SAE Aerospace
An SAE International Group

AEROSPACE RECOMMENDED PRACTICE

SAE ARP4402

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Reaffirmed 2013-06

Eddy Current Inspection of Open Fastener Holes in Aluminum Aircraft Structure

RATIONALE

ARP4402 has been reaffirmed to comply with the SAE five-year review policy.

1. SCOPE:

1.1 Purpose:

This SAE Aerospace Recommended Practice establishes the requirements and procedures for eddy current inspection of open fastener holes in aluminum aircraft structures.

1.2 Application:

This process has been used typically by maintenance and overhaul facilities personnel to inspect aluminum aircraft structures for service-induced cracks, but usage is not limited to such applications.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this specification to the extent specified herein. The applicable issue of referenced publications shall be the issue in effect on the date of the purchase order.

2.1 U.S. Government Publications:

Available from Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-STD-410 Nondestructive Testing Personnel Qualification and Certification (Eddy Current, Liquid Penetrant, Magnetic Particle, Radiographic, and Ultrasonic)

2.2 ASNT Publications:

Available from American Society for Nondestructive Testing, 1711 Arlingate Lane, Columbus, OH 43228-0518.

SNT-TC-1A Recommended Practice, Personnel Qualification and Certification in Nondestructive Testing

2.3 ATA Publications:

ATA 105 Certification of NDT Personnel

3. TECHNICAL REQUIREMENTS:

3.1 Equipment:

Instrument/probe combinations shall be capable of meeting the calibration requirements of 3.5.

3.1.1 Eddy Current Instruments: Instruments shall be equipped with at least one of the following signal response displays:

3.1.1.1 Meter

3.1.1.2 Impedance (Y/X)

3.1.1.3 Time base (Y/T)

3.1.1.4 Instruments typically shall be capable of operating between 100 and 500 KHz. Instruments may be operated at other frequencies if the requirements of 3.5 are met.

3.1.1.5 Instruments shall be equipped with an audible and/or visual alarm system.

3.1.2 Voltage Regulators: For other than battery-powered instruments, a voltage regulator shall be used on the power source if instrument internal voltage regulators are not adequate to prevent a signal variation of 20% or more.

3.1.3 Probes:

3.1.3.1 The probe diameter shall be determined by the diameter of the inspection hole.

3.1.3.1.1 Variable diameter (slotted) probes shall be selected so that a slight interference fit exists between the hole and probe.

3.1.3.1.2 Fixed diameter probes shall be selected such that the difference between the hole diameter and the probe outer diameter does not exceed 0.005 in (0.13 mm).

3.1.3.2 Probes typically shall be capable of operating between 100 and 500 KHz. Probes may be used at other frequencies if the requirements of 3.5 are met.

3.1.3.3 Probes shall be marked with the operating frequency or frequency range.

3.1.3.4 The impedance of probes and adaptors shall match the instrument being used.

3.1.3.5 Probe connectors and adaptors shall match the instrument being used.

3.1.3.6 Probes may have an absolute or differential coil arrangement.

3.1.3.7 Probes may be shielded or unshielded.

3.1.3.8 Probes shall not give interfering responses from handling pressures, manipulation, or normal operating pressure variations on the sensing coil which cause the signal-to-noise ratio to be less than 3:1.

3.1.4 Probe Collars: Probe collars shall be used to ensure uniform depth of rotation and to aid in reducing lift-off effects. Specific automated rotating probes may or may not require collars.

3.1.5 Scanners:

3.1.5.1 Fixed Insertion (Helical): Scanning units that drive a probe in a helical pattern through the length of an inspection hole. The rotation pitch and probe revolution speed may be adjustable or nonadjustable.

3.1.5.2 Free Insertion: Scanning units that rotate a probe at an adjustable or nonadjustable revolution speed.

3.1.5.3 Free Revolution: Scanners typically shall rotate at a speed greater than 500 rpm. Slower speeds may be used if the requirements of 3.5 are met.

