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(See 6.7)

MILITARY SPECIFICATION

STEEL FORGINGS, ALLOY, HIGH YIELD STRENGTH (HY-80 AND HY-100)

This specification is approved for use within the Naval Sea Systems Command, 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 grade HY-80 and grade HY-100 alloy steel forgings intended for critical structural applications where a weldable, high-strength, high-toughness material is required.

1.2 Classification. Steel forgings shall be of the following grades, as specified (see 6.2.1).

Grade HY-80 - 80,000 pounds per square inch (lb/in^2) (552 megapascal (MPa)) tensile yield strength, minimum.
Grade HY-100 - 100,000 lb/in^2 (690 MPa) tensile yield strength, minimum.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. The following specifications and standards 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.

AMSC N/A AREA FORG

SPECIFICATIONS

FEDERAL

QQ-S-781 - Strapping, Steel, and Seals.
PPP-B-621 - Boxes, Wood, Nailed and Lock-Corner.

MILITARY

MIL-C-3774 - Crates, Wood; Open 12,000- and 16,000-Pound Capacity.
MIL-H-6875 - Heat Treatment of Steel, Process for.
MIL-C-16173 - Corrosive Preventive Compound, Solvent Cut Back, Cold Application.
MIL-C-52950 - Crates, Wood, Open and Covered.

STANDARDS

MILITARY

MIL-STD-271 - Requirements for Nondestructive Testing Methods.
MIL-STD-1684 - Control of Heat Treatment.
MIL-STD-2149 - Standard Procedures for Explosion Testing Ferrous and Non-Ferrous Metallic Materials and Weldments.

(Copies of specifications and standards 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 documents form 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)

A 370 - Standard Method for Mechanical Testing of Steel Products. (DoD adopted)
A 700 - Standard Practices for Packaging, Marking, and Loading Methods for Steel Products for Domestic Shipment. (DoD adopted)
A 788 - Standard Specification for Steel Forgings, General Requirements. (DoD adopted)
E 23 - Standard Methods for Notched Bar Impact Testing of Metallic Materials. (DoD adopted)
E 604 - Standard Test Methods for Dynamic Tear Testing of Metallic Materials. (DoD adopted)

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

NATIONAL MOTOR FREIGHT TRAFFIC ASSOCIATION, INC., AGENT
National Motor Freight Classification

(Application for copies should be addressed to the National Motor Freight Traffic Association, Inc., ATA TRAFFIC Dept., 2200 Mill Road, Alexandria, VA 22314.)

UNIFORM CLASSIFICATION COMMITTEE AGENT
Uniform Freight Classification Ratings, Rules and Regulations

(Application for copies should be addressed to the Uniform Classification Committee Agent, Tariff Publication Officer, Room 1106, 222 South Riverside Plaza, Chicago, IL 60606.)

(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.

3. REQUIREMENTS

3.1 First article. When specified in the contract or purchase order, and prior to beginning production, a sample shall be subjected to first article inspection (see 4.3 and 6.3).

3.2 Material. Forgings shall be made from ingots or forging stock which have been made by the same processes used for production of first article specimens. The forgings shall be produced from steel made by the electric furnace process. The steel shall be fully killed and produced to a fine grain practice. Melting practice may include argon-oxygen decarburization (AOD), other refining processes, or remelting by the vacuum arc (VAR) or electroslag remelt (ESR) processes. For other than VAR or ESR, the molten steel may be vacuum degassed prior to or during pouring.

3.2.1 Recovered materials. All material incorporated in the steel forgings covered by this specification shall be new and produced from recovered materials to the maximum extent practicable without jeopardizing the intended use. The term "recovered materials" means suitable carbon and low alloy steel scrap which is used as a raw material, in lieu of virgin raw material.

3.2.2 Discard. Sufficient discard shall be taken from each ingot to ensure freedom from piping and prevent undue segregation.

3.3 Forging process. The forging process shall be as specified in 3.3.1 and 3.3.2.

3.3.1 Forging ratios. The original cross-sectional area of the ingot shall be at least three times the cross-sectional area of the main body of the forging. Palms, flanges, and other enlargements on forgings need not be reduced to the ratio of 3 to 1, but shall be reduced in a ratio of not less than 1.7 to 1. If bored ingots are used, the wall of the ingot shall be reduced in a ratio of not less than 2 to 1. Where an upsetting operation is employed or the forging is expanded on a mandrel, the metal shall be worked to an extent not less than that indicated above, but there is no fixed ratio between the cross-sectional area of the ingot and that of the forging.

3.3.2 Boring of forgings. Where the forgings are to be bored, the centerline of the ingot shall be in the discarded metal removed from the bore.

3.4 Chemical composition. The chemical composition shall conform to table I.

TABLE I. Chemical composition.[1]

Element	Percent[2][5]	
	HY-80	HY-100
Carbon	0.12 to 0.18	0.12 to 0.20
Manganese	.10 to .40	.10 to .40
Phosphorus	.015	.015
Sulfur	.008	.008
Silicon[3]	.15 to .35	.15 to .35
Nickel	2.50 to 3.25	2.75 to 3.50
Chromium	1.35 to 1.80	1.35 to 1.80
Molybdenum	0.30 to 0.60	0.30 to 0.60
Residual elements[4]		
Vanadium	.03	.03
Titanium	.02	.02
Copper	.25	.25
Trace elements[4]		
Arsenic	.025	.025
Tin	.030	.030
Antimony	.025	.025

[1] For definition of lot for heat analysis, see 4.4.1.1.
[2] Maximum unless a range is shown.
[3] When vacuum carbon deoxidation is used, the minimum silicon content may be reduced to 0.08 percent by weight.
[4] Elements not added intentionally.
[5] Unless otherwise specified (see 6.2.1), product analysis tolerances shall conform to the product analysis tolerances specified in ASTM A 788.

NOTE: Do not use this code for treating corroded or painting of

3.5 Mechanical properties. After all heat treatments, including stress relief, the material shall meet the requirements specified in tables II and III.

3.5.1 Explosion bulge. For first article testing only, two crack starter and four explosion bulge specimens shall be subjected to explosion bulge testing (see 4.5.7). Performance is considered satisfactory, provided the following conditions are met:

(a) Crack starter.

First shot:
Crack starter bead must crack.
Percent reduction in thickness obtained for information only.
No piece shall be thrown out of material being tested.
No through-thickness cracks shall be present.
No cracks shall extend into hold-down area.[1]

Second shot:
Percent reduction in thickness obtained for information only.
No piece shall be thrown out of material being tested.
Through-thickness cracks are acceptable.
No cracks shall extend into hold-down area.[1]

(b) Bulge.

