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**Non-destructive testing—Magnetic
particle testing—Part 1: General
principles**

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by The Japanese Society for Non-Destructive Inspection (JSNDI)/Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14. Consequently **JIS Z 2320-1:2007** is replaced with this Standard.

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JIS Z 2320 series consists of the following 3 parts under the general title “*Non-destructive testing—Magnetic particle testing*”:

Part 1: General principles

Part 2: Detection media

Part 3: Equipment

Non-destructive testing—Magnetic particle testing—Part 1: General principles

Introduction

This Japanese Industrial Standard has been prepared based on **ISO 9934-1:2015**, Edition 2, with some modifications of the technical contents in order to correspond to the needs of users in Japan.

The vertical lines on both sides and dotted underlines indicate changes from the corresponding International Standard. A list of modifications with the explanations is given in Annex JB.

1 Scope

This Standard specifies general principles for the magnetic particle testing of ferromagnetic materials. Magnetic particle testing is primarily applicable to the detection of surface-breaking discontinuities, particularly cracks. It can also detect discontinuities just below the surface but its sensitivity diminishes rapidly with depth. This Standard specifies the surface preparation of the part to be tested, magnetization techniques, requirements and application of the detection media, and the recording and interpretation of results. Acceptance criteria are not defined. Additional requirements for the particular items are defined in product standards (see relevant standards).

NOTE : The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows.

ISO 9934-1:2015 *Non-destructive testing—Magnetic particle testing—Part 1: General principles* (MOD)

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21-1**.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS C 2504 *Soft magnetic irons*

JIS G 0431 *Steel products—Employer's qualification system for non-destructive testing (NDT) personnel*

JIS Z 2300 *Terms and definitions of nondestructive testing*

JIS Z 2305 *Non-destructive testing—Qualification and certification of NDT personnel*

NOTE : Corresponding International Standard: ISO 9712 *Non-destructive testing—Qualification and certification of NDT personnel* (MOD)

JIS Z 2320-2 *Non-destructive testing—Magnetic particle testing—Part 2: Detection media*

NOTE : Corresponding International Standard: ISO 9934-2 *Non-destructive testing—Magnetic particle testing—Part 2: Detection media* (MOD)

JIS Z 2320-3 *Non-destructive testing—Magnetic particle testing—Part 3: Equipment*

NOTE : Corresponding International Standard: ISO 9934-3 *Non-destructive testing—Magnetic particle testing—Part 3: Equipment* (MOD)

JIS Z 2323 *Non-destructive testing—Penetrant testing and magnetic particle testing—Viewing conditions*

NOTE : Corresponding International Standard: ISO 3059 *Non-destructive testing—Penetrant testing and magnetic particle testing—Viewing conditions* (IDT)

3 Terms and definitions

For the purpose of this Standard, the terms and definitions given in JIS Z 2300, and the following apply.

3.1 effective testing region

region of a component that can be tested by one cycle of magnetic particle testing (application of detection media)

3.2 impulse current

impulse of electric current that flows for a very short period

3.3 longitudinal direct contact technique

a method for magnetization; the application of electric current in an axial direction, inserting a component between electrodes

3.4 prods technique

a method for magnetization; the application of electric current, placing two electrodes (prods) onto the surface of a component

3.5 cross current flow technique

a method for magnetization; the direct application of electric current at right angles to the axis of a component

4 Qualification and certification of testing personnel

It is assumed that magnetic particle testing is performed by qualified and capable personnel. In order to provide this qualification, it is recommended to certify the personnel in accordance with JIS Z 2305, JIS G 0431 or equivalent.

5 Safety and environmental requirements

National regulations which include health, safety and environment need to be taken into account.

Magnetic particle testing often creates high magnetic fields close to the object under test and the magnetizing equipment. Items sensitive to these fields should be excluded from such areas.

Since magnetic particle testing sometimes requires the use of toxic, combustible or volatile materials, the following measures shall be taken into consideration for safety.

- a) Avoid extensive and repeated contacts of skin or mucous membrane with organic solvent dispersion magnetic inks, organic carrier fluids and contrast aid paints.
- b) Locate a test site in a place which is free from heat source, sparks and flames, and ventilate the site in accordance with Industrial Safety and Health Act, and Fire Service Act.
- c) Use the detection media and the flaw detector in accordance with the directions for use provided by the manufacturer.
- d) When using UV-A source, protect the tester's eyes from direct exposure to UV rays. When UV-A irradiance (intensity of UV rays) is intense or when test is conducted for a long period, wear a long-sleeved shirts, gloves, etc. to protect skins from UV rays. Maintain the ultraviolet filter in a good condition.

6 Testing procedure

All testing shall be performed in accordance with an approved written procedure or the relevant product standard shall be referenced.

When required at the time of enquiry and order, magnetic particle testing shall be performed in accordance with a written procedure.

