V2500 First Stage High Pressure Turbine Disks

Off-Wing Immersion Ultrasonic Inspection for Crack Detection

NDIP-1226 Rev F

September 2021

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Instructions described within this procedure do not replace, amend or supersede any instructions included in other Pratt & Whitney technical publications. Active Service Bulletins and other technical publications published by Pratt & Whitney comprise approved technical data.

Written By: Dave Raulerson, Bill Brown

Approved By: Kevin Smith

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Revision History:

Revision Letter	Revision Date	Changes	Revision By	Approved By
Initial Release	23-Dec, 2020	N/A	D. Raulerson, B. Brown	K. Smith PL4
A	20-Mar, 2021	Correct typos, inspection angle clarification, disk cleaning, reporting requirements, revised noise description (7.8.5) and TOF rejection criteria (8.1.3)	D. Raulerson, B. Brown	D. Raulerson PL4
B	21-Mar, 2021	Corrected typos, revised equipment setup section (4.0), clarified calibration procedure regarding incident angle (5.1.1) and added 5.1.4, updated section 6.0, removed incident angle reference in 7.7.1, revised procedure (7.7 & 7.8), revised TOF criteria (8.1.3) , revised sections 9.1.7.21-23.	D. Raulerson, A. Harmon	D. Raulerson PL4
C	8-Jul, 2021	Added collimator and damping device options; Modified Marking Pencil details; Cal block holder is optional; Revise training requirement; Added post-calibration requirement and specifications; Added surface normalization requirement; Added baseline noise requirements	B. Brown, A. Harmon	D. Raulerson PL4
D	4-Aug, 2021	Added interface signal evaluation requirements to reject criteria (8.1.4) Added water contamination/debris evaluation requirement to reject criteria (8.1.5) Updated image in Appendix A to reflect current reject criteria	A. Harmon, A. Swope	D. Raulerson PL4
E	6-Aug, 2021	Updated formatting in 9.0 Reporting Updated phrasing associated with 8.1.4.1-8.1.4.3	A. Harmon	D. Raulerson PL4
F	2-Sept, 2021	Updated Rejection Criteria to address C-Scans with average noise below 5%FSH (8.1.3.3.2)	A. Harmon	D. Raulerson PL4

Table of Contents

1.0 General Information

1.1 Scope

1.1.1 The objective of this immersion ultrasonic inspection is to detect radial/axial cracks in the bore area of 1st stage high pressure turbine (HPT) disks manufactured from powdered nickel metal. The inspection is conducted on disks in the finished shape, disassembled condition, with the following part number(s):

1.1.1.1 PN 2A5001

1.2 This procedure describes the specific information for the V2500 engine model and details the individual scan plans.

1.3 The inspection is accomplished by applying several scans to the bore area of the disk. Scans are designed based on the bore geometry and include one positive 45-degree and one negative 45-degree circumferential shear inspection.

1.4 The development of calibration and inspection scan plans requires an inspector with a Level III or equivalent experience, who is familiar with the computer controlled immersion ultrasonic inspection system used, and is trained in the specific tasks of this inspection.

1.5 The application of the inspection requires an inspector with a Level II or equivalent experience, who is familiar with the computer controlled immersion ultrasonic inspection system used, and is trained in the specific tasks of this inspection.

1.6 Before testing can begin scan plans must be programmed for each part, with approval from Pratt & Whitney MPE-NDE.

1.7 Before inspection can begin, inspectors must achieve an acceptable score of the POD qualification testing as administered by Pratt & Whitney MPE-NDE. Only qualified operators, specifically designated, trained, and approved can perform this inspection. A Pratt & Whitney task specific certificate will be issued to qualified inspectors.

1.8 The use of collimating and/or damping devices requires approval from Pratt & Whitney MPE-NDE department. Such a device may be required to address structured noise associated with side lobes.

2.0 Required Equipment

2.1 Calibration Blocks

2.1.1 IAE2P16675 - The Angle Calibration Block consists of No. 1 flat bottom holes at various depths incorporated into a 45-degree angle side. No. 1 flat bottom holes are machined representing a specific depth from the sound entry surface

2.1.2 The calibration blocks shall be sourced from Pratt & Whitney MPE-NDE

2.2 Calibration Block Holder, optional

2.2.1 IAE2P16674 – 45-degree Calibration Block Holder

2.3 Immersion Ultrasonic Inspection System, consisting of the following or equivalent, available from:

2.3.1 Inspection Research & Technologies Ltd

2.3.1.1 Ex: LS-200 Immersion Tank and Ultrasonic Scanner

2.3.2 Matec

2.3.2.1 Ex: Model IMT3007-SS-TT-L-ARN or equivalent

Note: This inspection requires a computer-controlled scanning system with C-Scan and digital data recording. The equipment listed meets the requirements but is not intended to prevent the use of alternate equivalent scanning systems.