3.1.6 Reference Standards:

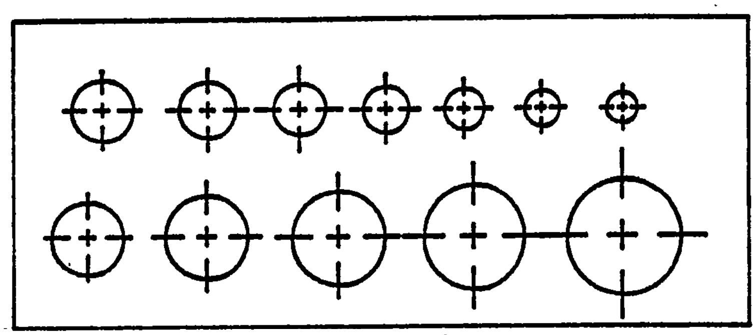
3.1.6.1 Reference standards to be used shall be agreed upon by purchaser and the cognizant quality assurance activity.

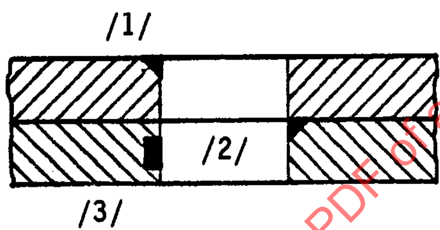
3.1.6.2 The reference standard to be used shall be specified in the applicable detailed written procedure.

3.1.6.3 The conductivity of the reference standard shall match the conductivity of the part to be inspected within ±15% International Annealed Copper Standard (IACS) (8.7 ms/m).

3.1.6.4 The finish of the reference standard hole shall be 63 RHR or better.

3.1.6.5 Reference standards shall meet the requirements of Figure 1 unless otherwise specified by purchaser, engineering drawing, or cognizant quality assurance activity.





TYPICAL ALL HOLES

NOTES

All dimensions in inches (millimeters in parentheses)
Tolerances: X.XXX + 0.003/-0.002 (+0.08/-0.05)
Notch Width: 0.007 (0.18), maximum
Material Thickness: 0.250 (6.35), maximum

/1/ EDM Corner Notch - 0.030 (0.76) long x 0.030 (0.76) deep
/2/ EDM Faying Surface Notch - 0.030 (0.76) long x 0.030 (0.76) deep
/3/ EDM In-Hole Notch - 0.060 (1.52) long x 0.030 (0.76) deep

FIGURE 1 - Typical Reference Standard

3.1.7 Recording Devices: When used, recording devices shall be compatible with the instrument and be capable of presenting a permanent copy of the instrument signal response display.

3.2 Personnel Qualification:

3.2.1 Personnel performing open fastener hole eddy current inspections shall be qualified in accordance with ATA No. 105; SNT-TC-1A, Supplement "E" and appendices; or MIL-STD-410.

3.3 Written Procedure Requirements:

Eddy current open hole inspections shall be done in accordance with this procedure or a detailed written procedure specific to the component being inspected.

3.3.1 Procedures shall comply with the general requirements of this document and shall provide all of the specific information required to set up and calibrate the equipment and perform the tests.

3.3.2 Each procedure shall be verified and approved by a Level III personnel.

3.3.3 Each procedure shall include not less than the following information:

3.3.3.1 A specific description of the hole configuration to be inspected, the alloy type, and the potential crack location and orientation, if known.

3.3.3.2 The required eddy current instrument, probes, fixturing equipment, reference standards, and test frequency.

3.3.3.3 The manufacturer and identification number of the required equipment.

3.3.4 A copy of each applicable procedure shall be readily available to purchaser, upon request, for reference, and use.

3.4 Preparation for Inspection:

3.4.1 Identify the location, number, and size of the holes to be inspected.

3.4.2 Clean loose dirt, paint, or sealant from the inside of the hole, and when a probe collar is used, from around the outer edge of the hole.

3.4.3 Visually inspect all applicable holes for conditions that could interfere with the inspection such as burrs, galling, corrosion, out-of-round conditions, cracks, or offset at component interfaces.

3.4.3.1 Holes having the above conditions may require a cleanup ream, or other disposition. Contact engineering for corrective action.