First shot:
Percent reduction in thickness obtained for information only.
No piece shall be thrown out of material being tested.
No through-thickness cracks shall be present.
No cracks shall extend into hold-down area.[1]

Second shot:
Percent reduction in thickness obtained for information; three percent reduction per shot is expected.
No piece shall be thrown out of material being tested.
No through-thickness cracks shall be present.
No cracks shall extend into hold-down area.[1]

(c) Additional shots. Shots shall continue until a minimum reduction in thickness of 16 percent for HY-80 or 14 percent for HY-100 is obtained on one or both sides. The performance is considered satisfactory provided the following conditions are met:

No piece shall be thrown out of material being tested.
Through-thickness cracks are acceptable.
No cracks shall extend into the hold-down area.[1]
Shots shall be discontinued when cracks go into the hold-down area, a through-thickness crack occurs, or if the reduction in thickness requirements are met.

[1] The bulge area is defined as that plate over the diehole (9-inch radius) (229 millimeter (mm) radius) plus the rounded outside corners (3-inch radius) (76 mm radius) plus 1/2 inch (13 mm) for total circle diameter of 25 inches (635 mm). The hold-down area is defined as the area outside of this circle.

TABLE II. Tensile properties.

	HY-80	HY-100
Tensile strength	Information only	Information only
Yield strength at 0.2 percent offset, lb/in^2 (MPa)	80,000 to 99,500 (552 to 686)	100,000 to 115,000 (690 to 793)
Minimum elongation in 2 inches, percent		
Longitudinal	20.0	18.0
Transverse	18.0	16.0
Minimum reduction in area, percent		
Longitudinal	55.0	50.0
Transverse	50.0	45.0

TABLE III. Minimum impact requirements.[1]

Nominal cross section[1] inches (millimeters)	Temperature °F(°C) ± 3°F/2°C	Charpy test[2] foot-pounds (joules)		Dynamic tear test[3] foot-pounds (joules)		Fibrous fracture, percent
		HY-80	HY-100	HY-80	HY-100	
[4]1/2 through 6 (13 through 152	-120 (-84) 0 (-18)	50 (68) 60 (81)				Test values at -120°F (-84°C) reported for information only.
Over 6 (over 152)	-120 (-84) 0 (-18)	30 (41) 60 (81)				Test values at 0°F (-18°C) shall show that the fracture transition curve of the material is on the upper shelf by having a minimum value of 90 percent.
[4]1/2 through 4 (13 through 104)	-120 (-84) 0 (-18)		[5]50 (68) 60 (81)			
Over 4 (over 104)	-120 (-84) 0 (-18)		30 (41) 60 (81)			
Over 5/8 (over 16)	-40 (-40)			Information only	Information only	

[1] Sampling and location of test specimens shall be as specified in 4.4.3.2.
[2] Average of three specimens. No single test value shall be below the minimum average by more than 5 foot-pounds (6.8 joules).
[3] Average of two specimens at minus 40 ± 3 degrees Fahrenheit (°F) (minus 84 ± 1.7 degrees Celsius (°C)). Unless otherwise specified (see 6.2.1), dynamic tear testing is not required for material less than 5/8 inch (16 mm) in maximum cross section.
[4] Unless otherwise specified (see 6.2.1), Charpy impact testing is not required for material less than 1/2 inch (38 mm) in maximum cross section.
[5] When longitudinal impact specimens are provided, the average impact value shall be 65 foot-pounds (88 joules) minimum at -120°F (-84°C).

3.6 Heat treatment. The contractor shall determine the detailed procedure that will produce castings that will meet the mechanical requirements specified herein, with the following restrictions:

(a) The forgings shall be quenched and tempered. When necessary, double tempering is permitted. The restrictions for single tempering shall apply to double tempering. The final tempering temperature shall be not less than 1175°F (635°C) for grade HY-80 and not less than 1125°F (607°C) for grade HY-100. After tempering, the forgings shall be removed from the furnace and rapidly cooled by water or forced air.

(b) When necessary for distortion control, grade HY-80 castings may be stress relieved after final tempering. The stress relief temperature shall be 1125 ± 25°F (607 ± 14°C). Stress relief of grade HY-100 is not permitted unless approved by the Naval Sea Systems Command (NAVSEA) on a case basis.

(c) If the forgings are stress relieved after final tempering, the stress relief temperature shall not exceed the tempering temperature and shall be not less than 1100°F (593°C) for grade HY-80 and not less than 1050°F (566°C) for grade HY-100.

(d) A complete record of the heat treatment given each forging, including stress relief, shall be maintained. Unless otherwise specified in the contract or order, a record of the final heat treatment shall be prepared (see 6.2.2). The final heat treatment record shall include the time and temperature for the final tempering cycle and for the stress relief cycle, if any, and the cooling method used.

3.6.1 Simulated stress relief. When a simulated stress relief is specified in the contract or order (see 6.2.1), a test block as specified in 4.3.1.2 shall be subjected to the stress relief thermal cycle based on the final tempering temperature of the material (see 3.6), and shall be tested for mechanical and impact properties in accordance with 4.4, and shall meet the requirements specified in 3.6. The fabricator (contracting activity) shall specify the stress relief thermal cycles (including cooling rates) to the contractor. Stress relief shall be specified only when necessary to meet machining tolerances.

3.6.1.1 Verification of properties. When specified (see 6.2.1), a representative sample as specified in 3.5.1 shall be forwarded with the material to verify properties after the proposed stress relief as specified in the applicable fabrication document.

3.6.2 Prolongations or test blocks. When integral prolongations or forged test blocks are specified for possible stress relief operations by the contracting activity (see 6.2.1), they shall be heat treated with the actual forgings and shall represent the maximum cross section of the thickest heat-treated component section.

3.7 Heat treatment equipment and controls. Continuous or automatic heat-treating equipment may be employed, provided such material produces heat-treated forgings to meet the requirements of this specification. The

furnaces and temperature recording equipment shall be proven to correlate with the actual temperature of the forgings and shall be maintained and calibrated on a regular basis in accordance with MIL-H-6875 or MIL-STD-1684. The temperature of the forgings shall be recorded during the heating and stress relieving cycles of the heat treatment. After the forgings reach the selected temperature control setting, furnaces for the heat treatment of grades HY-80 and HY-100 forgings shall maintain the temperature of the forgings at any point in the working zone within plus or minus 25°F (14°C).

3.8 Forging sketches. Unless otherwise specified in the contract or order, a forging sketch shall be prepared (see 6.2.2).

3.8.1 Location of specimens. Location of specimens for mechanical properties as shown on figures 1, 2, and 3 are to be considered when preparing the forging sketch for symmetrical forgings.

