

# JIS

## JAPANESE INDUSTRIAL STANDARD

Methods for measurement on  
ultrasonic velocity of solid  
by pulse technique using  
reference test pieces

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In the event of any doubt arising,  
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Methods for measurement on ultrasonic  
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## 1. Scope

This Japanese Industrial Standard specifies the methods for measurement of the ultrasonic velocity in solids by the ultrasonic pulse echo method and transmission method using reference test pieces and methods for indicating the results of measurement.

Remarks: The following Standards are cited in this Standard:

JIS C 3501-Radio-Frequency Coaxial Cables

JIS Z 2300-Glossary of Terms Used in Nondestructive Testing

JIS Z 2344-General Rule of Ultrasonic Testing of Metals by  
the Pulse Echo Technique

JIS Z 2345-Standard Test Blocks for Ultrasonic Testing

JIS Z 2355-Methods for Measurement of Thickness by  
Ultrasonic Pulse Echo Technique

## 2. Definition

The definitions of the main terms used in this Standard shall be as specified in JIS Z 2300 and JIS Z 2355.

## 3. Measuring devices and materials

3.1 Ultrasonic velocity measuring device One of the following ultrasonic velocity measuring devices shall be used:

- (1) Measuring devices which directly indicate the ultrasonic velocity The performance of measuring devices which directly indicate the ultrasonic velocity shall allow direct digital indication of the ultrasonic velocity to at least 4 significant figures.
- (2) Ultrasonic thickness meter with indicator This meter is A-scan display ultrasonic flaw detector, capable of indicating the pulse intervals on the indicator by digital values.
- (3) Digital ultrasonic pulse thickness meter The performance of this meter shall be such as allows direct digital indication of the thickness to at least 3 significant figures.
- (4) Ultrasonic flaw detector The performance of A-scan display ultrasonic flaw detectors, including the electromagnetic types, shall be such that the linearity of the time axis of the indicator is within  $\pm 1\%$  when measured as given in Annex 1 of JIS Z 2344.

**3.2 Measuring frequency** The frequency used for measurement by the pulse echo method shall be such as can give 5 or more easily discernible bottom echoes, or where this is difficult, at least 2 easily discernible bottom surface echoes.

**3.3 Contact probes** The contact probes used shall be as follows:

- (1) Contact probes of any oscillator size may be used, but in measurements on a curved measuring surface by the direct contact method, the probe used shall have an oscillator size small enough that the effect of such curvature can be neglected.

The contact probes shall operate at the frequencies specified in 3.2.

- (2) The deflection angle of the beam axis of the contact probes used for measurement shall be measured as given in Annex 1 and shall be verified to be within 1 degree.
- (3) For measurement of the longitudinal wave ultrasonic velocity, the contact probes may be single-oscillator longitudinal wave vertical contact probes for use by direct contact or water immersion, or double-oscillator vertical contact probes for use by direct contact.
- (4) For measurement of the transverse wave ultrasonic velocity, single-oscillator transverse wave vertical contact probes for use by direct contact shall be used.
- (5) The ultrasonic velocity measuring device may be used in combination with any of the contact probes listed in Table 1.

Table 1. Combinations of ultrasonic velocity measuring devices and contact probes

| Type of ultrasonic velocity measuring device                          | Type of contact probe                                                                                                                                                                                                                                                                                                           |
|-----------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (a) Measuring device which directly indicates the ultrasonic velocity | Single-oscillator longitudinal wave vertical contact probe                                                                                                                                                                                                                                                                      |
| (b) Ultrasonic thickness meter with indicator                         | (Double-oscillator vertical contact probe) <sup>(1)</sup>                                                                                                                                                                                                                                                                       |
| (c) Digital ultrasonic thickness meter                                | Single-oscillator transverse wave vertical contact probe                                                                                                                                                                                                                                                                        |
| Ultrasonic flaw detector                                              | Single-oscillator longitudinal wave vertical contact probe<br>(Double-oscillator vertical contact probe) <sup>(1)</sup><br>Single-oscillator transverse wave vertical contact probe<br>Electromagnetic ultrasonic longitudinal wave vertical contact probe<br>Electromagnetic ultrasonic transverse wave vertical contact probe |

Note <sup>(1)</sup> The use of probes indication parenthese shall be avoided as far as possible.

