BOMBARDIER
Toronto (de Havilland)
PROPRIETARY INFORMATION

PPS 20.09

PRODUCTION PROCESS STANDARD

Eddy Current Inspection

Issue 7
- This standard supersedes PPS 20.09, Issue 5.
- Vertical lines in the left hand margin indicate technical changes over the previous issue.
- Direct PPS 20.09 related questions to michael.wright@aero.bombardier.com.
- This PPS is effective as of the distribution date.

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1 Scope

1.1 This Production Process Standard (PPS) establishes the minimum requirements for eddy current inspection for the detection and evaluation of discontinuities in conductive, ferrous and non-ferrous components and assemblies. Specific procedures and applicable written instructions shall be developed for each component or family of components to supplement this specification. This specification shall be used when mentioned in the relevant process specification, material specification, engineering drawing or specific engineering documents. The types of discontinuities to be detected may include surface cracking, subsurface cracking, corrosion, inclusions, thickness measurement, and changes in conductivity. Other eddy current techniques not defined in this specification must be approved by Bombardier Toronto (de Havilland) Materials and Processes Engineering (MPE) eddy current (ET) Level 3 before use.

1.1.1 This PPS complements the engineering drawings that specify its use as an authorized instruction. The procedure specified in this PPS must be followed to ensure compliance with all applicable specifications. In general, if this PPS conflicts with the engineering drawing, follow the engineering drawing. The requirements specified in this PPS are necessary to fulfil the engineering design and reliability objectives.

1.1.2 Refer to PPS 13.26 for the subcontractor provisions applicable to this PPS.

1.1.3 Procedure or requirements specified in a Bombardier BAPS, MPS, LES or P. Spec. **do not** supersede the procedure or requirements specified in this PPS.

2 Hazardous Materials

2.1 Before receipt at Bombardier Toronto (de Havilland), all materials must be approved and assigned Material Safety Data Sheet (MSDS) numbers by the Bombardier Toronto (de Havilland) Environment, Health and Safety Department. Refer to the manufacturer's MSDS for specific safety data on any of the materials specified in this PPS. If the MSDS is not available, contact the Bombardier Toronto (de Havilland) Environment, Health and Safety Department.

3 References

3.1 General

3.1.1 Unless a specific issue is indicated, the issue of the reference documents specified in this section in effect at the time of manufacture shall form a part of this specification to the extent indicated herein.

3.2 Bombardier Toronto (de Havilland) Process Specifications

3.2.1 PPS 13.26 - General Subcontractor Provisions.

3.2.2 PPS 13.39 - Bombardier Toronto Engineering Process Manual.

3.2.3 PPS 15.01 - Part Marking.

3.2.4 PPS 15.04 - Use of Markers for Marking Aircraft Parts and Assemblies.

3.2.5 PPS 20.07 - Electrical Conductivity Testing of Aluminum Alloys.

3.3 Bombardier Aerospace Engineering Requirements Documents

3.3.1 BAERD GEN-012 - Non-Destructive Testing - Certification of Personnel.

3.4 Bombardier Aerospace Test Specifications

3.4.1 BATS 4002 - Coating Thickness Determination by Non-Destructive Procedure.

4 Materials, Equipment & Facilities

4.1 Materials

4.1.1 No materials are specified herein.

4.2 Equipment

4.2.1 Eddy Current Instruments

4.2.1.1 Eddy current inspection instruments shall be certified for accuracy by MEC (Measurement Equipment Control) at intervals determined by MLOM (Metrology Laboratories Operation Manual) or equivalent national industry standards to the original equipment manufacturers calibration requirement on a minimum of an annual basis or after repair.

4.2.1.2 Eddy current instruments are characterized into many categories. The main instrument categories for the inspection of aerospace components are flaw detection, coating thickness measurement, conductivity measurement and Magneto Optic Imaging (MOI).

4.2.1.3 Flaw detection instruments shall be impedance plane type, with a frequency range between 100Hz and 6MHz. The instrument shall have the capability of displaying the signals in the following modes to characterize signal responses:

- Surface, subsurface and thickness inspections: X:Y display (see Figure 1).
- Bolthole inspections: Time Base (Y Theta) and/or X:Y display (see Figure 1).

4.2.1.4 Flaw detection instruments shall have the capability of deploying alarm gates with a visible and/or audible alarm to monitor a preset acceptance/rejection level.

4.2.1.5 The instrument shall have adjustable high and low pass filters to aid in signal to noise ratio improvement.

4.2.1.6 Rotating scanners may be used for conducting bolthole inspections. They may be either of constant or variable revolving speed with a minimum speed of 500 RPM.

4.2.1.7 Conductivity measurement instruments may be fixed or variable frequency and shall display the conductivity measurement numerically. Direct and indirect reading instruments shall be capable of determining the conductivity of aluminum alloys as a percentage of the International Annealed Copper Standard (%IACS) with an accuracy of ± 1.0% IACS or better through electrically non-conductive films and coatings at least 0.003" thick, and have sensitivity such that changes of at least 0.5% IACS are clearly distinguishable over the conductivity range of the aluminum alloys under test. Refer to PPS 20.07 for further details.

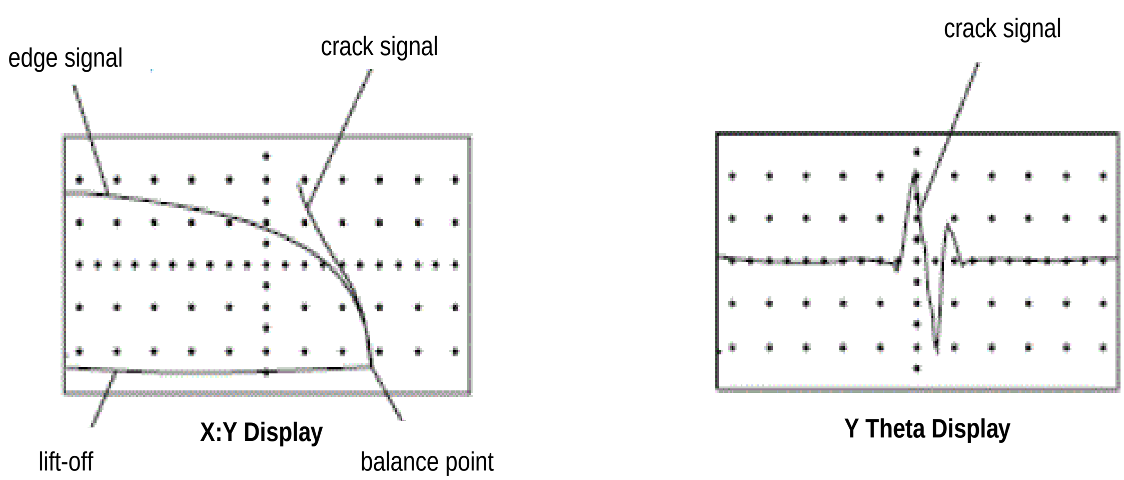


Figure 1 - Example of Screen Displays

4.2.2 Eddy Current Probes

4.2.2.1 General

4.2.2.1.1 Eddy current probes can be of a multitude of differing configurations depending on the application required to perform. Some determining factors are:

- mode of operation (ref. section 4.2.2.2)
- probe configuration (ref. section 4.2.2.3)
- probe design (ref. section 4.2.2.4)
- probe frequency

4.2.2.2 Mode of Operation (Eddy Current Probes)

4.2.2.2.1 Probe coils can be broken down onto 3 modes of operation (see Figure 2).

- **Absolute** eddy current coils consist of a single coil that senses changes in the magnetic field. Since any changes in the inspection area produce a response, absolute coils can be used to measure specific material properties such as conductivity and permeability.
- **Differential probes** have two active coils usually wound in opposition, although they could be wound in addition with similar results. When the two coils are over a flaw-free area of test sample, there is no differential signal developed between the coils since they are both inspecting identical material. However, when one coil is over a defect and the other is over good material, a differential signal is produced.
- **Reflection probes** have two coils similar to a differential probe, but one coil is used to excite the eddy currents and the other is used to sense changes in the test material. The advantage of reflection probes is that the driver and pickup coils can be separately optimized for their intended purpose.

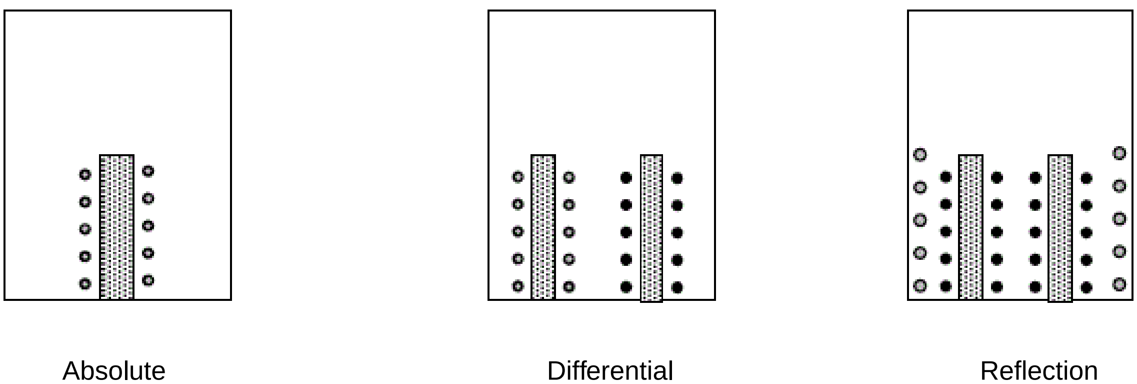


Figure 2 - Examples of Probe Operating Modes

4.2.2.3 Probe Configuration

4.2.2.3.1 Probe configuration can be broken down into 3 categories:

- **Surface probes** are handheld and designed for the coil to be in contact with the inspection surface. Surface probes generally consist of a coil of very fine wire encased in a protective housing. The size of the coil and shape of the housing are determined by the intended use of the probe. Most of the coils are wound so that the axis of the coil is perpendicular to the test surface. Surface probes can range from low frequencies for subsurface inspections to high frequencies for surface inspections. Examples of surface probes include pencil probes, spot probes, sliding probes and Bolthole probes (see Figure 3).
  Bolthole probes may be of a fixed or variable diameter. For fixed diameter probes

the maximum difference between the diameter of the inspection hole and the probe diameter shall not exceed 0.005". The diameter of the variable diameter probe shall be adjusted to provide slight interference between the inspection surface and the probe. Excessive tension can cause premature damage to the probe or damage to the inspection surface.
Surface probes shall have a non conductive wear tape (e.g., Teflon) applied to protect the coil from wear and reduce damage to the inspection surface. The maximum thickness shall be 0.005". The instrument shall be recalibrated when tape is applied or removed from the probe.

- **Bobbin probes** are inserted into hollow products to inspect from the inside surface. The coils are commonly wound around the circumference of the probe so that the probe inspects an area around the entire circumference of the test object at one time (e.g., Tubes). Also known as ID (inside diameter) probes.
- **Encircling probes** are similar to bobbin probes except that the coils encircle the material to inspect from the outside surface. Encircling probes are commonly used to inspect solid products, such as bars. Also known as are often called OD (outside diameter) coils.

4.2.2.4 Probe Design and Selection

4.2.2.4.1 General

4.2.2.4.1.1 The probe design will depend on the area to be inspected. Listed below are factors which affect the coil performance and determine the type of probe to be used (see Figure 3).

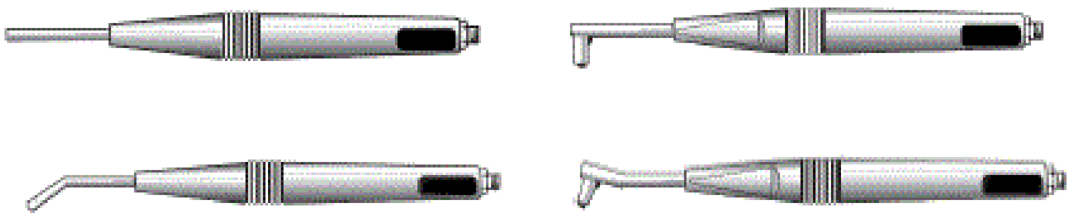
- Material conductivity.
- Material permeability.
- Minimum defect required to detect.
- Depth of defect to be detected.
- Test component geometry and accessibility of the inspection area.

4.2.2.4.1.2 Select a probe frequency within the range required. When the probe frequency is variable, a frequency which is mid range of the probes parameters is preferred for signal stability. The optimal frequency is determined by the best response from the representative flaws on the CRS.

4.2.2.4.1.3 The probe shall be clearly identified with the type and operating frequency. This data may be traceable via the part number.

