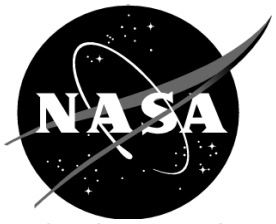
Process Specification for Liquid Penetrant Inspection

Engineering Directorate

Structural Engineering Division

March 2020



National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas

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Revised and Reviewed by:	Signature on File Ajay Koshti Materials and Processes Branch/ES4	01/07/2020 Date
Revised and Reviewed by:	Signature on File David Stanley Materials and Processes Branch/ES4	01/07/2020 Date
Revised and Reviewed by:	Signature on File Norman Ruffino Materials and Processes Branch/ES4	01/07/2020 Date
Revised and Reviewed by:	Signature on File Miles Skow Materials and Processes Branch/ES4	01/07/2020 Date
Approved by:	Signature on File Brian Mayeaux Materials and Processes Branch/ES4	01/21/2020 Date

REVISIONS		
VERSION	**CHANGES**	**DATE**
Baseline	Original version	7/22/99
A	Reviewed document per QMS requirements. Updated division name, organization codes, and document numbers.	12/19/02
B	Updated the Qualified Products List document number and title.	1/14/05
C	Addition of NASA-STD-5009 and NASA-STD-5019	9/25/06
D	Addition of PRC-5010 for part etching before penetrant inspection	04/02/08
E	Added SNT-TC-1A to paragraph 4.0. Revised paragraph 9.0 for uniformity across all NDE PRCs.	6/29/2011
F	Reviewed document per QMS requirements. Updated signatures and organization codes. Minor Changes. Added requirements for Standard dye penetrant to match with NASA-STD-5009B. 2.0 Applicability – added cracks and pores. 3.2 Added electro-polishing in accordance with PRC-5009. 6.1 General – added Standard Liquid Penetrant inspection, sensitivity Level 3 or 4 fluorescent penetrant shall be used. The “as-cast” surfaces of welds and additively manufactured parts are considered to be undisturbed and do not require pre-penetrant etching unless the surface is subsequently mechanically smeared. 6.3 Viewing Area – changed black light intensity shall be a minimum of 1000 □W/cm2 at the examination surface 10.0 Definitions – Added Standard NDE	03/25/2020

1.0 SCOPE

This process specification establishes the minimum requirements for liquid penetrant inspection of nonporous metal and nonmetal components.

2.0 APPLICABILITY

This specification is applicable to in-process, final, and in-service liquid penetrant inspections to detect discontinuities such as cracks and pores that are open to the part surface.

3.0 USAGE

This specification shall be invoked by an inspection note on the applicable engineering drawing or by reference in a Process Specification, Task Performance Sheet, Discrepancy Report/Material Review Record, or other appropriate work authorizing document. At a minimum, the inspection note shall specify the inspection Type (Section 3.3) and Level (Section 3.4).

The engineering drawing or referencing document shall specify the criteria by which components are judged acceptable. Where acceptance criteria are not otherwise specified the criteria in Section 3.6 shall apply. Other acceptance criteria, such as those in MIL-STD-1907, may be used as appropriate. When there are different acceptance criteria for different areas on a component, the drawing shall be zoned with the acceptance criteria identified for each zone. If the number of components to be inspected and the amount of coverage of each component is not specified, all components shall be examined and shall receive 100 percent liquid penetrant coverage.

Typical liquid penetrant inspection notes for flight hardware and critical ground equipment are given below.

PERFORM LIQUID PENETRANT INSPECTION PER JSC PRC-6506, TYPE I, LEVEL 3.

Above note is for using the default acceptance criteria given in Section 3.6.

PERFORM LIQUID PENETRANT INSPECTION PER JSC PRC-6506, TYPE I, LEVEL 3. ACCEPTANCE CRITERIA PER MIL-STD-1907, GRADE A.

Above inspection note invokes MIL-STD-1907 for acceptance criteria.

Liquid penetrant inspection notes in any work authorizing document shall be preceded by a note for pre-penetrant etching or electro-polishing, whichever is appropriate, unless exempted. See section 3.2 for further requirements on etching or electropolishing.

3.1 INSPECTION SEQUENCE

The stage in the manufacturing process where liquid penetrant inspection is performed should be specified on the engineering drawing or in the referencing document. Final liquid penetrant inspection shall be performed after completion of all manufacturing operations that can generate surface discontinuities or expose existing subsurface discontinuities. These operations include, but are not limited to, grinding, welding, straightening, machining, and heat treating.

Final penetrant inspection may be performed before surface treatments that do not by themselves generate surface discontinuities. These surface treatments include, but are not limited to, vapor blasting, grit blasting, bead blasting, sanding, buffing, polishing, lapping, and peening.

Final penetrant inspection shall be performed prior to application of any surface finish or coating such as anodize, paint, or plating.

