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REVISION: H
DATED: July 3, 1991
SUPERSEDES: NDTS 1101G
DATED: May 21, 1990
(Inc. Am 2 & 3)

PENETRANT INSPECTION

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FORT WORTH DIVISION
CODE IDENTIFICATION 81755

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REVISION: H
DATED: July 3, 1991
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PENETRANT INSPECTION

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REVISION H CHANGE INDEX

This document has been completely rewritten in standard specification format. Due to the extensiveness of change, a change index will not be provided.

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PENETRANT INSPECTION

1.0 SCOPE.

1.1 This standard establishes inspection procedures and process control requirements for liquid penetrant inspection of metal alloys. Penetrant inspection to this document shall be used when specified in Engineering drawings, standards, or specifications.

1.2 For preparation and inspection of materials not covered in this NDTS, contact General Dynamics/Fort Worth Division Process Engineering Development & Control for specific instructions. Any exceptions to this standard must be approved by General Dynamics Process Engineering Development & Control. In special cases, additional inspections may be directed by Engineering and/or Process Engineering Development & Control.

1.3 This standard applies to fluorescent penetrant inspections (FPI) performed on details and assemblies.

1.4 Facilities inspecting parts for which ZONE 1A, 1B, and/or 1C are specified shall be qualified by successful completion of a Penetrant Demonstration Program (See Appendix "A") Successful qualification at a higher zone constitutes qualification at any lesser zones, e.g., ZONE 1B qualification covers ZONE 1A.

1.5 This standard supersedes NDTS 10.00 and shall be used whenever NDTS 10.00 is required. When NDTS 10.00 is required, use the accept/reject criteria per NDTS 1101-1.

1.6 This standard shall become effective upon date of issue.

2.0 SPECIFICATIONS.

The following publications shall be applicable to the extent specified herein or as defined on the contract or purchase order. Refer to GDFW16PR711 document for the applicable issues of F-16 Materials Procurement and Processing Specifications. Insofar as any of the publications conflict with the requirements of this standard, this standard will prevail.

ASTM D 95	Test for Water in Petroleum Products and Bituminous Materials by Distillation
FPS-1051	Chemical Milling of Metals
FPS-1097	Inspection and Acceptance Standards for Fusion Welds, Specification for
FPS-3008	Marking of Aircraft and Aerospace Ground Equipment Parts
FPS-3020	Cleaning, Descaling for CRES Steels
FQML-3020	Fort Worth Qualified Manufacturer's List
FQPL: NDTS 1101	Fort Worth Qualified Processors List (FQPL)
FZM 13725	Nonconforming Material Corrective Action and Disposition Action
MIL-A-83444	Airplane Damage Tolerance Requirements
MIL-I-25135	Inspection Material, Penetrant
MIL-L-9909	Light, Ultraviolet, Metals Examining
MIL-STD-410	Qualification of Inspection Personnel
MIL-STD-45662	Calibration Systems Requirements
NDTS 10.00	Penetrant Inspection
NDTS 1101-1	Penetrant Inspection of F-111 Parts

NDTS 1101-2	Portable FPI
NWR 8090	Naval Weapons Report No. 8090, Binomial Reliability Table
P.s. 00.04	Materials and Process Control Tank Data
P.s. 40.01	Chemical Cleaning Methods
P.S. 92.01-1	Certification of Nondestructive Testing Personnel (GDFW)

3.0 REQUIREMENTS.

3.1 Personnel.

3.1.1 Penetrant inspection personnel shall be certified in accordance with P.S. 92.01-1 for GDFW and MIL-STD-410 for suppliers and co-producers. Only Level II or Level III personnel shall accept or reject penetrant indications.

3.2 Facilities.

3.2.1 Supplier and co-producer facilities must be approved by General Dynamics/Fort Worth Division Process Engineering Development & Control prior to furnishing services controlled by this standard.

3.2.2 Suppliers and co-producers must meet the requirements of this standard. Inspection to any procedure other than NDTS 1101 must be approved by Process Engineering Development & Control.

3.2.3 Approval of facilities for inspecting parts to Zone 1A, 1B, or 1C requirements shall be based on successful completion of a Penetrant Demonstration Program. This program is administered by General Dynamics/Fort Worth Division Process Engineering Development & Control to demonstrate penetrant detection capability on a specific flaw size with 90% probability of detection at a confidence level of 95%. Details of the penetrant demonstration program are shown in Appendix "A".

3.2.4 Qualified facilities for Zone 1A, 1B and 1C inspection are listed in FQPL: NDTS 1101.

3.3 Equipment.

3.3.1 Backlight equipment.

3.3.1.1 Backlight requirements shall be in accordance with MIL-L-9909.

a) Special application backlights (i.e., backlight fiber optics, pencil lights, explosion-proof backlights, etc.) shall not be used unless written approval has been granted by General Dynamics/Fort Worth Division Process Engineering Development & Control (GD/FW Pr-oduction Inspection is excluded from this requirement). Only explosion-proof backlights may be used on aircraft which contain or have contained fuel and present a safety hazard.

b) The following will be adhered to when utilizing the explosion-proof backlight:

1) Backlight will be held three inches or less from the surface to be inspected. Should access to the area of interest prohibit this, then the standard 100-watt backlight will be utilized and the Fire Department will be called on stand-by.

2) Assure appropriate steps have been taken to obtain maximum darkness in area of interest.

3.3.2 Backlight meter, Black-Ray Model J-221 or equivalent, shall be used to measure ultraviolet light intensity when required.

3.3.3 White light meter, Weston 703 or equivalent, shall be used to measure white light intensity when required.

3.4 Materials.

3.4.1 Penetrant materials shall be selected from the current Qualified Products List (QPL) of MIL-I-25135 unless otherwise permitted by General Dynamics/Fort Worth Division Process Engineering Development & Control.

3.4.2 Only Type 1 fluorescent penetrants shall be used.

3.4.3 Each facility approved for Zone 1A, 1B and/or 1C inspection shall be qualified using specific penetrant materials which shall not be changed without approval of General Dynamics/Fort Worth Division Process Engineering Development & Control. The facility and the specific materials will be listed in FQPL: NDTS 1101, latest revision.

3.4.4 Facilities using materials other than those qualified for Zone 1A, 1B, or 1C (i.e. for other than Fatigue & Fracture Critical parts) shall meet or exceed the minimum guidelines established in Table 1.