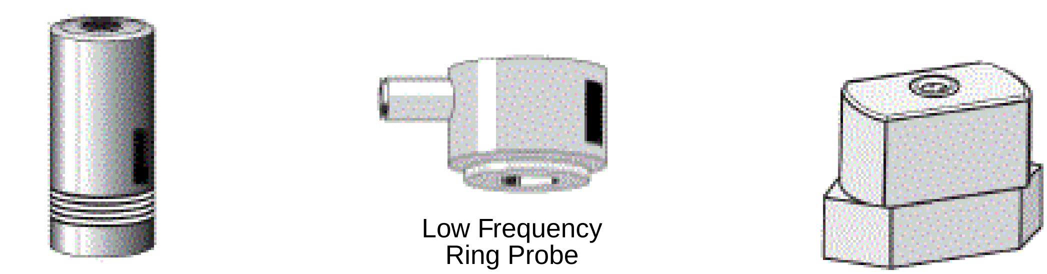
4.2.2.4.1.4 For most Eddy Current surface inspections, the coil diameter should be smaller than the minimum defect length to be detected.

4.2.2.4.1.5 When selecting the probe shape, the inspection area must be taken into account. The probe must not impede on the inspection area when the coil is perpendicular to the inspection surface (e.g., using a right angled probe when the height is restricted). When access is an issue, multiple probes may be used for the inspection provided that each probe is calibrated before use.



High Frequency Probes - Various Configurations

High Frequency Bolthole Probes - Manual and Rotating, Fixed and Adjustable Diameter



Low Frequency Spot Probe

Low Frequency Ring Probe

Low Frequency Sliding Probe

Figure 3 - Examples of Surface Probe Configurations

4.2.2.4.2 Inductive Reactance and Impedance

4.2.2.4.2.1 When the inspection is carried out using an impedance plane instrument, defects will alter the intensity and shape of the eddy current field and flow. These changes are expressed as a change to the coils impedance and determine the screen signal.

4.2.2.4.2.1.1 The inductance of a coil depends on the number of turns, the magnetic flux and the current flowing through the coil.

$$L = (n \times \Phi)/I$$

L = Inductance (Henries)
n = number of turns in the coil
Φ = Magnetic Flux (Webers)
I = Current through the coil (Amperes)

4.2.2.4.2.1.2 The measure of the reduction of the current flow in a circuit due to induction is Inductive Reactance (X_L).

$$X_L = 2 \times \pi \times f \times L$$

X_L = Inductive Reactance (Ohms)
π = 3.14159
f = Frequency (Hertz)
L = Inductance (Henries)

4.2.2.4.2.1.3 The total opposition to the rate of current charge (inductive reactance (X_L) and resistance (R)) is Impedance (Z). Impedance is the signal displayed on the instrument screen.

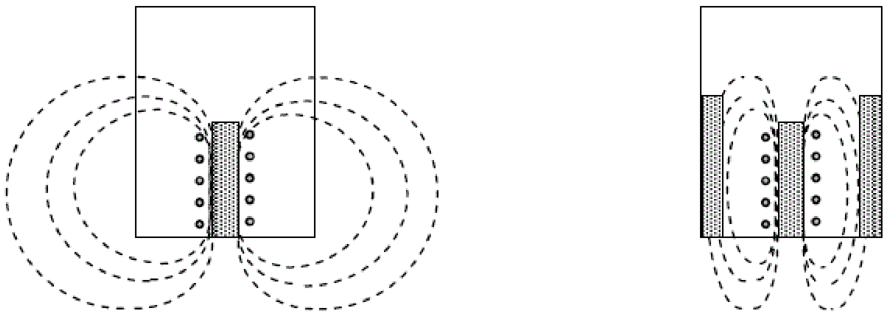
$$Z = \sqrt{R^2 + X_L^2}$$

Z = Impedance (Ohms)
X_L = Inductive Reactance (Ohms)
R = Resistance (Ohms)

4.2.2.5 Shielding

4.2.2.5.1 Shielding is used to minimize the effects when testing near geometric changes such as edges and holes by using skin effect, preventing the magnetic field reaching its normal dimension. Shielding also minimizes the effects of conductive or magnetic fasteners in the inspection area (see Figure 4).

4.2.2.5.2 Shielding is carried out by magnetic shielding or eddy current shielding. Magnetic shielded probes surround the coil with a material of high permeability and low conductivity. Probes using eddy current shielding surround the coil with a material of high conductivity and low permeability.



Non-Shielded Magnetic Field Shielded Magnetic Field

Figure 4 - Magnetic Field Shielding Effects

4.2.3 Calibration Reference Standards (CRS)

4.2.3.1 General

4.2.3.1.1 In eddy current testing, signal interpretation is made when comparing the results of a known object with similar features and defects (CRS) to the signals obtained from an unknown object (inspection area). A Calibration Reference Standard (CRS) is used to ensure detects in the inspection material are detected with a predetermined level of sensitivity based on the crack length and depth, and its location in relation to the inspection surface.

4.2.3.1.2 The CRS should be of the same material as the inspection article. When it is not possible to replicate the exact material, then a material with electrical conductivity (IACS) and permeability values within the range of the inspection article is acceptable.

4.2.3.1.3 All CRS shall be certified for dimensional tolerance and material properties when manufactured. The CRS shall be inspected for general condition (wear, corrosion, dents) prior to instrument calibration. Should the CRS display any characteristic which may impede on its performance, the CRS shall be deemed unserviceable and sent to Metrology or equipment manufacturer for repair and recalibration before it is deemed serviceable, or disposal if rehabilitation is not possible.

4.2.3.1.4 The CRS shall be stored in a clean and dry environment, and in a manner to prevent any accidental damage during storage.

4.2.3.1.5 The CRS shall be permanently identified (part number and/or serial number) per PPS 15.01 on the CRS surface where no interference of the inspection method and technique can occur.

4.2.3.1.6 The manufacturing drawing shall be available for each CRS. It shall specify the material constituents, the geometries and the dimensions and shall clearly characterize, identify, position (top view and through thickness), size/type of the artificial defects and manufacturing process. All CRS drawings must be approved by Bombardier Toronto (de Havilland) MPE ET Level 3 before use.

4.2.3.1.7 Ferrous CRS shall be checked for magnetization prior to calibration and after inspection using a field strength indicator and demagnetized if residual magnetization is present. If magnetism was evident after the inspection, the inspection shall be repeated.

4.2.3.2 Conductivity Testing

4.2.3.2.1 When performing conductivity testing, the CRS shall conform to the requirements of PPS 20.07.

4.2.3.3 Non Conductive Coating Thickness Testing

4.2.3.3.1 A CRS of a material with electrical conductivity (IACS) and permeability values within the range of the inspection article, and a thickness in excess of 3 times the standard depth of penetration at the test frequency shall be used. Non conductive shims of properties and thickness within the range of the coating to be measured, and in intimate contact to the substrate shall be used.

4.2.3.4 Material Thickness Measurement

4.2.3.4.1 A CRS of material with electrical conductivity (IACS) and permeability values within the range of the inspection article, and geometric characteristics of the material being measured shall be used. The CRS thickness shall be identical to the inspection material thickness with flat bottomed holes machined on the opposite surface to simulate material thinning. Alternatively a step wedge with the required range may be used.

4.2.3.5 Crack Detection

4.2.3.5.1 Crack detection CRS can be broken into 2 categories:

- **Surface testing**: A CRS with EDM notches applied to the surface. Bolthole testing is considered a surface testing method.
- **Subsurface testing**: A CRS with a single or multiple layers of material with the EDM notch applied to the lower surface of the upper layer to be inspected or subsequent layers of the stack-up as required. A subsurface CRS shall replicate all relevant properties of the inspection area (material, thickness, geometry, fasteners etc.) to ensure a reliable and repeatable inspection is achieved and to avoid false calls or missed defects.

4.2.3.5.2 When crack detection is to be performed, the crack shall be simulated by an Electrically Discharge Machined (EDM) notch. The EDM notch shall have a width of 0.003" - 0.005" with a length and depth as determined by engineering to the minimum crack dimensions required to be detected. Refer to Table 1 for the EDM notch length and depth tolerance requirements. Table 1 shall be used unless otherwise specified on the engineering drawing.

Table 1 - EDM Notch Length and Depth Tolerance

EDM LENGTH/DEPTH	TOLERANCE
Less than 0.500"	± 10%
Equal to or greater than 0.500"	± 5%

4.2.3.5.3 Magneto Optic Imaging (MOI) employs a CRS made from a material with electrical conductivity (IACS) and permeability values within the range of the inspection article for surface and subsurface crack detection. When subsurface corrosion is to be detected, it shall be simulated by removing material from the back surface of the CRS.

4.2.4 Scanning Aids

4.2.4.1 When the probe positioning is critical, scanning aids improve the quality and the accuracy of each scan path. Scanning aids shall be non conductive, and can be rigid or flexible depending on the profile of the inspection surface. Examples of scanning aids are probe guides profiled to radii or threads, edges, straight edges and circle templates.

4.2.5 Emerging and Advanced Eddy Current Technology

4.2.5.1 Recent technological advances have improved the sensitivity, resolution and the efficiency of the inspection process. Emerging methods (such as pulsed eddy current and eddy current array) that are applicable will be included into this document in future revisions.

4.3 Facilities

4.3.1 General

4.3.1.1 For most eddy current techniques, no specific facility is required as the equipment is taken to the task to perform the inspection. When a dedicated area is established to conduct inspections using portable equipment or fixed equipment, the facility shall be set up in a suitable manner to permit effective preparation, set-up, inspection and post cleaning of parts.

4.3.2 Facility Approval

4.3.2.1 This PPS has been categorized as a "Controlled Critical Process" according to PPS 13.39 and as such only facilities specifically approved according to PPS 13.39 are authorized to perform eddy current inspection according to this PPS.

4.3.2.2 Bombardier subcontractors must direct requests for approval to Bombardier Aerospace Supplier Quality Management. Bombardier Aerospace facilities must direct requests for approval to the appropriate internal Quality Manager.

4.3.2.3 Facility approval shall be based on a facility report, a facility survey and completion of a qualification test program as per section 6.7, if required. The facility report must detail the materials and equipment to be used, the process sequence to be followed and the laboratory facilities used to show compliance with the requirements of this PPS. Any deviation from the procedure or requirements of this PPS must be detailed in the facility report. Based upon the facility report, Bombardier Toronto (de Havilland) Materials Technology may identify additional qualification and/or process control test requirements. During the facility survey, the facility requesting qualification must be prepared to demonstrate their capability. Once approved, no changes to subcontractor facilities may be made without prior written approval from Bombardier Aerospace Supplier Quality Management.

5 Procedure

5.1 General

5.1.1 Definitions

5.1.1.1 Refer to Table 2 for a listing of terms used within this PPS and their definitions.

Table 2 - Definitions

TERM	DEFINITION
Absolute Probe	A probe containing a coil that responds to all electromagnetic properties of the test part.
AC (alternating current)	Electric current that reverses its direction of flow at regular intervals.
Amplitude Response	That property of the test system whereby the amplitude of the detected signal is measured without regard to phase.
Balance Point	The point on the impedance plane when the instrument and inspection material is in a balanced state. Any change in the characteristics of the material will cause a change in impedance and consequently a movement of the signal. Also known as the "Null Point".

Table 2 - Definitions

TERM	DEFINITION
Band Pass Filter	An electronic circuit which allows flow of signals of a specific frequency range but suppresses signals of both greater and smaller rates of response.
Bolthole Probe	A probe coil(s) assembly used for electromagnetically inspecting the walls of fastener holes or other small holes of limited length.
Bolthole Scanner	An eddy current device designed to provide automatic, uniform inspection of walls of fastener holes.
Bridge Circuit	An electrical circuit designed to pass only the changes in voltage or current flow through a system while eliminating the larger steady state component. Such circuits in eddy current inspection reflect the changes in the electromagnetic variables while eliminating the larger current from the readout.
Calibration	The standardization of the instrument, prior to test, to a known reference value.
Calibration Reference Standard	A piece of material, part, or piece from a part, containing an artificial discontinuity of known size; provides a means of producing a reflection of known characteristics; used to establish a measurement scale. Also, a known size discontinuity used to produce a reflection of known characteristics. References are constructed for thickness measurement, conductivity measurement or flaw detection.
Coil	One or more turns of conductor wound to produce a magnetic field when current passes through the conductor. The coil generating the magnetic field that produces eddy currents in the part being tested.
Coil Impedance	The total opposition to current flow through a coil and is represented by the ratio of the coil voltage to the coil current. This impedance is affected by the material within the magnetic field generated by the coil and is sometimes used to measure eddy current response.
Conductivity	This is the inverse of resistance, and refers to the ability of a conductor to carry current.
Conductivity Reference Standard	Sections of metallic materials with accurately measured electrical conductivity values in percent IACS. These standards are used to calibrate conductivity measuring eddy current instruments.
Coupling	An interaction between systems or between properties of a system.
Crack	A discontinuity that has a relatively large cross-section in one direction and a small or negligible cross section when viewed in a direction perpendicular to the first.
Defect	A discontinuity whose aggregate size, shape, orientation, location or properties does not meet specified acceptance criteria and is rejectable.
Differential Coils	Two or more coils electrically connected in series opposition such that any electromagnetic condition which is not common to the areas of the specimen being tested or the test specimen and the standard will produce an unbalance in the system and thereby be detected.

