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26 October 1971
SUPERSEDING
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29 November 1957
(See Section 6)

MILITARY SPECIFICATION

WELDMENT, STEEL, CARBON AND LOW ALLOY (YIELD STRENGTH 30,000-60,000 PSI)

This specification has been approved by the Naval Ordnance Systems Command, Department of the Navy.

1. SCOPE

1.1 Scope. This specification covers the requirements for steel weldments fabricated by metal electrode welding processes.

1.2 Classification. Weldments shall be of the following classes, as specified (see 6.2 and 6.3 and tables I-A and I-B).

Class 1
Class 2
Class 3
Class 4
Class 5

2. APPLICABLE DOCUMENTS

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

SPECIFICATIONS

Federal

QQ-E-450	Electrode, Welding, Covered, Mild Steel

FSC THJM

Military

MIL-I-6868	Inspection Process, Magnetic Particle
MIL-I-8950	Inspection, Ultrasonic, Wrought Metals, Process for
MIL-R-11468	Radiographic Inspection, Soundness Requirements for Arc and Gas Welds in Steel
MIL-R-11469	Radiographic Inspection, Soundness Requirements for Steel Castings
MIL-R-11470	Radiographic Inspection, Qualification of Equipment, Operators and Procedures
MIL-M-11473	Magnetic-Particle Inspection, Soundness Requirements for Weldments
MIL-E-18038	Electrodes, Welding, Mineral Covered, Low Hydrogen, Medium and High Tensile Steel as Welded or Stress Relieved Weld Application
MIL-E-22200/1	Electrodes, Welding, Mineral Covered, Iron-Powder, Low-Hydrogen Medium and High Tensile Steel, as Welded or Stress Relieved Weld Application

STANDARDS

Military

MIL-STD-22	Welded Joint Designs
MIL-STD-105	Sampling Procedures and Tables for Inspections by Attributes
MIL-STD-129	Marking for Shipment and Storage
MIL-STD-130	Identification Marking of U.S. Military Property
MIL-STD-163	Steel Mill Products, Preparation for Shipment and Storage
MIL-STD-248	Qualification Tests for Welders
MIL-STD-410	Qualification of Inspection Personnel (Magnetic Particle and Penetrant)
MIL-STD-453	Inspection, Radiographic

Federal

FED-STD-151 Metals: Test Methods

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

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

American National Standards Institute

ANSI Y14.5	Dimensioning and Tolerancing for Engineering Drawings
ANSI Y32.3	Welding Symbols

(Application for copies should be addressed to the American National Standards Institute, 1430 Broadway, New York, N.Y. 10018.)

American Welding Society

AWSA-2.2	Nondestructive Testing Symbols
AWSA-3.0	Definitions - Welding and Cutting

(Application for copies should be addressed to the American Welding Society, 345 East 47th Street, New York, N.Y. 10017.)

American Iron and Steel Institute

Steel Products Manual

(Application for copies should be addressed to the American Iron and Steel Institute, 150 East 42 Street, New York, N.Y. 10017.)

Steel Founders Society of America

Steel Casting Handbook

(Application for copies should be addressed to the Steel Founders Society of America, 21010 Center Ridge, Cleveland, Ohio 44113.)

3. REQUIREMENTS

3.1 Capability. When the low bidder has not had previous experience in building ordnance structures, as specified in the request for bids, or material

requiring a similar quality of workmanship, he may be required before contract award to demonstrate satisfactorily to the procuring activity that his methods of welding, shop and equipment, supervision, and welding procedures are such as to produce results which will comply with the provisions of this specification and permit fabrication of structures which will function satisfactorily for the purpose intended. These tests shall be conducted at the expense of the bidder. If the test results do not indicate the bidders ability to fulfill the requirements, his bid shall be rejected.

3.1.1 Weldment acceptance standards. Weldments shall meet the standards of acceptance for the applicable class as specified in 4.2.3.

3.2 Qualification of welding operators. Welding operators shall be qualified in accordance with MIL-STD-248.

3.3 Material.

3.3.1 Plates, bars, structural shapes, castings, forgings. The material for plates, castings, forgings, and other parts used for the fabrication of weldments covered by this specification shall be carbon or high strength low alloy steels as specified by the applicable drawings and shall meet the standards of acceptance specified in 4.2.3 when inspected in accordance with 4.2.2.

3.3.2 Welding electrodes. Unless otherwise specified by the procuring activity, welding electrodes shall be as specified in the applicable drawing and QQ-E-450. When mild steel electrodes are specified in accordance with QQ-E-450, low hydrogen electrodes may be used as a substitute in accordance with types MIL-70 and MIL-80 of MIL-E-18038 or MIL-E-22200/1.

3.4 Welding process. Weldments shall be fabricated in accordance with the process specified by the procuring activity, applicable drawing, or in accordance with 3.4.1.

3.4.1 Alternate welding process. Alternate processes of metal electrode arc welding, as defined in AWSA-3.0, may be used when prior approval has been obtained from the procuring activity.

3.5 Dimensions and tolerances. Dimensions and tolerances of weldments shall be in accordance with the applicable drawing and shall conform to ANSI Y14.5. When no specific tolerance appears on the applicable drawing, dimensions from a locating point or plane to a weldment surface shall not differ from the drawing dimension by more than the following dimensional tolerance:

3.11 Assembling.

3.11.1 Bracing. Temporary braces may be used in assembling parts of a welded structure to prevent distortion and hold the parts in their proper position during welding or stress relieving.

3.12 Welding assembly sequence.

3.12.1 Control of residual stresses. The actual welding of the structure and all parts entering into the assembly shall be done in such a manner that residual and locked-up stresses in the welds will be reduced to a minimum. As far as practical, to reduce welding stress, the various steps in welding shall be carried out so that external restraint shall not resist the shrinking incident to the welding and add stresses to those that are unavoidable in a free joint (see 3.12.2 and 3.14.1).

