

NOT MEASUREMENT  
SENSITIVE

MIL-STD-1890A(AT)  
21 November 1991  
SUPERSEDING  
(see 6.3)

MILITARY STANDARD  
WELDED JOINTS, INSPECTION OF



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MIL-STD-1890A(AT)

FOREWORD

1. This Military Standard is approved for use by U.S. Army Tank-Automotive Command, Department of the Army, and is available for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: U.S. Army Tank-Automotive Command, ATTN: AMSTA-GDS, Warren, MI 48397-5000, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document, or by letter.

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

## MIL-STD-1890A(AT)

## CONTENTS

Paragraph		Page
1.	SCOPE . . . . .	1
1.1	Scope . . . . .	1
1.1.1	Types . . . . .	1
1.1.2	Welding processes by group . . . . .	1
1.2	Classification . . . . .	1
2.	APPLICABLE DOCUMENTS . . . . .	2
2.1	Government documents . . . . .	2
2.1.1	Specifications, standards, and handbooks . . . . .	2
2.2	Non-Government publications . . . . .	2
2.3	Order of precedence . . . . .	3
3.	DEFINITIONS . . . . .	4
3.1	Definitions . . . . .	4
4.	GENERAL REQUIREMENTS . . . . .	5
4.1	Inspection sequence and methods . . . . .	5
4.1.1	Visual inspection . . . . .	5
4.1.2	Fluorescent penetrant inspection . . . . .	5
4.1.3	Magnetic particle inspection . . . . .	5
4.1.4	Radiographic and ultrasonic inspection . . . . .	5
4.1.4.1	Frequency of inspection . . . . .	5
4.1.5	Pressure test . . . . .	6
4.2	Responsibility for inspection . . . . .	6
5.	DETAILED REQUIREMENTS . . . . .	7
5.1	Production in process control . . . . .	7
5.2	Acceptance criteria . . . . .	7
5.2.1	Arc and oxyfuel gas welds . . . . .	7
5.2.2	Resistance welds . . . . .	8
5.3	Rejection . . . . .	8
5.4	Rework . . . . .	8
5.4.1	Repetition . . . . .	8
5.4.2	Material removal . . . . .	8
5.4.3	Stress relief . . . . .	8
5.4.4	Other weld rework . . . . .	8
5.4.5	Inspection . . . . .	9
5.5	Marking . . . . .	9
5.5.1	Acceptable parts . . . . .	9
5.5.2	Impression stamping . . . . .	9
5.5.3	Etching . . . . .	9
5.5.4	Dyeing . . . . .	9
5.5.5	Other identification . . . . .	9
6.	NOTES . . . . .	10
6.1	Intended use . . . . .	10
6.2	Issue of DODISS . . . . .	10
6.3	Data requirements . . . . .	10

## MIL-STD-1890(AT)

## CONTENTS

<u>Paragraph</u>		<u>Page</u>
6.4	Supersession data . . . . .	10
6.5	Post machining . . . . .	10
6.6	Physical limitations . . . . .	10
6.7	Straightening . . . . .	10
6.8	Subject term (key word) listing . . . . .	10
6.9	Changes from previous issue . . . . .	10

<u>Table</u>		<u>Page</u>
I.	Visual, fluorescent penetrant and magnetic particle inspection acceptance limits for arc or oxyfuel gas welded joints (iron, nickel, and cobalt base alloys) . . . . .	10
II.	Visual and fluorescent penetrant inspection acceptance limits for arc welded joints (aluminum, magnesium, copper, and titanium base alloys) . . . . .	11
III.	Radiographic and ultrasonic inspection acceptance limits for arc or oxyfuel gas welded joints (iron, nickel, and cobalt base alloys) . . . . .	12
IV.	Radiographic and ultrasonic inspection acceptance limits for arc welded joints (aluminum, magnesium, copper, and titanium base alloys) . . . . .	13
V.	Visual, fluorescent penetrant and magnetic particle inspection acceptance limits for resistance welded joints (all alloys) . . . . .	15
VI.	Radiographic and ultrasonic inspection acceptance limits for resistance welded joints (all alloys, except as noted) . . . . .	16

