

MIL-STD-1890(AT)
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SUPERSEDING
(see 6.5)

MILITARY STANDARD
WELDED JOINTS, INSPECTION OF



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MIL-STD-1890(AT)

DEPARTMENT OF DEFENSE
Washington, DC 20301

Welded Joints, Inspection of

MIL-STD-1890(AT)

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FOREWORD

This Military standard establishes the requirements for the nondestructive inspection of welded joints used in the manufacture of gas turbine tank engine components.

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1. SCOPE

1.1 Scope. This standard covers the requirements for the nondestructive inspection of the five basic types of welded joints and modifications used in the manufacture of gas turbine tank engine components.

1.1.1 Type. Basic types of joints referenced are:

- a. Butt
- b. Corner
- c. Edge
- d. Lap
- e. Tee

1.1.2 Welding processes. Processes categorized within groups that are incorporated in this standard are as follows:

Group	Welding process	Letter designation
Arc welding (AW)	Gas tungsten arc (manual or automatic)	GTAW (MA or AU)
	Gas metal arc (manual or automatic)	GMAW (MA or AU)
	Shielded metal arc	SMAW
	Submerged arc	SAW
	Plasma arc	PAW
	Atomic hydrogen	AHW
Oxyfuel gas Welding (OFW)	Oxyacetylene welding	OAW
Resistance Welding (RW)	Resistance - seam welding	RSEW
	Resistance - spot welding	RSW

1.2 Classification. Weld joints shall be classified as follows:

- Class 1 - Joints subject to high stress or fatigue loading.
- Class 2 - Joints subject to intermediate stresses or fatigue loading.
- Class 3 - Joints subject to intermediate stresses.
- Class 4 - Joints subject to low stresses.

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2. REFERENCED DOCUMENTS

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

SPECIFICATIONS
MILITARY

- | | |
|------------|--|
| MIL-I-6866 | - Inspection, Penetrant Method of. |
| MIL-I-6868 | - Inspection Process, Magnetic Particle. |
| MIL-W-6858 | - Welding, Resistance: Spot and Seam. |

STANDARDS
MILITARY

- | | |
|--------------|---|
| MIL-STD-410 | - Nondestructive Testing Personnel, Qualification and Certification. |
| MIL-STD-453 | - Inspection, Radiographic. |
| MIL-STD-1264 | - Radiographic Inspection for Soundness of Welds in Steel by Comparison to Graded ASTM E-390 Reference Radiographs. |
| MIL-STD-1875 | - Ultrasonic Inspection, Requirement for. |

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

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

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

- | | |
|------------|--|
| ASTM E 390 | - Steel Fusion Welds, Reference Radiographs for. |
|------------|--|

(Copies of the above publications may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

AMERICAN WELDING SOCIETY (AWS)

- | | |
|-----------|---|
| AWS A 2.4 | - Symbols for Welding and Nondestructive Testing. |
| AWS A 3.0 | - Welding Terms and Definitions. |

Welding Handbook, Sixth and Seventh Editions

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(Copies of the above publications may be obtained from the American Welding Society, Inc., 550 N. W. LeJeune Road, P.O. Box 351040, Miami FL 33135.)

(Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

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3. Definitions. Definitions of welding symbols and terms used herein shall conform to AWS A 2.4 and AWS A 3.0 respectively.

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4. GENERAL REQUIREMENTS

4.1 Inspection sequence and methods. Inspection of welded joints shall be done at a point where the entire joint is accessible for examination. It may be performed at the subassembly or assembly level. Inspection procedures shall be done in the most appropriate sequence and by personnel qualified and certified in accordance with MIL-STD-410.

4.1.1 Visual inspection. All welded joints shall be visually examined to determine conformance to the acceptance criteria. Parts requiring heat treatment shall be examined before and after performing this operation.

4.1.2 Fluorescent penetrant inspection. All welded joints in non-magnetic materials and materials welded with non-magnetic filler material shall be fluorescent penetrant inspected in accordance with MIL-I-6866 to determine conformance to the acceptance criteria. Should the parts require heat treatment, the inspection shall be immediately after that operation.

4.1.3 Magnetic particle inspection. All welded joints in magnetic materials and materials welded with magnetic filler material, shall be magnetic particle inspected in accordance with MIL-I-6868 to determine conformance to the acceptance criteria. Should the parts require heat treatment, the inspection shall be immediately after that operation.