**3.4 Measuring systems** The systems for ultrasonic velocity measurement shall be classified as shown in Table 2 based on the ultrasonic velocity measuring device used, the combined contact probes, and the pulse signal used for ultrasonic velocity measurement.

Table 2. Ultrasonic velocity measuring systems

| Measuring system                                                                       | Pulse signal used for ultrasonic velocity measurement                                                                                                    | Figure<br>(basic indication) |
|----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
| Multiple-echo system<br>( $B_m$ - $B_n$ system)                                        | As a rule, multiple echo $B_1$ and $B_n$ ; but where a number $n$ satisfying the condition $n \geq 2B_1$ can not be used, $B_2$ shall be used as $B_n$ . |                              |
| Surface echo and first bottom surface echo system<br>(S- $B_1$ system)                 | Surface echo of test specimen and first bottom surface echo                                                                                              |                              |
| Corrected point of incidence and first bottom surface echo system<br>(R- $B_1$ system) | Starting point of measurement, corrected by use of a test piece of known thickness, and first bottom surface echo                                        |                              |
| Transmission pulse system direct contact method<br>(TD system)                         | Dispatched pulse and transmitted pulse (U)                                                                                                               |                              |
| Transmission pulse system water immersion method<br>(TI system)                        | Starting point of measurement, corrected by use of a test piece of known thickness, and transmitted pulse (U)                                            |                              |

**3.5 Contact probe cables** The contact probe cables used shall be chosen from flexible type cables such as the 1.5 D - 2 V cable specified in JIS C 3501 to obtain a stable contact between the contact probe and the specimen for measurement, if the characteristic impedance is equivalent.

**3.6 Reference test pieces** The reference test pieces used for ultrasonic velocity measurement shall be selected on the basis of the difference between general and high-precision ultrasonic velocity measurement, and shall meet one of the requirements shown in Table 3.

Table 3. Selection of reference test pieces

| Item                                       | General measurement                                                            | High-precision measurement                                                   |
|--------------------------------------------|--------------------------------------------------------------------------------|------------------------------------------------------------------------------|
| Parallelism of front to back surface       | 0.01/100                                                                       | 0.002/50                                                                     |
| Degree of finish of front and back surface | 3.2 S                                                                          | 1.6 S                                                                        |
| Precision of thickness                     | Measured to an accuracy of within 0.05 mm.                                     | Measured to an accuracy of within 0.002 mm.                                  |
| Ultrasonic velocity                        | Measured as given in 2.3 of Annex 2.                                           | Measured as given in 2.1 or 2.2 of Annex 2.                                  |
| Acoustic characteristics                   | An acoustic impedance of the same degree as the measured specimen is required. | An acoustic impedance of the same degree as the measured object is required. |

#### 4. Preparation for measurement

**4.1 Treatment of the measured surface** The measured surface shall be treated to satisfy one of the conditions shown in Table 4, depending on the type of reference test piece used.

Table 4. Treatment of measured surface

| Measuring precision        | Finish of measured surface | Parallelism of the measured surface to the back surface | Finish of the back surface   |
|----------------------------|----------------------------|---------------------------------------------------------|------------------------------|
| General measurement        | 3.2 S                      | 0.01/100                                                | Same as the measured surface |
| High-precision measurement | 1.6 S                      | 0.002/50                                                | Same as the measured surface |

**4.2 Selection of the contact medium in the direct contact method** The contact medium shall be selected from those shown in Table 5 based on the subject of measurement-longitudinal wave or transverse wave ultrasonic velocity.

Measurement may be made with no contact medium where the surface of contact of the vertical contact probe is smooth and it is preliminarily determined that an acoustic combination of a measurable degree can be obtained.