Figure

1	Radiographic criteria for spot and seam welds . . . . .	18
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## MIL-STD-1890A(AT)

## 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) Gas metal arc (manual or automatic) Shielded metal arc Submerged arc Plasma arc Atomic hydrogen	GTAW (MA or AU) GMAW (MA or AU) SMAW SAW PAW AHW
Oxyfuel gas Welding (OFW)	Oxyacetylene welding	OAW
Resistance Welding (RW)	Resistance - seam welding Resistance - spot welding	RSEW 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.

## MIL-STD-1890A(AT)

## 2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

## SPECIFICATION

## MILITARY

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 E390 Reference Radiographs.  
 MIL-STD-1875 - Ultrasonic Inspection, Requirement for.  
 MIL-STD-1949 - Inspection, Magnetic Particle.  
 MIL-STD-6866 - Inspection, Liquid Penetrant.

(Unless otherwise indicated, copies of military specifications, standards, and handbooks are available from the Naval Publications and Printing Service Office, Standardization Document Order Desk, Bldg. 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

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

## AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM E390 - Standard Reference Radiographs for Steel Fusion Welds.

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103-1187.)

MIL-STD-1890A(AT)

AMERICAN WELDING SOCIETY (AWS)

- AWS A2.4 - Standard Symbols for Welding, Brazing and Nondestructive Examination.
- AWS A3.0 - Welding Terms and Definitions Including Terms for Brazing Soldering Thermal Spraying and Thermal Cutting.

Welding Handbook, Sixth and Seventh Editions.

(Application for copies should be addressed to the American Welding Society, 550 N.W. LeJeune Road, P.O. Box 351040, Miami, FL 33135.)

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

MIL-STD-1890A(AT)

3. DEFINITIONS

3.1 Definitions. Definitions of welding symbols and terms used herein shall conform to AWS A2.4 and AWS A3.0 respectively.



## MIL-STD-1890A(AT)

## 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-STD-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-STD-1949 to determine conformance to the acceptance criteria. At completion of inspection the parts or assemblies shall be de-magnetized. 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.

MIL-STD-1890A(AT)

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

4.2 Responsibility for inspection. The contractor is responsible to conduct complete and sufficient inspection to ensure:

- a. Compliance with all of the requirements in this standard.
- b. That adequate traceability exists for the Government to verify that the requirements of this standard have been met.
- c. That the manufacturing facility/supplier has the capability to weld the item in conformance with the process procedures/ techniques of this standard.

## MIL-STD-1890A(AT)

## 5. DETAILED REQUIREMENTS

5.1 Production in process control. The contractor shall ensure that the supplier identifies the part number of its welded item to the following:

- a. Engineering drawing and revision.
- b. Quantity of items in the lot.
- c. Applicable issue and revision of this standard.

5.2 Acceptance criteria.

5.2.1 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</u> <u>thickness inches</u>	<u>Flush weld</u> <u>allowance</u>	<u>Convex weld</u> <u>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 under-bead 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 E390 and MIL-STD-1264.

## MIL-STD-1890A(AT)

5.2.2 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.
- 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).
- g. When the nugget size is not specified in the engineering drawing, the minimum nugget size shall be in accordance with MIL-W-6858.
- h. A maximum of 5 gap areas between indentations circumferential weld joints shall be permitted provided no individual gap exceeds 0.060 inch and the cumulative total of all gaps per joint does not exceed 0.250 inch.

5.3 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.

5.4 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.

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

5.4.2 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.

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

5.4.4 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.

MIL-STD-1890A(AT)

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

5.5 Marking.

5.5.1 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.

5.5.2 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.

5.5.3 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.

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

5.5.5 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.

## MIL-STD-1890(AT)

## 6. NOTES

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

6.1 Intended use. The procedure 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 Issue of DODISS. When this standard is used in acquisition, the applicable issue of the DODISS must be cited in the solicitation (see 2.1.1 and 2.2).

