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INCH-POUND
MIL-W-21965D(NAVY)
5 February 1988
SUPERSEDING
MIL-W-21965C(NAVY)
30 June 1975
(See 6.5)

MILITARY SPECIFICATION

WATER COOLING OF SHIPBOARD ELECTRONIC EQUIPMENT GENERAL SPECIFICATION FOR

This specification is approved for use within the Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the general design and construction requirements and methods for the internal water cooling of electronic equipment utilizing shipboard cooling water support systems.

1.2 Classification. Heat transfer between heat sources internal to the equipment and the shipboard cooling water shall be of the following methods:

Method 1 - Convection cooling (see 3.2.1).
Method 2 - Conduction cooling (see 3.2.2).
Method 3 - Other cooling techniques (see 3.2.3).

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 55Z3, Department of the Navy, Washington, DC 20362-5101 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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SPECIFICATIONS

MILITARY

MIL-B-7883 - Brazing of Steels, Copper, Copper Alloys, Nickel Alloys, Aluminum and Aluminum Alloys.
MIL-C-15730 - Cooler, Fluid, Naval Shipboard: Lubricating Oil, Hydraulic Oil, and Fresh Water.
MIL-H-24520 - Hose and Hose Assembly for Water Cooling of Electronic Equipment.

STANDARDS

MILITARY

MIL-STD-278 - Welding and Casting Standard.
DOD-STD-1399, Section 532 - Interface Standard for Shipboard Systems Cooling Water for Support of Electronic Equipment. (Metric)

HANDBOOK

MILITARY

MIL-HDBK-251 - Reliability/Design Thermal Application.

(Copies of specifications, standards, and handbooks required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting activity.)

2.2 Other publications. The following document forms a part of this specification to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted shall be those listed in the issue of the DoDISS specified in the solicitation. Unless otherwise specified, the issues of documents not listed in the DoDISS shall be the issue of the nongovernment documents which is current on the date of the solicitation.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

B 152 - Standard Specification for Copper Sheet, Strip, Plate, and Rolled Bar. (DoD adopted)

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

(Nongovernment standards and other publications are normally available from the organizations which prepare or which distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein (except for associated detail specifications, specification sheets or MS standards), the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

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3. REQUIREMENTS

3.1 General. The cooling system of shipboard electronic equipment, or portions therefore, utilizing shipboard cooling water shall conform to the interface requirements and constraints established in section 532 of DOD-STD-1399.

3.2 Selection of cooling method. Unless otherwise specified in the individual equipment specification, method 1, convection cooling, shall be used where all cooling requirements of the equipment can be met. Where unit heat dissipation (watts per square inch) or heat concentration (watts per cubic inch) of a single heat source is beyond the capacity of method 1 cooling, method 2, conduction cooling, shall be used. In cases where a large portion of the total heat dissipation comes from one or a relatively small number of concentrated sources, method 1 cooling may provide general cooling, while method 2 cooling may provide cooling directly to the heat sources involved. Where method 1 or 2 cannot provide sufficient cooling, other cooling techniques of method 3 cooling may be used where approved by the Command or agency concerned. The cooling methods to be employed shall be determined in accordance with the guidelines provided in MIL-HDBK-251.

3.2.1 Method 1, convection cooling. Method 1, convection cooling, shall utilize a self-contained circulating forced air system consisting of the heat dissipating parts, air channels, blowers and air-to-water heat exchanger. The blower shall move the air over heat sources and heat exchangers in such direction, quantities, and velocities as to provide maximum protection to heat sensitive parts and to make maximum use of natural convection.

3.2.2 Method 2, conduction cooling. Method 2, conduction cooling shall employ conduction and radiation paths as the major heat transfer media from heat sources to water. Materials and mounting methods shall be chosen to provide the lowest practicable thermal resistances from the heat sources to water cooled sinks. Heat dissipating parts shall be mounted on and be thermally bonded to water cooled chassis and panels where feasible. Heat sensitive parts shall be mounted on cooled surfaces and shall have high thermal resistance paths to heat dissipatng parts. Radiant heat exchange among electronic parts shall be minimized by providing thermally grounded reflective shields and surfaces of low heat emissivity.

