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SUPERSEDING
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MILITARY SPECIFICATION

COOLERS, FLUID, AFTER AIR, DIESEL ENGINE, NAVAL SHIPBOARD

1. SCOPE

1.1 Scope. - This specification covers Diesel engine after air coolers for Naval shipboard application.

1.2 Classification. - The coolers shall be of the following classes, as specified (see 6.1):

Class 1 - Submarine applications.
Class 2 - Surface ships.
Class 3 - Landing craft and small boat application.

2. APPLICABLE DOCUMENTS

2.1 The following specifications, standards, drawings and publications, of the issue in effect on date of invitation for bids, form a part of this specification to the extent specified herein:

SPECIFICATIONS

FEDERAL

O-G-93 - Galvanizing Repair Compound.
QQ-N-281 - Nickel-Copper-Alloy (Monel and R-Monel) Bars, Plates, Rods, Sheets, Strips, Wire, Forgings, and Structural and Special Shaped Sections.
QQ-P-330 - Phosphor Bronze Bars, Plates, Rods, Sheets, Strips, Flat Wire, and Structural and Special Shaped Sections.
QQ-S-741 - Steel Plates, Shapes and Bars, Carbon, Structural.
QQ-S-775 - Steel, Sheet, Zinc-Coated.
UU-P-271 - Paper, Wrapping, Waterproofed Kraft.
PPP-B-591 - Boxes, Fiberboard, Wood-Cleated.
PPP-B-601 - Boxes, Wood Cleated-Plywood.
PPP-B-621 - Boxes, Wood, Nailed and Lock-Corner.

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MIL-C-104 - Crates, Wood; Lumber and Plywood Sheathed, Nailed and Bolted.
MIL-P-116 - Preservation, Methods of.
MIL-B-121 - Barrier Material, Greaseproofed, Waterproofed, Flexible.
MIL-C-132 - Crate, Wood, Open; Maximum Capacity 2,500 Pounds.
MIL-B-233 - Boxes, Repair Parts.
JAN-P-735 - Primer, Paint, Zinc-Chromate, Alkyd Type.
MIL-B-857 - Bolts, Nuts, and Studs.
MIL-S-901 - Shockproof Equipment, Class HI (High-Impact), Shipboard Application, Tests for.
MIL-D-963 - Drawings, Production, Procedure for Procurement of.
MIL-B-994 - Brass, Naval: Rods, Sheets, Strips, Wire, Shapes, Forgings and Flat Products (Flat Wire, Strip, Sheet, Bar and Plate).

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MIL-R-1149 - Rubber Sheets, Strips, and Gaskets; Solid, Synthetic, Medium and Medium Hard.
MIL-P-1384 - Packing, Synthetic-Rubber, Cloth-Insertion (Symbol 2353).
MIL-C-3774 - Crates, Open, Wood (2,500 to 10,000 Lbs.).
MIL-T-15005 - Tubes, 70-30 and 90-10 Copper Nickel Alloy Condenser and Heat Exchanger.
MIL-P-15024 - Plates, Identification————Information and Marking for Identification of Electrical, Electronic and Mechanical Equipment.
MIL-P-15137 - Provisioning and Technical Documentation for Repair Parts for Electrical and Mechanical Equipment (Naval Shipboard Use).
MIL-C-15328 - Coating, Pretreatment (Formula No. 117 for Metals).
MIL-B-15395 - Brazing Alloys, Silver.
MIL-C-15726 - Copper-Nickel Alloy Rods, and Flat Products (Flat Wire, Strip, Sheet, Bar, and Plate).
MIL-P-15742 - Plugs, Plastic (Heat-Exchanger-Tube).
MIL-E-15809 - Expander, Tube, Condenser and Heat Exchangers.
MIL-A-15939 - Aluminum Bronze Bars, Plates, Rods, Sheets, Strips, Forgings, and Structural and Special Shaped Sections.
MIL-T-16420 - Tube, 70-30 and 90-10 Copper-Nickel Alloy, Seamless and Welded.
MIL-B-16541 - Bronze, Valve: Castings.
MIL-M-16576 - Metal, Gun: Castings.
MIL-A-17357 - Aluminum Alloy 5154 (A54S) Plates and Sheets.
MIL-A-17472 - Asbestos Sheet Compressed (Packing Material).
MIL-C-17516 - Copper-Silicon Alloy Bars, Plates, Rods, Sheets, Strips, Flat Wire, Wire, Forgings, and Structural and Special Shaped Sections.
MIL-P-17545 - Primer, Paint, Shipboard, Alkyd - Red Lead Type, Formula No. 116.
MIL-C-17728 - Control and Drive Assembly, Tube Expander, Automatic.
MIL-Z-17871 - Zinc-Coating (Hot-Dip-Galvanizing).
MIL-A-18001 - Anodes, Corrosion Preventive, Zinc: Plate, Slab, Disc and Rod Shaped.
MIL-A-19070 - Aluminum Alloy Plates and Sheets, 5086 (K186).
MIL-P-19415 - Plugs, Zinc Anode Retaining, Heat Exchanger Cathodic Protection.
MIL-A-19521 - Anodes, Corrosion Preventive, Zinc; Design of and Installation in Shipboard Condensers and Heat Exchangers.
MIL-F-20042 - Flanges, Pipe, Bronze (Silver Brazing).
MIL-T-20168 - Tubes, Red Brass, Seamless, 6,000 PSI Maximum Pressure.
MIL-G-21610 - Gaskets, Heat Exchanger, Various Cross Section Ring, Synthetic Rubber.

NAVY DEPARTMENT

General Specifications for Inspection of Material.

STANDARDS

MILITARY

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 - Welding and Allied Processes for Machinery for Ships of the United States Navy.

DRAWINGS

BUREAU OF SHIPS
B-104 - Fittings, Pipe, Composition, Flanged; Pressures 100 P.S.I. and Below.
B-214 - Root Connections for Attaching Piping.
810-1385875 - Plugs, Zinc, and Adapters for Heat Exchangers.
5000-S4823-841338 - Fittings, Silver Alloy Brazing, for Oil, Water, Gas or Oxygen.

PUBLICATIONS

BUREAU OF SHIPS
NAVSHIPS 250-537-1 and -2 - Radiographic Standards for Bronze Castings.

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

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 shall apply.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS
Boiler and Pressure Vessel Code, Section VIII - Rules for Construction of Unfired Pressure Vessels.

(Application for copies should be addressed to the American Society of Mechanical Engineers, 29 West 39th Street, New York 18, N.Y.)

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, Washington 25, D.C.)

OFFICIAL CLASSIFICATION COMMITTEE
Uniform Freight Classification Rules.

(Application for copies should be addressed to the Official Classification Committee, 1 Park Avenue at 33rd Street, New York 16, N.Y.)

3. REQUIREMENTS

3.1 Preproduction model. - When specified (see 6.1), a preproduction model shall be furnished and tested in accordance with the requirements of 4.2.

