Machinery, Piping and Pressure Vessels in Ships of the United States Navy.
MIL-STD-438 - Schedule of Piping, Valves, Fittings, and Associated Piping Components for Submarine Service.
MIL-STD-777 - Schedule of Piping, Valves, Fittings and Associated Piping Components for Surface Ships.
MIL-STD-1399, Section 301 - Interface Standard for Shipboard Systems, Ship Motion and Attitudes.
MS16142 - Boss, Gasket Seal Straight Thread Tube Fitting, Standard Dimensions for.
MS17828 - Nut, Self-Locking, Hexagon, Regular-Height, (Nonmetallic Insert) 250°F., Nickel-Copper Alloy.
MS18116 - Bolt, Bolt-Stud, Stud, Stud-Bolt; Nickel-Copper-Aluminum Alloy; Special Requirements.

DRAWINGS

MILITARY

B-214 - Root Connections for Attaching Piping.
810-1385850 - Piping, Gage, For All Service.
810-1385917 - Temperature Indicator and Thermowell Selection.

PUBLICATIONS

MILITARY

NAVAL SHIP SYSTEMS COMMAND

SDB-63 - Structural Design Basis.

NAVSHIPS 250-423-30 - Shock Design of Shipboard Equipment Dynamic Analysis Method.

NAVSHIPS 0900-001-7000 - Fabrication and Inspection of Brazed Piping Systems.

DESIGN DATA SHEETS

DDS4601-1 - Steam Condensers.

NAVAL RESEARCH LABORATORY (NRL)

Report 1396 - Interim Design Values for Shock Design of Shipboard Equipment.

(Copies of specifications, standards, drawings and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer except that Design Data Sheet 4601-1 should be obtained from the cognizant Defense Contract Administration Service (DCAS) or Supervisor of Shipbuilding and the NRL Report 1396 should be obtained from Commander, Naval Ship Engineering Center, SEC 6105, Center Building, Prince George's Center, Hyattsville, MD 20782.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

A53 - Welded and Seamless Steel Pipe.

A105 - Forged or Rolled Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.

A106 - Seamless Carbon Steel Pipe for High-Temperature Service.

A131 - Structural Steel for Ships.

A193 - Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service.

A194 - Carbon and Alloy-Steel Nuts for Bolts for High-Pressure and High-Temperature Service.

A203 - Nickel Alloy Steel Plates for Pressure Vessels.

A249 - Welded Austenitic Steel Boiler, Superheater, Heat Exchanger, and Condenser Tubes.

A350 - Forged or Rolled Carbon and Alloy Steel Flanges, Forged Fittings, and Valves and Parts for Low-Temperature Service.

A508 - Quenched and Tempered Vacuum Treated Carbon and Alloy-Steel Forgings for Pressure Vessels.

A516 - Carbon Steel Plates for Pressure Vessels for Moderate and Lower Temperature Service.

A537 - Manganese-Silicon Steel Plate.

A588 - High-Strength Low-Alloy Structural Steel With 50,000 PSI Minimum Yield Point to 4 Inches Thick.

B98 - Copper-Silicon Alloy Rod, Bar, and Shapes.

B111 - Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock.

B139 - Phosphor Bronze Rod, Bar, and Shapes.

B143 - Tin Bronze and Leaded Tin Bronze Sand Casting.

B164 - Nickel-Copper Alloy Rod and Bar.

B171 - Copper Alloy Condenser Tube Plates.

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103.)

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

Boiler and Pressure Vessel Code

Section III - Rules for Construction of Nuclear Power Plant Components.

Section VIII - Division Pressure Vessels.

(Application for copies should be addressed to the American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, N.Y. 10017.)

AMERICAN ANTIONAL STANDARDS INSTITUTE, INC. (ANSI)
B1.12 - Class 5 Interference-Fit Thread.

(Application for copies should be addressed to the American National Standards Institute, Inc., 1430 Broadway, New York, N.Y. 10018.)

NATIONAL BUREAU OF STANDARDS
Handbook H28 - Screw Thread Standards for Federal Services.

(Application for copies should be addressed to the Superintendent of Documents, Government Printing Office, Washinton, D.C. 20402.)

OAK RIDGE NATIONAL LABORATORY
"CERL-II - A Computer Program for Analyzing Hemisphere-Nozzle Shells of Revolution with Axisymmetric and Unsymmetric Loadings" by S.E. Moore and F.J. Witt.

(Application for copies should be addressed to U.S. Department of Commerce, Technical Information Service, 5825 Port Royal Rd., Springfield, Virginia 22151.)

FRANKLIN INSTITUTE RESEARCH LABORATORY
Technical Report F-C2438-4 - Development of an Integrated Computer Program for Stress Analysis of Axisymmetric Double Tubesheet Heat Exchangers Subjected to Axisymmetric or Non-symmetric Thermal and Mechanical Loadings. (Defense Documentation Center Nr. AD890717L.)

SOUTHWEST RESEARCH INSTITUTE
Final Report - SWRI Project No. 03-3276 - Experimental Stress Analysis of Heat Exchanger Heads (Defense Documentation Center Nr. AD914581L).

(Application for copies should be addressed to Defense Documentation Center, Cameron Station, Alexandria, Virginia 22314.)

UNIFORM CLASSIFICATION COMMITTEE
Uniform Freight Classification Rules.

(Application for copies should be addressed to the Uniform Classification Committee, Room 1106, 222 South Riverside Plaza, Chicago, Illinois 60606.)

(Technical society and technical association specification and standards are generally available for references from libraries. They are also distributed among technical groups and using Federal agencies.)

3. REQUIREMENTS

3.1 Material. Materials shown in tables I and II shall be used in construction of the condensers as specified for the individual class. Other materials shall be as specified hereinafter.

3.2 General design.

3.2.1 Ship attitude. Unless otherwise specified (see 6.1.1), condensers shall operate satisfactorily under the ship motion conditions given in section 301 of MIL-STD-1399. In addition, submarine condensers shall be capable of operation, without flooding the turbine exhausts or air ejector suction, at trim angles up to plus or minus 45 degrees for short periods of time (less than 5 minutes).

3.2.2 Threaded parts. Threaded parts shall conform to Handbook H28. Design shall be such that standard wrenches can be used throughout. Tapered pipe threads shall not be used except for pumping groove connections. Unless otherwise specified herein form of bolts, nuts and studs shall conform to MIL-B-857. A class 5 interference fit conforming to ANSI B1.12 may be substituted for assembly of tap-end of studs. The practice of "bottoming" or "shouldering" studs shall not be used. For the set end of studs, a class 3A fit used with sealing compound, grade AV of MIL-S-22473 may be substituted for a class 5 interference fit.

Table I - Class A material (submarine application).

Part	Material	Applicable document
(a) Tube sheets, outer[1/]	Copper-nickel alloy, composition 70-30 soft temper	[5/]MIL-C-15726
(b) Tube sheets, inner[2/]	Steel, grade LF2 or LF3	ASTM A350
	Steel, grade A, B, D, E	ASTM A203
	Steel, class 1 or 2	ASTM A537
(c) Longitudinal pipe stays	Pipe, carbon steel, schedule 80	[3/]ASTM A53
		ASTM 106
		MIL-S-20157
(d) Tubes	Copper-nickel alloy, composition 70-30	[4/],[5/]MIL-T-15005
(e) Bolts or studs in joints involving sea water tightness, or subject to submergence pressure[6/]	Nickel-copper-aluminum alloy, class A, hot finished, annealed, and age hardened, or cold drawn, annealed, and age hardened	QQ-N-286
(f) Bolts or studs in contact with sea water	Nickel-copper alloy, class A	QQ-N-281
(g) Nuts for bolts and studs specified in (e)	Nickel-copper-aluminum alloy, class A	QQ-N-286
	Nickel-copper alloy, class A	QQ-N-281
(h) Nuts for bolts and studs specified in (f)	Nickel-copper alloy, class A or B	QQ-N-281
(i) Bolts, studs, and nuts exposed to steam or condensate	Corrosion-resisting steel or non-ferrous alloys	[7/]MIL-B-857
(j) Bolts, studs, and nuts for services other than as specified in (e), (f), and (i)	Carbon or alloy steel or non-ferrous alloys[8/]	MIL-B-857
(k) Stays in contact with sea water	Nickel-copper alloy, class A or B	QQ-N-281
(l) Gaskets for waterbox-tube sheet joints, waterbox cover joints, and waterbox inspection or manhole cover joints	"O"-ring, type I	MIL-G-21610
(m) Gaskets between double tubesheets	"O"-ring, type I	MIL-G-21610
(n) Gaskets for shell flange-tube sheet joints (U-bend tube-removable bundle construction), and shell covers	Packing, sheet asbestos, compressed	MIL-A-17472

See footnotes at top of next page.

1/ Outer tube sheets shall meet the inspection specified in 4.5.3 and 4.5.4.
2/ Inner tube sheets shall meet the impact test requirements in 4.3 and the inspection specified in 4.5.3 and 4.5.4.
3/ Carbon content 0.35 percent maximum.
4/ Heat transfer tubing shall conform to the tensile requirements of table 7 of the supplementary requirements of ASTM B-111 for copper alloy 715 in the annealed condition. Heat transfer tubing shall be eddy current or ultrasonically tested in accordance with MIL-T-15005 as modified in 4.5.7.
5/ Copper-nickel materials used in the units construction shall conform to the requirements of the specifications listed in table I and, in addition, shall have a yield strength of less than 48,000 pound per square inch (lb/in^2).
6/ Bolts and studs shall also conform to MS18116.
7/ Material for bolting which will be subjected to temperatures of 650°F or above shall be in accordance with MIL-S-1222, or ASTM A193, grade 7, for bolts and studs, or ASTM A194, grade 7, for nuts.
8/ See 3.2.9.5.1 and 3.2.9.5.2.

3.2.2.1 Preferred fastener types. Preferred fastener types are, in order of preference:

(a) Through bolt or through (2-nut) stud.
(b) Tap-end stud (1-nut).
(c) Cap screw or cap bolt.

3.2.2.1.1 Cap screws and cap bolts. Cap screws and cap bolts shall not be used for waterbox to shell or waterbox to tube sheet bolting, or waterbox inspection cover bolting.

3.2.2.1.2 Torque. For water side applications and for the bolting between inner and outer tube sheets, threaded fasteners shall be tightened to design torque requirements. The vendor shall establish these requirements, shall include them on outline drawings and in manual, and shall make them check-off items on the assembly inspection sheet. Threaded fasteners with torque requirements shall be lubricated by one of the following lubricants:

(a) The following lubricant shall be used on fasteners not exposed to steam or condensate where fastener preload is required:
    (1) Red lead - graphite-mineral oil. (Lubricant shall be made as follows: 4-1/2 pounds of high grade, dry red lead shall be weighed in a clean container. 1-1/4 pounds of finely divided, high grade, air-floated graphite shall be weighed in a clean container. One quart of straight mineral oil (viscosity shall be 275-325 saybolt universal seconds (SUS) at 100°F (37.8°C)), shall be measured in a clean, gallon container. Graphite shall be added slowly to the red lead, stirring contantly until the mixture is uniform in consistency and color. Mixture of red lead and graphite shall be added slowly to the oil, stirring constantly, until a smooth, uniform blend, free of lumps, is obtained. This lubricant shall not be used on alloys containing more than 15 percent nickel if the temperature of operation exceeds 400°F. Partial batches in the same proportions are acceptable.
(b) For fasteners exposed to steam or condensate where fastener preload is required, colloidal graphite in isopropanol shall be used as a thread lubricant.

3.2.2.2 Screw threads.

3.2.2.2.1 Unified thread series. Screw threads, except as specified in 3.2.2.3.3 shall be of the unified thread series in accordance with Handbook H28.

3.2.2.2.2 Coarse versus fine thread series. Coarse thread series shall be used unless the component design indicates a necessity for the use of the fine thread series.

3.2.2.2.3 Eight-thread series. For fasteners 1 inch diameter and larger, the eight-thread series shall be used wherever practicable.

3.2.2.3 Class of fit.

3.2.2.3.1 Class 2A-2B. Class 2A-2B fit shall be used for the major portion of interchangeable screw thread fasteners.

3.2.2.3.2 Class 3A-3B. Class 3A-3B shall be limited to applications where the necessity for accuracy of lead and angle of thread can be justified.

Table II - Class B material (surface ship application).

Part	Material	Applicable document
(a) Tube sheets, outer	Copper-nickel alloy, composition 90-10	ASTM B171
(b) Tube sheets, inner	Steel	MIL-S-24113
	Steel	MIL-S-23194
	Steel, class 1 or 2	ASTM A537
(c) Longitudinal pipe stays	Pipe, carbon steel, schedule 80	[1] ASTM A53
		ASTM A106
		MIL-S-20157
(d) Tubes	Copper-nickel alloy, composition 90-10	MIL-T-15005
(e) Bolts, studs and nuts in contact with sea water	Nickel-copper alloy, class A	ASTM B164
(f) Bolts, studs, and nuts in joints involving sea water tightness	Nickel-copper alloy, class A[2]	ASTM B164
	Bronze, aluminum, wrought, composition 614, stress relieved	QQ-C-465
	Phosphor-bronze, alloy A or D	ASTM B139
	Copper silicon alloy	ASTM B98
(g) Bolts, studs, and nuts exposed to steam or condensate	Corrosion-resisting or nonferrous alloys	[3] MIL-B-857
(h) Bolts, studs, and nuts for services other than as specified in (e), (f), and (g)	Steel	MIL-B-857
(i) Stays in contact with sea water	Nickel-copper alloy, class A or B	ASTM B164
(j) Gaskets for waterbox-tube sheet joints, waterbox cover joints, and waterbox inspection or manhole cover joints	Synthetic rubber, cloth inserted	Commercial, (U.S. Rubber style 210, or Garlock style 19 or equal)
(k) Gaskets for shell flange-tube sheet joints (U-bend tube-removable-bundle construction)	Packing, sheet asbestos, compressed	MIL-A-17472
(l) Condenser tube packing	Packing, flexible, metallic, grade A	MIL-P-2863

See footnotes on top of next page.

1/ Carbon content 0.35 percent maximum.
2/ Nuts may be class B of ASTM B164.
3/ In type I condensers, material for bolting which will be subjected to astern steam temperatures of 650°F or above (see 6.1.1) shall be in accordance with MIL-S-1222, or ASTM A193, grade 7 for bolts and studs, or ASTM A194, grade 7 for nuts.

3.2.2.3.3 Class 5. Class 5 interference fits shall be used only for tap-end of studs (see 3.2.2).

3.2.2.4 General rules for applications.

3.2.2.4.1 Thread engagement-nuts. Threads of nuts shall be fully engaged. Maximum protrusion of the fastener from the top of the nut shall not exceed 1/2 of the nominal height of the nut.

3.2.2.4.2 Thread engagement - tapped holes. Tapped holes for stud bolts and cap screws shall have full threads for a depth of not less than the nominal diameter of the fastener. In addition, for bolting used in areas subjected to submergence pressure, length of engagement shall meet requirements of SDB-63.

3.2.2.4.3 Internal bolting. The use of internal bolts and studs shall be avoided to the maximum extent practicable without unduly complicating the design. Where internal bolting must be removed before a part is disassembled, a warning plate so stating shall be permanently attached to the part and shall protrude beyond any lagging.

3.2.2.4.4 Locking devices. Threaded fasteners exposed to steam or condensate shall be securely locked. Self-locking nuts conforming to MS17828 may be used for low temperature applications (250°F and below). Self-locking nuts shall not have been threaded on to an engaging part more than 3 times or if 3 such engagements have been exceeded, shall not have lost more than 1/5 of its minimum breakaway torque as specified in MS17828 (see 3.10.3). Bent tab lock washers may also be used provided they are of annealed nickel-copper alloy and the gage as heavy as practicable (not less than 0.015 inch). Tab washers having only 2 tabs are not acceptable.

3.2.3 Life. Unless otherwise specified (see 6.1.1), the design shall be based on a life expectancy of 150,000 hours of operation. This includes 15,000 hours at design full power and 60,000 hours between 50 percent and 100 percent of design full power. (This represents 30 years life at approximately 58 percent utilization per year.)

3.2.4 Welding and allied processes.

3.2.4.1 For surface ship condensers, welding and allied processes shall be in accordance with class A-4 of MIL-STD-278 except as modified herein. Brazed connections may be used only for attachments to gun metal or valve bronze waterboxes; these shall be designed to permit ultrasonic testing for bond, and fabricated and inspected in accordance with NAVSHIPS 0900-001-7000, except that requirements for use of preinserted rings are applicable only to pipe fittings.

3.2.4.2 For submarine condensers, all welding on parts subjected to sea water pressure, including entire double tube sheet assembly, shall be in accordance with class A-F of MIL-STD-278 except as modified herein. Welded joints on the salt water side shall be radiographable except for vent and drain nipples. Waterbox vent and drain nipple welded connections shall meet the 100 percent weld efficiency requirement for pressure vessels.

3.2.4.3 When submarine and surface ship condensers are designed to support and maintain the alinement of turbines or turbo-generators, condenser shells and the turbine support structure, or only the latter, shall be stress-relieved after welding as required to insure adequate dimensional stability for maintenance of the turbine or turbo-generator alinement, when condensers are not designed to support and maintain the alinement of turbines or turbo-generator, thermal stress relief is not required.

3.2.4.4 For surface ship and submarine condensers, structural welding of steam dump and auxiliary exhaust pressure/velocity reducing configuration (see 3.2.17.3.1) shall be in accordance with class M of MIL-STD-278 (100 percent efficient weld joints) except that magnetic particle or liquid penetrant inspection of root welds and finished weld surfaces may be substituted for radiography.

3.2.5 Piping, valves, fittings, and associated piping components shall be in accordance with MIL-STD-777 for surface ships, and with MIL-STD-438 for submarines except as modified herein. In addition to brazing flanges allowed by MIL-STD-777, welded copper-nickel flanges of either the slip-on or weld-neck design are acceptable provided that interface geometry is not affected. For submarine systems subject to submergence pressure (category and group C-1), requirements will be as specified (see 6.1.1). Root connections shall be designed to minimize stress concentrations and shall have the increased wall thicknesses required by Drawing B-214. Methods and types shown on Drawing B-214 illustrate the desired principles. The location and general arrangement of piping shall provide ready access for take down and maintenance.

3.2.6 Mercury (Hg) shall not be used for any service (except fluorescent or Hg vapor lighting) in the production and testing of condensers.