3.4.3.2 Borescopes, endoscopes, or other optical aids may be used to enhance the visual inspection.

3.4.3.3 A record or map may be made indicating which holes require or have received rework.

3.4.4 Select the probe(s) to fit the holes to be inspected per 3.1.3.1.

3.4.4.1 To protect the probe from wear, nonconductive tape may be applied over the probe coil. The tape may require replacement occasionally during the inspection.

3.4.4.1.1 The nonconductive tape over the probe coil shall be no thicker than 0.005 in (0.13 mm).

3.4.4.1.2 The probe diameter with tape applied shall meet the requirements of 3.1.3.1.

3.4.5 Select the reference standard(s) to match the holes to be inspected per 3.1.6.

3.4.6 Except for battery-powered instruments, electrically ground the instrument during operation.

3.4.7 Locate inspection equipment not less than 10 ft (3 m) from any items that generate a large magnetic field, such as large motors, generators, transformers, or power lines.

3.5 Instrument Calibration:

3.5.1 Set the instrument frequency. Typical operating frequencies are between 100 and 500 KHz. However, other frequencies may be used if the requirements of 3.5 are met.

3.5.2 Attach the probe as selected per 3.4.4.

3.5.3 Insert the probe into the reference standard hole away from any reference notches and from outer and faying surfaces.

3.5.4 Balance the instrument in accordance with the manufacturer's instructions, or specific operating procedures.

3.5.5 Set the position of the balance point as follows:

3.5.5.1 Meter Display Instruments:

3.5.5.1.1 When using a single coil probe, use the meter position control to set the meter response to 20% of full-scale response. See Figure 2A.

NOTE: When using an instrument which gives a down scale crack response, the meter should be set to 80% of full-scale.

3.5.5.1.2 When using a dual coil probe, use the meter position control to set the meter response to 50% of full-scale response. See Figure 2B.