6.3 Data requirements. Although this standard does not include any requirements for data, it does not exclude contractors from obtaining data from its suppliers as required to ensure compliance to this standard and to verify conformance to the applicable engineering drawings.

6.4 Supersession data. This standard supersedes MIL-STD-1890(AT), dated 17 June 1985 and Textron Lycoming specification P6804K, dated 21 September 1987.

6.5 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.

6.6 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.

6.7 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.

6.8 Subject term (key word) listing.

Arc welding  
Etching  
Resistance welding  
Stress relief

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

## MIL-STD-1890A(AT)

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).

## MIL-STD-1890A(AT)

TABLE II. Visual and fluorescent penetrant and inspection acceptance limits for arc or 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).



## MIL-STD-1890A(AT)

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).

## MIL-STD-1890A(AT)

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"	T/2 up to 0.060 max.	T/2 up to 0.100 max.	T/2 up to 0.100 max.
Max. total length per linear inch	3 of max. size or equivalent length	6 of max. size or equivalent length	10 of max. size or equivalent length
Min. distance between indications	4D	2D	1D
Fine porosity			
Max. size "D"	T/5 up to 0.015 max.	T/5 up to 0.015 max.	T/5 up to 0.025 max.
Max. total length per linear inch	20 of max. size or equivalent length	no limit	no limit
Min. distance between indications	2D	1D	1D

## MIL-STD-1890A(AT)

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 0.080 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).

## MIL-STD-1890A(AT)

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

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% on 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.

## MIL-STD-1890A(AT)

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		Class 3	
	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	1D	1D	1D	1D
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	1D	1D	1D	1D	1D	1D

## MIL-STD-1890A(AT)

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		Class 3	
	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.

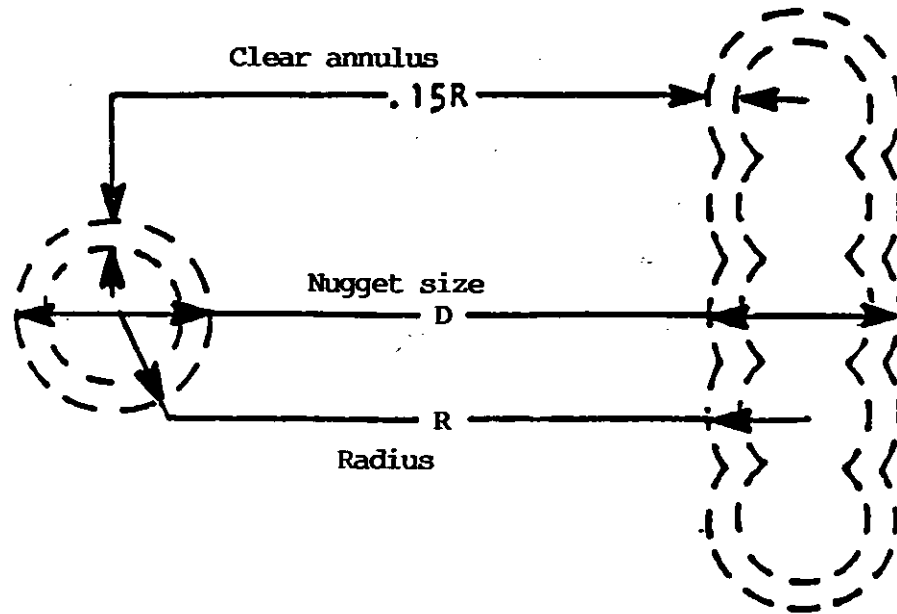
N - Number of spotwelds in the joint.

T - Thickness of thinnest sheet.

Notes:

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

## MIL-STD-1890A(AT)



## 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 in aluminum and aluminum alloys.

MIL-STD-1890A(AT)

Custodian:  
Army - AT

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(Project NDTI-A074)



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MIL-STD-1890A(AT); Welded Joints, Inspection of

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