BOMBARDIER Toronto (de Havilland) PROPRIETARY INFORMATION	**PPS 20.01** **PRODUCTION PROCESS STANDARD**

Magnetic Particle Inspection

Issue 28
- This standard supersedes PPS 20.01, Issue 27.
- Vertical lines in the left hand margin indicate technical changes over the previous issue.
- This PPS is effective as of the distribution date.
- Validation of issue status is the responsibility of the user.

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Issue 28 - Summary of Changes (over the previous issue)

The following summaries are not detailed and are intended only to assist in alerting PPS users to changes which may affect them; refer to the applicable section(s) of this PPS for detailed procedure and requirements.

- Added authorization to use light emitting diode (LED) type black lights (e.g., Magnaflux EV6000) in place of high pressure, mercury vapour sealed reflector type lamps.
- Added provisions for use of special battery operated black light equipment.
- Replaced all reference to “NDT Level III” with reference to “NDT Level 3”.
- Added inspection schedule for AMS6415 parts.
- Revised procedure for approval of Technique Sheets and Manufacturing Instructions to specify that all new Technique Sheets or Manufacturing Instructions require approval by Bombardier Toronto (de Havilland) NDT Level 3 personnel.
- Corrected illustration of 100 mL centrifuge tube (i.e., corrected numbered level indications).
- Revised acceptability limits for fluorescence of the liquid of the suspension fluid sample checked every shift.
- Revised the daily system performance check to specify the addition of an artificial notched shim to the steel test ring and to specify that as a result of testing the artificial flaw in the artificial notched shim must be visible when viewed under black light.

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1 Scope

1.1 This Production Process Standard (PPS) specifies the procedure and requirements for detection of surface and sub-surface discontinuities in ferromagnetic parts and material by the magnetic particle inspection method.

1.1.1 As an alternative to the procedure and requirements specified herein, it is acceptable to perform magnetic particle inspection according to BAPS 176-004.

- Perform magnetic particle inspection according to the procedure and requirements of either BAPS 176-004 or this PPS in their entirety; a piecemeal approach utilizing certain sections or portions of BAPS 176-004 and this PPS is **not** acceptable.
- Subcontractor facilities which have been approved by Bombardier to perform magnetic particle inspection according to BAPS 176-004 are considered approved to perform magnetic particle inspection according to this PPS without further approval needed.
- PPS Process Standard Deviations (PSD's) issued against this PPS are **not** applicable to BAPS 176-004. Likewise, requests for deviation (RFD's) allowed against BAPS 176-004 are not applicable to this PPS.
- When processing parts according to BAPS 176-004 as an alternative to processing parts according to PPS 20.01, deviations allowed by an approved RFD against BAPS 176-004 may be used unless a specific limitation regarding program applicability is specified by the RFD comments/restrictions.

1.1.2 This PPS complements the engineering drawings that specify its use as an authorized instruction. Except as noted in para. 1.1.1, 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.

1.1.3 Refer to PPS 13.26 for the subcontractor provisions applicable to 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) 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 16.01 - Application of Hard and Soft Film (F13) Corrosion Preventive Compound.

