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MSFC-STD-100
May 16, 1961

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

CASTINGS, ALUMINUM AND MAGNESIUM ALLOY,
RADIOGRAPHIC INSPECTION OF, ACCEPTANCE STANDARD FOR

1. SCOPE

1.1 Scope. - This standard establishes acceptance standards for aluminum and magnesium sand and permanent mold castings by the radiographic inspection method.

1.2 Classification. - Castings shall be classified as follows:

- | | |
|-------------|---|
| Grade I-F | A flight casting designed to function under engineered structural loading and pressurization in excess of one atmosphere during a flight mission. |
| Grade II-F | A flight casting designed to function under pressurization in excess of one atmosphere during a flight mission without the direct application of engineered structural loading. |
| Grade III-F | A flight casting designed to function primarily under engineered structural load or aerodynamic conditions, or both, during a flight mission. |
| Grade IV-F | All flight castings not defined under grades I-F, II-F, and III-F. |
| Grade I-G | A non-flight casting designed to function under engineered structural loading and pressurization in excess of one atmosphere. |

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| Grade IV-F | All flight castings not defined under grades I-F, II-F, and III-F. |
| Grade I-G | A non-flight casting designed to function under engineered structural loading and pressurization in excess of one atmosphere. |

MSFC-STD-100
AMENDMENT 1
August 17, 1966

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CASTINGS, ALUMINUM AND MAGNESIUM ALLOY,
RADIOGRAPHIC INSPECTION OF, ACCEPTANCE STANDARD FOR

This amendment forms a part of George C. Marshall Space Flight Center (MSFC) Standard MSFC-STD-100, dated May 16, 1961, and has been approved by MSFC and is available for use by MSFC and associated contractors.

(1) Page 2, paragraph 2.1, lines 1 and 2: Delete and substitute the following:

"2.1 The following documents form a part of this standard to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposals shall apply."

(2) Page 2, paragraph 2.1: Delete "MIL-I-6865" and substitute the following:

"STANDARDS

George C. Marshall Space Flight Center

MSFC-STD-397 Radiographic Laboratory
Qualification."

(3) Page 2, paragraph 4.1.1: Delete and substitute the following:

"4.1.1 Film. - All X-ray shall be made on a very fine grain film."

(4) Page 3, paragraph 4.4: Delete and substitute the following:

"4.4 Qualification. - Radiographic inspection shall be conducted by the manufacturer and shall be performed by a laboratory that conforms to Standard MSFC-STD-397."

Grade II-G	A non-flight casting designed to function under pressurization above one atmosphere during operation without major structural loading.
Grade III-G	A non-flight casting primarily designed to function under engineered structural loading requirements.
Grade IV-G	Includes all non-flight castings not defined under grades I-G, II-G, and III-G.

2. REFERENCED DOCUMENTS

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

SPECIFICATIONS

Military

MIL-X-6141	X-Ray Laboratories: Procedure for the Certification of (for Inspection of Aircraft Components).
MIL-I-6865	Inspection, Radiographic.

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

American Society for Testing Materials

ASTM E-155-60T (Series 11)	Reference Radiographs for Inspection of Aluminum and Magnesium Castings.
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3. DEFINITIONS (Not applicable).

4. GENERAL REQUIREMENTS

4.1 Materials.

4.1.1 Film. - All X-Rays shall be made on a very fine grain film.

4.2 Radiographic coverage.

4.2.1 Grades I-F, II-F, I-G and II-G. - Grades I-F, II-F, I-G and II-G shall have 100 percent radiographic coverage by area using a single wall technique where possible.

4.2.2 Grades III-F and III-G. - Grades III-F and III-G shall have 100 percent radiographic coverage by area, unless otherwise specified on the applicable drawing.

4.2.3 Grades IV-F and IV-G. - Radiographic coverage of grades IV-F and IV-G shall be at the option of the procuring agency.

4.3 Evaluation. - Castings produced to grades I-F and I-G shall be regarded as critical in all areas and evaluated accordingly unless noted on the casting drawing or purchase description. Castings produced to grades II-F, III-F, II-G and III-G shall be regarded as semi-critical, containing both critical and non-critical areas. Castings produced to grades IV-F and IV-G shall be regarded as non-critical and evaluated accordingly.

4.4 Qualification. - Radiographic inspection of castings shall be made by a laboratory qualified by Air Force Certification, as specified in Specification MIL-X-6141.