3.2.3 Method 3, other cooling techniques. Method 3, other cooling techniques such as direct immersion, with free or forced convection, and vaporization cooling either direct or indirect method may be employed where specifically approved by the Command or agency concerned. In the application of these cooling techniques, all effects of the intimate contact of the coolant and the electronics shall be carefully considered, including the thermal, electrical, chemical, and mechanical aspects.

3.3 Construction. The cooling system construction shall conform to the individual equipment specification, the thermal design guidelines of MIL-HDBK-251 and the requirements specified herein.

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3.3.1 Heat flow paths. The heat flow paths from heat sources to the cooling system shall be short, direct, and have as low a thermal resistance as practicable. Such means shall be consistent with the performance, operating, and maintenance requirements specified in the individual equipment specification and with the adequacy of the electronic and mechanical design.

3.3.2 Water distribution. The distribution of water from the shipboard cooling water system shall be apportioned in accordance with the heat dissipation of each heat exchanger, chassis, or panel served. The water distribution shall be controlled by the cross-sectional area of the water passages as much as possible. Any additional adjustments necessary shall be achieved with fixed built-in flow devices in the connecting tubing.

3.3.3 Water flow rate. The total water flow rate from the shipboard cooling water system shall be adjusted to be a maximum of 1.4 gallons per minute per kilowatt load, based on a maximum of 2 degrees Celsius (°C) temperature rise in the water.

3.3.4 Water pressure. Except as allowed by section 532 of DOD-STD-1399, the maximum water gauge pressure drop from inlet to outlet of each separately enclosed cabinet of the equipment using shipboard cooling water shall not exceed 10 pounds per square inch (lb/in^2) and the portion of the cooling water system of the equipment using the shipboard cooling water shall withstand a hydrostatic gauge pressure test of 150 lb/in^2 without evidence of leaks or weeps (see 4.4.4).

3.3.5 Water purity. The cooling system shall operate with the inlet water purity characteristics specified in section 532 of DOD-STD-1399.

3.3.6 Construction and placement of parts. The construction and placement of all parts of the water cooling circuit shall be such that:

(a) Minimum chance of leakage exists.
(b) Should a leak occur, there is a minimum possibility of water striking electronic parts or electrical circuitry.

3.3.7 Enclosures. Enclosures of equipment employing cooling method 1 shall provide for recirculation of internal air and prevent exchange between internal circulating air and the surrounding compartment environmental air. Air channels and baffles shall be provided to develop the local air flow rates and velocities necessary to cool all parts.

3.3.8 Water cooled panels. Water cooled panels containing equipment operating controls and indicators shall be constructed and installed so as not to interfere with the requirements for equipment operation or maintenance.

3.3.9 Heat exchanger. Heat exchangers shall be located so that water from leaks and condensation will not fall on any electronic parts or electrical circuitry. Drains shall be provided at the bottom of enclosure for the removal of this water. Heat exchangers shall be easily removable from the front of the enclosure without removal of or damage to adjacent parts or electrical circuitry. Heat exchangers shall be in accordance with MIL-C-15730.

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3.3.10 Piping and fittings. Piping and fittings of the cooling system shall be readily accessible for assembly, reassembly and replacement and shall not be an integral part of supporting structures that provide strength or rigidity to the equipment. Piping and fittings shall not bear any stresses other than those required to meet the cooling function. Wherever possible, mating piping and fittings shall be terminated or structurally supported to allow for one-handed connect or disconnect operation.

3.3.10.1 Internal connections. Connections required for channeling the cooling water to various passages within the unit shall be located inside the unit enclosure. These connections shall be positioned to minimize danger to electronic parts or circuitry within the unit, in case of leaking at the connection and to minimize danger of damage during maintenance.

