1.0 PURPOSE

This procedure outlines the requirements for the Magnetic Particle examination of ferro-magnetic materials or the Liquid Penetrant examination of non-porous materials in accordance with the following standards:

ASTM E709
ASTM E165

2.0 QUALIFICATION OF PERSONNEL

All personnel performing Magnetic Particle Inspection shall be qualified to CGSB (Canadian General Standards Board) 48.9712 Level 2 or 3 or as required by the referencing code or specification.

3.0 MATERIALS

Magnetic Particles

One of the following Magnetic particle materials may be used,

a) Wet fluorescent magnetic particle (Aerosol cans)
b) Wet visible magnetic particle (Aerosol cans)
c) Dry magnetic particle (red, black, yellow or light grey)
d) White contrast paint

The particles shall be treated to impart color (fluorescent pigments, nonfluorescent pigments or both) in order to make them highly visible (contrasting) against the background of the surface being examined.

Dry and wet particles, including wet particle suspension vehicles and particle concentrations shall be in accordance with ASTM E-709.

Particles shall be used within the temperature range limitations set by the manufacturer.
Liquid Penetrant
One of the following Liquid Penetrant materials combinations can be used.

Examples of Water Washable and Solvent Removable Product Families

<table>
<thead>
<tr>
<th>Water Washable</th>
<th>Manufacturer</th>
<th>Penetrant</th>
<th>Developer</th>
<th>Cleaner</th>
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<tbody>
<tr>
<td>Visible</td>
<td>Magnaflux</td>
<td>Spotcheck</td>
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<td>SKL-4C</td>
<td>SKD-S2</td>
<td>SKC-S</td>
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<td>SKL-WP2</td>
<td>SKD-S2</td>
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<th>Developer</th>
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<td>Spotcheck</td>
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<tr>
<td></td>
<td></td>
<td>SKL-SP2</td>
<td>SKD-S2</td>
<td>SKC-S</td>
</tr>
</tbody>
</table>

All chemicals used shall be of the same family, other equivalent manufacturers chemical may be used.

4.0 PRE-CLEANING

Prior to Liquid Penetrant Examination or Magnetic Particles Examination, the surface to be examined and all adjacent areas within at least 1” (25mm), shall be dry and free of any dirt, grease, lint, scale, welding flux, weld spatter, oil, or other extraneous matter, that could obscure surface openings, impede particles movement or otherwise interfere with the examination.

Typical cleaning agents which may be used, are detergents, organic solvents, descaling solutions, and paint removers. Degreasing and ultrasonic cleaning methods may also be used.

Cleaning solvents for Liquid penetrant Inspection shall meet the requirements of Annex A of ASTM E165.

5.0 DRYING AFTER CLEANING

After cleaning, drying of the surface to be examined shall be accomplished by normal evaporation or with forced hot (drying oven) or cold air. A minimum period of time shall be established (ten minutes) to ensure solution as evaporated prior to the application of the penetrant or magnetic particles.
6.0 MAGNETIC PARTICLE EQUIPMENT

Electromagnetic Yoke AC, DC or AC/DC

Permanent Magnet

Black light (U/V light intensity ≥1000 uw/cm²)

Black Light Meter

White light source (≥ 100 foot-candles)

White Light Meter

7.0 CALIBRATION OF YOKES

Calibration check of yokes shall be performed in accordance with SPEC-83014

8.0 BLACK LIGHT CALIBRATION

Black Light calibration shall be performed in accordance with SPEC-83014

9.0 APPLICATION OF PARTICLES

Dry Particles: Dry powder should be applied in such a manner that a light uniform dust-like coating settles on the surface to be tested, an applicator specifically designed for the purpose should be used. Dry powder must not be applied to a wet surface. Care should be taken in removing excess powder from the surface by blowing the excess powder lightly while the magnetizing current is present. Accumulations of excess dry particles in examinations shall be removed with a light air stream from a bulb or syringe or other source of low pressure air (mouth).

Wet Particles: Fluorescent or non-fluorescent suspended in a recommended concentration may be applied by spraying over the part. When using the non-fluorescent particles white paint should first be applied giving high contrast to the area being inspected. Visible and fluorescent wet suspension shall be contained in aerosols. Wet particles applied from aerosol spray cans may be applied before and/or after magnetizing current is applied. Wet particles may be applied during the application of magnetizing current if they are not applied directly to the examination area and are allowed to flow over the examination area or are applied directly to the examination area with low velocities insufficient to remove accumulated particles.
10.0 MAGNETIC PARTICLES INSPECTION EXTENT AND METHOD

Fluorescent magnetic particle inspection is performed using an ultraviolet light (nominal wavelength is 365 nm), called black light. The examination shall be performed as follows:

(a) It shall normally be performed in a darkened area unless clearly identified in the report.
(b) Examiners shall be in a darkened area for at least 5 min prior to performing examinations to enable their eyes to adapt to dark viewing. Glasses or lenses worn by examiners shall not be photochromic or exhibit any fluorescence.
(c) Black lights shall achieve a minimum of 1000 uW/cm² on the surface of the part being examined throughout the examination.
(d) Reflectors, filters, glasses, and lenses should be checked and, if necessary, cleaned prior to use. Cracked or broken reflectors, filters, glasses, or lenses shall be replaced immediately.