Table 5. Selection of the contact medium

| Type of measurement                   | Type of contact medium                                                                                                                              |
|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| Longitudinal wave ultrasonic velocity | Spindle oil, machine oil, or the equivalent                                                                                                         |
| Transverse wave ultrasonic velocity   | Highly viscous liquid (such as isopolybutane), solid adhesive (such as phenyl salicylate), or other medium suitable for transverse wave propagation |

4.3 Adjustment Using a reference test piece, required adjustments shall be made so that the figure or indicated value on the indicator shows either the thickness of the reference test piece or its ultrasonic velocity.

4.4 Calibration Calibration shall be made during measurement at least once every hour and immediately after completion of measurement, and where the calibration value differs from the previous one by a degree exceeding the prescribed value, measurement shall be made again for the concerned period.

The prescribed calibration values shall be decided upon agreement between the parties concerned in consideration of the required ultrasonic velocity precision.

Calibration is mandatory in the following cases:

- (1) Where an abnormality in the operation of the device is suspected.
- (2) Where a part or the whole of the measuring device has been replaced.
- (3) Where the engineer in charge has been relieved by another.

## 5. Measuring methods

5.1 Selection of the measuring system The measuring system shall be selected from among those shown in Table 2 by consultation between the parties concerned.

### 5.2 Measuring methods

5.2.1 Methods using a measuring device which directly indicates the ultrasonic velocity Methods using a measuring device which directly indicates the ultrasonic velocity shall be carried out as follows:

- (1) Method for measuring the longitudinal wave ultrasonic velocity
  - (a) Select a reference test piece and input its thickness, and, using a longitudinal wave vertical contact probe, adjust the ultrasonic velocity in the test piece as indicated by the  $B_m-B_n$ ,  $S-B_1$  or  $R-B_1$  system of Table 2.

- (b) Prepare the specimen, measure and set its thickness with micrometer callipers, in general to an error of within 0.05 mm (for high-precision measurement, within 0.005 mm), measure the ultrasonic velocity of the specimen as in (a), and read its value.

(2) Method for measuring the transverse wave ultrasonic velocity

- (a) Select a reference test piece and input its thickness, place a transverse wave vertical contact probe, in contact with the test piece through a suitable contact medium selected from those in Table 5, and adjust the ultrasonic velocity in the test piece as indicated by the  $B_1$ - $B_2$ , S- $B_1$  or R- $B_1$  system of Table 2.
- (b) Prepare the specimen, measure and set its thickness with micrometer callipers, in general to an error of within 0.05 mm (for high-precision measurement, within 0.005 mm), measure the ultrasonic velocity in the specimen as in (a), and read its value.

5.2.2 Methods using an ultrasonic thickness meter with indicator  
Methods using an ultrasonic thickness meter with an indicator shall be carried out as follows:

(1) Method for measuring the longitudinal wave ultrasonic velocity

- (a) Select a reference test piece and adjust to the longitudinal wave ultrasonic velocity of the test piece, measure its thickness by the  $B_m$ - $B_n$ , S- $B_1$  or R- $B_1$  system of Table 2 using a longitudinal wave vertical contact probe, and read its value.
- (b) Prepare the specimen, measure its thickness with micrometer callipers in general to an error of within 0.05 mm (for high-precision measurement, within 0.005 mm), and read the thickness of the specimen as in (a).

Find the longitudinal wave ultrasonic velocity  $V_L$  of the specimen from the following formula:

$$V_L = \frac{d_c \cdot t}{d \cdot t_c} \cdot V_{cl} \quad \dots\dots\dots (1)$$

where,  $V_L$ : longitudinal wave ultrasonic velocity of the specimen (m/s)

$d_c$ : thickness value of reference test piece read from the digital indicator (mm)

$t$ : thickness of the specimen measured mechanically (mm)

$V_{cl}$ : longitudinal wave ultrasonic velocity of the reference test piece (m/s)

$d$ : Thickness value of the specimen read from a digital indicator (mm)