The procedure may take the form of a brief technique sheet, containing a reference to this and other appropriate standards. The procedure should specify testing parameters in sufficient detail for the test to be repeatable.

7 Surface preparation

The surface preparation shall be as follows.

- a) The area of surface preparation shall be wider than the test area.
- b) Areas to be tested shall be free from dirt, scale, loose rust, weld spatter, grease, oil, and any other foreign materials that can affect the test sensitivity.
- c) The requirements for surface condition are dependent upon the size and orientation of the discontinuity to be detected. The surface shall be prepared so that relevant indications can be clearly distinguished from false indications.
- d) If a component to be tested is assembled and can be disassembled, dismantle it into individual parts before test.
- e) Perform demagnetization as necessary, e.g. when there is strong residual magnetism that can affect the test.
- f) When, like in prods technique, current is directly passed through a component to be tested, polish the areas of contact thoroughly, and as necessary mount contact pads on electrodes, in order to prevent the burnout of the component and to facilitate the flow of current.

- g) Prior to the test, protect oil holes and other holes from the ingress of magnetic particles, if the location of such holes makes it difficult to remove the particles after the test.
- h) Non-ferromagnetic coatings up to approximately 50 µm thickness, such as unbroken adherent paint layers, do not normally impair detection sensitivity. Thicker coatings reduce sensitivity. Under these conditions, the sensitivity shall be verified.
- i) There shall be a sufficient visual contrast between the indications and the test surface. For the technique using coloured magnetic particles, it might be necessary to apply a uniform, thin, temporarily adherent layer of approved contrast aid paint.
- j) When dry powders are used, dry the surface sufficiently.

8 Magnetization

8.1 General requirements

When magnetization is performed, the timing of magnetization, the direction and strength of necessary magnetic field, and effective testing region shall be determined, and magnetization method, type of magnetizing current (direct current, rectified current, alternating current, impulse current) and current value shall be selected according to the characteristics of equipment, magnetic properties, shape, dimensions, surface condition of a component to be tested, the properties of expected discontinuities, etc.

In the effective testing region, the direction of magnetic field shall be parallel to the test surface as much as possible. Furthermore, the magnetization method shall be taken into consideration so as to decrease the demagnetizing fields.

The continuous magnetization technique is a method to apply the detection media while magnetizing a component, and the residual magnetization technique is a method to apply the detection media after magnetizing.

The residual magnetization technique is intended to expose the component to more magnetic field than necessary for the magnetic saturation of the component.

For the continuous magnetization technique, the minimum magnetic flux density regarded as adequate for testing is 1 T. The applied magnetic field required to achieve this in low-alloy and low-carbon steels is determined by the relative permeability of the material. This varies according to the material, the temperatures, and also with the applied magnetic field and for these reasons, it is not possible to provide a definitive requirement for the applied magnetic field. However, typically a tangential field of approximately 2 kA/m will be required.

Where time varying currents are used to produce a magnetic field (which will also be time varying), it is important to control the crest factor (shape) of the waveform and the method of measurement of the current in order to establish a repeatable technique. Both peak and RMS measurements are typically used and measurement of the values can be affected by the response of the instrument. For this reason, only instruments that respond directly to the waveform shall be used (e.g. true RMS meters with appropriate crest factor capability for accurate RMS measurements). Instruments that calculate peak or RMS values based on theoretical calculation derived from other values shall not be used. This shall also apply to instruments used to measure magnetic fields.

Smooth shaped waveforms provide low crest factors and least variation between peak and true RMS values and are regarded as preferable for magnetic particle testing. Waveforms with a crest factor (i.e. I_{pk}/I_{RMS}) greater than 3 shall not be used without documented evidence of the effectiveness of the technique.

When using multidirectional magnetization techniques, the current used shall be purely sinusoidal or phase controlled but the phase cutting shall not be more than 90° . Practical demonstration that the technique is effective in all directions shall be carried out (e.g. using sample parts with known defects or shim type indicators).

Provided the permeability is in the normal range and the current measurement methods are controlled as described, calculations based on the use of 2 kA/m can provide a valuable method of technique preparation. The use of either peak current or true RMS current is acceptable if the crest factor is known. Knowing the entire waveform of the magnetizing curve would be optimal, but knowing the crest factor is a good practical approximation. For pure sinusoidal waveforms, the relationship between peak, mean, and RMS is shown in Table A.1. Techniques based on calculation shall be verified before implementation.

NOTE 1 For steels, with low relative permeability, a higher tangential field strength might be necessary. If magnetization is too high, spurious background indications can appear, which could mask relevant indications.

If cracks or other linear discontinuities are likely to be aligned in a particular direction, the magnetic flux shall be aligned perpendicular to this direction where possible.

NOTE 2 The flux can be regarded as effective in detecting discontinuities aligned up to 60° from the optimum direction. Full coverage can then be achieved by magnetizing the surface in two perpendicular directions.