3.12.2 Control of shrinking. Insofar as possible, the welding of an assembly shall begin at some central location situated so that outlying or adjacent parts may be added progressively. The unwelded sections shall be free to shrink toward the central welding location. No excessive welding, bolting, or rigid restriction shall be employed on parts at outlying points which will prevent their free movement toward the center of welding. The welding shall progress systematically so that shrinkage on both sides of the structure will be equal or balanced, insofar as practicable. Where possible, intersecting systems of framing and stiffeners shall be joined to each other before they are joined to plate or flange members.

3.13 Joints.

3.13.1 Design. Joint preparation shall be as shown on the applicable drawing with reference to ANSI Y32.3 and MIL-STD-22, as applicable.

3.13.2 Patented joints. Where joint edge preparation shown on the applicable drawing is that of a patented joint, the contractor, with prior approval from the procuring activity, may substitute other joint designs having equivalent efficiency.

3.13.3 Alternate joint designs. If so desired by the contractor, and with prior approval from the procuring activity, similar and equally effective designs of joints other than specified by the applicable drawing may be used.

3.13.4 Removing root of weld. Where a through joint requiring root chipping is indicated on the drawing, butt joints, "T" joints, or corner joints shall be chipped, gouged, machined, or ground down to sound continuous metal on the root side after sufficient welding has been done on one side and before welding on the root side is undertaken.

3.13.5 Form of chipping tool. Chipping shall be accomplished by means of a round nosed tool having a radius of not less than one-eighth inch. No section of the chipped or machined groove shall contain an irregularity with a corner having a radius of less than one-eighth inch.

3.13.6 Gouging. Gouging may be performed by the oxyacetylene or arc-air method provided that the cross section profile of the gouged groove shall comply with the specification requirements limiting the radius to one-eighth inch minimum at any point.

3.13.7 Defects in root areas. In class 1, 2, 3, and 4 weldments, the soundness of the metal remaining in the root area shall be determined by the magnetic-particle inspection method.

3.13.8 Electrode size. The maximum diameter of the electrode used for the first pass in chipped, gouged, or machined grooves shall not exceed the radius at the bottom of the groove.

3.13.9 Fillet size. Where the clearance between members to be joined by fillet welds is greater than one thirty-second of an inch, the size of the fillet to be deposited shall be the size specified plus the clearance.

3.13.10 Joint openings. Joint openings shall not be larger than those required for proper assembly. Joints with oversize root openings may be corrected by building up the basic edges or weld scarfs with weld metal and then suitably preparing such edges for welding.

3.14 Peening.

3.14.1 Uses. Peening, that is, mechanical working of the weld metal may be done to correct distortion or to minimize residual stresses

3.14.2 Care in peening. Peening shall be accomplished with a round or blunt nosed tool. Such mechanical work shall be performed in a manner that will not tear or burr the peened area. Care must be taken that all surface slag, slag inclusions, gas holes, or folds are removed from the weld before peening so that no foreign material or unfused area will be embodied in the weld. Peening should preferably be done at temperatures not exceeding 500° F, at a travel rate of 20 inches per minute with a medium hammer.

3.14.3 Restrictions.

3.14.3.1 Weldments not subsequently heat treated. Peening shall not be done on single layer fillet welds but may be done on all but the first and last

Weight (pounds)	Dimensional tolerance (inch ±)
Less than 50	0.060
50 to 99	0.125
100 to 499	0.156
500 to 4,999	0.187
5,000 to 14,999	0.250
15,000 to 29,999	0.313
30,000 and over	0.375

When a particular area or portion of a plate must be held within closer tolerances than those indicated, special limiting dimensions or notations shall be included on the applicable drawing.

3.5.1 Welded structures. The responsibility for furnishing welded structures that will finish to dimensions shown on the applicable drawing within functional tolerances, without additional straightening or other modifications, shall rest with the contractor. When no allowance for shrinkage is made on weldment drawings, it shall be the responsibility of the contractor to make necessary shrinkage allowances in dimensions of component parts to ensure that the completed weldment complies with the applicable assembly requirements. When the drawing does not specifically prohibit a stress relief annealing operation, it shall be the contractor's responsibility to provide this treatment, if necessary, to ensure dimensional stability during subsequent machining operations.

3.5.2 Allowance for machining. Unless otherwise specified, all parts of a welded structure where a machined finish is required shall have a minimum allowance of 1/16-inch stock for machining. Stock for finishing shall not be so great as to require excessive machining.

3.6 Shaping of parts.

3.6.1 Component parts. Unless otherwise specified on the applicable drawing, component parts may be machined, sheared, punched, gas cut, or arc-air shaped.

3.6.1.1 Sheared or punched parts. Sheared or punched parts shall be free from buckles, tears, or cracks before welding.

3.6.1.2 Gas cut parts. Gas cut and arc-air shaped parts shall be free from any cracks, checks, or cutting irregularities along the cut edges. All accumulations of slag shall be carefully removed before welding.

3.6.1.3 Sharp edges. All sharp edges caused by gas cutting, arc-air shaping, shearing, punching, or machining shall be removed from the parts before assembly for welding.

3.7 Direction of maximum stress. When the direction of maximum stress is indicated, the component plate parts of the welded structure shall be laid out so that the direction of rolling in the plate is parallel to the direction of maximum stress imposed on the part.

3.8 Surface preparation.

3.8.1 Surfaces. Surfaces to be welded shall be free from scale (other than light mill scale or cutting oxide), oil, paint, dirt, or other foreign materials.

3.8.2 Moisture. Water, snow, or ice shall be removed and the surface completely dried before welding. No welding shall be done in locations unprotected from rain, snow, or cold drafts.

3.8.3 Multiple layer welds. When multiple layer welds are deposited, each layer shall be thoroughly cleaned before depositing another layer. Any gas pits or slag in or along the edge of the weld shall be removed before subsequent layers are applied.

3.9 Tack welding.

3.9.1 Welding. Tack welding shall be accomplished in accordance with 3.4. When tack welds are to be incorporated in the final weld, operators shall be qualified in accordance with 3.2.

3.9.2 Electrodes. Electrodes shall conform to the requirements of 3.3.2. If the tack welds are to be incorporated into the final weld, electrodes shall not exceed five thirty-seconds of an inch in diameter.