4.1.4 Radiographic and ultrasonic inspection. Unless otherwise specified on the engineering drawing, all welded joints shall be radiographically or ultrasonically inspected in accordance with MIL-STD-453 and MIL-STD-1875 to determine conformance to the acceptance criteria. Should the parts require heat treatment, the inspection shall be immediately before that operation.

4.1.4.1 Frequency of inspection. Frequency of inspection shall be based on weld joint classification (see 1.2) as follows:

- a. Class 1 weld joints. All Class 1 welded joints shall be radiographically or ultrasonically inspected.
- b. Class 2 weld joints. All Class 2 welded joints shall be radiographically or ultrasonically inspected until the quality level satisfactory to the acquisition agency has been established. At that point a sampling plan may be instituted by the acquisition activity.
- c. Class 3 weld joints. All Class 3 welded joints shall be radiographically or ultrasonically inspected until the quality level of the joint is established. At that point a sampling plan may be instituted by the acquisition activity on the arc and oxyfuel gas welding processes.
- d. Class 4 weld joint. Class 4 welded joints shall not require radiographic or ultrasonic inspection.

4.1.5 Pressure test. When required, pressure tests shall be performed in the proper sequence to determine conformance to the engineering requirements.

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5. DETAIL REQUIREMENTS

5.1 Acceptance criteria.

5.1.1 Arc (AW) and oxyfuel gas (OFW) welds. Welds resulting from fusion occurring in these processes (see 1.1.2) shall conform to the following:

- a. Weld beads shall be reasonably smooth and free from irregularities and shall blend into the parent metal in smooth gradual curves.
- b. The weld shall show complete fusion without an excess of overlapping.
- c. Edge weld penetration shall be at least equal to or exceed the thickness of the thinner material and shall slightly overlap the outer edges of adjacent material to insure the weld cross sectional area requirement.
- d. The fillet weld size and intermittent or tack weld length shall not be in excess of 1.5 times the value specified on the engineering drawing.
- e. The surface imperfections of welds shall be in accordance with the limits of acceptability stated in table I and II.
- f. Scratches resulting from arc welding shall not be evidenced on adjacent part areas.
- g. Dimensional allowances for flush and convex welds shall be as follows:

<u>Nom. stock thickness inches</u>	<u>Flush weld allowance</u>	<u>Convex weld allowance</u>
0.000 to 0.030	0% to +20%	+10% to +60%
0.031 to 0.080	0% to +15%	+10% to +50%
0.081 to 0.156	0% to +10%	+10% to +40%
0.157 and over	0% to +0.02 in. max.	+10% to 0.12 in. max.

- h. Dimensional allowance for butt welds on the crown and underbead is a maximum of one third the thickness of the thinner material.
- i. Cracks, incomplete penetration or fusion, porosity and voids, and metallic and non-metallic inclusions shall be in accordance with the limits stated in table III and IV. Comparison reference radiographs are available from ASTM E 390 and MIL-STD-1264.

5.1.2 Resistance (RW) welds. Welds resulting from these processes (see 1.1.2) shall conform to the following:

- a. The centerline of the material overlap shall be the centerline of the spot or seam weld.
- b. The spot and seam welds shall be aligned within 0.060 inch of the centerline.
- c. Seam welds shall terminate within 0.120 inch of the ends of the weld run.

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- d. The surface imperfections of welds shall be in accordance with the limits stated in table V.
- e. There shall be no evidence of arc or oxyfuel gas weld methods in association with resistance welding.
- f. Cracks, porosity and voids, metal expulsion between sheets and surface flashes shall be in accordance with the limits stated in table VI (see also MIL-W-6858).

5.2 Rejection. Parts containing discontinuities or defects exceeding the permissible limits of the applicable specification, drawing, standard, or directive shall be separated from the acceptable material, appropriately identified as discrepant, and submitted for material review as may be provided in the contract.

5.3 Rework. Weld rework which will restore weld areas to meet all engineering drawing requirements shall only be done to the extent specified herein and with concurrence of the acquisition authority. Request for approval must be submitted in writing and shall encompass all pertinent data relative to the reason for rework, location and size of defect, and the procedure to be used in rework.

5.3.1 Repetition. Weld rework shall not be done to any one area more than twice without acquisition activity authority.

5.3.2 Material removal. Care shall be exercised to insure that the parent metal is not removed during the rework operations. For resistance welded parts, weld rework shall be confined to the nugget area. When the height of an arc or oxyfuel gas weld bead causes dimensional interference with mating parts, the weld(s) may be ground to fit.