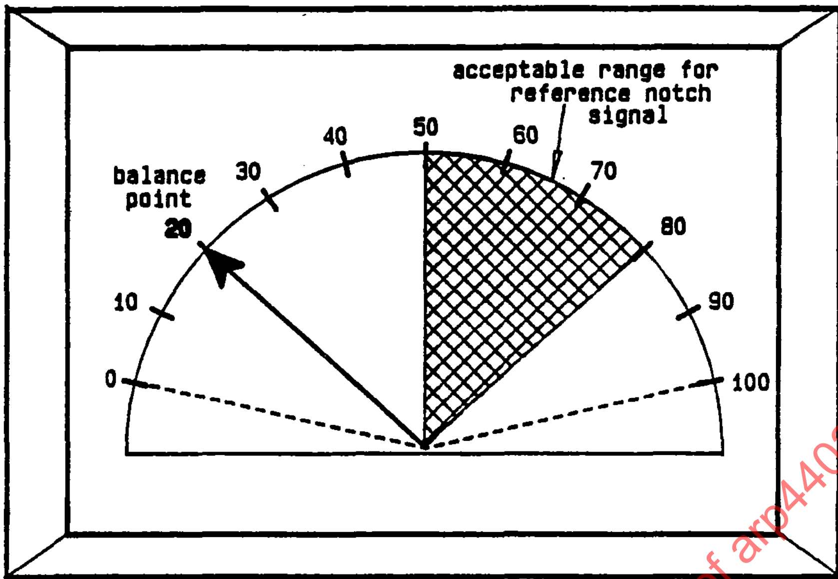


FIGURE 2A - Acceptable Range for Reference Notch Signal Using Single Coil Probe

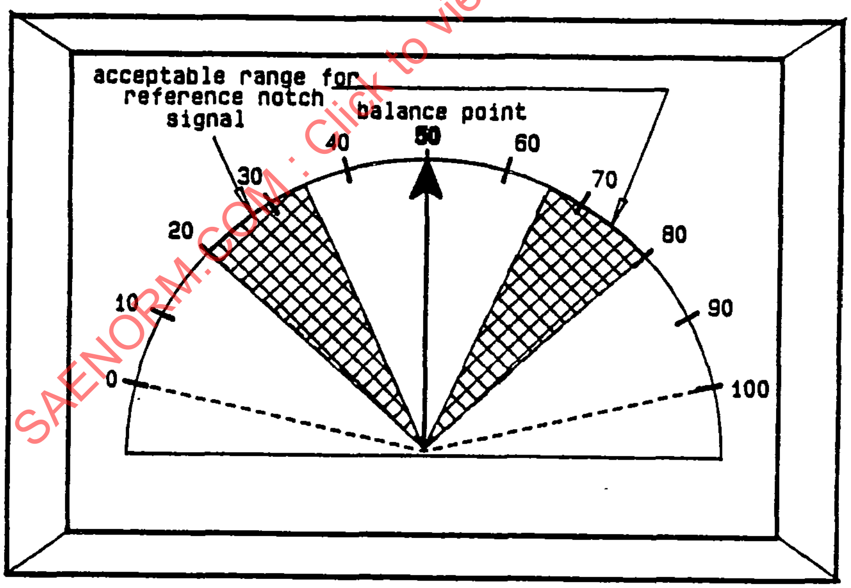


FIGURE 2B - Acceptable Range for Reference Notch Signal Using Dual Coil Probe

FIGURE 2 - Meter Display Instrument Calibration

3.5.5.2 Impedance Display Instruments:

3.5.5.2.1 When using a single coil probe, use the vertical and horizontal position controls to set the balance signal to the center of the lower right hand quadrant of the screen. See Figure 3A.

3.5.5.2.2 When using a dual coil probe, use the vertical and horizontal position controls to set the balance signal to the center of the screen. See Figure 3B.

3.5.5.3 Time Base Display Instruments:

3.5.5.3.1 Use the vertical position control to set the balance signal to the bottom of the screen or to the middle of the screen, depending on the display mode being used.

3.5.6 Adjust the lift-off (phase) as follows:

3.5.6.1 Meter Display Instruments:

3.5.6.1.1 Adjust the phase control to obtain the same response when the probe is on the bare standard as when the probe is lifted slightly off of the standard as follows:

3.5.6.1.1.1 With the probe in the hole, press the probe coil away from the hole surface by 0.004 to 0.006 in (0.10 to 0.15 mm).

3.5.6.1.1.2 Place a piece of paper or nonconductive tape 0.004 to 0.006 in (0.10 to 0.15 mm) thick on a section of the inside surface of the hole, and with the probe in the hole, rotate the probe coil on and off the paper or tape.

3.5.6.2 Impedance Display Instruments:

3.5.6.2.1 Adjust the phase control to obtain a horizontal deflection from the balance point to the left across the screen when probe sensing coil is lifted slightly off the standard when using a single coil probe, and to the left and right across the screen when using dual coil probes. See Figures 3A and 3B.

3.5.6.3 Time Base Display Instruments:

3.5.6.3.1 For instruments that have a Lissajous display mode, turn instrument to the Lissajous display mode and adjust the phase control to obtain a horizontal deflection as the probe rotates on the surface of the reference standard. See Figure 4A. Change to the time base setting.

3.5.6.3.2 For instruments that do not have a Lissajous display mode, adjust the instrument in accordance with the manufacturer's instructions to obtain a baseline response as flat as possible as the probe rotates in the reference standard hole away from any notches. See Figure 4B.