3.9.3 Tack weld deposit. Tack welds shall be deposited in such a manner as to facilitate their incorporation into the final weld without causing a discontinuity in the deposit.

3.10 Weld positions.

3.10.1 Flat position. Insofar as practical, all welding on structures shall be performed in the flat position as defined in AWSA-3.0.

3.10.2 Vertical or overhead position. Where flat position welding is not practicable and welding is to be accomplished in the vertical or overhead position, the use of electrode sizes larger than five thirty-seconds of an inch in diameter on the first pass, or three-sixteenths of an inch in diameter on subsequent passes, will not be permitted. Joints welded in the vertical position of welding shall be welded upwards.

layers of multiple layer fillet welds. Peening shall not be done on the first two layers or the last layer of single or double bevel "V", "U", or "J" groove welds.

3.14.3.2 Weldments subsequently heat treated. For weldments which will be subsequently stress relief annealed, peening may be done on any weld layer. Care must be taken on first pass layers not to crack the weld due to the reduced section in which work is being accomplished. The soundness of heavily peened first pass welds should be demonstrated by magnetic-particle inspection before subsequent passes are applied.

3.14.4 Damage to parent metal. Care shall be taken not to damage or reduce the cross sectional area adjacent to the weld with the peening tool.

3.15 Weldment temperatures.

3.15.1 Ambient temperature. Tack welding or production welding of any kind shall not be done when the ambient atmospheric and material temperature is less than 60° F.

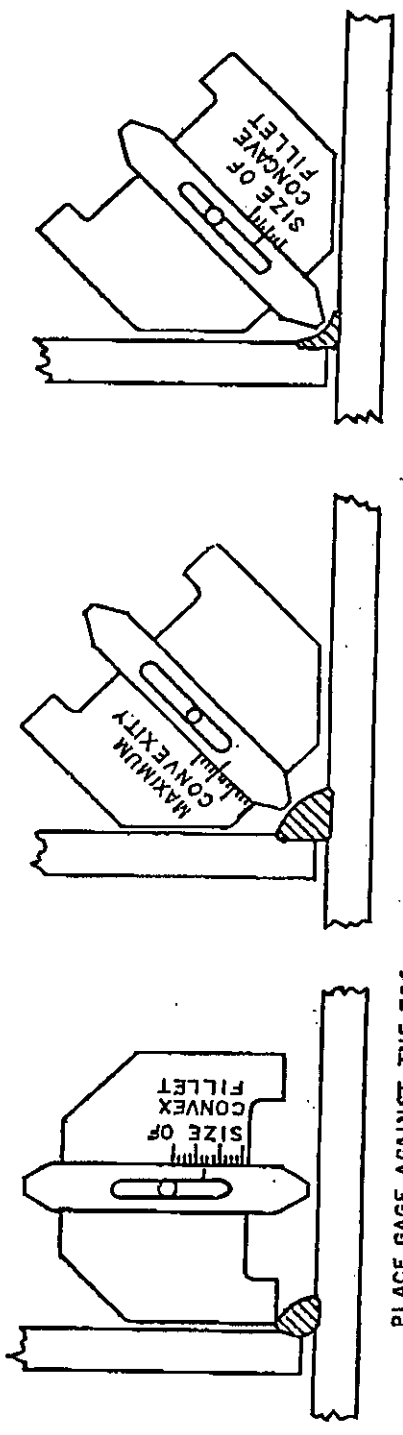
3.15.2 Preheat temperatures. When not otherwise specified in the applicable drawings, sufficient preheat shall be used to avoid cracking, control distortion, and otherwise to ensure sound welds.

3.15.3 Heavy sections. Heavy welded sections shall be welded continuously, that is, once welding has been started on a joint, the welding operation shall be continued until completed.

3.15.4 Straightening. Where appreciable straightening or forming is required, the weldment may be locally preheated. This preheating shall not exceed 1150° F unless subsequent corrective heat treatment is employed.

3.16 Size and shape of welds.

3.16.1 Size. The form and dimensions of the welds shall be in accordance with the applicable drawings except as specified in 3.13.1. Weld sizes given on the drawings shall be considered the minimum size when measured in accordance with AWSA-3.0. Fillet weld sizes shall not exceed the next 1/16-inch larger size for welds up to three-eighths inch. For welds three-eighths inch and larger, the size shall not exceed the next 1/8-inch larger size. Fillet weld sizes may be determined by the method shown in figure 1 using the gage shown in figure 2.



PLACE GAGE AGAINST THE TOE OF THE SHORTEST LEG OF THE FILLET AND SLIDE POINTER OUT UNTIL IT TOUCHES STRUCTURE AS SHOWN.

READ "SIZE OF CONVEX FILLET" ON FACE OF GAGE

AFTER THE SIZE OF A CONVEX WELD HAS BEEN DETERMINED, PLACE THE GAGE AGAINST THE STRUCTURE AND SLIDE POINTER UNTIL IT TOUCHES FACE OF FILLET WELD AS SHOWN.

THE MAXIMUM CONVEXITY SHOULD NOT BE GREATER THAN THAT INDICATED BY "MAXIMUM CONVEXITY" FOR THE SIZE OF FILLET BEING CHECKED.

PLACE GAGE AGAINST STRUCTURE AND SLIDE POINTER OUT UNTIL IT TOUCHES THE FACE OF THE FILLET WELD AS SHOWN.

