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Black Metal Industry Standard of the People's Republic of China

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Replace YB/T 4289—2012

Measurement method of comprehensive properties for automatic magnetic flux leakage testing system for steel tubes and steel bars

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(English Translation)

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Contents

Forward

SAC/TC 183 is in charge of this English translation. In case of any doubt about the contents of English translation, the Chinese original shall be considered authoritative.

This standard is drafted in accordance with the rules given in the GB/T 1.1 - 2009.

This standard was proposed by China Iron and Steel Association.

This standard was prepared by SAC/TC 183 (Technical Committee 183 on Steel of Standardization Administration of China).

This standard replaces YB/T 4289-2012 " Measurement method of comprehensive properties for automatic magnetic flux leakage testing system for steel tubes ", Compared with YB/T 4289-2012, the main technical changes are as follows:

——The name of the standard is changed to "Measurement method of comprehensive properties for automatic magnetic flux leakage testing system for steel tubes and steel bars";

——The reference sample and sample diagram of steel bar are added (see 5.3 and figure 3);

——The measurement method of comprehensive properties of steel bars is added (see Chapter 6);

——The requirement of residual magnetic flux density is added (see 7.7).

The previous versions of this standard are as follows:

——YB/T 4289-2012。

Measurement method of comprehensive properties for automatic magnetic flux leakage testing system for steel tubes and steel bars

1 Scope

This standard specifies the measurement conditions, reference samples, test preparations, measurement items, methods, and reports of the comprehensive properties of the automatic magnetic flux leakage testing systems which generally composed of magnetic flux leakage testing instrument, detecting element, magnetizer, mechanical transmission device, etc. for steel tubes and bars .

This standard is applicable to the measurement of comprehensive properties of the automatic eddy current testing systems for tubes and bars where the tubes or bars advance straight, the systems where the bars advance spirally, and the systems where the bars rotate in place.

2 Normative References

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

GB/T 12606 *Automated full peripheral flux leakage testing of seamless and welded (except submerged arc-welded) ferromagnetic steel tubes for the detection of longitudinal and/or transverse imperfections*

GB/T 32547 *Method for magnetic flux leakage testing of round steel*

GB/T 34357 *Non-destructive testing—Terminology—Terms used in magnetic flux leakage testing*

YB/T 145 *Steel tubes-Measurement method of sizes of standard artificial defect for flaw detection*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in GB/T 34357 and GB/T 12606 and the following apply.

3.1

combined display

In magnetic flux leakage testing, multiple detecting elements are combined into one channel for display, or multiple channel display signals are combined into one channel for display

3.2

calibrating sample

The steel tube or bar engraved with long longitudinal notches and circular transverse notches and used to calibrate the reference testing sensitivity of the magnetic flux leakage testing system

3.3

testing sample

The steel tube or bar are made according to the testing standard and this standard and used to test the comprehensive properties index of the magnetic flux leakage testing system. Tubular testing samples are called as “testing sample tubes” and rod-shaped testing samples are called as “testing sample bars”

4 Measurement conditions

4.1 The magnetic flux leakage testing instrument shall be calibrated generally every year.

4.2 For longitudinal defect testing equipment, the measurement speed of the system shall be the speed in normal use. When each detecting element channel (or combined display channel) is measured individually, the line speed of circumferential is constant and the measurement speed shall be no less than the ratio of the normal testing speed to the number of detecting element channels (or the number of combined display channels).

4.3 For transverse defect testing equipment, the testing speed of the system shall be the speed in normal use.

NOTE: the transverse defect testing equipment is only applicable to the magnetic flux leakage testing systems for tubes.

4.4 For the instrument with linear gain control, the adjusted amplitude of pulse echo shall be converted into logarithm value in dB during the measurement.

5. Reference samples

5.1 Classification of samples

For the magnetic flux leakage testing systems for tubes, the reference samples are classified into calibrating sample tubes and testing sample tubes. For the magnetic flux leakage testing systems for bars, the reference samples are testing sample bars.

5.2 Reference tubes

5.2.1 The calibrating sample tubes are used to adjust multiple detecting elements to the same starting point of testing sensitivity. The length and the notch size of sample tubes shall meet the adjustment requirements of the equipment. The curvature of the sample tubes shall not exceed 1.5 mm/m.