Table 2 - Definitions

TERM	DEFINITION
Discontinuity:	A lack of continuity or cohesion; an intentional or unintentional interruption in the physical structure or configuration of a material or component.
EDM	Electrical Discharge Machine.
EDM Notch	A notch induced by an Electrical Discharge Machine in the calibration reference standard used to represent the crack when calibrating the instrument to the required sensitivity level.
Eddy Currents	Currents caused to flow in an electrical conductor by the time and/or space variation of an applied magnetic field.
Eddy Current Testing	A nondestructive inspection method in which eddy current flow is induced in the test object. Changes in the flow caused by the variations in the specimen are reflected into a nearby coil or coils for subsequent analysis by suitable instrumentation and techniques.
Edge Effect	The effect on the magnetic field caused by the geometric boundaries of the test specimen. The effect is large in magnitude and similar in phase to a large crack.
Effective Depth of Penetration	The depth within a material, under test, where the transmitted or induced energy is: sufficient to detect discontinuities (determine condition of interest). EDP is approximately equal to three times standard DOP.
Evaluation	The process of deciding as to the severity of the condition after the indication has been interpreted. Evaluation leads to the decision as to whether the part must be rejected, salvaged or may be accepted for use.
Family of Components	Similar parts manufactured by the same fabrication process, such as machined parts, castings extrusions and sheet metal.
Filters	Filters are electrical circuits designed to eliminate various frequencies from a circuit output or input. Filter may be low pass (high frequencies suppressed), high pass (low frequencies suppressed) or band pass (frequencies outside a specified range suppressed).
Flaw	An imperfection in an item or material that may or may not be harmful. See “Discontinuity”.
Frequency	Frequency in uniform circular motion or in any periodic motion is the number of revolutions or cycles completed in unit time. The International Systems of Units expresses frequency in Hertz (1 Hz = 1 cycle per second).
Hysteresis:	A retardation or lagging of the magnetic effect when the magnetizing forces acting upon a ferromagnetic body are changed.
IACS	International Annealed Copper Standard is an international standard of electrical conductivity. It is based on a high purity grade of copper designated as 100 percent.
Impedance	This term is used to refer to the total opposition to the flow of current represented by the combined effect of resistance, inductance and capacitance of a circuit.

Table 2 - Definitions

TERM	DEFINITION
Impedance Plane Diagram	A graphical representation of the locus of points indicating the variations in the impedance of a test coil as a function of basic test parameters such as electrical conductivity, magnetic permeability, test frequency, thickness and magnetic coupling.
Impedance Testing	A term generally applied to eddy current testing which measures the overall change in impedance caused by variations in electromagnetic properties as differentiated from phase analysis testing which measures changes in phase.
Inclusion	Particles of impurities, usually oxides, sulphides, silicates, and such, which are retained in the metal during solidification or which are formed by subsequent reaction of the solid metal.
Indication	In nondestructive inspection, a response or evidence of a response, that requires interpretation to determine its significance.
Inductance	A property of a circuit that opposes any change in the existing current. Inductance is present only when the current is changing. A coil is a source of inductance.
Lift-Off	A measure of the gap between the face of a surface probe and the surface being inspected. It is a measure of the coupling between the probe and the material being inspected.
Lift-Off Compensation (Lift-Off Adjustment)	Procedures for instrument adjustments whereby impedance variations caused by a variable gap between an eddy current surface and the test part are suppressed. This adjustment is designed to provide a better signal-to-noise ratio for eddy current inspection.
Lift-Off Effect	The effect observed in the test system output due to a change in magnetic coupling between a test specimen and a probe coil whenever the distance of separation between them is varied.
Linear Indications	An indication having length three or more times its width.
Magnetic Flux	The total number of magnetic lines existing in a magnetic circuit is called “magnetic flux”.
Magneto Optic Imager (MOI)	A real time imaging system that relies on the Faraday magneto optic effect to induce magnetic fields in the inspection surface. A magneto-optics sensor is used to form images of the magnetic fields associated with the defects and structure.
Magnetic Permeability	A term indicating the ease with which a magnetic field can be established in a material. It: is determined by the ratio of the strength of the resultant magnetic force to the applied magnetic force.
Magnetic Saturation	The degree of magnetization when increasing the magnetizing force upon a part no longer increases the magnetic flux density (permeability) in the part.
Null Point	See “Balance Point”.

Table 2 - Definitions

TERM	DEFINITION
Optimum Frequency	That frequency which provides the highest signal-to-noise ratio obtainable for the detection of an individual property such as conductivity, crack, or inclusion of the test specimen. Each type of defect in a given material may have its own optimum frequency.
Phase	In periodic changes of any magnitude varying according to a simple harmonic law (as alternating electric currents,), the point or stage in the period to which the variation has advanced, considered in its relation to a standard position; can be expressed in degrees.
Phase Analysis	An instrumentation technique which discriminates between variables in the test part by the different phase angle changes which these conditions produce in the test signal.
Phase Angle:	The angular equivalent of the time displacement between corresponding points on two sine waves of the same frequency.
Phase Shift	A change in the phase relationship between two alternating quantities of the same frequency.
Probe	An assembly containing a small coil or coils designed for eddy current inspection of small areas immediately adjacent to the coil.
Probe Wobble	The change in angular orientation between a surface probe and the inspection surface. Probe wobble results in lift-off variations.
Secondary Magnetic Field	In eddy current testing, the magnetic field produced by the eddy currents in the test: material. The secondary field opposes the primary field.
Signal-To-Noise Ratio	The ratio of the signal from the variable of interest (flaw, thickness change or conductivity change) to signals from variables which are of no interest (lift-off, geometry and finish changes and electronic components).
Skin Effect	The phenomenon that causes current to flow along the surface of a conductor. As frequency increases, skin depth decreases.
Standard Depth of Penetration	The depth at which the eddy current field has fallen to I/ e, or 37 percent, of its strength at the surface. In practice, it is generally used to define the sensing limit of the eddy current field.
Subsurface Indication	Any indication that does not open onto the surface of the part in which it exists.
Surface Indication	Any indication that is open onto the surface of the part in which it exists.

5.1.2 Abbreviations

5.1.2.1 Refer to Table 3 for a listing of abbreviations used within this PPS and their meanings.

Table 3 - Abbreviations

ABBREVIATION	MEANING
CRS	Calibration Reference Standard
dB	Decibel (dB=20 Log (Amplitudes ratio))
EDM	Electrical Discharge Machine.
ET	Eddy Current
FSH	Full Screen Height
Hz	Hertz (MHz: megahertz; kHz: kilohertz)
HF	High frequency
IACS	International Annealed Copper Standard
LF	Low frequency
MOI	Magneto Optic Imaging
MPE	Materials and Processes Engineering
NDE	Non Destructive Evaluation
NDI	Non Destructive Inspection
NDT	Non Destructive Testing
RFD	Request for Deviation
POD	Probability of Detection
PSTS	Part Specific Technique Sheet
SNR	Signal-to-noise ratio (S:N)

5.1.3 Process Procedure

5.1.3.1 The procedure, as a minimum, shall include but is not limited to:

- Name and address of inspection facility
- Scope and limitation (including inspection technique)
- Date written, including record of applicable Revision(s)
- Applicable documents including reference to this specification
- Personnel certification requirements
- Surface preparation
- Special parts handling and processing instructions
- Part(s) Identification

continued on next page

- Identification of the required Calibration Reference Standards (CRS) and part number
- Sketches of the parts with inspection zone identification
- Type of instrument to be used
- Probe description, including frequency, coil diameter, coil configuration, shielding and overall dimensions.
- Identification of other miscellaneous equipment and materials used to perform the inspection
- Inspection Technique
- Calibration Procedure
- Evaluation of indications
- Acceptance and rejection criteria
- Reporting
- Post inspection cleaning requirements
- Approving ET Level 3 name and signature, and the date the procedure was approved.
- Approval signature by Bombardier Toronto (de Havilland) MPE ET Level 3.

5.1.4 Part Specific Technique Sheets (PSTS)

5.1.4.1 Part Specific Technique Sheets (PSTS), as a minimum, shall include but are not limited to:

- Part Preparation and general procedure
- Date and ET Level 3 signature
- Calibration procedure
- Equipment required (instrument, probes and CRS)
- Inspection procedure detailing the area to be inspected, scan directions and probe indexing
- Indication evaluation
- Acceptance and rejection criteria
- Reference to applicable procedure
- Rejected indication reporting
- Post cleaning requirements
- Inspection report requirements
- Approving ET Level 3 name and signature, and the date the procedure was approved.
- Approval signature by Bombardier Toronto (de Havilland) MPE ET Level 3.

5.1.4.2 Written Procedure and PSTS can be combined into one document, at the discretion of Bombardier Toronto (de Havilland) MPE ET Level 3, when requirements for both are included. Written procedures and Technique sheets shall be approved and signed by Bombardier Toronto (de Havilland) MPE ET Level 3.

5.1.5 Factors Effecting Eddy Currents

5.1.5.1 General

5.1.5.1.1 Due to the wide variety of materials, modes of operation, defect types and sizes to be detected, there are many variables which have an effect on the performance of the coil and therefore the quality of the inspection. Listed below are factors to take into consideration when selecting equipment and final test parameters.

5.1.5.2 Conductivity

5.1.5.2.1 The depth and intensity of eddy currents in non magnetic material is greatly affected by conductivity. In a material of high conductivity, eddy currents are concentrated at the surface and form a strong secondary electromagnetic field opposing the applied primary field. As a result, the strength of the primary field diminishes rapidly with increasing depth below the surface. In a low conductivity material, the primary field generated is weaker in intensity, which produces a weak opposing secondary field with an increased depth. Figure 5 shows the comparison between eddy current fields of high and low conductivity materials.

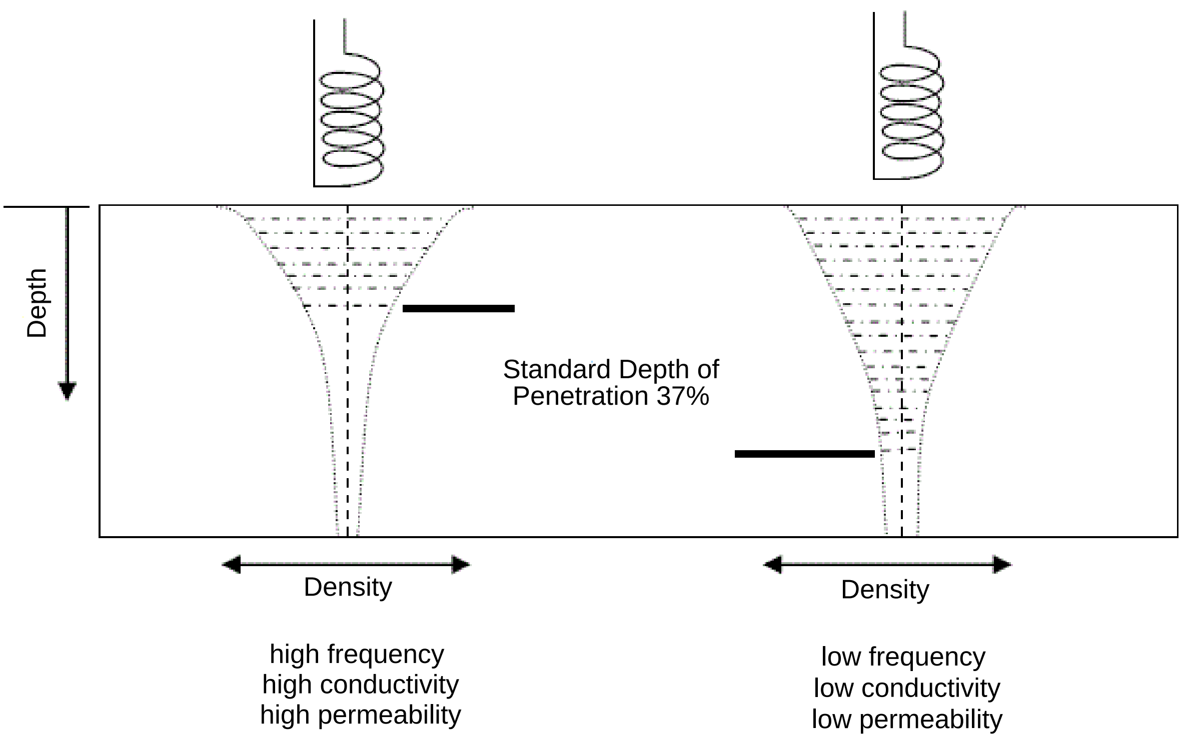


Figure 5 - Depth of Penetration Variables

5.1.6 Permeability

5.1.6.1 The inspection of ferromagnetic parts is usually limited to testing for surface or near surface flaws. Magnetic permeability causes skin effect, and hinders the generation of eddy currents below the surface. This results in an eddy current field that is concentrated at the surface and diminishes rapidly as depth increases. The presence of permeability is not considered a problem when inspecting surface defects. However when the permeability varies within the inspection area due to random heat affected zones, issues relating to a reliable inspection may exist. Where possible the inspection area shall be of a constant permeability to reduce the effects of permeability changes. Figure 6 shows the effects of permeability on the impedance curve.

