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**Non-destructive testing - Test method for non-ferromagnetic
metallic component pulsed eddy current testing**

无损检测 非铁磁性金属材料脉冲涡流检测

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Non-destructive testing - Test method for non-ferromagnetic metallic component pulsed eddy current testing

1 Scope

This document specifies the method that uses pulse eddy current technology to test corrosion and cracks in non-ferromagnetic metal materials.

This document is applicable to the testing of non-ferromagnetic metal components such as austenitic stainless steel, aluminum and aluminum alloys with a thickness of not more than 200mm, a thickness of 1 mm to 50mm, and a radius of curvature of not less than 25mm. Other non-ferromagnetic metal materials are verified and implemented by using this document as reference.

This document is applicable to the testing of discontinuous wall thickness of components of pressure-bearing equipment caused by extensive corrosion without removing the covering layer. It is applicable to the testing of small-volume discontinuities and cracks such as pitting corrosion and pitting in the deep skin of thin-walled bearing parts and the surrounding areas of connecting parts.

This document does not specify the acceptance criteria. The specific acceptance criteria shall be determined by the parties to the contract through negotiation.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

GB/T 9445, *Non-destructive testing - Qualification and certification of NDT personnel*

GB/T 11344, *Non-destructive testing - Ultrasonic thickness measurement*

GB/T 12604.6, *Non-destructive testing - Terminology - Eddy current testing*

GB/T 18851.1, *Non-destructive testing - Penetrant testing - Part 1: General principles*

GB/T 28705, *Non-destructive testing - Test method for pulsed eddy current testing*

NB/T 47013.3, *Nondestructive testing of pressure equipment - Part 3: Ultrasonic*

testing

3 Terms and definitions

For the purposes of this document, the terms and definitions defined in GB/T 12604.6, GB/T 28705 as well as the followings apply.

3.1 differential signal

The difference between the signal of the area to be tested and the signal of the reference area.

3.2 peak amplitude; PA

The maximum value of the differential signal amplitude.

3.3 time to peak amplitude; TPA

The time when the amplitude of the differential signal reaches the maximum value since the excitation signal stops.

3.4 time to zero-crossing; TZC

The time for the differential signal amplitude to change from positive to negative.

3.5 lift-off intersection; LOI

The point where the differential testing signals of different lift-off heights intersect.

4 Method summary

See GB/T 28705 for the basic principle of pulsed eddy current testing. The square wave excitation current signal shown in Figure 1 is passed through the probe. When the excitation current signal jumps from high (low) level to zero, the testing signal shown in Figure 1 is obtained by using magnetic sensitive elements (such as coils, Hall elements and magneto-sensitive resistors). The feature quantity obtained from the testing signal is used to evaluate the condition of the object to be inspected.

The common feature quantities of pulsed eddy current testing of non-ferromagnetic metal components are PA, TPA, TZC of the differential signal given in Figure 2 and LOI given in Figure 3. Usually, the peak amplitude is related to the magnitude of metal loss. The time to zero-crossing correlates with discontinuous depth. Both peak amplitude and time to zero-crossing are used to evaluate discontinuous dimensions.

7 Testing process specification

7.1 General testing process specification

Personnel engaged in pulsed eddy current testing of non-ferromagnetic metal materials shall formulate general testing procedures in accordance with the requirements of this document. Its content shall include at least the following elements:

- a) Scope of application
- b) Reference materials;
- c) Qualification of inspectors;
- d) Testing equipment information: probe, instrument host, analysis software and connecting line;
- e) Information of tested piece: geometry and size, material, design and operating parameters;
- f) Surface state and cover layer state of tested piece: protective layer material, thickness and thickness of thermal insulation layer;
- g) Sensitivity settings;
- h) During static testing, the distribution of measuring points at the testing site;
- i) During dynamic scanning, step distance setting;
- j) Testing results;
- k) Inspection records, reports and data archiving;
- l) Preparation, review and approval personnel;
- m) Compilation date.

7.2 Inspection work instructions or craft card

It shall be carried out according to 9.1.3.

8 Testing equipment

8.1 Overview

Testing equipment includes instrument host, probes and cables. Auxiliary equipment is used to calibrate the host machine of the testing instrument, including standard test

pieces, non-conductor spacers and metal sheets. When necessary, the testing equipment shall have a position recording device.

When testing on site, if the testing results of the equipment are suspected, the equipment shall be functionally checked and adjusted. Document the results of each maintenance inspection.

8.2 Instrument host machine

The host machine of the testing instrument shall have the functions of pulsed eddy current signal excitation, data acquisition, signal waveform display, analysis and storage. It shall at least meet the following requirements:

- a) The adjustable range of the repetition frequency of the excitation signal includes at least 0.2Hz~2Hz;
- b) The data acquisition hardware has the function of synchronizing with the signal excitation. For the selected probe, when the reference value is set within the effective testing range, its testing signal characteristics are obvious;
- c) Give the relative wall thickness value of the tested piece in the form of a percentage or give the test piece testing signal image of a certain area;
- d) Continuously store the testing results of more than 100 testing points and the original data corresponding to the testing signal waveform;
- e) Test the thinned walls, notches and flat bottom holes in the standard test pieces specified in 8.4.1.

