PART 6 - EDDY CURRENT

ALUMINUM PART SURFACE INSPECTION (METER DISPLAY)

1. **Purpose**

A. Use this procedure to do an inspection for surface cracks in aluminum parts.

B. This procedure uses an instrument with a meter display.

C. Part 6, 51-00-19 is an alternative inspection procedure.

2. **Equipment**

NOTE: Instrument/probe combinations used shall be capable of detecting the calibration notch in the reference standard to the sensitivity requirements of Paragraph 4.

A. Instruments -- Battery-operated multifrequency instruments with audible or visual alarms are recommended. The following instruments were used in the development of this procedure:

(1) ED 520, ED 530; Magnaflux Corporation

(2) MIZ 10, MIZ 10A, MIZ 10B; Zetec, Inc.

(3) Locator UH; Hocking Instruments

B. Probes -- Shielded pencil probes are recommended. Probes must meet the configuration and dimensional callouts of Figure 1, and the performance guidelines of Figure 2 and Figure 3.

(1) Shielded or non-shielded probes may be used, provided the calibration notch in the reference standard can be reliably detected.

Non shielded probes should be used carefully. Meter response interference can be expected from adjacent structure, radii or close edge margins due to the unrestricted magnetic field of these probes.

(2) Probe coil arrangement shall be such that a single coil in the probe tip comes in contact with the test structure.

(3) Normal probe operating frequency is between 100 kHz and 500 kHz. Other frequencies may be used, provided the calibration notch in the reference standard can be reliably detected.

(4) Probes should not give interfering responses from normal handling, manipulation, or operating pressure variations on the sensing coil.

C. Reference Standards

(1) Use reference standards 126, 188A, 189 or NDT1048. See Figure 4 thru Figure 7 for data about the reference standards.

(2) Other reference standards can be used if they are equivalent to those shown in Figure 4 thru Figure 7

D. Special Tools

(1) Use a nonconductive circle template as shown in Figure 9 to help examine the area around flush head fasteners for cracks.

(2) Use a nonconductive straightedge as shown in Figure 10 and Figure 11 to help examine near the edges of parts for cracks.

NOTE: The circle template and straightedge help to keep the probe a constant distance from a fastener head or structural edge. The signal will slowly increase when the probe gets nearer to an edge of a part.

3. **Preparation for Inspection**

A. Identify inspection location(s).

B. If needed, obtain a smooth inspection surface by lightly sanding away surface roughness and sharp edges of chipped paint.

NOTE: It is not necessary to remove paint or other nonconductive coatings.

C. Wipe surface clean.

D. Locate inspection equipment a minimum of 10 feet (3 m) away from any items that generate large magnetic fields, such as large motors, generators, transformers or power lines.

4. Instrument Calibration

A. Set the frequency, if applicable, between 50 and 500 kHz.

B. Calibrate the instrument with the applicable reference standard. Paragraph 5.D. identifies the different types of structural configurations that can be examined. The reference standards to use for the different structural configurations to be examined are:

(1) Large Areas, Near an Edge, On an Edge, Radius -- Use reference standard 126.

(2) Flush Head Fasteners -- Use reference standard NDT1048.

(3) Protruding Head Fasteners -- Use reference standard 188A.

C. If the inspection area is painted, put a nonconductive shim, which is the same thickness as the paint, on top of the reference standard. The nonconductive shim must be ± 0.003 inch of the paint thickness.

D. Put the probe on the surface crack reference standard at least 0.5 inch (1.27 cm) away from the edge of the block and artificial crack. Balance the instrument according to the manufacturer's instructions.

E. Adjust lift-off to obtain less than 5 percent of full scale needle movement when probe is slid from a 0.002- to 0.004-inch (0.005 to 0.010 cm) nonconductive shim to the bare surface of the reference standard.

NOTE: One sheet of ordinary writing paper, approximately 0.003 inch (0.007 cm) thick, can be used for the nonconductive shim.

F. Slide the probe across the reference standard notch and adjust the sensitivity control to obtain a 20 to 40 percent of full scale meter deflection when passing the probe across the notch. Refer to Figure 8, Detail A. The signal to noise ratio must be 3:1, or better.

NOTE: Inspection scanning speed may be increased by using an instrument with an audible or visual alarm. Set the alarm to respond at 50 percent of the reference standard notch signal amplitude. Refer to Figure 8, Detail B.

G. Check the balance and lift-off again. If adjustments are made, check sensitivity (Paragraph 4.F.) again.

H. Find the maximum inspection scanning speed by sliding the probe across the reference standard notch. Note when the meter response does not fall below 90 percent of the calibration response, or when the alarm set in Paragraph 4.F. NOTE fails to trigger.

5. Inspection Procedure

A. Prepare for inspection. Refer to Paragraph 3.

B. Perform instrument calibration. Refer to Paragraph 4.

C. Put the probe on the inspection surface. Check the balance and lift-off. If necessary, adjust on the part.

NOTE: Do not adjust sensitivity.

D. Scan all inspection areas. If not otherwise identified, a scanning pattern shall be established such that surface cracks 0.15 inch (0.38 cm) or more in length are detected. A scan direction should be chosen so that the probe is scanned across the crack. Do not exceed the maximum inspection scanning speed (Paragraph 4.H.).

Commonly encountered structural configurations may require these scanning techniques:

(1) Large area -- A grid system should be used for scanning. The distance between scans depends on the size of the probe sensing diameter and the minimum length crack to be detected. The scans should overlap so that the probe will scan over the potential crack twice.

(2) Flush-head fasteners -- Inspect using a hole template. Position template to detect a crack extending 0.10 inch (0.25 cm) beyond the fastener head. Instrument/probe combinations must meet the performance guidelines of Figure 9.

(3) Protruding-head fasteners -- Inspect using the fastener head or washer as probe positioner to detect a crack extending 0.10 inch (0.25 cm) beyond fastener head. Instrument/probe combinations shall meet performance guidelines of Figure 10.

(4) Radius -- As the probe is scanned in the radius, it should be adjusted so that it is held perpendicular to the surface of the radius. Select scan increments based on probe sensing diameter and minimum crack length to be detected. Where crack orientation is unknown, make scans parallel and across the radius. Refer to Figure 11.

(5) Edges -- A constant distance must be maintained between the probe and the edge of a part. The minimum probe-to-edge spacing depends on the sensing area of the probe coil. Inspect near an edge by putting a nonconductive straightedge a constant distance away from the edge of the part. Refer to Figure 12 for inspections near the edge of aluminum structure. Refer to Figure 13 for inspections on the edge of aluminum structure.

E. Periodically check the instrument/probe calibration responses. For balance and lift-off responses, refer to Paragraph 5.C. For sensitivity response, refer to Paragraph 4.E. If any response is found to be unsatisfactory, inspect again all areas that were inspected since last calibration check.

F. Note all locations where a rapid upscale meter deflection, similar to the response from reference standard notch is obtained.

NOTE: Probe held at an angle other than perpendicular may cause meter fluctuation. Probe should be held perpendicular to part surface throughout the inspection.

6. Inspection Results

NOTE: A potential defect is indicated by a rapid upscale meter deflection. Compare the defect response to the reference standard notch response at the same scanning speed.

A. A rapid meter deflection that is greater than 50 percent of the reference standard notch response amplitude and similar to the reference standard notch response indicates the presence of a crack.

(1) Determine the end points of the crack by scanning along the crack until a meter response is no longer received.

(2) Estimate crack depth (for crack lengths greater than probe sensing diameter) by comparing the crack response amplitude to the reference notch response amplitude. Note crack depth as less than, equal to, or greater than reference notch depth or compare crack response to reference notch responses of different depths.

NOTE: Approximate crack depth can be determined by high frequency surface eddy current measurements when the crack depth in aluminum is less than 0.1 inch (0.254 cm).

B. Questionable indications or a response less than 50 percent of the reference standard notch response amplitude may indicate a defect condition. The following may be used to help defect determination.

(1) A nonconductive probe fixture may reduce meter response variations caused by the probe not being held perpendicular to the part.

(2) Teflon tape put over the sensing coil may improve the ratio of the crack-to-noise responses. Calibrate again when tape is added or removed from the probe sensing area.

(3) The crack sensing distance traveled by the eddy current probe when crossing a suspected crack should be equal to the sensing distance traveled when crossing the reference standard notch.

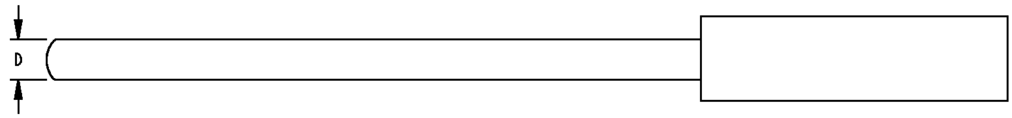
(4) Nonconductive coatings greater than 0.006 inch (0.015 cm) thick may reduce the amplitude of the crack signal. Remove the coating in the suspect area and inspect again.

C. Verification of surface cracks may be performed by either or both of the methods listed. The crack verification methods are not as sensitive in the detection of surface cracks as eddy current for inservice conditions. Care should be taken when comparing any negative verification results to a positive crack response obtained using eddy currents.

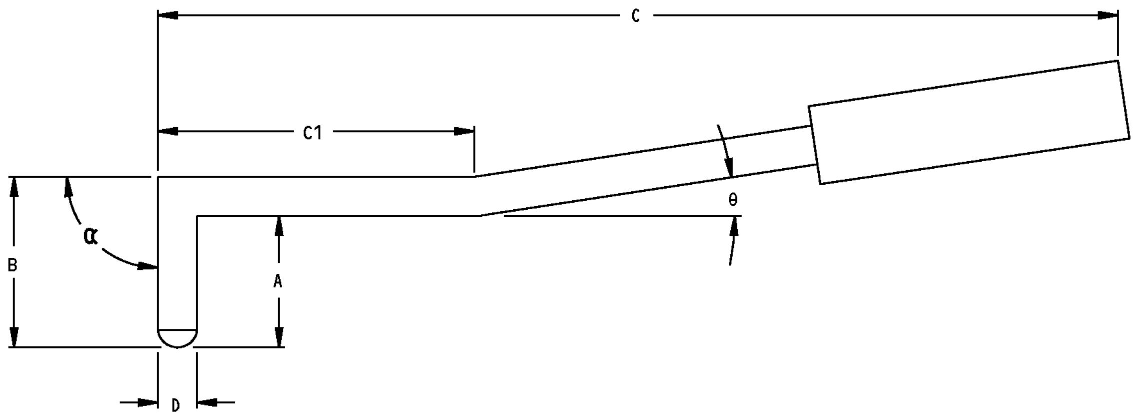
(1) Remove the surface finish, grease, etc., and examine the area at 10X to 25X magnification with adequate lighting. A crack visible by this method requires no further investigation.

(2) Perform a high sensitivity fluorescent penetrant inspection. Refer to D6-51702, SOPM 20-20-02, "Penetrant Methods of Inspection."

NOTE: Penetrant results may be enhanced on areas with metal smear or on tight fatigue cracks by surface etching. Etching requires local engineering approval.



PROBE 1



PROBE 2

NOTES

- THE PROBE CONFIGURATIONS SHOWN CAN BE USED TO ACCESS MOST INSPECTION AREAS WHEN IT IS NECESSARY TO USE PENCIL PROBES. SHIELDED PENCIL PROBES ARE RECOMMENDED. WHEN A SPECIAL PROBE CONFIGURATION IS NECESSARY, SPECIFY THE PROBE DIMENSIONS AS SHOWN FOR PROBE 2:

  A - THE PROBE DROP, OR DIMENSION A

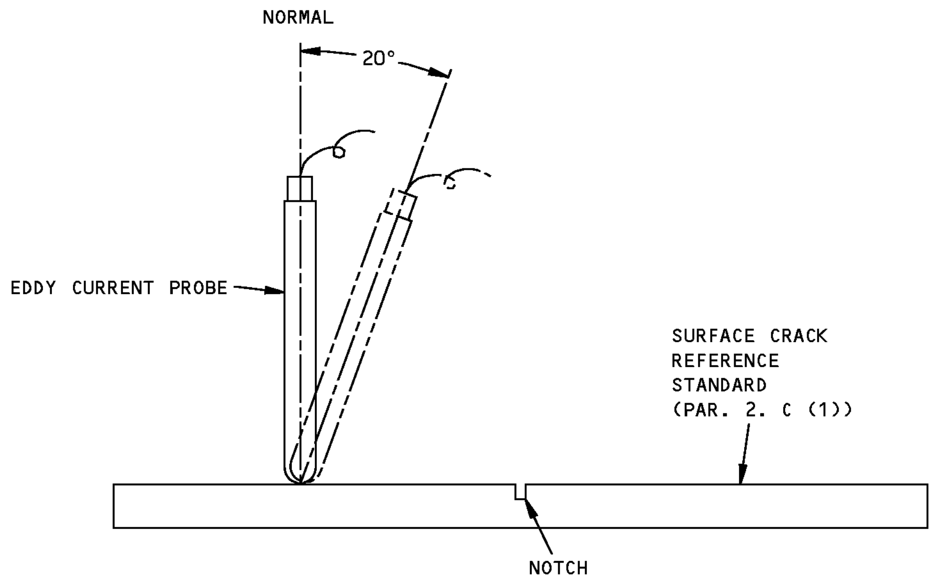
  B - THE PROBE HEIGHT, OR DIMENSION B

  C - THE PROBE HANDLE LENGTH, OR DIMENSION C. IF THE HANDLE MUST BE BENT, IT WILL BE NECESSARY TO KNOW DIMENSION C1 AND THE HANDLE ANGLE (ANGLE THETA - θ). FOR MOST USES, THE PROBE LENGTH WILL BE 3-5 INCHES (76.0-127.0 MM).

  D - DIAMETER: 0.20 INCH (5.1 MM) MAXIMUM. A DIAMETER OF 0.12 INCH (3.0 MM) IS RECOMMENDED FOR AREAS WITH NOT MUCH ACCESS.

  α - THE ANGLE (α = ALPHA). DIFFERENT ANGLES ARE POSSIBLE.

Example of Pencil Probe Configurations
Figure 1

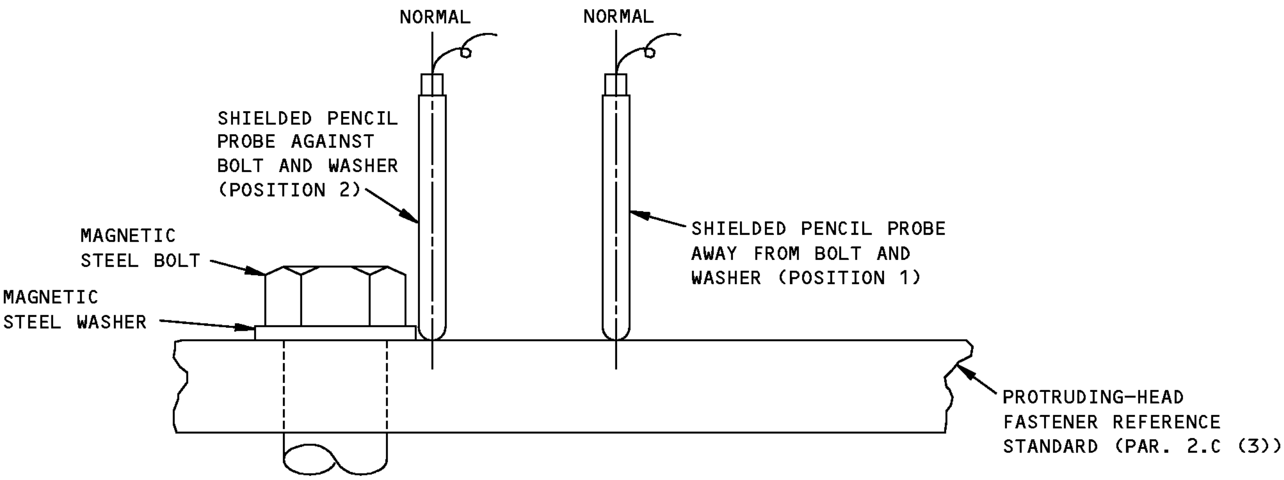


NOTES

- TO DETERMINE PENCIL PROBE ANGULARITY PERFORMANCE:
  1) CALIBRATE PROBE/INSTRUMENT COMBINATION TO THE REQUIREMENTS OF PAR. 4
  2) TIP PROBE ON THE SURFACE OF THE REFERENCE STANDARD IN SEVERAL DIRECTIONS 20 DEGREES TO THE SURFACE. THE PROBE ANGULARITY SHOULD NOT CAUSE MORE THAN A 10 PERCENT FULL SCALE SIGNAL RESPONSE CHANGE
  3) SCAN PROBE ACROSS NOTCH WHEN HELD NORMAL TO THE SURFACE AND AGAIN WHEN HELD AT 20 DEGREES FROM NORMAL. NOTCH SENSITIVITY SHOULD NOT DECREASE MORE THAN 30 PERCENT

     EXAMPLE: SIGNAL RESPONSE FROM A 0.015 TO 0.020 INCH (0.038 TO 0.051 CM) DEEP CALIBRATION NOTCH ON THE REFERENCE STANDARD IS 40 PERCENT OF FULL SCALE WHEN THE PROBE IS PERPENDICULAR TO THE SURFACE. AT A PROBE ANGLE OF 20 DEGREES TO THE SURFACE, THE NOTCH RESPONSE SHOULD NOT BE LESS THAN 28 PERCENT OF FULL SCALE (40% SIGNAL X 0.3 = 12% AND 40% −12% = 28%)

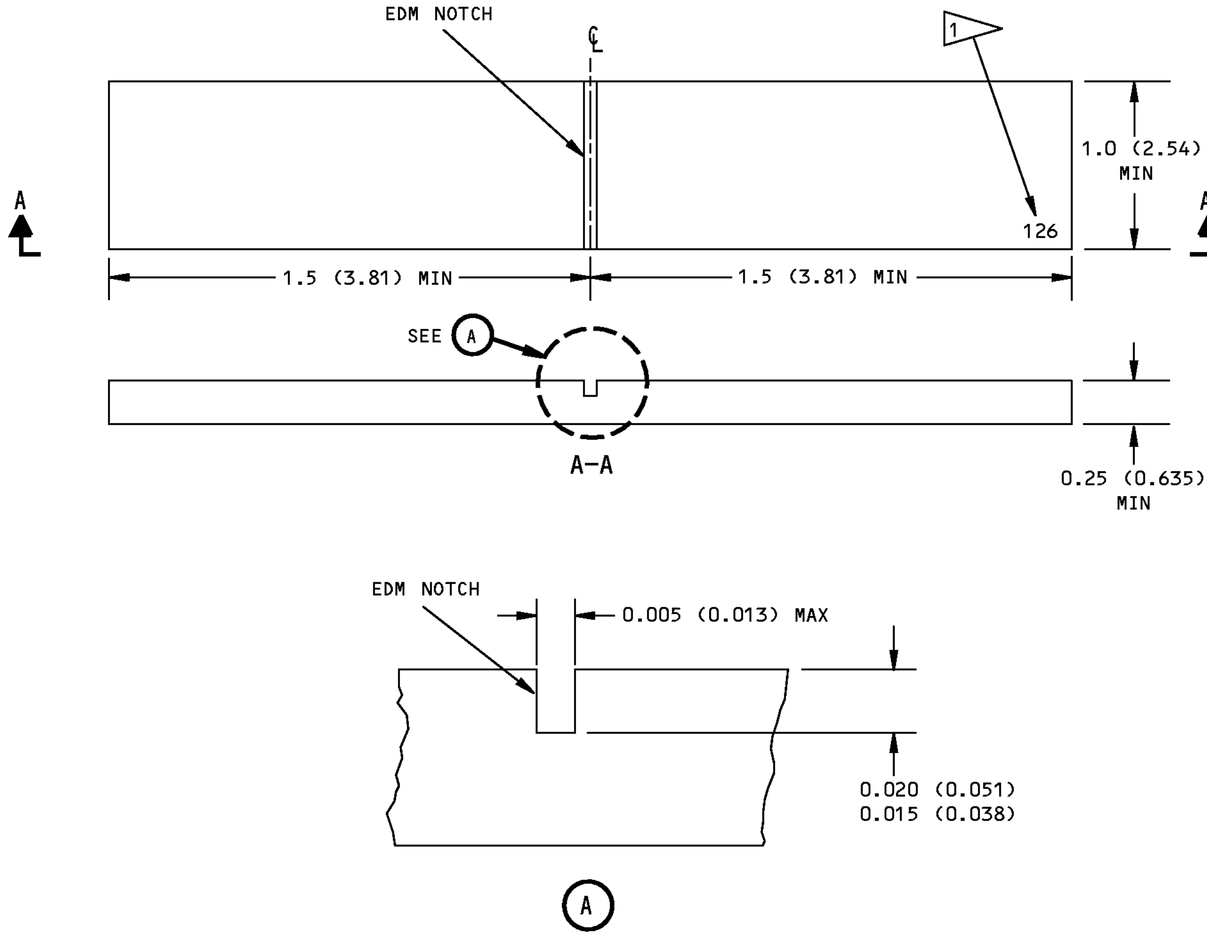
Pencil Probe Angularity Performance
Figure 2



NOTES

- TO DETERMINE IF A SHIELDED PENCIL PROBE HAS ADEQUATE SHIELDING:
  1) CALIBRATE PROBE/INSTRUMENT COMBINATION TO THE REQUIREMENTS OF PAR. 4
  2) USING THE PROTRUDING-HEAD FASTENER REFERENCE STANDARD, MOVE PROBE FROM POSITION 1 TO POSITION 2. THE MAGNETIC STEEL SHOULD NOT CAUSE MORE THAN A 10 PERCENT SIGNAL CHANGE

Shielded Pencil Probe Shielding
Figure 3

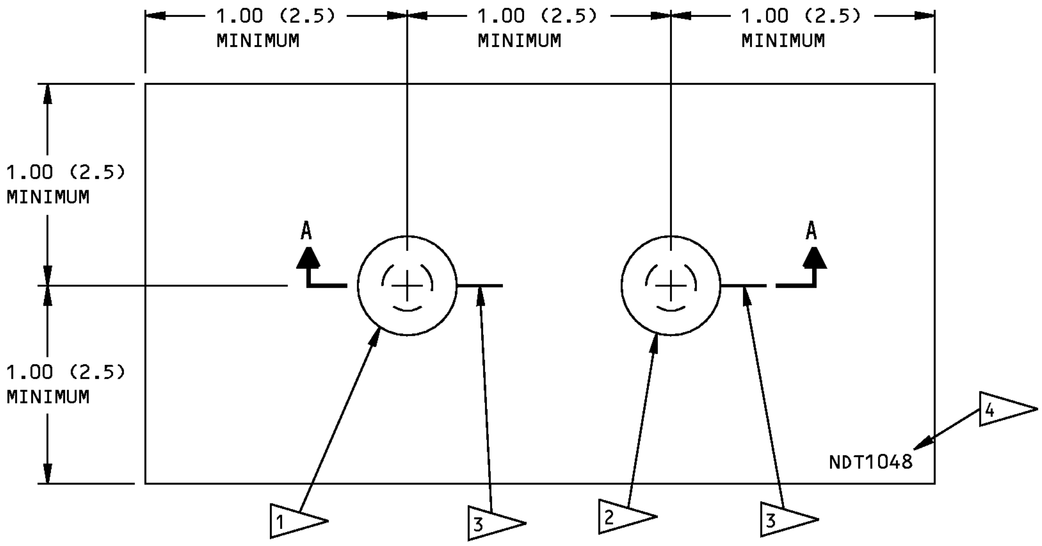


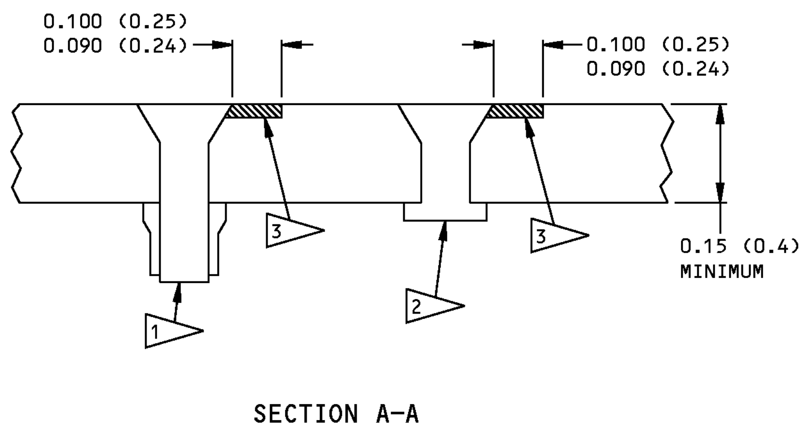
NOTES

- ALL DIMENSIONS ARE IN INCHES (CENTIMETERS ARE IN PARENTHESES)
- TOLERANCE ±0.050 (0.127 CM) ON ALL DIMENSIONS EXCEPT AS NOTED
- FABRICATE FROM ANY OF THE FOLLOWING:
  - 2024-T3 OR -T4
  - 7075-T6 OR -T73
  - 7079-T6
  - 7178-T6
- SURFACE FINISH: 63√ OR BETTER
- REFER TO PART 1, 51-01-00, FOR MANUFACTURING AND ORDERING INFORMATION

1 ETCH OR STEEL STAMP WITH THE NUMBER 126

Reference Standard 126 for Surface Inspection of Aluminum Parts
Figure 4





NOTES

- DRAWING IS NOT TO SCALE.
- ALL DIMENSIONS ARE IN INCHES (CENTIMETERS ARE IN PARENTHESES).
- MATERIAL: 2024-T3 OR T4, 7075-T6, 7079-T6 7178-T6
- SURFACE FINISH: 63√ OR BETTER.
- IF YOU HAVE REFERENCE STANDARD 187, YOU CAN USE IT FOR THE INSPECTION AROUND ALUMINUM FASTENERS.

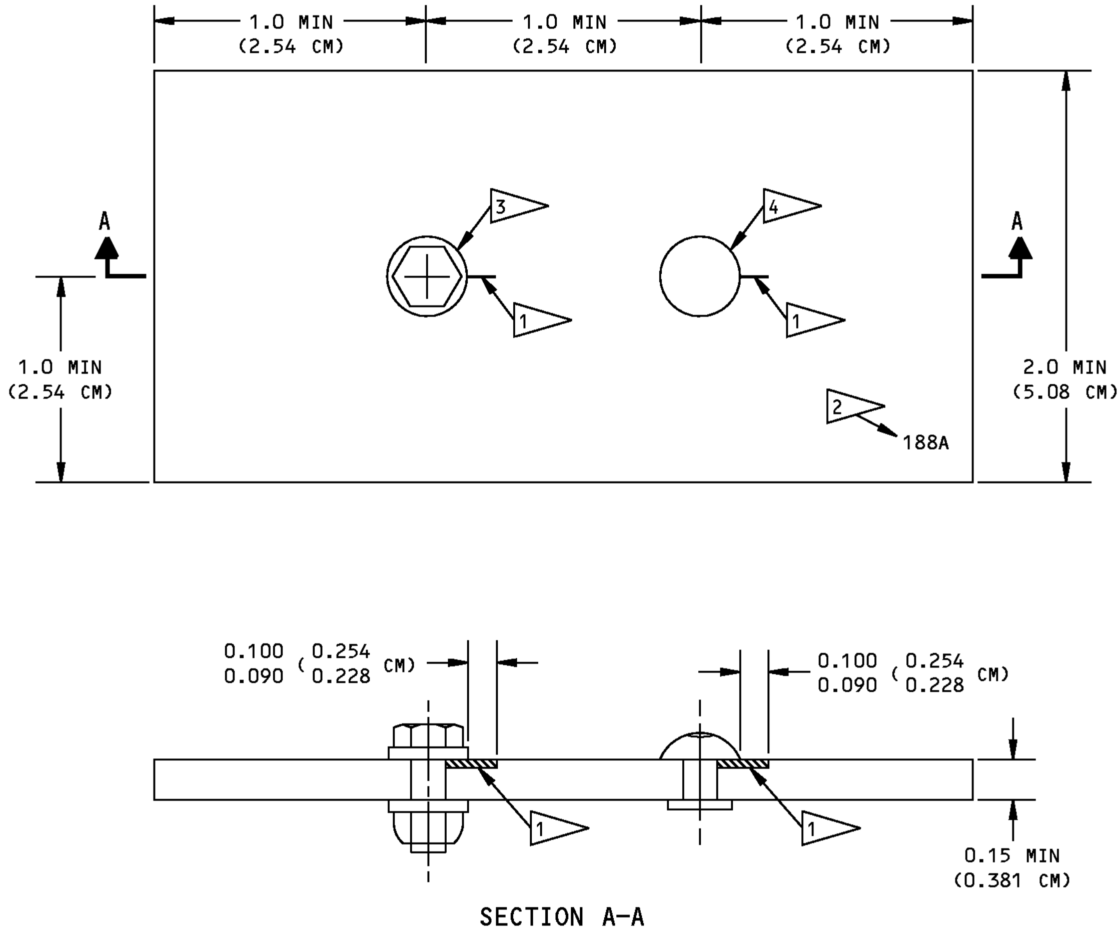
1 FASTENER - 0.25 (0.64) DIAMETER FLUSH-HEAD STEEL BOLT, SUCH AS BACB30JC8-*

2 FASTENER - 0.25 (0.64) DIAMETER FLUSH-HEAD ALUMINUM RIVET, SUCH AS BACR15BA*DD*

3 NOTCH - 0.005 (0.013) MAXIMUM WIDTH, 0.015-0.020 (0.038-0.051) DEPTH.

4 ETCH OR STEEL STAMP WITH NDT1048.

Flush-Head Fastener Reference Standard
Figure 5



NOTES

- ALL DIMENSIONS ARE IN INCHES (CENTIMETERS ARE IN PARENTHESES)
- TOLERANCE ±0.050 (0.127 CM) EXCEPT AS NOTED.
- FABRICATE FROM ANY OF THE FOLLOWING:
  2024-T3 OR -T4
  7075-T6
  7079-T6
  7178-T6
- REFER TO PARTS 1, 51-01-00, FOR MANUFACTURING AND ORDERING INFORMATION.
- SURFACE FINISH: 63 OR BETTER.

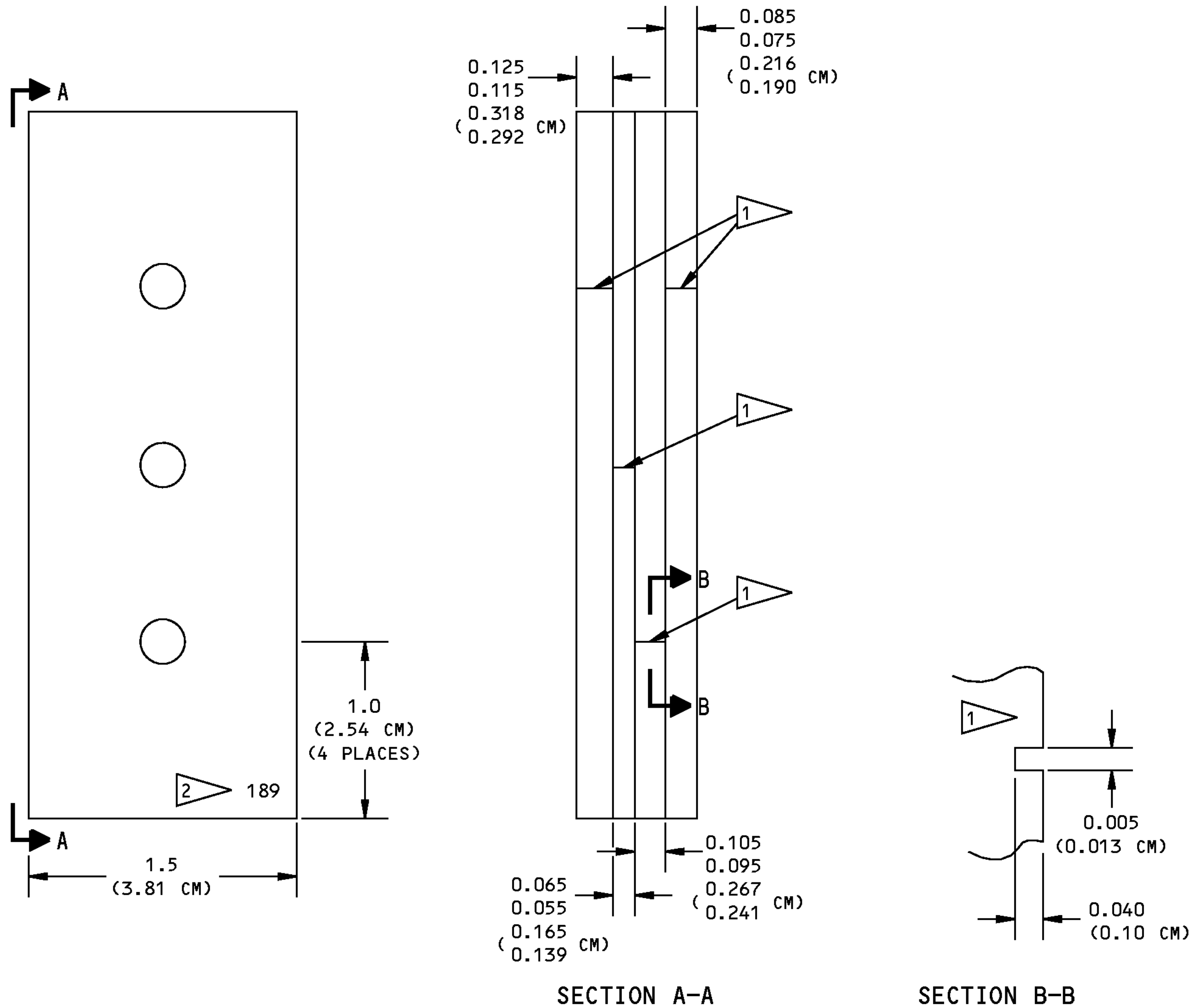
1 NOTCH - 0.005 (0.013 CM) MAX WIDTH, 0.015-0.020 (0.038-0.051 CM) DEPTH.

2 ETCH OR STEEL STAMP WITH 188A.

3 FASTENER - 0.25 (0.635 CM) DIAMETER EXTERNAL WRENCHING STEEL BOLT, SUCH AS BACB30NE *-*; FLAT STEEL WASHER, SUCH AS BACW10AK * WP.

4 RIVET BACR15BB6AD5

Protruding-Head Fastener Reference Standard
Figure 6



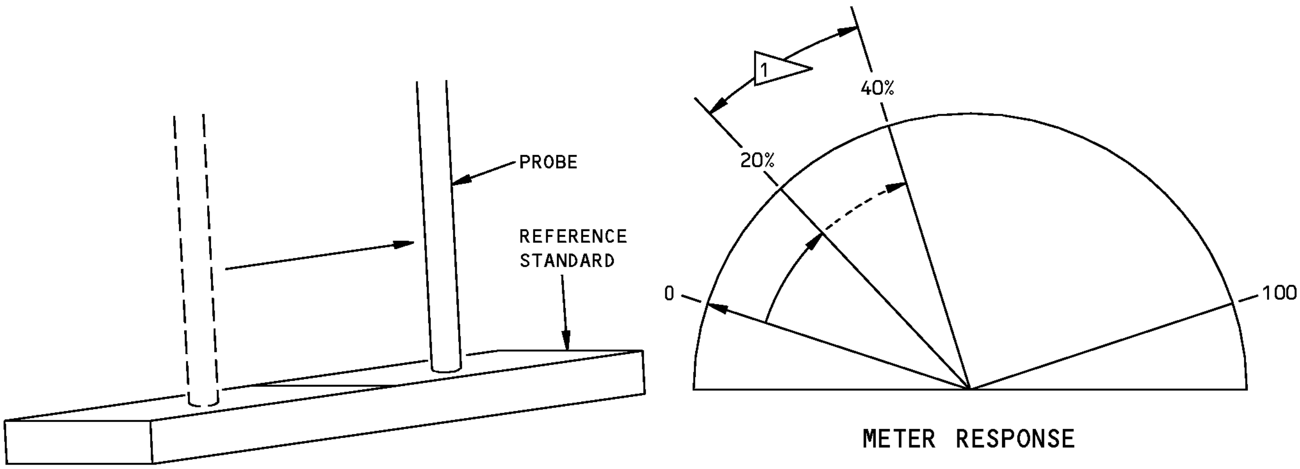
NOTES

- ALL DIMENSIONS ARE IN INCHES (CENTIMETERS ARE IN PARENTHESES)
- TOLERANCE ±0.050 (0.127 CM) EXCEPT AS NOTED
- FABRICATE FROM ANY OF THE FOLLOWING: 2024-T3 OR T4,7075-T6, 7079-T6 OR 7178-T6 (ALL MEMBERS MUST BE OF THE SAME ALLOY AND HEAT TREAT)
- SURFACE FINISH: 63 OR BETTER
- FASTENER - ANY ALUMINUM OR TITANIUM FASTENER WITH A HEAD DIAMETER LESS THAN 0.5 (1.27 CM)
- REFER TO PART 1, 51-01-00, FOR MANUFACTURING AND ORDERING INFORMATION

1 NOTCH - 0.005 (0.013 CM) MAX WIDTH, 0.040 (0.010 CM) DEPTH

2 ETCH OR STEEL STAMP WITH 189

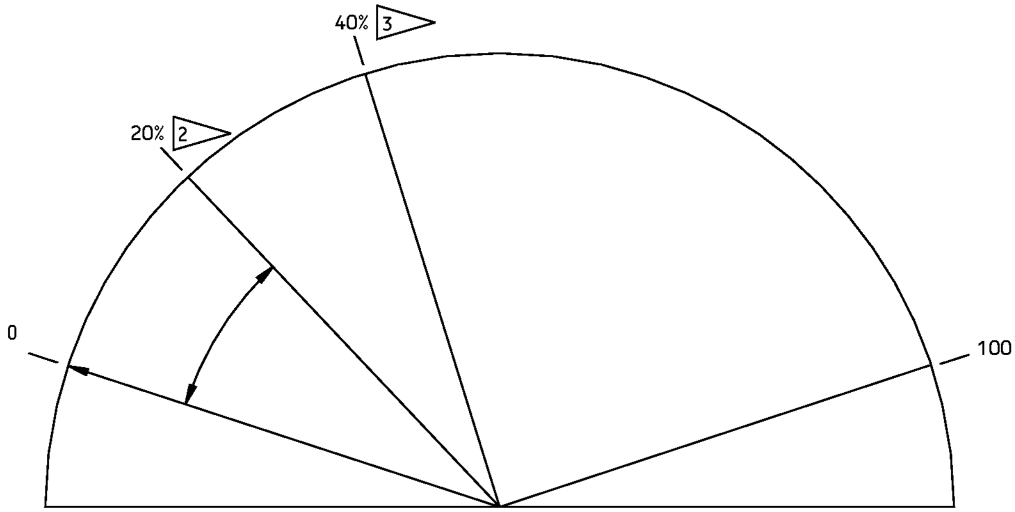
End of Part Reference Standard
Figure 7



NOTE

1 20 TO 40 PERCENT NEEDLE DEFLECTION FROM THE REFERENCE STANDARD NOTCH

SENSITIVITY ADJUSTMENT
DETAIL A



METER RESPONSE

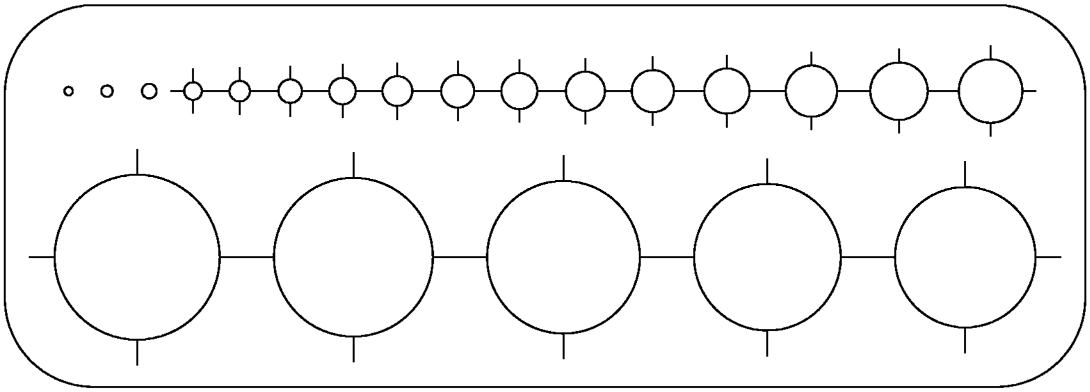
NOTES

2 ALARM RESPONSE SET POINT - 50 PERCENT OF NOTCH RESPONSE

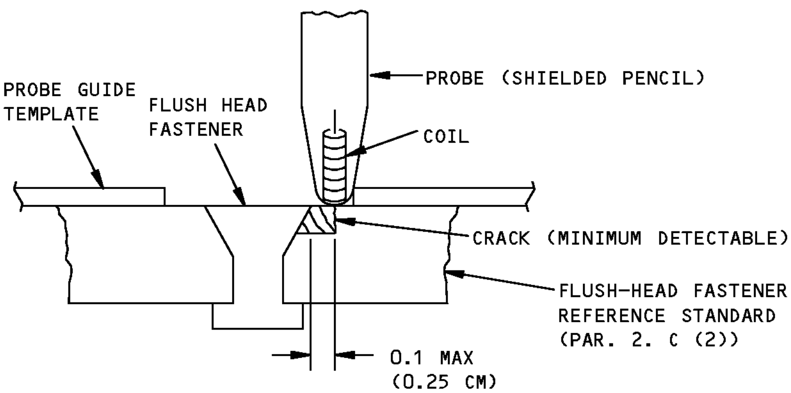
3 REFERENCE STANDARD NOTCH RESPONSE (TYP)

ALARM ADJUSTMENT
DETAIL B

Sensitivity and Alarm Adjustments
Figure 8



PROBE GUIDE
(NON-CONDUCTIVE CIRCLE TEMPLATE)



FASTENER SCANNING WITH TEMPLATE GUIDE

NOTES

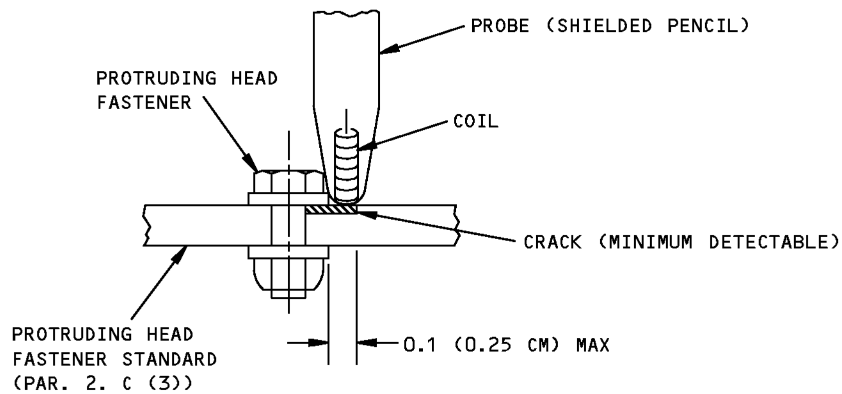
- TO CONFIRM PROBE/INSTRUMENT SENSITIVITY FOR 0.09-0.10 INCH (0.229-0.254 CM) NOTCH ON FLUSH-HEAD FASTENER REFERENCE STANDARD:

  1) CALIBRATE TO THE REQUIREMENTS OF PAR. 4

  2) USE THE HOLE TEMPLATE AS A SCANNING GUIDE AROUND THE FASTENER. SELECT TEMPLATE HOLE SIZE AND CENTER ON THE FASTENER SO THAT THE PROBE SENSING DIAMETER REACTS TO THE NOTCH WITH A METER RESPONSE EQUAL TO OR GREATER THAN THE RESPONSE FROM THE CALIBRATION NOTCH AS THE PROBE IS MOVED AROUND THE FASTENER

     REBALANCING THE INSTRUMENT MAY BE REQUIRED. DO NOT CHANGE THE CALIBRATION SENSITIVITY

Flush-Head Scanning Guidelines
Figure 9



FASTENER SCANNING WITH FASTENER HEAD AS GUIDE

NOTES

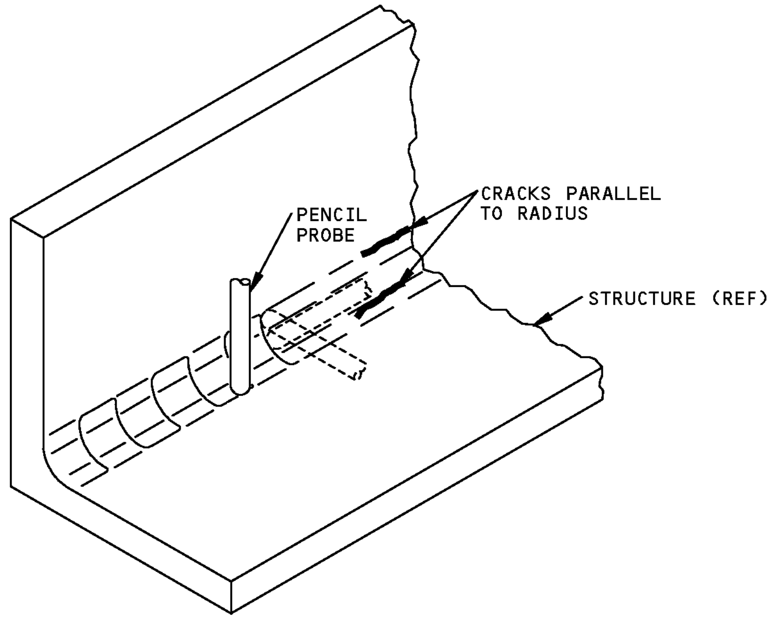
- TO CONFIRM PROBE/INSTRUMENT SENSITIVITY FOR 0.09-0.10 INCH (0.229-0.254 CM) NOTCH ON PROTRUDING-HEAD FASTENER REFERENCE STANDARD:

  1) CALIBRATE TO THE REQUIREMENTS OF PAR. 4

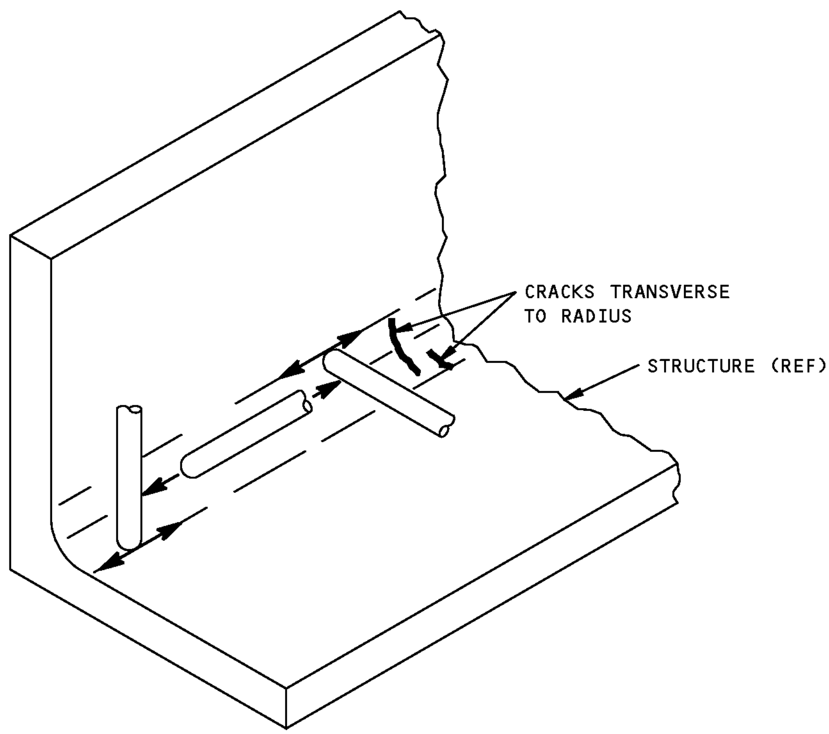
  2) USE THE FASTENER HEAD OR WASHER AS A SCANNING GUIDE SO THAT THE PROBE SENSING DIAMETER REACTS TO THE NOTCH WITH A METER RESPONSE EQUAL TO OR GREATER THAN THE RESPONSE FROM THE CALIBRATION NOTCH AS THE PROBE IS MOVED AROUND THE FASTENER

     REBALANCING THE INSTRUMENT MAY BE REQUIRED. DO NOT CHANGE THE CALIBRATION SENSITIVITY

Protruding-Head Scanning Guidelines
Figure 10



TRANSVERSE SCAN

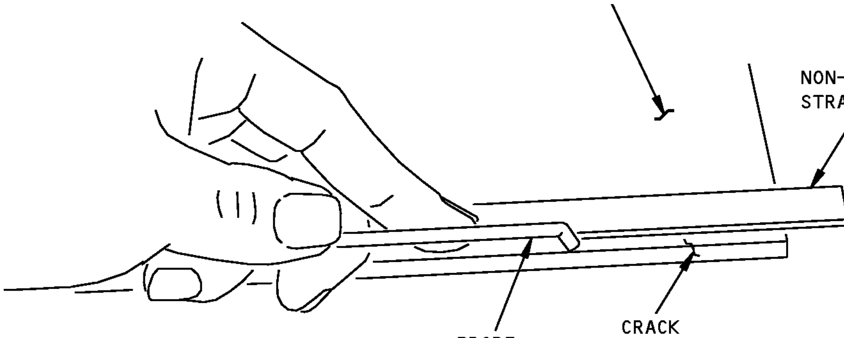


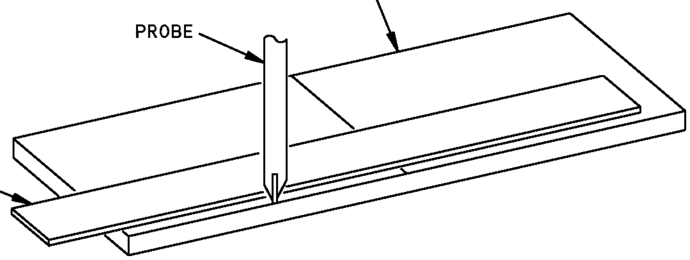
PARALLEL SCAN

NOTES

- HOLD PROBE NORMAL TO RADIUS
- SPACE BETWEEN SCANS IS DEPENDENT ON THE CRACK SIZE WHICH MUST BE DETECTED

Radius Inspection
Figure 11





NOTES

- POSITION A NON-CONDUCTIVE STRAIGHTEDGE A CONSTANT DISTANCE AWAY FROM THE STRUCTURE
- MINIMUM PROBE TO EDGE SPACING IS DEPENDENT UPON THE SENSING AREA OF THE PROBE COIL
- TO DETERMINE MINIMUM PROBE TO EDGE SPACING:

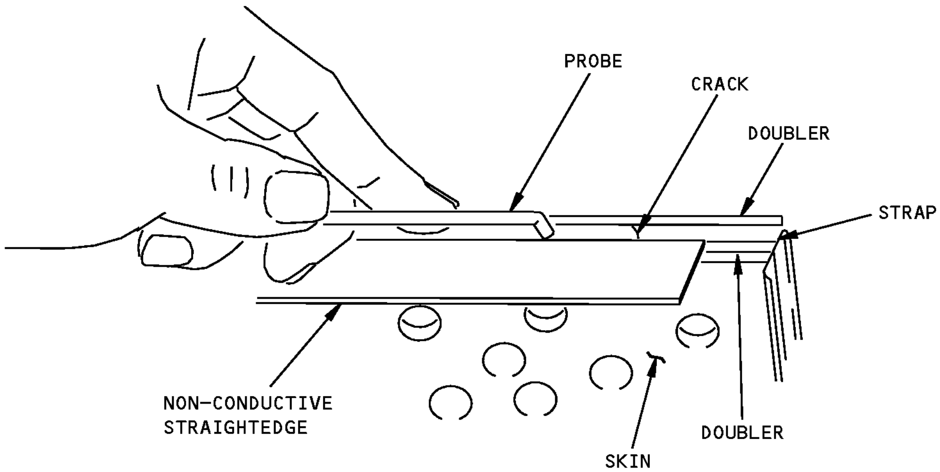
  1) CALIBRATE TO THE REQUIREMENTS OF PAR. 4

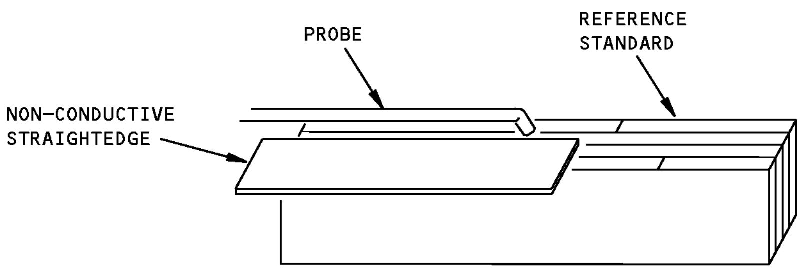
  2) PLACE THE NON-CONDUCTIVE STRAIGHTEDGE A CONSTANT DISTANCE AWAY FROM THE NOTCHED EDGE OF A REFERENCE STANDARD

  3) SCAN PROBE ALONG THE STRAIGHTEDGE AND NOTE THE METER RESPONSE. THE MINIMUM PROBE TO EDGE SPACING IS WHEN THE METER RESPONSE FALLS BELOW 90% OF THE CALIBRATION RESPONSE, OR WHEN THE ALARM SET IN ACCORDANCE TO PAR 4.E. FAILS TO TRIGGER

     REBALANCING THE INSTRUMENT MAY BE REQUIRED. DO NOT CHANGE THE CALIBRATION SENSITIVITY

Inspection Near an Edge
Figure 12





NOTES

- POSITION A NON-CONDUCTIVE STRAIGHTEDGE TO MAINTAIN A CONSTANT DISTANCE ON THE EDGE OF THE MEMBER IN QUESTION
- MINIMUM STRUCTURE WIDTH FOR CRACK DETECTION IS DEPENDENT UPON THE SENSING AREA OF THE PROBE COIL
- TO DETERMINE MINIMUM STRUCTURE WIDTH:

  1) CALIBRATE TO THE REQUIREMENTS OF PAR. 4. USE REFERENCE STANDARD 126.

  2) POSITION THE NON-CONDUCTIVE STRAIGHTEDGE TO MAINTAIN A CONSTANT DISTANCE ALONG A NOTCHED MEMBER OF THE REFERENCE STANDARD

  3) SCAN THE PROBE ALONG THE STRAIGHTEDGE AND NOTE THE METER RESPONSE. THE MINIMUM STRUCTURE WIDTH IS WHEN THE METER RESPONSE FALLS BELOW 90% OF THE CALIBRATION RESPONSE, OR WHEN THE ALARM SET IN ACCORDANCE TO PAR. 4.E. FAILS TO TRIGGER

  REBALANCING THE INSTRUMENT MAY BE REQUIRED. DO NOT CHANGE THE CALIBRATION SENSITIVITY

Inspection On an Edge
Figure 13

PART 6 - EDDY CURRENT

INSPECTION OF THE FAYING SURFACE OF THE OUTER ALUMINUM SKIN FOR CORROSION (METER DISPLAY)

1. **Purpose**

   A. Use this procedure to do an inspection for corrosion on the faying surface of the outer aluminum skin. The skin must have the characteristics specified below to be examined by this procedure:

      (1) The thickness of the outer skin must be between 0.032 inch (0.80 mm) and 0.125 inch (3.20 mm).

      (2) The skin material must be aluminum clad 2024-T3, 2024-T4.

   B. This procedure uses a meter display instrument.

   C. Part 6, 51-00-10 is an alternative inspection procedure that uses an impedance plane display. If a meter display and an impedance plane display instrument are available for your use, we recommend you use the impedance plane display instrument to do this type of inspection.

2. **Equipment**

   A. General

      (1) Use inspection equipment that can be calibrated on the reference standard as specified in Paragraph 4.

      (2) Refer to Part 1, 51-01-00 for data about the equipment manufacturers.

   B. Instrument

      (1) Use an eddy current instrument that:

         (a) Has a meter display.

         (b) Operates at a frequency range of 3.2 to 50 kHz.

      (2) The instruments specified below were used to prepare this procedure.

         (a) MIZ-10A, MIZ-10B; Zetec, Inc.

   C. Probes

      (1) Use a probe that operates in the frequency range specified in Table 1 for the outer skin thickness to be examined.

      (2) The reflection probes specified below were used to prepare this procedure.

         (a) SNR 375-3L, 5-50 kHz, 0.31 inch (8 mm) diameter; NDT Engineering

         (b) SPO 5327, 700 Hz - 80 kHz, 0.31 inch (8 mm) diameter; Nortec/Staveley Instruments

         (c) SPO 5329, 300 Hz - 40 kHz, 0.50 inch (12 mm) diameter; Nortec/Staveley Instruments

   D. Reference Standards

      (1) Use the applicable reference standard specified in Table 1 for the thickness of the outer skin to be examined. See Figure 1 or Figure 2 for data about the reference standards.

         NOTE: It will be necessary to use more than one reference standard if the outer skin thickness changes such that it falls within the different limits specified in Table 1.

3. **Preparation for Inspection**

   A. Get access to the inspection area.

   B. Remove loose paint, dirt and sealant from the surface of the inspection area.

   C. Measure the thickness of the outer skin.

      NOTE: Some outer skins are tapered and have more than one thickness.

4. Instrument Calibration

A. Set the frequency to the middle of the range specified in Table 1 for the thickness of the outer skin.

NOTE: You can adjust the frequency to increase the signal from the machined area at position 2 (see Figure 3) in the reference standard. The frequency must stay in the range shown in Table 1 for the applicable skin thickness.

B. Put a nonconductive shim on the reference standard. The thickness of the shim must be equivalent (± 0.003 inch (0.08 mm)) to the paint thickness on the outer skin.

C. Put the probe at position 1 on the reference standard as shown in Figure 3.

D. Balance the instrument.

E. Adjust the balance point to 20 percent of the display as shown in Figure 3.

F. Adjust the instrument for lift-off with a 0.003-inch (0.08 mm) nonconductive shim. Adjust the phase control so that the signal moves no more than 5 percent of the display during lift-off adjustment.

G. Move the probe to position 2 on the reference standard as shown in Figure 3. Probe position 2 is a location where there is a 10 percent decrease in the material thickness.

H. Adjust the gain to get a signal that is approximately 40 percent of the display as shown in Figure 3.

I. Put the probe at position 3 on the reference standard as shown in Figure 3.

J. If the signal is not between 5 percent and 15 percent of the display as shown in Figure 3, then adjust the frequency. Make sure to keep the frequency in the range specified in Table 1 for the applicable outer skin thickness.

K. If you adjusted the frequency in Paragraph 4.J., do the calibration again.

L. Move the probe to the area on the reference standard that has 20 percent less material. Make a record of the signal value. See Figure 4 for examples of the signals that occur when there is a decrease in the material thickness (equivalent to the results of corrosion).

M. Move the probe to the area on the reference standard that has 30 percent less material. Make a record of the signal value.

5. Inspection Procedure

A. Put the probe on the outer skin where there is second layer structure and no visual sign of corrosion.

B. Balance this instrument.

C. Adjust the balance point to 20 percent of the meter display.

NOTE: Do not adjust the gain. Gain adjustments will make the instrument calibration unsatisfactory.

D. Put the probe on an area of the outer skin without second layer structure.

E. If the signal is not in the shaded area shown in Figure 5, use a different frequency and do the calibration again. Go to Paragraph 5.A. if you do the calibration again.

F. Slowly make a scan of the inspection area and monitor the instrument display. During the inspection:

(1) Make a mark at the locations that cause signals that are more than 40 percent of the display.

(2) Frequently do a check of the instruments calibration as follows:

(a) Put the probe on the reference standard at the same locations as was done during calibration.

(b) Compare the value of the signal you got during calibration with the value of the signal you get now.

(c) If the value of the signal has changed 10 percent or more, do the calibration and inspection again.

6. **Inspection Results**

A. Signals that are more than 40 percent of the display are signs of a defect.

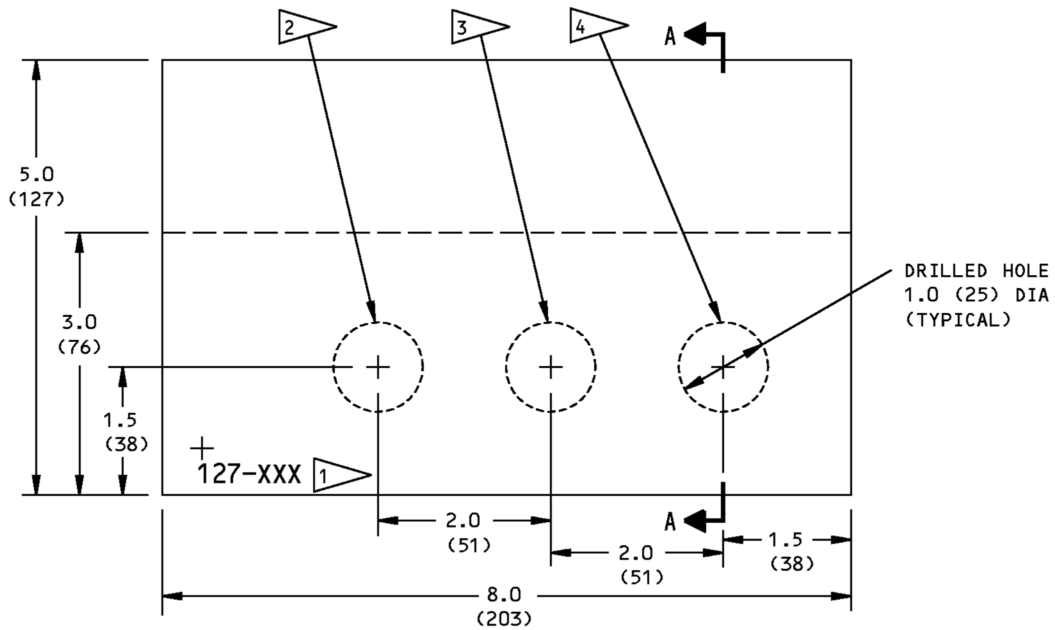
B. Compare the signals that occur during the inspection to the signals that you got from the machined areas in the reference standard to estimate the quantity of the corrosion.

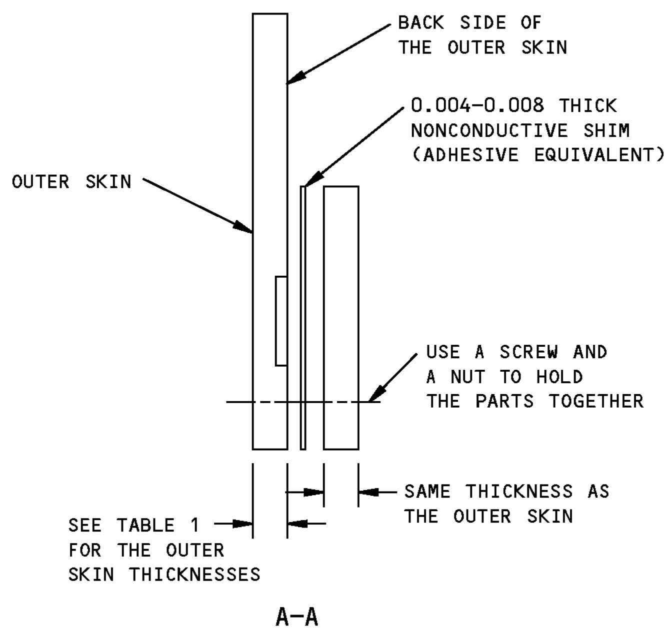
Table 1 Airplane Outer Skin Thickness to Reference Standard and Instrument Frequency Cross Reference

AIRPLANE OUTER SKIN THICKNESS *[1]	REFERENCE STANDARD NUMBER *[2]	INSTRUMENT TEST FREQUENCY RANGE kHz
0.032 - 0.034 (0.80 - 0.90)	127 - 0.032 127A - 0.032	44 - 50
0.034 - 0.038 (0.90 - 1.00)	127 - 0.036 127A - 0.036	35 - 44
0.038 - 0.045 (1.00 - 1.10)	127 - 0.040 127A - 0.040	25 - 35
0.045 - 0.056 (1.10 - 1.40)	127 - 0.050 127A - 0.050	16 - 25
0.056 - 0.068 (1.40 - 1.70)	127 - 0.063 127A - 0.063	11 - 16
0.068 - 0.076 (1.70 - 1.90)	127 - 0.072 127A - 0.072	9 - 11
0.076 - 0.085 (1.90 - 2.15)	127 - 0.080 127A - 0.080	7 - 9
0.085 - 0.095 (2.15 - 2.40)	127 - 0.090 127A - 0.090	5.6 - 7
0.095 - 0.105 (2.40 - 2.65)	127 - 0.100 127A - 0.100	4.6 - 5.6
0.105 - 0.118 (2.65 - 3.00)	127 - 0.110 127A - 0.110	3.6 - 4.6
0.118 - 0.125 (3.00 - 3.20)	127 - 0.125 127A - 0.125	3.2 - 3.6

*[1] DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES)

*[2] THE NUMBER THAT FOLLOWS THE DASH IS THE REFERENCE STANDARD THICKNESS (IN INCHES)





Corrosion Reference Standard 127-XXX
Figure 1 (Sheet 1 of 2)

NOTES

- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES).
- MATERIAL: CLAD 2024-T3 OR CLAD 2024-T4 SHEET.
- TOLERANCE: INCHES X.X = ±0.05; MILLIMETERS X = ±1.3

OUTER SKIN THICKNESS	SKIN THICKNESS TOLERANCE	SPOTFACE DEPTH TOLERANCE
0.032 TO 0.050 (0.80 TO 1.30)	±0.001 (0.025)	±0.001 (0.025)
0.063 TO 0.125 (1.60 TO 3.20)	±0.002 (0.050)	±0.0015 (0.040)

- THE BACK SIDE OF THE OUTER SKIN CAN BE MACHINED TO THE THICKNESS OF THE AIRPLANES SKIN. MAKE SURE THE ALUMINUM SHEET USED TO MAKE THE OUTER SKIN IS OF THE SPECIFIED OR NEXT THICKER GAGE. THIS IS DONE TO MAKE SURE THE CLAD THICKNESS OF THE REFERENCE STANDARD AND THE AIRPLANE ARE THE SAME. SEE TABLE 1.
- SPOTFACE TO A SURFACE ROUGHNESS OF 64 R_a OR BETTER.

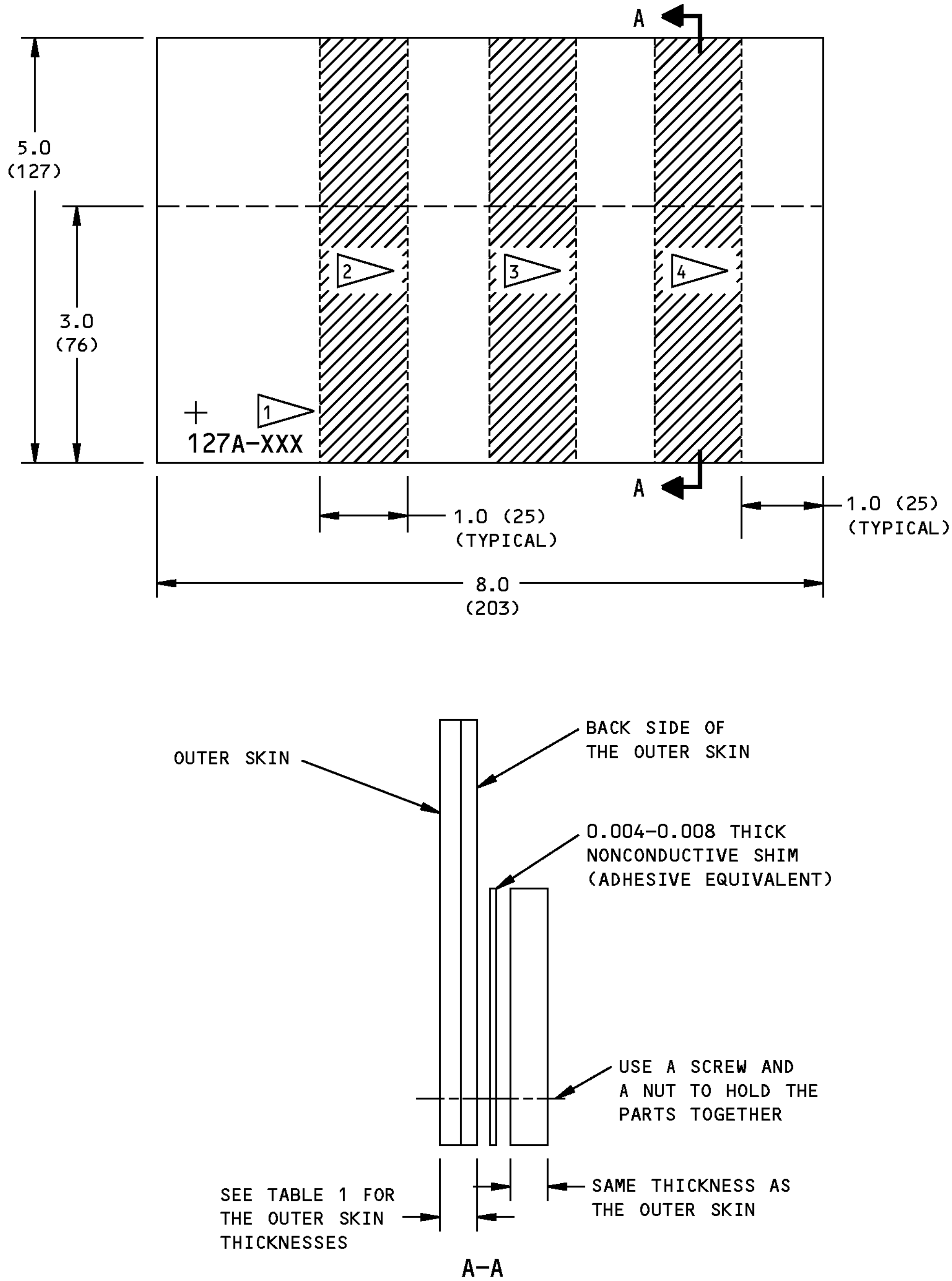
1 ETCH OR STEEL STAMP "127-XXX" (XXX IS THE REFERENCE STANDARD THICKNESS) ON THE TWO SKINS OF THE REFERENCE STANDARD. TABLE 1 IDENTIFIES THE REFERENCE STANDARD NUMBERS.

2 THE DEPTH OF THE MACHINED AREA IS 10 PERCENT OF THE THICKNESS OF THE OUTER SKIN OF THE REFERENCE STANDARD.

3 THE DEPTH OF THE MACHINED AREA IS 20 PERCENT OF THE THICKNESS OF THE OUTER SKIN OF THE REFERENCE STANDARD.

4 THE DEPTH OF THE MACHINED AREA IS 30 PERCENT OF THE THICKNESS OF THE OUTER SKIN OF THE REFERENCE STANDARD.

Corrosion Reference Standard 127-XXX
Figure 1 (Sheet 2 of 2)



Corrosion Reference Standard 127A-XXX
Figure 2 (Sheet 1 of 2)

NOTES

- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES).
- MATERIAL: CLAD 2024-T3 OR CLAD 2024-T4 SHEET.
- TOLERANCE:

	INCHES	MILLIMETERS
TOLERANCE:	X.X = ±0.05	X = ±1.3

OUTER SKIN THICKNESS	SKIN THICKNESS TOLERANCE	SPOTFACE DEPTH TOLERANCE
0.032 TO 0.050 (0.80 TO 1.30)	±0.001 (0.025)	±0.001 (0.025)
0.063 TO 0.125 (1.60 TO 3.20)	±0.002 (0.050)	±0.0015 (0.040)

- THE BACK SIDE OF THE OUTER SKIN CAN BE MACHINED TO THE THICKNESS OF THE AIRPLANES SKIN. MAKE SURE THE ALUMINUM SHEET USED TO MAKE THE OUTER SKIN IS OF THE SPECIFIED OR NEXT THICKER GAGE. THIS IS DONE TO MAKE SURE THE CLAD THICKNESS OF THE REFERENCE STANDARD AND THE AIRPLANE ARE THE SAME. SEE TABLE 1.
- SPOTFACE TO A SURFACE ROUGHNESS OF 64 R_a OR BETTER.

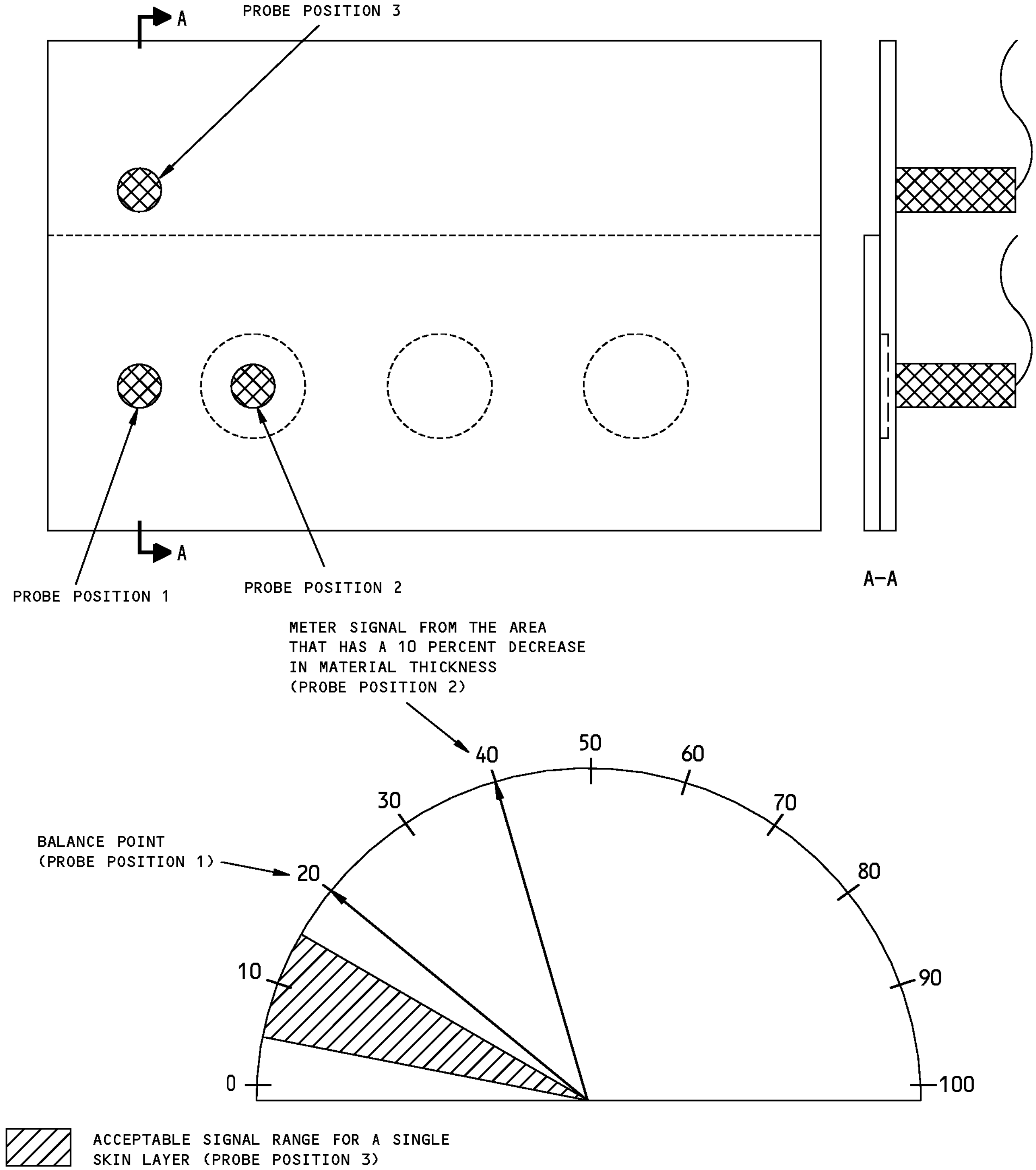
1 ETCH OR STEEL STAMP "127-XXX" (XXX IS THE REFERENCE STANDARD THICKNESS) ON THE TWO SKINS OF THE REFERENCE STANDARD. TABLE 1 IDENTIFIES THE REFERENCE STANDARD NUMBERS.

2 THE DEPTH OF THE MACHINED AREA IS 10 PERCENT OF THE THICKNESS OF THE OUTER SKIN OF THE REFERENCE STANDARD.

3 THE DEPTH OF THE MACHINED AREA IS 20 PERCENT OF THE THICKNESS OF THE OUTER SKIN OF THE REFERENCE STANDARD.

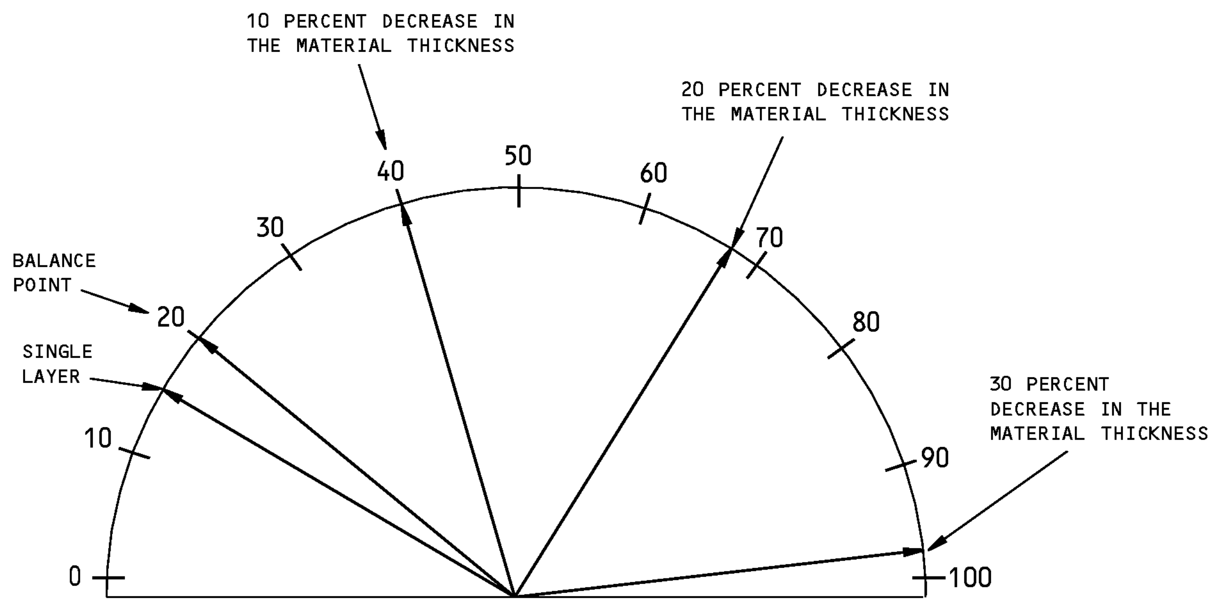
4 THE DEPTH OF THE MACHINED AREA IS 30 PERCENT OF THE THICKNESS OF THE OUTER SKIN OF THE REFERENCE STANDARD.

Corrosion Reference Standard 127A-XXX
Figure 2 (Sheet 2 of 2)



NOTE: PROBE CALIBRATION POSITIONS ARE SHOWN FOR THE 127-XXX TYPE REFERENCE STANDARD. THE PROBE CALIBRATION POSITIONS FOR THE 127A-XXX TYPE REFERENCE STANDARD ARE ALMOST THE SAME.

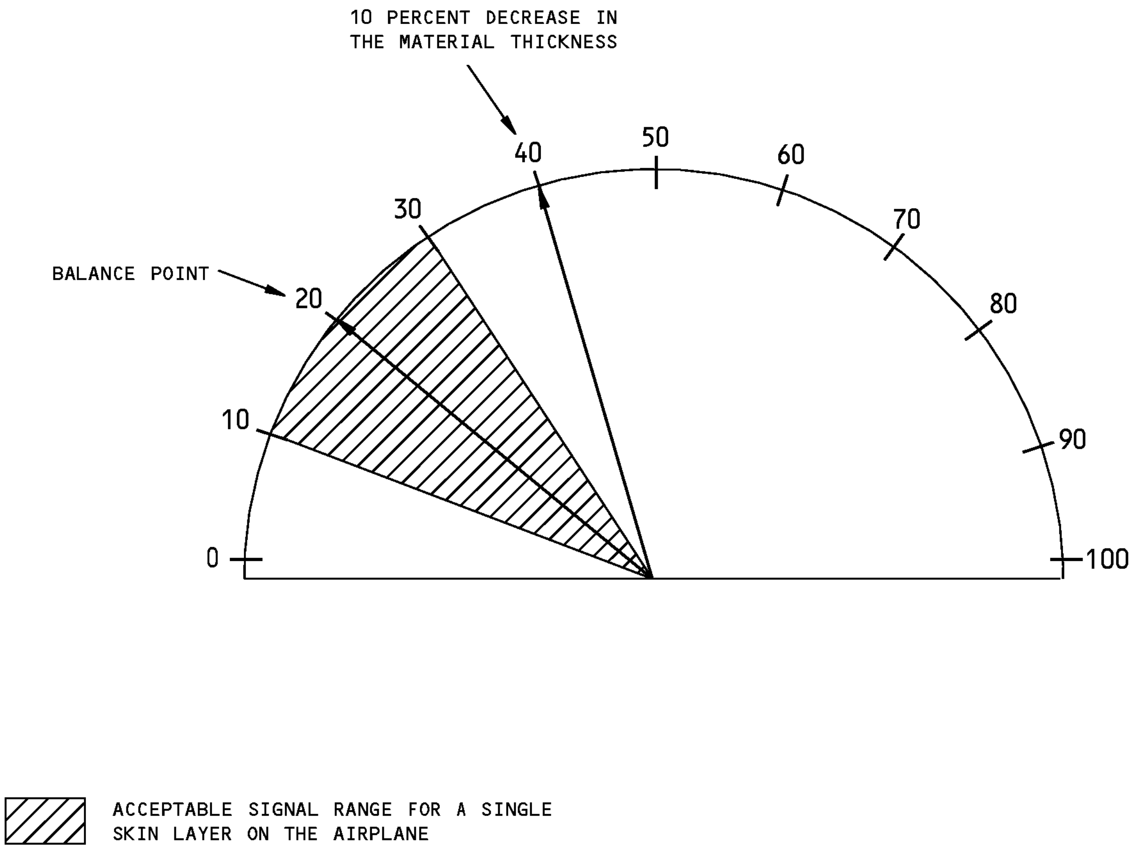
Calibration Probe Positions and Meter Signals
Figure 3



NOTES

- THIS FIGURE SHOWS EXAMPLES OF THE SIGNALS THAT USUALLY OCCUR ON THE METER DISPLAY DURING CALIBRATION. THE SIGNALS THAT OCCUR DURING YOUR CALIBRATION CAN BE DIFFERENT THAN THESE BECAUSE OF DIFFERENCES IN:
  - PROBE PERFORMANCE.
  - MACHINED REFERENCE STANDARD TOLERANCES.
  - CONDUCTIVITY CHANGES.
  - MATERIAL THICKNESS CHANGES.

Signal Examples for the Meter Display Instrument
Figure 4



Meter Display Instrument - Signal Examples
Figure 5

PART 6 - EDDY CURRENT

FIRE DAMAGE ON AIRCRAFT STRUCTURE INVESTIGATION

1. Purpose

A. The purpose of this procedure is to find areas where temperatures have changed the properties of aluminum parts. This procedure measures conductivity changes in the aluminum parts to find these areas.

NOTE: Electrical conductivity, when measured with eddy current instruments, usually is given as a percentage of the conductivity of the International Annealed Copper Standard (percent IACS).

B. This inspection procedure finds changes in conductivity. This procedure does not measure absolute values of conductivity.

NOTE: If absolute values of conductivity are necessary, refer to Boeing Process Specification BAC5946 - Temper Inspection of Aluminum Alloys.

2. Equipment

NOTE: Refer to Part 1, 51-01-00 for data about the manufacturers of this equipment.

A. Instrument and Probe - Use a metered or a digital eddy current conductivity instrument that reads values of conductivity directly. Use a probe that is the flat, surface type that can be used with the instrument and test material. The probe and instrument must satisfy the instructions specified in this procedure. The instruments and probes specified below were used to help make this procedure.

Autosigma 2000LF instrument and probe - Hocking Instruments, Inc.

Sigmascope S instrument and probe - Fischer Instruments

Verimet M4900C and probe - K. J. Law Engineers, Inc.

B. Reference Standard - Use certified conductivity standards. A set of three standards that have conductivity values of 16 ±3 percent IACS, 29 ±3 percent IACS and 42 ±3 percent IACS are recommended for use to do the range of aluminum alloys. The standards used to help make this procedure are available from Zetec, Inc.

3. Preparation for Inspection

A. Do a visual inspection of the area thought to be heat damaged. Look for changes in the paint/primer color and structural deterioration. Make a mark around the area thought to be heat damaged. See Figure 1.

B. Identify the structure to be examined. It is necessary to examine all of the external and internal structure (skins, stringers, frames, etc.).

C. Identify areas where the structural configuration changes (i.e., thickness, curvature, edges, etc.). See Figure 1. These areas must be examined independently because the normal conductivity indications will be different for each area.

D. Clean the area to be examined to make sure there is good contact between the probe and the inspection surface.

4. Instrument Calibration

A. Calibrate the instrument at the inspection location.

NOTE: The instrument, probe, reference standards, and inspection area must be at the same ambient temperature.

B. Get two certified conductivity standards. One must have a conductivity value that is higher than the conductivity of the part to be examined. The other must have a conductivity value that is lower than the conductivity of the part to be examined. (The 29 percent IACS and the 42 percent standards can be used for most aluminum alloys.)