TABLE I

Surface Inspected	MIL-I-25135 Sensitivity Level
All Titanium and High Temperature Alloys	3
Machine Surfaces (All Wrought Materials)	3
Machined Surfaces (Cast)	3
Extruded Surfaces (Except Aluminum & Titanium)	3
Forged/Extruded Aluminum	2
Cast Surfaces (Except Nickel)	2
Forged Surfaces (Except Aluminum, Titanium)	2
Nonmagnetic Alloys (Bronze, Brasses, etc.)	2
Surfaces Not Covered by Above	2

3.5 Inspection Sequence.

3.5.1 FPI is performed after all fabrication/processing is completed with the following exceptions:

a) FPI before application of any metallic, nonmetallic or organic coating.

b) FPI before shot peening or glass bead blasting.

c) FPI before anodize or themfilm

4.0 PRE-INSPECTION PART PREPARATION.

4.1 General.

4.1.1 For preparation and inspection of materials not covered in this NDTS, contact General Dynamics/Fort Worth Division Process Engineering Development & Control for specific instructions.

4.1.2 All items to be inspected shall be clean and dry prior to application of penetrant.

4.1.3 If supplier produced parts are etched for reasons other than pre-penetrant inspection cleaning (e.g., aluminum forgings for grain flow, etc.) and the required metal removal or more is accomplished, additional etching per this NDTS is not necessary provided no subsequent processes are performed which may smear metal. Refer to Paragraph 4.6 for alternate process controls and approvals.

4.1.4 Machined, ground, vibration deburred, or grit blasted surfaces of aluminum, titanium, corrosion resistant steels, and inconel shall be etched prior to penetrant inspection unless otherwise specified by the engineering drawing or Process Engineering Development & Control. Etching is not required on surfaces which have been wire-brushed by hand or sanded by hand (no power tools).

NOTE: Etching shall not be performed on the airplane or assemblies. Refer to Paragraph 4.1.8.

4.1.5 Areas of parts and holes with tolerances closer than +/- 0.002[$1] and threads must be masked prior to etching. The area masked must be covered to within ±1/16-inch; i.e., the maskant may extend 1/16-inch into the area to be etched or stopped short by 1/16-inch of the area to be masked. Masking is not required on hole chamfers or countersinks. Remove plugs and/or maskant prior to penetrant inspection. Drilled holes in non-machined areas of castings/forgings and pilot holes shall not be penetrant inspected unless specified on the engineering drawing.

4.1.6 Parts which contain welds, valves, screens fittings, etc., shall not be etched if there is a possibility of etchant entrapment.

4.1.7 Inspection of finished and/or reworked/repaired parts removed from the airplane or stockroom

a) The finish may be removed by hand-sanding or with solvent remover. Solvent remover must be approved by General Dynamics/Fort Worth Division Process Engineering Development & Control. Etching is not required prior to penetrant inspection.

4.1.8 Painted parts inspected on assembly or on the airplane:

a) Hand-sanding only (no power tools) shall be used to remove paint from aluminum, titanium or CRES parts unless otherwise permitted by Engineering documentation. Hand-sanding shall be done using 120 grit initially and finished with 180 grit to eliminate metal smearing.

b) Clean surface and allow to dry,

4.2 Preparation of Aluminum

4.2.1 Non-machined aluminum

a) Vapor or immersion degrease using a chlorinated hydrocarbon solvent or inhibited alkaline cleaner followed by water rinse. Other methods must be approved by Process Engineering Development & Control.

4.2.2 Machined, ground, grit blasted, vibration deburred parts and, parts which have been power-sanded, (including castings):

a) Vapor or immersion degrease using a chlorinated hydrocarbon solvent or inhibited alkaline cleaner followed by a water rinse. Other methods must be approved by Process Engineering Development & Control.

b) Etch to remove 0.0003 to 0.0007 inch from each surface. The etch solution shall produce a uniformly etched surface without pitting or intergranular attack. The" etch process shall meet the requirements and provisions of FPS-1051.

c) The etch solution to be used at GDFW on all aluminum alloys, which may be used by subcontractors without pre-production approval, shall be a room temperature solution formulated and maintained as follows: 10-22 percent by volume concentrated (68%) nitric acid; 3.5-4.5 ounce/gallon chromic acid; and 0.55% by volume concentrated (70%) hydrofluoric acid. Add hydrofluoric acid as required to maintain an etch rate of 0.000015 to 0.000030 inches per minute per surface on bare 2024-T3 sheet aluminum

d) Other etch procedures may be used per Paragraph 4.6 of this specification.

4.2.3 GD/FW P.S. 40.01-21 describes process procedures and P.S. 00.04. outlines solution control parameters.

4.3 Preparation of Steel.

4.3.1 For corrosion resistant steels (excluding 400 series) which have been machined, ground, vibration deburred, power-sanded, or grit blasted:

a) Vapor or immersion degrease using a chlorinated hydrocarbon solvent or inhibited alkaline cleaner followed by water rinse. Other methods must be approved by Process Engineering Development & Control.

b) Etch to remove 0.0002 to 0.0004 inch from each surface. The etched surface shall be uniform with no pitting or intergranular attack. The etch process shall conform to FPS-3020 or FPS-1051.

NOTE: For steels processed per FPS-3020, no further passivation is required after penetrant inspection, unless subsequent machining (or other forms of metal removal) is performed.

c) For corrosion resistant steels (excluding 400 series) the etch solution to be used at GDFW and which may be used by subcontractors without pre-production approval, shall consist of a material/process system listed in FQML-3020. Solution controls must be compatible with the controls required by the FQML material/process system supplier.

4.3.2 Alternate etch processes for CRES steels may be permitted with General Dynamics/Fort Worth Division Process Engineering Development & Control approval. Potential processors using alternate etchants shall submit complete process procedures and controls listed in Paragraph 4.6. Processors shall make no changes in process solutions, procedures, or solution controls without prior approval of General Dynamics/Fort Worth Division Process Engineering Development & Control.

4.3.3 All other steels:

a) Vapor or immersion degrease using a chlorinated hydrocarbon solvent or inhibited alkaline cleaner followed by water rinse. Other methods must be approved by Process Engineering Development & Control.

4.3.4 GD/FW P.S. 40.01-24 describes process procedures and P.S. 00.04 outlines solution control parameters.

4.4 Preparation of Titanium

4.4.1 Non-machined titanium

a) Vapor or immersion degrease using a chlorinated hydrocarbon solvent and/or degrease using an inhibited alkaline cleaner followed by water rinse. When solvent decreasing is employed, it shall be followed by immersion in inhibited alkaline cleaner and water rinse. Other methods must be approved by Process Engineering Development & Control.

