



AEROSPACE RECOMMENDED PRACTICE

ARP4402™**REV. A**

Issued 1992-04
Revised 2020-09
Reaffirmed 2024-09

Superseding ARP4402

(R) Eddy Current Inspection of Open Fastener Holes in Aluminum Aircraft Structure

RATIONALE

ARP4402A results from a Five-Year Review and update of this specification.

ARP4402A 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 document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 AIA Publications

Available from Aerospace Industries Association, 1000 Wilson Boulevard, Suite 1700, Arlington, VA 22209-3928, Tel: 703-358-1000, www.aia-aerospace.org.

NAS-410 Nondestructive Testing Personnel Qualification and Certification

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

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SAE WEB ADDRESS:

Full document details: SAE ARP4402A

For more information on this standard, visit
<https://www.sae.org/standards/content/ARP4402A/>

Documents

Standard, visit Sharing Hub

2.3 Airlines for America (A4A) Publications

Available from Airlines for America (A4A), 1301 Pennsylvania Avenue, NW, Suite 1100, Washington, DC 20004, Tel: 202-626-4000, www.airlines.org.

Spec 105 Guidelines for Training and Qualifying Personnel in Nondestructive Testing

3. TECHNICAL REQUIREMENTS

3.1 Equipment

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

3.1.1 Eddy Current Instruments

3.1.1.1 Instruments shall be capable of displaying both of the following signal response displays simultaneously:

3.1.1.1.1 Impedance (Y/X)

3.1.1.1.1.1 Eddy current instruments display eddy current information using a two-dimensional impedance plane display. The impedance plane refers to an orthogonal display of both the inductive reactance and resistance components of the complex impedance of the eddy current probe (Figures 1 through 3).