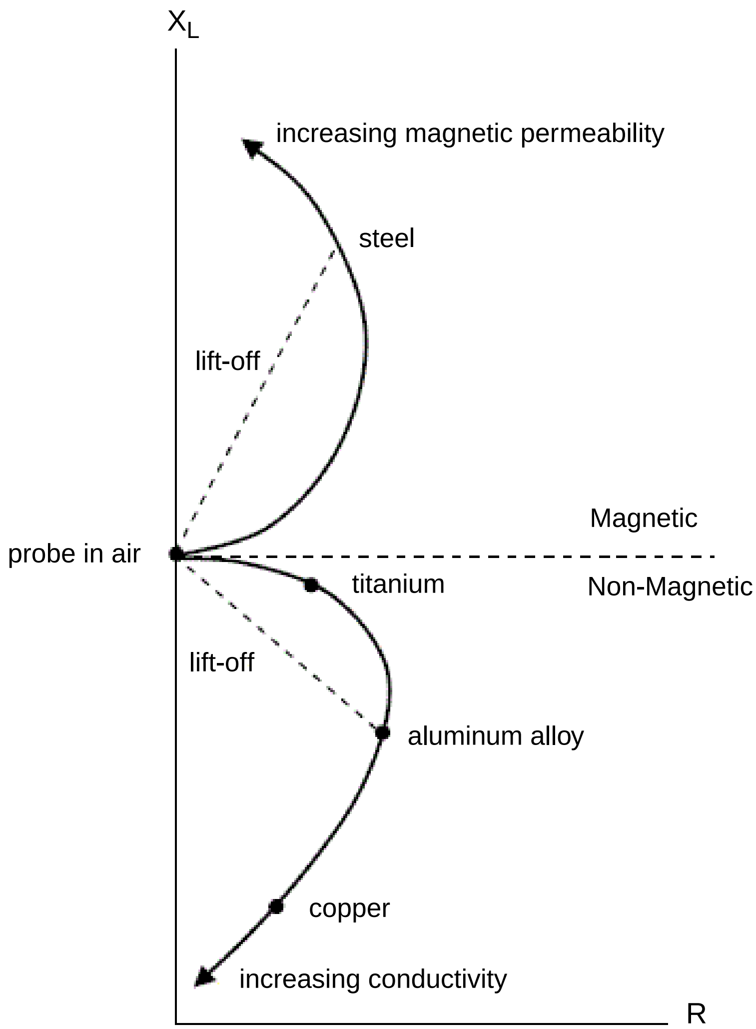


Figure 6 - Impedance Plane - Conductivity and Permeability Relationship

5.1.7 Frequency

5.1.7.1 Frequency is the primary factor which the inspector can adjust to optimize the inspection sensitivity. As the frequency is increased, the eddy currents generate a stronger magnetic field, which in turn reduces the penetration of the primary field. The eddy current field will be concentrated at the surface and diminish rapidly with an increase in depth. Higher frequencies improve the sensitivity to smaller cracks, however they may be prone to an increase in signal noise caused by probe wobble and/or surface imperfections such as scratches and rough surface condition when compared to a lower frequency capable of providing the same sensitivity.

5.1.7.2 When the frequency is reduced, the surface concentration is reduced, which permits the eddy current field to extend further into the material. An increase of a deeper eddy current density permits the detection of subsurface or far surface defects (see Figure 7).

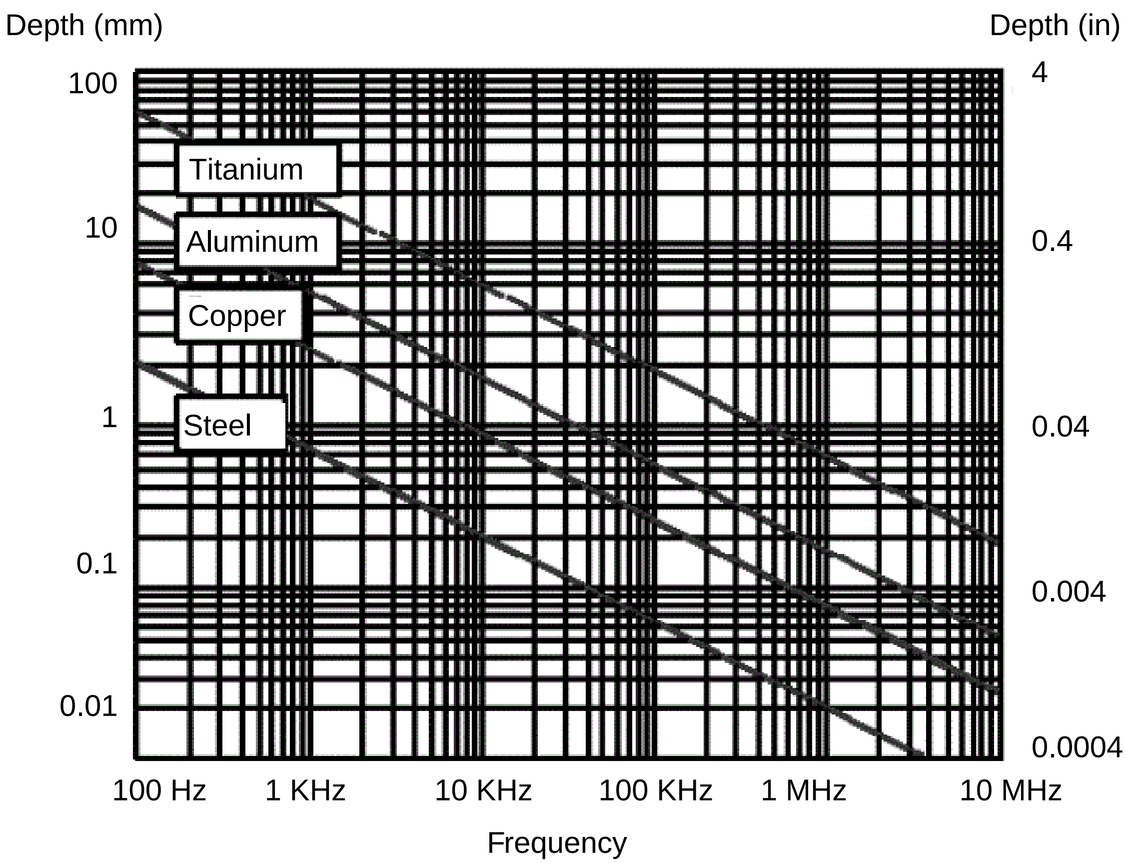


Figure 7 - Frequency and Depth of Penetration Relationship

5.1.7.3 The frequency required to detect a defect at a predetermined depth can be calculated using the following Depth Of Penetration (DOP) formulas.

$$\delta = 1.98\sqrt{\rho / (\mu \times f)}$$

δ = Standard Depth of Penetration (inches)
ρ = Resistivity ($\mu\Omega/cm^2$)
μ = Permeability (dimensionless)
f = Frequency (Hertz)

$$\rho = 172.41 / \sigma$$

ρ = Resistivity ($\mu\Omega/cm^2$)
σ = Conductivity Value (%IACS)

5.1.7.4 After the calculated depth has been established, it is essential to use a CRS to confirm the reliability of the inspection.

5.1.8 Part Geometry

5.1.8.1 Geometric factors can be changes in thickness, edges, curvature holes, corners, scratches etc. The eddy current field occupies a three dimensional space within the material. When defects and/or part geometric changes enter the field, the field becomes distorted and creates a change in the impedance value. The inspector shall take geometry of the inspection area into consideration when evaluating indications to prevent mistaking a defect for a geometric factor. When possible the inspector shall reduce or eliminate the effect of geometric factors by maintaining the eddy current field in a constant equilibrium (e.g., the use of scanning aids to maintain a constant edge distance).

5.1.9 Lift-Off

5.1.9.1 Lift-off is the change in the signal response when the distance between the coil and the inspection material is altered. The eddy current field is at its highest when the coil is in intimate contact with the inspection material. When the inspection surface has a non conductive coating applied (e.g., paint), the lift-off effect is increased and the eddy current intensity has been reduced. To ensure the correct sensitivity is applied to the inspection surface, the operator shall compensate for the lift-off effect on the CRS using non-conductive tape or shims to replicate the equivalent coating thickness.

5.1.10 Signal to Noise Ratio

5.1.10.1 The ratio of the defect signal (or CRS defect signal) to the background noise caused by surface conditions shall be maintained as low as possible to ensure the smallest defect is able to be detected reliably. Unless otherwise specified in the specific technique or by engineering, the signal to noise ratio shall be 5:1 or better. Inspections performed on BAEX Montreal test rigs shall use a signal to noise ratio of 3:1 or better unless specified.

5.1.11 Material Thickness

5.1.11.1 When the inspection material thickness is less than the effective depth of penetration, the eddy current field at the back surface increases and can become distorted, creating a change in the impedance value. The measuring of materials or the detection of thinning or corrosion can be accomplished by this means by comparing the signal variation between different material thicknesses. When inspecting structures with varying thickness and components, irrelevant signals may appear from underlying structure if the frequency is too low.

5.1.12 Temperature

5.1.12.1 Material conductivity decreases with temperature increases. Ensure the CRS, probe and inspection material are at a stable and equal temperature (+/- 2 degrees C) before starting calibration and the inspection.

5.1.12.2 Flaw detection and MOI inspection shall be carried out between 41°F and 104°F (5°C and 40°C).

5.1.12.3 Refer to PPS 20.07 for conductivity testing temperature requirements.

5.1.13 Defect Depth, Orientation and Dimensions

5.1.13.1 Knowledge of the defect required to be detected is essential prior to starting an inspection. Having a firm understanding will assist in determining the correct equipment and technique settings to carry out the task.

5.1.13.2 The following information is essential to establish the technique parameters:

- Defect type to be detected (crack, corrosion, conductivity, etc.)
- Minimum crack length and depth the length and depth of the crack influences selection of the probe coil diameter, scan path index and frequency.
- Defect orientation can influence the requirement for additional scans due to direction sensitive probes (see Figure 8).
- Area to be inspected a defined inspection area shall be specified to confirm the inspection requirements are followed. Scanning of large areas for randomly orientated defects is not recommended and an alternate NDT method shall be considered.
- The layer to be inspected (when the inspection area is a multi layered structure) if multi layers or defects initiating from the back surface are to be inspected, frequency optimization is required to ensure the maximum sensitivity is applied to the inspection area.

5.1.13.3 When performing subsurface inspections, the sensitivity of a constant dimension defect will reduce with increased depth. In some instances the sensitivity can be improved by using a more compatible probe or a change in frequency. If the simulated defect cannot be resolved during technique trials, notify engineering to increase the minimum detectable length or substitute NDT method if possible.