4.4.2 Titanium parts which have been machined, ground, vibration deburred, power-sanded or grit blasted:

a) Vapor or immersion degrease using a chlorinated hydrocarbon solvent and/or degrease using an inhibited alkaline cleaner followed by water rinse. When solvent decreasing is employed, it shall be followed by immersion in inhibited alkaline cleaner and water rinse. Other methods must be approved by Process Engineering Development & Control.

b) Etch to remove 0.0004 to 0.0008 inch from each surface. The etch solution shall produce a uniformly etched surface, with no pitting or intergranular attack, and shall introduce no more than 20 ppm hydrogen. The process shall meet FPS-1051 requirements and provisions.

NOTE: Unless the pre-approved etch solution formulation and controls are used, suppliers/coproducers are responsible for performing the hydrogen content analysis specified in FPS-1051 on a monthly basis. The titanium test specimen shall be processed along with a batch of GDFW parts.

c) The etch solution to be used at the General Dynamics/Fort Worth Division which may be used by subcontractors without pre-production approval shall be a room temperature solution formulated and maintained as follows: 40-50% by volume concentrated (68%) nitric acid and 0.5% by volume concentrated (70%) hydrofluoric acid. Add hydrofluoric acid as required to maintain an etch rate of 0.00002 to 0.00004 inches per minute per surface on bare 6AL/4V titanium

d) Alternate etch solutions may be used by subcontractors subject to the provisions of Paragraph 4.6 of this specification.

4.4.3 GD/FW P.S. 40.01-25 describes process procedures and P.S. 00.04 outlines solution control parameters.

4.5 Preparation of Nickel Based Alloys

4.5.1 Non-machined nickel based alloys

a) Vapor or immersion degrease using a chlorinated hydrocarbon solvent or inhibited alkaline cleaner followed by water rinse. Other methods must be approved by Process Engineering Development & Control.

4.5.2 For MP35N, Inconel 625, and Inconel 718 parts which have been machined, ground, vibration deburred, power sanded or grit blasted.

a) Etch to remove 0.0002 to 0.0004 inch from each surface. The etch solution shall produce a uniformly etched surface with no pitting or intergranular attack. The etch process shall meet requirements and provisions of FPS-1051.

b) The etch solution which may be used by subcontractors without pre-production approval shall be a room temperature solution formulated as follows: 83-89% by volume concentrated hydrochloric acid, 1-3% by volume concentrated nitric acid, 8-16% by volume deionized water and 175 grams per liter ferric chloride (volume displacement discounted). The solution shall maintain an etch rate of 0.000005 to 0.000015 inches per minute per surface on the bare material undergoing etch.

c) Alternate procedures may be used with General Dynamics/Fort Worth Division Process Engineering Development & Control approval. Potential processors using alternate etchants shall submit complete process procedures and controls as listed in paragraph 4.6.

4.6 Alternate Process Approval.

4.6.1 The use of pre-penetrant etch processes other than those specified herein requires pre-production approval by General Dynamics/Fort Worth Division Process Engineering Development & Control. Requests for approval shall be accompanied by the following, unless otherwise specified:

4.6.2 For aluminum etch processes:

a) Chemical composition of the proposed solution(s).

b) Etch rates, immersion times, and operating temperatures of proposed solutions. Etch rates shall be determined for each alloy and heat-treated condition to be processed in the pre-penetrant etch solution.

c) Solution and etch rate control procedures.

d) The following two (2) coupons furnished by General Dynamics Process Engineering Development & Control are to be etched at the same time and then returned to General Dynamics/Fort Worth Division Process Engineering Development & Control for testing:

1) A 0.25" x 3" (approximately) x full thickness coupon (cut transverse to grain), from 2124-T851 plate over 2" in thickness, which has been etched in the proposed alternate etchant. The coupon will be examined for uniformity of etch and absence of intergranular attack.

2) A 0.040" x 4" x 4" coupon from 2024-T3. This coupon will be pre-weighed by General Dynamics/Fort Worth Division Process Engineering Development"& Control prior to release and will be used to verify the required metal removal quantity of 0.0003 to 0.0007 inch per surface.

e) For supplier-produced forgings, the .0003 inch per surface removal quantity minimum shall be applicable, but the maximum allowable removal quantity shall be limited only by the dimensional requirements specified by the engineering drawing.

4.6.3 For steel etch processes:

a) Chemical composition of proposed solution(s).

b) Etch rates, immersion times, and operating temperatures of proposed solutions. Etch rates will be determined for each alloy and heat-treated condition to be processed in the pre-penetrant etch solution.

c) Solution and etch control procedures.

d) Results of intergranular attack examination per Paragraph 4.6.6.

4.6.4 For titanium etch processes:

a) Chemical composition of the proposed solution(s).

b) Etch rates, immersion times, and operating temperatures of proposed solutions.

c) Solution and etch rate control procedures.

d) A test report showing that the proposed etch process will produce a uniformly etched surface without introducing more than 20 ppm hydrogen. Once this proposed etch process is approved, this test is the suppliers responsibility to perform on a monthly basis. The titanium test coupon shall be processed along with a batch of GD/FW parts.

4.6.5 For MP35N, Inconel 625 and Inconel 718 etch processes.

a) Chemical composition of the proposed solution(s).

b) Etch rates, immersion times and operating temperatures of proposed solutions. Etch rates will be determined for each alloy and heat-treated condition to be processed in the pre-penetrant etch solution.

c) Solution and etch procedures.

d) Results of intergranular attack examination per paragraph 4.6.6.

4.6.6 All steel alloys, MP35N, Inconel 625 and Inconel 718, processed in an alternate etchant shall be tested for intergranular attack by the following procedure.

a) After etching, cut two cross-sectional specimens. whose outer perimeter contains at least 0.75 inch of surface material. Polish the cross-section and examine along the etched edge for intergranular attack. No intergranular attack shall be visible when viewed at magnification of 500X.

4.6.7. Unless otherwise specified, the requirements referred to in paragraph 4.6 shall be satisfied on a one-time qualification basis. If significant changes are made to the qualified alternate etch, re-qualification will be required. General Dynamics/Fort Worth Division Process Engineering Development & Control reserves the right to require re-qualification upon request.

4.7 Cleanliness Prior To Penetrant Inspection

4.7.1 It is preferred that parts and materials be inspected as soon as possible after etch. Parts that must be temporarily stored after etch shall be covered to prevent collection of dust, dirt and other environmental particles. Contaminated parts shall be re-cleaned.

