MIL-J-24445A(SH)
25 July 1977
SUPERSEDING
MIL-J-24445(SHIPS)
1 March 1971
(See 6.4)

MILITARY SPECIFICATION

JOINT, BIMETALLIC BONDED, ALUMINUM TO STEEL

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

1. SCOPE

1.1 Scope. This specification covers aluminum to steel transition joints made by the roll bonding and explosion bonding processes. The joints are obtained from aluminum to steel bonded plate, and may be supplied in various geometries such as bars, discs, rings, or rectangles. This specification does not cover joints made by welding or brazing.

2. APPLICABLE DOCUMENTS

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

STANDARD

MILITARY
MIL-STD-271 - Nondestructive Testing Requirements for Metals.

PUBLICATION

NAVAL SEA SYSTEMS COMMAND
NAVSEA 0900-LP-000-1000 - Fabrication, Welding, and Inspection of Ship Hulls.

(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.)

3. REQUIREMENTS

3.1 First article. When specified (see 6.2.1), the contractor shall furnish sample bonded material for first article inspection and approval (see 4.3 and 6.3). Bonded material shall conform to the mechanical properties shown in table I.

TABLE I. Mechanical properties for bonded joint material.

Condition	Bond ultimate tensile strength	Shear strength	Welded fatigue strength	Fabricated tensile strength
	lb/in^2	lb/in^2		
As clad	11,000	8,000	1/	
Simulated welding cycle 2/	11,000	8,000		
As welded				3/

See footnotes at top of next page.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Ship Engineering Center, SEC 6124, Department of the Navy, Washington, D.C. 20362 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

1/ Per 4.6.4.

2/ Simulated welding thermal treatment shall consist of heating the sample to 600°F ± 25°F and holding for a period of 15 minutes.

3/ Per 4.6.5.

3.2 Materials. Steel and aluminum alloy base materials in all joints produced to this specification shall conform to the applicable base plate specifications specified in the contract (see 6.2.1). An intermediate aluminum alloy plate may be used as an interface material if required by the bonding process, and shall conform to the applicable plate specification of the contract (see 6.2.1).

3.3 Thickness and width or diameter. Thickness and width or diameter (unit cross section) shall be based on the composition and thickness of the members which will be welded to the bimetallic strip for the intended application. The composition (that is, material types) and thickness of materials to be welded to the bimetallic joint will be specified in the contract (see 6.2.1).

3.4 The bimetallic joint bond shall not fail when subjected to the mechanical tests of 4.5.1 and 4.5.3.

3.5 The bimetallic joint bond shall not exhibit any complete loss of back reflection when ultrasonically inspected as specified in 4.5.2.

3.6 Out of flatness.

3.6.1 Bars. Out of flatness for linear (bar) joints produced to this specification shall not exceed 1/16 inch over any 12 inch length. This shall be determined by moving a 12-inch straightedge along the length of the bar. Overall out of flatness shall not exceed 3/4 inch for bars 96 inches or less in length, or 1 inch for longer bars.

3.6.2 Plates. Out of flatness for joints procured in plate form shall not exceed 1/8 inch over any 12-inch span. Overall out of flatness shall not exceed 3/4 inch.

3.7 Edge chamfer. Bar edges shall be chamfered to 1/16 inch minimum radius. Bar out of squareness shall not exceed 1/32 inch deviation for cut ends or 1/16 inch for cut edges.

3.8 Edge straightness. Deviation of edge straightness or contour for any product shall not exceed 1/8 inch over any 12-inch span. The total straightness deviation shall not exceed 1/2 inch.

4. QUALITY ASSURANCE PROVISIONS

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

4.2 Classification of inspections. The inspection requirements specified herein are classified as follows:

(a) First article inspection (see 4.3).
(b) Quality conformance inspection (see 4.4).

4.3 First article inspection. First article inspection shall consist of the tests specified in 4.6.

4.4 Quality conformance inspection.

4.4.1 Quality conformance tests. Samples shall be subjected to the tests of 4.5. Records of all quality conformance tests shall be available for inspection by representatives of the Government.

4.4.2 Sampling.

4.4.2.1 Lot. For the purpose of testing and examination, a lot shall consist of 10 or fewer bonded plates produced at one time under a unique set of conditions. Any change in these conditions, or essential variables, shall constitute a new lot. The essential variables are as shown in 4.4.2.1.1 and 4.4.2.1.2. Additional variables which the manufacturer considers essential in controlling a particular process shall also be included.

4.4.2.1.1 Explosion bonding. The essential variables are as follows:

(a) Plate heat numbers.
(b) Plate thicknesses.
(c) Charge size.
(d) Standoff distance.
(e) Charge type, contractor or batch.
(f) Sequencing (tandem, individual, etc.).
(g) Base plate cleaning procedures.
(h) Bonding agent, if used.
(i) Assembly width and length.

4.4.2.1.2 Roll bonding. The essential variables are as follows:

(a) Plate heat numbers.
(b) Plate thicknesses.
(c) Roll pressure setting or roll gap.
(d) Roll temperature range or temperature after rolling.
(e) Number of rolling passes.
(f) Base plate cleaning procedures.
(g) Bonding agent and inert atmosphere, if used.
(h) Assembly width and length.

4.4.2.2 Sampling procedure.

4.4.2.2.1 Mechanical tests. Two sample pieces shall be removed from one bonded plate or assembly in each lot. The sample pieces shall be selected from diagonally opposite corners after any necessary trimming. One tensile and one bend specimen shall be fabricated from each sample piece in accordance with 4.5.1 and 4.5.3.

4.4.2.2.2 Retest sampling. Where a lot is rejected due to failure in tensile or bend test, individual plates in this lot may be reinstated by successful completion of two bend and two tensile tests from each bonded plate or assembly. Where a specimen from one plate fails any mechanical test, retest of that plate shall be prohibited.