3.3.10.2 Rigidly mounted chassis and panels. Connections to rigidly mounted water-cooled chassis and panels that are not normally movable for maintenance shall be by rigid piping with fixed connections.

3.3.10.3 Movable chassis, panels, and parts. Connections to movable water-cooled chassis, panels, and parts shall be through a flexible cooling hose assembly. The flexible hose shall be in accordance with 3.5.2 and shall be of sufficient length to allow chassis movement to the furthest expected extremity. A stowing mechanism shall be provided to ensure proper stowage. The flexible hose shall connect to rigid tubing attached to fixed members at such locations as to minimize hazard from weeping at joints.

3.3.11 Vents and drains. Vents and drains shall be provided, as necessary, to allow complete filling, draining, and venting of the cooling system.

3.4 Thermal instrumentation and protection. Thermal instrumentation and protection shall be in accordance with the individual equipment specification and the requirements specified herein.

3.4.1 High temperature warning. Warning of abnormal temperature (see 6.3.3) shall be provided by an audible alarm and flashing red light. A switch shall be provided to silence the audible alarm after it has sounded and to cause the red warning light to maintain visual indication without flashing as long as the abnormal temperature exists. This switch shall not hold the alarm circuit disabled during normal operation of the unit. The audible alarm shall not require manual resetting. The red light shall not be extinguished by automatic shutdown of the unit. The location of the alarm, light, and switch shall be as specified in the individual equipment specification.

3.4.1.1 Remote indication. To permit monitoring at a remote location, contacts which close when an abnormal temperature is reached shall be provided. These contacts shall be wired to a connector on the unit or, if stuffing tubes are utilized, to a terminal board in the equipment.

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3.4.2 Emergency cooling. Each unit in which cooling method 1 is employed shall operate at full power with the shipboard cooling water supply shut off for a period of at least 8 hours in a 35 ± 3°C operating environmental temperature without activating the automatic shutdown. This requirement may be met by opening panels or removing portions of the enclosure thereby providing circulation of compartment air in the unit. This procedure shall be of a quick changeover design requiring only the use of screwdriver.

3.4.3 Pressure relief devices. Safety pressure plugs, relief valves, or other devices, shall be provided in each removable water-cooled chassis having quick disconnect fittings, such that a chassis removed to a workbench and placed in operation will not build up dangerous pressures within the water circuits due to water expansion. Pressure relief devices shall blow out at a maximum gauge pressure of 155 lb/in^2. A safety warning plate shall be affixed adjacent to each pressure relief device.

3.5 Parts, materials, and processes.

3.5.1 Selection. The selection of parts, materials, and processes shall be in acordance with the individual equipment specification and the requirements specified herein.

3.5.2 Hose and hose assembly. The hose and hose assembly shall conform to MIL-H-24520 and shall be not more than 2 years old upon installation or more than 4 years.

3.5.3 Copper, flat. Flat copper products used in the fabrication of cooling surfaces shall be in accordance with ASTM B 152.

3.5.4 Brazing. Brazing shall be in accordance with MIL-B-7883.

3.5.5 Welding. Welding shall be in accordance with MIL-STD-278.

3.5.6 Water flow rate identification. A label plate shall be installed at each external connection indicating the required gallons per minute water flow rate.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the contractor 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.

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4.1.1 Responsibility for compliance. All items must meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of assuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling in quality conformance does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material.

4.2 Inspections. First article and quality conformance inspections shall be as specified in the individual equipment specification and shall include the examinations and tests as specified herein.

4.3 Examination and test plan. For those equipments utilizing method 1 or 2 cooling, the examination shall include the examination and tests specified herein. For those equipments utilizing method 3 cooling, the contractor shall include those examinations and tests needed to determine the adequacy and reliability of the applicable cooling systems utilized.