3.2 Materials. -

3.2.1 In the design of coolers for salt water service, care shall be taken to avoid combinations of materials which may produce detrimental galvanic action.

3.2.2 Threaded parts. - Threaded parts shall conform to Handbook H28. Designs shall permit the use of standard wrenches throughout. Cap screws shall not be used. Stud sizes and number of studs for zinc cover bolt circles shall be comparable to those required for bolt circle layout for coolant side flanges. The use of bolts less than 7/16 inch diameter for pressure joints shall be avoided. The Unified thread form is preferred for threaded parts. When using this form, the setting end of studs shall be a class 3A-3B fit, and the class 2A-2B fit shall be used as the general working fit.

3.2.3 Welding shall be in accordance with Standard MIL-STD-278. When brazing alloys containing nickel, such as composition 70-30 or 90-10 copper-nickel, grade IV silver-base-brazing-alloy conforming to Specification MIL-S-15395 shall be used.

3.3 General design. -

3.3.1 Space and weight. - In all designs, space and weight shall be held to a minimum consistent with strength and reliability of the coolers.

3.3.2 Inclining, pitching, and rolling. - The design of all coolers shall be such that they will perform satisfactorily under the following conditions of operation with the ship:

(a) Permanently inclined from the normal position in the fore and aft plane, up or down:
Surface ship ---------- 5 degrees.
Submarines ---------- 30 degrees.
(b) Permanently inclined to either side of the vertical:
Surface ship ---------- 15 degrees.
Submarines ---------- 15 degrees.
(c) Rolling from the vertical to either side:
Surface ship ---------- 45 degrees.
Submarines ---------- 60 degrees.
(d) Pitching up or down from the normal horizontal plane:
Surface ship ---------- 10 degrees.
Submarines ---------- 10 degrees.

3.3.3 Shock resistance. -

3.3.3.1 Shock test of the complete cooler assembly is required. If engine mounted, shock test requirement for the engine shall govern. Shock tests shall be performed as specified in Specification MIL-S-901 with the following modifications:

(a) Under the test procedure for medium weight equipment, the first blow in each group shall be applied using the standard (horizontal) mounting adapter; the second blow in each group shall be applied with the adapters holding it at a 45-degree angle from the horizontal in the direction of the units least transverse strength.

3.3.3.1.1 Waiver of shock testing will be considered for units if they are of similar design, construction, weight and materials to units which have successfully passed the tests specified in Specification MIL-S-901.

3.3.3.2 Shock resistance design. -

3.3.3.2.1 Unless otherwise specified in the contract or order, bolts designed to be stressed in shear shall be installed in holes no greater than the following sizes:

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

3.3.3.2.2 Units that are rigidly supported shall not be attached to two structures which can deflect relative to each other under shock loadings.

3.3.3.2.3 Shock mounts shall not be used without prior approval of the bureau or agency concerned.

3.3.3.3 For guidance in developing a shock resistance design see appendix to this specification.

3.3.3.4 Vibration. - Each cooler shall be designed to withstand type I vibration of Standard MIL-STD-167 if separately mounted and a combination of types I and II vibration of Standard MIL-STD-167 if engine mounted.

3.3.4 Coolers may be single or multi-pass on the cooling side.

3.3.5 Unless otherwise specified (see 6.1), the maximum permissible pressure drop at design conditions shall be 6 p.s.i. for the coolant water and 1 inch mercury (Hg.) for the air side.

3.3.6 These coolers shall be class 1 for submarine applications, class 2 for surface ship applications, and class 3 for landing craft and small boat applications, unless otherwise specified (see 6.1).

3.3.7 Inlet and outlet connections for sea water, shall be flanged unless hose connections are specified (see 6.1). Unless otherwise specified in the contract or order, flanges shall be type PR, plain, 250 pounds, 1/4 to 12 inch size, inclusive, of Specification MIL-F-20042, with cast nozzles conforming to the dimensions shown on Drawing B-104. For fabricated nozzles, in lieu of the plain, 250-pound flange of Specification MIL-F-20042, slip-on flanges of the same dimensions in regard to diameter, thickness, and drilling will be acceptable. For higher pressures, the flange design shall be as specified (see 6.1).

3.3.8 All coolers shall be provided with vent and drain connections so located as to permit complete venting and draining of the coolant. Minimum size for vents and drains shall be 1/8 inch iron pipe size (i.p.s.). Such connections shall be made by one of the following methods, as applicable:

(a) Where space will permit, the vent or drain connection shall consist of a pipe tapped hole fitted with an oversize adaptor, piece 1 of Drawing 5000-S4823-841338. A hexagonal wrenching shoulder may be provided on such adaptors and is considered a desirable feature. The use of this adaptor will permit the shipyard either to pipe up to the connection in an approved manner and without the necessity of applying brazing heat to the cooler (that is, by brazing to the adaptor), or to replace the adaptor with a pipe plug when connecting piping is not required.

(b) Where space will not permit use of the above method, the vent or drain connection shall conform to figure 6 of Drawing B-214, with a short length of tubing welded or brazed into the socket. (The provision of this nipple is to eliminate the need for the shipbuilder to apply heat to the cooler proper with consequent risk of warping or damage to gaskets.) Such nipples shall conform to Drawing B-214, having a wall thickness not less than that of the corresponding size of extra strong brass pipe; as an exception to the nonferrous materials called for by Drawing B-214, where such nipples are provided on the salt water side of a cooler they shall be of copper-nickel alloy conforming to composition 70-30 of Specification MIL-T-16420 for class 1 coolers, of copper-nickel alloy conforming to composition 90-10 of Specification MIL-T-16420 for class 2 coolers, and of red brass conforming to Specification MIL-T-20168 for class 3 coolers.

(c) For large coolers vent or drain connections conforming to figure 2 or 3 of Drawing B-214 will be acceptable as an alternate to the method specified in (a) above.

3.3.9 Connections for pressure gages shall be provided at inlets and outlets of coolant sides when specified (see 6.1). Such connections shall conform to 3.3.8. Where additional connections are considered desirable for occasional use in testing, pipe tapped holes fitted with pipe plugs may be used.

3.3.10 Hydrostatic pressure. - Coolers shall be designed to withstand the hydrostatic pressure test specified in 4.5.4.

3.3.11 Zinc protectors. - The cooling water side of coolers shall be fitted with corrosion preventive anodes in accordance with Specification MIL-A-19521.

3.3.12 Cooling water flow. - In the design of cooling water spaces and connections, a smooth flow path shall be provided in order to minimize erosion-corrosion attack. Sharp corners and projecting edges shall be avoided. Zincs and internal fittings shall be arranged so that interference with the water flow will be minimized. Cooling water velocities at design point shall not exceed 6.5 feet per second through the inlet flange and 4.5 feet per second through the tubes.