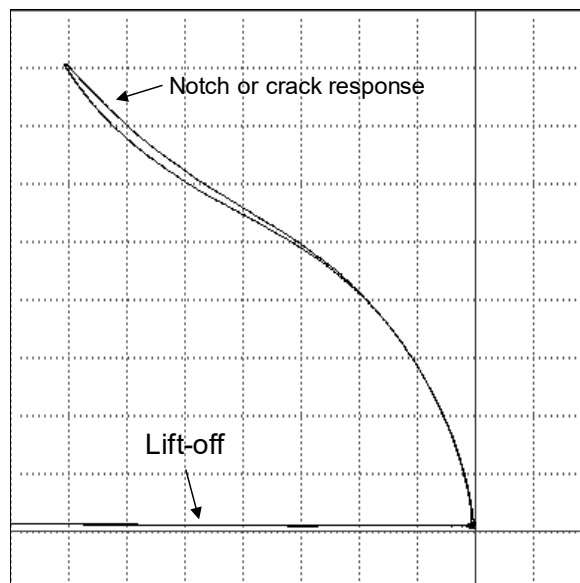


Figure 1 - Eddy current impedance plane – non-filtered absolute display

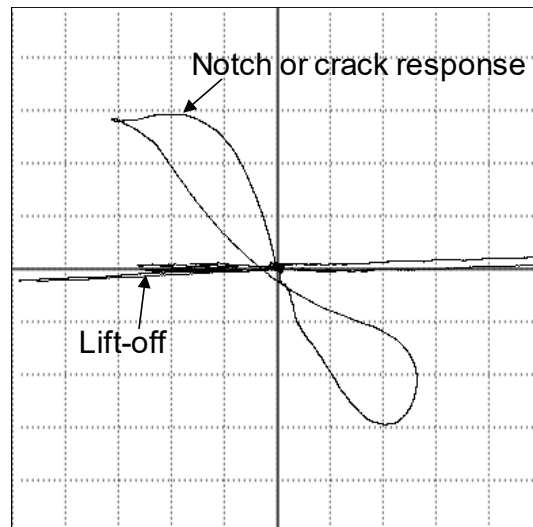


Figure 2 - Eddy current impedance plane – filtered absolute display

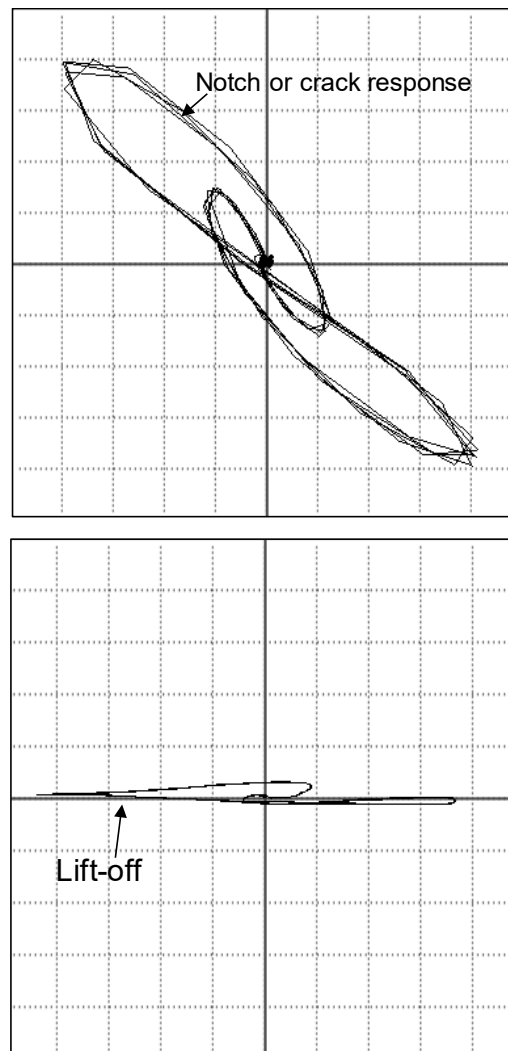


Figure 3 - Eddy current impedance plane – filtered differential display

3.1.1.1.2 Sweep (Y/T)

- 3.1.1.1.2.1 Sweep displays show the vertical component of the eddy current impedance plane signal as a function of time. The horizontal axis displays the clock position of a single rotation of the probe in the hole. The clock position is the location of an indication around the circumference of the hole and can be configured to any location across the horizontal axis during standardization. Figure 4 shows an example where a crack or notch has been configured to be displayed at approximately 6 o'clock (180 degrees) and the corresponding signal produced in the sweep display, but other configurations are possible and acceptable.

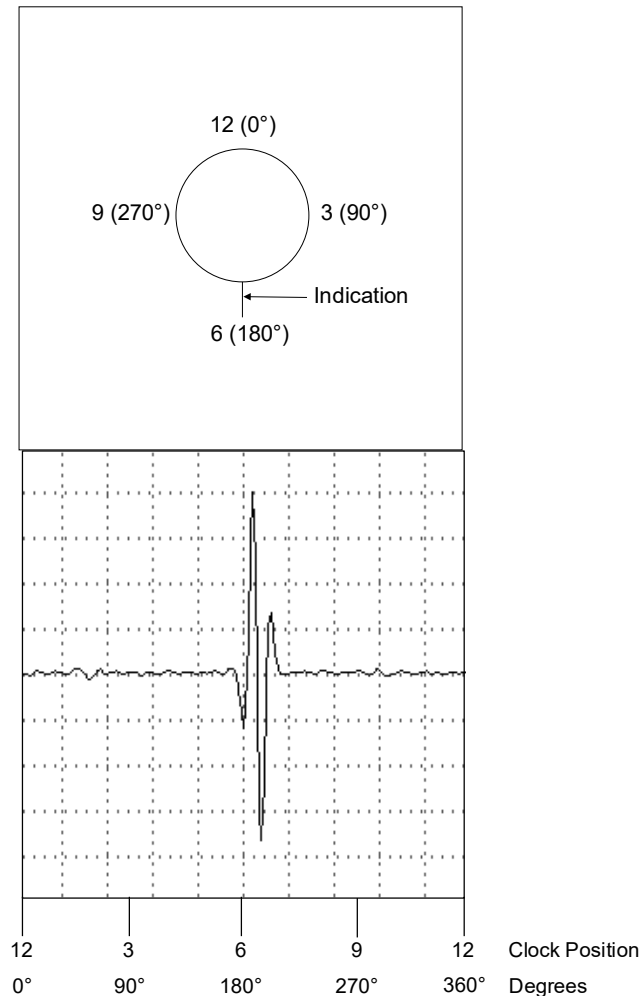


Figure 4 - Sweep display signal of hole with an indication at 6 o'clock (180 degrees)

- 3.1.1.2 The impedance and sweep displays can be used simultaneously (Figure 5). This display style is recommended because it is helpful when there are multiple indications at different positions around a hole. An inspector can use the sweep display to identify the clock position of each indication and the corresponding signal on the impedance plane to determine if the signal is in phase with a crack signal or whether the signal is produced from another anomaly (lift-off, hole damage, etc.). Figure 5 shows an example of a signal produced by two indications. Indication A is located at 9 o'clock (270 degrees) and has a large signal response. Indication B is located at 3 o'clock (90 degrees) and has a smaller signal response.