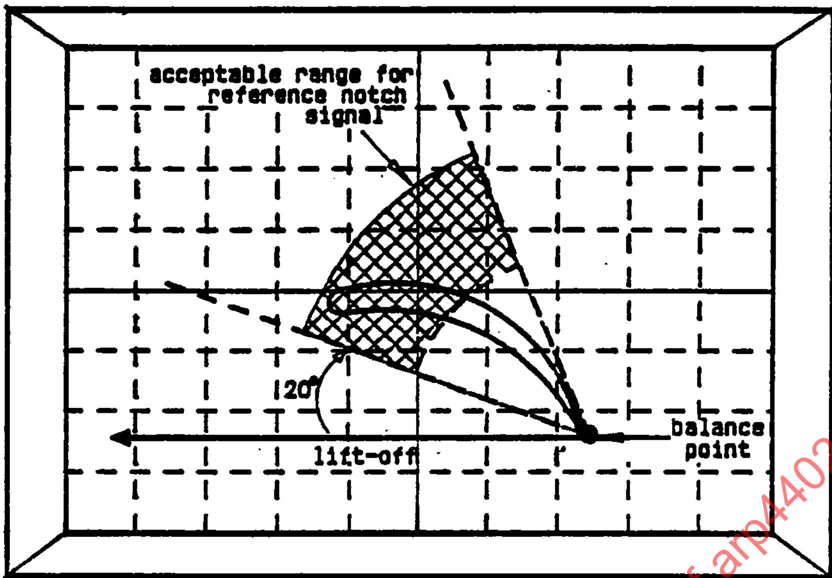


FIGURE 3A - Acceptable Range for Reference Notch Signal and Typical Response From Reference Notch Using Single Coil Probe

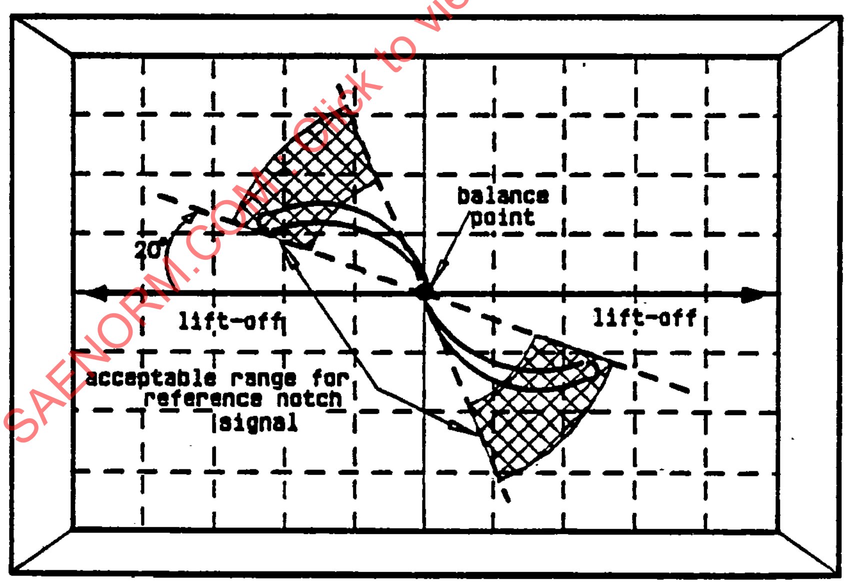


FIGURE 3B - Acceptable Range for Reference Notch Signal and Typical Response From Reference Notch Using Dual Coil Probe

