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MSFC-STD-397
July 21, 1964

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

STANDARD
RADIOGRAPHIC LABORATORY QUALIFICATION

MSFC-STD-397
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GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Standard

Radiographic Laboratory Qualification

MSFC-STD-397

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

2. All recommended changes shall be submitted to the Technical Writing and Editing Section of the Propulsion and Vehicle Engineering Laboratory (R-P&VE-VNW) for approval and incorporation into this standard.

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

STANDARD

RADIOGRAPHIC LABORATORY QUALIFICATION

1. SCOPE

1.1 This standard establishes the requirements for equipment, techniques, quality levels, and records and reports for qualified radiographic laboratories performing inspection of materials and parts intended for use in space vehicles and related structures.

2. REFERENCED DOCUMENTS

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.

STANDARDS

George C. Marshall Space Flight Center (MSFC)

MSFC-STD-355

Radiographic Inspection of
Electronic Components.

3. DEFINITIONS

3.1 Qualification. - Qualification, as used in this standard, shall indicate MSFC sanction, in accordance with the requirements of this standard, for performing radiographic inspection of materials and parts intended for use in space vehicles and related structures.

3.2 Disqualification. - The term disqualification shall signify loss of MSFC sanction because of failure to meet the requirements of this standard.

3.3 Intensifying screen. - Intensifying screens shall be defined as sheets of lead or layers of fluorescent crystals between which the film is placed to decrease exposure time and improve image quality.

3.4 Filters. - Filters shall be defined as sheets of lead or other materials placed in the radiation beam to improve image quality by selectively removing low energy components from the radiation beam and by absorbing scattered radiation.

3.5 Penetrameter. - A penetrameter shall be defined as a device of calibrated thickness used to produce a radiographic image which indicates radiographic quality level. It is not intended for judging size or establishing acceptance limits of discontinuities.

3.6 Radiographically similar materials. - Materials which have similar X-ray absorption characteristics (within ± 2 percent) regardless of chemical composition.

3.7 H&D film density. - H&D density shall be defined as 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).

4. GENERAL REQUIREMENTS

4.1 Qualification procedure. - Upon request, a radiographic laboratory shall be assigned a qualification identification number by the MSFC Quality and Reliability Assurance Laboratory. No formal qualification procedure or survey shall be required. However, the laboratory shall be subject to survey at any time, on 24-hour notice, by an authorized representative of the MSFC Quality and Reliability Assurance Laboratory to determine compliance with the requirements of this standard. The qualification survey shall be conducted within the guidelines given in appendix A.

4.1.1 Loss of qualification. - Qualification shall be withdrawn if, during the course of the survey or because of the performance of the laboratory, it is established that the requirements of this standard are not being met. Qualification shall be withdrawn by a formal communication which presents the specific reasons for disqualification.

4.2 Requalification procedure. - Requalification must be formally requested by a disqualified laboratory. The request shall be made to the MSFC Quality and Reliability Assurance Laboratory. Laboratory qualification shall be reinstated if, during a facility survey conducted by an authorized MSFC Quality and Reliability Assurance Laboratory representative on 24-hour notice, conformance to the requirements of this standard is demonstrated. Laboratories failing to gain reinstatement shall be so notified by formal communication giving the reasons for the failure. A waiting period of 6 months shall be imposed before another survey is conducted.

5. DETAIL REQUIREMENTS

5.1 Laboratories to be qualified shall meet the detail requirements specified herein.

5.2 Equipment.

5.2.1 Laboratory equipment. - Laboratory equipment shall be adequate for the production and inspection of radiographs which meet the requirements of this standard.

5.2.2 X-ray machines. - The X-ray machines used shall be capable of producing radiographs which meet the requirements of this standard.

5.2.3 Radioisotopes. - Radioisotopes may be used as the radiation source if the resulting radiographs meet the requirements of this standard unless prohibited by applicable documents.

5.2.4 Penetrameters. - Penetrameters shall be made from material identical or radiographically similar to the object being radiographed. Penetrameter dimensions shall be as shown in figure 1. The T diameter minimum perceptibility hole may be in a separate penetrameter.