READ "SIZE OF CONCAVE FILLET" ON FACE OF GAGE

FIGURE 1. METHOD OF USING BUTT AND FILLET WELD GAGE

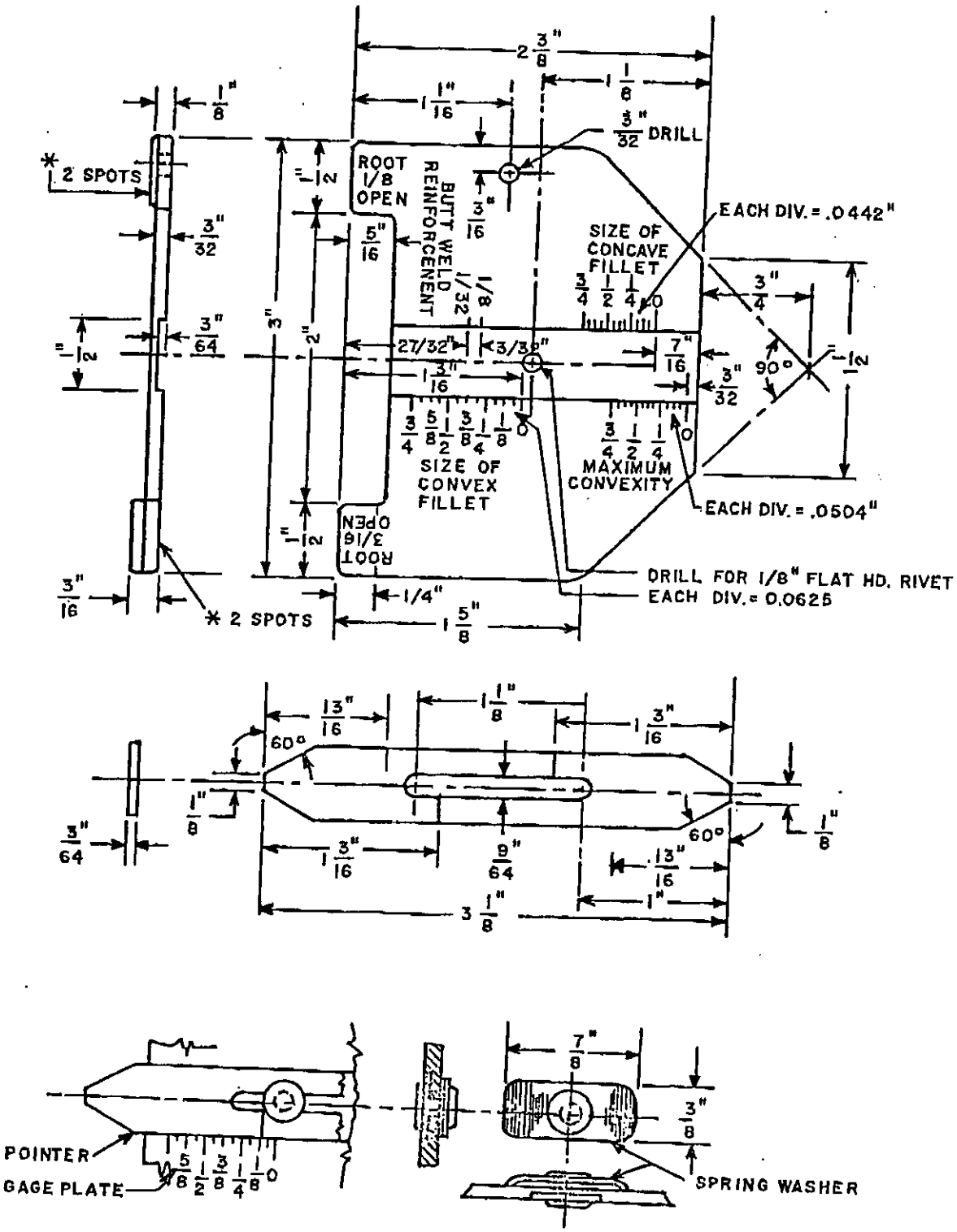


FIGURE 2. BUTT AND FILLET WELD GAGE

3.16.2 Weld reinforcement. For plate one-half inch and greater in thickness the reinforcement of butt welds shall not exceed one-eighth inch except as specified for individual joints on the applicable drawings. For material under one-half inch, the reinforcement shall not exceed 25 percent of the material thickness.

3.16.3 Fillet weld form. Fillet welds having a concave face are desirable. Excessive convexity, as determined by the gage (figure 1), may be corrected by grinding or chipping.

3.16.4 Length of fillet welds. The length of a correctly proportioned fillet weld, whether intermittent or continuous and exclusive of any craters and starts, shall be in accordance with the length specified on the applicable drawing.

3.16.5 Extension of fillet welds. Fillet welds shall extend around the ends of abutting members when practicable.

3.17 Undercut and overlapping welds. Undercutting or overlapping welds will not be permitted except as specified in 4.2.3 for the applicable class of weldment.

3.18 Removal of reinforcements. Where butt welds which are to be finished flush occur on unmachined surfaces, the reinforcement shall be removed by chipping or grinding. Care shall be taken to avoid undercutting or nicking the surface of the plates in the vicinity of the welds.

3.19 Width of deposit. Welds may be built up by weave beads or by stringer beads. The width of the deposit shall not be greater than four times the nominal diameter of the electrode.

3.20 Stress relief annealing. When specified by the procuring activity or applicable drawing, weldments shall be stress relieved after completion of all welding and straightening operations except as specified in 3.20.1.

3.20.1 Stress relief after minor repairs. Minor repairs of weldments may be made without subsequent stress relief annealing by excavating defective areas until clear of defects and rewelding the excavation while the area is locally preheated to 200° - 400° F provided that the area is so located that the resultant stresses will not cause the weldment to be dimensionally unstable during machining or in service. An excavated weldment or a sketch showing the location of repairs and the dimensions of the excavations shall be submitted to the procuring activity prior to finish machining any part of the weldment to decide if stress relief annealing is necessary.

3.20.2 Annealing procedure. The following procedure shall be used for stress relief annealing completed weldments or for any interim annealing that may be necessary on subassemblies and weldments in the course of repair:

(a) Adequate supports shall be provided in the stress relief annealing furnace to minimize changes in the shape of the weldment due to its own weight or the weight of the charge.

(b) The stress relief annealing furnace shall be equipped with adequate recording equipment and thermocouples in sufficient number attached to the charge and so located as to record accurately the temperature of the weldments or annealing charge. Care shall be taken to see that the probable hottest and coolest point of the charge for both heating and cooling cycles is recorded. The temperature of the charge shall be considered the mean between the highest and lowest reading. The maximum temperature difference between any two parts in the charge shall not exceed 100° F, except as permitted under 3.20.2(f) during the heating or cooling cycle, or 50° F during the soaking period.