3.2.7 Shock. When shock-resistance is required (see 6.1.1), condensers shall be grade A, class I equipment as defined in MIL-S-901 and shall pass the high-impact shock test specified in 4.4.1.

3.2.7.1 Shock-resistant design.

3.2.7.1.1 Clearance for bolts shall be no greater than the following unless permitted by the applicable pipe flange standard:

Nominal bolt diameter (Inches)	Nominal diameter of hole (Inches)
3/4 and smaller	Nominal bolt diameter + 1/32
Larger than 3/4	Nominal bolt diameter + 1/16

3.2.7.1.2 Where braces must be employed to afford stability under shock or vibration, the braces shall be designed to fail under a load caused by a force equal to five times the weight of the unit. This load shall be assumed to be acting at the center-of-gravity of the unit.

3.2.7.2 Static design method. Shock design of apparatus not ordered tested in accordance with 4.4.1 shall be based on the minimum "g-load" values for the vertical, athwartships, and fore and aft directions as specified (see 6.1.1).

3.2.7.2.1 Use of "g-load" values. The apparatus shall be capable of withstanding shock loads due to steady acceleration at the static "g-load" values applied separately in each direction. Each mass element of the unit shall have an inertia load applied equal to (dm X G X g), where:

dm = distributed mass
G = static g-load value tabulated above
g = acceleration-of-gravity

The resulting stresses and deflections, when added to the maximum normal operating values, shall not exceed allowable stresses or deflections as limited by equipment operation.

3.2.7.2.2 Allowable stresses. The combination of shock and operating stresses shall not exceed the 0.2 percent offset yield strength at operating temperature where deflection or alinement is critical or where a slight plastic set is not permissible. The criteria for failure when plastic set is permissible is the effective yield strength of the material (except for condenser tubes where consideration will be given to the acceptance of calculated stresses up to 2.0 times the yield strength of the material provided the configuration does not become unstable or result in fracture). This effective yield strength in tension and shear is represented by σ and τ respectively, which are defined as:

$$\sigma = \sigma_y + F(\sigma_u - \sigma_y)$$
$$\tau = 0.6\sigma$$

Where: σ_y is the 0.2 percent offset yield, elastic limit or other normal definition of material yield strength (shall be taken from applicable material specification).
σ_u is the normal definition of material failure strength (shall be taken from applicable material specification).
F is a factor which takes into account the efficiency with which the material in the member is utilized and is dependent on the kind of loading and cross section of the member. The value of F is equal to (that load required to completely yield the member divided by that load required to just initiate yielding -1).
F equals zero for members in tension and where material has less than 10 percent elongation before fracture in a tension test; F equals 0.5 for a rectangular section in pure bending.

3.2.7.2.3 Dynamic analysis. When specified (see 6.1.1), the manufacturer shall conduct a concurrent dynamic analysis. The acceptable design analysis method is outlined in NAVSHIPS 250-423-30 using the input quantities for the appropriate type of installation (submarine or surface ship) from NRL Report 1396. The mathematical model that the contractor proposes to use shall be approved by the drawing review agency (see 6.2), prior to release for fabrication. For a multi-degree of freedom system, the shock/stress deflection is the sum of the greatest stress/deflection for any mode and the square root of the sum of the squares of stresses/deflections calculated for the other modes. The number of modes shall be not less than half the number of degrees of freedom. A sufficient number of modes shall be taken so that the total of modal weights considered will be not less than 80 percent of the total weight of the condenser. Allowable stresses/deflections are given in 3.2.7.2.2. Items found deficient by the analysis shall be identified and corrective actions proposed.

3.2.7.2.4 Stress report. When calculations by the static design method or the dynamic design method are required, a stress summary report shall be submitted along with the calculations to the drawing review agency for approval. Report shall cover all areas for which shock stresses were calculated and shall indicate the applicable yield strength for each stress reported.

3.2.7.5 Exceptions. The above basis for shock design applies except in the following cases:

(a) When the apparatus proposed is of identical design to one that has been previously shock tested and finally accepted by the Navy, such design shall be acceptable if it meets all other requirements for the proposed application.

(b) When the apparatus proposed is of identical design to one that has been previously dynamically analyzed and such analysis has been finally accepted by Navy, such design shall be applicable if:
  (1) The mathematical model applies without change; i.e., the equipment involved is a repeat procurement for which the foundation and other equipment affecting the model are the same.
  (2) The apparatus meets all other requirements for the proposed application.

(c) When the apparatus proposed is similar, but not identical, to a design previously tested or dynamically analyzed and accepted by the Navy, the manufacturer may define areas of dissimilarity, including calculated "g-load" capability in these areas, and propose to the Navy the acceptance of such design in lieu of the requirement in 3.2.7.2. If the drawing review agency concurs that the similar design will provide equal or better shock capabilities in the intended application, extension approval will be given.

3.2.7.6 Positive means other than shear resistance of waterbox bolting shall be provided to prevent waterbox displacement relative to the tube sheet under vertical and transverse shock.

3.2.8 Condenser design.

3.2.8.1 Condensers for submarine service shall have the sea water side, including the double tube sheet complex, designed to withstand the design pressure (see 6.1.1), temperature (see 6.1.1) and cyclic conditions (see 3.2.13.2.2, 3.2.13.4, 3.2.13.5.3, 3.2.15.4.1.1 and 3.2.15.4.1.2). The ability of the condenser to withstand the loads resulting from the design pressure, temperature, and cyclic conditions shall be demonstrated by the use of methods and criteria contained in SUB-63. Guidance with regards to structural design of waterboxes may be obtained from Southwest Research Institute Report "Experimental Stress Analysis of Heat Exchanger Heads". An acceptable method of calculating local stresses in nozzles at the nozzle-hemisphere intersection (no local reinforcement) resulting from external loading is Oak Ridge National Laboratory's computer program "CLRL-II" (see note 1). An acceptable method of analysis for double tube sheet complexes is the computer program "HYBUS" (see note 2), presented in Franklin Institute Research Lab. Report F-C2438-4. The manufacturer may use other comparable methods of analysis for calculating local stresses in nozzles at the nozzle-hemisphere intersection and for analyzing double tube sheet complexes. Material properties shall be as specified in SUB-63 or herein.

NOTE 1. Computer program source deck is available from NAVSEC (Code 6147).
NOTE 2. Computer program will be made available upon application to NAVSEC (6147) to naval activities and contractors engages in current submarine condenser design effort.

3.2.8.2 Condensers for submarines shall be designed to operate at an ambient pressure of 30 inches of Hg., absolute with a variation of plus of minus 6 inches Hg., and shall not be damaged when subjected to an ambient pressure of between 10 and 30 pounds per square inch absolute (lb/in^2a) with the minimum internal pressure which will prevail under any condition of operation.

3.2.8.3 Condensers shall be capable of operating at any back pressure from minimum obtainable to standard atmospheric pressure during the condenser life.

3.2.8.4 For surface ship condensers, the sea water side, including the double tube sheet complex for nuclear ships, shall be designed to withstand the design pressure and temperature, and all parts subjected to such pressure and temperature shall be designed in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII (Division I). Unless otherwise specified (see 6.1.1), design (maximum working) pressure for the sea water side shall be 20 lb/in^{2}g. Waterbox shell thickness shall be established under the rules of Section VIII, Division I. Use of the calculation method to establish design thickness is restricted to those simple shapes for which thickness formulas are given in Section VIII, Division I. Where noncalculable configurations are used (as defined in Section VIII, Division I the provisions of paragraph UG-101 in Section VIII, Division I shall be met and test results be submitted to drawing review agency for review and approval. Other methods may be employed if approved by the drawing review agency. Welded joints on the waterbox shall be of the full penetration type except for attachment of waterbox stiffeners, for attachment of the principal flange to the waterbox, and for nozzle to nozzle flange attachment; weld joint design for the latter two attachments may be of the slip-on type with welded joint design conforming to P-16 of MIL-STD-22 (see 3.2.15.12.1). Intermittent welding in attachment of waterbox stiffening members shall not be allowed. Weld joint efficiencies shall be in accordance with Section VIII, Division I.

3.2.9 Shells. If known, the shell limiting dimensions shall be specified by the command or agency concerned (see 6.1.1). The shell shall be stiffened by shapes welded to the shell plates, as required. Entire shell shall be constructed using welded joints. Shells for condensers, except as specified in 3.3.2.4, shall have a minimum plate thickness of 3/16 inch for cylindrical shells or 1/4 inch for other shapes. Where the thickness of steel condenser shells is determined by calculations, a corrosion allowance of 1/32 inch shall be provided for types I, II and III condensers, and a corrosion allowance of 1/16 inch shall be provided for type IV condensers.

3.2.9.1 Shells for straight tube units. Tube sheets shall form the shell ends and be directly welded thereto, or shall be welded to an extended neck or collar section of the shell. For surface ship condensers, the shell to tube sheet weld shall be of the full penetration type and be liquid penetrant or magnetic particle inspected to the requirements of MIL-STD-278. For submarine condensers, the shell to tube sheet weld shall be of the full penetration type and shall be in accordance with class A-F of MIL-STD-278 except that, if a radiographable weld cannot be provided, the weld shall be magnetic particle or liquid penetrant inspected on the root passes, the back chipped side of the initial root weld, and the surface passes, to the requirements of MIL-STD-278 in lieu of being radiographed.

3.2.9.2 Shells for U-bend tube units. The requirements of 3.2.9.1 shall apply except, that when removable tube bundle is specified (see 6.1.1), a flange shall be welded to the open end of the shell for securing the tube sheet assembly and waterbox. The shell to flange weld (full penetration type) shall be magnetic particle or liquid penetrant inspected to the requirements of MIL-STD-278. When removable tube bundle is specified the interior of the shell shall be provided with guides or rails for easy removal of the bundle with no cutting or burning operations required. If the bundle is not removable, complete retubing shall be possible with no cutting of the shell required, such as by providing a bolted closure at the end of the shell away from the tube sheet. U-bend tube condensers shall be provided with an inspection opening at the U-bend end to permit inspection of outer tube U-bends.

3.2.9.3 Provisions for expansion of tubes and shells. Shells for condensers in which straight tubes are expanded at both ends shall have positive means provided to compensate for the relative expansion between shell and tubes. Bowing of tubes is not an acceptable means of providing for relative expansion between shell and tubes. Additional means, such as one flexible support foot (small condensers), or lubricated sliding support foot or feet (large condensers), shall be provided on the condensers except those suspended from the turbine exhaust flange, to compensate for expansion and contraction of the shell. When a flexible support foot is used, the fixed foot and its foundation bolting shall be designed to withstand the full-load due to high-impact shock in the direction longitudinal of the condenser. Sliding feet shall be provided with oversized foundation bolt holes and shouldered bushings for the foundation bolts, so machined as to allow not more than 0.005 inch clearance between the bottom surface of the bushing shoulder and a finished or spot-faced surface of the foot. In addition, keys shall be provided in the supporting feet as necessary to withstand high-impact shock and to preserve the alinement of the turbine when supported by the condenser. Arrangement of foundation bolting and keys shall be worked out between the shipbuilder and the condenser manufacturer and shall be subject to approval of the drawing review agency for double tube sheet condensers. Condensers with U-bend tubes shall have provision for shell expansion as described herein. Condensers with U-bend tubes do not require shell expansion joints.

3.2.9.3.1 Expansion joints. Expansion joints shall be designed to permit accomplishment of field repairs and field replacement. Expansion joint design shall consider the effects or corrosion, fatigue stresses (for all condensers except type I condensers of non-nuclear powered ships - 10,000 cycles of normal condenser operation from start up at 70°F to full-power at 28°F inlet water temperature; for type I condensers on non-nuclear powered ships - 10,000 cycles from full-power ahead to full-power astern with 75°F inlet water temperature) and shock stresses. For double tube sheet condensers, justification of expansion joint design and outline of field repair and replacement methods shall be submitted to the drawing review agency for approval. Methods of field repair and field replacement of expansion joints shall be included in the condenser technical manual in detail. Where the configuration of the joint will result in condensate being trapped, fittings on the joint and on the hotwell shall be provided for running a drain line to insure joint drainage. Outline drawing and the manual shall indicate the proper method of running this line.

3.2.9.4 Supporting feet or brackets shall be designed to secure the condenser, its components and accessories adequately when the ship is listed, rolling, or pitching (see 3.2.1) and for the shock conditions specified in 3.2.7. Nozzle flanges or piping shall not constitute the primary means of support of components or accessories. Where design of supports is based on use of holddown bolts of higher strength than grade 2 of MIL-B-857, specific information for shipbuilder's guidance shall be given on the outline drawing. For submarine condensers adequate jacking screws shall be fitted in each supporting foot for use during installation and alinement of the condenser.

3.2.9.5 Nozzles or pads shall be welded to the shell. Nozzles may be fabricated of short lengths of pipe provided with a flange, and pads may be bar stock or plate of requisite thickness for studs. Nozzles shall be of the minimum length possible for through bolts. Flanges and pads shall be in accordance with applicable piping schedules, except where applicable category and group for the connection requires non-ferrous material, the mating condenser flange and nipple or pad connection may be of steel in conformity with the appropriate flange specification.

3.2.9.5.1 When pads are furnished, the pads shall be tapped for studs and the studs and nuts shall be furnished and installed by the condenser manufacturer. Studs and nuts furnished on condenser shells for submarines shall be of the non-ferrous materials specified for items (f) and (h) in table I.

3.2.9.5.2 Access openings in the shell of condensers for submarines, flanges of which are in the form of pads tapped for studs, shall be provided with studs and nuts of the materials specified in 3.2.9.5.1. The vendor shall provide internal access to examine and repair condenser steam impingement baffles with condenser tubes in place. The location of access covers shall be mutually agreed between the condenser vendor, shipbuilder, and drawing review agency.

3.2.10 Baffles for separating the condensing surface from the air cooling surface shall be fitted as necessary and their arrangement shall be such as to produce minimum interference with the effectiveness of any cooling surface.

3.2.10.1 Baffles over the air cooling section shall be located high enough so that the air suction will not be blocked off by a normal rise of condensate level, or by operation under any of the conditions of ship attitude. Air ejector suction connections shall be located high enough on the shell to provide for drainage into the condenser.

3.2.11 It is the responsibility of the vendor to insure that turbine exhaust, auxiliary exhaust (see 3.2.17.3.1) and dump steam (see 3.2.17.3.1), are introduced into the condenser in such a manner that condenser tubes, shell and internals will not be damaged by high velocity steam or any moisture picked up and carried by the steam flow.

3.2.11.1 For exhausts of turbines which are supplied with saturated steam, for dump steam (see 3.2.17.3.1.2) and for auxiliary exhaust (when required - see 3.2.17.3.1.2), three rows of impingement tubes shall be installed to protect the tube bundle unless otherwise approved by the drawing review agency. Impingement tubes shall be 3/4 inch outside diameter (o.d.) of 16 Birmingham Wire Gage (BWG) minimum nominal wall thickness and the material shall be stainless steel. If welded impingement tubes are furnished, tubing shall be in accordance with ASTM A249 in an annealed condition. The first two rows of impingement tubes shall be arranged on a 1-inch nominal triangular pitch. Arrangement of the third row of impingement tubes shall be such that steam entering the arc of impingement tube protection will not be able to enter the tube bundle without striking at least one impingement tube. Space between the inner row of impingement tubes and the tube bundle periphery shall be minimized in order to reduce reacceleration of water droplets. Impingement tubes shall not penetrate any tube sheet. Length of the impingement tubes and the arc of coverage shall be such that any straight line to the tube bundle from the turbine exhaust trunk exit, steam dump baffle exit (see 3.2.17.3.1), and auxiliary exhaust baffle exit (when required see 3.2.17.3.1) will pass through this arc of coverage or through the metal of a tube support plate. For submarine condensers, the impingement tube support plates shall be attached to the condenser shell and shall not contact tubes or tube support plates. Arrangement of the impingement tubes and their method of support shall be submitted to the drawing review agency to demonstrate that the requirements of this paragraph have been met.

3.2.11.2 For condensers serving turbines supplied with saturated steam, stay rods, or other structural members in the turbine exhaust area and subject to direct impingement of turbine exhaust steam shall be protected against erosion by either covering them with sleeves of erosion resistant material or other similar means.

3.2.12 Type I, II, or III condensers shall be provided with a condensate sump or well having a volumetric capacity at maximum design working condensate level equal to or exceeding the volume of condensate handled by the condensate pumps during 1 minute of normal operation when the connected equipment is operating at rated full-load. Condensate sump or well shall be attached to the bottom of the condenser shell; shall be provided with the necessary swash plates, liquid level gage connections, clean-out holes, flanged connections for the condensate pump suctions; and, if required for maintaining proper submergence of the condensate pump suctions under the conditions specified in 3.2.1, a drain pocket extending the length of the hotwell and having the low point and suction connections at the end nearest the pumps. Type IV condensers shall be provided with condensate outlet(s). To minimize the amount of foreign material that may enter the condensate pump suction, the condensate pump suctions of condensers shall incorporate a 1-inch high standpipe arrangement whenever the pump suction is taken from the bottom of the hotwell.

3.2.13 Tube sheets and supporting plates.

3.2.13.1 Tube sheets shall be rolled in one-piece. The minimum tube sheet thickness for expanded tubes shall be 7/8 inch, and for packed tubes it shall be 1 inch.

3.2.13.2 Sea water cooled condensers for nuclear propelled surface ships and submarines shall be provided with double tube sheet construction. Tubes shall be expanded into both the outer and inner tube sheets at each end.

3.2.13.2.1 Double tube sheets shall be separated by a space at least 1/2 inch wide. Space shall be vented and drained to atmosphere. Space may be formed by machining the face of one or both tube sheets, or a spacer may be used bewteen the tube sheets.

3.2.13.2.2 It shall be the responsibility of the vendor to determine the width of the space between the tube sheets so that the span of the tubes included will be sufficient to prevent the tubes from being overstressed due to radial expansion differentials of the tube sheets under cyclic operating conditions, including start-up-normal operation, shutdown, astern operation and steam dumping. Conditions of operation shall assume 28° and 85°F inlet circulating water temperature, water velocity as produced by full-speed circulating pump operation and the highest steam temperature condition in the shell resulting from the above mentioned cyclic conditions. Calculations to support the structural adequacy of the double tube sheet assembly (i.e. tubes, tube sheets, spacers) shall be submitted to the drawing review agency in support of the outline drawings.