4.4.2.2.3 Ultrasonic examination. All bimetallic joints in each plate shall be ultrasonically inspected over 100 percent of the bond area in order to detect regions of lack of bond (unbond).

4.5 Test methods. The tests specified in 4.5.1, 4.5.2, and 4.5.3 are required for quality conformance testing.

4.5.1 Tensile test. The samples selected in accordance with 4.4.2 shall be tested in accordance with the requirements of 3.4. Each sample shall be tested using the ram tensile test fixture of figure 1 and the specimen of figure 2. In each sample, one specimen shall be tested in the as-clad condition and one specimen shall be subjected to a heat treatment at 600°F ± 25°F for 15 minutes prior to testing at room temperature. A minimum tensile strength of 11,000 pounds per square inch (lb/in^2) in both the as-clad and heat-treated conditions shall be required for acceptance.

4.5.2 Ultrasonic examination. The material selected in accordance with 4.4.2 shall be inspected for conformance to the requirements of 3.5. Ultrasonic calibration and inspection shall be accomplished to the bonding requirements of 6.7 of MIL-STD-271, using the bimetallic joint in lieu of the clad weld specimen. Any complete loss of back reflection, resulting from a discontinuity at the bond interface, shall be cause for rejection. The inspection shall utilize the continuous scanning technique and a crystal which has an active area not greater than one square inch. All defective areas shall be removed from each lot.

4.5.3 Bend test. The samples selected in accordance with 4.4.2 shall be tested in accordance with the requirements of 3.4. The method of removing specimen from the plate or assembly is shown in figure 3. Testing of bend specimens shall be as shown on figures 3 and 4. The test shall be repeated if any cracking occurs in the aluminum or steel base metal.

4.5.3.1 The triple lug shear test of figure 5 and the chisel test of figure 6 may be used in lieu of the bend test at the manufacturer's option. Where the manufacturer elects not to use the bend test, one triple lug shear test and one chisel test shall be performed in lieu of each required test bend. A minimum shear strength of 8,000 lb/in^2 in the as-clad condition shall be required for acceptance. Acceptable performance in the chisel test shall consist of base metal tearing without separation of bond interface in advance of the chisel point.

4.6 First article testing. Prior to delivery of bimetallic bonded joints supplied to this specification, vendors shall demonstrate by first article testing that their facilities are capable of producing joints of acceptable quality. Test joints shall be manufactured using procedures representative of normal production. The joint to be tested shall be fabricated from aluminum and steel plates of thicknesses identical to those incorporated in the production joint.

4.6.1 First article test. The tests of 4.6.2, 4.6.3, 4.6.4, and 4.6.5 shall be conducted for first article testing. First article testing shall be required for each type of bonded joint to be produced by each manufacturer. The manufacturer shall produce enough bonded material and weldments from one lot to provide the data required for each set of tests. One set of first article tests shall comprise the specimens of 4.6.1.1.

4.6.1.1 First article specimen requirements.

(a) One specimen tested per each of the two joint conditions of 4.6.2.
(b) One specimen tested per each of the two joint conditions of 4.6.3.
(c) Three specimens tested per each of the three fatigue testing conditions of 4.6.4.
(d) Two specimens tested per 4.6.5.

4.6.1.2 Test stresses. The stresses specified for the specimens of (a) and (b) above are on the bimetallic bond interface and assume a uniform stress distribution. The stresses specified for the specimens of (c) above apply to the cross-sectional area of the aluminum web.

4.6.2 Ultimate tensile strength. Using ram tensile test fixture (see figure 1) and specimen (see figure 2):

(a) 11,000 lb/in^2 minimum in as-clad condition.
(b) 11,000 lb/in^2 minimum at room temperature after heating to 600°F ± 25°F and holding for a period of 15 minutes.

4.6.3 Shear strength. Using triple-lug shear test of figure 5.

(a) 8,000 lb/in^2 minimum in as-clad condition.
(b) 8,000 lb/in^2 minimum at room temperature after heating to 600°F ± 25°F and holding for a period of 15 minutes.

4.6.4 Axial fatigue strength - tension to compression. Use specimen of figure 7 with length to suit machine capacity. The ratio of the cross sectional area of the aluminum web to the bond area of the bimetallic joint shall be one to four for the fatigue test specimens. Three different fatigue tests shall be carried out on separate specimens. Loadings and total numbers of cycles shall be the following:

(a) 15,000 lb/in^2 compression to 5,000 lb/in^2 tension - 175,000 cycles.
(b) 15,000 lb/in^2 compression to 1,000 lb/in^2 tension - 650,000 cycles.
(c) 10,000 lb/in^2 compression to 3,000 lb/in^2 tension - 1,000,000 cycles.

NOTE: In the above fatigue tests, any failure in the bond shall be cause for rejection. The test shall be repeated if base metal failure occurs prior to reaching the required number of cycles.

4.6.5 Welded tensile test. Use specimen of figure 7. Welding of the aluminum web shall be accomplished using the gas metal arc process. Each specimen tested must comply with one of the following conditions for acceptance. Failure of a web weld shall require retest.

(a) Failure in one of the web members.
(b) Failure of the bond interface or adjacent bonded material at a load above that calculated to cause failure in one of the web members, based on the specified minimum tensile strength of the web material.

4.7 Test reports. The contractor shall prepare a verified first article test report in accordance with the data ordering document included in the contract (see 6.2.2). Two copies of the first article test report shall be forwarded via the local DCAS representative to the Commander, Naval Ship Engineering Center (Engineering Materials and Services Office), Metals Section, Washington, D.C. 20362. To facilitate NAVSEC review of the test report, a basic description of the facilities, process used, quality assurance procedures, essential variables (see 4.4.2.1), and raw material specifications is required.