C. Make sure the instrument is on. Adjust for lift-off as specified in the manufacturers instructions.

NOTE: If the instrument does not have an internal lift-off adjustment, put a nonconductive shim between the probe and the calibration standard to adjust for lift-off. The nonconductive shim must be the same thickness as the paint/primer on the test part.

D. Calibrate the instrument as specified in the manufacturers instructions. The instrument must indicate a value that is plus or minus 1.0 percent IACS of the certified values of the two conductivity standards.

5. Inspection Procedure

A. Prepare the area for the inspection as specified in Paragraph 3.

B. Calibrate the instrument as specified in Paragraph 4..

C. Put the probe on the surface of known good structure at different locations to get a baseline conductivity value. See Figure 1.

NOTE: If different types of material or structural configuration are present in the inspection area, get baseline conductivity values from each type of material or structure. Identify a location for a baseline conductivity value as a good area. Regularly refer to this area during the inspection to do a check of the instrument calibration.

NOTE: Visible distortion to the structure or a change in the paint/primer color are indications that the aluminum structure has heat damage. Identify a baseline conductivity value outside such areas.

D. Get conductivity values from the area of the structure that is not damaged and from the area of the structure thought to be heat damaged. Start the examination in a good area and work to the center of the area thought to be heat damaged. A conductivity change of 1 percent IACS or more from the baseline conductivity value indicates an area of heat damage.

NOTE: Be sure to examine areas of different structural configurations independently. See Figure 1.

E. Identify the boundary between the heat-damaged area and the good structure. Make a mark of the boundary on the part when a value that is 1 percent IACS different from the baseline conductivity value is gotten. Do a check to make sure that all of the damaged material has been identified.

F. Examine all of the structure (skins, stringers, frames, etc.).

6. Inspection Results

A. Heat-damaged structure is indicated by a conductivity change of 1 percent IACS or more from the identified baseline conductivity values.

NOTE: A change of 1 percent IACS or more from the baseline conductivity value in an area thought to be heat damaged indicates an area that has heat damage. This is true even if the values are within the acceptable conductivity limits for that material and temper.

B. Changes in the conductivity values that are not caused by heat damage can occur if:

(1) The probe gets too close to the edge of the structure.

(2) The probe gets too close to adjacent structure.

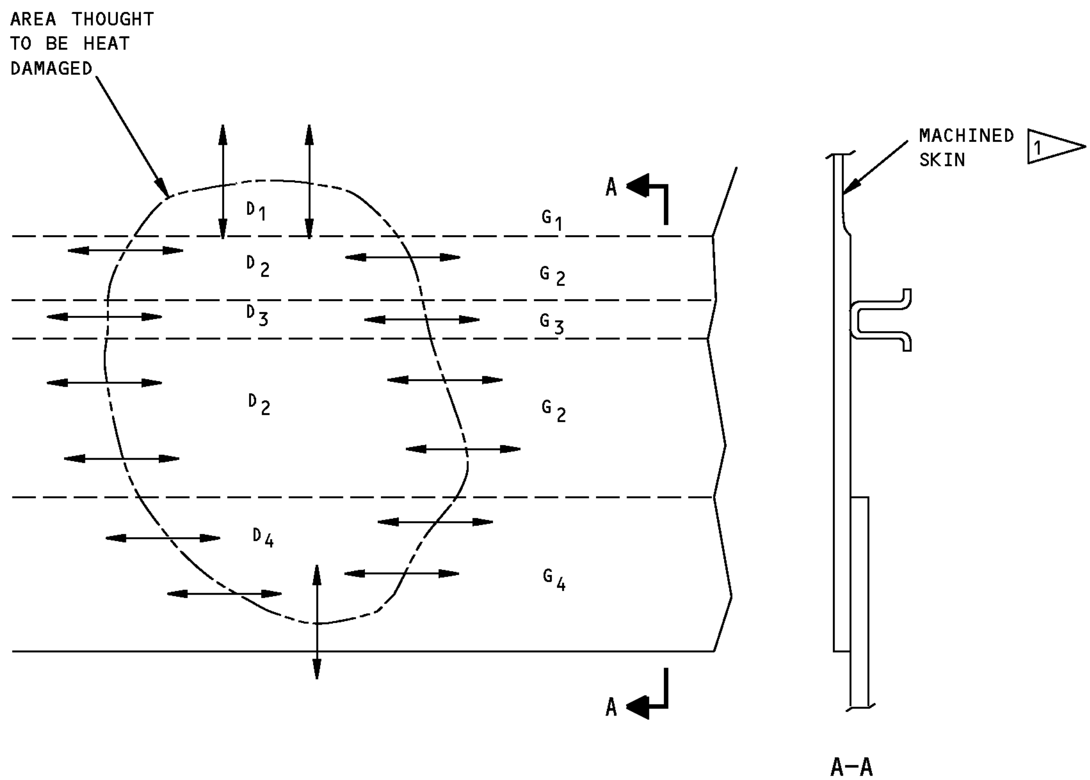
(3) The fasteners are too close to each other.

(4) The structural thickness changes.

(5) The paint thickness changes.

(6) The part curvature changes.

(7) The part temperature changes.



NOTES

- G - GOOD AREA (NOT DAMAGED)
- D - AREA THOUGHT TO BE HEAT DAMAGED
- GET BASELINE CONDUCTIVITY VALUES FROM GOOD AREAS (G_1, G_2 ETC.). THEN MAKE A SCAN INTO THE AREAS YOU THINK HAVE HEAT DAMAGE (D_1, D_2 ETC.).
- EACH DIFFERENT STRUCTURAL CONFIGURATION (G_1-D_1, G_2-D_2, ETC.) MUST BE EXAMINED INDEPENDENTLY.

1 CLAD SKINS WITH ONE MACHINED SURFACE WILL HAVE DIFFERENT CONDUCTIVITY VALUES FOR THE SAME AREA WHEN THE CONDUCTIVITY IS MEASURED FROM OPPOSITE SIDES OF THE SKIN. THIS IS BECAUSE OF CLAD REMOVAL.

Inspection of the Exterior Surface of the Skin
Figure 1

PART 6 - EDDY CURRENT

ALUMINUM PART FASTENER HOLE INSPECTION (METER DISPLAY)

1. **Purpose**

   A. To inspect, with a metered instrument, fastener holes in aluminum parts with fasteners removed.

   B. Part 6, 51-00-11 can be used as an alternate procedure.

   C. Part 6, 51-00-16 is recommended as an alternative procedure. It is highly recommended for inspections of materials less than 0.063 inch thick.

2. **Equipment**

   NOTE: Refer to Part 1, 51-01-00 for equipment manufacturers.

   A. Instrument - Eddy current instruments that get the necessary performance conditions of this procedure are permitted for this inspection. The following instruments were used to make this procedure and were found satisfactory:

      (1) Magnatest ED-520, ED-530, Magnaflux Corporation

      (2) P/N EM-1500, Automation Industries, Inc.

      (3) P/N MIZ-10, MIZ-10A, Zetec, Inc.

   B. Probes - The probe/instrument set used in this procedure must meet the necessary liftoff and sensitivity conditions of Paragraph 4.

      (1) The probe diameter must be adjustable to get a tight fit in the hole.

      (2) The probes must have an adjustable collar which controls the depth into the hole. The collar is to be used an a guide while the probe is turned inside of the hole.

      NOTE: See Figure 1 for an example of the design for the probe.

      (3) The probes must not give interfering responses from usual handling pressures or manipulation, or from the usual operating pressure changes on the sensing coil.

   C. Reference Standards - Reference standards should have suitable natural cracks or artificial slots to simulate cracks in each of the hole sizes being tested. A reference standard should meet the following requirements:

      (1) Reference standard should be of aluminum alloy with approximately the same conductivity as the part to be inspected.

      (2) Reference standard should contain a suitable range of hole diameters to permit calibration of instrument for diameter of each hole to be tested.

      (3) The crack or slot in the reference standard must give an eddy current instrument calibration comparable to that obtained from the recommended Boeing reference standard (See Figure 2).

3. **Preparation for Inspection**

   A. Clean loose dirt, chipped paint, and sealant from inside and around fastener hole.

   B. Remove buildup of paint, sealant, etc., from around outside of hole where probe collar will bear.

   NOTE: If surface of hole is extremely rough, a cleanup ream may be necessary. A 1/64 inch diameter oversize is usually satisfactory.

4. **Instrument Calibration**

   A. Attach appropriate probe to instrument.

   B. Turn instrument on and allow to warm up per manufacturer's instructions.

   C. Set frequency, if applicable, between 100 and 250 kHz.

D. Select appropriate test block and place probe in hole. Probe should fit snugly but not so tight as to cause excessive wear of probe. Expand loose probe to obtain snug fit.

E. Balance instrument according to the manufacturer's instructions.

F. Adjust instrument for liftoff.

(1) Place sensitive (coil) part of probe on a flat surface of material to be inspected. Because of edge effect interference, place coil at least 1/4 inch away from edge of part.

(2) Manipulate probe to obtain maximum eddy current effect.

(3) Place a single sheet of ordinary writing paper (approximate thickness 0.003 inch) between probe and material.

(4) Remove paper and note direction and amount of deflection of needle.

(5) Adjust controls to obtain minimum needle movement when paper is removed.

(6) For final lift-off adjustment, insert the probe in the test block and manipulate the probe to cause the coil to lift-off from the surface of the hole. This can be achieved by squeezing the probe so the coil moves away from the surface or by placing a piece of tape on the inside surface of the hole and rotating the probe so the coil is on the tape. Adjust the controls to obtain minimum needle movement when the coil is lifted off from the surface of the hole. When no needle movement is noted, the instrument and probe have been calibrated for lift-off.

G. Use the collar to adjust depth of coil in hole to obtain maximum needle deflection on meter from edge slot (center of coil approximately 0.025 inch deep for 0.030-inch edge slot).

H. Adjust sensitivity to obtain a minimum of 10% full scale meter deflection from standard slot. Instrument is now calibrated for detection of edge cracks in hole to be inspected.

NOTE: Boeing Service Bulletin rework and modification procedures are based on the reliable detection of cracks 0.030 inch or greater in depth (radially). The instrument and probe should detect the 0.030-inch standard slot reliably.

I. Insert probe in test block, and adjust depth in hole to obtain maximum needle deflection from slot located between ends of hole in test block. Tighten setscrew on collar of probe.

J. Repeat Paragraph 4.H. Instrument is now calibrated for detection of cracks between ends of hole.

5. Inspection Procedure

A. Adjust collar on probe to set depth of penetration into hole at 0.025 inch from top end of hole.

B. Tighten collar on probe and insert probe into hole. Adjust balance control to bring needle approximately to midscale.

C. Slowly scan entire circumference of hole, using the collar to maintain a constant depth in the hole. Note position of any needle deflection of 10% of full scale or greater, giving a positive crack response.

D. Loosen collar and repeat Paragraph 5.B. and Paragraph 5.C. at incremental depths of 0.050 inch to within 0.025 inch from bottom end of hole or mating layer interfaces.

E. Recheck calibration of instrument with test block periodically to ensure proper sensitivity of instrument.

6. Inspection Results

A. A positive crack response is characterized by a rapid deflection of the meter needle over a short scan distance. Deflection occurs as the coil moves over the crack. This movement is equivalent to an arc of approximately 40 degrees in 1/4-inch fastener hole, and 20 degrees in a 1/2-inch hole. Compare crack response with reference standard slot response for similar hole diameter.

B. Note locations of any questionable indications, i.e., crack-like indications causing needle deflection of less than 10% of full scale, or indications not conforming to a positive crack indication. To help do the inspections at these locations, do a maximum 1/64-inch cleanup ream and do this test again, paying particular attention to areas where the indications were noted. Note the location and the response of all positive crack indications.

C. When a hole is reamed to clean up or remove the cracks, do an eddy current test after each increase in hole diameter. It is recommended that a hole be oversized in increments of no more than 1/64 inch in diameter. This is done to make sure the piece stays within permitted oversizing limits. The permitted limits for hole oversizing are specified in the repair document applicable to the structure (i.e., service bulletin, repair drawing or structural repair manual).

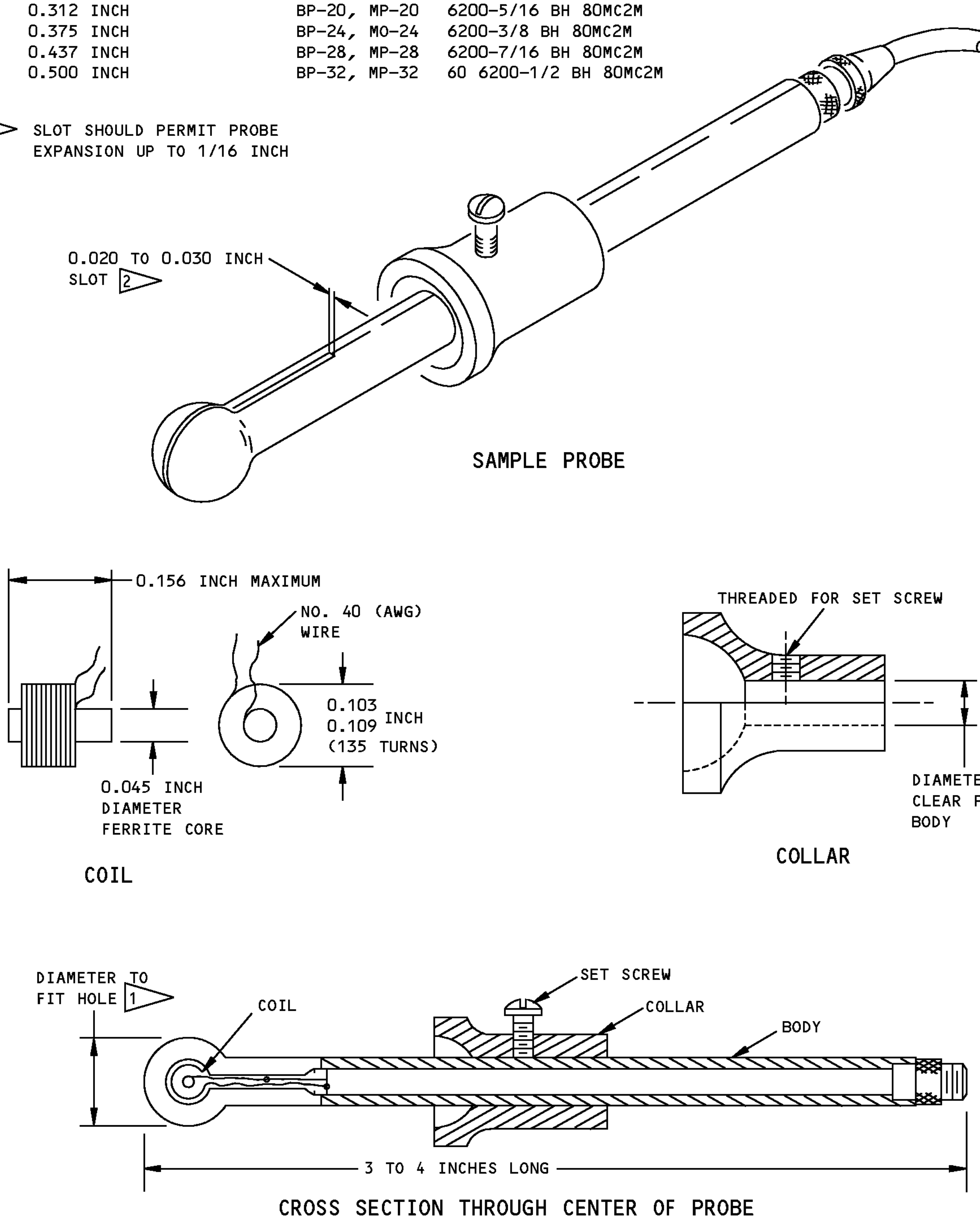
NOTE: When reworking cracked part, it is imperative that an "insurance cut" be made after the eddy current inspection shows that the crack is fully removed. If possible, the depth of the insurance cut should be equal to or greater than the depth of the minimum detectable crack to make sure of complete crack removal. Get local engineering approval before you do an insurance cut.

NOTE

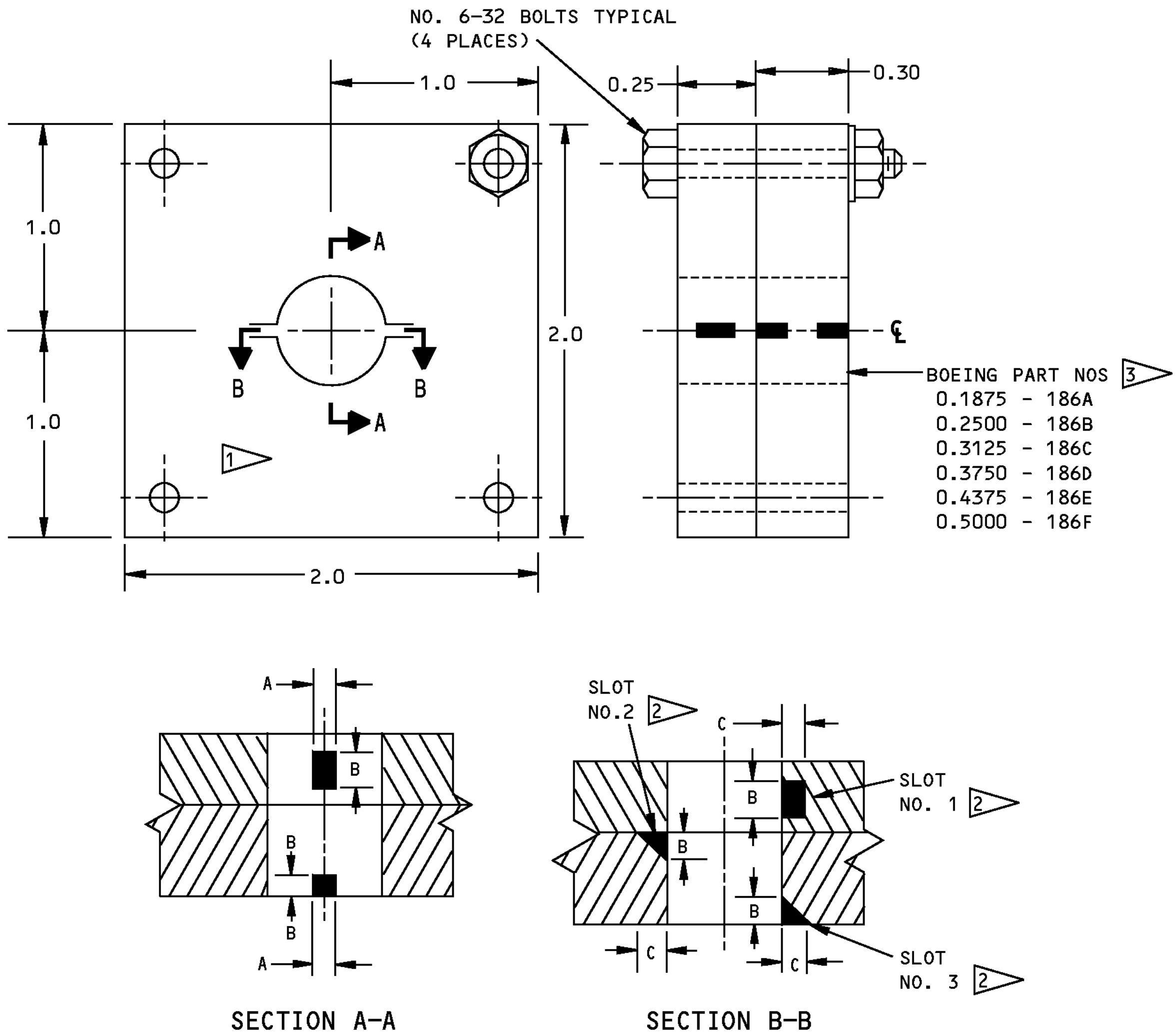
PART NUMBERS

1 STANDARD PROBE DIAMETERS	NORTEC	IDEAL SPECIALTY CO.
0.187 INCH	BP-12, MP-12	6200-3/16 BH 80MC2M
0.250 INCH	BP-16, MP-16	6200-1/4 BH 80MC2M
0.312 INCH	BP-20, MP-20	6200-5/16 BH 80MC2M
0.375 INCH	BP-24, MO-24	6200-3/8 BH 80MC2M
0.437 INCH	BP-28, MP-28	6200-7/16 BH 80MC2M
0.500 INCH	BP-32, MP-32	60 6200-1/2 BH 80MC2M

2 SLOT SHOULD PERMIT PROBE EXPANSION UP TO 1/16 INCH



Typical Eddy Current Bolt Hole Probe
Figure 1



NOTES

- ALL DIMENSIONS ARE IN INCHES
- TOLERANCE ON ALL DIMENSIONS ±0.050 INCH EXCEPT AS NOTED
- MATERIAL: 2014, 2024-T3 OR -T4, 7075, 7079, 7175, 7178 ALUMINUM ALLOY
- SEE PART 1, 51-01-00, FOR MANUFACTURING AND ORDERING INFORMATION

1 FINISH REAM HOLE AND DO NOT DEBURR

2 ELECTRIC DISCHARGE MACHINE PER GIVEN DIMENSIONS

3 HOLE DIAMETER (6 STANDARD)
0.1875 0.2500 0.3125
0.3750 0.4375 0.5000
TOLERANCE $^{+0.005}_{-0.000}$ ON ALL HOLES

SLOT NUMBER	A	B	C
	WIDTH	LENGTH	DEPTH
1 2	0.005	0.060	0.030
2 2	0.005	0.030	0.030
3 2	0.005	0.030	0.030
TOLERANCE	MAXIMUM	±0.003	±0.003

Aluminum Part Fastener Hole Reference Standard
Figure 2

PART 6 - EDDY CURRENT

STEEL PART FASTENER HOLE INSPECTION (METER DISPLAY)

1. **Purpose**

   A. This procedure will detect cracks which propagate in fastener holes on bare or nonconductive coated magnetic steel structure using metered instrumentation.

   B. Part 6, 51-00-17 is a recommended alternative procedure.

   C. Refer to Part 6, 51-00-14 to do an inspection for cracks in nonmagnetic steel parts.

2. **Equipment**

   A. Instrument/probe combinations used must be capable of detecting the calibration notch in the reference standard to the sensitivity requirements of Paragraph 4.

      (1) Instrument -- Battery-operated, multi-frequency, meter response instruments with audible or visual alarms are recommended. The following instruments were used to develop this procedure:

         NOTE: For other than battery-powered models, a voltage regulator is required on the power source if the instruments internal regulators are not adequate to prevent signal variation.

      (2) Locator UH -- Hocking Instruments

      (3) MIZ-10A, MIZ-10B -- Zetec, Inc.

   B. Probe -- Non-shielded, adjustable diameter (slotted) bolt hole probes are recommended. Probes must meet configuration and dimensional callouts noted in Figure 1.

      (1) Shielded probes may be used, provided the calibration notch in the reference standard can be reliably detected.

         NOTE: A shielded probes' highly restricted primary magnetic field requires and excessively slow inspection scanning speed. It is recommended that shielded probes be used with instruments equipped with an alarm system which responds to a crack signal more quickly than the meter. This provides greater assurance of crack detection.

      (2) Probe diameter shall be based on the minimum nominal diameter of hole to be inspected.

      (3) Probe coil arrangement may be either a single coil (absolute) or double coil (differential) in contact with the test structure.

      (4) Normal probe operating frequency is between 100 kHz and 500 kHz. Other frequencies may be used, provided the calibration notch in the reference standard can be reliably detected.

      (5) Probe should not give interfering responses from normal handling pressures or manipulation, or from normal operating pressure variations on the sensing coil.

   C. Reference Standards -- Reference standards with suitable natural cracks or artificial notches to simulate cracks in each of the hole sizes being tested. A reference standard must meet the following requirements:

      (1) Reference standards should be of low alloy steel (4130, 4140, or 4340) similar to the material being tested.

      (2) Reference standards should contain a suitable range of hole diameters to permit calibration of instrument for the diameter of each hole to be tested.

      (3) Recommended reference standards are as follows:

REFERENCE STANDARD HOLE DIAMETER

0.1875 inch - 3/16 inch

0.2500 inch - 1/4 inch

0.3125 inch - 5/16 inch

0.3750 inch - 3/8 inch

0.4375 inch - 7/16 inch

0.5000 inch - 1/2 inch

NOTE: See Figure 2 for reference standard details.

3. Preparation for Inspection

A. Clean loose dirt and paint from inside and around fastener hole.

B. Remove buildup of paint, sealant, etc., from around outside of hole where probe collar will bear.

NOTE: If surface of hole is extremely rough, a 0.015 inch (0.039 cm) cleanup ream may be necessary. The cleanup ream should be limited to the minimum required to facilitate the inspection.

NOTE: Any cadmium plating inside the fastener hole may interfere with the inspection procedure, therefore, cadmium plating should be removed by a procedure compatible with the type of steel being inspected.

4. Instrument Calibration

A. Attach appropriate probe to instrument.

B. Turn instrument on and allow to warm up per manufacturer's instructions.

C. Select appropriate reference standard and place probe in hole. Probe should fit snugly but not so tight as to cause excessive wear of probe. Expand loose probe to obtain snug fit.

D. Adjust instrument controls according to the manufacturer's instructions.

E. Adjust instrument for lift-off.

(1) Place sensitive (coil) part of probe on a flat surface of material to be inspected.

(2) Manipulate probe to obtain maximum eddy current indication.

(3) Place a single sheet of ordinary writing paper (approximate thickness 0.003 inch) between probe and material.

(4) Remove paper and note direction and amount of deflection of needle.

(5) Adjust lift-off control to obtain minimum needle movement when paper is removed. When no needle movement is noted, place probe in hole in test block and perform final lift-off adjustment while wobbling probe. Lift-off is adjusted when wobbling motion of probe produces minimum meter motion.

F. With probe inserted in the reference standard, adjust depth in hole to obtain maximum needle deflection on meter from edge crack (center of coil approximately 0.025 inch deep for 0.045 inch edge crack).

G. Adjust sensitivity to obtain a minimum of 20 percent full scale meter deflection from standard crack. Instrument is now calibrated for detection of cracks in hole to be inspected.

5. Test Procedure

A. Adjust collar on probe to set depth of coil penetration into hole at 0.025 inch from top end of hole.

B. Tighten collar on probe and insert probe into hole. Recheck lift-off setting by wobbling probe in hole. Adjust lift-off if necessary to obtain minimum meter needle movement.

C. Slowly scan entire circumference of hole. Note crack-like needle deflection of 15 percent of full scale or greater. This may be a crack indication and should be investigated further.

NOTE: A positive crack response is identified by a rapid deflection of the needle over a short scan distance. Deflection occurs as coil passes over the crack. Compare with notch response from hole standard with approximately the same hole diameter.

6. Inspection Results

A. Note locations of any questionable crack-like indications, perform a 0.015-inch (0.039-cm) cleanup ream and repeat inspection, paying particular attention to areas where indications were noted. Record all locations and response to all crack indications.

B. Perform eddy current scan after each increase in hole diameter by reaming.

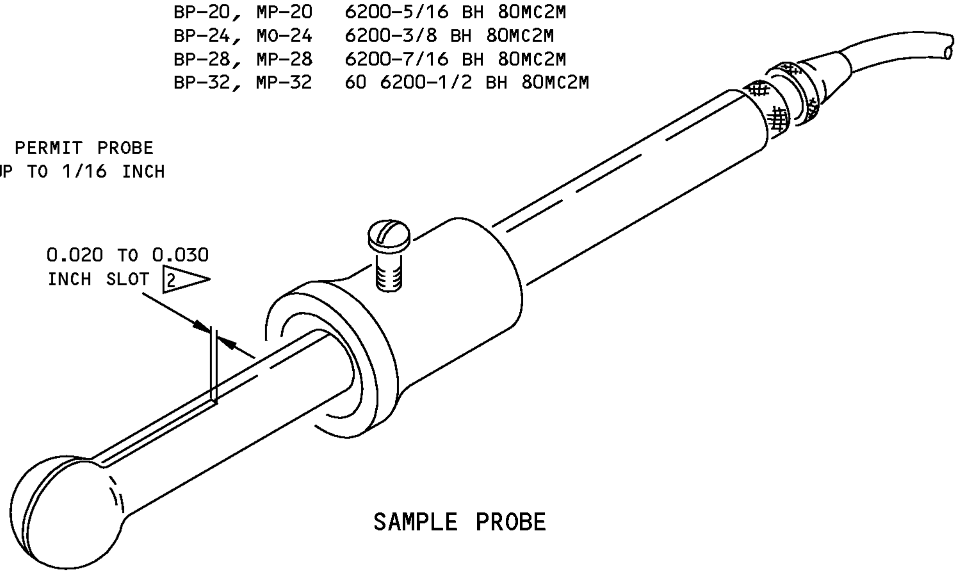
C. Magnetic rubber may be used to confirm eddy current crack indications in magnetic materials.

NOTES

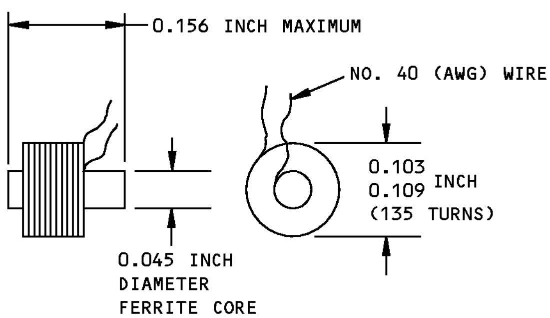
PART NUMBERS

1 STANDARD PROBE DIAMETERS	NORTEC	IDEAL SPECIALTY CO.
0.187 INCH	BP-12, MP-12	6200-3/16 BH 80MC2M
0.250 INCH	BP-16, MP-16	6200-1/4 BH 80MC2M
0.312 INCH	BP-20, MP-20	6200-5/16 BH 80MC2M
0.375 INCH	BP-24, MO-24	6200-3/8 BH 80MC2M
0.437 INCH	BP-28, MP-28	6200-7/16 BH 80MC2M
0.500 INCH	BP-32, MP-32	60 6200-1/2 BH 80MC2M

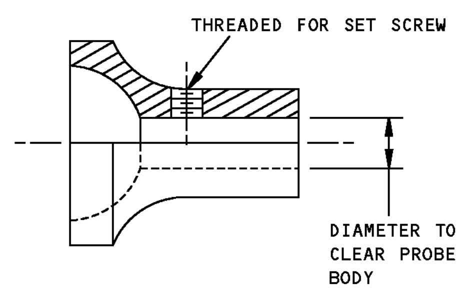
2 SLOT SHOULD PERMIT PROBE EXPANSION UP TO 1/16 INCH



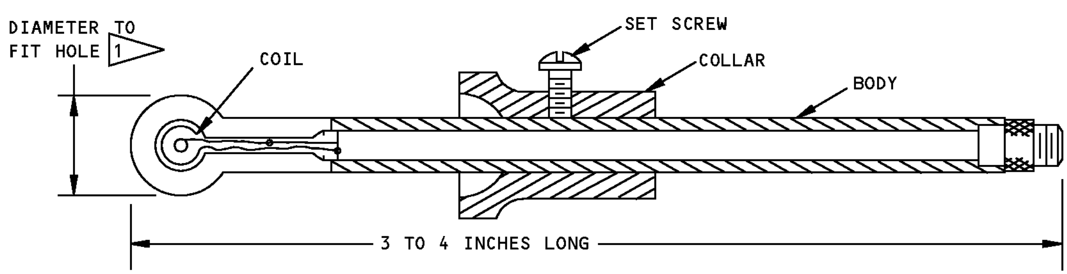
SAMPLE PROBE



COIL

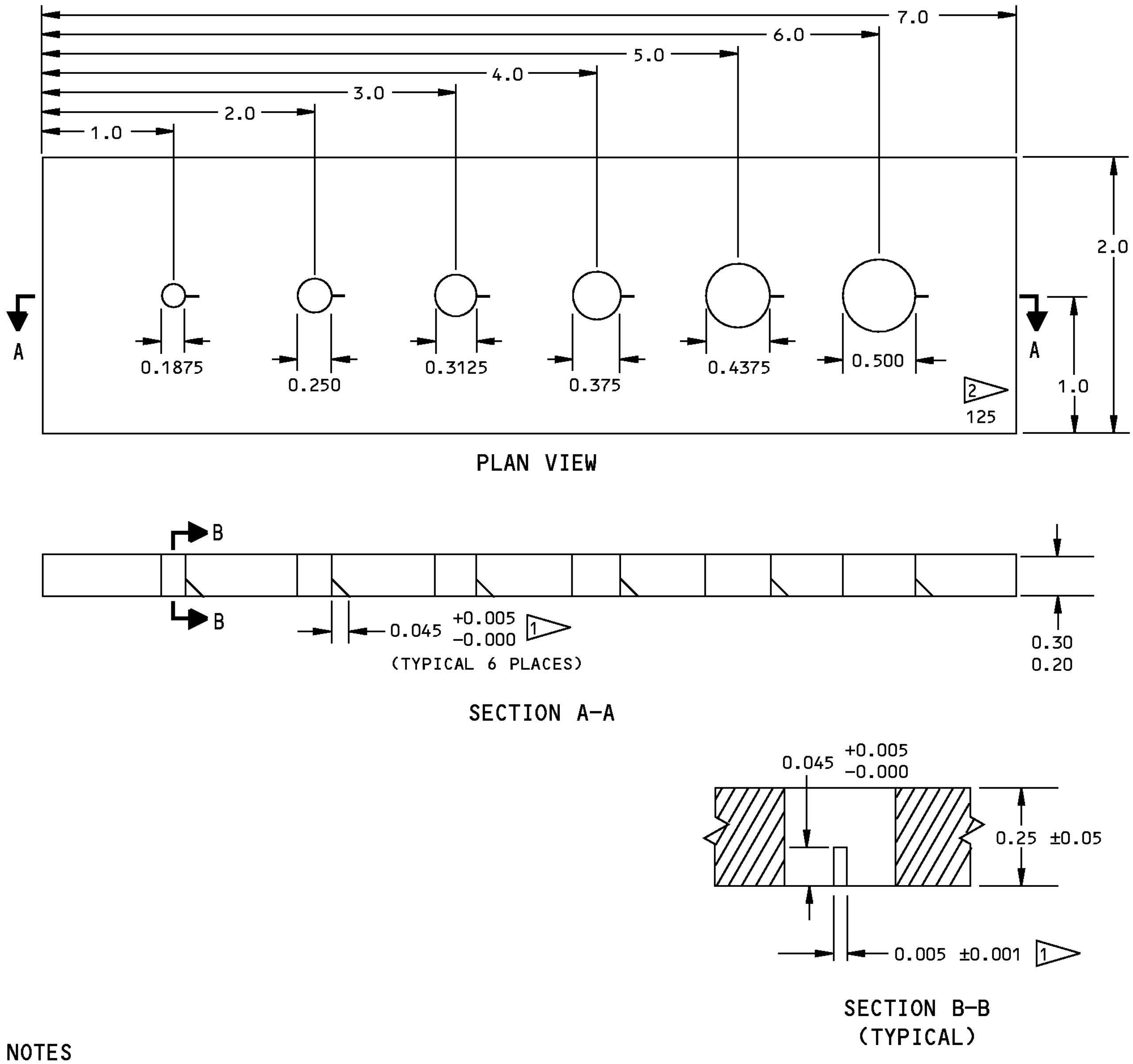


COLLAR



CROSS SECTION THROUGH CENTER OF PROBE

Typical Eddy Current Bolt Hole Probe
Figure 1



NOTES

- ALL DIMENSIONS ARE IN INCHES
- TOLERANCE UNLESS STATED: X.X ±0.030, X.XXX ±0.005
- MATERIAL: LOW ALLOY STEEL (4130, 4140 OR 4340)
- REAM HOLES FOR SMOOTH FINISH
- ALTERNATE CONSTRUCTION METHOD: 2.0 INCH SEPARATE SQUARE BLOCK FOR EACH HOLE SIZE WITH ONE HOLE IN CENTER OF EACH BLOCK
- P/N 6412-159 AVAILABLE FROM IDEAL SPECIALTY CO.

1 ELECTRIC DISCHARGE CUT 0.005 ±0.001 WIDTH

2 ETCH OR STEEL STAMP WITH 125

Steel Part Fastener Hole Reference Standard 125
Figure 2

PART 6 - EDDY CURRENT

TAPERED PART FASTENER HOLE INSPECTION (METER DISPLAY)

1. **General**

   A. This technique is for eddy current crack inspection at hole interfaces in tapered members of aluminum or steel. The inspection for small cracks (0.05 inch) at the interface of holes in tapered members requires that the position of the probe coil be controlled to assure a uniform edge distance and minimal edge interference.

2. **Equipment**

   NOTE: See Part 1, 51-01-00 for equipment manufacturers.

   A. Instrument - Any eddy-current unit designed for crack detection which is comparable to those listed below and which meets the lift-off and sensitivity requirements of Paragraph 4.E. and Paragraph 4.G.

      (1) Magnatest ED-520; Magnaflux Corporation

      (2) P/N EM-1500; Automation Industries, Inc.

      (3) Defectometer 2.154; Foerster Instruments, Inc.

      (4) P/N MIZ-10; Zetec, Inc.

      (5) P/N NDT-3, NDT-8; Nortec

   B. Probes - Probes used in this procedure should have the following characteristics:

      (1) Diameter should be adjustable to obtain a snug fit in the hole.

      (2) Probe should be adjustable to permit the penetration depth of the sensing coil be adjusted.

      (3) Probe should not give interfering responses from normal handling pressures or manipulation, or from normal operating pressure variations on the sensing coil.

      (4) Probe shaft diameter should be small enough to allow clearances with hole edge when inserted into the hole at the angle required for inspection of the tapered interface (Figure 3).

   C. Reference Standards - Reference standards with suitable natural cracks or artificial notches to simulate cracks. A reference standard should meet the following requirements:

      (1) Reference standard should be of aluminum alloy, steel alloy (4130, 4140, or 4340), or aluminum and steel combination similar to the test part.

      (2) Reference standard should contain hole diameters which permit calibration of instrument for each hole to be tested.

      (3) The crack or notch in the reference standard must give an eddy-current instrument calibration comparable to that obtained from the recommended test block (Figure 1).

      (4) The tapered part reference standard permits setting instrument sensitivity and check of interface noise using the probe guide.

   D. Probe Guide - The probe guide maintains a uniform eddy current coil distance to the tapered interface of the hole (Figure 2 and Figure 3).

3. **Preparation for Inspection**

   A. Clean loose dirt and paint from inside and around fastener hole.

   B. Remove buildup of paint, sealant, etc., from around outside of hole where probe will bear.

      NOTE: If surface of hole is extremely rough, a cleanup ream may be necessary to reduce erratic eddy current responses.

4. **Instrument Calibration**

A. Attach appropriate probe to instrument.

B. Turn instrument on and allow to warm up per manufacturer's instructions.

C. Select appropriate test block and place probe in hole. Adjust probe to fit snugly but not so tight as to cause excessive wear of probe. If test block is tapered, use the probe guide to maintain a uniform probe coil to interface distance.

D. Adjust instrument controls according to the manufacturer's instructions.

E. Adjust instrument for lift-off.

(1) Place sensitivity (coil) part of probe on a flat surface of material to be inspected. Because of edge effect interference, place coil at least 1/4 inch away from edge of part.

(2) Manipulate probe to obtain maximum eddy-current effect.

(3) Place a single sheet of ordinary writing paper (approximate thickness 0.003 inch) between probe and material.

(4) Remove paper and note direction and amount of needle deflection.

(5) Adjust lift-off control to obtain minimum needle movement when paper is removed. When no needle movement is noted, instrument and probe have been calibrated.

F. Insert probe into hole in reference standard (use probe guide with tapered part reference standard) and adjust depth in hole to obtain maximum needle deflection on meter from faying surface crack (center of coil approximately 0.050 inch from interface for 0.050-inch edge crack).

G. Adjust sensitivity to obtain a minimum of 10% full scale meter deflection from standard crack. Instrument is now calibrated for detection of interface cracks in hole with a tapered interface.

5. **Inspection Procedure**

A. With probe guide properly positioned, adjust collar on probe to set depth of penetration into hole at 0.050 inch above or below the faying surface depending on which part is to be inspected.

NOTE: Make sure probe guide is positioned so that probe coil maintains a uniform distance to the tapered interface. If large swings occur in instrument meter readings, check for proper alignment of probe and probe guide and for correct probe guide angle.

B. Tighten collar on probe and insert probe into hole. Adjust balance control to bring needle approximately to midscale.

C. Slowly scan entire circumference of hole. Note position of any needle deflection of 10% of full scale or greater, giving a positive crack response.

NOTE: A positive crack response is characterized by rapid deflection of the meter needle over a short scan distance. Deflection occurs as the coil moves over the crack. This movement is equivalent to an arc of approximately 40 degrees in a 1/4-inch fastener hole, and 20 degrees in a 1/2-inch hole.

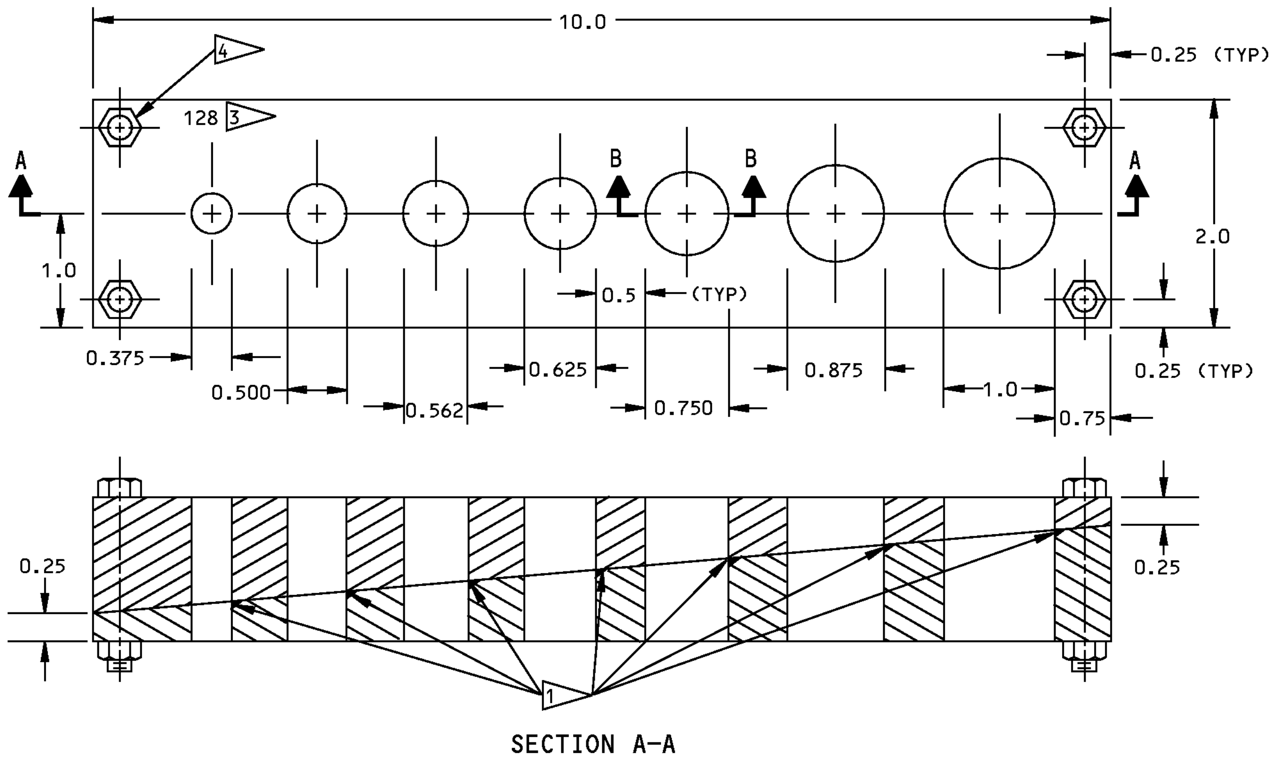
D. Note locations of any questionable indications, i.e., crack-like indications causing needle deflection of less than 10% of full scale, or indications not conforming to a positive crack indication. Perform a 1/64-inch cleanup ream and repeat test, paying particular attention to areas where indication was noted. Note location and response of all positive crack indications.

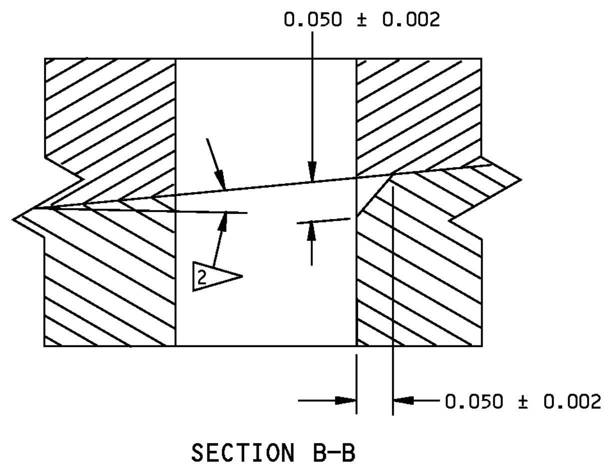
E. Repeat Paragraph 5.B. thru Paragraph 5.D. at incremental depths of 0.050 inch.

NOTE: For the inspection of hole surfaces or interfaces which are not tapered, use the procedure of Part 6, 51-00-04, Part 6, 51-00-11 or Part 6, 51-00-16 for holes in aluminum, and Part 6, 51-00-05 or Part 6, 51-00-17 for holes in steel.

F. When hole is reamed to clean up or remove cracks, perform eddy-current test after each increase in hole diameter.

G. Recheck calibration of instrument with reference standard periodically to ensure proper sensitivity of instrument.





NOTES

- TOLERANCE ON ALL LINEAR DIMENSIONS ± 0.050 INCH EXCEPT AS NOTED
- TOLERANCE $^{+0.005}_{-0.000}$ ON ALL HOLES
- ALL DIMENSIONS ARE IN INCHES
- THE SIZE AND NUMBER OF CALIBRATION HOLES IS DEPENDENT ON INSPECTION NEED
- MATERIAL - ALUMINUM ALLOY OR STEEL OR COMBINATION OF BOTH
- STEEL STAMP MATERIAL TYPE ON BOTH MEMBERS OF STANDARD
- SEE PART 1, 51-01-00, FOR MANUFACTURING AND ORDERING INFORMATION
- P/N 6412-4 AVAILABLE FROM IDEAL SPECIALTY CO

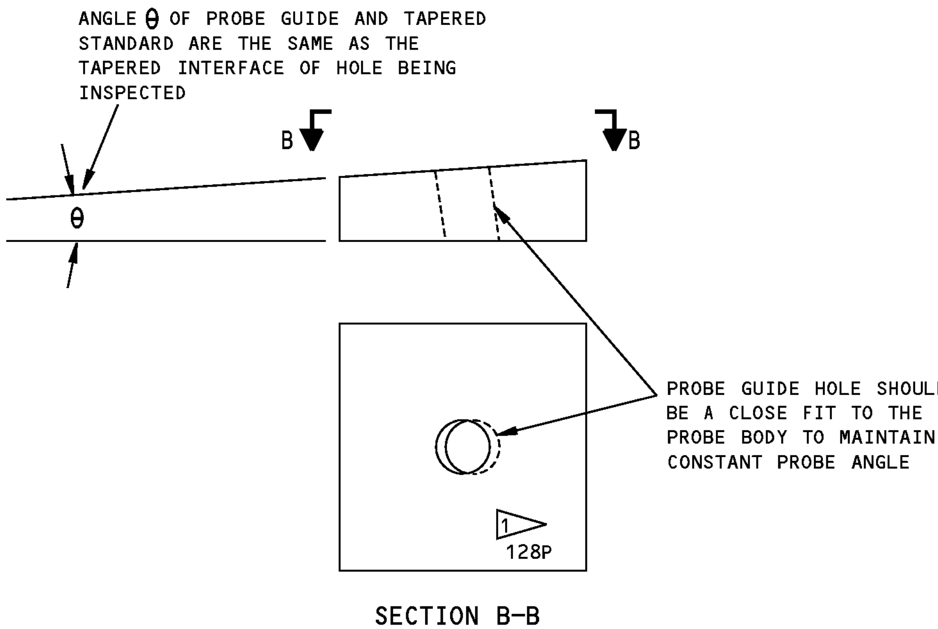
1 ELECTRIC DISCHARGE MACHINE (EDM) NOTCH - 0.006 MAX WIDTH (TYP 7 PLACES)

2 ANGLE MATCHES TAPERED INTERFACE OF PART BEING INSPECTED

3 ETCH OR STEEL STAMP WITH 128 FOLLOWED BY ANGLE OF TAPERED INTERFACE

4 10-24 OR 10-32 BOLT AND NUT (4 PLACES)

Tapered Part Fastener Hole Reference Standard 128
Figure 1

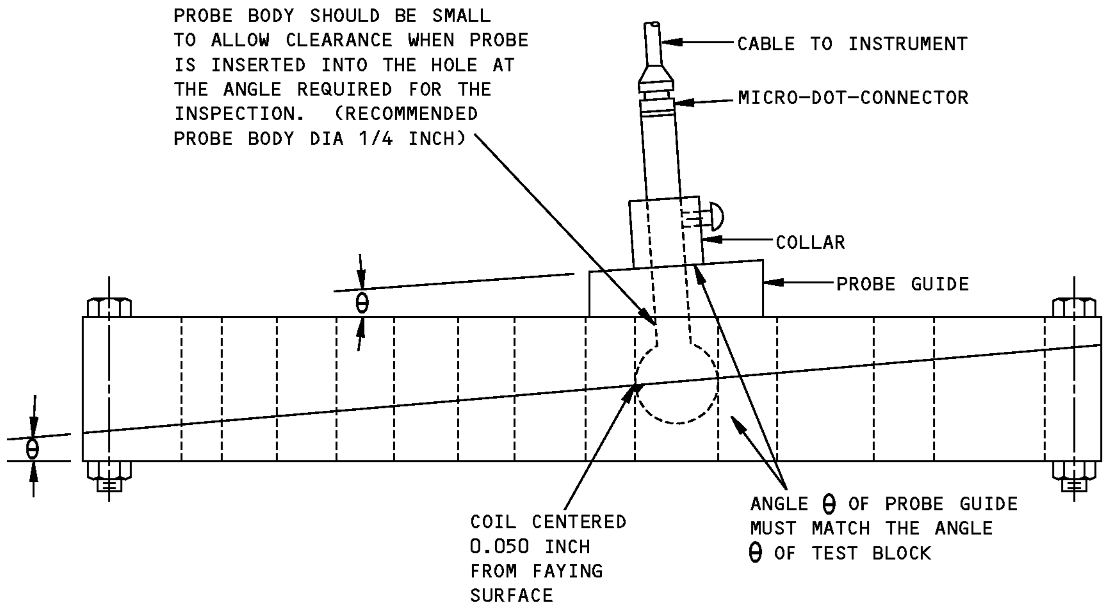


NOTE

- P/N 6413-1 AVAILABLE FROM IDEAL SPECIALTY CO

1 ETCH WITH 128P

Typical Probe Guide
Figure 2



Instrument Calibration Details
Figure 3

PART 6 - EDDY CURRENT

LOW FREQUENCY INSPECTION FOR SUBSURFACE CRACKS IN ALUMINUM STRUCTURE (METER DISPLAY)

1. **Purpose**

   A. To provide a general low frequency eddy current inspection procedure for the detection of subsurface cracks in aluminum structure. This procedure uses a probe scanned or placed at the area to be inspected.

   NOTE: This general procedure must be used in conjunction with a specific procedure which will identify inspection locations and give specific requirements for probes, reference standards, and test frequencies.

2. **Equipment**

   A. Instrument - Any eddy current instrument that will satisfy the performance requirements of this procedure is suitable for this inspection. One of the following instruments was used during development of this procedure.

      (1) P/N MIZ-10 or MIZ-10A; Zetec Inc.

      (2) Alcoprobe-S; Inspection Instruments (NDT) Ltd.

   B. Probes - Refer to the specific inspection procedure for probe requirements.

   C. Reference Standards - Refer to the specific inspection procedure for reference standard requirements.

   NOTE: Refer to Part 1, 51-01-00 for information on equipment manufacturers.

3. **Preparation for Inspection**

   A. Clean inspection surfaces.

4. **Instrument Calibration**

   A. Connect the appropriate probe, identified in the specific inspection procedure, to the instrument.

   B. Set the instrument frequency per the specific inspection procedure.

   C. Place probe on the unnotched area of the reference standard. Refer to Position 1 of the Probe Position Figures of the specific inspection procedure.

   D. Balance instrument per manufacturer’s instructions.

   E. Adjust liftoff control per manufacturer’s instructions to obtain the same response when the probe is on the bare standard as with the probe lifted off the part by 0.006 inch (approximately the thickness of two sheets of paper).

   NOTE: The probe is located at Position 1 during liftoff calibration.

   F. Keep the probe at Position 1 and use the meter position control to adjust meter response to indicate 20% of full scale.

   G. Position or scan probe over the notched portion of the reference standard. Meter response should be upscale. Refer to Position 2 of the Probe Position Figure of the specific inspection procedure.

   H. Adjust instrument sensitivity to obtain 50% of full scale meter response difference between the notched and unnotched locations. (Position 1 and 2.)

   I. Reposition probe at Position 1 and recheck balance and liftoff. If readjustments are made, recheck sensitivity per Paragraph 4.G. and Paragraph 4.H.

5. **Inspection Procedure**

   A. Inspect each location by placing the probe at inspection locations or by scanning the probe over the inspection area, depending on the requirements of the specific procedure.

B. When the specific procedure calls for placing probe at inspection locations, use several locations on the airplane to establish an acceptable baseline response.

(1) Select a representative location from this group and set its response to 20% of full meter scale.

NOTE: Do not change instrument sensitivity when establishing the airplane baseline response.

(2) Refer back to this location periodically to ensure that instrument response is the same as originally recorded. (Changes in meter response may occur as a result of instrument drift or probe temperature change.)

(3) Compare meter readings obtained at all inspection locations which have similar inspection conditions. Refer to the specific inspection procedure for locations which may be compared.

C. When the specific procedure calls for scanning the probe over inspection areas, use the reference standard to establish a scan speed and type of meter deflection which occurs as the probe is scanned over a crack.

(1) Slowly scan the probe over all inspection areas, and note all meter deflections.

NOTE: When scanning around a fastener head, maintain a uniform distance between probe and fastener head.

6. Inspection Results

A. Any location that gives a response 30% of full meter scale higher than the baseline response, or when scanning, any meter deflection which is 30% of baseline response or greater should be investigated further.

NOTE: The following conditions may cause meter reading changes similar to crack indications:

A decrease in fastener spacing - Compare with similarly spaced fasteners on the airplane or on the reference standard.

Close edge of skin or subsurface structure - Check drawings in the specific inspection procedure and compare with a similar location on the airplane.

Differences in conductivity between skin panels - Compare only inspection locations common to a skin panel.

Placing or scanning the probe too close to a magnetic steel fastener - Compare the response obtained with the probe placed near a similar fastener, or by scanning the probe around the fastener at a constant distance away from it.

Magnetic chips trapped in paint - Remove paint and reinspect.

NOTE: When investigating crack-like indications, compare meter responses obtained at the same location on the opposite side of the airplane or at the same location on another airplane of the same configuration.

PART 6 - EDDY CURRENT

INSPECTION FOR SUBSURFACE CRACKS AT FASTENER HOLES IN ALUMINUM STRUCTURE

1. **Purpose**

   A. Use this procedure to do an inspection for subsurface cracks that start at the fastener holes in aluminum structure. Do this procedure with the fasteners in the holes.

   B. This is a general, secondary procedure; it does not give all of the data necessary to do the inspection. Refer to the primary procedure for more data about the inspection locations, instrument frequencies, and equipment specifications.

   C. This procedure uses an instrument with an impedance-plane or meter display and a ring probe.

2. **Equipment**

   A. General

      (1) Use inspection equipment that can be calibrated on the reference standard as specified in Paragraph 4.

      (2) Refer to Part 1, 51-01-00 for data about the equipment manufacturers.

   B. Instrument

      (1) Use an eddy-current instrument that has an impedance-plane or meter display.

      (2) The instrument must operate at the frequency range given in the primary procedure.

   C. Probes

      (1) Use a ring probe that operates at a frequency given in the primary procedure.

      (2) Refer to the primary procedure for the probe dimensions.

   D. Reference Standards

      (1) Use reference standards that are specified in the primary procedure.

      NOTE: The primary procedure must have a different reference standard for each important change in structure and fastener material.

3. **Preparation for Inspection**

   A. Get access to the inspection areas as shown in the primary procedure.

   B. Remove loose paint, dirt, and sealant from the surface of the inspection area.

4. **Instrument Calibration**

   A. Set the frequency between the values given in the primary procedure.

   B. For an instrument with an impedance-plane display, set the vertical to horizontal gain to 1:1.

   C. For an instrument with an impedance-plane display, set the filters as follows:

      (1) Set the high-pass filter to off or zero Hz.

      (2) If the instrument has a low-pass filter, do the steps below:

         (a) Set the low-pass filter to its highest value.

         (b) Decrease the filter value to get a stable dot or until the signal from the notch in the reference standard starts to decrease.

   D. Put a nonconductive shim on the reference standard. The thickness of the shim must be equivalent (± 0.003 inch [0.08 mm]) to the paint thickness on the airplane.

   E. Find the fastener on the reference standard that does not have a notch that goes into the fastener hole. Put the center of the probe on the center of the fastener.

F. Move the probe to get a minimum signal.

G. Balance the instrument.

H. Adjust the balance point to 20 percent of the vertical display and 50% of the horizontal display as shown in Figure 1.

I. Adjust the instrument for lift-off with a 0.006 inch (0.15 mm), nonconductive shim. Adjust the phase control so that:

(1) The signal moves horizontally to the left for instruments with impedance-plane displays.

(2) The meter needle does not move more than 5 percent of the display for instruments with meter displays.

J. Find the fastener on the reference standard that has a notch that goes into the fastener hole. Put the center of the probe on the center of the fastener.

K. Move the probe to get a minimum signal.

L. For an instrument with an impedance-plane display, adjust the gain as follows:

(1) If necessary, decrease the horizontal gain so that the signal is between 20 and 80 percent of the horizontal display.

(2) Adjust the vertical gain to get a signal that is approximately 80 percent of the vertical display as shown in Figure 1.

M. For an instrument with a meter display, adjust the gain to get a signal that is approximately 80 percent of the display as shown in Figure 1.

5. Inspection Procedure

A. Balance the instrument on the airplane as follows:

(1) From the inspection area that is shown in the primary procedure, make a selection of three or more fasteners. Each fastener location in the inspection area must have the same fastener type and structure (material, dimensions, and edge margin).

(2) Put the center of the probe on the center of each of the fasteners and monitor the display. Move the probe at each fastener location to get a minimum signal.

(3) Balance the instrument, if necessary, so that the signal stays in the display range.

(4) Put the center of the probe on the center of the fastener that had the lowest signal.

(5) Balance the instrument.

(6) Adjust the balance point to 20 percent of the display as shown in Figure 1.

NOTE: Do not adjust the gain. Gain adjustments will make the instrument calibration unsatisfactory.

B. Make an inspection of each of the fasteners that are in the inspection area as follows:

(1) Move the probe at each fastener location to get a minimum signal.

(2) Make a mark at the locations that cause signals that are more than 40 percent of the display.

C. Do a check of the instrument and probe after the inspection as follows:

NOTE: Do not adjust the gain.

(1) Find the fastener on the reference standard without a notch that goes into the fastener hole. Put the center of the probe on the center of the fastener.

(2) Balance the instrument.

(3) Adjust the balance point to 20 percent of the display as shown in Figure 1.

(4) Find the fastener on the reference standard that has a notch that goes into the fastener hole.

(5) Put the center of the probe on the center of the fastener.

(6) Move the probe to get a minimum signal.

(7) Compare the signal with the signal you got from the notch during calibration.

(8) If the signal from the notch in the reference standard has changed 10 percent or more from the signal you got during calibration, do the calibration and inspection again.

6. Inspection Results

A. Signals that are more than 40 percent of the display are signs of a defect.

B. The conditions that follow can cause signals that are almost the same as crack signals.

(1) A small space between fasteners.

(2) A different fastener diameter.

(3) A different countersink depth.

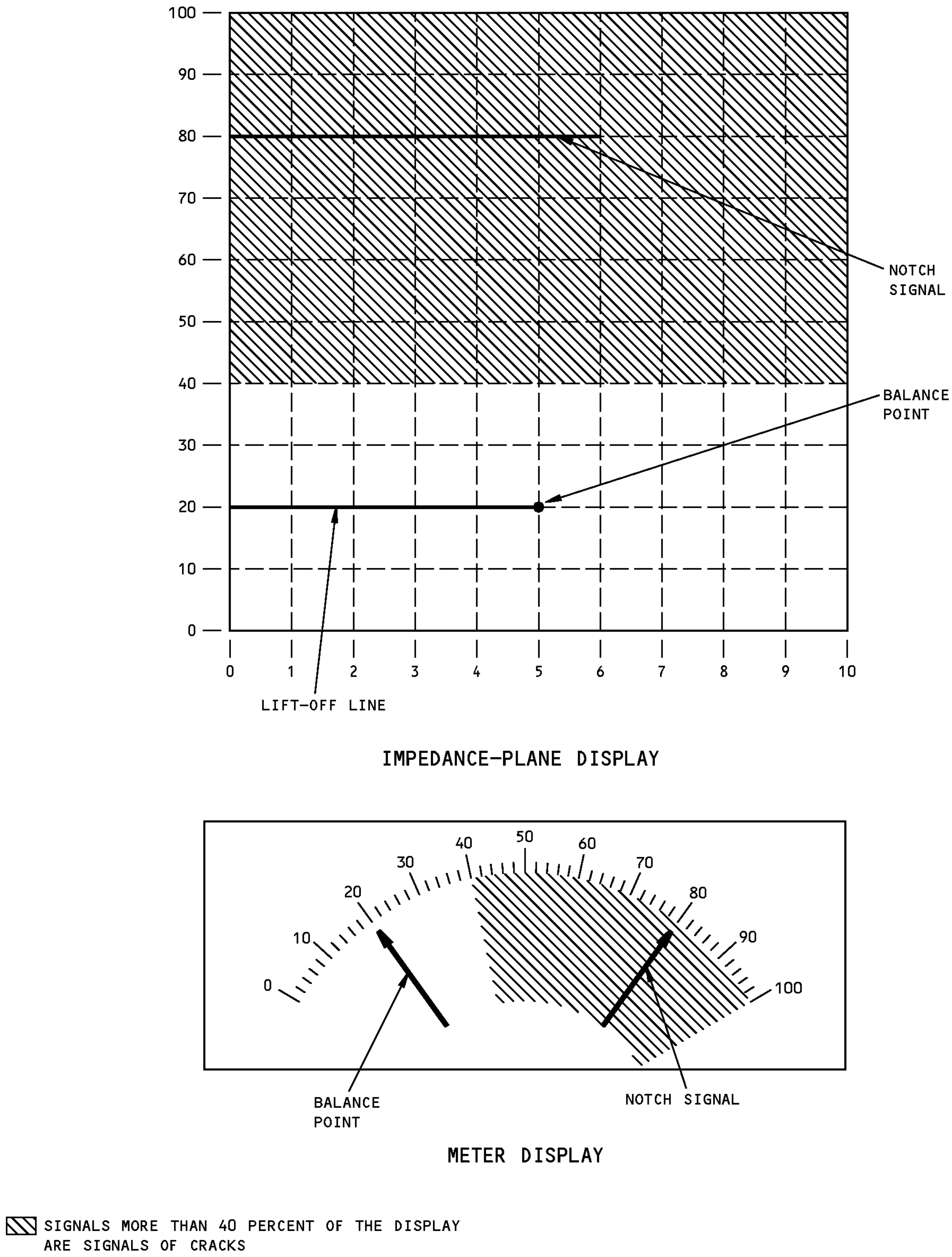
(4) A different edge margin.

(5) A difference in structural conductivity.

(6) A difference in fastener material.

C. If possible, compare the defect signals with the signals from the fasteners that are at the same location on the opposite side of the airplane to make sure the defect signals are from defects.

D. If it is necessary to make sure of the crack signals, remove the fastener and do a fastener hole inspection as specified in Part 6, 51-00-04, Part 6, 51-00-11 or Part 6, 51-00-16.



Instrument Display Examples
Figure 1

PART 6 - EDDY CURRENT

LOW FREQUENCY INSPECTION FOR SUBSURFACE CRACKS WHICH PROPAGATE TRANSVERSE TO A SPLICE GAP (METER DISPLAY)

1. **Purpose**

   A. To provide a general low frequency eddy current procedure for the detection of subsurface cracks which propagate transverse to a splice gap. This procedure uses a probe scanned along the splice gap.

   NOTE: This general procedure must be used in conjunction with a specific procedure which will identify inspection locations and give specific requirements for probes, reference standards, and test frequencies.

2. **Equipment**

   A. Instrument - Any eddy current instrument that will satisfy the performance requirements of this procedure is suitable for this inspection. One of the following instruments was used during development of this procedure.

      (1) P/N MIZ-10 or MIZ-10A; Zetec Inc.

      (2) Alcoprobe-S; Inspection Instruments (NDT) Ltd.

   B. Probes - Refer to the specific inspection procedure for probe requirements.

   C. Reference Standards - Refer to the specific inspection procedure for reference standard requirements.

   NOTE: Refer to Part 1, 51-01-00 for information on equipment manufacturers.

3. **Preparation for Inspection**

   A. Clean inspection surfaces.

4. **Instrument Calibration**

   A. Connect the appropriate probe, identified in the specific inspection procedure, to the instrument.

   B. Set the instrument frequency per the specific inspection procedure.

   C. Visually center the probe over the splice gap on the unnotched area of the reference standard. Refer to position 1 of the specific procedure for Probe Position Figures.

   D. Balance instrument per manufacturer's instructions.

   E. Adjust liftoff control per manufacturer's instructions to obtain the same response when the probe is on the bare standard as with the probe lifted off the part by 0.006 inch (approximately the thickness of two sheets of paper). Care should be taken to hold the probe in the same position relative to the splice gap during liftoff adjustment.

   F. Keep the probe centered at Position 1 and use the meter position control to set the meter response at 20% of full scale.

      (1) After the liftoff calibration is complete, the probe is usually centered over the splice gap by moving the probe across the gap to obtain a maximum meter response.

      (2) In some cases, the probe must be visually centered over the splice gap, because the maximum meter response does not occur when the probe is centered over the gap. These cases will be identified in the specific inspection procedure.

   G. Scan the probe along the splice gap to the notched location. Meter response should be upscale. Refer to Position 2 of the Probe Position Figure of the specific inspection procedure.

   H. Adjust instrument sensitivity to obtain 50% of full scale meter response difference between the notched and unnotched locations.

I. Recheck balance and liftoff. If readjustments are made, recheck sensitivity per Paragraph 4.G. and Paragraph 4.H.

5. **Inspection Procedure**

A. Select a section of the inspection area that has fastener spacing and edge margins similar to the reference standard.

B. Center the probe on this location. If necessary, adjust the meter response to 20% of full scale.

(1) The meter response adjustments must be made with the probe on a crack-free area of the structure.

(2) To ensure that the probe is on a crack free area, scan the probe along the length of the gap for several inches in each direction.

(3) Do not change instrument sensitivity when adjusting the meter response.

C. Inspect the length of the splice gap as indicated in the specific inspection procedure. Perform the inspection by slowly scanning the probe along the splice gap. Use the reference standard to establish the scan speed and type of meter deflection which occurs as the probe is scanned over a crack.

NOTE: Some inspections may require the use of a straightedge to keep the probe centered on the splice gap.

6. **Inspection Results**

A. Any meter deflection 30% or greater is a potential crack indication and further investigation is required.

B. The following conditions may cause meter reading changes similar to crack indications:

(1) Metal chips trapped in the sealant at the splice gap may cause a crack-like indication. Remove sealant and reinspect.

(2) A fastener close to the splice gap may cause a crack-like indication. Compare with similarly spaced fasteners on the airplane.

C. When investigating crack-like indications, compare meter responses obtained at the same location on the opposite side of the airplane or at the same location on another airplane of the same configuration.

PART 6 - EDDY CURRENT

ALUMINUM SKIN CORROSION LOSS INSPECTION (IMPEDANCE PLANE DISPLAY)

1. **Purpose**

A. To find and to make an estimate of corrosion of 10 percent or more in the aluminum outer skin at the faying surface of structures with two layers. This procedure uses an eddy current instrument with an impedance plane display. The calibration details are given for clad 2024-T3 or -T4 and clad 7075-T6 aluminum alloys which have an outer skin thickness between 0.032 inch and 0.125 inch.

NOTE: Differences in the conductivity or the thickness between the reference standard and the airplane skin, separation between the skins, intergranular cracking related to corrosion, and paint will cause changes in the eddy current response. Thus, this procedure cannot be used to give, with precision the depth of corrosion, or to make an estimate of the decrease in the material thickness of less than 10 percent.

It is recommended to do eddy current inspections for corrosion with an eddy current instrument with an impedance plane display. But, the other procedure which uses an eddy current instrument with a meter display, Part 6, 51-00-02 can be used.

2. **Equipment**

A. Instruments - To do this procedure, eddy current instruments with an impedance plane display which have a continuous frequency selection and which get the necessary results of this procedure must be used. These instruments were used to prepare this procedure:

(1) NDT 19, Staveley Instruments

(2) AV 100L, Hocking Instruments

(3) MIZ 20, Zetec, Inc.

B. Probes - To do this procedure, flat surface probes must be used. Select probes which operate at the necessary frequency. Usually, probes with small active diameters are better because they find small areas of corrosion more accurately. These probes were used to prepare this procedure:

(1) SPO 1598; 20 - 50 kHz; Staveley Instruments

(2) SNG 375-3L; 20 kHz; NDT Engineering Corp.

(3) SPO 565A; 500 Hz; Staveley Instruments

NOTE: Probes can be used at more frequencies than their published operating frequency if they can get the necessary results of this procedure.

C. Reference Standard - Reference Standard 127-XXX or 127A-XXX (Figure 1 and Figure 2).

3. **Preparation for Inspection**

A. Lightly sand all thick or rough paint until it is smooth.

B. Wipe the area of the inspection until it is clean.

4. **Instrument Calibration**

A. Find the thickness of the outer skin of the airplane. Refer to the applicable service bulletin or the skin drawings.

B. Make a selection of the necessary reference standard from Table 1. Refer to Flagnote 1.

C. Make a selection of a frequency from the frequency range from Table 1.

NOTE: The instrument test frequency may have to be adjusted during the calibration procedure to optimize the instrument test frequency, but the frequency must be in the range of Table 1.

D. Put a nonconductive shim which is the same thickness as the paint on top of the reference standard. The nonconductive shim must be ± 0.003 inch of the actual paint thickness.

E. If the area of the inspection is painted, put the probe on a full thickness area of the reference standard, Figure 3, probe position 1.

F. Balance the instrument. Refer to the instructions of the manufacturer. Use the vertical and horizontal position controls to move the balance point to the lower middle part of the screen (Figure 3).

G. Adjust the phase/rotation control so that the signal moves in a horizontal direction and to the left when the probe is lifted off of the part (Figure 3).

H. Move the probe to the area on the reference standard where there is a 10 percent decrease in the material thickness, Figure 3, probe position 2. Adjust the instrument sensitivity to get a signal which is 20 percent of the full screen height (Figure 3).

I. Move the probe to an area where there is only the outer layer, Figure 3, probe position 3. The position of the signal of the instrument must be between 5 and 10 percent of the full screen height below the balance point (Figure 3).

WARNING: IF THE FREQUENCY IS TOO LOW, SEPARATION BETWEEN THE SKINS CAN CAUSE INCORRECT CORROSION SIGNALS. TOO HIGH A FREQUENCY WILL NOT GIVE SUFFICIENT SENSITIVITY.

J. If the signal is not in the correct position in Paragraph 4.I., adjust the frequency. If the signal is above the permitted range, increase the frequency; if the signal is below the permitted range, decrease the frequency (Figure 3). The frequency must be in the limits of Table 1.

K. If the frequency is changed, do Paragraph 4.E. thru Paragraph 4.J. again.

L. Move the probe to the areas where there is a 20 percent and, if applicable, a 30 percent decrease in the material thickness areas on the reference standard. Monitor the signal from each area. Figure 4 shows an example of indications.

5. Inspection Procedure

A. Calibrate the instrument. Refer to Paragraph 4.

B. Put the probe on the skin that is to be inspected in an area where there is a second layer structure and no apparent corrosion.

C. Balance the instrument. Refer to the instructions of the manufacturer.

D. Slide the probe onto the adjacent area where there is a single skin. The signal must be in the range shown in Figure 5. If it is not, do the check in another area to make sure that corrosion was not present. If the signal is again not in the permitted range, check the reference standard and the airplane to make sure that the material alloy and thickness are correct. Refer to Table 1.

NOTE: When the inspection is done on tapered or machined skins, it is very important to make sure that the correct skin thickness is known.

E. Put the probe on the skin at the balance position Paragraph 5.B. Slowly slide the probe into the area of possible corrosion. Monitor the instrument response.

6. Inspection Results

A. Refer to the applicable Service Bulletin for the corrosion limits.

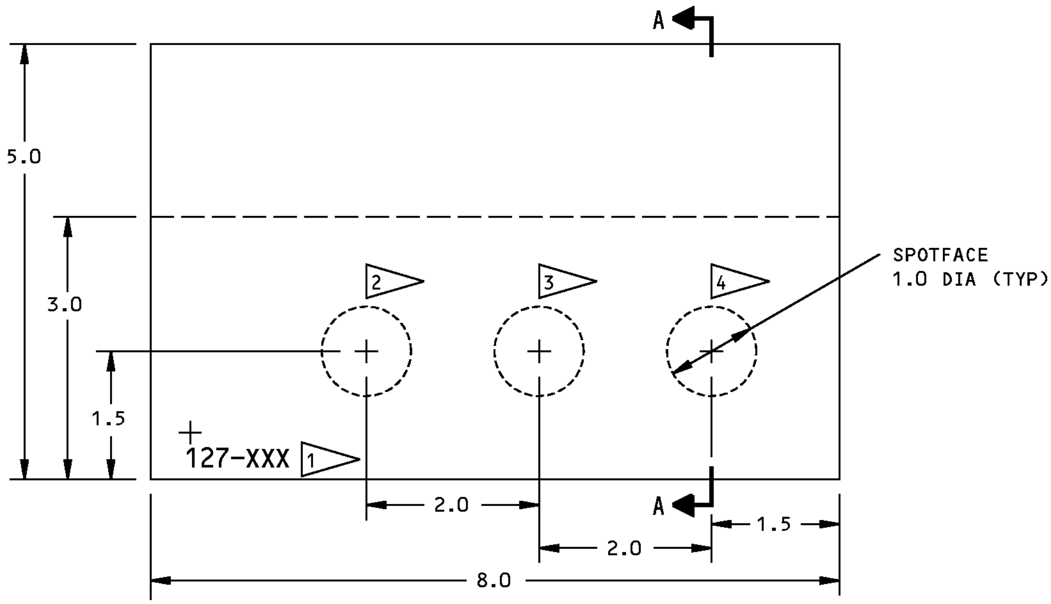
B. This procedure must not be used to find material loss less than 10 percent.

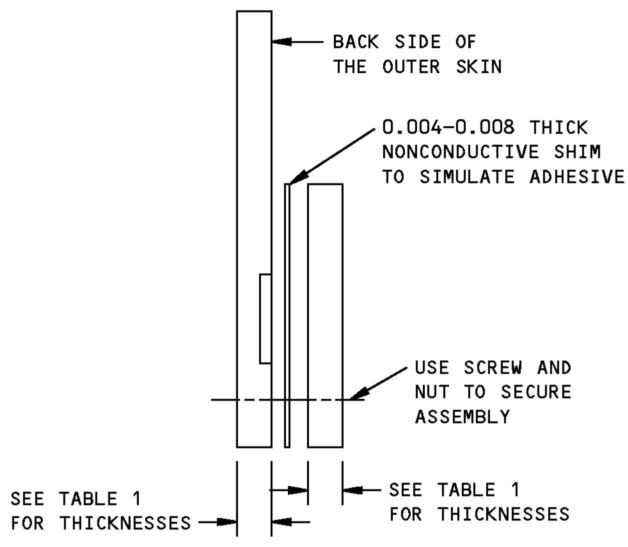
C. An area of possible corrosion which does not give eddy current evidence of corrosion of the faying surface of the outer skin should be investigated for possible corrosion of the second layer. This can be done by the disassembly of the structure or possibly by an eddy current inspection from the opposite side. Contact Boeing if more help is needed.

Table 1 Airplane Outer Skin Thickness to Reference Standard and Instrument Frequency Cross Reference

AIRPLANE OUTER SKIN THICKNESS	REFERENCE STANDARD NUMBER *[1]	INSTRUMENT TEST FREQUENCY RANGE kHz
0.032 - 0.034	127 - 0.032 127A - 0.032	44 - 50
0.034 - 0.038	127 - 0.036 127A - 0.036	35 - 44
0.038 - 0.045	127 - 0.040 127A - 0.040	25 - 35
0.045 - 0.056	127 - 0.050 127A - 0.050	16 - 25
0.056 - 0.068	127 - 0.063 127A - 0.063	11 - 16
0.068 - 0.076	127 - 0.072 127A - 0.072	9 - 11
0.076 - 0.085	127 - 0.080 127A - 0.080	7 - 9
0.085 - 0.095	127 - 0.090 127A - 0.090	5.6 - 7
0.095 - 0.105	127 - 0.100 127A - 0.100	4.6 - 5.6
0.105 - 0.118	127 - 0.110 127A - 0.110	3.6 - 4.6
0.118 - 0.125	127 - 0.125 127A - 0.125	3.2 - 3.6

*[1] DASH NUMBER INDICATES REFERENCE STANDARD THICKNESS IN INCHES.





A-A

NOTES

- ALL DIMENSIONS ARE IN INCHES
- MATERIAL: CLAD 2024-T3 OR
  CLAD 2024-T4 SHEET
- TOLERANCE: X.X ±0.05

OUTER SKIN THICKNESS	SKIN THICKNESS TOLERANCE	MACHINE DEPTH TOLERANCE
0.032-0.050	±0.001	±0.001
0.063-0.125	±0.002	±0.0015

- THE BACK SIDE OF THE OUTER SKIN CAN BE MACHINED TO THE THICKNESS OF THE AIRPLANES SKIN. MAKE SURE THE ALUMINUM SHEET USED TO MAKE THE OUTER SKIN IS OF THE SPECIFIED OR NEXT THICKER GAGE. THIS IS DONE TO MAKE SURE THE CLAD THICKNESS ON THE STANDARD AND THE AIRPLANE ARE THE SAME. SEE TABLE 1.
- SPOTFACE TO A SURFACE FINISH OF 64 RHR OR BETTER

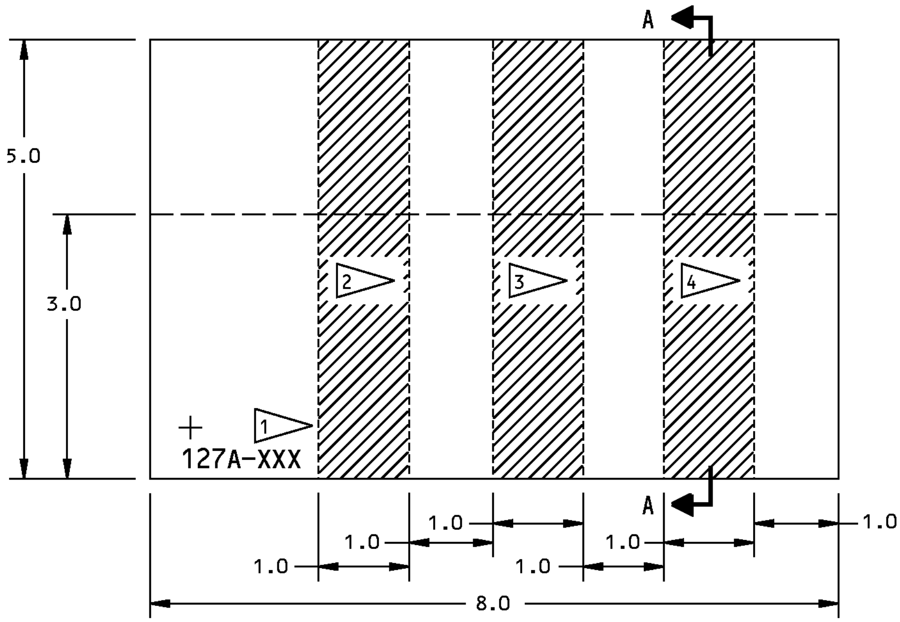
1 ETCH OR STEEL STAMP WITH 127-XXX ON BOTH SKINS OF THE REFERENCE STANDARD. SEE TABLE 1 FOR REFERENCE STANDARD PART NUMBER IDENTIFICATION

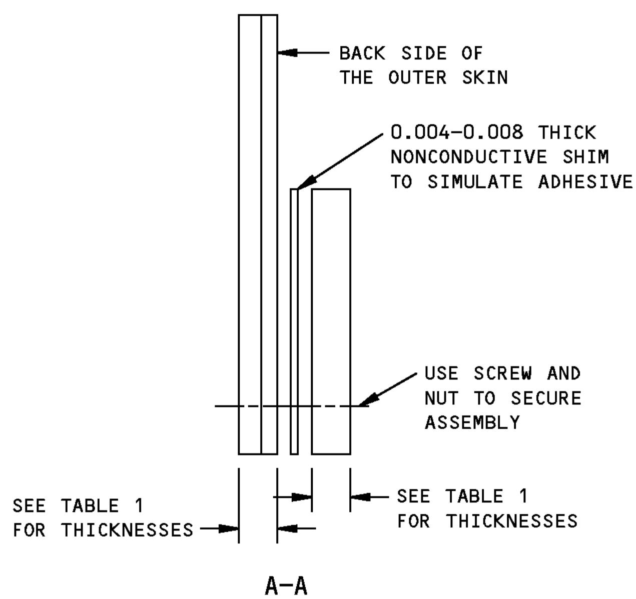
2 THE DEPTH OF THE SPOTFACE IS 10 PERCENT OF THE ACTUAL THICKNESS OF THE OUTER SKIN OF THE REFERENCE STANDARD

3 THE DEPTH OF THE SPOTFACE IS 20 PERCENT OF THE ACTUAL THICKNESS OF THE OUTER SKIN OF THE REFERENCE STANDARD

4 THE DEPTH OF THE SPOTFACE IS 30 PERCENT OF THE ACTUAL THICKNESS OF THE OUTER SKIN OF THE REFERENCE STANDARD

Corrosion Reference Standard 127-XXX
Figure 1





NOTES

- ALL DIMENSIONS ARE IN INCHES
- MATERIAL: CLAD 2024-T3 OR
  CLAD 2024-T4 SHEET
- TOLERANCE: X.X ±0.05

OUTER SKIN THICKNESS	SKIN THICKNESS TOLERANCE	MACHINE DEPTH TOLERANCE
0.032-0.050	±0.001	±0.001
0.063-0.125	±0.002	±0.0015

- THE BACK SIDE OF THE OUTER SKIN CAN BE MACHINED TO THE THICKNESS OF THE AIRPLANES SKIN. MAKE SURE THE ALUMINUM SHEET USED TO MAKE THE OUTER SKIN IS OF THE SPECIFIED OR NEXT THICKER GAGE. THIS IS DONE TO MAKE SURE THE CLAD THICKNESS ON THE STANDARD AND THE AIRPLANE ARE THE SAME. SEE TABLE 1.
- MILL OR GRIND TO A SURFACE FINISH OF 64 RHR OR BETTER

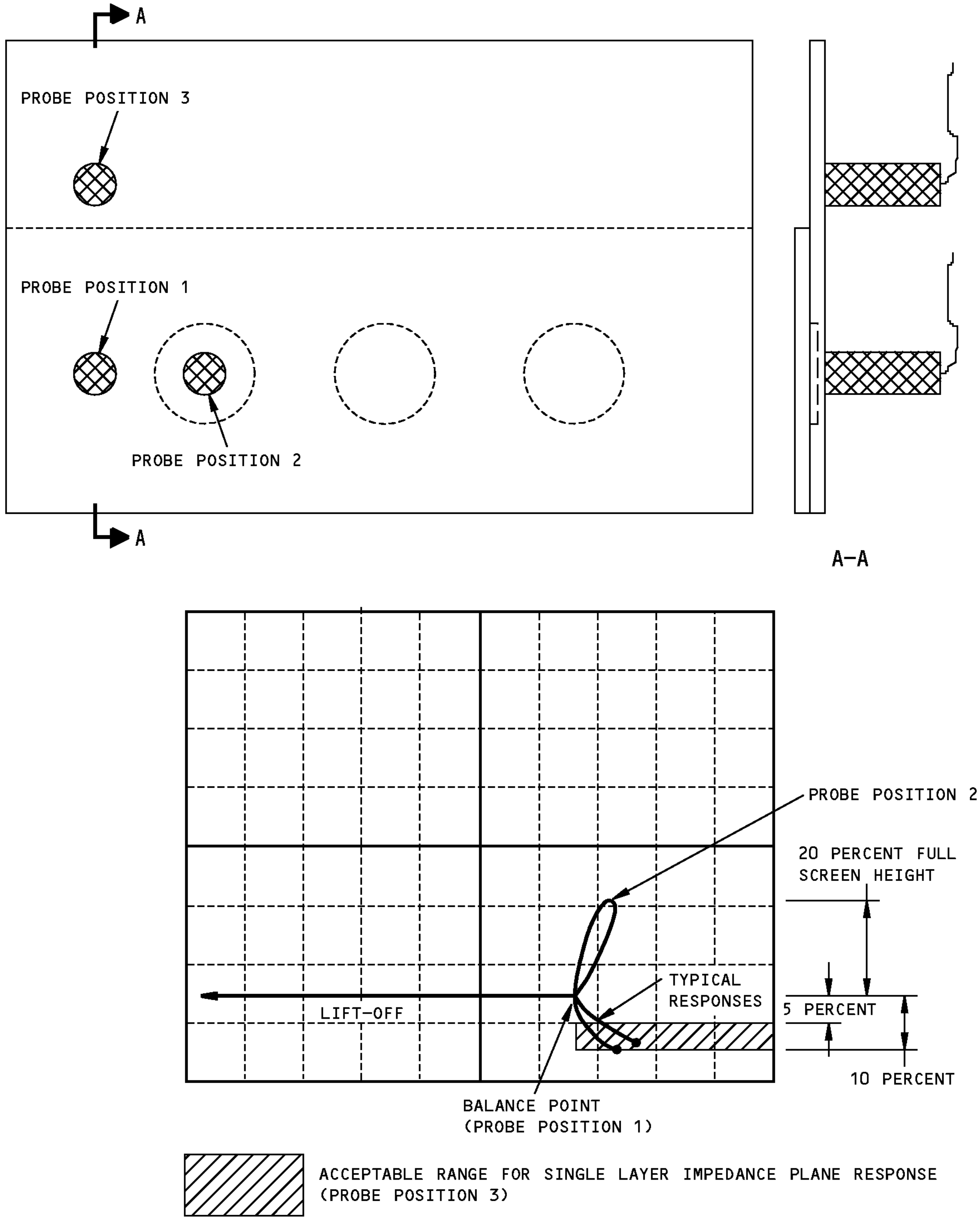
1 ETCH OR STEEL STAMP WITH 127A-XXX ON BOTH SKINS OF THE REFERENCE STANDARD. SEE TABLE 1 FOR REFERENCE STANDARD PART NUMBER IDENTIFICATION

2 THE DEPTH OF THE MACHINING IS 10 PERCENT OF THE ACTUAL THICKNESS OF THE OUTER SKIN OF THE REFERENCE STANDARD

3 THE DEPTH OF THE MACHINING IS 20 PERCENT OF THE ACTUAL THICKNESS OF THE OUTER SKIN OF THE REFERENCE STANDARD

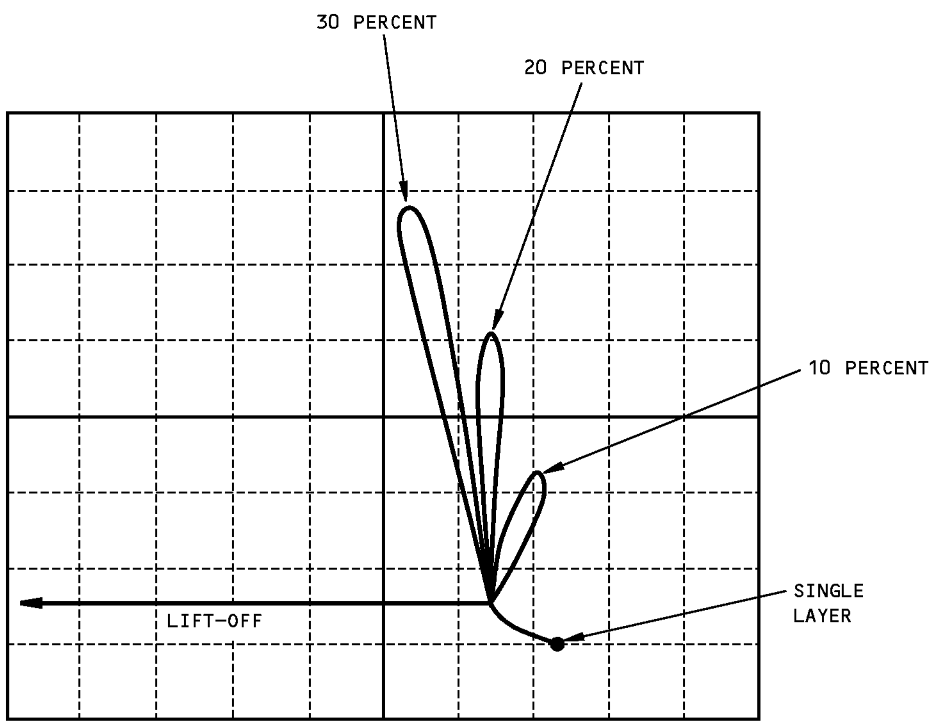
4 THE DEPTH OF THE MACHINING IS 30 PERCENT OF THE ACTUAL THICKNESS OF THE OUTER SKIN OF THE REFERENCE STANDARD

Corrosion Reference Standard 127A-XXX
Figure 2



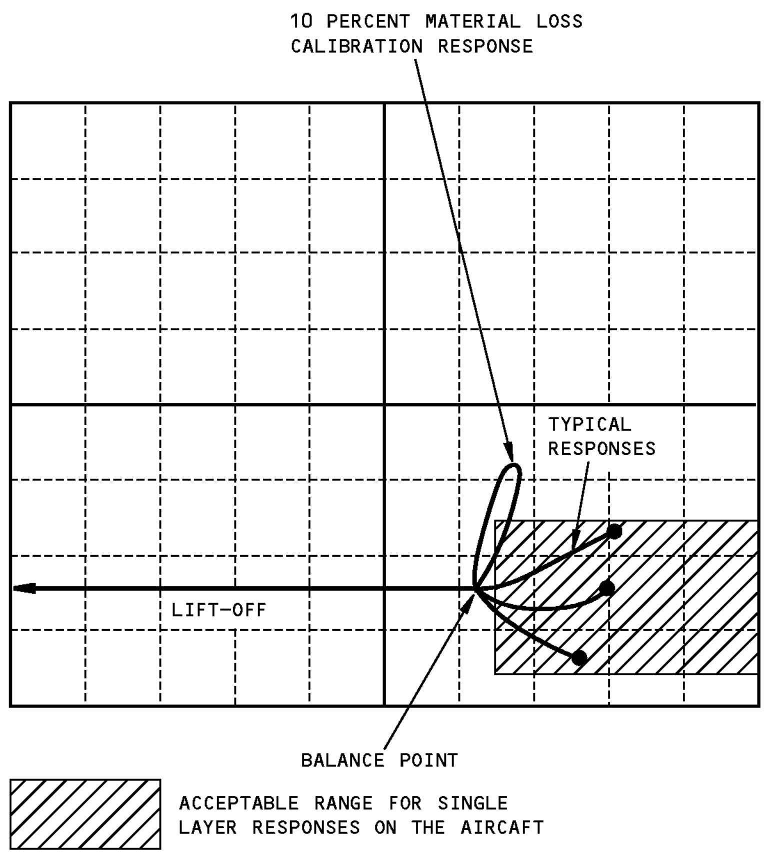
NOTE: PROBE CALIBRATION POSITIONS SHOWN FOR 127-XXX TYPE REFERENCE STANDARD. 127A-XXX TYPE REFERENCE STANDARD PROBE CALIBRATION POSITIONS ARE SIMILAR.

