

INCH-POUND
MIL-T-15005F
06 DECEMBER 1989
SUPERSEDING
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9 July 1962
(See 6.5)

MILITARY SPECIFICATION

TUBES, CONDENSER AND HEAT EXCHANGER, COPPER-NICKEL ALLOYS (UNS C70600 & C71500)

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

1. SCOPE

1.1 Scope. This specification covers copper-nickel alloy condenser and heat exchanger tubes for sea water service.

1.2 Classification. Tubes shall be furnished in the following compositions and tempers, as specified (see 6.2). When no temper is specified, tubes shall be supplied in the annealed condition.

Composition:

Copper alloy C70600 (Formerly 90-10)
Copper alloy C71500 (Formerly 70-30)

Temper:

C70600 - 061 - Annealed
 H55 - Light drawn
C71500 - 061 - Annealed
 HR50 - Drawn, stress relieved

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 5523, 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.

AMSC N/A

FSC 4710

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

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 document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

STANDARDS

MILITARY

- MIL-STD-271 - Requirements for Nondestructive Testing Methods.
- MIL-STD-792 - Identification Marking Requirements for Special Purpose Components.

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Naval Publications and Forms Center, (ATTN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099.)

2.2 Non-Government publications. The following document(s) form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

- B 111 - Standard Specification for Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock. (DoD adopted)
- B 153 - Standard Test Method for Expansion (Pin Test) of Copper and Copper-Alloy Pipe and Tubing. (DoD adopted)
- E 243 - Standard Practice for Electromagnetic (Eddy-Current) Testing of Seamless Copper and Copper Alloy Tubes.

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

(Non-Government standards and other publications are normally available from the organizations that prepare or 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 document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Material. Copper alloys C70600 and C71500 condenser tubes shall conform to ASTM B 111 (see 6.2) with supplementary requirements S2, S3 and S4 as modified herein.

3.1.1 Recovered materials. Unless otherwise specified herein, material covered by this specification shall be new and may be produced from recovered materials to the maximum extent possible without jeopardizing the intended use. The term recovered materials means materials which have been collected or recovered from solid waste and reprocessed to become a source of raw materials, as opposed to virgin raw materials. None of the above shall be interpreted to mean that the use of rebuilt products is allowed under this specification unless specifically specified.

3.2 Chemical analysis. Chemical analysis of the tube shall conform to that in ASTM B 111 including the tighter trace element limits listed as applicable to material for subsequent welding applications.

3.3 Mechanical properties and grain size. Tubes shall conform to the requirements of ASTM B 111 for flattening and grain size. When specified (see 6.2), tubes shall conform to the mechanical property requirements of ASTM B 111. Tubes shall meet the expansion test requirements of this specification.

3.4 Soundness. Tubes shall be of uniform temper, free of grooves, indentations, cracks, laps and blisters to the extent determinable by visual or nondestructive testing. Nondestructive testing shall be by eddy current and hydrostatic tests to ASTM B 111. When specified (see 6.2), tubes shall be hydrostatic tested by the requirements of ASTM B 111, ultrasonic tested to the requirements of 4.4.3, and liquid penetrant inspected in accordance with 4.4.2.

3.5 Cleanliness. The inner and outer surface of the tube shall be delivered clean, free of dirt, oils, grease, acid, chips, carbonaceous material, free carbon, sulfur bearing compounds or any other foreign material that render the tubes unfit for their intended use. Contaminants such as sulfur or sulfur bearing compounds, carbon or carbon bearing compounds, from lubricants used in forming, machining or other processing and marking materials used for in-process identification shall be removed from the material prior to any heat treatment. Tubing shall be cleaned either by acid pickling after heat treating or by using an inert or reducing atmosphere during heat treatment. All trace of acid shall be removed following acid cleaning.

3.5.1 Mercury contamination. The tubes shall be free of all contamination. During the manufacturing processes, tests, and inspections the product to be offered for acceptance shall not have come into direct contact with mercury or any of its compounds nor with any mercury bearing device employing a single boundary of containment.