3.2.13.2.3 Double tube sheet design for nuclear propelled surface ships shall be in accordance with one of the following:

(a) Bolted and gasketed. Outer tube sheet shall be secured to the inner tube sheet or spacer piece (if furnished) by means of threaded fasteners which shall be of sufficient size and number to maintain tightness of the gasketed joint when the specified water side hydrostatic test pressure (see 4.2.1.6) is applied to the space between double tube sheets without dependence on the waterbox flange bolting. Gasket shall be replaceable without necessity for retubing the condenser. The spacer piece (if furnished) shall be welded to the inner tube sheet, and this weld (full penetration weld) shall be liquid penetrant or magnetic particle inspected to the requirements of MIL-STD-278. The structural adequacy of this welded joint shall be justified by analysis.

(b) Completely welded. Outer tube sheet shall be secured to the inner tube sheet by a welded joint which shall maintain the tightness of the assembly when the specified water side hydrostatic test pressure (see 4.2.1.6) is applied to the space between the sheets without dependence on the waterbox flange bolting. The welded joint (full penetration weld) shall be liquid penetrant or magnetic particle inspected to the requirements of MIL-STD-278. Structural adequacy of this welded joint shall be justified by analysis. Distortion of tube sheets due to welding adversely affecting tube hole alinement shall not be permitted.

(c) Seal welded. Outer tube sheet shall be secured to the inner tube sheet or spacer piece (if furnished) by means of threaded fasteners which shall be of sufficient size and number to maintain tightness of the welded seal joint when the specified water side hydrostatic test pressure (see 4.2.1.6) is applied to the space between double tube sheets without dependence on the waterbox flange bolting. A membrane seal weld shall be used to seal the joint between the outer tube sheet and inner tube sheet or spacer piece (if furnished). The spacer piece (if furnished) shall be liquid penetrant or magnetic particle inspected to the requirements of MIL-STD-278. The structural adequacy of this welded joint shall be justified by analysis (see 3.2.13.2.4).

(d) Other designs. Other designs may be employed if specifically approved by the drawing review agency. Designs shall permit examination of all tube-to-tube sheet joints for leakage at the outer tube sheet during hydrostatic testing of the void space between the tube sheets.

3.2.13.2.4 Double tube sheet seal weld membranes.

3.2.13.2.4.1 Seal weld membranes shall be nonstructural except for the fluid pressure load on its own area and loading imposed by 3.2.13.2.4.2.

3.2.13.2.4.2 Seal weld membranes shall accommodate the relative motion between adjacent parts under all operating and nonoperating conditions including preload, shock, vibration, all transient and steady state temperatures and pressures, shipping, handling, and assembly.

3.2.13.2.4.3 Seal weld membrane materials shall be in accordance with MIL-C-15726, MIL-T-16420, or QQ-N-281.

3.2.13.2.4.4 Seal welds shall be capable of being repaired with onboard hand tools and by manual arc welding. Repair procedure shall be included in the component technical manual.

• 3.2.13.2.4.5 Condenser manufacturer shall perform pressure and deflection cycling test to prove the adequacy of all seal weld membrane designs used. Condenser manufacturer may submit to the command or agency concerned experimental and analytical data for similar seal weld membrane designs and operating conditions as justification for requesting waiver of pressure and deflection cycling tests.

3.2.13.2.4.6 External surface of the seal members shall be accessible for examination or practical repair without cutting any welds.

3.2.13.2.4.7 Design of the condenser shall permit the detection and location of leaks in all seal weld membranes during hydrostatic testing of the void space between the tube sheets.

• 3.2.13.2.4.8 For surface ship application, the seal weld shall be liquid penetrant inspected to the requirements of MIL-STD-278. For submarine application, each weld pass shall be inspected in accordance with MIL-STD-278.

• 3.2.13.3 Tube sheets shall be machined to accommodate tubes expanded at both ends for submarine and nuclear-propelled surface ship condensers, and expanded at the water inlet end and expanded or packed at the water outlet end for non-nuclear surface ships. Lack of normality between drill spindle path and surface of tube sheet shall not exceed 0 degrees, 20 minutes. For submarine condensers, holes into which tube ends will be expanded shall be machined to a diameter of 0.626 inch with a tolerance of plus 0.005 inch, minus 0.000 inch (see 4.1.2.1.1). For nuclear-propelled surface ship condensers, holes into which tubes will be expanded shall be machined to a diameter of 0.626 inch with a tolerance of plus 0.007 inch, minus 0.000 inch (see 4.1.2.1.3). For non-nuclear surface ship condensers, holes into which tubes will be expanded shall be machined to a diameter of 0.626 inch with a tolerance of plus 0.007 inch, minus 0.000 inch. For the case of tubes to be expanded at both ends, the minimum tube sheet ligament shall be 0.182 inch unless fatigue calculations for a submarine condenser establish the need for a thicker ligament, in which case such design value shall become the minimum ligament thickness. Out-of-roundness of these holes shall not exceed 0.001 inch. When both ends of the tubes are to be expanded the tube sheet holes shall be grooved as follows:

(a) Condensers for non-nuclear surface ships. One groove, 0.025 inch wide, 0.007

inch deep, with the outer edge of the groove 3/8 inch from the outer (water) side of the tube sheet.

(b) Condensers for nuclear propelled surface ships. Outer tube sheets, as specified in (a). Inner tube sheets, no groove.

(c) Condensers for submarines. Outer tube sheets, three grooves, 1/16 inch wide, 0.007 inch deep, 3/32 inch apart, located with the outer edge of the first groove 5/16 inch from the outer (water) side of the tube sheet. Inner tube sheets shall be provided with three grooves 1/16 inch wide, 0.007 inch deep, located midway of the rolled joint.

For the case of tubes to be packed at the outlet ends, the tube sheet hole shall be drilled to a diameter of 0.635 inch, then counterbored truly concentric to a depth of 3/4 inch, and tapped 7/8 inch diameter, 18 threads-per-inch. For these holes the minimum tube sheet ligament shall be 0.148 inch in way of counterbore (prior to threading). All tube holes at each face of tube sheet shall be deburred and rounded off to a radius of approximately 1/16 inch, or chamfered using chamfer of 1/16 inch by 45 degrees to remove the corner, except that the water inlet end of tubes on the outer (water) side of tube sheet, the tube holes shall be belled with 1/2 inch radius to a diameter of 3/4 inch.

3.2.13.3.1 Design tube pitch shall be established by taking the sum of the following values:

(a) Minimum ligament.
(b) Maximum allowable hole diameter (see 4.1.2.1.1 and 4.1.2.1.3).
(c) Maximum drill runout multiplied by two.
(d) Maximum hole location error multiplied by two.
(e) An error factor.

A breakdown of these numbers upon which design tube pitch is based shall be shown on the tube sheet drawing. For submarine condensers this calculation of design tube pitch shall be submitted to the drawing review agency for approval with the fatigue calculations for the tube sheet.

3.2.13.3.2 Holes for tubes in double tube sheets shall be so machined that each hole in the outer tube sheet registers accurately with the corresponding hole in the inner tube sheet This alinement shall be examined by the method described in 4.1.2.1.2.

3.2.13.4 For submarine condensers, the structure composed of outer and inner tube sheet together with the short sections of tubes between paired inner and outer sheets shall be designed to withstand the specified design pressure in combination with the specified piping loads with full consideration being given to the cyclic nature of the pressure loading and sea water and steam side temperatures. Design shall be based on 20,000 cycles to full design submergence and associated temperature variations and other transients as specified (see 6.1). An analysis of fatigue loading on a cumulative damage basis shall be submitted to the drawing review agency. Tube sheet structure shall be capable of withstanding 200 cycles each of the specified hydrostatic test pressure when applied in the waterbox or between the double tube sheets (see 4.2.1.5 and 4.2.1.6).

3.2.13.4.1 The double tube sheet design for submarine application shall be in accordance with one of the following:

(a) Bolted and gasketed. Outer tube sheet shall be secured to the inner tube sheet or spacer piece (if furnished) by means of threaded fasteners which shall be of sufficient size and number to maintain tightness of the "O-ring" gasketed joint when the specified design pressure (see 3.2.13.4) is applied to the space between double tube sheets without dependence on the waterbox flange bolting. "O-ring" gasket shall be replaceable without necessity for retubing the condenser. The spacer piece (if furnished) shall be welded (full penetration weld) to the inner tube sheet, and this weld may be inspected on the root passes, the back-chipped side of the initial root weld, and the surface passes, to the requirements of MIL-STD-278 in lieu of radiographic inspection, if so elected. If materials involved are not magnetic, liquid penetrant inspection of the root passes, the back-chipped side of the initial root weld, and the surface passes, to the requirement of MIL-STD-278 may be substituted for radiographic inspection. The structural adequacy of this welded joint shall be justified by analysis.

(b) Completely welded. Outer tube sheet shall be secured to the inner tube sheet by a full penetration butt welded joint which shall maintain the tightness of the assembly when the specified design pressure (see 3.2.13.4) is applied to the space between the sheets without dependence on the waterbox flange bolting. For providing a sound weld root condition, the use of consumable insert or alternate means (which must be proven satisfactory to the drawing review agency) is required. It shall be demonstrated by means of a full scale mock-up that no detrimental distortion of tube sheets occurs during the welding process. Weld shall be in accordance with class A-F of MIL-STD-278 except that magnetic particle inspection shall be substituted for radiographic inspection; in addition to the magnetic particle inspection coverage required for class A-F vessel welds, a magnetic particle inspection to the same standards shall be carried out on each pass of the weld. If materials involved are not magnetic, liquid penetrant inspection of each weld pass in accordance with MIL-STD-278 shall be substituted for magnetic particle inspection.

(c) Seal welded. Outer tube sheet shall be secured to the inner tube sheet or spacer piece (if furnished) by means of threaded fasteners which shall be of sufficient size and number to maintain tightness of the welded seal joint when the specified design pressure (see 3.2.13.4) is applied to the space between double tube sheets without dependence on the waterbox flange bolting. A membrane seal weld shall be used to seal the joint between the outer tube sheet and inner tube sheet or spacer piece (if furnished). The seal weld membrane shall meet the requirements of 3.2.13.2.4. The spacer piece (if furnished) shall be welded (full penetration weld) to the inner tube sheet, and this weld may be inspected on the root passes, the back-chipped side of the initial root weld, and the surface passes, to the requirements of MIL-STD-278 in lieu of radiographic inspection, if so elected. If materials involved are not magnetic, liquid penetrant inspection of the root passes, to the requirements of MIL-STD-278 may be substituted for radiographic inspection. The structural adequacy of this welded joint shall be justified by analysis.

(d) Other designs. Other designs may be employed if specifically approved by the drawing review agency.

Designs shall permit examination of all tube-to-tube sheet joints for leakage at the outer tube sheet during hydrostatic testing of the void space between the tube sheets.

3.2.13.5 Tube sheets of condensers for surface ships (except for U-bend tube condensers with removable bundles (see 3.2.9.2)) shall be welded to the condenser shell or to an extended neck or collar section of the shell. Tube sheets shall be sufficiently larger than the shell attachment to act as flanges to which the waterboxes shall be bolted. Studs shall be used to attach the waterboxes only where it is impracticable to use through bolts. When U-bend tube removable bundle construction is utilized, the tube sheet shall be secured to the flange of the shell by through bolts or studs which shall extend through the waterbox flange. Likewise, in U-bend tube removable bundle construction, studs shall be used only where it is impracticable to use through bolts. Designs shall be such that a positively tight joint between the tube sheet and shell flange is maintained at all times and that this joint will not be broken when the waterbox is removed. Accordingly, in U-bend tube removable bundle construction when through bolts are used, at least every second bolt should be a collar bolt. Bolts, including collar bolts, shall be renewable without removing the waterbox. Collar bolts shall have a square extension beyond the threads on one end for use with a wrench to prevent turning of the bolt when the nuts are tightened or removed. As an alternative to collar bolts, the use of continuous threaded stud bolts with the tube sheet threaded is permitted; these shall have the square extension on one end.

3.2.13.5.1 When necessary to fasten attachments to the tube sheets, studs accessible from the waterbox or steam space shall be used; stud holes shall not extend or penetrate through the tube sheet unless the hole is blanked by a brazed or welded closure. Stud holes which penetrate through the tube sheet shall be hydrostatically tested before the tube sheet is tubed as specified in 4.2.1.2.

3.2.13.5.2 Inner tube sheets of submarine condensers shall be welded to the shell, except for U-bend tube units with removable bundles. Inner tube sheets shall be sufficiently larger than the shell end attachment to act as flanges to which the waterboxes shall be bolted.

3.2.13.5.3 For all waterbox and tube sheet bolting on submarine and surface ship condensers, the following requirements shall apply:

(a) Bolting shall be tightened to a stipulated prestress value by means of a torque wrench.
(b) Drawings shall contain instructions covering the prestressing of bolts and a full description of the procedures shall be contained in the technical manual.

(c) For submarines, bolting design including stipulated prestress values shall be established as provided by SDB-63 hereinafter, and supporting calculations shall be furnished.

(d) Bolting design shall allow margin between the minimum and maximum acceptable prestress values. The margin shall be sufficient to guarantee that an actual bolt stress which is 1/3 above the stipulated value is not greater than the upper prestress limit, and that an actual bolt prestress which is 1/3 below the stipulated value is not less than the lower prestress limit. Calculations supporting the upper and lower prestress limits shall be furnished for submarine condensers.

(e) For submarines, studs used in sea water boundary application shall not be physically reversible unless functionally reversible.

3.2.13.6 Tube supporting plates shall be so spaced that the unsupported tube length between tube sheets and support plates or between support plates will not exceed 3-feet. Supporting plates (non-removable bundles) shall be welded to the shell or supported by angle clips welded to the shell and welded or bolted to the plates. Holes in the tube supporting plates shall be arranged so that tubes do not chafe and so that a minimum of tube vibration occurs. Tube supporting plates shall be at least 9/16 inch thick and the tube holes in the supporting plates shall be 41/64 inch in diameter with both edges of holes rounded off to a radius of approximately 1/16 inch or chamfered using 1/16 inch - 45 degree chamfer.

3.2.14 Stays.

3.2.14.1 When tubes are packed at one end (non-nuclear surface ship application) the tube sheets shall be stayed with longitudinal through stays as necessary. The stays shall be schedule 80 steel pipe with provisions for threading a tap bolt or stud into each end.

3.2.14.1.1 Tap bolts shall be threaded into each end of the stay and backed out until the heads bear on the inner surfaces of the tube sheets and shall be welded thereto.

3.2.14.1.2 As an alternative, tube sheets shall be drilled through to provide passage for studs to be threaded into the ends of the longitudinal through stay. Acorn nuts shall be threaded on the ends of the studs protruding from the exterior of the tube sheets, shall be drawn up snug, bearing on the exterior faces of the tube sheets, and seal welded thereto. Tap bolts and studs shall be of materials specified for item (e) of table II. Acorn nuts shall be of copper-nickel material of the same composition as the tube sheet, or of nickel-copper alloy.

3.2.14.2 Stays shall not be fitted in the waterboxes except as necessary to support the flat surfaces of circulating water inlet and outlet nozzles; they shall be welded to the walls of the nozzles.

3.2.14.3 In condensers having the shell extended for forming the main exhaust connection, sufficient stays shall be provided for the flat surfaces involved. These steam-side stays shall be attached by welding at the end and at points where they pass through any plate stiffeners to promote rigidity of the structure.

3.2.15 Waterboxes.

3.2.15.1 Waterboxes shall be so proportioned as to provide sufficient area at all points for easy flow of the circulating water, and for uniform distribution of water to all tubes in each pass.

3.2.15.1.1 Waterboxes of condensers for submarines shall be of hemispherical or semi-ellipsoidal form, except the semi-ellipsoidal form shall not be used for these waterboxes if the circulating water nozzle openings or manhole or handhole openings and their reinforcements fall wholly or in part outside the central area of the waterbox based on 40 percent of the waterbox diameter. Openings in the shell of the waterboxes for submarine condensers shall be radial and the circulating water inlet and discharge nozzles shall be straight and as short as is possible for the use of through bolts in the flanges. Permanent marking on condenser waterboxes, except for flanges, is prohibited.

3.2.15.2 Except in the case of condensers for submarines, waterboxes may be stiffened with ribs as necessary. Strengthening ribs shall be placed on the outside.

3.2.15.3 In two or multipass condensers, the joint between the partition edge and the face of the tube sheet shall be provided with a gasket, of the same material as the gasket for the waterbox-tube sheet flange joint or, in accordance with type I of MIL-G-21610.

3.2.15.4 Waterboxes of condensers for surface ships shall be secured to the tube sheets by through bolts extending through the tube sheet or by studs (see 3.2.13.5). In U-bend tube removable bundle construction the waterbox shall be secured to the tube sheet by through bolts extending through the tube sheet and flange of the shell or by studs (see 3.2.13.5).

3.2.15.4.1 Waterboxes of condensers for submarines may have either internal or external flanges for attachment to the tube sheets. Studs shall be used in internal flanges. Studs shall project through holes in the outer and inner tube sheets with nuts on the inner tube sheet side external to the shell. This construction shall be used only if guide pins longer than the studs are provided to facilitate installation of the waterbox and to prevent damage to the threads on the ends of the studs. Such guide pins shall project into holes in the tube sheets which have less diametral clearance than the holes provided for the studs. Calculations demonstrating the adequacy of the guide pins shall be submitted to the drawing review agency for approval. Allowable stress shall not exceed 90 percent of the yield strength of the guide pin material.

3.2.15.4.1.1 In the design of waterboxes for submarines, full consideration shall be given to the cyclic nature of the pressure, sea water temperature, and external force loading. Design shall be based on 200 cycles to the hydrostatic pressure specified (see 6.1.1), 20,000 cycles to full design submergence, and associated temperature variations and other transients as specified (see 6.1.1). An analysis of fatigue loading on a cumulative damage basis shall be submitted to the drawing review agency for approval.

3.2.15.4.1.2 In the design of submarine condenser waterboxes, the loads exerted by circulating water inlet and discharge piping shall be calculated from 1-480 of SUB-63.

3.2.15.4.1.3 Condensers with straight tubes designed for submarine service shall have an even number of passes, so that the circulating water inlet and outlet connections will be at the same end and the stresses in the piping will, therefore, not affect the expansion or contraction of the tubes or shell.

3.2.15.4.1.4 Design of bolted closures shall be such that pieces threaded into waterbox flanges do not require removal each time the closure is opened.