5.2.2 The reference tubes shall be made according to the product type and specifications. Their lengths shall meet the requirements of the testing method and equipment, and their curvatures should not exceed 1.5mm/m. The standards are usually longitudinal or transverse notches or boreholes. The manufacturing method, grade, size and permission variation of the notch or borehole shall meet the requirements of GB/T 12606. Unless clearly specified in the testing standard, the length of the artificial notch shall not exceed 50mm. The quantity and positions of artificial notches on the testing sample tube are shown in Figure 1; those of artificial boreholes are shown in Figure 2. The dead zone at the tube end shall not include the size of the notch or borehole. The distance l_1 from the end longitudinal notch to the tube end, the distance l_2 from the end transverse notch to the tube end, and the distance l from the end borehole to the tube end may be chosen respectively according to the testing capability of the equipment. When the testing equipment cannot distinguish between longitudinal and transverse notches, Two sample tubes can be used to make longitudinal and transverse notches, or make longitudinal and transverse notches at different positions of the same tube. The testing sample tube is used to test the comprehensive properties of the testing system.

5.2.3 For the testing sample tube with notches, when the inside diameter of the sample tube is smaller or the wall is thicker, a notch on the inside wall may not be maked according to the testing standard or as agreed with the parties concerned. If there is no notch made on the inside

wall, a notch on outside wall shall be made at the corresponding position.

5.3 Reference bars

The finished reference bars shall be made according to the product type and specifications. Their lengths should meet the requirements of the testing method and equipment, and their curvatures shall not exceed 1.5mm/m. The standards are usually longitudinal notches. The manufacturing method, grade, size and permissible variation of the notch shall meet the requirements of GB/T 32547. Unless clearly specified in the testing standard, the length of the artificial notch shall not exceed 40mm. The quantity and positions of artificial notches on the testing sample bar are shown in Figure 3, the dead zone at the bar end should not include the size of the notch. The distance l_3 from the end longitudinal notch to the bar end may be chosen according to the testing capability of the equipment.

5.4 Requirements for reference standards

The reference samples shall be used only after the standards on them are calibrated. The calibration certificate should record the number, steel type, dimension, surface condition of the sample, and size of standards. The calibration report of the testing sample tube/bar should record the tubes/bars number, steel type, specification, surface condition, the size of each standard, and the distances l_1, l_2, l and l_3 from the standard end to the sample tube/bar end (these distances are the length of the dead zone at the end of the testing system). The depth of the notch may be measured by optical methods, mechanical methods or replica methods specified in YB/T 145, etc. If necessary, the inside wall notch shall be verified after the system test is completed (only for tubes); the diameter of the borehole may be measured by reading microscope, plug gauge and other methods (only for tubes).