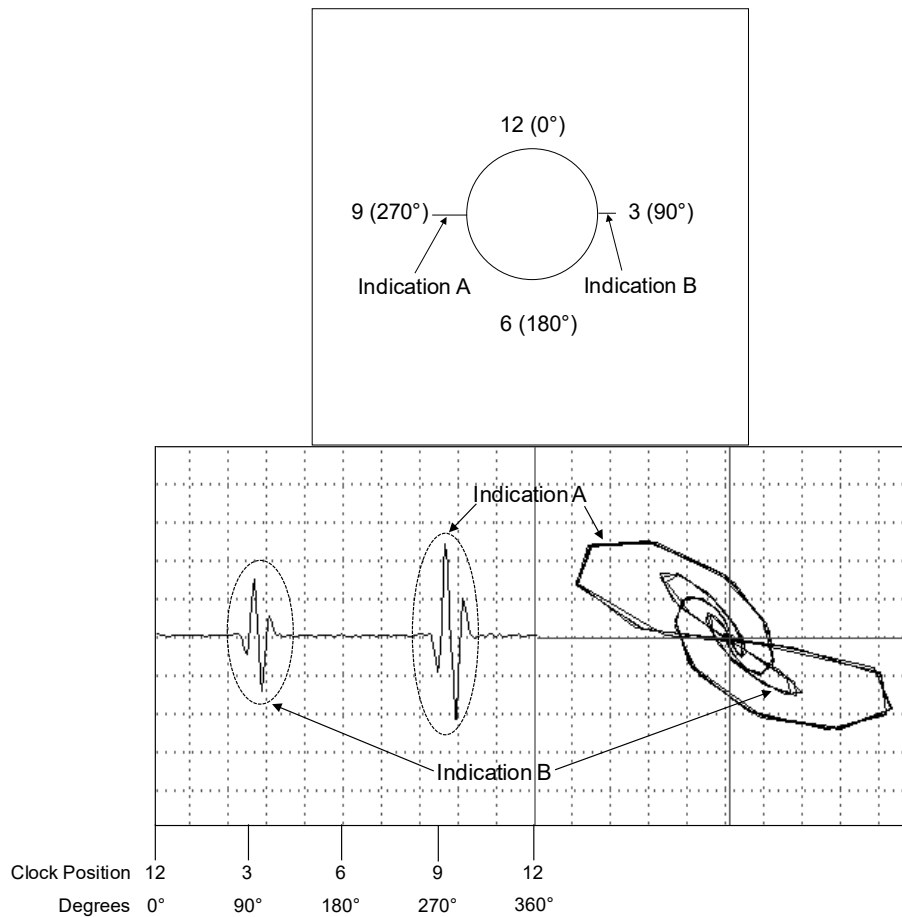


Figure 5 - Simultaneous use of impedance plane and sweep displays

- 3.1.1.3 Instruments typically shall be capable of operating between 100 KHz and 500 KHz. Instruments may be operated at other frequencies if the requirements of 3.5 are met.
- 3.1.1.4 Instruments shall be equipped with an audible and/or visual alarm system.
- 3.1.1.5 Filters
 - 3.1.1.5.1 Electronic filters are often useful for reducing noise or spurious geometric signals and improving the signal to noise ratio of an inspection. Some inspections may be dependent upon the use of appropriate filters for their success. Such requirements shall be specified in the appropriate inspection procedure. Three general types of filters are described as follows:
 - 3.1.1.5.1.1 High Pass Filters (HPF) – Eliminates or reduces the amplitude of signals which have a frequency below the frequency setting of the filter.
 - 3.1.1.5.1.2 Low Pass Filters (LPF) – Eliminates or reduces the amplitude of signals which have a frequency above the frequency setting of the filter.
 - 3.1.1.5.1.3 Band Pass Filters – A combination of a high pass and a low pass filter which acts to eliminate or reduce the amplitude of signals which have a frequency above or below the frequency settings of the filter.

3.1.1.5.2 Filter Setting and Flaw Frequency Calculations

The optimal signal response is dependent on the filter settings. Filter frequencies are related to the speed at which the coil passes over the flaw and the duration the coil is sensing the flaw and registering a response. This flaw frequency is measured in Hz and is different than test/oscillator frequency, which is typically measured in kHz or MHz. The flaw frequency can be calculated if the effective coil diameter (D_{eff}) and coil surface scan speed are known by using the following equation:

$$Flaw\ Frequency = \frac{Surface\ Scan\ Speed}{D_{eff}}$$

The coil surface scan speed can be approximated using the following equation:

$$Surface\ Scan\ Speed = \pi(Scanner\ RPM) \left(\frac{2\pi}{60\ seconds} \right) (Probe\ Diameter)$$

Scanner RPM can be controlled with the use of a rotary scanner.