NOTE: THE USE OF ALTERNATE EQUIVALENT SCANNING SYSTEMS MUST BE APPROVED BY PRATT & WHITNEY MPE-NDE.

2.4 Immersion Ultrasonic Transducers

2.4.1 IAE2P16679 - 5 MHz, 8" Focus, medium bandwidth

2.4.2 Transducers to be sourced through Pratt & Whitney NDE: gppwmpendetoolsup@prattwhitney.com

2.5 Immersion Ultrasonic Transducer Mirrors

2.5.1 IAE2P16678 - 45-degree 5” length, for 5MHz 8” focus

2.6 Chuck Riser, turn table

2.6.1 The chuck riser is used to allow centering of the various size diameter disks

2.7 Marking Pencil, PMC-4059

2.8 Optional - IAE1P16217 and IAE1P16014 Handling Tools, Stage 1 HPT disk configurations.

2.9 Optional - IAE1P16221 and IAE1P16366 Handling Tools, Stage 2 HPT disk configurations.

CAUTION: METAL TO METAL CONTACT MUST BE AVOIDED WITH THE HPT DISKS

3.0 Inspection Qualifications

3.1 Airlines or overhaul facility immersion ultrasonic systems used to conduct this inspection must be source approved by Pratt & Whitney MPE-NDE. Acceptable POD performance is required for any systems used for this NDIP.

3.1.1 Interim Testing/Qualification Asset(s) may be provided by MPE-NDE until POD assets are available.

3.1.2 Once available, POD assets must be used to requalify inspectors.

3.2 Only qualified and approved operators can perform this inspection. A Pratt & Whitney task specific certificate will be issued to qualified inspectors who successfully complete the POD process.

3.3 Inspection personnel performing the immersion ultrasonic inspection must meet the following requirements:

3.3.1 Inspector must have Level II or equivalent training in ultrasonic inspection

3.3.2 Inspector must have demonstrated proficiency in operation of the computer controlled immersion ultrasonic inspection system

3.3.3 Familiarization with inspection method to be provided by local Level 3.

3.3.4 Inspector must pass POD, or Interim, qualification administered by Pratt & Whitney MPE-NDE based on successful completion and accurate quantification of known defects in the PW-approved test part(s). This evaluation is conducted by Pratt & Whitney approved proctors only. The proctor may advise inefficiencies as needed to a candidate. Retesting is limited to a single repeat.

3.3.5 Inspector recertification is required if more than six months elapses without having performed an inspection.

3.3.6 Contact the Pratt and Whitney MPE/NDE for questions regarding POD qualification and/or Interim testing/qualification.

4.0 General Equipment Setup

4.1 This NDIP is written with the assumption the inspector is familiar with the operation of the ultrasonic inspection scanning system and analysis tools.

4.2 Move manipulator to a safe position.

4.3 Home the system.

4.3.1 Select and attach the transducer to the manipulator.

4.3.2 Lower the transducer/manipulator into the water.

4.3.3 Check for air bubbles.

4.3.3.1 Remove any air bubbles with the transducer immersed in the water.

4.3.3.2 Check for air bubbles on the part surfaces such as under the web. Remove any air bubbles from the part surfaces.

4.4 Place the Angled Calibration Block sensitivity setting standard in the tank.

4.4.1 Check for air bubbles on the ultrasound entry surfaces of the standard.

5.0 Calibration

5.1 Conduct the calibration procedure to ensure an amplitude of 80 percent vertical screen height is obtained from each No. 1 FBH in the standard.

5.1.1 Perform calibration.

5.1.1.1 Normalize the transducer to the top surface of the calibration standard.

5.1.1.2 Set the water path (8-inches).

5.1.1.3 Tilt the transducer to required incidence angle (approximately 18.6 degrees).

5.1.1.3.1 Incident angle may vary depending on environmental factors. The ultrasonic level III shall identify the appropriate incident angle sufficient to achieve a 45-degree refracted shear wave in the part.