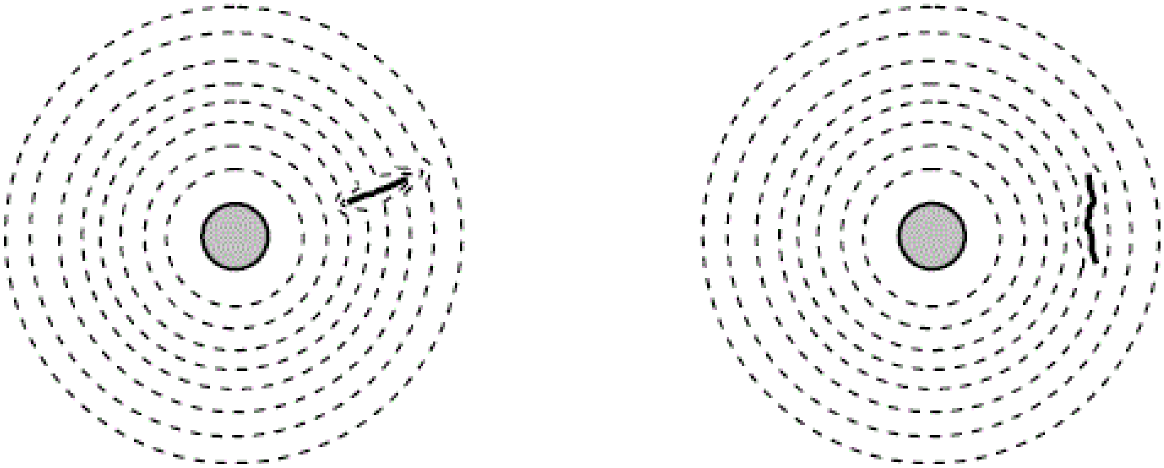


Figure 8 - Cracks and Eddy Current Field

5.1.14 Human Factors

5.1.14.1 After a technique has been developed, providing the correct equipment is utilized and no parameter changes have been made, the technique can be deemed to be reliable enough to detect defects of the required sensitivity. Unless the inspection system is fully automatic, there will always be an inspector to set-up, calibrate, inspect and evaluate the integrity of components. There are rigid design measures which control the reliability and repeatability of a technique, including an inspectors training and experience.

5.1.14.2 The remaining variables are the environmental conditions and the psychological condition of the inspector at the time of testing. Human factors shall be taken into account when designing a technique. Whenever possible every attempt shall be made to minimize the effects of environmental and psychological conditions which may reduce the concentration of the inspector during the inspection process.

5.2 Pre-Inspection Requirements

5.2.1 Prior to inspection, the inspection area shall be clean and free of dirt, oils, greases, sealants or other contamination. Any cleaning operation shall be carried out in a manner that no alteration to the material properties has occurred.

5.2.2 Unless detailed in the specific procedure, there is no requirement to remove surface coatings unless:

- The coating is in poor condition which can impede on the inspection and result in improper interpretation.
- Irregular or excessive coating thickness.
- The coating is conductive.

5.2.3 If the inspection area has an integral conductive coating contact engineering for advice.

5.2.4 If a surface coating is present, the coating thickness shall be compensated for when calibrating the instrument to ensure the correct sensitivity is achieved during the inspection. Thickness compensation is carried out applying non conductive tape or shims on the surface of the CRS to simulate coating thickness. The position of the operating point on the inspection area shall be compared to the balance point on the CRS. The thickness of the non conductive tape or shim shall be increased or decreased until the operating point of the inspection area matches the balance point of the CRS.

5.2.5 When required, remove brackets, bushings and rivets etc. to gain access to the entire inspection area.

5.2.6 Visually inspect the inspection surface for the conditions that may impede on the inspection:

- Surface roughness
- Scratches, blends, burrs and gouges
- Corrosion
- Out of round holes or offset component interfaces
- Partially removed conductive coatings (e.g., Alclad)

5.2.7 Do not carry out any rework operation unless authorized to do so by the appropriate authority.

5.2.8 Prior to calibration and during the inspection, the instrument shall be located a minimum of 10 feet from items that may generate large magnetic fields (e.g., generators, transformers and motors, etc.) to avoid external electromagnetic interference.

5.2.9 When inspecting thin materials and the eddy current field exceeds the material thickness, ensure there are no conductive materials underneath that will cause interference to the eddy currents during CRS calibration and inspection.

5.2.10 All equipment used for the inspection shall be inspected to ensure it is in serviceable condition prior to calibration.

- The instrument shall have a valid and current calibration.
- CRS shall be free of dents, contaminants and corrosion.
- Cables shall contain no exposed wires and bent pins.
- Probes shall not have loose connectors, cracked casings or worn/exposed coils.

5.3 Calibration

5.3.1 Proper instrument calibration using the appropriate CRS is an essential part of all eddy current inspections. Prior to the start of any inspection, the instrument calibration process shall confirm the test can be conducted to the required sensitivity.

5.3.2 Calibration shall be carried out:

- Prior to inspection.
- After completion of the inspection.
- After equipment changes (i.e., probe, lead changes or replacing the wear tape) have been made.
- After changes to the instrument settings have been made.
- After every 15 minutes of continuous operation for large inspection areas.
- During the inspection, if the operator suspects the validity of the calibration, the instrument shall be recalibrated and the inspection repeated from the last known valid calibration.

5.3.3 Calibration shall be carried out in accordance with the specific procedure.

5.4 Filters

5.4.1 Signal filtering is used to eliminate unwanted frequencies from the received signal. Filtering can be carried out using:

- High Pass Filters (HPF) to allow high frequencies to pass and filter remove unwanted low frequency components of the signal such as gradual changes in conductivity or out of round holes. High pass filtering is not recommended when performing manual surface scanning as relevant signals can be suppressed by the filtering if the probe does not traverse the defect at sufficient speed. The most common application of high pass filtering is Bolthole inspection using a scanner of constant speed.
- Low Pass Filters (LPF) to allow low frequencies to pass and remove unwanted high frequency components of the signal such as electronic noise.
- Band Pass Filters (BPF) which combine high pass and low pass filters (HPF and LPF).

5.4.1.1 It is essential to have the correct filter settings as incorrect filter settings may suppress or eliminate a defect signal from the screen display (see Figure 9).

5.4.1.2 Filter settings are not to be adjusted after calibration or during the inspection. If any change to the filter settings is made, the instrument shall be recalibrated before any further inspection is carried out.

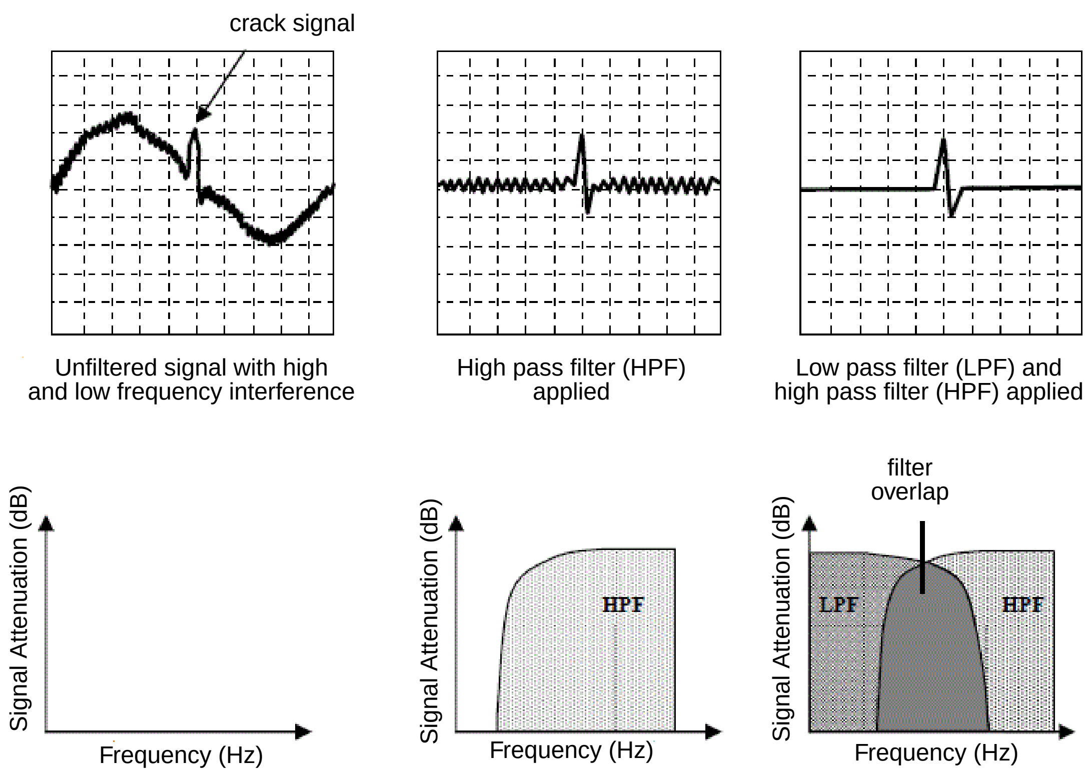


Figure 9 - Use of High and Low Pass Filters

5.5 Scanning

5.5.1 MOI scans shall cover 100 percent of the inspection area. When using MOI systems which are direction specific (i.e., non multidirectional imaging system), a second scan 90 degrees to the initial scan orientation is required to ensure defects are detected regardless of orientation.

5.5.2 Surface scans shall provide the coverage as detailed in the specific procedure which is determined by engineering. The scanning pattern required is based on the following factors:

- Expected defect initiation site.
- Defect orientation
- Minimum defect size required to be detected.

5.5.3 The probe coil shall be perpendicular to the inspection surface when scanning to avoid the effects of probe wobble.

5.5.4 The scanning speed shall not exceed the scan speed used during the instrument calibration.

5.5.5 If a defect is expected to initiate from an edge, a single scan adjacent to the edge will be sufficient to reliable detect the defect. When the material is thicker, scans may be required on both surfaces adjacent to the edge.

5.5.6 When performing linear scans the probe index shall be smaller than the minimum defect size required to be inspected. If the defect orientation is unknown, a second linear scan path shall be carried out 90 degrees to the initial scan path. Non-conductive scanning aids (e.g., plastic ruler) shall be used to maintain straight and consistent scan paths.

5.5.7 When inspection around raised fasteners or bushings is required, use the fastener head or tail, or the bushing flange as a probe guide, maintaining the probe as close as possible to the fastener or bush. When inspecting around holes or flush fasteners, use a non-conductive circle template to maintain a constant distance from the edge of the hole. Use a diameter which maintains the probe as close as possible to the hole without any edge effect.

