MSFC-SPEC-259A
April 9, 1965
SUPERSEDING
MSFC-SPEC-259
November 16, 1962

GEORGE C. MARSHALL SPACE FLIGHT CENTER

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPECIFICATION

RADIOGRAPHIC INSPECTION: SOUNDNESS REQUIREMENTS FOR FUSION WELDS IN ALUMINUM AND MAGNESIUM ALLOY SHEET AND PLATE MATERIAL (SPACE VEHICLE COMPONENTS)

This specification has been approved by the George C. Marshall Space Flight Center (MSFC) and is available for use by MSFC and associated contractors.

1. SCOPE

1.1 This specification establishes requirements for acceptance or rejection of welds on the basis of radiographic inspection only. It in no way relieves or reduces requirements for visual or other inspections specified in other applicable documents.

2. APPLICABLE DOCUMENTS

2.1 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 proposals shall apply.

STANDARDS

Military

MIL-STD-453	Inspection, Radiographic.

George C. Marshall Space Flight Center

MSFC-STD-397 Radiographic Laboratory Qualification.

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

3. REQUIREMENTS

3.1 Qualification. - Radiographic equipment, laboratory facilities, and procedures shall conform to Standards MIL-STD-453 and MSFC-STD-397.

3.2 Equipment.

3.2.1 X-ray machines. - X-ray machines shall be capable of making radiographs with a sensitivity (see 6.3) of 2 percent or better.

3.2.2 Penetrameters. - Unless otherwise specified by the procuring activity, penetrameters shall be in accordance with Standards MIL-STD-453 and MSFC-STD-397.

3.2.3 Radiograph film. - Production radiographs shall be made with an acceptable safety film of fine grain (see 6.3) on material at least 1/2-inch thick or very fine grain (see 6.3) on material less than 1/2 inch.

3.3 Procedures.

3.3.1 Radiographic procedures. - Unless otherwise specified by the procuring activity, radiographic procedures shall be in accordance with Standards MIL-STD-453 and MSFC-STD-397.

3.3.2 Focal film distance. - Maximum feasible focal spot-to-film distance shall be used for all exposures to obtain best definition. Unless otherwise specified by the procuring activity, minimum focal spot-to-film distance shall be 36 inches.

3.3.3 Film density. - H and D density (see 6.3) of the radiographs of the welds covered by this specification shall be not less than 1.50 nor greater than 3.00.

4. QUALITY ASSURANCE

4.1 Soundness requirements.

4.1.1 Cracks. - Cracks in the weld bead or base metal shall be unacceptable.

4.1.2 Fusion. - Incomplete fusion between the base metal and the weld bead or between weld beads in multiple pass welding shall be unacceptable.

4.1.3 Penetration. - Unless otherwise specified on applicable drawings, incomplete penetration shall be unacceptable.

4.1.4 Undercutting. - Undercutting, though detectable by radiography, shall be evaluated mechanically. Undercutting shall be unacceptable under the following conditions:

(a) In a weld where undercutting occurs as a sharp notch that acts as a stress-riser.

(b) In welds where undercutting occurs as a smooth or rounded depression exceeding 5 percent (see 6.3) in depth.

4.2 Porosity. - The acceptability of isolated, scattered, or clustered porosity shall be determined by the following procedure:

(a) The diameter of each pore shall be measured in inches using an optical comparator or similar instrument.

(b) The measured diameter shall then be squared (multiplied by itself).

(c) This squared diameter number shall be used to determine acceptability by applying the rules listed in 4.2.1 and 4.2.2.

(d) The squared diameter number for elongated or irregularly shaped porosity can be determined by considering the longest dimension as the diameter; or by considering the pore as a rectangle, multiplying the long dimension by the short dimension, and taking three-fourths of the resulting number.

4.2.1 Class I welds. - Isolated, scattered, and clustered porosity in class I welds (see 6.3) shall be evaluated for conformance to rule 1 below. If a weld area fails to meet the requirements of rule 1, the area in question shall be evaluated for conformance to rule 2. If a weld area fails to meet the requirements of both rule 1 and rule 2, the area in question shall be unacceptable. If a weld area conforms to the requirements of either rule 1 or rule 2, the area in question shall be acceptable.

(a) Rule 1. - The summation of the squared diameter numbers of pores in any (worst) linear inch of weld shall be equal to or less than the value listed under rule 1, in table I, that corresponds to the parent material thickness.

(b) Rule 2. - The summation of the squared diameter numbers of pores in any (worst) 20 t or 6 inches of weld, whichever is less, shall be equal to or less than the value listed under rule 2, table I, that corresponds to the parent material thickness.