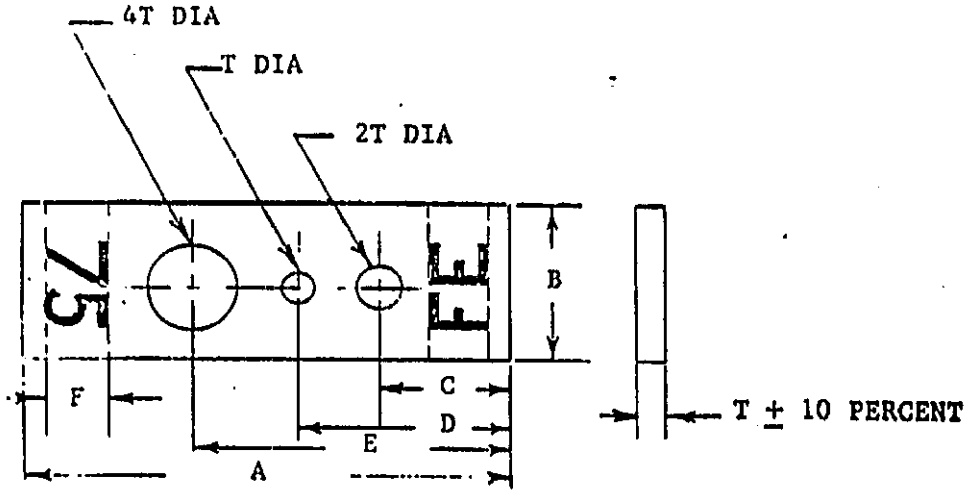
5.2.4.1 Penetrameter thickness. - The penetrameter thickness shall be not greater than 2 percent of the thickness of the section to be radiographed. For thicknesses of less than 1/4-inch, however, 0.005-inch thick penetrameters shall be used.

5.2.4.2 Penetrameter identification. - Penetrameter identification shall be by means of a lead alloy number attached to the penetrameter as shown in figure 1. This number shall represent the thickness, in inches, of the material being radiographed. Fractions of an inch shall be expressed as decimals.

5.2.4.3 Material identification. - Penetrameters shall be identified as to material by lead alloy letters located as shown in figure 1. The predominant constituent shall be identified by the letters as listed in figure 1. Materials not listed shall be identified by using the chemical symbol.

5.2.4.4 Circular penetrameter identification. - Lead numbers and letters shall be placed adjacent to circular penetrameters to identify them on the film.

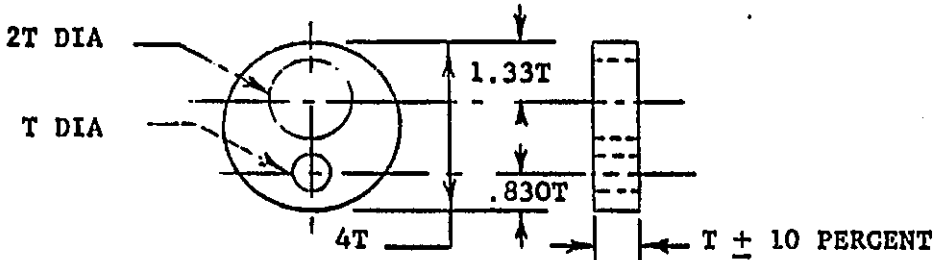
5.2.4.5 Wire penetrameters. - Wire penetrameters used in the radiographic inspection of electronic components shall conform to Standard MSFC-STD-355.



| T | INCREMENTS | A | B | C | D | E | F |
|-----------------|------------|-------|-------|------|-------|-------|------|
| .005-.020 INCL. | .0025 | 2.000 | .500 | .520 | .800 | 1.150 | .250 |
| .025-.050 INCL. | .005 | 2.000 | .500 | .520 | .800 | 1.150 | .250 |
| .060-.160 INCL. | .010 | 2.850 | 1.000 | .800 | 1.250 | 1.900 | .375 |

- MIN PENETRATOR THICKNESS .005 \pm 10 PERCENT
- MIN DIAMETER FOR 1T HOLE .010 \pm 10 PERCENT
- MIN DIAMETER FOR 2T HOLE .020 \pm 10 PERCENT
- MIN DIAMETER FOR 4T HOLE .040 \pm 10 PERCENT