4.8 Inspection of preparation for delivery. The packaging, packing, and marking shall be inspected for compliance with section 5 of this document.

5. PREPARATION FOR DELIVERY

5.1 Packing.

5.1.1 Unless otherwise specified (see 6.2.1), the bimetallic joints shall be prepared for shipment in accordance with commercial practice to insure carrier acceptance and safe delivery at destination and shall meet, as a minimum, the requirements of carrier rules and regulations applicable to the mode of transportation.

5.1.2 The bimetallic joints, when shipped in open cases or trucks, unpacked or not wrapped in waterproof barriers or otherwise unprotected, shall be covered or shrouded with a suitable barrier adequately secured to protect the material against the corrosive or destructive effects of cinders, dust, dirt, rain, sleet, and snow. When practicable, the covering or shrouding shall cover individual piles or lifts in lieu of a single cover for a carload shipment.

5.2 Marking. Marking shall be as required in the contract (see 6.2.1).

6. NOTES

6.1 Intended use. The bimetallic bonded joints are intended for welded structure where steel is to be jointed to aluminum alloy, such as the joining of an aluminum deck house to a steel deck aboard ship. The joints may be used in atmospheric and dry structural applications only, and require suitable coatings to prevent galvanic corrosion.

6.2 Ordering data. Procurement documents should specify:

6.2.1 Procurement requirements.

(a) Title, number, and date of this specification.
(b) When a first article is required for inspection and approval (see 3.1, 4.3, and 6.3).
(c) Titles, numbers, and dates of the specifications governing the aluminum and steel base materials (and aluminum interface plate if applicable) required in the bimetallic joint. Governing base material specifications shall be those required by the applicable building specifications for the attaching members, or shall be for materials compatible to these members by welding (see 3.2).
(d) Type and thickness of material to be welded to the bimetallic joint (see 3.3).
(e) Special packing requirements, if different (see 5.1).
(f) Marking required on individual joints (see 5.2).

6.2.2 Data requirements. When this specification is used in a procurement which invokes the provision of the "Requirements for Data" of the Armed Services Procurement Regulations (ASPR), the data identified below, which are required to be developed by the contractor, as specified on an approved Data Item Description (DD Form 1664), and which are required to be delivered to the Government, should be selected and specified on the approved Contract Data Requirement List (DD Form 1423) and incorporated in the contract. When the provisions of the "Requirements for Data" of the ASPR are not invoked in a procurement, the data required to be developed by the contractor and required to be delivered to the Government should be selected from the list below and specified in the contract.

Paragraph	Data requirements	Applicable DID	Option
4.7	First article inspection report	UDI-T-23450	------

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

6.2.2.1 The data requirements of 6.2.2 and any task in section 3, 4, or 5 of the specification required to be performed to meet a data requirement may be waived by the procuring/purchasing activity upon certification by the offeror that identical data were submitted by the offeror and accepted by the Government under a previous contract for identical item procured to this specification. This does not apply to specific data which may be required for each procurement, regardless of whether an identical item has been supplied previously (for example, test reports).

6.3 First article inspection.

6.3.1 Invitations for bids should provide that the Government reserves the right to waive the requirement for samples for first article inspection as to those bidders offering a product which has been previously procured or tested by the Government, and that bidders offering such products, who wish to rely on such production or test, must furnish evidence with the bid that prior Government approval is presently appropriate for the pending procurement.

6.3.2 When a first article is required, it shall be tested and approved under the appropriate provisions of 7-104.55 of the Armed Services Procurement Regulation. The first article should be a first production item. The first article should consist of a bonded plate or assembly selected at random from the first production lot. The contracting officer should include specific instructions in all procurement instruments regarding arrangements for examinations, test, and approval of the first article.

6.4 Changes from previous issue. The extent of changes (deletions, additions, etc.) precludes the annotation of the individual changes from the previous issue of this document.

Preparing activity:
Navy - SH
(Project 9535-N037)