3.2.15.4.1.5 Where studded pads are employed for access openings on submarine condenser waterboxes, guide pins shall be provided to prevent damage to the threads on the studs. Calculations demonstrating the adequacy of the guide pins shall be submitted to the drawing review agency for approval. Allowable stress shall not exceed 90 percent of the yield strength of the guide pin material.

3.2.15.4.2 Design of types I, II, and III condenser waterboxes weighing more than 300 pounds shall provide for ready interior accessibility to permit plugging tubes, caulking or replacing tube packing, or re-expanding the tube ends without removal of the waterboxes. The relation of the contour of the waterbox at the periphery to the position of the outermost tube in the tube bundle and the relation of the positions of the tubes immediately adjacent to the waterbox partition, above and below, shall be such that these tubes may be plugged, using tube plugs in accordance with MIL-P-15742 (single tube sheets), or the method specified in 3.9.2 (double tube sheets), or can be repacked or re-expanded with the tools furnished without removal of the waterboxes.

3.2.15.4.2.1 In order that tubes in types I, II and III condensers can be "probologged" with waterboxes in place, the design shall provide a minimum clearance of 7-1/2 inches between the inside surface of the waterbox head and the outer tube sheet face measured perpendicular to the tube sheet on the axis of the outermost tube(s) in the tube bundle. This clearance shall be provided in both waterboxes. This does not apply for waterboxes weighing less than 300 pounds.

3.2.15.5 Waterboxes of large condensers shall have manholes providing access to all tube ends and zincs (when fitted). Manholes may be circular, oval, or rectangular. Preferred minimum dimensions are 16 inches diameter or 12 by 16 inches. If for any reason connected with manufacturer's design or shipbuilder's adjacent structure, the preferred minimum dimensions prove to be impracticable, smaller dimensions will be acceptable, provided the manufacturer demonstrates to the satisfaction of the cognizant DCAS or supervisor of shipbuilding by use of a full scale mock-up that an average sized man can successfully plug and tube end or renew any zinc by access through such smaller manholes.

3.2.15.5.1 Waterboxes of small condensers (type I, II and III) shall generally have sufficient handholes for access to all tube ends and zincs (when fitted). In some cases, it may proved necessary also to utilize the inlet and outlet circulating water openings for access to tubes or zincs. This shall be acceptable, provided that the necessity therefor is noted on the outline drawing so that it will alert the shipbuilder to the necessity of providing a short removable section in the adjacent connecting piping.

3.2.15.5.2 Except for type IV condensers, it shall not be necessary to remove a waterbox weighing more than 300 pounds in order to gain access to any tube end in order to plug, re-expand, or repack a tube. Except for type IV condensers, it shall not be necessary to remove a waterbox to examine or renew the sacrificial anodes (when fitted).

3.2.15.5.3 Singlepass condensers for surface ships shall be provided with an observation handhole on each waterbox, located above the topmost tubes, where it can be used for observation in locating a tube leak. Such location will be accomplished by applying air pressure to the steam space of the condenser and gradually filling the waterboxes and tubes with sea water, so that as a leaking tube is filled and covered, air bubbles will appear at the tube ends. Air venting manifold required in 3.2.15.8 may be made removable and the opening in the waterbox used as the observation handhole on top of the inlet waterbox.

3.2.15.6 Circulating water inlet and outlet nozzles shall be integral with the waterboxes, and the inlet nozzles shall be as nearly normal to the tube sheet as practicable for each installation (except in the case of a submarine condenser (see 3.2.15.1.1)). Sharp corners or edges in the flow of circulating water through the boxes shall be eliminated to provide a smooth streamlined flow and zinc plates (when fitted), stays, and internal fittings shall be arranged so that a minimum of interference with water flow and minimum turbulence results. Entrance nozzle may be of a diverging type (7-1/2 degree maximum taper). In order to absorb high entrance velocities which may produce erosion of tube ends by impingement effect, the inlet waterbox depth, measured normal to the tube sheet, shall be not less than one-half the mean tube sheet diameter, except that this depth need not exceed 45 inches. For multipass condensers the mean tube sheet diameter shall be computed from the area of the tube sheet exposed to water flow from the inlet section of the head. For the return waterboxes of twopass condensers, the interpass waterbox compartments of multipass condensers and for outlet waterboxes, the head depth shall be not less than two-thirds of the depth required for the inlet waterbox.

3.2.15.7 For surface ship condensers with scoop injection of circulating water, both inlet nozzles (the scoop and the circulating water pump connections) shall be designed to support the weight of the unsupported circulating water system components (piping and valves), the water contained therein, and loads due to hydraulic effects. The size and weight of the unsupported sea water system components shall be as specified (see 6.1.1). For double tube sheet condensers, verification of the adequacy of the waterbox in this regard shall be submitted to the drawing review agency for approval. Maximum allowable forces and moments for both inlet nozzles shall be shown on the condenser outline drawing.

3.2.15.8 Provision shall be made for the venting and removal of entrained air from the inlet waterbox compartment and from the reversing waterbox. An air venting manifold extending across the entire top of the inlet waterbox of singlepass condensers for surface ships shall be provided. A vent connection on top of the discharge waterbox shall be provided.

3.2.15.9 Waterboxes of surface ship condensers shall be provided with bosses for connecting gages and thermometers. Four bosses shall be provided on the main condenser overboard waterbox nozzles or adjacent piping of surface ships for installation of thermometers during tests. Bosses shall be located around the perimeter so that an average temperature of the circulating water discharge can be obtained.

3.2.15.10 <u>Waterbox connections</u>.

3.2.15.10.1 Flanges for openings on waterboxes for surface ships shall be in accordance with the applicable schedule of MIL-STD-777 in regard to diameter, minimum thickness, finish, and drilling. Flanges of sizes greater than those covered by MIL-STD-777 shall be subject to approval by the drawing review agency.

3.2.15.10.2 Requirements for openings on waterboxes for submarines shall be as specified (see 6.1.1). When flanged openings are specified, "O-ring" gaskets shall be used between flanges, the groove for the "O-ring" being furnished in the companion flange on the shipbuilder's piping.

3.2.15.10.3 Studs and nuts shall be furnished and installed by the condenser manufacturer in all pad type flanges.

3.2.15.11 For submarine waterboxes, vent, and drain connections shall be made via waterbox flange or tube sheet, in order to avoid penetrating the waterbox shell.

3.2.15.12 For surface ship condensers, when the use of steel flanges is elected, a construction shall be used which will insure that the steel cannot come in contact with sea water. This shall be accomplished by lining the steel flange to a depth of not less than 3/16 inch thick with nickel-copper alloy or 70-30 copper-nickel alloy in accordance with MIL-E-22200/4 or type MIL-EN-67 of MIL-E-21562, or nickel-copper alloy in accordance with MIL-9N10 of MIL-E-22200/3 or types MIL-RN60 or MIL-EN60 of MIL-E-21562. On the face of the flange this protection shall extend from the bore to at least the inner edge of the bolt holes. The 3/16 inch thickness of the protecting alloy is a required minimum after final machining of the flange. Inlay thickness shall be verified after depositing (allowance for machining must be provided) and after final machining of the flange verification of thickness shall be an inspection check-off item.

3.2.15.12.1 When the use of steel slip-on flanges is elected (see 3.2.8.4) for surface ship condenser waterboxes the attachment of these flanges shall be in accordance with MIL-STD-22 weld joint design P-16. "D" values for pipe sizes over 16 inch diameter shall be subject to approval by the drawing review agency.

3.2.15.13 Waterboxes fabricated of nickel-copper alloy shall have the inside surfaces carefully coated with solder (two parts lead, and part tin) to a thickness of not less than 1/64 inch and not more than 1/16 inch. Examination of solder application shall be in accordance with 4.5.8.

3.2.15.14 For submarine waterboxes an analysis of bolting adequacy for sea water side closures and connections shall be submitted to the drawing review agency for approval.

3.2.15.15 Condenser waterboxes and waterbox access covers shall be provided with lifting pads or eyes or other lifting devices to permit safe and efficient removal and manipulation.

3.2.16 Tubes and packing.

3.2.16.1 Unless otherwise specified in the case of condensers for some submarines (see 6.1.1), condenser tubes shall be seamless drawn, 5/8 inch (o.d.) with a wall thickness of 0.049 inch (number 18 BWG). Unless otherwise specified (see 3.6.2.2) tubes shall be straight.

3.2.16.2 Water inlets ends of tubes shall be expanded and belled to suit holes in tube sheets as specified in 3.2.13.3, then faced off flush with the surface of the tube sheet. Water outlet ends of tubes shall be expanded or packed according to design. Outlet ends of tubes may project not more than 3/16 inch beyond face of tube sheets, but in no case shall the end of the tubes be within the surface of the tube sheet. In order that the tube metal shall not be overworked, tubes shall be expanded by means of an automatic tube expander control. For each condenser design for nuclear propelled ships, the tube expander and control method shall be subject to procedure approval (see 4.2.4). For non-nuclear propelled ships, tube expansion may either be accomplished by a procedure which has been approved for the given material and joint configuration in accordance with 4.2.4, or by a procedure based on use of expander in accordance with MIL-E-15809.

3.2.16.2.1 For single tube sheet construction, the expander shall be adjusted so that the depth of expansion does not extend further than within 1/8 inch of the inner face of the tube sheet. In expanding the tubes in double tube sheets, care shall be taken that there is no abrupt change in contour of the inside tube wall caused by the tube end expansion. Expansion of the tubes in the inner tube sheet holes shall start 1/8 inch inside the outer face and shall not extend beyond a plane 1/8 inch inside the inner face of the tube sheet. Minimum length of tube expansion (prescribed wall reduction) in the inner tube sheet shall be 5/8 inch; any remainder (within above limits) shall be expanded metal-to-metal as a minimum.

3.2.16.3 When tubes are packed the packing shall be flexible metallic packing conforming to MIL-P-2862. Ferrules shall not be used. The threading of the counterbore shall be used to hold the packing in place. Tube ends shall not be injured by excessive pressure when the packing is installed.

3.2.16.4 Ends of condenser tubes shall not be specially annealed prior to installation in condensers. Tubes shall be obtained from the tube manufacturer in a satisfactorily annealed condition for installation so that further annealing of the tube ends will not be required.

3.2.16.5 Where blind nipples are used in the design as stays between inner and outer tube sheets, they shall be made from a single piece of bar stock of the same composition as the outer tube sheet. Before the unit is placed in service, the open ends of these nipples shall be plugged with tapered phenolic plugs in accordance with MIL-P-15742. Each nipple shall pass the test specified in 4.5.5.

3.2.17 Fittings.

3.2.17.1 Drain connections for steam and salt water sides shall be provided. Main condenser inlet waterboxes on single shaft surface ships shall be provided with a minimum 2-1/2 inch iron pipe size drain connection to which may be fitted a tee capable of accepting a standard fire main jumper hose coupling. Fittings to be attached to this drain connection (which will permit emergency utilization of fire main water supply) shall be provided by the shipbuilder.

3.2.17.2 One or more protected liquid level gages conforming to type I of MIL-I-20037, with shock-resistant features, shall be provided for the condensate will and lower part of the shell of types I, II and III condensers, to indicate accurately the existing condensate level in the condenser. Liquid level gages shall be located for optimum visibility by operators.

3.2.17.2.1 Liquid level gage and hotwell level control tap positions shall be located and designed with consideration given to the velocity and pressure effects present in the condenser, to permit accurate read-out and control of hotwell level during all phases of condenser operation, including steam dumping.

3.2.17.2.2 When a make-up feed connection is required on condensers for submarines, it shall be so designed and located as to permit maximum deaeration of the make-up feed before it enters the condensate well. This does not nullify the intent of 3.2.17.3.6.

3.2.17.3 In addition to the connections specified in 3.2.17.1 and 3.2.17.2, the following connections shall be fitted as required (see 6.1.1):

(a) Auxiliary exhaust steam (see 3.2.17.3.1).
(b) Air ejector suction.
(c) First effect evaporator coil drains for each auxiliary and one main condenser in each engine room.
(d) Fresh water drain collecting tank discharge.
(e) Drain from intercondenser of air ejector.
(f) Condensate recirculating.
(g) Condensate pump vent.
(h) Steam dump connection (see 3.2.17.3.1 and 6.1.1).
(i) Drains and vents for spaces between double tube sheets.
(j) Make-up feed.
(k) Hotwell level control connections as required.
(l) Turbine drains as required.
(m) Other connections as required by the shipbuilder.

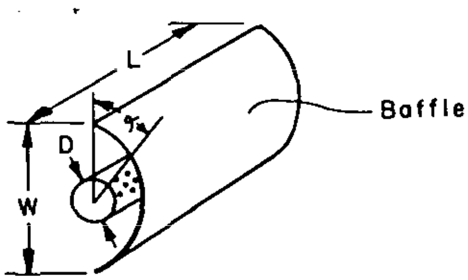
3.2.17.3.1 It shall be the responsibility of the vendor to insure that auxiliary exhaust[1/] and dump steam[2/] are introduced into the condenser in such a manner that condenser tubes, shell and internals will not be damaged by high velocity steam or any moisture picked up and carried by the steam flow. Accomplishment of this shall be by means of the pressure/velocity reducing configurations described in 3.2.17.3.1.2. In order to minimize moisture pickup by auxiliary exhaust or dump steam, the pressure/velocity reducing configuration shall be located above the centerline of the condenser tube bundle unless otherwise approved by the drawing review agency. Construction of the pressure/velocity reducing configuration shall meet the requirements of MIL-STD-278 and the applicable requirements of MIL-STD-438 or MIL-STD-777 for the service. Structural welding shall be as specified in 3.2.4.4.

1/ "Auxiliary exhaust steam" means steam which has been expanded through an auxiliary prime mover to about 15 lbs/in^{2}g. It is introduced into the condenser in order to conserve feed water. Two flow values shall be used in designing the condenser, a "full-power steady state condition flow" (see 6.1.1) which shall be included in the determination of condenser size (see 3.3.2.9), and a "maximum transient condition flow" (see 6.1.1). This latter value shall be increased by 10 percent to allow for eventual increased consumptions by auxiliary machinery due to aging, and then used as the basis for design of the pressure velocity reducing configuration; it should not be used as a basis for determining condenser size (surface).

2/ "Dump steam" means boiler steam which is introduced into the condenser without having done useful work in a prime mover.

3.2.17.3.1.1 The vendor shall be responsible for ensuring that the steam dump and auxiliary exhaust configurations are designed so that the auxiliary exhaust and dump steam will not heat the turbine exhaust flexible connection (if employed) above its maximum design temperature (see 6.1.1) or result in the pickup and carryover of water droplets into the turbine. The vendor shall also be responsible for ensuring that the flexible connection will not be damaged by high velocity steam or by any water droplets picked up and carried by the auxiliary exhaust and dump steam flow. The foregoing requirements also apply to the high pressure turbine drain connection and all other openings which introduce steam into the condenser.

3.2.17.3.1.2 Unless otherwise approved by the drawing review agency the pressure/velocity reducing configuration shall be in the form of the perforated pipe and baffle which shall have the following general configuration:



SH 10476

Note: Other pipe and baffle configurations may be used provided they meet the guidelines below.

Perforations in the pipe shall be such that the steam will exit evenly along the pipe length and shall be located such that the steam emerging from the perforations will strike the baffle. To insure this, the minimum angle shall be 30 degrees where is the angle from the outermost row of perforations to the edge of the baffle as measured from the center of the pipe. Maximum orifice or perforation size shall be 3/8 inch diameter. The location of tubes with respect to the baffle opening is optional.

(a) For auxiliary exhaust steam, the area L x W shall be such that the average velocity of the auxiliary exhaust steam when expanded to a 29 inch vacuum (referred to a 30 inch barometer) and passed through this area shall not exceed 250 feet per second (ft/s) or 750 ft/s if the impingement tubes of 3.2.11.1 are installed between the auxiliary exhaust baffle and the tube bundle and the requirements of 3.2.11.1 are satisfied with respect to the auxiliary exhaust baffle exit.

(b) For the steam dump, "L" shall be as nearly equal to the effective tube length as possible, allowing for shell neck where fitted and differential expansion between the shell and steam dump pipe and "W" shall be at least three times the steam pipe diameter "D". The impingement tubes of 3.2.11.1 shall be installed between the steam dump baffle and the tube bundle and the requirements of 3.2.11.1 shall be satisfied with respect to the steam dump baffle exit. For the steam dump assembly the vendor shall justify the structural adequacy of the design by submitting the following to the drawing review agency for approval:

(1) Vibration analysis.

(2) Fatigue analysis (in accordance with SDB-63) due to thermal and pressure loads for the number of operating cycles specified (see 6.1.1)). Operating cycles shall be based on the maximum dump steam temperature and pressure (see 6.1.1).

Multiple parallel pressure/velocity reducing configurations may be used provided the sum of the individual areas and the sum of the individual lengths satisfy the relationships of (a) or (b) as applicable.

3.2.17.3.2 In type IV condensers furnished as after and gland steam leak-off condensers, the openings for introduction of the second stage air ejector steam and the gland leak-off ejector steam shall be baffled to protect the tubes from impingement.

3.2.17.3.3 When condensate recirculation is required to maintain adequate circulation through the air ejector inter and after condenser, two connections shall be provided. One, to be used only when starting up, shall be provided with a perforated or slotted pipe inside the condenser shell, so located and directed that the condensate issuing from such perforations or slots will trickle down over the condenser tubes and will not impinge in jet streams on any of them or on the turbine or condenser exhaust reinforcing stay rods. The other condensate recirculating connection, for normal operation use, shall be so located or so piped inside the condenser shell that it discharges near the bottom of the shell, but above the maximum condensate level, in such location that there will be no chance of water droplets impinging directly on the tubes or being entrained by the steam flow and thereby impinged on the tubes.

3.2.17.3.4 Other openings (except turbine drain connections) which introduce water or steam into the condenser shell, such as drain connections, make-up feed connections, condensate recirculation connection required for condensate pump regulation, and the inter-condenser drain connection shall be treated in the same manner as the condensate recirculation connection for normal operation specified in 3.2.17.3.3. Design shall be based on the amounts of drains, make-up feed, recirculated condensate, inter-condenser drains, and other such heat inputs as specified (see 6.1.1). Provisions shall be made for venting the upper end of any leg of the inter-condenser drain connection piping located inside the shell, in order that the loop seal between condenser and inter-condenser will not be affected by any siphon action in this piping.