3.3.13 Cooling surface. - The amount of cooling surface installed in all coolers shall be based on the service specified (see 6.1), applying a 10 percent fouling factor to the heat transfer coefficient for clean tubes. The design cooling water inlet temperature shall be taken as 85° Fahrenheit (F.) unless otherwise specified (see 6.1).

3.3.13.1 Tube supports. -

3.3.13.1.1 For coolers mounted on the engine, minimum distance between tube support plates shall be 12 inches. For separately mounted coolers minimum distance between support plates shall be 18 inches. Minimum thickness for support plates shall be 1/4 inch.

3.3.14 Supports. - All coolers shall be provided with adequate supports for securing to a foundation. When required by the conditions of service, provision shall be made in the design of the supports to provide for expansion or contraction of the shell. Cooler support shall be independent of any attached piping, and if arranged for support of the cooler from a vertical structure, shall be so designed that bolts in shear do not constitute the primary means of support. Coolers shall not be supported by plates or brackets in such manner that the primary means of support is obtained from the bolts securing the shell end flange-tube sheet-water box flange joints.

3.3.15 Flat gaskets. - Compressed asbestos gaskets shall be 1/16 or 1/32 inch thick. Cloth inserted rubber gaskets shall be 1/16 inch thick. Coolers shall be so designed that an adequate gasket width is provided under water box partitions. In coolers having an equivalent shell diameter of 12 inches or more, this gasket width shall be not less than 5/16 inch.

3.3.16 O-ring gaskets. - Where a test pressure above 300 pounds per square inch gage (p.s.i.g.) is specified, recessed flat gaskets or O-ring gaskets conforming to Specification MIL-G-21610 shall be furnished.

3.3.17 Selection of packing materials. - In selection of packing materials full consideration shall be given to temperature resistance requirements.

3.4 Drawings shall be furnished in accordance with Specification MIL-D-963.

3.4.1 Types of drawings. - In lieu of the drawing types listed in Standard MIL-STD-7, the following types are required:

3.4.1.1 Outline drawing. - An external arrangement drawing shall show all necessary external views of the cooler assembly, shall include all external dimensions necessary for reproduction on ship's or engine's machinery arrangement drawing, for guidance of the engine manufacturer or shipyard in designing the foundation structure for the assembly, for installation thereof, and for connection of the assembly to the external piping. The drawing shall show the space required for removal and replacement of the tubes or tube bundle, removal of waterboxes, access opening covers, zinc anodes, location of lifting lugs or eyebolts provided for handling the unit or its components and size of openings therein.

3.4.1.2 Assembly drawing. - A drawing showing complete longitudinal and transverse cross-sectional views of the cooler assembly shall also show the relationship of all parts, arrangement of tubes in the heat exchanger component, method of tube end expansion or packing, baffles, support plates and welding of adjacent parts. Liberal use of enlarged views or sections shall be made. If necessary, sub-assembly drawing conforming to the above may be furnished for individual components of the unit. The drawing(s) shall be such that a thorough understanding of the design and construction may be obtained without reference to related detail drawings.

3.4.1.2.1 The assembly drawing shall contain a complete list of materials showing names and corresponding identifying numbers and materials of all parts used in the construction of the cooler. The identifying part shall also be shown adjacent to the part depicted in the various views with arrows pointed to the parts.

3.4.1.2.2 The assembly drawing shall indicate that the zinc anodes provided in the heat exchanger comply with Specification MIL-A-19521.

3.4.1.2.3 Detail drawing of major parts such as shells, tube sheets, support plates, baffles, support feet, waterboxes, and the like, shall be completely and accurately dimensioned with finishes, welding symbols and identifying part numbers indicated, as required for manufacture.

3.4.1.3 Ship's drawing. - One drawing shall be a ship's drawing. It shall be titled "Drawing List; Performance Data, and Onboard Repair Parts List for Diesel Engine After-Air Cooler" (designation of cooler by model number, or by size and class, to be entered to complete the title). A list of materials is not required for this drawing. The ship's drawings shall be included in the first submission of working drawings.

3.4.1.3.1 The drawing list tabulation shall include the following columns:

(a) Drawing title.
(b) Manufacturer's drawing number.
(c) Bureau or agency drawing number.
(d) Revision symbol.

This list shall include all master drawings which comprise the given design. The revision symbol column shall be kept up to date to the time of manufacture so that it will finally indicate the latest revision of each drawing applicable to the equipment as built.

3.4.1.3.2 The performance data tabulation shall include the following:

(a) Identification of cooled and cooling mediums.
(b) Flow rate of cooled and cooling mediums (gallons per minute (g.p.m.); cubic feet per minute (c.f.m.)).
(c) Inlet temperature of cooled and cooling mediums (°F.).
(d) Outlet temperature of cooled and cooling mediums (°F.).
(e) Pressure drops of cooled and cooling mediums through cooler (p.s.i.); (inches Hg.).
(f) Velocities of cooled and cooling mediums at inlet connection (feet per second).
(g) Velocities of cooled and cooling mediums through tubes and shell (feet per second).
(h) Number of passes of cooled and cooling mediums through cooler.
(i) Working pressure of cooled and cooling mediums (p.s.i.g.).
(j) Test pressure, tube side (p.s.i.g.).
(k) Test pressure, space between double tube sheets (p.s.i.g.), when applicable.[2]
(l) Logarithmic mean temperature difference (°F.).

[1] When coolers are for service on submarines, in lieu of an entry in the tabulation opposite this heading, the space should be left blank. Beside the tabulation use an arrow leading in to indicate this blank space, and at the tail of the arrow add a note "FOR TUBE SIDE TEST PRESSURE SEE NOTE ___ ON ___ DWG _____, BUSHIPS NR _____, TEST DATA, ____". This note is to be completed when the specific information becomes available from the building yard.

[2] When coolers are for service on submarines, in lieu of an entry in the tabulation opposite this heading, the space should be left blank. Beside the tabulation use an arrow leading in to indicate this blank space, and at the tail of the arrow add a note "FOR TEST PRESSURE FOR SPACE BETWEEN DOUBLE TUBE SHEETS SEE NOTE ___ ON ___ DWG____, BUSHIPS NR _____, TEST DATA, _____". This note is to be completed when information becomes available from the building yard.

(m) Heat transfer rates for both service and clean tube conditions (British thermal units (B. t. u.) per hour per square foot per °F. logarithmic mean temperature difference).
(n) Effective cooling surface (square feet).
(o) Heat transfer capacity at design point (B. t. u. per hour).

3. 4. 1. 3. 3 The onboard repair parts list shall be headed "ONBOARD REPAIR PARTS LIST - QUANTITIES FOR ONE SET" and shall itemize the repair parts and tools (see 3. 8). This tabulation shall include the following columns:

(a) Piece number (may be omitted when parts are detailed on mono-detail type drawings).
(b) Name of piece.
(c) Quantity.
(d) Manufacturer's drawing number.
(e) Manufacturer's service part number.[1]
(f) Weight. (Each entry in this column shall be the product of the number required and the unit weight of the part. The total of this column shall indicate the weight of the onboard set.)