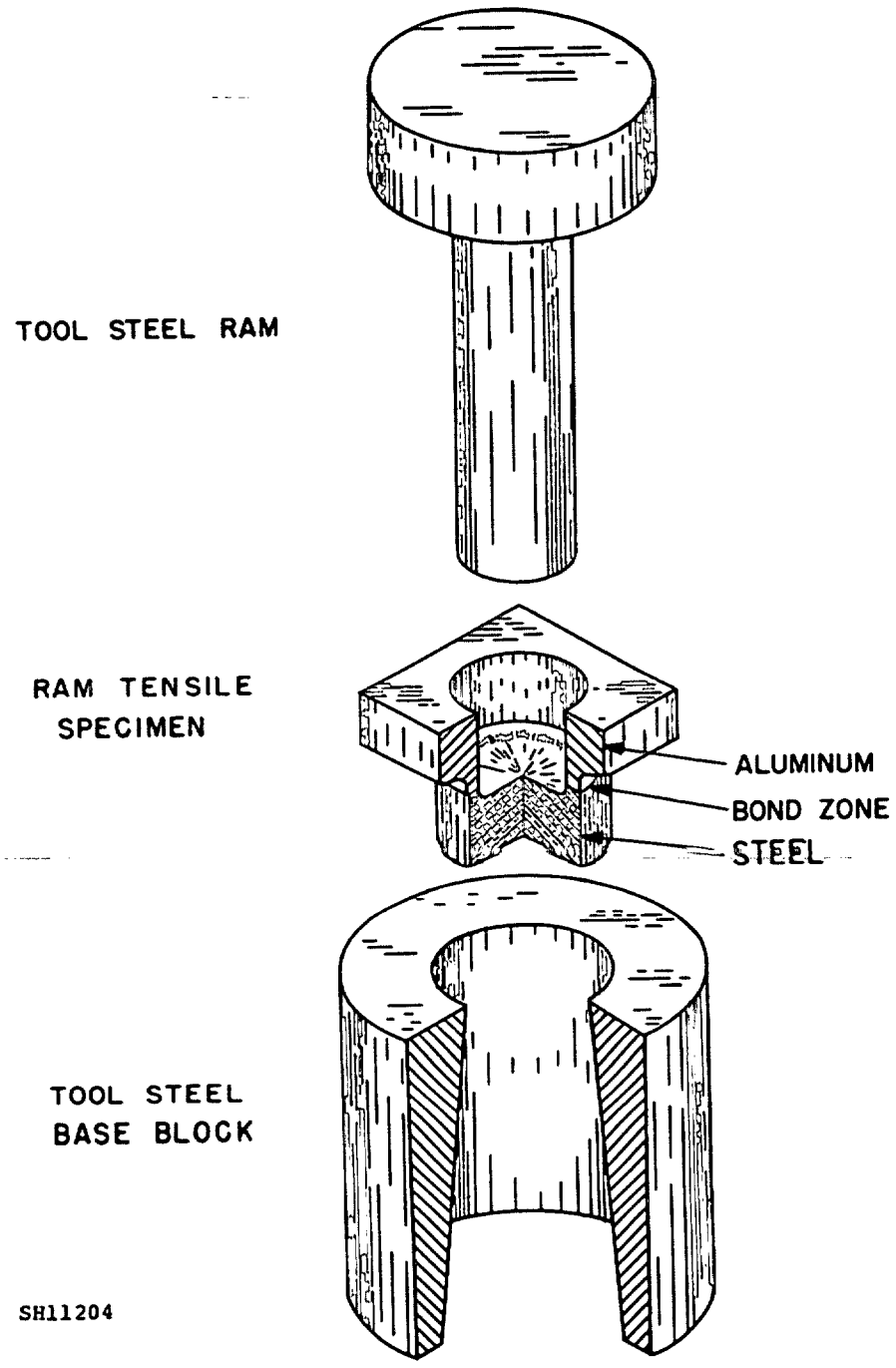
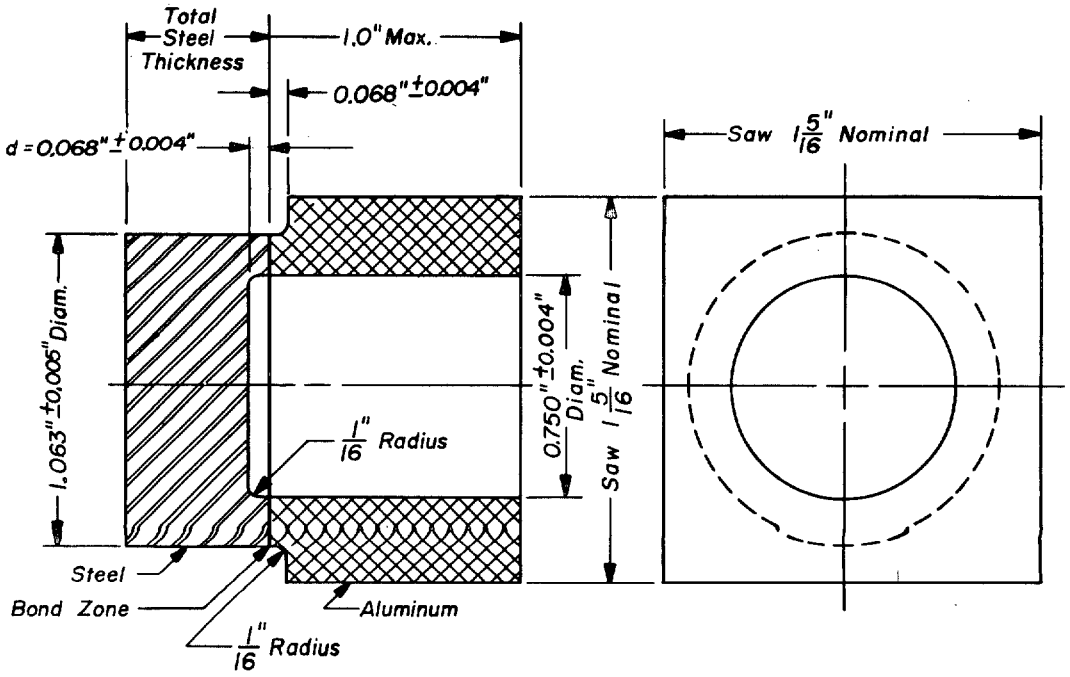


FIGURE 1. Sketch of ram tensile. (Specimen and fixture for testing bond zone tensile strength.)