5.0 INSPECTION PROCEDURE.

NOTE: Refer to NDTS 1101-2 for portable FPI procedures.

5.1 Penetrant Application and Dwell.

5.1.1 Apply penetrant to all surfaces by dipping, spraying, brushing or flowing. The parts/materials, penetrant and ambient temperatures "shall be in the range of 40 deg. F to 120 deg. F.

5.1.2 Minimum penetrant dwell time shall be 10 minutes. Allow penetrant to drain from parts during the dwell time. For dwell times greater than 2 hours, the penetrant shall be reapplied, if necessary, to enhance washability.

5.2 Penetrant Removal.

5.2.1 Water Washable Penetrants:

a) Excess penetrant may be removed by manual or automated water spray or manual wipe.

b) Penetrant removal shall be accomplished by rinsing with a coarse spray nozzle at a maximum pressure of 40 psi. Water temperature shall be between 50 deg. F and 100 deg. F.

c) Hydro-air nozzles shall be permitted only for Level 1 and Level 2 sensitivity. The added air pressure shall be 25 psi maximum

d) Manual washing shall be conducted under backlight. Backlight is not required in automated wash stations.

5.2.2 Solvent Removable Penetrants:

a) First remove excess penetrant with a clean, lint free, dry cloth or absorbent towel. The remainder of the surface penetrant is then removed with a solvent-dampened cloth or towel. The surface of the component shall not be flushed with solvent and the cloth or towel shall not be saturated with solvent. Let the part dry by evaporation.

5.2.3 Lipophilic Emulsified Penetrants:

a) Lipophilic emulsifiers shall be applied by immersion, then allowed to drain. Lipophilic emulsifiers shall not be applied by spray or brush and shall not be agitated while on the surface of the component under test. Maximum dwell times, unless otherwise specified, shall be three minutes. After the appropriate emulsifier dwell time, emulsification shall be stopped by water immersion or water spray. Complete penetrant removal per Paragraph 5.2.1.

5.2.4 Hydrophilic Remover Systems.

a) A water spray pre-wash shall be used to mechanically remove the bulk of excess penetrant.

b) Hydrophilic remover shall be applied by spraying, flowing or agitated immersion.

c) Complete penetrant removal per Paragraph 5.2.1.

5.2.4.1 For immersion applications, the concentration shall be as specified by the manufacturer but shall not exceed 35 percent by volume. For spray applications, the concentration shall not exceed 5 percent by volume.

5.3 Drying.

a) Water rinsed parts or materials shall be dried prior to application of dry or nonaqueous developer, or inspection without developer.

b) Drying may be accomplished in a re-circulating hot air dryer at a temperature not to exceed 160 deg. F.

c) Parts shall not remain in the dryer longer than necessary. Excessive time prior to developer application will affect sensitivity of the process.

5.4 Application of Developer.

5.4.1 penetrant inspections to Zone 1A, 1B, and 1C shall use a developer unless previously demonstrated without developer to Process Engineering Development & Control. The satisfactory results shall be published in the FQPL: NDTS 1101, latest revision.

5.4.1.1 Dry Developer.

a) Apply dry developer by electrostatic spraying, dipping, dusting, or pouring. Dwell time shall be 10 minutes minimum and 4 hours maximum

5.4.1.2 Aqueous Wet Developer.

a) Developer shall be applied after rinsing or after the part is dry. Aqueous developers shall be applied by spraying or momentary dipping.

b) Minimum and maximum dwell times after the developer has dried on the part's surface shall be 10 minutes and 2 hours respectively.

5.4.1.3 Non-Aqueous Wet Developer.

a) Non-aqueous wet developer shall be applied only to parts and materials which are dry and cool enough to handle.

b) Apply developer by spraying. Inspection shall take place within 1 hour after non-aqueous wet developer has been applied.

6.0 INSPECTION.

6.1 Parts not inspected before the maximum developer dwell time shall be cleaned (no pre-penetrant etch required) and returned for penetrant inspection starting with penetrant application.

6.2 Inspection of parts shall be conducted under backlight in a darkened area. For AUTOMATED RINSE SYSTEMS: If background fluorescence is unacceptable, a second rinse and air dry is permitted.

6.3 Inspectors shall allow a sufficient time for vision adjustment (dark conditioning) each time the darkened area is entered from white light, and shall not wear photosensitive, tinted, or permanently darkened lenses during evaluations.

7.0 ACCEPT/REJECT CRITERIA.

7.1 Indications. There are basically two types of penetrant indications Linear and Rounded. Linear indications are linear in shape and have a length three times or greater than the width. Rounded indications are round in shape. Indications which are not linear but have discernible pointed or sharp edges are to be considered linear.

7.1.1 Indication Verification. All questionable indications shall be wiped with a solvent moistened cloth, cotton swab, or towel. If the indication persists after wiping it shall be considered a relevant indication or discontinuity and shall be evaluated per the following paragraphs. For discontinuities which touch, the conglomerate size shall be considered as one discontinuity.

7.2 Discontinuity. If the inspector identifies a discontinuity as a defect, the defect may be removed the part evaluated for dimensional tolerance, and either accepted or rejected. If rejected, the part shall be Processed in accordance with FZM 13725.

7.2.1 Defect Removal. Defect(s) may be removed by sanding or grinding. EXCEPTION: See paragraph 7.2.2. After removal the area must be cleaned and reinspected. If power tools were used to remove the defect(s), the removal area must be 1) cleaned and etched or 2) hand-sanded with 320 grit or finer and cleaned, and then reinspected.

7.2.2 Parts made from vendor-supplied castings, forgings, etc. that have discontinuity(s) shall be processed in accordance with FZM 13725. EXCEPTION: If GDFW caused the discontinuity(s), the discontinuity(s) may be removed and reinspected.

7.3 ZONE Standards. The accept/reject criteria specified on the Engineering Drawing is based on the ZONES specified herein. Final dispositions to reject parts which exceed ZONE allowable shall be based on the measurement of actual discontinuity sizes. Regardless of Zone Standards linear defects are not allowed.

NOTE: IRP 0077-2 (Illustrated in Figure 1) may be used as a visual aid in determining approximate discontinuity sizes based on the Zone criteria.

7.3.1 When no zone number is specified on the Engineering Drawing, ZONE O shall be used as the accept/reject criteria.

7.3.2 For portions of parts where the thickness is 0.13 inch or less, indications that are in-line on opposite sides are rejectable. The inspector shall use his or her best judgment in determining whether the two indications are in-line.