3.2.17.3.5 Connections for introduction of turbine drains into the condenser shall be so piped or baffled inside the condenser shell that the shell structure or tubes will not be damaged by impingement of high velocity steam, or condensate entrained by such steam flow, should a valve in a "normally closed after warm-up" drain line be inadvertently left open or a steam trap stick open and allow a continuous flow of steam through the connection. Turbine drain connections shall be treated in the same manner as auxiliary exhaust, and the requirements of 3.2.17.3.1 through 3.2.17.3.1.3 shall apply except that there is no restriction regarding location with respect to the condenser tube bundle centerline.

3.2.17.3.6 External tube wall erosion due to impingement of either high velocity steam or water on the tubes has been, in the past, a continual source of trouble in shipboard condensers. Strict compliance with 3.2.17.3.1 through 3.2.17.3.5 is therefore of the utmost importance.

3.2.17.3.6.1 Pipe and fittings in lines discharging steam or condensate or both into the condenser shall (except for auxiliary exhaust and steam dump) be of schedule 80 thickness, and shall be of type 316 or 316L stainless steel. Where fitted, baffles, screens, or other protective devices shielding the discharge of drain connections shall be of type 316 or 316L stainless steel.

3.2.17.3.7 Relief valves. Relief valves for salt water side protection shall be shipbuilder furnished. For submarine condensers, relief valves shall be mounted on the circulating water piping adjacent to the inlet waterbox of the condenser rather than on the waterbox. The following is intended as a guide to relief valve sizes:

Type of ship	Type of condenser	Valve size (inches)
Surface	I	2
Surface	II, III	1/2
Surface	IV	1/4
Submarines	I, II	1/2
Submarines	IV	1/4

Relief valves shall be set as prescribed by applicable system drawings.

3.2.18 Zinc protectors.

3.2.18.1 Zinc anode protection shall be provided for nuclear ship condensers in accordance with MIL-A-19521 with the following exceptions:

(a) For pencil zincs tapered thread plugs, class A plugs shall be used.
(b) An acceptable alternate method of supporting pencil zincs is the use of straight thread "O-ring" plugs conforming to MIL-F-21467 except plug body is to be solid and tapped in accordance with MIL-A-19521 for desired pencil zinc, together with a straight thread tapped boss on the waterbox machined in accordance with MS16142.
(c) Pencil anodes for submarine condensers shall be type ZDM of MIL-A-19521 and shall be comprised of not more than 7 discs per assembly.

Compliance with MIL-A-19521, with above exceptions being noted if applicable, shall be certified by a drawing notation.

3.2.18.2 For non-nuclear ship condensers, zinc anodes and provisions for their attachment are not required.

3.2.19 "O-ring" gasket retention. All "O-ring" gasket retaining surfaces shall be of such construction and material that the finish will be maintained to that necessary for proper sealing over the design life of the condenser (see 3.2.3) considering the effects of the working environment and periodic hydrostatic testing of the gasketed enclosure. Where ferrous materials form all or part of the "O-ring" seating surface, a non-ferrous weld clad over the ferrous seating surfaces, or other technique as approved by the drawing review agency, shall be used to maintain seating surface finish for the design life of the condenser. Design of retaining grooves for "O-ring" gaskets shall conform to MIL-G-5514.

3.2.20 Environmental vibration. When specified (see 6.1.1), the condenser shall be designed and constructed to withstand type I environmental vibration, of MIL-STD-167. Maximum environmental vibration shall be as specified (see 6.1.1). Vibration analysis or testing is not required.

3.3 Type I, for main propulsion turbines or engines.

3.3.1 Material. Materials used in the construction of type I condensers shall be as shown in table IV.

Table IV - Material for type I and type II condensers.

Part	Material	Applicable document
Shells, tube support plates and swash plates	Steel, grade N or QT	MIL-S-24113
	Steel, grade A or B	ASTM A537
	Steel	[1/] ASTM A588
Shell pressure/velocity reducing configurations, tube protection baffles, bars, tubes or screens, and piping and fittings subject to internal or external impingement	Stainless steel, type 316 or 316L	Commercial
Waterboxes (for class A)	Nickel-copper alloy, class A	QQ-N-281
Waterboxes (for class B)	Copper-nickel alloy, composition 90-10 with reinforcing ribs of composition 90-10 copper-nickel alloy or of steel	MIL-C-15726 or MIL-T-16420 MIL-C-15726 ASTM A516

1/ For double tube sheet condensers procuring activity approval to use this material shall be obtained.

3.3.2 Design.

3.3.2.1 Condenser arrangement with respect to the turbine or turbines, or engine it serves shall be as specified (see 6.1.1).

3.3.2.2 Condensers shall be of the double or singlepass straight tube surface type, as specified (see 6.1.1), except for submarine service (see 3.2.15.4.1.3). Cooling water shall be inside the tubes.

3.3.2.3 Condensers with which scoop injection is specified shall have waterboxes arranged for singlepass. Waterboxes shall have a plate thickness of 3/16 inch minimum. Waterboxes for surface ships may be sectionalized as necessary for handling with minimum interference to adjacent machinery, piping, and ship's structure. Degree of sectionalization shall be dependent on the machinery arrangement of individual ships and shall be as approved by the drawing review agency in all cases.

3.3.2.4 Condensers shall be provided with adequate supports. Condensers normally shall be suspended from the exhaust flange of the low pressure turbine, shall be used as a support or foundation for the main propulsion turbines, or shall be supported independently of the turbine and connected thereto by means of an exhaust trunk expansion joint as specified (see 6.1.1). Shells for type I condensers shall have a plate thickness of 5/16 inch minimum. Condenser shells shall be reinforced to withstand the stresses involved in either arrangement, and brackets for attachment of sway braces shall be provided, as required, for suspended condensers.

3.3.2.5 Design shall be given careful consideration in order that a low pressure drop across the condenser and a low temperature differential between the vacuum and discharge circulating water temperatures are obtained. Design shall be such that the difference between the temperature corresponding to the absolute pressure at the steam inlet flange and the condensate temperature at the condensate pump suction shall not exceed 1°F at full-load condenser rating with 65°F or higher inlet circulating water temperature or 2°F under all other conditions of operation, and that the oxygen content of the condensate measured at the condensate pump discharge shall not exceed 0.05 milliliter per liter ml/l (0.07 parts per million (p/m)) under these operating conditions in condensers for non-nuclear powered ships. Condensers for nuclear-powered surface ships or submarines shall be designed so that the oxygen content of the condensate measured at the condensate pump discharge shall not exceed 0.01 ml/l (0.014 p/m) when the condenser is operating at design conditions, nor more that 0.02 ml/l (0.028 p/m) of oxygen at 50 percent full-power load.

3.3.2.5.1 To accomplish these requirements, the tube sheet layout shall provide for the most efficient steam distribution that can be obtained by spacing the tubes in a converging pattern, or by steam distribution or reheating lanes, or other design shall be used to accomplish this purpose. The total area of the tube holes in the tube sheet shall not exceed 22 percent (for condensers designed for 1-1/4 lb/in^2a pressure or less at the steam inlet) or 24 percent (for condensers designed for higher pressure than 1-1/4 lb/in^2a at the steam inlet) of the total tube sheet area exposed to circulating water flow, the tube sheet area being determined prior to drilling. In condensers in which the design includes space for steam flow between the shell and tube bundle, the tube sheet being smaller than the shell, this space shall be included as part of the tube sheet area exposed to circulating water flow. Flow of steam shall be such that the best practicable advantage is taken of the difference of pressure between the steam inlet and air ejector suction and such that the cooling surface of each group of tubes is most effectively utilized. Main steam inlet opening or openings shall be as large as possible and shall be arranged so that the steam is uniformly distributed over the entire tube surface. Tube sheet layout shall also provide for a sufficient number of tubes for precooling the air ejector suction. Such tube surface shall be not less than 6 percent of the total cooling surface.

3.3.2.6 In the flow of circulating water, the arrangement of waterboxes and water passes shall be such that as nearly as possible equal distribution of water to all tubes is obtained, that turbulence of friction is minimized, and that erosion and corrosion caused by excessive velocity or entrained air are eliminated to the greatest possible extent in the design.

3.3.2.7 The water velocity entering the inlet nozzle, or the waterbox if diverging nozzle (7-1/2 degree maximum taper) if used, shall not exceed 11.0 ft/s on scoop injected singlepass condensers, or 9.0 ft/s on doublepass condensers used on surface ships, or 11.0 ft/s on doublepass condensers used on submarines. The average water velocity in the tubes shall not exceed 9.0 ft/s in scoope injected singlepass condensers, or 7.5 ft/s in doublepass condensers used on surface ships, or 9.0 ft/s in doublepass condensers used on submarines.

3.3.2.8 The vacuum requirements shall be as specified (see 6.1.1). Unless otherwise specified (see 6.1.1), performance calculations for condensers for surface ships shall be based on circulating water injection temperature of 75°F and for submarines, 65°F.

3.3.2.9 Condenser surface shall be based on a heat transfer rate (British thermal units (Btu) per square foot per hour per °F logarithmic mean temperature difference) of 267 times the square root of the average water velocity through the tubes ft/s, corrected by the following factors:

0.85 for tube cleanliness.
.90 for 18 BWG, 90-10 copper-nickel tubes.
.85 for 16 BWG, 90-10 copper-nickel tubes.
.82 for 18 BWG, 70-30 copper-nickel tubes.
.77 for 16 BWG, 70-30 copper-nickel tubes.
1.025 for 75°F or 0.962 for 65°F inlet water temperature and an assumed heat rejection to the circulation water equal to at least 950 Btu per pound of steam condensed.

If determined by heat balance calculation that the total heat rejection to the circulating water will be less than 950 Btu per pound, the actual figure may be used, if more than 950 Btu, the higher value shall be used.

3.3.2.10 Exhaust connections.

3.3.2.10.1 Main condenser exhaust connection to a propulsion turbine located above the condenser shall be a continuation of the condenser shell and shall be provided with a flange for connecting to the exhaust casing flange of the turbine. When the condenser forms the support for the turbine and no gasket is provided between flanges, a simple system of flange grooving shall be provided on the condenser flange for pressure pumping with a sealing compound, should leakage develop in service. Flat surfaces shall be stiffened in such a manner as not to interfere with the flow of exhaust steam.

3.3.2.10.2 Securing turbine to condenser. Where the turbine and the condenser are bolted directly together, their flanges, steam exhaust and steam inlet, respectively, shall be drilled by their respective manufacturers, except that holes for bodybound bolts will be finish reamed by the shipbuilder at installation. Condenser flange shall be drilled to a template furnished by the turbine manufacturer. Gasket (if required), through bolts, and stud bolts between the turbine and the main condenser shall be furnished with the condenser, and studs (one-nut studs) and tap bolts shall be furnished with the component tapped for same.

3.3.2.10.3 Access. Adequate access for examination of condenser internals shall be provided, especially in those areas where steam or water are released into the condenser, and for cleaning out the hotwell. For type I condensers a manhole (or manholes) shall be provided in the top of the condenser shell for access for examination of the entire upper section of the tube bundle and the shell areas adjacent to the steam inlet(s), including baffling when fitted. For condensers fitted with a steam dump or an auxiliary exhaust steam connection or both, manholes (or examination openings in type II or III condensers) shall be provided to permit examination of the condenser interior in the vicinity of the connection, or of each connection if both are provided.

3.3.2.10.4 Flexible connection between turbine and condenser. Where the turbine and the main condenser are connected by a common flexible connection, it will be necessary for the turbine and condenser manufacturers to maintain close liaison with the shipbuilder to develop a coordinated installation procedure. Since the flexible connection will have a fixed face-to-face dimension and predrilled flanges (to permit interchangeability between propulsion units in the ship class), it may be necessary (at the discretion of the shipbuilder) to leave the turbine or condenser flange undrilled until installation to insure proper alinement and installation of bolting. Regardless of who furnishes the flexible connection, and regardless of whether the turbine and the condenser are furnished under the same or different contract(s), the turbine and condenser manufacturers shall each be responsible for providing bolting and a gasket (if required) where their respective components attach to the common connection.

3.3.2.10.5 Unless otherwise specified (see 6.1.1), the flexible connection between the turbine and condenser shall not be furnished with the condenser.

3.3.2.10.6 Pads shall be placed on the exhaust connection in an accessible location for the installation of two temperature indicators, and for connection of a dial type vacuum gage. Temperature indicators and gages shall be so located and connected as to obtain a measure of the average condition.

3.3.2.11 Unless otherwise specified (see 6.1.1) temperature indicators will be furnished by the shipbuilder. Condenser manufacturers shall provide and install the wells for the temperature indicators as required in 3.3.2.11.3.

3.3.2.11.1 Temperature indicators shall be installed in the following locations:

(a) Exhaust connection as close to turbine as practicable. One indicator shall be installed for indicating the normal temperature encountered. An additional indicator shall be installed to indicate the timperature of the exhaust steam when the ship is running at full-power astern (see 3.3.2.10.6).
(b) 1-Circulating water inlet (see 3.2.15.9).
(c) 1-Circulating water outlet (see 3.2.15.9).
(d) 1-Condensate well. (Suitable pad for installation shall be provided on the condensate well.)

3.3.2.11.2 Temperature indicators shall conform to MIL-I-17244. Distant reading dial type indicators, in accordance with class C of MIL-T-19646, may be substituted when location is difficult for access for reading. Exhaust steam temperature indicator for ahead operation, in either case, shall be of such design that it will not be damaged when subjected to astern steam temperature.

3.3.2.11.3 Wells for steam and condensate temperature indicators shall be of corrosion-resistant steel in accordance with MIL-W-24270 and MIL-W-24270/3. Wells for sea water temperature indicators shall be of the same material as the waterbox or of nickel-copper in accordance with MIL-W-24027, and the form shall be in accordance with MIL-W-24270/3. Drawing 810-1385917 may be used as a guide for installation of wells.

3.3.2.12 Unless otherwise specified (see 6.1.1) an 8-1/2 inch vacuum gage shall be provided for each condenser by the shipbuilder. Vacuum gage for surface ships shall conform to MIL-I-18997/1. Vacuum gage for submarines shall conform to MIL-I-18997/1 except that the range of the scale shall be 0 to 36 inches of Hg and shall be so constructed that when subjected to a case pressure of 30 pounds lb/in^2a no damage will occur to the pointer or pointer stops. Gages will be mounted by the shipbuilder. In addition for submarines there shall be provided by the shipbuilder a nonmercurial absolute pressure gage. Gage piping shall in accordance with Drawing 810-1385850.

3.3.2.13 Design of the condenser shall be such that the ordering length of tubes will be in integral multiples of 6 inches, except when U-bend tubes are used.

3.4 Type II for turbines of steam turbo-generator sets.

3.4.1 Material. The materials used in the construction to type II condensers shall be as shown in table IV.

3.4.1.1 Materials for type II condensers for submarine service shall be as specified in table IV, except waterboxes shall be nickel-copper alloy in accordance with class A of QQ-N-281.

3.4.2 Design.

3.4.2.1 The requirements of 3.3.2.2, 3.3.2.5, 3.3.2.5.1, 3.3.2.6, 3.3.2.8, 3.3.2.9, 3.3.2.10.3, 3.3.2.12 and 3.3.2.13 shall apply.

3.4.2.2 Internal surfaces of the waterboxes and division plates shall be smooth to reduce the water friction and turbulence to a minimum. Fabricated waterboxes shall have a minimum thickness of 3/16 inch.

3.4.2.3 Condensers shall be provided with adequate supports if furnished as separate units, or shall be furnished as part of a packaged steam turbo-generator set, designed to be supported from the turbo-generator bedplate or to support the turbine, generator and reduction gear (if provided), as specified (see 6.1.1).

3.4.2.4 Unless otherwise specified (see 6.1.1) condensers furnished as separate units shall not be provided with a flexible steam inlet connection.

3.4.2.5 When a condenser is furnished as part of a packaged turbo-generator set and is designed to be supported from the turbo-generator bedplate, the necessity for a flexible connection between the turbine exhaust and the condenser steam inlet shall be determined by the turbine and condenser manufacturers. If required, the flexible connection, bolts, and gaskets (if required) shall be furnished by either the turbine or condenser manufacturer as mutually agreed. Condenser drawings shall indicate what is furnished with the condenser.

3.4.2.6 Pads shall be placed on the steam inlet of the condenser as close as possible to the turbine exhaust flange for installation of a temperature indicator and connection of a vacuum gage. Pads shall also be provided for installation of the temperature indicators specified in 3.2.4.7(b), (c), and (d). Condenser manufacturer shall provide and install the wells for the temperature indicators. Requirements for temperature indicator wells are specified in 3.3.2.11.3

3.4.2.7 Temperature indicators shall conform to MIL-I-17244. Distant reading dial type indicators may be substituted when location is difficult of access for reading; such indicators shall be in accordance with class C of MIL-T-19646. Indicators shall be installed to indicate temperatures of the following:

(a) Exhaust connection, as close to turbine as practicable (one).
(b) Circulating water inlet (one).
(c) Circulating water outlet (one).
(d) Condensate well (one).

3.4.2.7.1 Unless otherwise specified (see 6.1.1) temperature indicators will be supplied by the shipbuilder.

3.4.2.8 Sea water velocity entering the inlet waterbox nozzle, or the waterbox if a diverging nozzle (7-1/2 degree maximum taper) is used, shall not exceed 9.0 ft/s and the average sea water velocity in the tubes shall not exceed 7.5 ft/s under any condition of operation.

3.5 Type III, for auxiliary steam turbines or steam reciprocating engines.

3.5.1 The requirements of 3.4.1, 3.4.1.1, 3.4.2.1, 3.4.2.2, 3.4.2.4 and 3.4.2.6 through 3.4.2.8 shall apply.

3.5.2 Condensers shall be provided with adequate supports.

3.6 Type IV, for condensing gland leak-off vent or steam, including steam from ship's heating drain system vents; also for service as combined air ejector after condenser and gland leak-off condenser for submarine sea water cooled application.

3.6.1 Material. Materials used for the construction of type IV condensers shall be as shown in table V. Materials for parts not listed shall be of the quality best suited for the purpose intended.

Table V - Material for type IV condensers.

Part	Material	Applicable document
Shells, tube support plates and swash plates	Steel	MIL-24113
	Steel, grade A or B	ASTM A537
	Steel	[1]ASTM A588
		ASTM A106
		ASTM A516
Shell pressure/velocity reducing configurations and tube protection baffles, bars, tubes and screens and piping and fittings subject to internal or external impingement	Stainless steel type 316 or 316L	Commercial
Waterboxes (for class A)	Copper-nickel alloy, composition 70-30	MIL-C-15726
	Copper-nickel alloy, composition 70-30, cast	MIL-C-20159
See footnote at end of table.		