Probe Calibration Positions and Impedance Plane Response
Figure 3



NOTE: THIS SHOWS TYPICAL IMPEDANCE PLANE RESPONSES. ACTUAL RESPONSES MAY VARY DUE TO DIFFERENCES IN PROBE PERFORMANCE, ACTUAL MATERIAL LOSS PERCENTAGES, CONDUCTIVITY, AND MATERIAL THICKNESS.

Typical Impedance Plane Calibration Responses
Figure 4



Acceptable Single Layer Thickness Responses
Figure 5

PART 6 - EDDY CURRENT

ALUMINUM PART FASTENER HOLE INSPECTION (IMPEDANCE PLANE DISPLAY)

1. **Purpose**

   A. To identify requirements for eddy current inspection, using impedance plane analysis, of fastener holes in aluminum structure with fasteners removed.

   B. Part 6, 51-00-04 can be used as an alternative procedure.

   C. Part 6, 51-00-16 is recommended as an alternative procedure. It is highly recommended for inspections of materials less than 0.063 inch thick.

2. **Equipment**

   NOTE: Refer to Part 1, 51-01-00 for equipment manufacturers.

   A. Instrument -- Any eddy current instrument with impedance plane signal display that will satisfy the performance requirements of this procedure is suitable for this inspection. The following instruments were used during the development of this procedure and found suitable:

      (1) EM 4300; Automation Industries, Inc.

      (2) Defectoscope 2.830; Foerster Instruments, Inc.

      (3) MIZ-10, MIZ-10A, MIZ-17; Zetec, Inc.

         NOTE: Auxiliary CRT monitor for impedance plane display required with MIZ-10 or MIZ-10A.

      (4) NDT-18, NDT-19; Nortec

         NOTE: Instruments for impedance plane analysis usually work on a dual coil or driver-pickup coil principle. These instruments require dual coil probes with balance coil adapters.

   B. Probes -- The probe/instrument combination used in this procedure should meet the liftoff and sensitivity requirements of Paragraph 4. See Figure 1 for typical fastener hole probe configuration.

      (1) Probes should be compatible with dual coil or driver-pickup coil impedance plane instrumentation. Probes may have dual coils or single coil with balance coil adapter.

      (2) Probe diameter should be adjustable to obtain a snug fit in the hole.

      (3) Probes should have an adjustable collar which controls the penetration depth in the hole. The collar is to be used as a guide as the probe is rotated inside the hole.

         NOTE: See Figure 2 for sample probe list.

      (4) Probes should not give interfering responses from normal handling pressures or manipulation, or from normal operating pressure variations on the sensing coil.

   C. Test Block -- Test blocks should have suitable natural cracks or artificial slots to simulate cracks in each of the hole sizes being tested. A standard test block should meet the following requirements:

      (1) Block should be of aluminum alloy with approximately the same conductivity as the part to be inspected.

      (2) Block should contain a suitable range of hole diameters to permit calibration of instrument for diameter of each hole to be tested.

      (3) The crack or slot in the block must give an eddy current instrument calibration comparable to that obtained from the recommended Boeing test block (see Figure 3).

3. **Preparation for Inspection**

   A. Clean loose dirt, chipped paint, and sealant from inside and around fastener hole.

B. Remove buildup of paint, sealant, etc., from around outside of hole where probe collar will bear.

NOTE: If surface of hole is extremely rough, a cleanup ream may be necessary. A 1/64 (0.016) inch diameter oversize is usually satisfactory.

4. **Instrument Calibration**

A. Attach appropriate probe to instrument, and if necessary, balance coil adapter.

B. Turn instrument on and allow to warm up per manufacturer's instructions.

C. For instruments with adjustable frequency select frequency appropriate for test probe, usually between 100 and 500 kHz.

D. Select appropriate test block and place probe in hole with sensing coil away from notch. Expand loose probe to obtain snug fit. Probe should fit snugly to reduce probe wobble, but not so tight as to cause excessive wear of probe.

E. Balance instrument according to the manufacturer's instructions.

F. With probe balanced in calibration hole, adjust instrument/CRT controls to position "flying dot" in center of screen.

G. Adjust instrument for liftoff.

(1) With probe balanced in calibration hole, manipulate probe to cause the coil to be lifted from hole surface.

NOTE: Probe liftoff can be achieved by squeezing the end of the probe so the coil moves away from the hole surface, or by placing a piece of tape 0.002-0.003 inch (0.005-0.007 cm) thick on the inside surface of the hole and rotating the probe until the coil is on the tape.

(a) Single coil probe - Adjust phase rotation control so that when probe coil is lifted off from the hole surface, the flying dot deflects horizontally toward the left side of screen (see Figure 4).

(b) Dual coil probe - Adjust phase rotation control so that when the probe is rocked in the hole, the flying dot deflects horizontally both right and left (see Figure 5).

H. Adjust instrument sensitivity for hole edge crack inspection.

(1) Use the probe collar to adjust depth of coil in hole to obtain maximum flying dot deflection from 0.030-inch (0.076 cm) edge slot (see Figure 3, Slot No. 3). Check instrument balance for flying dot at center of screen and liftoff lying horizontal toward left side of screen.

(2) Adjust instrument sensitivity to obtain approximately one-third full screen width flying dot deflection from the 0.030-inch (0.076 cm) test block notch.

(a) Single coil impedance plane signal for notch will appear approximately as indicated in Figure 4.

(b) Dual coil impedance plane signal for notch will appear approximately as indicated in Figure 5.

NOTE: Both sides of loop may not always appear exactly the same.

NOTE: Boeing Service Bulletin rework and modification procedures are based on the reliable detection of cracks 0.030-inch (0.076 cm) or greater in depth (radially). The instrument and probe should detect the 0.030-inch (0.076 cm) notch reliably.

I. Adjust instrument sensitivity for hole centered crack inspection.

(1) Repeat Paragraph 4.H. except use the probe collar to adjust depth of coil in hole to obtain maximum flying dot deflection from slot located between ends of hole in test block (see Figure 3, Slot No. 1).

J. Adjust instrument sensitivity for hole faying surface crack inspection.

(1) Repeat Paragraph 4.H. except use the probe collar to adjust depth of coil in hole to obtain maximum flying dot deflection from slot located at faying surface of hole in test block (see Figure 3, Slot No. 2).

5. **Inspection Procedure**

A. Calibrate instrument per Paragraph 4. for specific area of bolthole to be inspected, i.e., surface, faying surface or mid-hole.

B. Adjust probe to required depth and insert into hole.

NOTE: Use test block to establish probe to upper or faying surface edge distance for detection of 0.030-inch (0.076 cm) hole edge cracks.

C. Check liftoff and flying dot placement. If necessary adjust balance control to position flying dot at center of screen and liftoff deflection lying horizontal toward left of screen.

D. Slowly scan entire circumference of hole using probe collar to maintain a constant probe depth in hole. Note position of any response which has approximately the same direction as and a length which is 60 percent, or more, of the response obtained from the 0.030-inch (0.076 cm) notch in the test block.

NOTE: Significant distortion of fastener hole impedance plane response patterns can result from hole gouges, out-of-round, corrosion, sealant, etc. These conditions generally produce horizontal deflections of the impedance plane signal without the rapid signal change associated with a surface crack. Significant improvement in the response pattern may be obtained by a 1/64 (0.016) inch hole oversize ream (see Figure 6).

NOTE: For instruments with signal horizontal deflection control, an improved signal presentation maybe obtained by employing reduced horizontal sensitivity. If adjustment is made to signal horizontal deflection, check test block notch response. Note indications which are approximately in the same direction and 60 percent or more of test block response.

E. Adjust probe collar and repeat Paragraph 5.A. thru Paragraph 5.D. at incremental depths of 0.050-inch (0.13 cm) to within 0.025-inch (0.064 cm) from bottom end of hole or mating layer interfaces.

F. Recheck calibration of instrument with aluminum test block periodically to ensure proper sensitivity.

6. **Inspection Results**

A. A positive crack response is characterized by a rapid deflection of the impedance plane signal over a short scan distance and in the same general direction as the test block notch response. Deflection occurs as the coil moves over the crack. The related probe movement is equivalent to an arc of approximately 40 degrees in a 0.025-inch fastener hole and 20 degrees in a 0.50-inch hole for a hole probe with a 0.1-inch (0.25 cm) diameter coil.

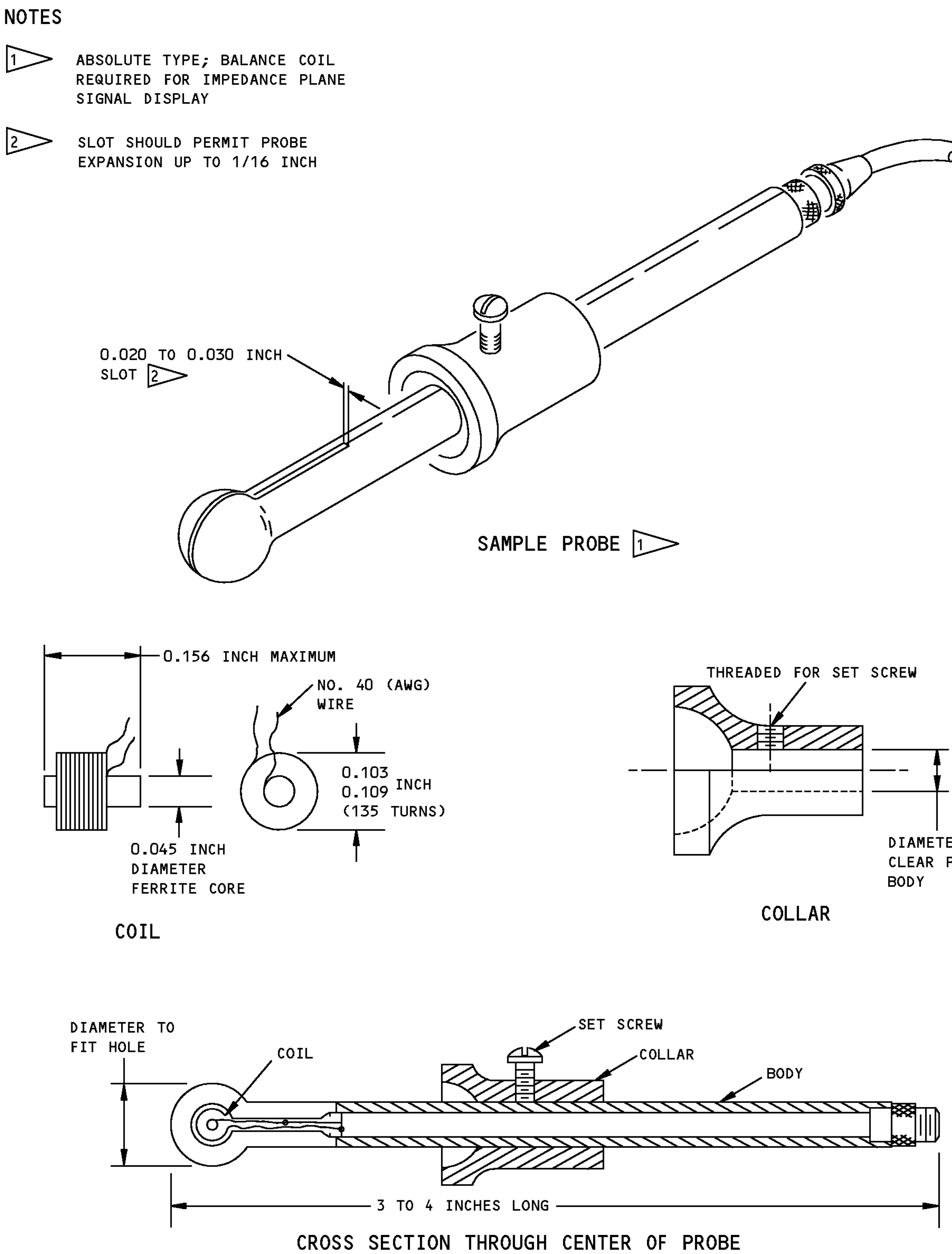
NOTE: Impedance plane signal of in-service crack indication may not appear exactly like the notch response of the test block. Crack signals may appear as a sharp peak within a rounded or conical shaped signal. A 1/64 (0.016) inch ream may improve response interpretation. Examples of hole crack impedance plane response before and after reaming 1/64 (0.016) inch oversize is given in Figure 6 for a single coil probe.

B. Note locations of any questionable indications, i.e., crack-like indications causing responses less than the one obtained from 0.030-inch (0.076 cm) notch in test block, or indications not conforming to a positive crack response. To help do the inspections at these locations, do a maximum 1/64-inch cleanup ream and do this test again, paying particular attention to areas where the indications were noted. Note the location and the response of all positive crack indications.

C. When hole is reamed to clean up or remove the cracks, do an eddy current test after each increase in hole diameter. It is recommended that a hole be oversized in increments of no more than 1/64 inch in diameter. This is done to make sure the piece stays within permitted oversizing limits. The permitted limits for hole oversizing are specified in the repair document applicable to the structure (i.e., service bulletin, repair drawing or structural repair manual).

NOTE: When reworking a cracked part, it is imperative that an "insurance cut" be made after the eddy current inspection shows that the crack is fully removed. If possible, the depth of the insurance cut should be equal to or greater than the depth of the minimum detectable crack to make sure of complete crack removal. Get local engineering approval before you do an insurance cut.

D. An acceptable bolthole response lies near the liftoff line and can oscillate horizontally along this line up to the entire screen width.



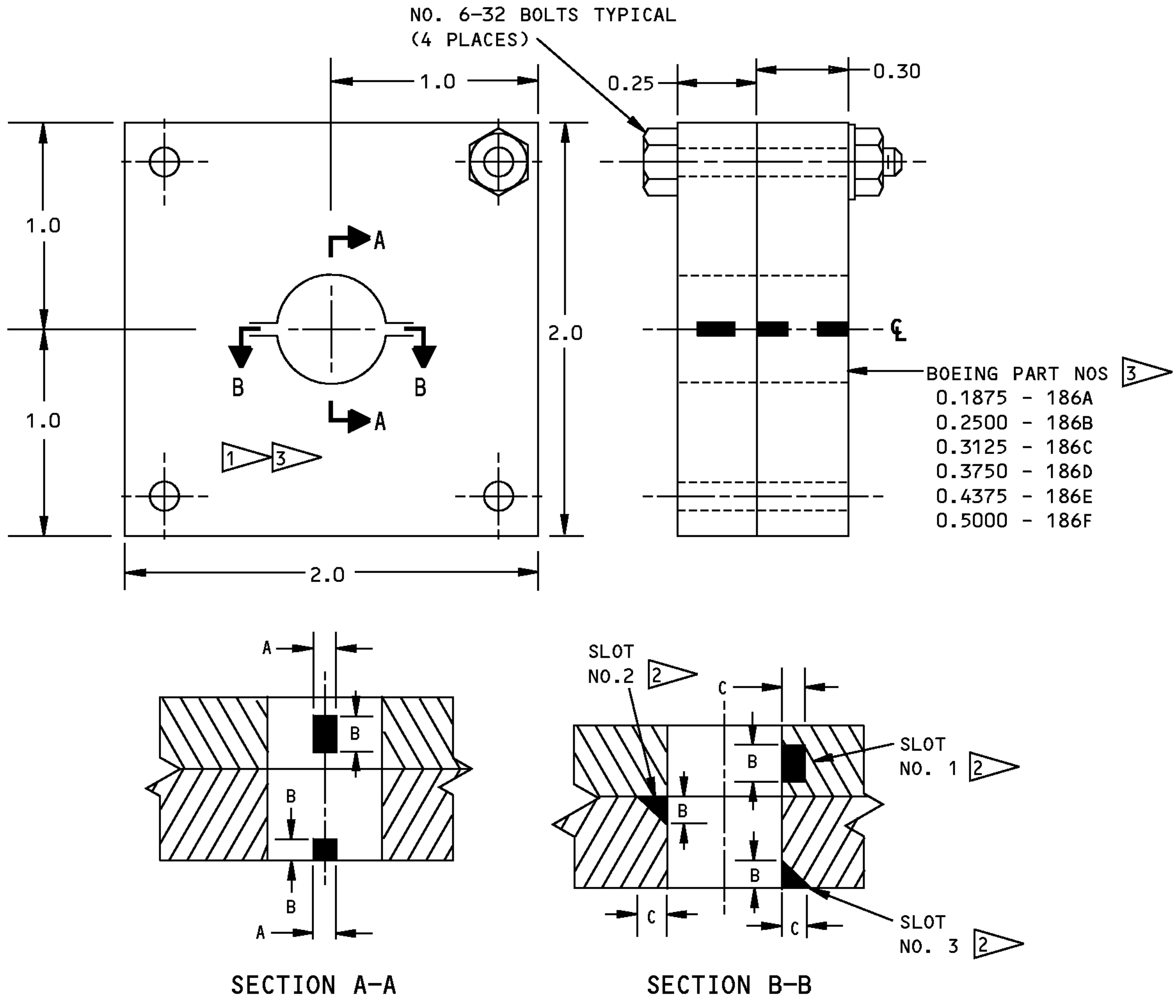
Typical Eddy Current Bolt Hole Probe - Absolute Type
Figure 1

HOLE DIA (INCHES)	ABSOLUTE BOLT HOLE PROBES 1			DIFFERENTIAL BOLT HOLE PROBES
	NORTEC PART NO.	NDT PRODUCT ENG PART NO.	IDEAL SPECIALTY PART NO.	NORTEC PART NO.
3/16 (0.188)	2917 BP-12	BPFG-12	6200-3/16 BH	9204813 DP-12
7/32 (0.219)	2918 BP-14	BPFG-14	6200-7/32 BH	9204814 DP-14
1/4 (0.250)	2919 BP-16	BPFG-16	6200-1/4 BH	9204815 DP-16
5/16 (0.313)	2921 BP-20	BPFG-20	6200-5/16 BH	9204817 DP-20
3/8 (0.375)	2923 BP-24	BPFG-24	6200-3/8 BH	9204819 DP-24
7/16 (0.438)	2925 BP-28	BPFG-28	6200-7/16 BH	9204821 DP-28
1/2 (0.500)	2926 BP-32	BPFG-32	6200-1/2 BH	9204823 DP-32
9/16 (0.563)	2927 BP-36	BPFG-36	6200-9/16 BH	9204825 DP-36
5/8 (0.625)	2928 BP-40	BPFG-40	6200-5/8 BH	9204827 DP-40
11/16 (0.688)	2929 BP-44	BPFG-44	6200-11/16 BH	9204828 DP-44
3/4 (0.750)	2930 BP-48	BPFG-48	6200-3/4 BH	9204829 DP-48

NOTES

1 WHEN USING ABSOLUTE BOLT HOLE PROBES WITH INSTRUMENTS REQUIRING TWO COILS, USE TWO SIMILAR ABSOLUTE PROBES OR SINGLE ABSOLUTE PROBE WITH BALANCE COIL ADAPTER

Vendor Part Numbers for Typical Bolt Hole Probes
Figure 2



NOTES

- ALL DIMENSIONS ARE IN INCHES
- TOLERANCE ON ALL DIMENSIONS ±0.050 INCH EXCEPT AS NOTED
- MATERIAL: 2014, 2024-T3 OR -T4, 7075, 7079, 7175, 7178 ALUMINUM ALLOY
- SEE PART 1, 51-01-00, FOR MANUFACTURING AND ORDERING INFORMATION

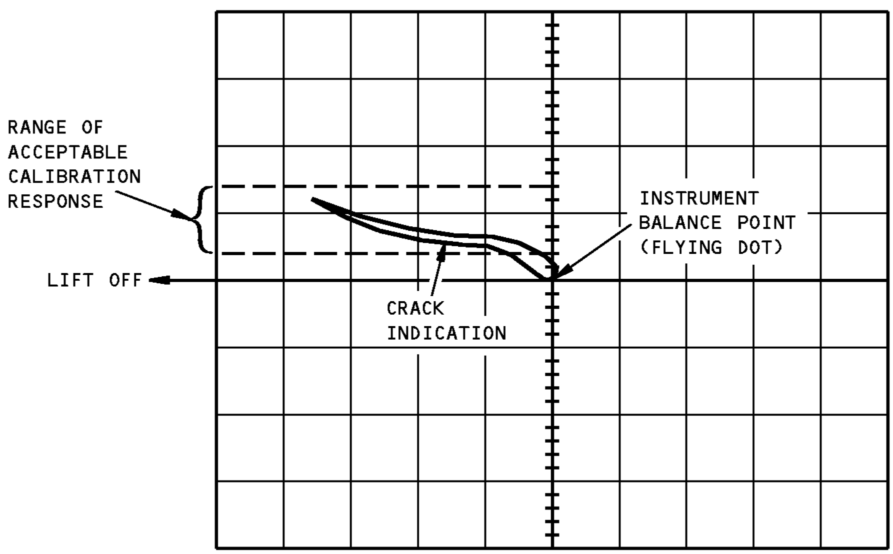
1 FINISH REAM HOLE AND DO NOT DEBURR

2 ELECTRIC DISCHARGE MACHINE PER GIVEN DIMENSIONS

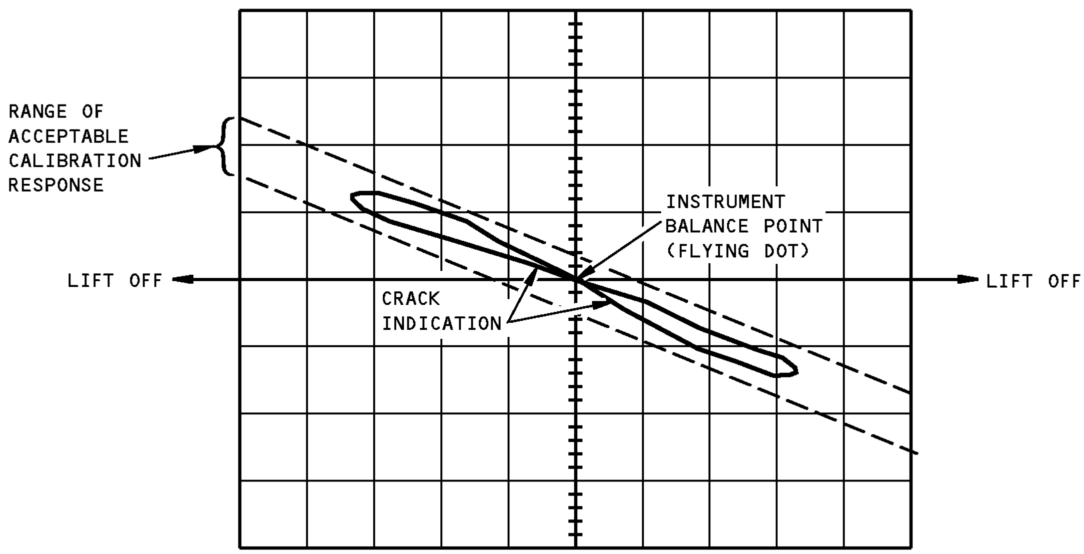
3 HOLE DIAMETER (6 STANDARD)
0.1875 0.2500 0.3125
0.3750 0.4375 0.5000
TOLERANCE $^{+0.005}_{-0.000}$ ON ALL HOLES

SLOT NUMBER	A	B	C
	WIDTH	LENGTH	DEPTH
1 2	0.005	0.060	0.030
2 2	0.005	0.030	0.030
3 2	0.005	0.030	0.030
TOLERANCE	MAXIMUM	±0.003	±0.003

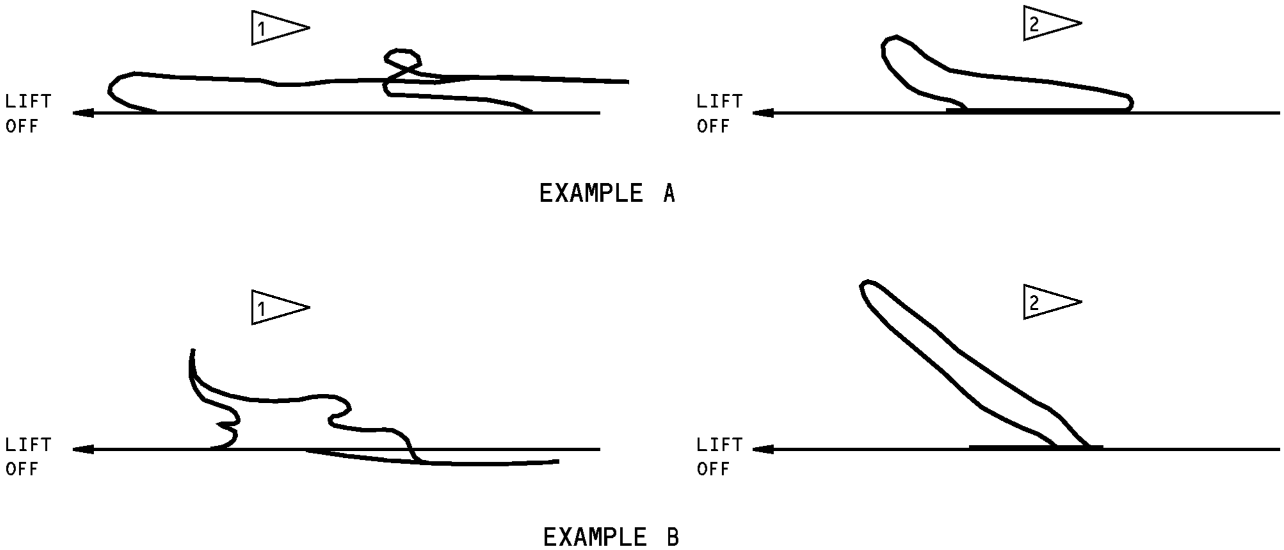
Aluminum Part Fastener Hole Test Block
Figure 3



Generalized Single Coil Impedance Plane Response from a 0.030 - Inch Notch
Figure 4



Generalized Dual Coil Impedance Plane Response from a 0.030 - Inch Notch
Figure 5



NOTES

- SCREEN OMITTED FOR CLARITY
- SINGLE COIL PROBE RESPONSE

1 UNACCEPTABLE RESPONSE PATTERNS

2 ACCEPTABLE RESPONSE PATTERNS OBTAINED AFTER 1/64 (0.016) INCH CLEAN-UP REAM

Impedance Plane Crack Response Improvement
Figure 6

PART 6 - EDDY CURRENT

STEEL PART SURFACE INSPECTION (METER DISPLAY)

1. **Purpose**

   A. This procedure uses metered instruments to find surface cracks in magnetic steel parts.

   NOTE: It is possible to get crack type signals from steel parts that are plated with cadmium, titanium-cadmium, chrome or other conductive finishes when the finish has been scratched. Part 6, 51-00-21 is an alternative procedure that is recommended for steel parts with conductive finishes.

   B. This procedure examines two types of magnetic steel parts:

   (1) High permeability steels such as 4000 series, 15-5PH and 17-4PH CRES

   (2) Low permeability steels such as 301 1/2 hard.

   C. Refer to Part 6, 51-00-13 to do an inspection for cracks in non-magnetic steel parts.

2. **Equipment**

   NOTE: Instrument/probe combinations used shall be capable of detecting the calibration notch in the reference standard to the sensitivity requirements of Paragraph 4.

   A. Instruments -- Battery-operated, multifrequency instruments with audible or visual alarms are recommended. The following instruments were used in the development of this procedure:

   (1) Locator UH, Locator UHB; Hocking Instruments

   (2) MIZ 10A, MIZ 10B; Zetec, Inc.

   B. Probes

   (1) To examine low permeability steels, use a shielded probe to examine all large area structural configurations.

   (2) To examine high permeability steels, use a nonshielded probe to examine all large area structural configurations.

   (3) It can be necessary to use a shielded probe to examine the surface of a steel part.

   (a) In the areas around fasteners.

   (b) In the areas where there is adjacent structure.

   (c) When the surface is curved (has a radius).

   (d) When the surface is near the edge of the steel part.

   (e) When the surface to be examined is the edge of the steel part.

   (4) Use a probe that:

   (a) Operates at a frequency in the range of 50 to 500 kHz

   (b) Has the configuration shown in Figure 1.

   (c) Can satisfactorily do the angularity check as shown in Figure 2.

   C. Reference Standards

   (1) To examine high permeability steels, use reference standards 185, 192, NDT1061 and NDT1062 as applicable. See Figure 4 thru Figure 7 for data about the reference standards.

   (2) To examine low permeability steels, use reference standards NDT1072, NDT1073, NDT1074, and NDT1075 as applicable. See Figure 4 thru Figure 7 for data about the reference standards.

   (3) Other reference standards can be used if they are equivalent to those shown in Figure 4 thru Figure 7.

3. Preparation for Inspection

NOTE: It is possible to get crack type signals from steel parts that are not plated with cadmium, titanium-cadmium, chrome or other conductive finishes when the finish has been scratched. Part 6, 51-00-21 is an alternative procedure that is recommended for steel parts with conductive finishes.

A. Identify inspection location(s).

B. If needed, obtain a smooth inspection surface by lightly sanding away surface roughness and sharp edges of chipped paint.

NOTE: It is not necessary to remove paint or other nonconductive coatings.

C. Wipe surface clean.

D. Locate inspection equipment a minimum of 10 feet (3 m) away from any items that generate large magnetic fields, such as large motors, generators, transformers or power lines.

4. Instrument Calibration

A. Set the frequency as follows:

(1) Use a frequency between 50 and 500 kHz to examine high permeability steels.

(2) Use a frequency between 100 and 200 kHz to examine low permeability steels.

B. Calibrate the instrument with the applicable reference standard. Paragraph 5.D. identifies the different types of structural configurations that can be examined. The reference standards to use for the different structural configurations to be examined are:

(1) Large Areas, Near an Edge, On an Edge, Radius: Use reference standard 185 to examine high permeability steels. Use reference standard NDT1072 to examine low permeability steels.

(2) Flush Head Fasteners: Use reference standard NDT1061 to examine high permeability steels. Use reference standard NDT1073 to examine low permeability steels.

(3) Protruding Head Fasteners: Use reference standard NDT1062 to examine high permeability steels. Use reference standard NDT1074 to examine low permeability steels.

C. If the inspection area is painted, put a nonconductive shim, which is the same thickness as the paint, on top of the reference standard. The nonconductive shim must be ± 0.003 inch of the paint thickness.

D. Place the probe on the surface crack reference standard at least 0.5 inch (1.27 cm) away from the edge of the block and artificial crack. Balance the instrument according to the manufacturer's instructions.

E. Adjust lift-off to obtain less than 5 percent of full scale needle movement when probe is slid from a 0.002- to 0.004-inch (0.005 to 0.010 cm) nonconductive shim to the bare surface of the reference standard.

NOTE: One sheet of ordinary writing paper, approximately 0.003 inch (0.007 cm) thick, can be used for the nonconductive shim.

F. Slide the probe across the reference standard notch. Adjust the sensitivity control to obtain a 30 to 60 percent of full scale meter deflection when passing the probe slowly across the notch (readjust the lift-off if an upscale meter response is not obtained. Refer to Paragraph 4.C.). Refer to Figure 8, Detail A. The signal to noise ratio must be 5:1, or better.

NOTE: Inspection scanning speed may be increased by using an instrument with an audible or visual alarm. Set the alarm to respond at 50 percent of the reference standard notch signal amplitude. Refer to Figure 8, Detail B.

G. Check the balance and lift-off again. If adjustments are made, check sensitivity (Paragraph 4.F.) again.

H. Find the maximum inspection scanning speed by sliding the probe across the reference standard notch. Note when the meter response does not fall below 90 percent of the calibration notch response, or when the alarm set in Paragraph 4.F. NOTE fails to trigger.

5. **Inspection Procedure**

A. Prepare for inspection. Refer to Paragraph 3.

B. Perform instrument calibration. Refer to Paragraph 4.

C. Put the probe on the inspection surface. Check the balance and lift-off. If necessary, adjust on the part.

NOTE: Do not adjust sensitivity.

D. Scan all inspection areas. If not otherwise identified, a scanning pattern shall be established such that surface cracks 0.15 inch (0.38 cm) or more in length are detected. A scan direction should be chosen so that the probe is scanned across the crack. Do not exceed the maximum inspection scanning speed (Paragraph 4.H.). Commonly encountered structural configurations may require these scanning techniques:

(1) Large area -- A grid system should be used for scanning. The distance between scans depends on the size of the probe sensing diameter and the minimum length crack to be detected. The scans should overlap so that the probe will scan over the potential crack twice.

(2) Flush-head fasteners -- Inspect using a hole template. Position template to detect a crack extending 0.10 inch (0.25 cm) beyond the fastener head. Instrument/probe combinations must meet the performance guidelines of Figure 9.

(3) Protruding-head fasteners -- Inspect using a fastener head or washer as a probe positioner to detect a crack extending 0.10 inch (0.25 cm) beyond the fastener head. Instrument/probe combinations shall meet performance guidelines of Figure 10.

(4) Radius -- As the probe is scanned in the radius, it should be adjusted so that it is held perpendicular to the surface of the radius. Select scan increments based on probe sensing diameter and minimum crack length to be detected. Where crack orientation is unknown, make scans parallel and across the radius. Refer to Figure 11.

(5) Edges -- A constant distance must be maintained between the probe and the edge of a part. The minimum probe-to-edge spacing depends on the sensing area of the probe coil. Inspect near an edge by putting a nonconductive straightedge a constant distance away from the edge of the part. Refer to Figure 12 for inspections near the edge of steel structure. Refer to Figure 13 for inspections on the edge of steel structure.

E. Periodically check the instrument/probe calibration responses. For balance and lift-off responses, refer to Paragraph 5.C. For sensitivity response, refer to Paragraph 4.E.. If any response is found to be unsatisfactory, inspect again all areas that were inspected since the last calibration check.

F. Note all locations where an upscale meter response, similar to the reference standard notch response, is obtained.

NOTE: Probe held at an angle other than perpendicular may cause meter fluctuation. Probe should be held perpendicular to part surface throughout the inspection.

6. **Inspection Results**

NOTE: A potential defect is indicated by a rapid upscale meter deflection. Compare the defect response to the reference standard notch response at the same scanning speed.

A. A rapid meter deflection that is greater than 50 percent of the reference notch response amplitude and similar to the reference standard notch response indicates the presence of a crack.

(1) Determine the end points of the crack by scanning along the crack until a meter response is no longer received.

(2) Estimate crack depth (for crack lengths greater than probe sensing diameter) by comparing the crack response amplitude to the reference notch response amplitude. Note crack depth as less than, equal to, or greater than reference notch depth or compare crack response to reference notch responses of different depths.

NOTE: Approximate crack depth can be determined by high frequency surface eddy current measurements when the crack depth in steel is less than 0.04 inch (0.10 cm).

B. Questionable indications or a response less than 50 percent of the reference standard notch response amplitude may indicate a defect condition. The following may be used to help defect determination.

(1) A nonconductive probe fixture may reduce meter response variations caused by the probe not being held perpendicular to the part.

(2) Teflon tape placed over the sensing coil may improve the ratio of the crack-to-noise responses. Calibrate again when tape is added or removed from the probe sensing area.

(3) Magnetic changes in the steel may cause false defect indications. A rapid meter response over a short scan distance is characteristic of a crack indication while a slower meter response over a longer scan distance is characteristic of permeability changes in steel.

(4) Ensure structure is not plated with cadmium, titanium-cadmium, chrome or other conductive coatings. Thickness changes of, or scratches in, the conductive coating may cause false defect indications.

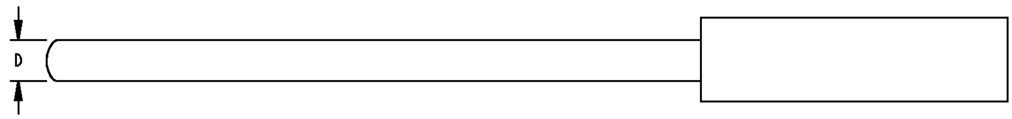
(5) The crack sensing distance traveled by the eddy current probe when crossing a suspected crack should be equal to the sensing distance traveled when crossing the reference standard notch. See Paragraph 4.C.

(6) Nonconductive coatings greater than 0.006 inch (0.015 cm) thick may reduce the amplitude of the crack signal. Remove the coating in the suspect area and inspect again.

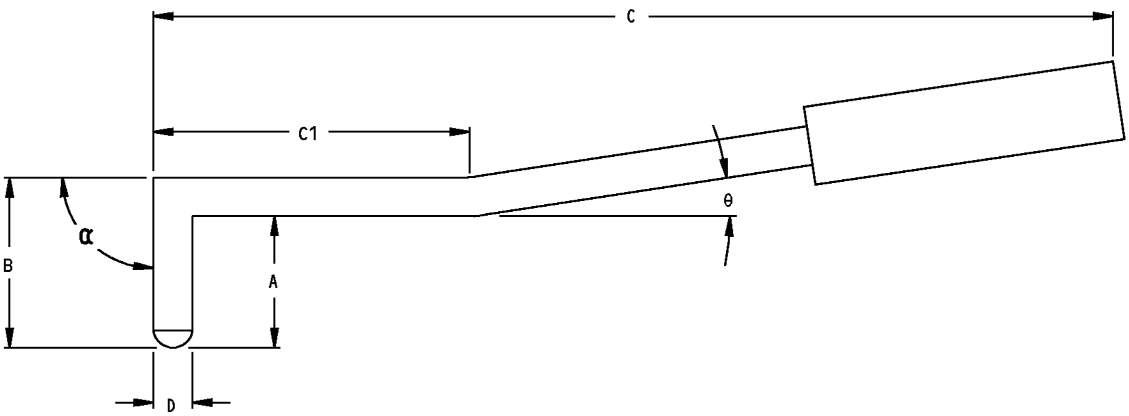
C. Verification of surface cracks may be performed by either or both of the methods listed. The crack verification methods are not as sensitive in the detection of surface cracks as eddy current for inservice conditions. Care should be taken when comparing any negative verification results to a positive crack response obtained using eddy currents.

(1) Remove the surface finish, grease, etc., and examine the area at 10X to 25X magnification with adequate lighting. A crack visible by this method requires no further investigation.

(2) Perform a magnetic particle inspection. Refer to D6-51702, SOPM 20-20-01, "Magnetic Particle Inspection."



PROBE 1



PROBE 2

NOTES

- THE PROBE CONFIGURATIONS SHOWN CAN BE USED TO ACCESS MOST INSPECTION AREAS WHEN IT IS NECESSARY TO USE PENCIL PROBES. SHIELDED PENCIL PROBES ARE RECOMMENDED. WHEN A SPECIAL PROBE CONFIGURATION IS NECESSARY, SPECIFY THE PROBE DIMENSIONS AS SHOWN FOR PROBE 2:

  A - THE PROBE DROP, OR DIMENSION A

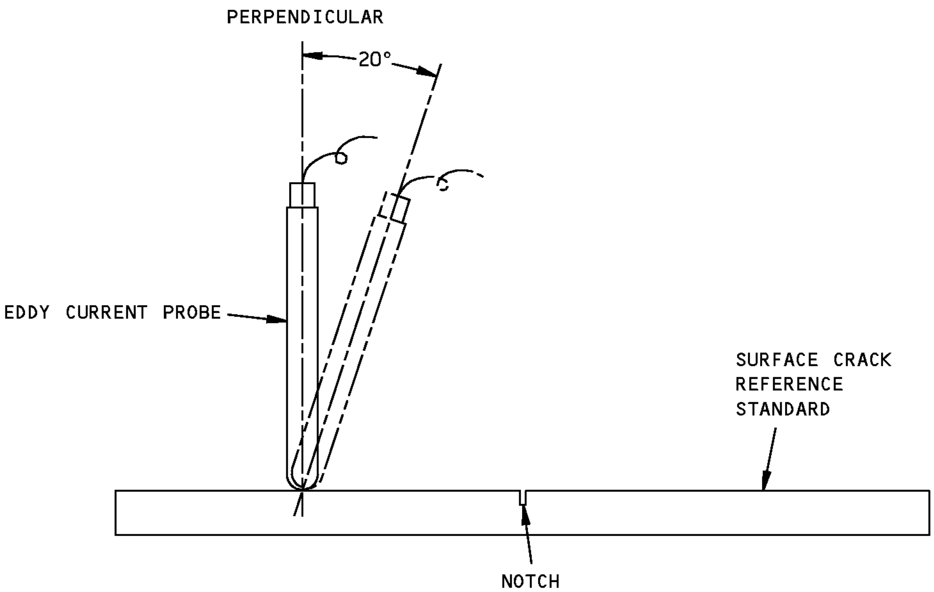
  B - THE PROBE HEIGHT, OR DIMENSION B

  C - THE PROBE HANDLE LENGTH, OR DIMENSION C. IF THE HANDLE MUST BE BENT, IT WILL BE NECESSARY TO KNOW DIMENSION C1 AND THE HANDLE ANGLE (ANGLE THETA - θ). FOR MOST USES, THE PROBE LENGTH WILL BE 3-5 INCHES (76.0-127.0 MM).

  D - DIAMETER: 0.20 INCH (5.1 MM) MAXIMUM. A DIAMETER OF 0.12 INCH (3.0 MM) IS RECOMMENDED FOR AREAS WITH NOT MUCH ACCESS.

  α - THE ANGLE (α = ALPHA). DIFFERENT ANGLES ARE POSSIBLE.

Example of Pencil Probe Configurations
Figure 1

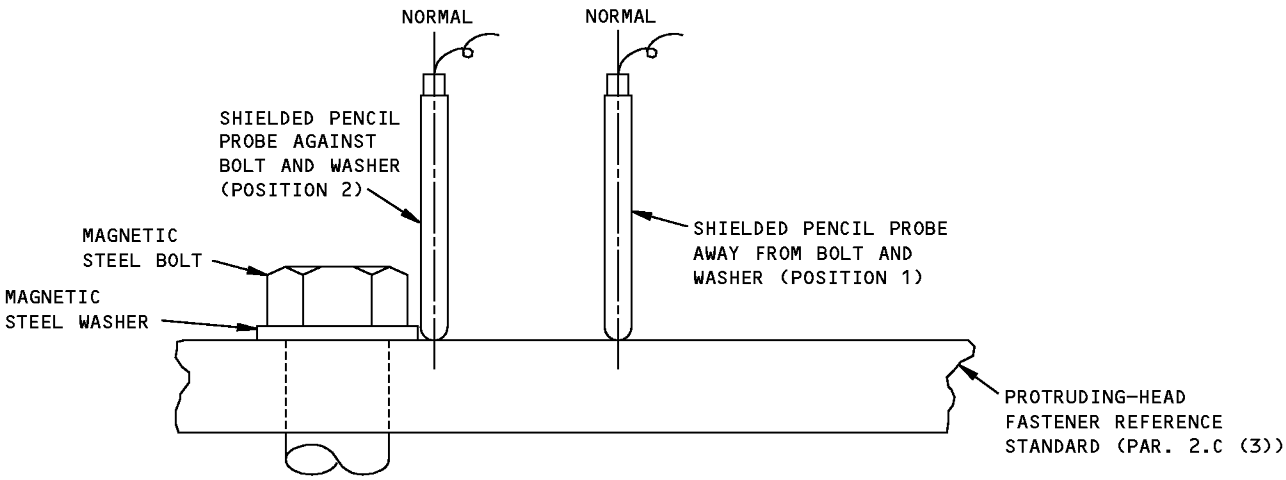


NOTES

- TO IDENTIFY THE ANGULAR PERFORMANCE OF THE PENCIL PROBE:
  - USE REFERENCE STANDARD 185 TO CALIBRATE THE INSTRUMENT AS SPECIFIED IN PARAGRAPH 4. USE REFERENCE STANDARD 185 FOR HIGH PERMEABILITY STEELS; USE REFERENCE STANDARD NDT1072 FOR LOW PERMEABILITY STEELS.
  - ANGLE THE PROBE 20 DEGREES TO THE SURFACE OF THE REFERENCE STANDARD IN MANY DIRECTIONS. THE ANGULAR POSITION OF THE PROBE MUST NOT CAUSE THE SIGNAL TO CHANGE MORE THAN 10 PERCENT OF THE DISPLAY.
  - MOVE THE PROBE ACROSS THE NOTCH AS IT IS HELD PERPENDICULAR TO THE SURFACE OF THE REFERENCE STANDARD AND AGAIN AS IT IS HELD 20 DEGREES FROM PERPENDICULAR. THE NOTCH SIGNAL MUST NOT DECREASE MORE THAN 30 PERCENT.

  EXAMPLE: A SIGNAL FROM THE NOTCH ON THE REFERENCE STANDARD IS 40 PERCENT OF FULL SCALE WHEN THE PROBE IS HELD PERPENDICULAR TO THE SURFACE. WHEN THE PROBE IS HELD AT AN ANGLE THAT IS 20 DEGREES TO THE SURFACE, THE NOTCH SIGNAL MUST NOT BE LESS THAN 28 PERCENT OF THE DISPLAY. (40% SIGNAL X 0.3 = 12% AND 40% - 12% = 28%)

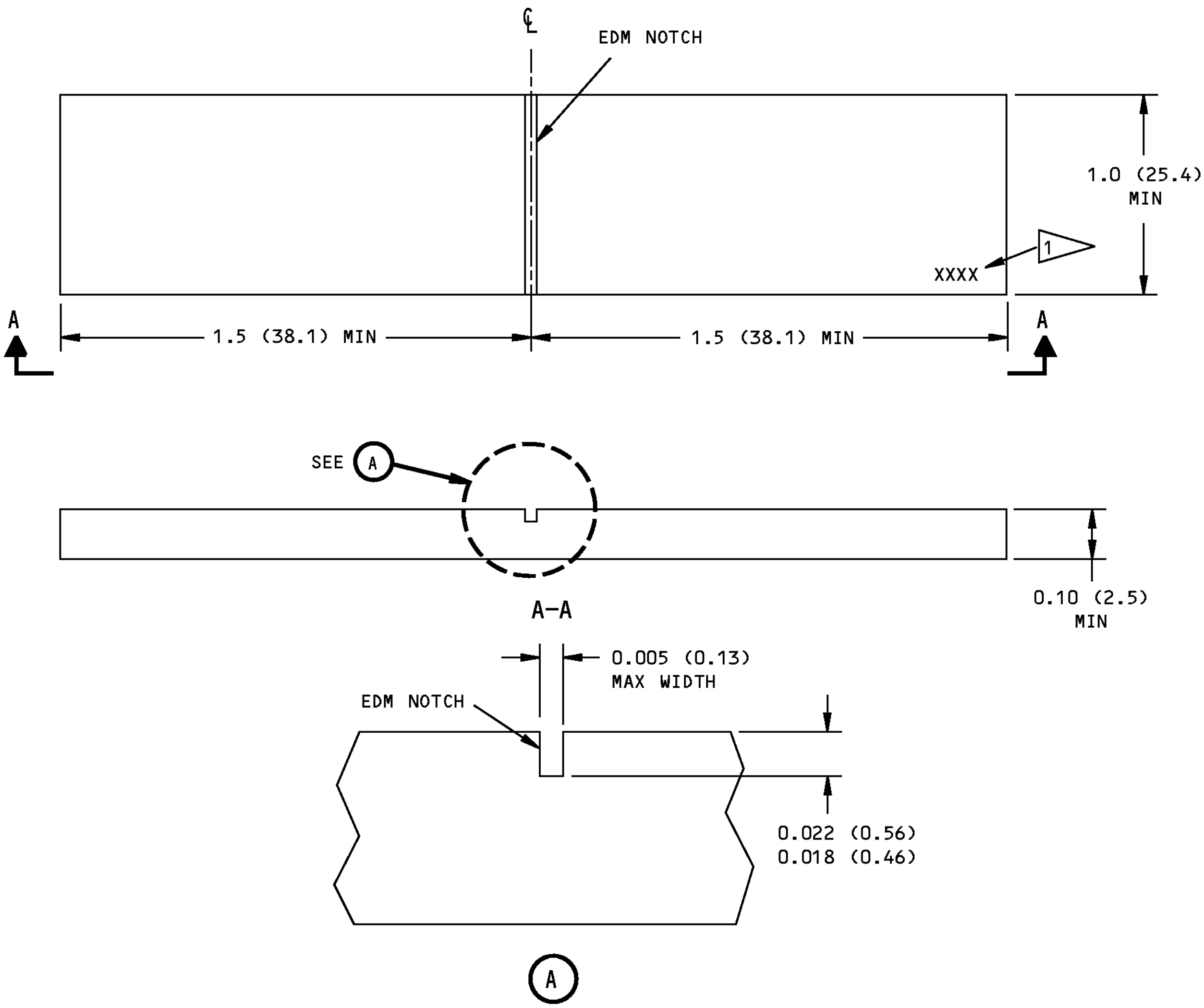
Pencil Probe Angular Performance
Figure 2



NOTES

- TO DETERMINE IF A SHIELDED PENCIL PROBE HAS ADEQUATE SHIELDING:
  1) CALIBRATE PROBE/INSTRUMENT COMBINATION TO THE REQUIREMENTS OF PAR. 4
  2) USING THE PROTRUDING-HEAD FASTENER REFERENCE STANDARD, MOVE PROBE FROM POSITION 1 TO POSITION 2. THE MAGNETIC STEEL SHOULD NOT CAUSE MORE THAN A 10 PERCENT SIGNAL CHANGE

Shielded Pencil Probe Shielding
Figure 3

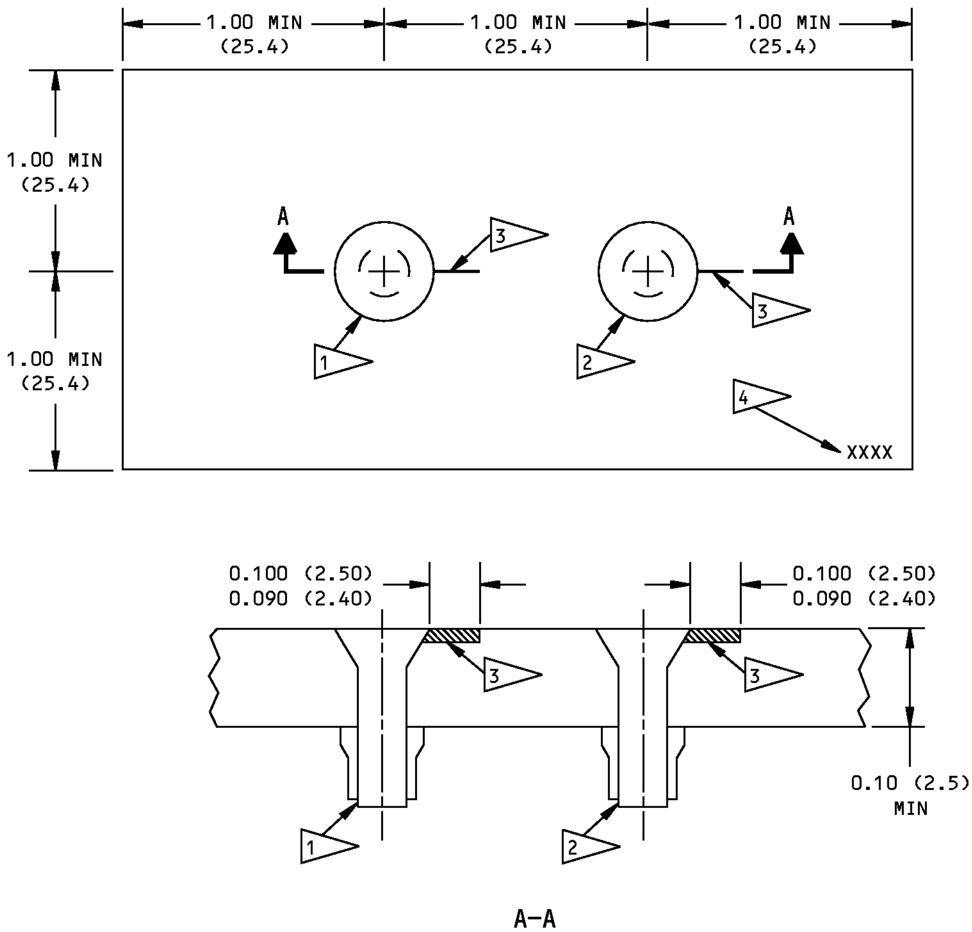


NOTES

- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES).
- SURFACE ROUGHNESS: $32\surd$ OR BETTER.
- REFER TO PART 1, 51-01-00, FOR DATA ABOUT THE REFERENCE STANDARD MANUFACTURERS.
- MATERIAL: FOR REFERENCE STANDARD 185, USE 4130, 4140, 4340, 4330M OR 4340M STEELS (HEAT TREAT OPTIONAL). FOR REFERENCE STANDARD NDT1072, USE 301 1/2 HARD.

1 ETCH OR STEEL STAMP THE REFERENCE STANDARD NUMBER THAT REFERS TO THE TYPE OF STEEL IDENTIFIED IN THE MATERIAL NOTE.

Reference Standard 185 and NDT1072 - for the Surface Inspection of Steel Parts
Figure 4



NOTES

- REFER TO PART 1, 51-01-00, FOR DATA ABOUT THE REFERENCE STANDARD MANUFACTURERS
- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES).
- MATERIAL: FOR REFERENCE STANDARD NDT1061, USE 4130, 4140, 4340, 4330M OR 4340M STEELS (HEAT TREAT OPTIONAL). FOR REFERENCE STANDARD NDT1073, USE 301 1/2 HARD.
- SURFACE FINISH: 32√ OR BETTER.
- REFERENCE STANDARD 190 CAN BE USED FOR THE INSPECTION AROUND STEEL FASTENERS IN HIGH PERMEABILITY STEELS.

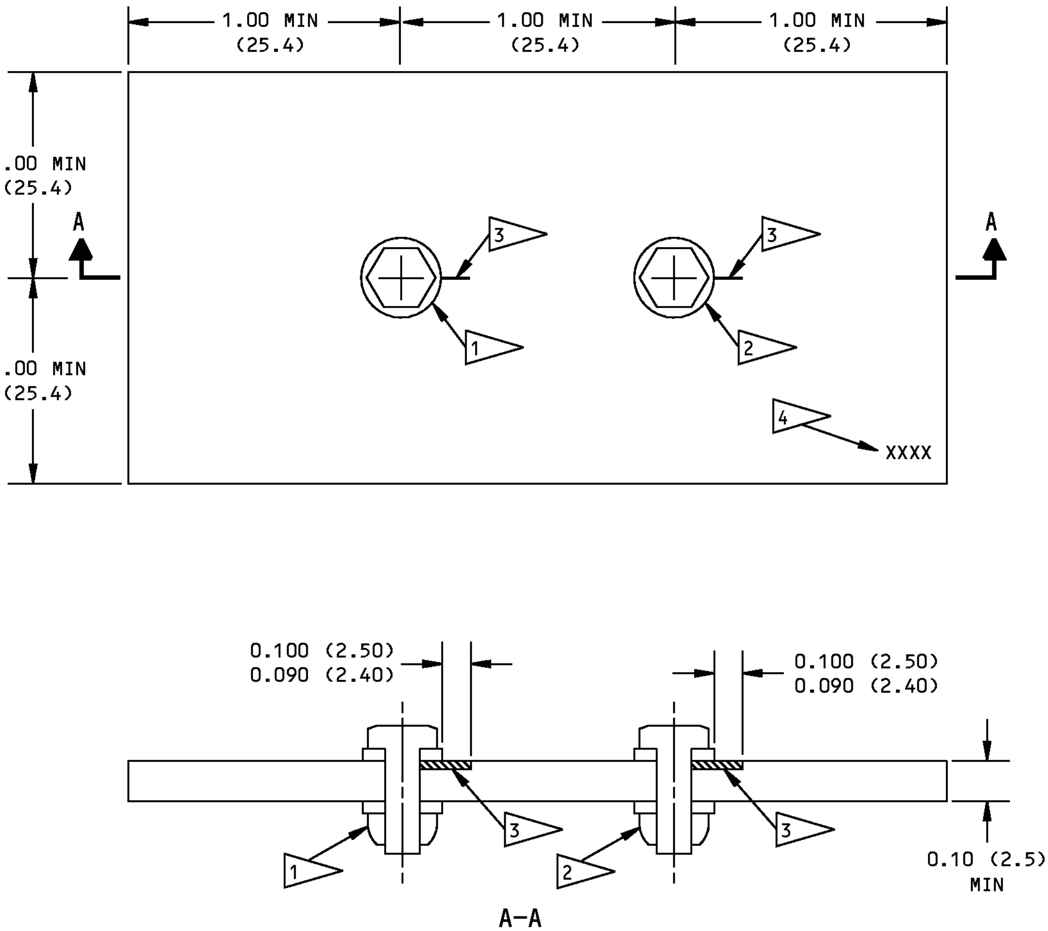
1 FASTENER - 0.25 (6.40) DIAMETER FLUSH-HEAD STEEL BOLT, SUCH AS BACB30JC8-* (REFERENCE STANDARDS THAT HAVE BEEN MADE WITH STEEL RIVETS ARE SATISFACTORY FOR USE).

2 FASTENER - 0.25 (6.40) DIAMETER FLUSH-HEAD TITANIUM BOLT, SUCH AS BACB30NY8K-* (REFERENCE STANDARDS THAT HAVE BEEN MADE WITH TITANIUM RIVETS ARE SATISFACTORY FOR USE).

3 NOTCH - 0.005 (0.13) MAXIMUM WIDTH, 0.018-0.022 (0.46-0.56) DEPTH.

4 ETCH OR STEEL STAMP THE REFERENCE STANDARD NUMBER THAT REFERS TO THE TYPE OF STEEL IDENTIFIED IN THE MATERIAL NOTE.

Reference Standard NDT1061 and NDT1073 - For Flush-Head Fasteners
Figure 5



NOTES

- REFER TO PART 1, 51-01-00, FOR DATA ABOUT THE REFERENCE STANDARD MANUFACTURERS
- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES).
- MATERIAL: FOR REFERENCE STANDARD NDT1062, USE 4130, 4140, 4340, 4330M OR 4340M STEELS (HEAT TREAT OPTIONAL). FOR REFERENCE STANDARD NDT1074, USE 301 1/2 HARD.
- SURFACE FINISH: 32 OR BETTER
- REFERENCE STANDARD 191 CAN BE USED FOR THE INSPECTION AROUND STEEL FASTENERS IN HIGH PERMEABILITY STEELS.

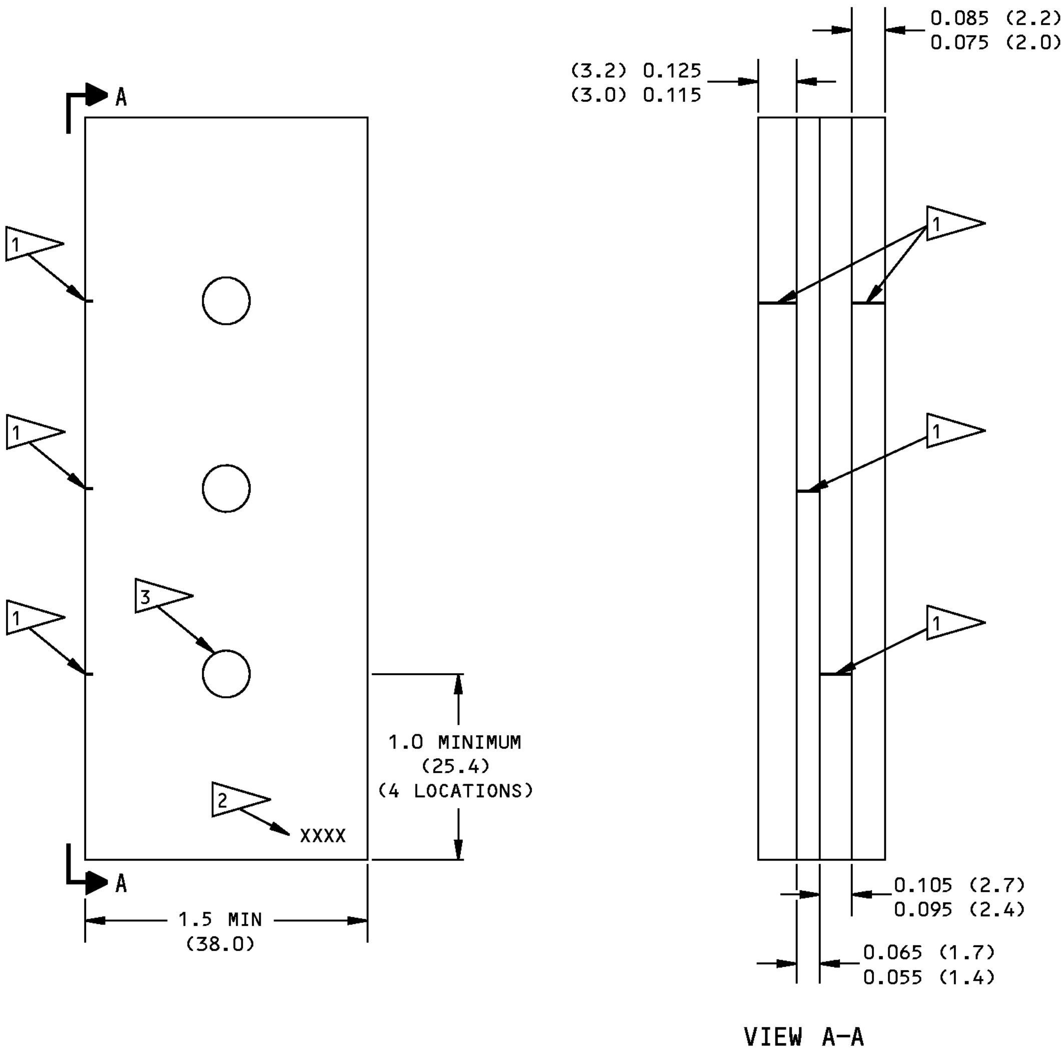
1 FASTENER - 0.25 (6.40) DIAMETER EXTERNAL WRENCHING STEEL BOLT, SUCH AS BACB30NF4-*; FLAT STEEL WASHER, SUCH AS AN960-416.

2 FASTENER - 0.25 (6.40) DIAMETER EXTERNAL WRENCHING TITANIUM BOLT, SUCH AS BACB30NM4K*; FLAT ALUMINUM WASHER, SUCH AS AN960D-416.

3 NOTCH - 0.005 (0.13) MAXIMUM WIDTH, 0.018-0.022 (0.46-0.56) DEPTH.

4 ETCH OR STEEL STAMP THE REFERENCE STANDARD NUMBER THAT REFERS TO THE TYPE OF STEEL IDENTIFIED IN THE MATERIAL NOTE.

Reference Standard NDT1062 and NDT1074 - For Protruding-Head Fasteners
Figure 6



NOTES

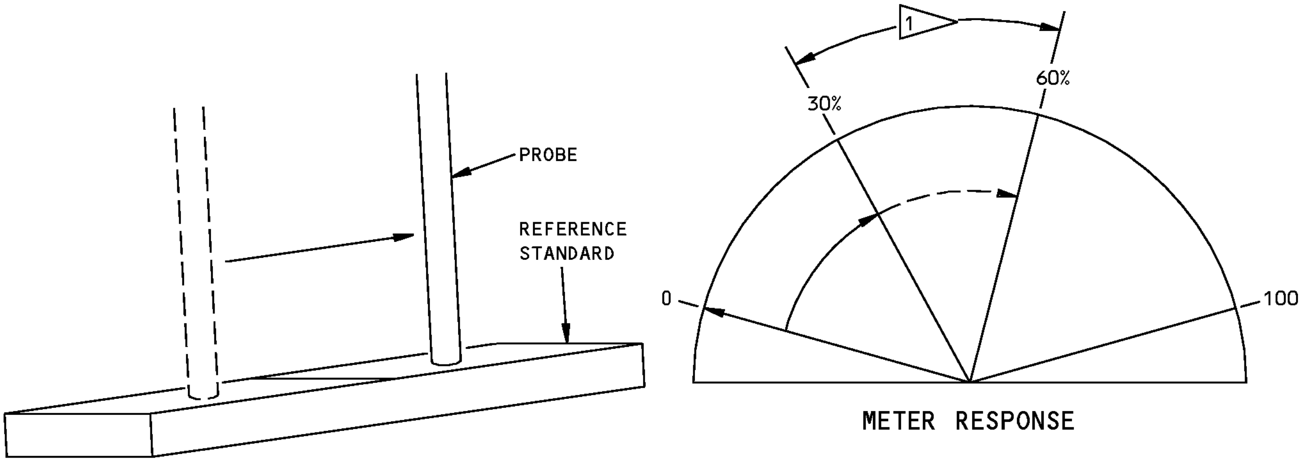
- REFER TO PART 1, 51-01-00, FOR DATA ABOUT THE REFERENCE STANDARD MANUFACTURERS
- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES).
- MATERIAL: FOR REFERENCE STANDARD 192, USE 4130, 4140, 4340, 4330M OR 4340M STEELS (HEAT TREAT OPTIONAL). FOR REFERENCE STANDARD NDT1075, USE 301 1/2 HARD.
- SURFACE FINISH: 32 OR BETTER.

1 NOTCH - 0.005 (0.13) MAXIMUM WIDTH, 0.035 TO 0.040 (0.90 TO 1.00) DEPTH.

2 ETCH OR STEEL STAMP THE REFERENCE STANDARD NUMBER THAT REFERS TO THE TYPE OF STEEL IDENTIFIED IN THE MATERIAL NOTE.

3 FASTENER - USE A FASTENER WITH A HEAD DIAMETER LESS THAN 0.50 (13.0), (3 LOCATIONS).

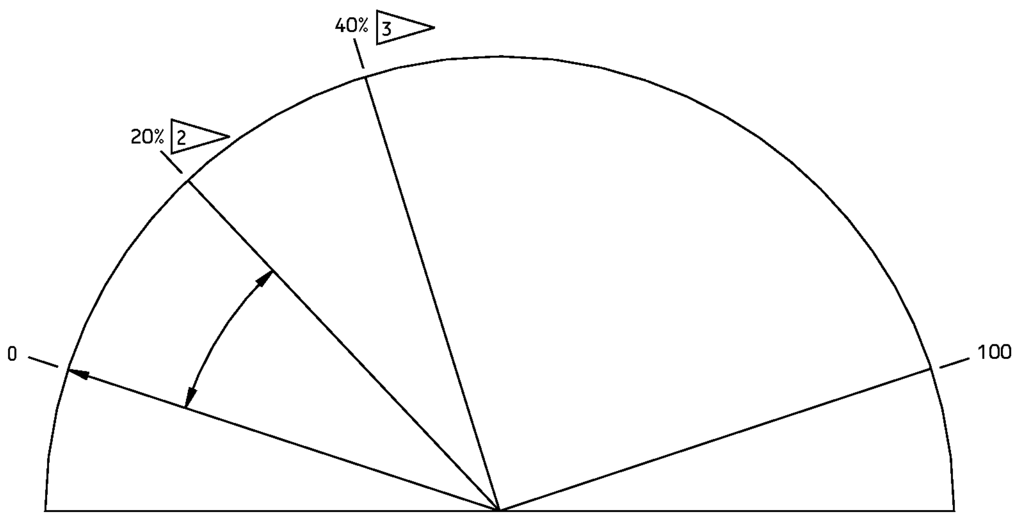
Reference Standard 192 and NDT1075 - for Cracks at the Edge of a Steel Part
Figure 7



NOTE

1 30 TO 60 PERCENT NEEDLE DEFLECTION FROM REFERENCE STANDARD NOTCH

SENSITIVITY ADJUSTMENT
DETAIL A



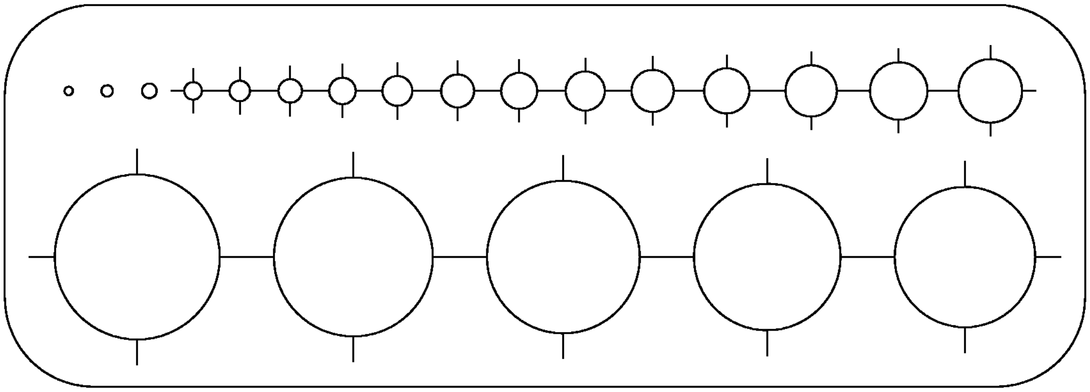
NOTES

2 ALARM RESPONSE SET POINT - 50 PERCENT OF NOTCH RESPONSE

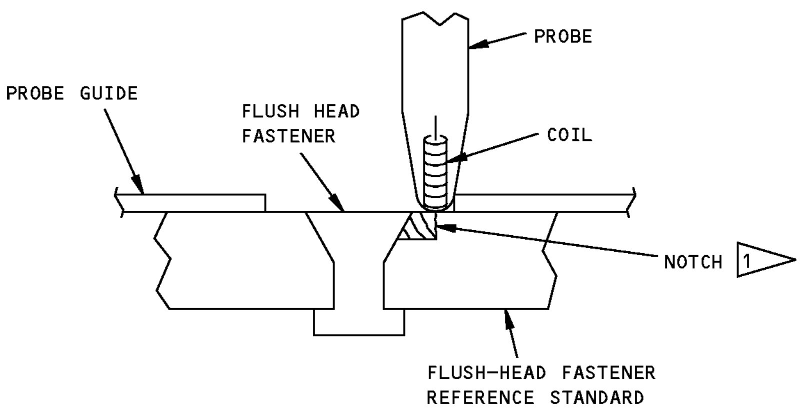
3 REFERENCE STANDARD NOTCH RESPONSE (TYP)

ALARM ADJUSTMENT
DETAIL B

Sensitivity and Alarm Adjustments
Figure 8



PROBE GUIDE
(NONCONDUCTIVE CIRCLE TEMPLATE)



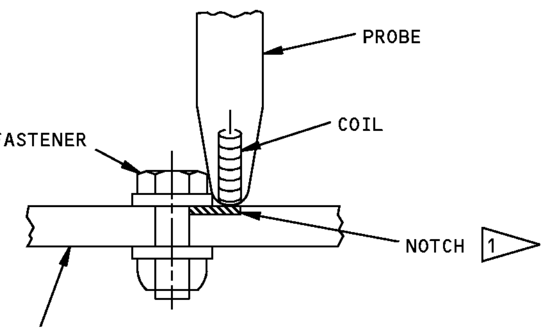
PROBE GUIDE USE FOR INSPECTIONS NEAR FLUSH-HEAD FASTENERS

NOTES

- USE THE HOLE DIAMETER IN THE PROBE GUIDE THAT WILL PERMIT YOU TO FIND CRACKS THAT ARE 0.10 INCH (2.5 MM) IN LENGTH.

1 THE MINIMUM NOTCH LENGTH THAT CAN BE FOUND WITH THIS PROCEDURE IS 0.10 INCH (2.5 MM) FROM THE HEAD OF THE FASTENER

Flush-Head Fastener Inspection Guidelines
Figure 9

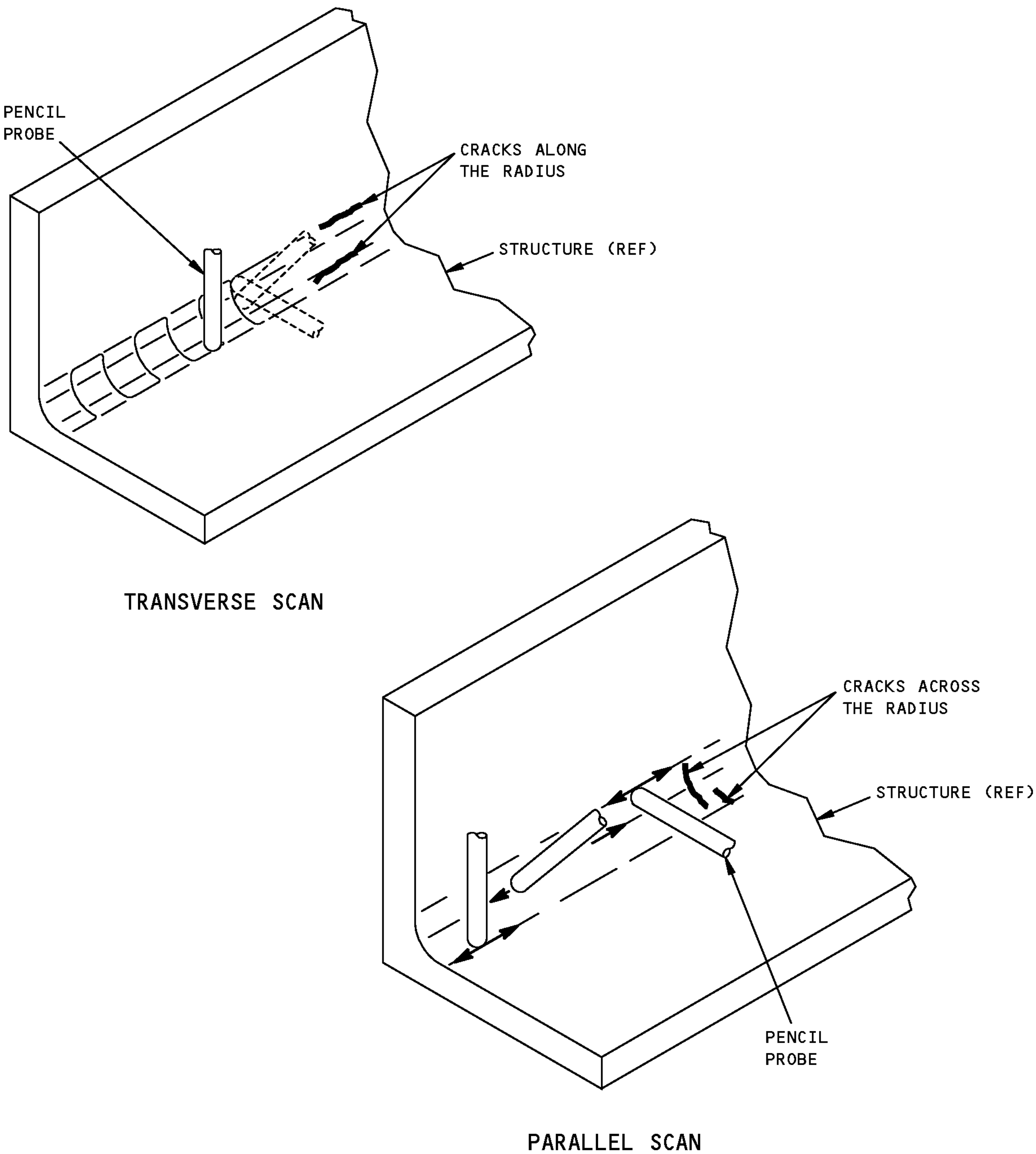


PROBE POSITION FOR INSPECTIONS NEAR PROTRUDING-HEAD FASTENERS

NOTES

- USE THE FASTENER HEAD OR WASHER AS A PROBE GUIDE.
- 1 THE MINIMUM NOTCH LENGTH THAT CAN BE FOUND WITH THIS PROCEDURE IS 0.10 INCH (2.5 MM)

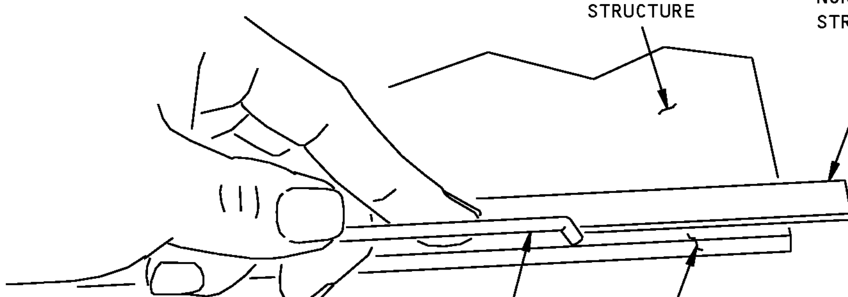
Protruding-Head Fastener Inspection Guidelines
Figure 10

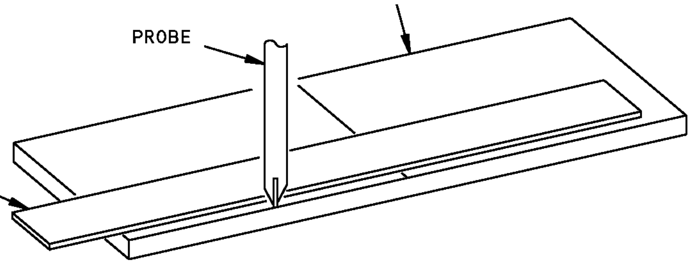


NOTES

- HOLD THE PROBE AS VERTICAL AS POSSIBLE TO THE SURFACE OF THE RADIUS.
- THE LENGTH OF THE CRACK THAT YOU WANT TO FIND AND THE DIAMETER OF THE PROBE WILL SET THE INCREMENT DISTANCE FOR WHICH TO MOVE THE PROBE BETWEEN EACH SCAN.

Radius Inspection
Figure 11

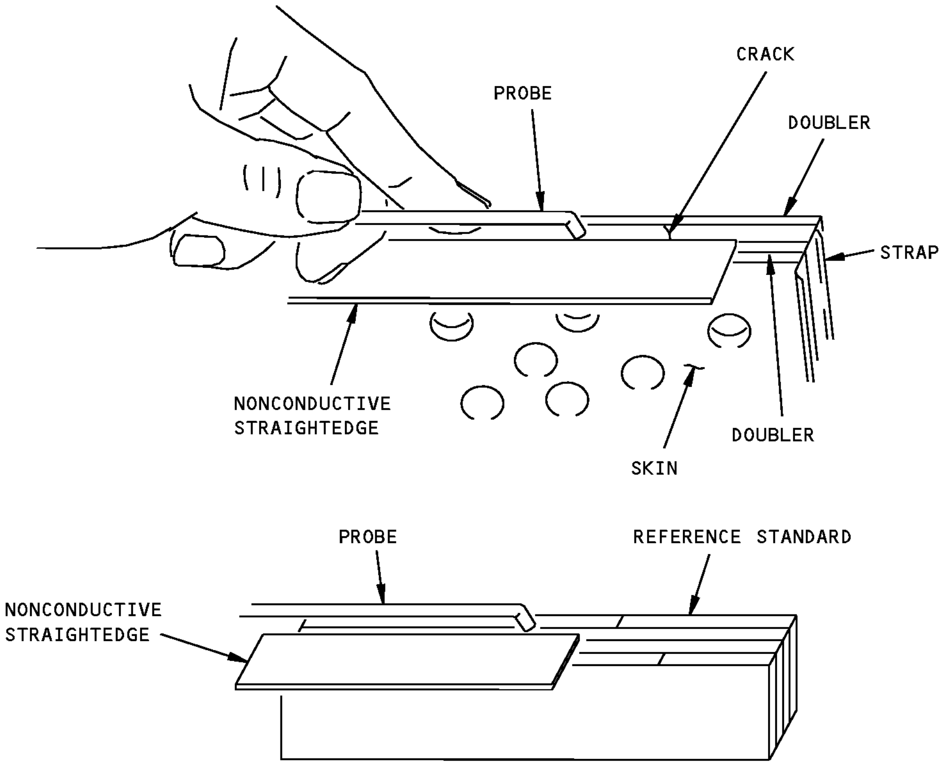




NOTES

- POSITION A NONCONDUCTIVE STRAIGHTEDGE A CONSTANT DISTANCE FROM THE EDGE OF THE STRUCTURE.
- THE MINIMUM DISTANCE THE PROBE MUST BE FROM AN EDGE IS RELATED TO THE DIAMETER OF THE PROBE COIL AND IF THE PROBE IS SHIELDED OR UNSHIELDED.
- TO IDENTIFY THE MINIMUM DISTANCE THE PROBE MUST BE FROM THE EDGE:
  - CALIBRATE THE INSTRUMENT AS SPECIFIED IN PARAGRAPH 4. USE REFERENCE STANDARD 185 FOR HIGH PERMEABILITY STEELS; USE REFERENCE STANDARD NDT1072 FOR LOW PERMEABILITY STEELS.
  - POSITION A NONCONDUCTIVE STRAIGHTEDGE A CONSTANT DISTANCE FROM THE NOTCHED EDGE OF THE REFERENCE STANDARD
  - MOVE THE PROBE ALONG THE STRAIGHT EDGE AND MONITOR THE DISPLAY. THE MINIMUM PROBE TO EDGE DISTANCE OCCURS WHEN THE SIGNAL FROM THE NOTCH FALLS BELOW 90% OF THE SIGNAL YOU GOT DURING CALIBRATION. IF NECESSARY, BALANCE THE INSTRUMENT AGAIN BUT DO NOT CHANGE THE CALIBRATION SENSITIVITY.