5.1.1.4 Adjust water path to 8-inches after transducer angulation.

5.1.1.5 Normalize the A and B axes to maximize the amplitude from the back surface (45-degree surface) of the calibration standard.

5.1.1.6 Scan transducer while maintaining transducer angulation and water path.

5.1.1.7 Maximize amplitude from each FBH target, Figure 1.

5.1.1.7.1 Holes L through S, omitting hole J & hole K.

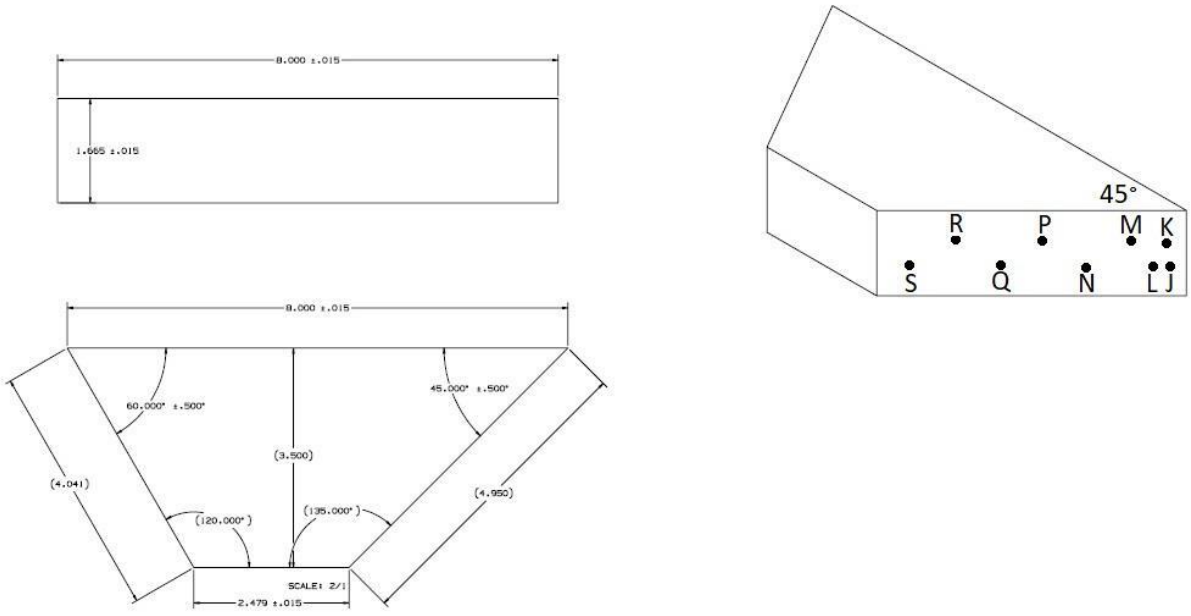

Figure 1 – Calibration standard

5.1.2 Distance-Amplitude-Correction (DAC)

5.1.2.1 Establish DAC such that all holes used during calibration in section. 5.1.1 achieve 80 percent Full Screen Height.

5.1.3 Curvature Correction

5.1.3.1 Curvature Correction will be required, value(s) are supplied by Pratt & Whitney specific to each transducer and system.

5.1.3.2 Add Curvature Correction gain to each of the DAC points.

5.1.4 Calibration standard specific gain offsets.

5.1.4.1 Calibration standards have been referenced to a master calibration standard and gain offsets are provided on the calibration card.

5.1.4.2 Add calibration standard specific gains to each of the DAC points.

5.1.5 Post-Calibration

5.1.5.1 Post-calibration is performed by returning to the calibration block and verifying the amplitude response of every utilized DAC point. Acceptable amplitude variance is within +/- 1 dB of initial calibration amplitude.

5.1.5.1.1 Post-calibrations exceeding this tolerance will require all surfaces that yielded rejectable indications since last successful calibration/post-calibration to be re-scanned.

5.1.5.1.2 Post-calibrations falling below this tolerance will require all surfaces since last successful calibration/post-calibration to be re-scanned.

5.1.5.2 Calibration and post-calibrations must be documented and reported to Pratt & Whitney via MFT upon completion of data collection/evaluation.

5.1.5.2.1 Calibration and post-calibrations, and other required information, must be recorded in Pratt & Whitney provided template, or approved equivalent document.