Table V - Material for type IV condensers (cont'd).

Part	Material	Applicable document
Waterboxes (for class B)	Copper-nickel alloy, composition 90-10 with flanges and reinforcing ribs of composition 90-10 copper-nickel, or of steel	MIL-C-15726 or MIL-T-16420 MIL-C-15726 ASTM A516
	Copper-nickel alloy, composition 90-10, cast	MIL-C-20159
	Bronze, nickel-aluminum, cast	MIL-B-24480
	Bronze, tin, sand castings, alloy 903 or 922	ASTM B143

1/ For double tube sheet condensers, procuring activity approval to use this material shall be obtained.

3.6.2 Design.

3.6.2.1 The requirements of 3.3.2.6, 3.3.2.13 and 3.4.2.8 shall apply.

3.6.2.2 Condensers may be of the straight tube type or may be provided with U-bend tubes, (U-bend tubes are tubes formed into a continuous bend of not more than 180 degrees in a single plane.) and shall have the cooling water inside the tubes. If U-bend tubes are used; the minimum radius of the U-bends shall be 15/16 inch.

3.6.2.3 Condensers shall be provided with supports.

3.6.2.4 Condensers may have waterboxes arranged for single or multipass circulation except for submarine service (see 3.2.15.4.1.3). Internal surfaces of the waterboxes and division plates shall be smooth to reduce water friction and turbulence to a minimum. Waterboxes for surface ships shall have a minimum thickness of 3/16 inch.

3.6.2.5 Condensers shall be provided with an adequately sized atmospheric vent and shall be so designed that the total amount of steam and air entering the condenser will vent to atmosphere without exceeding the design working pressure in case of failure of circulating water supply.

3.6.2.6 Gland leak-off or vent steam condensers shall have sufficient surface to condense the amount of steam and cool the amount of air as specified (see 6.1.1) and unless otherwise specified (see 6.1.1) shall vent the air to atmosphere at a temperature not exceeding 35°F above design inlet water temperature for surface ships and 15°F above design inlet water temperature for submarines.

3.6.2.7 Condensers used to condense steam vented from a ship's heating drain system equipped with an air ejector shall be provided with an after condenser section for the air ejector. The two condensing sections shall be contained in a common shell, and the design shall incorporate positive provision against leakage from the after condenser section into the vent condensing section.

3.6.2.8 Unless otherwise specified (see 6.1.1), the temperature of the air vented from combination after and gland leak-off condensers for submarines shall not exceed 15°F above design inlet water temperature with one air ejector operating or 65°F above design inlet water temperature with both air ejectors operating.

3.6.2.9 Type IV condenser performance shall be based on 85°F inlet circulating water temperature (see 6.1.1) and 85 percent clean tubes.

3.6.2.10 Baffling shall be provided under the steam inlet to protect the adjacent tubes from impingement of high velocity steam and moisture entrained in the steam flow.

3.7 Identification plates. Each condenser shall bear an identification plate in accordance with types A, B, C, or D of MIL-P-15024 and MIL-P-15024/5 with material choice being limited to the wrought brass, cast brass, cast bronze or corrosion-resisting steel prescribed therein. Provision shall be made for the following information:

(a) Name of unit.
(b) Type and class of unit (see 1.2).
(c) Serial number.
(d) National stock number if required (allow 20 spaces).
(e) Name of manufacturer.
(f) Contract or order number. (The procuring activity's contract or purchase order number.) (Utilize width of plate to allow maximum number of spaces.)
(g) Blank space for Government inspector's stamp.
(h) Blank space for "Unit number" (allow 2 spaces). (This space shall be used for numbering for shipboard reference purposes - stamping to be done by the shipbuilder).
(i) Hydrostatic test pressure, shell side.
(j) Hydrostatic test pressure, tube side (For submarine application, no entry shall be made in space).
(k) Hydrostatic test pressure, inter-tube sheet void space (if applicable). (For submarine application, no entry shall be made in this space).
(l) Date of manufacture.
(m) Designation "U.S.".

3.8 Painting. Condensers shall be painted as specified hereinafter:

(a) External and internal non-ferrous surfaces of waterboxes and tube sheets shall not be painted. Internal ferrous surfaces shall not be painted.
(b) External surfaces of the steel shell and steel inner tube sheets shall be thoroughly cleaned and coated with two coats of heat-resisting paint in accordance with TT-P-28. External surfaces of steel reinforcing ribs and flanges on waterboxes shall be thoroughly cleaned and coated with two coats of zinc-chromate primer in accordance with formula 84 of TT-P-645.

3.9 Repair parts and tools. Lists of stock repair parts, onboard repair parts, and tools, shall be developed as provisioning lists as specified in the contract or order (see 6.1.2).

3.9.1 Onboard repair parts and tools. Onboard repair parts set is defined as the assemblage of repair parts and special tools carried onboard ship for maintenance use. Special tools are defined as those tools not listed in the Federal Supply Catalog. (Copies of this catalog may be consulted in the office of the DCAS.) For all ships the set shall include the following:

(a) Zinc anodes (see note)	100 percent.
(b) Tube packing, if used	10 percent.
(c) Gage glasses	25 percent. (Minimum:1)
(d) In addition for nuclear propelled ships:	
(1) "O-ring" gaskets	100 percent
(2) Tube expanders (for double tube sheet condensers only)	One of each size required (see 3.2.15.4.2 and 3.2.15.5.2).
(3) Right angle gear drive and extension(s) or flexible shaft for operating the tube expanders and permanent tube plug insertion tools (see 3.9.2) as required	One
(4) Tube plugs in accordance with MIL-P-15742 for temporary plugging of tubes (double tube sheet condensers only)	10 percent of total number of tubes to maximum of 100 plugs.

(5) Permanent tube plugging tool set (see 3.9.2) for surface ship double tube sheet condensers only - One

NOTE:
Where pencil zincs are fitted there shall be supplied 25 percent of supporting plugs or 100 percent of plugs for one condenser, whichever is the greater. Pencil plug subassemblies shall not be listed.

3.9.2 Permanent tube plugging tool set. For nuclear propelled ship condensers, permanent tube plugging tool sets shall be furnished as specified (see 3.9.1(d)(5) for surface ships, and 6.1.1 (for submarines). Tool set shall be based on the following:

(a) Tools shall be provided for removing the tube end from the hole in the outer tube sheet, across the space betweeen the double tube sheets and for finishing the tube end flush with the outer face of the inner tube sheet free from burrs. Tools shall also be provided for expanding the permanent tube plugs (see (b)) into the tube hole in the outer tube sheet and into the tube end in the inner tube sheet. Such tools shall be arranged for power operation, including the use of the right angle gear drive, extensions or flexible shaft therefor specified in 3.9.1(d)(3) if required for permanent plugging of those tubes adjacent to the periphery of the waterboxes or the waterbox partition (see 3.2.15.4.2 and 3.2.15.5.2).
(b) Permanent tube plugs shall be fabricated from condenser tube stock of same material as the condenser tubes and of proper gage so that, when turned down to fit inside the tube end in the inner tube sheet, the wall thickness will be not less than that of the condenser tubes. An end plug in accordance with MIL-C-15726, composition 70-30 or 90-10 as applicable, shall be welded into the small diameter end of the tube plug. Alternatively, the permanent tube plugs may be machined from bar stock in accordance with MIL-C-15726, composition 70-30 or 90-10 as applicable, with the above limitation as to wall thickness. Each permanent plug shall pass the inspections specified in 4.5.5.
(c) Tapered phenolic tube plugs in accordance with MIL-P-15742 shall be provided for plugging the open end of the permanent tube plug after the permanent plug has been installed and the installation proved satisfactory.

3.9.2.1 Condenser manufacturer shall forward the following to the drawing review agency:

(a) Permanent tube plugging procedure.
(b) Drawing(s) of the permanent tube plug and tools (including tapered tube plug).
(c) Drawing(s) showing the permanent plug and each tool in its proper position in the tube end or permanent plug.

3.9.2.1.1 The drawing(s) and procedure specified in 3.9.2.1 shall be included in the condenser technical manual.

3.9.2.2 For types I, II and III condensers it shall be demonstrated to the satisfaction of the cognizant DCAS, or Supervisor of Shipbuilding by means of a full-scale mock-up, that the tools provided can be used satisfactorily within the confines of both waterboxes (see 3.2.15.4.2 and 3.2.15.5.2) using the access openings provided thereon. Use of the condenser waterboxes and dummy tube sheets is suggested. Such dummy tube sheets shall be provided with at least three test jigs, and located in the positions of the tubes closest to the periphery of the waterboxes and the waterbox partition. The tightness of the permanent tube plugs, when expanded into the tube end and the tube hole in the outer tube sheet shall be demonstrated, the expanding being accomplihsed inside the confines of the waterbox. Tightness of the tube plugs shall be demonstrated by a hydrostatic test pressure equal to specified submergence test pressure in the space between the simulated tube sheets of the test jigs. If the same plugs and tools have been successfully used in a previous demonstration on waterboxes of the same design, there may be substituted for the mock-up and tube plugging described, a demonstration of ability to position tools and plugs as for use in cutting out and plugging the most inaccessible tubes (as described above); this shall be done to the satisfaction of the DCAS or Supervisor of Shipbuilding.

3.9.2.2.1 For type IV condensers, a demonstration shall be made in the same way of the satisfactoriness of the tools provided, except that the requirements of working via the waterbox access openings and within the confines of the waterbox are not applicable. For the case where type IV air ejector after condensers are being purchased in conjuction with type I or II condensers and permanent tube plugs and tools demonstrated for the larger condenser are applicable to the smaller condenser, it shall not be necessary to redemonstrate their use on the latter. Upon successful completion of the demonstration, the condenser manufacturer shall submit a letter certifying the capability of the tool set to fulfill its intended purpose. The letter shall contain the signature of the DCAS or Supervisor of Shipbuilding witnessing the demonstration, and it shall be submitted to the drawing review agency.

3.9.2.3 Each tool set shall contain the following:

- (a) 100 permanent tube plugs (for each type of condenser).
- (b) Tapered phenolic plugs equal to the number of permanent plugs.
- (c) One each of all tools required to install the permanent plug (including bevel gear, extension, universal joint, or flexible shaft if required, however a drive motor shall not be furnished).
- (d) One spare set of tube cutter bits (if tube cutter is used).
- (e) One spare set of rollers for each expander.
- (f) One copy of procedure and drawings referred to in 3.9.2.1.

3.9.2.4 Each tool set shall be contained in a sturdy metal tool box suitable for the intended purpose. The outside of each tool box shall be marked as follows:

- (a) Nomenclature - "Tool Set for Permanent Plugging of Tubes in Double Sheet Condensers".
- (b) "Tool Set NSN - (add if available)".
- (c) Condenser manufacturer.
- (d) Name of component and its CID (APL) number.
- (e) Contract number.
- (f) Applicable ships.
- (g) "Tube plug NSN - (add if available)".

3.10 Technical data. The supplier shall prepare drawings, design report, technical manual, microfilm, aperture/tabulating cards, list of onboard and stock repair parts and listing of aperture cards in accordance with the data ordering documents included in the contract or order (see 6.1.2).

3.10.1 Drawings. In addition to the drawing content required by the data ordering document the unique technical features specified in 3.10.1.1 through 3.10.2.1 shall be included. Proposed areas of departure from the specifications must be explicitly requested with supporting basis and, if accepted by the drawing review agency, they shall be called out as exceptions in the certification data sheet statement of conformance.

3.10.1.1 An external arrangement drawing, called "Outline Drawing", shall show all necessary external views of the unit, shall include all external dimensions required for reproduction on ship's machinery arrangement drawings, for guidance of the shipyard in designing the foundation structure for the unit, for installation thereof, and for connection of the unit to the external piping. Drawing shall show the space required for removal and replacement of tubes, removal of waterboxes, covers of access openings, zinc-anodes (if fitted), location of lifting lugs or eyebolts provided for handling of the unit or its components and size of openings therein provided for lifting, center-of-gravity information for dry and operating conditions, and allowable forces and moments for waterbox inlet nozzles on surface ship scoop injected condensers (see 3.2.15.7).

3.10.1.2 A drawing showing complete longitudinal and transverse cross-sectional views of the unit shall be called "Assembly Drawing". This drawing shall show the relationship of all parts, arrangement of tubes, method of tube end expansion and baffles. Liberal use of enlarged views or sections shall be made. If necessary, subassembly drawings conforming to the above may be furnished for individual components of the unit. The drawing or drawings shall be such that a thorough understanding of the design and construction of the apparatus may be obtained without reference to related detail drawings.

3.10.1.2.1 The assembly drawing shall contain a list of materials showing names of parts with identifying numbers and materials of all parts.

3.10.1.2.2 The drawing shall bear a certification that the zinc anodes provided comply with the requirements of MIL-A-19521 (nuclear ship condensers only).

3.10.1.3 Detail drawings of all major parts such as shell, waterboxes, tube sheets, tube supports, and baffles shall be furnished. Drawings shall be completely dimensioned, with finishes and welding symbols indicated, as required for manufacture. For submarine condensers, all submergence pressure boundary weld joints shall be identified by a unique weld joint identification number.

3.10.1.4 Certification data sheet shall be furnished and shall include a tabulation of the following data:

(a) Curves showing absolute pressure (inches of Hg) obtainable versus heat loading (Btu) for inlet circulating water temperatures of 28°, 45°, 65°, and 85°F at circulating water flows of 1/4, 1/2 and full design quantities for condensers serving submarines, or 45°, 65°, 75°, and 85°F for condensers serving surface ships. Heat transfer rates shall be calculated as specified in 3.3.2.9 using correction factors of 0.520, 0.745, 0.962, 1.025 and 1.060 for 45°, 65°, 75°, and 85°F inlet circulating water temperatures, respectively.
(b) Quantity of steam from main turbines at full and various partial loads or quantity of steam from ship's generator turbine at maximum rated-load.
(c) Quantities of auxiliary exhaust provided for in the design in pounds per hour (see 3.2.17.3.1).
(d) Total quality of condensate including estimates and tabulation of turbine exhaust, steam dump, auxiliary exhaust steam (design steady state condition), make-up feed via deaerating tank, recirculating water from feed tank, distilling plant coil drains, air ejector intercondenser drains, surge tank vapors, and all other drains or connections involving the condenser condensate.
(e) Number, o.d., wall thickness and ordering length of tubes.
(f) Total cooling surface and the subdivision of this surface alloted for air ejector suction pre-cooling.
(g) Quantity of circulating water for full-power or rated-load conditions and its temperature rise.
(h) Velocity of circulating water at rated-load in the tubes of each pass with the total friction drop in feet from inlet to outlet connection at rated-load.
(i) Calculated initial temperature difference, logarithmic mean temperature difference, and final temperature difference at full- or rated-load.
(j) Calculated value of heat transfer coefficient at full-load under specified conditions.
(k) Predicted condenser pressures (inches of Hg absolute) that will occur at the design dump steam flow with circulating water at design inlet temperature and full pump flow.
(l) Dry weight, operating weight, and flooded weight (flooded steam, and sea water sides) of condenser.
(m) Hydrostatic test pressures for all pressure parts. (In case of condensers for submarine service hydrostatic test pressure of waterboxes and space between tube sheets shall not appear on the drawing. Reference shall be made to the appropriate salt water piping system diagrammatic drawing as a source of this information, with a notation confirming that the test pressure value for the salt water side also applies to the double tube sheet void space.)
(n) Name and address of manufacturer of condenser tube packing.
(o) Number of condensers per ship.
(p) List of critical materials (see 4.1.2.2).

3.10.2 Design report. For types I and II condensers, the condenser manufacturer shall prepare a condenser design report which shall be submitted to the drawing review agency for approval prior to fabrication. The design report shall contain technical proof of equipment compliance with design and performance requirements. Technical proof shall include calculations, sketches, test data, service experience, and similar pertinent information. Design report format shall permit ready evaluation of the contents. As a minimum, the technical justification for the items listed shall be included where applicable. Drawings submitted for acceptance shall be accompanied by that portion of the design report applying to the drawing submitted. (Item (p) shall be submitted prior to installation of tubes in production units.) A final and complete version of the design report shall be submitted for information to the drawing review agency after all of the items have been completed. Final and complete version shall be a consolidation of all reports generated and shall contain all corrections.

(a) Auxiliary exhaust distribution system (see 3.2.17.3.1).
(b) Steam dump distribution system (see 3.2.17.3.1).
(c) Condenser heat transfer surface (see 3.3.2.9).
(d) Condenser shell expansion joint design for double tube sheet condenser (see 3.2.9.3.1).
(e) Submarine condenser tube sheet design (see 3.2.13.3).
(f) Submarine waterbox design (see 3.2.15.4.1.1 and 4.2.3).
(g) Double tube sheet assembly design for nuclear ships (see 3.2.13.2.2, 3.2.13.2.3, 3.2.13.2.4, 3.2.13.4, and 3.2.13.4.1).
(h) Provisions for tube bundle examination, zinc maintenance, and tube plugging for double tube sheet condenser (see 3.2.15.4.2, 3.2.15.4.2.1, 3.2.15.5, 3.2.15.5.1, and 3.3.2.10.3).
(i) Turbine exhaust connection design for double tube sheet condenser (see 3.2.11).
(j) Surface ship waterbox scoop and circulating pump inlet nozzle design for double tube sheet condenser (see 3.2.15.7).
(k) Surface ship waterbox design for double tube sheet condenser (see 3.2.8.4).
(l) Design of baffles or distribution pipes or both (see 3.2.11.2, 3.2.17.3.3, 3.2.17.3.4, and 3.2.17.3.5).
(m) Shock resistance design (see 3.2.7).
(n) Analysis of bolting adequacy for all bolting associated with sea water containing elements or double tube sheet void spaces on submarine condensers (see 3.2.13.5.3 and 3.2.15.14).
(o) Submarine guide pin adequacy (see 3.2.15.4.1 and 3.2.15.4.1.5).
(p) Tube expanding procedure for double tube sheet condenser (see 4.2.4).