Visible magnetic particle inspection shall take place with a minimum white light intensity at the inspection surface of 100 foot candles.

The AC method shall only be applied to detect discontinuities that are open to the surface of the part.

10.1 NONMAGNETIC SURFACE CONTRAST ENHANCEMENT

Nonmagnetic surface contrasts may be applied by the examiner to uncoated surfaces, only in amounts sufficient to enhance particle contrast.

10.2 MAGNETIC PARTICLE EXAMINATION USING THE AC YOKE TECHNIQUE ON FERRITIC MATERIALS COATED WITH NONMAGNETIC COATINGS

Normally, paint and other non-magnetic coatings should be removed to improve the sensitivity of the inspection. But if at the request of the customer, the inspection is to be done through paint, it shall be clearly indicated on the report.

10.3 DIRECTION OF MAGNETIZATION

Whichever method is used to produce magnetization, the maximum sensitivity is to linear indications that are perpendicular to the lines of flux. Each area of the part being examined shall be magnetized at least twice so that the lines of flux from one examination are perpendicular to the second.
All examinations shall be conducted with sufficient overlap to assure 100% coverage at the required sensitivity.

When it is necessary to verify the adequacy of magnetic field strength, it shall be verified by using a magnetic particle field indicator (Pie Gauge) or artificial flaw shim(s). The gauge or shim(s) will be positioned on the surface to be examined during magnetization. Adequacy of a suitable flux or field strength is indicated when a clearly defined line of magnetic particles form across the face of the indicator or shim. When there is no line of particles in the desired direction the magnetizing technique shall be changed or adjusted.

**11.0 EVALUATION OF MAGNETIC PARTICLE INDICATIONS**

An indication is the evidence of a mechanical imperfection. Only indications which have any dimensions greater than 1/16 inch shall be considered relevant.

A linear indication is one having a length greater than three times the width.

A rounded indication is one of circular or elliptical shape with a length equal to or less than three times its width.

Any questionable or doubtful indications shall be reexamined to determine whether or not they are relevant.

**11.1 INDICATIONS**

Indications will be revealed by retention of magnetic particles. All such indications are not necessarily imperfections, however, since excessive surface roughness, magnetic permeability variations (such as at the edge of heat affected zones), etc., may produce similar indications.

**11.2 VALID INDICATIONS**

All valid indications formed by magnetic particle examination are the result of magnetic leakage fields. Indications may be relevant, nonrelevant, or false.

**11.3 RELEVANT INDICATIONS**

Relevant indications are produced by leakage fields which are the result of discontinuities. Relevant indications require evaluation with regard to the acceptance standards agreed upon between the manufacturer/ test agency and the purchaser.
11.4 NONRELEVANT INDICATIONS

Nonrelevant indications can occur singly or in patterns as a result of leakage fields created by conditions that require no evaluation such as changes in section (like keyways and drilled holes), inherent material properties (like the edge of a bimetallic weld), magnetic writing, etc.

11.5 FALSE INDICATIONS

False indications are not the result of magnetic forces. Examples are particles held mechanically or by gravity in shallow depressions or particles held by rust or scale on the surface.

12.0 LIQUID PENETRANT APPLICATION

The penetrant will be applied to the part by brushing, dipping, flooding or spraying. A dwell time of a minimum of 10 minutes to a maximum of 30 minutes will be employed before removing excess penetrant unless otherwise specified as per specific specifications.

The temperature of the penetrant materials and the surface must be between 40°F and 125°F (5°C and 52°C).

13.0 EXCESS PENETRANT REMOVAL

13.1 WATER-WASHABLE PENETRANTS METHOD A

After the required dwell period has elapsed, the excess penetrant remaining on the surface of the part being examined must be removed with water. It can be removed manually using a coarse spray or wiping the part surface with a dampened rag. The water spray shall be under 40 psi and between 50°F to 100°F.

13.2 WATER-WASHABLE PENETRANTS METHOD C

After the required dwell period has elapsed, the excess penetrant remaining on the surface of the part is removed by wiping with a clean, lint-free cloth/towel. Then use a clean lint-free cloth/towel lightly moistened with water or solvent to remove the remaining traces of surface penetrant.