5.3.3 Stress relief. Stress relief of rework weldments shall be performed in accordance with the requirements specified on the engineering drawing.

5.3.4 Other weld rework. All other types of weld rework, i.e., replacement of details and rework using processes other than shown in 1.1.2 shall require approval of the acquisition authority.

5.3.5 Inspection. All weld rework shall be inspected in accordance with the applicable requirements of 4.1.

5.4 Reports of inspection. Unless otherwise specified, the contracting agency responsible for the inspections specified herein shall furnish the acquisition activity certified results of the complete evaluation. Documentation signed by an NDT Level II or Level III inspector (see MIL-STD-410) shall be available to the acquisition authority at all times. The reports shall list the purchase order number or equivalent identification, the number of parts, and the date of test. Each part shall be listed by part number, serial number (when applicable), serial number of the test, and rated condition of the part (accepted or rejected).

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5.5 Records retention. Unless otherwise specified, the contracting agency responsible for the inspections specified herein shall prepare and maintain on file for a period of not less than 4 years, results of tests, and records of the requirements and techniques involved for the inspection of each part number. This documentation shall be available to the Government representative upon reasonable notification.

5.6 Marking.

5.6.1 Acceptable parts. Parts which conform satisfactorily to applicable inspection requirements shall be marked in a manner and location harmless to the part that will preclude removal, smearing, or obliteration by subsequent handling. When processing which would remove identification is planned, the applicable symbol shall be affixed to the records accompanying the parts.

5.6.2 Impression stamping. Impression stamping shall be used where permitted by the applicable specifications or drawings. Marking shall be located in areas adjacent to the part number or the Government inspector stamp.

5.6.3 Etching. When applicable parts shall be marked by etching, suitable etchants and application methods shall be employed. Etching methods other than fluid etching may be used.

5.6.4 Dyeing. Where etching or impression stamping is not appropriate, identification may be accomplished by dyeing.

5.6.5 Other identification. Other means of identification such as tagging may be applied to completely ground and polished parts for which construction, finish or functional requirement preclude the use of etching, stamping, or dyeing.

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6. NOTES

6.1 Intended use. The procedures covered in this standard are intended to be used to insure that joints welded in accordance with the processes of 1.1.2 shall meet the inspection requirements of 4.1.

6.2 Post machining. Welded joints inspected in-process prior to machining of the weld, shall require visual and fluorescent penetrant or magnetic particle inspection after machining operations.

6.3 Physical limitations. When part configuration or size make magnetic particle inspection impractical, the weld joint may be inspected by fluorescent penetrant method providing approval has been given in writing by the responsible acquisition agency.

6.4 Straightening. Parts distorted as a result of excessive overall or localized heat input during welding, may be straightened provided they are not in the heat treated condition. Parts shall be fluorescent penetrant or magnetic particle inspected for cracks after the straightening operation.

6.5 Supersession. This document supersedes AVCO-Lycoming specification P6804H, dated 26 April 1982.

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Preparing activity:
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(Project No. NDTI-A045)

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TABLE I. Visual, fluorescent penetrant and magnetic particle inspection acceptance limits for arc or oxyfuel gas welded joints (iron, nickel and cobalt base alloys).

Type of defect	Class 1	Class 2	Class 3	Class 4
Cracks and crack-like indications	U	U	U	U
Incomplete penetration & fusion	U	U	U	U
Surface porosity				
Max. size "D"	U	T/4 up to 0.060 max.	T/3 up to 0.080 max.	T/3 up to 0.100 max.
Max. total	U	2 of max. size or equivalent length	3 of max. size	5 of max. size or equivalent length
Min. distance between indications	U	4D	3D	2D
Undercutting				
Max. depth	U	T/20	T/15	T/10
Max. length	U	10T in 50T	10T in 20T	10T in 20T

U - Unacceptable.

T - Thickness of thinnest base material.

D - Diameter of largest dimension of defect(s).

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TABLE II. Visual and fluorescent penetrant inspection acceptance limits for arc welded joints (aluminum, magnesium, copper and titanium base alloys).

Type of defect	Class 1	Class 2	Class 3	Class 4
Cracks and crack-like indications	U	U	U	U
Incomplete penetration & fusion	U	U	U	U
Surface porosity				
Max. size "D"	U	T/3 up to 0.060 max.	T/2 up to 0.080 max.	T/2 up to 0.100 max.
Max. total length per linear inch	U	4 of max. size or equivalent length	5 of max. size or equivalent length	5 of max. size or equivalent length
Min. distance between indications	U	3D	2D	1D
Undercutting				
Max. depth	U	T/20	T/15	T/10
Max. length	U	10T in 20T	10T in 20T	10T in 20T

U - Unacceptable.