Unit in millimeter

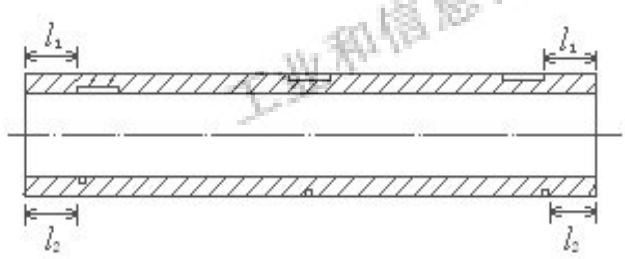

Figure 1 Testing sample tube with artificial notches

Unit in millimeter

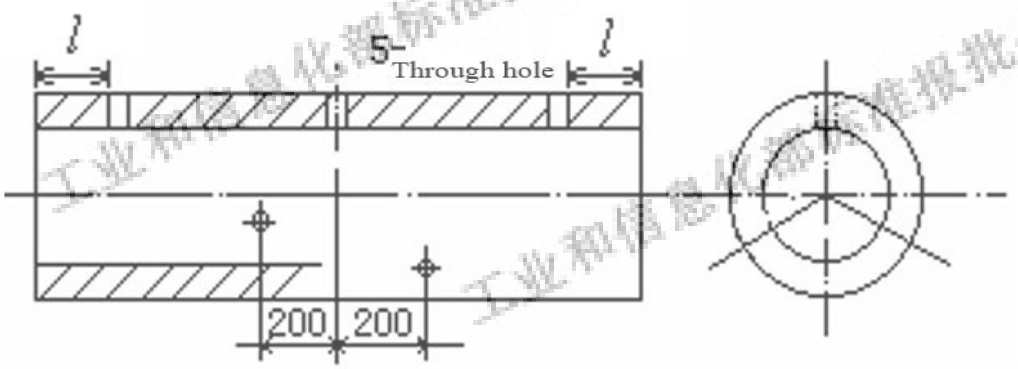

Figure 2 Testing sample tube with artificial boreholes

Unit in millimeter

Figure 3 Testing sample bar with artificial notches

5.5 Dimension of testing samples for measurement

The testing sample tube and bar shall be made separately with the reference samples whose diameters are respectively equal to the maximum and minimum ones of the tubes or bars which the system can test.

6. Testing Equipment

6.1 For the multi-channel testing equipment with each detecting element corresponding to one display channel, a calibrating sample tube or testing sample tube shall be used before testing to adjust the corresponding channel of every single detecting element in the transverse defect testing equipment to the same sensitivity.

6.2 For the multi-channel testing equipment with combined display, a calibrating sample shall be used before testing to respectively adjust the corresponding channel of every detecting element in the testing equipment for longitudinal and transverse defects (transverse defects are for tubes only) to the same sensitivity.

7 Measurement items and methods

7.1 Measurement requirements

The measurement shall be carried out dynamically with the reference samples whose diameters are respectively equal to the maximum and minimum ones of tubes or bars which the system can test. The circumferential sensitivity difference (CSD), signal-to-noise ratio (SNR) and stability shall be tested by detecting element channels one by one or by combining display channels one by one. If the result of each channel measured is different, the worst value shall be taken. For the steel tube testing system for the detection of transverse defects displayed by single detecting element channel, the adjustment of the instrument gain (dB value) during the measurement shall increase or decrease simultaneously (at the same time, by equal magnitude) for all channels.

7.2 Measurement of CSD and CSF

7.2.1 The CSD and CSF of longitudinal defect testing equipment and transverse defect testing equipment shall be tested separately.

NOTE the transverse defect testing equipment is only applicable to the magnetic flux leakage testing systems for tubes.

7.2.2 When a testing sample with artificial notches is used to test the testing system whose probe rotates and the pieces to be test advance straight, use the sample tube as shown in Figure 1 or the sample bar as shown in Figure 3 to let standards in the middle to pass repeatedly through the testing system. First, set 0° position for the testing sample, adjust the instrument gain, record the dB value when the standard triggers the alarm, Second, rotate the testing sample to carry out the test in the same way at the 120 ° and 240 ° positions and record the dB value when the standard triggers the alarm. The maximum difference between these dB values is the CSD, and the absolute value of this difference shall be no greater than 3dB. Carry out the test 3 times in succession. If the results are different, the worst value shall be taken.

7.2.3 When a testing sample with artificial notches is used to test the testing system whose probes fix and the pieces to be tested advance spirally, use the sample tube as shown in Figure 1 or the sample bar as shown in Figure 3 to let the standards in the middle to pass repeatedly through the system. Record the dB value of the gain when the standard triggers the alarm for 3 times. The maximum difference between these dB values is the CSD, and the absolute value shall be no greater than 3dB. Carry out the test 3 times in succession. If the results are different, the worst value shall be taken.

7.2.4 When a testing sample tube with artificial boreholes is used to test the steel tube magnetic flux leakage testing system, use the sample tube as shown in Figure 2 to let the 3 standards in the middle to pass repeatedly through the system, and record dB value when the standard triggers the alarm; adjust the testing sensitivity, and record the dB value when the alarms of all the 3 artificial holes just disappear. The maximum difference between these dB values is the CSD. For tubes and bars with diameters less than 100mm, the absolute value of this difference shall be no greater than 3dB. Carry out the test 3 times in succession. If the results are different, the worst value shall be taken. For those with diameters no less than 100mm, the CSD or CSF shall be no greater than 4dB.