3.6 Dimensions. Dimensions of the tube shall be as specified (diameter, wall thickness and length) (see 6.2). The outside diameter tolerances for tubes acquired to this specification shall be as specified in ASTM B 111, but shall be all on the minus side. Tubes shall be supplied to minimum wall requirements of ASTM B 111.

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3.7 Marking. Each length of tube 1/2 inch in outside diameter and larger, shall be marked in accordance with MIL-STD-792, types I, II, VII, VIII or A, with the manufacturer's name or identifying mark, specification number, alloy, temper and heat number. On smaller than 1/2 inch outside diameter tubing that is packaged, the same information may be provided on a single metal tag securely attached to each package.

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 (examinations and tests) 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 this specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items shall 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 ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of the manufacturing operations, is an acceptable practice to ascertain conformance to requirements, however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to accept defective material.

4.2 Sampling.

4.2.1 Lot. For sampling purposes, a lot shall consist of lengths of tubes of the same composition, temper, and size, heat treated at the same time in the same furnace, offered for delivery at the same time and identifiable by mill records as originating from one or more heats, as necessary, which conform to the chemical requirements. The total weight of the lot shall not exceed 10,000 pounds.

4.2.2 Chemical analysis. Samples shall be taken at the time the metal is cast. One sample shall be taken for each group of castings poured simultaneously from the same source of molten metal (see 6.3).

4.2.3 Destructive tests. From the lot as defined in 4.2.1, representative samples for expansion test, flattening test, and when required, tension test and microscopic examination shall be selected in accordance with table I (see 4.5).

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TABLE I. Sampling for destructive tests.

Number of pieces in the lot	Number of sample pieces to be selected
1 to 50	1
51 to 200	2
201 to 1500	3
over 1500	0.2 percent of total number of pieces in the lot but not to exceed 10 sample pieces

4.2.4 Visual and dimensional examination. From each lot, a representative sample of tubes shall be selected in accordance with table II (see 4.5).

TABLE II. Acceptance and rejection levels for visual and dimensional examination.

Number of tubes in inspection lot	Number of tubes in sample	Acceptance number (defectives)	Rejection number (defectives)
40 or under	15	0	1
41 to 110	25	0	1
111 to 300	35	1	2
301 to 500	50	1	2
501 to 800	75	2	3
801 to 1300	110	3	4
1301 to 3200	150	4	5
3201 and over	225	5	6

4.2.5 Nondestructive tests. Each tube shall be subjected to the specified nondestructive test (see 4.5).

4.3 Examination. Each sample selected in accordance with 4.2.4 shall be dimensionally examined for compliance with 3.6 and the dimensional tolerances of ASTM B 111 and visually examined for compliance with 3.4, 3.5, and 3.7 and the workmanship, finish and appearance requirements of ASTM B 111 except as modified by 3.5 above (see 4.5).

4.4 Tests.

4.4.1 Eddy current test. The eddy current test shall be performed as specified in ASTM B 111 except as modified herein.

4.4.1.1 Calibration. The tube used to adjust the testing device shall be of the same alloy, temper, and nominal dimensions as the lot of tubes being tested and be of such length as to permit the required spacing of the artificial discontinuities. Artificial discontinuities sizes shall be in accordance with ASTM E 243 and as follows:

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- (a) Two round bottom notches which have a depth of 0.005 inch or 5 percent of the nominal tube wall whichever is greater, and
- (b) Two 0.025 inch diameter holes.

4.4.1.2 Calibration periods. In addition to calibrating at the start of each run and periodically during testing in accordance with ASTM E 243, calibration shall be performed at the conclusion of testing. If during any calibration attempt the equipment does not calibrate, all tube tested since the last calibration shall be retested.

4.4.1.3 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 evaluate these 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. Tubes so reworked shall be reinspected by the same test method that originally rejected the tube.