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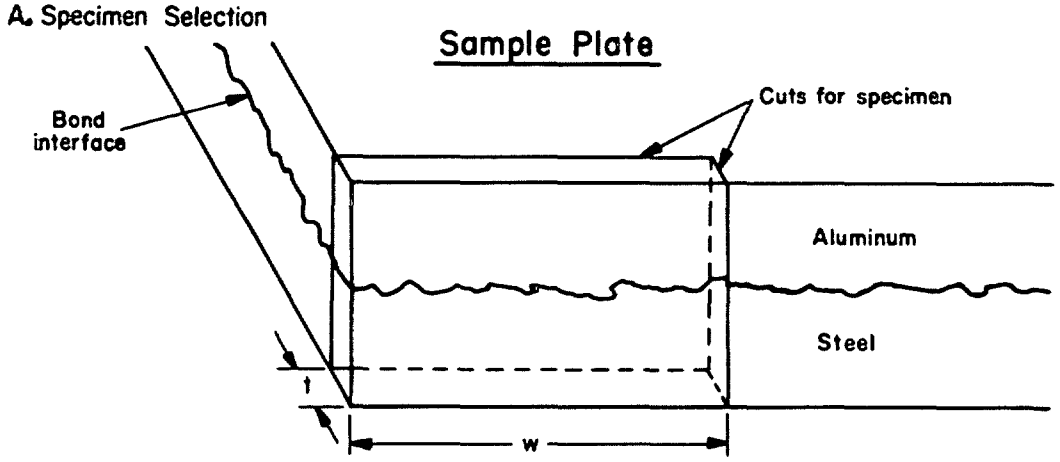
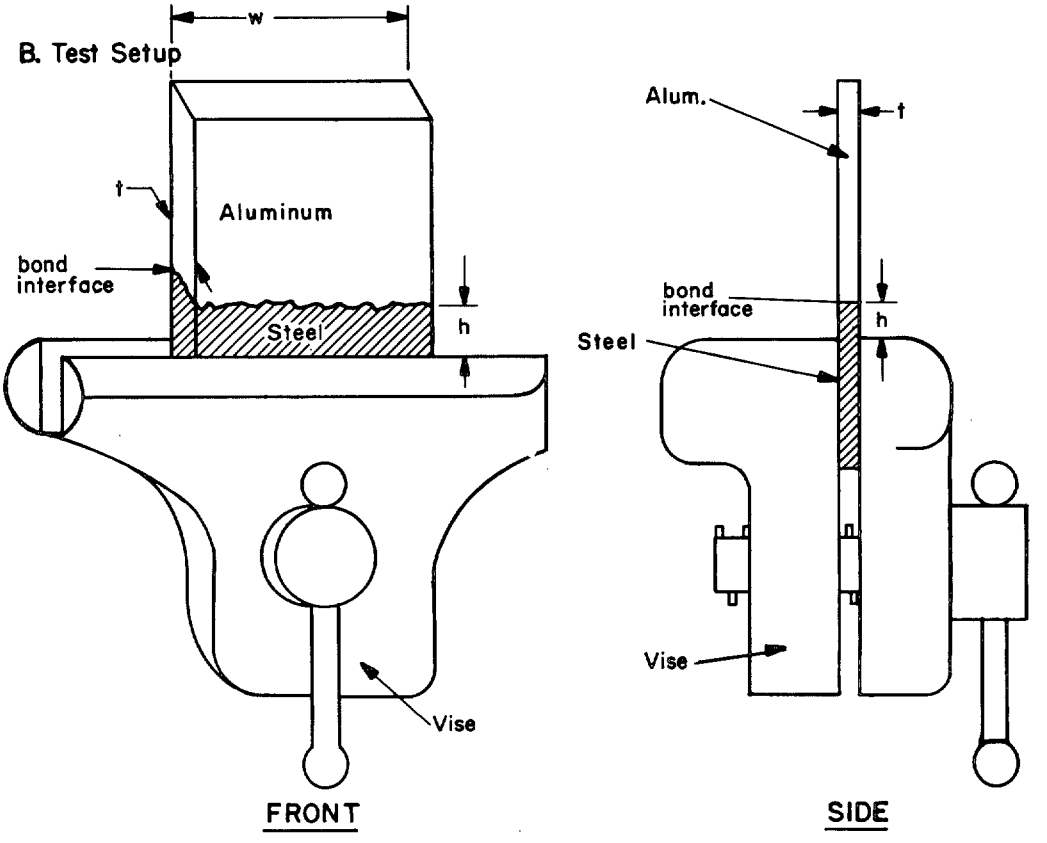
NOTES:
1. Sketch dimensions may be appropriately scaled for testing of products less than 1-5/16 inch wide.
2. Hole depth d below bond line shall be 0.064 inch or greater in all cases.

FIGURE 2. Ram tensile specimen.



NOTES:
1. Thickness t - 1/16 inch minimum.
2. Width W = 2 inch. Where width of product manufactured is less than 2 inch, or product geometry requires a curved bond interface of radius less than 12 inch, two (2) specimens of width W = 1 inch may be substituted for each 2 inch specimen.

FIGURE 3. Selection and setup of bend test specimens. - Continued



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NOTES:
1. Height h of top of bond interface above vise shall be at least 1/2 t, but not more than t.
2. Bond line shall be parallel to top of vise or edge of clamping jaws.
3. Test shall be commenced with specimen at ambient temperature.

FIGURE 3. Selection and setup of bend test specimens.

