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**Method of automatic ultrasonic
inspection for graphite ingot**

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Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee according to the proposal of establishing a Japanese Industrial Standard from The Japanese Society for Non-Destructive Inspection (JSNDI)/ Japanese Standards Association (JSA) with a draft being attached based on the provision of Article 12 Clause 1 of the Industrial Standardization Law.

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Method of automatic ultrasonic inspection for graphite ingot

1 Scope This Japanese Industrial Standard specifies the method of the automatic ultrasonic inspection of planar flaws in all directions of isotropic graphite ingots which shall be performed underwater by utilizing a pulse echo technique using a single probe.

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 Z 2300 *Terms and definitions of nondestructive testing*

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

JIS Z 3070 *Methods for automatic ultrasonic testing for welds of ferritic steel*

3 Definitions For the purpose of this Standard, the definitions given in clauses 3 of **JIS Z 2300** and **JIS Z 3070** and the following definitions apply.

- a) **plane scanning** two-dimensional scanning along the incidence plane of the test block among methods for the setting of a direction of movement and a gap of the probe

Either R-X scanning of 3 b) or R-Z scanning of 3 c) shall be performed according to two incidence planes.

- b) **R-X scanning** test block rotation—test block diametrical direction scanning of the plane scanning, which shall be performed at the time of incidence from the upper and the lower surfaces of the test block, which are plane surfaces (see figure 1)
- c) **R-Z scanning** test block rotation—test block longitudinal direction scanning of the plane scanning, which shall be performed at the time of the incidence from the side surface of the test block, which is a curved surface (see figure 2)
- d) **incident-angle scanning** scanning which changes the incident angle in sequence at the time of the plane scanning among methods for the setting of a direction of movement and a gap of the probe

Either i_1 - i_2 scanning or i_1 - o_{ff} scanning shall be performed by the method of either orthogonal scanning or staggered scanning according to the incident plane.

- e) **i_1 - i_2 scanning** upper and lower angle (probe inclining angle) i_1 —horizontal angle (probe swivel angle) i_2 scanning of incident-angle scanning, which shall be performed at the time of the incidence from the upper and lower surfaces of the test block (see figure 1)

R-X scanning shall be performed at each scanning point (data obtaining point).

- f) **i_1 - o_{ff} scanning** upper and lower angle (probe inclining angle) i_1 —offset o_{ff} scanning of incident-angle scanning, which shall be performed at the time of the incidence from the side surface of the test block (see figure 2)

R-Z scanning shall be performed at each scanning point (data obtaining point).

- g) **orthogonal scanning** scanning performed in such a way that scanning point draws square lattices in incident-angle scanning
- h) **staggered scanning** scanning performed in such a way that scanning point draws perfect hexagonal lattices and alternate zig-zag patterns are obtained in order to reduce the number of scanning points in incident-angle scanning (see figure 3)
- i) **primary inspection** inspection performed at the first step of the two stages
The primary inspection shall be carried out at a comparatively high sensitivity using a scanning pitch equivalent to a comparatively large apparent beam width, and the location where the secondary inspection is to be carried out is identified.
- j) **secondary inspection** inspection performed at the second step of the two stages
The secondary inspection shall be carried out for the location identified in the primary inspection at a sensitivity lower than that of the primary inspection by only the amount of beam-edge compensation using a scanning pitch equivalent to a comparatively small apparent beam width, and a decision whether to accept or reject the test block is made.
- k) **two-axis swivel scanning** scanning performed to obtain the maximum echo height by scanning two incident-angle axes in order to compensate the fluctuation of the wave front of an ultrasonic beam which propagates through graphite when the echo height of a flat-bottomed hole is measured for the setting of specified sensitivity
- l) **geometric refraction angle** refraction angle calculated from the incident angle according to Snell's law using an average sound velocity in graphite
For the sound velocity here, the rough order of magnitude of two-digit significant figures shall be used.
- m) **planar width of beam spread** range of plane direction where an echo appears within the specified strength reduction from the maximum echo height when an plane scanning is performed for a flat-bottomed hole equivalent to the flaw to be detected