4.4.2 Liquid penetrant inspection. When specified (see 3.4 and 6.2), the entire length of the outside diameter of each tube shall be liquid penetrant inspected in accordance with MIL-STD-271.

4.4.2.1 Acceptance criteria. Tubes which show the following liquid penetrant indication shall be subject to rejection:

- (a) Any linear liquid penetrant indications except those that can be definitely established to the satisfaction of the contracting activity as scratches whose depth is less than 5 percent of the wall thickness.
- (b) Rounded indications 1/16 inch diameter or greater.
- (c) Rounded indications which are linearly disposed whose center-to-center distance is less than 3/16 inch.

4.4.2.2 Defect evaluation. Superficial polishing with 120 grit emery cloth may be used as an aide in determining the extent of the indications defined in 4.4.2.1. Not more than 5 percent of the wall thickness shall be removed to define the indications. The wall thickness shall not be reduced below minimum specified wall thickness. All areas polished to remove indications shall be reinspected in accordance with 4.4.2 to assure that all indications have been removed.

4.4.3 Ultrasonic inspection. When specified, each tube shall be inspected ultrasonically by the shear wave (angle beam) and the compressional wave techniques. This inspection shall be conducted in two opposite circumferential directions and one longitudinal direction.

4.4.3.1 Compressional wave technique. Ultrasonic gauging for laminations shall be carried out circumferentially along the entire length of the tube by the compressional wave technique in accordance with MIL-STD-271. Tube shall be examined for laminar discontinuities by ultrasonic gauging for compliance with the wall thickness requirements of ASTM B 111. Laminar discontinuities shall be considered as reductions of wall thickness. The maximum dimension of the transducer active element shall be 1 inch. Each circumferential scan shall

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overlap the previous scan by a minimum of 25 percent of the transducer active element width. Indications whose maximum amplitude is less than 25 percent of the normal back reflection amplitude shall be disregarded. Each sample or all tubes, as applicable, that do not meet the requirements of ASTM B 111 shall be rejected.

4.4.3.2 Shear wave technique. Shear wave technique ultrasonic inspection shall be in accordance with the applicable sections of MIL-STD-271 except as modified by 4.4.3.2.1 through 4.4.3.2.8 below.

4.4.3.2.1 Instruments. The ultrasonic test instrument shall meet the equipment qualification requirements of MIL-STD-271. Instrument to be used in the inspection system shall have a minimum bandwidth of plus or minus 10 percent (measured at the 3 decibels (dB) down points) from the nominal 5 megahertz (MHz) operating frequency. Instrument bandwidth may be verified by the manufacturer's certification.

4.4.3.2.2 Search units. Search units to be used in the inspection system shall provide an inspection frequency of 5 MHz plus or minus 10 percent. For longitudinal defect inspection a cylindrically focused transducer shall be used. The active unit shall not exceed $1/2$ by 1 inch in size. It shall produce a sound beam having a width not greater than $3/16$ inch when measured at a distance of 3 to 5 inches in water. The beam profile shall not deviate more than minus 2 dB from the peak amplitude along the axis and be at least $1/2$ inch wide at the 2 dB down point. The beam profile and width shall be maintained within the 3 to 5 inch zone in water as shown on figure 1.

4.4.3.2.3 Reference standard. Calibration reference standard shall be made from a length of ultrasonically sound tube or pipe of the same type, wall thickness, and outside diameter as that to be tested as defined in MIL-STD-271. The standard shall meet the flatness requirement shown on figure 2 and shall have two longitudinal notches and two transverse notches. One of each type of notch shall be on the outside surface and one on the inside surface. The longitudinal notch dimensions shall be within the tolerances shown on figure 2 and may be machined or electro-discharged machined. The longitudinal notch dimensions shall have a depth of 3 percent of the specified minimum wall or 0.005 inch whichever is greater. Dimensions of the transverse notches shall not exceed those of the longitudinal notches.

