IS 15435 (2003): Recommended Practice for Measuring Thickness Using Ultrasonic Method [MTD 21: Non-Destructive Testing]

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IS 15435 : 2003

भारतीय मानक

पराश्रव्य प्रणाली के प्रयोग द्वारा मोटाई मापने हेतु अनुशंसित रीति

Indian Standard

RECOMMENDED PRACTICE FOR MEASURING THICKNESS USING ULTRASONIC METHOD

ICS 77.040.20

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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Price Group 2

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Non-destructive Testing Sectional Committee had been approved by the Metallurgical Engineering Division Council.

This method is applicable to any material in which ultrasonic waves will propagate at a constant velocity throughout the part and from which back reflection can be obtained and resolved.

There are two different situations in which thickness measurement is done:

a) Where the requirement is to determine the exact thickness, and

b) Where the requirement is to determine only the variations in thickness from point to point.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

RECOMMENDED PRACTICE FOR MEASURING THICKNESS USING ULTRASONIC METHOD

1 SCOPE

1.1 This standard deals in with the procedures of measurement of thickness using ultrasonic pulse echo method.

1.2 This standard is applicable to all such materials which will give a clear resolvable back wall echo and which do not have variation in the ultrasonic velocity in any direction.

2 REFERENCES

2.1 The standards listed below contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreement based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
2417 : 2003	Glossary of terms relating to ultrasonic testing (*second revision*)
12666 : 1988	Method for performance assessment of ultrasonic flaw detection equipment
13805 : 1993	Guidelines for certification for personnel for non-destructive testing

3 GLOSSARY

For the purpose of this standard, the definitions given in IS 2417 shall apply.

4 PRINCIPLE OF MEASUREMENT

There are two different situations in which thickness measurement is done:

a) Where the requirement is to determine the exact thickness.

b) Where the requirement is to determine only the variation in thickness from point to point.

In all these situations, the thickness is evaluated as a product of ultrasonic velocity in the sample and the time of travel of the ultrasonic waves. The instrument (thickness gauge) evaluates the time of flight basically and then multiplies it with a preset value of velocity. In situation (a), this preset velocity is the velocity in the test material, and in (b) it is the approximate velocity. In place of feeding in the velocity data, the instrument can be calibrated using parallel plate in both the cases. The time interval between the pulse that triggers the circuit on and the pulse that puts the circuit off is measured by a timer or flip-flop circuit. The start of time interval can be done by initial pulse, interface echo or the back wall echo. The initial pulse, with electronic delay to compensate for travel time in delay block, etc, gives good near surface resolution. Interface echo, via receiver channel, suffers from poor resolution which improves, if echo is received via transmitter channel. The back wall echo suffers from amplitude variation.

The end of time interval is done by the first back wall echo. It depends upon the threshold level and the echo amplitude or the successive back wall echo as the case may be which in turn depends upon the transmitted pulse amplitude, receiver gain, beam characteristics, surface conditions, attenuation, etc. Setting up of threshold level is important as it may lead to an error that occurs when the measurements are made at thicker section and the first half cycle used for calibration at thin section may get attenuated well below the threshold level. This inherent error of ultrasonic gauges can be reduced appreciably by integrating the full wave rectified echo.

The ultrasonic wave depends upon the frequency, probe characteristics and the acoustic properties and thickness of the material of the sample. Since the exact beam characteristic in the sample is not known, it forces some errors to enter in. The inherent errors of ultrasonic gauges can be appreciably reduced by some adjustments both in the instrument as well as during calibration. The instrument can be provided with automatic amplitude control that makes the heights of echoes equal even if these are coming from different thicknesses. This electronic correction is specially necessary in thick samples. It may not be necessary in case (b) above if the expected variation in thickness is not much. The thin samples do not require this correction but pose the problem of non-linearity in the Vee path, if twin probe is being used.

5 EQUIPMENT FOR MEASUREMENT

5.1 Instrument

Three different types of instruments can be used. One fitted only with a cathode ray tube (CRT), second with an additional attachment for digital display and the third with only digital display. The CRT displays A-scan presentation. Some of the instruments are additionally equipped with B-scan presentation for display of variation of thickness at different points. This is done

by displaying A-scan presentations of various positions in straight parallel lines. The display is used to measure the separation between initial pulse and any of the back wall echoes or between any two echoes. The digital display simplifies the task of measurement. The instrument must be calibrated as per IS 12666 for linearity and repeatability.

