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**Method for evaluating performance
characteristics of ultrasonic
pulse-echo testing systems**

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Contents

	Page
Introduction.....	1
1 Scope.....	1
2 Normative references	1
3 Terms and definitions	2
4 Measurement items of performance characteristics	2
5 Matters concerning measurement that are to be noted	3
5.1 Measurement items and measurement range	3
5.2 Reading of digital flaw detector	3
5.3 Person in charge of measurement	3
5.4 Measurement frequency	3
5.5 Accuracy of reading of display	3
5.6 Test condition	3
5.7 Distance amplitude correction	3
5.8 Position of reading of the time base of echo	3
6 Methods for evaluating performance characteristics	4
6.1 Evaluation of performance characteristics concerning time base	4
6.2 Measurement of performance characteristics concerning normal axis	5
6.3 Resolution of straight beam testing technique	12
6.4 Resolution of angle beam testing technique.....	16
6.5 Margin of sensitivity of straight beam testing technique	17
6.6 A1 sensitivity and A2 sensitivity of angle beam testing technique	18
6.7 Dead zone after transmitter pulse with straight beam testing technique	20
7 Periodic checks	21
8 Record.....	21
Annex JA (informative) Comparison table between JIS and corresponding International Standard	24

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 of 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 2352:1992** is replaced with this Standard.

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Attention is drawn to the possibility that some parts of this Standard may conflict with a patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have technical properties. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying the patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have the said technical properties.

Method for evaluating performance characteristics of ultrasonic pulse-echo testing systems

Introduction

This Japanese Industrial Standard has been prepared based on the first edition of **ISO 18175** published in 2004, while modifying some of the technical contents, based on the actual management of the standard in Japan, in such a way as to facilitate smoother management of the standard in Japan.

The portions with dotted underlines are the matters in which the contents of the corresponding International Standard have been modified. A list of modifications with the explanations is given in Annex JA.

1 Scope

This Standard specifies the method for evaluating performance characteristics and the method for periodic checks of the ultrasonic pulse-echo testing systems that are composed of the combination of the manually controlled ultrasonic test instrument having a basic display based on an ultrasonic pulse-echo technique and a probe.

NOTE 1 For the method for evaluating the electrical characteristics of an ultrasonic testing instrument, see **JIS Z 2351**.

NOTE 2 The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows.

ISO 18175:2004 *Non-destructive testing—Evaluating performance characteristics of ultrasonic pulse-echo testing systems without the use of electronic measurement instruments* (MOD)

The symbols which denote the degree of correspondence in the contents in the corresponding 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 B 0405 *General tolerances—Part 1: Tolerances for linear and angular dimensions without individual tolerance indications*

JIS B 0601 *Geometrical Product Specifications (GPS)—Surface texture: Profile method—Terms, definitions and surface texture parameters*

JIS G 0801 *Ultrasonic testing of steel plates for pressure vessels*

JIS Z 2300 *Terms and definitions of nondestructive testing*

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

JIS Z 2344 *General rule of ultrasonic testing of metals by pulse echo technique*

JIS Z 2345 *Standard test blocks for ultrasonic testing*

JIS Z 2350 *Method for measurement of performance characteristics of ultrasonic probes*

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 digital flaw detector

ultrasonic test instrument that performs digital processing of echo information and displays it

The control position of a flaw detector and the selection of a function also are digitally processed.

3.2 dummy signal

signal generated in an electronic circuit as an input signal in order to measure the performance characteristics of a flaw detector

3.3 normal axis

axis of ordinates of the display of a flaw detector

3.4 position of reading of the time base

position of reading of the echo on a display such as rise position and peak position

3.5 %fs

relative value when the full scale of the time base or normal axis of a display is taken as 100 %

4 Measurement items of performance characteristics

The measurement items of performance characteristics of an ultrasonic pulse-echo testing system shall be as follows.