(c) The temperature of the furnace shall not exceed 105° F plus the ambient temperature at the time the charge is loaded. The charge shall be heated to 1175° F ± 25° at a rate not exceeding 150° F per hour, except as permitted under 3.20.2(f).

(d) When the charge has reached a mean temperature of 1175° F ± 25°, as specified in 3.20.2(c), it shall be held within this temperature range for the minimum period of 1 hour for each inch or fraction thereof of maximum thickness of the weldment section, unless the holding time is otherwise specified by the procuring activity or applicable drawing. For thicknesses less than 1 inch, the holding time shall be proportional to the thickness but not less than 30 minutes.

(e) The charge shall be cooled in the furnace. The rate of cooling shall not exceed 150° F per hour except as permitted under 3.20.2(f). When the furnace has cooled to a temperature of 300° F or less, the charge may be removed from the furnace and allowed to cool to ambient temperature in still air protected from moisture.

(f) The heating and cooling rate of 150° F specified in 3.20.2(c) and 3.20.2(e) may be exceeded if the furnace is such that a maximum temperature difference of any two points in any weldment does not exceed 75° F.

3.21 Straightening.

3.21.1 Progressive straightening. To avoid the necessity for major straightening of weldments, check measurements shall be made at frequent intervals during the course of fabrication. Corrective measures shall be taken concurrently as required rather than permitting warpage to accumulate for a final straightening.

3.21.2 Stress caused by straightening. No excessive concentration of stress in any section of a weld or plate shall be created by straightening. Buckled or stressed sections may be relieved by opening welded seams and rewelding. Requests for the making of additional seams must be authorized by the procuring activity. Preliminary stress relief annealing may be performed on weldments prior to straightening in order to reduce the possibility of rupturing the base metal or cracking the welds.

3.22 Weldment finish.

3.22.1 Scale. All scale, oxides, and foreign material shall be removed from the weldment surface after stress relief annealing.

3.22.2 Rust prevention. Unless otherwise specified, the weldments shall be protected against corrosion by coatings of paint, agreeable with the finish specifications given on the detail drawing of the part. Weldments received from the contractor shall be free from rust. The contractor shall be liable for the cost of cleaning or blasting weldments received in a rusted condition or in a condition tending to promote rusting.

3.23 Identification marking. Weldments covered by this specification shall be legibly and permanently marked in accordance with MIL-STD-130 and the applicable drawings. In addition, weldments shall be further identified and marked as specified in 3.23.1 and 3.23.2. Weldments shall not be marked by identification stamp, welders stamp, or other marking in any area where the impression could act as a stress raiser leading to ultimate failure of the weldment.

3.23.1 Serial numbers. Weldments required to be indented with the identification marking in accordance with 3.23 also shall be indented with a serial number in characters of the same size as those of the identification mark. The serial number so assigned shall be selected, in regular sequence, from a block of serial numbers furnished by the contractor or procuring activity. No two serial numbers shall be alike for the same part number, and all inspection records, reports, and correspondence shall thereafter refer to a specific weldment by its serial number.

3.23.2 Weldment drawing numbers. Where practicable, the applicable weldment drawing (not the finish machine drawing) piece number and revision letter shall be painted in relatively large characters on the parts. This marking shall be performed subsequent to the protective coating specified in 3.22.2 so that the marking will not be obliterated.

3.24 Workmanship. Workmanship in all respects shall be such as to assure production of acceptable weldments in accordance with the requirements of the applicable drawing, the detail specification, the contract or order, and this specification.

4. QUALITY ASSURANCE PROVISIONS

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

4.2.1 Sampling.

4.2.1.1 Lot sizes. For sampling purposes, a lot shall consist of all like weldments of the same class and design or kind, manufactured by essentially the same process from each welding operator's production, and submitted for acceptance inspection at one time.

4.2.1.2 Samples. Unless otherwise specified, samples of each inspection lot shall be selected in accordance with MIL-STD-105, Inspection Level I. Lot acceptance shall be based on the Acceptable Quality Level (AQL) of 2.5 percent defectives.

4.2.2 Inspection.

4.2.2.1 General inspection. Unless otherwise specified herein, general inspection and test procedures for contractor and Government inspection shall be in accordance with FED-STD-151.

4.2.2.1.1 Nondestructive tests. Unless otherwise specified herein or on the applicable drawing, weldments shall be inspected in accordance with nondestructive testing symbols of AWSA-2.2.

4.2.2.1.2 Visual and dimensional. Samples selected in accordance with 4.2.1.2 shall be visually inspected for completeness of weld and for dimensional and other requirements as set forth on applicable drawings.

4.2.2.1.3 Acceptance tests. Unless otherwise specified, weldments selected in accordance with 4.2.1.2 shall be subject to inspection tests as specified for the applicable class of weldment (see tables I-A and I-B).

Table I-A

STANDARDS OF ACCEPTANCE (WELDS)

Inspection method	Weldment class				
	1	2	3	4	5
Visual	—[1]	—[1]	—[4]	—[6]	—[8]
Magnetic-particle	No defects of any kind[2]	—[3]	—[5]	—[7]	Commercial quality[9]
Radiographic	STD I of MIL-R-11468	STD II of MIL-R-11468	STD III of MIL-R-11468	Not required	Commercial quality[9]

[1]No undercuts, overlaps, slag, or weld spatter permitted in welds.

[2]Typical weld defects are shown in figures 1, 2, 3, 4, 5, 8A, 8B, and 9 of MIL-M-11473.

[3]No defects permitted in metal thicknesses one-fourth inch or less. No crack-type defects permitted in metal thicknesses over one-fourth inch. The greatest summation of other type defects shall not exceed T/3 in any 6T length with the maximum length of an individual defect not to exceed T/6. ("T" equals the nominal material thickness for repair welds in castings.)

[4]No overlaps, slag, or loosely adhering weld spatter permitted in welds (weld spatter remaining after sand or grit blasting may be presumed to be not loosely adhering). Permissible undercut shall not exceed 5 percent of the material thickness or one-thirty-second inch. Minimum radius at root of undercut shall be 0.01 inch.