13.3 SOLVENT REMOVABLE PENETRANT
Excess solvent removable penetrants shall be removed by wiping with a cloth or absorbent paper, repeating the operation until most traces of penetrant have been removed. The remaining traces shall be removed by lightly wiping the surface with cloth or absorbent paper moistened with solvent. To minimize removal of penetrant from discontinuities, care shall be taken to avoid the use of excess solvent. Flushing the surface with solvent, following the application of the penetrant and prior to developing, is prohibited.

13.4 DRYING

Regardless of the type and method of penetrant used, drying the surface of the part(s) is necessary prior to applying dry or nonaqueous developers or following the application of aqueous developer. Drying time will vary with the type of drying used and the nature of the part being examined.

Components shall be air dried at room temperature or in a drying oven. Room temperature drying can be aided by the use of fans. Oven temperature shall not exceed 71°C. Drying time shall only be that necessary to adequately dry the part.

14.0 DEVELOPER APPLICATION

Non-Aqueous Developer
Developers shall be applied to a dry surface using a pressure sprayer containing clean, filtered compressed air or an aerosol propellant. The developer shall be thoroughly agitated before application to ensure adequate dispersion of suspended particles. Dipping or flooding parts with nonaqueous developers is prohibited, since they may flush or dissolve the penetrant from within the discontinuities because of the solvent action of these types of developers. The length of time the developer is to remain on the part prior to examination should be not less than 10 minutes. Developing time begins as soon as the wet nonaqueous developer coating is dry. The maximum permitted developing time is 1 hour for nonaqueous developers.

Dry Developer

Apply dry developer (by dusting), immediately after drying to the dry surfaces to be inspected. Develop for 10 minutes minimum to 30 maximum for penetrant to bleed before inspecting. Developing time begins immediately after the application of dry powder developer. Excess powder may be removed by gently shaking or tapping the part, or by blowing with low pressure (5 to 10 psi, 34 to 70 kpa) dry, clean compressed air.

On parts that are too large for dry developer application or whenever an alternate is required, a non-aqueous wet developer shall be used.

15.0 EXAMINATION OF LIQUID PENETRANT INDICATIONS
The surface of the part will be observed during application of the developer; however, final interpretation will be made between 7 minutes minimum and a maximum of 30 minutes after the developer has dried. Adequate illumination is required to ensure no loss of sensitivity in the examination.

Visible penetrant indications can be examined in either natural or artificial light. Adequate illumination is required to ensure no loss in the sensitivity of the examination. A minimum light intensity at the examination site of 100 fc (1000 Lx) is required.

Unless otherwise agreed, it is normal practice to interpret and evaluate the discontinuity based on the size of the indication.
16.0 EVALUATION OF LIQUID PENETRANT INDICATIONS

All indications shall be evaluated in terms of the acceptance criteria.

Mechanical discontinuities at the surface will be indicated by bleeding out of the penetrant, however, localized surface imperfections such as machining marks or surface conditions may produce similar indications which are non-relevant to the detection of unacceptable discontinuities.

Any indication, which is believed to be non-relevant shall be regarded as a defect and shall be re-examined to verify whether or not actual defects are present. Surface conditioning may precede the re-examination. Non-relevant indications, and broad areas of pigmentation, which would mask indications of defects are unacceptable.

Relevant Indications are those which result from mechanical discontinuities. Linear indications are those indications in which the length is more than three times the width.

Rounded indications, are indications which are circular or elliptical with the length less than three times the width.

17.0 ACCEPTANCE

All Relevant Indications shall be reported for further evaluation by engineering.

18.0 POST CLEANING

When post cleaning is required by the customer, all traces of the examination material shall be removed as soon as practical using a process that does not adversely affect the part.

19.0 REPORTING

Report shall include at least the following:
   a) Contract Reference (Work Order)
   b) Date of examination
   c) Items examined
   d) Quantity of items examined.
   e) Identification of items examined e.g. Part #, Heat # and Serial #
   f) Results of examination including photos showing all relevant indications
   g) Serial number of instruments used.
   h) Name, signature and qualification of the inspector.
   i) A sketch or picture clearly showing the extent of inspection
   j) Type of particles applied.
   k) Liquid penetrant type (visible or fluorescent)
l) Dwell time(s)

The report shall be signed by a qualified Level 2 or 3 person (as per this procedure) certifying that interpretation was made in accordance with the procedure.

20.0 REFERENCE DOCUMENTATION

The following documents were used in the development of this document or have instructions and procedures applicable to it. They shall be used in their most recent revision.

ASTM E709 Standard Guide for Magnetic Particle Testing
ASTM E165 Standard Guide for liquid Penetrant Examination for General Industry
21.0 REVISION AND TRANSITION NOTES

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<tr>
<td>B</td>
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<td>C</td>
<td>For this revision, a PHR or other risk management tool has been used to address risk and minimize hazards. This risk assessment has been documented and is available through Central Engineering.</td>
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22.0 APPENDICES

None