- a) Measurement of performance characteristics concerning time base
- b) Measurement of performance characteristics concerning normal axis
- c) Resolution of straight beam testing technique
- d) Resolution of angle beam testing technique
- e) Margin of sensitivity of straight beam testing technique
- f) A1 and A2 sensitivities of angle beam testing technique
- g) Dead zone after transmitter pulse with straight beam testing technique

5 Matters concerning measurement that are to be noted

5.1 Measurement items and measurement range

The selection of the measurement items of performance characteristics and the evaluation method and the setting of the measurement range shall be determined by the users of this Standard on their own responsibility under the condition of a flaw detection test that is premised on the application of this Standard. This Standard does not force the users to implement all the measurement items of performance characteristics, the evaluation methods and the display methods.

5.2 Reading of digital flaw detector

When a digital flaw detector is used in the actual flaw detection test, and the numerical display function of echo height and beam path length is used, the same numerical values shall be used. However, the measurement of resolution and the judgment of disappearance of echo shall be performed by a display.

5.3 Person in charge of measurement

The measurement in this Standard shall be performed by an engineer who has sufficient knowledge and experiences concerning the ultrasonic pulse-echo testing system and ultrasonic flaw detection method and has a qualification equivalent to level 2 or better in **JIS Z 2305**, or under the supervision of such an engineer.

5.4 Measurement frequency

The measurement frequency shall be determined by the user of this Standard in consideration of the use, environment and the stability of the testing system.

5.5 Accuracy of reading of display

The reading of the time base and normal axis of a display shall be performed with the accuracy in which error becomes 1 %fs or less of the full scale. When a particular accuracy is specified, the reading shall be performed with the specified accuracy.

5.6 Test condition

The measurement items, measurement range, required probe and reference block shall be determined according to the application purpose of this Standard. Unless otherwise specified, the adjusted position of a knob shall be a typical position in the actual service condition. Unless specifically desired to be evaluated, the rejection control shall be set to OFF.

5.7 Distance amplitude correction

If required by the user, two sets of test data, i.e. that with the distance amplitude correction and that without shall be taken. If two sets of data are not required by the user, the test data without the distance amplitude correction shall be taken.

5.8 Position of reading of the time base of echo

The position of reading of the time base of echo shall be the same as the position under the actual flaw detection condition.

Usually, measurement shall be performed at the rise position of an echo, the position in which an echo signal exceeds one half the echo height, the peak position of an echo, the zero cross position or the position that exceeds the threshold set beforehand.

6 Methods for evaluating performance characteristics

6.1 Evaluation of performance characteristics concerning time base

6.1.1 Linearity of the time base

6.1.1.1 Test block and signal source

The test block and signal source shall be as follows.

- a) The flat test block of a thickness of about one fifth or about one-tenth the measurement range or the signal generator that can generate false echoes at intervals of about one-fifth or about one-tenth the measurement range shall be used.
- b) In the case of the test block method, for sound coupling, either the contact testing or the immersion testing is available.

6.1.1.2 Measurement procedure

The measurement procedure shall be as follows.

- a) Display 6 echoes (adjustment method 1 of table 1) or 11 echoes (adjustment method 2 of table 1) using the test block or the signal source.
- b) Adjust the sweep controls (range, delay) to position the echo according to table 1.
- c) Read the position on the display of other echoes in %fs, or convert the position of reading into %fs.
- d) When the echo height affects reading of the echo position (for example, when reading at the rise of the echo), set the echo height to 50 %fs to read the echo position.

6.1.1.3 Recording of data

The recording of data shall be performed as follows.

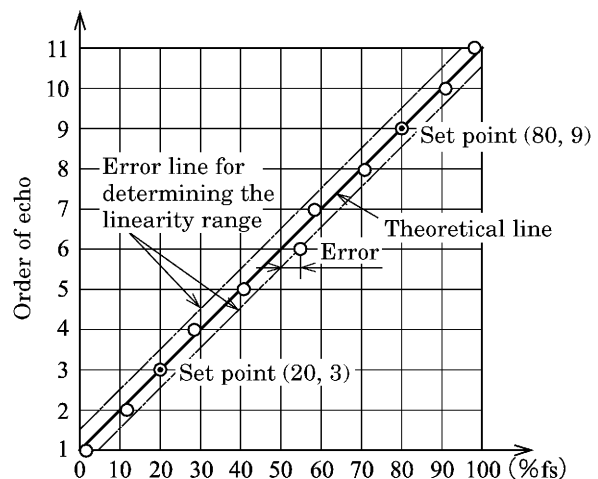
- a) Present the relation between the order of an echo and the read-out value by a table (see table 2) or a graph (see figure 1) and take it as data that shows the linearity of the time base. Record also the error obtained by subtracting the theoretical value from the measured value in the table.
- b) Give the linearity range by the continuous echo positions which are contained within the error set beforehand.
- c) Obtain the positive maximum error $+\Delta x_{\text{MAX}}$ and the negative maximum error $-\Delta x_{\text{MAX}}$, and take them as the errors of linearity of the time base.