T - Thickness of thinnest base material.

D - Diameter of largest dimension of defect(s).

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TABLE III. Radiographic and ultrasonic inspection acceptance limits for arc or oxyfuel gas welded joints (iron, nickel and cobalt base alloys).

Type of defect	Class 1	Class 2	Class 3
Cracks (weld and base material), including cavities or inclusions with a tail	U	U	U
Incomplete penetration & fusion	U	Butt and corner welds: U Fillet welds: max length - 4T in any 10T length of weld, or 40% of joint length, whichever is less. Plug: 20% along crcmf.	Butt and corner welds: U Fillet welds: max length - 10T in any 20T length of weld, or 50% of joint length, whichever is less. Plug: 50% along crcmf.
Porosity & voids			
Max. size "D"	T/3 up to 0.060 max.	T/2 up to 0.080 max.	T/2 up to 0.100 max.
Max. total length per linear inch	2 of max. size or equivalent length	3 of max. size or equivalent length	6 of max. size or equivalent length
Min. distance between indications	5D	4D	3D
Metallic and non-metallic Inclusions			
Max. size "D"	T/3 up to 0.060 max.	T/2 up to 0.080 max.	T/2 up to 0.100 max.
Max. total length	2 of max. size or equivalent length	3 of max. size or equivalent length	4 of max. size or equivalent length
Min. distance between indications	5D	4D	3D

U - Unacceptable.

T - Thickness of thinnest base material.

D - Diameter of largest dimension of defect(s).

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TABLE IV. Radiographic and ultrasonic inspection acceptance limits for arc welded joints (aluminum, magnesium, copper and titanium base alloys).

Type of defect	Class 1	Class 2	Class 3
Cracks (weld and base material), including cavities or inclusions with a tail	U	U	U
Incomplete penetration & fusion	U	Butt and corner welds: U Fillet welds: max length - 4T in any 10T length of weld, or 40% of joint length, whichever is less.	Butt and corner welds: U Fillet welds: max length - 10T in any 20T length of weld, or 50% of joint length, whichever is less.
Coarse porosity & voids Max. size "D" Max. total length per linear inch Min. distance between indications	 T/2 up to 0.060 max. 3 of max. size or equivalent length 4D	 T/2 up to 0.100 max. 6 of max. size or equivalent length 2D	 T/2 up to 0.100 max. 10 of max. size or equivalent length 1D
Fine porosity Max. size "D" Max. total length per linear inch Min. distance between indications	 T/5 up to 0.015 max. 20 of max size or equivalent length 2D	 T/5 up to 0.015 max. no limit 1D	 T/5 up to 0.025 max. no limit 1D

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TABLE IV. Radiographic and ultrasonic inspection acceptance limits for arc welded joints (aluminum, magnesium, copper and titanium base alloys) - Continued.

Type of defect	Class 1	Class 2	Class 3
Metallic and non-metallic inclusions			
Max. size "D"	T/3 up to 0.060 max.	T/2 up to 0.080 max.	T/2 up to 0.100 max.
Max. total length per linear inch	2 of max. size or equivalent length	3 of max. size or equivalent length	4 of max. size or equivalent length
Min. distance between indications	5D	4D	3D

U - Unacceptable.

T - Thickness of thinnest base material.

D - Diameter of largest dimension of defect(s).

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TABLE V. Visual, fluorescent penetrant and magnetic particle inspection acceptance limits for resistance welded joints (all alloys).

Type of defect	Class 1		Class 2		Class 3	
	Spot	Seam	Spot	Seam	Spot	Seam
Cracks or crack-like indications	U	U	U	U	U	U
Surface pits (or clusters)						
Max. size "D"	0.040 inch	0.040 inch	0.060 inch	0.060 inch	0.060 inch	0.060 inch
Max. number	10% of N	3 per linear inch or equivalent length	20% of N	5 per linear inch or equivalent length	30% of N	5 per linear inch or equivalent length
Electrode Pickup Max. acceptance	2% of N	2% of joint length and/or W per linear inch	3% of N	3% of joint length and/or W per linear inch	5% of N	5% of joint length and/or W per linear inch
Sheet Separation Max. acceptable length	3% of N	3% of joint length and/or 3W max length	10% of N	10% of joint length and/or 5W max length	20% of N	20% of joint length and/or 5W max length
Max. acceptable separation	0.005 or T/10 whichever ever is greater	0.005 or T/10 whichever ever is greater	0.005 or T/10 whichever ever is greater	0.005 or T/10 whichever ever is greater	0.005 or T/10 whichever ever is greater	0.005 or T-10 whichever ever is greater
Excessive Indentation:						
Max. Acceptable	3% of N	3% of joint length and/or W per linear inch	10% of N	10% of joint length and/or W per linear inch	20% of N	20% of joint length and/or W per linear inch