FIGURE 3 - Impedance Display Instrument Calibration

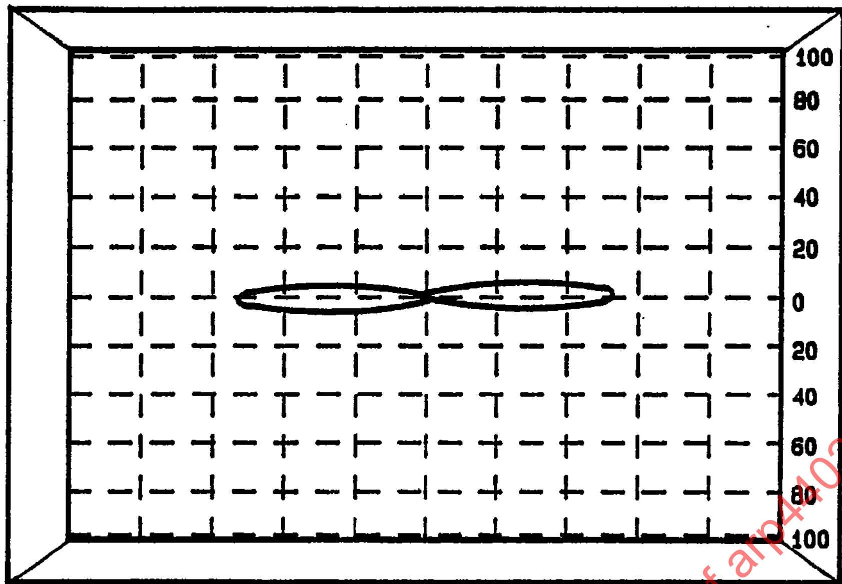


FIGURE 4A - Lift-Off Adjustment in Lissajous Mode

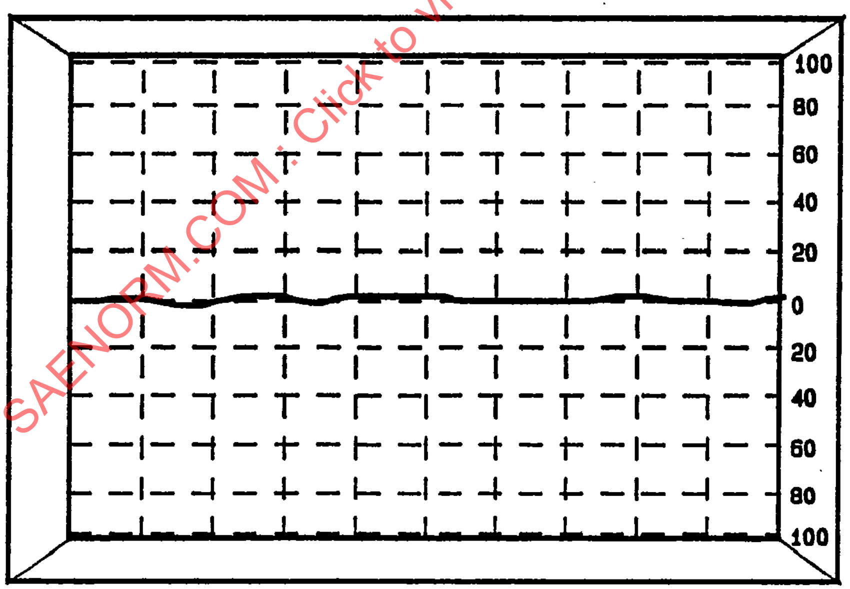


FIGURE 4B - Lift-Off Adjustment in Time Base Mode

FIGURE 4 - Time Base Display Instrument Calibration

3.5.7 Adjust the sensitivity as follows:

3.5.7.1 Meter Display Instruments:

3.5.7.1.1 Adjust the probe coil depth in the reference standard hole to the same depth as the reference notch.

3.5.7.1.2 Rotate the probe in the hole until the coil scans over the reference notch.

3.5.7.1.2.1 The meter response should be upscale if using a single coil probe.

3.5.7.1.2.2 The meter response should be upscale and down scale if using a dual coil probe.

3.5.7.1.3 Obtain the maximum deflection from the reference notch by adjusting the probe depth in the hole.

3.5.7.1.4 Adjust the sensitivity to obtain a 30 to 60% full-scale deflection from the reference notch. See Figures 2A and 2B.

3.5.7.1.5 The signal-to-noise ratio shall be at least 3:1.

3.5.7.2 Impedance Plane Instruments:

3.5.7.2.1 Adjust the probe coil depth in the reference standard hole to the same depth as the reference notch.

3.5.7.2.2 Rotate the probe in the hole until the coil scans over the reference notch. The angle between the lift-off line and the reference notch signal should be maximized, but shall be at least 20°. See Figures 3A and 3B.

3.5.7.2.3 Obtain the maximum deflection from the reference notch by adjusting the probe depth in the hole.

3.5.7.2.4 Adjust the sensitivity to obtain a 30 to 60% full-scale scope deflection from the reference notch. See Figures 3A and 3B.

3.5.7.2.5 The signal-to-noise ratio shall be at least 3:1.

3.5.7.3 Time Base Display Instruments:

3.5.7.3.1 Scan the rotating probe through the reference standard hole.

3.5.7.3.2 Obtain the maximum deflection from the reference notch by adjusting the probe depth in the hole.

3.5.7.3.3 Adjust the sensitivity to obtain a 30 to 60% full-scale scope deflection from the reference notch. See Figures 4C and 4D.