5.1.5.3 Post-calibration is required:

5.1.5.3.1 Prior to shift change.

5.1.5.3.2 Prior to part number change.

5.1.5.3.3 Prior to transducer change.

5.1.5.3.4 Immediately following any event that caused an unexpected interruption to part scanning/data evaluation. Such an example would include unexpected power outage.

5.2 Calibration blocks are to be recertified at Pratt & Whitney NDE on a yearly basis.

6.0 Disk Preparation

6.1 The disk to be inspected shall be clean and free of any foreign material or marking which interfere with the ultrasound penetration & reflection or obscure indications.

6.2 Mark a “start” inspection position (12 o’clock or 0 degrees) on the HPT disk.

6.2.1 Locate the Serial Number (S/N).

6.2.1.1 The S/N is typically located on the rear surface of a blade attachment tang, adjacent to the tangs with the part number (P/N) and the heat code (H/C).

6.2.1.2 If “S/N” is on one blade attachment tang and the serial number is on an adjacent tang, use the blade attachment tang with the “S/N”.

6.2.2 Mark a “start” inspection position on the front and rear surface of the blade attachment tang with the S/N using an approved marking pencil.

6.3 Record the P/N, S/N, and H/C on the Inspection Sheet.

6.4 Install the disk.

6.5 Set the 12 o’clock position of the disk on the inspection system turntable at 0.0-degree position.

6.6 Check for, and remove, air bubbles on any surfaces of the volume to be inspected.

7.0 Inspection Procedure

7.1 Inspect the bore area of the HPT disk for the surfaces identified in Figure 2.

7.1.1 Circumferential shear wave ±45-degree refracted angle.

7.1.2 For Bore ID surface inspection, if Bore offset method is used to generate ±45-degree refracted angle, use an offset equal to approximately 0.943" (for nominal radius of 2.910").

7.1.3 Minimal 2.6" radial volumetric coverage is required, see Figure 2.

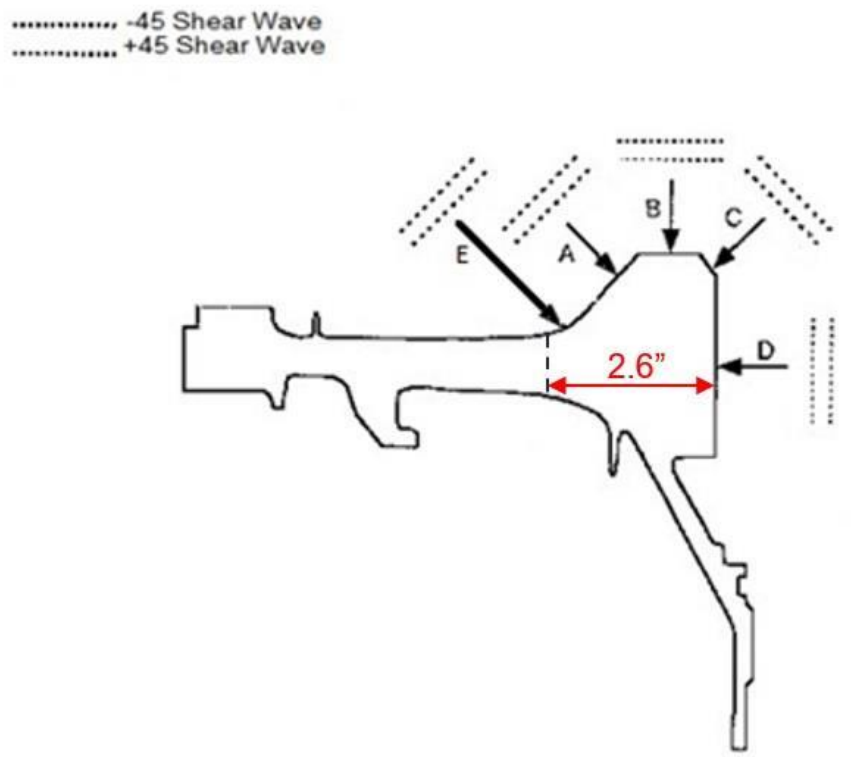

Figure 2 V2500 Stage 1 HPT disk - P/N 2A5001, immersion ultrasonic inspection scan plan

7.2 The maximum scan increment for all modes of inspection shall be 0.020 inches.

7.3 The maximum index increment for all modes of inspection shall be 0.020 inch per revolution.

7.4 The gate threshold for this inspection is set to a minimum amplitude to allow all inspection data to be collected.

7.5 Verify water path is set to 8-inches.

7.6 Verify mirror is fully seated on the transducer

7.7 Normalize on the inspection surface

7.8 Scan the maximum inspectable dimensional range of each inspection surface.

7.8.1 Edge signals will be excluded from the evaluation area of the C-Scan. Edge signals are associated with index transitions from the current inspection surface to an adjacent surface such as over an edge or onto a contour.