3.2.4 PPS 16.20 - Temporary Corrosion Protection of Carbon and Low Alloy Steel Parts.

3.2.5 PPS 31.03 - Cleaning of Carbon and Low Alloy Steels.

3.2.6 PPS 31.05 - Surface Treatment of Corrosion Resistant Steels.

3.2.7 PPS 31.07 - Cleaning and Stripping of Painted Surfaces.

3.2.8 PPS 35.04 - Requirements for Steel Forgings.

3.2.9 PPS 35.07 - Requirements for Investment and Sand Castings.

3.2.10 PPS 37.10 - Requirements for Fusion Welds.

3.3 Bombardier Toronto (de Havilland) Internal Forms, Cards and Records

3.3.1 DH 4254 - Magnetic Particle Inspection Record Card.

3.3.2 DH 5107 - Non-Destructive Testing, Magnetic Particle Inspection Technique Card.

3.3.3 DH 5111 - MPI System Control Record.

3.3.4 DH 5112 - Ammeter Comparison Check Card.

3.3.5 DH 5113 - Black Light Record Card.

3.4 Bombardier Toronto (de Havilland) Internal NDT Written Practice

3.4.1 WP-001 – Nondestructive Testing Certification of Personnel.

3.5 **Bombardier Aerospace Engineering Requirements Documents**

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

3.6 **Bombardier Aerospace Forms**

3.6.1 BT0213-01 - Bombardier Aerospace Request for Deviation (RFD) Form.

3.7 **Industry Specifications**

3.7.1 AMS 2641 - Vehicle, Magnetic Particle Inspection - Type 1.

3.7.2 AMS 3045 - Magnetic Particles, Fluorescent, Wet Method, Oil Vehicle, Ready-To-Use.

3.7.3 AMS 3046 - Magnetic Particles Fluorescent Wet Method, Oil Vehicle, Aerosol Packaged.

3.7.4 ANSI/ASQ Z1.4-2008 - Sampling Procedures and Tables for Inspection by Attributes.

3.7.5 ANSI/ASQ Z1.9-2008 - Sampling Procedures and Tables for Inspection by Variables for Percent Nonconforming.

3.7.6 ASTM D 1966 - Standard Test Method for Foots in Raw Linseed Oil.

3.7.7 ASTM E 1444 - Standard Practice for Magnetic Particle Testing.

3.7.8 DOD-F-87935 - Fluid, Magnetic Particle Inspection, Suspension.

3.7.9 ISO 10012-1 – Quality Assurance Requirements for Measuring Equipment.

3.7.10 SAE AS5282 - Tool Steel Ring for Magnetic Particle Inspection.

3.7.11 SAE AS5371 - Reference Standard Notched Shims for Magnetic Particle Inspection (artificial flaw shims - QQI's).

4 **Materials, Equipment and Facilities**

4.1 **Materials**

4.1.1 Unless otherwise specified in this section, use only the materials specified; use of superseding or alternative materials is not allowed.

4.1.2 Hard grease and sealing plugs (e.g., wood, rubber or plastic).

4.1.3 Magnetic particle powder (fluorescent), AMS 3045.

4.1.4 Suspension fluid, DOD-F-87935 or AMS 2641, Type I.

4.1.5 Magnetic particles, aerosol packaged, for in-situ inspection to AMS 3046.

4.2 **Equipment**

4.2.1 All equipment and facilities employed in carrying out the process specified herein must be approved by Bombardier Aerospace as meeting the requirements of this standard and ASTM E 1444.

4.2.2 Magnetizing equipment, stationary wet method bench unit. Direct current (DC) used for magnetization may be obtained from a single or three phase alternating current (AC) source, full-wave rectified current (FWDC) obtained from a three-phase alternating current source and half-wave rectified current (HWDC) obtained from a single-phase AC source. The unit shall adequately meet the magnetizing and demagnetizing requirements of this specification without exhibiting damage to the part under examination and provide the necessary features required for safe operation.

4.2.3 Demagnetizing unit, open box type or other equivalent type capable of demagnetizing all parts inspected so that 3 Gauss is the maximum residual magnetic field intensity. When possible, place and position the demagnetization unit so that the long axis of the part being demagnetized is in an east-west direction.

4.2.4 Black light source, high pressure, mercury vapour sealed reflector type lamp, filtered through a 3600 ± 300 angstrom unit filter, providing a light intensity of 1200 $\mu W/cm^2$ or greater 15" from the light source. Special portable black light equipment may be used to supplement regular lights for inspecting inner surfaces of holes, tubing, recesses and otherwise inaccessible areas.

4.2.4.1 It is acceptable to use light emitting diode (LED) type black lights (e.g., Magnaflux EV6000) in place of high pressure, mercury vapour sealed reflector type lamps.

4.2.4.2 Special battery operated black light equipment may be used to supplement regular black light for inspecting inside surfaces of holes, tubing and otherwise inaccessible areas. Special black light equipment may be used for portable on site inspections, when necessary provided that conditions noted in para. 4.2.5 are met. Compensate for drop-off in light intensity by positioning the black light source closer to the inspection surface.

4.2.5 Darkened work area or inspection booth whose ambient white light background does not exceed 2 foot-candles (20 lux).

4.2.6 Centrifuge tube, meeting the requirements of ASTM D 1966.

4.2.7 Field indicator (e.g., Magnetic Analysis #432 Indicator or Magnaflux Field Indicator).

4.2.8 Magnetic field strength meter (Gauss meter) capable of measuring the peak values of the tangential field strength on the part surface, in the range of 30 to 60 Gauss (e.g., Ardrox MD 200 Field Strength Meter).

4.2.9 Black light intensity light meter (e.g., Ultra Violet Products Inc., Model J-221).

4.2.10 Light meter suitable for testing ambient white light intensity.

4.2.11 Suitable calibration and testing equipment (e.g., quick break tester, shunt meter; timer control device, pie field indicator, etc.).

4.2.12 ANSI Ketos 01 tool steel ring or SAE AS5282 tool ring, meeting the requirements of ASTM E 1444.

4.2.13 SAE AS5371 reference standard notched shims, meeting the requirements of ASTM E 1444.

4.3 Facilities

4.3.1 This PPS has been categorized as a "Controlled Critical Process" according to PPS 13.39 and, except as noted in para. 1.1.1, only facilities specifically approved according to PPS 13.39 are authorized to perform magnetic particle inspection according to this PPS.

4.3.1.1 Facilities approved to perform magnetic particle inspection according to BAPS 176-004 are also considered approved to perform magnetic particle inspection according to this PPS without further approval needed (i.e., approval according to PPS 13.39 is not required).

4.3.2 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.

4.3.3 Facility approval shall be based on a facility report, a facility survey and completion of a qualification test program, 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.

4.3.3.1 Unless otherwise specified by Bombardier Aerospace Supplier Quality Management, approval of subcontractor facilities to perform magnetic particle inspection according to this PPS does not require completion of a test program or submission of test samples.

5 Procedure

5.1 General

5.1.1 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 Manufacturing Instructions (e.g., DH 5107). All new Technique Sheets or

Manufacturing Instructions require approval by Bombardier Toronto (de Havilland) NDT Level 3 personnel. Once approved, Technique Sheets or Manufacturing Instructions shall not be changed in any way, without re-approval.