Inspection Near an Edge
Figure 12



NOTES

- POSITION A NONCONDUCTIVE STRAIGHTEDGE A CONSTANT DISTANCE FROM THE EDGE OF THE PART TO BE EXAMINED.
- THE MINIMUM WIDTH THAT THE STRUCTURE MUST BE SO THAT YOU CAN IDENTIFY CRACKS IS RELATED TO THE DIAMETER OF PROBE COIL.
- TO IDENTIFY THE MINIMUM WIDTH THE STRUCTURE MUST BE BEFORE YOU CAN EXAMINE IT FOR CRACKS:
  - CALIBRATE THE INSTRUMENT AS SPECIFIED IN PARAGRAPH 4. USE REFERENCE STANDARD 185 FOR HIGH PERMEABILITY STEELS; USE REFERENCE STANDARD NDT1072 FOR LOW PERMEABILITY STEELS.
  - PUT A NONCONDUCTIVE STRAIGHTEDGE A CONSTANT DISTANCE ALONG A NOTCHED PART OF REFERENCE STANDARD 192 FOR HIGH PERMEABILITY STEELS OR REFERENCE STANDARD NDT1075 FOR LOW PERMEABILITY STEELS. SET THE STRAIGHTEDGE SO THE PROBE WILL BE CENTERED ON THE NOTCHED PART
  - MOVE THE PROBE ALONG THE STRAIGHTEDGE AND MONITOR THE DISPLAY. THE MINIMUM STRUCTURE WIDTH IS IDENTIFIED WHEN THE SIGNAL FALLS BELOW 90% OF THE SIGNAL YOU GOT DURING CALIBRATION. IF NECESSARY, BALANCE THE INSTRUMENT AGAIN BUT DO NOT CHANGE THE CALIBRATION SENSITIVITY.

Inspection on an Edge
Figure 13

PART 6 - EDDY CURRENT

SURFACE INSPECTION OF TITANIUM AND OTHER LOW CONDUCTIVITY MATERIALS

1. **Purpose**

   A. This procedure will find surface cracks on titanium structures with the use of a meter display or an impedance plane display instrument. Cracks to be found are those:

      (1) On flat or moderately curved surfaces.

      (2) That come out of fastener holes and extend into the outer area of the fastener head or collar.

      (3) That come out or along a radius.

      (4) That come out to the edge of a part where access is available.

   B. This procedure will also find cracks in other low conductivity materials such as non-magnetic corrosion resistant steels and inconel.

2. **Equipment**

   NOTE: Refer to Part 1, 51-01-00 for data about the manufacturers of the equipment.

   A. Instruments

      (1) To do this procedure, all eddy current instruments with a meter display or an impedance plane display are permitted for use if they:

         (a) Can operate between 990 kHz and 2 MHz.

         (b) Can satisfy the calibration instructions of this procedure.

      (2) The instruments that follow were used to help prepare this procedure:

         (a) Meter display instruments:

            1) MIZ 10, MIZ 10A, MIZ 10B; Zetec, Inc.

            2) Locator UH; Hocking Instruments

         (b) Impedance plane display instruments:

            1) AV100L; Hocking Instruments

            2) NDT-19; Nortec/Staveley, Inc.

            3) MIZ-20A; Zetec, Inc.

   B. Probes

      (1) Shielded pencil probes are recommended, but non-shielded probes can also be used. Be sure the calibration notch in the reference standard can be satisfactorily found with a probe before you use the probe. Use non-shielded probes carefully. Adjacent structures, radii or close edge margins can cause a noise response due to the larger magnetic field of non-shielded probes.

      (2) The probe must operate at frequencies between 990 kHz and 2 MHz.

      (3) The probe configuration must be such that a single coil in the probe tip will contact the test structure.

      (4) Probes are to agree with the configuration and dimensional conditions of Figure 1, and the performance conditions of Figure 2 and Figure 3, as applicable.

      (5) Probes must not give noise responses from usual movement, adjustments, or pressure changes that occur on the sensing coil during normal operation.

C. Reference Standards - Below are the four reference standards used to do an inspection of the usual types of structural configurations.

NOTE: Other reference standards can be used if they are equivalent to those shown in Figure 4 thru Figure 7.

(1) Surface crack standard 1002 as specified in Figure 4.

(2) Flush-head fastener standard 1003 as specified in Figure 5.

(3) Protruding-head fastener standard 1004 as specified in Figure 6.

(4) Edge of part standard 1005 as specified in Figure 7.

3. Prepare for the Inspection

A. Make sure that the instrument, probe, reference standard and the inspection area are at the same temperature.

B. Identify the inspection location(s).

C. If necessary, lightly sand sharp edges of chipped paint to get a smooth inspection surface.

NOTE: It is not necessary to remove paint or other nonconductive layers.

D. Clean the inspection surface.

E. Put the inspection equipment a minimum of 10 feet (3 m) away from all items that make large magnetic fields. Examples of such items include large motors, generators, transformers or power lines.

4. Calibration

A. Set the instrument frequency between 990 kHz and 2 MHz.

B. Calibrate the instrument with the applicable reference standard. Paragraph 5.D. identifies the different types of structural configurations that can be examined. The reference standards to use for the different structural configurations to be examined are:

(1) Large Areas, Near an Edge, On an Edge, Radius: Use reference standard 1002.

(2) Flush Head Fasteners: Use reference standard 1003.

(3) Protruding Head Fasteners: Use reference standard 1004.

C. If the inspection area is painted, make all instrument adjustments with a nonconductive shim on the surface of the reference standard. The shim must be the same thickness as the paint within ± 0.003 inch (0.07 mm).

D. Put the probe on the reference standard surface at least 0.50 inch (13.0 mm) away from the edge of the standard and notch. Balance the instrument as specified in the manufacturers' instructions.

NOTE: If an impedance plane display instrument is used: it is recommended that the balance point be set on the right side of the screen.

E. Adjust the instrument for lift-off.

NOTE: One sheet of regular writing paper, approximately 0.003 inch (0.07 mm) thick, can be used for a nonconductive shim.

(1) If a meter display instrument is used: adjust the instrument so that the meter needle moves no more than 5 percent of full scale when the probe is moved from the surface of the reference standard to a 0.002 to 0.004 inch (0.05 to 0.10 mm) nonconductive shim.

(2) If an impedance plane display instrument is used: adjust the phase control so that the signal moves horizontally from right to left when the probe is lifted off the surface.

F. Move the probe across the reference standard notch to get the maximum signal response.

(1) If a meter display instrument is used: adjust the sensitivity control to get an upward meter needle response difference of 30-60 percent of full scale when the probe is moved from the balance point position across the notch on the reference standard. See Figure 8, Detail I.

(2) If an impedance plane display instrument is used: adjust the sensitivity controls to get a horizontal signal response of 40 percent full screen width and a peak vertical signal response that is between 10 and 30 percent of full screen height. Refer to Figure 9 for screen displays that show horizontal to vertical sensitivity ratios of 1:1, 1:2 and 1:5.

NOTE: The signal to noise ratio must be 3:1, or better. If an impedance plane display instrument is used, adjust the vertical sensitivity if the peak vertical response is below 10 percent of full screen height.

G. It is recommended to use instruments that have audible and/or visual alarms. The use of an alarm can help the scan inspections to be done at increased speeds.

(1) If a meter display instrument is used: set the alarm to alarm at 75 percent of the reference standard notch response. See Figure 8, Detail II.

(2) If an impedance plane display instrument is used: set the alarm to alarm at 75 percent of the peak vertical signal response from the reference standard notch. See Figure 10.

H. To find the maximum speed to do an inspection scan, move the probe across the reference standard notch and increase the scan speed until the results below occur.

(1) If a meter display instrument is used:

(a) Instruments without an alarm:

The needle response starts to go less than 80 percent of the calibration response.

(b) Instruments with an alarm:

The alarm will not operate.

(2) If an impedance plane display instrument is used:

(a) The peak vertical signal response is less than 80 percent of the calibration response.

NOTE: Filter values affect responses. Do not use the High Pass Filter (HPF = 0) and set the Low Pass Filter as high as possible (LPF = 100 Hz usually).

5. Inspection Procedure

A. Prepare for the inspection. Refer to Paragraph 3.

B. Do the instrument calibration. Refer to Paragraph 4.

C. Put the probe on the inspection surface. Do a balance and lift-off check. If necessary, make adjustments on the part surface.

NOTE: Do not adjust sensitivity.

D. Do a scan of all the inspection areas. The best response will occur when the probe is moved across the crack. The maximum speed to do a scan inspection must be no faster than that found in Paragraph 4.H.

E. Usual types of structural configurations and procedures to make a scan inspection of the area:

(1) Large area - A grid system should be used to make a scan inspection. The size of the probe sensing diameter and the minimum crack length which to find, is used to set the distance between each scan. Make an overlap of each scan so that the probe moves 0.05 inch (1.30 mm) (or approximately half of the probe diameter) between each scan.

(2) Flush-head fasteners - Do a scan inspection with the aid of a hole template as a guide. Set the template in such a way to find a crack that extends 0.10 inch (2.50 mm) away from the fastener head. See Figure 11.

(3) Protruding-head fasteners - The probe is moved around the fastener head or washer to find a crack that extends 0.10 inch (2.50 mm) away from the fastener head. See Figure 12.

(4) Radius - To do a scan inspection in the radius, adjust the probe during the scan to keep it as vertical as possible to the surface of the radius. The size of the probe sensing diameter and the minimum crack length which to find, is used to set the distance between each scan. Where the crack angle is unknown, make a scan inspection along and across the radius. See Figure 13.

(5) Edges - A constant distance must be kept between the probe and the edge of the part. The minimum probe-to-edge distance is controlled by the probe sensing diameter. Do a scan inspection near an edge with the aid of a nonconductive straightedge that is a constant distance away from the edge of the part. See Figure 14 for inspections near edges of titanium structures. See Figure 15 for inspections on the edges of titanium structures.

F. Do a check of the instrument/probe calibration responses regularly. For balance and lift-off responses, refer to Paragraph 5.C. For sensitivity responses refer to Paragraph 4.F. If the above responses are unsatisfactory, do a calibration again and make an inspection again of all areas that were examined since the last calibration.

G. Identify all locations that give a response equal to or more than the reference standard notch response.

(1) If a meter display instrument is used: look for a meter needle response where the needle moves upscale fast.

(2) If an impedance plane display instrument is used: look for a vertical signal response. See Figure 16 for examples of signal responses on an impedance plane display.

NOTE: Be careful to keep the probe as vertical to the part surface as possible during the inspection.

6. Inspection Results

A. On a meter display instrument, when the meter needle moves upscale fast, it indicates a possible defect. For impedance plane display instruments, see Figure 16 for signal responses that indicate possible cracks. Compare the defect signal response to the reference standard notch response (make sure the probe is moved at the same speed for each scan inspection).

B. Indications equal to or more than the calibration response.

(1) Meter display instrument: a fast, upscale, meter needle response that is 100 percent or more of the reference standard notch response is a possible crack indication.

(2) Impedance plane display instrument: a peak vertical signal response that is 100 percent or more of the peak vertical signal response of the reference standard notch, is a possible crack indication.

(3) To make an estimate of the end points of the crack, do a scan along the crack until a signal response is no longer received.

(4) It is not possible to make an accurate estimate of crack depth when an electrodischarge machined (EDM) notch is used for the instrument calibration. There is a large difference between the signal response of an (EDM) notch and a fatigue crack of the same size. See Figure 16 for an example of the reference standard notch response and a crack response.

C. Indications less than the calibration response.

(1) Meter display instrument: an irregular indication or an indication that gives an upscale meter needle response that is less than 100 percent of the reference standard notch response can be a sign of a defect condition.

(2) Impedance plane display instrument: a vertical signal response that is less than 100 percent of the reference standard notch response, can be a sign of a defect condition. Below are some ways to help make a decision if a signal response does indicate a defect:

(a) The use of Teflon tape on the sensing coil can make the ratio of the crack-to-noise response better. Calibrate the equipment again when tape is added or removed from the probe sensing area.

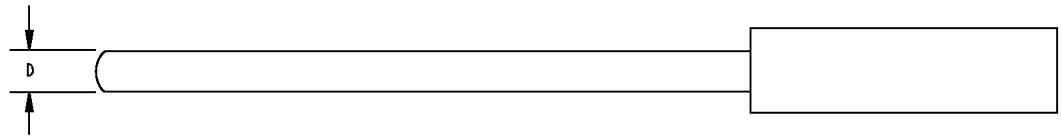
(b) When moved across a possible crack, the probe should move the same distance as when it moves across the reference standard notch.

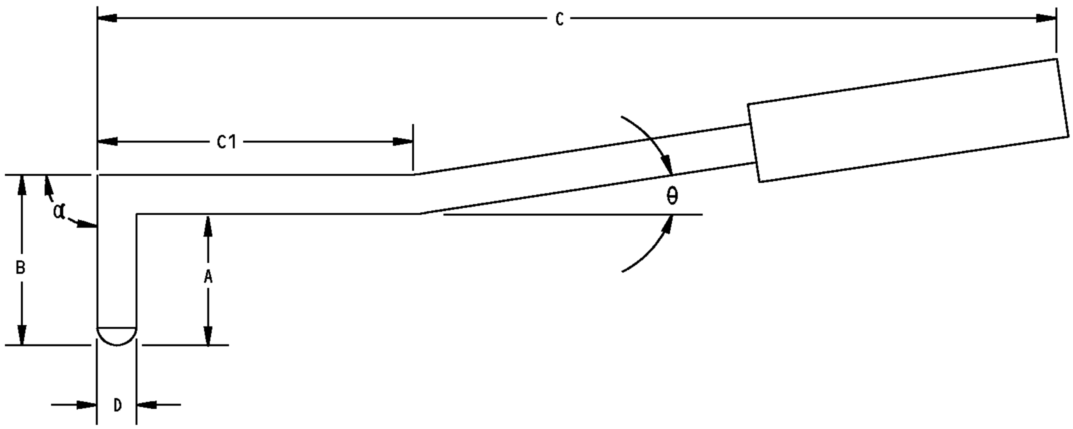
D. Other inspection methods can be used to do a check of a positive crack-like eddy current response. The inspection methods below are not as sensitive as eddy current for in-service conditions. Be careful when you compare the eddy current results with the results of one or both of the inspection methods identified below. Examples of other inspection methods are as follows:

(1) Visual inspection of the bare surface examined at 10 to 25 times magnification with a sufficient quantity of light. If a crack is found by this method, no other inspection is necessary.

(2) High sensitivity fluorescent penetrant inspection. Refer to D6-51702, SOPM 20-20-02, "Penetrant Methods of Inspection."

NOTE: To make penetrant results show better on areas with metal smear or on tight fatigue cracks, do a chemical etch on the surface. To do an etch, local engineering approval is necessary.





NOTES

- THE PROBE CONFIGURATIONS SHOWN ABOVE CAN ACCESS MOST AREAS TO DO INSPECTIONS WHEN PENCIL PROBES ARE NECESSARY. SHIELDED PENCIL PROBES ARE RECOMMENDED. WHEN A SPECIAL PROBE CONFIGURATION IS NECESSARY, SPECIFY THE PROBE DIMENSIONS AS SHOWN FOR PROBE 2.

A - THE PROBE DROP, OR DIMENSION A

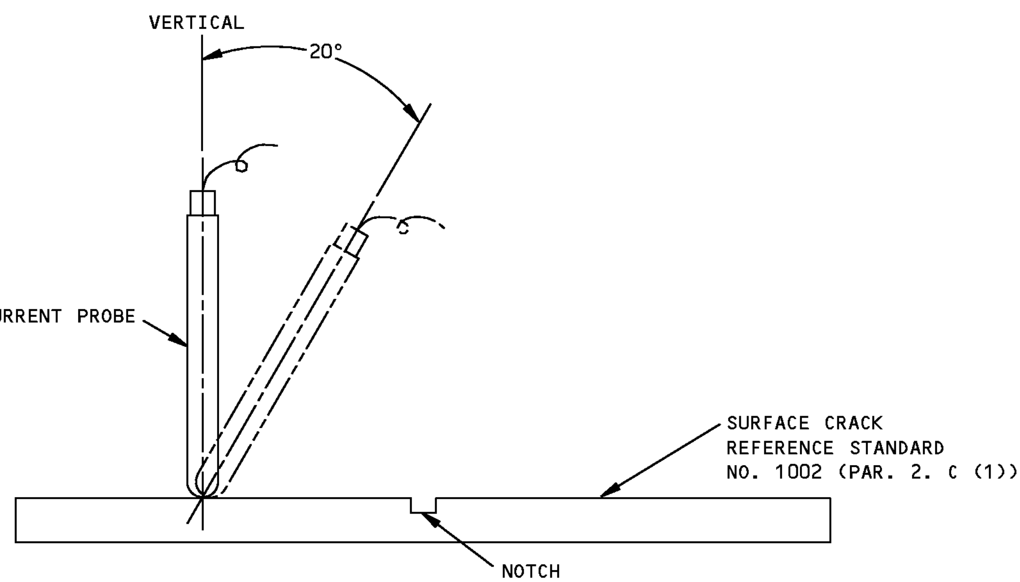
B - THE PROBE HEIGHT, OR DIMENSION B

C - THE PROBE HANDLE LENGTH, OR DIMENSION C. IF THE HANDLE IS TO BE BENT, DIMENSION C1 AND THE HANDLE ANGLE (ANGLE THETA - θ) WILL NEED TO BE SPECIFIED. FOR MOST APPLICATIONS THE PROBE LENGTH WILL BE 3-5 INCHES (76.0-127.0 MM).

D - DIAMETER: 0.20 INCH (5.00 MM) MAXIMUM. 0.12 INCH (3.00 MM) RECOMMENDED FOR AREAS WITH LIMITED ACCESS.

α - THE DESIRED ANGLE (ANGLE ALPHA).

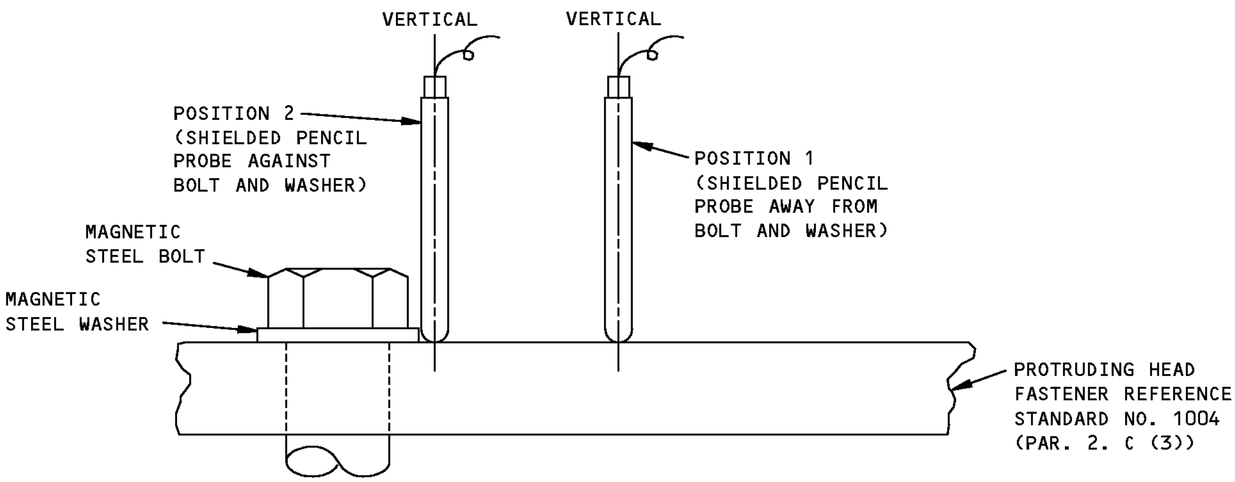
Example of Pencil Probe Configurations
Figure 1



NOTES

- TO FIND THE PENCIL PROBE ANGLE LIMIT:
  1. CALIBRATE THE PROBE/INSTRUMENT ON REFERENCE STANDARD NO. 1002 AS SPECIFIED IN PARAGRAPH 4.
  2. MOVE THE PROBE AT AN ANGLE OF 20 DEGREES FROM THE VERTICAL POSITION, IN DIFFERENT DIRECTIONS, ON THE SURFACE OF THE REFERENCE STANDARD. FOR METER DISPLAY INSTRUMENTS, THE PROBE ANGLE MUST NOT CAUSE THE SIGNAL TO CHANGE MORE THAN 10 PERCENT OF THE DISPLAY. FOR IMPEDANCE PLANE DISPLAY INSTRUMENTS, THE PROBE ANGLE MUST NOT CAUSE THE SIGNAL TO CHANGE MORE THAN 40 PERCENT OF FULL SCREEN WIDTH OR 10 PERCENT OF FULL SCREEN HEIGHT.
  3. DO A SCAN ACROSS THE NOTCH WITH THE PROBE HELD VERTICAL TO THE SURFACE AND AGAIN WITH THE PROBE HELD AT A 20 DEGREE ANGLE FROM THE VERTICAL POSITION. THE NOTCH SENSITIVITY MUST NOT DECREASE MORE THAN 30 PERCENT OF THE CALIBRATION RESPONSE FOR METER DISPLAY INSTRUMENTS. FOR IMPEDANCE PLANE INSTRUMENTS THE NOTCH SENSITIVITY MUST NOT DECREASE MORE THAN 30 PERCENT OF THE PEAK VERTICAL NOTCH RESPONSE.

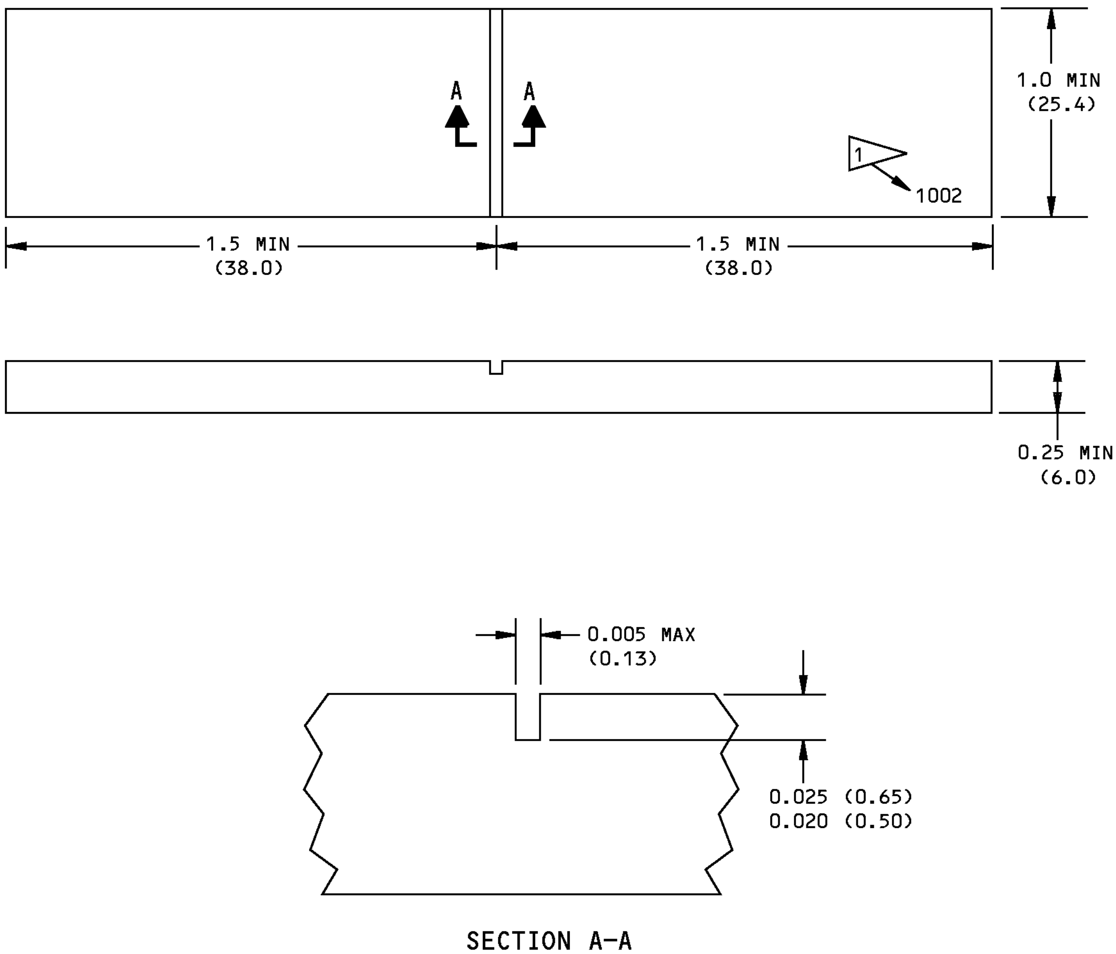
Pencil Probe Angle Limit Performance
Figure 2



NOTES

- TO FIND IF A SHIELDED PENCIL PROBE HAS SUFFICIENT SHIELDING:
  1. CALIBRATE THE PROBE/INSTRUMENT ON REFERENCE STANDARD NO. 1004 AS SPECIFIED IN PARAGRAPH 4.
  2. PUT THE PROBE ON THE PROTRUDING-HEAD REFERENCE STANDARD AT POSITION 1 AND MOVE THE PROBE TO POSITION 2. THE MAGNETIC STEEL MUST NOT CAUSE MORE THAN A 10 PERCENT SIGNAL CHANGE OF THE CALIBRATION NOTCH RESPONSE. IF THE SIGNAL CHANGE IS MORE THAN 10 PERCENT, IT CAN BE POSSIBLE TO DO A SCAN AROUND THE FASTENER AT A CONSTANT DISTANCE FROM THE FASTENER.

Pencil Probe Shielding Performance
Figure 3

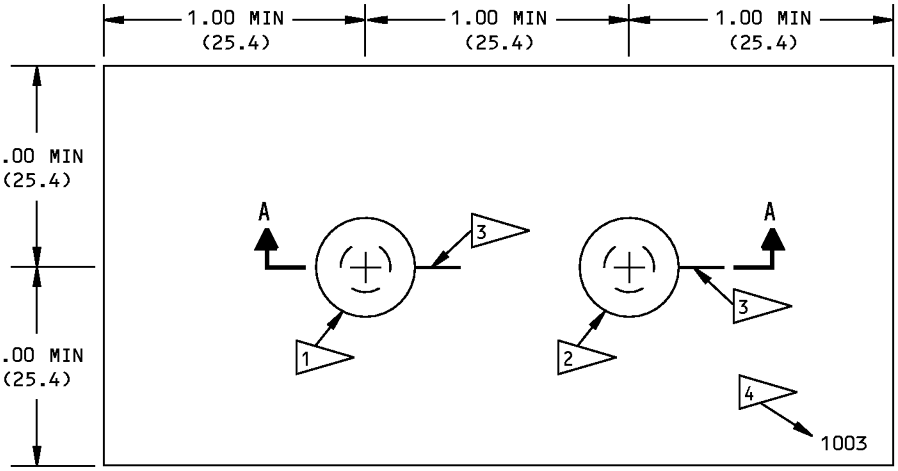


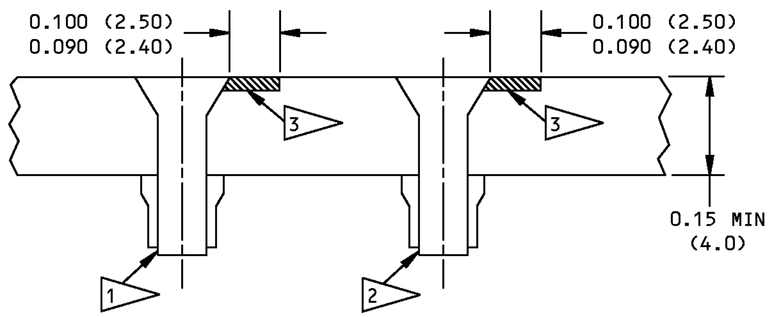
NOTES

- DRAWING IS NOT TO SCALE.
- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES).
- MATERIAL: 6AL-4V TITANIUM ALLOY.
- SURFACE FINISH: 63 OR BETTER.

1 ETCH OR STEEL STAMP WITH 1002.

Surface Crack Reference Standard
Figure 4





SECTION A-A

NOTES

- DRAWING IS NOT TO SCALE.
- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES).
- MATERIAL: 6AL-4V TITANIUM ALLOY.
- SURFACE FINISH: 63 OR BETTER.

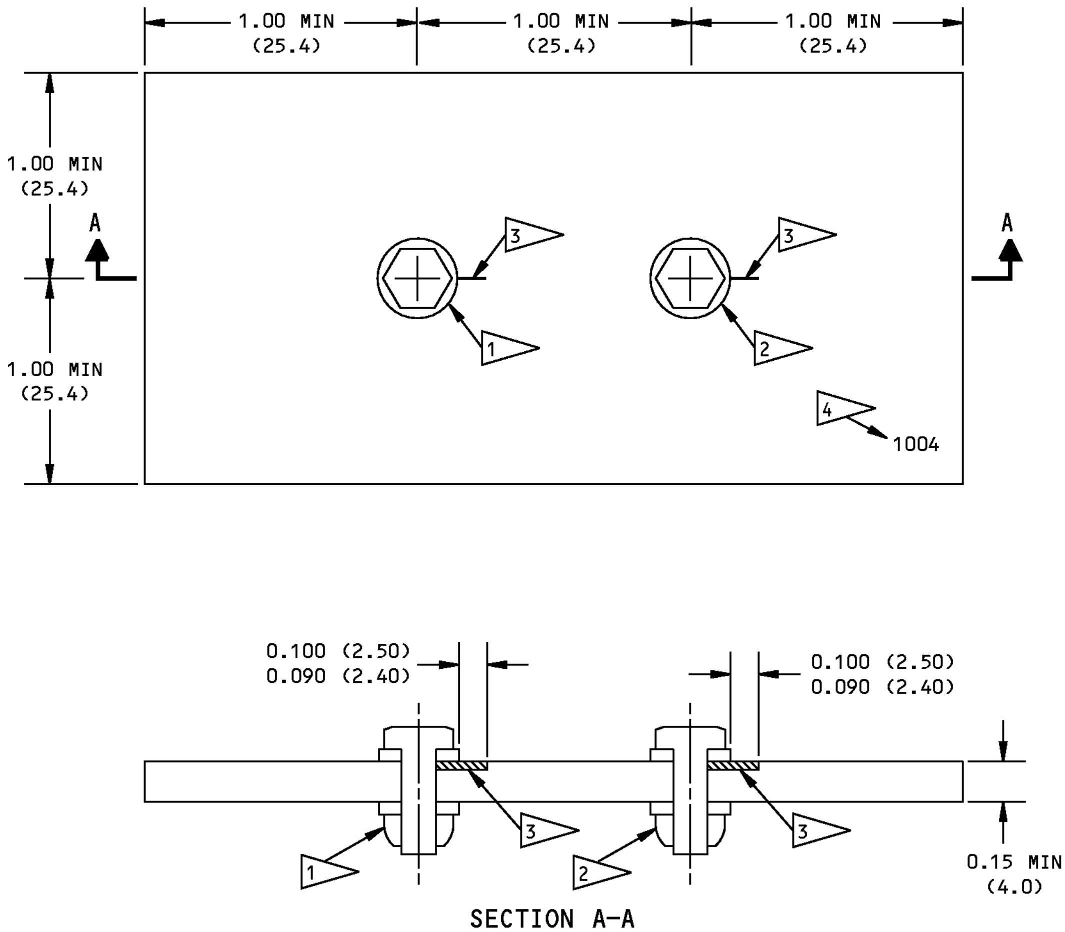
1 FASTENER - 0.25 (6.40) DIAMETER FLUSH-HEAD STEEL BOLT, SUCH AS BACB30JC8-* (REFERENCE STANDARDS THAT HAVE BEEN MADE WITH STEEL RIVETS ARE SATISFACTORY FOR USE).

2 FASTENER - 0.25 (6.40) DIAMETER FLUSH-HEAD TITANIUM BOLT, SUCH AS BACB30NY8K-* (REFERENCE STANDARDS THAT HAVE BEEN MADE WITH TITANIUM RIVETS ARE SATISFACTORY FOR USE).

3 NOTCH - 0.005 (0.13) MAXIMUM WIDTH, 0.035-0.040 (0.90-1.00) DEPTH.

4 ETCH OR STEEL STAMP WITH 1003.

Flush-Head Fastener Reference Standard
Figure 5



NOTES

- DRAWING IS NOT TO SCALE.
- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES).
- MATERIAL: 6AL-4V TITANIUM ALLOY.
- SURFACE FINISH: 63√ OR BETTER.

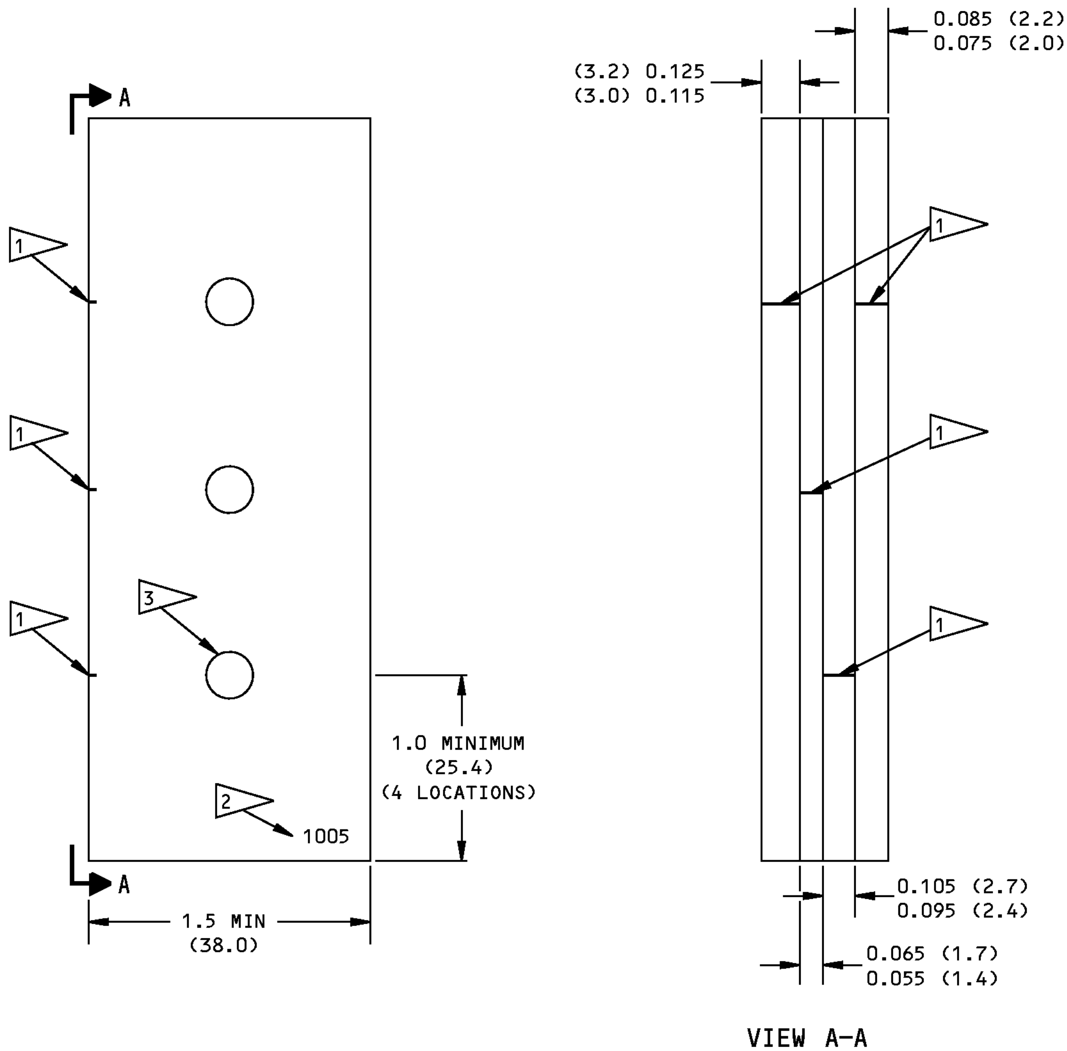
1 FASTENER - 0.25 (6.40) DIAMETER EXTERNAL WRENCHING STEEL BOLT, SUCH AS BACB30NF4-*; FLAT STEEL WASHER, SUCH AS AN960-416.

2 FASTENER - 0.25 (6.40) DIAMETER EXTERNAL WRENCHING TITANIUM BOLT, SUCH AS BACB30NM4K*; FLAT ALUMINUM WASHER, SUCH AS AN960D-416.

3 NOTCH - 0.005 (0.13) MAXIMUM WIDTH, 0.035-0.040 (0.90-1.00) DEPTH.

4 ETCH OR STEEL STAMP WITH 1004.

Protruding-Head Fastener Reference Standard
Figure 6

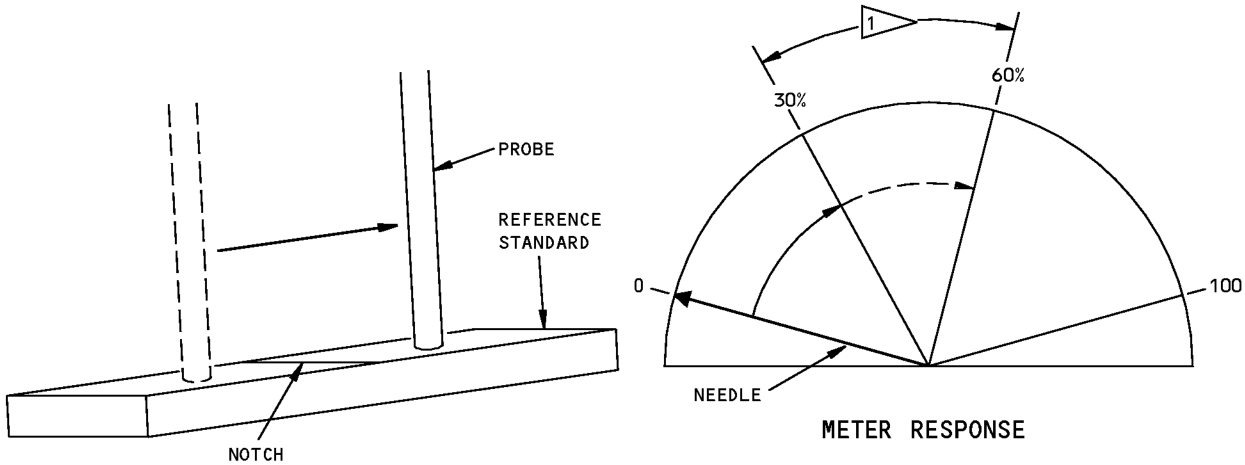


NOTES

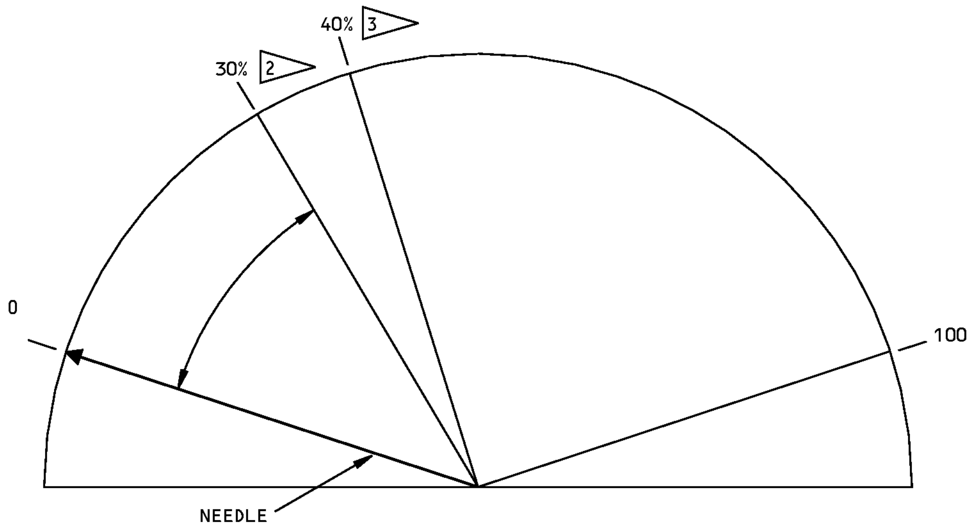
- DRAWING IS NOT TO SCALE.
- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES).
- MATERIAL: 6AL-4V TITANIUM ALLOY, ALL PIECES MUST BE OF THE SAME ALLOY.
- SURFACE FINISH: 63 OR BETTER.

1. NOTCH - 0.005 (0.13) MAXIMUM WIDTH, 0.035 TO 0.040 (0.90 TO 1.00) DEPTH.
2. ETCH OR STEEL STAMP WITH 1005.
3. FASTENER - A STEEL OR TITANIUM FASTENER WITH A HEAD DIAMETER LESS THAN 0.50 (13.0), (3 LOCATIONS).

Edge of Part Reference Standard
Figure 7



SENSITIVITY ADJUSTMENT
DETAIL I



METER RESPONSE

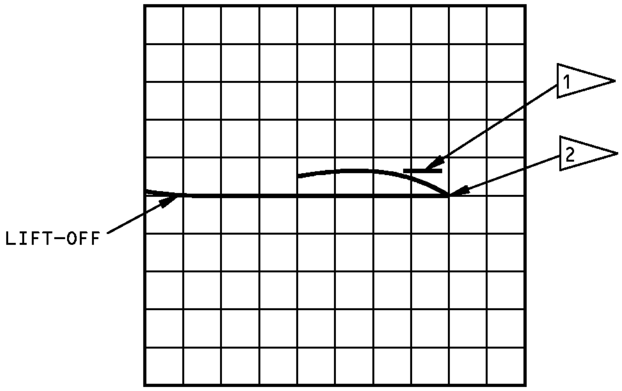
ALARM ADJUSTMENT
DETAIL II

1 ADJUST THE SENSITIVITY TO GET A 30 TO 60 PERCENT NEEDLE DIFFERENCE AS THE PROBE IS MOVED ACROSS THE REFERENCE STANDARD NOTCH.

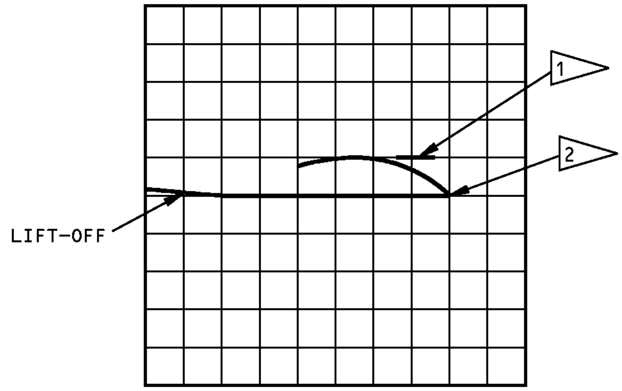
2 ALARM RESPONSE SET POINT (ADJUST THE ALARM TO ALARM AT 75 PERCENT OF THE REFERENCE STANDARD NOTCH RESPONSE).

3 REFERENCE STANDARD NOTCH RESPONSE (EXAMPLE).

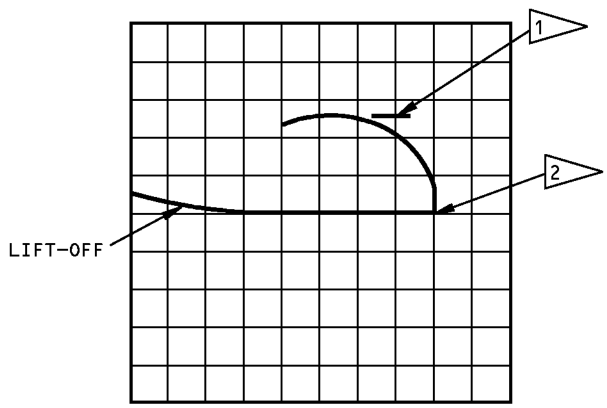
Meter Display Sensitivity and Alarm Adjustments
Figure 8



SCREEN DISPLAY OF THE NOTCH SIGNAL RESPONSE WITH A HORIZONTAL TO VERTICAL SENSITIVITY RATIO OF 1:1



SCREEN DISPLAY OF THE NOTCH SIGNAL RESPONSE WITH A HORIZONTAL TO VERTICAL SENSITIVITY RATIO OF 1:2



SCREEN DISPLAY OF THE NOTCH SIGNAL RESPONSE WITH A HORIZONTAL TO VERTICAL SENSITIVITY RATIO OF 1:5

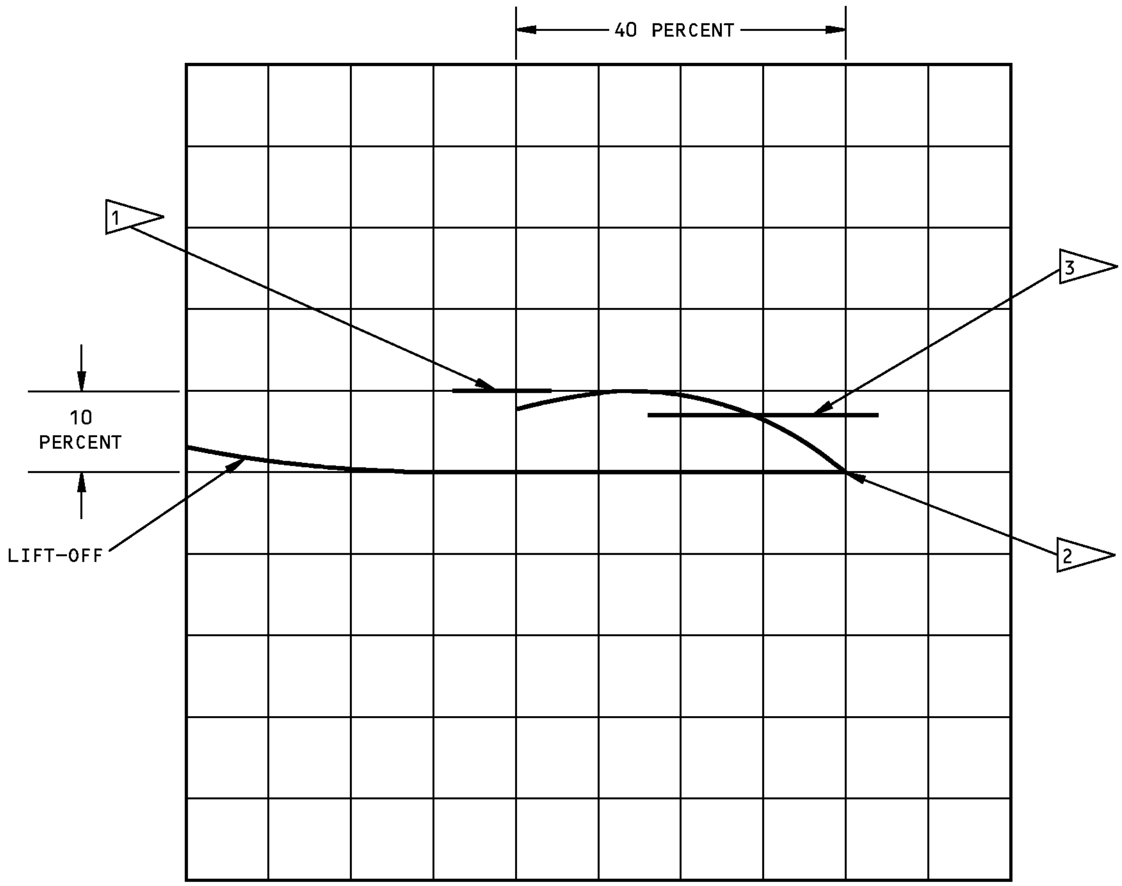
NOTES

- THE SCREEN DISPLAY EXAMPLES ABOVE ARE TO SHOW THE SIGNAL RESPONSES OF THE SURFACE CRACK REFERENCE STANDARD NOTCH AT HORIZONTAL TO VERTICAL SENSITIVITY RATIOS OF 1:1, 1:2, AND 1:5.

1 PEAK VERTICAL SIGNAL RESPONSE OF THE SURFACE CRACK REFERENCE STANDARD NOTCH.

2 BALANCE POINT

Impedance Plane Display Notch Responses
Figure 9



NOTES

- THE SCREEN DISPLAY EXAMPLE ABOVE SHOWS WHERE TO SET THE ALARM AS SPECIFIED IN PARAGRAPH 4.G.(2).

1 PEAK VERTICAL SIGNAL RESPONSE OF THE SURFACE CRACK REFERENCE STANDARD NOTCH.

2 BALANCE POINT

3 ALARM START POSITION AS SPECIFIED IN PARAGRAPH 4.G.(2) (THE ALARM IS SET TO ALARM AT 75 PERCENT OF THE PEAK VERTICAL SIGNAL THAT OCCURS FROM THE REFERENCE STANDARD NOTCH).

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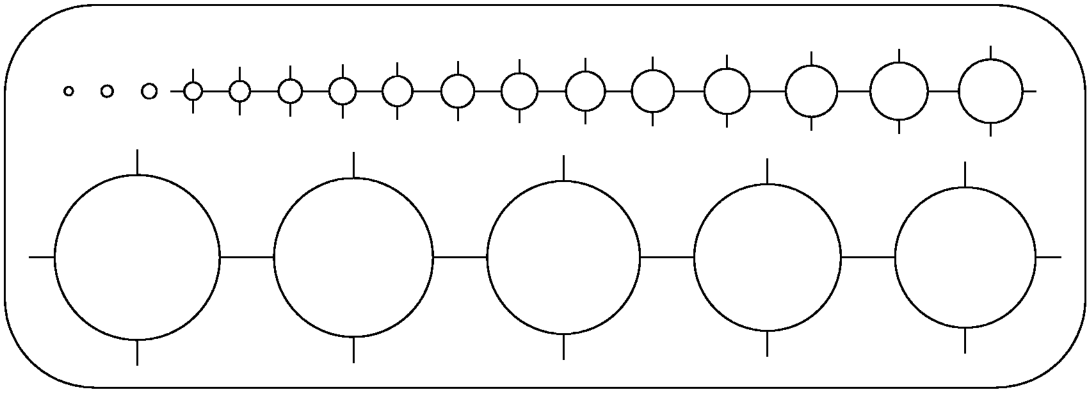
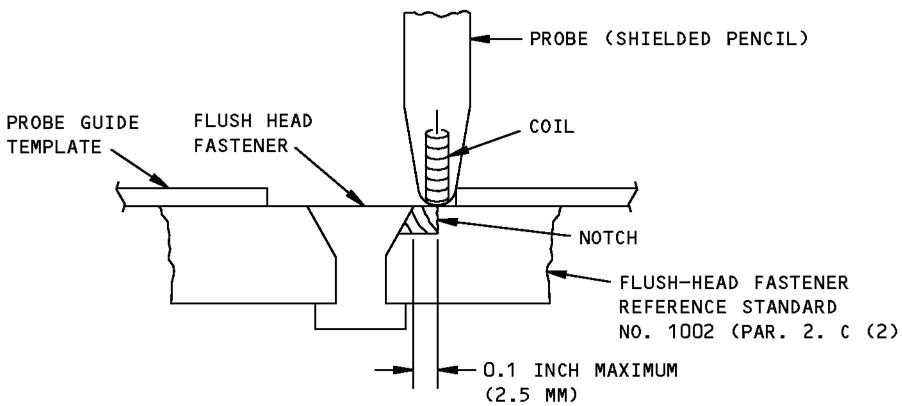
Impedance Plane Display Alarm Adjustment
Figure 10



PROBE GUIDE TEMPLATE
(NONCONDUCTIVE CIRCLE TEMPLATE)

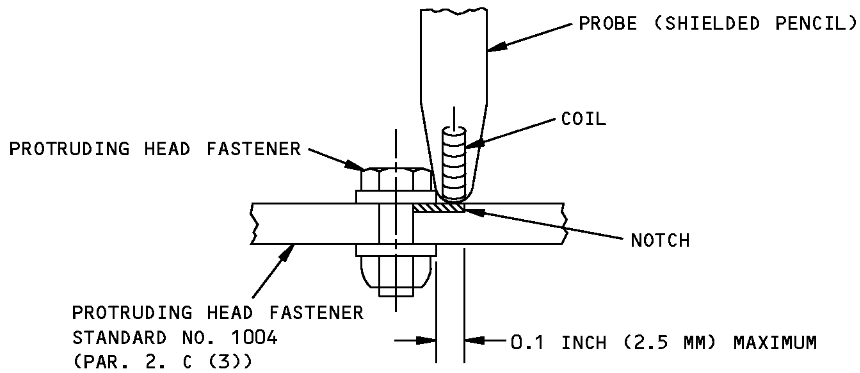


FASTENER INSPECTION WITH A PROBE GUIDE TEMPLATE

NOTES

- TO DO A CHECK OF THE PROBE/INSTRUMENT SENSITIVITY FOR A 0.09-0.10 INCH (2.30-2.50 MM) NOTCH ON REFERENCE STANDARD NO. 1003, CONTINUE AS FOLLOWS:
  1. CALIBRATE THE EQUIPMENT ON REFERENCE STANDARD NO. 1003 AS SPECIFIED IN PARAGRAPH 4.
  2. USE THE PROBE GUIDE TEMPLATE TO HELP DO A SCAN AROUND THE FASTENER. USE A HOLE OF THE PROBE GUIDE TEMPLATE THAT, WHEN THE PROBE IS MOVED ALONG THE HOLE EDGE, WILL CAUSE A MAXIMUM SIGNAL RESPONSE WHEN THE FASTENER IS IN THE CENTER OF THE HOLE.

Flush-Head Fastener Inspection Guidelines
Figure 11

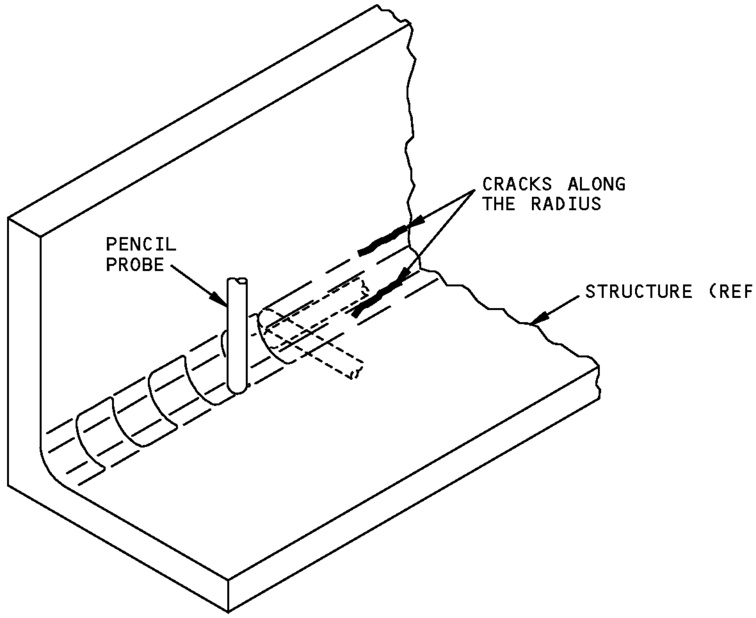


FASTENER INSPECTION WITH THE FASTENER HEAD AS A GUIDE

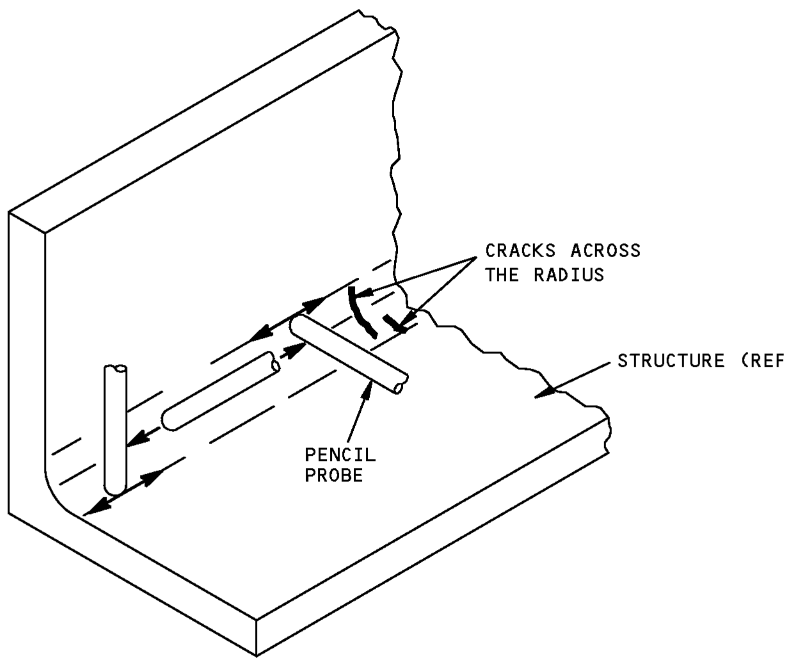
NOTES

- TO DO A CHECK OF THE PROBE/INSTRUMENT SENSITIVITY FOR A 0.09-0.10 INCH (2.30-2.50 MM) NOTCH ON REFERENCE STANDARD NO. 1004, CONTINUE AS FOLLOWS:
  1. CALIBRATE THE EQUIPMENT ON REFERENCE STANDARD NO. 1004 AS SPECIFIED IN PARAGRAPH 4.
  2. USE THE FASTENER HEAD OR WASHER AS A TEMPLATE TO DO A SCAN AROUND THE FASTENER.

Protruding Head Fastener Inspection Guidelines
Figure 12



TRANSVERSE SCAN

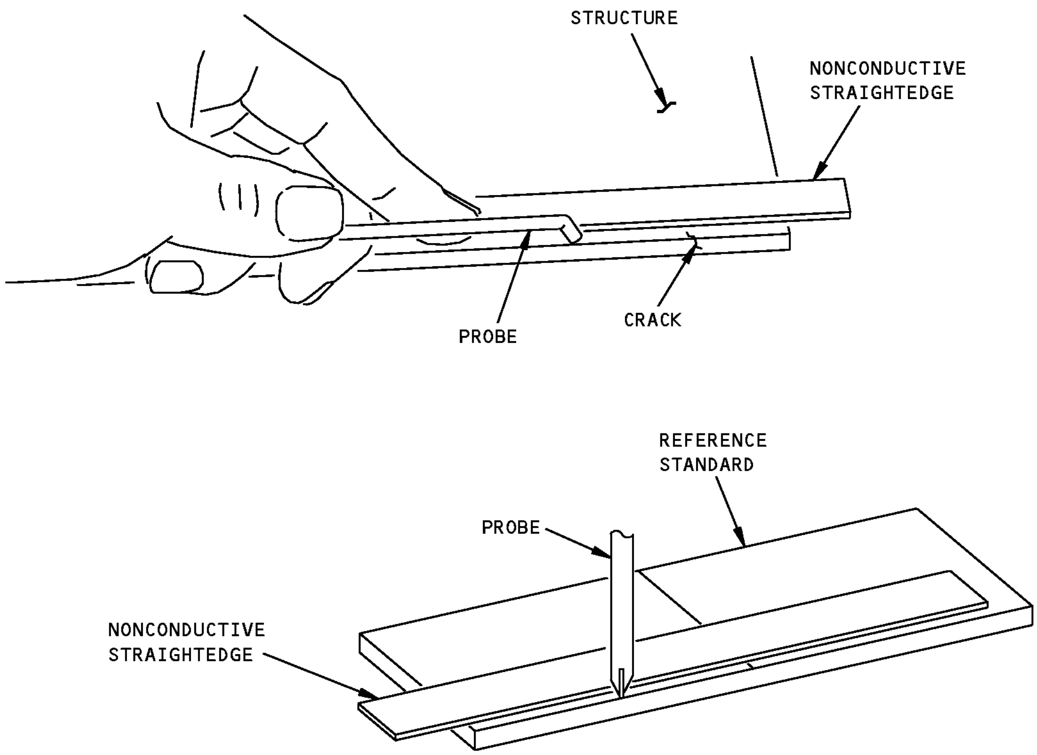


PARALLEL SCAN

NOTES

- HOLD THE PROBE VERTICAL TO THE RADIUS
- THE CRACK SIZE THAT YOU WANT TO FIND AND THE SIZE OF THE PROBE SENSING DIAMETER WILL SET THE DISTANCE YOU NEED TO MOVE THE PROBE BETWEEN EACH SCAN.

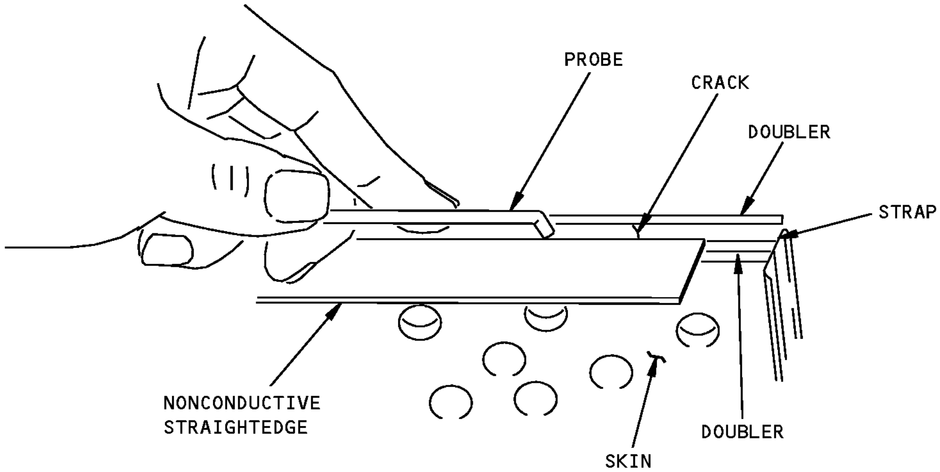
Radius Inspection
Figure 13

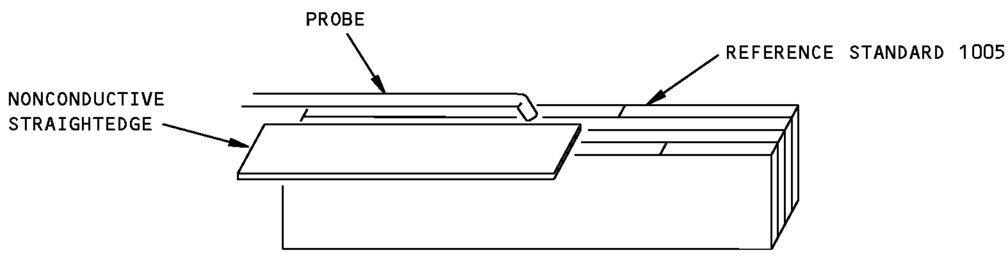


NOTES

- PUT A NONCONDUCTIVE STRAIGHTEDGE A CONSTANT DISTANCE AWAY FROM THE EDGE OF THE STRUCTURE.
- THE MINIMUM PROBE-TO-EDGE SPACING IS CONTROLLED BY THE PROBE COIL SENSING AREA.
- TO FIND THE MINIMUM PROBE-TO-EDGE DISTANCE:
  1. CALIBRATE THE EQUIPMENT ON REFERENCE STANDARD 1002 AS SPECIFIED IN PARAGRAPH 4.
  2. PUT THE NONCONDUCTIVE STRAIGHTEDGE A CONSTANT DISTANCE AWAY FROM THE NOTCHED EDGE OF REFERENCE STANDARD 1002.
  3. DO A SCAN ALONG THE STRAIGHTEDGE AND MONITOR THE SIGNAL.
  4. THE MINIMUM PROBE-TO-EDGE DISTANCE OCCURS WHEN THE SIGNAL FROM THE NOTCH FALLS BELOW 90% OF THE SIGNAL THAT YOU GOT DURING CALIBRATION.

Inspection Near an Edge
Figure 14

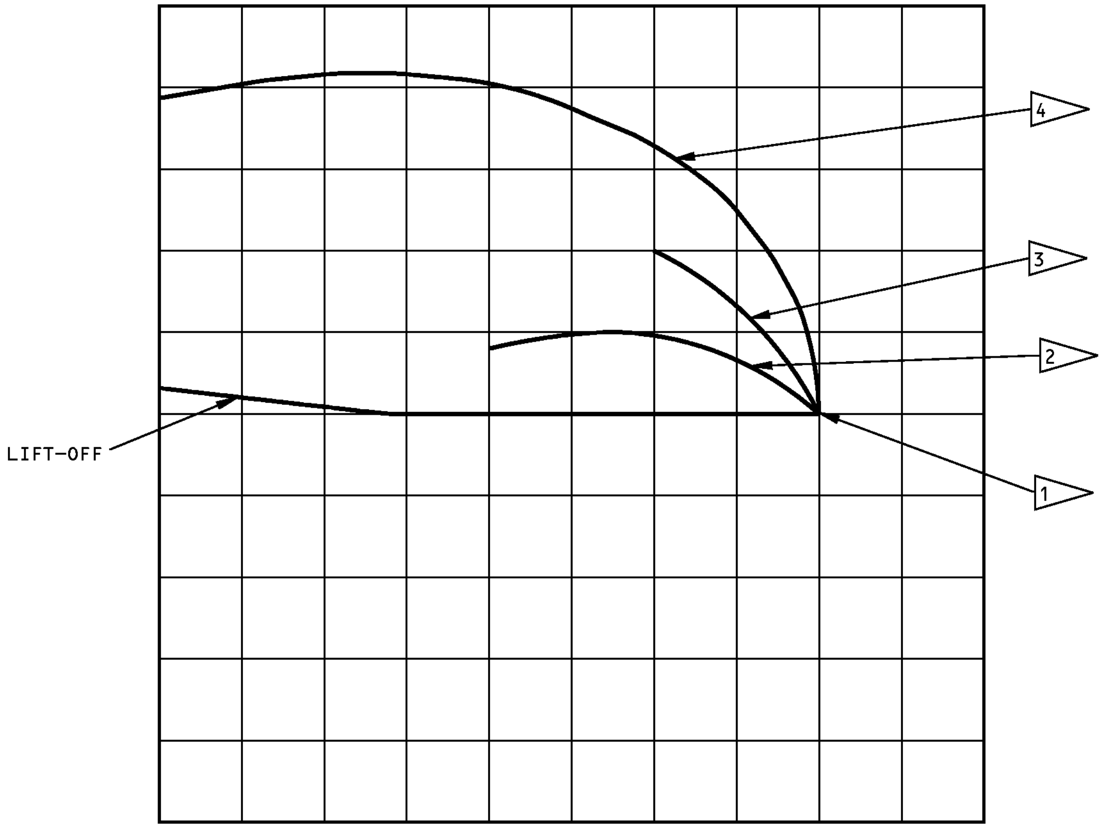




NOTES

- TO KEEP A CONSTANT DISTANCE, PUT A NONCONDUCTIVE STRAIGHTEDGE ON THE EDGE OF THE STRUCTURE THAT IS TO BE EXAMINED.
- THE MINIMUM STRUCTURE WIDTH TO FIND A CRACK IS CONTROLLED BY THE PROBE COIL SENSING AREA.
- TO FIND THE MINIMUM STRUCTURE WIDTH:
  1. CALIBRATE THE EQUIPMENT ON REFERENCE STANDARD 1005 AS SPECIFIED IN PARAGRAPH 4.
  2. PUT THE NONCONDUCTIVE STRAIGHTEDGE ALONG THE EDGE OF ONE OF THE NOTCHED PIECES OF REFERENCE STANDARD 1005. THE NONCONDUCTIVE STRAIGHTEDGE KEEPS THE PROBE A CONSTANT DISTANCE FROM THE EDGE OF THE PIECE.
  3. DO A SCAN ALONG THE STRAIGHTEDGE AND MONITOR THE SIGNAL.
  4. THE MINIMUM STRUCTURE WIDTH IS IDENTIFIED WHEN THE SIGNAL FROM THE NOTCH FALLS BELOW 90% OF THE SIGNAL YOU GOT DURING CALIBRATION.

Inspection On an Edge
Figure 15



NOTES

- THE SCREEN DISPLAY ABOVE SHOWS WHAT THE SIGNAL RESPONSES FROM THE NOTCH IN REFERENCE STANDARD NO. 1002 AND A 0.020 INCH (0.50 MM) DEEP CRACK SHOULD LOOK LIKE WITH A HORIZONTAL TO VERTICAL SENSITIVITY RATIO OF 1:2.
- THE SCREEN DISPLAY SIGNAL RESPONSES ARE DONE WITH A 1 MHZ SHIELDED PENCIL PROBE. OTHER PROBES AND FREQUENCIES COULD GIVE DIFFERENT SIGNAL RESPONSES TO THE NOTCH AND CRACK.

1 BALANCE POINT
2 0.020 INCH (0.50 MM) NOTCH RESPONSE FROM REFERENCE STANDARD NO. 1002.
3 0.020 INCH (0.50 MM) FATIGUE CRACK RESPONSE
4 EDGE EFFECT RESPONSE

Impedance Plane Display of a Notch and Crack Response
Figure 16

PART 6 - EDDY CURRENT

OPEN HOLE INSPECTION OF TITANIUM AND OTHER LOW CONDUCTIVITY MATERIALS

1. **Purpose**

   A. This procedure does an eddy current inspection of open fastener holes in titanium parts with the use of a rotary scanner. The minimum material thickness that can be examined during this procedure is 0.020 inch (0.50 mm).

   B. This procedure will find fatigue cracks as small as 0.030 inch (0.75 mm). Instrument calibration is done on a 0.050 inch (1.25 mm) reference corner notch which has been found to give signals equivalent to a 0.030 inch (0.75 mm) fatigue crack in titanium.

   C. This procedure will also find cracks in other low conductivity materials such as non-magnetic corrosion resistant steels and inconel.

2. **Equipment**

   NOTE: Refer to Part 1, 51-01-00 for data on equipment manufacturers.

   A. All eddy current instruments with a rotary scanner that can be calibrated as specified in this procedure can be used.

      (1) Instrument - An eddy current instrument that can operate in the dynamic mode (time related display) with a rotary scanner is necessary to do this procedure. The instrument must operate between 1 MHz and 2 MHz. The instruments that follow were used to help prepare this procedure.

         (a) Phasec 1.1; Hocking/Krautkramer

         (b) Defectoscop D2.831; Institute Dr. Forster

         (c) Elotest B1; Rohmann GmbH

         (d) NDT-19; Nortec/Staveley Inc.

         (e) AV100SE; Hocking/Krautkramer

      (2) Rotary Scanner - To do this procedure, a rotary scanner is necessary. The rotary scanner is used to automatically turn the probe connected to it. The rate at which the probe is turned is controlled by the eddy current instrument. The rate of probe movement through a fastener hole is controlled by the operator.

   B. Probes - Refer to Figure 1 and Figure 2 for examples of probe configurations for use with the rotary scanner. Probes that can be expanded for a close fit in the fastener hole are recommended. To do this procedure, the instrument and probe must be able to get the necessary lift-off and sensitivity results. Fastener hole probes must have these properties:

      (1) Probes must operate in a frequency range between 1 MHz and 2 MHz.

      (2) The probes must have a differential-bridge coil or a differential-reflection coil.

      (3) The probes must operate with a minimum 5:1 signal-to-noise ratio on the reference standard and a minimum 3:1 signal-to-noise ratio on the part to be examined.

      (4) Use a probe with a diameter that is correct for the size of the fastener hole to be examined:

         (a) If you use a probe that cannot be expanded, make sure the difference between the hole diameter and the probe outer diameter is not more than 0.010 inch (0.25 mm).

         (b) Probes that can be expanded must be set so that there is a light interference fit when the probe is put into the fastener hole.

         NOTE: If the probe fit is too tight, the probe will not rotate freely and will wear quickly.

      (5) These probes were used to prepare this procedure:

(a) 0.125 inch (3.18 mm) diameter, BPD-10, NDT Engineering Corp.

(b) 0.125 inch (3.18 mm) diameter, VMED101-.125, VM Products, Inc.

(c) 0.187 inch (4.75 mm) diameter, BPD-12, NDT Engineering Corp.

(d) 0.187 inch (4.75 mm) diameter, VMED101-.187, VM Products, Inc.

(e) 0.187 inch (4.75 mm) - 0.250 inch (6.35 mm) diameter, adjustable probe; BXEM-12/16, NDT Engineering Corp.

NOTE: These probes need an adapter for use with the NDT-19 rotary scanner. The probes have a four-pin Fischer connector.

C. Reference Standards - Fastener hole reference standards must have EDM notches. See Figure 3 for the correct notch size. A reference standard for each hole size to be examined is necessary unless expandable probes are used. Reference standards can be different than those specified in Figure 3 if the hole sizes, EDM notches, locations, and EDM notch sizes agree with the conditions specified in Figure 3.

3. Preparation for Inspection

A. Identify the inspection location(s) and the size of the fastener holes to be examined.

B. Clean loose dirt and sealant from inside the fastener hole.

C. Visually look in all holes to be eddy current examined for surface conditions that can cause rejectable noise signals during the inspection. Borescopes, endoscopes, or other optical aids can be used to help the visual inspection. Look for these conditions:

(1) burrs

(2) galling

(3) out-of-round holes

NOTE: If a cleanup ream is necessary to remove one or more of these conditions, a 63 RHR or better surface finish is necessary. Get local Engineering approval to do a cleanup ream.

4. Instrument Calibration

A. Connect the rotary scanner to the instrument.

B. Make sure the instrument is on and let it warm up. Refer to the instrument instruction manual for operation instructions.

C. Get the applicable reference standard and probe.

D. Connect the probe to the rotary scanner.

E. Set the instrument frequency to between 1 MHz and 2 MHz.

F. If possible, set the speed above 1000 RPM. Rotary scanner speeds less than 1000 RPM are not recommended because it is not as easy to find a short defect at the lower speed.

G. Set the instrument in the impedance plane mode (X/Y). Make sure the rotary scanner is on and put the probe into the reference standard hole. Make sure the probe coil is away from the EDM notch.

H. Balance the instrument. Refer to the instrument instruction manual. Use the instrument vertical and horizontal position controls to put the signal at approximately the center of the screen.

NOTE: If your instrument does not have a balance function, ignore this step and go to Paragraph 4.I..

I. Put the probe on the surface of the reference standard. With the phase control, adjust the lift-off signal to the horizontal position. See Figure 4.

J. Change the instrument display to the timesweep mode. To do this, make sure the sweep function is on. Refer to the instrument instruction manual.

K. If the instrument filters are set automatically when the rotary scanner is connected, go to Paragraph 4.L. If the instrument filters are not set automatically when the rotary scanner is connected, it will be necessary to set the filters manually. Use the steps that follow to adjust the filters.

(1) High Pass Filters (HP) - Increase the filter to maximum or until the reference notch signal is decreased by 50 percent. This will decrease low frequency noise signals.

(2) Low Pass Filters (LP) - Decrease to the lowest adjustment possible that does not cause the reference notch signal height to decrease.

(3) Band Pass (BP) - If available, it is an alternative to the high pass and low pass filters. Adjust to get the best signal-to-noise ratio. A minimum signal to noise ratio of 5:1 is necessary.

NOTE: If the speed of the rotary scanner is changed, the filters will need to be adjusted. The maximum high pass filter adjustment must not be higher than the low pass filter adjustment.

L. Put the probe in the hole of the reference standard.

M. Adjust the instrument gain (vertical) to get a 40 to 60 percent full screen height signal. See Figure 5. A minimum signal-to-noise ratio of 5:1 is necessary. See Figure 6. Adjust the instrument gain and filter controls to get the necessary signal-to-noise ratio. Refer to Paragraph 4.K. for data on how to adjust the filters.

NOTE: To get a better signal-to-noise ratio, you can add a 0.003-inch (0.076 mm) thick plastic tape to the probe coil area.

N. Find the maximum speed that the probe can be moved through a fastener hole. To do this, follow these steps:

(1) Move the probe through the reference standard used to set the screen calibration. Refer to Paragraph 4.L.

(2) Monitor the response level of the instrument because of the reference standard notch.

(3) Increase the speed the probe is moved through the reference standard until the signal from the notch drops to 90 percent of the calibration level. This is the maximum speed that the probe can be moved through a fastener hole.

O. The use of an audible or visual alarm is recommended. Set the alarm to operate at a signal that is 50 percent of the reference standard notch signal.

P. The location of a crack or notch signal on the timebase line is directly related to the location of the crack or notch in the fastener hole. See Figure 7.

5. Inspection Procedure

A. Prepare for the inspection. Refer to Paragraph 3.

B. Do the instrument calibration. Refer to Paragraph 4.

NOTE: Do not change the control settings from those you get during calibration.

C. Examine all necessary fastener holes. To do this, make sure the rotary scanner unit is on and move the probe smoothly through the length of each fastener hole. Do not do a scan faster than the scan rate found in Paragraph 4.N. Do an instrument calibration check regularly and after all fastener holes have been examined. If the sensitivity has decreased since the last calibration, all the fastener holes examined since the last calibration must be examined again.

NOTE: If plastic tape is not used, an approved light oil or grease can be put on the probe coil area to help decrease probe wear.

D. Do Paragraph 5.A. thru Paragraph 5.C. for each size fastener hole to be examined.

E. Make a record of all fastener hole locations where a crack signal occurs. Also make a record of those fastener holes where it is necessary to do a cleanup ream before a satisfactory inspection can be made. Refer to Paragraph 3.

F. Do a minimum approved cleanup ream on those fastener holes recorded in Paragraph 5.E. where a cleanup ream is necessary.

NOTE: Get local Engineering approval to do a cleanup ream.

G. Make an inspection again of all fastener holes where a ream was necessary.

6. Inspection Results

A. Fastener holes with no crack signals are acceptable. An eddy current crack signal will look almost the same as the reference standard notch signal and will give at least the same amplitude. Tight cracks will produce increased crack to lift-off phase angles and as a result, a crack will give more vertical amplitude than an EDM notch of the same depth.

B. Noise signals can make it hard to see crack signals. If the signal-to-noise ratio between the reference standard notch signal and the inspection surface noise level is less than 3:1, refer to Paragraph 3.C.

C. Fastener holes with crack signals that are 50 percent or more of the reference standard notch signal must be rejected.

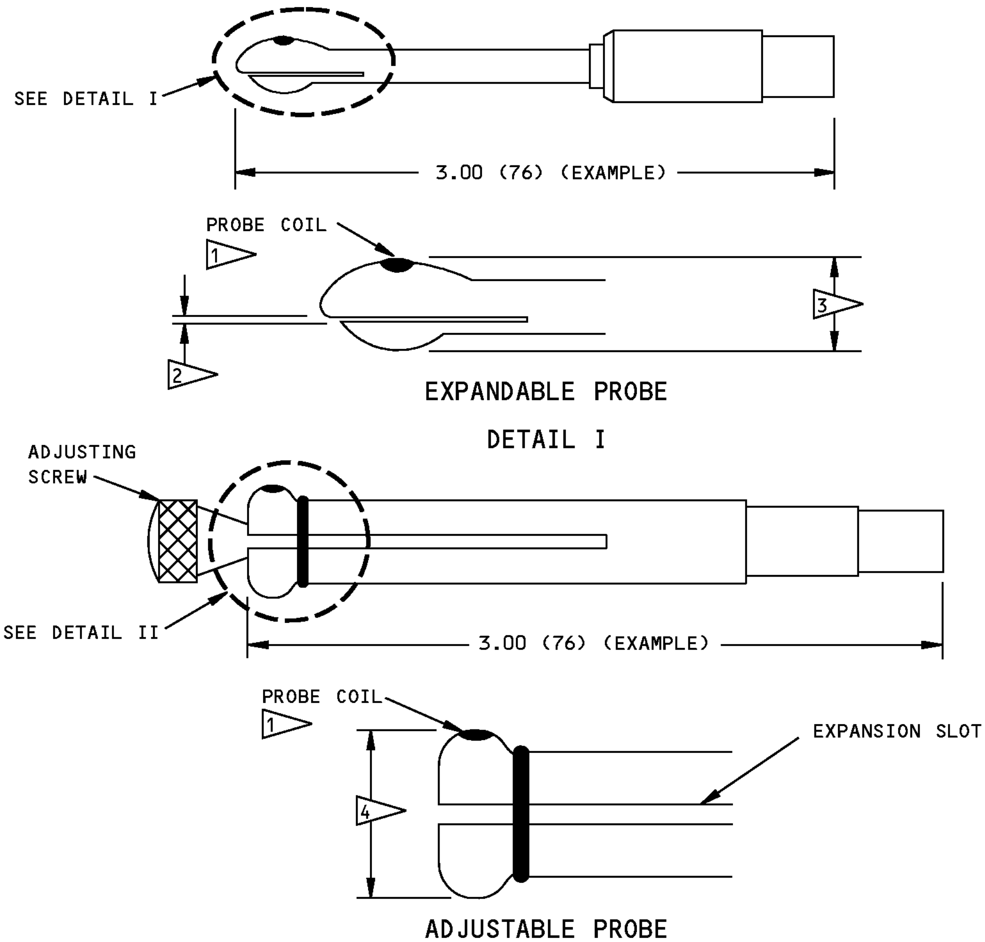
NOTE: If it is necessary to oversize a hole to remove a crack, you must get Engineering approval. Ask the Engineering group for the maximum amount of oversize allowed.

D. To remove a crack, oversize the hole to the minimum amount that has been approved by Engineering and do an eddy current inspection again. If the eddy current crack signal was not removed by the first oversize ream, continue to oversize the minimum approved, but do not exceed the maximum allowed by Engineering. Do an eddy current inspection after each oversize ream to see if the crack has been removed. If no eddy current crack signals are seen after the oversize ream, it is recommended to do another ream. This is called the "insurance cut". This "insurance cut" is done to make sure that a crack too small to find by the eddy current inspection is fully removed.

E. A fastener hole with an eddy current signal that looks almost the same as a crack but is less than 50 percent of the reference standard notch signal, must be examined in more detail. Examine by:

(1) Doing a visual inspection of the fastener hole. Look for surface conditions that can cause an eddy current crack signal. Refer to Paragraph 3.C.. If a surface condition is seen in the same location as the eddy current signal on the screen display (Figure 7), the fastener hole can be accepted. If no surface conditions are seen that could be the cause of the eddy current signal, go to Paragraph 6.E.(2))

(2) Ream the fastener hole the minimum amount approved and do an eddy current inspection again. If no eddy current crack signals are seen after a ream, do an "insurance cut". If the eddy current signal was not removed after the hole was oversized, report this to your local Engineering group.