[5]No crack-type defects permitted on any thickness. In welds one-fourth inch or less in thickness, no individual defect other than cracks shall be permitted in excess of one-sixteenth inch, minimum spacing of one-fourth inch between defects and not more than three defects in any one and one-half inch length. In welds over one-fourth inch in thickness, no individual defect other than cracks shall be greater than T/4, and the greatest summation shall not exceed 3T/4 in any 6T length.

[6]Welds shall have no overlaps, slag, or loosely adhering weld spatter (weld spatter remaining after sand or grit blasting may be presumed not to be loosely adhering). Permissible undercut shall not exceed 10 percent of the material thickness or one-sixteenth inch. Minimum radius at root of undercut shall be 0.01 inch.

[7]No crack-type defects will be permitted. For other type defects, no individual defect shall be permitted greater than T/3, with the greatest summation of defects not exceeding "T" in any 6T length.

[8]Permissible undercut shall not exceed 10 percent of material thickness or one-sixteenth inch. No slag or loosely adhering weld spatter will be permitted (weld spatter remaining after grit or sand blasting may be presumed not to be loosely adhering). Overlap will be permitted, but not exceeding 2T in any 6T length.

[9]Commercial quality material does not require radiographic or magnetic-particle inspection. In other respects it shall conform to the following commercial standards: American Iron and Steel Institute "Steel Products Manuals", for Structural Shapes, Section 4; for plates (Structural Quality), Section 6; for bars (Merchant Quality), Section 8; and Steel Founders Society of America "Minimum Standards for Carbon Steel Castings".

Table I-B

STANDARDS OF ACCEPTANCE (MATERIAL)

Inspection method	Weldment class				
	1	2	3	4	5
Castings					
Magnetic particle	No defects of any kind	STD 1A or 1B of MIL-M-11473	STD 2A or 2B of MIL-M-11473	STD 3A or 3B of MIL-M-11473	Commercial quality[3]
Radiographic	No defects of any kind	STD I of MIL-R-11469[1]	STD I of MIL-R-11469	STD II of MIL-R-11469	Commercial quality[3]
Forgings					
Magnetic particle	No defects of any kind	STD 1A or 1B of MIL-M-11473	STD 2A or 2B of MIL-M-11473	STD 3A or 3B of MIL-M-11473	Commercial quality[3]
Radiographic	No defects of any kind	-[2]	-[2]	-[2]	Commercial quality[3]
All other material					
Magnetic particle	No defects of any kind	STD 1A or 1B of MIL-M-11473	STD 2A or 2B of MIL-M-11473	STD 3A or 3B of MIL-M-11473	Commercial quality[3]
Radiographic	Not required	Not required	Not required	Not required	Commercial quality[3]

[1] Defects in castings intended for incorporation into class 2 weldments will be limited to a maximum concentration of one-half that permitted by Standard 1.

[2] Radiographs of the forgings shall show no shrinkage, laps, bursts, or nonmetallic inclusions in excess of defects permitted by applicable magnetic particle standards referenced in table I-B.

[3] Commercial quality material does not require radiographic or magnetic-particle inspection. In other respects it shall conform to the following commercial standards: American Iron and Steel Institute "Steel Products Manuals", for Structural Shapes, Section 4; for plates (Structural Quality), Section 6; for bars (Merchant Quality), Section 8; and Steel Founders Society of America "Minimum Standards for Carbon Steel Castings".

4.2.2.1.4 Finish of welds. Welds shall be inspected for smoothness, workmanship, and for conformance to the requirements of 3.16 through 3.19 and 3.24. The inspector may require chipping, grinding, or rewelding whenever necessary to obtain weld surface appearance equivalent to those shown in QQ-E-450. Surface irregularities that interfere with the interpretation of radiographs or magnetic-particle inspection or make it questionable shall be removed.

4.2.3 Standards of acceptance.

4.2.3.1 Welds. Welds shall be inspected to ensure compliance with the standards established for the class of weldment specified on the applicable drawing, detail specification, or by the procuring activity (see 6.3). Weld root areas prepared in accordance with 3.13.4 shall be inspected to the magnetic-particle standard established for the class of weldment specified on the applicable drawing, detail specification, or by the procuring activity (see 6.3).

4.2.3.1.1 Class 1, 2, and 3 weldments. Welds shall be subjected to radiographic, magnetic-particle, and visual inspection in accordance with the standards of acceptance as specified in table I-A.

4.2.3.1.2 Class 4 weldments. Welds shall be subjected to magnetic-particle and visual inspection in accordance with the standards of acceptance as specified in table I-A.

4.2.3.1.3 Class 5 weldments. Welds shall be subjected to visual inspection only. The standards of acceptance shall be as specified in table I-A.

4.2.3.2 Material. The plates, bars, structural shapes, castings, stampings, formed parts, and forgings used in the fabrication of weldments shall be inspected in accordance with 4.2.3.2.1 through 4.2.3.2.5 as applicable. The standards of acceptance shall be as specified in table I-B for the class of weldment specified on the applicable drawing, detail specification, or by the procuring activity (see 6.3). Wrought materials one-half inch and over in classes 1 through 4 weldments shall be subjected to magnetic-particle inspection.

4.2.3.2.1 Plates and stampings. Normal inspection of plates and stampings shall be confined to magnetic-particle inspection of the edges of prepared parts before welding and of exposed plate edges of the completed weldment at final inspection.

4.2.3.2.2 Structural shapes. Normal inspection of the structural shapes shall be confined to magnetic-particle inspection of edges and areas exposed by cutting.

4.2.3.2.3 Bars, tubes or extrusions, and formed parts. Normal inspection of bar tubes or extrusions shall be confined to magnetic-particle inspection, oriented to show defects on the edges and areas exposed by cutting. Formed parts shall be subjected to magnetic-particle inspection in the bent or drawn areas of such parts.