3.10.2.1 For submarine sea water cooled condensers, the design report shall be in a format to facilitate an independent review of its contents. It is therefore imperative that it be simple to follow and free from ambiguity and shall contain the following as a minimum:

(a) Description of design requirements such steady state and transient pressures, temperatures and external loads.
(b) A general description of the methods of analysis and assumptions.
(c) Reference sources shall be indentified.
(d) Computer programs shall be properly identified and described.
(e) Report shall contain a copy of the computer printouts (input and output).
(f) The following tabulation shall be included in the design report:

Materials and mechanical properties

Part	Material used	Su	Sy	Sm
(i.e., Identify various parts of the component)	(Fully indentify by specification and finish)	(Indicate value and source)		(From SDB-63)

Primary and secondary stresses

Area analyzed	Maximum calculated stress intensity	Allowable stress intensity	Page on which calculated stress appear
	(i.e., show comparison of calculated stress and allowable stress)		

Peak stress intensity

Area analyzed	Usage factor	Pages on which calculated stresses appear
	(Based on 48,000 lb/in^2 yield for CuNi materials)	

3.10.3 Technical manuals. In addition to technical manual content required by the data ordering document, technical manuals shall include sufficient drawings to permit ship and shore activities to repair and maintain the unit without supplier's assistance. The manual shall contain instructions for proper installation of locking devices and criteria for their renewal.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Quality program. The supplier shall provide and maintain a quality program in accordance with the data ordering document included in the contract or order (see 6.1.2).

4.1.2 In addition to the quality program requirements required by the data ordering document the requirements specified in 4.1.2.1 through 4.1.2.2 shall be included.

4.1.2.1 Critical dimensions such as waterbox thicknesses, tube sheet thicknesses, tube hole sizes, and tube sheet ligaments shall be measured. Departures from limits established by accepted drawings shall be classed as major variations. Approval consideration of major variations shall be only by the drawing review agency (see 6.3). Where the dimension affected is based on fatigue analysis or directly related to another dimension so based (for example the size of a tube hole), a prerequisite for approval consideration will be supporting calculations demonstrating the effect of the error on the fatigue life. For submarine condensers, a 100 percent examination of the tube sheet tube holes and ligament widths shall be made.

4.1.2.1.1 For submarine condenser inner tube sheets, tube holes which are over 0.631 inch inside diameter (i.d.) up to and including 0.641 inch (i.d.) shall be classed as minor variations. The DCAS or Supervisor of Shipbuilding has authority to approve these oversized holes provided their number does not exceed 4 percent of the total number of tube holes in that sheet and provided the minimum ligament thickness (see 3.2.13.3) is maintained. These oversize holes shall be tubed with selected tubes meeting specification requirements except having an o.d. of not less than 0.624 inch. Tube hole machining deviations shall be completely documented on drawings which shall be included in the technical manual.

4.1.2.1.2 Accuracy of registration and alinement of holes for tubes in double tube sheets shall be established at final assembly of outer tube sheets by gaging the amount of offset of the centerlines of matching pairs of holes. Centerlines shall not be offset more than 0.006 inches for more than 1 percent of the sets of corresponding inner and outer tube sheet holes. Sample inspection is acceptable.

4.1.2.1.3 For surface ship condenser inner and outer tube sheets, tubes holes which are over 0.633 inch i.d. up to and including 0.641 inch shall be classed as minor variations provided ligament widths at the oversized holes meet or exceed the minimum ligament requirement (see 3.2.13.3). The DCAS or Supervisor of Shipbuilding has the authority to approve these oversized holes provided their number does not exceed 4 percent of the total number of tube holes in that tube sheet.

4.1.2.2 For submarine sea water cooled condensers, the following items are designated as critical materials. Each of these items shall have material traceability including heat lots, chemical and physical test reports. Critical materials shall be designated on drawings and shall consist of the following:

- (a) Tube sheets (both inner and outer).
- (b) Sea water vent and drain connections including double tube sheet void space vents and drains.
- (c) Heat transfer tubing (this tubing shall not be marked for traceability identification but shall be stored in secured containers and the container identified).
- (d) Waterboxes including all parts, subparts and access covers.
- (e) Nuts, studs, bolts and washers, joining sea water containing parts.
- (f) Steam dump piping from condenser inlet up to but not including replaceable dissipators.
- (g) Permanent tube plugs including blind nipples (see 3.2.16.5).

4.2 Tests.

4.2.1 Hydrostatic.

4.2.1.1 Shells of type IV condensers designed as vent condensers for ship's heating drain systems and provided with an after condenser for the air ejector shall be tested to a hydrostatic pressure of 30 lb/in^2g before tubes are installed. When waterboxes are furnished with the condenser and are available at the time of test, they may be used on the condenser for performance of the test. If not furnished or available, blank flanges shall be used over the tube sheets. Hydrostatic test shall be applied to the two shell sections separately.

4.2.1.2 Stud holes which penetrate through the tube sheet as described in 3.2.13.5.1 shall be hydrostatically tested to the highest test pressure for either side of that tube sheet before the tube sheet is tubed.

4.2.1.3 For condensers with single tube sheets, after installation of tubes, a hydrostatic pressure of 30 lb/in^2g shall be applied to the condenser shell, and all leaking tubes, or tube end joints shall be corrected. In the event of leakage in the shell welds, repairs shall be made to the welds in accordance with accepted drawings and procedures, such repairs to include removal and replacement of tubes to the extent that requirements for internal access necessitate.

4.2.1.4 For condensers with double tube sheets, after installation of tubes, a hydrostatic pressure of 30 lb/in^2g shall be applied to the condenser shell and any leaking tubes shall be replaced. *For submarine condensers the 30 lb/in^2g hydrostatic test pressure shall* be increased as necessary to demonstrate that no damage to the condenser shell will result from the conditions described in 3.2.8.2. Drain connections for the spaces between the double tube sheets shall be examined for drainage of water leaking between the tubes and the tube holes in the inner tube sheets due to inadequate expansion of the tubes in the tube sheets. Such leakage shall be corrected by minimum possible rerolling of the tubes, to avoid excessive cold working of the metal. In the event of leakage in the shell welds, repairs shall be made to the welds in accordance with accepted drawings and procedures, such repairs to include removal and replacement of tubes to the extent that internal access is required.

4.2.1.5 Before or after the test of 4.2.1.4, for condensers equipped with double tube sheets, the specified water side hydrostatic test pressure (see 4.2.1.6) shall be applied to the spaces between the double tube sheets. The expanded tube ends in the outer tube sheets shall be examined for leakage. Any leakage shall be corrected by rerolling the individual tube end.

4.2.1.6 Unless otherwise specified (see 6.1.1), a hydrostatic pressure of 30 lb/in^2g shall be applied to the sea water side of condensers for surface ships. Hydrostatic test pressure specified (see 6.1.1) shall be applied to the sea water side of condensers for submarines. Any leakage in waterbox welds or gasketed joints shall be corrected.

4.2.1.7 For steam dump or auxiliary exhaust assemblies, the hydrostatic test pressure shall be applied to that portion of the assembly between the inlet to the condenser and the last internal connection which permits installation of a test blank.

4.2.1.8 Satisfactory completion of the tests specified in 4.2.1.1 through 4.2.1.7 shall be demonstrated following any tube rerolling or replacement, weld repair, gasket replacement, etc., required by the aforementioned tests. Performance of any test specified in 4.2.1.1 through 4.2.1.7 more than 5 times is not permitted on submarined condensers without approval of the drawing review agency. However, a screening pressure not greater than the design pressure (see 6.1.1) may be applied without limit prior to final hydrostatic pressure being applied.

4.2.2 Performance.

4.2.2.1 After installation in the ship, the condensers shall be subjected to a performance test at full-power. For types I, II and III condensers, this test shall include a check and correction of all vacuum leaks and a check of the oxygen content of condensate for at least one full-power run. For type IV condensers, satisfactory condensation of steam and cooling of the air shall be determined.

4.2.2.1.1 The absolute pressure (inches of Hg) requirements specified (see 6.1.1) and the condensate depression (see 3.3.2.5) shall be determined. If the temperature of the circulating water obtainable at the time of test is not 75°F as specified, the absolute pressure (inches of Hg) maintained by the main condenser under the specified conditions shall be corrected to that corresponding to 75°F in the following manner:

(a) Trial data required:
  (1) Condenser pressure.
  (2) Sea water temperature.
(b) Assumptions:
  (1) *Trial condition heat rejection equals corrected condition heat rejection.*
  (2) Trial water velocity through condenser tubes equals design water velocity.
  (3) Trial cleanliness factor = 1.00 = F_{1_t}

(c) Symbols:

(1) All symbols are the same as those indicated on Design Data Sheet DDS4601-1, except as follows:

θ = initial temperature difference, °F
(By definition $\theta = T_s - T_i$)

Subscript "T" refers to trial condition
Subscript "75" refers to 75 degree condition

(d) Derivations:

(1) $Q = 500\ G(T_o - T_i)$

From Design Data Sheet DDS4601-1,

$$\frac{t_s - t_i}{t_s - t_o} = e^a$$

(2) $(t_o - t_i) = (t_s - (t_s - t_o) - t_i)$

$$(t_o - t_i) = t_s - \frac{t_s - t_i}{e^a} - t_i = \theta(1 - e^{-a})$$

$$\text{therefore } \frac{Q_T}{Q_{75}} = \frac{(t_o - t_i)_T}{(t_o - t_i)_{75}} = \frac{\theta_T(1 - e^{-a})_T}{\theta_{75}(1 - e^{-a})_{75}}$$

But basic assumption is that $Q_T = Q_{75}$

(e) Then $\theta_T(1 - e^{-a})_T = \theta_{75}(1 - e^{-a})_{75}$

$$(t_s - t_i)_T(1 - e^{-a})_T = (t_{s75} - 75)(1 - e^{-a})_{75}$$

$$\boxed{t_{s_{75}} = \frac{(1 - e^{-a})_T}{(1 - e^{-a})_{75}}(t_s - t_i)_T + 75}$$

Where: $a = \frac{U_c Lk}{500V}$; Design Data Sheet DDS4601-1

$U_c = F_1 \times F_2 \times F_3 \times 267 \sqrt{V}$; Design Data Sheet DDS4601-1.

In solving for $(1 - e^{-a})_T$, ${F_1}_T = 1.00$

In solving for $(1 - e^{-a})_{75}$, ${F_1}_{75} = \underline{0.85}$

$(1 - e^{-a})_{75}$ can be determined from the condenser design.

$(1 - e^{-a})_T$ shall be computed during the trials since the trial sea water temperature is required for ${F_3}_T$.

4.2.2.1.2 In the case of types I, II and III condensers for submarines, similar correction to 65°F inlet water temperature shall be made.

4.2.2.2 When specified for condensers which are to be fitted with steam dumping connections, a shipboard steam dump test shall be conducted during power plant testing. Test shall ensure that proper steam dumping can be accomplished from zero power levels to full-power condition. During the performance of the test there shall be no faulty operation of condenser instrumentation, detrimental vibration which could lead to structural failure, or erosion of condenser internals unless such internals have been made purposely replaceable or have been given added allowances in consideration of the erosion potential. Such replaceable parts shall be designed for 2000 hours full-power steam dumping. Design life of 2000 hours actual operation for replaceable parts shall not be construed or interpreted as a warranty requirement or otherwise affect the manufacturer's warranty if the design is adequately justified. In accordance with 3.2.11, the design of the condenser shall be such that high velocity steam or entrained moisture shall not cause erosion or impingement damage on the tubes. The vendor shall ensure that baffling and the location of the steam dump will provide adequate drainage of condensate to the hotwell. The vendor shall be responsible for evaluation of the test data obtained during the steam dump performance test. Steam dump performance test duration, conditions, instrumentation and acceptance criteria shall be as specified (see 6.1.1).

4.2.3 Proof test. For submarine condensers which will be subjected to full submergence pressure, the structural adequacy of the inlet-outlet waterbox or a scale model thereof shall be verified by a proof test if the configuration or other factors of the design are such that proof testing is required by SDB-63. If required, the proof test shall consist of a qualitative survey of the waterbox, utilizing brittle coating (stress coat or its equivalent), or photostress (molded birefringent coatings) techniques as deemed suitable, in order to determine the location of maximum strain. Quantitative measurement of the magnitude of maximum principal strain in the waterbox shall be obtained from strain gages of 1/8 inch gage length or smaller. Waterbox loadings shall be comprised of a combination of design submergence pressure in conjunction with the piping reaction load (that load which produces the highest stress) applied to the nozzles. The nozzle loads shall be calculated as specified in 3.2.15.4.1.2. A loading jig incorporating mechanical or hydraulic jacks shall be provided to induce external loads on the nozzle flanges. The following combinations of loads shall be applied:

(a) Internal pressure and external piping load (that piping reaction load which produces the highest stress) applied to one flange.
(b) Internal pressure and equal external loads (that piping reaction load which produces the highest stress) applied to both flanges.

4.2.3.1 Since the angular orientations of the applied bending moments to give the maximum stress for each load combination are unknown, and the location of maximum stress is also unknown, the angular orientations of the applied bending moments for load combinations 1 and 2 shall correspond to increments of 45 degrees around the nozzles from 0 to 360 degrees in the first run, and a minimum of 9 degrees increments shall be used in the 45 degree maximum stress sector in the second run. The location, magnitude and direction of the maximum principal strain (stress) can be determined by brittle coating or photostress, but must be checked with electric resistance strain gages. If the maximum range of strain (stress) intensities thus determined in any location of the waterbox (by either load combination of 4.2.3(a) or (b)) does not exceed the allowable strain (stress) intensity range for a 20,000 cycle life as determined by the Modified Goodman Diagram and Fatigue Curve for the particular material involved, the waterbox design is acceptable. The contractor shall submit to the drawing review agency an outline of the test procedure to be used, describing test fixtures, proposed instrumentation and procedures involved. Approval of the test procedures, apparatus, and models are required prior to test performance. The DCAS or Supervisor of Shipbuilding shall monitor the set-up for test, procedures, and taking of data. Certification that a proof test in accordance with the above has been previously performed on equipment identical to that furnished hereunder will suffice for the above requirements.

4.2.3.2 Fatigue test. As an alternative to the proof test of 4.2.3, the capability of the inlet/outlet waterbox to withstand cyclic loading may be demonstrated experimentally governed by the procedure outlined in Article III-10, paragraphs 1080 to 1085, of SDB-63. The magnitude and orientation of loads to be applied in the fatigue evaluation shall be as determined from 4.2.3 and 4.2.3.1.

4.2.4 Tube expanding. For each condenser design for a nuclear propelled ship there shall be submitted to the drawing review agency for approval a tube rolling procedure applicable to the materials, tube size and wall, joint configuration and specific equipment used. This procedure shall be supported by data derived from mock-up test work to demonstrate the adequacy of the tube rolling procedure. The procedure with substantiating data shall guarantee tightness against the prescribed hydrostatic test pressure and minimum pullout and pushout forces equal to the yield strength of the tube. The minimum acceptable tube wall reduction shall be determined and prescribed. The maximum limit of tube wall reduction (limit where a tube in service should be replaced in lieu of being rerolled further) shall be established for insertion in equipment manual for guidance in corrective maintenance work. The maximum acceptable "shop tube wall reduction" shall be determined for use as a production control, this value being set to insure ability to reroll the tubes at least three times for corrective maintenance purposes. There shall be inserted in the equipment manual the recommended increment of additional tube wall reduction for the respective rerollings. The mock-up test shall be comprised of a tube (or tubes) rolled into plates of the same thickness and material as the inner and outer tube sheets respectively. The joint configuration, tube size and material shall conform to the specific equipment used. A jig, for use in a tensile test machine shall be provided for application of forces to the tube sheets. The supplier, in his report shall furnish plots of pullout and pushout forces versus linear deflection measured from the inner surface of the outer tube sheet to the inner surface of the inner tube sheet (that is, the change of length in the distance between tube sheets). Tube elongation (growth) shall also be measured upon completion of the pullout test. A strain gage shall be installed in the longitudinal axis of the tube, located at the midlength of the tube between the double tube sheets. Force versus strain shall be plotted for every increment of 100 pounds of force. Any portion of the above test which has been previously performed for equipment identical to that being furnished hereunder need not be repeated.

4.3 Impact tests. Steel material for submarine condenser inner tube sheets shall meet the fracture toughness requirements of NB2300 of Section III of the ASME Boiler and Pressure Vessel Code. In no case shall the reference temperature (RT_{NDT}) be higher than minus 30°F.

4.4 Shock tests.

4.4.1 Test requirement. When specified (see 6.1.1), one condenser of each size, type and design shall be subjected to high-impact shock testing in accordance with MIL-S-901 including post shock examination and test and accomplishment of such corrective measures as may be found necessary.

4.5 Nondestructive inspection.

4.5.1 Castings. When cast construction is elected for submarine condenser waterboxes subject to submergence pressure (see 3.6.1.1) the inspections specified in 4.5.1.1 and 4.5.1.2 shall be carried out.

4.5.1.1 Castings shall be given 100 percent radiographic inspection in accordance with MIL-STD-278.

4.5.1.2 After machining, castings shall be given 100 percent liquid penetrant inspection in accordance with MIL-STD-278 except that no indication shall exceed 0.050 inch in depth.

4.5.2 Expansion joints. Nondestructive testing shall be employed to assure the integrity of expansion joints (see 3.2.9.3.1) prior to installation and of the welds made for their installation.

4.5.3 Tube sheets and waterboxes. For submarine condensers, welded or forged waterboxes over 3/4 inch thick, and tube sheets shall be ultrasonically inspected in accordance with MIL-STD-271. Acceptance criteria shall be as specified in the applicable material specification for waterboxes and outer tube sheets and MIL-S-23194 for inner tube sheets. Areas, which by design configuration do not permit ultrasonic inspection, may be omitted if specifically approved by the drawing review agency. Areas excluded from inspection shall be noted on design drawings.

4.5.4 For submarine condensers, waterboxes and outer tube sheets shall be liquid penetrant inspected on the final machined surfaces. Inner tube sheet of submarine condensers shall be magnetic particle inspected. Drilled or tapped holes do not require liquid penetrant or magnetic particle inspection. Inspection and acceptance criteria shall be as specified in the applicable material specification for waterboxes and outer tube sheets, and MIL-S-23194 for inner tube sheets.