7.3.3 ZONE O and Zone 1: Rounded discontinuities equal to or exceeding 0.02 inches in the maximum dimension shall be rejected. Any two discontinuities closer than 0.02 inches shall be rejected.

7.3.4 ZONE 1A, 1B, 1C. The accept-reject criteria are identical to ZONE 1 for rounded discontinuities. Only those facilities listed in the current revision of FQPL: NDTS 1101, as having successfully completed a Penetrant Demonstration Program, shall perform inspections to Zones 1A, 1B, or 1C. (See Appendix "A").

7.3.5 ZONE 2. (EXCEPT FOR CAST SURFACES). Rounded discontinuities equal to or exceeding 0.03 inches in the maximum dimension shall be rejected. Any two discontinuities closer than 0.03 inches shall be rejected.

7.3.6 ZONE 2. (CAST SURFACES). Rounded discontinuities equal to or exceeding 0.05 inches in the maximum dimension or any two discontinuities closer than 0.05 inches shall be rejected.

7.3.7 ZONE 3. Retained for future expansion.

7.3.8 ZONE 4. This zone is intended for inspection of raw materials surfaces, i.e. as forged, as rolled, etc. Indications resulting from surface imperfections which are permitted by the procurement specification are acceptable. Cracks and other linear defects which result from heat treatment, forming or other manufacturing processes are not acceptable.

7.3.9 ZONE 5. This zone is intended for areas where subsequent processing, such as machining, etching, grinding, etc., will be used to remove surface material. Indications resulting from rough surfaces, minor pitting, etc., shall not be cause for rejection providing the conditions are removable within drawing tolerances. Gross defects, such as cracks, laps, seams, cold shuts, etc., are not acceptable. If these conditions are removable within tolerances, parts can be accepted.

7.3.10 ZONE 6. This zone is intended for as-cast surfaces which remain on the finished part of aircraft quality castings. Use the same accept/reject criteria in ZONE 2 (CASTINGS).

7.4 Unless otherwise specified by Engineering, acceptance criteria in FPS-1097 shall be applied to all welds.

7.5 The P.S. 92.01-1 (MIL-STD-410) Level III Penetrant Inspector shall be the final authority in cases of questionable interpretation.

8.0 POST-INSPECTION REQUIREMENTS.

8.1 Defects shall be marked on the part and/or identified on the rejection paperwork as to approximate location and dimension. Markings used shall not be detrimental to the part.

8.2 Residue from the penetrant inspection (e.g., Penetrant, developer, etc.) shall be removed.

8.2.1 If wet developers are used and parts are to be stocked prior to further chemical surface treatment, these parts shall be alkaline cleaned in an inhibited cleaner (non-etching) followed by rinsing, acid cleaning, then final rinsing and drying. Manual wiping with solvent cleaner may be necessary to aid final cleaning process.

8.3 Post-inspection clean-up operations which require minor surface metal removal do not require a subsequent etch/penetrant cycle provided the parts were previously pre-penetrant etched, penetrant inspected, and found acceptable. Such operations are limited to the following:

a) Removal and re-application of vibro-engraved markings.

b) Smoothing of isolated areas of surface roughness not in compliance with drawing requirements.

c) Removal of minor amounts of excess metal, such as flash and chill marks.

d) Cosmetic improvement of other surface conditions not related to removal of linear defects; excluding gating, risers, weldments or other similar instances where removal of considerable materials would be involved.

9.0 QUALITY ASSURANCE PROVISIONS.

9.1 This section provides the controls necessary to assure that the penetrant system materials and equipment provide an acceptable level of performance. The frequency of checks may be altered provided a plan justifying this change is prepared by the NDT facility and approved by General Dynamics/Fort Worth Division Process Engineering Development & Control. The NDT facility may perform these process control operations or contract for their performance with an independent laboratory.

9.2 Blacklights. All backlights shall be checked daily, and after bulb replacement, for output. Minimum acceptable intensity is 800 micro watts/square centimeter measured at a distance of at least 38 cm (15 inches) from the front of the bulb or filter.

9.3 White Light. The inspection area shall be checked for white light incursion. This check shall be performed weekly to assure it does not exceed two foot-candles.

9.4 Process Performance.

9.4.1 The entire penetrant inspection system shall be tested once a week for detectability and background. The record of these" results shall be kept for review. Significant changes shall be investigated and corrective, action taken.

9.4.2 GDFW shall use a Penetrant System Monitor (PSM) which is a cracked chrome panel containing cracks on one half of the panel and the other half grit blasted (medium roughness). The following are acceptable PSM's:

Pratt and Whitney Tam Panel P/N 146040
Sherwin Company P/N PSM-5
Magnaflux Corp. P/N 198055

9.4.2.1 The PSM shall be processed through all GDFW penetrant systems using appropriate processing parameters. A comparison shall be made between a PSM panel freshly processed through the penetrant inspection system and a second PSM (standard) freshly processed through a manual system using unused penetrant materials. Significant changes in detectability and/or background shall be reported to Process Engineering Development & Control.

NOTE: A photograph is an acceptable substitute for the PSM standard. The photograph shall be approved by a GDFW penetrant level III and Quality Control.

9.4.2.2 After comparing the processed PSM panels they shall be cleaned immediately by vapor decreasing or ultrasonic cleaning. An acceptable alternative is to wipe with a chlorinated hydrocarbon solvent followed by a 4 hour soak in the solvent. Do not clean specimens with a brush. The PSM panel must be clean, dry and free of any solvent or penetrant residue. Each PSM panel shall be checked for cleanliness under backlight before reuse.

9.5 Materials. Materials will be selected from MIL-I-25135 Qualified Products List. Operators shall report any changes in performance, color, odor, consistency or appearance of all penetrant materials in use. Process Engineering Development & Control shall conduct the appropriate tests on materials suspected of being substandard.

9.5.1 New (unused) materials do not require periodic checks.

9.5.2 Unused materials shall be stored in a temperature-controlled environment between 40 and 150 deg. F maximum If the temperature decreases below or increases above this range, the penetrant must be retested in accordance with paragragh 9.6.

9.5.3 Penetrant materials stored more than five years shall be retested in accordance with paragraph 9.6.

9.6 Penetrants. The following checks on in-use penetrants shall be conducted at least monthly with the exception of brightness which shall be conducted at least quarterly. Unsatisfactory performance shall be cause for replacement of the in-use material or corrective action as appropriate.

9.6.1. Brightness. Brightness tests of in-use penetrants shall be conducted in accordance with MIL-I-25135 with a sample of the unused penetrant serving as the reference. Brightness values less than 90 percent of the unused penetrant brightness are unsatisfactory.