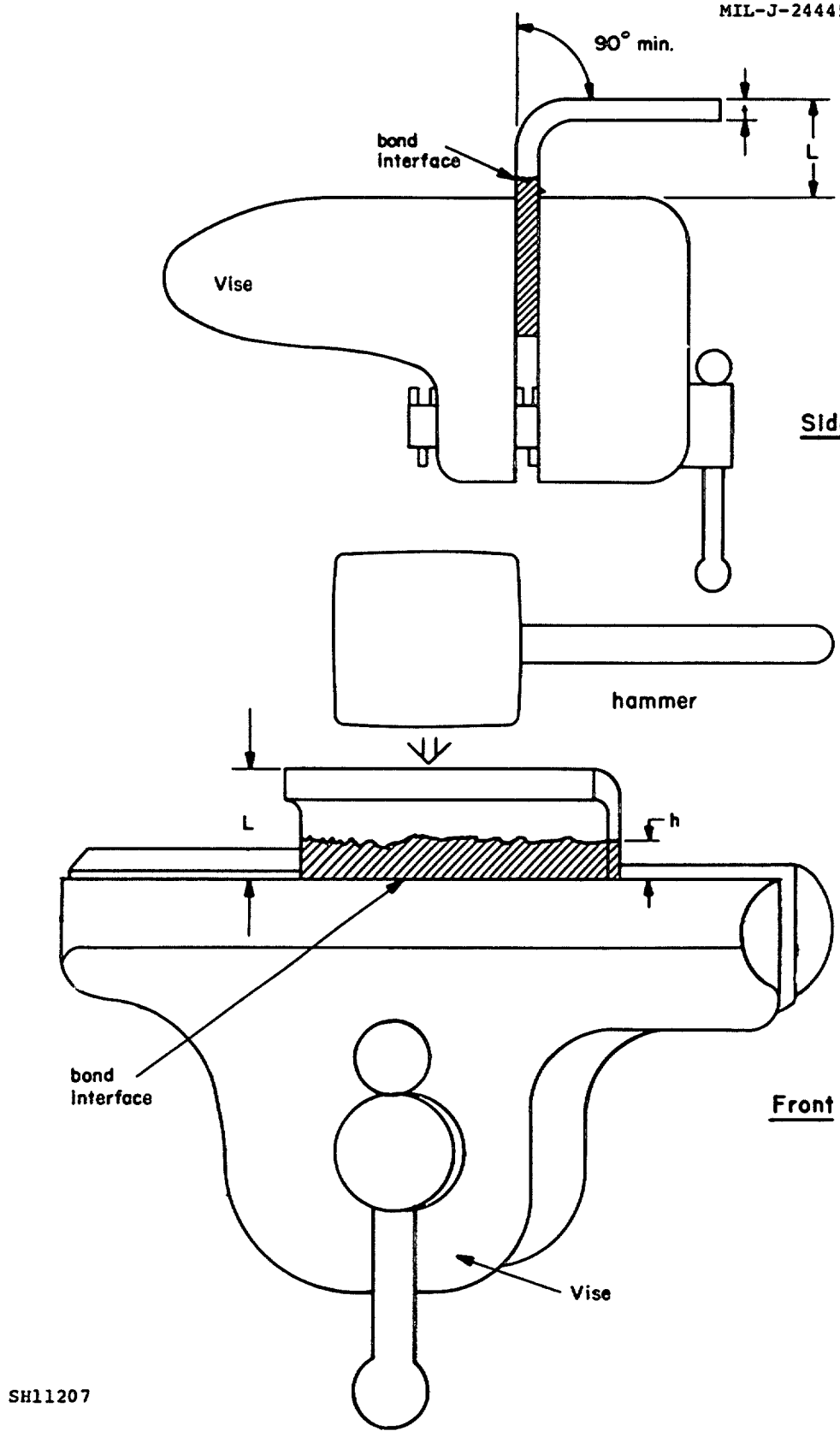


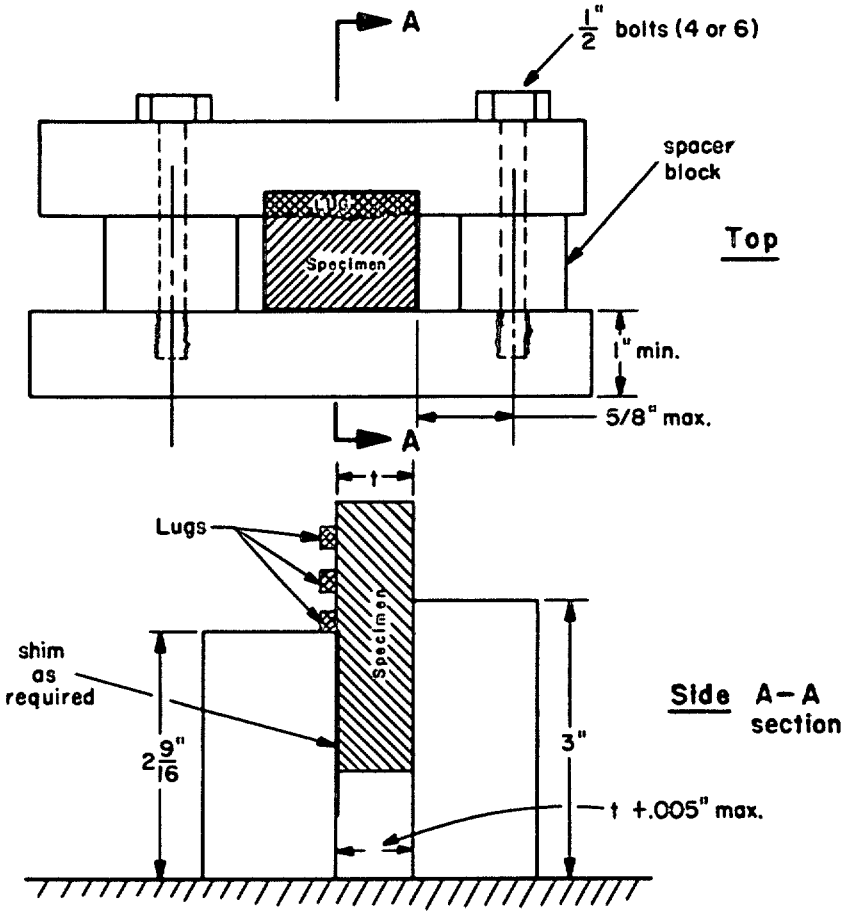
FIGURE 4. Performance of bend test. - Continued

NOTES:

1. Specimen shall be tested by hammer bending or by bending in a press brake.
2. Bending shall result in the formation of an angle of at least 90 degrees between the aluminum portion and a line defined by continuation of the steel portion of the specimen held in the vise or clamping jaws.
3. Bending shall be accomplished so that plastic deformation of the aluminum is initiated at the bond interface.
4. Distance L of highest portion of hammer bent specimens from the level of the top of the vise shall not exceed 3 t. For specimens bent by press brake, bend radius measured to outer fiber of the aluminum shall not exceed 3 t.
5. Bent specimen shall be examined with the unaided eye. For acceptance, there shall be no individual crack or other open defect greater than 1/8 inch. Total accumulated length of all visible defects shall not exceed 20 percent of the bond length W.
6. The test shall be repreated if any failure occurs in the aluminum or steel base metal before the specimen is bent 90 degrees.

FIGURE 4. Performance of bend test.