7.3 Measurement of SNR

7.3.1 SNRs of longitudinal outer-surface defect, longitudinal inner-surface defect, transverse outer-surface defect and transverse inner-surface defect or SNR of borehole defect shall be tested separately.

NOTE For bars, only the SNR of longitudinal surface defects is tested.

7.3.2 The testing sample is used to pass repeatedly through the system, adjust the gain control of the instrument, and record the dB value when each kind of standards just triggers the alarm. These dB values are the defect detection sensitivities (DDS)of various defects. Carry out the test 3 times in succession. If the results are different, the worst value shall be taken.

7.3.3 The testing sample is used to pass repeatedly through the system, adjust the gain control of the instrument, and record the dB value when any noise signal just triggers the alarm. The difference between it and the DDS is the SNR of the system. The SNR of outer-surface defects shall be no less than 8dB; the SNR of inner-surface defects is only recorded and regarded as a reference characterization of equipment performance. Carry out the test 3 times in succession. If the results are different, the worst value shall be taken.

7.4 Measurement of missed test rate and false alarm rate

The gains of all channels may be increased by 3dB on the basis of DDS. The reference sample is tested continuously 25 times at the speed in normal use, and the number of missed alarms and false alarms for the standards is recorded respectively. If the system gives no alarm when a standard passes, it will be called as a missed test. If any channel gives an alarm when no standard passes, it will be called as a false alarm. If there are 1 or more false alarms during each measurement, it will be counted as 1 false alarm. If there exist too many missed tests and false alarms within the number measured above, the number may be increased to 50 times. The missed test rate (MTR) of the system shall be no greater than 1%, and the false alarm rate (FAR) shall be no greater than 3%. The missed test rate and false alarm rate are calculated respectively by Formula (1) and (2):

$$MTR = \frac{\text{the number of standards missed alarm}}{\text{the number of standards on reference sample} \times \text{the number of measurement}} \times 100\% \quad (1)$$

$$FAR = \frac{\text{the number of false alarm}}{\text{the number of measurement}} \times 100\% \quad (2)$$

7.5 Measurement of the dead zone at the end

7.5.1 The dead zones at the ends of longitudinal defect testing equipment and transverse defect testing equipment shall be tested separately.

NOTE the transverse defect testing equipment is only applicable to the magnetic flux leakage testing systems for tubes.

7.5.2 The dead zone at the end shall be measured on the basis of 7.4. If the standards at both ends of the testing sample are reliably reported in 3 successive tests, the distance from the two standards to the sample end is recorded as the dead zone at the end.

7.6 Measurement of stability

7.6.1 The CSD or CSF is measured again according to 7.2. The CSD or CSF difference between 2 hours ago and later shall be no greater than 2 dB, and shall meet the requirements of 7.2.

7.6.2 The DDS and SNR are measured again according to 7.3 after the system works continuously for 2h. The DDS difference in the same channel between 2 hours ago and later shall be no greater than 2 dB, and the SNR shall meet the requirements of 7.3.

7.6.3 The measurement stability is only applicable for the maximum diameter reference sample.

7.7 Residual magnetic flux density

For the automatic magnetic flux leakage testing systems for tubes, the performance of the attached demagnetizer shall be tested. At normal testing speed, Switch on the demagnetizer, let the reference sample tube pass through the magnetic flux leakage testing system. Use a teslameter (or magnetometer) to measure the residual magnetic flux density at both ends of the reference sample tube. After demagnetization, the residual magnetic flux density of the reference sample tube shall not exceed 20Gs.

8 Measurement report

The measurement report shall include at least the following information:

a) CSD or CSF, DDS, SNR, MTR, FAR, dead zone at the end, stability, residual magnetic flux density;

b) manufacturer names, models and numbers of the testing equipment and instrument;

c) steel type, specification, surface condition and number of the reference sample and reference standards in it;

d) parameters of the element, such as the type and specifications;

e) parameters such as gain, speed, line speed (or rotation speed), etc.;

f) name of tester and test date;

g) test location, environmental conditions, etc.;

h) exceptional circumstances and explanations.