9.6.2 Water Content. (Water washable penetrants only). Water content of Method A penetrants in dip tanks shall be measured in accordance with ASTM D 95. Water content in excess of 5 percent by volume is unsatisfactory.

9.7 Emulsifiers/Removers. The following checks on in-use emulsifiers/removers shall be performed as specified. Unsatisfactory performance shall be cause for replacement of the in-use emulsifier/remover or corrective action as appropriate.

9.7.1 Removability. Removability of the in-use emulsifier/rernover shall be checked weekly in accordance with MIL-I-25135. The in-use emulsifier/remover will be used with the unused penetrant and compared to the reference system of unused emulsifier/remover used with the unused penetrant. Removability less than that of the reference system is unsatisfactory.

9.7.2 Water Content. (lipophilic emulsifier). Water content shall be checked monthly in accordance with ASTM D 95. Water content in excess of 5 percent is unsatisfactory.

9.7.3 Concentration (hydrophilic remover). Concentration of immersion solutions shall be checked weekly with a refractometer. Variation of concentration greater than three percentage points from the initial, unused concentration is unsatisfactory. Spray concentrations shall be checked weekly with the refractometer and shall not exceed the specified manufacturer's concentration for the system

9.8 Developers. The following checks on in-use developers shall be performed as specified. Unsatisfactory performance shall be cause for replacement or corrective action as appropriate.

9.8.1 Dry developer. Dry developer shall be checked daily to ensure it is fluffy and not caked. Caked dry developer is unsatisfactory. For dry developer that is recycled, 10 or more fluorescent specks observed in a 10 cm (4 inch) circle, when a sample is spread into a thin layer on a flat surface, is unsatisfactory.

9.8.2 Aqueous Developer.(soluble and suspended). Aqueous developers shall be checked daily for fluorescence. Concentration shall be checked weekly with a hydrometer and shall be in accordance with the developer supplier recommended concentration.

9.9 Inspection Area. Good product discipline (housekeeping) practices shall be maintained in the inspection area. The inspection area shall be clean and free of penetrant contamination which may hinder the inspection.

9.10 Operating Pressures/Temperatures. Indicators and controls shall be checked at the start of each shift to assure proper settings. Those processes not within tolerance shall be adjusted to acceptable limits before proceeding with part inspection. Indicators and controls shall be calibrated in accordance with MIL-STD-45662.

9.11 Sensitivity.

9.11.1 All GD/FW penetrant systems shall be tested bi-annually for sensitivity by Process Engineering Development & Control or a designated representative.

9.11.2 The test will consist of processing single fatigue crack specimens made of titanium using normal production processes. The specimens will be evaluated based on the crack brightness (signal) compared with the specimen background brightness (noise). Sensitivity is acceptable if the indications from the cracks are distinct.

9.12 If specified, parts which have been inspected by FPI shall be marked in accordance with the applicable drawing, specification or purchase order. If marking method is not specified, marking shall be in accordance with FPS 3008, Class II, applied in a manner and location that is harmless to the component, or its intended function, and to preclude removal, smearing or obliteration by subsequent handling. Plated parts and parts that receive subsequent processing that will remove the identification shall be identified by marking the records that accompany the parts.

9.12.1 Suppliers and coproducers that perform subsequent processing shall identify parts with a penetrant transfer stamp or equivalent after processing is complete. (Applies to details delivered to GDFW only)

10.0 DEFINITIONS.

Black Light. The term given to electromagnetic radiation having wavelengths between 2000 and 4000 Angstrom units. Typical units used in penetrant inspection provide a minimum intensity of 800 micro-watts/square centimeter at 38 cm (15 inches) from the face of the filter and are used to excite fluorescent materials in a range visible to the eye.

Defects. Discontinuities which a) interfere with the usefulness of a part, or b) contain faults in the material which are detrimental to its serviceability, or c) exceed Engineering specification/tolerances.

Developer. Material, wet or dry, which will draw or absorb penetrant from a surface crack or defect to the extent that the defect will be visible under black light.

Discontinuities. The interruption in the normal physical structure or configuration of a part such as cracks, laps, seams, inclusions, scratches, porosity, etc. A discontinuity may or may not affect the usefulness/serviceability of a part.

Emulsifier. A liquid agent which must be applied to the non-water-washable penetrant after the proper dwell time has elapsed to permit water rinsing. This requires an additional step and a period of time must be allowed for the combining to occur. A suspension of one liquid phase in another.

Etching. Subjecting the surface of a metal to preferential chemical or electrolytic attack in order to reveal structure/defects.

Fluorescent penetrant inspection (FPI). Is performed after all fabrication/processing is completed.

High Temperature Alloys. Nickel, tungsten, columbium and cobalt based alloys.

Hydrophilic. Having an affinity for, attracting, adsorbing, or absorbing water. A substance soluble in water.

Hydrophilic Remover. A water compatible remover used with standard penetrants. Provides for improved control for the emulsification process. It requires different processing steps than the standard lipophilic emulsifiers.

Indications. The visible evidence of penetrant which has come out of a discontinuity, indicating a surface opening is present. Indications which touch shall be considered as one indication.

Linear Indications. Indications having sharp/pointed edges and whose length is more than three times their width.

Lipophilic. Relating to or having a strong affinity for fats or other liquids. Promoting the solubilization or absorption of lipids. An oil or fat based substance.

Machined. Metal removal by mechanical power tools, such as milling, turning, spot-facing, counterboring, countersinking, sanding, and routing.

Penetrant. A liquid of high surface tension and high capillary action which is a vehicle for a colored or fluorescent dye, used to penetrate into and detect surface discontinuities.

Penetrant Sensitivity. Penetrant sensitivity is the ability of the penetrant, processing technique, and developer to detect surface-connected discontinuities and provide an indication visible to the unaided eye.

Process Control. A general term used to encompass the actions and documentation, as required by official directives or logic, that are necessary for an NDI method to be effective in detecting conditions of interest (e.g., cracks, foreign objects, corrosion, alignment of parts, thickness of parts/coating, and pressure/vacuum leaks).