DESIGN FOR PENETRATOR THICKNESSES UP TO AND INCLUDING 0.160



DESIGN FOR PENETRATOR THICKNESSES OF 0.180 AND OVER MADE IN .020 INCREMENTS

| SYMBOL | MATERIALS |
|--------|-----------------|
| SS | STAINLESS STEEL |
| AL | ALUMINUM |
| FE | STEEL |
| MG | MAGNESIUM |
| CU | COPPER |
| TI | TITANIUM |

ALL DIMENSIONS IN INCHES.
 HOLES SHALL BE TRUE AND NORMAL TO THE SURFACE OF THE PENETRATOR. DO NOT CHAMFER.
 TOLERANCES ON PENETRATOR THICKNESSES AND HOLE DIAMETERS SHALL BE \pm 10 PERCENT OR 1/2 OF THE THICKNESS INCREMENT BETWEEN PENETRATOR SIZES, WHICHEVER IS SMALLER.

Figure 1. Penetrator dimensions.

5.2.5 Metallic screens and filters. - Metallic screens and filters may be used to give better definition and sensitivity. Fluorescent intensifying screens shall not be used without prior MSFC approval.

5.2.6 Film. - Production radiographs shall be made on safety film having as fine a grain as practical or feasible for the material and thickness of material being radiographed. Film shall be of such quality as to produce optimum radiographs.

5.3 Personnel.

5.3.1 Radiographic personnel. - Personnel engaged in radiographic inspection shall be familiar with the requirements of this standard and with all other documentation controlling radiographic inspection of parts and materials. They shall be capable of producing radiographs which meet the requirements of all applicable documentation.

5.3.2 Radiographic interpreters. - Personnel engaged in the interpretation of radiographs shall be familiar with the requirements of this standard and with all other documentation controlling radiographic quality of parts and materials being inspected. They shall be capable of evaluating radiographs to determine conformance of parts and materials to the requirements of all applicable documentation.

5.4 Procedures. - The laboratory procedures described herein shall be followed when inspecting parts or materials intended for use in space vehicles and related structures.

5.4.1 Radiographic quality level. - One of three minimum quality levels listed in table I shall be assigned to radiographs on the basis of the perceptibility of the holes in the penetrameter image. Unless otherwise specified, all radiographs shall show the image of at least two holes (quality level 2-2T, table I) and the outer edge of the penetrameter panel.

Table I. Radiographic quality levels

| Radiographic quality level | Minimum perceptible penetrameter hole | Equivalent sensitivity (percent) |
|----------------------------|---------------------------------------|----------------------------------|
| 1 | 1T | 1.4 |
| 2 | 2T | 2 |
| 3 | 4T | 2.8 |

5.4.2 Inspection during production. - The part or material shall be radiographically inspected during or after manufacturing and processing sequences or both as specified in applicable documents.

5.4.3 Areas radiographed. - The areas to be radiographed shall be as specified in the applicable documents.

5.4.4 Film location. - The film shall be located as close to the surface of the part as practical during exposure.

5.4.5 Penetrameter placement. - A penetrameter of suitable design (see 5.2.4) shall be placed on each part radiographed for the duration of exposure unless a number of identical parts are simultaneously exposed. In this case a single penetrameter upon the top surface of that part at the outer edge of the cone of radiation will suffice. When it is impractical to place the penetrameter on the part radiographed it may be placed on the upper surface of a block of radiographically similar material of the same thickness as the part to be radiographed. Location on the film shall be at the outer edge of the cone of radiation.

5.4.5.1 Applicable area. - One penetrameter shall represent an area within which radiographic film densities do not vary more than plus 30 or minus 15 percent from the density at the penetrameter location.

5.4.6 Film identification. - Unless otherwise specified each radiograph shall contain the following identification information exposed on the film and processed in the emulsion:

- (a) Date of radiograph.
- (b) Radiographic report number.
- (c) Radiographic view number and location markers.
Films of parts or materials that have been rejected and later repaired shall carry the original view number followed by "R1".
Subsequent repairs shall be marked "R2", "R3", etc.
- (d) Part or material number and serial number.
- (e) Laboratory identification.
- (f) Radiographic identification symbol.
- (g) The letters "DW" when double wall radiographic technique is used.

5.4.6.1 Location marker. - Whenever practical and necessary, location markers shall be placed so that their images will appear on the film. Their position shall be permanently marked on the surface of the part or material so that orientation of the film may be established and defects precisely located.