3.2 ELECTROPOLISHING AND ETCHING

All mechanically disturbed surfaces shall be electropolished in accordance with PRC-5009 or etched in accordance with PRC-5010 to remove smeared metal prior to final penetrant inspection. Processes that mechanically disturb the surface include, but are not limited to, machining, vapor blasting, grit blasting, bead blasting, sanding, buffing, polishing, lapping, peening, deburring, wire brushing, and grinding. A minimum of 0.0004 inch of metal shall be removed from nonferrous metals such as aluminum and titanium. A minimum of 0.0002 inch of metal shall be removed from steels, stainless steels, and nickel-based alloys. Etching for penetrant inspection in accordance with other process specifications must be approved by the NASA JSC Materials and Processes Branch.

Parts with close tolerance surfaces or fine surface finishes that cannot be etched may be rough machined to within 0.030 inch or less of the final dimension, etched, liquid penetrant inspected, and then finish machined. Fracture critical parts shall be re-inspected without electropolishing or etching after finish machining.

Parts shall be electropolished or etched and penetrant inspected prior to drilling. Electropolishing or etching and inspection of the holes after drilling is not required. However, this does not apply when the load is transmitted through a single hole such as in a lug. All such holes shall be either etched and penetrant inspected or inspected using an alternative method.

3.3 TYPES

The “Type” designator governs the type of liquid penetrant used and shall be specified in the inspection note on the basis of the following definitions:

a. Type I – Fluorescent dye
b. Type II – Visible dye

Only Type I (fluorescent dye) penetrant shall be used for final inspection of flight hardware.

3.4 LEVELS

The "Level" designator governs the sensitivity of Type I penetrant systems and shall be specified in the inspection note on the basis of the following definitions:

a. Level 1/2 — Very Low
b. Level 1 — Low
c. Level 2 — Medium.
d. Level 3 — High.
e. Level 4 — Ultrahigh.

Only sensitivity Level 3 or 4 penetrant materials shall be used for final inspection of flight hardware.

3.5 SPECIAL NDE OF FRACTURE CRITICAL COMPONENTS

When implementation of fracture control requirements necessitates Special Nondestructive Evaluation (NDE) of a fracture critical component, the requirement for Special NDE shall appear in the inspection note as shown below. When Special NDE is required, the specific inspection procedure and inspector shall be qualified in accordance with Section 7.0.

PERFORM LIQUID PENETRANT INSPECTION PER JSC PRC-6506, TYPE I, LEVEL 3. SPECIAL NDE CERTIFICATION REQUIRED.

3.6 ACCEPTANCE CRITERIA

The engineering drawing or referencing document shall indicate the criteria by which components are judged acceptable. Where acceptance criteria are not otherwise specified the following criteria shall apply:

a. Linear indications – all linear indications, regardless of length, shall be cause for rejection of the component.

b. Single rounded indications – a single rounded indication greater than 0.030 inches in diameter shall be cause for rejection of the component.

c. Multiple rounded indications - two or more rounded indications each less than 0.030 inches in diameter but separated by less than 0.030 inches shall be cause for rejection of the component.

4.0 REFERENCES

The following specifications, standards, and handbooks form a part of this document to the extent specified herein. All documents listed are assumed to be the current revision unless a specific revision is listed. In the case of conflict between this specification and the technical requirements cited in other referenced documents, the requirements of this document take precedence.

ASTM E 1417	*Standard Practice for Liquid Penetrant Examination*
MIL-STD-1907	*Inspection, Liquid Penetrant and Magnetic Particle, Soundness Requirements for Materials, Parts, and Weldments*
NASA-STD-5009	*Nondestructive Evaluation Requirements for Fracture Critical Metallic Components*
NAS 410	*NAS Certification & Qualification of Nondestructive Test Personnel*
QPL-AMS2644-4	*Qualified Products List of Products Qualified Under SAE Aerospace Material Specification AMS 2644, Inspection Material, Penetrant*

SNT-TC-1A	*Personnel Qualification and Certification in Nondestructive Testing*
PRC-5009	*Process Specification for Electropolishing of Corrosion-Resistant Steel*
PRC-5010	*Process Specification for Pickling, Etching, and Descaling of Metals*

The following references were used to develop this process specification:

SOP-007.1	*Preparation and Revision of Process Specifications (PRC's)*
JPR 8500.4	*Engineering Drawing System Requirements*

5.0 MATERIAL REQUIREMENTS

Only materials listed or approved for listing on QPL-AMS2644-4 shall be used for penetrant inspection.

6.0 PROCESS REQUIREMENTS

6.1 GENERAL

Liquid penetrant examinations shall be performed in accordance with ASTM E 1417 except as modified by this specification. For Standard Liquid Penetrant inspection, sensitivity Level 3 or 4 fluorescent penetrant shall be used. The "as-cast" surfaces of welds and additively manufactured parts are considered to be undisturbed and do not require pre-penetrant etching unless the surface is subsequently mechanically smeared.