3.9 Dimensions and tolerances. Each forging shall conform to the dimensions and tolerances specified on the applicable drawing, contract, or order (see 6.2.1). Heat treated forgings shall be furnished that can be machined to the finished dimensions within the tolerance given without further straightening. Layout points, when required, shall be shown as such on the applicable drawings, and shall be incorporated in the forgings.

3.10 Soundness. Forgings and forging test blocks shall be of uniform quality and condition, and shall be free of defects harmful to their intended use, as determined by visual examination and the applicable nondestructive tests.

3.10.1 Surface soundness. Forgings shall be subjected to a magnetic particle test in accordance with 4.5.6. Indications of linear discontinuities 1/8 inch or longer shall be investigated to ensure there are not cracks or other injurious defects. Defects discovered by this test shall be removed in accordance with the requirements of 3.10.1.1 or 3.10.1.2.

3.10.1.1 Repair of surface defects. Defects may be removed by chipping, grinding, or other mechanical means, provided the width of the involved area is three times its depth and gradually tapers into the defects, and the design dimensions are not violated. Heat shall not be applied to remove defects after heat treatment or stress relief.

3.10.1.2 Repair of surface defects by welding. Weld repair shall not be used unless specifically approved on a case basis by the Command or agency concerned.

3.10.2 Internal soundness. Unless otherwise specified (see 6.2.1), each forging shall be ultrasonically tested in accordance with 4.5.5 and shall meet the acceptance criteria specified in 3.10.2.1.

3.10.2.1 Ultrasonic soundness acceptance criteria. Any discontinuity whose reflection exceeds the calibration standard set forth in MIL-STD-271, or causes complete loss of back reflection between parallel surfaces, shall be cause for rejection of the forging. For applications requiring other acceptance criteria, the criteria shall be as specified (see 6.2.1).

3.11 Identification marking. Forgings including prolongations or forging test blocks shall be identified with the contractor's name or trademark and a serial number which will positively identify the forging part number, melt from which they were poured, and the lot with which they were heat treated. Markings shall be placed in a location such that they will not be machined off in finishing, and in an area that is stressed least in service.

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.

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.

4.1.2 Certification of quality conformance. Unless otherwise specified in the contract or order, a certificate of quality conformance shall be prepared for each lot of material offered for acceptance (see 6.2.2).

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 testing the samples specified in 4.3.1 in accordance with the procedures specified in 4.5. First article inspection is required for forging sources melting their own forging stock or using stock from an unapproved source. Approval of a reforger using an approved source may be extended to all other approved sources of stock without further testing other than quality conformance.

4.3.1 First article samples. First article samples shall consist of material from one heat sufficient to obtain measurements of the mechanical properties of the material and its weldment. In addition, weldments shall be subjected to the explosion bulge test as specified in MIL-STD-2149. The test shall be conducted under Government direction to evaluate weldment performance in shock applications.

4.3.1.1 Forgings. First article samples shall be forgings representative of the largest size to be forged at the facility and from one lot (see 4.4.1). A minimum of two forgings of sufficient thickness and complexity to demonstrate the capability to provide homogeneous forgings with uniform chemistry and mechanical properties throughout the forging section shall be produced for first article inspection. Unless otherwise specified (see 6.2.1), HY-80 and HY-100 shall be tested separately.

4.3.1.2 Test prolongations. Prolongations sufficient to meet the testing requirements of this specification shall be provided. Prolongations shall be part of the forgings until after heat treatment.

4.3.1.2.1 Prolongation size. The size of the prolongation shall be equivalent to the largest cross section of the forging.

4.3.1.3 Explosion bulge test specimens. Twelve unwelded plate forgings 2 by 16 by 55 inches (51 by 406 by 1397 mm) shall be provided for explosion bulge testing as specified in MIL-STD-2149.

4.3.1.4 Test specimen location. Test specimens for first article inspection shall be taken from the prolongations and from the prototype forgings. Samples shall be taken from the prototype forgings at the center and from the opposite extremes (the locations between which the longest straight line can be drawn). Samples from prolongations shall be taken as specified in 4.4.3.1. All test specimens shall be taken at a depth of T/2 inches from the heat-treated surface for T up to 4 inches and T/4 or 2 inches, whichever is greater, for T greater than 4 inches and less than or equal to 12 inches where T is defined as the as-quenched thickness (minimum dimension) of the heaviest cross section of the forging. For T greater than 12 inches, test specimen location shall be as approved. "T" is defined as the as-quenched thickness (minimum dimension) of the heaviest cross section of the forging.

4.3.1.4.1 Charpy V-notch. A set of three Charpy impact specimens shall be tested from each of the four test locations specified in 4.3.1.4 for a total of 12 specimens at each temperature. These specimens shall be tested at 0°F (minus 18°C) and minus 120°F (minus 84°C).

4.3.1.4.2 Chemical analysis. Chemical analysis shall be determined at each of the locations specified in 4.3.1.4 and from a suitably prepared heat analysis sample.

4.3.1.4.3 Tensile test. A tensile test specimen shall be taken at the locations as specified in 4.3.1.4.

4.3.1.4.4 Dynamic tear. Sets of two transverse dynamic tear test specimens shall be taken from the center of the forging and the prolongations. These specimens shall be tested at minus 40°F (minus 40°C).

4.3.1.4.5 Charpy impact transition curves. Charpy V-notch transition curves (longitudinal and transverse), with a minimum of five temperatures from minus 120°F (minus 84°C) to room temperature, shall be obtained. A minimum of five specimens for each temperature is required, and all individual values shall be reported.

4.3.2 First article inspection report. When specified in the contract or order, a first article inspection report shall be prepared (see 6.2.2).

4.4 Quality conformance inspection. Quality conformance inspection shall be as specified in 4.4.1 through 4.4.6.

4.4.1 Lot size. The lot size shall be as specified in 4.4.1.1 through 4.4.1.3.

4.4.1.1 Lot size for chemical analysis. Each melt or heat of steel shall constitute a lot. For remelted, vacuum arc remelt (VAR), or electroslag remelt (ESR) materials, a lot for heat analysis is defined as the products of one remelted ingot of each melt. In the case of argon-oxygen decarburization (AOD), each charged AOD vessel is considered a lot for heat analysis.

4.4.1.2 Lot size for mechanical tests. The lot size for mechanical tests shall be as follows:

(a) Forgings with an as-heat treated weight of less than 1,000 pounds (454 kilograms (kg)). All forgings of one design, produced from the same heat or melt, and heat treated in the same furnace charges shall constitute a lot.
(b) Forgings with an as-heat treated weight of 1,000 pounds (454 kg) or more. Each forging shall constitute a lot.