[1] The manufacturer's service as a constant number, assigned by the manufacturer, which is the infallible identification of a part wherever used. When it is the practice to assign part numbers to all pieces, these shall be recorded on the proper drawings. Where a complete part numbering system is not in use, the manufacturer shall assign service part numbers to each cooler and to each part of sub-assembly which in his judgment may require replacement during the life of the unit. Such numbers shall then be recorded on the proper drawings.

3. 4. 1. 3. 4 The ship's drawing shall include notes indicating the contract or order number, the application (service) of the unit, the number of coolers per ship and per unit of parent equipment, and the dry and wet weights of the cooler. The following examples illustrate the type of notes required:

(a) Bureau of Ships Contract NObs-1234 with ABC Engine Company; ABC Engine Company purchase order 5678 on EFG Cooler Mfg. Co.
(b) Service: After air cooling for propulsion Diesel engine.
(c) Eight coolers per ship, one cooler per engine, or 12 coolers furnished as stock material.
(d) Dry weight of cooler ____ pounds; weight of cooler ____ pounds.

3. 4. 1. 3. 5 The ship's drawing shall also include a view of the identification plate with all data entered except date of manufacture, serial number, and tube side maximum test pressure for submarine salt water applications. For these applications use an arrow leading in to indicate the blank space where tube side maximum test pressure would have been entered, with the notation "TUBE SIDE MAXIMUM TEST PRESSURE NOT TO BE STAMPED ON IDENTIFICATION PLATE" placed at the tail of the arrow. This view shall be enlarged when necessary to insure that data entries will meet lettering size requirements of Specification MIL-D-963.

3. 4. 1. 3. 6 Above the title block of this drawing there shall be entered the designations of the applicable ships.

3. 5 Painting. - Coolers shall be painted as specified hereinafter:

(a) External and internal nonferrous surfaces of water boxes, tubes, and tube sheets shall not be painted.
(b) Steel surfaces shall be thoroughly cleaned and coated with one coat of pretreatment in accordance with formula No. 117 of Specification MIL-C-15328 and one coat of primer in accordance with formula No. 84/47 of Specification JAN-P-735 or formula No. 116 of Specification MIL-P-17545.

3.6 Identification plates. - Identification plates shall be provided in accordance with Specification MIL-P-15024, and shall include the following:

(a) Name of unit.
(b) Manufacturer's service part number.
(c) Stock number.
(d) Name of manufacturer.
(e) Contract number.[2] (The procuring activity's contract or purchase order number shall be entered in this space.)
(f) Blank space for Government inspector's stamp.
(g) Date of manufacture.
(h) Serial number.
(i) Maximum test pressure, tube side.
(j) Blank space for "unit" number.[3] (This space will be used for numbering for shipboard reference purposes when required, the stamping to be done by shipyard.)
(k) Designation "U.S.".

[1] Allow 17 spaces.
[2] Utilize width of plate to allow maximum number of spaces.
[3] Allow 4 spaces.

Working pressure entries shall not appear on identification plates.

3.7 Construction. -

3.7.1 Materials. - The materials used in construction of coolers shall be as follows:

3.7.1.1 The materials shown in tables I, II and III and as specified hereinafter shall be used as the basis for design. These materials shall be used in the construction of the coolers, except that the manufacturer shall have the option of substituting commercial material having equal or better physical and chemical properties than the materials specified in Federal or Military specifications. If the manufacturer exercises the above option, he shall include two specification columns in the list of materials on his drawings; one column shall be used for the specified Federal or Military specifications, and the other shall show the commercial specification number for the substituted material. Notes shall then appear on the drawing stating that:

(a) The design is based on the Federal or Military specification materials.
(b) The materials listed in the commercial specification column have physical and chemical properties which are equal to or better than the specified Federal or Military specification and may be substituted by the manufacturer.

It shall be the responsibility of the manufacturer to satisfy the Government inspector that this is the case. Any parts for which materials are not specified shall be of the quality best suited for the purpose intended.

3.7.1.1.1 Class 1 cooler materials shall be as specified in table I.

Table I - Class 1 cooler materials.

Part	Material	Specification
Shell	Aluminum (quarter hard)	MIL-A-19070
	Aluminum (half hard)	MIL-A-17357
	Steel[1]	QQ-S-741
	Steel[2] (zinc coated)	QQ-S-775
Water boxes	Copper-nickel-alloy, composition 70-30;	MIL-C-15726
	tubing, copper-nickel-alloy; composition 70-30	MIL-T-16420
	gun metal;	MIL-M-16576
	or valve bronze	MIL-B-16541
Tube sheets	Copper-nickel-alloy, composition 70-30	MIL-C-15726
Tubes	Copper-nickel-alloy, composition 70-30	MIL-T-15005
Fins on tubes	*Nonferrous*	
Gland rings, if used	Gun metal;	MIL-M-16576
	valve bronze; or	MIL-B-16541
	copper-nickel-alloy, composition 70-30	MIL-C-15726
Bolts,[3] studs,[3] and jack screws	Nickel-copper-alloy, class a	QQ-N-281
Nuts[3]	Nickel-copper-alloy, class b; or	QQ-N-281
	Aluminum bronze, stress relieved, composition 5	MIL-B-15939
Zinc protectors	Zinc	MIL-A-18001
Plugs, zinc support 5/	Aluminum bronze, stress relieved, composition 5	MIL-P-19415
Gaskets[4]	Rubber, synthetic, cloth insertion; or	MIL-P-1384
	asbestos, compressed	MIL-A-17472
Washers	Bronze, aluminum, wrought;	MIL-B-15939
	or brass, Naval wrought	MIL-B-994
Pipe plugs and adaptors	Aluminum bronze, stress relieved, composition 5;	MIL-B-15939
	valve bronze;	MIL-B-16541
	gun metal; or	MIL-M-16576
	copper-nickel-alloy, composition 70-30	MIL-C-15726
Packing rings[4]	Rubber synthetic:	
	class 1, 2 or 5	MIL-R-1149
Zinc inspection covers	Copper-nickel-alloy, composition 70-30;	MIL-C-15726
	gun metal; or	MIL-M-16576
	valve bronze	MIL-B-16541

[1]After complete fabrication of shell, the shell shall be hot dip galvanized in accordance with Specification MIL-Z-17871.

[2]After complete fabrication of the shell, a zinc coating conforming to Specification O-G-93 or its equivalent as approved by the bureau or agency concerned shall be applied where necessary.

[3]Form to be in accordance with Specification MIL-B-857.

[4]See 3.3.17.

5/Zinc support plugs for submarines shall conform to Drawing 810-1385875.

3.7.1.1.2 Class 2 cooler materials shall be as specified in table II.

Table II - Class 2 cooler materials.