5.1.2 Unless otherwise specified on the engineering drawing, inspect parts according to Table 1.

Table 1. Inspection Schedule

Material or Part Group	**Inspection** (Note 1)
Cargo tie-down and safety belt attachment fittings	100% inspection
Coil springs	100% inspection or as determined by Bombardier Aerospace
Engine mounts, attachment fittings and mounting bolts	100% inspection
Flash butt welded joints	100% inspection
Fusion welded parts	Inspect according to PPS 37.10
Heat treated non-standard bolts, nuts, screws and pins 1/4" and under in diameter	Sample inspect according to ANSI/ASQ Z1.4-2008 and ANSI/ASQZ1.9-2008
Heat treated non-standard bolts, nuts, screws and pins over 1/4" in diameter	100% inspection or as determined by Bombardier Aerospace
Heat treated steel parts	100% inspection or as determined by Bombardier Aerospace
Investments and sand castings	Inspect according to PPS 35.07
Landing gear attachment fittings and shock absorbing devices	100% inspection
MIL-S-5000 or AMS6415 parts	100% inspection or as determined by Bombardier Aerospace
Steel forgings	Inspect according to PPS 35.04
Wing, fin and stabilizer attachment fittings and bolts	100% inspection

Note 1. If an engineering drawing, product specification or process sheet specifies magnetic particle inspection, this table shall not be construed to be in conflict with it.

5.1.2.1 Each technique shall be developed that will consistently produce the required test results and quality level. The Technique Sheet shall include at least the following information or elements, either directly or by reference to the applicable documents.

a) Procedure/Technique unique identification number and the date it was written.

b) Part Number, part & material description and heat treat condition.

c) Part surface condition prior to inspection and stage of inspection.

d) The type of magnetizing current and the equipment to be used (i.e. machine number and type).

e) The number turns in the fixed coil.

f) A drawing of the part showing the direction of the magnetic field for circumferential and/or longitudinal magnetization (head, central conductor, coil, etc.) and the areas of the part that are in contact with the electrodes. The placement location of the Gauss meter or artificial flaw shims on the part used to verify the field strength and direction.

g) A table listing the inspection sequence, the direction of magnetization, the current level and/or number of ampere turns to be used, including any demagnetization between shots. The inspection sequence number shall also be indicated on the drawing.

h) Type of magnetic particle material used i.e. wet or dry, fluorescent or visible and the method of application.

5.2 Manufacturing Inspection Sequence

5.2.1 Magnetic particle inspect parts after completion of any operations that may cause surface and/or sub-surface discontinuities including grinding, final machining, heat treatment, straightening and proof loading.

5.2.2 Except for parts to be electroplated, perform magnetic particle inspection before the application of platings. For parts to be electroplated, perform magnetic particle inspection as indicated in Table 2.

5.2.3 Magnetic particle inspect welded assemblies after final heat treatment and straightening operations and before finish machining.

5.2.4 Always carry out magnetic particle inspection before shot peening and before applying organic finishes (e.g., paint, grease, dry film lubricant, etc.).

Table 2. Magnetic Particle Inspection of Parts to be Electroplated

Final Electroplate Thickness	Magnetic Particle Inspection
Less than 0.0008"	Perform magnetic particle inspection either before or after electroplating.
0.0008" - 0.0050"	Perform magnetic particle inspection both before and after electroplating (Note 1).
Greater than 0.0050"	Perform magnetic particle inspection before electroplating.

Note 1. For steels with a tensile strength less than or equal to 160 ksi, magnetic particle examination after electroplating as well as before electroplating is not required (i.e., it is acceptable to perform magnetic particle inspection only before electroplating).

5.3 **Preparation of Suspension Bath**

5.3.1 Prepare the suspension bath as follows:

Step 1. Ensure that the magnetic particle powder is free of contamination.

Step 2. Ensure that the tank and the appliances within it are clean.

Step 3. Fill the tank to the operating level with suspension fluid.

Step 4. Measure out a suitable amount of magnetic particle powder for each gallon of solution in the tank and pour into a clean container.

Step 5. Fill the container with suspension fluid and mix.

Step 6. Turn on the tank motor and slowly add the mixture to the tank.

Step 7. Allow the motor to run for at least 30 minutes to thoroughly mix the suspension fluid.

Step 8. Test the mixture for the volume of magnetic particles according to section 9.3.1.

Step 9. Record the type of suspension fluid and magnetic particle powder used to make up the bath.

5.4 **Part Preparation**

5.4.1 Clean parts as follows:

Step 1. Remove grease, oil, rust, scale, paint or other substances which may interfere with the concentration of magnetic particles at defects or which may improperly accumulate or concentrate magnetic particles in a non-defective area.

Step 2. Strip paint according to PPS 31.07.

Step 3. Clean parts according to PPS 31.03 or PPS 31.05, as applicable.

Step 4. If necessary to facilitate inspection, grit blast or wire brush rough forgings.