A. Shear Test Fixture

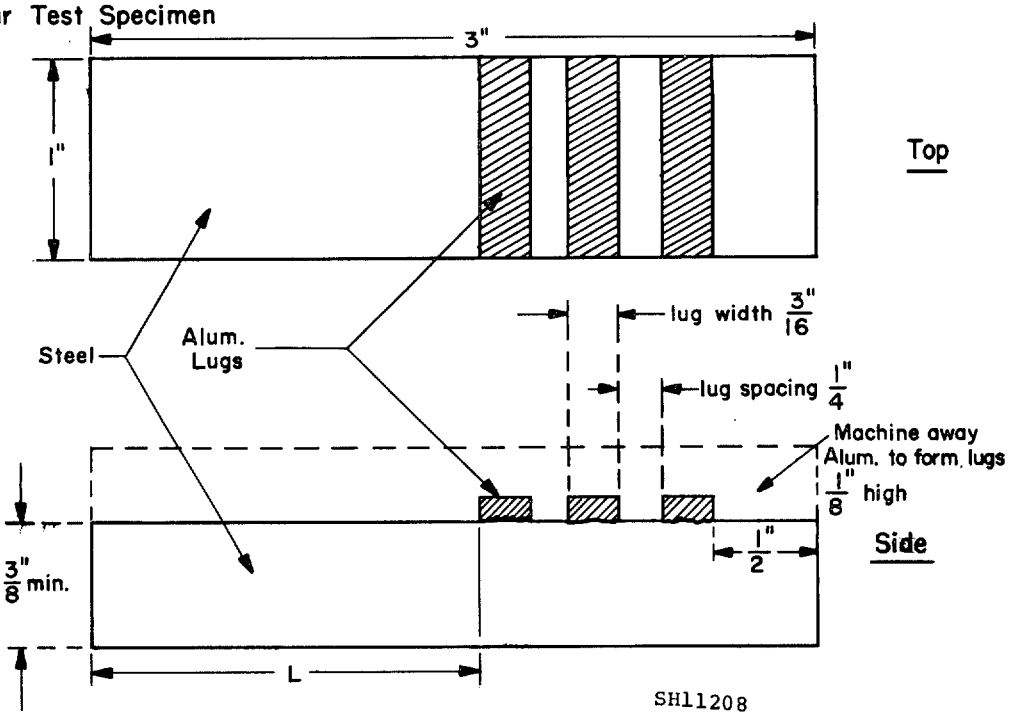


NOTES:

1. Fixture material: hardened tool steel.
2. Spacer blocks sized to produce gap no more than .005 inch larger than specimen depth from bond interface to machined steel back face and no less than .002 inch.
3. Front steel face of specimen may be shimmed so that shorter shear block contacts lug at bond interface. On no account shall shim be so thick that shear block contacts aluminum lug outside bond interface.
4. Grease slinding surfaces lightly.
5. Apply load with calibrated testing machine.

FIGURE 5. Triple lug shear test. - Continued

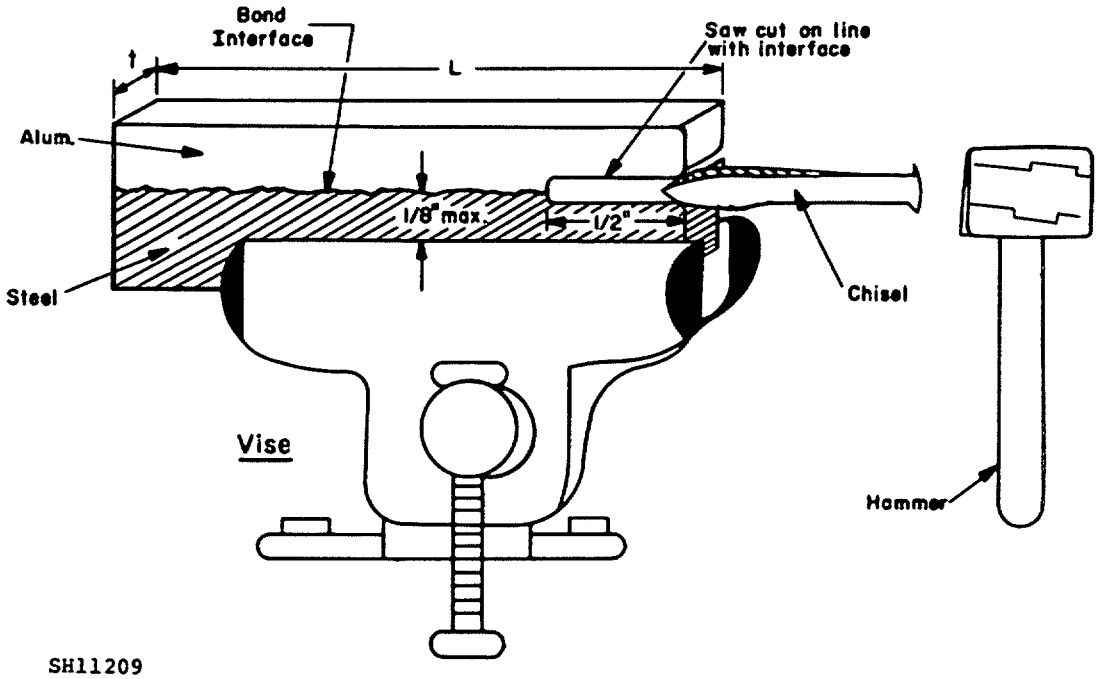
B. Shear Test Specimen



NOTES:

1. Measure length and width of each lug for area determination prior to testing.
2. Shear each lug individually, recording load.
3. File burrs and smeared material smooth before shearing next lug.
4. All corners are 90° lug-steel root radius shall be no greater than .005 inch.
5. Machining of aluminum to form lugs shall not undercut the steel at the bond interface more than .010 inch. Saturated aqueous $CuSO_4$ may be used to etch surface to determine that all aluminum is removed from the steel.
6. Back surface of the steel shall be machined flat and parallel.