7.9 Evaluate all ultrasonic indications relevant to the rejection criteria in section 8.0.

7.9.1 Move the manipulator to the location of the ultrasonic indication.

7.9.2 Maximize the response of the ultrasonic indication by manipulating the various ultrasonic axis.

7.9.3 Record any ultrasonic indication with an amplitude equal to or greater than 20 percent vertical screen height.

7.9.4 Mark on the disk surface the location of sound entry in line with the ultrasonic indication which has an amplitude equal to or greater than the rejection criteria defined in the corresponding NDIP.

7.9.5 Evaluate and record mean (average) Noise level

7.9.5.1 Select largest area possible not including edge signals or ultrasonic indications.

7.9.5.2 Record the mean (average) noise level for the entire C-Scan.

7.9.5.3 Average noise level for the entire C-Scan area shall be less than or equal to 7.5%, excluding edge effect. If average noise level is greater than 7.5%, re-calibrate, re-normalize, and re-scan.

7.9.5.4 The maximum noise level for any given band in the C-Scan is 8.5%. If band noise level is greater than 8.5%, re-calibrate, re-normalize, and re-scan.

7.9.5.5 For the case when noise banding is present in the amplitude C-Scan, select the largest area associated with the noise band. Time of Flight (TOF) C-Scan may be used to refine the location of noise banding.

7.9.6 Evaluate indications based on TOF rejection criteria.

7.9.7 Save all inspection results to a file and record the filename on the inspection data sheet.

7.10 Disk cleaning

7.10.1 When scanning is complete wipe clean all surfaces and use compressed air to dry

8.0 REJECTION CRITERIA

8.1 Any HPT disk exhibiting a rejectable ultrasonic indication(s) must be removed from service and returned to Pratt & Whitney.

8.1.1 Rejection criteria will include analysis of time-of-flight and amplitude C-Scan data

8.1.2 Amplitude C-Scan Criteria:

8.1.2.1 Indications shall be a minimum of a three (3) pixel grouping with adjacent pixel depths within 0.025" of one another. Groupings smaller than 3 pixels are considered non-relevant and disregarded – see Figure 3.

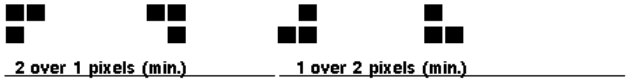

Figure 3 – examples of 3 pixel groupings

8.1.2.2 REJECTION CRITERIA: Max amplitude of three (3) pixel cluster, as defined above, must be equal to or exceed 25% of FBH#1 (Set FBH#1 to 80%FSH, Reject at 20%FSH, Evaluation at 15%FSH)

8.1.3 Time of Flight C-Scan Criteria:

8.1.3.1 Indications shall meet the following criteria:

8.1.3.1.1 minimum of a fifteen (15) pixel grouping (reference 8.1.3.3)

8.1.3.1.2 adjacent pixels forming a group shall share edges. Do not include pixels oriented diagonally only.

8.1.3.1.3 adjacent scan pixel depths within 0.025"

8.1.3.1.4 adjacent index pixel depths within 0.010"

8.1.3.1.5 at least three (3) adjacent scan lines

8.1.3.2 Groupings smaller than fifteen (15) pixels are considered non-relevant and disregarded

8.1.3.3 Reject discontinuities with at least fifteen (15) pixels, connected along an edge and having a Signal-to-Noise Ratio (SNR) exceeding 1.5 to 1 or greater from mean (average) of amplitude C-scan not including C-Scan edges (section 7.7).

8.1.3.3.1 SNR refers to individual pixel amplitude divided by mean (average) noise level, for corresponding noise band.

8.1.3.3.2 When the average noise of the C-Scan is below 5%FSH, the TOF rejection criteria will be set to 7.5%FSH. This corresponds to evaluating a C-Scan with a mean noise of 5%FSH.

8.1.4 Amplitude and TOF indications resulting from the interface signal encroaching into the inspection gate are subject to the following supplemental evaluations. If the indication fails to meet any of the prescribed conditions/persists after corrective action, then the location is rejectable.