$t_c$ : thickness of the reference test piece measured mechanically (mm)

(2) Method for measuring the transverse wave ultrasonic velocity

- (a) Select a reference test piece and adjust to its transverse wave ultrasonic velocity, place a transverse wave vertical contact probe in contact with the test piece through a suitable contact medium selected from those in Table 5, measure the thickness of the test piece by the  $B_m-B_n$ ,  $S-B_1$  or  $R-B_1$  system of Table 2, and read its value.
- (b) Prepare the specimen, measure its thickness with micrometer callipers in general to an error of within 0.05 mm (for high-precision measurement, within 0.005 mm), and read the thickness of the specimen as in (a).

Find the transverse wave ultrasonic velocity  $V_s$  of the specimen from the following formula:

$$V_s = \frac{d_c \cdot t}{d \cdot t_c} \cdot V_{cs} \dots \dots \dots (2)$$

where,  $V_s$ : transverse wave ultrasonic velocity of specimen (m/s)

$d_c$ : thickness value of reference test piece read from the digital indicator (mm)

$t$ : thickness of the specimen measured mechanically (mm)

$V_{cs}$ : transverse wave ultrasonic velocity value of the reference test piece (m/s)

$d$ : thickness value of the specimen read from a digital indicator (mm)

$t_c$ : thickness of the reference test piece measured mechanically (mm)

### 5.2.3 Methods using a digital indication ultrasonic thickness meter

The methods using this type of thickness meter shall be carried out as follows:

(1) Method for measuring the longitudinal wave ultrasonic velocity

- (a) Select a reference test piece and adjust the ultrasonic velocity of the ultrasonic thickness meter to the longitudinal wave ultrasonic velocity of the test piece, measure the thickness of the test piece by ultrasonic waves using a longitudinal wave vertical contact probe, and read its value.
- (b) Prepare the specimen, measure its thickness with micrometer callipers, in general to an error of within 0.05 mm (for high-precision measurement, within 0.005 mm), and read the thickness of the specimen as in (a).

Find the longitudinal wave ultrasonic velocity  $V_L$  of the specimen from the following formula:

$$V_L = \frac{d_c \cdot t}{d \cdot t_c} \cdot V_{CL} \dots\dots\dots (3)$$

where,  $V_L$ : longitudinal wave ultrasonic velocity of the specimen (m/s)

$d_c$ : thickness of the reference test piece read from a digital indicator (mm)

$t$ : thickness of the specimen measured mechanically (mm)

$V_{CL}$ : longitudinal wave ultrasonic velocity of the reference test piece (m/s)

$d$ : thickness of the specimen read from a digital indicator (mm)

$t_c$ : thickness of the reference test piece measured mechanically (mm)

## (2) Method for measuring the transverse wave ultrasonic velocity

- (a) Select a reference test piece and adjust the ultrasonic velocity of the ultrasonic thickness meter to the transverse wave ultrasonic velocity of the test piece, place a transverse wave vertical contact probe in contact with the test piece through a suitable contact medium selected from those in Table 5, and read the thickness of the test piece by ultrasonic waves.
- (b) Prepare the specimen, measure its thickness with micrometer callipers to an error of within 0.05 mm (for high-precision measurement, within 0.005 mm), and read the thickness of the specimen as in (a).

Find the transverse wave ultrasonic velocity  $V_s$  of the specimen from the following formula:

$$V_s = \frac{d_c \cdot t}{d \cdot t_c} \cdot V_{CS} \dots\dots\dots (4)$$

where,  $V_s$ : transverse wave ultrasonic velocity of the specimen (m/s)

$d_c$ : thickness of the reference test piece read from a digital indicator (mm)

$t$ : thickness of the specimen measured mechanically (mm)

$V_{CS}$ : transverse wave ultrasonic velocity of the reference test piece (m/s)

$d$ : thickness of the specimen read from a digital indicator (mm)

$t_c$ : thickness of the reference test piece measured mechanically (mm)