4.4.3.2.4 Couplant. Visible suspended foreign particles (solids or air) shall be excluded from the couplant used.

4.4.3.2.5 Calibration for inspection. Scan until the notch indication on the inside diameter, shown as position 1 on figure 3 is clearly resolved. The reference calibration standard shall be moved until the indication from this notch reappears along the horizontal trace, shown as position 3 on figure 3. Scan until the notch indication from the outside diameter is produced at maximum amplitude, shown as position 2 on figure 3. The distance between the front surface signal and the leading edge of the gate shall be determined by the front surface noise level. For the circumferential scan, the test angle shall be adjusted so that the signals shown as positions 1 and 2 on figure 3 achieve the nearest amplitude match. Adjust the lower of signals 1 and 2 to 80 percent of full screen height. Electronic balancing shall not be used. The alarm or recorder shall be set at 50 percent of full screen height.

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4.4.3.2.6 Recalibration. During acceptance testing, any realignment of the search unit with respect to the tube, or any change in search unit, couplant, instrument settings, or scanning speed from that used for calibration shall require recalibration. In addition, the calibration shall be rechecked at least once per 8-hour shift and at the completion of testing. If a recheck indicates that recalibration is required, all items tested since the last instrument check shall be reinspected.

4.4.3.2.7 Testing (scanning). The search unit position with respect to the tube axis shall be maintained within 1 percent of the nominal outside diameter of the tube or 0.010 inch, whichever is greater. Proper rotation and through speeds shall be used to ensure 100 percent inspection coverage. The helix shall be adjusted such that the standard reference notches shall each be detected above the alarm level not less than two times during the traverse of each notch. This scanning shall be done with the same couplant, search unit alignment and instrument settings as were used during calibration.

4.4.3.2.8 Acceptance criteria. Any portion of a tube which produces an indication equal to or greater than the reject levels established during calibration shall not be offered for delivery.

4.4.4 Expansion test. Each specimen selected in accordance with 4.2.3 shall be subjected to the expansion test specified in ASTM B 153. The tube outside diameter shall be increased 50 percent for annealed and 35 percent for light drawn tube and shall show no cracking or rupture visible to the unaided eye after expansion.

4.5 Informational summary of quality conformance provisions. Table III is presented for information only and in no way modifies the requirements of this specification.

TABLE III. Summary of quality conformance provisions.

Characteristic	Requirement	Sampling	Examination or test
Group A			
Dimensions	ASTM B 111 & 3.6	4.2.4	4.3
Finish	ASTM B 111	4.2.4	4.3
Marking	3.7	4.2.4	4.3
Workmanship	3.4	4.2.4	4.3
Group B			
Eddy current test	3.4	4.2.5	4.4.1
Pneumatic test	3.4	4.2.5	ASTM B 111
Liquid penetrant (Opt)	3.4	4.2.5	4.4.2
Ultrasonic test (Opt)	3.4	4.2.5	4.4.3
Hydrostatic test (Opt)	3.4	4.2.5	ASTM B 111

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TABLE III. Summary of quality conformance provisions - Continued.

Characteristic	Requirement	Sampling	Examination or test
Group C			
Chemical analysis	3.2	4.2.2	ASTM B 111
Mechanical properties	ASTM B 111	4.2.3	ASTM B 111
Flattening	ASTM B 111	4.2.3	ASTM B 111
Grain size	ASTM B 111	4.2.3	ASTM B 111
Expansion test	ASTM B 111	4.2.3	4.4.4
Cleanliness	3.5	4.2.3	3.5

4.6 Inspection of packaging. Sample packages and packs, and the inspection of the preservation, 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, packing and marking. Preservation, packing and marking shall be in accordance with ASTM B 111.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. Tubes covered by this specification are intended for use in heat exchangers and condensers which use sea water as the cooling medium.