Part	Material	Specification
Shell	Aluminum (quarter hard)	MIL-A-19070
	Aluminum (half hard)	MIL-A-17357
	Steel[1]	QQ-S-741
	Steel[2] (zinc coated)	QQ-S-775
Water boxes	Gun metal	MIL-M-16576
	Valve bronze	MIL-B-16541
Tube sheets	Copper-nickel-alloy, composition 90-10	MIL-C-15726
	Aluminum-bronze, composition 2	MIL-B-15939
Tubes	Copper-nickel-alloy, composition 90-10	MIL-T-15005
Fins for tubes	Nonferrous	
Gland rings	Gun metal;	MIL-M-16576
	valve bronze; or	MIL-B-16541
	copper-nickel-alloy, composition 90-10	MIL-C-15726
Bolts,[3] studs,[3] and jack screws	Aluminum bronze, stress relieved, composition 5	MIL-B-15939
Nuts[3]	phosphor bronze; or	QQ-P-330
	copper-silicon alloy	MIL-C-17516
Zinc protectors	Zinc	MIL-A-18001
Plugs, zinc support	Aluminum bronze, stress relieved, composition 5	MIL-P-19415
Gaskets[4]	Rubber, synthetic, cloth insertion; or	MIL-P-1384
	asbestos, compressed	MIL-A-17472
Washers	Bronze, aluminum, wrought;	MIL-B-15939
	or brass, Naval wrought	MIL-B-994
Pipe plugs and adaptors	Aluminum bronze, stress relieved, composition 5;	MIL-B-15939
	valve bronze;	MIL-B-16541
	gun metal; or	MIL-M-16576
	copper-nickel-alloy, composition 90-10	MIL-C-15726
Packing rings[4]	Rubber, synthetic:	
	class 1, 2 or 5	MIL-R-1149
Zinc inspection covers	Copper-nickel-alloy, composition 90-10	MIL-C-15726
	gun metal; or	MIL-M-16576
	valve bronze	MIL-B-16541

[1] After complete fabrication of shell, the shell shall be hot dipped galvanized in accordance with Specification MIL-Z-17871.
[2] After complete fabrication of the shell, a zinc coating conforming to Specification O-G-93, or its equivalent as approved by the bureau or agency concerned shall be applied where necessary.
[3] Form to be in accordance with Specification MIL-B-857.
[4] See 3.3.17.

3.7.1.1.3 Class 3 cooler materials shall be as specified in table III.

Table III - Class 3 cooler materials.

Part	Material	Specification
Shell	Aluminum (quarter hard)	MIL-A-19070
	Aluminum (half hard)	MIL-A-17357
	Steel[1]	QQ-S-741
	Steel[2] (zinc coated)	QQ-S-775
Water boxes	Bronze, aluminum, wrought, composition 5;	MIL-B-15939
	gun metal;	MIL-M-16576
	or valve bronze	MIL-B-16541
Tube sheets	Bronze, aluminum wrought, composition 5	MIL-B-15939
Tubes	Copper-nickel-alloy, composition 90-10	MIL-T-15005
Fins for tubes	Nonferrous	
Gland rings, if used	Gun metal;	MIL-M-16576
	valve bronze;	MIL-B-16541
	bronze, aluminum, wrought, composition 5;	MIL-B-15939
	copper-nickel-alloy, composition 90-10	MIL-C-15726
	or brass, Naval wrought	MIL-B-994
Bolts,[3] studs,[3] and jack screws		
	Aluminum bronze, stress relieved, composition 5;	MIL-B-15939
	phosphor bronze; or	QQ-P-330
	copper-silicon alloy	MIL-C-17516
Nuts[3]	Aluminum bronze, stress relieved, composition 5;	MIL-B-15939
	phosphor bronze; or	QQ-P-330
	copper-silicon-alloy	MIL-C-17516
Zinc protectors	Zinc	MIL-A-18001
Gaskets[4]	Rubber, synthetic, cloth insertion;	MIL-P-1384
	or asbestos, compressed	MIL-A-17472
Washers	Bronze, aluminum, wrought;	MIL-B-15939
	or brass, Naval wrought	MIL-B-994
Pipe, plugs and adaptors	Valve bronze; aluminum bronze, stress relieved, composition 5	MIL-B-15939
	gun metal;	MIL-M-16576
	or Naval wrought brass	MIL-B-994
Packing rings[4]	Rubber, synthetic:	
	class 1, 2 or 5	MIL-R-1149
Zinc inspection covers	Brass, Naval wrought;	MIL-B-994
	gun metal;	MIL-M-16576
	valve bronze;	MIL-B-16541
	or bronze, aluminum, wrought, composition 5	MIL-B-15939

[1] After complete fabrication of shell, the shell shall be hot dip galvanized in accordance with Specification MIL-Z-17871.

[2] After complete fabrication of the shell, a zinc coating conforming to Specification O-G-93 or its equivalent as approved by the bureau or agency concerned shall be applied where necessary.

[3] Form to be in accordance with Specification MIL-B-857.

[4] See 3.3.17.

3.7.2 Coolers shall have straight or U-bent plain or finned tubes with sea water circulated through the tubes.

3.7.3 Coolers shall be designed to allow for expansion of the tube bundle and shell.

3.7.4 Double tube sheet construction. - When specified (see 6.1), the coolers shall be provided with two tube sheets at each end. A space between the two sheets approximately 1/2 inch wide shall be provided by use of a spacing ring or by machining one or both sheets. The joint between the sheets or the joints between sheets and ring may be welded or brazed, or may be a bolted design using restrained flat gaskets or O-ring gaskets (see 3.3.16). The space between the tube sheets shall be vented and drained to atmosphere. The tubes shall be expanded into each tube sheet as provided in 3.7.5.1, and care shall be taken that the discontinuity in tube surface caused by the expansion is kept to a minimum. After expansion of the tubes, the specified tube side hydrostatic test pressure shall be applied to the spaces between the two tube sheets at each end, and there shall be no leakage under this pressure.

3.7.5 Tubes and tube sheets. - Coolers shall be provided with tubes of 5/8 inch outside diameter, 0.049 inch (number 18 Birmingham wire gage (BWG)) wall thickness, 3/8 inch outside diameter, 0.049 inch (number 18 BWG) wall thickness; or 1/4 inch outside diameter 0.035 inch (number 20 BWG) wall thickness, as specified (see 6.1). Tubes shall be provided with external nonferrous fins.

3.7.5.1 Tubes of all coolers shall be expanded into the tube sheets at both ends. The expansion shall be done by means of a tube expander in accordance with Specification MIL-E-16809 and shall be governed by an automatic tube expander control in accordance with Specification MIL-C-17728. The minimum depth of expansion of tubes shall be as specified in table IV. When pressure or other design considerations require thicker tube sheets than specified in table V, the depth of the tube expansion may be increased over that shown in table IV, but a distance of 1/8 inch from the inner face of the outer tube sheet shall be the limit of expansion. Where an inner (supplementary) tube sheet is used expansion shall not extend closer than to within 1/8 inch of either face.

Table IV - Minimum depth of expansion.