NOTES

- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES)
- THE USUAL PROBE CONFIGURATION IS SHOWN. DIFFERENT PROBE MANUFACTURERS MAKE PROBES THAT ARE SYMMETRICALLY DIFFERENT OR HAVE DIFFERENT END CONNECTOR FITTINGS

1 PROBES MUST HAVE A DIFFERENTIAL-BRIDGE COIL OR A DIFFERENTIAL-REFLECTION COIL

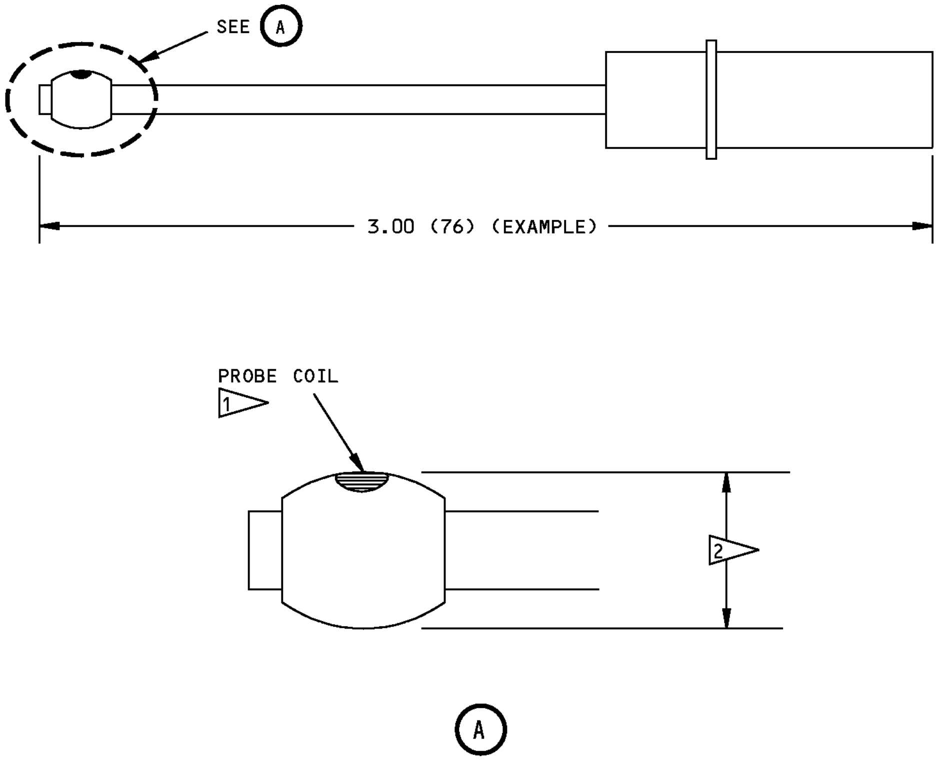
2 0.020-0.030 (0.50-0.76) EXPANSION SLOT. THE SLOT MUST PERMIT THE PROBE TO BE EXPANDED UP TO 0.063 (1.60)

3 THE PROBE HEAD DIAMETER MUST FIT THE INSPECTION HOLE. USUAL PROBE HEAD DIAMETERS ARE: 0.187 (4.75)
0.250 (6.35)
0.312 (7.92)
0.375 (9.53)
0.437 (11.1)
0.500 (12.7)

4 THE PROBE IS ADJUSTABLE FOR THE DIAMETER RANGE SPECIFIED ON THE PROBE BODY. THE USUAL NDT ENGINEERING PROBES THAT WILL DO AN INSPECTION OF HOLE DIAMETERS FROM 0.188-0.875 (4.75-22.2) ARE:

BXU-12/16	0.187-0.250	(4.75-6.35)
BXU-16/20	0.250-0.312	(6.35-7.92)
BXU-20/24	0.312-0.375	(7.92-9.53)
BXU-24/28	0.375-0.437	(9.53-11.1)
BXU-28/32	0.437-0.500	(11.1-12.7)
BXU-32/40	0.500-0.625	(12.7-15.8)
BXU-40/48	0.625-0.750	(15.8-19.1)
BXU-48/56	0.750-0.875	(19.1-22.2)

Example of Expandable and Adjustable Fastener Hole Probes
Figure 1



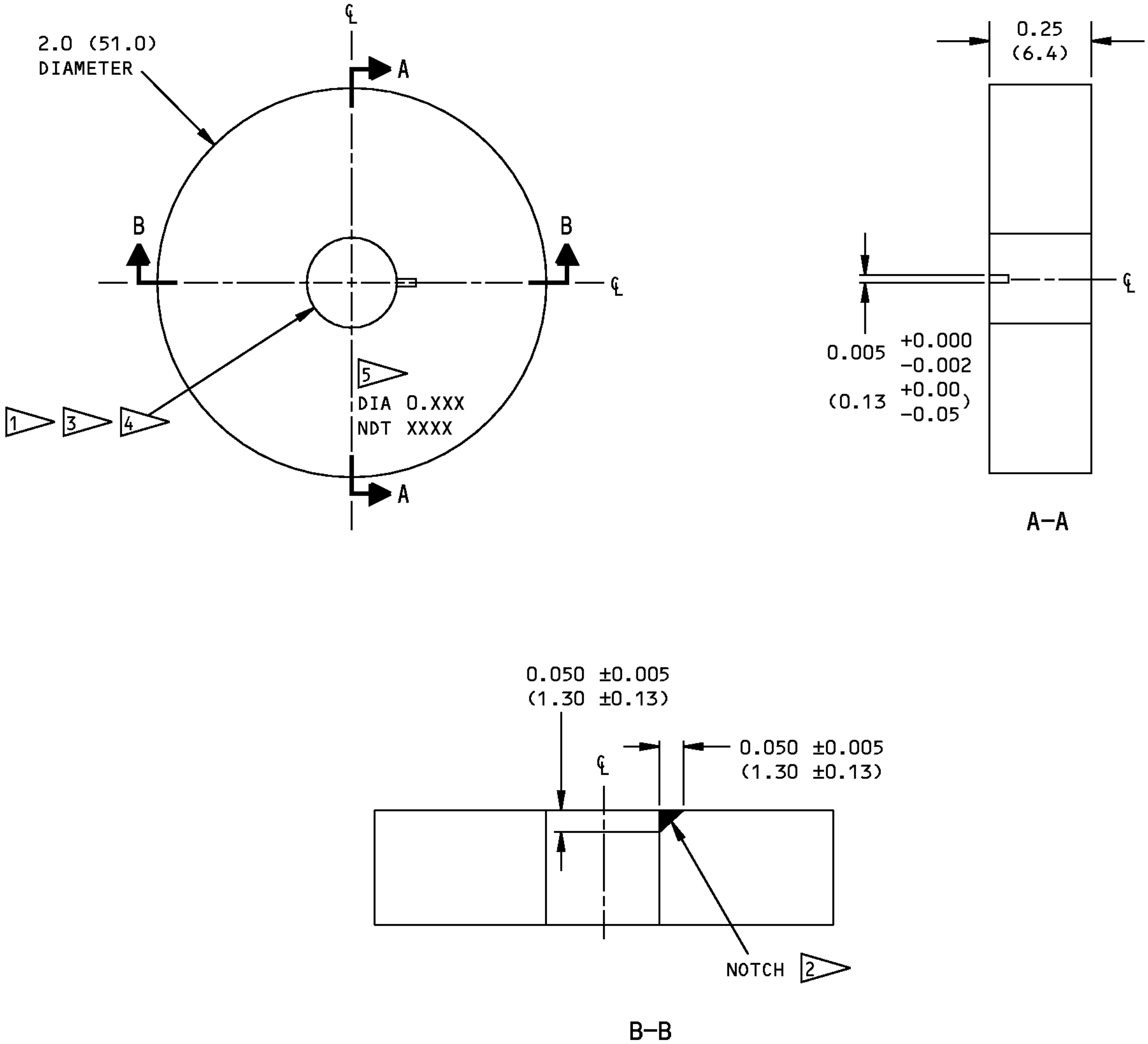
NOTES

- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES)
- THE USUAL PROBE CONFIGURATION IS SHOWN. DIFFERENT PROBE MANUFACTURERS MAKE PROBES THAT ARE SYMMETRICALLY DIFFERENT OR HAVE DIFFERENT END CONNECTOR FITTINGS
- USE PROBES SO THAT THE DIFFERENCE BETWEEN THE HOLE DIAMETER AND THE PROBE OUTER DIAMETER IS NOT GREATER THAN 0.010 (0.25)

1 PROBES MUST HAVE A DIFFERENTIAL-BRIDGE COIL OR A DIFFERENTIAL-REFLECTION COIL

2 THE PROBE HEAD DIAMETER MUST FIT THE INSPECTION HOLE. DIFFERENT PROBE SIZES ARE AVAILABLE TO ORDER.

Example of a Fastener Hole Probe that is not Adjustable
Figure 2



NOTES

- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES)
- TOLERANCE ON ALL DIMENSIONS IS ±0.050 (1.27) OR AS NOTED
- MATERIAL: 6AL−4V TITANIUM ALLOY

1 FINISH THE REAM HOLE TO 63 RA. DO NOT DEBURR

2 ELECTRICAL DISCHARGE MACHINE (EDM) NOTCH. REFER TO THE GIVEN DIMENSIONS

3 WHEN PROBES THAT ARE NOT ADJUSTABLE ARE USED, THE HOLE DIAMETER OF THE REFERENCE STANDARD MUST EQUAL THE FASTENER HOLE TO BE EXAMINED

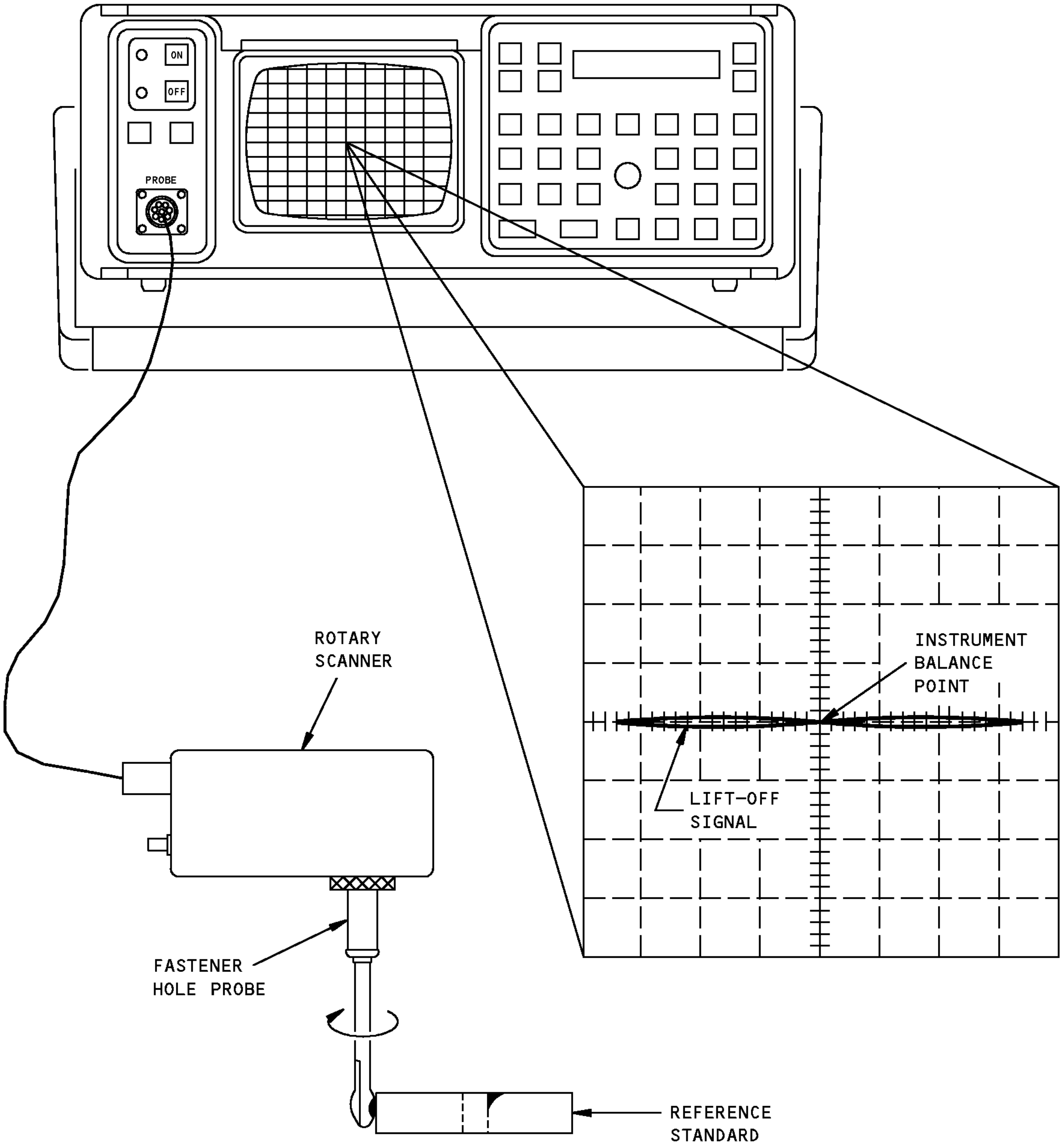
4 REFERENCE STANDARD HOLE DIAMETERS FOR ADJUSTABLE PROBES:

REFERENCE STANDARD PART NUMBER	HOLE DIAMETER
NDT1022	0.188 (4.76)
NDT1023	0.250 (6.35)
NDT1024	0.313 (7.94)
NDT1025	0.375 (9.53)
NDT1026	0.438 (11.11)
NDT1027	0.500 (12.7)

TOLERANCE ON ALL HOLES: ±0.005 (±0.13)

5 IDENTIFY THE HOLE DIAMETER AND THE REFERENCE STANDARD PART NUMBER ON THE REFERENCE STANDARD. (THE LOCATION FOR THESE IDENTIFICATION MARKS IS OPTIONAL)

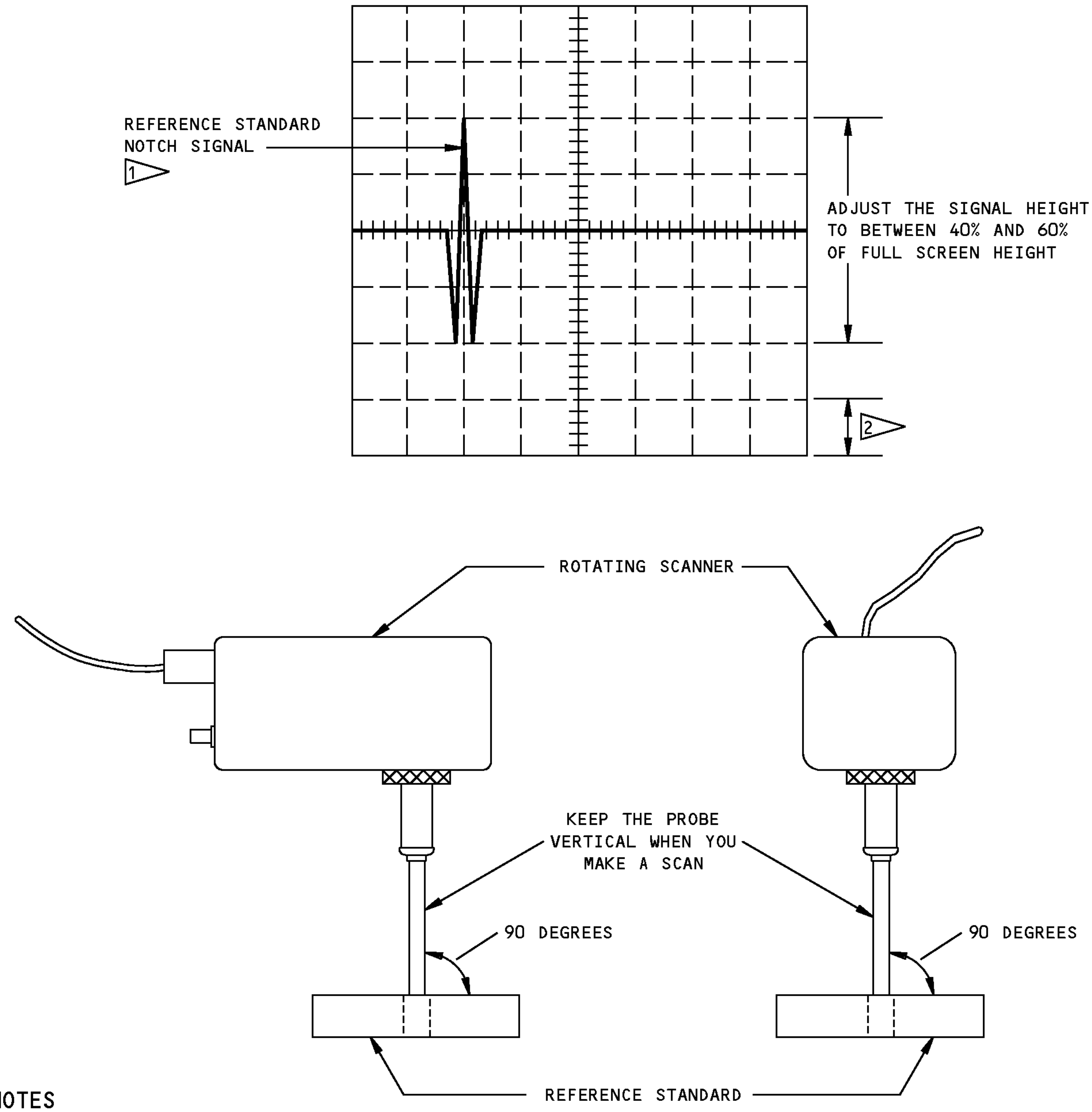
Reference Standard
Figure 3



NOTE

- WITH THE ROTARY SCANNER ON, AND THE PROBE AGAINST THE SIDE OF THE REFERENCE STANDARD, USE THE PHASE CONTROL TO TURN THE LIFT-OFF SIGNAL TO THE HORIZONTAL POSITION

Phase Adjustment
Figure 4

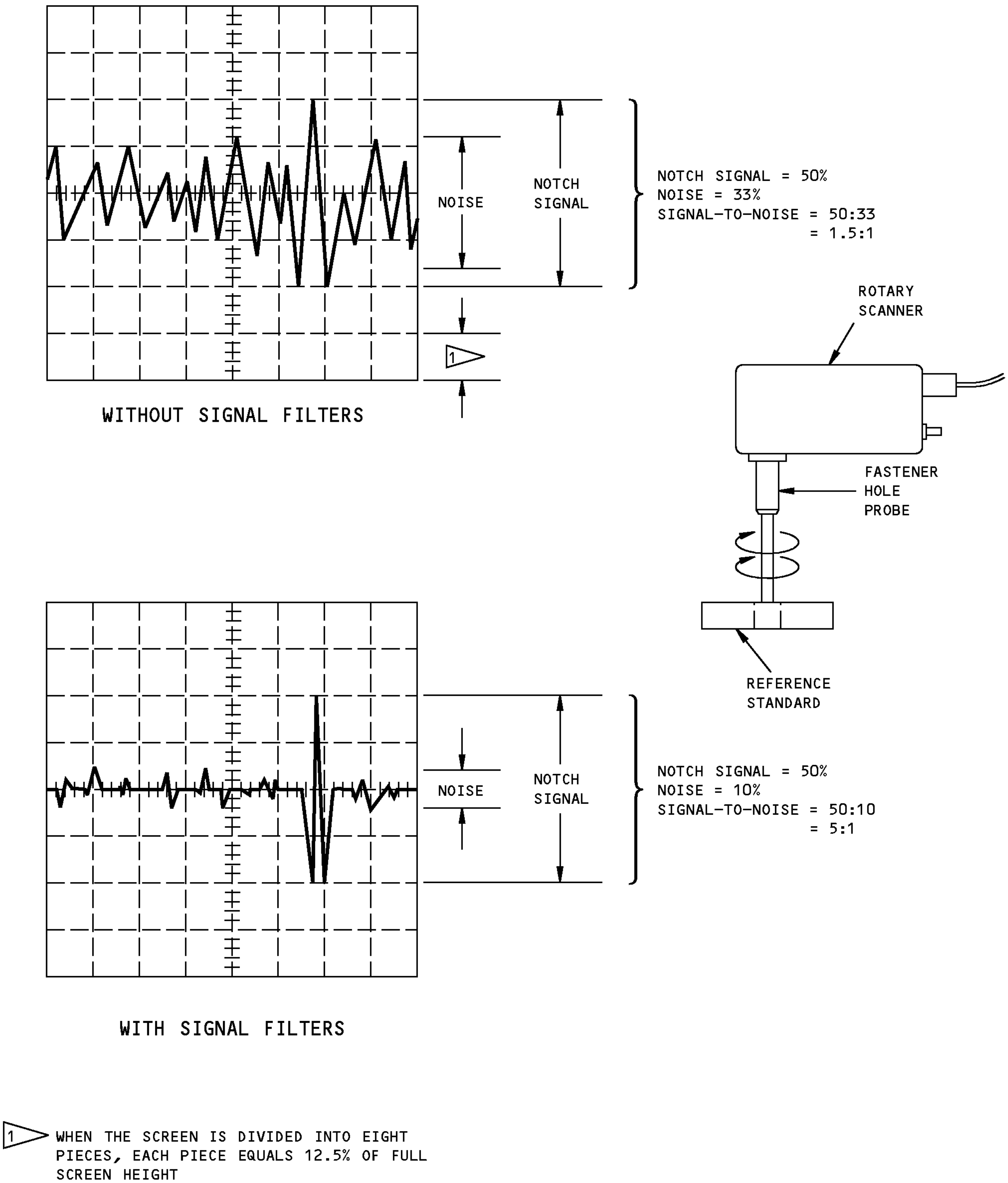


NOTES

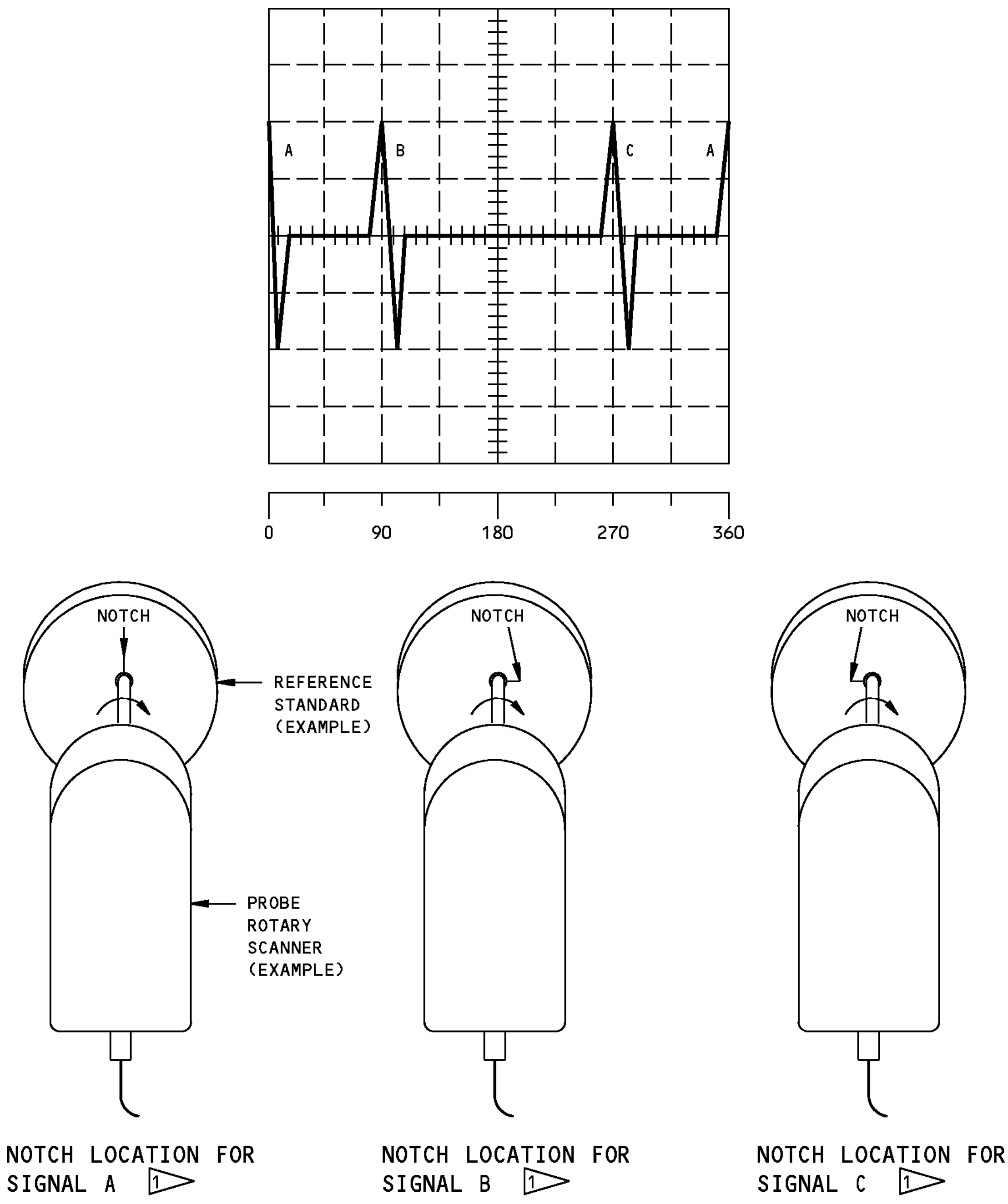
1. THE HORIZONTAL POSITION OF THE SIGNAL ALONG THE TIMEBASE LINE IS RELATED TO THE LOCATION OF THE NOTCH OR CRACK IN THE FASTENER HOLE. SEE FIGURE 7

2. WHEN THE SCREEN IS DIVIDED INTO EIGHT PIECES, EACH PIECE EQUALS 12.5% OF FULL SCREEN HEIGHT

Instrument Calibration
Figure 5



Use of Signal Filters to get 5:1 Signal-to-Noise Ratio
Figure 6



1 THE SIGNAL LOCATION ON THE TIMEBASE LINE WILL BE DIFFERENT WITH DIFFERENT INSTRUMENTS. USE A REFERENCE STANDARD NOTCH TO COMPARE THE SIGNAL LOCATION ON THE TIMEBASE LINE TO THE CRACK LOCATION IN THE TEST PIECE

Crack Location
Figure 7

PART 6 - EDDY CURRENT

GENERAL SURFACE INSPECTION OF ALUMINUM WITH THE MAGNETO OPTIC IMAGER (MOI)

1. **Purpose**

A. Use this procedure to find cracks on flat or convex aluminum structure with the use of the Turbo Magneto Optic Imager (MOI). This procedure can find cracks that are 0.10 inch (2.5 mm) long or more at 5/32 and 3/16 inch diameter countersunk rivet locations. Cracks to be found at larger countersunk rivet locations must extend 0.06 inch (1.5 mm) farther than the heads of the rivets.

NOTE: Only the Turbo MOI (Model 308TDF) is permitted for use with this procedure. The 308TDF is a new MOI instrument with more power than other MOI instruments.

B. This procedure will find cracks at fasteners with conductive (Alodine) and non-conductive (anodized) surface finishes.

2. **Equipment**

NOTE: Refer to Part 1, 51-01-00, for data about the equipment manufacturers.

A. Use a Magneto Optic Imaging System, Model 308TDF, which is made by QUEST Integrated, with the equipment components that follow:

(1) Power supply control unit

(2) Video monitor or heads-up display set

(3) Video recorder

(4) Imager head

(5) Five-inch (125 mm) wide tape (protective surface)

NOTE: The video recorder is necessary only to record the inspection results.

B. Reference Standard

(1) Use reference standard NDT1091. See Figure 1 for a drawing of the reference standard.

3. **Preparation for Inspection**

A. Identify the inspection location.

B. Make an estimate of the total thickness of paint or other nonconductive layers. Remove the nonconductive layers if the total thickness is more than 0.015 inch (0.4 mm).

NOTE: The use of a digital eddy current thickness measurement instrument is recommended to examine the thickness of the nonconductive layers in the inspection area. Use the instructions of the instrument to do the thickness measurement.

4. **Calibration**

NOTE: The earth's magnetic field has an effect on the imager. When you change the position of the imager head it can be necessary to adjust the bias control. Thus, you must do the calibration with the reference standard in the same position as the inspection surface. For example, if you examine the skin below the fuselage, you must hold the reference standard in an overhead position equivalent to the skin surface.

Also, steel structure near the inspection area will have an effect on the image quality of the instrument. If it is necessary to adjust the bias control to improve the image, calibrate again with the reference standard in the same location and position as the inspection surface. See the calibration instructions.

A. Connect the different components of the instrument. Refer to the manufacturer's instructions.

B. Supply power to the instrument control unit and monitor the instrument display.

C. Set the excitation mode to ‘‘rotate’’.

D. Adjust the instrument frequency to 20 kHz.

E. This procedure has two calibrations. The low power calibration is for most rivets. The high power calibration is for Alodined rivets that cause very weak signals. If you find weak signals on your airplane with the low power calibration, make a mark at those rivets and examine them with the high power calibration.

F. Low power calibration:

(1) Set the excitation level to ‘‘low’’.

(2) Put the MOI imager head on the reference standard at Position A, above the flat-bottomed hole. See Figure 2, View A.

(3) Adjust the MOI bias control with the buttons on the imager handle until you see the flat-bottomed hole show as a dark image against a bright background. You will see the complete circular outline of the flat-bottomed hole. See Figure 2, View B. If you can not see the circular outline, increase the excitation level of the instrument until a circular outline is visible as shown in Figure 2, View B.

NOTE: Do not adjust the bias control after this step. You will make more adjustments only when you are on the airplane.

(4) Put the MOI imager head on the reference standard at the anodized fastener without a notch. See Position C in Figure 3, View A.

(5) Look at the display. You will see a symmetrical circular indication with a light area in the center. The display in Figure 3, View B is a typical display for anodized fasteners, or Alodined fasteners with a loose fit.

(6) Put the MOI imager head on the reference standard at the notched anodized fastener. See Position D in Figure 3, View C.

(7) Make a note of the display. You will again see an indication at the fastener location, but it will not be symmetrical. A bulge on one side shows a crack on that side of the fastener. The display in Figure 3, View D is a typical display for anodized fasteners, or Alodined fasteners with a loose fit, with a crack at the fastener hole.

(8) Put the MOI imager head on the reference standard at the Alodined fastener without a notch. See Position E in Figure 4, View A.

(9) Look at the display. You will see an indication at the fastener location, but it can look weak or non-symmetrical. See Figure 4, View B, low power calibration examples.

(10) Put the MOI imager head on the reference standard at the notched Alodined fastener on the reference standard. See Position F in Figure 5, View A.

(11) Make a note of the display. You will see an indication at the fastener location, but it can look weak or not symmetrical. See Figure 5, View B, low power calibration examples. It is possible that you can identify the bulge on one side that shows the EDM notch, but crack indications on the airplane can be weaker. For weak rivet indications on the airplane use the high power calibration.

(12) Hold the reference standard against the imager head and move them until they are in an overhead position. Monitor the change in the display while you do this. The change in the display is caused by the earth’s magnetic field.

(13) Go to Paragraph 4.H. to do the final calibration on the airplane.

G. High power calibration.

(1) Set the excitation level to ‘‘high’’.

(2) Put the MOI imager head on the reference standard at Position A, above the flat-bottomed hole. See Figure 2, View A.

(3) Adjust the MOI bias control with the buttons on the imager handle until you see the flat-bottomed hole show as a dark image against a bright background. You will see the complete circular outline of the flat-bottomed hole. See Figure 2, View C. The image will be stronger than the image you saw with the low power calibration setting.

(4) Put the MOI imager head on the reference standard at Position B, above the flat-bottomed hole. See Figure 2, View D.

(5) Adjust the MOI bias control with the buttons on the imager handle until you see the flat-bottomed hole show as a dark image against a bright background. You will see the complete circular outline of the flat-bottomed hole. See Figure 2, View E.

NOTE: Do not adjust the bias control after this step. You will make more adjustments only when you are on the airplane.

(6) Put the MOI imager head on the reference standard at the Alodined fastener without a notch. See Position E in Figure 4, View A.

(7) Look at the display. You will see an indication at the fastener location. The indication can look weak or not symmetrical but it will look circular. See Figure 4, View B, high power calibration examples. These displays are typical for Alodined fasteners with a tight fit.

(8) Put the MOI imager head on the reference standard at the notched Alodined fastener. See Position F in Figure 5, View A.

(9) Look at the display from the Alodined fastener with the EDM notch. The fastener can look weak or not symmetrical, but it will look circular with a bulge or darker area on one side. See Figure 5, View B, high power calibration examples. These displays are typical for Alodined fasteners with a tight fit, with a crack at the fastener hole.

(10) Hold the reference standard against the imager head and move them until they are in an overhead position. Monitor the change in the display while you do this. The change in the display is caused by the earth's magnetic field.

H. Do the final calibration on the airplane (mandatory for the low power calibration and the high power calibration) as follows:

(1) Set up the instrument and reference standard on the airplane, in the applicable inspection area.

(2) Put the reference standard on the inspection surface, in the same position as the surface that you will examine (for example: flat, vertical, or overhead).

(3) Put the MOI imager head against the surface of the reference standard, with the center of the imager on the flat-bottomed hole at calibration position A (low power calibration, see Figure 2, View A) or calibration position B (high power calibration, see Figure 2, View D).

(4) Adjust the MOI bias control again to get the best image quality on the flat-bottomed hole when the reference standard is in the same position as the surface to be examined. Adjust the bias control until the image looks the same as it did when you calibrated on a bench.

5. Inspection Procedure

A. Calibrate as specified in Paragraph 4., low power calibration.

B. Make a scan along the fastener row with the center of the imager accurately positioned above each fastener head. During the inspection:

(1) Monitor the MOI viewer for:

(a) Signals at a fastener where it is not possible to see the circular outline of the fastener. See Figure 4, View B, low power calibration examples.

(b) Signals at a fastener where there is a bulge in the circular outline of the fastener. See Figure 3, View D, and Figure 5, View B, high power calibration examples.

(c) Signals that occur between two fastener locations. See Figure 6. Make a mark at all these locations.

(2) Do not do a scan faster than 1 inch (25 mm) for each second. The scan rate must be slow to identify cracks.

(3) If the display changes, do the calibration again as specified in Paragraph 4.H. with the reference standard adjacent to the inspection area. The image quality can change while you move down the airplane because of the magnetic properties of the building or equipment near the inspection area.

(4) Look for fastener locations in the inspection area that can not be examined with MOI and must be examined with a different NDT procedure. The conditions that follow prevent inspection with MOI:

(a) Magnetic steel fasteners in the inspection area. MOI inspection is possible if the magnetic fasteners are removed.

(b) Protruding head fasteners in the inspection area.

(c) Doublers, repairs, or other structure that interfere with the inspection.

(d) Fairing support frames or other structure that does not let you put the center of the MOI imager on the inspection area.

(e) A concave surface in the inspection area.

(f) Surface corrosion in the inspection area. Remove surface corrosion to do the inspection.

(5) Temperature effects can have an important effect on the performance of the MOI. They can cause the image quality (contrast) to decrease. Monitor these conditions during the inspection:

(a) Imager head temperature build-up. During use, the imager head becomes warm. A good procedure is to turn the imager head off when it is not in use.

(b) High air temperature. High imager head temperatures become more of a problem when the air temperature is 90°F (32°C) or higher. If the air temperatures are too high, do the inspection when the air temperature is lower.

(c) High airplane skin temperature. Do not do the inspection if sunlight makes the surface of the airplane too hot.

(6) Calibrate as specified in Paragraph 4.G., high power calibration, and examine all of the areas where you made a mark as specified in Paragraph 5.B.(1).

(7) Areas that cause signals like the EDM notch signals in the reference standard, and areas that cause unusual signals, must be examined some more. Refer to Paragraph 6.

6. Inspection Results

A. The signals that follow are indications of cracks:

(1) Signals at a fastener location that are not symmetrical, or signals where there is a bulge in the circular outline of the fastener. See Figure 3, View D and Figure 5, View B, high power calibration examples.

(2) Signals that occur between two fastener locations. See Figure 6.

B. The signals that follow must be examined with an alternative inspection procedure:

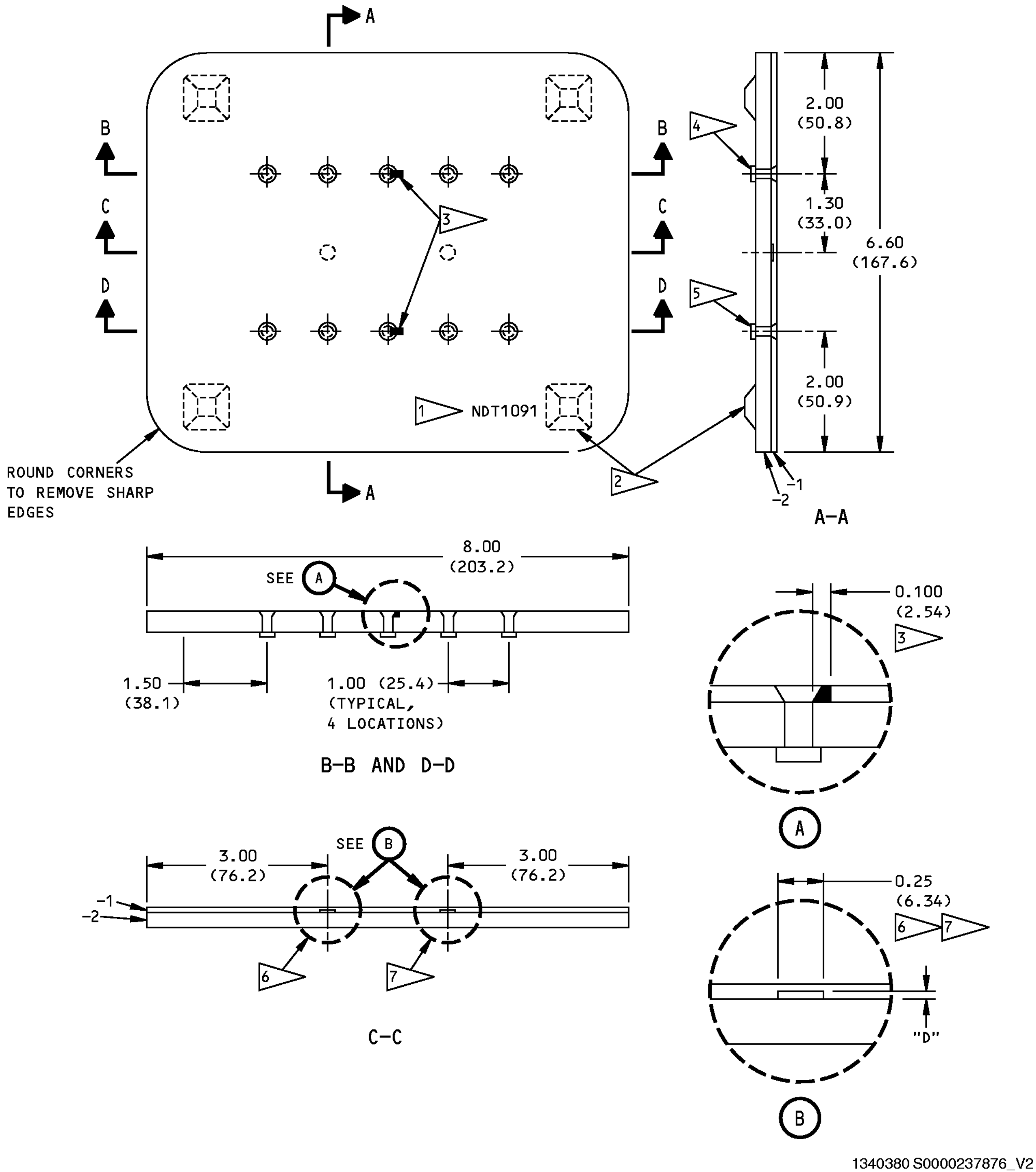
(1) A signal where it is not possible to see the circular outline of the fastener even at high power settings. See Figure 4, View B, low power calibration examples to see these types of signals.

(2) An unusual signal such as a solid circular signal or a signal that is larger than the usual signal from the fastener.

C. Do a check of all areas that give crack indications and unusual signals. Use a high frequency pencil probe with a circle template. Make sure that your pencil probe calibration will find the EDM notch on the NDT1091 MOI reference standard before you check the MOI indications. You can use these procedures to do the check on the MOI indications:

(1) For 757 and 767 airplanes: Part 6, 51-00-01 or 51-00-19.

(2) For 777 airplanes: Part 6, 51-00-01.



Reference Standard NDT1091
Figure 1 (Sheet 1 of 2)

UPPER-1 SHEET THICKNESS	LOWER-2 SHEET THICKNESS	EDM NOTCH LENGTH	UPPER (ANODIZED) 4 RIVET ROW	LOWER (ALODINED) 5 RIVET ROW
0.040 (1.00)	0.125 (3.17)	0.100 (2.50)	***5D6 (See Table 2)	BACR15GF5D6

REFERENCE STANDARD DATA
TABLE 1

RIVET CODE	ALLFAST FASTENING SYSTEMS INC. PART NUMBER	SIERRA PACIFIC SUPPLY CO. PART NUMBER
***5D6	AF1049U1D5C6	NAS1097D5-6D

FASTENER DATA
TABLE 2

NOTES:

- ALL DIMENSIONS ARE IN INCHES
  (MILLIMETERS ARE IN PARENTHESES)
- TOLERANCES (UNLESS SPECIFIED DIFFERENTLY):

INCHES	MILLIMETERS
X.XXX = ±0.005	X.XX = ±0.10
X.XX = ±0.025	X.X = ±0.5
X.X = ±0.050	X = ±1

- SURFACE ROUGHNESS: 125 Ra OR BETTER
- MATERIAL: 2024-T3 ALUMINUM; CLAD OR BARE (SEE TABLE 1 FOR THICKNESS)

1 ETCH OR STEEL STAMP THE REFERENCE STANDARD NUMBER NDT1091

2 BOND 4 RUBBER FEET TO THE REFERENCE STANDARD IN THE APPROXIMATE LOCATIONS SHOWN.

3 EDM NOTCH ALONG FASTENER CENTERLINE (2 LOCATIONS)
MAXIMUM WIDTH: 0.007 (0.17)
DEPTH: THROUGH-THICKNESS AS SHOWN IN VIEW A
NOTCH LENGTHS: 0.100 (2.54)

4 INSTALL ANODIZED RIVETS AS SPECIFIED IN PART 1, 51-01-04

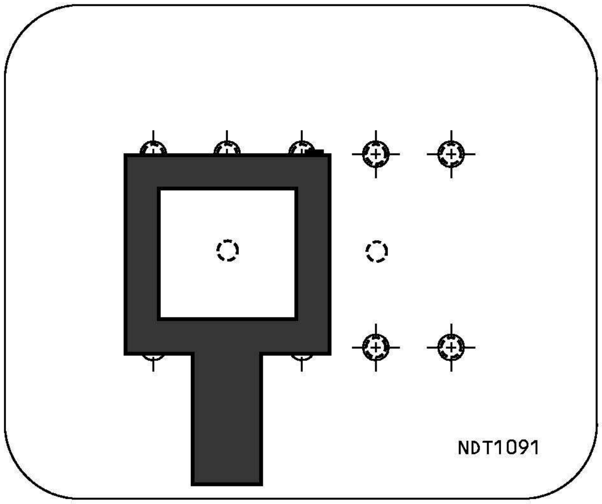
5 INSTALL ALODINED RIVETS AS SPECIFIED BELOW:

- SOLVENT CLEAN EACH RIVET AND RIVET HOLE BEFORE INSTALLATION
- COUNTERSINK DEPTH:
  0.033 (0.84) FOR 5/32 RIVETS +0.000/-0.002 (+0.00/-0.05)
- MINIMUM BUTTON DIAMETER:
  0.230 (5.8) FOR 5/32 RIVETS
- ALL OTHER INSTALLATION DATA AS SPECIFIED IN PART 1, 51-01-04

6 FLAT BOTTOMED HOLE
DEPTH "D" = 0.025 (0.64)

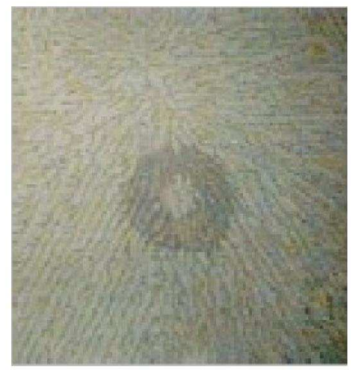
7 FLAT BOTTOMED HOLE
DEPTH "D" = 0.020 (0.50)

Reference Standard NDT1091
Figure 1 (Sheet 2 of 2)

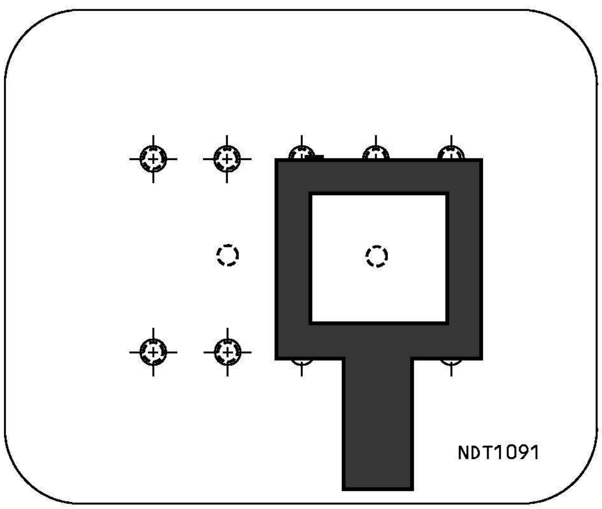


CALIBRATION POSITION A
VIEW A

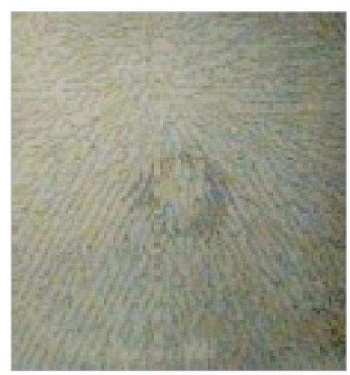
IMAGER DISPLAY WHEN THE MOI IMAGER HEAD IS AT POSITION A, LOW POWER CALIBRATION
VIEW B



IMAGER DISPLAY WHEN THE MOI IMAGER HEAD IS AT POSITION A, HIGH POWER CALIBRATION
VIEW C



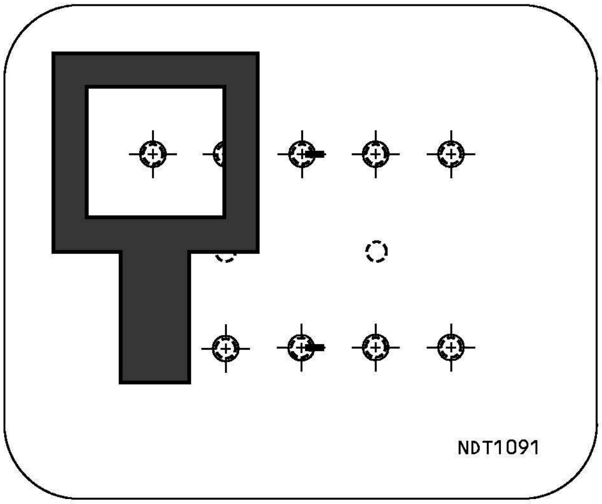
CALIBRATION POSITION B
VIEW D



IMAGER DISPLAY WHEN THE MOI IMAGER HEAD IS AT POSITION B, HIGH POWER CALIBRATION
VIEW E

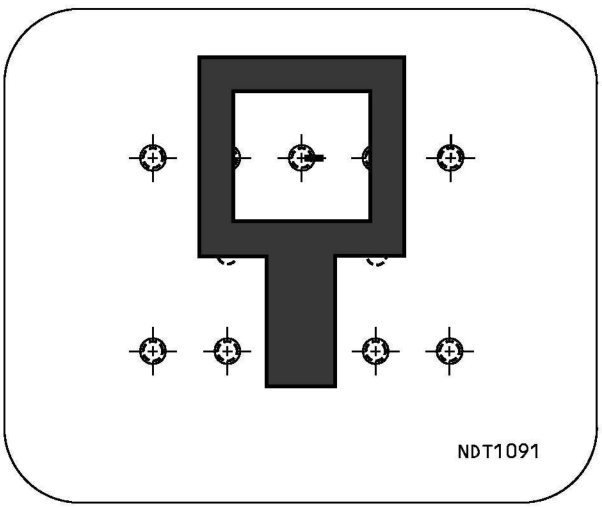
CALIBRATION POSITIONS ON REFERENCE STANDARD NDT1091

Calibration Positions on Reference Standard NDT1091
Figure 2



CALIBRATION POSITION C
VIEW A

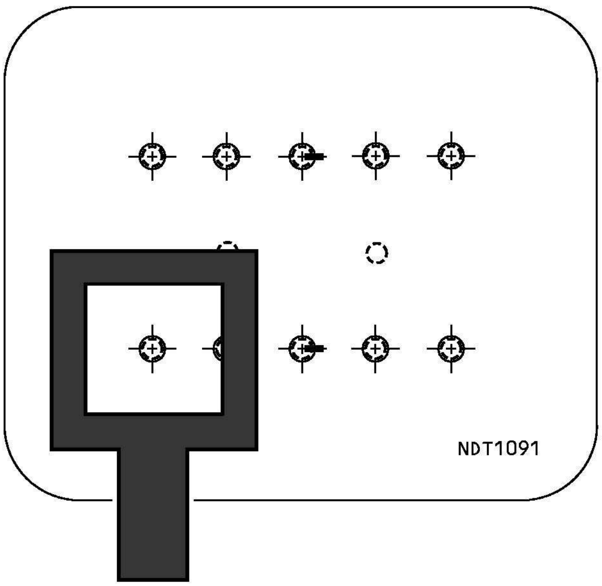
IMAGER DISPLAY WHEN THE MOI IMAGER
HEAD IS AT POSITION C
VIEW B



CALIBRATION POSITION D
VIEW C

IMAGER DISPLAY WHEN THE MOI IMAGER
HEAD IS AT POSITION D
VIEW D

Calibration Positions on Reference Standard NDT1091
Figure 3

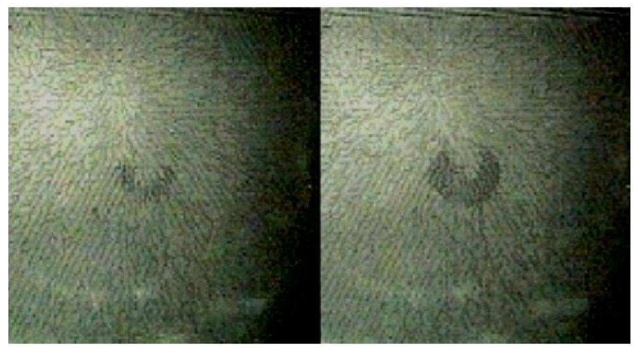


CALIBRATION POSITION E
VIEW A

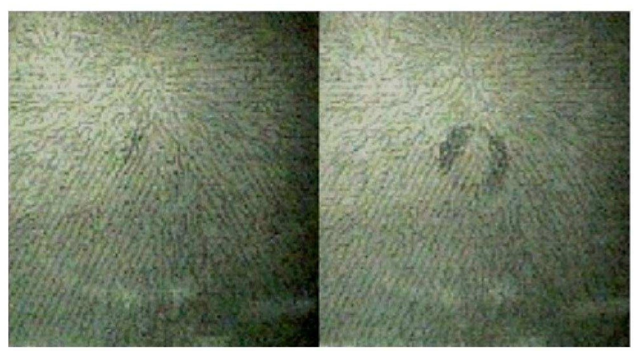
NOTES:

- THE SIGNALS FROM ALODINED FASTENERS WILL CHANGE IF THE INSTALLATION FIT OF THE FASTENERS CHANGES.
- VIEW B SHOWS EXAMPLE ALODINED FASTENER SIGNALS. THE ALODINED FASTENERS IN YOUR REFERENCE STANDARD MUST CAUSE SIGNALS TO OCCUR THAT LOOK ALMOST THE SAME.

LOW POWER CALIBRATION HIGH POWER CALIBRATION
EXAMPLE A



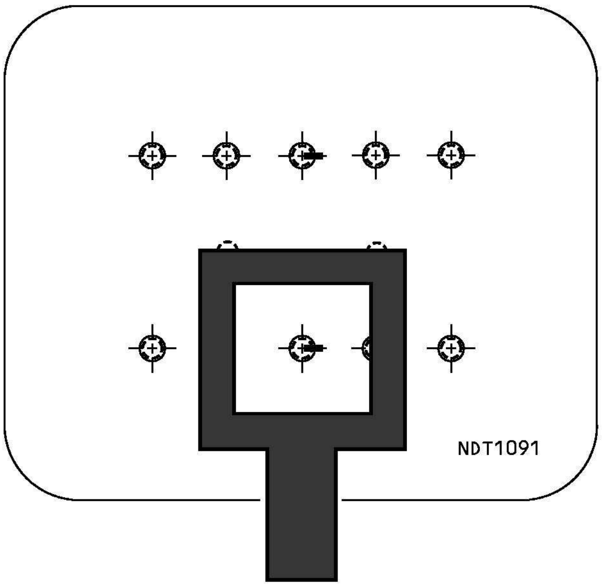
LOW POWER CALIBRATION HIGH POWER CALIBRATION
EXAMPLE B



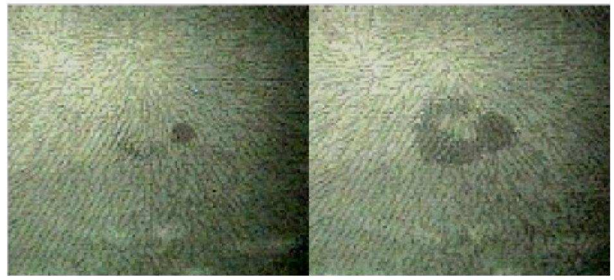
LOW POWER CALIBRATION HIGH POWER CALIBRATION
VIEW C

POSSIBLE IMAGER DISPLAYS WHEN THE MOI IMAGER HEAD IS AT POSITION E
DETAIL B

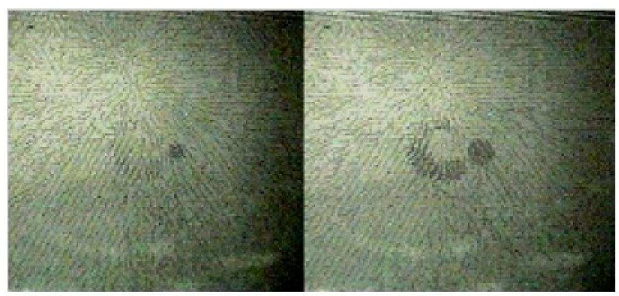
Calibration Positions on Reference Standard NDT1091
Figure 4



CALIBRATION POSITION F
VIEW A



LOW POWER CALIBRATION HIGH POWER CALIBRATION
EXAMPLE A



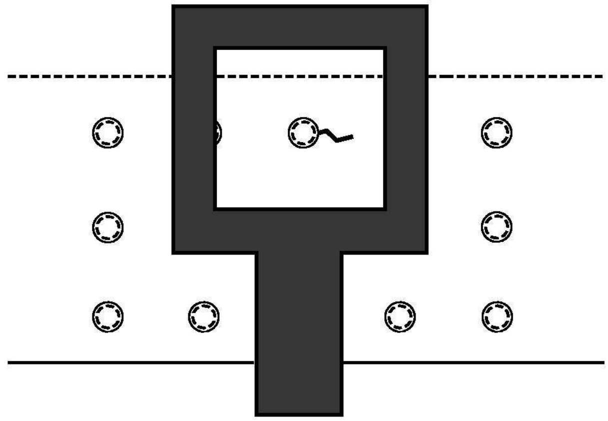
LOW POWER CALIBRATION HIGH POWER CALIBRATION
EXAMPLE B

POSSIBLE IMAGER DISPLAYS WHEN THE MOI IMAGER HEAD IS AT POSITION F
VIEW B

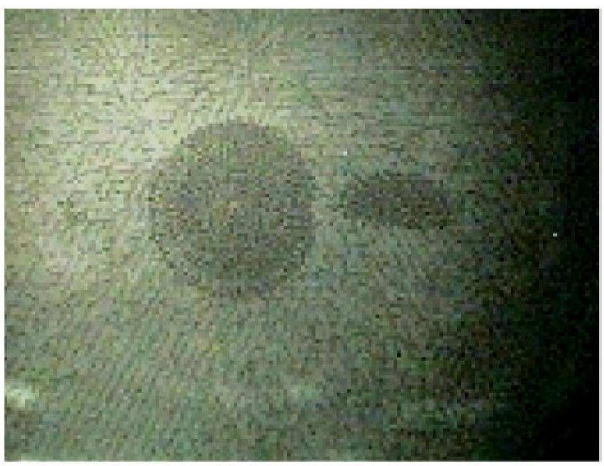
NOTES:

- THE SIGNALS FROM ALODINED FASTENERS WILL CHANGE IF THE INSTALLATION FIT OF THE FASTENERS CHANGES.
- VIEW B SHOWS EXAMPLE ALODINED FASTENER SIGNALS. THE ALODINED FASTENERS IN YOUR REFERENCE STANDARD MUST CAUSE SIGNALS TO OCCUR THAT LOOK ALMOST THE SAME.

Calibration Positions on Reference Standard NDT1091
Figure 5



POSITION ABOVE A LONG CRACK
VIEW A



POSSIBLE DISPLAY FROM A LONG CRACK
VIEW B

Signal Display of a Crack that is Between Fastener Locations
Figure 6

PART 6 - EDDY CURRENT

ALUMINUM PART FASTENER HOLE INSPECTION (ROTARY SCANNER)

1. **Purpose**

   A. To do an eddy current inspection of open fastener holes in aluminum parts with the use of a rotary scanner. The minimum material thickness that can be examined during this procedure is 0.020 inch (0.50 mm).

2. **Equipment**

   NOTE: Refer to Part 1, 51-01-00 for data on the manufacturers of the equipment.

   A. All eddy current instruments with a rotary scanner that can satisfy the calibration instructions of this procedure can be used.

   (1) Instrument - An eddy current instrument that can operate in the dynamic mode (time related display) with a rotary scanner is necessary. The instrument must be able to operate between 300 kHz and 500 kHz. These instruments were used to prepare this procedure:

   (a) AV100SE - Hocking, Ltd.

   (b) Defectoscop D2.831 - Forster

   (c) Elotest BI - Rohman

   (d) NDT-19 - Nortec

   (e) Phasec 1.1 - Hocking, Ltd.

   (2) Rotary Scanner - To do this procedure, a rotary scanner is necessary. The rotary scanner is used to turn automatically the probe connected to it. The rate at which the probe is turned is a function of the eddy current instrument. The rate of probe movement through a fastener hole is controlled by the operator.

   B. Probes - See Figure 1 and Figure 2 for examples of probe configurations for use with the rotary scanner. Probes that can be expanded for a close fit in the fastener hole are recommended. To do this procedure, the instrument and probe must be able to get the necessary lift-off and sensitivity results. Fastener hole probes must have these properties:

   (1) Probes must be able to operate at a frequency range between 300 kHz and 500 kHz.

   (2) The probes must have a differential-bridge coil or a differential reflection coil.

   (3) The probes must be able to operate with a minimum 5:1 signal-to-noise ratio on the reference standard and a minimum 3:1 signal-to-noise ratio on the part to be examined. Refer to Paragraph 4.K.

   NOTE: To get a better signal-to-noise ratio, you can add 0.003 inch (0.076 mm) thick tape to cover the probe coil area. Make sure that the tape is not conductive.

   (4) The probe diameter to use is determined by the diameter of the fastener hole to be examined.

   (a) If you use a probe that cannot be expanded, make sure the difference between the hole diameter and the probe outer diameter is not more than 0.010 inch (0.25 mm).

   (b) Probes that can be expanded must be set so that there is a light interference fit when the probe is put into the fastener hole.

   NOTE: If the probe fit is too tight, the probe will wear quickly.

   1) 0.125 inch (3.18 mm), Part Number BPD-8, NDT Engineering Corp.

   2) 0.187 inch (4.75 mm), Part Number BPD-12, NDT Engineering Corp.

3) 0.187 inch (4.75 mm) to 0.25 inch (6.35 mm) adjustable probe; Part Number BXEM-12/16, NDT Engineering Corp.

C. Reference Standards - Fastener hole reference standards must have EDM notches. See Figure 3 for the correct notch size. A reference standard for each hole size to be examined is necessary unless expandable probes are used. Reference standards can be different than those specified in Figure 3 if the hole sizes, EDM notch locations, and EDM notch sizes agree with the conditions specified in Figure 3. Reference standards made as specified in Part 6, 51-00-04 or Part 6, 51-00-11 are acceptable.

3. Preparation for Inspection

A. Identify the inspection location(s) and the size of the fastener holes to be examined.

B. Clean loose dirt and sealant from inside the fastener hole.

C. Visually look into all holes to be eddy current examined for surface conditions that can cause rejectable noise signals during the inspection. Borescopes, endoscopes or other optical aids can be used to help the visual inspection. Look for these conditions:

(1) Burrs

(2) Galling

(3) Corrosion

(4) Out-of-round holes

NOTE: If a cleanup ream is necessary to remove one or more of these conditions, a 125 RHR or better surface finish is necessary. Get local engineering approval to do a cleanup ream.

4. Instrument Calibration

A. Connect the rotary scanner to the instrument.

B. Make sure the instrument is on and let it warm up. Refer to the manufacturer's instruction manual.

C. Get the applicable reference standard and probe.

D. Connect the probe to the rotary scanner.

E. Set the instrument's frequency between 300 and 500 kHz.

F. If possible, set the speed above 1000 RPM. Rotary scanner speeds less than 1000 RPM are not recommended because it is easy to miss a small defect at the lower speeds.

G. Set the instrument in the impedance plane mode (X/Y). Make sure the rotary scanner is on and put the probe into the reference standard hole. Make sure the probe coil is away from the EDM notch.

H. Balance the instrument. Refer to the instrument's instruction manual. Use the instrument's vertical position control to put the signal at approximately the center of the screen.

NOTE: If your instrument does not have a balance function, ignore this step and go to Paragraph 4.I.

I. Put the probe on the surface of the reference standard. With the phase control, turn the signal to the horizontal position. See Figure 4.

J. Change the instrument display to the timebase mode. To do this, turn the sweep function on. Refer to the instrument's instruction manual.

K. If the instrument filters are set automatically when the rotary scanner is connected, go to Paragraph 4.L. If the instrument filters are not set automatically when the rotary scanner is connected, it will be necessary to set the filters manually. Use the steps that follow to adjust the filters:

(1) High Pass Filters (HP) - Increase the filter to maximum or until the reference notch signal is decreased by 50%. This will decrease low frequency noise signals.

(2) Low Pass Filters (LH) - Decrease to the lowest adjustment possible that does not cause the signal height to decrease.

(3) Band Pass (BP) - If available, it is an alternative to the high pass and low pass filters. Adjust to get the best signal-to-noise ratio. A minimum signal to noise ratio of 5:1 is necessary.

NOTE: If the speed of the rotary scanner is changed, the filters will need to be adjusted. The maximum high pass filter adjustment must not be higher than the low pass filter adjustment.

L. Put the probe in the hole of the reference standard.

M. Adjust the instrument gain (vertical) to get a 40 to 60 percent full screen height signal from the 0.020-inch or the 0.030-inch reference notch. See Figure 5. A minimum signal-to-noise ratio of 5:1 is necessary. See Figure 6. Adjust the instrument gain and filter controls to get the necessary signal-to-noise ratio. Refer to Paragraph 4.K. for information on how to adjust the filters. Refer to the note in Paragraph 2.B.(3) for more information on how to decrease the signal-to-noise ratio.

NOTE: The reference standard has the usual 0.030-inch (0.76 mm) notch but also includes a 0.020-inch (0.51 mm) notch. If your instrument can satisfactorily find the 0.020-inch (0.51 mm) notch, an instrument calibration with this notch permits a more sensitive evaluation.

N. Find the maximum speed that the probe can be put into a fastener hole. To do this, follow these steps:

(1) Move the probe through the reference standard used to set the screen calibration. Refer to Paragraph 4.L.

(2) Monitor the response level of the reference standard notch.

(3) Increase the speed the probe is moved through the reference standard until the signal drops to 90% of the calibration level. This is the maximum speed that the probe can be moved through a fastener hole.

NOTE: The use of an audible or visual alarm is recommended. Set the alarm to operate at 50 percent of the reference standard notch signal.

O. The location of a crack or notch signal on the timebase line is directly related to the location of the crack or notch in the fastener hole. See Figure 7.

5. Inspection Procedure

A. Prepare for inspection. Refer to Paragraph 3.

B. Do the instrument calibration. Refer to Paragraph 4.

NOTE: If the equipment or the instrument controls are changed after an instrument calibration, you must calibrate again.

C. Examine all necessary fastener holes. To do this, make sure the rotary scanner unit is on and move the probe smoothly through the length of each fastener hole. Do not do a scan faster than the scan rate found in Paragraph 4.N. Do an instrument calibration check regularly and after all fastener holes have been examined. If the sensitivity has decreased since the last calibration, all fastener holes examined since the last calibration must be examined again.

NOTE: An approved light oil or grease put on the probe coil area will decrease probe wear.

D. Do Paragraph 5.A. thru Paragraph 5.C. for each size fastener hole to be examined.

E. Make a record of all fastener hole locations where a crack signal occurs. Also make a record of those fastener holes where it is necessary to do a cleanup ream before a satisfactory inspection can be made. Refer to Paragraph 3.

F. Do a minimum 0.016-inch (0.41 mm) cleanup ream on those fastener holes recorded in Paragraph 5.E. where a cleanup ream is necessary.

NOTE: Get local engineering approval to do a cleanup ream.

G. Make an inspection again of all fastener holes where a ream was necessary.

6. Inspection Results

A. Fastener holes with no crack signals are acceptable. An eddy current crack signal will look almost the same as the reference standard notch signal. Noise signals have a wider shape than crack signals and can make it hard to see crack signals. If the signal-to-noise ratio between the reference standard notch signal and the inspection surface noise level is less than 3:1, refer to Paragraph 3.C.

B. Fastener holes with crack signals that are 100% or more of the reference standard notch signal must be rejected.

C. To remove a crack, oversize the hole a minimum 0.016 inch (0.40 mm) and do an eddy current inspection again. If the crack was removed by the first oversize ream, go to Paragraph 6.D. If the crack was not removed after the first oversize ream, continue to oversize and do an eddy current inspection of the hole until the crack is completely removed.

NOTE: Get local engineering approval for all holes that need to be oversized.

NOTE: Monitor and make a record of the depth of the position of the crack. When you examine the hole again, look carefully at this location. New indications that occur at other locations can be caused when the hole is oversized and can be ignored.

NOTE: If a larger probe is necessary to examine an oversize hole, you must calibrate again before you do the examination.

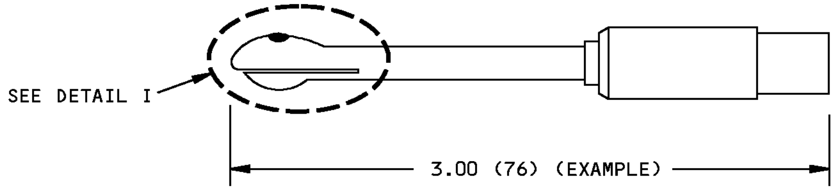
D. When a crack has been removed and cannot be found by the eddy current inspection, it is necessary to do one more ream as an "insurance cut". If the 0.020-inch (0.51 mm) reference standard notch was used for the instrument calibration, a 0.047-inch (1.19 mm) oversize ream is recommended. If the 0.030-inch (0.8 mm) reference standard notch was used for the instrument calibration, a 0.063-inch (1.59 mm) oversize ream is recommended. This "insurance cut" is done to make sure that a crack too small to find by the eddy current inspection is fully removed.

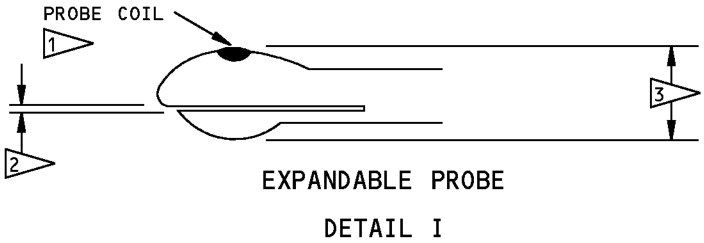
NOTE: Get local engineering approval before you do an insurance cut.

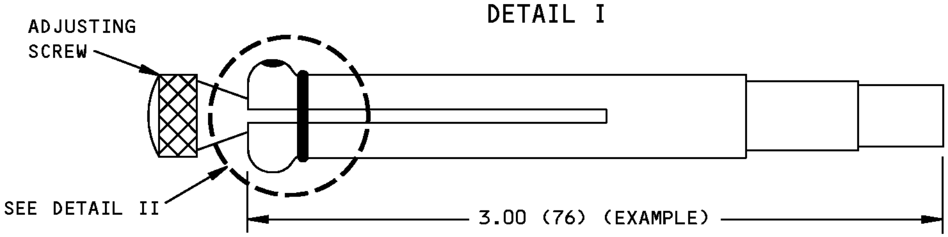
E. A fastener hole with an eddy current signal that looks almost the same as a crack signal and is between 50% and 100% of the reference standard notch signal must be examined some more. Examine by:

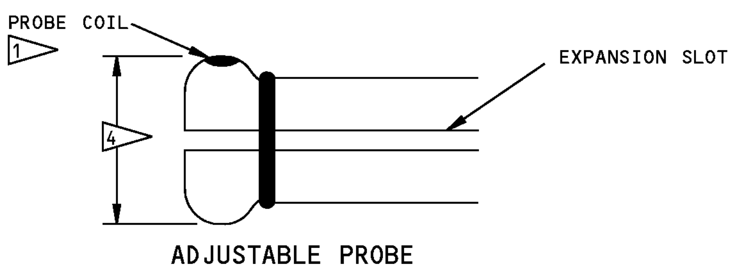
(1) Do a visual inspection of the fastener hole. Look for surface conditions that can cause an eddy current crack signal. Refer to Paragraph 3.C. If a surface condition is seen at the same depth and in the same position of the eddy current signal, the fastener hole can be accepted. If no surface conditions are seen that could be the cause of the eddy current signal, reject the hole and go to Paragraph 6.C.

NOTE: Get local engineering approval to accept the hole with the surface condition that caused the eddy current indication.









NOTES

- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES)
- THE USUAL PROBE CONFIGURATION IS SHOWN. DIFFERENT PROBE MANUFACTURERS MAKE PROBES THAT ARE SYMMETRICALLY DIFFERENT OR HAVE DIFFERENT END CONNECTOR FITTINGS

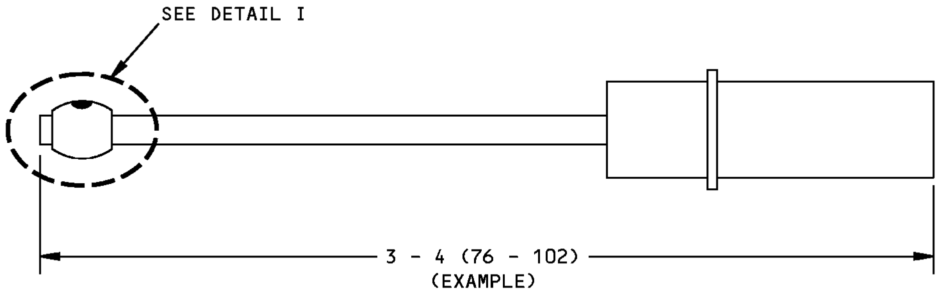
1 PROBES MUST HAVE A DIFFERENTIAL-BRIDGE COIL OR A DIFFERENTIAL-REFLECTION COIL

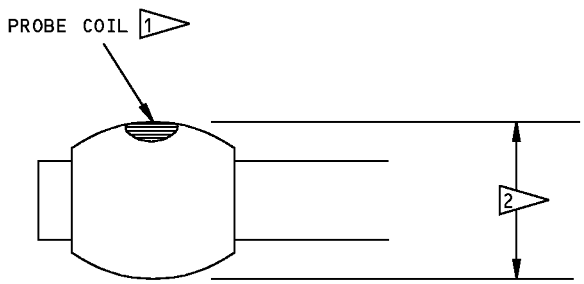
2 0.020-0.030 (0.50-0.76) EXPANSION SLOT. THE SLOT MUST PERMIT THE PROBE TO BE EXPANDED UP TO 0.063 (1.60)

3 THE PROBE HEAD DIAMETER MUST FIT THE INSPECTION HOLE. USUAL PROBE HEAD DIAMETERS ARE: 0.187 (4.75)
0.250 (6.35)
0.312 (7.92)
0.375 (9.53)
0.437 (11.1)
0.500 (12.7)

4 THE PROBE IS ADJUSTABLE FOR THE DIAMETER RANGE SPECIFIED ON THE PROBE BODY. THE USUAL NDT ENGINEERING PROBES THAT WILL DO AN INSPECTION OF HOLE DIAMETERS FROM 0.188-0.875 (4.75-22.2) ARE:
BXU-12/16 0.187-0.250 (4.75-6.35)
BXU-16/20 0.250-0.312 (6.35-7.92)
BXU-20/24 0.312-0.375 (7.92-9.53)
BXU-24/28 0.375-0.437 (9.53-11.1)
BXU-28/32 0.437-0.500 (11.1-12.7)
BXU-32/40 0.500-0.625 (12.7-15.8)
BXU-40/48 0.625-0.750 (15.8-19.1)
BXU-48/56 0.750-0.875 (19.1-22.2)

Example of an Expandable Fastener Hole Probe
Figure 1





DETAIL I

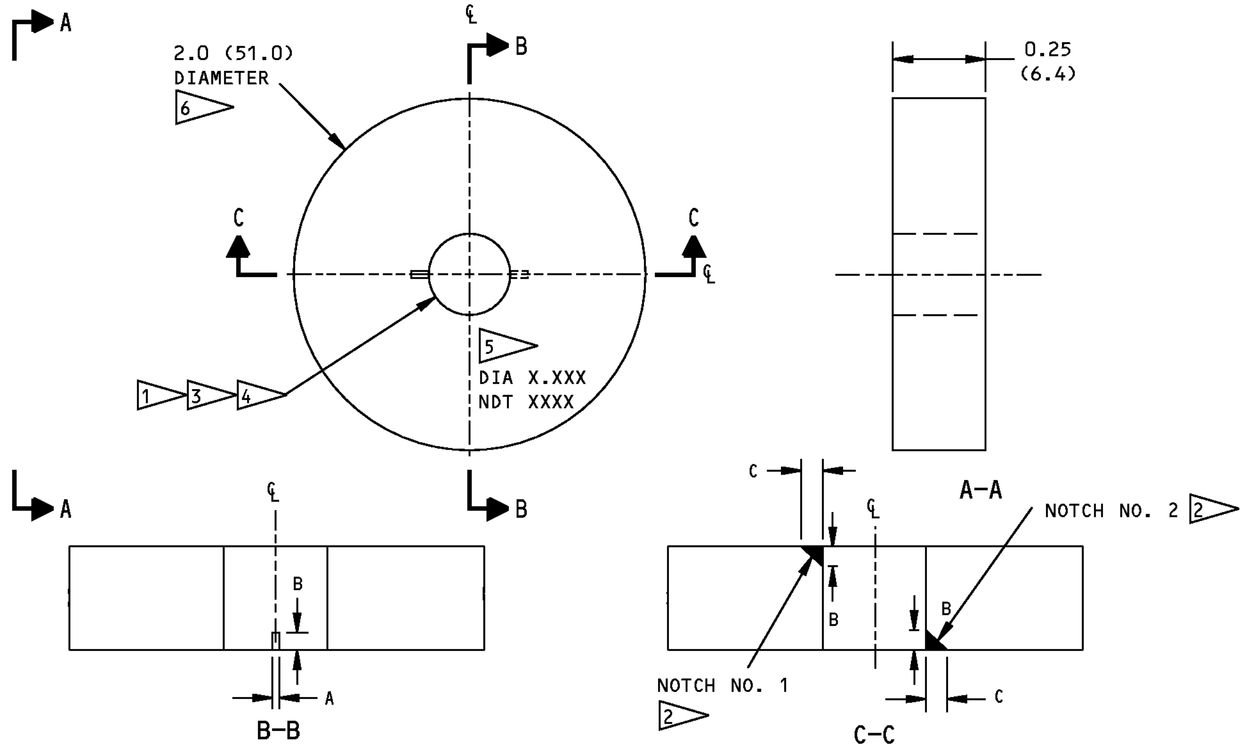
NOTES

- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES)
- THE USUAL PROBE CONFIGURATION IS SHOWN. DIFFERENT PROBE MANUFACTURERS MAKE PROBES THAT ARE SYMMETRICALLY DIFFERENT OR HAVE DIFFERENT END CONNECTOR FITTINGS
- USE PROBES SO THAT THE DIFFERENCE BETWEEN THE HOLE DIAMETER AND THE PROBE OUTER DIAMETER IS NOT GREATER THAN 0.010 (0.25)

1 PROBES MUST HAVE A DIFFERENTIAL-BRIDGE COIL OR A DIFFERENTIAL-REFLECTION COIL

2 THE PROBE HEAD DIAMETER MUST FIT THE INSPECTION HOLE. DIFFERENT PROBE SIZES ARE AVAILABLE IN 0.031 (0.79) INCREMENTS

Example of a Fastener Hole Probe That Is Not Adjustable
Figure 2



NOTCH NUMBER	A	B	C
	WIDTH	LENGTH	DEPTH
1	0.005 (0.13)	0.030 (0.76)	0.030 (0.76)
2	0.005 (0.13)	0.020 (0.51)	0.020 (0.51)
TOLERANCE	+0.002 (0.05) -0.002 (0.05)	+0.002 (0.05) -0.002 (0.05)	+0.002 (0.05) -0.002 (0.05)

NOTES

- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES).
- TOLERANCE ON ALL DIMENSIONS ±0.050 (1.27) UNLESS SPECIFIED DIFFERENTLY.
- MATERIAL: ALL ALUMINUM ALLOYS THAT HAVE A CONDUCTIVITY BETWEEN 28 AND 36% IACS (INTERNATIONAL ANNEALED COPPER STANDARD) SUCH AS 2024-T3 OR -T4, 7075-T6, 7079-T6
- REFERENCE STANDARDS MADE AS SPECIFIED IN PART 6, 51-00-04 OR 51-00-05 ARE ACCEPTABLE.

1 FINISH THE REAM HOLE TO 63 R_a. DO NOT DEBURR.

2 ELECTRICAL DISCHARGE MACHINE (EDM) NOTCH. REFER TO THE GIVEN DIMENSIONS.

3 WHEN PROBES THAT ARE NOT ADJUSTABLE ARE USED, THE HOLE DIAMETER MUST EQUAL THE FASTENER HOLE TO BE EXAMINED.

4 REFERENCE STANDARD HOLE DIAMETERS FOR ADJUSTABLE PROBES:

REFERENCE STANDARD PART NUMBER	HOLE DIAMETER
NDT1016	0.188 (4.76)
NDT1017	0.250 (6.35)
NDT1018	0.313 (7.94)
NDT1019	0.375 (9.53)
NDT1020	0.438 (11.11)
NDT1021	0.500 (12.7)
NDT1084 6	X.XXX (XX.XX)

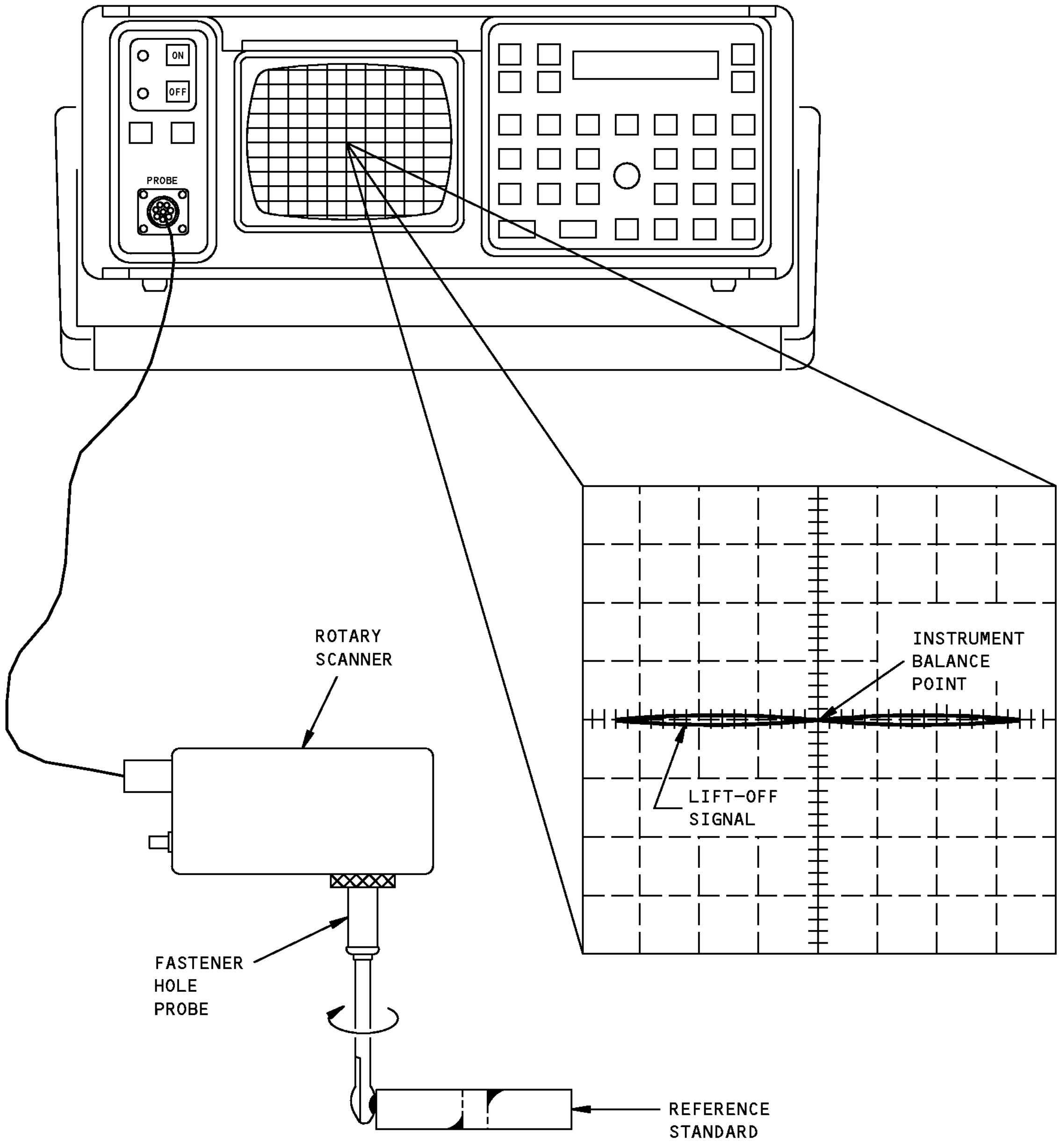
TOLERANCE ON ALL HOLES: ±0.005 (±0.13).

OTHER HOLE DIAMETERS CAN ALSO BE USED IF NECESSARY. USE REFERENCE STANDARD NUMBER NDT1084 AND MAKE SURE TO IDENTIFY THE HOLE DIAMETER AS SPECIFIED IN FLAG NOTE 5.

5 IDENTIFY THE HOLE DIAMETER AND THE REFERENCE STANDARD PART NUMBER ON THE REFERENCE STANDARD. (THE LOCATION FOR THESE IDENTIFICATION MARKS IS OPTIONAL).