4.4.1.3 Lot size for visual examination and inspection. Each forging shall be considered a lot.

4.4.2 Sampling for chemical analysis. The test sample shall be taken during the pouring of the heat at a time which best represents the composition of the cast. In case the heat analysis samples are lost or inadequate, or when it is evident that the sample does not truly represent the heat, representative samples may be taken from the product. The analysis shall meet the specified limits for heat analysis. Product analysis limits shall only apply when the analysis is performed by the contracting activity and shall not be used as a substitute for the heat analysis.

4.4.3 Sampling for mechanical properties. Sampling for mechanical properties shall be as follows:

(a) From each lot as specified in 4.4.1.2(a), two of the forgings shall be tested for mechanical properties.
(b) From each lot as specified in 4.4.1.2(b), each forging shall be tested for mechanical properties.

4.4.3.1 Location, orientation, and number of specimens. The location in the forging, the orientation, and the number of specimens to be tested shall be in accordance with the approved forging drawing and as specified herein. One longitudinal and one transverse tensile, three transverse impact, and two dynamic tear impact specimens for each test temperature shall be taken from each forging tested. Forgings with a length excluding test metal of 80 inches (2032 mm) or less shall have the tensile and impact tests removed from one end

of the forging. When the length of the forging, excluding test metal, exceeds 80 inches (2032 mm), the testing as designated for forgings less than 80 inches (2032 mm) in length shall be carried out at each end of the forging.

4.4.3.2 Location of mechanical test specimens. Integral prolongations of full section thickness shall be provided whenever feasible. If integral prolongations are not feasible, then a production forging or a forged block of representative section size, made from the same heat and subjected to the same type and degree of hot working as the forging it represents, may be used for test material. When prolongations are used but it is impractical to provide enough material to meet the required distance between test material and quenched surfaces, then metal buffers may be used to meet the distance requirement for quenching. The buffer material may be any weldable carbon or low-alloy steel and shall be joined to the forging with a partial-penetration weld that completely seals the buffered surface.

4.4.3.2.1 Distance of tensile specimen from the nearest heat treated surface.

(a) For as-quenched section sizes up to 4 inches (102 mm) in thickness, the midpoint of tensile specimens shall be located at mid-thickness (1/2 T). "T" is defined as the as-quenched thickness (minimum dimension) of the heaviest cross section of the forging.

(b) For as-quenched section sizes over 4 inches (102 mm) in thickness, the midpoint of tensile specimens shall be located at T/4 or 2 inches (51 mm) below the surface, whichever is greater. For ring or hollow cylindrical forgings, this distance shall be measured from the inside diameter (id) surface.

4.4.3.2.2 Distance of tensile specimen from the second nearest heat treated surface. (Not applicable to ring or hollow cylindrical forgings (see 4.4.3.2.1)). The midpoint of the specimens shall be located at W/4 minimum distance from the second nearest heat-treated surface. "W" is defined as the as-quenched width (second smallest dimension) of the heaviest cross section of the forging.

4.4.3.2.3 Distance of tensile specimen from the end of the forging. The midpoint of the tensile specimen shall be located a minimum of A, D/4, or T/2 from the end of the forging, as shown on figures 1, 2, or 3.

4.4.3.2.4 Distance of impact specimen from heat-treated surface. Impact specimens shall be taken at a depth of T/2 from the heat-treated surface for T up to 4 inches where T is defined as the as-quenched thickness (minimum dimension) of the heaviest cross section of the forging. For T greater than 4 inches and less than or equal to 12 inches, impact specimens shall be taken such that one of the longitudinal sides of the specimen shall be no closer to the heat-treated surface than T/4 or 2 inches, whichever is greater. For T greater than 12 inches, the distance of impact specimens from the heat-treated surface shall be as approved.

4.4.3.2.5 Sampling for mechanical properties following simulated stress relief. When specified (see 6.2.1), sample material (see 4.4.3) shall be subjected to simulated stress relief operations after quenching and tempering,

but prior to testing for conformance to the mechanical property requirements specified in 3.5. The sample material shall not be removed from the material prior to quenching and tempering. The total time at temperature and cooling rate for the simulated stress relief operations shall be as specified (see 6.2.1). The cooling rate, and the maximum and minimum time at temperature used on the sample material shall be incorporated in the test certification along with the destructive and nondestructive test results.

4.4.3.2.6 Multiple forgings. When forgings are made and heat treated in multiples, such as when two or more individual pieces are machined from a single heat-treated forging, specimens representing the composite forging shall be required. The composite forging's weight and size shall govern the lot definition and scheme of testing.

4.4.3.3 Orientation of longitudinal tensile specimens. Unless otherwise shown on the forging sketch (see 3.8), the major axis of the longitudinal tensile specimen shall be oriented as follows:

(a) In a tangential direction for upset disc, hollow (pierced and expanded) cylindrical and ring forgings; that is, perpendicular to both radius and central axis of the forging. If the wall thickness or radius of the hollow cylindrical forging is too small to permit tangential orientation of the longitudinal specimen axis, the axis of the specimens may be aligned perpendicular to the radius of and parallel to the central axis of the cylindrical forging.
(b) Parallel to the central axis of the cylindrical forging for extruded or drawn hollow cylinders, and for extruded or drawn solid cyclinders subsequently bored out where the principal direction of metal working during forging is parallel to the central axis of the cylindrical forging.
(c) Parallel to the principal direction in which forged metal was worked for all other forging configurations as shown on the forging sketch.

4.4.3.3.1 Orientation of transverse tensile specimens. Unless otherwise shown on the forging sketch, the major axis of the transverse specimen shall be oriented as follows:

(a) Perpendicular to the radius of and parallel to the central axis of the forging for upset disc, hollow (pierced and expanded) cylindrical and ring forgings. No transverse specimen is required when longitudinal specimen is oriented in longitudinal direction as specified in 4.4.3.3(a).
(b) Perpendicular to both the radius and central axis of the forging for extruded or drawn cylinders (hollow or solid); that is, in the tangential direction. When the wall thickness or radius of the hollow cylindrical forging is too small to permit the tangentially oriented specimen, no transverse specimen is required.
(c) Perpendicular to the principal direction in which the forged metal was worked for all other forging types or configurations as shown on the forging sketch.

4.4.3.3.2 Orientation of impact specimens. Orientation of impact specimens shall be as follows:

(a) Impact specimens shall be transverse to the principal axis or length of the forging with the notch perpendicular to the nearest forged surface.
(b) When longitudinal impact specimens are provided, the specimen's longitudinal axis shall be parallel to the principal axis of length of the forged section. The axis of the notch shall be perpendicular to the longitudinal axis and perpendicular to the nearest quenched and tempered surface.
(c) When impact specimens as defined in 4.4.3.3.2(a) and (b) above cannot be obtained, longitudinal impact specimens shall be provided. The specimen's longitudinal axis shall be located at the center of the cross section.