FIGURE 5. Triple lug shear test.



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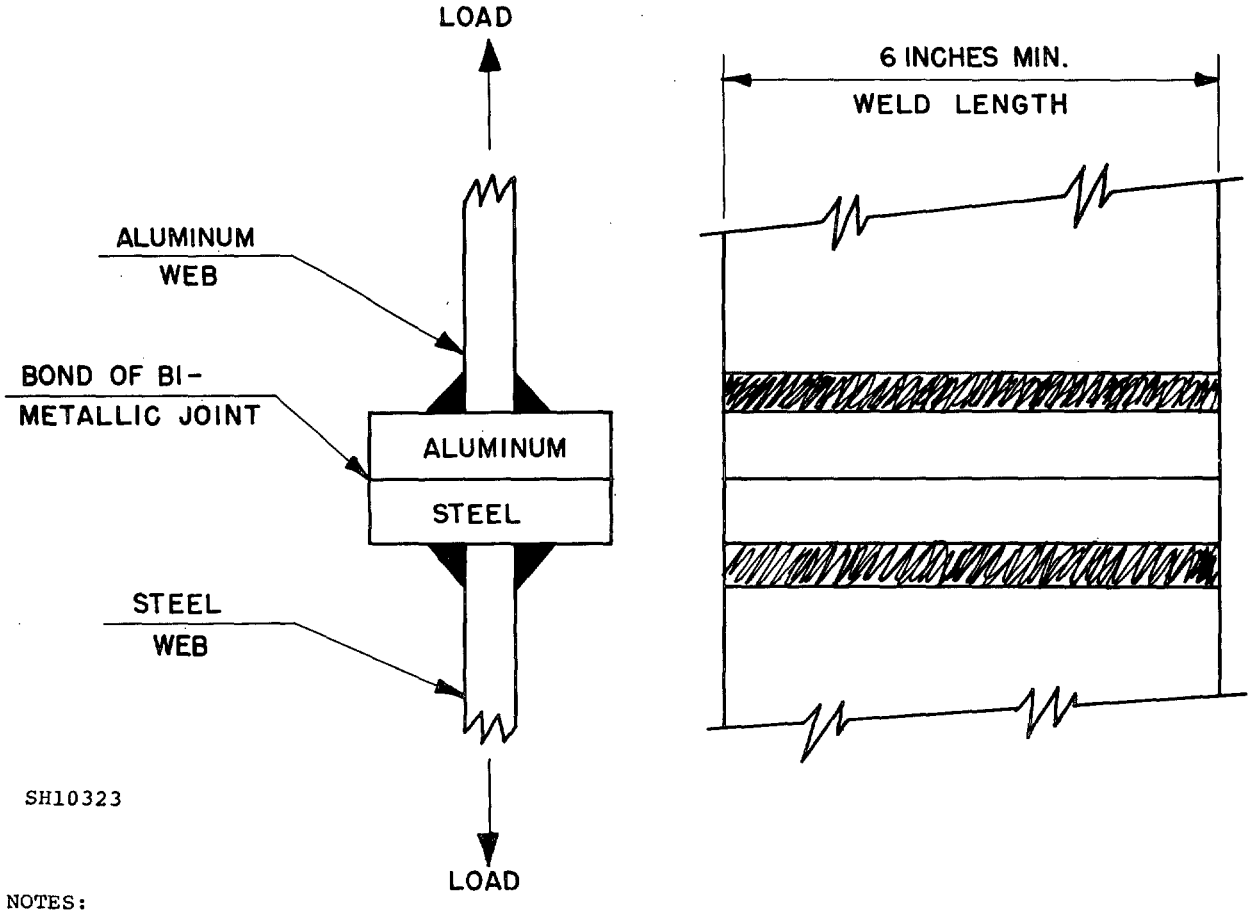
NOTES:
1. Chisel shall be driven to end of saw cut and at least 3/8 inch beyond.
2. Hammer weight 8 lbs nominal.
3. t = 1-1/4 inch or width or bar as produced.
4. L = 6 inches.

FIGURE 6. Chisel test.



NOTES:

1. The web members shall be of the same composition and thickness as those which will be used for service application, (see 6.2.1(c)).
2. The width of the transition joint shall be the same as that furnished the purchaser.
3. The weld filler material shall be chosen in accordance with the requirements of the applicable tables of section 10 of NAVSEA 0900-000-1000.
4. The test assembly shall be cut from approximately the center of the welded assembly and shall be a minimum of 2 inches in length.
5. The welded assembly shall incorporate the necessary pull tabs.

FIGURE 7. Tensile test assembly.

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

OMB Approval
No. 22-R255

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

DOCUMENT IDENTIFIER AND TITLE

NAME OF ORGANIZATION AND ADDRESS

CONTRACT NUMBER

MATERIAL PROCURED UNDER A

☐ DIRECT GOVERNMENT CONTRACT ☐ SUBCONTRACT

1. HAS ANY PART OF THE DOCUMENT CREATED PROBLEMS OR REQUIRED INTERPRETATION IN PROCUREMENT USE?
   A. GIVE PARAGRAPH NUMBER AND WORDING.

   B. RECOMMENDATIONS FOR CORRECTING THE DEFICIENCIES

2. COMMENTS ON ANY DOCUMENT REQUIREMENT CONSIDERED TOO RIGID

3. IS THE DOCUMENT RESTRICTIVE?

   ☐ YES ☐ NO *(If "Yes", in what way?)*

4. REMARKS

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

TELEPHONE NO.

DATE

DD FORM 1 JAN 72 1426 REPLACES EDITION OF 1 JAN 66 WHICH MAY BE USED

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