5.4.7 Focal spot-to-film distance. - The focal spot-to-film distance shall be as specified in the applicable documents. If the distance is not specified, it shall be established so as to produce sharply defined images.

5.4.8 Exposure. - Exposure parameters of time, voltage, and amperage shall be established to insure radiographic sensitivity meeting the requirements of this standard and other applicable documents and an H&D film density of 1.5 to 3.0.

5.4.9 Processing. - Processing techniques shall result in radiographs that are free from blemishes, and that meet the requirements of this standard.

5.4.10 Film interpretation. - Radiographs shall be interpreted under a suitable environment using suitable viewing equipment. Acceptability of the part or material shall be determined in accordance with applicable drawings, specifications, and acceptance standards. Areas resulting in rejection shall be identified on the film and on the part or material.

5.4.11 Disposition of parts and materials.

5.4.11.1 Acceptance parts and materials. - Parts and materials conforming to the applicable documents shall be marked as specified in a manner and location harmless to the part. Type of marking shall preclude removal, smearing, and obliteration by subsequent handling.

5.4.11.2 Rejected parts and materials. - Parts and materials not conforming to the requirements of applicable documents shall be marked and disposed of as specified.

5.5 Reports and records.

5.5.1 Inspection reports. - Unless otherwise specified, the laboratory shall furnish inspection reports giving the results of the radiographic inspection and signed by an authorized representative of the laboratory. All reports required herein shall be available to the MSFC representative at all times. Reports shall list the purchase order number or equivalent identification, the number of parts or quantity of material on order, and the date of test. For each piece of material there shall be listed

the part or material number, the serial number of the tests, and the rated condition of the part or material.

5.5.2 Detailed data. - The laboratory shall keep a complete record of the inspection details on a form which shall list the following information:

- (a) Potentials and currents used in the radiographic process.
- (b) Exposure time.
- (c) The distance of the radiation source from the surface of the part or material.
- (d) The distance of the film from the same surface (focal-film distance).
- (e) The approximate angle between the central beam of radiation and the film.
- (f) Screens and filters used.
- (g) Size of the focal spot.
- (h) Film development time.
- (i) Serial number (or numbers) of the test part or material.
- (j) A dimensional sketch of the part or material (if required).

5.5.2.1 Data from inspection of similar parts. - When an identical technique is used for a number of parts or pieces of material, a single record tabulating identical features shall be satisfactory.

5.5.2.2 Copies of records. - Copies of data records shall be supplied to the authorized MSFC inspector at his request.

5.5.3 Retention of radiographs. - Unless otherwise specified by the procuring activity, radiographs shall be kept on file at the laboratory and available for reference for 24 months from the date the radiographs are made.

- 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 be in any way related thereto.

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.

Custodian:

Preparing activity:

**NASA - George C. Marshall Space
Flight Center**

**George C. Marshall Space
Flight Center**

APPENDIX A

RADIOGRAPHIC LABORATORY QUALIFICATION SURVEY GUIDELINES

10. Qualification survey. - The radiographic laboratory qualification survey shall be conducted within the following guidelines:

10.1 Documentation. - On-hand documentation shall be surveyed to determine adequate radiographic procedures and quality levels. Survey shall include applicable drawings, specifications, and standards.

10.1.1 Procedures. - Compatibility of laboratory standard operating procedures with MSFC requirements, as defined in applicable documents, shall be established.

10.2 Performance. - Adequacy of laboratory performance shall be determined by the following inspections:

- (a) Inspection of test parts which correspond to the MSFC associated activities of the laboratory. These parts shall be accompanied by documentation defining the desired radiographic coverage, procedures, and quality levels.
- (b) Review of radiographic films of test parts for adequacy of film processing, coverage, density, and sensitivity.
- (c) Review of laboratory analysis of part quality and part disposition.

10.3 Reports and records. - The laboratory's procedure for making reports, keeping records, and storing films shall be inspected for adequacy.

MSFC-STD-397
AMENDMENT 2
May 24, 1965
SUPERSEDING
AMENDMENT 1
January 26, 1965

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

STANDARD

RADIOGRAPHIC LABORATORY QUALIFICATION

This amendment forms a part of George C. Marshall Space Flight Center (MSFC) Standard MSFC-STD-397, July 21, 1964, and has been approved by MSFC and is available for use by MSFC and associated contractors.