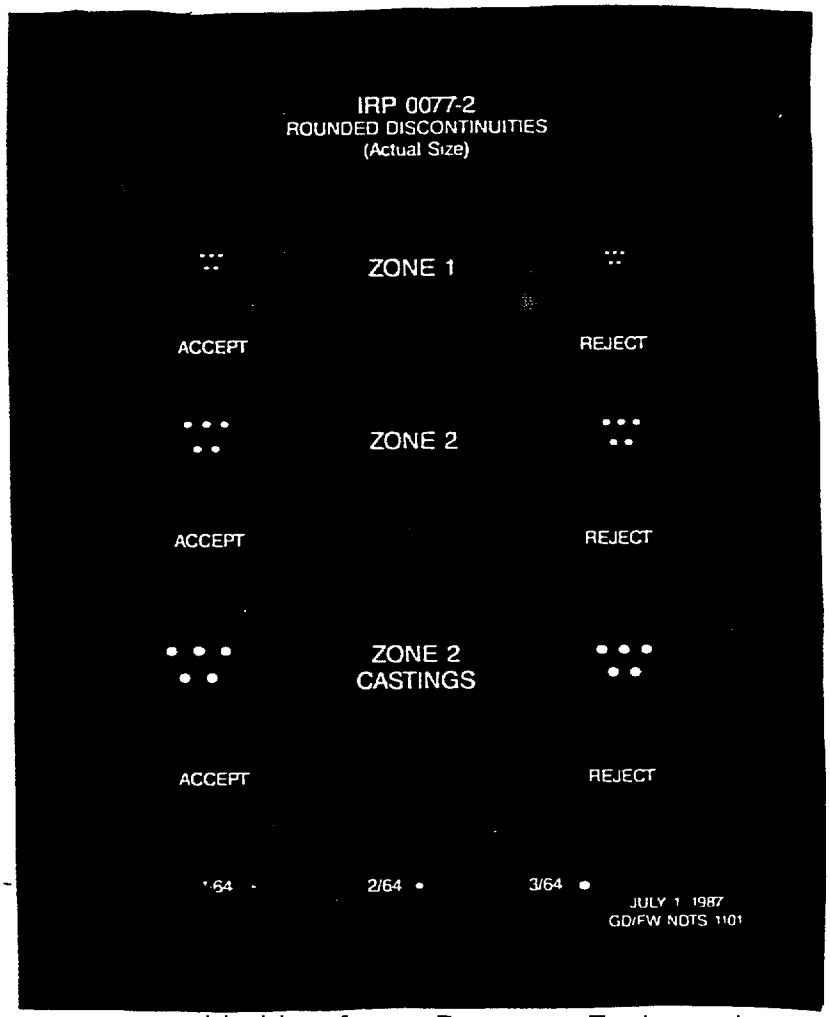
Processing. Operation to convert raw material to a finished product.

Rounded Indications. Indications which have rounded edges and whose length is less than three times their width.

Wrought Products. All forms except castings.

FIGURE 1

Print of IRP 0077-2, Visual Aid/Standard For FPI of Rounded Indications



IRP's are available from Process Engineering Development and Control General Dynamics/Fort Worth Division

APPENDIX "A"

PRODUCTION PENETRANT DEMONSTRATION PROGRAM "ZONE 1A, 1B, AND 1C" CRACK DETECTION CAPABILITY

The following program is established per MIL-A-83444 to demonstrate the capability of liquid penetrant inspection facilities to detect cracks in selected materials with 90% probability of detection at a confidence level of 95%

Test Specimens

Fatigue cracked specimens fabricated for the General Dynamics/Fort Worth Division Penetrant Demonstration Program will be used. A backup set of specimens will be available if needed.

The production liquid penetrant materials, procedures and certification program of each facility processing parts which require ZONE 1A, 1B, or 1C criteria shall be approved by General Dynamics Process Engineering Development and Control.

At least two certified (Level II or Level III per MIL-STD-410) penetrant inspectors at each facility shall participate in the inspections. Each inspector will process sufficient specimens so that the total inspections per facility will be at least 30 defect and 15 control specimens for a specific crack size. If sufficient misses occur, the backup specimens will be utilized to obtain more data and increase the probability of satisfying the program requirements.

The inspectors will process the specimens per approved procedures and document their findings on inspection forms provided. The tests will be witnessed by a General Dynamics/Fort Worth Division Process Engineering Development and Control representative who will evaluate the results.

Cleaning of specimens between inspections will be directed and monitored by the General Dynamics/Fort Worth Division representative utilizing available equipment at each facility. Cleaning may be accomplished by vapor-degreasing, solvent immersion, or other methods determined by the General Dynamics/Fort Worth Division representative.

	ZONE	DEFECT SPECIMEN	QUALITY SIZE	CONTROL SPECIMEN	SIZE RANGE
PRIMARY	1A	30	.100	15	.090-.100
	1B	30	.050	15	.045-.055
	1C	30	.040	15	.035-.044
BACK-UP	1A	15	.100	5	.090-.100
	1B	15	.050	5	.045-.055
	1C	15	.040	5	.035-.044

RESULTS

1. If all 30 primary defects are correctly detected, the facility will be approved.

2. If one primary defect is missed by either inspector and all back-up defects are detected, the facility will be qualified.

3. If more than one defect is missed, the facility will not be qualified. The penetrant materials/system must be changed and/or additional training must be conducted before the inspection sequence can be repeated.

Statistical procedures are based on the Binomial Reliability Table, Naval Weapons Report No. 8090, China Lake, California, 1964.

APPENDIX B

TEST FREQUENCIES

TEST	FREQUENCY
Black Light	Daily
Process Performance	Weekly
Brightness	Quarterly
Water Content (Penetrant)	Monthly
Sensitivity	Bi-Annually
Removability (Emulsifier)	Weekly
Water Content (Emulsifier)	Monthly
Concentration (Emulsifier)	Weekly
Dry Developer	Daily
Concentration (Developer)	Weekly
White Light	Weekly
Pressures/Temperatures	Beginning of Each Operational Shift

GENERAL DYNAMICS
Fort Worth Division
FSCM 81755

Amendment 2 to NDTS 1101 H
Date: 17 February 1993
Superseding: Amendment 1

C1

AMENDMENT TO
NDTS 1101H
PENETRANT INSPECTION

Contract Number: F33857-84-C-0247

Releasability of this material under the Freedom of Information Act is subject to the restrictions on release in DoD Regulation 5400.7-R and DoD Directive 5230.25.

C 2

GENERAL DYNAMICS
Fort Worth Division
FSCM 81755

Amendment 2 to NDTS 1101H
Date: 17 February 1993
Superseding: Amendment 1

PENETRANT INSPECTION

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C3

GENERAL DYNAMICS
Fort Worth Division
FSCM 81755

Amendment 2 to NDTS 1101 H
Date: 17 February 1993
Superseding: Amendment 1

This amendment forms apart of and shall be attached to General Dynamics/Fort Worth Division Standard NDTS 1101H, Penetrant Inspection, dated July 3, 1992. This amendment shall become effective immediately upon issue.