U - Unacceptable.

D - Diameter of largest dimension of defect.

W - Weld nugget diameter.

N - Number of spotwelds in the joint.

T - Thickness of thinnest sheet.

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TABLE VI. Radiographic and ultrasonic inspection acceptance limits for resistance welded joints (all alloys, except as noted [1]).

Type of defect	Class 1		Class 2 (1)		Class 3 (1)	
	Spot	Seam	Spot	Seam	Spot	Seam
Cracks	U	U	U	U	U	U
Fine porosity:						
Max. size "D"	0.010 inch	0.010 inch	0.015 inch	0.015 inch	0.025 inch	0.025 inch
Max. number of indications	2 indications per spot in 30% of N	5 per linear inch	2 per spot in 50% of N	10 per linear inch	2 per spot in 50% of N	15 per linear inch
Min. distance between indications	2D	2D	ID	ID	ID	ID
Void and large porosity:						
Max. size	W/4	W/4	W/2	W/2	W/2	W/2
Max. number of indications	in 25% of N, 2 successive spots	3 of max size per linear inch or equivalent length	in 35% of N, 4 successive spots	3 of max size per linear inch or equivalent length	in 50% of N, 6 successive spots	5 of max size per linear inch or equivalent length
Limits of extension within the nugget	to within 15% of W of fusion line	to within 15% of W of fusion line	to within 10% of W of fusion line	to within 10% of W of fusion line	to within 5% of W of fusion line	to within 5% of W of fusion line
Min. distance between indications	ID	ID	ID	ID	ID	ID

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TABLE VI. Radiographic and ultrasonic inspection acceptance limits for resistance welded joints (all alloys, except as noted (1)) - Continued.

Type of defect	Class 1		Class 2 (1)		Class 3 (1)	
	Spot	Seam	Spot	Seam	Spot	Seam
Metal expulsion between sheets (spits) and surface flashes - max acceptable						
Nickel and cobalt base alloys	30% of N	6 per linear inch	50% of N	10 per linear inch	60% of N	15 per linear inch
All other alloys	10% of N	3 per linear inch	25% of N	5 per linear inch	35% of N	10 per linear inch

U - Unacceptable.

D - Diameter of largest dimension of defect.

W - Weld nugget diameter.

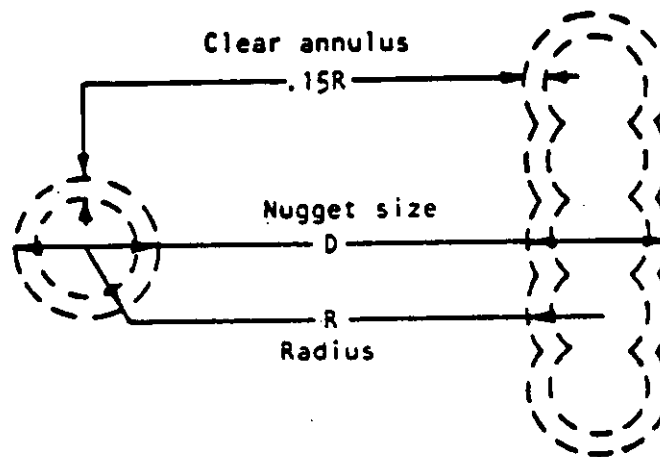
N - Number of spotwelds in the joint.

T - Thickness of thinnest sheet.

Notes:

(1) See Figure 1. (reference MIL-W-6858)

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**Note:**

1. No part shall be acceptable when the number of welds having cracks, pores, or instances of incomplete fusion with a linear dimension greater than $0.15D$ or that extend into the $0.15R$ clear annulus area, exceeds 6 percent of the total number of welds in the part.

FIGURE 1. Radiographic criteria for spot and seam welds.

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