4.4.4 Sampling for forging soundness (internal). Unless otherwise specified (see 6.2.1), each forging shall be ultrasonically tested at the latest point in processing which will produce a meaningful test in determining conformance to the soundness requirements specified in 3.10. Scanning shall be such that 100 percent of the forging's cross section is probed from three principal directions; for example, from the end, side, and top for rectangular forgings, from the end and 180 degrees of the circumference of solid rounds, and from the end and 360 degrees of the circumference of bored rounds. For long or rectangular parts, inspection shall be at least equal to part thickness calibration.

4.4.5 Sampling for forging soundness (external). Each forging shall be subject to magnetic particle inspection. Each forging shall be in the finished condition ready for shipment as specified (see 4.5.6).

4.4.6 Visual and dimensional examination. Each forging shall be examined for conformance to the specified dimensions and soundness (see 3.9 through 3.10.2.1).

4.5 Test procedures. Test procedures shall be as specified in 4.5.1 through 4.5.7.

4.5.1 Chemical composition. Each sample selected in accordance with 4.4.2 shall be analyzed in accordance with a standard ASTM method or a method that will assure equally accurate results for conformance to 3.4, as applicable. The methods shall be correlated with the National Bureau of Standards standard reference materials, when available, to ensure the validity of the method that is used as a control in chemical analysis, or for calibration in instrumental methods of analysis. If any analysis fails to conform to 3.4, the lot represented by that analysis shall be rejected. When both a heat and product analysis are determined, the product analysis shall be used to determine acceptance or rejection.

4.5.2 Tensile tests. Tensile testing shall be in accordance with ASTM A 370. The largest round standard tensile specimen of ASTM A 370 which can be obtained from the test material shall be prepared and tested.

4.5.3 Charpy impact test. The impact strength shall be determined in accordance with ASTM E 23 using the type A, Charpy V-notch specimen and the Charpy (simple beam type) apparatus in accordance with ASTM E 23. In addition, the accuracy of the Charpy impact machine shall be verified in accordance with the requirements for standard specimens of ASTM E 23.

4.5.4 Dynamic tear test. Specimens taken from each lot shall be tested in accordance with ASTM E 604 to determine impact energy and percent fibrous fracture.

4.5.5 Ultrasonic test. Ultrasonic testing shall be performed in accordance with MIL-STD-271.

4.5.6 Magnetic particle inspection. Unless otherwise specified (see 6.2.1), 100 percent of each forging's surface shall be magnetic particle tested in the final heat treated condition in accordance with MIL-STD-271. Bored surfaces shall be examined for three times the bore diameter from each end only. When magnetic particle testing is injurious to a machined surface, dye penetrant testing in accordance with MIL-STD-271 is a satisfactory substitute.

4.5.7 Explosion bulge tests. The explosion bulge tests shall be conducted and specimens fabricated in accordance with MIL-STD-2149. Specimens are to be tested with weld reinforcement in place. Tests shall be conducted at 0 ± 3°F (minus 18 ± 1.7°C).

4.6 Rejection. Individual forgings not meeting the requirements of this specification shall be cause for rejection. If a forging representative of a lot fails to meet the chemical or mechanical property requirements, the lot shall be subject to rejection. Retests shall be made in accordance with 4.7.

4.6.1 When a rejected lot consists of more than one piece, each remaining piece in the lot may be retested for the nonconforming characteristic and each piece that conforms to requirements may be offered for acceptance.

4.7 Retests. When a test specimen representing a lot of material fails to meet specification requirements, the lot is rejected. The lot may be reworked or retested as provided. Rejected lots shall be identified and separated from acceptable lots until the rejected lots are withdrawn or demonstrated as meeting specification requirements.

4.7.1 Reheat treatment. It will be permitted to reheat treated forgings which fail to meet tensile or impact requirements of this specification. Inspection tests originally performed on the failed forgings, except chemical analysis, shall be repeated when the material is reinspected.

4.7.2 Tensile retest. If the results of an original tensile specimen are within 1,000 lb/in^2 (6.9 MPa) of the required yield strength, within 2 percent of the required elongation, or within 2 percent of the required reduction in area, a retest on a duplicate specimen (selected from the same approximate location) will be permitted.

4.7.2.1 Conditions for selection of another specimen. If the percentage of elongation or reduction in area of any tensile specimen is less than that specified in table II, and any part of the fracture is outside the gauge length or within the gauge length, and less than 25 percent of the gauge length from either datum point, another specimen from essentially the same location may be selected in its place.

4.7.3 Charpy impact retest. In the event a Charpy specimen does not meet individual value requirements, a retest of three specimens at the same test temperature which failed shall be permitted on the same forging. If the retest specimens do not meet requirements (average and individual value), the lot represented by the specimens shall be rejected. As an option, each forging in the rejected lot may be impact tested in accordance with 4.5.3. Each forging that fails to meet the requirements of table III shall be rejected.

4.7.4 Defective specimen. If any test specimen reveals obvious defective machining or obvious lack of continuity of metal, it may be discarded and another selected.

4.8 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-packaging. Preservation-packaging shall be level A, C, or commercial, as specified (see 6.2.1).

5.1.1 Level A. Level A preservation-packaging shall be as specified in 5.1.1.1 and 5.1.1.2.

5.1.1.1 Preservative application. Unless otherwise specified (see 6.2.1), machined surfaces of forgings shall be protected with an application of preservative conforming to grade 1 or grade 4 of MIL-C-16173.

5.1.1.2 Wrapping. Forgings weighing less than 50 pounds each, without preservative application, shall be individually wrapped with a minimum of two thicknesses of 40-pound basis weight kraft paper. For forgings with preservative application, two thicknesses of equal weight greaseproof paper shall be used for wrapping.

5.1.2 Level C. Forgings shall be packaged to afford protection against corrosion, deterioration, and physical damage during shipment from the supply source to the first receiving activity for immediate use. A preservative shall be applied to forgings with machined surfaces. The contractor's normal retail or wholesale packaging methods may be utilized when these meet the requirements of this level.

5.1.3 Commercial. Commercial preservation-packaging shall be as specified in ASTM A 700 or by the contracting activity (see 6.2.1).