5.5.8 Refer to Figure 10 and Figure 11 for typical high frequency surface scan path scenarios.

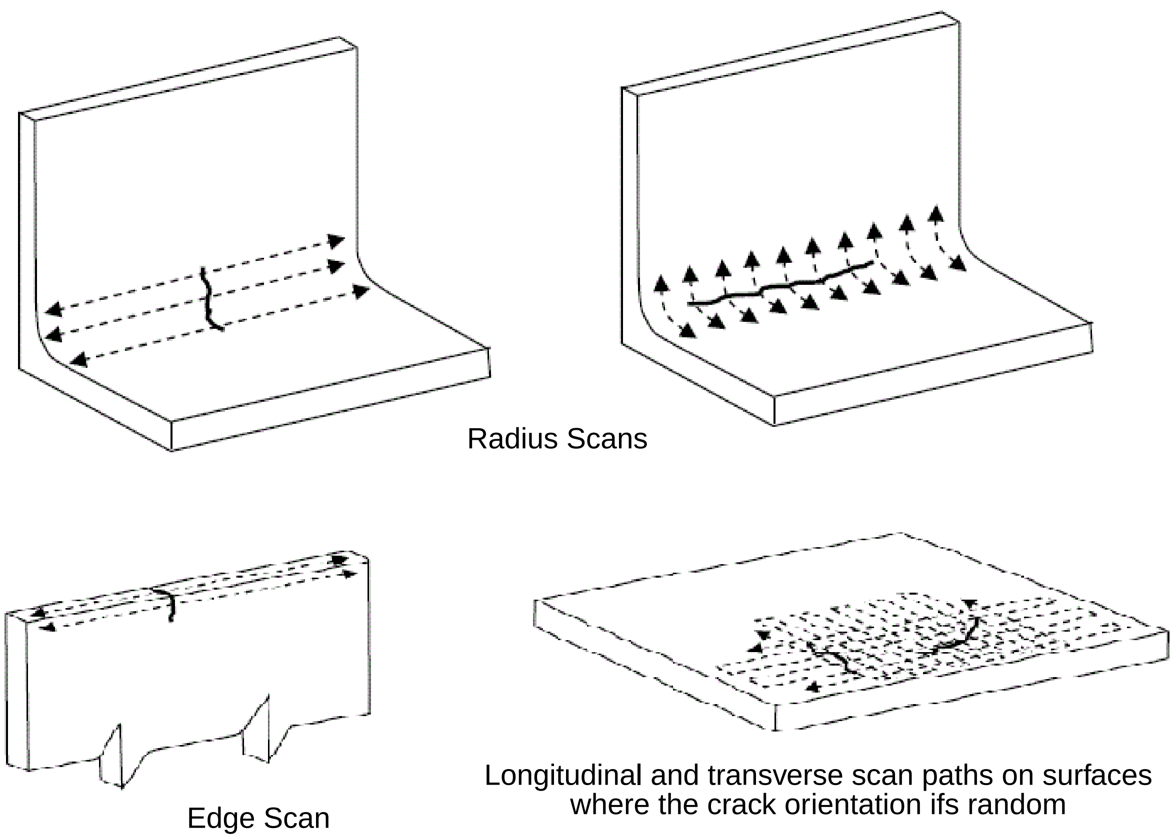


Figure 10 - Typical Radius, Edge and Surface Scans

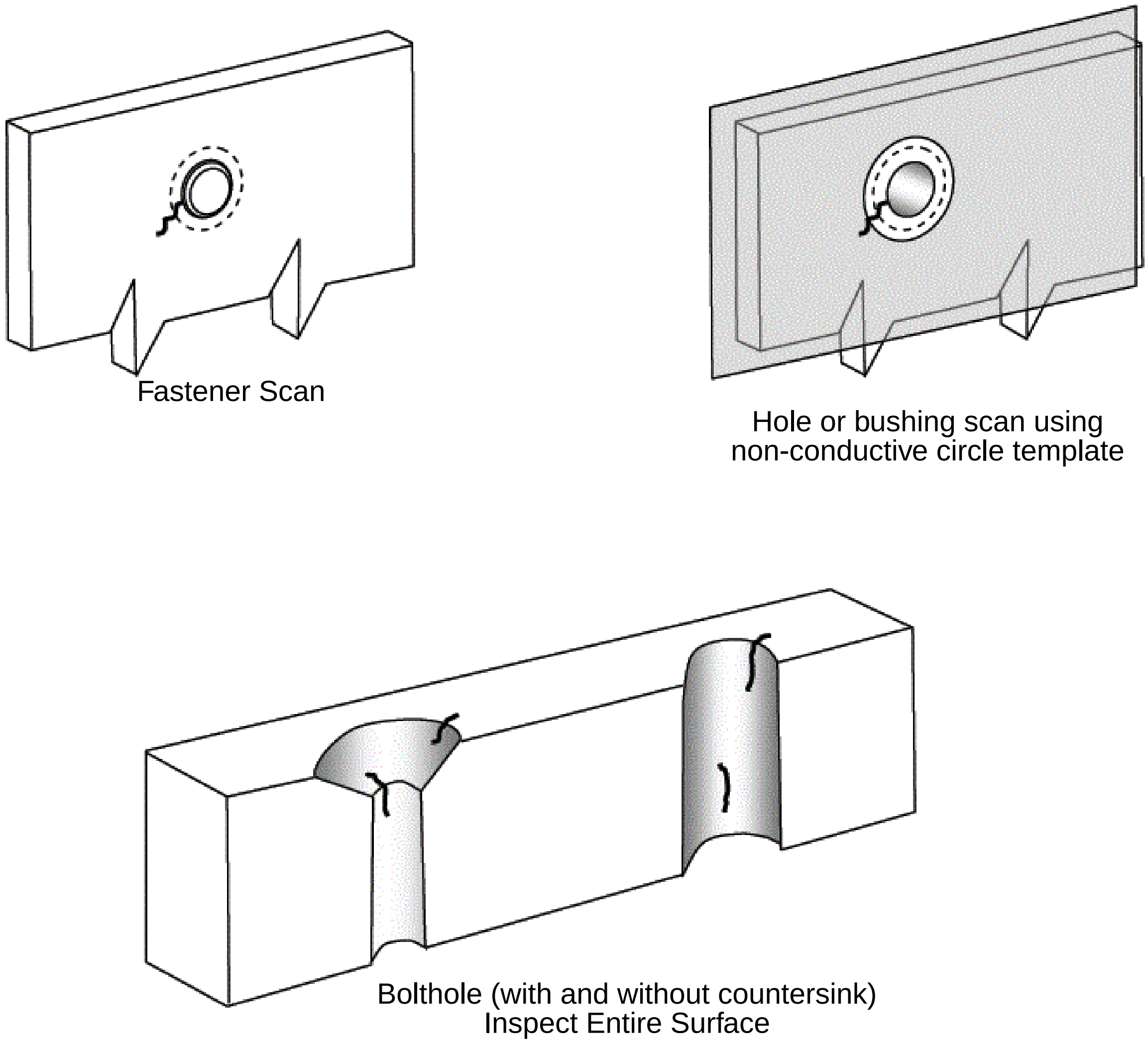
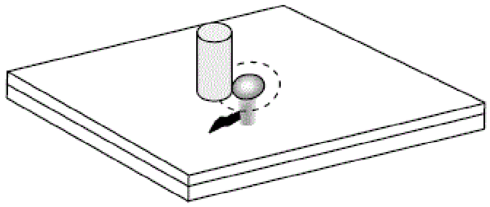


Figure 11 - Typical Fastener and Hole Scans

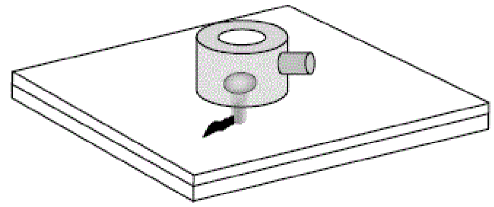
5.5.9 Low frequency surface scans are carried out in a similar manner to high frequency surface scanning, with the main difference being the size and configuration of the probe. Low frequency inspection is typically used to detect cracking initiating from fastener holes and/or edges in underlying structure, with the exception of corrosion detection at material interfaces of on the opposite side of the material. Corrosion detection shall use a linear scan with a probe index of one coil diameter of less between scans.

Note: Some low frequency probes are direction sensitive, notable sliding probes. Ensure the probe alignment is correct for the expected crack orientation.

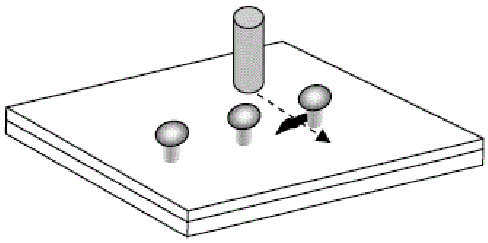
5.5.10 Refer to Figure 12 for typical low frequency scan path scenarios.



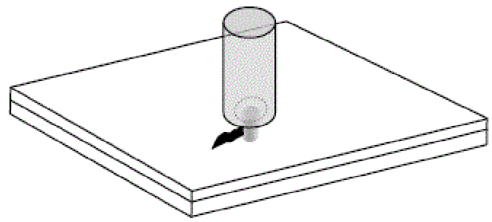
Low frequency scan around raised fasteners (Spot Probe)



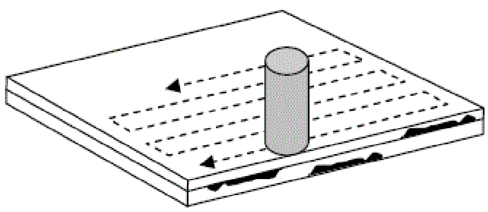
Low frequency scan directly above raised fasteners (Ring Probe)



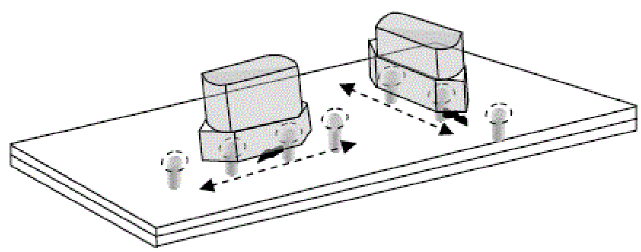
Low frequency scan between raised fasteners (Spot Probe)



Low frequency scan directly above flush fasteners (Spot Probe)



Low frequency scan detecting subsurface corrosion (Spot Probe)



Low frequency scan directly above and between flush fasteners (Sliding Probe)

Figure 12 - Typical Low Frequency Surface Scans

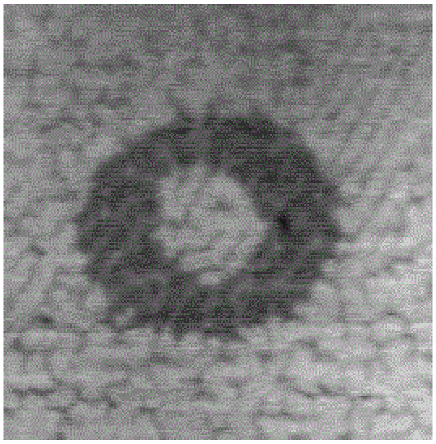
5.6 Interpretation and Evaluation of Indications

5.6.1 General

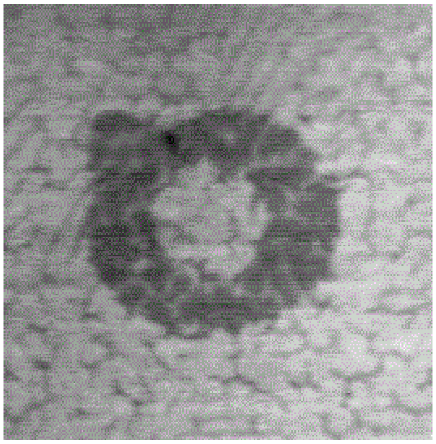
5.6.1.1 When the eddy current field is introduced into an area containing a defect, the field becomes distorted, creating an impedance change. This change creates a change of the shape and/or the location of the screen signal. As eddy current is a comparison method, the signal obtained from the area of interest shall be compared to the signal obtained from the CRS used for calibration. Any repeatable change in the shape or amplitude of the signal that cannot be attributed to geometry, conductivity (where applicable) and background noise shall be considered a relevant indication.

5.6.2 Magneto Optic Imaging (MOI)

5.6.2.1 Surface cracking indication using MOI will appear as a black line. When the crack initiates from a fastener hole, small cracks will give the hole a bulged appearance at the hole/crack intersection (see Figure 13). As the crack increases in length the hole will resemble its normal shape combined with a black line emanating from it. Corrosion or blend outs will have a darker appearance (with the dimensions of the defect) compared to defect free surface. When performing subsurface inspection with the MOI, it is essential to have knowledge of the underlying structure to assist in evaluating signals.



MOI Image - Crack Free Fastener



MOI Image - Fastener with Crack

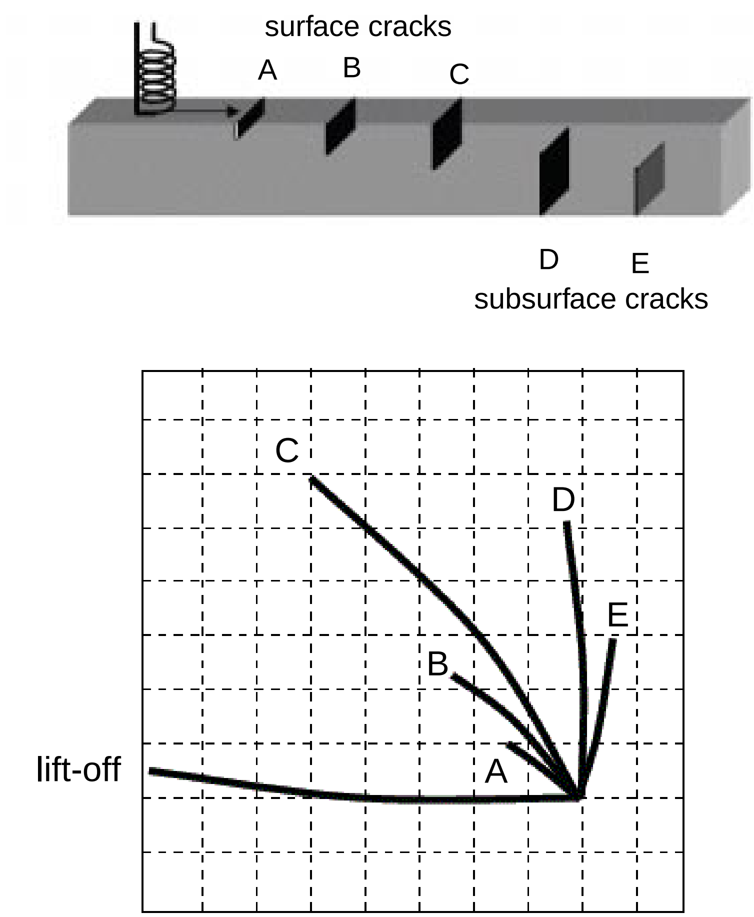
Figure 13 - Magneto Optic Imaging (MOI) Images

5.6.3 Surface Scan Signals

5.6.3.1 General

5.6.3.1.1 As with other NDT methods, eddy current inspection has relevant and non relevant indications. While surface breaking cracks may present interpretation problems associated with geometric factors within the eddy current field, confirmation of a relevant defect can be carried out using another method capable of detecting surface defects with relative ease (visual, fluorescent penetrant or magnetic particle inspection). When the inspection carried out is detecting subsurface defects, the options become limited if disassembly cannot be considered. A firm knowledge of the surrounding structure is essential for evaluating the relevance of a signal.