4.4.1 Identification. - Film identification and penetrameter usage shall be in accordance with Specification MIL-I-6865.

4.4.2 Film density. - Film density shall be maintained within the range of 1.8 to 2.3 (H&D density), unless otherwise directed by the procuring agency.

4.4.3 Film placement. - Film placement and direction of radiation shall be determined from the applicable casting drawings where indicated. Otherwise, procedures in accordance with best radiographic practice shall be used.

4.5 Repair. - Upon the approval of the procuring agency, grades IV-F, III-G and IV-G castings may be repaired by welding. Radiographic views of the defective area taken prior to and after such repair must be clearly identified on the films and accompany the castings. All castings to which allowable repair has been made shall have the repaired area clearly marked on the casting by encircling the repair with paint or enamel.

4.5.1 Other repair. - Other forms of repair are prohibited unless written permission is obtained from the procuring agency.

5. DETAIL REQUIREMENTS

5.1 Foundry control castings.

5.1.1 New casting designs. - Castings, designed to function within the limits defined under all grades of this standard, which have not been released as a production casting shall be defined as a new casting design.

5.1.1.1 Foundry control castings for new designs. - Castings for fulfillment of production purchase orders covering new casting designs shall not be poured prior to approval, by the procuring agency, of foundry control castings. Such castings shall be produced under the same foundry conditions as developed by the casting vendor for his production castings. The control castings will be evaluated both structurally and metallurgically by the procuring agency to determine if the foundry product is acceptable to design requirements.

5.1.2 Established casting design. - Those cast parts currently in use as production items or qualified through prototype tests are defined as established casting designs.

5.1.2.1 Foundry control castings for established designs. - Submission of foundry control castings on established designs is not required except on the first lot of castings produced from supplied pattern equipment or any new or altered patterns. Major changes in sprue, runners, gates and risers shall be considered as an altered pattern.

5.2 Changes in casting alloy. - Authorized changes in casting alloy shall require submission of foundry control casting in accordance with paragraph 5.1.1.1.

5.3 Number of foundry control castings required. - Unless otherwise specified, at least three control castings shall be required on castings meeting grades I-F, II-F, III-F, I-G, II-G, and III-G. The number of control castings for grades IV-F and IV-G shall be at the option of the procuring agency. At least one of the castings shall have a 1/4-inch stock minimum remaining of all sprues, runners, gates and risers to show their position on the casting.

5.4 X-ray film. - X-ray film of foundry control castings shall be made in accordance with the casting drawings or special instructions by the procuring agency in cases where drawings are lacking. X-ray film shall be included with all foundry control castings submitted for examination.

5.5 Radiographic inspection procedures.

5.5.1 Grades I-F, II-F, I-G and II-G. - Each lot of grades I-F, II-F, I-G, and II-G castings shall have 100 percent radiographic inspection using single wall technique wherever possible.

5.5.2 Grades III-F and III-G. - Unless otherwise specified by the procuring agency, radiographic inspection on grade III-F and III-G castings shall be through lot sampling as specified in table I.

Table I - Lot and Sample Size

Lot Size	Sample Size
1	1
2	2
2-4	2-4
5-6	5-6
7-8	6
9-11	7
12-15	8
16-20	10
21-26	13
27-50*	15

* In quantities over 50 pieces, special sampling plans are at the option of the procuring agency.

5.5.2.1 Lot. - A lot shall consist of all castings of a specific design or one alloy produced by one particular vendor and submitted for acceptance at one time (see table I).

5.5.3 Grades IV-F and IV-G. - Sampling for radiographic inspection of grades IV-F and IV-G shall be at the option of the procuring agency.

5.5.4 Vendor qualification for production lot acceptance by sampling grades III-F, IV-F, III-G and IV-G.

5.5.4.1 First lot. - The first production lot of castings received from a new vendor source on the first lot of a new casting design qualified under paragraph 5.1.1.1 of this standard and received from any vendor shall have 100 percent radiographic inspection. If the entire lot of castings is acceptable to the governing radiographic standards, the casting vendor shall be considered qualified for lot inspection and the level shall be reduced to the applicable schedules.

5.5.4.2 Subsequent lots. - If the first lot of production castings contains castings which do not meet the quality standard, 100 percent inspection will be required on subsequent lots of castings until acceptance criteria of paragraph 5.5.4.1 are met.