Outside tube diameter	Minimum depth of expansion
Inch	Inch
5/8	5/8
3/8	1/2
1/4	3/8

3.7.5.2 Tube sheet thickness shall be not less than that shown in table V.

Table V - Tube sheet thickness.

Outside tube diameter	Minimum tube sheet thickness
Inch	Inch
5/8	3/4
3/8	5/8
1/4	1/2

3. 7. 5. 3 Holes for tubes in tube sheets shall be spaced, center-to-center of the holes, and reamed to diameters shown in table VI.

Table VI - Diameter of holes.

Outside tube diameter	Diameter of holes for tubes[1]
Inch	Inch
5/8	0. 626
3/8	. 376
1/4	. 251

[1] A tolerance of plus 0. 002 inch will be permitted.

3. 7. 5. 4 The holes for the inlet ends of the tubes shall be flared in accordance with table VII, to allow for belling the ends of the tubes.

Table VII - Flaring of holes for inlet ends.

Outside tube diameter	Radius of flare	Diameter of flare, at outside face of tube sheet
Inch	Inch	Inch
5/8	1/2	3/4
3/8	5/16	1/2
1/4	No flare required: edge shall be rounded on 1/16 inch radius	

3. 7. 5. 5 Grooving of holes in tube sheets. - Grooving of the holes for tubes in the tube sheets is required for 5/8 inch outside diameter tubes. Holes for 3/8 and 1/4 inch outside diameter tubes shall not be grooved.

3. 7. 5. 5. 1 The holes for 5/8 inch outside diameter tubes in single tube sheets shall be provided with one groove, 0. 025 inch wide and 0. 007 inch deep, located with the outer edge of the groove 3/8 inch from the outer face of the sheet.

3. 7. 5. 5. 2 Where double tube sheet construction is used, the outer (main) tube sheet holes shall be grooved for 5/8 inch outside diameter tubes by providing three grooves 1/16 inch wide by 0. 012 inch deep in each, with 1/8 inch spaces between grooves, and the edge of the first groove being 3/8 inch from the outer face of the sheet; the inner (rear) tube sheet holes shall each have one such groove centered between the faces of the sheet.

3. 7. 5. 6 The edges of the holes for tubes shall be rounded on a 1/16 inch radius except where a belled contour is required for the tube inlet end.

3.7.5.7 The inlet ends of 5/8 or 3/8 inch outside diameter tubes shall be expanded and belled and the ends shall then be finished flush with the face of the tube sheet. Inlet ends of 1/4 inch outside diameter tubes shall not be belled, but after expansion shall be finished flush with the face of the tube sheet. In no case shall the ends of tubes be below the face of the tube sheets. Discharge ends of tubes shall not protrude more than 1/16 inch beyond the face of the tube sheet.

3.7.6 Water boxes. - In order to absorb the entrance velocities which may produce erosion of tube ends by impingement attack, the water box depth measured normal to the tube sheet shall be not less than one-half the mean diameter of the tube sheet area exposed to the flow of the cooling water into the tubes. For cylindrical coolers having an inside shell diameter "D" the water box head depth shall be not less than 0.50 "D" for single pass coolers, 0.354 "D" for two pass coolers and 0.25 "D" for four pass coolers.

3.7.7 The water inlet connection to coolers shall be as nearly as possible normal to the tube sheet. Shell connections shall be located to give counterflow between the cooling and the cooled mediums as far as possible. Cooling water flow in multipass coolers shall pass horizontally or vertically upward between passes, never downward. Vent holes shall be provided in the water box partitions.

3.7.7.1 Water box design. -

3.7.7.1.1 Water boxes shall conform to the requirements of the ASME Code, Section VIII and addenda thereto. Hemispherical heads are preferred. Both cast and fabricated water boxes are acceptable.

3.7.7.1.2 For calculating the strength of welded joints, weld efficiencies shall be in accordance with Standard MIL-STD-278.

3.7.7.1.3 If operating pressure dictates that a fabricated water box be classified as an A2 class pressure vessel under Standard MIL-STD-278, all welded connections 2 inches nominal iron pipe size and over shall be full penetration welded.

3.7.7.1.3.1 For submarines, unless otherwise specified in the contract or order, cast water boxes which will be subjected to submergence pressure shall be 100 percent radiographed. Castings with nominal wall thickness of 1/2 inch or less shall meet class 1 requirements of Publication NAVSHIPS 250-537-1 or NAVSHIPS 250-537-2 and those with nominal wall thickness of over 1/2 inch shall meet class 2 requirements of Publication NAVSHIPS 250-537-1 or NAVSHIPS 250-537-2, as applicable. In addition, machined surfaces of castings for this service shall be 100 percent liquid penetrant tested in accordance with Standard MIL-STD-271 using type III or type IV fluorescent penetrant. Defects shall not exceed 0.050 inch in depth or 0.100 inch in length.

3.7.7.1.4 Water box bolting requirements. - Bolting for securing the water box to the tube sheet shall be sized so that the prestress necessary to maintain a tight joint under the specified hydrostatic test pressure will not exceed 25 percent of the yield strength of the bolt material based on 0.2 percent offset as specified in the applicable material specification. When making up the water box/tube sheet joint, a torque wrench set so as not to exceed the above stress, shall be used.

3.7.7.1.5 In the design of water boxes of after coolers for submarines, the forces exerted by the circulating water inlet and discharge piping on the respective nozzles shall be considered as resulting from a combined bending and torsion maximum bending stress in the piping of 11,000 p.s.i. and a direct axial force of 1,000 pounds times the nominal pipe size. These two loadings may be treated as a single overturning moment equal to:

$$M = 10,000\ dm^2t$$

where:

M = overturning moment, inch pounds.
dm = mean diameter of attached piping, inches, (not counting transitions immediately adjacent to the connection) (see 6.1).
t = thickness of piping, inches (see 6.1).

(Note. - This formula includes a factor of about 1.05 to cover slight increases in pipe wall above nominal values, a factor of 1.10 in moment to cover the above specified axial load and a simple approximation for section modulus which is always slightly conservative.)

3.7.7.1.6 In the design of water boxes for submarines full consideration shall be given to the cyclic nature of the pressure loading. The design shall be based on (a) 5,000 cycles to full design submergence plus (b) 50,000 cycles to 50 percent of the design submergence. An analysis of fatigue loading on this basis shall be submitted to the bureau or agency concerned.

3.8 Repair parts. - Lists of stock repair parts and onboard repair parts shall be developed in accordance with Specification MIL-P-15137.

3.8.1 Onboard repair parts. - The onboard repair parts set is defined as the assemblage of repair parts and tools carried onboard ship for maintenance use. Each set[1] shall include the following:

(a) Gaskets, for each cooler installed - 100 percent.
(b) Packing rings, for each cooler installed - 50 percent; or 100 percent for one cooler, whichever is the greater.
(c) One metal parts box, when onboard repair parts are destined for a ship not fitted with bin or drawer type stowage (see 5.3 and 6.1).
(d) Zinc protectors, when fitted, for each cooler installed - 200 percent (see 3.8.2).
(e) Tube plugs, conforming to Specification MIL-P-15742 - [1]30.