Table 1 Echo and adjustment method used for measurement of linearity of the time base

	Adjustment method 1	Adjustment method 2
Generation method of echo	Plate of a thickness of about one-fifth the measurement range or dummy signal generated at intervals of about one-fifth the measurement range	Plate of a thickness of about one-tenth the measurement range or dummy signal generated at intervals of about one-tenth the measurement range
Number of echoes to be used	6 echoes	11 echoes
Adjusted position of echo ^{a)}	B ₁ is positioned at 0 %fs. B ₆ is positioned at 100 %fs.	B ₃ is positioned at 20 %fs. B ₉ is positioned at 80 %fs.
Note ^{a)} The subscript of B indicates the order of a back wall echo.		

Table 2 Presentation method of linearity of the time base by table

Order of echo	Signal position on display			Error ^{a)}
	Theoretical value		Measured value	
	Adjustment method 1	Adjustment method 2		
	%fs	%fs		
1	0	0		
2	20	10		
3	40	20		
4	60	30		
5	80	40		
6	100	50		
7		60		
8		70		
9		80		
10		90		
11		100		
Note ^{a)} The maximum continuous area stayed in the error range determined beforehand shall be taken as the linearity range.				

**Figure 1 Example of graphical presentation of linearity of the time base (in the case of adjustment method 2)**

6.2 Measurement of performance characteristics concerning normal axis

6.2.1 Types of measurement method

The measurement methods of vertical linearity are: a measurement method using a gain control including evaluation of disappearance of an echo (measurement method A), a measurement method using an echo from two reflectors (measurement method B) and a measurement method using an external attenuator (measurement method C). Unless otherwise specified, the measurement method A shall be used.

6.2.2 Vertical linearity (measurement method A)

6.2.2.1 Test block and instrument

Calibration block STB-G V15-5.6 (specified in **JIS Z 2345**), and a reflector calibrated by the said calibration block, or a signal generator (that can be synchronized by the transmitter pulse from ultrasonic test instrument) that generates dummy echo signals.

6.2.2.2 Measurement

The measurement shall be performed as follows.

- a) Connect the probe contacted to the test block via couplant or a signal generator to the flaw detector (see figure 2), and display the echo or dummy echo from the signal generator on the display.
- b) Set the other controls of the flaw detector to the conditions simulating the actual use.
- c) Adjust the gain controls of the ultrasonic test instrument to make the height of the echo or dummy echo 100 %fs.
- d) Reduce the gain in 2 dB steps by gain controls and read the echo height in %fs. Continue this procedure until 26 dB is read.
- e) The difference between the theoretical value and the measured value shall be designated as the error. The “positive” maximum error ($+h_{\text{MAX}}$) and the “negative” maximum error ($-h_{\text{MAX}}$) shall be obtained.
- f) Continue to reduce the gain to 30 dB and observe to judge whether echo can be clearly seen.
- g) When setting of the echo height of 100 %fs in the measurement above-mentioned is difficult, set to the value which is nearest to 100 %fs but not more than 100 %fs, and read the echo height.

6.2.2.3 Recording of data

The recording of data shall be as follows.

- a) Obtain the “positive” maximum error ($+h_{\text{MAX}}$) and the “negative” maximum error ($-h_{\text{MAX}}$), and take them as the errors of vertical linearity.
- b) If the echo is clearly observed at the reduced gain of 30 dB, record as “echo does not disappear”. If the echo disappears at 30 dB or lower, record the amount of gain reduced at the disappearance.