5.2 Packing. Packing shall be level A, B, C, or commercial, as specified (see 6.2.1).

5.2.1 Level A. Level A packing shall be as specified in 5.2.1.1 through 5.2.1.2.1.

5.2.1.1 Small forgings. Small forgings weighing less than 200 pounds each shall be packed individually, or in multiple units with adequate blocking or bracing in nailed wood boxes conforming to PPP-B-621, class 2, with box closure and strapping in accordance with the appendix to the box specification. Small forgings may also be bundled utilizing steel strapping conforming to QQ-S-781, class 1, finish A. The gross weight shall not exceed 200 pounds for boxes or 250 pounds for bundles.

5.2.1.2 Large forgings. Forgings that exceed the boxed gross weight of 200 pounds, and have projections which may be damaged in handling or shipping, shall be packed individually or in multiple units with adequate blocking and bracing in an unsheathed crate conforming to MIL-C-3774 or MIL-C-52950. Type, style, and crate selection shall be at the option of the contractor. The gross weight of the crates shall not exceed 500 pounds unless individual forgings exceed this weight. Steel strapping shall be applied in accordance with the applicable crate specification.

5.2.1.2.1 Unpacked forgings. Forgings weighing more than 200 pounds each and not subjected to damage in shipment may be shipped unpacked.

5.2.2 Level B. Small and large forgings shall be packed as specified in 5.2.1, except that wood boxes shall be of the domestic class, and steel strapping is not required.

5.2.3 Level C. Forgings shall be packed in containers, or in a manner acceptable to the common carrier and which will ensure safe delivery at destination in a satisfactory condition at the lowest applicable rate. Containers, packing, or method of shipment shall conform to Uniform Freight Classification Ratings, Rules and Regulations or National Motor Freight Classification or other carrier rules as applicable to the mode of transportation.

5.2.4 Commercial. Commercial packing shall be in accordance with ASTM A 700, unless otherwise specified (see 6.2.1).

5.3 Marking. In addition to any special marking required (see 6.2.1), shipments shall be marked in accordance with ASTM A 700.

6. NOTES

6.1 Intended use. Grade HY-80 and grade HY-100 alloy steel forgings are intended primarily for use in critical structural applications where a notch-tough, high-strength material is required. The use of this steel in fabricated structure or equipment entails much more than a material specification and caution is advised in the areas of welding, fabrication, and nondestructive testing.

6.2 Ordering data.

6.2.1 Acquisition requirements. Acquisition documents should specify the following:

(a) Title, number, and date of this specification.
(b) Grade required (see 1.2).
(c) If first article is required (see 3.1 and 4.3).
(d) If chemical product analysis tolerances are to be different than those specified (see table I).
(e) If Charpy impact is required under 1/2 inch or if dynamic tear test is required under 5/8 inch (see table III).
(f) When a simulated stress relief sample is required; if required, the number of thermal cycles, the heating and cooling rates, and the time at temperature (see 3.6.1 and 4.4.3.2.5).
(g) When a representative sample is required to be forwarded with the material to verify properties (see 3.6.1.1).
(h) When integral prolongations or forged test blocks are required for stress relief operations (see 3.6.2).
(i) Dimensions and tolerances (see 3.9).
(j) If each forging shall not be ultrasonically tested (see 3.10.2 and 4.4.4).
(k) If acceptance criteria is different than as specified (see 3.10.2.1).
(l) If HY-80 and HY-100 forgings are to be first article tested together (see 4.3.1.1).
(m) If magnetic particle testing is other than as specified (see 4.5.6).
(n) Preservation, packing, and marking requirements other than those specified (see 5.1, 5.1.1.1, 5.2, 5.2.4, and 5.3).
(o) Whether first article approval from previous revisions or amendments is valid (see 6.3).
(p) When explosion bulge data is required (see 6.3.1).

6.2.2 Data requirements. When this specification is used in an acquisition and data are required to be delivered, the data requirements identified below shall be developed as specified by an approved Data Item Description (DD Form 1664) and delivered in accordance with the approved Contract Data Requirements List (CDRL), incorporated into the contract. When the provisions of DoD FAR Supplement, Part 27, Sub-Part 27.475-1 (DD Form 1423) are invoked and the DD Form 1423 is not used, the data specified below shall be delivered by the contractor in accordance with the contract or purchase order requirements. Deliverable data required by this specification are cited in the following paragraphs.

Paragraph no.	Data requirement title	Applicable DID no.	Option
3.6	Reports, test	DI-T-2072	---
3.8	Forgings manufacturing sketch	DI-FORG-80412	---
4.1.2	Certification data/report	UDI-A-23264	---
4.3.2	First article inspection report	DI-T-4902	---

(Data item descriptions related to this specification, and identified in section 6 will be approved and listed as such in DoD 5010.12-L., AMSDL. Copies of data item descriptions required by the contractors in connection with specific acquisition functions should be obtained from the Naval Publications and Forms Center or as directed by the contracting officer.)

6.2.2.1 The data requirements of 6.2.2 and any task in sections 3, 4, or 5 of this specification required to be performed to meet a data requirement may be waived by the contracting/acquisition 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 acquired to this specification. This does not apply to specific data which may be required for each contract regardless of whether an identical item has been supplied previously (for example, test reports).

6.3 First article. When a first article inspection is required, the item should be a first article sample. The first article should consist of one unit. The contracting officer should include specific instructions in acquisition documents regarding arrangements for examinations, approval of first article test results and disposition of first articles. Invitations for bids should provide that the Government reserves the right to waive the requirement for samples for first article inspection to those bidders offering a product which has been previously acquired 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 contract. Unless otherwise specified (see 6.2.1), first article approval for previous specification revisions or amendments are valid for this revision.

6.3.1 Before delivery, contractors who have not previously produced forgings under this specification of the strength level specified should demonstrate to the Commander, Naval Sea Systems Command, Materials Engineering Division, that their facilities produce forgings conforming to the requirements of this specification. When either HY-80 or HY-100 forged material has met first article test requirements, the other may be reviewed for first article approval by submitting the required first article data exclusive of explosion bulge tests unless specifically required by the contract or purchase order (see 6.2.1).

6.3.2 Where a contract does not exist, the manufacturer may submit first article test data directly to NAVSEA. The first article inspection report should be verified by the Defense Contract Administration Services Management Area (DCASMA) representative or by the American Bureau of Shipping (ABS) representative. The report should be forwarded to the Commander, Naval Sea Systems Command, Materials Engineering Division via DCASMA. Upon review of the report, authorization will be forwarded for preparation of test specimens for the explosion bulge tests as required by MIL-STD-2149, and instructions will be furnished for shipment to a designated Government testing location. Specimen preparation and shipping should be under the cognizance of DCASMA or ABS.