5.6.3.1.2 For accurate interpretation, the signals obtained during the inspection shall be compared to the signals obtained from the CRS during calibration. The signal phase, amplitude and shape can aid in determining the type of defect, the size and the depth (see Figure 14).



The phase lag angle can be calculated using the following formulas:

$$\theta = x/\delta$$

θ = Phase lag in Radians
x = Distance below surface (inches or mm)
δ = Standard Depth of Penetration (inches or mm)

$$\theta = 57.3 \times (x/\delta)$$

θ = Phase lag in Degrees
x = Distance below surface (inches or mm)
δ = Standard Depth of Penetration (inches or mm)

Figure 14 - Phase Lag due to Defect Depth (Aluminum Alloy)

5.6.3.2 Surface Cracks

5.6.3.2.1 Surface cracks will have a sharp vertical deflection (depending on the material) when the coil is moved over the crack.

5.6.3.2.2 When the coil follows the crack, the signal will rise sharply and remain up until the coil is not over the crack.

5.6.3.2.3 The phase of the signal shall be compared to the phase of the lift-off effect and the edge signals.

5.6.3.2.4 As the depth of a surface crack becomes deeper, the phase will rotate away from the lift-off signal. No change will be noticed when the depth exceeds three times the standard depth of penetration.

5.6.3.2.5 Bolthole eddy current inspection is normally carried out in X:Y mode display (see Figure 15). The X:Y mode display can be of benefit for detecting out of round holes (similar to a lift-off signal), the presence of dissimilar metallic particles in the hole, and increase or decrease in phase angle when compared to a crack indication. Additional interpretation and finding exact crack location can be carried out using Timebase (Y Theta) mode display. The defect signal in Timebase (Y Theta) mode is based on the defect depth and the location in relation to the 0 degree datum of the probe (see Figure 16).

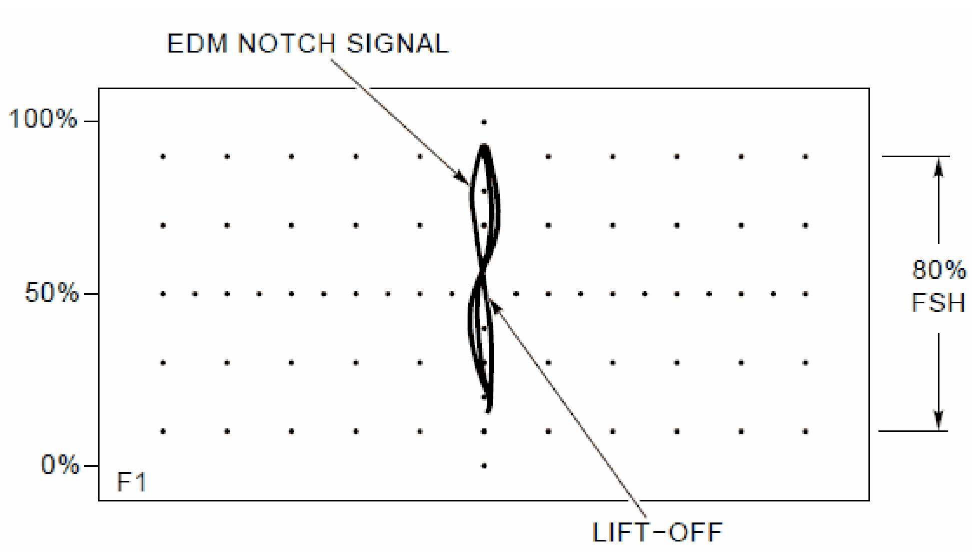


Figure 15 - Bolthole Inspection in X:Y Mode Display

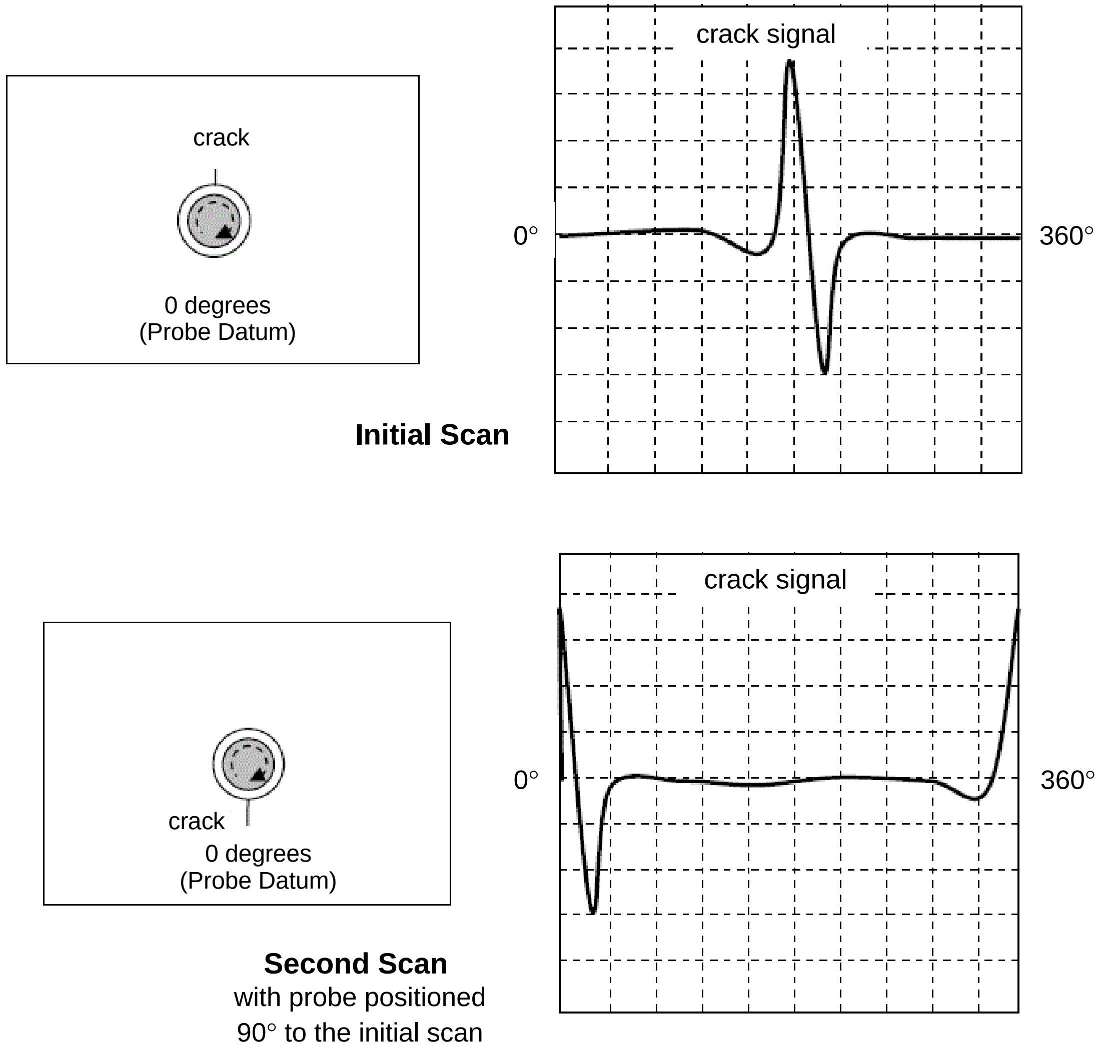


Figure 16 - Bolthole Inspection Timebase Screen Display

5.6.3.3 Subsurface Cracks

5.6.3.3.1 The size and shape of subsurface crack indications will vary depending on the probe configuration and the method of scanning employed. Signal interpretation shall always be compared to the signals obtained during calibration (see Figure 17).

5.6.3.3.2 Ensure the indication is not caused by any of the following factors:

- Changes in lift-off due to variations in non conductive coating thickness.
- Probe wobble caused by inconsistent coil to inspection surface angle.
- Variations in cladding or plating after rework.
- Conductivity/permeability changes due to the close proximity of fasteners or dissimilar materials.
- Changes in part geometry such as edges, curvature and thickness.

5.6.3.3.3 To discriminate between a resistivity change (defect) and a permeability change, reduce the frequency by one tenth (1/10) or as low as possible. A frequency close to 10kHz (providing probe stability) is recommended.

5.6.3.3.4 If the indication is caused by a resistivity change (defect), the signal from the defect will rotate counter clockwise, bringing the signal closer to the lift-off trace. No other indication should be observed in the upper quadrant of the display.

5.6.3.3.5 If the indication is caused by a permeability change (ferromagnetic inclusion), the signal should remain vertical in the upper quadrant of the display.

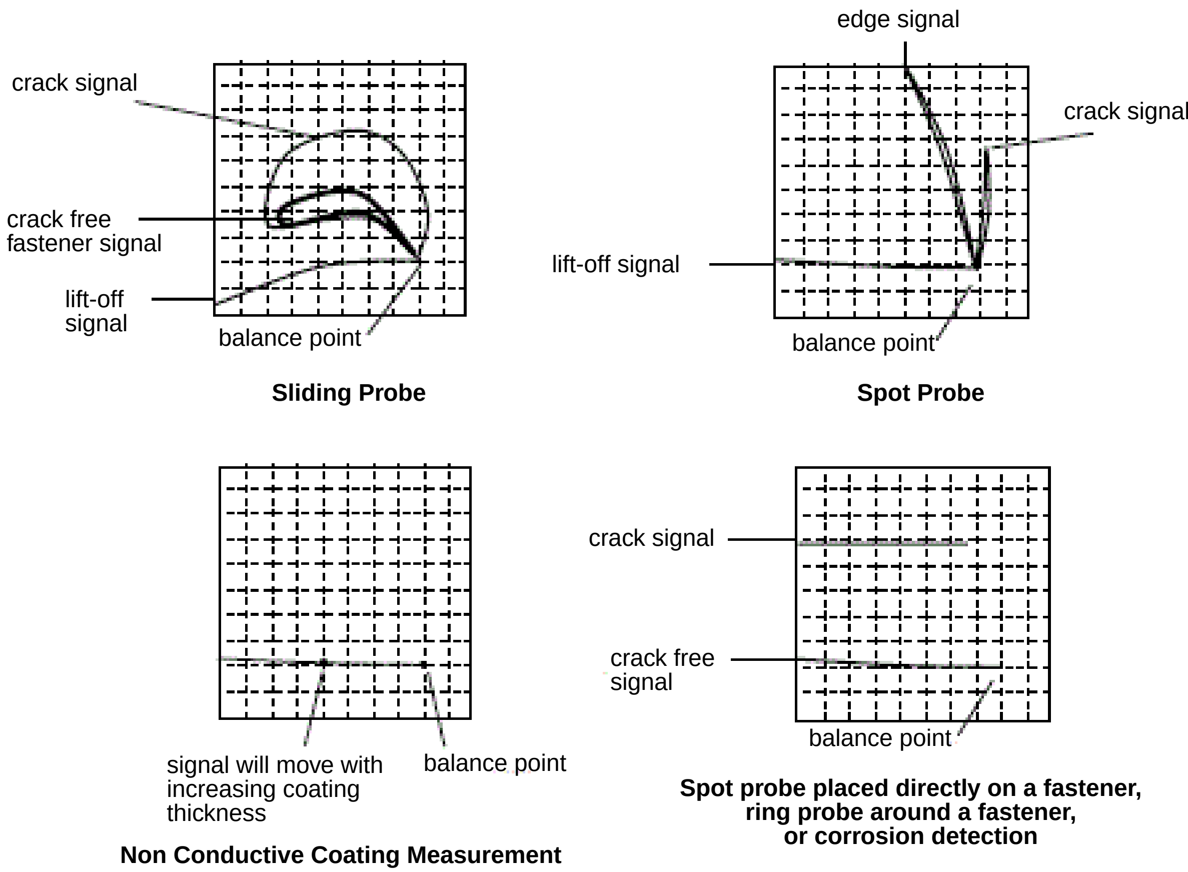


Figure 17 - Typical Subsurface Inspection Signals

5.7 Alternative Inspection Methods/Techniques

5.7.1 Whenever possible a back-up technique shall be employed to assist in evaluation and to confirm the relevance of the defect.

5.7.2 Surface breaking defects may use optical and visual aids, fluorescent penetrant or magnetic particle methods to complement the eddy current inspection.

5.7.3 Subsurface inspections require radiographic or ultrasonic inspections to aid in evaluation. After permission is granted by the relevant engineering authority, partial disassembly of the component may be carried out to confirm indications using a surface defect eddy current method (e..g., removal of a fastener to conduct Bolthole eddy current inspection).