5.4.2 Seal all portions of parts and assemblies which may be damaged by the suspension fluid or which are so shaped that accumulations of the magnetic particles could not be removed. Use wood, rubber, plastic sealing plugs or hard grease for sealing. Do not mask the edges of the sealed openings with the sealing material. Such edges must remain visible to allow inspection for defects.

5.4.3 If previous inspections have produced a residual magnetic field in the part, de-magnetize the part according to section 5.5.5.

5.5 Inspection Procedure

5.5.1 General

5.5.1.1 For each part number, record the inspection technique and method on the MPI Technique Card (e.g., DH 5107).

5.5.1.2 The inspection shall start at the lowest amperage, based on the smallest cross section and with increasing steps to cover each increase in section.

5.5.1.3 When circular and longitudinal magnetizations are used to inspect a part, the circular magnetization shall precede the longitudinal magnetization.

5.5.1.4 AC/DC electromagnetic yokes may be used to supplement other methods of magnetization.

5.5.1.5 The applied magnetic field shall have sufficient strength to ensure detection of discontinuities.

5.5.1.6 For magnetization current and field strength verification the use of a Gauss meter and/or artificial flaw indicator such as a flaw shim (ref. para. 4.2.13) is required to verify the field strength and direction on all parts. When using a Gauss meter, field strength readings in the range of 30 to 60 Gauss (2.4 to 4.8 kA/m) measured anywhere on the part surface are considered adequate.

5.5.1.7 Magnetization consists of two shots of 0.5 - 1.0 second duration at the current level specified on the MPI Technique Record Card. Magnetize parts in at least two directions, 90° apart. Depending on part geometry, this may consist of:

- Circular magnetization (ref. section 5.5.2) in two or more directions
- Both circular magnetization (ref. section 5.5.2) and longitudinal magnetization (ref. section 5.5.3)
- Longitudinal magnetization (ref. section 5.5.3) in two or more directions

5.5.2 Circular Magnetization

5.5.2.1 The circular magnetic field surrounds the part at normal to the applied current. Circular magnetization can be obtained using the Direct Contact Method (Head Shot) as per para. 5.5.2.2 or the Central Conductor Method (Indirect) as per para. 5.5.2.3.

5.5.2.2 Apply circular magnetism using the Direct Contact Method (Head Shot) as follows:

a) When passing electrical current directly through the part by clamping it between electrodes, ensure that the contact areas are clean and sufficient pressure applied to prevent burning (arcing) at the contact areas.

b) Use copper braided pads between the electrodes and the part.

c) When developing magnetic particle inspection techniques for particular parts, the current shall be from 300 to 800 A/inch of part diameter where the diameter is the greatest distance between any two points along the outside circumference of the part. Normally currents will be 500 A/inch or lower, with the higher current up to 800 A/inch being used to inspect for inclusions or to inspect low permeability alloys such as precipitation hardened steels. Higher amperages, up to 1000 A/inch may be used to detect subsurface inclusions in precipitation hardened steels.

d) Field strengths in the range of 30 - 60 Gauss peak values of tangential field measured on the part surface are adequate when using a gauss meter.

e) The use of QQI s is strongly recommended for magnetic field strength validation.

5.5.2.3 Apply circular magnetism using the Central Conductor Method (Indirect) as follows:

a) Whenever possible, use the central conductor method to inspect the inner surfaces of hollow parts and ring shaped parts. If the wall thickness is not excessive, both the inner and outer walls of the part can be inspected, thus eliminating a head shot.

b) The central conductor used shall be as large a diameter as practical.

c) The central conductor shall be made from a nonferrous and highly conductive material such as copper.

d) When developing magnetic particle inspection techniques for particular parts for centrally located conductors (see Figure 1), the current shall be from 300 to 800 A/inch of part diameter where the diameter is the greatest distance between any two points along the outside circumference of the part. Normally currents will be 500 A/inch or lower, with the higher current up to 800 A/inch being used to inspect for inclusions or to inspect low permeability alloys such as precipitation hardened steels. Higher amperages, up to 1000 A/inch may be used to detect subsurface inclusions in precipitation hardened steels.

e) When developing magnetic particle inspection techniques for particular parts for offset central conductors (see Figure 2), the current levels specified for centrally located conductors shall apply except that the diameter shall be the sum of the central conductor's diameter plus twice the wall thickness. The distance along the inner circumference of the part that is effectively magnetized shall be four times the diameter of the central conductor as shown in Figure 2. The entire circumference shall be inspected by rotating the part on the conductor, allowing for approximately 10% magnetic field overlap.