6.4 Sampling of forgings for mechanical properties as shown on figures 1, 2, or 3 is considered to be in accordance with 4.4.3 for symmetrical forgings or forgings which will be used as bar or tube.

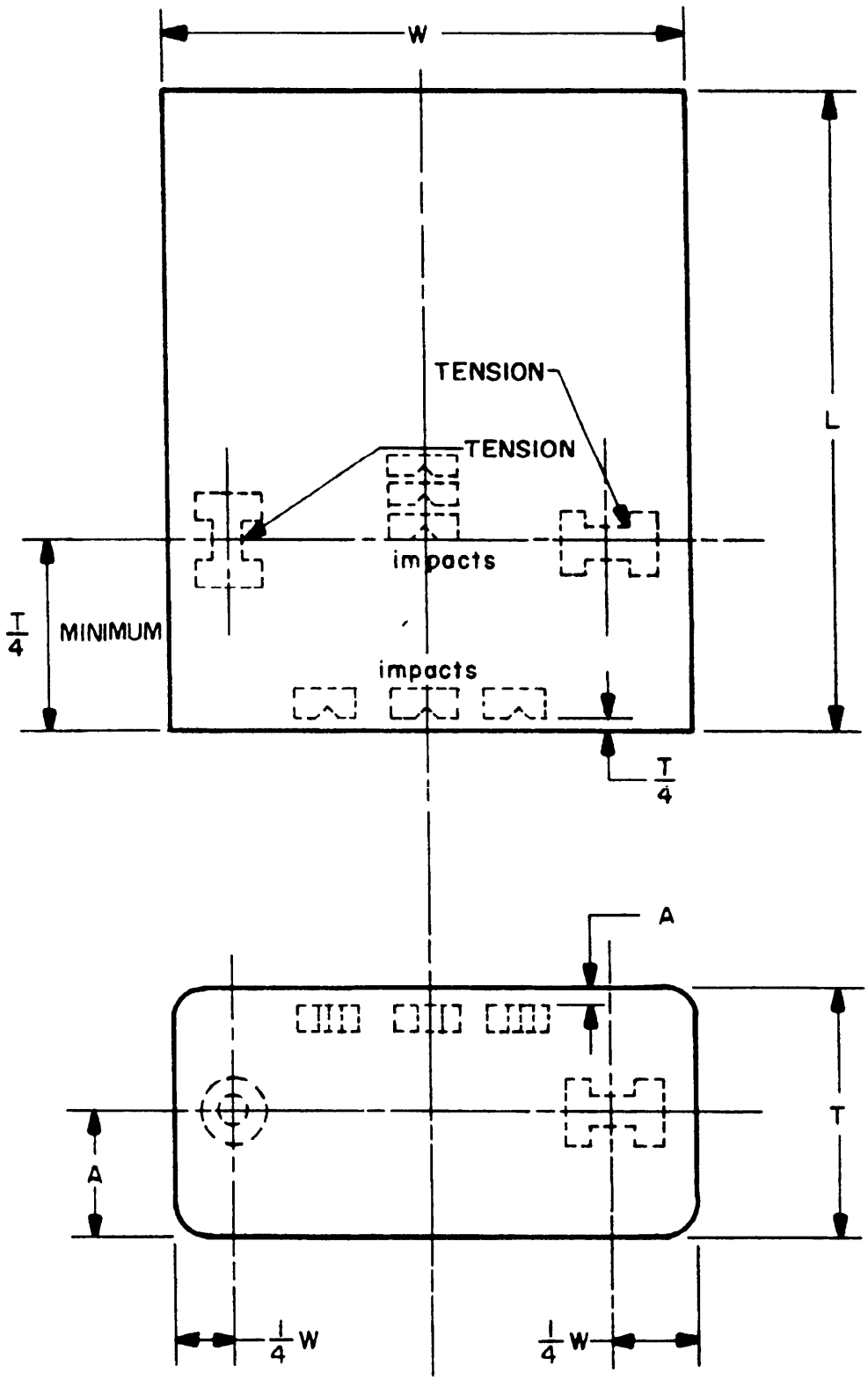
6.5 Receipt inspection. The forgings should be subject to receipt inspection by the contracting activity to verify conformance to the requirements of this specification. Forgings not conforming to the requirements may be rejected by the contracting activity. The forging manufacturer may verify the results of the contracting activity's receipt inspection. It is the responsibility of the contracting activity to determine the acceptability of the forgings for the intended application.

6.6 Subject term (key word) listing.

Charpy V-notch test
Dynamic tear test
Explosion bulge
Heat treatment
Simulated stress relief
Ultrasonic inspection

6.7 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.

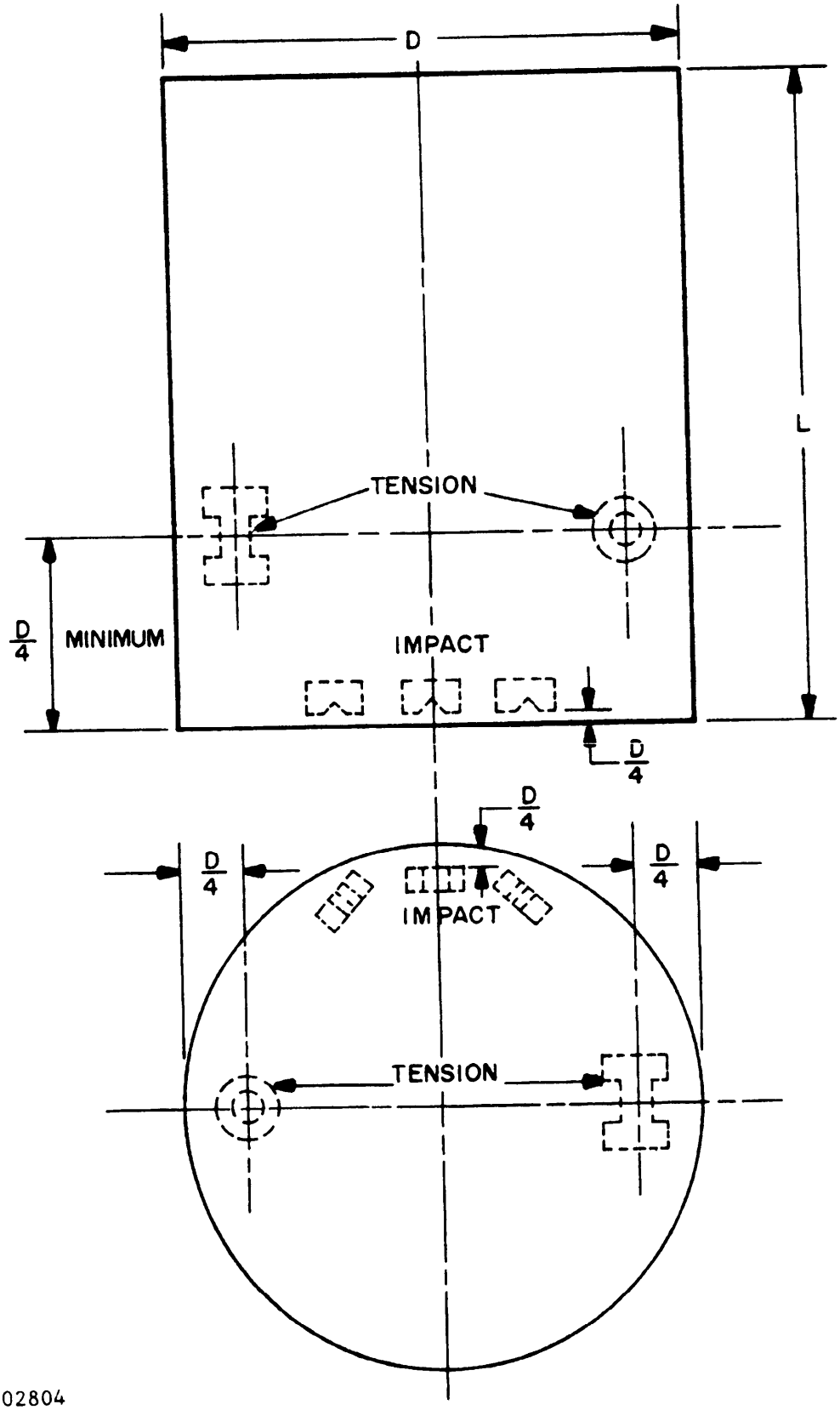
Preparing activity:
Navy - SH
(Project FORG-N145)



