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(JSNDI/JSA)

**Method for measurement of  
ultrasonic attenuation coefficient of  
solids**

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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 2354**:1992 is replaced with this Standard.

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# Method for measurement of ultrasonic attenuation coefficient of solids

## 1 Scope

This Japanese Industrial Standard specifies the method for measurement of the ultrasonic attenuation coefficient of solids at a frequency of 2 MHz or more.

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

JIS G 4053 *Low-alloyed steels for machine structural use*

JIS Z 2300 *Terms and definitions of nondestructive testing*

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

JIS Z 2352 *Method for evaluating performance characteristics of ultrasonic pulse-echo testing systems*

## 3 Terms and definitions

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

### 3.1 measurement specimen

specimen cut out from test body in a certain shape and dimensions to be used for measurement of attenuation coefficient

### 3.2 reference block

low damping material block with the same shape and dimensions as measurement specimen, used as a standard in measurement of attenuation coefficient

### 3.3 delay material

material inserted between the transducer and the measurement specimen to keep them apart in a certain distance during measurement by contact testing technique

Generally, hard synthetic resin of which the acoustic impedance is much smaller than metal is used for delay material.

## 4 Measuring engineer

The measuring engineer shall have sufficient knowledge in propagation of ultrasonic waves and shall be proficient in operating the measuring device.

## 5 Measurement specimen for attenuation coefficient

### 5.1 When the object of measurement is steel

When the object of measurement is steel, the measurement specimen shall be as follows.

- a) The measurement specimen shall be either a cuboid with a square measurement surface or a cylinder with a circular measurement surface, having dimensions as given in table 1. For the measurement of attenuation coefficient not using reference block, however, the measurement specimen of any thickness can be used.

**Table 1 Dimensions of measurement specimen**

| Nominal frequency used for measurement<br>MHz | Side length or diameter of measurement surface<br>mm | Thickness<br>mm |
|-----------------------------------------------|------------------------------------------------------|-----------------|
| 2 or over to and excl. 10                     | 100 or over                                          | 25 to 50        |
| 10 or over                                    | 50 or over                                           | 25 to 50        |

- b) Parallelism between the measurement surface and the back wall shall be 0.01/100 or under.
- c) For contact testing technique, the measurement surface of the specimen shall be lapped and the back wall shall be finished to about *Rz* 3.2 expressed in accordance with **JIS B 0601**. In the case of using synthetic resin delay material, however, both surfaces shall be finished to about *Rz* 3.2. For immersion testing technique, both the measurement surface and the back wall of the measurement specimen shall be finished to about *Rz* 3.2.

### 5.2 When the object of measurement is other than steel

The size of the measurement specimen shall be determined considering the ultrasonic characteristics of the material, such that the echo used for the measurement can be displayed with sufficient SN ratio without the influence of the edges of the specimen.

## 6 Reference block

The sound velocity, acoustic impedance, shape, dimensions, parallelism and the degree of finish of the reference block shall be as specified for the measurement specimen in clause 5.

When the object of measurement is steel as specified in 5.1, the material of the reference block shall be SNCM447 steel specified in **JIS G 4053** that is quenched and tempered (and then air cooled) or material with equal or smaller attenuation coefficient.

## 7 Equipment used

### 7.1 Ultrasonic pulse transmitter and receiver

### 7.1.1 Type

For ultrasonic generation, an ultrasonic flaw detector, pulse transmitter or function generator shall be used. For ultrasonic reception, an ultrasonic flaw detector, pulse receiver or oscilloscope shall be used.

### 7.1.2 Performance

The performance required for equipment shall be as follows.

- a) In the case of an ultrasonic flaw detector, the following requirements shall be met.
  - 1) The vertical linearity shall be measured in accordance with **6.2.2** of **JIS Z 2352**, and the resultant error shall be within  $\pm 2\%$ .
  - 2) The linearity of the time base shall be measured in accordance with **6.1.1** of **JIS Z 2352**, and the resultant error shall be within  $\pm 2\%$ .
- b) In the case of an oscilloscope, the oscilloscope used shall be capable of displaying frequency up to twice or more the nominal frequency of the probe used for the measurement.

### 7.2 Probe

The probe shall be as follows.

- a) An immersion probe or a normal probe for contact testing (including those which have been confirmed to have sufficient S/N ratio when connected to a pulse transmitter/receiver, such as a bare transducer) shall be used. A focused probe shall not be used. A normal probe with delay material made of hard synthetic resin, etc. may be used. Figure 1 shows an example of normal probe with delay material. To the normal probe for contact testing, a tuning circuit may be added as required, to increase the number of cycles.