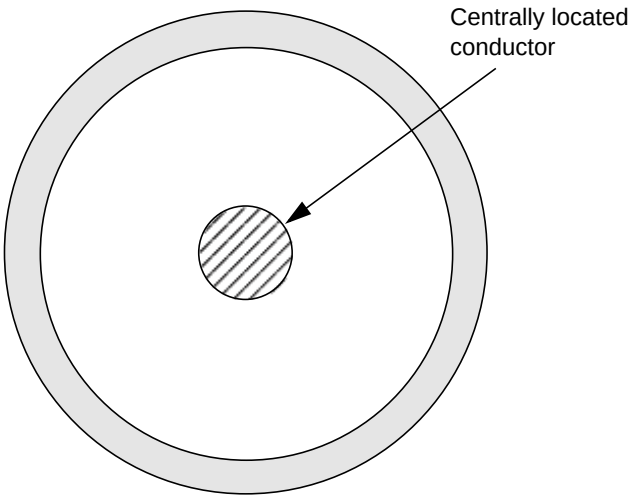


Figure 1. Centrally Located Conductor in Cylindrical Part

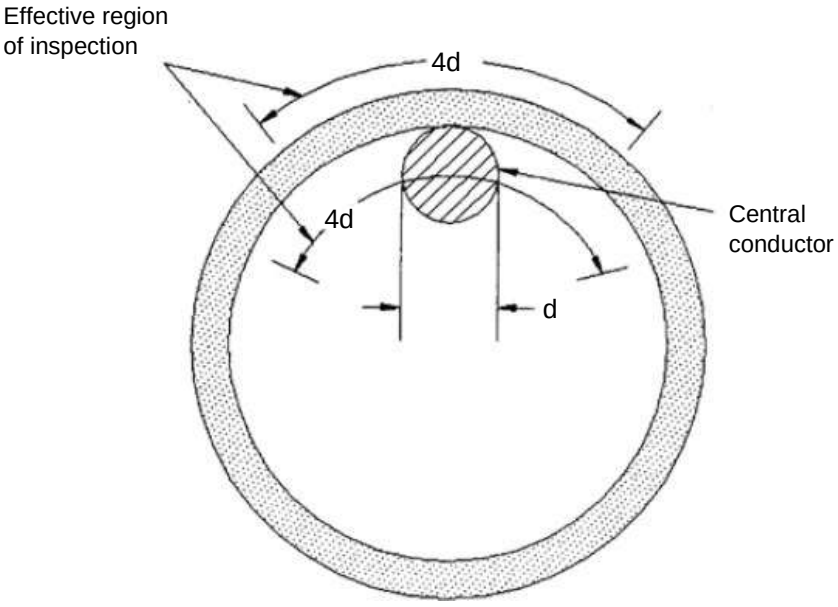


Figure 2. Offset Central Conductor in Cylindrical Part

5.5.3 Longitudinal Magnetization

5.5.3.1 Longitudinal magnetization is obtained by passing current through a coil (solenoid) encircling the part. The indirectly induced magnetic field in the part is approximately parallel to the axis of the coil. Electromagnetic yokes and permanent magnets also induce a longitudinal magnetic field in the part.

5.5.3.2 When developing magnetic particle inspection techniques for particular parts, refer to ASTM E 1444 for formulae related to determining the required current level. based on coil fill factor. Consider the formulae referenced in ASTM E 1444 only as a guide to establish the required current level.

5.5.4 **Application of Magnetic Particles & Inspection**

5.5.4.1 Except as noted in para. 5.5.4.2, apply magnetic particles and inspect parts using the Continuous Method as follows:

Step 1. Gently spray or wash the suspension fluid over the part surface to be inspected.

Step 2. Divert the stream of suspension fluid from the part simultaneously with, or just before, energizing the magnetic circuit according to para. 5.5.1.7.

Step 3. After each magnetization examine the part thoroughly for particle indications. Interpret and evaluate any discontinuity detected to determine if it meets the acceptance or rejection criteria according to section 6.

5.5.4.2 If specifically authorized by NDT Level 3, apply magnetic particles and inspect parts using the Residual Magnetization Method to aid in the interpretation of questionable indications as follows:

Step 1. Apply the magnetizing current according to para. 5.5.1.7.

Step 2. Apply the magnetic particles to the surface of the part immediately after magnetizing.

Step 3. After each magnetization examine the part thoroughly for particle indications. Interpret and evaluate any discontinuity detected to determine if it meets the acceptance or rejection criteria according to section 6.

5.5.4.3 If linear surface indications are evident on 15-5 PH, 17-4 PH, 17-7 PH or Custom 455 steel parts, confirm indications as follows:

Step 1. Clean the part according to section 5.6.

Step 2. Fluorescent penetrant inspect the part according to PPS 20.03 using the immersion method for a penetrant dwell time of 30 minutes minimum.

Step 3. If the defect indications re-appear, classify and disposition parts according to section 6. If the defect indications do not re-appear, refer to Liaison Engineering or NDT Level 3 for disposition.

5.5.5 **Demagnetization**

5.5.5.1 Demagnetize material or parts between magnetizing operations whenever residual magnetism could interfere with the interpretation of indication, and after completion of magnetic particle inspection.

5.5.5.2 If possible, magnetize parts in the longitudinal direction before demagnetization.

5.5.5.3 When using AC demagnetization, subject the parts to a field with a peak value greater than, and in nearly the same direction, as the field used during inspection; this AC field is then decreased gradually to zero. Hold the part approximately one

foot in front of the AC demagnetizing coil and move it slowly through the coil and at least three feet beyond the end of the coil. Rotate and tumble parts of complex shape while passing through the coil.

5.5.5.4 When using DC demagnetization, the initial field shall be greater than and nearly in the same direction as the field reached in the part during inspection. The field shall then be reversed, decreased in magnitude, the process repeated until an acceptable value of residual field is reached.