4.2.2 Class II welds. - Isolated, scattered, and clustered porosity in class II welds (see 6.3) shall be evaluated for conformance to rule 3 below. If a weld area fails to meet the requirements of rule 3, the area in question shall be evaluated for conformance to rule 4. If a weld area fails to meet the requirements of both rule 3 and rule 4, the area in question shall be unacceptable. If a weld area conforms to the requirements of either rule 3 or rule 4, the area in question shall be acceptable.

(a) Rule 3. - The summation of the squared diameter numbers of all pores in any (worst) linear inch of weld shall be equal to or less than the value listed under rule 3 in table I that corresponds to the parent material thickness.

(b) Rule 4. - The summation of the squared diameter numbers of pores in any (worst) 20 t or 6 inches of weld, whichever is less, shall be equal to or less than the value listed under rule 4, in table I, that corresponds to the parent material thickness.

4.2.3 Connected porosity. - Connected porosity shall be considered as a single void.

4.2.4 Overlapping porosity. - Overlapping porosity, when not connected, shall be considered as scattered porosity.

Table I. Diameter squared values,

Parent metal thickness	Maximum total value, diameter squared			
	Rule 1	Rule 2	Rule 3	Rule 4
0.010 - 0.015	0.0000173	0.0000392	0.000392	0.0000692
0.016 - 0.020	0.0000360	0.0000820	0.0000820	0.0001440
0.021 - 0.025	0.0000593	0.0001323	0.0001323	0.0002372
0.026 - 0.030	0.0000865	0.0001960	0.0001960	0.0003540
0.031 - 0.040	0.0001440	0.0003240	0.0003240	0.0005760
0.041 - 0.050	0.0002250	0.0005063	0.0005063	0.0009000
0.051 - 0.060	0.0003500	0.0007463	0.0007465	0.0013396
0.061 - 0.090	0.0006250	0.0013463	0.0013463	0.002500
0.091 - 0.120	0.0012250	0.0021200	0.0021200	0.004900
0.121 - 0.160	0.001405	0.0028300	0.0028300	0.005590
0.161 - 0.200	0.001705	0.0036300	0.0036300	0.007200
0.201 - 0.250	0.002205	0.0045400	0.0045400	0.009000
0.251 - 0.300	0.002755	0.0055200	0.0055200	0.011000
0.301 - 0.360	0.003305	0.006650	0.006650	0.013190
0.361 - 0.420	0.003905	0.007890	0.007890	0.015600
0.421 - 0.490	0.004555	0.009150	0.009150	0.018200
0.491 - 0.560	0.005255	0.010290	0.010290	0.021000
0.561 - 0.640	0.006005	0.012100	0.012100	0.024000
0.641 - 0.730	0.006855	0.013850	0.013850	0.027400
0.731 - 0.820	0.007755	0.015500	0.015500	0.030900
0.821 - 0.910	0.008655	0.01730	0.01730	0.034700
0.911 - 0.999	0.009555	0.01920	0.01920	0.038100
1.000 & over	0.010000	0.02020	0.02020	0.040000

4.2.5 Linear porosity. - Porosity groupings of three or more cavities less than one diameter apart that can be joined by a straight line shall be considered linear porosity. Linear porosity in class I welds shall be unacceptable if the summation of the areas of the cavities exceeds that allowed by 4.2.1, or if the length of the line connecting the voids exceeds the requirements of table II.

Table II. Linear porosity, class I welds,

Thickness (t) inches	Length of linear porosity
0.040 through 0.300	0.250 inch
0.301 through 0.500	0.375 inch
0.501 through 1.000	0.500 inch
1.001 through 2.000	0.625 inch
2.001 through 4.000	1.000 inch
Over 4 inches	1.500 inches

Linear porosity in class II welds shall be unacceptable if the summation of the areas of the cavities exceeds that allowed by 4.2.2, or if the length of the line connecting the voids exceeds the requirements of table III.

Table III. Linear porosity, class II welds

Thickness (t) inches	Length of linear porosity
0.040 through 0.300	0.500 inch
0.301 through 0.500	0.750 inch
0.501 through 1.000	1.000 inch
1.001 through 2.000	1.250 inches
2.001 through 4.000	2.000 inches
Over 4 inches	3.000 inches

4.3 Inclusions of foreign material. - Inclusions of foreign material shall be considered porosity.

4.4 Sharp angle indications. - Indications (see 6.3) characterized by sharp angles including porosity with tails shall be unacceptable.