6 IF THE HOLE DIAMETER IS FROM 1.750 (44.45) TO 2.250 (57.10), MAKE THE OUTER DIAMETER 3.0 (76)

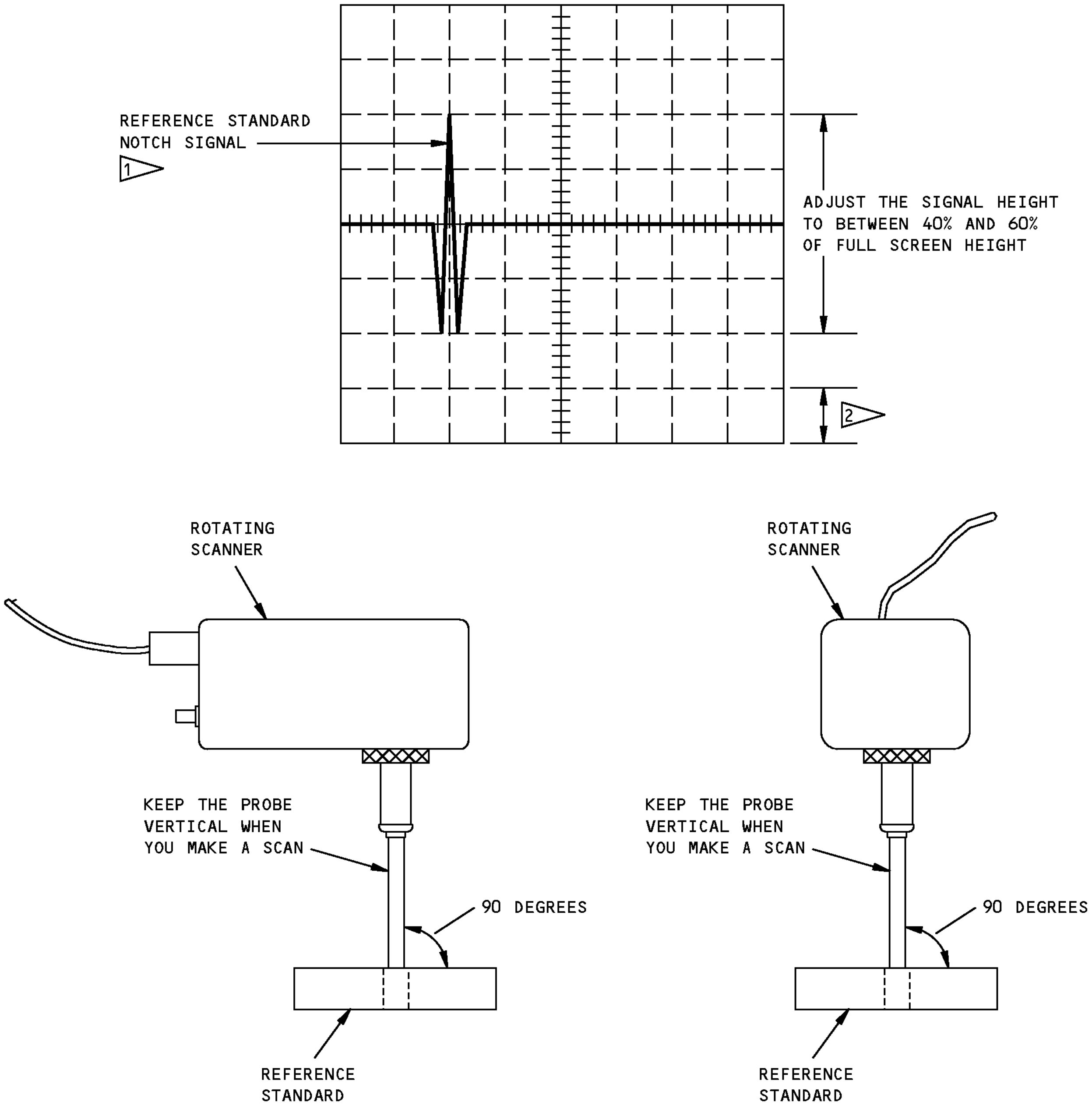
Reference Standard
Figure 3



NOTE

- WITH THE ROTARY SCANNER ON, AND THE PROBE AGAINST THE SIDE OF THE REFERENCE STANDARD, USE THE PHASE CONTROL TO TURN THE LIFT-OFF SIGNAL TO THE HORIZONTAL POSITION

Phase Adjustment
Figure 4

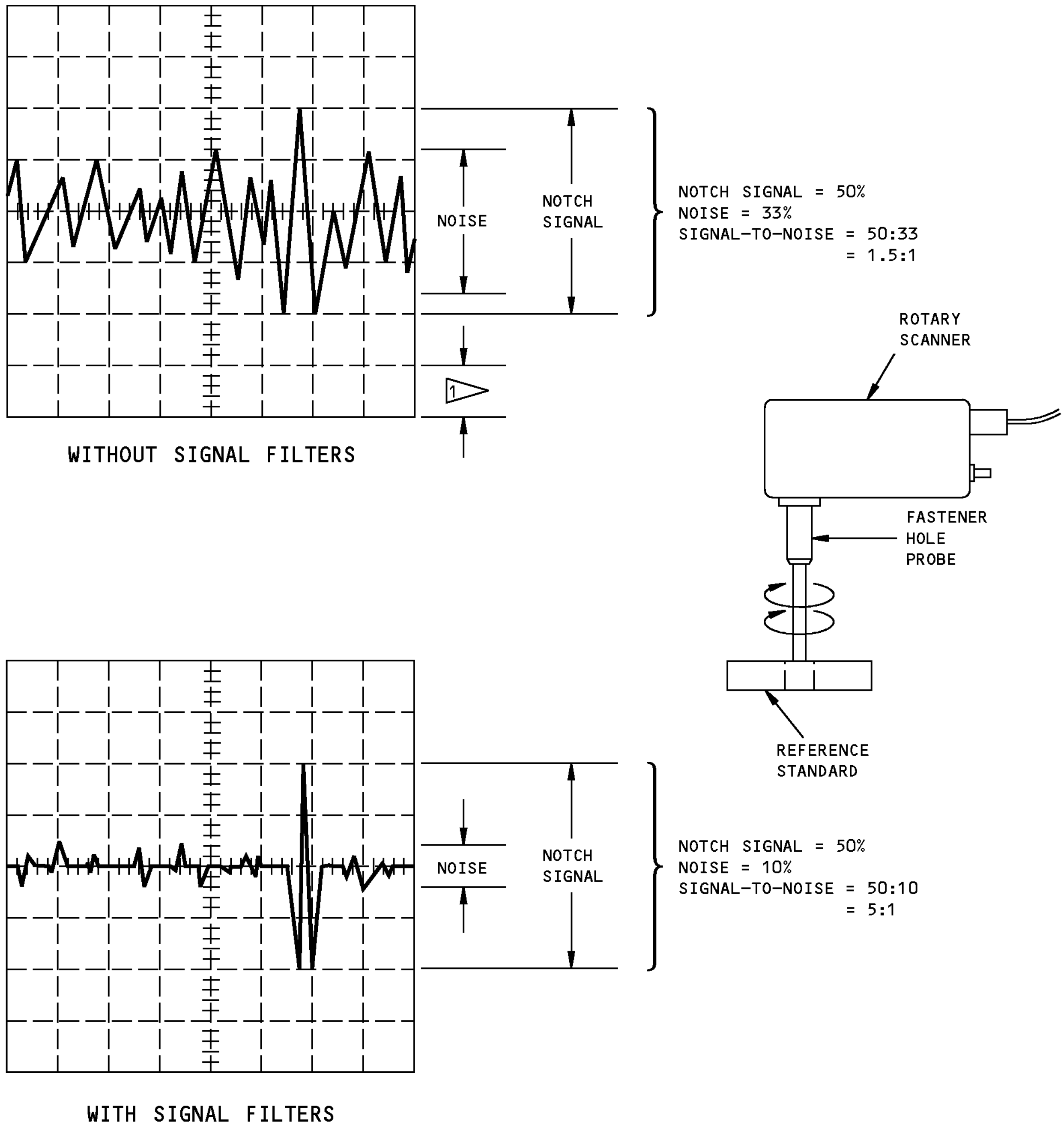


NOTES

1 THE HORIZONTAL POSITION OF THE SIGNAL ALONG THE TIMEBASE LINE IS RELATED TO THE LOCATION OF THE NOTCH OR CRACK IN THE FASTENER HOLE. SEE FIGURE 7

2 WHEN THE SCREEN IS DIVIDED INTO EIGHT PIECES, EACH PIECE EQUALS 12.5% OF FULL SCREEN HEIGHT

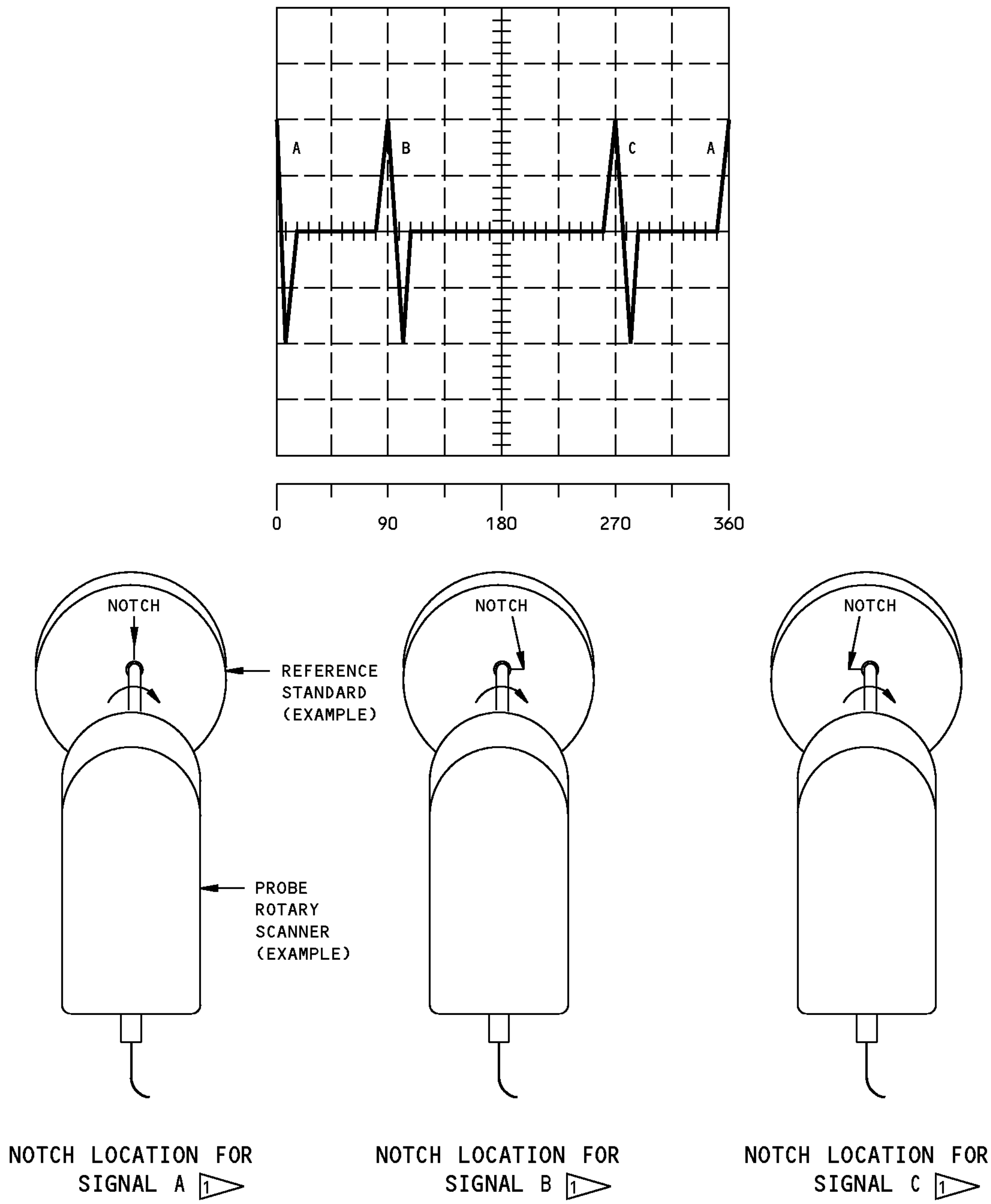
Instrument Calibration
Figure 5



NOTE

1 WHEN THE SCREEN IS DIVIDED INTO EIGHT PIECES, EACH PIECE EQUALS 12.5% OF FULL SCREEN HEIGHT

Use of Signal Filters to Get 5:1 Signal-To-Noise Ratio
Figure 6



NOTE

1 THE SIGNAL LOCATION ON THE TIMEBASE LINE WILL BE DIFFERENT WITH DIFFERENT INSTRUMENTS. USE A REFERENCE STANDARD NOTCH TO COMPARE THE SIGNAL LOCATION ON THE TIMEBASE LINE TO THE CRACK LOCATION IN THE TEST PIECE

Crack Location
Figure 7

PART 6 - EDDY CURRENT

OPEN HOLE INSPECTION IN STEEL WITH A ROTARY SCANNER

1. **Purpose**
   - A. Use this procedure to do an inspection for cracks that are on the inside surface of holes in magnetic steel parts.
   - B. This procedure uses an instrument with an impedance plane display and a rotary scanner.
   - C. The thickness of the material must be 0.020 inch (0.51 mm) or more.
   - D. Refer to Part 6, 51-00-14 to do an inspection for cracks in non-magnetic steel parts.
2. **Equipment**
   - A. General
     - (1) Use inspection equipment that can be calibrated on the reference standard as specified in Paragraph 4.
     - (2) Refer to Part 1, 51-01-00 for data about the equipment manufacturers.
   - B. Instrument
     - (1) Use an eddy current instrument that:
       - (a) Has an impedance plane display and a rotary scanner.
       - (b) Operates at a frequency range of 200 kHz to 1 MHz.
     - (2) The instruments specified below were used to prepare this procedure.
       - (a) Phasec 1.1; Hocking/Krautkramer
       - (b) Defectoscop 2.831; Foerster Instruments
       - (c) Elotest B1; Rohman GmbH
       - (d) NDT-19e; Nortec/Staveley Inc.
   - C. Probes
     - (1) Use a probe that:
       - (a) Operates at a frequency range of 200 kHz to 1 MHz.
       - (b) Has a differential-bridge coil or a differential reflection coil.
       - (c) Operates with a minimum signal-to-noise ratio of 5:1 on the reference standard and a minimum signal-to-noise ratio of 3:1 on the part to be examined.
       - (d) Use a probe with a diameter that is correct for the diameter of the hole to be examined (see Figure 1 and Figure 2 for examples of different probes).
         - 1) If you use a probe that cannot be expanded, make sure the difference between the hole diameter and the probe outer diameter is not more than 0.010 inch (0.25 mm).
         - 2) Probes that can be expanded must be set so that there is a light interference fit when the probe is put into the hole.

           NOTE: If the probe fit is too tight, the probe will not turn freely and will wear quickly.
     - (2) The probes specified below were used to prepare this procedure.
       - (a) VMED101-.125; VM Products, Inc.
       - (b) BPD-12; NDT Engineering Corp.
       - (c) BXEM-12/16; NDT Engineering Corp.
   - D. Reference Standards

(1) See Figure 3 for data about reference standards NDT1040, NDT1041, NDT1042, NDT1043, NDT1044, and/or NDT1045.

(2) Reference standards can be different than those specified in Figure 3. The material, hole diameter, EDM notch location and EDM notch dimensions must agree with the conditions specified in Figure 3.

3. **Preparation for Inspection**

A. Get access to the inspection areas.

B. Remove loose paint, dirt, and sealant from the surface of the inspection area.

C. Look in all the holes to be examined for surface conditions that can cause noise signals to occur during the inspection. Look for these surface conditions.

(1) a rough edge (burr)

(2) metal smears and/or rough surface (galling)

(3) grooves caused by a tool or fastener (gouge)

(4) an out-of-round hole

D. Do a cleanup ream, if necessary, to remove one or more of the conditions specified in Paragraph 3.C.. The surface roughness for a cleanup ream must be 63 microinches Ra or better.

NOTE: Get local engineering approval to do a cleanup ream.

4. **Instrument Calibration**

A. Set the frequency between 200 kHz and 1 MHz.

B. If it is possible, set the speed of the rotary scanner to approximately 1000 RPM or more. Small cracks may not be found if the scanner speed is below 1000 RPM.

C. Set the display to the X/Y mode (impedance plane mode).

D. Balance the instrument.

E. Set the balance point in the center of the screen display as shown in Figure 4.

F. Start the rotary scanner.

G. Put the probe on the surface of the reference standard as shown in Figure 4.

H. Adjust the instrument phase control to set the lift-off signal to the horizontal position as shown in Figure 4.

I. Set the instrument to the timebase mode, or start the sweep function.

J. Put the probe in the hole and get a maximum signal from the EDM notch. Make sure the probe fits in the hole as specified in Paragraph 2.C.(1)(d).

K. Adjust the gain to get a 40 to 60 percent full screen height signal as shown in Figure 5.

L. If necessary, adjust the instrument gain and filter controls to get a minimum signal-to-noise ratio of 5:1 (Figure 6). You can get a better signal-to-noise ratio if you add a piece of 0.003 inch (0.08 mm) thick plastic tape to the probe coil area. If necessary, set the filters as follows.

(1) Instruments with a high pass filter:

(a) Set the filter to its lowest value.

(b) Increase the filter value to get the best signal-to-noise ratio. Do not let the notch signal decrease more than 50 percent of the signal height set in Paragraph 4.K.

(2) Instruments with a low pass filter:

(a) Set the filter to its highest value.

(b) Decrease the filter value to get a stable dot or until the signal from the notch in the reference standard starts to decrease. Do not decrease the filter value below the value of the high pass filter.

(3) For instruments that have only one filter control or that have a bandpass filter.

(a) Adjust the filter to get the best signal-to-noise ratio.

NOTE: Refer to the instrument operation manual for more filter adjustment instructions, if necessary.

M. Find the maximum speed that the probe can be moved through the hole. To do this, follow these steps:

(1) Move the probe through the reference standard used to set the screen calibration.

(2) Monitor the signal height on the screen display from the reference standard notch.

(3) Increase the speed the probe is moved through the reference standard hole until the signal from the notch drops to approximately 90 percent of the calibration level. This is the maximum speed that the probe can be moved through the hole to be examined.

N. The use of an audible or visual alarm is recommended. Set the alarm to operate when a signal is 50 percent of the reference standard notch signal.

O. Monitor the location of the notch signal on the screen display to the location of the notch in the reference standard. See Figure 7.

5. Inspection Procedure

A. Prepare for the inspection as specified in Paragraph 3.

B. Start the rotary scanner.

C. Slowly move the probe through the hole to be examined. Do not move the probe faster than the maximum speed that was found in Paragraph 4.M. Do the steps that follow while you examine the hole:

NOTE: If plastic tape is not used, use an approved light oil, silicon spray, or grease on the probe when possible to decrease probe wear. If plastic tape is used after the initial calibration, do a calibration again.

(1) Make a mark at the holes that cause crack signals.

(2) If you get a crack signal, examine the holes for the conditions specified in Paragraph 3.C.

(3) If the hole has a condition specified in Paragraph 3.C., do a minimum approved cleanup ream and examine the hole again.

NOTE: Get local engineering approval to do a cleanup ream.

(4) Do a calibration test regularly as follows if a large quantity of holes are to be examined:

NOTE: Do not make adjustments to the instrument gain or filters.

(a) Put the probe in the hole of the reference standard to get a signal from the notch.

(b) Compare the signal you got from the notch during calibration with the signal you get now.

(c) If the signal from the notch in the reference standard has decreased 10 percent or more, do a calibration and examine all holes since the last calibration again.

D. Do a calibration test as specified in Paragraph 5.C.(4) at the end of the examination to compare the signal height from the EDM notch to that set in Paragraph 4.K.

NOTE: Do not make adjustments to the instrument gain or filters.

(1) If the signal from the notch in the reference standard has decreased 10 percent or more, do a calibration and examine all holes since the last calibration again.

6. Inspection Results

A. Fastener holes with no crack signals are acceptable. An eddy current crack signal will look almost the same as the reference standard notch signal. Noise signals have a wider shape than crack signals and can make it hard to see crack signals. If the signal-to-noise ratio between the reference standard notch signal and the inspection surface noise level is less than 3:1, refer to Paragraph 3.C.

NOTE: Cadmium plating is frequently used on steel parts. If the plating is broken in some locations, a crack signal can occur. The removal of the plating in that area will be necessary to get a satisfactory inspection.

B. Fastener holes with crack signals that are 100% or more of the reference standard notch signal must be rejected.

C. To remove a crack, oversize the hole a minimum 0.016 inch (0.40 mm) and do an eddy current inspection again. If the crack was removed by the first oversize ream, go to Paragraph 6.D. If the crack was removed after the first oversize ream, continue to oversize and do an eddy current inspection of the hole until the crack is completely removed.

NOTE: Get local engineering approval for all holes that need to be oversized.

NOTE: Monitor the screen display and make a record of the depth of the position of the crack. When you examine the hole again, look carefully at this location. New indications that occur at other locations can be caused when the hole is oversized and can be ignored.

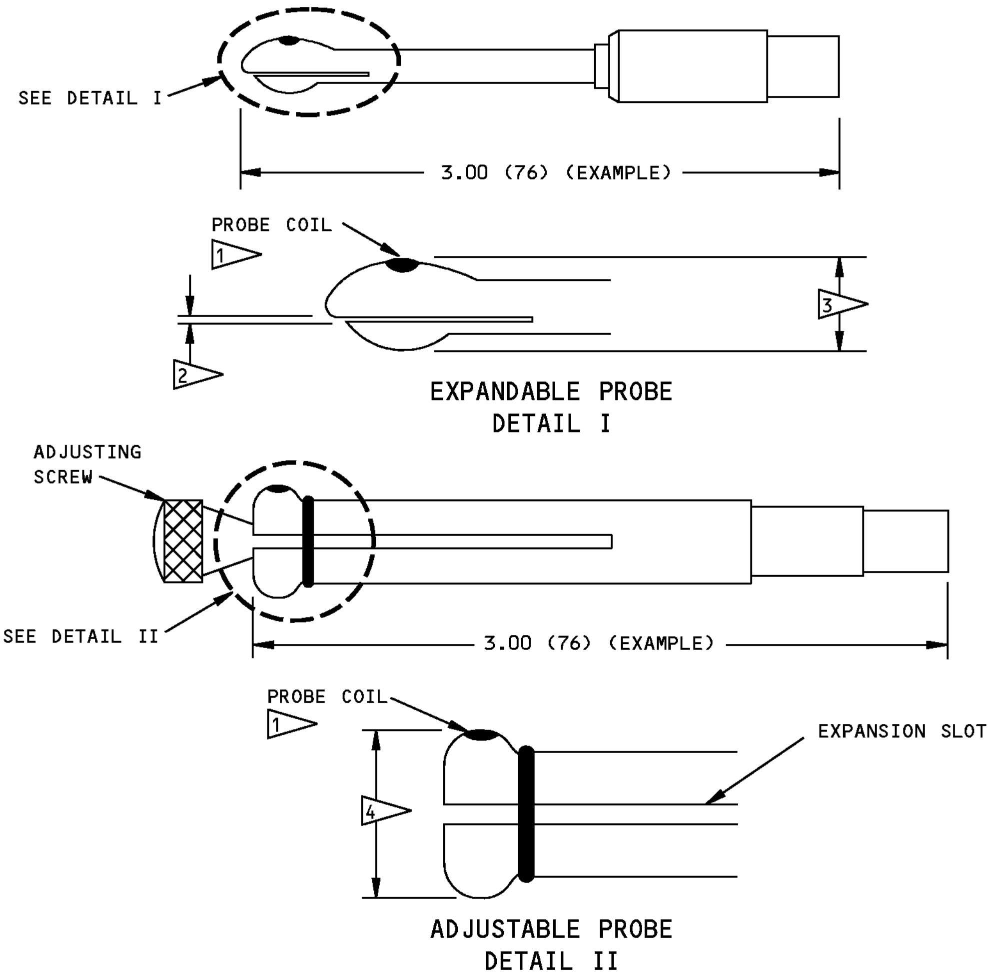
NOTE: If a larger probe is necessary to examine an oversize hole, you must calibrate again before you do the examination.

D. When a crack has been removed and cannot be found by the eddy current inspection, it is necessary to do one more ream as an "insurance cut". A 0.063-inch (1.59 mm) oversize ream is recommended. This "insurance cut" is done to make sure that a crack too small to find by the eddy current inspection is fully removed.

E. A fastener hole with an eddy current signal that looks almost the same as a crack signal and is between 50% and 100% of the reference standard notch signal must be examined some more. Examine by:

(1) Do a visual inspection of the fastener hole. Look for surface conditions that can cause an eddy current crack signal. Refer to Paragraph 3.C. If a surface condition is seen at the same depth and in the same position of the eddy current signal, the fastener hole can be accepted. If no surface conditions are seen that could be the cause of the eddy current signal, reject the hole and go to Paragraph 6.C.

NOTE: Get local engineering approval to accept the hole with the surface condition that caused the eddy current indication.



NOTES

- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES)
- THE USUAL PROBE CONFIGURATION IS SHOWN. DIFFERENT PROBE MANUFACTURERS MAKE PROBES THAT ARE SYMMETRICALLY DIFFERENT OR HAVE DIFFERENT END CONNECTOR FITTINGS

1 PROBES MUST HAVE A DIFFERENTIAL-BRIDGE COIL OR A DIFFERENTIAL-REFLECTION COIL

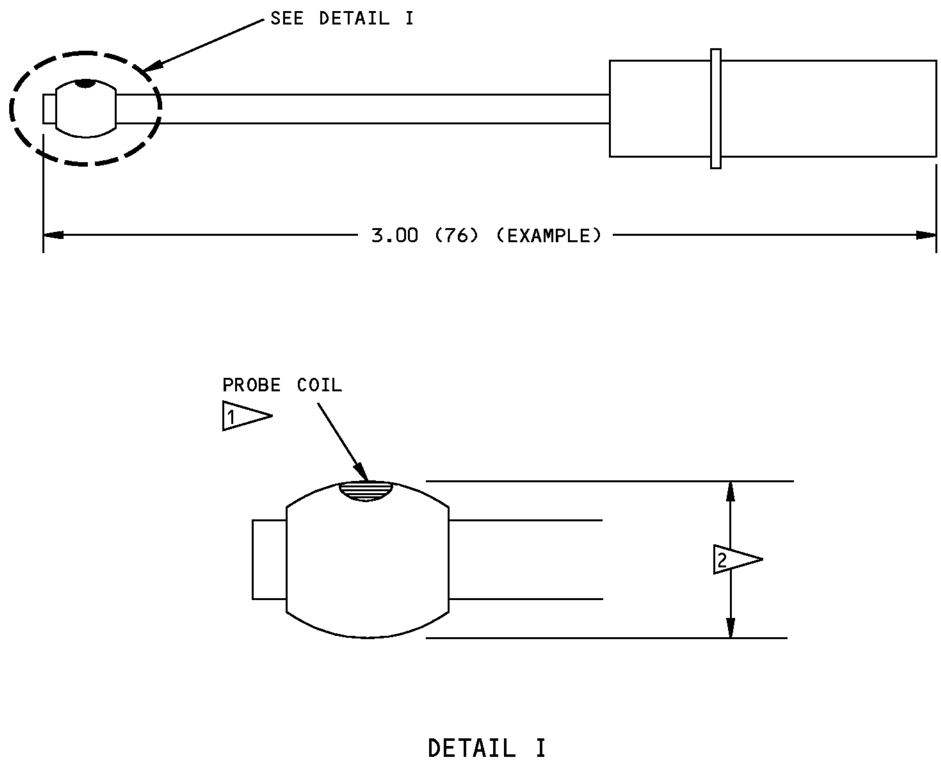
2 0.020-0.030 (0.50-0.76) EXPANSION SLOT. THE SLOT MUST PERMIT THE PROBE TO BE EXPANDED UP TO 0.063 (1.60)

3 THE PROBE HEAD DIAMETER MUST FIT THE INSPECTION HOLE. USUAL PROBE HEAD DIAMETERS ARE: 0.187 (4.75)
0.250 (6.35)
0.312 (7.92)
0.375 (9.53)
0.437 (11.1)
0.500 (12.7)

4 THE PROBE IS ADJUSTABLE FOR THE DIAMETER RANGE SPECIFIED ON THE PROBE BODY. THE USUAL NDT ENGINEERING PROBES THAT WILL DO AN INSPECTION OF HOLE DIAMETERS FROM 0.188-0.875 (4.75-22.2) ARE:

BXU-12/16	0.187-0.250	(4.75-6.35)
BXU-16/20	0.250-0.312	(6.35-7.92)
BXU-20/24	0.312-0.375	(7.92-9.53)
BXU-24/28	0.375-0.437	(9.53-11.1)
BXU-28/32	0.437-0.500	(11.1-12.7)
BXU-32/40	0.500-0.625	(12.7-15.8)
BXU-40/48	0.625-0.750	(15.8-19.1)
BXU-48/56	0.750-0.875	(19.1-22.2)

Example of Expandable and Adjustable Fastener Hole Probes
Figure 1

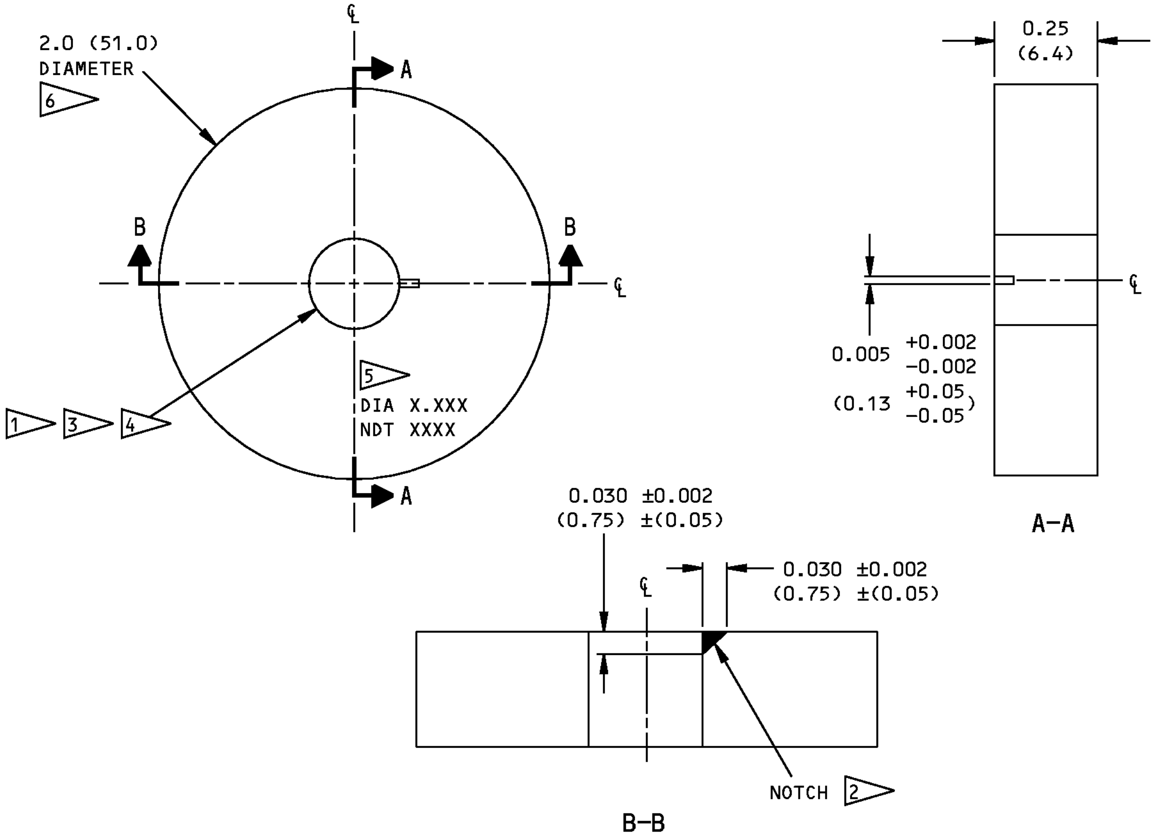


NOTES

- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES)
- THE USUAL PROBE CONFIGURATION IS SHOWN. DIFFERENT PROBE MANUFACTURERS MAKE PROBES THAT ARE SYMMETRICALLY DIFFERENT OR HAVE DIFFERENT END CONNECTOR FITTINGS.
- USE PROBES SO THAT THE DIFFERENCE BETWEEN THE HOLE DIAMETER AND THE PROBE OUTER DIAMETER IS NOT MORE THAN 0.010 (0.25).

1. PROBES MUST HAVE A DIFFERENTIAL-BRIDGE COIL OR A DIFFERENTIAL-REFLECTION COIL.
2. THE PROBE HEAD DIAMETER MUST FIT THE INSPECTION HOLE. DIFFERENT PROBE HEAD DIAMETERS ARE AVAILABLE TO ORDER.

Example of a Fastener Hole Probe that is Not Adjustable
Figure 2



NOTES

- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES)
- TOLERANCE ON ALL DIMENSIONS IS ±0.050 (1.27) UNLESS SPECIFIED DIFFERENTLY
- MATERIAL: LOW ALLOY STEEL SUCH AS 4330, 4340, 4330M OR 4340M (HEAT TREAT IS OPTIONAL)

1 REAM THE HOLE TO A 63 R_a SURFACE ROUGHNESS (OR BETTER). DO NOT DEBURR.

2 ELECTRICAL DISCHARGE MACHINE (EDM) NOTCH. REFER TO THE GIVEN DIMENSIONS.

3 WHEN PROBES THAT ARE NOT ADJUSTABLE ARE USED, THE HOLE DIAMETER OF THE REFERENCE STANDARD MUST EQUAL THE FASTENER HOLE TO BE EXAMINED.

4 REFERENCE STANDARD HOLE DIAMETERS FOR ADJUSTABLE PROBES:

REFERENCE STANDARD PART NUMBER	HOLE DIAMETER
NDT1040	0.188 (4.76)
NDT1041	0.250 (6.35)
NDT1042	0.313 (7.94)
NDT1043	0.375 (9.53)
NDT1044	0.438 (11.11)
NDT1045	0.500 (12.7)
NDT1083 6	X.XXX (XX.XX)

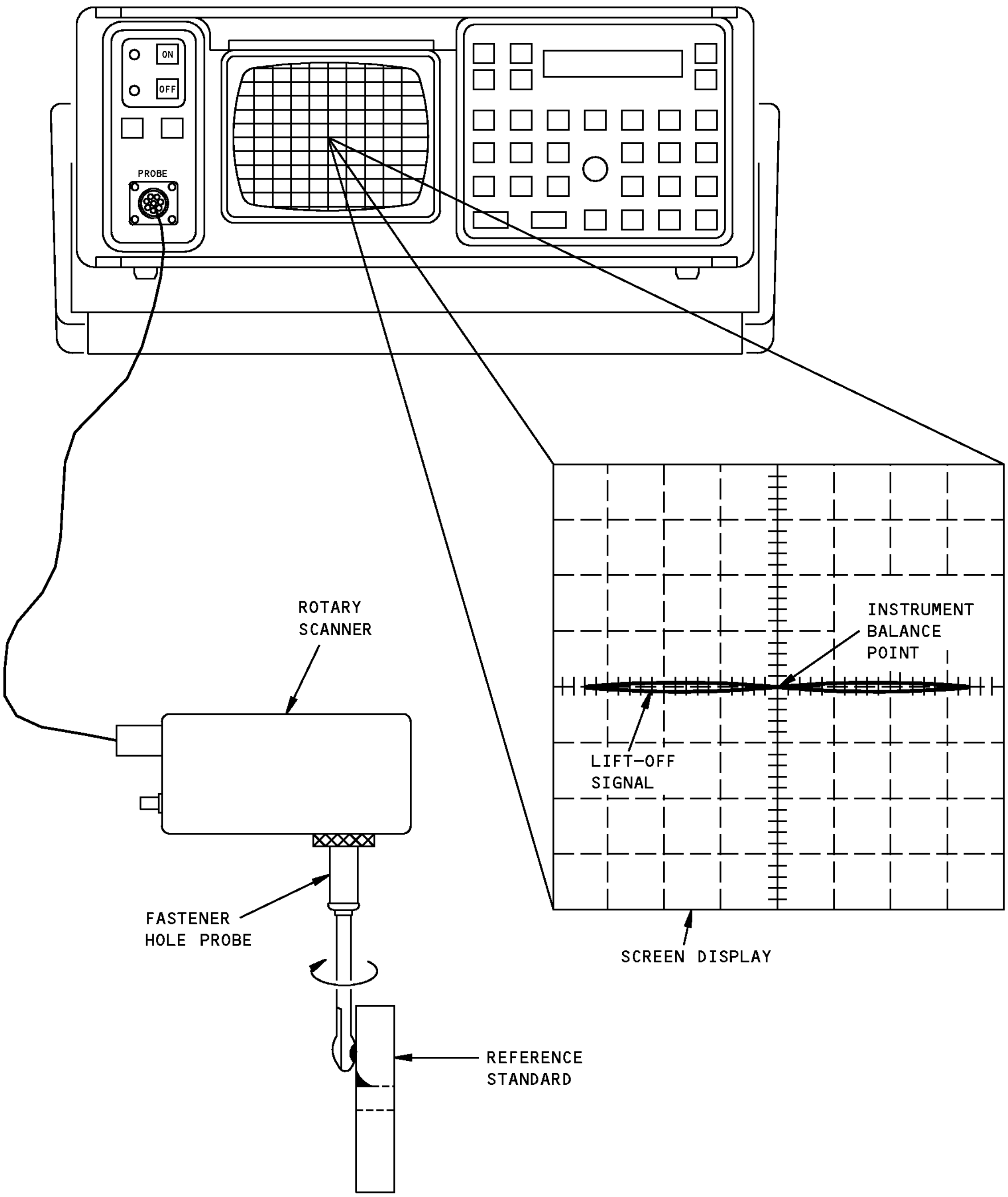
TOLERANCE ON ALL HOLES: ±0.005 (±0.13)

OTHER HOLE DIAMETERS CAN BE USED. USE REFERENCE STANDARD NUMBER NDT1083 AND MAKE SURE TO IDENTIFY THE HOLE DIAMETER AS SPECIFIED IN FLAG NOTE 5.

5 IDENTIFY THE HOLE DIAMETER AND THE REFERENCE STANDARD PART NUMBER ON THE REFERENCE STANDARD. (THE LOCATION FOR THESE IDENTIFICATION MARKS IS OPTIONAL)

6 IF THE HOLE DIAMETER IS FROM 1.750 (44.45) TO 2.250 (57.10), MAKE THE OUTER DIAMETER 3.0 (76)

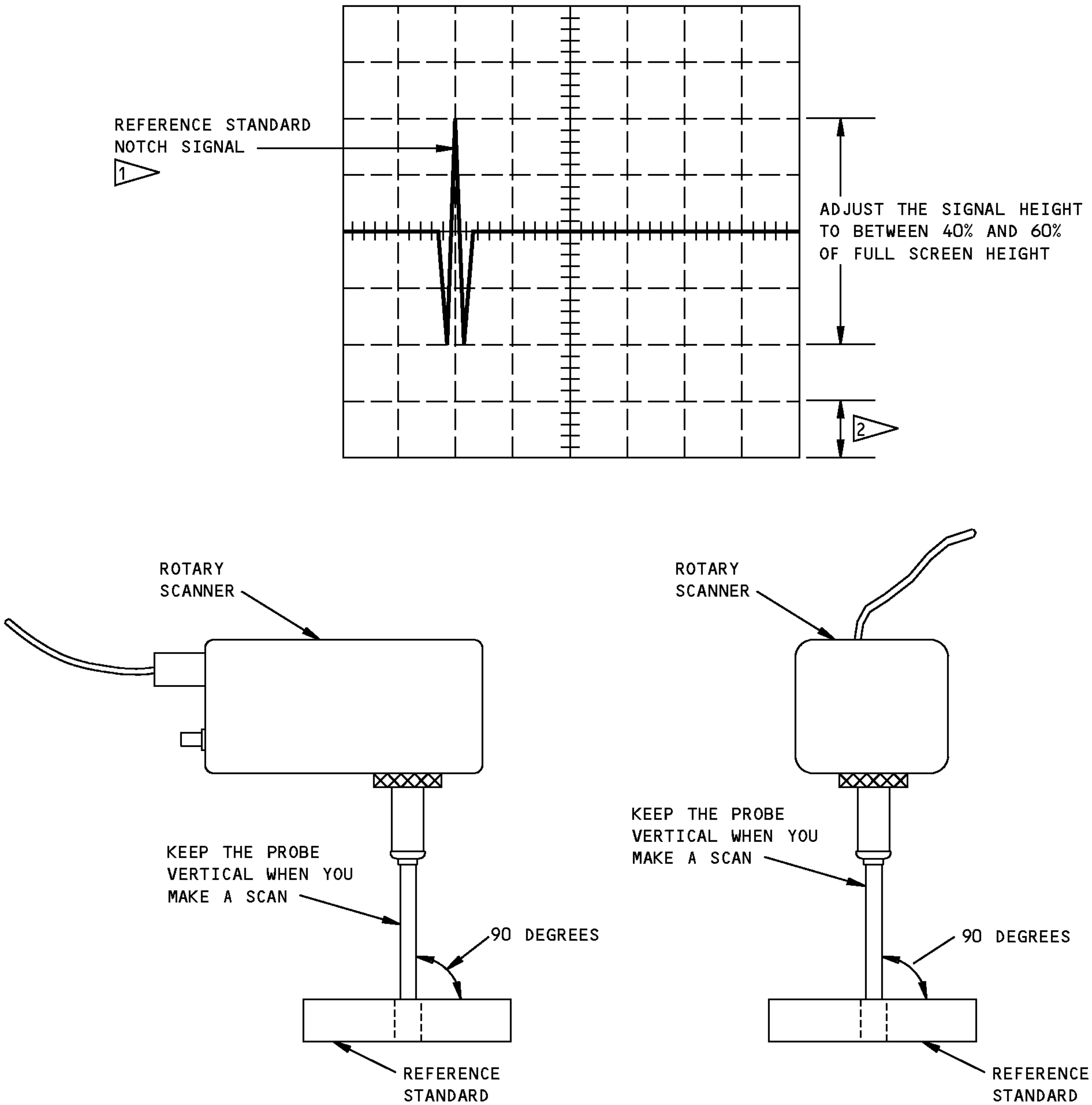
Reference Standard
Figure 3



NOTE

- WITH THE ROTARY SCANNER ON, AND THE PROBE AGAINST THE SIDE OF THE REFERENCE STANDARD, TURN THE PHASE CONTROL TO PUT THE LIFT-OFF SIGNAL IN THE HORIZONTAL POSITION.

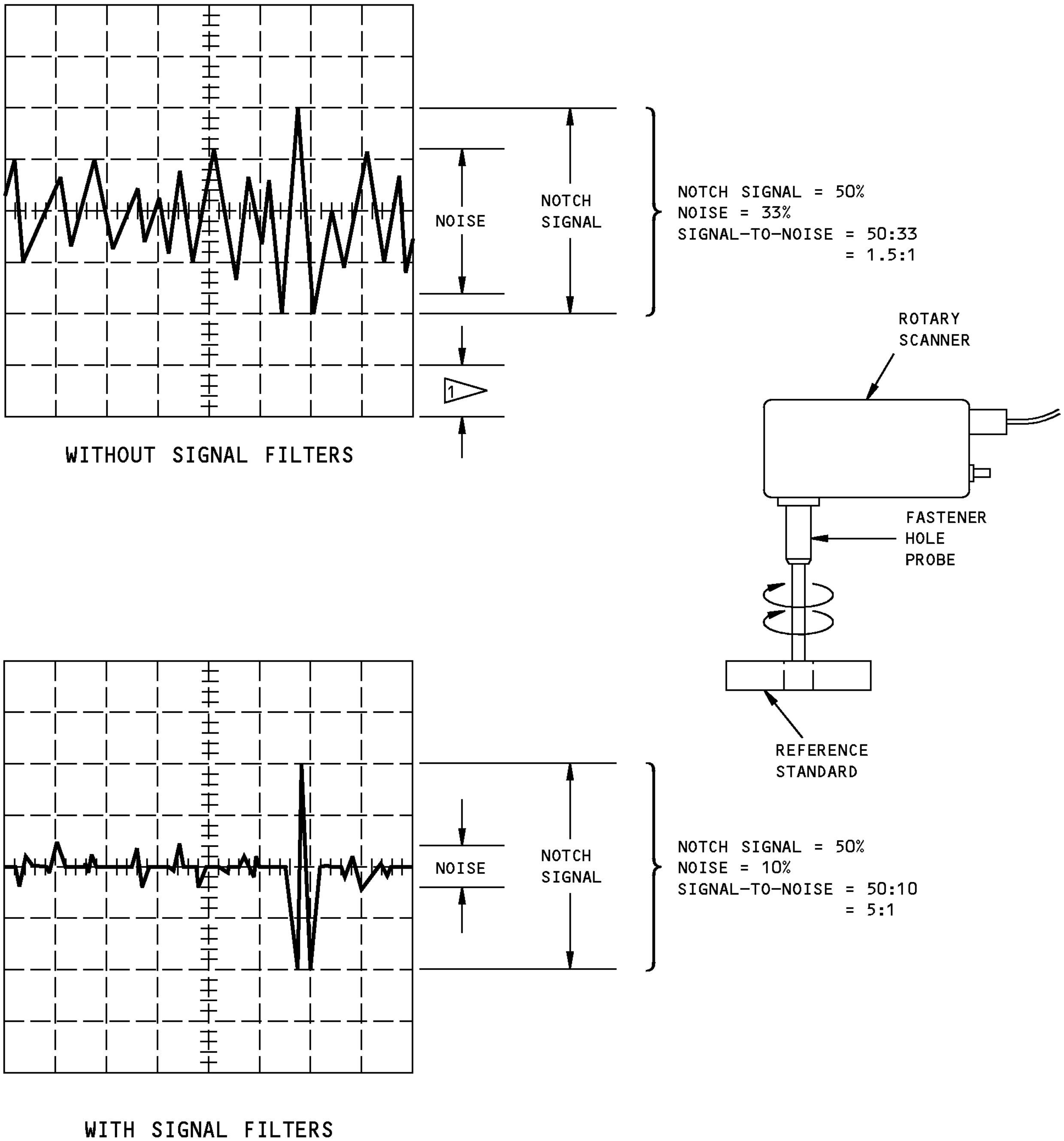
Phase Adjustment
Figure 4



1 THE HORIZONTAL POSITION OF THE SIGNAL ALONG THE TIMEBASE LINE IS RELATED TO THE LOCATION OF THE NOTCH OR CRACK IN THE FASTENER HOLE. SEE FIGURE 7.

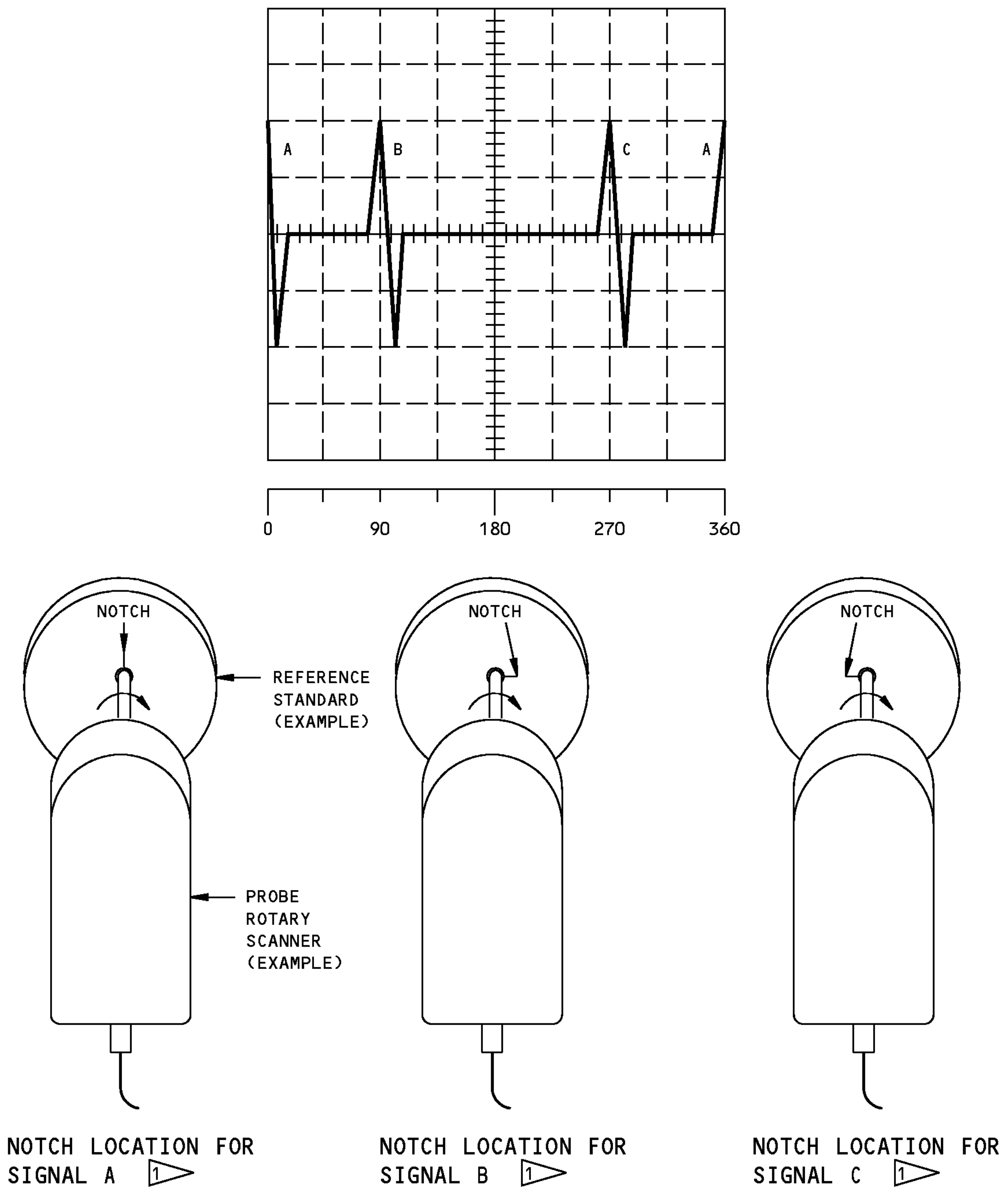
2 WHEN THE SCREEN IS DIVIDED INTO EIGHT PIECES, EACH PIECE EQUALS 12.5% OF FULL SCREEN HEIGHT.

Instrument Calibration
Figure 5



1 WHEN THE SCREEN IS DIVIDED INTO EIGHT PIECES, EACH PIECE EQUALS 12.5% OF FULL SCREEN HEIGHT.

Use of Signal Filters to Get 5:1 Signal-to-Noise Ratio
Figure 6



1 THE SIGNAL LOCATION ON THE TIMEBASE LINE WILL BE DIFFERENT WITH DIFFERENT INSTRUMENTS. USE A REFERENCE STANDARD NOTCH TO COMPARE THE SIGNAL LOCATION ON THE TIMEBASE LINE TO THE CRACK LOCATION IN THE PART.

Crack Location
Figure 7

PART 6 - EDDY CURRENT

ELECTRICAL CONDUCTIVITY MEASUREMENT FOR ALUMINUM

1. **Purpose**

   A. Use this procedure to measure the electrical conductivity of aluminum material.

   B. This procedure is for aluminum material that:

      (1) Is bare (unclad).

      (2) Has a thickness at least 2.66 times the standard depth of penetration for the conductivity instrument and probe used.

      NOTE: Figure 1 identifies how to calculate the standard depth of penetration. Figure 2 identifies the minimum thickness a material must be before you can do a conductivity test on it at frequencies of 60 kHz, 100 kHz, and 250 kHz.

      (3) Does not have a convex surface radius of curvature less than 3 inches (76 mm) or a concave surface radius of curvature less than 10 inches (254 mm).

      (4) Has a surface roughness of 150 Ra or better.

      (5) Does not have a nonconductive finish that is thicker than the maximum permitted lift-off for the instrument to be used. See Paragraph 4.E. to see how to find the maximum permitted lift-off.

      NOTE: If you want to measure the conductivity of aluminum material that does not meet the requirements of Paragraph 1.B., refer to Boeing Process Specification BAC 5946, or ask Boeing.

      NOTE: If you want to measure the conductivity of aluminum material to see if it is heat damaged, refer to Part 6, 51-00-03, "Investigation of Fire Damage on Aircraft Structure".

2. **Equipment**

   A. General

      (1) Use inspection equipment that can be calibrated as specified in Paragraph 4.

      (2) Refer to Part 1, 51-01-00 for data about the equipment manufacturers.

   B. Instrument

      (1) Use an eddy current instrument that:

         (a) Has a metered or digital display.

         (b) Gives conductivity values directly in percent International Annealed Copper Standard (IACS), or in MegaSiemens per Meter (MS/m).

         (c) Operates at a frequency between 50 kHz and 300 kHz.

         (d) Can clearly identify conductivity changes of 0.5 percent IACS (0.3 MS/m) in the applicable conductivity range.

         (e) Can measure the conductivity of the applicable reference standards with a precision of plus or minus 0.5 percent IACS (0.3 MS/m) or better.

         (f) Gives a conductivity change that is no more than 0.2 percent IACS (0.11 MS/m) for a lift-off distance of 0.003 inch (0.08 mm) between the test probe and the reference standard. The reference standard must be in the applicable conductivity range.

         (g) Has identified minimum distances that the probe must be from part edges and adjacent structure to make sure that the conductivity measurements will be accurate within plus or minus 0.2 percent IACS (0.11 MS/m).

(h) Has identified limits for curvature to make sure that the conductivity measurements on rounded surfaces will be accurate within plus or minus 0.2 percent IACS (0.11 MS/m).

(2) The instruments specified below were used to prepare this procedure.

(a) Autosigma 2000; Hocking Krautkramer Branson

(b) Sigmascope S; Fischer Instruments

(c) Verimet M4900C; K. J. Law Engineers, Inc.

(d) Sigmatest 2.068; Institute Dr. Forster

C. Probes

(1) Use a probe that:

(a) Is made specifically to be used with the instrument.

(b) Is flat on the surface that touches the test material.

(c) Is not sensitive to the small pressure differences that occur when it touches the test material.

(d) Is not sensitive to heat transfer from the hand to the probe and between the probe and the test material.

D. Reference Standards

(1) Use reference standards that:

(a) Are certified to a known standard, such as ASTM B193.

(b) Are sufficiently large to prevent edge effect. The surface area must be at least 1.2 inches (30.5 mm) by 1.2 inches (30.5 mm).

(c) Have a thickness at least 3.0 times the standard depth of penetration for the conductivity instrument and probe used.

NOTE: Figure 1 identifies how to calculate the standard depth of penetration. See Figure 3 for the minimum material thickness that can be used for conductivity standards to test material at 60 kHz, 100 kHz, and 250 kHz.

(d) Are accurate within plus or minus 0.35 percent IACS (0.2 MS/m) or better for conductivity values less than 50 percent IACS (29 MS/m) and plus or minus 0.70 percent IACS (0.4 MS/m) for conductivity values more than or equal to 50 percent IACS (29 MS/m).

(2) A minimum of three reference standards must be used to do this procedure. The certified conductivity values of the reference standards must agree with the required conductivity range of the material to be examined. See Table 1 for the conductivity range of some aluminum alloys. Use reference standards with conductivity values such that:

(a) One reference standard is no more than 7 percent IACS (4 MS/m) above or below the required conductivity range.

(b) One reference standard is no more than 25 percent IACS (15 MS/m) below the required conductivity range.

(c) One reference standard is no more than 25 percent IACS (15 MS/m) above the required conductivity range.

(d) There is a minimum of 3 percent IACS (1.7 MS/m) between the three reference standard values.

(3) The reference standards specified in this procedure are available from Zetec, Inc.

3. Preparation for Inspection

A. Get access to the inspection area.

B. Remove loose paint, dirt and sealant from the surface of the part to be examined.

C. Make sure the material to be examined is approved for this procedure. See Paragraph 1.B. for the necessary conditions.

D. Make sure that the temperature in the area where the material will be examined is between 49 and 90°F (4.5 and 32.2°C) and will not change during the test. Do not do a test of the material in direct sunlight or in a cool airflow.

NOTE: Changes in material temperature will change the conductivity.

E. Identify the required conductivity range for the material to be examined. See Table 1 for the conductivity range of some aluminum alloys.

4. Instrument Calibration

A. Use at least three reference standards. See Paragraph 2.D.(2) for the necessary conductivity values of the reference standards.

B. To decrease the risk of errors caused by temperature, put the instrument, probe, reference standards, and the material to be examined at the location where the inspection will be done.

C. Make sure that the instrument, probe, reference standards, and the material to be examined are at the same temperature (plus or minus 5°F (2°C)).

D. Calibrate the instrument as specified in the manufacturer's instructions. Make sure that the instrument can measure the (certified) conductivity of the conductivity reference standards within plus or minus 0.5 percent IACS (0.3 MS/m).

E. Identify the maximum permitted lift-off as follows:

(1) Measure the conductivity of the reference standard that is nearest in conductivity to the material to be examined.

(2) Put a 0.003 inch (0.08 mm) nonconductive shim on the surface of the reference standard and measure the conductivity again.

(3) Continue to add nonconductive shims and measure the conductivity until the conductivity measurement changes by more than plus or minus 0.3 percent IACS (0.17 MS/m).

(4) The thickness of the nonconductive layer used before the conductivity measurement changed by more than 0.3 percent IACS (0.17 MS/m) is the maximum permitted lift-off.

F. Identify the minimum distance the probe must be from edges, fasteners, ridges or other structure and the curvature limit that cause a conductivity measurement change of 0.2 percent IACS.

5. Inspection Procedure

A. Calibrate the instrument as specified in Paragraph 4.

B. Set the probe on the inspection surface. Do not set the probe at an angle or move it along the inspection surface. Keep the probe at least the minimum distance from edges, fasteners, ridges, or other structure as specified in Paragraph 4.F.

C. Make conductivity measurements on the surface of the test material.

D. Do a check of the instrument calibration regularly during the inspection and at the end of the inspection. If the conductivity measurement on each reference standard is not within plus or minus 0.5 percent IACS (0.3 MS/m) of the conductivity measurement you got during calibration, do the calibration again. Then, examine all the test material that was examined since the last satisfactory instrument calibration.

6. Inspection Results

A. Compare the conductivity values measured in Paragraph 5. to the electrical conductivity range specified in Table 1 for the alloy and tempers identified.

B. If the measured conductivity values are not in the specified conductivity range, refer to the applicable document for what to do.

Table 1 Electrical Conductivity Ranges For Some Aluminum Alloys

ALLOY	TEMPER	ELECTRICAL CONDUCTIVITY RANGE PERCENT IACS	(MS/m)
2014	0	48.5 - 51.0	(28.1 - 29.6)
	T3XX	31.5 - 35.0	(18.3 - 20.3)
	T4XXX	31.5 - 35.0	(18.3 - 20.3)
	T6XXX	35.0 - 40.0	(20.3 - 23.2)
2017	0	48.5 - 51.0	(28.1 - 29.6)
	T4XXX	31.5 - 35.0	(18.3 - 20.3)
2024	0	45.5 - 49.0	(26.4 - 28.4)
	T3XXX	28.5 - 32.0	(16.5 - 18.6)
	T4XXX	28.5 - 32.0	(16.5 - 18.6)
	T6X	36.0 - 40.0	(20.9 - 23.2)
	T8XXX	38.0 - 42.0	(22.0 - 24.4)
2219	0	44.0 - 49.0	(25.5 - 28.4)
	T3XXX	26.0 - 31.0	(15.1 - 18.0)
	T37	27.0 - 31.0	(15.7 - 18.0)
	T4X	28.0 - 32.0	(16.2 - 18.6)
	T6X	32.0 - 35.0	(18.6 - 20.3)
	T8XXX	31.0 - 35.0	(18.0 - 20.3)
	T87	31.0 - 35.0	(18.0 - 20.3)
6061	0	47.0 - 56.0	(27.3 - 32.5)
	T4XXX	36.0 - 45.5	(20.9 - 26.4)
	T42	36.0 - 45.5	(20.9 - 26.4)
7075	0	44.0 - 47.5	(25.5 - 27.5)
	T6XXX	30.0 - 35.0	(17.4 - 20.3)
	T76XX	38.0 - 42.0	(22.0 - 24.4)
7079	T6XX	30.0 - 33.5	(17.4 - 19.4)
7150	T651	34.0 - 39.5	(19.7 - 22.9)
	T6511	32.0 - 37.5	(18.6 - 21.8)
7178	0	43.0 - 47.0	(24.9 - 27.3)
	T6XXX	29.5 - 33.0	(17.1 - 19.1)
	T76XXX	38.0 - 42.0	(22.0 - 24.4)

NOTE: For alloys not included above, refer to Boeing Process Specification BAC 5946, or ask Boeing for the electrical conductivity ranges.

Use one of the equations that follow to calculate the standard depth of penetration for aluminum alloys:

English: $\boldsymbol{\delta} = 26/\sqrt{f\sigma}$

where

$\boldsymbol{\delta}$ = the standard depth of penetration in inches

f = the instrument test frequency in hertz

σ = the electrical conductivity in percent International Annealed Copper Standard (IACS)

Metric: $\boldsymbol{\delta} = 1.34/\sqrt{f\sigma}$

where

$\boldsymbol{\delta}$ = the standard depth of penetration in millimeters

f = the instrument test frequency in hertz

σ = the electrical conductivity in MegaSiemens per meter (MS/m)

Standard Depth of Penetration Equations
Figure 1

CONDUCTIVITY % IACS (MS/m)		MINIMUM THICKNESS OF THE CONDUCTIVITY STANDARD, INCHES (MILLIMETERS) 1 — INSTRUMENT TEST FREQUENCY							
		60 kHz		100 kHz		250 kHz		500 kHz	
25.0	(14.5)	0.056	(1.43)	0.044	(1.11)	0.028	(0.70)	0.020	(0.50)
30.0	(17.4)	0.052	(1.31)	0.040	(1.01)	0.025	(0.64)	0.018	(0.45)
35.0	(20.3)	0.048	(1.21)	0.037	(0.94)	0.023	(0.59)	0.017	(0.42)
40.0	(23.2)	0.045	(1.13)	0.035	(0.88)	0.022	(0.56)	0.015	(0.39)
45.0	(26.1)	0.042	(1.07)	0.033	(0.83)	0.021	(0.52)	0.015	(0.37)
50.0	(29.0)	0.040	(1.01)	0.031	(0.79)	0.020	(0.50)	0.014	(0.35)
55.0	(31.9)	0.038	(0.97)	0.029	(0.75)	0.019	(0.47)	0.013	(0.33)
60.0	(34.8)	0.036	(0.93)	0.028	(0.72)	0.018	(0.45)	0.013	(0.32)

1 THE MINIMUM THICKNESS OF A CONDUCTIVITY STANDARD MUST BE EQUAL TO 2.66 TIMES THE STANDARD DEPTH OF PENETRATION.

Minimum Thickness of the Test Material
Figure 2

CONDUCTIVITY % IACS (MS/m)		MINIMUM THICKNESS OF THE CONDUCTIVITY STANDARD, INCHES (MILLIMETERS) 1 INSTRUMENT TEST FREQUENCY 60 kHz		100 kHz		250 kHz		500 kHz	
25.0	(14.5)	0.064	(1.62)	0.049	(1.25)	0.031	(0.79)	0.022	(0.56)
30.0	(17.4)	0.058	(1.48)	0.045	(1.14)	0.028	(0.72)	0.020	(0.51)
35.0	(20.3)	0.054	(1.37)	0.042	(1.06)	0.026	(0.67)	0.019	(0.47)
40.0	(23.2)	0.050	(1.28)	0.039	(0.99)	0.025	(0.63)	0.017	(0.44)
45.0	(26.1)	0.047	(1.21)	0.037	(0.93)	0.023	(0.59)	0.016	(0.42)
50.0	(29.0)	0.045	(1.14)	0.035	(0.89)	0.022	(0.56)	0.016	(0.40)
55.0	(31.9)	0.043	(1.09)	0.033	(0.84)	0.021	(0.53)	0.015	(0.38)
60.0	(34.8)	0.041	(1.04)	0.032	(0.81)	0.020	(0.51)	0.014	(0.36)

1 THE MINIMUM THICKNESS A CONDUCTIVITY STANDARD MUST BE IS EQUAL TO 3.0 TIMES THE STANDARD DEPTH OF PENETRATION.

Minimum Thickness of the Conductivity Standard
Figure 3

PART 6 - EDDY CURRENT

ALUMINUM PART SURFACE INSPECTION (IMPEDANCE PLANE DISPLAY)

1. **Purpose**
   A. Use this procedure to do an inspection for surface cracks in aluminum parts.
   B. This procedure uses an impedance plane display instrument.
   C. Part 6, 51-00-01 is an alternative inspection procedure.
2. **Equipment**
   A. General
      (1) Use inspection equipment that can be calibrated on the reference standard as specified in Paragraph 4.
      (2) Refer to Part 1, 51-01-00 for data about the equipment manufacturers.
   B. Instrument
      (1) Use an eddy current instrument that:
         (a) Has an impedance plane display.
         (b) Operates at a frequency range of 50 kHz to 500 kHz.
      (2) The instruments specified below were used to prepare this procedure.
         (a) Phasec 1.1; Hocking Krautkramer.
         (b) Nortec NDT-19e; Staveley Instruments.
         (c) MIZ-22; Zetec, Inc.
   C. Probes
      (1) Use a probe that:
         (a) Operates at a frequency in the range of 50 kHz to 500 kHz.
         (b) Has the configuration shown in Figure 1.
         (c) Can satisfactorily do the angularity check as shown in Figure 2.
         (d) Can satisfactorily do the probe shield test of Figure 3. This is necessary if the inspection area is near adjacent structure to make sure the adjacent structure will not change the signals.

         NOTE: Shielded probes are recommended.
   D. Reference Standards
      (1) Use reference standards 126, 188A, 189 or NDT1048. See Figure 4 thru Figure 7 for data about the reference standards.
      (2) Other reference standards can be used if they are equivalent to those shown in Figure 4 thru Figure 7.
   E. Special Tools
      (1) Use a nonconductive circle template as shown in Figure 9 to help examine the area around flush head fasteners for cracks.
      (2) Use a nonconductive straightedge as shown in Figure 10 and Figure 11 to help examine near the edges of parts for cracks.

      NOTE: The circle template and straightedge help to keep the probe a constant distance from a fastener head or structural edge. The signal will slowly increase when the probe gets closer to an edge of a part.

3. Preparation for Inspection

A. Get access to the inspection area.

B. Remove loose paint, dirt and sealant from the surface of the inspection area.

4. Instrument Calibration

A. Set the frequency between 50 and 500 kHz.

B. Calibrate the instrument with the applicable reference standard. Paragraph 5.E. identifies the different types of structural configurations that can be examined. The reference standards to use for the different structural configurations to be examined are:

(1) Large Areas, Near an Edge, On an Edge, Radius: Use reference standard 126.

(2) Flush Head Fasteners: Use reference standard NDT1048.

(3) Protruding Head Fasteners: Use reference standard 188A.

C. Set the vertical to horizontal gain between 2:1 and 4:1.

D. Set the filters as follows:

(1) Set the high-pass filter to off or zero Hz.

(2) If the instrument has a low-pass filter:

(a) Set the low-pass filter to its highest value.

(b) Decrease the filter value to get a stable dot.

E. Put a nonconductive shim on the reference standard. The thickness of the shim must be equivalent (± 0.003 inch (0.08 mm)) to the paint thickness on the airplane.

F. Put the probe on the reference standard at least 0.5 inch (12.7 mm) away from the EDM notch and the edge of the reference standard.

G. Balance the instrument.

H. Adjust the balance point to 20 percent of the display as shown in Figure 8.

I. Adjust the instrument for lift-off. Adjust the phase control so that the lift-off signal moves horizontally to the left when the probe is lifted off of the part surface.

J. Move the probe across the notch in the reference standard.

K. Adjust the gain to get a signal that is 20 to 40 percent of the display above the balance point as shown in Figure 8.

L. If the instrument has an alarm, set the alarm as shown in Figure 8.

M. Move the probe across the notch in the reference standard to find the maximum scan speed. The scan speed is too fast if the signal is less than 90 percent of the calibration notch signal.

NOTE: Higher scan speeds are possible with a higher low-pass filter value.

5. Inspection Procedure

A. Put the probe on the inspection surface.

B. Balance the instrument.

C. Adjust the balance point to 20 percent of the display as shown in Figure 8.

NOTE: Do not adjust the gain. Gain adjustments will make the instrument calibration unsatisfactory.

D. Make sure the signal moves horizontally to the left when the probe is lifted off of the part surface.

E. Slowly make a scan of the inspection area and monitor the instrument display during the scan. Do the scan as follows:

(1) Use a scan pattern that:

(a) Will help you find cracks that are 0.1 inch (2.5 mm) in length.

(b) Move the probe across the crack at 90°. This is done to increase the probability that you will find a crack.

(2) During the scan, move the probe no faster than the maximum scan speed that was identified during calibration.

(3) Do the scan as follows for the specified structural configurations:

(a) Large Areas: Use a grid system to do the inspection of large areas. The grid lines must be spaced so that when the probe is moved along the grid lines, the probe will cross the smallest crack you want to find at least two times.

NOTE: If you are not sure of the minimum crack length, use 0.1 inch (2.5 mm).

(b) Flush Head Fasteners: Use a nonconductive circle template to do inspections around flush head fasteners. Put the template adjacent to the fastener so that you can find cracks that extend 0.1 inch (2.5 mm) from the fastener head as shown in Figure 9.

(c) Protruding Head Fasteners: To examine areas around fasteners with protruding heads, use the fastener head or the washer as a probe guide as shown in Figure 12.

(d) Radius: To examine the radius of a part, keep the probe perpendicular to the radius surface. If the crack direction is not known, move the probe along and across the radius as shown in Figure 13.

(e) Edges: When you do an inspection near the edge of a part, use a nonconductive straightedge to keep the probe the same distance from the edge of the part. See Figure 10 to see how to examine a part near the edge. See Figure 11 to examine the edge of a part.

(4) Make a mark at the locations that cause signals that are more than 20 percent of the display above the balance point.

NOTE: To find the end of the crack, continue to move the probe across the crack until there is no more crack signal.

(5) Frequently do a check of the instrument calibration as follows:

NOTE: Do not adjust the gain.

(a) Put the probe on the reference standard to get a signal from the notch.

(b) Compare the signal you got from the notch during calibration with the signal you get now.

(c) If the signal has changed 10 percent or more, do the calibration and inspection again.

6. Inspection Results

A. Fast upscale signals that are more than 50 percent of the signal height from the reference notch are signs of possible cracks.

B. Compare the signal that occurs during the inspection to the signal you got from the notch in the reference standard.

NOTE: The signal from a crack can have less horizontal movement than the signal from the notch in the reference standard. See Figure 8.

(1) To find the end of a crack, continue to move the probe across the crack until there is no more crack signal.

(2) To make an estimate of the depth of a crack that is less than 0.02 inch (0.5 mm) deep, compare the vertical movement of the crack signal to the vertical movement of the reference standard notch. A reference standard with notches that are less than 0.02 inch (0.5 mm) deep can also be used.

C. The conditions specified below can also cause crack signals:

(1) The probe is moved too close to an edge. Use a nonconductive straightedge to keep the probe the same distance from the edge.

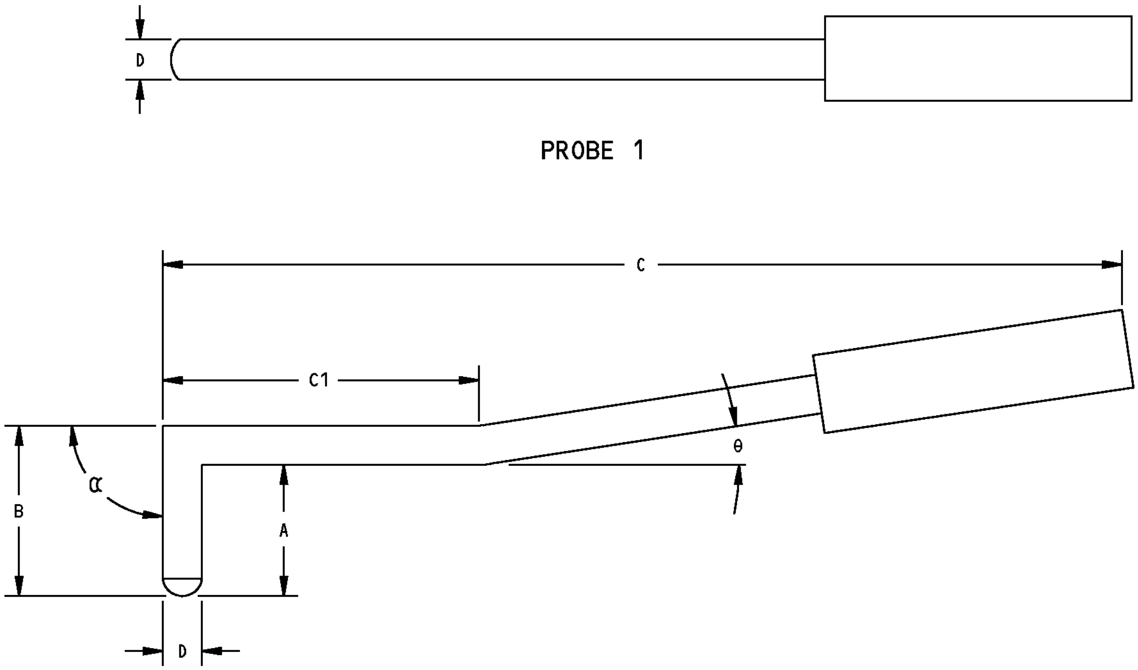
(2) A worn probe coil. Put a piece of tape on the surface of the probe coil or get a new probe and calibrate the instrument again.

(3) Local changes in material conductivity. Compare the signal to the signal from the reference standard. Signals from conductivity changes will be slower than the signal from the reference standard.

D. Do one of the procedures that follow to make sure a signal is the result of a crack.

(1) Remove the surface finish and do a visual inspection with 10-power (or higher) magnification and sufficient light.

(2) Do a penetrant inspection of the area as specified in SOPM 20-20-02, "Penetrant Inspection Methods".



NOTES

- THE PROBE CONFIGURATIONS SHOWN CAN BE USED TO ACCESS MOST INSPECTION AREAS WHEN IT IS NECESSARY TO USE PENCIL PROBES. SHIELDED PENCIL PROBES ARE RECOMMENDED. WHEN A SPECIAL PROBE CONFIGURATION IS NECESSARY, SPECIFY THE PROBE DIMENSIONS AS SHOWN FOR PROBE 2:

  A - THE PROBE DROP, OR DIMENSION A

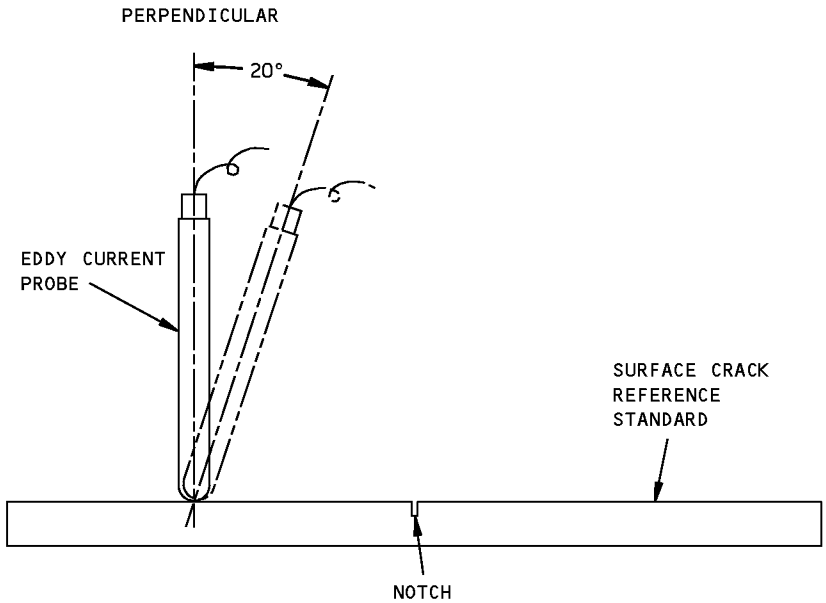
  B - THE PROBE HEIGHT, OR DIMENSION B

  C - THE PROBE HANDLE LENGTH, OR DIMENSION C. IF THE HANDLE MUST BE BENT, IT WILL BE NECESSARY TO KNOW DIMENSION C1 AND THE HANDLE ANGLE (ANGLE THETA - θ). FOR MOST USES, THE PROBE LENGTH WILL BE 3-5 INCHES (76.0-127.0 MM).

  D - DIAMETER: 0.20 INCH (5.1 MM) MAXIMUM. A DIAMETER OF 0.12 INCH (3.0 MM) IS RECOMMENDED FOR AREAS WITH NOT MUCH ACCESS.

  α - THE ANGLE (α = ALPHA). DIFFERENT ANGLES ARE POSSIBLE.

Example of Pencil Probe Configurations
Figure 1

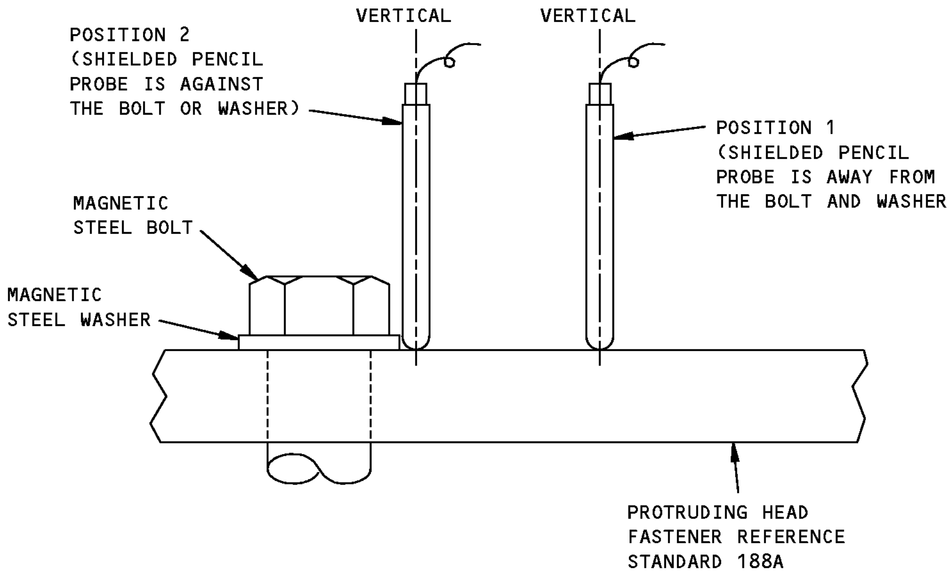


NOTES

- TO IDENTIFY THE ANGULAR PERFORMANCE OF THE PENCIL PROBE:
  - CALIBRATE THE PROBE WITH THE INSTRUMENT AS SPECIFIED IN PARAGRAPH 4.
  - ANGLE THE PROBE 20 DEGREES TO THE SURFACE OF THE REFERENCE STANDARD IN MANY DIRECTIONS. THE ANGULAR POSITION OF THE PROBE MUST NOT CAUSE THE SIGNAL TO CHANGE MORE THAN 10 PERCENT OF THE DISPLAY.
  - MOVE THE PROBE ACROSS THE NOTCH AS IT IS HELD PERPENDICULAR TO THE SURFACE OF THE REFERENCE STANDARD AND AGAIN AS IT IS HELD 20 DEGREES FROM PERPENDICULAR. THE NOTCH SIGNAL MUST NOT DECREASE MORE THAN 30 PERCENT.

  EXAMPLE: A SIGNAL FROM THE NOTCH ON THE REFERENCE STANDARD IS 40 PERCENT OF FULL SCALE WHEN THE PROBE IS HELD PERPENDICULAR TO THE SURFACE. WHEN THE PROBE IS HELD AT AN ANGLE THAT IS 20 DEGREES TO THE SURFACE, THE NOTCH SIGNAL MUST NOT BE LESS THAN 28 PERCENT OF THE DISPLAY. (40% SIGNAL X 0.3 = 12% AND 40% - 12% = 28%)

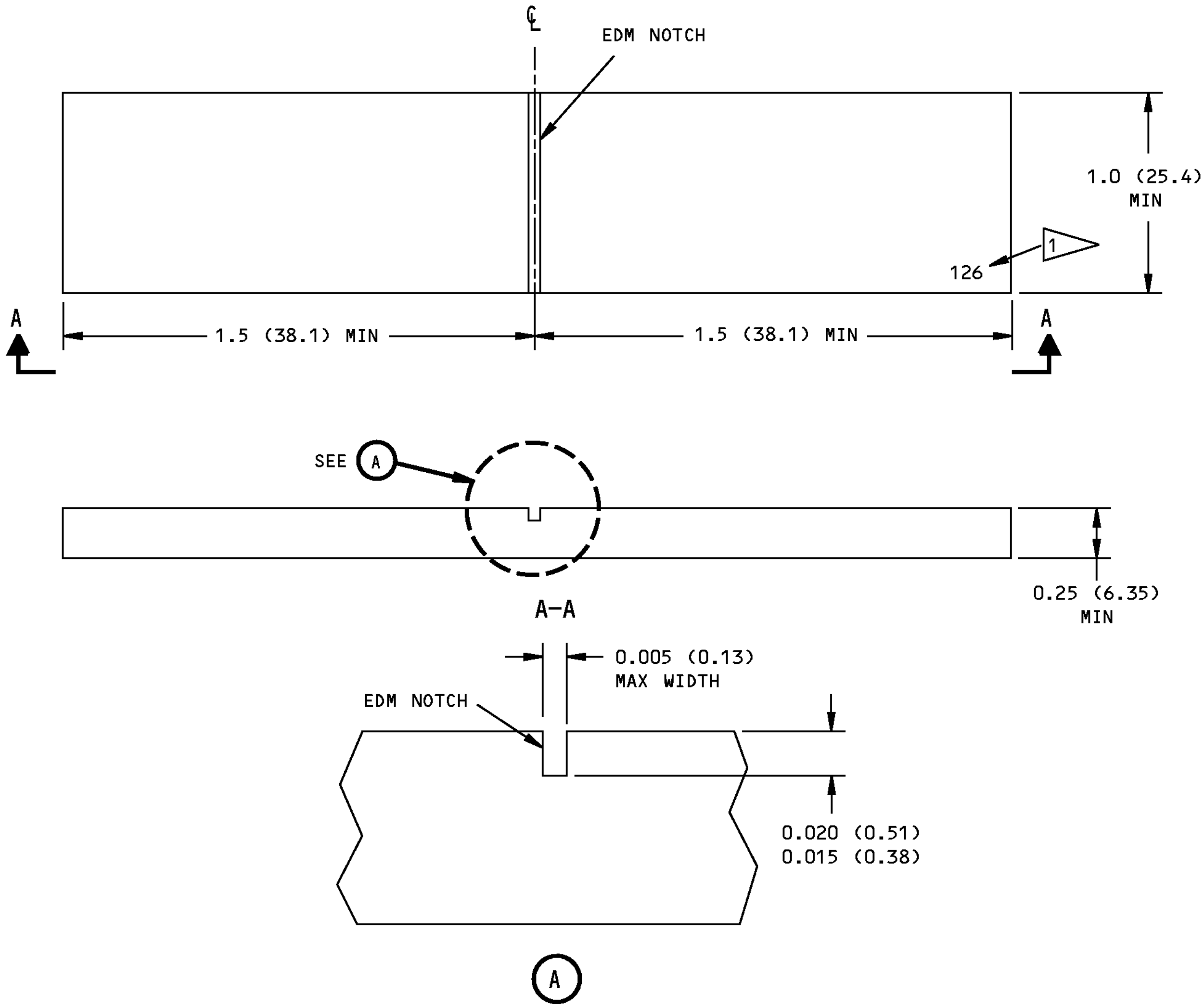
Pencil Probe Angular Performance
Figure 2



NOTES

- TO IDENTIFY IF A SHIELDED PENCIL PROBE HAS SUFFICIENT SHEILDING:
  - CALIBRATE THE PROBE/INSTRUMENT ON REFERENCE STANDARD 188A AS SPECIFIED IN PARAGRAPH 4.
  - PUT THE PROBE ON THE PROTRUDING-HEAD REFERENCE STANDARD AT POSITION 1 AND MOVE THE PROBE TO POSITION 2. THE MAGNETIC STEEL MUST NOT CAUSE THE CALIBRATION NOTCH SIGNAL TO CHANGE MORE THAN 10 PERCENT. IF THE SIGNAL CHANGES MORE THAN 10 PERCENT, IT IS NECESSARY TO DO A SCAN AROUND THE FASTENER AT A CONSTANT DISTANCE FROM THE FASTENER.

Pencil Probe Shield Performance
Figure 3

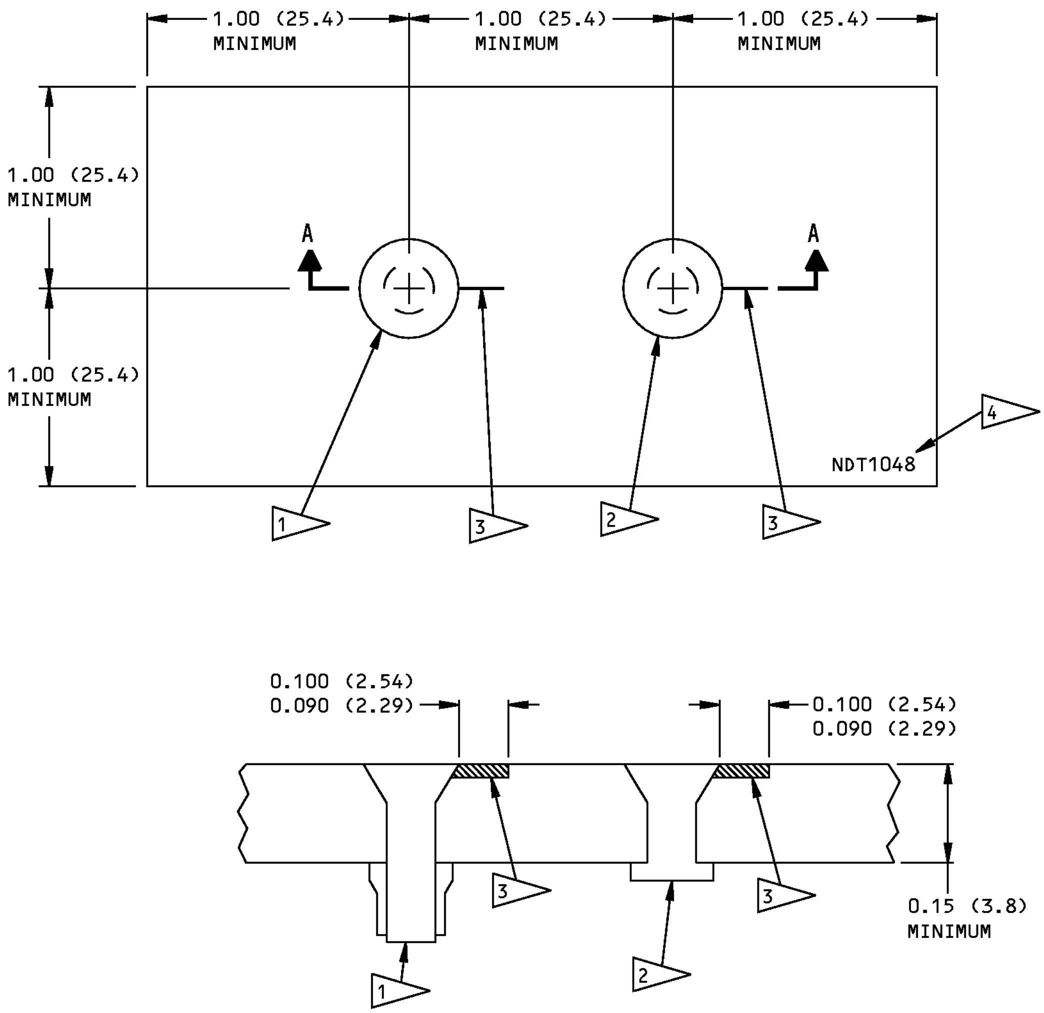


NOTES

- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES).
- TOLERANCE ±0.050 (±1.3) ON THE DIMENSIONS UNLESS SPECIFIED DIFFERENTLY.
- SURFACE ROUGHNESS: 63√ OR BETTER.
- REFER TO NDT PART 1, 51-01-00, FOR DATA ABOUT THE REFERENCE STANDARD MANUFACTURERS.
- MATERIAL: 2024-T3 OR -T4, 7075-T6 OR -T73, 7079-T6 OR 7178-T6 ALUMINUM.

1 ETCH OR STEEL STAMP THE NUMBER 126 ON THE REFERENCE STANDARD.

Reference Standard 126 - for the Surface Inspection of Aluminum Parts
Figure 4



A-A

NOTES

- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES).
- MATERIAL: 2024-T3 OR T4, 7075-T6, 7079-T6, 7178-T6
- SURFACE FINISH: 63/ OR BETTER.
- IF YOU HAVE REFERENCE STANDARD 187, YOU CAN USE IT FOR THE INSPECTION AROUND ALUMINUM FASTENERS.