6.2 WRITTEN PROCEDURES

A detailed written procedure shall be prepared for each part to be inspected. The procedure shall meet the requirements of this specification and shall ensure the consistency and reproducibility of the inspection at the required sensitivity level. General procedures covering a variety different parts may be used provided they meet the requirements of this specification and clearly apply to the parts to be inspected. When general procedures are used, a written part specific technique shall be prepared. At a minimum, the part specific procedure or the general procedure and part specific technique shall cover all of the information required by ASTM E1417.

For work performed at JSC facilities, written procedures should consist of Detailed Process Instructions (DPIs) selected for use from the DPI-6506-XX series of work instructions.

6.3 VIEWING AREAS

For Type I liquid penetrant inspections the black light intensity shall be a minimum of 1000 $\mu W/cm^2$ at the examination surface. The visible light background shall not exceed 2 fc (20 lx) at the examination surface for both stationary and portable Type I inspections.

6.4 INDICATION REMOVAL

Local areas that are sanded, ground, or machined to remove discontinuity indications shall be etched prior to the final inspection. Etching is not required for intermediate inspections performed during the removal process. Removal of discontinuity indications shall be approved by the responsible engineering organization.

6.5 FRACTURE CRITICAL COMPONENTS

Liquid penetrant inspections of fracture critical components shall be performed in accordance with the process requirements of NASA-STD-5009. The requirements in NASA-STD-5009 not otherwise covered in this specification are included in the following:

a. Examination surfaces must be easily accessible with no sharp root recesses and a surface roughness of 125 µin RMS or better.

b. Evaluation of questionable indications by wiping the indication with a solvent dampened swap, drying, and redeveloping is not acceptable. The relevance of questionable indications shall be evaluated by cleaning and reprocessing the component.

When Special NDE is specified by the engineering drawing or referencing document, the inspection procedure and inspector shall be qualified in accordance with Section 7.0.

7.0 <u>SPECIAL NDE QUALIFICATION</u>

Use of Special NDE in accordance with NASA-STD-5009 requires formal demonstration of the capability to detect flaws at least as small as the critical initial crack size for the specific component to a 90/95 detection level. Each procedure, procedure application, and operator must demonstrate the required

capability. Requests for Special NDE certification shall be directed to the JSC Materials and Processes Branch (ES4).

8.0 DEVIATIONS AND WAIVERS

Any deviations or waivers regarding the use of this process specification shall be requested in writing. This request shall be directed to the JSC Materials and Processes Branch (ES4) with the appropriate justification and rationale. A written response will be provided upon such a request.

9.0 TRAINING AND CERTIFICATION OF PERSONNEL

Personnel performing acceptance inspections of Class I, II, IIIW and GSE hardware shall be qualified and certified, at a minimum, to Level 2 in accordance with NAS 410. Personnel performing acceptance inspections requiring Special NDE shall also be qualified and certified for Special NDE in accordance with NASA-STD-5009.

Personnel performing acceptance inspections of Class III, STE/D, mockup, and facility hardware shall be qualified and certified in accordance with either NAS 410 or SNT-TC-1A. Personnel making accept/reject decisions shall, at a minimum, be certified to Level 2. Level 3 personnel making accept/reject decisions shall have successfully completed a hands-on practical examination equivalent to the examination required for Level 2. Level 1 personnel may perform acceptance inspections under the direct supervision of a Level 2 but shall not make accept/reject decisions.

Formal qualification and certification is not required for personnel performing engineering evaluation inspections.

10.0 DEFINITIONS

90/95	The point where the 95% lower confidence bound on the Probability of Detection (POD) vs. flaw size curve crosses 90% POD or 90% POD with 95% confidence.
Discontinuity	An intentional or unintentional interruption in the physical structure or configuration of a material or component that may be detectable by nondestructive testing; a flaw. Discontinuities are not necessarily rejectable.
Final Inspection	The final inspection performed for the acceptance of the component.

Fracture Critical	Classification which assumes that fracture or failure of the Component resulting from the occurrence of a crack will result in a catastrophic hazard. Fracture critical components will be identified as such on the engineering drawing.
Indication	Evidence of a discontinuity that requires interpretation to determine its significance.
In-Process	Inspections which occur during manufacturing before a component is in final form.
In-Service	Inspections performed on components that are in use or storage.

Linear Indication Penetrant indication with a length to width ratio of 3:1 or greater.

Rounded Indication	Penetrant indication with a length to width ratio of less than 3:1.
Special NDE	A fracture control term denoting nondestructive inspection personnel, procedures, and equipment with a demonstrated capability to reliably (90/95) detect flaws smaller than those normally detected by Standard NDE procedures.
Standard NDE	NDE methods of metallic materials for which a statistically based flaw detection capability has been established. Standard NDE methods employ techniques with established capabilities.