5. PREPARATION FOR DELIVERY

There are no applicable requirements.

6. NOTES

6.1 Intended use. - The acceptance criteria given herein are primarily intended to apply to space vehicle components; other items may, or may not, have lesser requirements.

6.2 Limitation. - Where requirements exist for weld quality exceeding the radiographic acceptance limits specified herein, these requirements will be specified in the contract or on drawings.

6.3 Definitions. - For the purpose of this specification, the following definitions shall apply:

6.3.1 Class I weld. - A critical weld whose failure could result in the failure of the system or function.

6.3.2 Class II weld. - A noncritical, low stressed weld.

6.3.3 Fine grain or very fine grain film. - X-ray film specifically designed for minimum graininess and so designated by the manufacturer.

6.3.4 H and D density. - Film density (blackening) expressed in terms of the Hurter and Driffield curve, which is defined as the logarithm of the reciprocal of the transparency of the film: density equals log $\frac{1}{T}$ (T = light transmission).

6.3.5 Indication. - Evidence of the radiograph of a defect in the weld, usually requiring interpretation to determine significance of the defect.

6.3.6 Sensitivity. - The ratio between the thickness of the smallest detectable defect and the thickness of the specimen, expressed as percent. (For example, an equipment and film combination capable of detecting a 0.02-inch defect in 2-inch plate would have a sensitivity of 1 percent.)

6.3.7 t. - The thickness of the material being welded. Where material of different thicknesses is being jointed, t refers to the thickness of the thinner plate.

Notice. - When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder, or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Custodian:	Preparing activity:
NASA - George C. Marshall Space Flight Center	George C. Marshall Space Flight Center

MSFC DOCUMENTATION REPOSITORY - DOCUMENT INPUT RECORD

I. GENERAL INFORMATION

1. APPROVED PROJECT:	2. DOCUMENT/ DRAWING NUMBER:	3. CONTROL NUMBER:	4. RELEASE DATE:	5. SUBMITTAL DATE:
	MSFC-SPEC-259A		4/9/65	

6. DOCUMENT/DRAWING TITLE: Radiographic Inspection: Soundness Requirements for Fusion Welds in Aluminum and Magnesium Alloy Sheet and Plate Material

7. REPORT TYPE:

8. CONTRACT NUMBER / PERFORMING ACTIVITY:

9. DRD NUMBER:

10. DPD / DRL / IDRD NUMBER:

11. DISPOSITION AUTHORITY (Check One):
- [x] Official Record - NRRS 8/121A
- [ ] Reference Copy - NRRS 8/5/A/3 (destroy when no longer needed)

12. SUBMITTAL AUTHORITY:

13. RELEASING AUTHORITY: MBCook

14. SPECIAL INSTRUCTIONS:

15. CONTRACTOR/SUBMITTING ORGANIZATION, ADDRESS AND PHONE NUMBER:

16. ORIGINATING NASA CENTER:

17. OFFICE OF PRIMARY RESPONSIBILITY:

18. PROGRAMMATIC CODE (5 DIGITS):

19. NUMBER OF PAGES:

II. ENGINEERING DRAWINGS

20. REVISION:	21. ENGINEERING ORDER:	22. PARTS LIST:	23. CCBD:

III. REPORTS, SPECIFICATIONS, ETC.

24. REVISION:	25. CHANGE:	26. VOLUME:	27. BOOK:	28. PART:	29. SECTION:
A					

30. ISSUE:	31. ANNEX:	32. SCN:	33. DCN:	34. AMENDMENT:

35. APPENDIX:	36. ADDENDUM:	37. CCBD:	38. CODE ID:	39. IRN:

IV. EXPORT AND DISTRIBUTION RESTRICTIONS

- [ ] Privacy Act (see MWI 1382.1)
- [ ] Proprietary (see MPD 2210.1)
- [ ] Patent (see MPG 2220.1)
- [ ] ITAR (see MPG 2220.1)
- [ ] EAR (see MPG 2220.1)
- [ ] Other ACI (see NPG 1620.1 and MPG 1600.1) _____
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V. ORIGINATING ORGANIZATION APPROVAL

40. ORG. CODE:	41. PHONE NUMBER:	42. NAME:	43. SIGNATURE/DATE:
ED32	544-9323	Linda Clark	Linda Clark 10/30/02

VI. TO BE COMPLETED BY MSFC DOCUMENTATION REPOSITORY

44. RECEIVED BY:	45. DATE RECEIVED:	46. WORK ORDER:
Tammy Wise	10-15-03	