[1]Where this quantity is sufficient to plug more than 10 percent of installed tubes it shall be reduced to the number required to plug 10 percent of installed tubes or 10, whichever is larger.

3.8.2 For pencil zincs there shall be supplied 200 percent of installed zinc pencils, and 25 percent of supporting plugs or 100 percent of plugs required for one cooler whichever is the greater. Pencil-plug subassemblies shall not be listed.

3.9 Workmanship. - The workmanship shall be first class in every respect.

[1]Quantities are based upon one set being furnished per ship.

4. QUALITY ASSURANCE PROVISIONS

4.1 Unless otherwise specified herein the supplier is responsible for the performance of all inspection requirements prior to submission for Government inspection and acceptance. Except as otherwise specified, the supplier may utilize his own facilities or any commercial laboratory acceptable to the Government. Inspection records of the examinations and tests shall be kept complete and available to the Government as specified in the contract or order.

4.2 Preproduction tests. - Preproduction tests when specified (see 6.1), shall consist of the tests specified in 4.5 and shall be conducted at a laboratory satisfactory to the Bureau of Ships.

4.3 Production inspection. - Production inspection shall consist of the examination and test specified in 4.4 and 4.5.4. When specified in the contract or order, the bureau or agency concerned may require HI shock tests of representative production coolers. Where other specifications form a part of this specification, sampling, examination and tests shall be conducted as specified therein.

4.4 Examination. - Each cooler shall be examined by the Government inspector to determine conformance to approved production drawings (dimensions, tolerances, material and finish).

4.5 Tests. -

4.5.1 Performance test. - A performance test shall be conducted to determine compliance with performance requirements. This test shall include accurate measurements of coolant and cooled medium flows, pressure drops, and heat dissipated at or corrected to operating conditions.

4.5.2 Shock test. - The preproduction model shall be class HI shock tested in accordance with Specification MIL-S-901.

4.5.3 Vibration test. - A vibration test shall be conducted in accordance with Standard MIL-STD-167.

4.5.4 Hydrostatic pressure test. - Unless otherwise specified, each cooler shall be given the following hydrostatic tests:[2]

	Test pressure
Coolant side	100 p.s.i.g.
Space between double tube sheets (if furnished)	Same as coolant side.

4.6 Inspection procedures. - For Naval purchases, the general inspection procedures shall be in accordance with General Specifications for Inspection of Material.

5. PREPARATION FOR DELIVERY

5.1 Preservation and packaging (see 6.1). -

5.1.1 Level A. -

5.1.1.1 Coolers of nonferrous construction shall be packaged in accordance with method III of Specification MIL-P-116. Openings shall be sealed with caps, plugs or barrier material conforming to Specification MIL-B-121 secured in place with tape.

5.1.1.2 Preservative type P-2 of Specification MIL-P-116 shall be coated on ferrous surfaces which normally operate in oil.

[2]In the case of the salt water side of a cooler designed for submarine service, the hydrostatic test shall be conducted in the presence of the Government inspector.

5.1.2 Level C. - Coolers shall be preserved and packaged in accordance with the manufacturer's commercial practice. Openings shall be sealed to prohibit the entrance of foreign matter.

5.2 Packing (see 6.1). -

5.2.1 Level A. - Coolers, packaged as specified, shall be packed in wood cleated plywood or nailed wood boxes or sheathed crates conforming to Specification PPP-B-601 (overseas type), PPP-B-621 (class 2), or MIL-C-104, as applicable. The gross weight of wood or wood cleated boxes shall not exceed 200 pounds unless the weight of a single cooler exceeds this weight. Wood cleated plywood and nailed wood boxes shall be used for gross weights not exceeding 500 pounds. The boxes shall be modified by the addition of skids in accordance with the applicable box specification and the coolers bolted through the skids. When the gross weight of the unit exceeds 500 pounds, the cooler shall be packed in a sheathed crate. Anchoring, blocking, bracing and cushioning shall be in accordance with the appendix to Specification MIL-C-104.

5.2.1.1 Waterproofing. - Equipment bolted to the base of a wood or wood cleated box shall be shrouded within the box with barrier material conforming to Specification UU-P-271. Shrouding shall be applied at least two-thirds of the way down in a manner to prevent the formation of water pockets and to permit free circulation of air. All sharp projections which would tend to tear the shroud shall be padded or covered with a suitable cushioning material.

5.2.2 Level B. - Coolers, packaged as specified, shall be packed in wood-cleated fiberboard, wood-cleated plywood, nailed wood boxes or crates conforming to Specifications PPP-B-591, PPP-B-601 (domestic type), PPP-B-621 (class 1), MIL-C-104, MIL-C-3774 or MIL-C-132. The gross weight of wood and wood cleated boxes shall not exceed 200 pounds unless the weight of a single item exceeds this weight. Boxes shall be modified for gross weights over 200 pounds by the addition of skids in accordance with the applicable box specification and the cooler shall be bolted through the base and skids. Coolers packed in unsheathed crates shall be shrouded as specified in Specification MIL-C-132 and appendix thereto. Anchoring, blocking, bracing and cushioning shall be in accordance with the appendix to Specification MIL-C-104.

5.2.3 Level C. - Coolers, packaged as specified, shall be packed to insure carrier acceptance at the lowest rate and safe delivery at destination. Containers shall comply with Uniform Freight Classification Rules or regulations of other carriers as applicable to the mode of transportation.

5.3 Onboard repair parts and tools. - Onboard repair parts and tools shall be cleaned, preserved and packaged in accordance with Specification MIL-P-116. Onboard repair parts and tools shall be packaged one item per unit package unless used in sets or in quantities greater than one. Where onboard repair parts and tools are destined for a ship that is not fitted with bin or drawer type stowage (see 6.1), the onboard repair parts and tools shall be packed in type M metal boxes conforming to Specification MIL-B-233 and shall be overpacked in shipping containers conforming to Specification PPP-B-621, or MIL-C-132. Where onboard repair parts and tools are destined for a ship that is fitted with bin or drawer type stowage (see 6.1), onboard repair parts shall be packed in shipping containers specified in 5.2.1 or 5.2.2 and shall be subject to the weight limitations therein.

5.4 Marking. - In addition to any special marking required by the contract or order, interior packages and shipping containers shall be marked in accordance with Standard MIL-STD-129 and requirements of the applicable container specification or appendix thereto. Equipment serial number shall be marked on one face of the shipping container.

6. NOTES

6.1 Ordering data. - Procurement documents should specify the following:

(a) Title, number, and date of this specification.
(b) Class and service of cooler (see 1.2 and 3.3.6).
(c) Identification of fluid to be cooled.
(d) Rate of flow of fluid to be cooled, CFM at S.T.P.