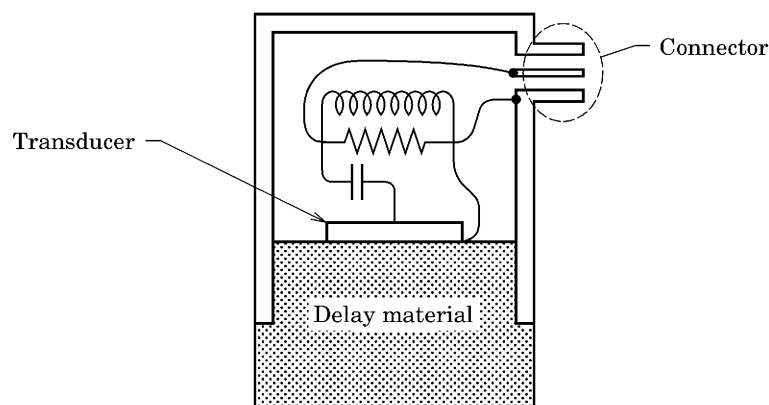


**Figure 1 Example of normal probe with delay material**

- b) When using a probe in combination with a pulse transmitter and pulse receiver or ultrasonic flaw detector, the cycle number of echo measured in accordance with **7.2.4** of **JIS Z 2350** shall be not less than 5. Alternatively, a probe capable of generating 5 or more cycles can be used in combination with a burst transmitter, in which case, the frequency shall be measured in accordance with the method specified in **JIS Z 2350**, the method using a frequency analyzer, or other suitable method.

In the case of using broadband pulse with small number of cycles, the method in Annex A shall be used.

- c) Deviation angle of the centre axis of the beam shall not exceed  $1^\circ$ , when measured by the method specified in **JIS Z 2350**.

### 7.3 Probe cable

The probe cable specified by the pulse transmitter and receiver shall be used for this measurement. To obtain stable contact between the probe and the measurement specimen, a cable with maximum flexibility shall be selected.

### 7.4 Couplant

The couplant shall be as follows.

- a) For contact testing technique, the couplant used shall be spindle oil or machine oil. In the case of using shear wave, the couplant shall be a material that is suitable for transmission of shear wave, such as high viscosity liquid and solid adhesive (phenyl salicylate).
- b) For immersion testing technique, the couplant used shall be water. However, where use of water is not appropriate, spindle oil or the like shall be used instead.

### 7.5 Water tank

The water tank shall have a structure satisfying the following. An example of a tank to be used is shown in figure 2.

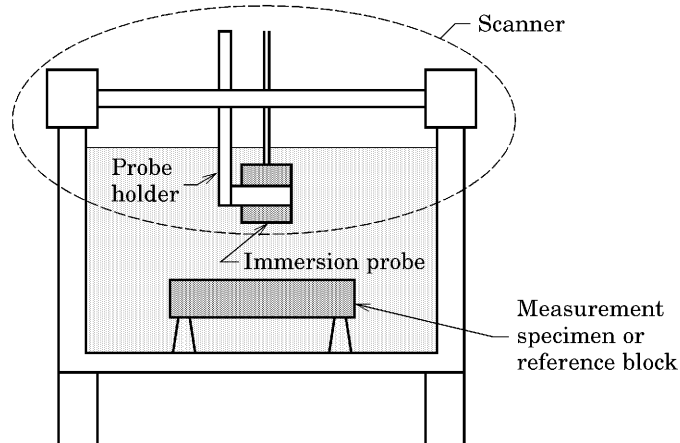


**Figure 2 Example of water tank to be used**

- a) Incident ultrasonic beam can enter the surface of the measurement specimen immersed in the water.
- b) In order to make the incident ultrasonic beam enter the approximate centre of the surface of the measurement specimen, the probe shall be able to scan in two orthogonal directions (X direction and Y direction) on the horizontal plane.
- c) The probe shall have a swivel scanning function of  $0.1^\circ$  (inclination of 1/600) in order to make the incident ultrasonic beam enter the measurement specimen perpendicularly.

- d) The probe shall be able to be moved in the vertical direction (Z direction) in order to adjust the water distance.
- e) It shall be easy to observe the air bubbles on the front surface of the probe and measurement surface of the measurement specimen, and remove them.
- f) To prevent generation of air bubbles, sufficiently deaerated water, such as water cooled after boiling, shall be used.

## 8 Measurement of attenuation coefficient of measurement specimen

### 8.1 General

The method specified in this clause is generally applied using a probe for narrowband of not less than 5 in number of cycles. In the case of using a broadband probe, however, measurement may be performed according to the method described in Annex A.

### 8.2 Methods using reference block

#### 8.2.1 Contact-multiple echo technique

The measurement of attenuation coefficient by contact-multiple echo technique using reference block shall be as follows.

- a) The pulse transmitter and receiver, or the ultrasonic flaw detector shall be adjusted as follows.
  - 1) The test range shall be adjusted so that the first back wall echo (hereafter referred to as “ $B_1$ ”) and the final back wall echo (hereafter referred to as “ $B_m$ ”) used for measurement are within a display graticule.

The suffix  $m$  of  $B_m$  represents the number of the order of the final back wall echo. The maximum is the number where the SN ratio of  $B_m$  is 14 dB or more, but it is further limited by the value obtained by the following formula (1):

$$m \leq 0.29 \frac{Ddf}{CT} \dots\dots\dots (1)$$

where,       $m$  : number of order of final back wall echo  
                   $D$  : diameter or side length of reference block (mm)  
                   $T$  : thickness of reference block (mm)  
                   $C$  : sound velocity of reference block (km/s)  
                   $d$  : diameter of transducer (mm)  
                   $f$  : test frequency (MHz)

- 2) The rejection control shall be set to “OFF” or “0”.
- 3) The receiving bandwidth shall contain the frequency of ultrasonic wave used for measurement.
- b) The probe shall be closely contacted, via a small amount of couplant, to the approximate centre of the measurement surface of the measurement specimen by rubbing together. To obtain a stable acoustic coupling between the probe and the measurement specimen, a constant pressure shall be exerted on the probe housing.