4.5.5 Permanent tube plugs. Each permanent tube plug for nuclear propelled surface ship and submarine condensers shall be subjected to a minimum internal hydrostatic test equal to the same test pressure required for the heat transfer tubes. Each plug shall be tight under this pressure and shall show no bulges, cracks, flaws, porous places, or other harmful defects. In addition, each permanent tube plug for submarine condensers shall also be given a 100 percent liquid penetrant inspection in accordance with MIL-STD-271 on its outer surface after the hydrostatic test. The liquid penetrant inspection standards shall be as follows:

(a) Plugs which show the following liquid penetrant indications shall be subject to rejection:
  (1) Any liquid penetrant indications of cracks, seams, or laps, that is any linear type of indication except those which can be definitely established to the satisfaction of the drawing review agency as scratches whose depth is less than 5 percent of the wall thickness.
  (2) Round indications 1/16 inch diameter or greater.
  (3) Round indications which are linearly disposed whose center to center distance is less than 3/16 inch.

(b) Superficial polishing with 120 grit emery cloth may be used as an aid in determination of the extent of the indications defined in (a)(1), (2) and (3). Not more than 5 percent of the wall thickness may be removed in the effort to remove the indications, always provided that design wall thickness is maintained.

(c) If the vendor chooses to remove the defects, reinspection of the area containing the indication shall be performed by liquid penetrant inspection after polishing, to assure that all indications have been removed.

4.5.6 Heat transfer tubing for condensers for surface ships shall be inspected by the "eddy-current" method of tube inspection specified in MIL-T-15005.

4.5.7 Heat transfer tubing for submarine sea water cooled condensers shall be tested as follows:

(a) The tube supplier shall hydrostatically test the heat transfer tubing in accordance with the requirements of MIL-T-15005 to the pressure specified, or at the pressure prescribed by SDB-63, whichever is higher.

(b) Heat transfer tubing shall be eddy-current or ultrasonically tested in accordance with MIL-T-15005 except as specified in 4.5.7.1 through 4.5.7.7.

4.5.7.1 Inspection lot. A lot shall consist of all tubes of the same composition, diameter, wall thickness, produced from the same heat of material, and heat treated in the same batch or by a continuous process under the same conditions with regard to temperature, and time, and submitted for quality assurance tests at one time.

4.5.7.2 Eddy-current or ultrasonic test. Condenser and heat exchanger tubes, when specified (see 6.1.1), shall be tested by either eddy-current or shear wave ultrasonic methods. Sensitivity of the device used for testing shall be adjusted to detect the artificial discontinuities on the calibrated tube in accordance with 4.5.7.3. Tubes shall be tested along the entire length and shall have at least 4 inches cut from each end of the length after testing.

4.5.7.3 Calibrating tube. Tubing used to adjust and calibrate the testing device shall be of the same alloy, temper and nominal dimensions as the lot of tubes to be tested. It shall be of sufficient length to permit spacing of the required artificial discontinuities and also simulate processing of production tubes through the testing device. The artificial discontinuities shall consist of two electric discharge machining notches 0.005 inch in depth or 5 percent of the nominal tube wall, whichever is greater. Each notch shall be approximately 0.002 inch in width and 1/4 inch maximum in length arranged parallel to the longitudinal axis of the tube. The first notch shall be placed on the inside surface of the tube, 6 inches from one end. The other notch is to be placed in line with the first but on the outside surface, 18 inches from the same end of the tube. Tolerance on the depth of the notches shall be 0 plus and 0.001 minus inch.

4.5.7.4 Sensitivity setting.

4.5.7.4.1 Eddy-current testing. Testing device shall be adjusted to the lowest sensitivity required to repetitively detect the artificial discontinuities when the calibrating tube passes through the testing device at the regular production speed (f/m) used in testing tubes.

4.5.7.4.2 Ultrasonic testing. Ultrasonic transducer shall be so collimated and the angle adjusted to equalize (to the maximum extent possible) the peak response from both the i.d. and o.d. notches. The lower response (of the equalized condition) at that angle shall be adopted as the calibration reference. Ultrasonic instrument settings shall be made such that the peak indications from the calibration reference are at least 50 percent but not more than

90 percent of linear full screen amplitude. The tube, the search unit, or both the tube and search unit shall be moved uniformly during testing in such a manner that the search unit motion, relative to the tube, describes a helix concentric with the tube so that each pass of the scanning crystal overlaps the previous pass not less than 1/2 inch when testing to a 1/2 inch calibration notch.

4.5.7.5 Recalibration. Testing devices shall be calibrated at the start of the test run and at least once every hour of continuous operation or at any change in search unit, couplant, instrument settings, or scanning speed from that used for calibration or whenever improper functioning of the testing unit is indicated. If the testing device is found to be out of calibration, all tubing processed since the last correct calibration check shall be retested.

4.5.7.6 Rework. Tubes which are rejected by the eddy-current or ultrasonic inspection may be visually examined for surface defects. Superficial polishing with 120 grit emery cloth may be used to eliminate these surface defects. Not more than 5 percent of the wall thickness shall be removed to definitely remove the indications. Tubing wall thickness shall not be reduced below minimum specified wall thickness or below minimum design wall thickness, whichever is greater. Tubes so reworked shall be reinspected by the same test method that originally rejected the tube.

4.5.7.7 Acceptance criteria. After final inspection has been performed, tubes which have defects in excess of those determined by calibration of the testing device in accordance with 4.5.7.3 shall be subject to rejection.

4.5.8 Solder coated sections of waterboxes shall be visually examined to verify that surfaces are completely covered. Solder coating shall be checked by micrometer or by masking an area with tape to be removed after spraying and checking the thickness, then respraying. Thickness shall be checked in one place for each 10 square feet of area coated, but no less than two places for each item coated.

4.5.9 Welds of surface ship fabricated waterboxes, except stiffening rib welds, shall be liquid penetrant inspected to the requirements of MIL-STD-278 after completion of all welding operations.

4.6 Additional inspection. Unless otherwise specified in the contract or order, where other specifications form a part of this specification, sampling, examination, and tests shall be performed as required by the referenced specification.

4.7 Inspection of preparation for delivery. Packaging, packing and marking shall be inspected for compliance with section 5 of this document.

5. PREPARATION FOR DELIVERY

(The preparation for delivery requirements specified herein apply only for direct Government procurements. For the extent of applicability of the preparation for delivery requirements of referenced documents listed in section 2, see 6.3.)

5.1 Preservation and packaging. Preservation and packaging shall be level A or C as specified (see 6.1.1).

5.1.1 Level A.

5.1.1.1 *Condensers. Condensers shall be cleaned and dried to meet the cleanliness* requirements of MIL-P-116. Immediately after cleaning, and drying, all internal steel surfaces shall be preserved using grade 5 of MIL-C-16173. Preservative shall be applied and the condenser handled in such a manner as to produce a uniform protective film. Excessive use of the preservative shall be avoided. After completion of preservation, the excess preservative shall be thoroughly drained from all low places and pockets. External unpainted ferrous surfaces such as flange faces and bearing surfaces shall be coated with preservative conforming to grade 4 of MIL-C-16173. Closure of openings shall be by attaching steel plates with gaskets or 3/4 inch weather resistant plywood bolted to flanges. Barrier material conforming to grade A of MIL-B-121 or class 1 of MIL-B-131 shall be placed between the plywood and flange.

5.1.1.2 Accessories. Gages and temperature indicators shall be unit packaged by method III in accordance with MIL-P-116. The packaged accessories shall then be packed in fiberboard boxes conforming to PPP-B-636, weather resistant class V3c or V3s fiber boxes shall be used for domestic shipment and storage or overseas shipment. Packed accessories shall be secured in an unused portion of the condenser shipping crate.

5.1.2 Level C.

5.1.2.1 Condensers. Condensers shall be cleaned and dried after which all internal steel surfaces shall be preserved with grade 5 of MIL-C-16173. External unpainted ferrous surfaces such as flange faces and bearing surfaces shall be protected against corrosion and physical damage. Closure of openings shall be by attaching steel plates with gaskets or 3/4 inch weather resistant plywood bolted to flanges. Barrier material conforming to grade A of MIL-B-121 or class 1 of MIL-B-131 shall be placed between the plywood and flange.

5.1.2.2 Accessories. Preservation and packaging shall be sufficient to afford adequate protection against corrosion, and physical damage during shipment from the supply source to the using activity and until early installation.

5.2 Packing. Packing shall be level A, B, or C as specified (see 6.1.1).

5.2.1 Levels A and B. Units 30,000 pounds and under shall be individually packed in crates conforming to MIL-C-104 and the appendix thereto. For units exceeding 30,000 pounds or the dimensional limitations of MIL-C-104 the planned packing, handling and transportation procedure shall be forwarded to the procuring agency for review. Units exceeding 30,000 pounds shall be skidded, uncrated. These units shall be provided with a flexible waterproof shroud material conforming to PPP-B-1055 or MIL-B-13239. Shrouds shall be secured to prevent damage or loosening and arranged to avoid formation of water pockets. All sharp points of contact between the item(s) and shroud shall be cushioned to prevent rupture or chafing of the shroud.

5.2.2 Level C. Packing of condensers and accessories shall be accomplished in a manner which will insure acceptance by common carrier and will afford protection against physical or mechanical damage during direct shipment from the supply source to the using activity for early installation. The shipping containers or method of packing shall conform to the Uniform Freight Classification Rules or other carrier regulations as applicable to the mode of transportation.

5.3 Marking. In addition to any special marking required (see 6.1.1), interior packages and exterior shipping containers shall be marked in accordance with MIL-STD-129. A tag identifying the condenser steam side preservative shall be attached to the condenser or its shipping crate.

5.4 Repair parts and tools.

5.4.1 Stock repair parts and tools. Stock repair parts and tools shall be preserved and packaged level A, packed level B and marked in accordance with MIL-R-196 or PPP-P-40 as applicable.

5.4.2 Onboard repair parts and tools. Onboard repair parts and tools shall be preserved and packaged level A, packed level C and marked in accordance with MIL-R-196 or PPP-P-40 as applicable.

5.4.3 Quantity per package. Unless otherwise specified in the contract or order, repair parts and tools shall be individually packaged unless used in sets or quantities greater than one. Parts within a set shall be individually protected.

6. NOTES

6.1 Ordering data.

6.1.1 Procurement requirements. Procurement documents should specify the following:

(a) Title, number and date of this specification.
(b) Type and class required (see 1.2).
(c) Ship motion and attitude requirements, if other than specified in 3.2.1.
(d) Condenser design operating life if other than specified in 3.2.3.
(e) For submarine application, requirements for waterbox openings and any associated piping components for the salt water side (see 3.2.5 and 3.2.15.10.2).
(f) Shock requirements:
  (1) Whether or not shock design is required (see 3.2.7).
  (2) For static shock design method, specify minimum "g-load" values for vertical, athwartships, and fore and aft directions (see 3.2.7.2).
  (3) Whether or not concurrent dynamic analysis is required when shock design is based upon static g-load values (see 3.2.7.3).
  (4) Whether shock testing is required (see 4.4.1).
(g) For submarine application, the design pressure, temperature and hydrostatic test pressure on sea water side (see 3.2.8, 3.2.15.4.1.1, 4.2.1.6 and 4.2.1.8) (Observe security requirements).

(h) Whether, for surface ships of deep draft, a water side hydrostatic test pressure greater than 30 lb/in^{2}g is required; if so state design (maximum working) and hydrostatic test pressure requirements (see 3.2.8.4 and 4.2.1.6).
(i) If known, specify condenser shell limiting dimensions (see 3.2.9).
(j) For U-tube construction whether the tube bundle shall be removable from the shell (see 3.2.9.2).
(k) For submarine application, the temperature variations and other transients to be considered in waterbox and double tube sheet design (see 3.2.13.4 and 3.2.15.4.1.1). (Observe security requirements).
(l) For scoop injected surface ship condensers, indicate size and weight of components to be attached to and supported by the inlet waterbox nozzles (see 3.2.15.7).
(m) Tube wall thickness if other than that specified (see 3.2.16.1).
(n) Condenser connection requirements (see 3.2.17.3).
(o) For nuclear propelled ships, whether steam dump connection is required; if so, specify dump steam pressure, temperature enthalpy and maximum quantity. Also specify operating cycles, and maximum dump steam pressure and temperature (see 3.2.17.3, 3.2.17.3.1.1 and 3.2.17.3.1.2(b)). Also specify maximum design temperature for turbine exhaust flexible connections (if used) (see 3.2.17.3.1.1).
(p) Full-power steady state condition auxiliary exhaust steam flow to the condenser (see 3.2.17.3.1).
(q) Maximum transient condition auxiliary exhaust steam flow to the condenser (see 3.2.17.3.1).
(r) Amounts of drains, make-up feed, recirculated condensate, inter-condenser drains, and other such heat in-puts (see 3.2.17.3.4).
(s) Whether environmental vibration should be considered; if so, state maximum environmental vibration in hertz (Hz) (see 3.2.20).
(t) Condenser arrangement (see 3.3.2.1, 3.3.2.4 and 3.4.2.3).
(u) Number of water passes, quantity of steam flow and its enthalpy from each turbine exhaust connection and astern steam temperature (see 3.3.2.2).
(v) Absolute pressure (inches of Hg) requirements (see 3.3.2.8 and 4.2.2.1.1).
(w) Inlet circulating water temperature, if other than specified in 3.3.2.8 or 3.6.2.9 as applicable.
(x) If flexible connection between main turbine and type I condenser is furnished with condenser (see 3.3.2.10.5), include specification therefor.
(y) If temperature indicators and gages are to be furnished with condensers; if so, sizes, types and graduations required, as applicable (see 3.3.2.11, 3.3.2.12 and 3.4.2.7.1).
(z) If flexible connection for steam inlet is furnished with condenser (see 3.4.2.4), include specification therefor.
(aa) For gland leak-off or vent steam condensers; amount of steam to be condensed, amount of air to be vented, and maximum temperature of vented air if other than as specified (see 3.6.2.6).
(bb) For submarine combination after and gland leak-off condensers, temperature of air vented if other than that specified (see 3.6.2.8).
(cc) Number of submarine condenser permanent tube plugging tool sets required (see 3.9.2). (It is intended that the tool set for submarine condensers be carried by the appropriate sub tenders and repair yard(s)).
(dd) For condensers of nuclear propelled ships which are to be fitted with steam dumping connections, whether a steam dumping test is required, and, if so, the number of hours duration, test conditions, special instrumentation, and acceptance criteria for the test (see 4.2.2.2).
(ee) Preservation, packing and marking requirements:
 (1) Levels of preservation, packaging and packing required (see 5.1 and 5.2).
 (2) Special marking requirements (see 5.3).

6.1.2 Contract data requirements. When this specification is used in a procurement invoking the provisions of Armed Service Procurement Regulations (ASPR) paragraph 7-104.9(n) and which incorporates ADD Form 1423 (CDRL), the following data items should be specified and delivered in accordance with such CDRL. When the ASPR provisions are not invoked, the following data should be specified for delivery in accordance with the contract or order:

Spec. Paragraph	Data requirement	Service	Applicable DID	Options
(a) 3.9	Provisioning parts list	SH	UDI-V-2078	Option 4

Spec. Paragraph		Data requirement	Service	Applicable DID	Options
(b)	3.10	Engineering drawings and associated lists (preliminary)	SH	UDI-E-23174	Catergories A, B, D, G, H, I, Types II and III, form 2 Blueline print type II, class 1
(c)	3.10	Technical manual	SH	UDI-M-23455	Para 10.1b(1)
(d)	3.10	Technical manual quality assurance data	SH	DI-M-2051	Para 10.2a
(e)	3.10	Microfilm, aperture/ tabulating cards and listing	SH	UDI-E-23140	Para 10.2.1a Para 10.2.1b Para 10.3.2
(f)	3.10.2	Design report	SH	UDI-E-23213	-----
(g)	4.1.1	Quality program plan	SH	UDI-R-23743	-----

(Copies of DID's required by the contractor in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.)

6.2 Definition - drawing review agency. As used herein "drawing review agency" is generally a Government command or agency such as Naval Sea Systems Command, Naval Ship Engineering Center, a Supervisor of Shipbuilding or an authorized representative. Communication with the drawing review agency should be handled through the procuring activity.

6.3 Sub-contracted material and parts. The preparation for delivery requirements of referenced documents listed in section 2 do not apply when material and parts are procured by the supplier for incorporation into the equipment and lose their separate identity when the equipment is shipped.

6.4 THE MARGINS OF THIS SPECIFICATION ARE MARKED "•" TO INDICATE WHERE CHANGES (ADDITIONS, MODIFICATIONS, CORRECTIONS, DELETIONS) FROM THE PREVIOUS ISSUE HAVE BEEN MADE. THIS WAS DONE AS A CONVENIENCE ONLY AND THE GOVERNMENT ASSUMES NO LIABILITY WHATSOEVER FOR ANY INNACCURACIES IN THESE NOTATIONS. BIDDERS AND CONTRACTORS ARE CAUTIONED TO EVALUATE THE REQUIREMENTS OF THIS DOCUMENT BASED ON THE ENTIRE CONTENT IRRESPECTIVE OF THE MARGINAL NOTATIONS AND RELATIONSHIP TO THE LAST PREVIOUS ISSUE.

Preparing activity:
Navy - SH
(Project 4420-N017)

INDEX

INDEX, cont'd

INDEX, cont'd

INDEX, cont'd

INDEX, cont'd

INDEX, cont'd

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL	OMB Approval No. 22-R255

INSTRUCTIONS: The purpose of this form is to solicit beneficial comments which will help achieve procurement of suitable products at reasonable cost and minimum delay, or will otherwise enhance use of the document. DoD contractors, government activities, or manufacturers/vendors who are prospective suppliers of the product are invited to submit comments to the government. Fold on lines on reverse side, staple in corner, and send to preparing activity. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements. Attach any pertinent data which may be of use in improving this document. If there are additional papers, attach to form and place both in an envelope addressed to preparing activity.

DOCUMENT IDENTIFIER AND TITLE

NAME OF ORGANIZATION AND ADDRESS

CONTRACT NUMBER

MATERIAL PROCURED UNDER A

☐ DIRECT GOVERNMENT CONTRACT ☐ SUBCONTRACT

1. HAS ANY PART OF THE DOCUMENT CREATED PROBLEMS OR REQUIRED INTERPRETATION IN PROCUREMENT USE?

A. GIVE PARAGRAPH NUMBER AND WORDING.

B. RECOMMENDATIONS FOR CORRECTING THE DEFICIENCIES

2. COMMENTS ON ANY DOCUMENT REQUIREMENT CONSIDERED TOO RIGID

3. IS THE DOCUMENT RESTRICTIVE?

☐ YES ☐ NO *(If "Yes", in what way?)*

4. REMARKS

SUBMITTED BY *(Printed or typed name and address - Optional)*

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