5.5.4.3 Rejection. - Casting lots radiographically inspected on a sampling basis and subsequently found to contain any castings having defects in excess of the standard shall be rejected. In consideration of the rejection rate and general quality of the castings the vendor may, at his discretion and expense, have each casting radiographically inspected.

Castings in the balance of the inspection lot found to be of satisfactory quality may be accepted. The remaining castings in the lot shall be rejected and returned to the vendor as scrap.

5.5.5 Inspection standards.

5.5.5.1 Defect limits. - All cracks will be unacceptable. Unless otherwise shown on the casting drawings, or detailed in the purchase description, radiographic defect limits for the eight grades defined in this standard shall be as specified in tables II and III. Table II applies to aluminum alloy castings. Table III applies to magnesium alloy castings.

Table II - Maximum Permissible Defect Limits in Aluminum Alloy Castings

Defects	Ref.** Film Group	Mat. Thickness (inches)	Casting Grade and Reference Film Number*							
			I-F	II-F	III-F	IV-F	I-G	II-G	III-G	IV-G
Gas Holes (isolated)	1.1	(1/4-3/4)	0	1	1	2	0	1	2	3
Gas Porosity (round)	1.21	(")	0	1	2	3	1	2	3	5
Gas Porosity (elongated)	1.22	(")	0	1	1	2	1	1	2	3
Shrinkage Cavity	2.1	(1/4)	0	0	0	1	0	0	1	1
Shrinkage Sponge	2.2	(1/4-3/4)	0	0	1	1	0	1	2	3
Inclusions (less dense)	3.11	(")	0	0	1	2	0	1	1	3
Inclusions (more dense)	3.12	(")	0	0	1	2	0	1	2	3

* Reference film number "0" requires the quality of the casting to be superior to that shown by reference film number 1 of the respective reference film group.

** The A.S.T.M. reference radiographs for inspection of aluminum and magnesium castings E-155-60T (series 11) are produced as film transparencies. Copies of these transparencies may be purchased from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.

Table III - Maximum Permissible Defect Limits in Magnesium Alloy Castings

Defects	Ref.** Film Group	Mat. Thickness (inches)	Casting Grade and Reference Film Number*							
			I-F	II-F	III-F	IV-F	I-G	II-G	III-G	IV-G
Gas Holes (isolated)	1.1	(1/4-3/4)	0	0	1	1	0	1	2	3
Segregation	1.2	(")	0	0	1	1	0	1	2	3
Micro-Shrinkage (fetchery)	2.31	(")	0	1	1	2	0	1	2	4
Micro-Shrinkage (sponge)	2.32	(")	0	1	1	2	0	1	2	4
Foreign Mate- rial (less dense)	3.11	(")	0	0	1	1	0	1	2	4
Foreign Mate- rial (more dense)	3.12	(")	0	0	1	1	0	1	1	2

* Reference film number "0" requires the quality of the casting to be superior to that shown by reference film number 1 of the respective reference film group.

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5.5.6 Waiver of inspection. - Castings obtained for purpose of "Mock-up" and special training aids which will not be used under service conditions, may have radiographic inspection waived provided the castings are marked "SAMPLE" with a steel stamp having letters no less than 1/8-inch high and marked in an obvious and permanent location.

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.

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

MSFC DOCUMENTATION REPOSITORY - DOCUMENT INPUT RECORD

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8. CONTRACT NUMBER / PERFORMING ACTIVITY:		9. DRD NUMBER:		10. DPD / DRL / IDRD NUMBER:
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14. SPECIAL INSTRUCTIONS:				
15. CONTRACTOR/SUBMITTING ORGANIZATION, ADDRESS AND PHONE NUMBER:			16. ORIGINATING NASA CENTER:	
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II. ENGINEERING DRAWINGS

20. REVISION:	21. ENGINEERING ORDER:	22. PARTS LIST:	23. CCBD:
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III. REPORTS, SPECIFICATIONS, ETC.

24. REVISION:	25. CHANGE:	26. VOLUME:	27. BOOK:	28. PART:	29. SECTION:
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40. ORG. CODE: <i>ED32</i>	41. PHONE NUMBER: <i>544-9323</i>	42. NAME: <i>Linda Clark</i>	43. SIGNATURE/DATE: <i>Linda Clark 10/30/02</i>
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VI. TO BE COMPLETED BY MSFC DOCUMENTATION REPOSITORY

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