(1) Page 2, paragraph 4.1; delete the entire paragraph and substitute the following:

"4.1 Qualification procedure. - The radiographic laboratory shall submit a written request for qualification to the NASA center or organization imposing this standard. The request shall include sample X-ray films of components comparable to the items specified in the contract or order, X-ray procedures, and a description of X-ray equipment. Upon approval, the requesting laboratory shall be assigned a qualification identification number. No formal qualification survey shall be required, however, the requesting laboratory shall be subject to survey at any time, on 24 hours notice, by an authorized representative of the Government to determine compliance with the requirements of this standard. The qualification survey shall be conducted within the guidelines given in appendix A."

(2) Page 2, add the following as paragraph 4.1.1:

"4.1.1 Subcontractor laboratory qualification. - The prime contractors shall be responsible for the continuing qualification status of radiographic laboratories, including the status of all tier subcontractors. The qualification of any tier subcontractor radiographic laboratory shall be subject to review by a representative of the Government."

(3) Page 2, change the number of the paragraph presently designated "4.1.1" to "4.1.2".

MSFC-STD-397
AMENDMENT 2
May 24, 1965

(4) Page 3, add the following as the fourth and fifth sentences of paragraph 5.2.4:

"It shall be permissible to use American Society of Mechanical Engineers (ASME) penetrameters where isotopes are used in field radiography where the laboratory has only one set of penetrameters. In any case, penetrameters shall be ASME or as shown in figure 1."

Custodian:

NASA - George C. Marshall Space
Flight Center

Preparing activity:

George C. Marshall Space
Flight Center

MSFC DOCUMENTATION REPOSITORY - DOCUMENT INPUT RECORD

I. GENERAL INFORMATION

| | | | | |
|--|--|--------------------------|---------------------------------------|---|
| 1. APPROVED PROJECT: | 2. DOCUMENT / DRAWING NUMBER: <i>MSFC-STD-397</i> | 3. CONTROL NUMBER: | 4. RELEASE DATE: <i>5/4/65</i> | 5. SUBMITTAL DATE: |
| 6. DOCUMENT/DRAWING TITLE: <i>Radiographic Laboratory Qualification</i> | | | 7. REPORT TYPE: | |
| 8. CONTRACT NUMBER / PERFORMING ACTIVITY: | | 9. DRD NUMBER: | | 10. DPD / DRL / IDRD NUMBER: |
| 11. DISPOSITION AUTHORITY (Check One): <input checked="" type="checkbox"/> Official Record - NRRS <i>8/12/1A</i> <input type="checkbox"/> Reference Copy - NRRS 8/5/A/3 (destroy when no longer needed) | | 12. SUBMITTAL AUTHORITY: | | 13. RELEASING AUTHORITY: <i>MBCook</i> |
| 14. SPECIAL INSTRUCTIONS: | | | | |
| 15. CONTRACTOR/SUBMITTING ORGANIZATION, ADDRESS AND PHONE NUMBER: | | | 16. ORIGINATING NASA CENTER: | |
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| 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: <i>2</i> | 26. VOLUME: | 27. BOOK: | 28. PART: | 29. SECTION: |
| 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

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|---|--|
| <input type="checkbox"/> Privacy Act (see MWI 1382.1) | <input type="checkbox"/> EAR (see MPG 2220.1) |
| <input type="checkbox"/> Proprietary (see MPD 2210.1) | <input type="checkbox"/> Other ACI (see NPG 1620.1 and MPG 1600.1) |
| <input type="checkbox"/> Patent (see MPG 2220.1) | <input checked="" type="checkbox"/> No statutory or institutional restrictions applicable -- material may be electronically distributed to user in the NASA domain |
| <input type="checkbox"/> ITAR (see MPG 2220.1) | |

V. ORIGINATING ORGANIZATION APPROVAL

| | | | |
|-------------------------------|--------------------------------------|---------------------------------|--|
| 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> |
|-------------------------------|--------------------------------------|---------------------------------|--|

VI. TO BE COMPLETED BY MSFC DOCUMENTATION REPOSITORY

| | | |
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| 44. RECEIVED BY: <i>Dummy Wise</i> | 45. DATE RECEIVED: <i>10-15-03</i> | 46. WORK ORDER: |
|---------------------------------------|---------------------------------------|-----------------|