6.2 Acquisition requirements. Acquisition documents must specify the following:

- (a) Title, number and date of this specification.
- (b) Composition required (see 1.2).
- (c) Temper, if other than annealed (see 1.2).
- (d) Issue of DoDISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.1.1 and 2.2).
- (e) Applicable issue of ASTM B 111 (see 3.1).
- (f) Whether tensile tests are required (see 3.3).
- (g) Whether hydrostatic testing, ultrasonic inspection or liquid penetrant inspection are required (see 3.4 and 4.4.2).
- (h) If cleaning procedures are to be other than specified (see 3.5).
- (i) Outside diameter, wall thickness and length required (see 3.6).

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6.3 Consideration of data requirements. The following data requirements should be considered when this specification is applied on a contract. The applicable Data Item Descriptions (DID's) should be reviewed in conjunction with the specific acquisition to ensure that only essential data are requested/provided and that the DID's are tailored to reflect the requirements of the specific acquisition. To ensure correct contractual application of the data requirements, a Contract Data Requirements List (DD Form 1423) must be prepared to obtain the data, except where DoD FAR Supplement 27.475-1 exempts the requirement for a DD Form 1423.

<u>Reference Paragraph</u>	<u>DID Number</u>	<u>DID Title</u>	<u>Suggested Tailoring</u>
4.2.2	DI-MISC-80678	Certification/ data report	----

The above DID's were those cleared as of the date of this specification. The current issue of DoD 5010.12-L, Acquisition Management Systems and Data Requirements Control List (AMS DL), must be researched to ensure that only current, cleared DID's are cited on the DD Form 1423.

6.4 Subject term (key word) listing.

Annealed
Light drawn
Stress relieved

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

Custodians:

Army - MR
Navy - SH
Air Force - 99

Preparing activity:

Navy - SH
(Project 4710-0860)

Review activities:

Army - MR
Navy - YD
DLA - CS

User activity:

Navy - MC

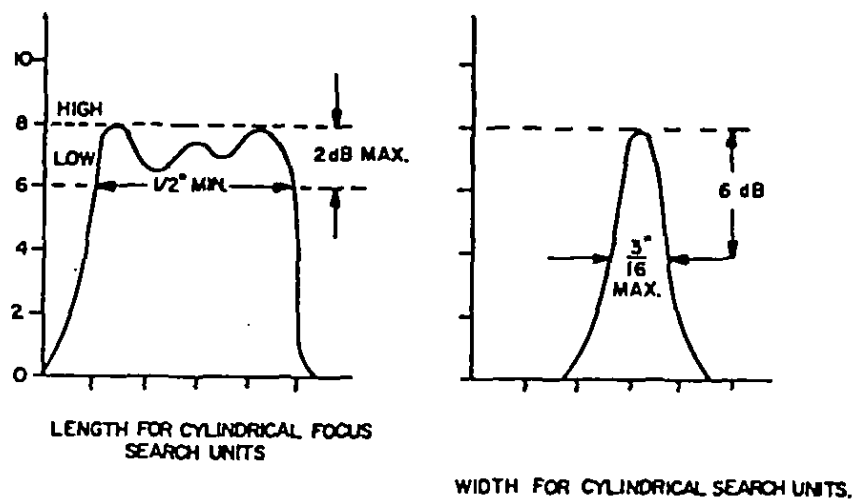
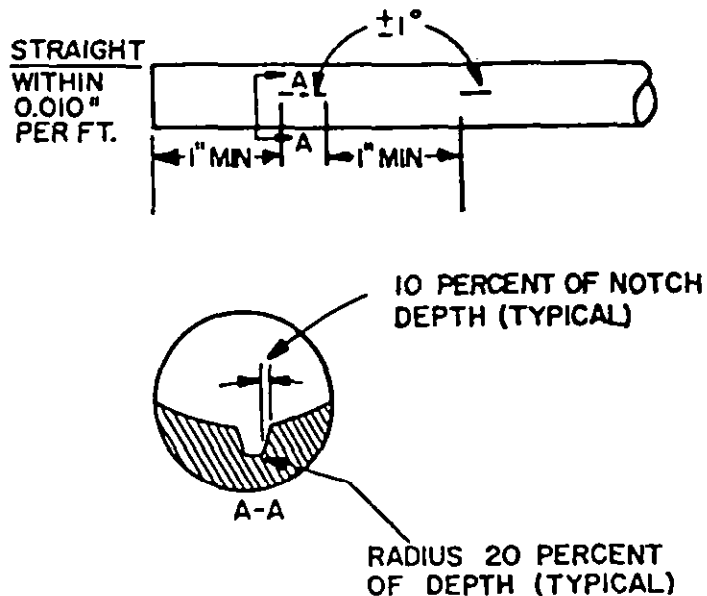