5.7.4 Alternative eddy current techniques may be used in lieu of the primary eddy current inspection technique provided it can demonstrate to meet all the requirements established in this specification and approval is obtained from Bombardier Toronto (de Havilland) MPE ET Level 3.

5.7.5 The use of alternative techniques or methods require an approved technique sheet and shall be reviewed and approved using a BT0213-01 (Request for Deviation) form.

5.8 Defect Sizing

5.8.1 Conductivity

5.8.1.1 Refer to PPS 20.07 for conductivity values for each material and temper states. When heat effected zones are to be measured, the probe shall be positioned away from the area of interest and moved towards the area of interest gradually until a conductivity variation greater than 2.0% IACS is recorded. For mapping purposes the outer edge of the probe shall be used to outline the damaged area.

5.8.2 Surface Probe Inspection

5.8.2.1 General

5.8.2.1.1 After a defect has been identified as being relevant, an in-depth evaluation shall be carried out to provide an accurate dimension and location for reporting.

5.8.2.1.2 Indication marking shall be carried out using approved removable markers in accordance with PPS 15.04 to map the location of the defect on the component.

5.8.2.2 Surface Cracks

5.8.2.2.1 Cracks shall be evaluated using a shielded probe whenever possible to reduce external effects caused by edges etc. Scanning perpendicular to the crack direction, mark the inspection surface where the center of the probe coil is located, when the signal amplitude is at its highest. The depth can be determined by comparing the indication signal to the signal obtained from the CRS EDM notches at known depths. The tip (end) of the crack shall be identified when the signal amplitude is 50% of the signal obtained during calibration (see Figure 18).

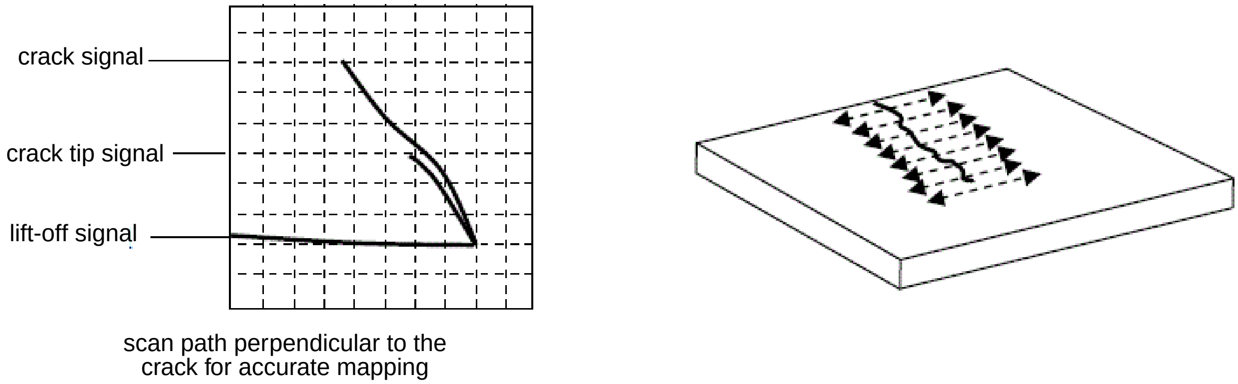
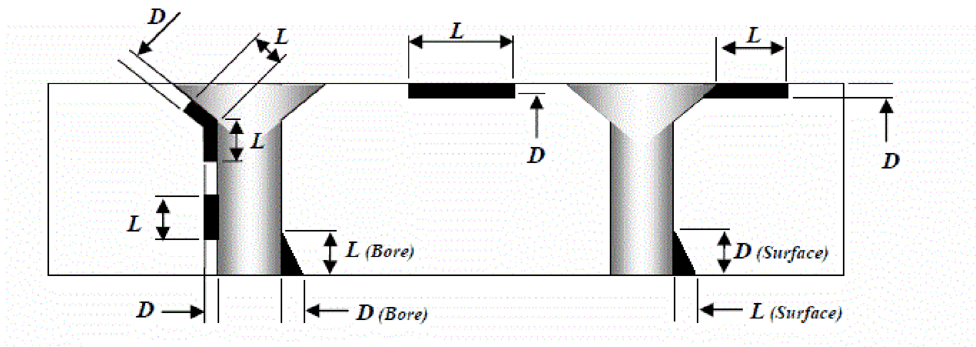


Figure 18 - Typical Crack Indication Sizing

5.8.2.3 Bolthole Cracks

5.8.2.3.1 When sizing using manual or rotating Bolthole inspection, the dimensions and orientation of the defect must be established. The orientation is carried out by comparing the position of the signal of the inspection area to the signal from the CRS EDM notch using Y Theta screen presentation. The defect length is measured by identifying the extremities of the defect and measuring the distance between them. This can be accomplished by marking the shaft of the probe when the defect starts and finishes. The defect depth can be established by comparing the signal amplitude to EDM notches of various depths.

5.8.2.3.2 The length and depth dimensions are in relation to the surface the inspection is carried out from (e.g., surface or Bolthole scans). Figure 19 shows the format for measuring surface cracks in holes and on the surface. When a relevant indication is inspected and measured from 2 surfaces(e.g., corner cracking) a drawing is required to detail the location and dimensions of the defect.



Dimension format when inspecting from the bore

Dimension format when inspecting from the surface

Figure 19 - Dimension Format for Defect Identification

5.8.2.4 Corrosion and Material Thickness

5.8.2.4.1 Move the probe towards the corrosion location. Mark the inspection surface where the center of the probe is located, when the signal amplitude is 50% of the signal obtained during calibration. Repeat the scans from all accessible sides of the inspection area until the entire area of interest has been identified.

5.8.2.5 Non Conductive Coating Measurement

5.8.2.5.1 Refer to BATS 4002 for inspection carried out using coating thickness instruments. When using a conventional eddy current instrument, place the probe on the area requiring measurement. Compare the location of the inspection surface balance point to the location of the CRS balance point. Mark the inspection surface when the balance point starts to shift away from the CRS balance point.

6 Requirements

6.1 Acceptance and Rejection Criteria

6.1.1 General

6.1.1.1 This specification does not detail or specify the acceptance criteria for a specific task. The criteria for acceptance or rejection shall be defined on the applicable procedure, PSTS and/or drawing.

6.1.2 Conductivity Measurement

6.1.2.1 Conductivity acceptance and rejection shall be carried out in accordance with PPS 20.07.

6.1.3 Magneto Optic Imaging (MOI)

6.1.3.1 MOI acceptance and rejection criteria shall be carried out in accordance with the specific procedure which has been determined by engineering.

6.1.4 Surface Scan Inspection

6.1.4.1 Surface scan acceptance and rejection criteria shall be carried out in accordance with the specific procedure which has been determined by engineering.

6.2 Rework of Rejected Parts

6.2.1 Reworking of rejected parts must first be approved by the appropriate authority prior to any reworking operation carried out. Parts may then be reworked providing the defect can be removed by mechanical means to the drawing tolerance. Reworked parts shall be re-inspected to ensure the defect has been removed.

6.3 Marking of Inspected Parts

6.3.1 Each component which has been inspected using eddy current method and found to conform to the requirement of this specification shall be identified with the letter E and the employees identification number, by ink stamping or tag stamping in accordance with PPS 15.01. When subsequent processing will remove the identification or the stamping will impede on the final finish, the process card shall be identified with the letter E and the employees identification number.

6.4 Inspection Documentation

6.4.1 An inspection report or traveler documentation shall be prepared for each part or group of parts inspected and maintained on file The report or traveller documentation shall include the date of inspection, the approved written instruction/technique or procedure, part number(s) and serial number(s), reference standard used (including applicable S/N), inspector name, employee number and level of certification, acceptance criteria and indicate whether the part(s) was accepted or rejected. Documentation accompanying the part shall be certified with the letter E and the employee's identification number by ink stamping.

6.4.2 Include all Non Conformity Report references.

6.5 Disposition of Rejectable Parts

6.5.1 All rejected components shall be clearly identified as rejected, and quarantined for Engineering disposition. The parts shall be identified and traceable to the BA Non Conformity Report (NCR). All the relevant defect information such as defect type, size, shape and location shall be recorded and documented in accordance with BA Non Conformity Report (NCR) Procedure. Inspection records shall be retained for a retention period outlined per Quality Assurance requirements.

6.6 Inspection Records

6.6.1 Records shall be maintained for all inspected parts. The record shall include the part number, the serial number, the inspection facility identification, inspection date, inspection result, inspector identification, calibration reference standard(s) used and acceptance criteria. Inspector identification may be by signature, inspection stamp or electronic ID.

6.7 Qualification Requirements

6.7.1 General

6.7.1.1 No production processing shall be attempted before full approval / qualification status has been granted by BAMPE.

6.7.1.2 Qualified status automatically lapses for any qualified process that is inoperative for more than four months. The process is operative as long as acceptable routine process control specimens continue to be produced.

6.7.2 Process Qualification

6.7.2.1 Prior to production, the process shall be qualified by successful completion of the process qualification procedure per section 6.7.3.

6.7.2.2 Qualification of a process is site and line specific and is not transferable under any circumstances.

6.7.2.3 Once the process is qualified, no change shall be made to any of the processing conditions used to perform and control the process, without written agreement of BAMPE.

6.7.2.4 Approved subcontractors shall be listed in the Bombardier Aerospace Approved Supplier List (BAASL).

6.7.3 Qualification Tests

6.7.3.1 The purpose of the NDI System Qualification is to verify and demonstrate the system capability to reliably inspect material and maintain integrity to the requirements of this specification.

6.7.3.2 Standards for System qualification require design approval by Bombardier Toronto (de Havilland) MPE ET Level 3. The calibration reference standards (CRS) for system qualification shall meet the requirements of section 4.2.3. This maintains a scan quality standard appropriate for reliable detection of the relevant rejection criteria specified by engineering. An acceptable probability of detection is thereby established by equipment qualification, and maintained by the quality system and the use of part specific technique sheet requirements. The qualification shall be specific to the specified equipment and the range of parts listed, based on geometric configuration and material contingencies.

6.7.3.3 Each deviation shall be submitted with its applicable BT213-01 RFD with the Qualification package, including evidence, to Bombardier Toronto (de Havilland) MPE ET Level 3.

6.7.3.4 Process Qualification shall be reviewed by Bombardier Toronto (de Havilland) MPE ET Level 3. Corrective action will be implemented for any unsatisfactory results and a subsequent schedule submitted. If the Qualification package submitted is acceptable, Bombardier Toronto (de Havilland) MPE ET Level 3 shall issue a recommendation for approval to Supplier Quality Management (SQM).

6.8 Reproducibility Control

6.8.1 Prior to production, the process shall be developed to meet the requirements of this specification. Process parameters shall be documented in the form of a Technique Sheet or Written Instruction(s). All Technique Sheets or Written Instructions require approval by Bombardier Toronto (de Havilland) MPE ET Level 3.

6.8.2 Once approved, Technique Sheets or Written Instructions shall not be changed in any way, unless approved by Bombardier Toronto (de Havilland) MPE ET Level 3.

6.9 Process Controls - General Requirements

6.9.1 Quality shall ensure that all requirements of this specification and applicable approved deviations are met.

6.9.2 Bombardier Aerospace laboratories shall provide testing support for Bombardier production operations.

6.9.3 Bombardier Aerospace Accredited Laboratories listed in BAASL shall be used by Bombardier subcontractors to provide testing support for subcontractor production operations.

7 Safety Precautions

7.1 The safety precautions specified herein are specific to Bombardier Toronto to meet Canadian Federal and Provincial government environmental, health and safety regulations. It is recommended that other facilities consider these safety precautions; however, suppliers, subcontractors and partners are responsible for ensuring that their own environmental, health and safety precautions satisfy the appropriate local government regulations.

7.2 Observe general shop safety precautions when performing the procedure specified herein.

7.3 Precautions to be exercised when performing eddy current inspection include exposure to electrical current. The instrument shall be turned off when any equipment changes are made. Refer to the instrument operating manual for specific safety warnings.

7.4 Do not operate the equipment in an explosive environment unless all equipment has been certified as intrinsically safe.

7.5 When operating instruments on an external power source, ensure all the power cords are not damaged and are in a serviceable condition. Position cords where they cannot be stepped on or present a trip hazard.

7.6 Some of the cleaning materials used may be toxic, flammable and/or irritating to the skin. Consult the Environment, Health and Safety Department for specific handling precautions.

8 Personnel Requirements

8.1 Personnel responsible for performing eddy current crack detection must be certified according to BAERD GEN-012.

8.2 This PPS has been categorized as a “Controlled Critical Process” by PPS 13.39. Refer to PPS 13.39 for personnel requirements.