5.5.5.5 After demagnetization, place a magnetic field indicator on several areas of the part. The residual fields in all areas shall not exceed 3 Gauss.

5.6 Post Inspection Procedure

5.6.1 Clean parts as follows:

Step 1. Remove all sealing materials.

Step 2. Clean according to PPS 31.03 or PPS 31.05, as applicable.

5.6.2 Unless the parts will be subjected to further processing immediately after cleaning and demagnetizing, protect magnetic particle inspected parts with F13 Grade 3 corrosion preventive compound according to PPS 16.01 or with a suitable non-detergent oil treatment according to PPS 16.20.

6 Requirements

6.1 If parts show indications of defects, determine the nature of the defect as acceptable or unacceptable as specified in para. 6.1.1, para. 6.1.2 and para. 6.1.3. If there is doubt about the extent of the defect(s), submit parts with indefinite indications to a qualified NDT Level 3 to perform a comprehensive examination to determine the extent of the defect(s).

6.1.1 The following are considered acceptable:

a) magnetic writing

b) indications produced by abrupt changes in section

c) indications of cold work or hard or soft spots

d) normal machine or die marks

e) minor nicks, scratches or pits

f) indications in the weld plane of flash butt weld joints where the flash has not been removed

g) minor longitudinal indications in the shank or threads of bolts, on the threads of screws or on the outside of nuts

6.1.2 The following are considered unacceptable:

a) Unless otherwise specified (i.e., by engineering drawing or PPS), linear type indications, heat treat cracks, cooling cracks, seams, laps, voids or other discontinuities are considered unacceptable defects unless subsequent machining, if any, will fully remove the defect. If a defect has been accepted on the basis that it will be removed by subsequent machining, the part must be re-inspected after machining to ensure the defect has been removed. If a defect has not been removed by subsequent machining, reject the part.

b) Bolts or screws are not acceptable if exhibiting evidence of a) inclusions, nicks or gouges deeper than 0.010" on the head; b) cracks in the fillet from head to shank (longitudinal seams up to 0.005" deep are acceptable in this area); c) transverse indications on the shank, threads or fillet; d) heat treat cracks; or e) grinding cracks on the shank thread.

c) Nuts with longitudinal cracks deeper than 0.005" on either the outside or inside diameter penetrating into either end face are not acceptable.

6.1.3 Design factors such as keyways, drilled holes, abrupt changes in section, metallurgical changes and permeability variations may produce non-relevant or false indications. These indications can be minimized by reducing the current. Magnetic writing, this indication appears as a scrawl due to one part rubbing against another. Any indication which is believed to be non-relevant shall be regarded as unacceptable, until a re-inspection by the same method or another nondestructive inspection method indicates that the indications are non-relevant. Non-relevant indications that may mask a discontinuity indication are unacceptable.

6.2 If a Test Report is required, it shall include as a minimum the following information:

a) Name of the company; work location.

b) Description and identity of the part tested.

c) Stage of test (e.g. before or after heat treatment, before or after final machining).

d) Reference to the written test procedure and the technique sheets used

e) Description of equipment used.

f) Magnetization technique, including indicated current values, tangential field strengths, waveform, contact or pole spacing, coil dimensions, etc.

g) Detection media used; surface preparation; viewing conditions; maximum residual field strength after test, if appropriate; method of recording or marking of indications.

h) Date of test; name, qualification and signature of the person performing the tests.

i) Test results including a detailed description of the indications and a statement as to whether they meet the acceptance criteria.

6.3 Maintain a record for each part number of items inspected according to this PPS. Record the appropriate information on the NDT MPI Record Card (e.g., DH 4254).

6.4 Identify each item of an inspected and accepted lot with the appropriate NDT stamp. If individual stamping is impractical due to the size or quantity of parts, a bagging or tagging method may be employed. Use blue dye to mark parts accepted on a 100% inspection basis. Use orange dye to mark parts accepted on a sampling basis. If a bagging or tagging method is employed instead of stamping each individual part, mark the bag or tag with the appropriate colour dye. If possible, apply the marking in a location such that it will not be removed by subsequent handling. Due to the possibility that the NDT stamp on a part may be obliterated during subsequent processing, the NDT stamp in supporting records on file is sufficient evidence that the part has been non-destructive tested.

7 Safety Precautions

7.1 **The safety precautions specified herein are specific to Bombardier Toronto (de Havilland) 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 **Some of the materials used in this specification may be toxic, flammable and/or irritating to the skin. Observe all of the safety precautions specified by each manufacturers MSDS (including specific requirements related to facilities, equipment, ventilation and handling precautions, etc.).**

8 Personnel Requirements

8.1 Personnel responsible for performing magnetic particle inspection must be certified according to BAERD GEN-012.

8.2 Personnel who are engaged in specifying, reviewing, monitoring or evaluating test methods must be qualified NDT Level 3 according to BAERD GEN-012.

8.2.1 Subcontractor/supplier personnel performing NDT Level 3 activities must also be approved by Bombardier Toronto (de Havilland) NDT Level 3.