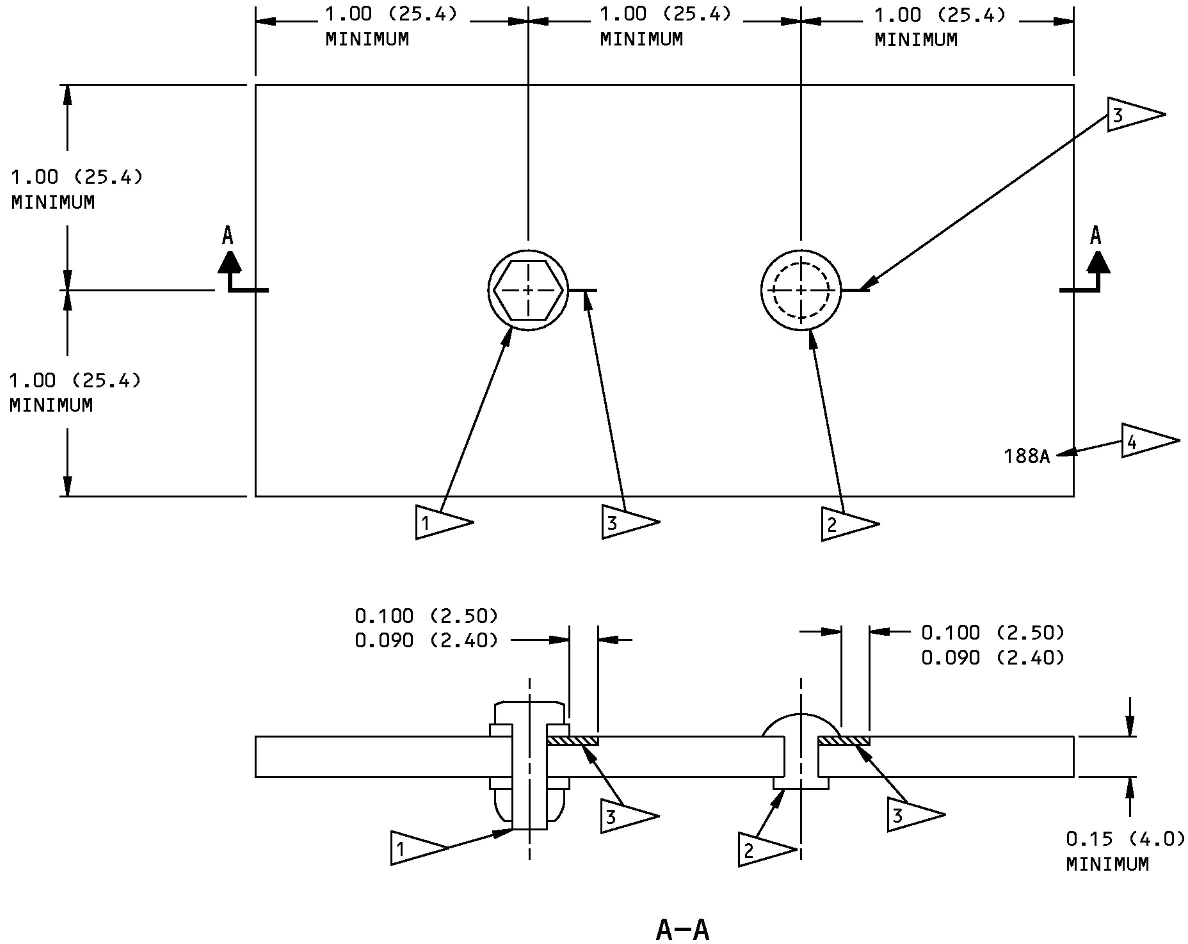
1 FASTENER - 0.25 (6.4) DIAMETER FLUSH-HEAD STEEL BOLT, SUCH AS BACB30JC8-*

2 FASTENER - 0.25 (6.4) DIAMETER FLUSH-HEAD ALUMINUM RIVET, SUCH AS BACR15BA*DD*

3 NOTCH: 0.005 (0.13) MAXIMUM WIDTH, 0.015-0.020 (0.38-0.51) DEPTH.

4 ETCH OR STEEL STAMP THE REFERENCE STANDARD NUMBER NDT1048 IN THIS LOCATION

Reference Standard NDT1048 - For Flush-Head Fasteners
Figure 5



NOTES

- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES).
- TOLERANCE ±0.050 (±1.27) UNLESS SPECIFIED DIFFERENTLY.
- SURFACE ROUGHNESS: 63 $\surd$ OR BETTER.
- REFER TO PART 1, 51-01-00, FOR DATA ABOUT THE REFERENCE STANDARD MANUFACTURERS.
- MATERIAL: 2024-T3 OR -T4, 7075-T6, 7079-T6 OR 7178-T6 ALUMINUM

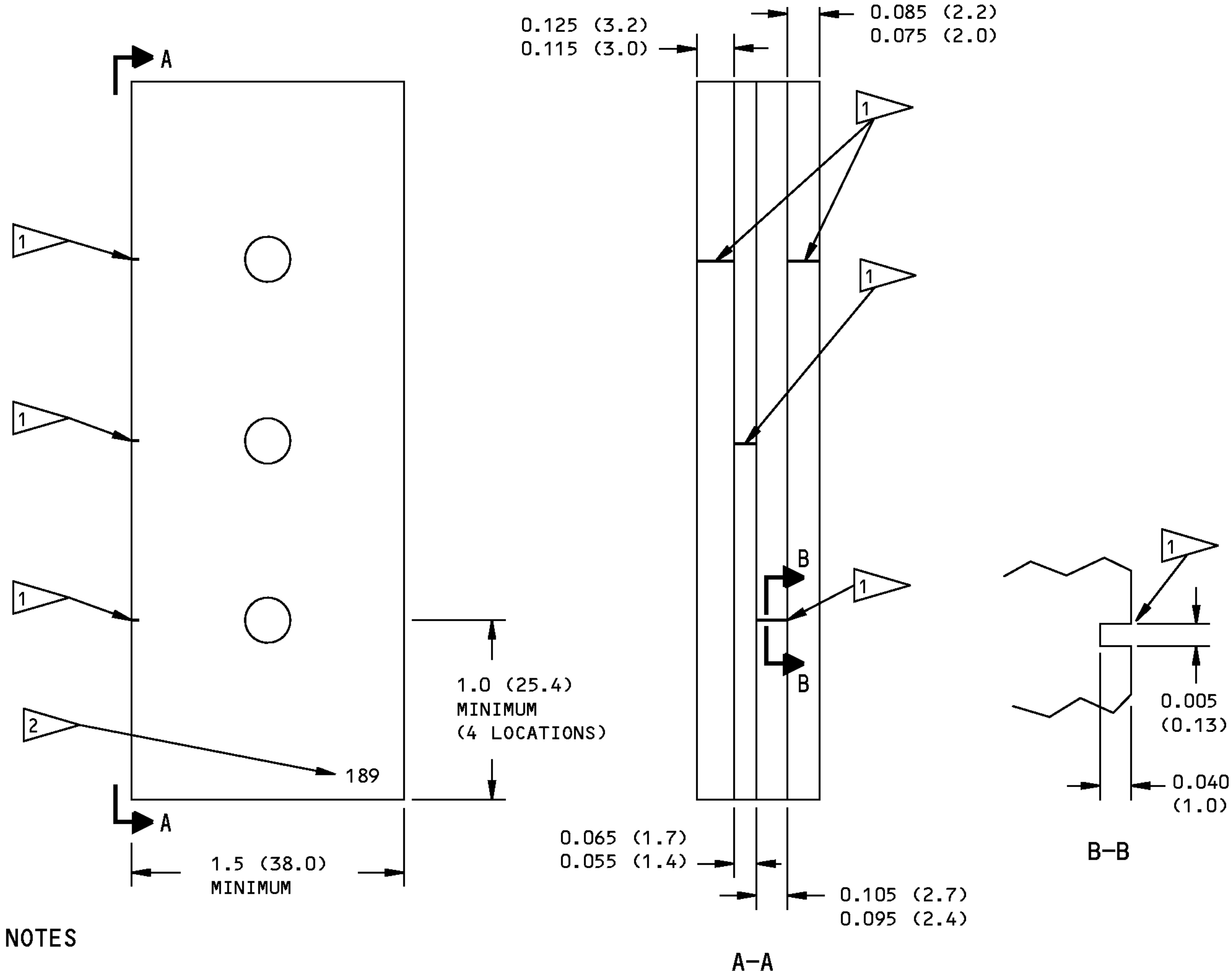
[1] FASTENER - 0.25 (6.4) DIAMETER EXTERNAL WRENCHING STEEL BOLT, SUCH AS BACB30NE*-*; FLAT STEEL WASHER, SUCH AS BACW10AK*WP.

[2] RIVET BACR15BB6AD5

[3] NOTCH - 0.005 (0.13) MAXIMUM WIDTH, 0.015-0.020 (0.38-0.51) DEPTH.

[4] ETCH OR STEEL STAMP THE NUMBER "188A" ON THE REFERENCE STANDARD.

Reference Standard 188A - for Protruding-Head Fasteners
Figure 6



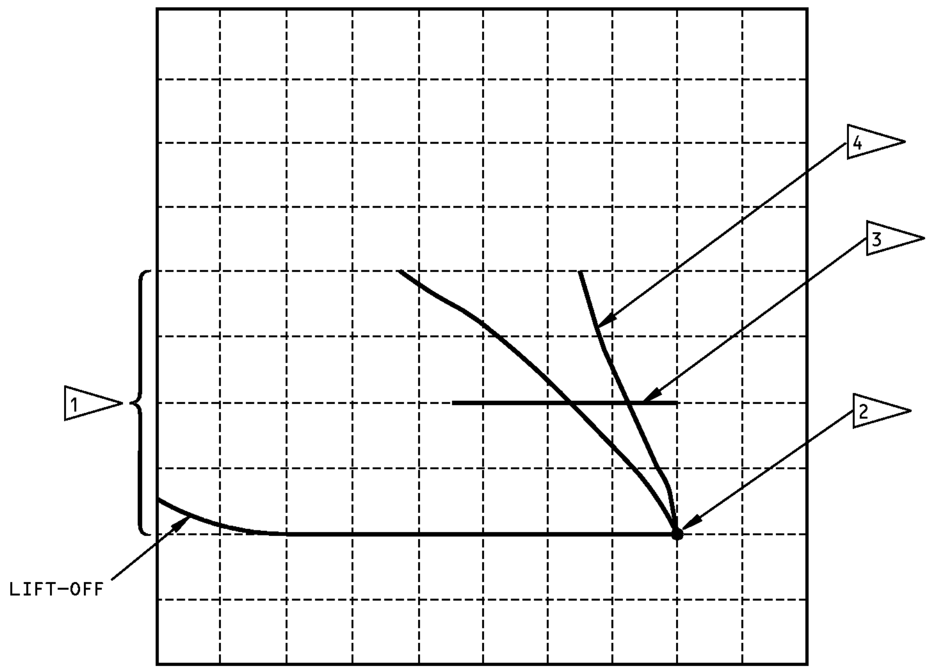
NOTES

- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES).
- TOLERANCE ±0.050 (±1.27) UNLESS SPECIFIED DIFFERENTLY.
- SURFACE ROUGHNESS: 63 OR BETTER.
- REFER TO PART 1, 51-01-00, FOR DATA ABOUT THE REFERENCE STANDARD MANUFACTURERS.
- MATERIAL: 2024-T3 OR T4, 7075-T6, 7079-T6 OR 7178-T6 ALUMINUM (ALL PARTS MUST BE OF THE SAME ALLOY AND HEAT TREAT).
- FASTENER: USE AN ALUMINUM OR TITANIUM FASTENER WITH A HEAD DIAMETER THAT IS LESS THAN 0.5 (12.7).

1 NOTCH - 0.005 (0.13) MAXIMUM WIDTH; 0.040 (1.0) DEPTH.

2 ETCH OR STEEL STAMP THE NUMBER "189" ON THE REFERENCE STANDARD.

Reference Standard 189 - for Cracks at the End of Parts
Figure 7



NOTES

- THE DISPLAY EXAMPLE ABOVE SHOWS WHERE TO SET THE ALARM AS SPECIFIED IN PARAGRAPH 4.

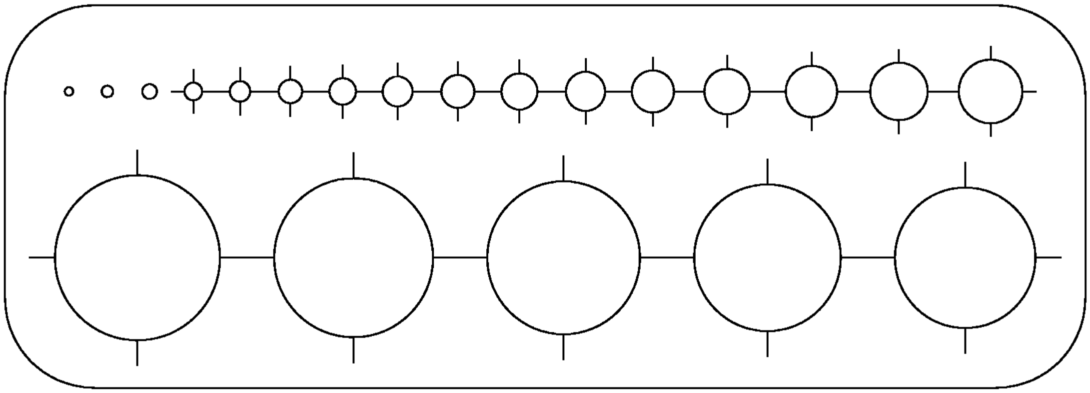
1 SIGNAL FROM THE NOTCH IN THE REFERENCE STANDARD. SET AT 20 TO 40 PERCENT OF THE DISPLAY ABOVE THE BALANCE POINT.

2 BALANCE POINT.

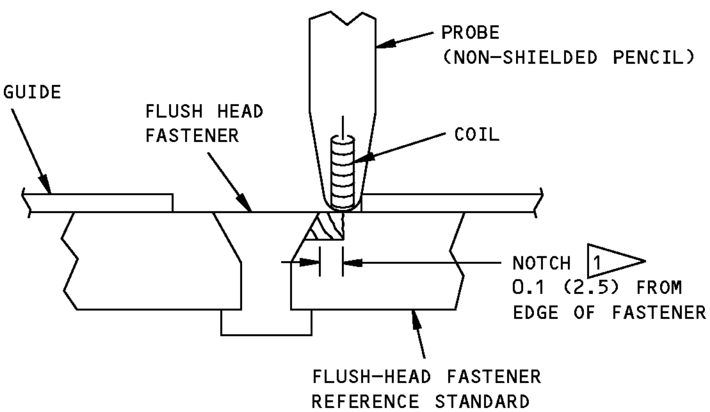
3 ALARM SET POINT (50 PERCENT OF THE REFERENCE NOTCH SIGNAL).

4 THE SIGNAL FROM A CRACK CAN HAVE LESS HORIZONTAL MOVEMENT THAN THE SIGNAL FROM THE NOTCH IN THE REFERENCE STANDARD.

Calibration and Alarm Adjustment
Figure 8



PROBE GUIDE
(NONCONDUCTIVE CIRCLE TEMPLATE)



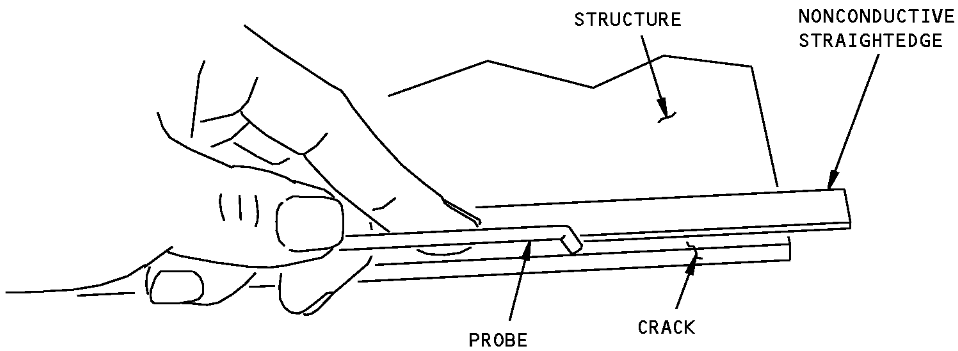
PROBE GUIDE USE FOR INSPECTIONS NEAR FLUSH-HEAD FASTENERS

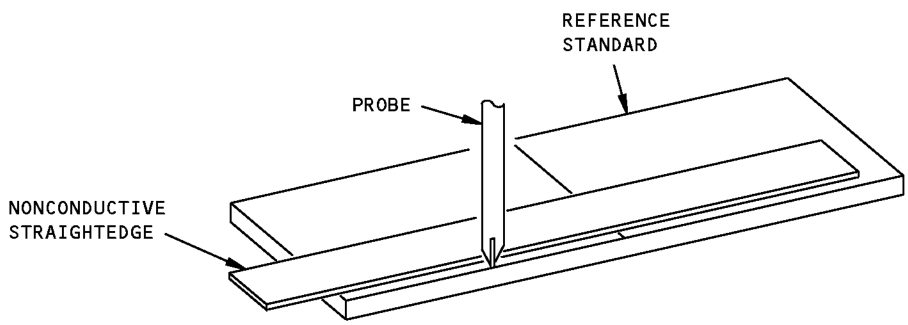
NOTES

- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES).
- USE THE HOLE DIAMETER IN THE PROBE GUIDE THAT WILL PERMIT YOU TO FIND CRACKS THAT ARE 0.10 INCH (2.5 MM) IN LENGTH FROM THE EDGE OF THE FASTENER.

1 THIS IS THE MINIMUM NOTCH LENGTH THAT CAN BE FOUND WITH THIS PROCEDURE.

Flush-Head Fastener Inspection Guidelines
Figure 9

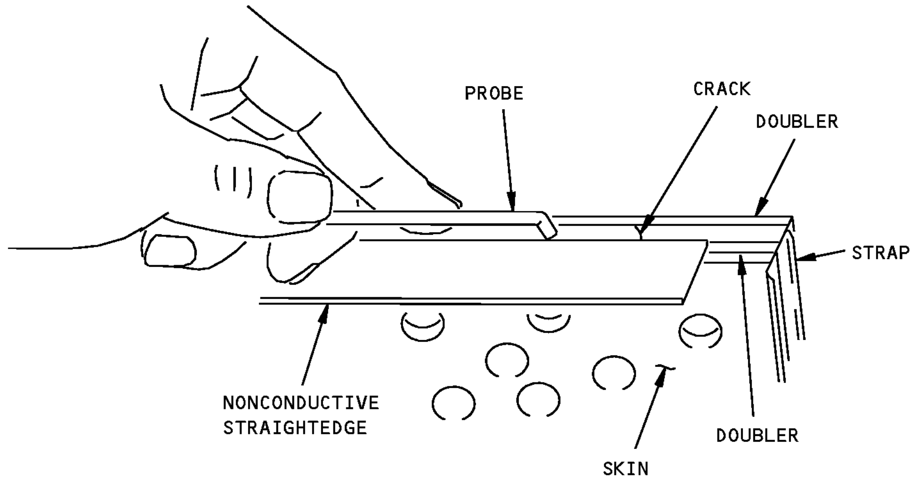


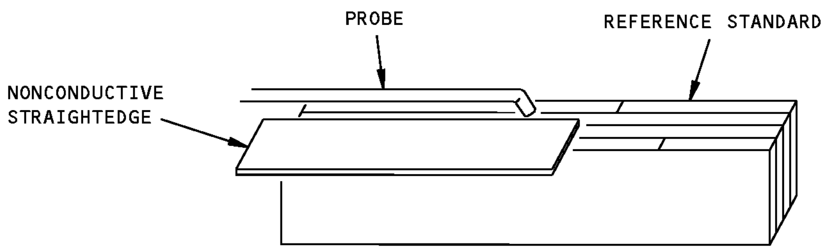


NOTES

- POSITION A NONCONDUCTIVE STRAIGHTEDGE A CONSTANT DISTANCE FROM THE EDGE OF THE STRUCTURE.
- THE MINIMUM DISTANCE THE PROBE MUST BE FROM AN EDGE IS RELATED TO THE DIAMETER OF THE PROBE COIL AND IF THE PROBE IS SHIELDED OR UNSHIELDED.
- TO IDENTIFY THE MINIMUM DISTANCE THE PROBE MUST BE FROM THE EDGE:
  - CALIBRATE THE INSTRUMENT AS SPECIFIED IN PARAGRAPH 4.
  - POSITION A NONCONDUCTIVE STRAIGHTEDGE A CONSTANT DISTANCE FROM THE NOTCHED EDGE OF REFERENCE STANDARD 126.
  - MOVE THE PROBE ALONG THE STRAIGHT EDGE AND MONITOR THE DISPLAY. THE MINIMUM PROBE TO EDGE DISTANCE OCCURS WHEN THE SIGNAL FROM THE NOTCH FALLS BELOW 90% OF THE SIGNAL YOU GOT DURING CALIBRATION, OR WHEN THE ALARM (IF SET) DOES NOT OPERATE. IF NECESSARY, BALANCE THE INSTRUMENT AGAIN BUT DO NOT CHANGE THE CALIBRATION SENSITIVITY.

Inspection Near an Edge
Figure 10

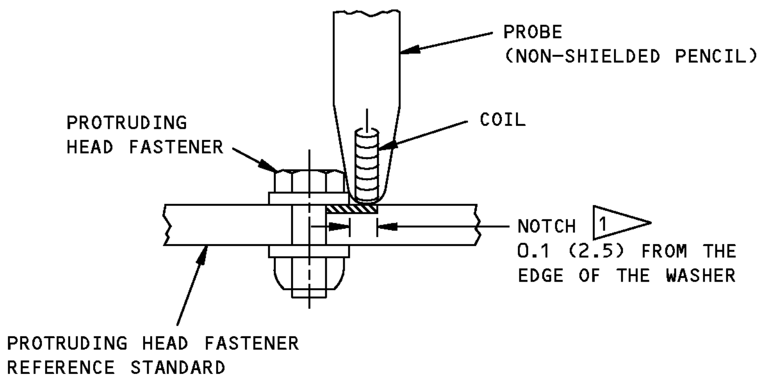




NOTES

- POSITION A NONCONDUCTIVE STRAIGHTEDGE A CONSTANT DISTANCE FROM THE EDGE OF THE PART TO BE EXAMINED.
- THE MINIMUM WIDTH THAT THE STRUCTURE MUST BE SO THAT YOU CAN IDENTIFY CRACKS IS RELATED TO THE DIAMETER OF PROBE COIL AND IF THE PROBE IS SHIELDED OR UNSHIELDED.
- TO IDENTIFY THE MINIMUM WIDTH THE STRUCTURE MUST BE BEFORE YOU CAN EXAMINE IT FOR CRACKS:
  - CALIBRATE THE INSTRUMENT AS SPECIFIED IN PARAGRAPH 4. USE REFERENCE STANDARD 126.
  - PUT A NONCONDUCTIVE STRAIGHTEDGE A CONSTANT DISTANCE ALONG A NOTCHED PART OF REFERENCE STANDARD 189.
  - MOVE THE PROBE ALONG THE STRAIGHTEDGE AND MONITOR THE DISPLAY. THE MINIMUM STRUCTURE WIDTH IS IDENTIFIED WHEN THE SIGNAL FALLS BELOW 90% OF THE SIGNAL YOU GOT DURING CALIBRATION OR WHEN THE ALARM (IF SET) DOES NOT OPERATE. IF NECESSARY, BALANCE THE INSTRUMENT AGAIN BUT DO NOT CHANGE THE CALIBRATION SENSITIVITY.

Inspection on an Edge
Figure 11



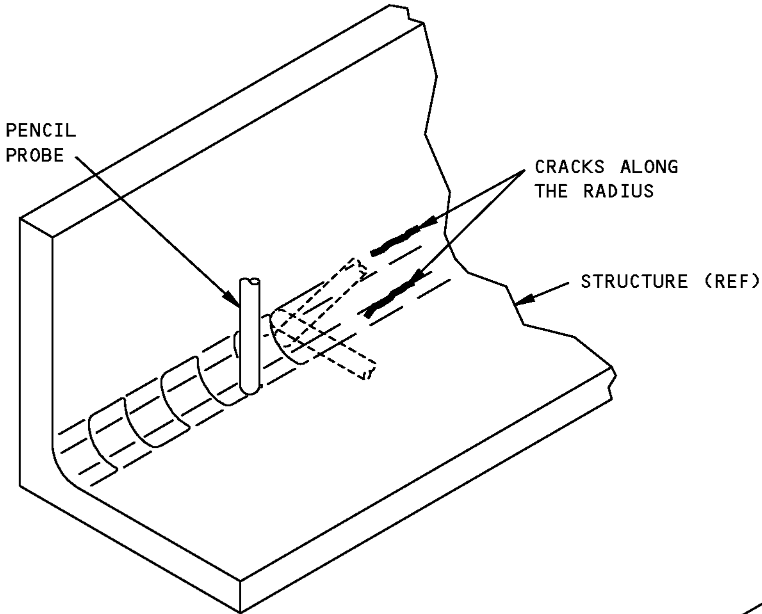
PROBE POSITION FOR INSPECTIONS NEAR PROTRUDING-HEAD FASTENERS

NOTES

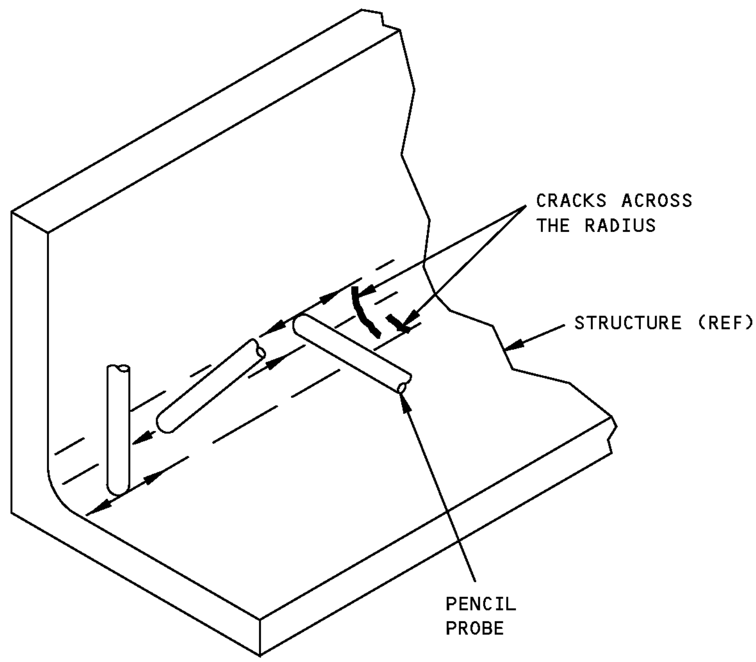
- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES).
- USE THE FASTENER HEAD OR WASHER AS A PROBE GUIDE.

1 THIS IS THE MINIMUM NOTCH LENGTH THAT CAN BE FOUND WITH THIS PROCEDURE.

Protruding-Head Fastener Inspection Guidelines
Figure 12



TRANSVERSE SCAN



PARALLEL SCAN

NOTES

- HOLD THE PROBE PERPENDICULAR TO THE SURFACE OF THE RADIUS.
- MAKE THE DISTANCE BETWEEN SCAN INCREMENTS SUCH THAT, WHEN MOVED PERPENDICULAR TO THE LENGTH OF THE CRACK, THE PROBE WILL GO ACROSS THE CRACK AT LEAST 2 TIMES.

Radius Inspection
Figure 13

PART 6 - EDDY CURRENT

DUAL FREQUENCY EDDY CURRENT FOR SECOND LAYER CORROSION (IMPEDANCE PLANE DISPLAY)

1. **Purpose**

   A. Use this procedure to find corrosion on the faying surface of the second skin (second layer corrosion) on structures with two or more aluminum skin layers. This procedure can find material loss of 10% or more in the second skin layer.

   B. The material thickness of the second layer must be between 0.032 inch (0.80 mm) and 0.125 inch (3.2 mm). The total thickness of all the skins must be between 0.064 inch (0.16 mm) and 0.25 inch (6.4 mm). The separation between skins (the gap) must be included as part of the total thickness of all the skins.

   C. The material must be aluminum clad 2024-T3/T4 or aluminum clad 7075-T6.

   NOTE: Use this procedure only after you do the top layer corrosion inspection procedure (Part 6, 51-00-02, or Part 6, 51-00-10). See Figure 1 for a flow chart that shows how to use this procedure.

2. **Equipment**

   A. General

   (1) Use equipment that can be calibrated on the reference standard as specified in Paragraph 4.

   (2) Refer to Part 1, 51-01-00 for data about the equipment manufacturers.

   B. Instrument

   (1) Use an eddy current instrument that:

   (a) Has as impedance plane display.

   (b) Operates at frequencies from 1 to 7 kHz.

   (c) Operates in a dual frequency mode.

   (2) The instruments specified below were used to prepare this procedure:

   (a) NDT 19 (Dual Frequency); Staveley Instruments

   (b) NDT 19e (Dual Frequency); Staveley Instruments

   (c) MIZ-22; Zetec Inc.

   C. Probes

   (1) Use an eddy current probe that:

   (a) Operates at a frequency range shown in Table 1 and can make an inspection of the second skin.

   (b) Has a flat surface.

   (c) Has a small diameter.

   (2) The probes specified below were used to prepare this procedure:

   (a) SPO 565; Staveley Instruments

   (b) SPO 5254; Staveley Instruments

   (c) SPO 5255; Staveley Instruments

   (d) VM112; VM Products

   (e) 927-8657; Zetec, Inc.

   D. Reference Standard

(1) Make reference standard NDT1037 to the specifications shown in Figure 2. Also, make a nonconductive shim to the specifications shown in Figure 2.

NOTE: Reference Standard 127-XXX, specified in Table 1, is acceptable for use if the nonconductive shim specified in Figure 2 is added.

3. **Preparation for Inspection**

A. Make sure that you know the operation of your dual frequency eddy current instrument.

B. Get access to the inspection areas.

C. Remove loose paint, dirt, sealant from the surface of the inspection area.

D. Make the inspection surfaces smooth if they are rough.

4. **Instrument Calibration**

NOTE: These instructions are for the Staveley NDT 19e and the Zetec MIZ-22 instruments. Use the applicable calibration instructions for your instrument. Other instruments with manual mixing and separate horizontal and vertical gain controls can use the NDT 19e calibration instructions.

A. Calibrate the NDT 19e, or equivalent, dual frequency eddy current instrument as follows:

(1) Preliminary Calibration

(a) Find the thickness of the outer skin of the airplane. Refer to the applicable service bulletin or skin drawings for the skin thickness if necessary.

NOTE: Some skins have more than one thickness.

(b) With the thickness of the outer skin, refer to Table 1 and identify the reference standard to use during calibration. During calibration, use the skin of the reference standard without machined spots as the upper skin layer and the spotfaced skin of the reference standard as the lower skin layer.

NOTE: If it is necessary to examine an area that has three layers of material (for example, two skins and a stringer), add a third layer of material to the bottom of the reference standard and do the calibration with the three layer reference standard. The thickness of the added (third) layer to the reference standard must be equal to the thickness of the third layer (for example, stringer) of the airplane.

(c) With the thickness of the outer skin, refer to Table 1 and identify the frequencies ("frequency 1" and "frequency 2") to use during calibration.

(2) "Frequency 1" Display Mode Calibration

(a) Set the channel 1 frequency to "frequency 1" identified in Paragraph 4.B.(1)(c).

(b) Set the eddy current instrument controls to show the "frequency 1" display mode.

(c) Adjust the horizontal gain so that it is equal to the vertical gain.

(d) Put the probe on the reference standard at probe position 1 as shown in Figure 3. The reference standard layers in this area are their full thicknesses (no spotfaces) and the separation (gap) between the layers is the smallest.

(e) Balance the instrument.

(f) Use the vertical and horizontal position controls to move the balance point to the upper left part of the display as shown in Figure 3, Detail I.

(g) Adjust the phase or rotation control so that the signal moves in a horizontal direction and to the right when you lift the probe off the reference standard. Figure 3, Detail I shows the correct location of the lift-off signal.

(h) Move the probe from position 1 to position 2 (Figure 3) in the direction of the larger gap. The signal will move down the display. Adjust the "frequency 1" gain control so that the signal difference between probe position 1 and position 2 is 80% of the full screen height as shown in Figure 3, Detail I.

(3) "Frequency 2" Display Mode Calibration

(a) Set the channel 2 frequency to "frequency 2" identified in Paragraph 4.B.(1)(c).

(b) Set the eddy current instrument controls to show the "frequency 2" display mode.

(c) Do Paragraph 4.A.(2)(b) thru Paragraph 4.A.(2)(h) again but make all of the adjustments specified to the "frequency 2" controls.

(4) Frequency Subtraction Calibration

(a) Set the eddy current instrument to show the frequency subtraction display mode (F1-F2).

(b) Put the probe on the reference standard at probe position 1, as shown in Figure 3.

(c) Balance the instrument.

(d) Use the horizontal and vertical position controls to move the balance point to the lower right part of the screen display as shown in Figure 3, Detail II.

(e) Lift the probe off the reference standard. The lift-off signal must move in a horizontal direction to the left. If the lift-off signal moves to the right when you lift the probe off the reference standard:

1) Put the probe at probe position 1 as shown in Figure 3.

2) Decrease the "frequency 1" horizontal gain.

3) Monitor the lift-off signal.

4) Continue to decrease the "frequency 1" horizontal gain until the lift-off signal moves horizontally to the left.

NOTE: A small phase angle adjustment of 1 or 2 degrees can be necessary to make the lift-off signal move in a horizontal direction. Adjust the phase angle for "frequency 1" or "frequency 2" as necessary.

(f) Balance the instrument.

(g) Move the probe from position 1 to position 2 as shown in Figure 3 and monitor the signal on the display. This is the signal from the separation (gap) between the two skins of the reference standard and will be referred to as the "gap signal". If there is more than a 30% full screen width separation between the signals as probe position 1 and probe position 2, then:

1) Put the probe at position 1 as shown in Figure 3 and balance the instrument.

2) Move the probe to position 2 as shown in Figure 3.

3) Keep the probe at position 2 and decrease the "frequency 2" horizontal gain until the signal is within 30% of the balance point.

4) Do a check of the lift-off signal. If the lift-off signal is not horizontal and to the left, then decrease the "frequency 1" horizontal gain so the lift-off signal moves from right to left.

5) Do Paragraph 4.A.(4)(g)1) thru Paragraph 4.A.(4)(g)4) again until the horizontal lift-off signal decreases to approximately 30% of full screen width.

(h) Make sure that the lift-off signal and the gap signal are nearly on top of each other. Figure 4 shows the correct signal locations.

1) If the gap signal is above the lift-off signal (Figure 4), then increase the "frequency 1" vertical gain, with the probe at position 2 until you get the lift-off signal shown in Figure 4.

2) If the gap signal moves below the lift-off signal (Figure 4), then decrease the "frequency 1" vertical gain with the probe at position 2 until you get the lift-off signal shown in Figure 4.

(i) Balance the instrument with the probe at probe position 1 as shown in Figure 3.

(j) Put a 0.003-inch (0.08 mm) nonconductive shim between the probe and the reference standard. The display shows the lift-off signal.

(k) If there is more than a 30% full screen width separation with and without the nonconductive shim, then decrease the "frequency 1" horizontal gain and do Paragraph 4.A.(4)(i) and Paragraph 4.A.(4)(j) again.

(l) Remove the shim.

(m) Put the probe at probe position 1 as shown in Figure 3 and balance the instrument.

(n) Move the probe to probe position 3 (10% thickness decrease) as shown in Figure 3.

(o) The signal difference between probe position 1 and probe position 3 must be 20% of full screen height. See Figure 3. If the signal difference is not 20% of full screen height then:

1) Put the probe at position 2 as shown in Figure 3.

2) Increase the "frequency 2" vertical gain until the gap signal at position 2 moves up four divisions.

3) Increase the "frequency 1" vertical gain to bring the gap signal at position 2 back to 20% of the display height as shown in Figure 3, Detail II.

4) Do Paragraph 4.A.(4)(m), Paragraph 4.A.(4)(n) and Paragraph 4.A.(4)(o) again until the signal at probe position 3 is approximately 20% of full screen height above the signal at probe position 1.

NOTE: If it is not possible to get a signal at 20% of full screen height for the 10% spotface, then use a different probe.

(p) Make a scan of all the spotfaces and monitor the signals. These are the calibration signals that can be used to indicate the approximate quantity of material lost to corrosion when you do the inspection.

B. Calibrate the Zetec MIZ-22 as follows:

(1) Preliminary Calibration

(a) Find the thickness of the outer skin of the airplane. Refer to the applicable service bulletin or skin drawings for the skin thickness if necessary.

NOTE: Some skins have more than one thickness.

(b) With the thickness of the outer skin, refer to Table 1 and identify the reference standard to use during calibration. During calibration, use the skin of the reference standard without machined spots as the upper skin layer and the spotfaced skin of the reference standard as the lower skin layer.

NOTE: If it is necessary to examine an area that has three layers of material (for example, two skins and a stringer), add a third layer of material to the bottom of the reference standard and do the calibration with the three layer reference standard. The thickness of the added (third) layer to the reference standard must be equal to the thickness of the third layer (for example, stringer) of the airplane.

(c) With the thickness of the outer skin, refer to Table 1 and identify the frequencies ("frequency 1" and "frequency 2") to use during calibration.

(d) Set "Display 1" to "frequency 1" identified in Paragraph 4.B.(1)(c).

(e) Set Display 2 to the off position.

(f) Put a nonconductive shim that has the same thickness as the paint on the part to be examined on top of the reference standard. The nonconductive shim must be within ± 0.003 inch (0.008 mm) of the paint thickness.

(2) "Frequency 1" Display Mode Calibration

(a) Use the "Frequency 1" in the "Display 1" mode on the eddy current instrument.

(b) Adjust the V/H controls on the instrument so the vertical and horizontal gains are the same.

(c) Put the probe on the full thickness area of the reference standard as shown in Figure 3, probe position 1.

(d) Balance the instrument.

(e) Use the horizontal and vertical position controls to move the balance point to the upper left part of the screen as shown in Figure 3, Detail I.

(f) Adjust the phase control so the signal moves in a horizontal direction and to the right when you lift the probe off the reference standard. Figure 3, Detail I shows the correct position for the lift-off signal.

(g) Move the probe from position 1 to position 2 (Figure 3) in the direction of the larger gap. The signal will go down the display. Adjust the "frequency 1" gain control so that the signal difference between probe position 1 and position 2 is 80% of the full screen height as shown in Figure 3, Detail I.

(3) "Frequency 2" Display Mode Calibration

(a) Set the "Display 1" to "Frequency 2" found in Table 1.

(b) Do Paragraph 4.B.(2)(b) thru Paragraph 4.B.(2)(g), but make all of the adjustments specified to the "frequency 2" controls.

(4) Frequency Subtraction Calibration

(a) Balance a probe at probe position 1 (Figure 3) and move the probe to position 2.

(b) Keep the probe at position 2 (Figure 3) until you push the hold button.

(c) If the gap signal is not recorded (the hold button pushed) within 10 seconds after you push the balance button, do Paragraph 4.B.(4)(a) and Paragraph 4.B.(4)(b) again.

(d) Push "Draw Buffer" on the screen menu to display the stored signal.

(e) Push "Data #" and "View" to adjust the display window until the complete gap signal is shown.

(f) Push "Mix Menu."

1) Make sure that "Mix 1" is shown on the display.

2) Push "Clear" and then "Suppress" on the display.

3) Leave the "Mix Menu" mode.

4) Push "hold" on the display.

(g) Put the mixed signal on the display.

1) Set "Display 1" to the mixed signal.

2) Put the probe at position 1 (Figure 3) and balance the instrument.

3) Move the balance point to the lower right of the display as shown in Figure 3, Detail II.

4) Move the probe on the reference standard from position 1 to position 2 (Figure 3).

5) If the signal movement is more than half a division from the balance point, then do Paragraph 4.B.(2)(a) thru Paragraph 4.B.(2)(g) again.

(h) Adjust the lift-off signal with the phase rotation control so that it moves horizontally to the left.

(i) Put the probe at position 1 as shown in Figure 3 and balance the instrument.

(j) Move the probe to position 3.

(k) The signal difference between probe position 1 and probe position 3 should be 20% of full screen height. See Figure 3. If the signal difference is less than 20%:

1) Increase the mix channel gain.

2) Do Paragraph 4.B.(2)(a) thru Paragraph 4.B.(4)(h) again. Use a different probe if necessary.

(l) Make a scan of all the spotfaces and monitor the signals. These are the calibration signals that can be used to indicate the approximate quantity of material lost to corrosion when you do the inspection.

5. Inspection Procedure

A. Calibrate the instrument with a reference standard that is the same thickness as the skin of the airplane. Paragraph 4. specifies how to calibrate the instrument.

NOTE: Add a third layer to the bottom of the reference standard to calibrate for an inspection area that has three skin or material layers.

B. Put the probe on an inspection area that has only two layers and no visual corrosion indications.

C. Balance the instrument as specified in the instrument instructions.

D. Move the probe to an adjacent area where there is a single layer. Look for the position on the airplane where the signal begins to increase as the probe is moved toward the single layer. Use a nonconductive straightedge to keep the correct edge margin to make sure that you do not get an edge margin signal.

NOTE: When you do the inspection on tapered or machined skins, it is very important to know the correct skin thickness. See Table 1 for permitted calibration thickness limits.

E. Put the probe at the same location it was put in Paragraph 5.B.

F. Slowly move the probe into the area of possible corrosion and monitor the display.

G. If you get a signal, slowly move the probe around the possible defect area to try to decrease the signal. Compare this signal with signals from adjacent areas.

6. Inspection Results

A. Refer to the applicable service bulletin or repair instructions for corrosion limits.

B. Do not use this procedure to find material loss less than 10%.

C. Differences in the conductivity of the material or the thickness between the reference standard and the airplane skin, intergranular corrosion, and paint will cause changes in the eddy current signals.

D. These conditions can cause signals to occur that look almost the same as corrosion signals:

- The probe is too near to an edge.

- The probe is too near to a fastener.

- The gap thickness change on the inspection part is more than the gap thickness change of the reference standard.

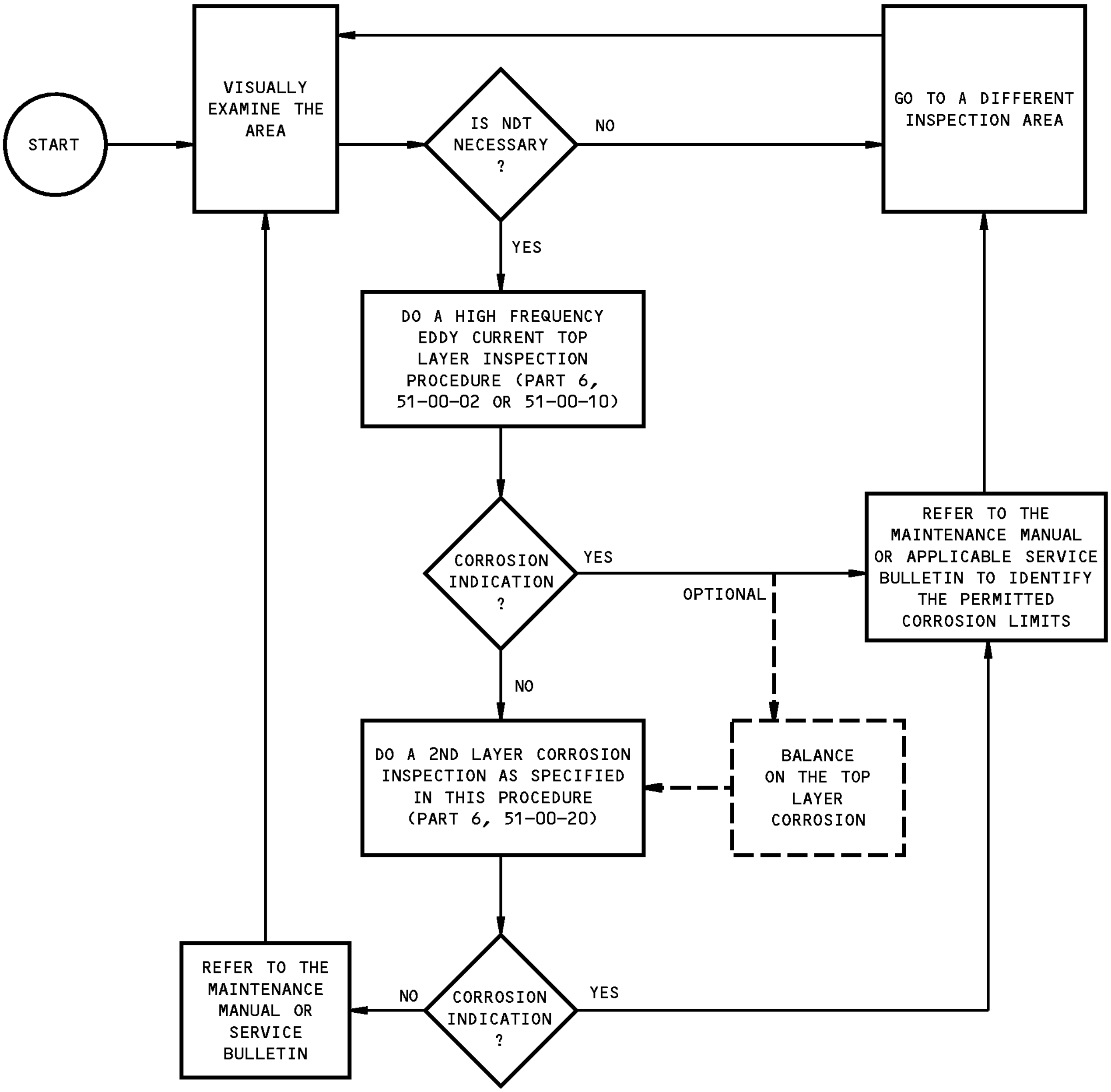
- The skin thickness has decreased.

E. Compare adjacent areas with the probe at equivalent locations on the airplane to make sure the area is corroded.

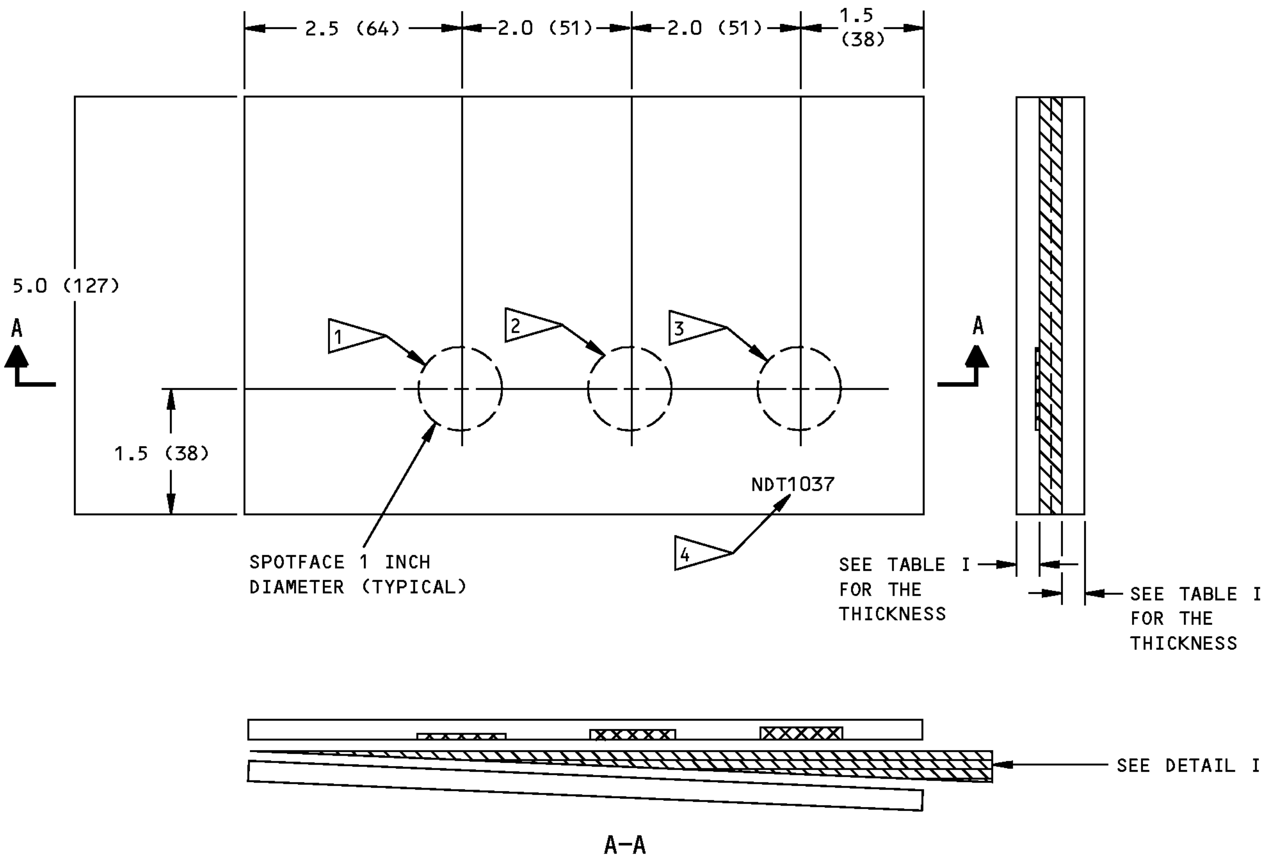
Table 1 Corrosion Loss in Aluminum Skins (Impedance Plane Display)

AIRPLANE OUTER SKIN THICKNESS	REFERENCE STANDARD NUMBER *[1]	INSTRUMENT TEST FREQUENCY RANGE	kHz
		FREQ 1	FREQ 2
0.032-0.034	NDT1037 or 127 -0.032	5-7	2.5-3.5
0.034-0.038	NDT1037 or 127 -0.036	5-7	2.5-3.5
0.038-0.045	NDT1037 or 127 -0.040	5-7	2.5-3.5
0.045-0.056	NDT1037 or 127 -0.050	3-7	1.5-3.5
0.056-0.068	NDT1037 or 127 -0.063	3	1.5
0.068-0.076	NDT1037 or 127 -0.072	3	1.5
0.076-0.085	NDT1037 or 127 -0.080	3	1.5
0.085-0.095	NDT1037 or 127 -0.090	2	1
0.095-0.105	NDT1037 or 127 -0.100	2	1
0.105-0.118	NDT1037 or 127 -0.110	2	1
0.118-0.125	NDT1037 or 127 -0.125	2	1

*[1] THE NUMBER AFTER THE DASH IDENTIFIES THE ALUMINUM CLAD THICKNESS (IN INCHES) OF EACH LAYER OF THE REFERENCE STANDARD



Corrosion Inspection Flow Chart
Figure 1



NOTES

- TOLERANCES:

INCHES	MILLIMETERS
X.XXX = ± 0.005	X.XX = ± 0.10
X.XX = ± 0.025	X.X = ± 0.5
X.X = ± 0.050	X = ± 1.0

- SURFACE ROUGHNESS = 125 R_a OR BETTER
- MATERIAL: CLAD 2024-T3 OR-T4 SHEET THAT HAS A BASE ALLOY CONDUCTIVITY OF 28.5 TO 32.0% IACS
- THE FAYING SURFACE OF THE REFERENCE STANDARD SKIN CAN BE MACHINED TO MAKE THE THICKNESS OF THE SKIN EQUIVALENT TO THE THICKNESS OF THE AIRPLANES SKIN. BEFORE YOU MACHINE, MAKE SURE THE SKIN IS THE SPECIFIED THICKNESS OR NEXT THICKER GAGE.

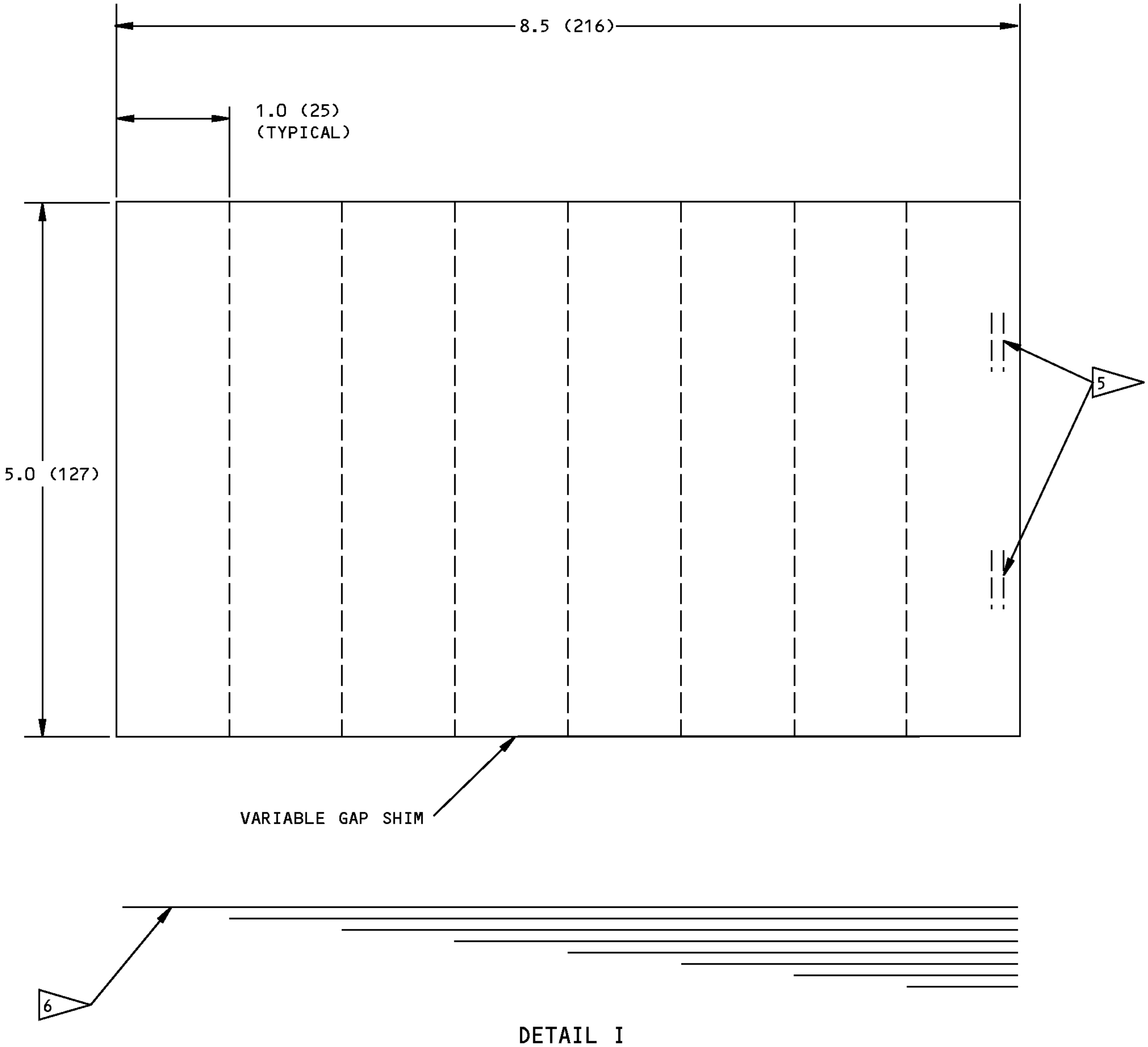
1 THE SPOTFACE DEPTH IS 10 PERCENT OF THE REFERENCE STANDARD SKIN THICKNESS

2 THE SPOTFACE DEPTH IS 20 PERCENT OF THE REFERENCE STANDARD SKIN THICKNESS

3 THE SPOTFACE DEPTH IS 30 PERCENT OF THE REFERENCE STANDARD SKIN THICKNESS

4 ETCH OR STEEL STAMP THE REFERENCE STANDARD NUMBER "NDT1037"

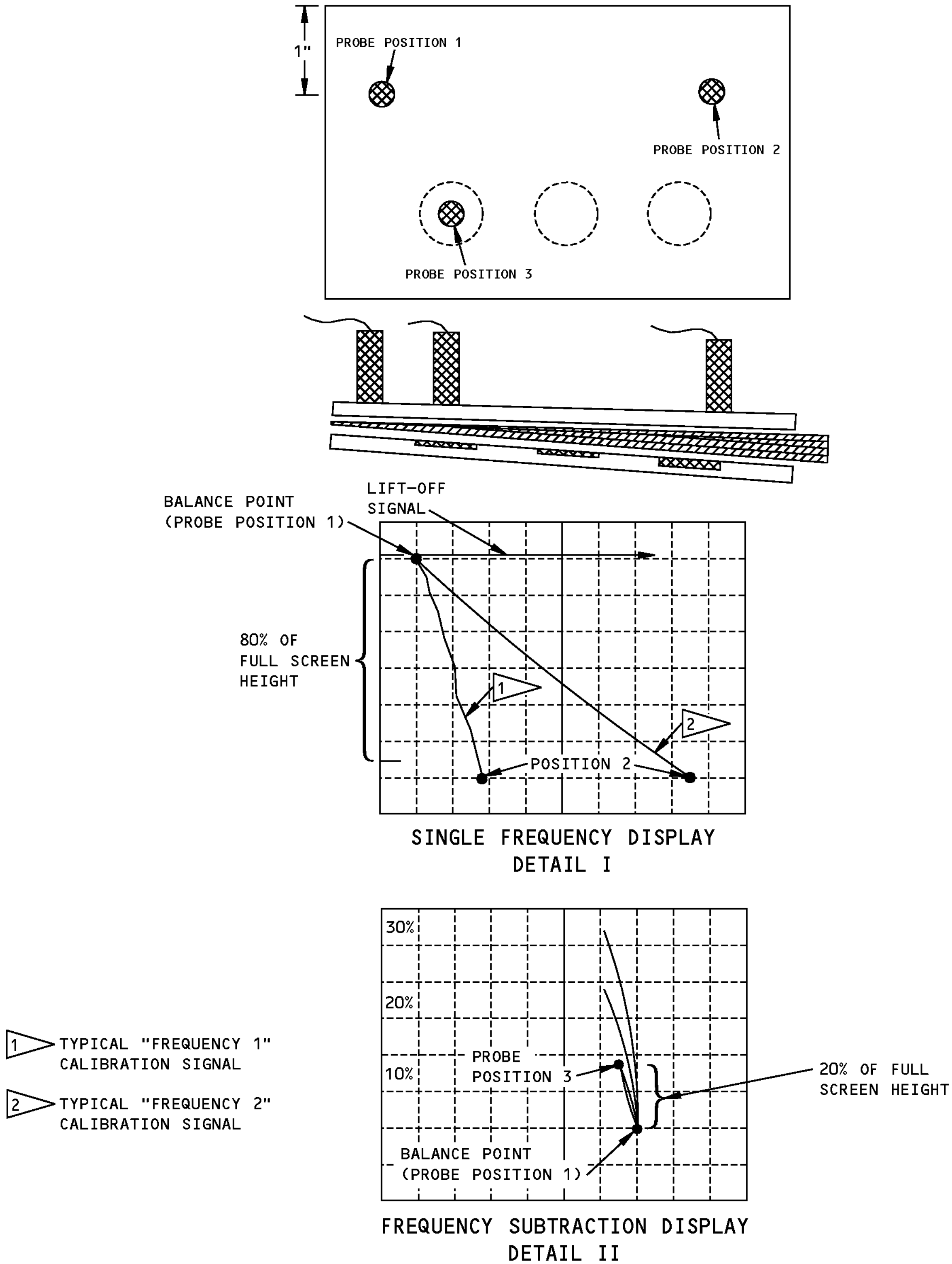
Reference Standard NDT1037
Figure 2 (Sheet 1 of 2)



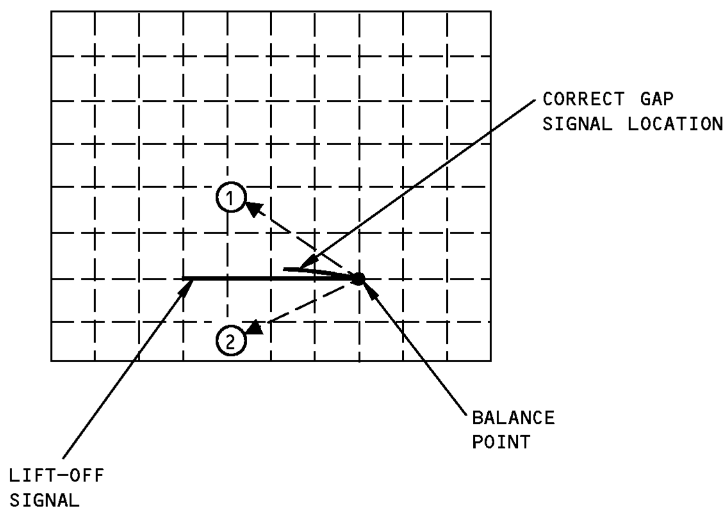
5 STAPLE THE SHEETS TOGETHER IN 2 LOCATIONS

6 MATERIAL: PLASTIC OR PAPER.
NOMINAL THICKNESS 0.003 (0.08)

Reference Standard NDT1037
Figure 2 (Sheet 2 of 2)



Instrument Calibration
Figure 3



1 IF THE GAP SIGNAL IS ABOVE THE LIFT-OFF SIGNAL:
-INCREASE THE "FREQUENCY 1" GAIN

2 IF THE GAP SIGNAL IS BELOW THE LIFT-OFF SIGNAL:
-DECREASE THE "FREQUENCY 1" GAIN

Gap Signal Adjustment
Figure 4

PART 6 - EDDY CURRENT

STEEL PART SURFACE INSPECTION (IMPEDANCE PLANE DISPLAY)

1. **Purpose**

   A. Use this procedure to do an inspection for surface cracks in magnetic steel parts.

   CAUTION: WHEN STEEL PARTS WITH CONDUCTIVE FINISHES SUCH AS CADMIUM, TITANIUM-CADMIUM OR CHROME ARE EXAMINED, IT IS POSSIBLE TO GET CRACK TYPE SIGNALS WHEN THE FINISH HAS BEEN SCRATCHED.

   B. This procedure examines two types of magnetic steel parts:

      (1) High permeability steels such as 4000 series, 15-5PH and 17-7PH CRES.

      (2) Low permeability steels such as 301 1/2 hard.

   C. This procedure uses an impedance plane display instrument.

   D. Part 6, 51-00-12 is an alternative inspection procedure that uses meter display instruments to find cracks in the surfaces of steel parts.

   E. Part 6, 51-00-13 to do an inspection for cracks in non-magnetic steel parts.

2. **Equipment**

   A. General

      (1) Use inspection equipment that can be calibrated on the reference standard as specified in Paragraph 4.

      (2) Refer to Part 1, 51-01-00 for data about the equipment.

   B. Instrument

      (1) Use an eddy current instrument that:

         (a) Has an impedance plane display.

         (b) Operates at a frequency range of 50 to 500 kHz.

      (2) The instruments specified below were used to prepare this procedure.

         (a) Phasec 2200, Phasec 1.1; Hocking Krautkramer.

         (b) Nortec 1000 and 2000, Nortec NDT-19e; Staveley Instruments.

         (c) MIZ-21A, MIZ-22; Zetec, Inc.

   C. Probes

      (1) To examine low permeability steels, use a shielded probe to examine all large area structural configurations (refer to Paragraph 5.D.(3)(a)).

      (2) To examine high permeability steels, use a nonshielded probe to examine all large area structural configurations (refer to Paragraph 5.D.(3)(a)).

      (3) It can be necessary to use a shielded probe to examine the surface of a steel part:

         (a) In the areas around fasteners.

         (b) In areas where there is adjacent structure.

         (c) When the surface is curved (has a radius).

         (d) When the surface is near the edge of the steel part.

         (e) When the surface to be examined is the edge of the steel part.

      (4) Use a probe that:

         (a) Operates at a frequency in the range of 50 to 500 kHz.

(b) Has the configuration shown in Figure 1.

(c) Can satisfactorily do the angularity check as shown in Figure 2.

D. Reference Standards

(1) To examine high permeability steels, use reference standards 185, 192, NDT1061, and NDT1062 as applicable. See Figure 3 thru Figure 6 for data about the reference standards.

(2) To examine low permeability steels, use reference standards NDT1072, NDT1073, NDT1074, and NDT1075 as applicable. See Figure 3 thru Figure 6 for data about the reference standards.

(3) Other reference standards can be used if they are equivalent to those shown in Figure 3 thru Figure 6.

E. Special Tools

(1) Use a nonconductive circle template as shown in Figure 9 to help examine the area around flush-head fasteners.

(2) Use a nonconductive straightedge as shown in Figure 12 and Figure 13 to help examine near and on edges of parts.

NOTE: The circle template will help to keep the probe a constant distance from a flush-head fastener head and a straightedge will help to keep the probe a constant distance from an edge.

3. Preparation for Inspection

A. Get access to the inspection area.

B. Remove loose paint, dirt and sealant from the surface of the inspection area.

4. Instrument Calibration

A. Set the frequency as follows:

(1) Use a frequency between 50 and 500 kHz to examine high permeability steels.

(2) Use a frequency between 100 and 200 kHz to examine low permeability steels.

B. Calibrate the instrument with the applicable reference standard. Paragraph 5.D.(3) identifies the different types of structural configurations that can be examined. The reference standards to use for the different structural configurations to be examined are:

(1) Large Areas, Near an Edge, On an Edge, Radius: Use reference standard 185 to examine high permeability steels. Use reference standard NDT1072 to examine low permeability steels.

(2) Flush-Head Fasteners: Use reference standard NDT1061 to examine high permeability steels. Use reference standard NDT1073 to examine low permeability steels.

(3) Protruding Head Fasteners: Use reference standard NDT1062 to examine high permeability steels. Use reference standard NDT1074 to examine low permeability steels.

C. If the inspection area is painted, put a nonconductive shim that has the same thickness (± 0.003 inch (0.08 mm)) as the paint, on the reference standard.

D. Put the probe on the reference standard at a location that is at least 0.25 inch (6 mm) away from the EDM notch and the edge of the reference standard.

E. Balance the instrument.

F. Set the instrument balance point in the lower center of the screen as shown in Figure 7 (instrument calibration for high permeability steels) and Figure 8 (instrument calibration for low permeability steels).

G. Adjust the instrument phase control so that when the probe is lifted off of the surface the lift-off signal moves horizontally from right to left.

H. Use a vertical to horizontal gain ratio of 2:1.

I. Move the probe across the notch in the reference standard.

J. Adjust the instrument gain to get a signal that looks almost the same as the screen display in Figure 7 or Figure 8. The vertical height can be lower or higher than that shown in Figure 7 or Figure 8.

K. Set the filters as follows:

(1) Set the high-pass filter to off or zero Hz.

(2) If the instrument has a low-pass filter:

(a) Set the low-pass filter to its highest value.

(b) Decrease the filter value to get a stable dot.

L. If the instrument has an alarm, set the alarm as shown in Figure 7 or Figure 8.

M. Move the probe across the notch in the reference standard to find the maximum scan speed. The scan speed is too fast if the signal is less than 90 percent of the calibration notch signal.

NOTE: Higher scan speeds are possible when the low-pass filter is set at a higher value.

5. Inspection Procedure

A. Put the probe on the inspection surface.

B. Balance the instrument.

C. Make sure the lift-off signal moves horizontally to the left when the probe is lifted off of the part surface. Adjust the phase control again if necessary.

D. Slowly make a scan of the inspection area and monitor the instrument display during the scan. Do the scan as follows:

(1) Use a scan pattern that will move the probe across the length of a possible crack. This is done to increase the probability that you will find a crack.

(2) During the scan, move the probe no faster than the maximum scan speed that was identified during calibration.

(3) Do the scan as follows for the specified structural configurations:

(a) Large Areas: Use a grid system to do the inspection of large areas. The distance between the grid lines (increment distance) must be less than the diameter of the probe to get 100 percent complete examination of the area.

(b) Flush-Head Fasteners: Use a nonconductive circle template to do inspections around flush-head fasteners. Use a hole in the template that has a larger diameter than the fastener so that you can find cracks that extend 0.1 inch (2.5 mm) from the fastener head as shown in Figure 9.

(c) Protruding Head Fasteners: To examine areas around fasteners with protruding heads, use the fastener head or the washer as a probe guide as shown in Figure 10.

(d) Radius: To examine the radius area of a part, keep the probe as vertical as possible to the radius surface. If the crack direction is not known, move the probe along (parallel scan) and across (transverse scan) the radius as shown in Figure 11. Use an increment distance that is less than the diameter of the probe to get 100 percent complete examination of the area.

(e) Edges: When you do an inspection near or on the edge of a part, use a nonconductive straightedge to keep the probe the same distance from the edge of the part. See Figure 12 to see how to examine a part near the edge. See Figure 13 to see how to examine on the edge of a part.

NOTE: Cadmium thickness can change on the part surface. Thickness changes will cause the balance point to move up or down and cause the lift-off line to have a different phase angle. Balance the instrument and adjust the phase as necessary. It can be necessary to use an instrument frequency of 50 kHz to help decrease the balance point movement caused by cadmium thickness changes.

NOTE: Thickness changes in nonconductive (paint) and conductive (cadmium) finishes can cause the balance point to move out of the screen display frequently. It can be necessary to decrease the horizontal gain to keep the balance point on the screen display. Use a vertical to horizontal gain ratio of 3:1 or 4:1.

NOTE: Steel parts can have areas that will have changes in permeability. The permeability changes will give the same results as thickness changes of cadmium. Balance the instrument and adjust the phase as necessary.

(4) Make a mark at the locations that cause signals that are more than 50 percent of the notch signal from the reference standard.

NOTE: To find the end of the crack, continue to move the probe across the crack until there is no more crack signal.

(5) Frequently do a check of the instrument calibration as follows:

NOTE: Do not adjust the gain.

(a) Put the probe on the reference standard to get a signal from the notch.

(b) Compare the signal you got from the notch during calibration with the signal you get now.

(c) If the signal has changed 10 percent or more, do the calibration and inspection again.

6. Inspection Results

A. Fast upscale signals that are more than 50 percent of the notch signal from the reference standard are signs of cracks. See Figure 7 for an example of a signal from a crack in high permeability steels. See Figure 8 for an example of a signal from a crack in low permeability steels.

B. Compare the signal that occurs during the inspection to the signal you got from the notch in the reference standard.

C. The conditions specified below can cause signals that look the same as crack signals:

(1) A worn probe coil. Put a piece of tape on the surface of the probe coil or get a new probe and calibrate the instrument again.

(2) Magnetic poles (domains) in the material can cause signals that look almost the same as a crack signal. Compare the signal to the signal from the reference standard. Signals from magnetic poles (domains) will almost always (or usually) be slower than the signal from the reference standard.

(3) Scratches in conductive finishes such as cadmium plating.

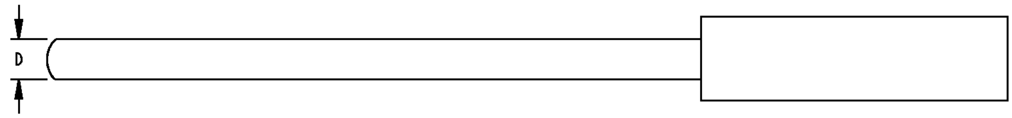
NOTE: It may be necessary to remove the conductive finish and do the inspection again.

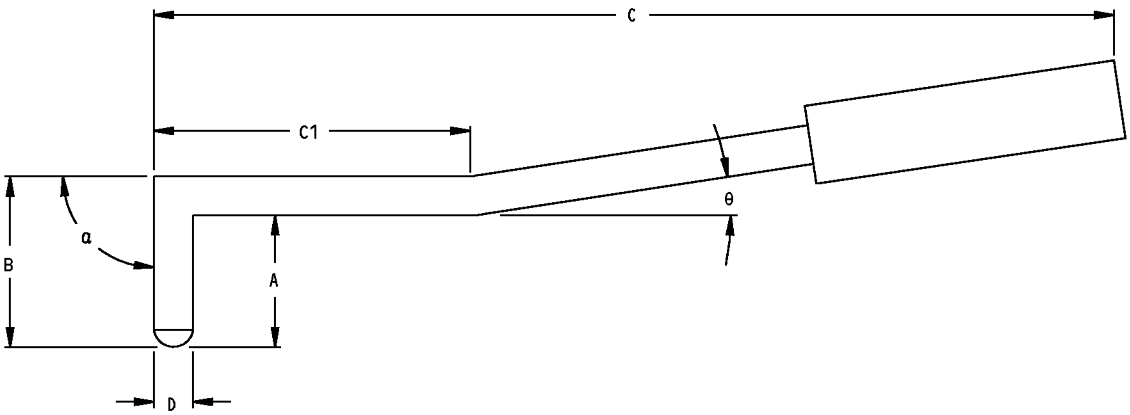
D. You can use one or more of the procedures that follow to make sure a signal is the result of a crack. Be careful as you compare results with the eddy current procedure.

(1) Remove the surface finish and do a visual inspection with 10-power (or higher) magnification and sufficient light.

NOTE: The visual inspection is not always as sensitive to cracks as eddy current.

(2) Do a magnetic particle inspection of the area as specified in SOPM 20-20-01, "Magnetic Particle Inspection".





NOTES

- THE PROBE CONFIGURATIONS SHOWN CAN BE USED TO ACCESS MOST INSPECTION AREAS WHEN IT IS NECESSARY TO USE PENCIL PROBES. WHEN A SPECIAL PROBE CONFIGURATION IS NECESSARY, SPECIFY THE PROBE DIMENSIONS AS SHOWN FOR PROBE 2:

  A - THE PROBE DROP, OR DIMENSION A

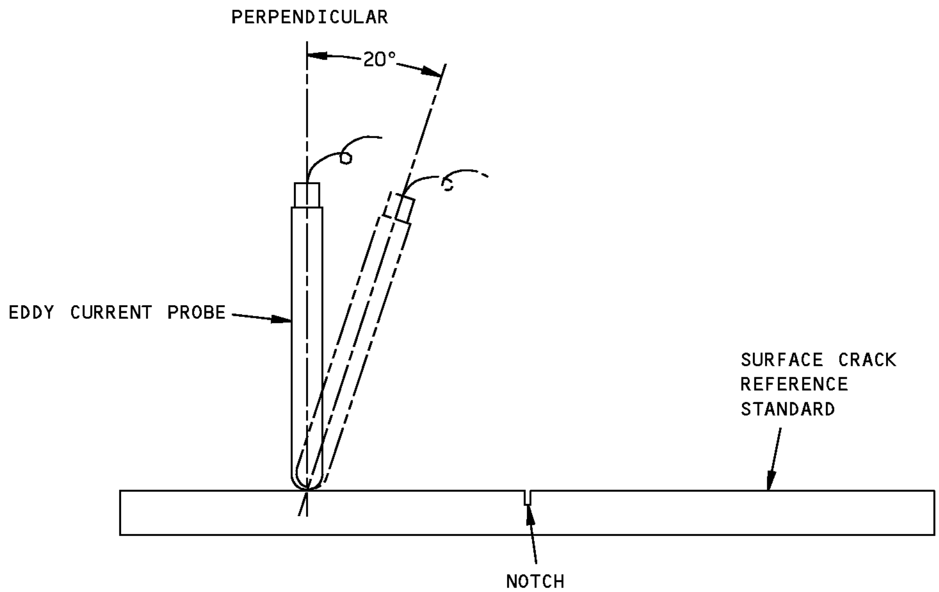
  B - THE PROBE HEIGHT, OR DIMENSION B

  C - THE PROBE HANDLE LENGTH, OR DIMENSION C. IF THE HANDLE MUST BE BENT, IT WILL BE NECESSARY TO KNOW DIMENSION C1 AND THE HANDLE ANGLE (ANGLE THETA - θ). FOR MOST USES, THE PROBE LENGTH WILL BE 3-5 INCHES (76.0-127.0 MM).

  D - DIAMETER: 0.25 INCH (6.4 MM) MAXIMUM. A DIAMETER OF 0.12 INCH (3.0 MM) IS RECOMMENDED FOR AREAS WITH NOT MUCH ACCESS.

  α - THE ANGLE (α = ALPHA). DIFFERENT ANGLES ARE POSSIBLE.

Example of Pencil Probe Configurations
Figure 1

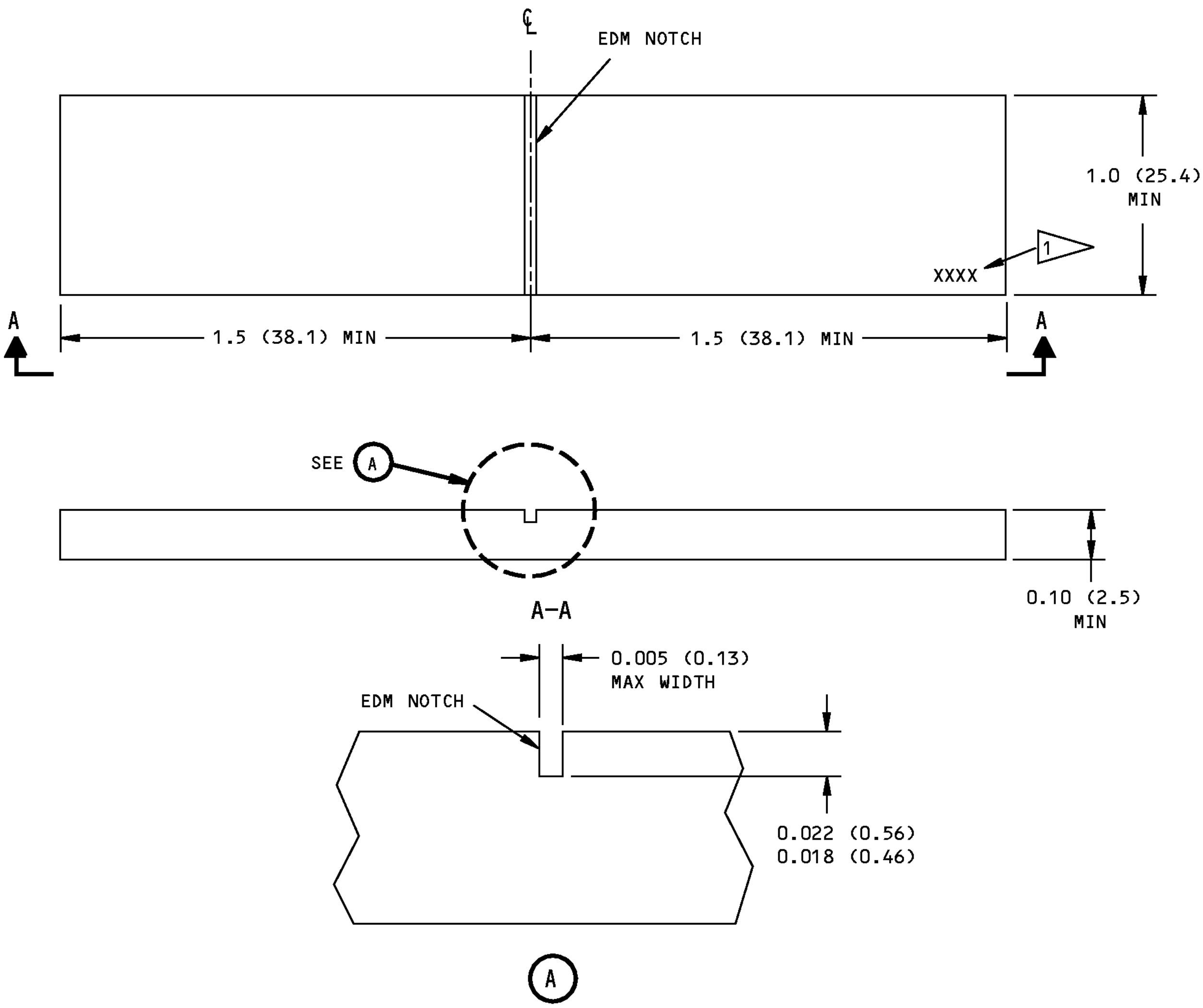


NOTES

- TO IDENTIFY THE ANGULAR PERFORMANCE OF THE PENCIL PROBE:
  - CALIBRATE THE INSTRUMENT AS SPECIFIED IN PARAGRAPH 4. USE REFERENCE STANDARD 185 FOR HIGH PERMEABILITY STEELS; USE REFERENCE STANDARD NDT1072 FOR LOW PERMEABILITY STEELS.
  - ANGLE THE PROBE 20 DEGREES TO THE SURFACE OF THE REFERENCE STANDARD IN MANY DIRECTIONS. THE ANGULAR POSITION OF THE PROBE MUST NOT CAUSE THE SIGNAL TO CHANGE MORE THAN 10 PERCENT OF THE DISPLAY.
  - MOVE THE PROBE ACROSS THE NOTCH AS IT IS HELD PERPENDICULAR TO THE SURFACE OF THE REFERENCE STANDARD AND AGAIN AS IT IS HELD 20 DEGREES FROM PERPENDICULAR. THE NOTCH SIGNAL MUST NOT DECREASE MORE THAN 30 PERCENT.

EXAMPLE: A SIGNAL FROM THE NOTCH ON THE REFERENCE STANDARD IS 40 PERCENT OF FULL SCALE WHEN THE PROBE IS HELD PERPENDICULAR TO THE SURFACE. WHEN THE PROBE IS HELD AT AN ANGLE THAT IS 20 DEGREES TO THE SURFACE, THE NOTCH SIGNAL MUST NOT BE LESS THAN 28 PERCENT OF THE DISPLAY. (40% SIGNAL X 0.3 = 12% AND 40% - 12% = 28%)

Pencil Probe Angular Performance
Figure 2

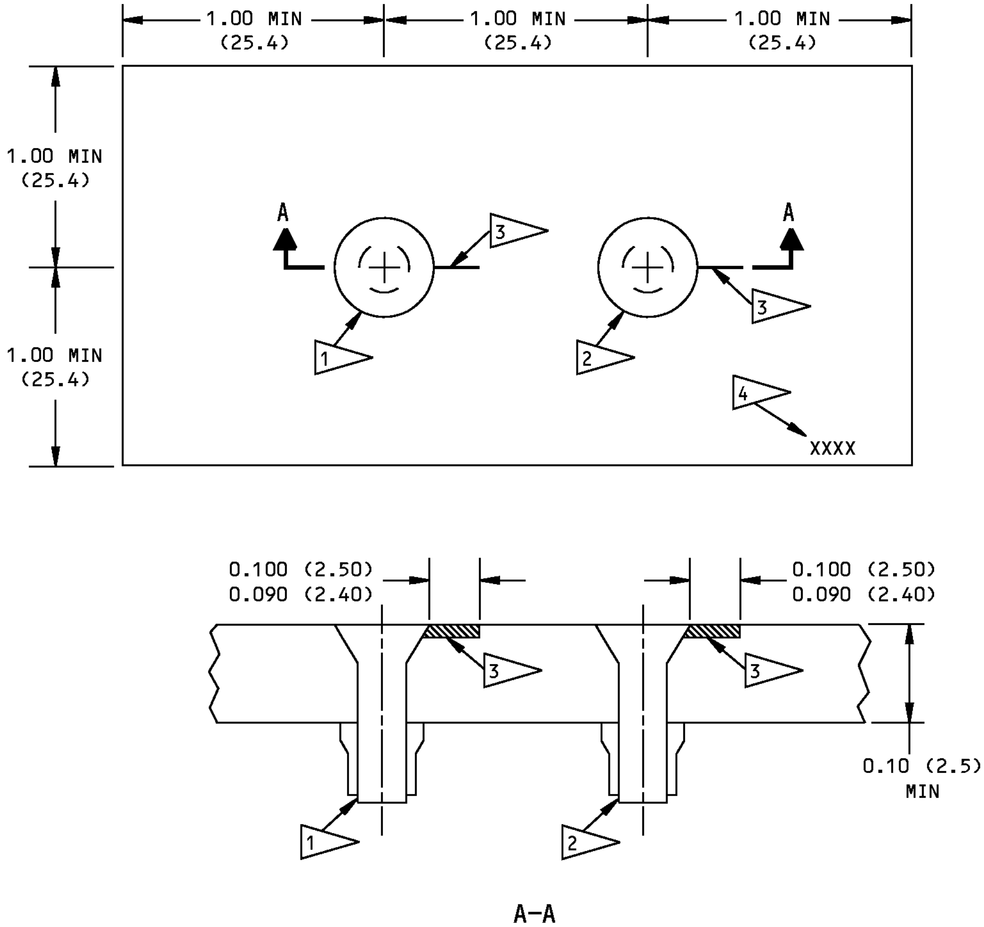


NOTES

- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES).
- SURFACE ROUGHNESS: 32 √ OR BETTER.
- REFER TO PART 1, 51-01-00, FOR DATA ABOUT THE REFERENCE STANDARD MANUFACTURERS.
- MATERIAL: FOR REFERENCE STANDARD 185, USE 4130, 4140, 4340, 4330M OR 4340M STEELS (HEAT TREAT OPTIONAL). FOR REFERENCE STANDARD NDT1072, USE 301 1/2 HARD STAINLESS STEEL.

1 ETCH OR STEEL STAMP THE REFERENCE STANDARD NUMBER THAT REFERS TO THE TYPE OF STEEL IDENTIFIED IN THE MATERIAL NOTE.

Reference Standard 185 and NDT1072 - for the Surface Inspection of Steel Parts
Figure 3



NOTES

- REFER TO PART 1, 51-01-00, FOR DATA ABOUT THE REFERENCE STANDARD MANUFACTURERS
- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES).
- MATERIAL: FOR REFERENCE STANDARD NDT1061, USE 4130, 4140, 4340, 4330M OR 4340M STEELS (HEAT TREAT OPTIONAL). FOR REFERENCE STANDARD NDT1073, USE 301 1/2 HARD STAINLESS STEEL.
- SURFACE FINISH: 32√ OR BETTER.
- REFERENCE STANDARD 190 CAN BE USED FOR THE INSPECTION AROUND STEEL FASTENERS IN HIGH PERMEABILITY STEELS.