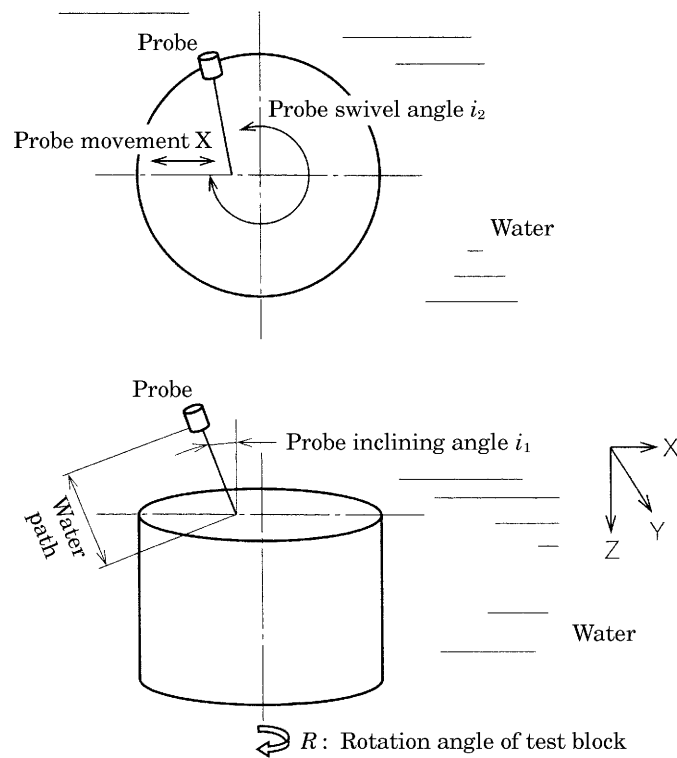


Figure 1 Schematic diagram of R-X scanning

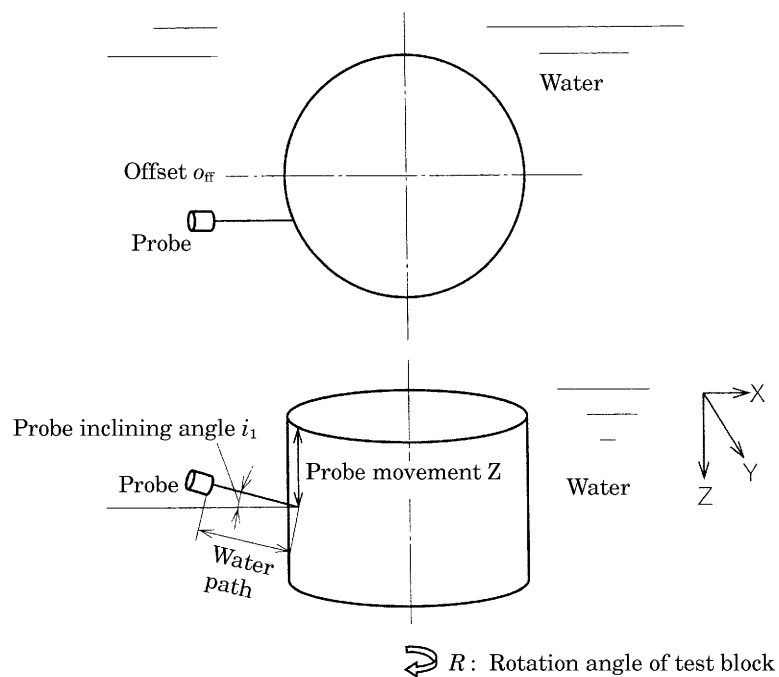


Figure 2 Schematic diagram of R-Z scanning

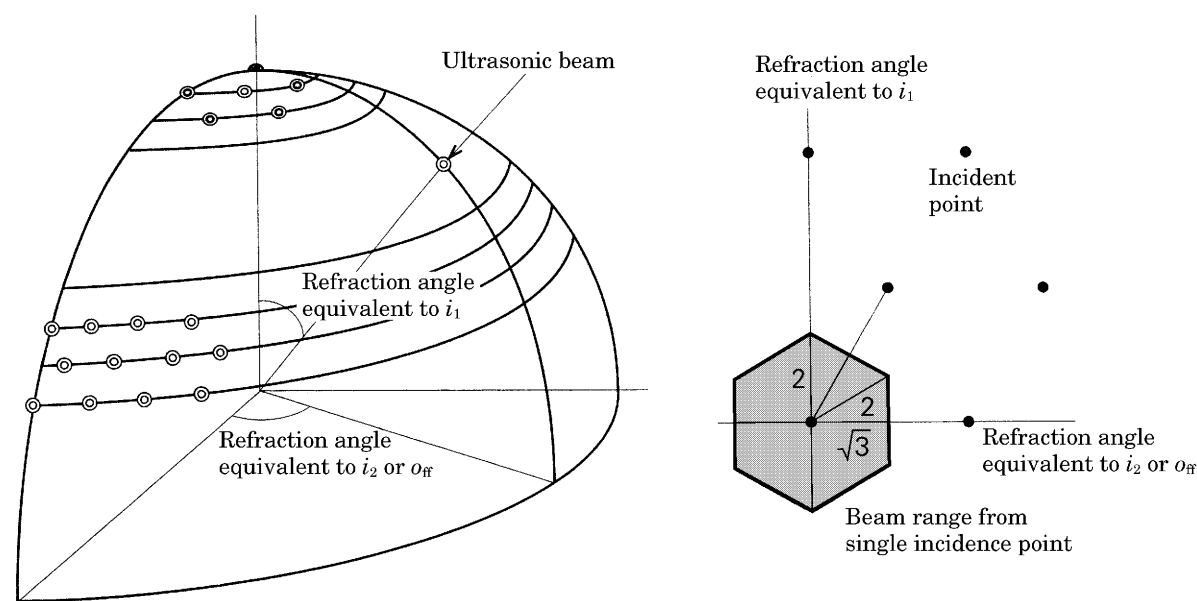


Figure 3 Schematic diagram of staged scanning in incident-angle scanning

- n) **angular width of beam spread** range of angle direction where an echo appears within the specified strength reduction from the maximum echo height when an angle scanning is performed for a flat-bottomed hole equivalent to the flaw to be detected
- o) **apparent attenuation-compensation rate** a rate of detection sensitivity correction performed by regarding the difference between the maximum echo height of a reference block and that of the test block remained even though fluctuation of the wave front is compensated by a two-axis swivel scanning when the setting of detection sensitivity is carried out as the difference of attenuation factor for every lot of graphite ingot