A = 1/2T if T is 4 inches (102mm) or less.
A = 1/4T or 2"(51mm)(whichever is greater) if T is 4 inches (102mm).

SH 13202802

FIGURE 1. Schematic diagram of test specimen location for forgings "rectangular-like" in cross section.



SH 13202804

FIGURE 2. Schematic diagram of test specimen location for forgings of solid circular cross section.

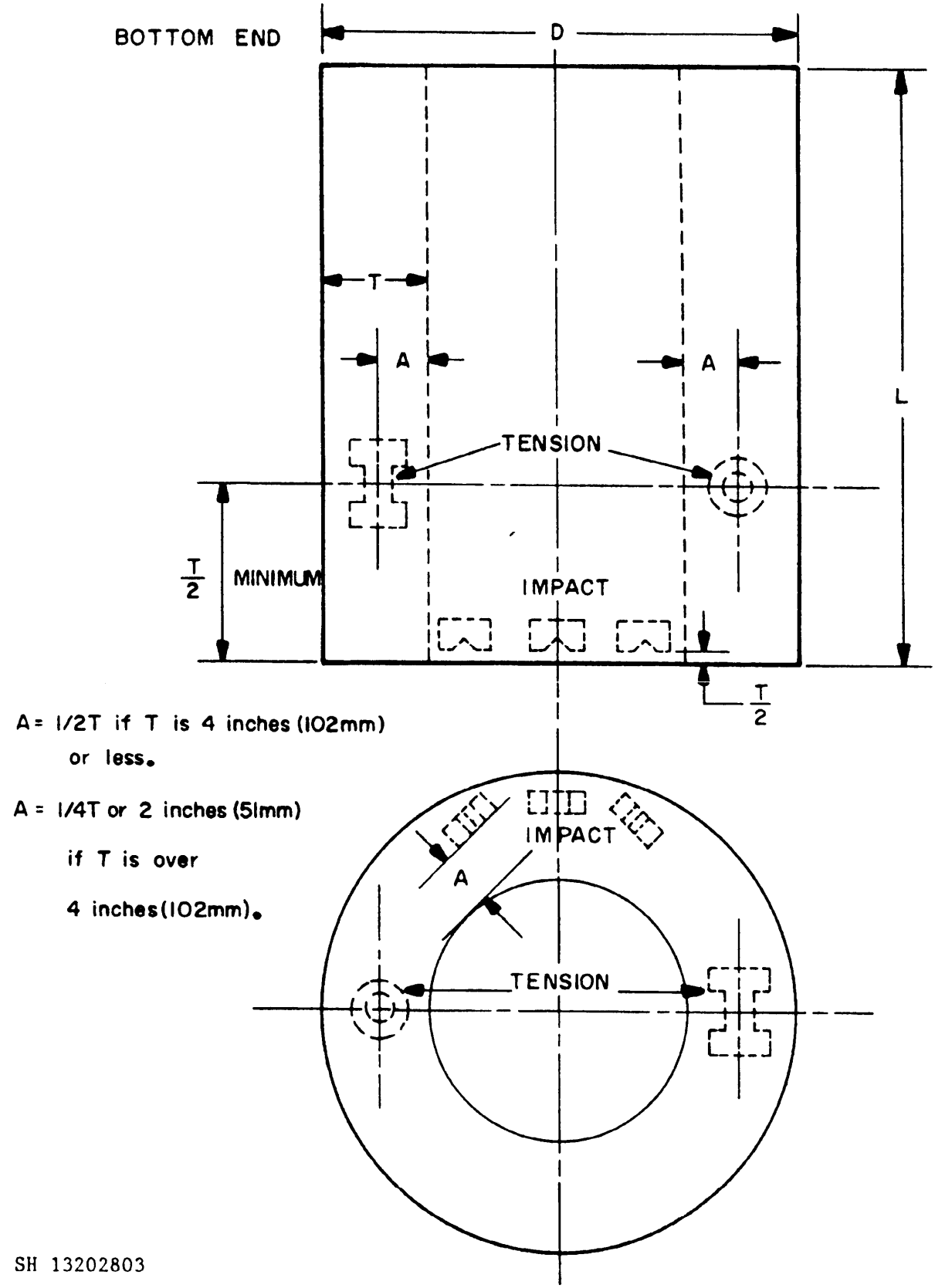


FIGURE 3. Schematic diagram of test location for forgings of bored circular cross section.

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STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE
MIL-S-23009C(SH)	STEEL FORGINGS, ALLOY HIGH YIELD STRENGTH (HY-80 AND HY-100)

3a. NAME OF SUBMITTING ORGANIZATION

b. ADDRESS *(Street, City, State, ZIP Code)*

4. TYPE OF ORGANIZATION *(Mark one)*

- ☐ VENDOR
- ☐ USER
- ☐ MANUFACTURER
- ☐ OTHER *(Specify)*: _____

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)*

DD FORM 82 MAR 1426

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