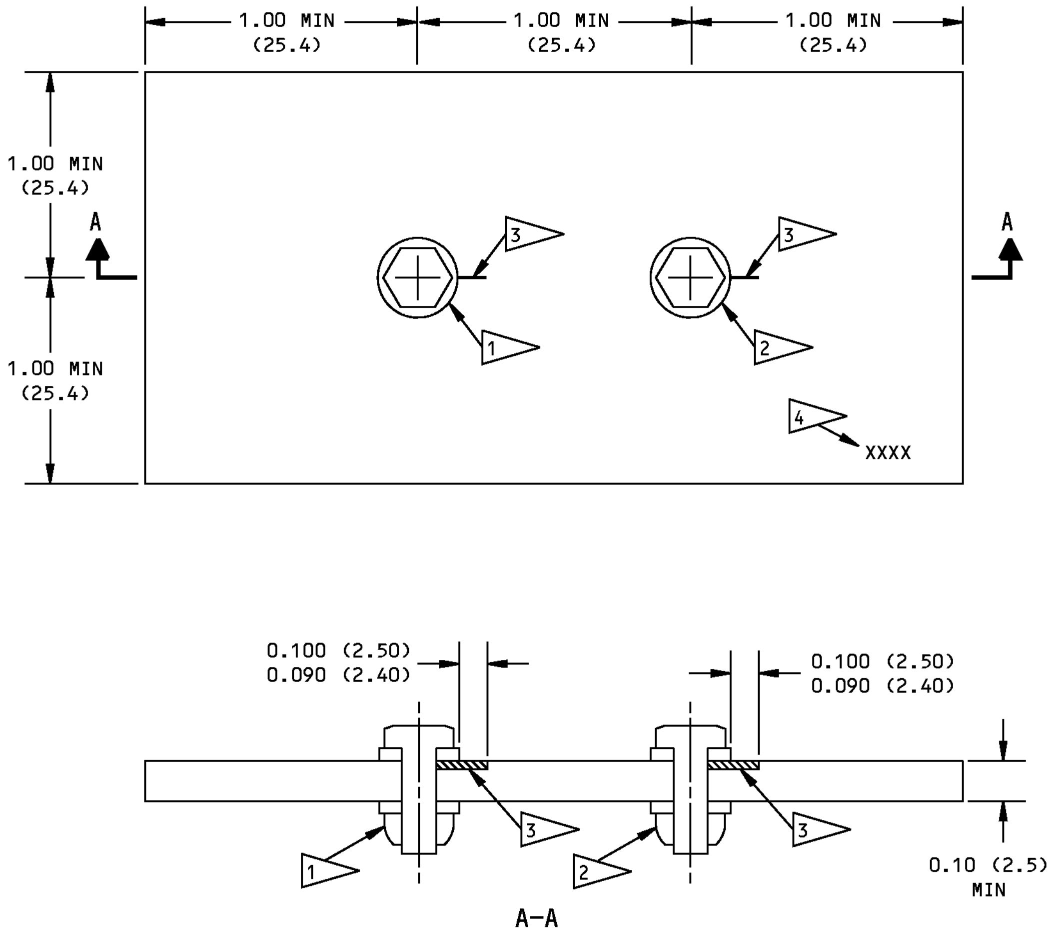
1 FASTENER - 0.25 (6.40) DIAMETER FLUSH-HEAD STEEL BOLT, SUCH AS BACB30JC8-*

2 FASTENER - 0.25 (6.40) DIAMETER FLUSH-HEAD TITANIUM BOLT, SUCH AS BACB30NY8K-* (REFERENCE STANDARDS THAT HAVE BEEN MADE WITH TITANIUM RIVETS ARE SATISFACTORY FOR USE).

3 NOTCH - 0.005 (0.13) MAXIMUM WIDTH, 0.018-0.022 (0.46-0.56) DEPTH.

4 ETCH OR STEEL STAMP THE REFERENCE STANDARD NUMBER THAT REFERS TO THE TYPE OF STEEL IDENTIFIED IN THE MATERIAL NOTE.

Reference Standard NDT1061 and NDT1073 - for Flush-Head Fasteners
Figure 4



NOTES

- REFER TO PART 1, 51-01-00, FOR DATA ABOUT THE REFERENCE STANDARD MANUFACTURERS
- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES).
- MATERIAL: FOR REFERENCE STANDARD NDT1062, USE 4130, 4140, 4340, 4330M OR 4340M STEELS (HEAT TREAT OPTIONAL). FOR REFERENCE STANDARD NDT1074, USE 301 1/2 HARD STAINLESS STEEL.
- SURFACE FINISH: 32√ OR BETTER
- REFERENCE STANDARD 191 CAN BE USED FOR THE INSPECTION AROUND STEEL FASTENERS IN HIGH PERMEABILITY STEELS.

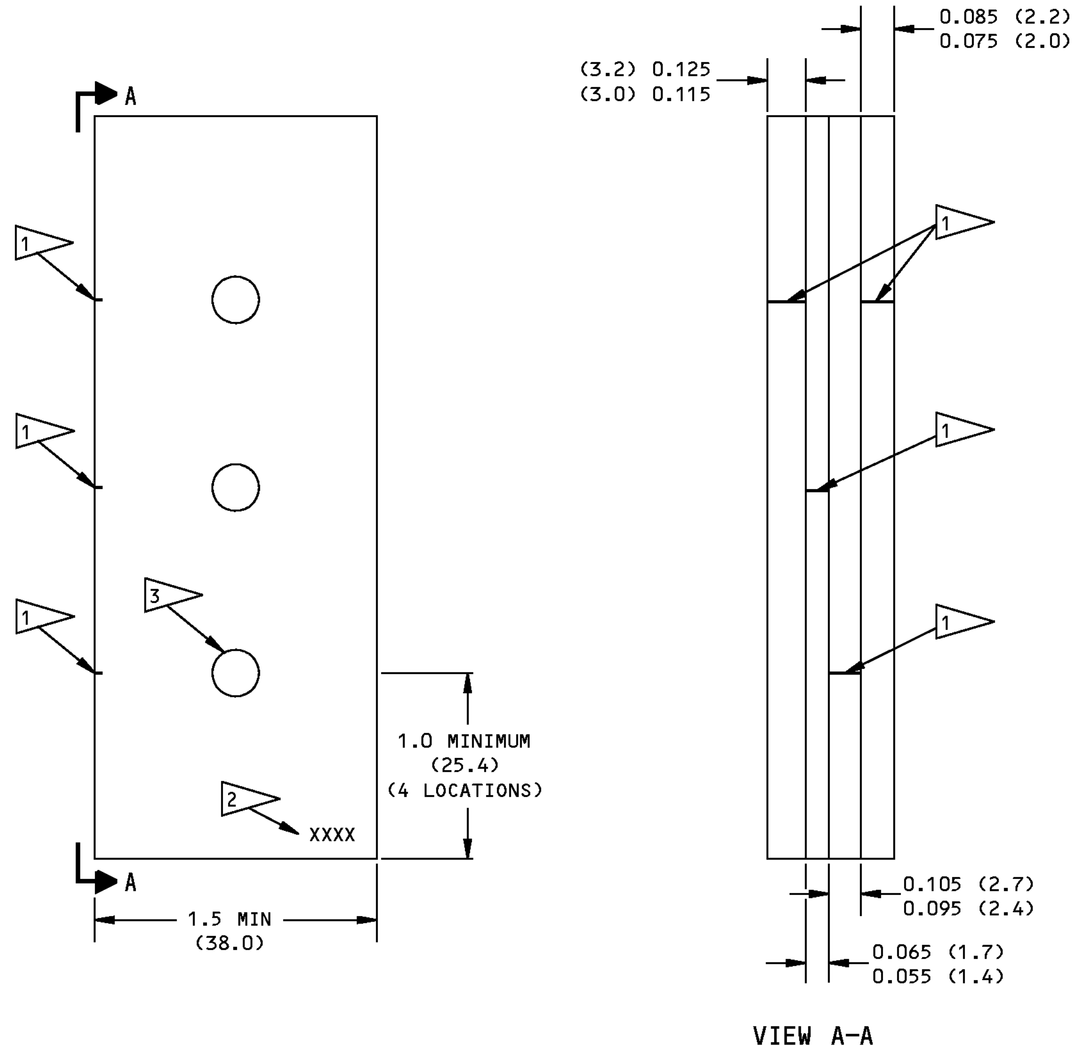
1 FASTENER - 0.25 (6.40) DIAMETER EXTERNAL WRENCHING STEEL BOLT, SUCH AS BACB30NF4-*; FLAT STEEL WASHER, SUCH AS AN960-416.

2 FASTENER - 0.25 (6.40) DIAMETER EXTERNAL WRENCHING TITANIUM BOLT, SUCH AS BACB30NM4K*; FLAT ALUMINUM WASHER, SUCH AS AN960D-416.

3 NOTCH - 0.005 (0.13) MAXIMUM WIDTH, 0.018-0.022 (0.46-0.56) DEPTH.

4 ETCH OR STEEL STAMP THE REFERENCE STANDARD NUMBER THAT REFERS TO THE TYPE OF STEEL IDENTIFIED IN THE MATERIAL NOTE.

Reference Standard NDT1062 and NDT1074 - for Protruding-Head Fasteners
Figure 5



NOTES

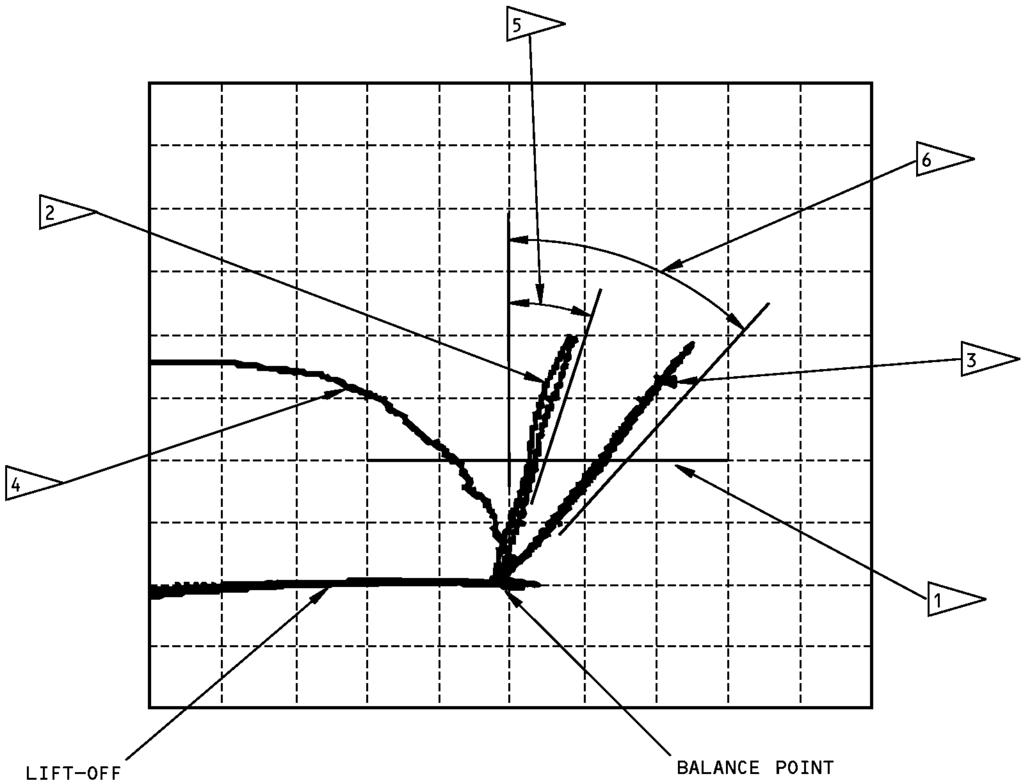
- REFER TO PART 1, 51-01-00, FOR DATA ABOUT THE REFERENCE STANDARD MANUFACTURERS
- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES).
- MATERIAL: FOR REFERENCE STANDARD 192, USE 4130, 4140, 4340, 4330M OR 4340M STEELS (HEAT TREAT OPTIONAL). FOR REFERENCE STANDARD NDT1075, USE 301 1/2 HARD STAINLESS STEEL.
- SURFACE FINISH: 32√ OR BETTER.

1 NOTCH - 0.005 (0.13) MAXIMUM WIDTH, 0.035 TO 0.040 (0.90 TO 1.00) DEPTH.

2 ETCH OR STEEL STAMP THE REFERENCE STANDARD NUMBER THAT REFERS TO THE TYPE OF STEEL IDENTIFIED IN THE MATERIAL NOTE.

3 FASTENER - USE A FASTENER WITH A HEAD DIAMETER LESS THAN 0.50 (13.0), (3 LOCATIONS).

Reference Standard 192 and NDT1075 - for Cracks at the Edge of a Steel Part
Figure 6



NOTES:

- THE SCREEN DISPLAY ABOVE SHOWS SIGNALS THAT OCCURRED WHEN A 200 KHZ, UNSHIELDED PROBE WITH A VERTICAL TO HORIZONTAL GAIN RATIO OF 2:1, WAS USED. DIFFERENT PROBES AND FREQUENCIES CAN MAKE THE NOTCH AND CRACK SIGNALS LOOK DIFFERENT.

1 ALARM LEVEL. SET THE ALARM TO ALARM AT 50% OF THE VERTICAL HEIGHT OF THE SIGNAL THAT OCCURS FROM THE REFERENCE STANDARD NOTCH.

2 SIGNAL FROM THE 0.020 INCH (0.50 MM) NOTCH IN REFERENCE STANDARD 185.

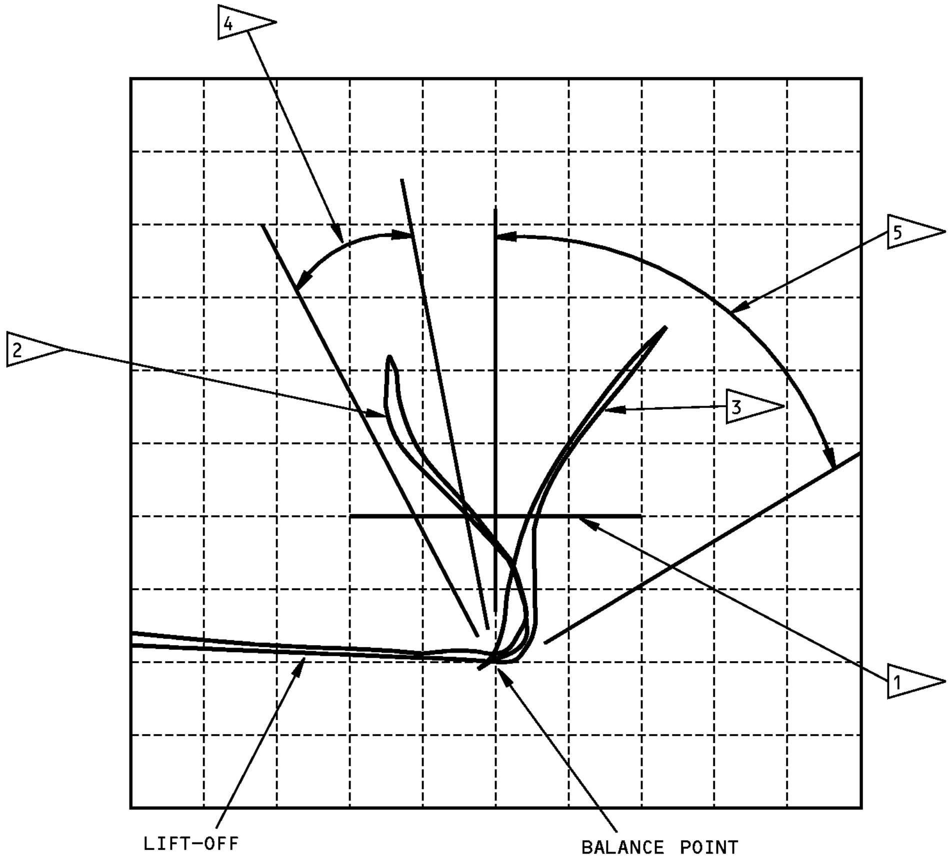
3 SIGNAL FROM A TIGHT FATIGUE CRACK IN A TEST PART OF 4340 STEEL THAT IS HEAT TREATED TO 185 KSI.

4 EDGE EFFECT SIGNAL WITH AN UNSHIELDED PROBE.

5 PHASE ANGLE RANGE THAT THE 0.020 INCH (0.50 MM) NOTCH SIGNAL CAN COME INTO VIEW.

6 PHASE ANGLE RANGE THAT A CRACK SIGNAL CAN COME INTO VIEW. THE PHASE ANGLE OF THE CRACK SIGNAL CAN CHANGE AS THE WIDTH OF THE CRACK CHANGES.

Instrument Calibration and Alarm Adjustment for High Permeability Steels
Figure 7



NOTES:

- THE SCREEN DISPLAY ABOVE SHOWS SIGNALS THAT OCCURRED WHEN A 150 KHZ, SHIELDED PROBE WITH A VERTICAL TO HORIZONTAL GAIN RATIO OF 1:1, WAS USED. DIFFERENT PROBES, FREQUENCIES AND GAIN RATIOS CAN MAKE THE NOTCH AND CRACK SIGNALS LOOK DIFFERENT.

1 ALARM LEVEL. SET THE ALARM TO ALARM AT 50% OF THE VERTICAL HEIGHT OF THE SIGNAL THAT OCCURS FROM THE REFERENCE STANDARD NOTCH.

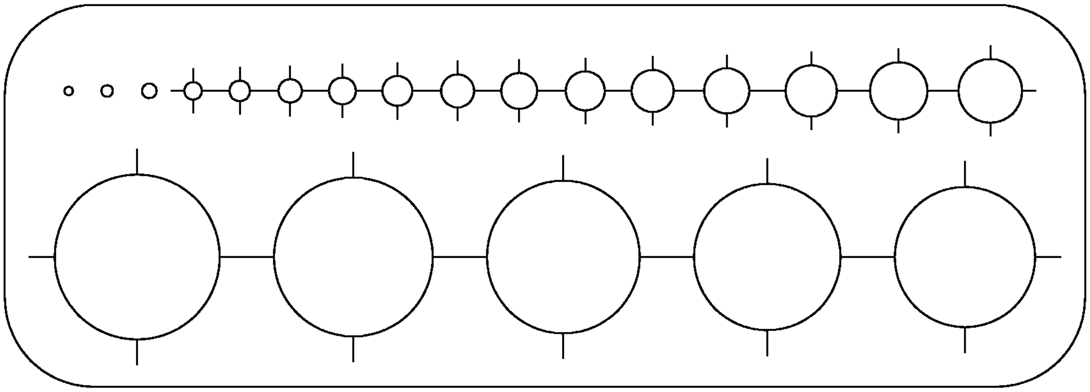
2 SIGNAL FROM THE 0.020 INCH (0.50 MM) NOTCH IN REFERENCE STANDARD NDT1072.

3 SIGNAL FROM A TIGHT FATIGUE CRACK, APPROXIMATELY 0.020 INCH (0.50 MM) DEEP, IN A TEST PART OF 301 1/2 HARD STAINLESS STEEL.

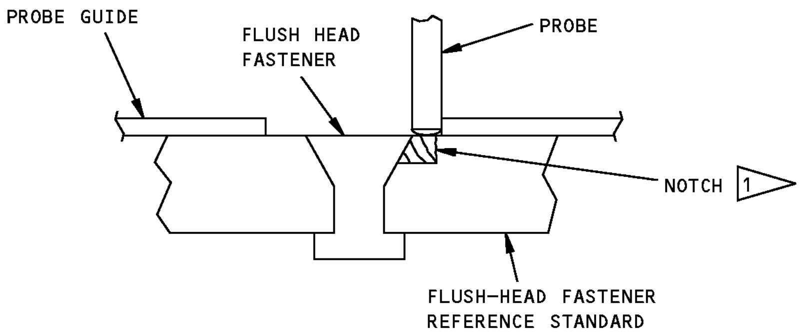
4 PHASE ANGLE RANGE THAT THE 0.020 INCH (0.50 MM) NOTCH SIGNAL CAN COME INTO VIEW.

5 PHASE ANGLE RANGE THAT A CRACK SIGNAL CAN COME INTO VIEW.

Instrument Calibration and Alarm Adjustment for Low Permeability Steels
Figure 8



PROBE GUIDE
(NONCONDUCTIVE CIRCLE TEMPLATE)



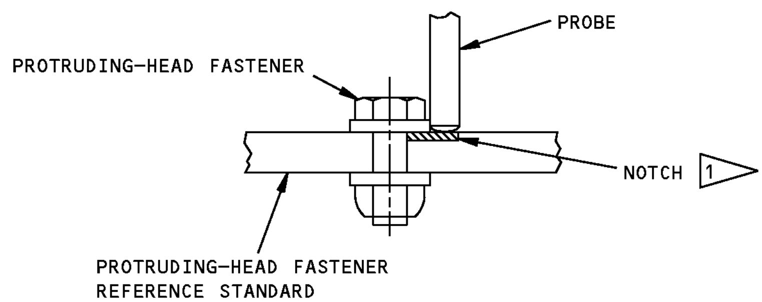
PROBE GUIDE USE FOR INSPECTIONS NEAR FLUSH-HEAD FASTENERS

NOTES

- USE THE HOLE DIAMETER IN THE PROBE GUIDE THAT WILL PERMIT YOU TO FIND CRACKS THAT ARE 0.10 INCH (2.5 MM) IN LENGTH.

1 THE MINIMUM NOTCH LENGTH THAT CAN BE FOUND WITH THIS PROCEDURE IS 0.10 INCH (2.5 MM) FROM THE HEAD OF THE FASTENER

Flush-Head Fastener Inspection Guidelines
Figure 9



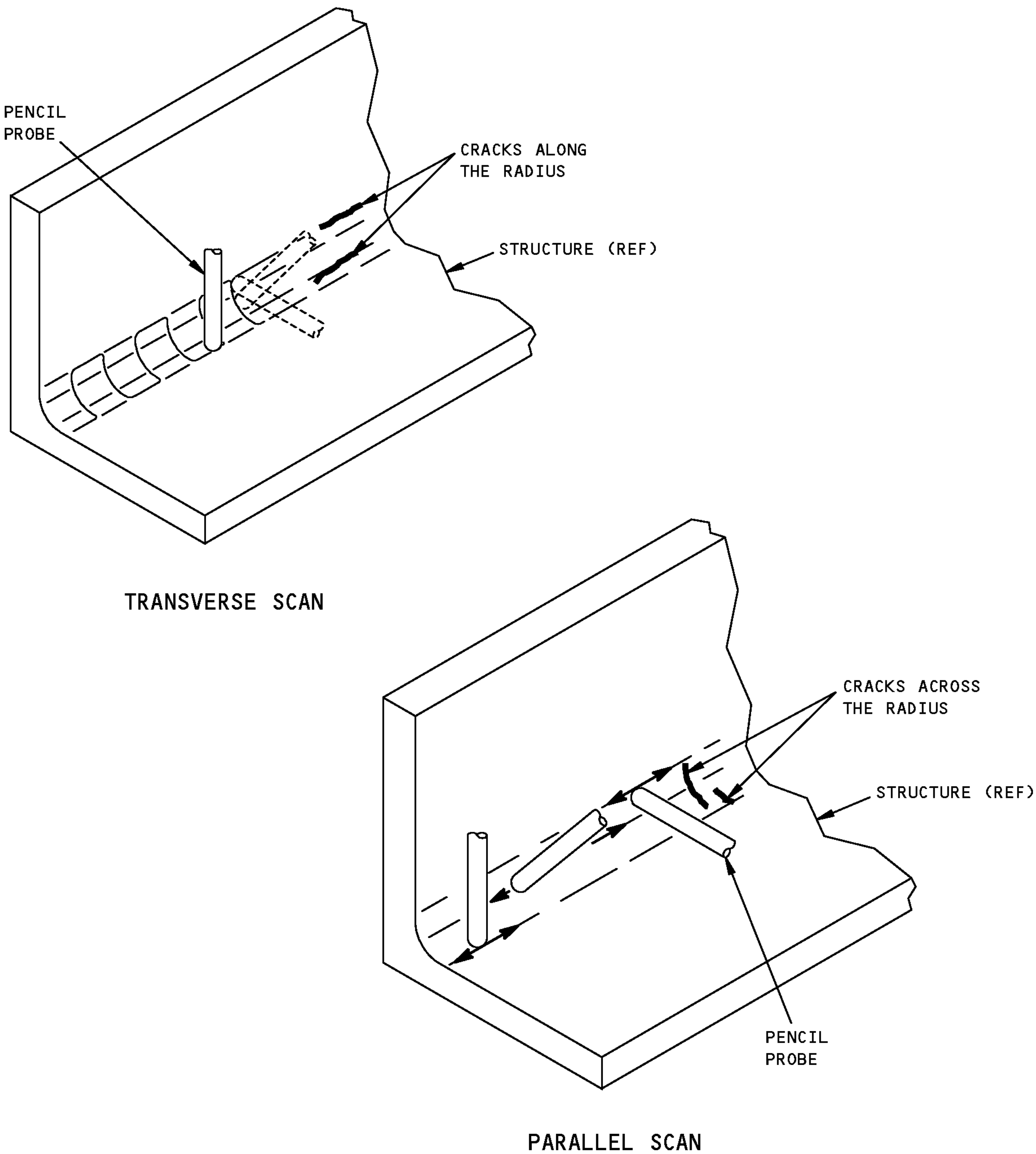
PROBE POSITION FOR INSPECTIONS NEAR PROTRUDING-HEAD FASTENERS

NOTES

- USE THE FASTENER HEAD OR WASHER AS A PROBE GUIDE.

1 THE MINIMUM NOTCH LENGTH THAT CAN BE FOUND WITH THIS PROCEDURE IS 0.10 INCH (2.5 MM) FROM THE HEAD OF THE FASTENER OR COLLAR OR THE EDGE OF A WASHER.

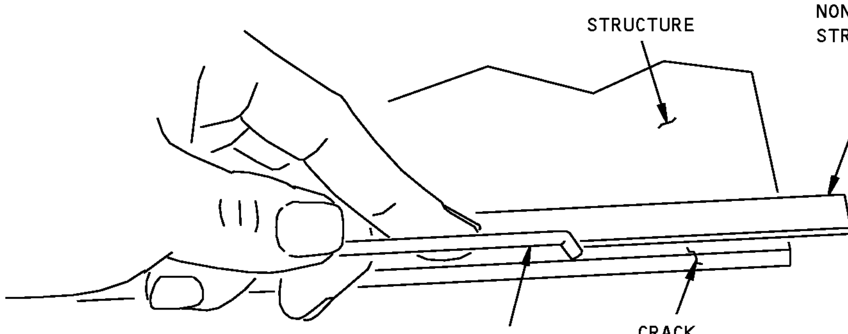
Protruding-Head Fastener Inspection Guidelines
Figure 10

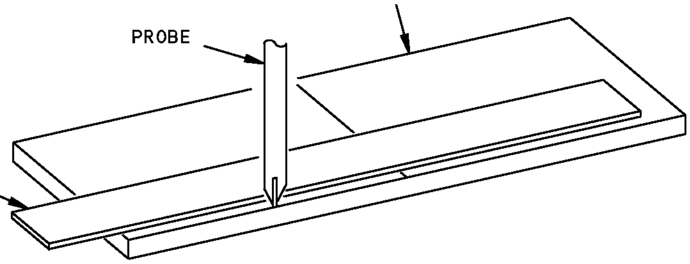


NOTES

- HOLD THE PROBE AS VERTICAL AS POSSIBLE TO THE SURFACE OF THE RADIUS.
- THE LENGTH OF THE CRACK THAT YOU WANT TO FIND AND THE DIAMETER OF THE PROBE WILL SET THE INCREMENT DISTANCE FOR WHICH TO MOVE THE PROBE BETWEEN EACH SCAN.

Radius Inspection
Figure 11

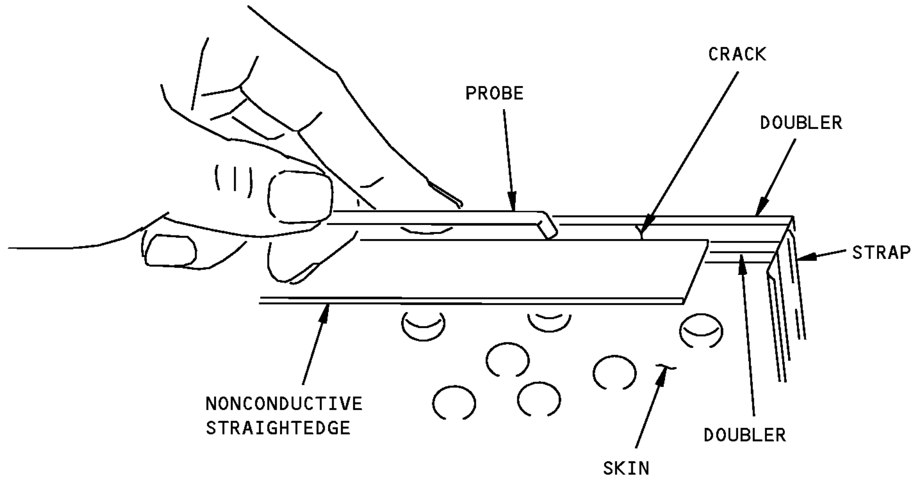


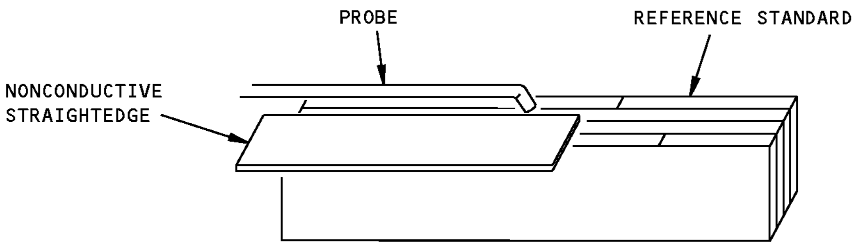


NOTES

- POSITION A NONCONDUCTIVE STRAIGHTEDGE A CONSTANT DISTANCE FROM THE EDGE OF THE STRUCTURE.
- THE MINIMUM DISTANCE THE PROBE MUST BE FROM AN EDGE IS RELATED TO THE DIAMETER OF THE PROBE COIL AND IF THE PROBE IS SHIELDED OR UNSHIELDED.
- TO IDENTIFY THE MINIMUM DISTANCE THE PROBE MUST BE FROM THE EDGE:
  - CALIBRATE THE INSTRUMENT AS SPECIFIED IN PARAGRAPH 4. USE REFERENCE STANDARD 185 FOR HIGH PERMEABILITY STEELS; USE REFERENCE STANDARD NDT1072 FOR LOW PERMEABILITY STEELS.
  - POSITION A NONCONDUCTIVE STRAIGHTEDGE A CONSTANT DISTANCE FROM THE NOTCHED EDGE OF THE REFERENCE STANDARD
  - MOVE THE PROBE ALONG THE STRAIGHT EDGE AND MONITOR THE DISPLAY. THE MINIMUM PROBE TO EDGE DISTANCE OCCURS WHEN THE SIGNAL FROM THE NOTCH FALLS BELOW 90% OF THE SIGNAL YOU GOT DURING CALIBRATION. IF NECESSARY, BALANCE THE INSTRUMENT AGAIN BUT DO NOT CHANGE THE CALIBRATION SENSITIVITY.

Inspection Near an Edge
Figure 12





NOTES

- POSITION A NONCONDUCTIVE STRAIGHTEDGE A CONSTANT DISTANCE FROM THE EDGE OF THE PART TO BE EXAMINED.
- THE MINIMUM WIDTH THAT THE STRUCTURE MUST BE SO THAT YOU CAN IDENTIFY CRACKS IS RELATED TO THE DIAMETER OF PROBE COIL.
- TO IDENTIFY THE MINIMUM WIDTH THE STRUCTURE MUST BE BEFORE YOU CAN EXAMINE IT FOR CRACKS:
  - CALIBRATE THE INSTRUMENT AS SPECIFIED IN PARAGRAPH 4. USE REFERENCE STANDARD 185 FOR HIGH PERMEABILITY STEELS; USE REFERENCE STANDARD NDT1072 FOR LOW PERMEABILITY STEELS.
  - PUT A NONCONDUCTIVE STRAIGHTEDGE A CONSTANT DISTANCE ALONG A NOTCHED PART OF REFERENCE STANDARD 192 FOR HIGH PERMEABILITY STEELS OR REFERENCE STANDARD NDT1075 FOR LOW PERMEABILITY STEELS. SET THE STRAIGHTEDGE SO THE PROBE WILL BE CENTERED ON THE NOTCHED PART
  - MOVE THE PROBE ALONG THE STRAIGHTEDGE AND MONITOR THE DISPLAY. THE MINIMUM STRUCTURE WIDTH IS IDENTIFIED WHEN THE SIGNAL FALLS BELOW 90% OF THE SIGNAL YOU GOT DURING CALIBRATION. IF NECESSARY, BALANCE THE INSTRUMENT AGAIN BUT DO NOT CHANGE THE CALIBRATION SENSITIVITY.

Inspection on an Edge
Figure 13

PART 6 - EDDY CURRENT

CRACKS IN SKINS BELOW FLUSH HEAD RIVETS

1. **Purpose**

   A. To find cracks in skins that extend from fastener holes below flush head rivets, without removal of the rivets.

2. **Equipment**

   A. The Foerster RivetCheck was used to prepare this procedure. Other automatic scanners are permitted if they can do the calibration specified in this procedure.

   NOTE: See Part 1, 51-01-00 for data about the equipment manufacturers.

   B. Probe

   (1) Use the manufacturer's probe that comes with the scanner equipment. The probe scan radius must be correct for the fasteners to be examined.

   C. Reference Standard

   (1) Use reference standard NDT1071-D-t_1/t_2. See Figure 1. The reference standard number includes data on the part structure as specified below:

   NOTE: This reference standard is the same design as the NASA reference standard in the Standard Practice Manual (SPM, Document Number MDC 93K0393) for McDonnell Douglas aircraft. Refer to SPM procedures 06-00-03, 06-00-06, and 06-20-01.

   (a) The "D" code identifies the diameter of the fastener shank, in 1/32 inch increments, of the inspection fasteners. The fasteners in the reference standard must be the same diameter as the inspection fasteners.

   (b) The ''t_1/t_2'' code shows the first layer and the second layer thicknesses of the reference standard in thousandths of an inch. For this high frequency inspection procedure, it is not necessary for each layer of the reference standard to fully agree with the airplane structure.

   (2) The NDT1071-5-080/040 reference standard is the same as many Boeing skin laps on Boeing 737 and 727 airplanes.

3. **Preparation for Inspection**

   A. Do a check of the inspection area for magnetic fasteners, protruding-head fasteners, or fasteners that are larger than usual. You must use an alternative procedure to examine these areas.

   B. Measure and make a record of the head diameters of the rivets in the inspection area.

4. **Instrument Calibration**

   A. Connect the RivetCheck cable to the RivetCheck scanner and laptop computer.

   B. Energize the laptop computer and start the RivetCheck software.

   C. Push the "test config" button.

   D. Identify the diameter of the rivet head in the instrument data entry window. Make a record of the scale adjustment after you identify the diameter of the rivet head.

   E. Identify the adjustment screws on the bottom of the scan head. Use a flat-bladed screwdriver to unlock the small lockscrew, then turn the large adjustment screw until the index mark aligns with the correct number on the housing. The number must be the same as the scale adjustment on the lap top display. For example: for a rivet head diameter of 0.238 inch (6 mm), the adjustment must be 2.2.

   F. Tighten the lockscrew.

   G. Loosen the adjustment screw on the side of the scan head housing to adjust the lift-off as follows:

(1) With the probe on a flat surface, turn the support ring until the probe touches the surface.

(2) Then turn the support ring two increments clockwise to lift the probe from the part by 0.010 inch (0.25 mm). Each increment mark on the support ring is equivalent to a 0.005 inch (0.13 mm) lift of the probe.

H. Tighten the lockscrew on the side of the housing.

I. Set the test depth to "top layer".

J. Set "save delay" to 0.500 seconds.

K. Set "file mode", "file prefix", and "file index" as necessary. Refer to the instrument instruction manual.

L. Click "exit".

M. From the subsequent screen, click "test".

N. Click "motor on".

O. When the dialog box comes on the screen, put the rotating probe in calibration position A on a good area of the skin material to be tested. This area must not have a rivet head near the probe. See Figure 2, View A.

P. Push the button on the side of the test head (the scanner head button) and monitor the display (Figure 2, View B). Do not move the probe head until you hear a "beep".

Q. At the subsequent dialog box, align the rotating probe at calibration position B (Figure 3, View A) on a good rivet in the reference standard. Use the vector signal that occurs in the left side of the display to help you center the probe head. See Figure 3, View B.

NOTE: You can adjust the "rotate" control until the probe head movement direction agrees with the vector signal direction on the display.

R. Push the scanner head button. Do not move the probe head until you hear a "beep".

S. At the subsequent dialog box, hold the probe in air at calibration position C. See Figure 4, View A.

T. Push the scanner head button and monitor the display (Figure 4, View B). Do not move the probe head until you hear a "beep". The instrument is now ready to find cracks.

U. Push and release the scanner head button.

V. Align the probe at position D on the reference standard. See Figure 5, View A.

(1) The computer display will "freeze" when the probe is aligned. The reference standard notch signal will show on the waveform display, as well as a "flaw peak value". See Figure 5, View B.

W. Make a record of the signal height and the flaw peak value.

NOTE: It is not possible to adjust the gain level of the instrument.

X. Push the scanner head button and align the probe at position E on the reference standard. The computer display will "freeze" when the probe is centered. See Figure 6, View A.

Y. Make a record of the waveform signal and the flaw peak value. See Figure 6, View B.

Z. Push the scanner head button and align the probe at position F on the reference standard. The computer display will "freeze" when the probe is centered. See Figure 7, View A.

AA. Make a record of the waveform signal and the flaw peak value. See Figure 7, View B.

AB. Adjust the threshold control to 10 mV. The flaw peak values with the probe at positions A and B must be above 10 mV. If they are not, do a check of your calibration adjustments, the probe rotation adjustment, and the lift-off adjustment.

5. **Inspection Procedure**

A. Examine skin layers for cracks in areas where the fastener diameter is the same as the fastener diameter of the reference standard for which the instrument was calibrated. If there are fasteners that are larger or smaller in diameter than those you used for calibration, then you must calibrate again using a reference standard with the correct fasteners.

B. Align the rotating probe on each rivet in the inspection area. The instrument display will "freeze" when the probe is aligned correctly above the rivet.

C. During the inspection, monitor the raw signal (left side of the display) for bulges and the waveform signal (right side of the display) for sharp peaks. These are indications of cracks. The data that follows was recorded from cracked structures. This data can be used as reference data, to help identify cracks:

(1) Display from a 0.040 inch long crack (Figure 8).

(2) Display from a rivet with a 0.040-inch long crack at 90 degrees and a 0.050-inch crack at 260 degrees (Figure 9).

(3) Display from a 0.060-inch long crack (Figure 10).

D. If the instrument alarm is triggered, save the crack indication signal. Use an applicable file name that identifies the crack location.

E. If the rotating head is not positioned above the center of the rivet (Figure 11, View A), an off-center indication will show on the display. The raw signal will be asymmetrical and the waveform display will show large peaks which look almost the same as crack signals. See Figure 11, View B. The instrument display will not "freeze" when this occurs.

6. **Inspection Results**

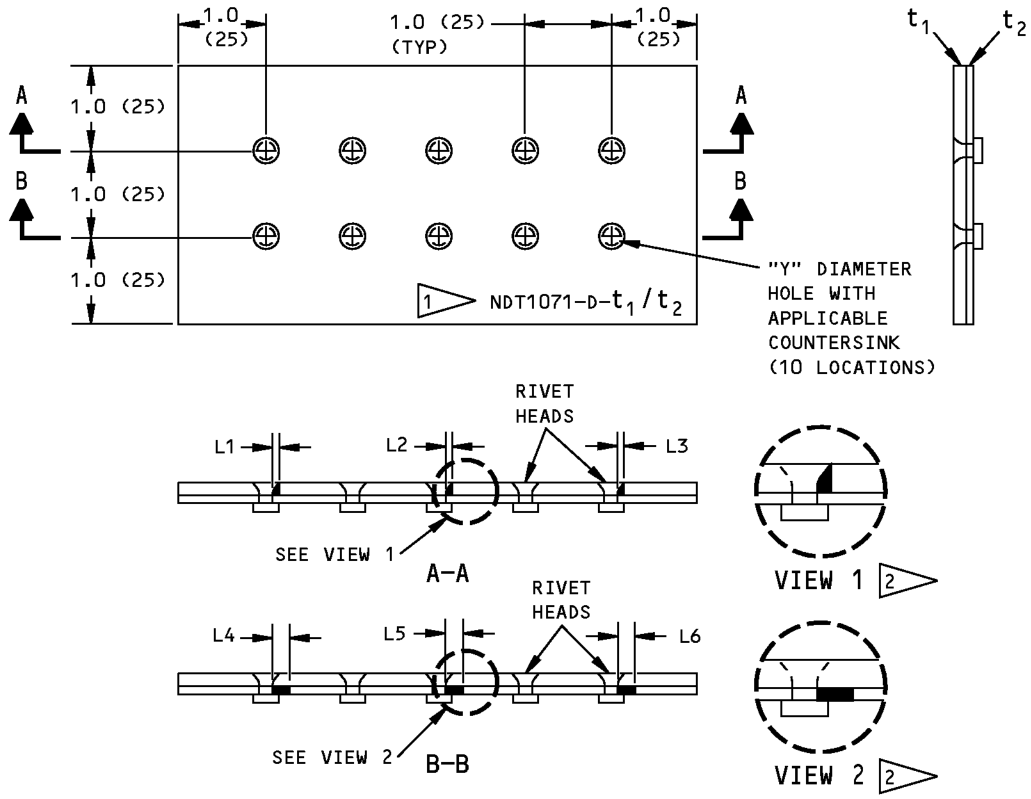
A. A waveform signal that is more than 10 mV is a crack indication and the inspection area must be fully examined.

B. To make sure there is a crack, you can remove the fastener and examine the countersunk hole area. Refer to:

(1) Part 6, 53-30-00, Fig. 1, 3, or 4 (707, 727, 737, 747 NDT Manuals).

(2) Part 6, 53-30-02, 53-30-03, or 53-30-04 (757 NDT Manual).

(3) Part 6, 53-30-01, Part 6, 53-30-02, or Part 6, 53-30-03 (767, 777 NDT Manuals).



NOTES:

- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES)
- TOLERANCES:

INCHES	MILLIMETERS
X.XXX = ±0.005	X.XX = ±0.10
X.XX = ±0.025	X.X = ±0.5
X.X = ±0.050	X = ±1

- SURFACE ROUGHNESS = 125 Ra OR BETTER
- RIVETS: USE 10 RIVETS THAT HAVE THE SAME DIAMETER AS THOSE IN THE INSPECTION AREA
- MATERIAL: 2024-T3 ALUMINUM; CLAD OR BARE USE THE SAME SHEET THICKNESS AS THE SHEET THICKNESS IN THE INSPECTION AREA

1 ETCH OR STEEL STAMP THE REFERENCE STANDARD NUMBER NDT1071-D-t_1/t_2.

- "D" IDENTIFIES THE FASTENER SHANK DIAMETER IN 1/32 INCH INCREMENTS.
- "t_1" IDENTIFIES THE TOP SHEET THICKNESS IN 0.001 INCH INCREMENTS.
- "t_2" IDENTIFIES THE BOTTOM SHEET THICKNESS IN 0.001 INCH INCREMENTS.

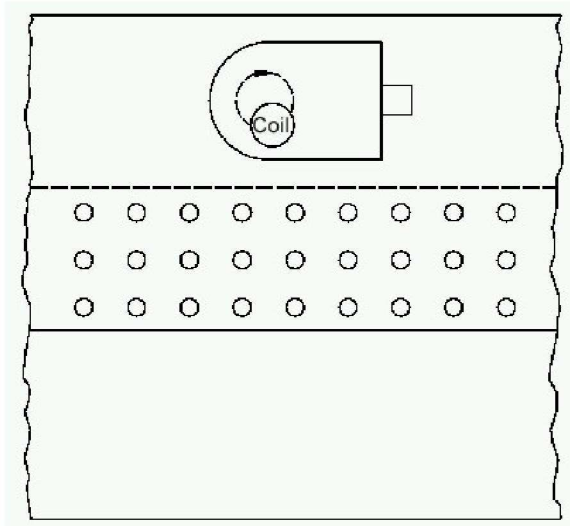
2 EDM NOTCH LENGTHS (SEE VIEW 1 AND 2 ABOVE):

L1 0.030 INCH (0.76)
L2 0.040 INCH (1.00)
L3 0.050 INCH (1.27)
L4 0.050 INCH (1.27)
L5 0.100 INCH (2.54)
L6 0.150 INCH (3.81)

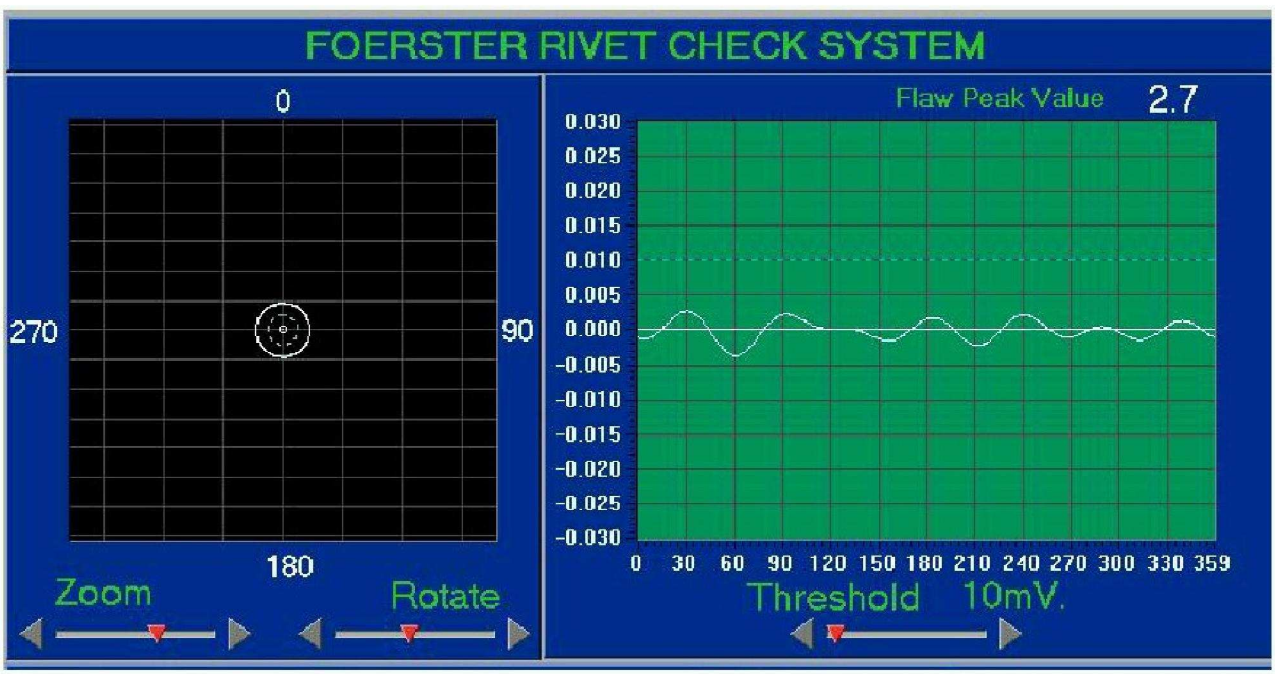
THE NOTCH LENGTH IS FROM THE EDGE OF THE HOLE OUTWARD. MAKE SURE THE NOTCH IS WITHIN ±0.005 (0.10) OF THE CENTERLINE OF THE HOLE. THE MAXIMUM NOTCH WIDTH IS 0.007 (0.18) FOR L1-L3, 0.010 (0.20) FOR L4-L6.

3 USE A NONCONDUCTIVE PAINT OR PRIMER TO PAINT ALL OF THE COUNTERSUNK SURFACES BEFORE THE RIVETS ARE INSTALLED.

Reference Standard NDT1071-D-t_1/t_2
Figure 1



CALIBRATION POSITION A
VIEW A

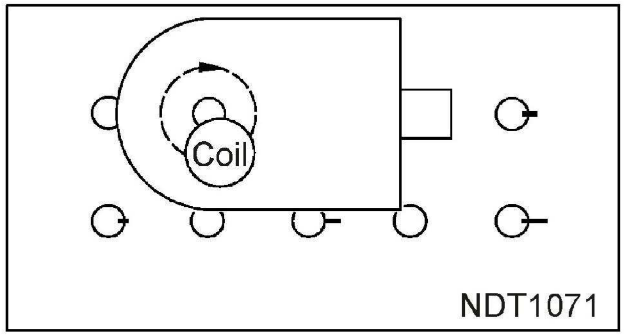


RAW SIGNAL DISPLAY

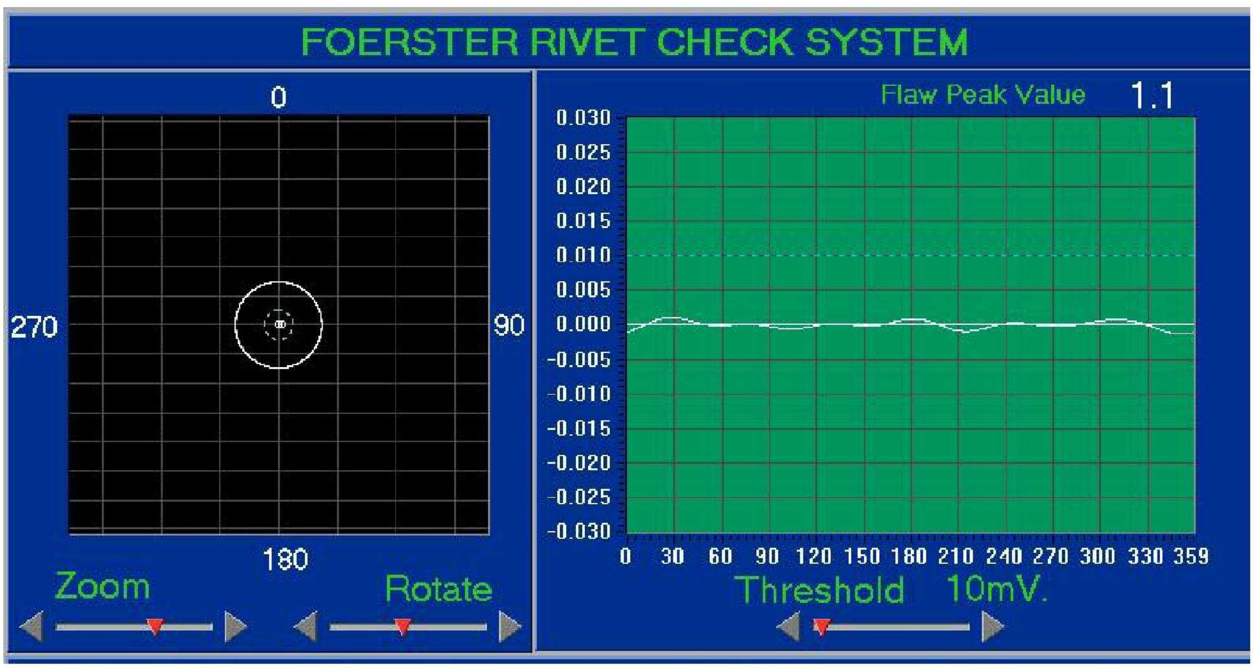
WAVEFORM DISPLAY

RIVET CHECK ACTIVE DISPLAY WINDOW
VIEW B

Calibration Position and Display on a Good Area of the Skin to be Examined
Figure 2



CALIBRATION POSITION B
VIEW A



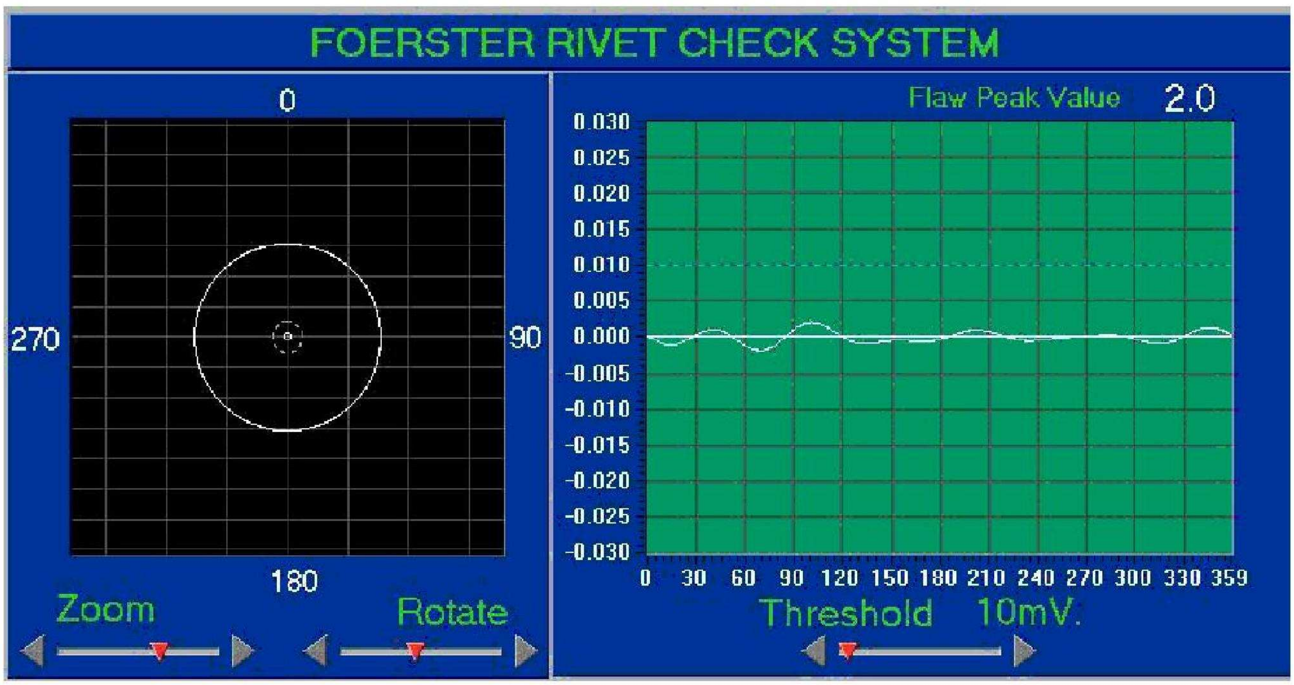
RAW SIGNAL DISPLAY

WAVEFORM DISPLAY

RIVET CHECK ACTIVE DISPLAY WINDOW
VIEW B

Calibration Position and Display for a Good Rivet Location
Figure 3

CALIBRATION POSITION C
VIEW A

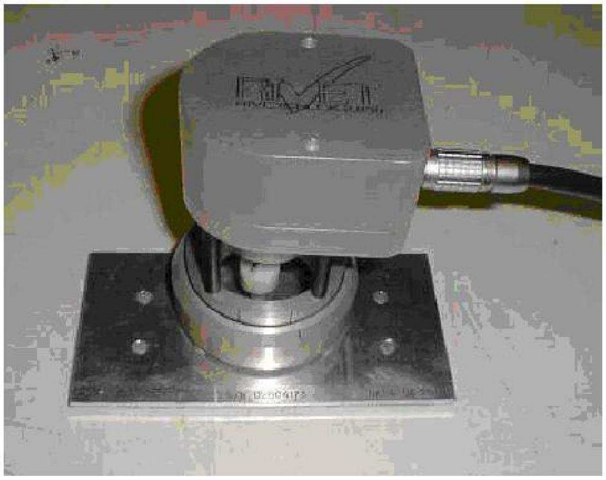


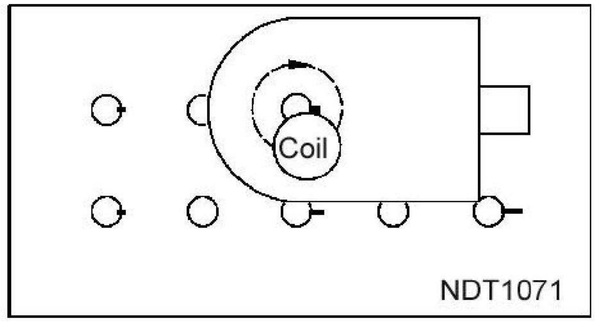
RAW SIGNAL DISPLAY

WAVEFORM DISPLAY

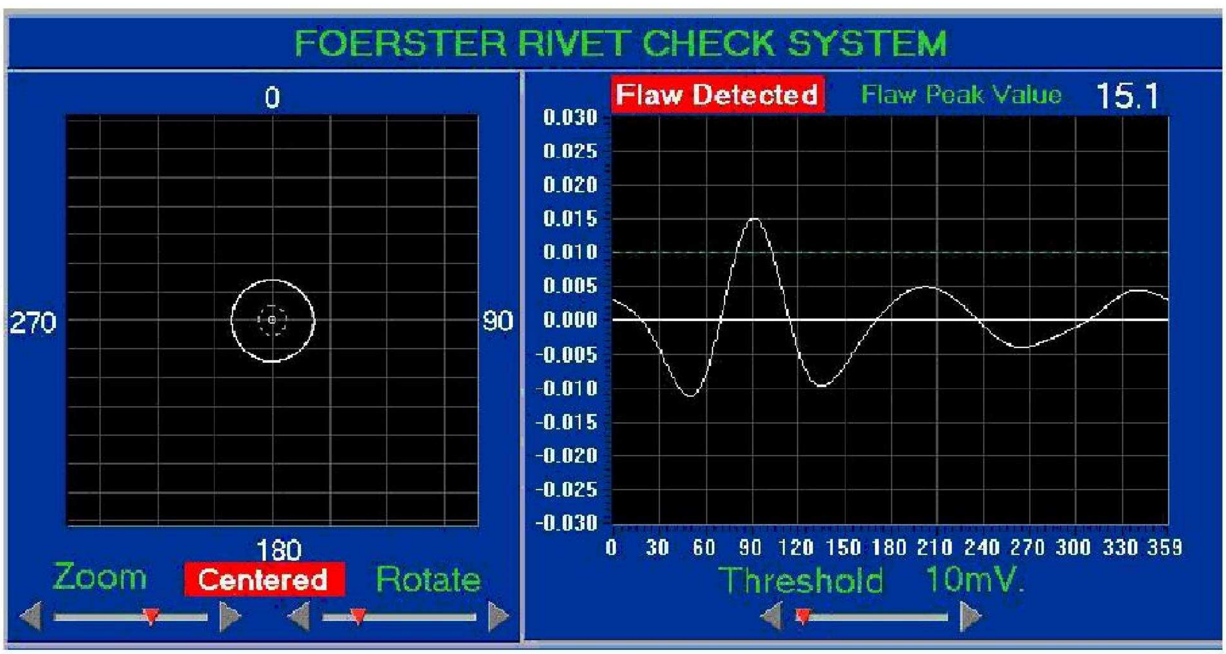
RIVET CHECK ACTIVE DISPLAY WINDOW
VIEW B

Calibration Position and Display for Air
Figure 4





CALIBRATION POSITION D
VIEW A

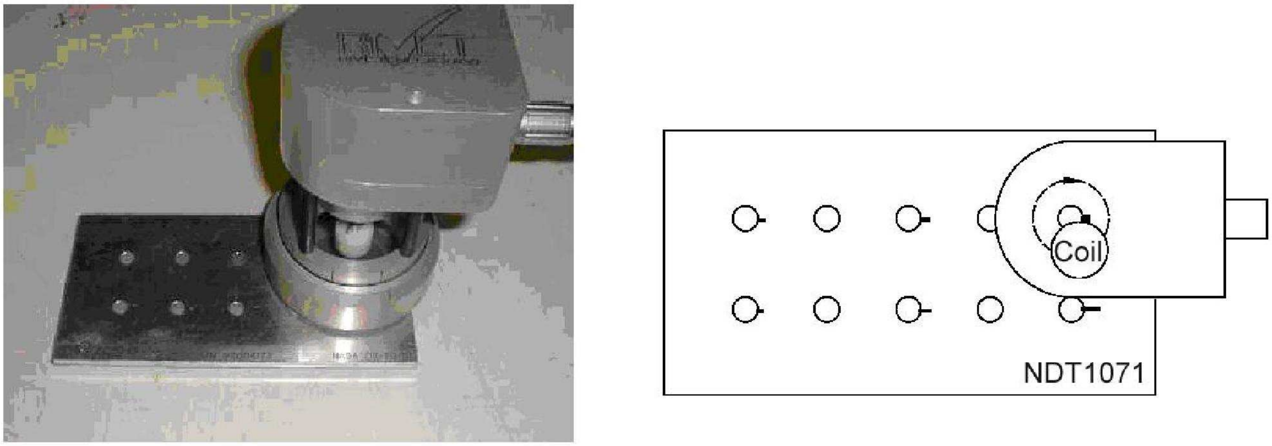


RAW SIGNAL DISPLAY

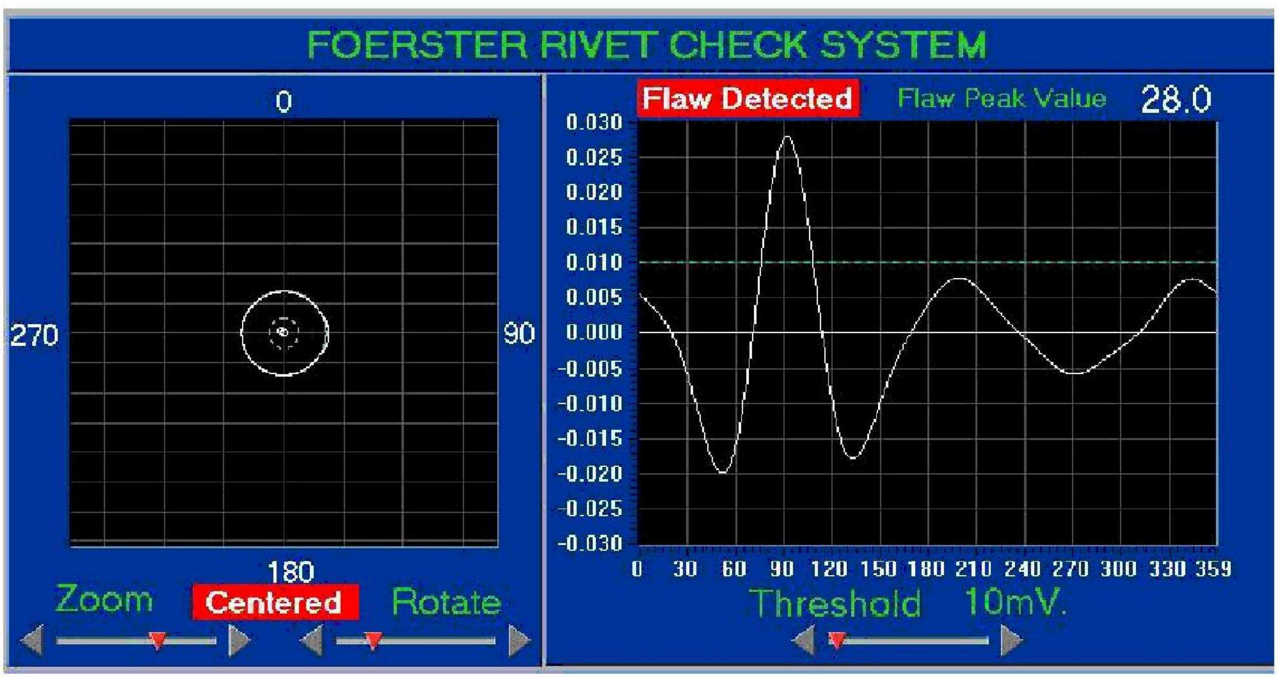
WAVEFORM DISPLAY

RIVET CHECK ACTIVE DISPLAY WINDOW
VIEW B

Calibration Position and Display for a 0.040 Inch (1.0 MM) Long EDM Notch
Figure 5



CALIBRATION POSITION E
VIEW A

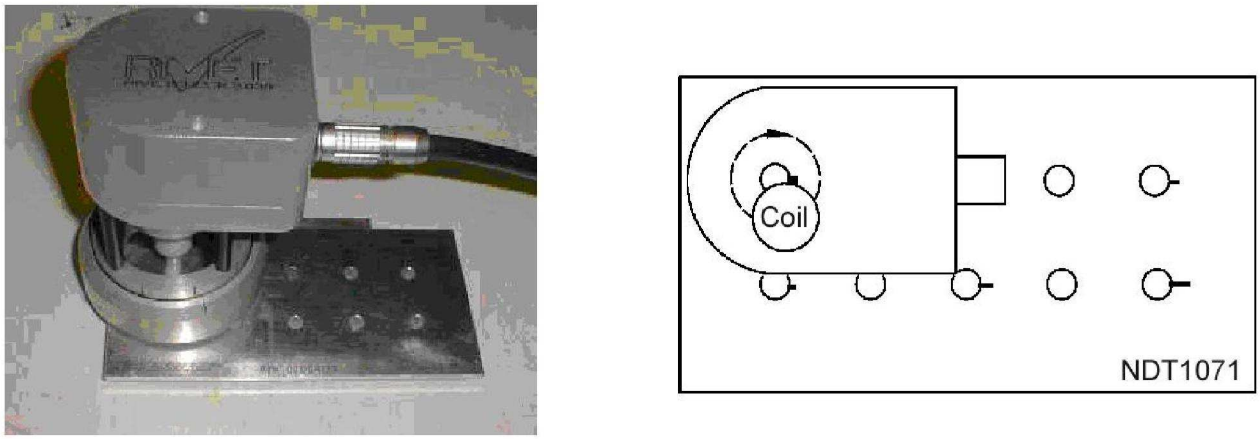


RAW SIGNAL DISPLAY

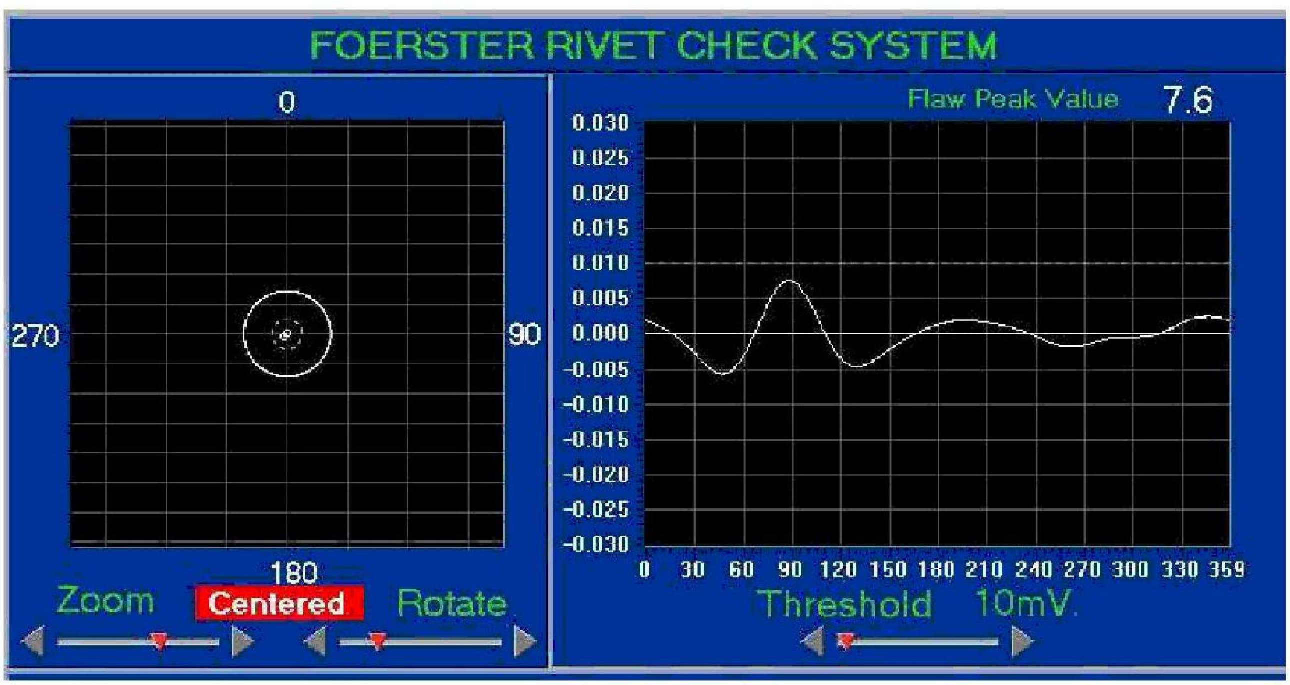
WAVEFORM DISPLAY

RIVET CHECK ACTIVE DISPLAY WINDOW
VIEW B

Calibration Position and Display for a 0.050 Inch (1.3 MM) Long EDM Notch
Figure 6



CALIBRATION POSITION F
VIEW A

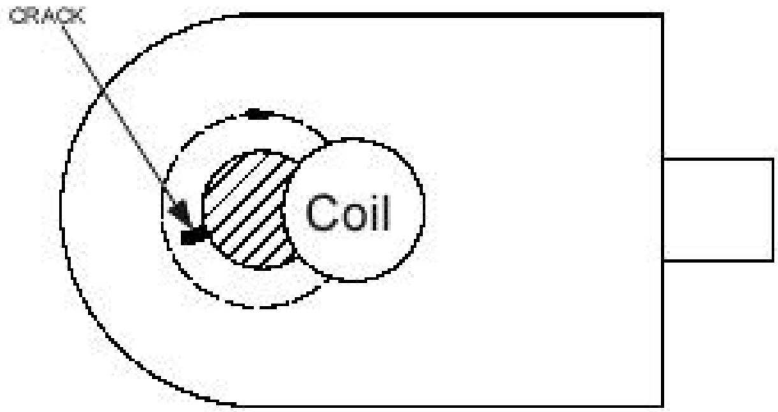


RAW SIGNAL DISPLAY

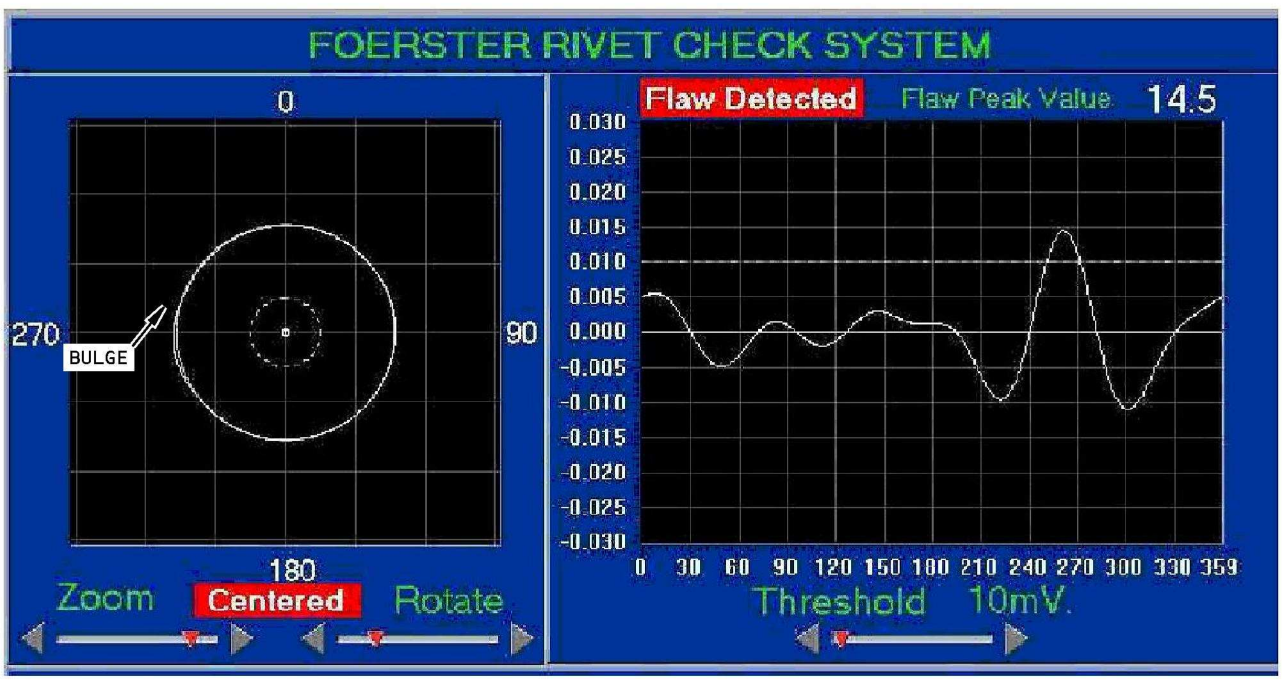
WAVEFORM DISPLAY

RIVET CHECK ACTIVE DISPLAY WINDOW
VIEW B

Calibration Position and Display for a 0.030 Inch (0.7 MM) Long EDM Notch
Figure 7



CALIBRATION POSITION X
VIEW A

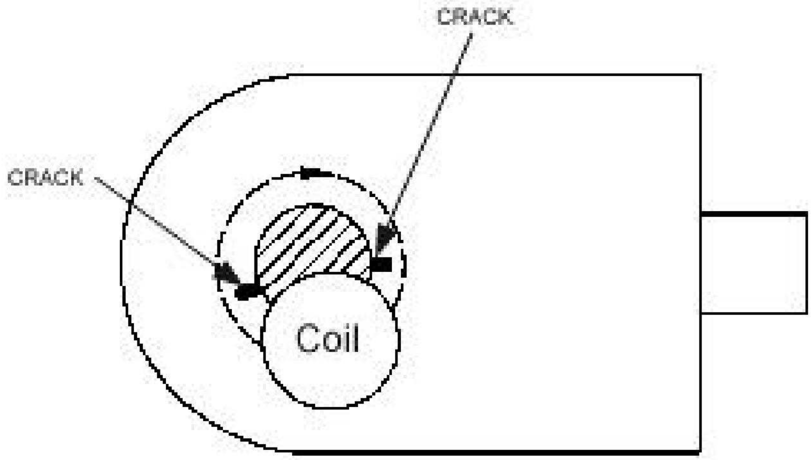


RAW SIGNAL DISPLAY

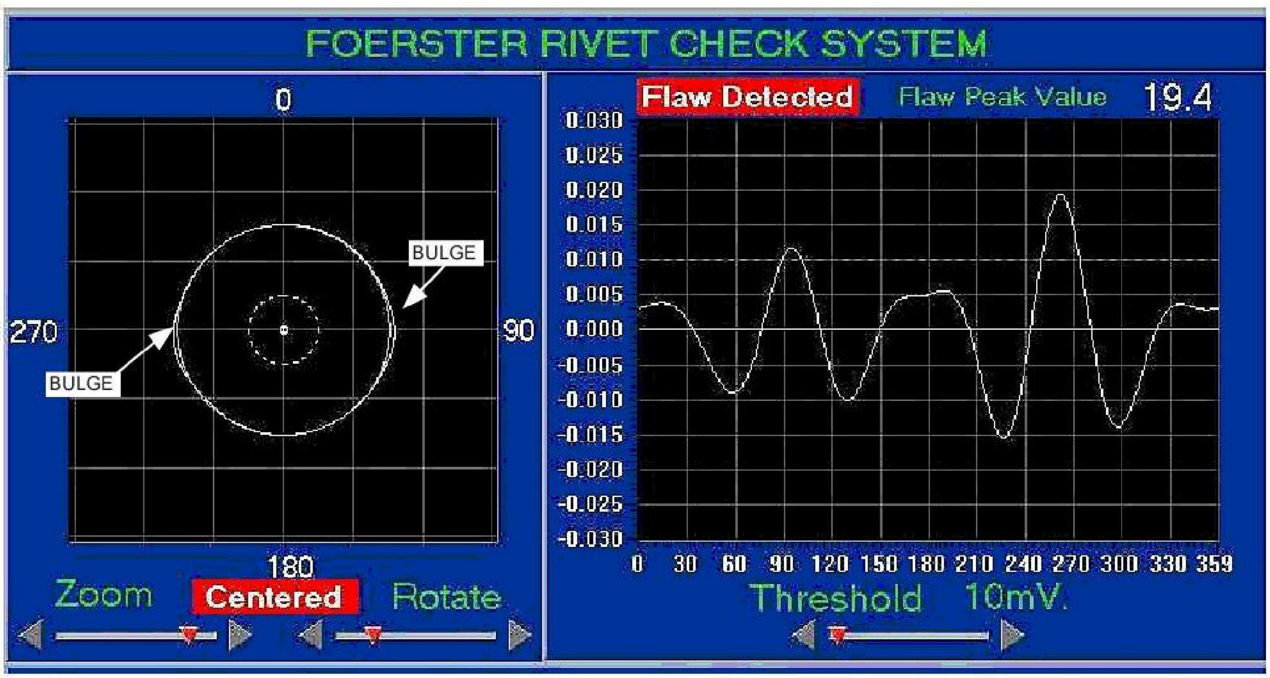
WAVEFORM DISPLAY

RIVET CHECK ACTIVE DISPLAY WINDOW
VIEW B

Signal Display from a 0.040 Inch (1.0 MM) Long Crack at 260 Degrees
Figure 8



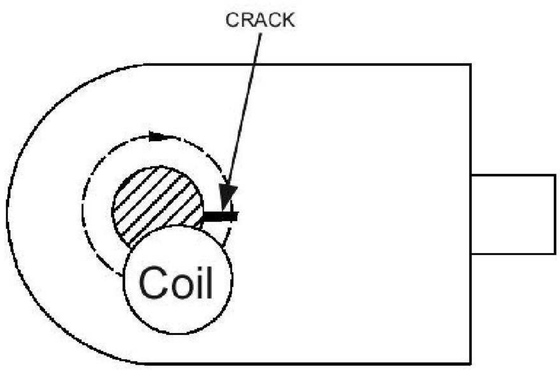
CALIBRATION POSITION X
VIEW A



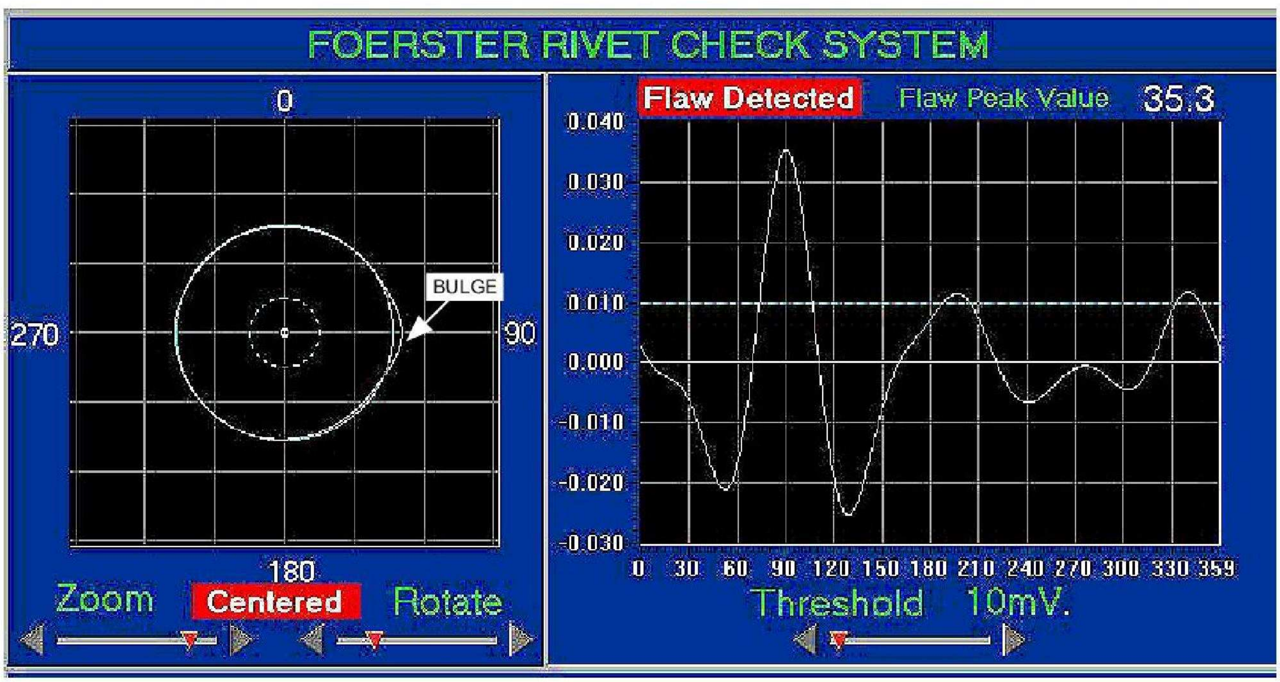
RAW SIGNAL DISPLAY WAVEFORM DISPLAY

RIVET CHECK ACTIVE DISPLAY WINDOW
VIEW B

Signal Display from a 0.040 Inch (1.0 MM) Long Crack at 90 Degrees and a 0.050 Inch (1.3 MM) Long Crack at 260 Degrees
Figure 9



CALIBRATION POSITION X
VIEW A

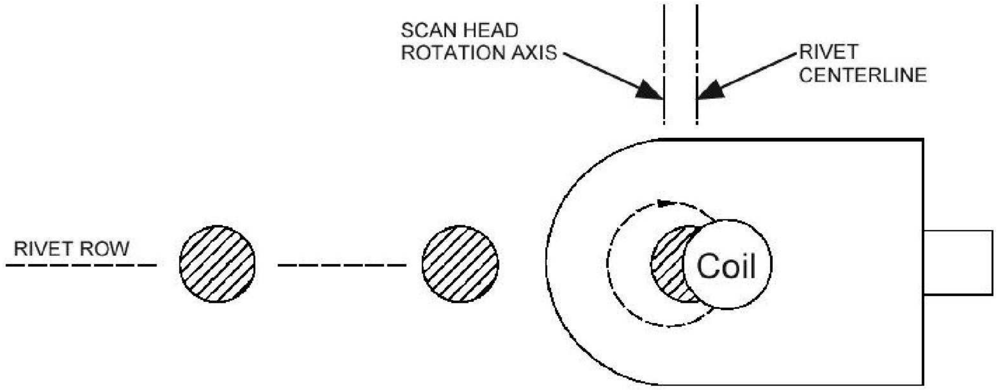


RAW SIGNAL DISPLAY

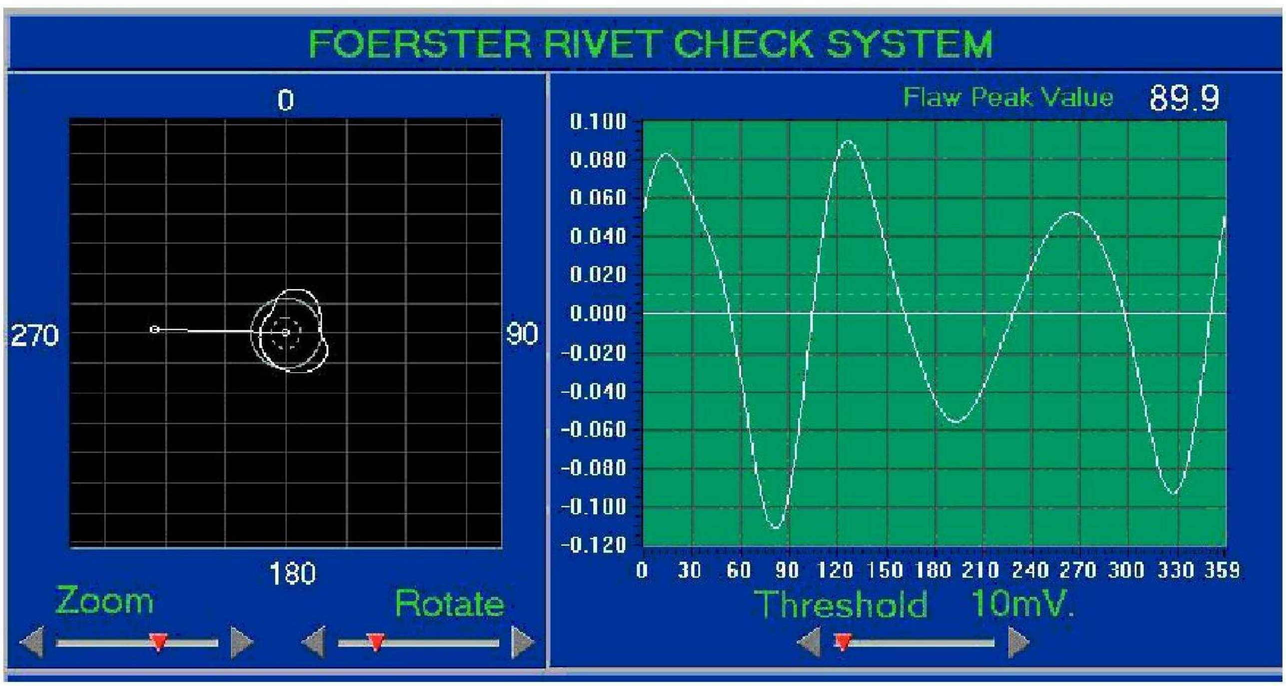
WAVEFORM DISPLAY

RIVET CHECK ACTIVE DISPLAY WINDOW
VIEW B

Signal Display from a 0.060 Inch (1.5 MM) Long Crack at 90 Degrees
Figure 10



OFF-CENTER PROBE
VIEW A



RAW SIGNAL DISPLAY

WAVEFORM DISPLAY

RIVET CHECK ACTIVE DISPLAY WINDOW
VIEW B

Signal Display when the Scanner is Off Center
Figure 11