4 Principle of inspection In this inspection, the automatic ultrasonic inspection shall be performed according to the method of the vertical and oblique incidence which uses a pulse echo technique of single probe while immersing the whole test block in water after the measurement of the ultrasonic wave propagation characteristics is performed for every test block, since materials in which fluctuation of the wave front appears in the propagating ultrasonic beam shall be the target. Furthermore, the scanning shall be performed by changing two independent incident angles for one incident plane in addition to the plane surface scanning in order to detect planar flaws in all directions since the flaw direction cannot be limited for a sintered body such as graphite.

5 Test block and flaw to be detected The test block used in this Standard shall be an arbitrary-sized cylinder with a ratio of diameter to height which is about 1 to 1, and the maximum value of diameter and height shall be 225 mm, respectively. The minimum dimension of flaws to be detected shall be set to be any value of the equivalent diameter of 3 mm or more.

NOTES 1 The isotropic graphite here refers to that which is manufactured by applying a hydrostatic moulding method.

- 2 As a premise of the inspection, the evaluation of the dimension, location and direction of a permissible defect shall be required to be performed in design, and the minimum dimension of flaws to be detected shall be set to be not less than the dimension of the permissible defect and any value of the equivalent diameter of 3 mm or more.

6 Engineer The engineer engaged in the ultrasonic inspection of a graphite ingot shall be the qualified person of UT level 2 of **JIS Z 2305** or the engineer with comparable qualifications who has the knowledge on the graphite ingot and sufficient knowledge on the flaw detection, and has received the education and training on the use of automatic ultrasonic test equipment.

7 Constitution of automatic ultrasonic test equipment

7.1 Basic constitution of equipment The equipment to use shall consist of an ultrasonic test instrument, a probe and its associated scanning device, and displaying and recording device. The constitution of the equipment shall be as shown in figure 4.

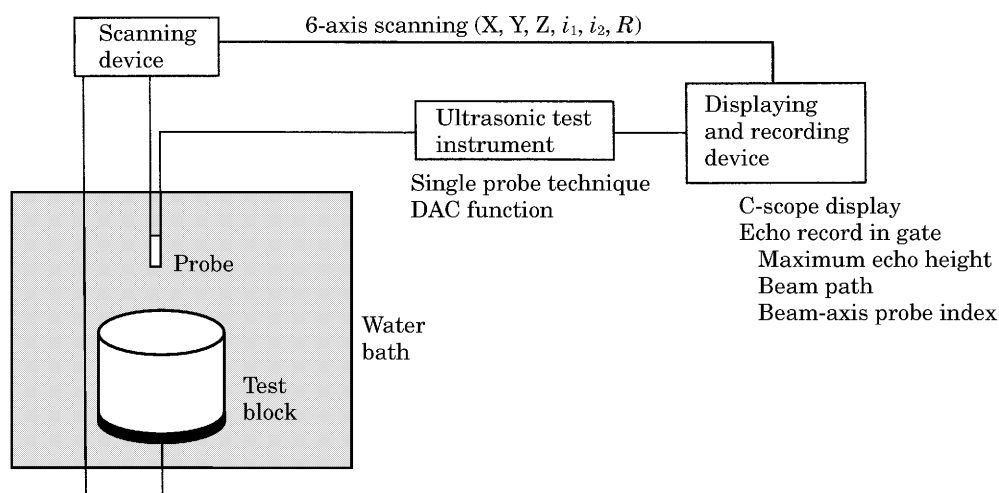


Figure 4 Constitution of automatic ultrasonic test equipment

7.2 Ultrasonic test instrument The ultrasonic test instrument shall have not only the function and performance specified in clause 6 of **JIS Z 3070**, but also the echo-recording gate function, distance-amplitude correction function (DAC circuit), data output and memory function given in 7.2.1 to 7.2.3.

7.2.1 Echo-recording gate It shall have at least one echo-recording gate.

7.2.2 Distance-amplitude correction The DAC curve shall be created from the echo height of 6 points or more within the beam path in which the flaw detection is carried out. The DAC circuit shall have compensation capability of 30 dB or more.

7.2.3 Data output and memory function On each scanning condition, the ultrasonic test instrument not only outputs the echo height and beam path of the echo which shows the maximum echo height within the echo recording gate, but also has the memory function of A-scope diagram.