3.5.7.3.4 The signal-to-noise ratio shall be at least 3:1.

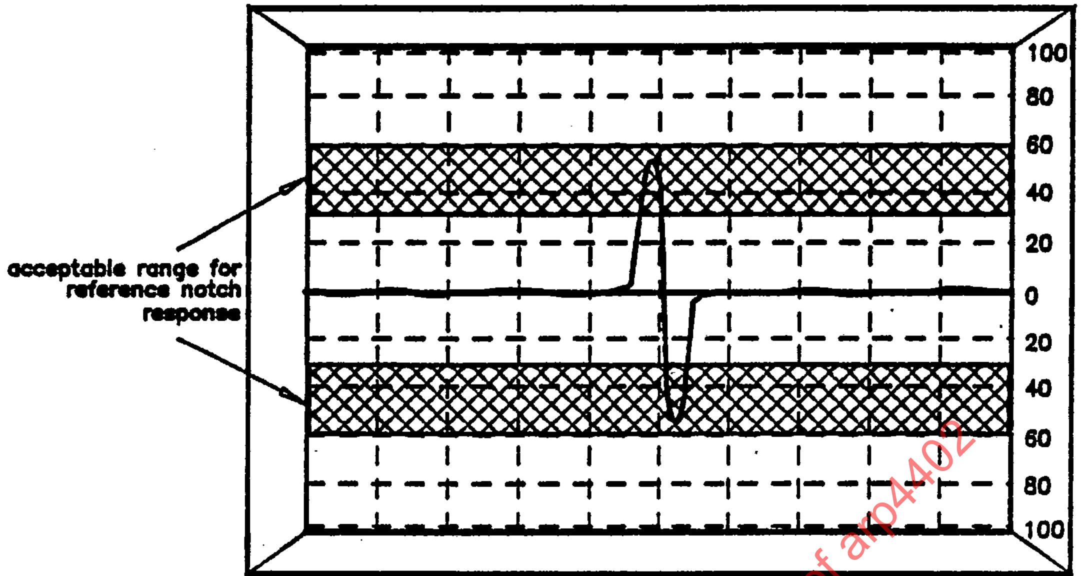


FIGURE 4C - Acceptable Range for Reference Notch Signal and Typical Response From Reference Notch

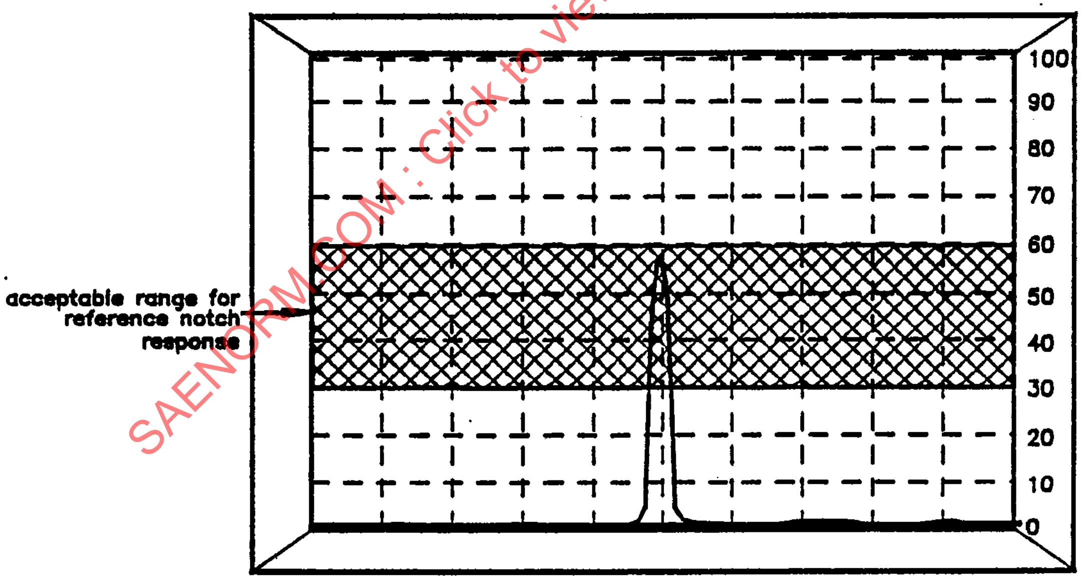


FIGURE 4D - Acceptable Range for Reference Notch Signal and Typical Response From Reference Notch

FIGURE 4 (Continued)