Magnetic particle testing should be regarded as a surface NDT method; however, discontinuities close to the surface can also be detected. For time varying waveforms, the depth of magnetization (skin depth) will depend on the frequency of the current waveform. Magnetic leakage fields produced by imperfections below the surface will fall rapidly with distance. Therefore, although magnetic particle testing is not recommended for the detection of imperfections other than on the surface, it can be noted that the use of smooth DC or rectified waveforms can improve detection of imperfections just below the surface.

The most suitable type of magnetizing current shall be used, especially in consideration for the following a) to e).

- a) When discontinuities below the surface are to be detected, direct current or rectified current shall be used; the use of alternating current results in relatively weak magnetization below the surface due to the skin effect, compared to the use of direct current.
- b) Normally, the use of alternating current is permitted only for continuous magnetization technique.
- c) The use of direct current or rectified current is permitted for both continuous and residual magnetization technique.

- d) The larger the ratio of alternating current components contained in rectified current is, the poorer the detection performance of internal discontinuities becomes.
- e) The use of impulse current is permitted only for residual magnetization technique.

8.2 Verification of magnetization

The adequacy of the surface flux density shall be established by one or more of the following methods. However, it shall be verified by one of the methods in **a)**, **c)** or **d)** for the residual magnetization technique:

- a) by testing a representative component containing fine natural or artificial discontinuities in the least favourable locations;
- b) by measuring the tangential field strength as close as possible to the surface (information on this is given in **JIS Z 2320-3**);
- c) by calculating the tangential field strength for current flow techniques —
simple calculations are possible in many cases, and they form the basis for current values specified in Annex A;
- d) by the use of other methods based on established principles.

As an example of established principles, type A or C standard test piece specified in Annex JA may be used for continuous magnetization technique.

8.3 Magnetizing techniques

8.3.1 General

This subclause describes a range of magnetization techniques.

Multi-directional magnetization can be used to find discontinuities in any direction.

In the case of simple-shaped objects, formulae are given in Annex A for achieving approximate tangential field strengths.

Magnetizing equipment shall meet the requirements of and be used in accordance with **JIS Z 2320-3**.

More than one technique might be necessary to find discontinuities on all test surfaces and in all orientations. Demagnetization might be required where the residual field from the first magnetization cannot be overcome.

The precautions for testing shall be as follows.

- a) When a whole test surface cannot be tested by a cycle of consecutive testing procedures i.e. magnetization, application of magnetic particles and viewing, the test surface shall be divided into some effective testing regions, and the necessary cycles of test procedures shall be repeated. In this case, the ends of adjacent effective testing regions shall overlap by a required width.
- b) When the residual magnetization technique is used, the test surface shall not come into contact with other test specimens or ferromagnetic materials during the period from the completion of magnetization to the completion of indication viewing.
- c) The post-magnetization time shall be as follows.

- 1) For the continuous magnetization technique, until the applied magnetic particles stop moving.
- 2) For the residual magnetization technique, normally a period of 1/4 s to 1 s. When the impulse current is used, however, the current shall be passed for 1/120 s or over, and it shall be repeated three or more times. This does not apply when the sufficient magnetomotive forces can be applied.

The classification of magnetizing techniques shall be as follows. When it is possible to perform the proper magnetization satisfying the requirements in 8.1, other methods than the following may be used.

8.3.2 Current flow techniques

8.3.2.1 Longitudinal direct contact technique

Magnetization is performed, inserting a component between electrodes as shown in Figure 1 and applying current. Current passes through the component, which shall be in good electrical contact with the pads.

The current is assumed to be distributed evenly over the surface and shall be derived from the peripheral dimensions.

Current flow offers high sensitivity for detection of discontinuities parallel to the direction of the current (axial direction).

An example of approximate formula for the current required to achieve a specified tangential field strength is given in A.2.

Care shall be taken to avoid damage to the component at the point of electrical contacts.

Possible hazards include excessive heat, burning, and arcing. The contact part of the pads shall be clean and large enough for the test, and made of materials which do not affect the component.

8.3.2.1A Cross current flow technique

Magnetization is performed by placing the electrodes at right angles to the axis of the component and passing the current directly, as shown in Figure 1A. As in the case of the longitudinal direct contact technique, current passes through the component, which shall be in good electrical contact with the pads, and care shall be taken to avoid damage to the component at the point of electrical contacts.

8.3.2.2 Prods; current flow

Magnetization is performed by applying current by placing two prods (electrodes) onto the surface of a component, as shown in Figure 2. Current is passed between hand-held or clamped contact prods. The prods are then moved in a prescribed pattern to cover the required total area. Examples of the effective testing region and the overlap are shown in Figure 2 and Figure 3, respectively.

This technique offers the highest sensitivity for discontinuities elongated parallel to the direction of the current. This technique provides an inspection of a small area of a larger surface.