FIGURE 1. Beam profile and width.

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Tolerance 1/

- Depth - 5 percent of minimum wall or 0.005 inch whichever is greater plus or minus 0.0005 inch 2/.
- Width - 2X nominal depth - maximum.
- Length - 1.0 inch plus or minus 1/16 inch.
- Alignment - Plus or minus 1 degree.

1/ Measurement may be made by optical or replicating techniques. Destructive means may be used on duplicate notches which have identical ultrasonic response.

2/ For wall thicknesses in excess of 0.100 inch, the tolerance shall be plus or minus 0.001 inch.

FIGURE 2. Reference standard dimensions and tolerances.

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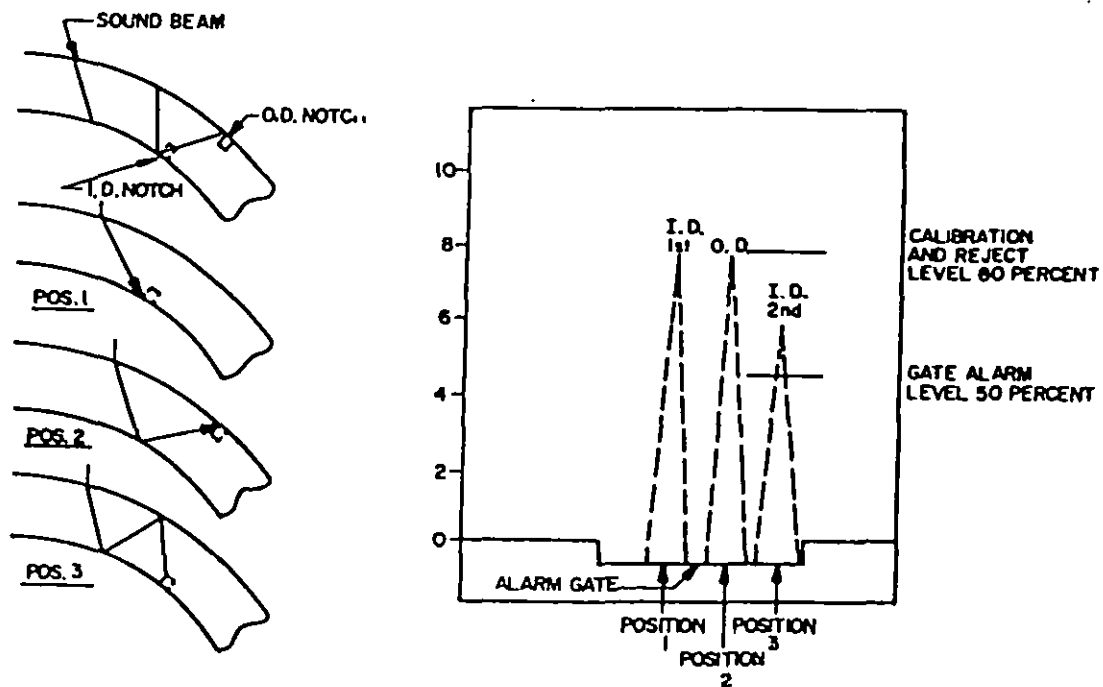


FIGURE 3. Calibration and flaw alarm/rejection/acceptance signal amplitude levels.