For a shielded coil, the effective coil diameter (D_{eff}) can be estimated as the coil diameter. For unshielded coils, D_{eff} can be estimated using the following equation:

$$D_{eff} = \frac{26}{\sqrt{\sigma\mu_r f}}$$

where:

σ = conductivity in %IACS of the material being tested

μ_r = relative permeability (1 for nonmagnetic materials)

f = test/oscillator frequency in Hertz

3.1.1.5.3 Flaw Frequency Example

Figure 6 provides calculated flaw frequencies for a typical 0.0625 inch diameter shielded coil at various scanner RPM and probe diameters.

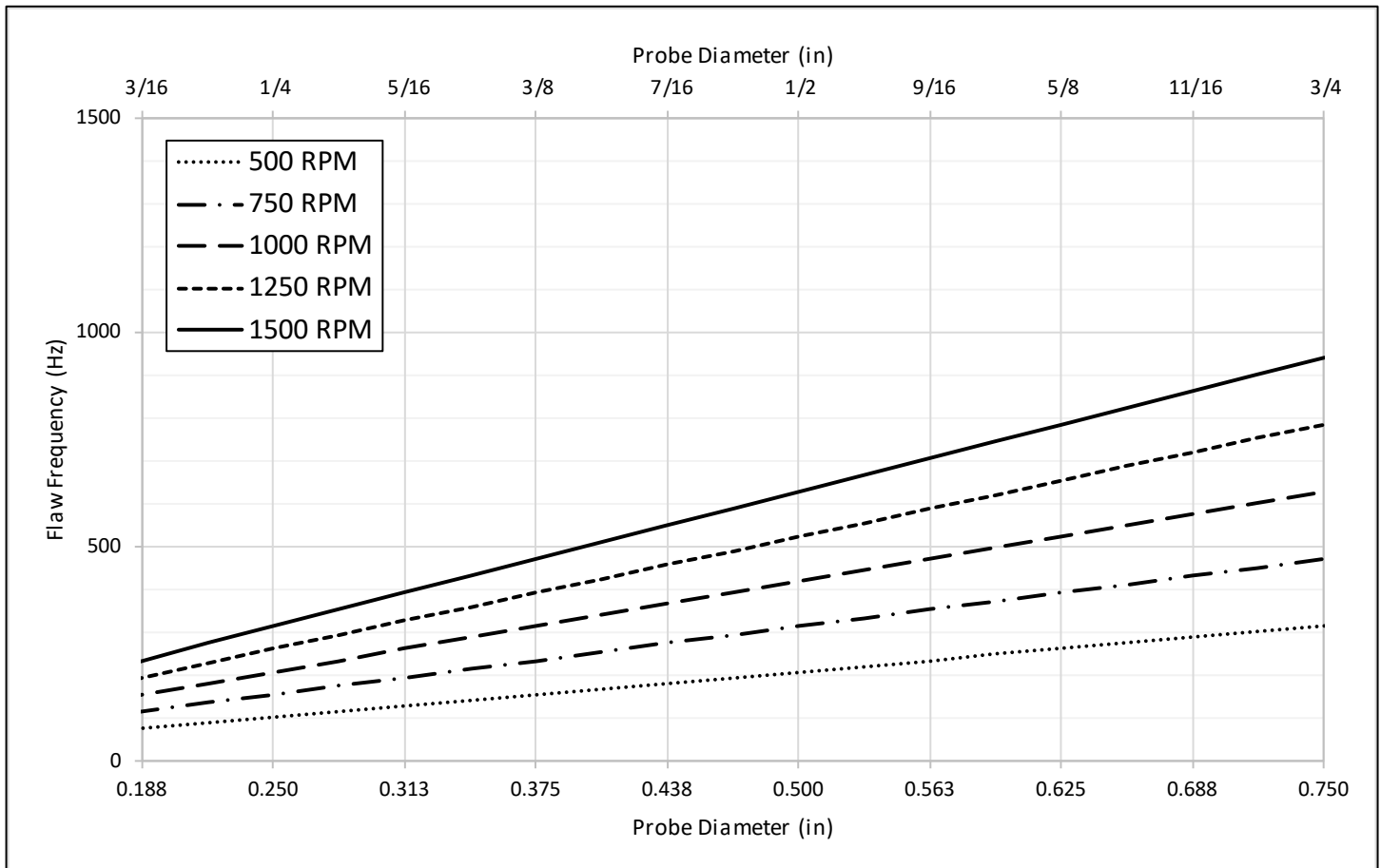


Figure 6 - Flaw frequencies for various scanner rpm for a range of probe diameters

3.1.1.5.4 Filter Setting Example

Table 1 provides calculated surface speeds and flaw frequencies for a typical 0.0625 inch diameter shielded coil at 1500 rpm and various probe diameters.