8.3 At Bombardier Toronto (de Havilland) only, certification according to WP-001 constitutes certification to BAERD GEN-012.

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

9 Maintenance of Solutions and Equipment

9.1 General

9.1.1 If no inspection will be performed within the frequency specified (i.e., if the frequency required is daily and there will be no inspection that day) then it is acceptable to waive that maintenance/inspection check. Before resuming inspection, perform each type of maintenance/inspection check which has been waived. Maintain a record of checks performed or waived in the MPI System Control Record (e.g., DH 5111).

9.2 Continuous Checks

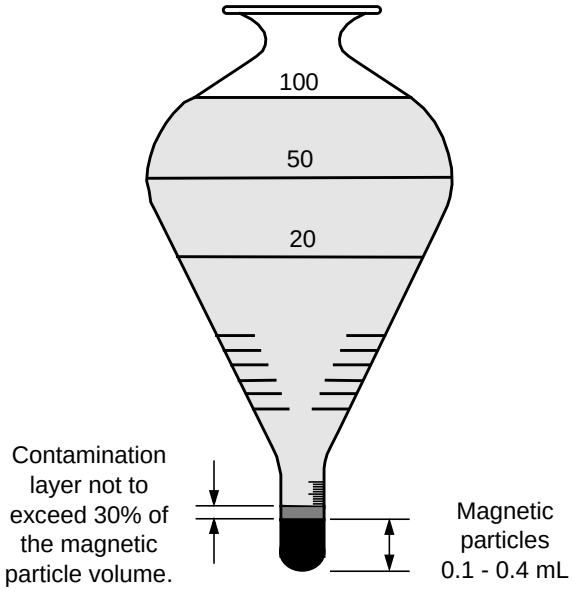
9.2.1 Maintain a constant observation on the suspension for evidence of contamination by oil or foreign particles and for changes in fluorescence or colour under black light. If evidence of any of these conditions is detected, drain and clean the tank and refill according to para. 5.3.1.

9.3 Checks Performed every Shift

9.3.1 At the start of each 8 hour shift, check the suspension for correct operating strength and contamination as follows:

Step 1. Scrape the sides of the tank to remove adhering magnetic particles and run the tank motor for 30 minutes to completely mix the particles and fluid.

Step 2. Transfer sufficient suspension fluid from the bath to a centrifuge tube to bring it up to the 100 mL mark as shown in the adjacent figure.



Step 3. De-magnetize the suspension and place the centrifuge tube in a stand located in a vibration free location.

Step 4. Allow the suspension to stand for 60 minutes or until the solids have fully settled.

Step 5. The volume of magnetic particles must be 0.1 - 0.4 mL, not including the volume of any contamination layer. If the reading is higher than allowed, add sufficient suspension fluid to the tank to bring the reading within the specified limits. If the reading is lower, add the appropriate type of magnetic particle powder to the tank according to para. 5.3.1. When replenishing the bath, refer to the recorded bath make-up data to ensure that the type of suspension fluid and magnetic particle powder being added is the same as that of the original bath. Record any additions to the bath in the MPI System Control Record (e.g., DH 5111). The fluorescent quality of the magnetic particles must be bright and distinct when inspected under black light.

If there is any evidence of a loss of fluorescence, drain and clean the tank and refill according to para. 5.3.1.

Step 6. Check the fluorescence in the liquid above the precipitate when inspected under black light. The fluorescence in the liquid should be comparable to the fluorescence of the original unused solution. If there is evidence of fluorescence exceeding that of the original unused sample in the liquid, drain, clean and refill the tank according to para. 5.3.1. Fluorescence exceeding that of the original unused sample would indicate that the magnetic particles have lost some of their fluorescent coating or the fluid has become contaminated with fluorescent foreign material.

Step 7. Examine the area immediately above the magnetic particles for evidence of a contamination layer and check if the contamination layer fluoresces when inspected under black light. If the contamination volume exceeds 30% or shows fluorescence, drain, clean and refill the tank according to para. 5.3.1.

9.3.2 At the start of each 8 hour shift, perform a short circuit check of the magnetizing equipment as follows:

Step 1. Position the head plates 14" apart without any workload on the system.

Step 2. Operate the magnetizer in circular field and check the ammeter for current flow. Current flow indicates a short circuit in the system.

Step 3. Record daily readings in the MPI System Control Record (e.g., DH 5111). Notify the Maintenance Department when a short circuit is detected in the system.

9.4 **Daily Checks**

9.4.1 Clean the magnetic particle inspection unit filter daily and maintain a record of the cleaning in the MPI System Control Record (e.g., DH 5111).

9.4.2 Check all black light sources to be used daily as follows. If more than one black light source is used, record the black light intensities on the Black Light Record Card (e.g., DH 5113). The record shall indicate qualification of the black lights to this standard.

Step 1. Ensure that the black light meter has a valid calibration tag affixed to it.

Step 2. Measure the black light intensity at the center of the beam in a totally dark environment. The intensity as measured with a black light meter shall be at least 1200 $\mu W/cm^2$ measured at a distance of 15" from the face of the filter.