5.2 Probes

A twin probe shall be used for thickness measurement between 1.5 mm and 20 mm. These probes pose a problem due to their different Vee path in thinner samples resulting into large non-linearity below 3 mm of steel. This requires the linearity correction if twin probes are used for thin sections.

Single probes have large dead zone or poor near surface resolution due to the continuous ringing of crystal and the finite saturation time of receiver. Such probes shall be used for measurement of samples with thickness above 20 mm. For samples with thickness below 1.5 mm, single probe with delay lines shall be used. These probes shall be highly damped and will have nominal frequency of 10 MHz or more.

The diameter of the probe chosen depends upon several factors. It would be better to have as small diameter as possible, say 10 mm, to allow proper contact on curved surface. This will also result in smaller beam diameter which gives finer resolution in the measurement of variation in thickness. However, small diameter probes suffer from larger beam diffraction giving some times spurious echoes from lateral wall after the first back wall echo. If the lateral dimensions are not large enough, either high frequency has to be used or higher diameter has to be used.

5.3 Couplant

The couplant that allows the transfer of energy from transducer to sample and back can affect the measurement of thickness. The variation in thickness of couplant while scanning the sample and also the difference between couplant thickness on reference block and test sample shall be kept minimum. The use of delay line made of a material having small acoustic impedance, such as perspex, is recommended for thin sections.

6 PROCEDURE OF MEASUREMENT

The procedure of measurement depends upon the two situations described in **4** and is given in the following clauses.

6.1 Determination of Exact Thickness

Either of the following two methods can be used for determination of exact thickness.

6.1.1 *Using Instrument with A-scan Display*

A reference block shall be prepared from the same material as that of the sample in the form of a parallel plate. Its thickness will be exactly measured. Alternately, a site will be selected on the sample where parallel faces are available and where probe can be placed and the gap (thickness) can be measured.

The instrument having A-scan display facility will be calibrated on this reference block or at this selected site. The difference between x-axis positions of leading edges of first and *n*th back wall echoes from the reference block or selected site and that from the test location is recorded. The thickness at the test location is then calculated using the following expression:

$$\text{Sample thickness} = \frac{\text{Block thickness} \times \text{Difference for sample}}{\text{Difference for block}}$$

Use of twin probes is not recommended. High frequency will give better accuracy. The frequency of probe shall be so chosen that at least two echoes from back wall are clearly visible.

6.1.2 *Using Thickness Gauges*

Two reference blocks shall be made out of the material under test in the form of parallel plates. One will have the thickness near the maximum range of interest and the other near the minimum of this range. Their thickness will preferably be measured within the accuracy better than the display resolution of the gauge.

For the adjustment of delay and range controls, the probe is first placed on the thicker of the two reference blocks. Any deviation in the thickness reading from the true value is offset by the adjustment of range (material calibration) control. The probe is then placed on the thinner block and delay control is adjusted to get true thickness value. The steps are repeated several times till the instrument reads the correct thickness of the two blocks. The thickness of the test sample is then measured directly from the gauge.

6.2 Evaluation of Variation in Thickness

6.2.1 *Using Instrument with A-scan Display*

The procedure used to measure the exact thickness (*see* **6.1.1**) is used for the evaluation of variation in thickness. However, the reference block need not be made of the same material as that of test sample. It can be of a material acoustically similar to the sample material. For fast calculations, the ratio of block thickness to difference in positions of echoes can be rounded off to a single place of decimal. Also, the first back wall echo may be brought to zero position by introducing the suitable delay.

6.2.2 *Using Thickness Gauges*

The procedure is similar to that given in **6.1.2** except

that the two blocks need not be made of the same material as the test sample. These blocks may be made of hard, non-corrosive material if thickness to be measured is between 3 mm and 20 mm. Below 3 mm, blocks made of material acoustically identical to test sample have to be taken, if twin probe is used. Above 20 mm, blocks made of material with nearly same attenuation as test sample are to be used. The variation in thickness of the test sample is measured directly from the gauge.

7 TEMPERATURE EFFECT

The calibration of equipment and reference block must be done with the same couplant and at the same temperature at which the thickness of the test material is to be measured. If however, the temperatures of calibration block and that of test material are different, the correction factor must be applied. The correction factor shall be different for different materials and must be known experimentally.

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