7.0 to 7.4 & 3.4.4 **Reason for Amendment 2:** Replace paragraphs 7.0 to 7.4 and revise paragraph 3.4.4, TABLE 1, to adequately define accept/reject criteria.

New items in this amendment.

3.4.4

TABLE 1

Surface Inspected	MIL-I-25135 Sensitivity Level
All Titanium and High Temperature Alloys	3
Machine Surfaces (All Wrought Materials except for Aluminum)	3
All other surfaces including welds which are not covered above	1

7.0 **ACCEPT/REJECT CRITERIA**

7.1 **Indications** - There are two types of penetrant indications, linear and rounded. Linear indications are linear in shape and have a length three times or greater than the width. Rounded indications are round in shape. Rounded indications which are jagged shall be considered round.

7.1.1 **Indication Verification** - For a rounded indication to be rejectable, it must be visible under black light. All questionable rounded indications shall be wiped with a solvent moistened swab, cloth, or towel and non-aqueous developer applied. If the indication persists after a maximum of three wipes and developments, it shall be considered a relevant indication or discontinuity and shall be evaluated per the following paragraphs. Unless otherwise specified by Engineering, acceptance criteria for welds shall be per FPS-1097.

7<1.1.1 **Discontinuity P** - - For discontinuities which touch, the conglomerate size shall be considered as one discontinuity. Discontinuities whose separation distance is equal to or closer than zone criteria size (see below) and which are visible under black light, shall be rejected regardless of individual size.

7.2 **Zone Standards**

7.2.1 **General** - The accept/reject criteria for rounded discontinuities specified on the Engineering Drawing is based on the zones specified herein. When no zone number is specified on the Engineering Drawing, Zone O shall be used as the accept/reject criteria for rounded discontinuities. The final decision to reject parts which exceed zone allowables shall be based on the measurement of actual discontinuity sizes. IRP 0077-2 (illustrated in Figure 1) or transparent comparators maybe used as a visual aid in determining approximate discontinuity sizes based on zone criteria. REGARDLESS OF ZONE CALLOUTS, LINEAR DEFECTS ARE NOT ALLOWED WHETHER VISIBLE UNDER WHITE LIGHT OR BLACK LIGHT.

7.2.2 **Zone O and Zone 1** - Rounded discontinuities equal to or exceeding 0.02 inches shall be rejected.

7.2.3 Zone 2 - (EXCEPT FOR CAST SURFACES). Rounded discontinuities equal to or exceeding 0.03 inches shall be rejected.

7.2.4 Zone 2 - (CASTINGS). Rounded discontinuities equal to or exceeding 0.05 inches shall be rejected.

7.2.5 Zone 3 - Reserved for future use.

7.2.6 Zone 4 - This zone is intended for inspection of raw materials surfaces, i.e. as forged, as rolled, etc. Discontinuities resulting from surface imperfections which are permitted by the procurement specification are acceptable.

7.2.7 Zone5 - This zone is intended for areas where subsequent processing, such as machining, etching, grinding, etc., will be used to remove surface material. Discontinuities resulting from rough surfaces, minor pitting, etc., shall not be cause for rejection providing the conditions are removable within drawing tolerances,

7.2.8 _- This zone is intended for as-cast surfaces which remain on the finished part of aircraft quality castings. Use the same accept/reject criteria in Zone 2 (CASTINGS).

7.2.9 Zone 1A, 1 B, 1C - The designation of Zones 1A, 1 B, or 1C are reserved for primary structural parts, e.g. Fatigue and/or Fracture Critical parts. The suffix A, B, or C designates the level of facility qualification. A part requiring one of these Zones requires an accept/reject decision to Zone 1 criteria. Only those facilities that have successfully completed the Production Penetrant Demonstration Program per Appendix "A" shall perform inspections to 1A, 1 B, or 1C.

7.3 Discontinuity Evaluation - If the inspector identifies a discontinuity(s), the discontinuity(s) may be lightly hand sanded with 120 grit or finer sand paper, the part evaluated for dimensional tolerance, and either accepted or rejected. A discontinuity(s) need only be sanded to the extent that the zone criteria are met. If rejected, the part shall be processed in accordance with FZM 13725.

7,4 Defect Rework: Defect(s) maybe reworked by sanding or grinding to the extent of being acceptable per zone allowables. Rounded defects which have been reworked shall be checked either visually under magnification or cleaned, and penetrant inspected (etch not required). A linear defect(s) which has been reworked shall be locally etched, cleaned, and re-penetrant inspected.

AMENDMENT 3 TO NDTS 110IH, PENETRANT INSPECTION

Contract Number: F33657-88-C-O037

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C6

LOCKHEED
Fort Worth Company
FSCM 81755

Amendment 3 to NDTS 1101 H
Date: 29 September1995

This amendment forms a part of and shall be attached to LOCKHEED Fort Worth Company Specification NDTS1 101 H, PENETRANT INSPECTION, dated 21 MAY 1990. This amendment is effective immediately upon issue.

PAGE 9
Para. 4.3.1

Change: Delete "corrosion resistant steels (excluding 400 series) which have" and inserf "300 series corrosion resistant steel which has".

PAGE 9
Para. 4.3.1(c)

Change: Delete "corrosion resistant steels (excluding 400 series)" and insert "300 series corrosion resistant steel".

PAGE 9
Para. 4.3.2

Change: Delete "CRES steels" and replace with "300 series CR ES"

Reason: To exclude CRES materials other than 300 series CRES from the pre-penetrant etch requirements since the motivation for conducting pre-penetrant etching of those materials has gone away. This should eliminate future REA's of the same type as MG64746, MG64754, and 64760.

PAGE 11
Para. 4.5 Change: Delete paragraph.

Para. 4.5.1 Change: Delete paragraph.

Para. 4.5.2 Change: Delete paragraph, including sub-paragraphs a), b), and c).

Reason: To exlclude nickel based alloys from the pre-penetrant etch requirements since the motivation for conducting pre-penetrant etching of those materials has gone away. This should eliminate future REA's of the same type as MG64746, MG64754, and 64760.

PAGES 12, 13, 14, and 15

Change: Decrement paragraph numbers of paragraphs 4.6,4.7, and all associated sub-paragraphs by one.

Reason: To account for the fact that paragraph 4.5 was deleted.

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