8.1.4.1 For a given scan line, if interface signal is widening/contracting rather than moving, then encroachment is most-likely caused by surface roughness. Move gate start outside of interface signal and re-scan the location to ensure there are no other signals in the gate that could meet the rejection criterion.

8.1.4.2 For a given scan line, if interface signal is moving in-and-out of the gate rather than widening/contracting, then the encroachment is most-likely caused by run-out. Adjust water path to local area and re-scan the location to ensure there are no other signals in the gate that could meet the rejection criterion.

8.1.4.3 For a given scan line, if interface signal is stationary within the gate, then the encroachment is most-likely caused by a water path deviation. Adjust transducer to intended water path and re-scan the

location to ensure there are no other signals in the gate that could meet the rejection criterion.

8.1.5 Amplitude and TOF indications suspected to be contributed to water contamination/debris ("Floaters") are subject to local re-scan to confirm repeatability. If repeatable, indication is rejectable.

8.1.5.1 Floaters are characterized by single scan line pixel clusters.

9.0 REPORTING

9.1 Report inspection results to Pratt & Whitney detailing the following information

9.1.1 Inspector Name, Inspection Date, Inspection System SN, Transducer SN, Calibration Standard SN.

9.1.2 Aircraft serial number, and engine position.

9.1.3 Engine model, engine serial number, and engine total time and total cycles.

9.1.4 HPT disk part number, HPT disk serial number, HPT disk heat code, and total part time and total part cycles since new and last inspection.

9.1.5 Inspection method, and location and amplitude of rejectable ultrasonic indication(s):

9.1.5.1 Electronic report detailing the A-scan presentation showing the maximum amplitude.

9.1.5.2 Electronic report detailing the position of the rejectable ultrasonic indication(s).

9.1.6 Electronic amplitude & time of flight C-Scan data sent to Pratt & Whitney MPE-NDE. A managed file transfer (MFT) site will be established to facilitate data transfer.

9.1.7 Any rejectable indication must include, refer to Appendix A:

- 9.1.7.1 Inspection Date
- 9.1.7.2 Inspector Name
- 9.1.7.3 Inspection System
- 9.1.7.4 Inspection System Serial Number
- 9.1.7.5 Transducer Part Number
- 9.1.7.6 Transducer Serial Number
- 9.1.7.7 Calibration Block Serial Number
- 9.1.7.8 Engine Serial Number
- 9.1.7.9 Disk Part Number
- 9.1.7.10 Disk Serial Number
- 9.1.7.11 Disk Heat Code
- 9.1.7.12 Time Since New (TSN)
- 9.1.7.13 Cycles Since New (CSN)
- 9.1.7.14 Inspection surface where found
- 9.1.7.15 Index location (inches)
- 9.1.7.16 Depth along sound path (inches)
- 9.1.7.17 Scan (circumferential) location (degrees)
- 9.1.7.18 Amplitude pixels: number greater than 2x1; 1x2 – yes/no
- 9.1.7.19 Calibration amplitude (80% FSH)
- 9.1.7.20 Peak indication amplitude, with DAC applied (%FSH)
- 9.1.7.21 TOF pixels: greater than 15 pixels over at least 3 scan lines – yes/no
- 9.1.7.22 TOF average Noise Level (% FSH – referencing amplitude C-Scan)
- 9.1.7.23 TOF Signal-to-Noise Ratio (SNR – referencing amplitude C-Scan)
  - 9.1.7.23.1 Peak indication amplitude divided by Average Noise Level

Appendix A

Rejectable Indication Report

Inspection Date	
Inspector Name	
Inspection System	
Inspection System Serial Number	
Transducer Part Number	
Transducer Serial Number	
Calibration Block Serial Number	
Engine Serial Number	
Disk Part Number	
Disk Serial Number	
Disk Heat Code	
Time Since New (TSN)	
Cycles Since New (CSN)	
Inspection surface where found	
Index location (inches)	
Depth along sound path (inches)	
Scan (circumferential) location (degrees)	
Amplitude pixels: number greater than 2x1; 1x2 – yes/no	
Calibration amplitude (80% FSH)	
Peak indication amplitude, with DAC applied (%FSH)	
ToF pixels: greater than 15 pixels over at least 3 scan lines – yes/no	
ToF average Noise Level (% FSH – referencing amplitude C-Scan)	
ToF Signal-to-Noise Ratio (SNR – referencing amplitude C-Scan)