4.2.3.2.4 Forgings. Forgings shall be subjected to magnetic-particle inspection so as to show defects in any orientation on all surfaces. In addition, radiographic inspection shall be performed as shown on the drawing or as specified by the procuring agency.

4.2.3.2.5 Castings. Castings shall be subjected to magnetic-particle inspection so as to show defects in any orientation on all surfaces. In addition, castings shall be radiographed as required by the drawing or contracting agency.

4.3 Test methods.

4.3.1 Radiographic inspection.

4.3.1.1 General. Radiographic equipment, operators, and procedures used in radiographic inspection of weldments shall be qualified in accordance with MIL-R-11470.

4.3.1.1.1 Position and direction of radiation. Radiographs shall be taken in the position and direction and at the stages of assembly required by the applicable drawing. When not otherwise indicated on the drawings, the direction of radiation shall be perpendicular to the surface of the radiographic film and to the surface of the material where feasible. No deviations shall be permitted unless authorized by the procuring activity.

4.3.1.1.2 Additional radiographs. Where appreciable defects are disclosed in the areas radiographed or where soundness is questioned, additional radiography may be required at the discretion of the inspector.

4.3.1.1.3 Identification of radiographs.

4.3.1.1.3.1 Radiographic negatives and inspection records. The radiographic negatives and written radiographic inspection records shall be submitted in accordance with the requirements of MIL-STD-453 unless otherwise specified by the procuring activity.

4.3.1.1.3.2 Weldment serial numbers. Each weldment radiographed shall be assigned a serial number (see 3.23.1) in accordance with MIL-STD-453.

4.3.1.1.3.3 Negative identification numbers. All radiographic negatives shall carry the image of the lead markers identifying the individual part, position number, and locating markers. These markers shall be of such size and so located as to render minimum interference with the interpretation of the radiographic image in the area of the weld.

4.3.1.1.3.4 Radiographic position number. The position number shall represent a definite area of the structure. The numbering system shall be consistent for similar parts, and the location of areas shall be readily determinable from a radiographic position chart which will be furnished by the contractor. The above requirements do not apply to additional radiographs made at random under 4.3.1.1.2 which shall be otherwise identified.

4.3.1.1.3.5 Radiographic location markers. The exact location of the markers shall be permanently stamped on the surface of the weldment so that the radiograph may be accurately located whenever desired. Generally, the markers shall be placed on the side of the metal toward the radiation, but it is permitted to place markers on the film side of the metal when it is anticipated that repairs will be made from this surface.

4.3.1.1.3.6 Alternate method of identifying negatives. In cases when the image of the identifying markers would interfere with proper interpretation of the radiograph, such identification may be entered on the film after exposure, but prior to development.

4.3.1.1.4 Radiographic technique. Except as otherwise noted in this specification, the technique employed shall conform to the provisions of MIL-STD-453.

4.3.1.1.4.1 Unequal thicknesses. When members being radiographed are unequal thicknesses or when the section of a weld (such as a fillet weld) varies considerably, the density of the radiograph shall be such as to show the root of the weld or the section which is most likely to contain defects.

4.3.1.1.4.2 Examination of radiographs. Suitable facilities shall be provided for the viewing and examination of negatives.

4.3.1.1.4.3 Surface irregularities. Any indication on radiographs that are definitely identified as the shadows of surface irregularities on the weldments shall be so indicated in pencil on the radiograph. In case of sharp indications closely resembling typical defects, the radiograph shall be rejected, the surface of the weld repaired, and the weld reradiographed.

4.3.2 Magnetic-particle inspection.

4.3.2.1 General. The method used shall be the dry powder method conforming to the requirements of this specification and shall apply to rolled plates, shapes, forgings, castings, welded joints, and to any necessary replacements or repair of materials or welds. When stress relief annealing is required, the final inspection shall be conducted after stress relief annealing of the complete assembly.

4.3.2.2 Inspection areas. Areas not accessible for inspection after completion of the assembly shall be inspected at a suitable subassembly stage. In addition to the areas designated on the drawing, the government inspector may require such additional inspections as he deems necessary to assure a sound weldment.

4.3.2.3 Direction of magnetizing current. Areas shall be inspected so that the magnetizing current essentially flows parallel to the direction of anticipated defects. For plate edge inspection, unless otherwise specified, unidirectional inspection will suffice where the prods are positioned so as to pass the current lengthwise through the plate edge. Unless otherwise specified, bidirectional inspection shall be used for inspection of areas other than welds or plate edges. This inspection shall be carried out with the prods positioned so that the direction of the second current flow is approximately at right angles to the direction of the first current flow.

4.3.2.4 Records. When required by the procuring activity, a complete record of the results of final magnetic-particle inspection of each weldment shall be submitted on an approved form.

4.3.2.5 Qualified personnel. Inspection carried out under this specification shall be performed only by personnel who have been certified in their respective categories as required by MIL-STD-410 or by the procuring activity.

4.3.2.6 Equipment.

4.3.2.6.1 General. Magnetic-particle inspection equipment shall be subject to the requirements of MIL-I-6868.

4.3.3 Ultrasonic inspection. When specified by the procuring agency, ultrasonic inspection shall be performed in accordance with the applicable classification of MIL-I-8950 in lieu of, or in addition to, radiographic inspection (see 6.3).

4.4 Replacement and repair criteria.

4.4.1 Material. Parts which do not meet the specified material requirements shall be discarded or, if already assembled, removed and replaced with satisfactory material. Repairs may be made under the following listed conditions:

(a) When the defects are confined to small areas and do not extend through an appreciable portion of the part

(b) When the defects are in an area of low stress

(c) When the defects are not excessive but parallel to the direction of principal stress

(d) When it is desirable to remove all traces of defects in a highly stressed area or in a weld kerf before welding.

4.4.2 Defects. Welds and component parts containing repairable defects shall be repaired in accordance with the following applicable procedures:

(a) If the defect is detected by surface or magnetic inspection, the defect shall be removed, and the underlying area shall be magnetic-particle tested further to demonstrate compliance with the specified requirements prior to re-welding. No section of the excavation shall contain an irregularity with a corner having a radius less than one-eighth inch. After repair, the soundness of the weld shall be demonstrated by magnetic tests. If the repair is in a radiographed area, and deeper than one-fourth inch, it shall also be radiographed.