8.3 Testing probe

8.3.1 The performance parameters such as wall thickness, minimum diameter, thickness of thermal insulation layer, material and thickness of protective layer for the tested piece shall be given.

8.3.2 The magnetic field testing area of the probe corresponds to the probe size. Large magnetic field testing area reduces testing accuracy. Therefore, in the case of ensuring the testing sensitivity, accuracy and signal quality, the probe with the smallest size shall be selected as much as possible.

8.3.3 The probe shall be equipped with a support rod to facilitate high-altitude testing operations.

8.3.4 In the case of ensuring the sensitivity and testing accuracy, the length of the cable connecting the probe and the instrument can be increased.

8.4 Test piece

of the tested object can be used to simulate the thermal insulation layer casing.

8.5 Maintenance and calibration of testing equipment

Develop written procedures. Periodically maintain and inspect the testing equipment to ensure the function of the instrument.

Before going to the site for testing, standard test pieces of corresponding specifications shall be selected to calibrate the testing instrument. If the testing results are consistent with the known defects of the test piece, it indicates that the instrument is normal.

When testing on site, if the testing results of the equipment are suspected, the equipment shall be functionally checked and adjusted. Document the results of each maintenance inspection.

9 Testing

9.1 Preparation before testing

9.1.1 Data review

The data review shall include the following:

- a) The manufacturing documents of the tested piece: product certificate, quality certification documents and as-built drawings;
- b) The operation records of the tested piece: start and stop conditions, operating parameters, working medium, load changes and abnormal conditions during operation;
- c) Inspection data: previous inspection and testing report;
- d) Additional information: documentation of repairs and alterations, and so on.

9.1.2 On-site investigation

Investigate the site of the tested piece. Identify factors that may affect the testing results, such as hangers, internal or external accessories. The interference of these factors shall be avoided during testing.

9.1.3 Preparation of work instructions or craft cards

For each tested piece, according to the instrument used and the actual situation on site, prepare pulsed eddy current testing work instructions or craft cards according to general testing process regulations. Determine the location and surface conditions for pulsed eddy current testing. Draw a schematic diagram of the structure of the tested piece. Number the testing sites. The testing site shall avoid internal or external metal

accessories.

9.2 Requirements for testing surface conditions

Check the surface condition of the test piece to ensure the testing accuracy. The surface condition to be checked mainly includes the following elements:

- a) There shall be no large-area welding scars and other metal connection structures;
- b) The insulation layer shall be continuous and uniform in thickness;
- c) For the tested piece with a metal thermal insulation layer casing, the inspection shall be avoided at the damaged or overlapping part of the metal casing.

9.3 Implementation of testing

9.3.1 Testing method

For pressure-bearing equipment, it shall be carried out in the way of static inspection or dynamic scanning. For thin-walled bearing parts, the dynamic scanning method shall be used.

For flat panel inspection, keep the probe face parallel to the area to be tested. For curved surface inspection, the probe surface shall be kept tangent to the tested area.

9.3.2 Static testing method

9.3.2.1 Selection principle of reference area

In static testing, the area with obvious testing signal characteristics shall be selected as the reference area. Reference area shall have known wall thickness or ultrasonic thickness measurement. Ultrasonic thickness measurement is performed in accordance with GB/T 11344.

When the acquired inspection data has the same material, the same covering material and thickness, the same surface conditions, the same working conditions, and the same probe as the tested piece, data of known wall thicknesses can also be used as reference values.

9.3.2.2 Adjustment of reference area

When the following conditions exist between the testing area and the reference area, the reference area shall be re-selected.

- a) The material of the tested piece is inconsistent;
- b) The nominal wall thickness deviation exceeds 10%;
- c) The curvature changes more than 20%;

After the testing is completed, the testing results shall be given in the form of a list or an image.

When the testing area has a large difference in physical properties compared to the reference area, appropriate corrections or compensations shall be made to the testing data. Then re-evaluate the results after correction and compensation.

9.6.2 Verification of testing results

The result given by pulsed eddy current testing is the equivalent of the remaining metal wall thickness under the probe footprint. The size and shape of corrosion are different from artificial defects, and the actual part of the tested piece is different from the reference area. Therefore, there will be a certain difference between the equivalent value displayed by the testing results and the actual situation. Once the testing signal of wall thickness loss of more than 20% or cracks is found, the covering layer shall be removed first. Then use one or more of the following methods to verify:

- a) Use visual inspection and hammering method for testing, used to distinguish whether the corrosion is located on the outer surface or the inner surface;
- b) Use an ultrasonic thickness gauge to measure the remaining wall thickness of the site. Ultrasonic thickness measurement complies with the regulations in GB/T 11344;
- c) For external surface corrosion, a depth gauge can be used to directly measure the corrosion depth. For internal surface corrosion, ultrasonic testing shall be performed, so as to measure the corrosion depth more accurately. Carry out according to NB/T 47013.3;
- d) Penetration testing can be used for surface cracks. Carry out according to GB/T 18851.1. For internal cracks, ultrasonic testing shall be carried out;
- e) Use radiography or other nondestructive testing methods for verification testing.

If necessary, with the consent of the parties to the contract, the verification can also be carried out by means of random inspection and autopsy.

10 Testing report

The content of the testing report shall be formulated according to the test requirements. It shall contain the followings:

- Testing agency name;
- Identification of tested piece;
- Material of tested piece;

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