When using special battery operated black light equipment, black light intensity measurements must be performed before and after magnetic particle inspection. If the black light intensity requirement is not met after magnetic particle inspection, all parts processed since the last acceptable black light intensity verification must be re-processed.

Step 3. Record the intensity on the MPI System Control Record Card (e.g., DH 5111). The

record must indicate qualification of the black light to this PPS.

9.4.3 Check the ambient white light intensity in the booth daily with a suitable white light meter. The ambient white light intensity shall not exceed 2 foot-candles (20 lux).

9.4.4 Every day check the system performance of the magnetic particle inspection unit using the wet continuous method with circular magnetization and a KETOS 01 or AS 5282 steel test ring as follows:

Step 1. Demagnetize the steel test ring according to section 5.5.5.

Step 2. Place a non-ferromagnetic conductor with a diameter between 1" and 1.25" through the center of the ring.

Step 3. Center the ring on the conductor.

Step 4. Attach an artificial notched shim similar to those required by ASTM E 1444, with the notch towards the ring specimen, approximately 0.5" from the #1 hole, away from inspector. The shim may be placed on the outer radius or the side of the ring.

Step 5. Magnetize the ring circularly by passing the required current through the conductor. Use the current levels of Table 3 as applicable to the ring being used.

Step 6. Apply the suspension to the ring using the continuous method.

Step 7. Examine the ring within 1 minute after current application. Perform the examination under a black light source meeting the requirements of para. 4.2.4 in a darkened work area or inspection booth meeting the requirements of para. 4.2.4.1. The number of hole indications shall meet or exceed those specified in Table 3, as applicable to the ring and amperage being used. In addition, the artificial flaw indication in the artificial notched shim shall be visible. Maintain a record of the results on the MPI System Control Record (e.g., DH 5111).

Table 3. System Performance - Required Indications

Type of Ring	Type of Particles	FWDC Amperage (±10%)	Minimum Number of Holes Indicated
KETOS 01 Tool Steel Ring	Fluorescent Oxides (Wet)	1400	3
		2500	5
		3400	6
AS 5282 Ring	Fluorescent Oxides (Wet)	500	3
		1000	5
		1500	6
		2500	7
		3500	9

9.5 **Weekly Checks**

9.5.1 Except for magnetic particle inspection units equipped with screen filters which prevent clogging of the agitator tube, clean the agitator tube every week and maintain a record of the cleaning in the MPI System Control Record (e.g., DH 5111). For magnetic particle inspection units equipped with screen filters which prevent clogging of the agitator tube, it is acceptable to omit agitator tube cleaning provided that the screen filters are cleaned on at least a weekly basis and a record of screen filter cleaning is maintained in the MPI System Control Record (e.g., DH 5111).

9.6 **Semi-Annual Checks**

9.6.1 At least every 6 months, check ammeter accuracy as follows:

Step 1. Connect an ammeter calibrated according to ISO 10012-1 in series with the output circuit.

Step 2. Take comparative readings at a minimum of three output levels covering the usable range of the equipment. The equipment ammeter reading shall not deviate by more than ± 10% or 50 Amperes, whichever is greater, than the current value shown by the ISO 10012-1 calibrated ammeter. Record and keep the results on file.

9.6.2 At least every 6 months, meters used for measurement of light intensity both black light and white light shall be certified and recertified at the required intervals and be accurate to ± 5% of the standard reading. The value of 5% is in reference to a comparison of the light meter being calibrated to another calibrated (traceable to NIST or other National Standard) light meter. It is not meant to represent a “True” ± 5% calibration tolerance. The calibration shall be performed at a minimum of 3 points to establish linearity. Record and keep the results on file.

9.6.3 For equipment using a timer to control the applied current duration, at least every 6 months the timer shall be checked for its accuracy with a certified electronic timer. The timer must accurate within ± 0.1 second.

9.6.4 At least every 6 months, perform a magnetic field quick break check. Perform the test with a suitable oscilloscope or other applicable method as specified by the equipment manufacturer for proper function of the quick break circuitry.

9.6.5 At least every 6 months, perform a dead weight check.

a) The lifting force requirement for AC electromagnetic is at least 10 lbs with a 2" - 6" spacing between the legs.

b) The lifting force requirement for DC electromagnetic is at least 30 lbs with a 2" - 4" spacing between the legs.

c) The lifting force requirement for DC electromagnetic is at least 50 lbs with a 4" - 6" spacing between the legs.

9.6.6 At least every 6 months, certify Gauss meters to NIST traceable standards per ISO 10012-1. The minimum accuracy is 5% of the full scale taken at a minimum of 3 points within the range of use.

9.6.7 At least every 6 months, certify field indicators to NIST traceable standards per ISO 10012-1. The minimum accuracy is 5% of the full scale at a minimum of 1 point within the range used.

10 Eye-Wear and Dark Adaptation

10.1 Do not wear sunglasses (regular or prescription) or light-sensitive glasses (photo-grey) when inspecting parts as they reduce the resolution of defects.

10.2 It is recommended that glasses with lenses treated to absorb UV light be worn when inspecting parts.

10.3 Before inspecting parts, allow the eyes to adjust to the darkness for a minimum of one minute.