(e) Inlet temperature of fluid to be cooled, °F.
(f) Outlet temperature of fluid to be cooled, °F.; or rate of heat exchange, B.t.u./hr.
(g) Identification of coolant.
(h) Rate of flow of coolant, if established, g.p.m.
(i) Inlet temperature of coolant, if other than 85°F. (see 3.3.13).
(j) Allowable design point pressure drops of respective cooler sides, p.s.i. inches Hg., if other than specified in 3.3.5.
(k) Whether coolers are for submarine, surface ship, landing craft or small boat, application (see 3.3.6, 3.7.1).
(l) Whether hose connections are required (see 3.3.7).
(m) Type of flanged connections, if other than as specified in 3.3.7.
(n) If pressure gage connections are required at inlet and outlet of coolant and cooled fluid sides (see 3.3.9).
(o) Whether double tube sheets at each end are required (see 3.7.4).
(p) Outside diameter of tubes (see 3.7.5).
(q) Hydrostatic test pressure on tube side, p.s.i.g. if other than as specified in 4.5.4.
(r) Whether onboard repair parts sets are required (see 3.8).
(s) Selection of applicable levels of preservation, packaging and packing (see 5.1 and 5.2).
(t) Whether or not the ships for which equipment is destined are fitted with bin or drawer type stowage (see 3.8.1 and 5.3).
(u) If ships are fitted for bin or drawer type stowage, whether onboard repair parts and tools should be packed for level A or B (see 5.3).
(v) Whether preproduction tests are required (see 3.1 and 4.2).
(w) Mean diameter of attached piping and thickness of piping (see 3.7.7.1.5).

6.2 Strainer recommendation. - As a matter of information it should be noted that the use of strainers in salt water coolant systems is recommended for coolers using 3/8 inch or 1/4 inch outside diameter tubes.

Notice. - When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Preparing activity:
Navy - Bureau of Ships
(Project 4420-0017Sh)

APPENDIX

10. This appendix is intended to guide the manufacturer in developing shockproof units.

10.1 General requirements for shockproofness. - Coolers shall be designed to withstand shock due to firing of the ship's own armanent and noncontact underwater explosions of near-miss aerial bombs, torpedoes, and mines. The coolers shall be designed to resist shock as specified by curves A, B, and C of figure 1. Shockmounts shall not be used unless bureau or agency approval of the mount and its proposed application is obtained. For submarine applications, use curve A for both vertical and athwartships accelerations.

10.2 General design information. - It is important that all components be designed to withstand the shock design shown by curves A, B, and C, of figure 1 without failure or permanent deformation of the base, holding down bolts and footing.

10.3 In no case shall a piece of equipment be rigidly supported from more than one plane.

10.4 Shock design numbers specified by curves A, B, and C, of figure 1 shall be applied at the points of attachment to the hull structure.

10.5 Bolts designed to be stressed in shear shall be installed in holes with a minimum of clearance, as experience indicates that large clearances allow impacting and subsequent failure.

10.6 Where two or more components are installed on a common rigid subbase, the feet and holding-down bolts as well as the subbase shall be designed for an acceleration based on the total weight of the assembly.

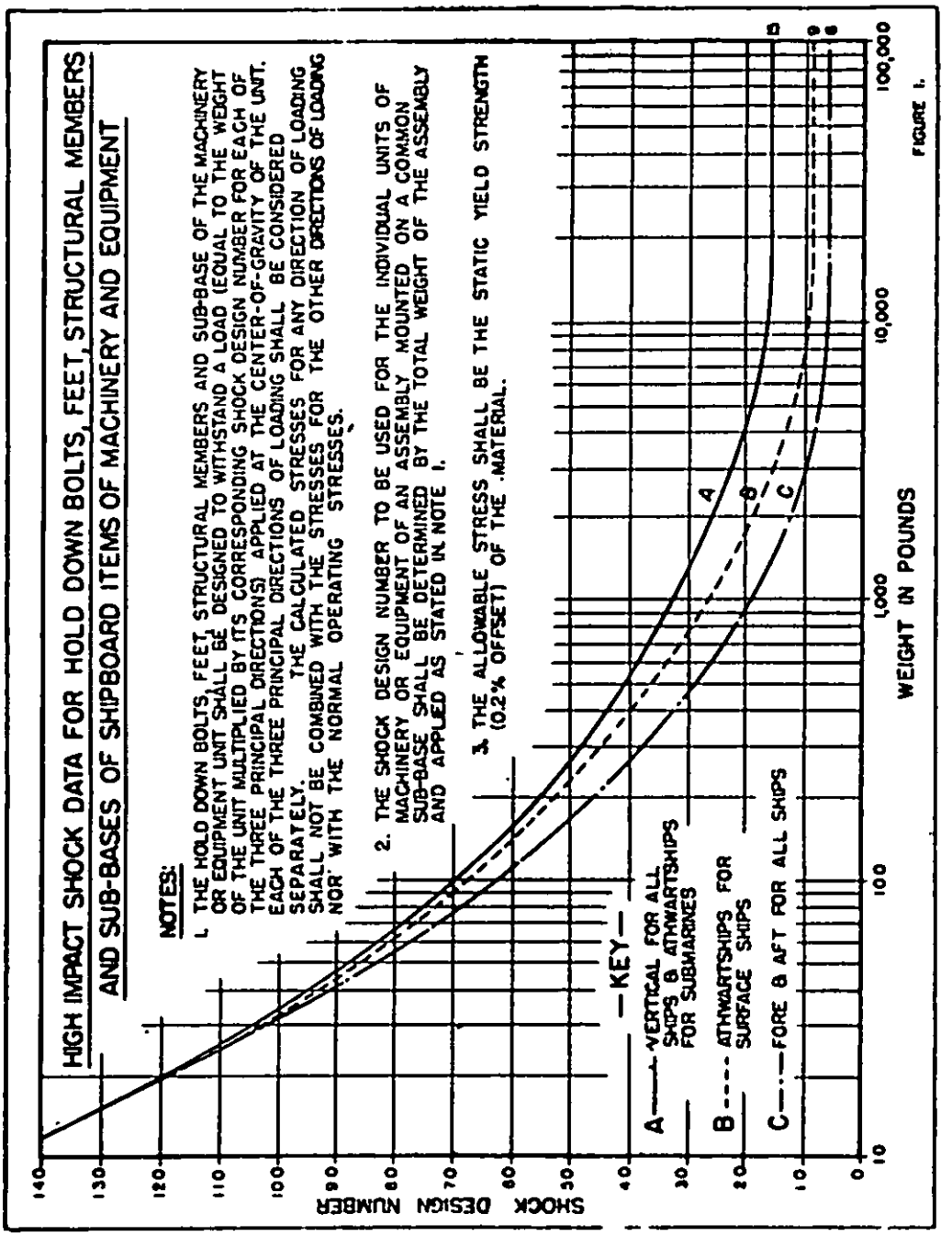

FIGURE 1.