4.4 Examination and tests.

4.4.1 Performance test. The equipment shall be operated for a period of 8 hours in the following conditions:

(a) The mode which will cause the maximum power dissipation.
(b) Ambient environmental temperature of 35 $\pm$ 3°C.
(c) Inlet cooling water at 40 +5 -0°C.

4.4.1.1 Performance data. A record shall be made of all data necessary to determine compliance with required performance as specified in the individual equipment specification.

4.4.2 High temperature warning test. Following the test of 4.4.1, the cooling water supply shall be shut off to equipment employing the use of cooling method 1, while inlet cooling water temperature is increased in increments of 3°C to equipment units employing cooling method 2. The equipment shall be operated until both the high temperature flashing red warning lgiht and the audible alarm are energized. The audible alarm shutoff switch shall be operated and the audible alarm shall be silenced while the red warning light remains on without flashing. Operation shall be continued until automatic shutdown occurs. Following automatic shutdown, the cooling water shall be turned on, or reduced in temperature, as applicable. The equipment shall resume normal operation when the internal equipment temperature falls below the abnormal temperature. The cooling water supply shall again be shut off to the equipment employing cooling method 1 or the water supply temperature raised in 3°C increments to equipment units employing cooling method 2, and the equipment operated until the audible alarm is energized to determine that the audible alarm will sound without manual resetting.

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4.4.3 Emergency cooling test. The equipment shall be operated continuously at full power for a period of at least 8 hours in an ambient temperature of 35 ± 3°C with the cooling water supply shut off to equipment employing cooling method 1. All doors and panels removable for emergency operation shall be opened or removed. The warning light and alarm may operate during this test; however, automatic shutdown shall not occur as an indication of unsafe operating temperature.

4.4.4 Hydrostatic test. The portion of the cooling system using shipboard cooling water shall be subjected to a hydrostatic gauge pressure of 150 lb/in^2 and shall then be examined for leaks and weeps.

4.5 Inspection of packaging. Sample packages and packs, and the inspection of the preservation-packaging, packing and marking for shipment and storage shall be in accordance with the requirements of section 5 and the documents specified therein.

5. PACKAGING

(The packaging requirements specified herein apply only for direct Government acquisition.)

5.1 Preservation. Prior to shipment of the equipment, the water passages shall be thoroughly cleaned of all contaminates and surface deposits, drained, dried out, and plugged.

6. NOTES

6.1 Intended use. The water cooling systems covered by this specification are intended for cooling of electronic equipment.

6.2 Ordering data. Acquisition documents should specify the following:

(a) Title, number, and date of this specification.

6.3 Definitions. For the purpose of this specification the following definitions shall apply:

6.3.1 Individual equipment specification. An individual equipment specification is the specification defining the detailed requirements of a particular equipment.

6.3.2 Equipment. The term equipment is generic and applies to any or all item levels as defined in MIL-STD-280.

6.3.3 Abnormal temperature. The term abnormal temperature is applied to a temperature that is higher than the upper limit of the maximum design operating temperature. An abnormal temperature represents an intolerable operating condition and may be due to a failure or malfunction in the cooling system or may be due to abnormal operational or ambient conditions. This temperature shall be low enough to provide an adequate safety margin such that warning devices are actuated before the maximum allowable thermal stress of parts is reached.

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6.4 Subject term (key word) listing.

Cooling, conduction
Cooling, convection

6.5 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

User activities:
Navy - EC, MC, OS

Preparing activity:
Navy - SH
(Project 4420-N067)

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STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE
MIL-W-21965D(NAVY)	WATER COOLING OF SHIPBOARD ELECTRONIC EQUIPMENT GENERAL SPECIFICATION FOR

3a. NAME OF SUBMITTING ORGANIZATION	4. TYPE OF ORGANIZATION *(Mark one)*
	☐ VENDOR ☐ USER ☐ MANUFACTURER ☐ OTHER *(Specify)*:
b. ADDRESS *(Street, City, State, ZIP Code)*	

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional	b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional
c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional	8. DATE OF SUBMISSION *(YYMMDD)*

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