(b) If the defect is disclosed as a result of radiographic inspection, the defective area shall be excavated until the remaining metal appears to be wholly sound. No section of the excavation shall contain an irregularity with a corner having a radius less than one-eighth inch. After the defect has been removed, the area shall be repaired by welding as prescribed in 4.5. The weld reinforcement shall be removed flush with the base metal, or shaped to the proper contour, and the repair weld radiographed.

(c) If an undercut condition occurs, it may be corrected by depositing a small bead at the toe of the undercut portion of the weld after any adhering slag, scale, dirt, or other foreign material has been removed. Undercuts less than 5 percent of the material thickness, but not exceeding 0.020 inch, may be removed by grinding so that a smooth transition from weld to base metal results.

4.5 Weld repair procedure. Unless otherwise approved by the procuring activity, cavities caused by the removal of defects shall be repaired by welding. When the cavity extends entirely through a section, the repair shall be accomplished either by welding from one side, chipping out the first weld layers to

sound metal from the opposite side, and rewelding, or by welding from one side onto a backing strap of suitable dimensions and of the same material as that being welded. In the latter case, soundness of the weld root shall be demonstrated by magnetic-particle inspection after removal of the backing strap. Repair welds may be peened in accordance with 3.14, to reduce distortion and probable cracking.

4.6 Supplementary requirements.

4.6.1 Inspection reports. All radiographic, magnetic-particle, and annealing inspection reports shall be maintained by the contractor for a period of 3 years, unless otherwise specified by the procuring activity (see 6.3).

5. PREPARATION FOR DELIVERY

5.1 Preservation and packaging. Preservation and packaging shall be level A, B, or C as specified by the procuring activity (see 6.3).

5.1.1 Level A. When level A is specified, material shall be preserved and packaged in accordance with MIL-STD-163.

5.1.2 Level B. Level B preservation and packaging is intended to provide economical but limited protection and should be specified only where it is determined that weldments will be held for a specified period of time prior to further processing. When level B preservation and packaging is specified, and weldments are not used within the specified period, they shall be inspected to determine condition and represerved and repackaged as necessary.

5.1.3 Level C. When level C is specified, weldments shall be preserved by the application of coatings of paint as specified in 3.22.2. Packaging, if required, shall be in accordance with manufacturers commercial standards.

5.2 Packing. Packing shall be level A, B, or C as specified by the procuring activity (see 6.3).

5.2.1 Levels A and B. When level A or B is specified, weldments shall be packed or crated for shipment in accordance with MIL-STD-163.

5.2.2 Level C. When level C is specified, weldments shall be packed or crated in such a manner as to insure acceptance by common or other carrier for safe and expeditious delivery to the point of destination at the lowest transportation rate. Any special packing or equipment which may be required for transportation purposes shall be provided by the contractor. The contractor shall be responsible for the safe delivery of weldments to the specified destination and

shall replace or repair any damaged weldments to the satisfaction of the procuring activity without additional expense to the Government.

5.3 Marking. In addition to any special marking which may be required by the procuring activity (see 6.3), weldments or weldment shipping containers shall be marked for shipment in accordance with the applicable drawing and MIL-STD-129.

6. NOTES

6.1 Intended use. Weldments covered by this specification are intended for use in military equipment and as specified by the procuring activity (see 6.3). The various classes (see 1.2) are intended to be used as indicated in table II.

Table II

SAFETY FACTORS[1] REQUIRED FOR CLASSES OF WELDMENTS AS A FUNCTION OF SERVICE CONDITION

Class of weldment	Service condition					
	Severe			Mild		
	Consequence of failure			Consequence of failure		
	Critical	Minor	Negligible	Critical	Minor	Negligible
1	2-3	2	2	2	2	2
2	3-4	2-3	2	2-3	2	2
3	4-5	3-4	2-3	3-4	2-3	2
4	5	4-5	3-4	4-5	3-4	2-3
5	5	5	4-5	5	4-5	3-4

[1] Safety factor equals the minimum yield strength of the material divided by the applied stress.

6.2 Weldment class selection guide. The class of weldment and related safety factor have been established on the basis that, as safety increases, certain amounts of reduction in effective cross section of the weld or material can be tolerated. However, selection of a particular class of weldment for a design should be based not only on the safety factor in the design, but also on the severity of service and the seriousness of the consequence, if failure should occur. Any weldment, the failure of which should be classed as critical or which is subjected to severe service conditions of impact or vibration, should be rated class 3 or higher (class 2 and class 1) in order to take advantage of inspection methods adequate to detect serious defects and to limit such defects to a safe level regardless of the safety factor. Conversely, if a weldment with a

high safety factor is not subject to severe service conditions and its failure is not classified as critical, such a weldment should not be rated higher than class 4. This avoids unnecessarily increasing the cost by over inspection and repair, or rejection on the basis of noncritical defects. Consideration should also be given to establishing separate classes for different parts of the weldment in order to avoid over classification of unimportant parts.

6.3 Ordering data. Procurement documents should specify the following as applicable:

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

(b) Identification of weldments being ordered

(c) Quantity required

(d) Class of weldment (see 1.2 and 6.2

(e) Ultrasonic inspection, if required (see 4.3.3)

(f) Inspection reports required (see 4.6.1)

(g) Level of preservation and packaging required (see 5.1)

(h) Level of packaging required (see 5.2)

(i) Special marking required (see 5.3)

(j) Title, date, and number of detail procurement specification, if applicable

(k) Other pertinent data peculiar to the weldments being ordered

(l) Severity of service condition expected for the weldments being procured.

6.4 Manufacturing drawings. The procuring agency will supply one set of blueprints and one set of transparencies of all the applicable manufacturing drawings and sketches with the initial award of any item of the contract.

6.5 Supersession data. This specification supersedes the requirements of the following NAVORD OS's: OS 1132, OS 1135, OS 1172, OS 1188, OS 1196, OS 1253, and OS 1367.

Custodian:
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