BS EN 4050-2:2012

BSI Standards Publication

Aerospace series — Test method for metallic materials — Ultrasonic inspection of bars, plates, forging stock and forgings

Part 2: Performance of test

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National foreword

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A list of organizations represented on this committee can be obtained on request to its secretary.

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Contents

Foreword

This document (EN 4050-2:2012) has been prepared by the Aerospace and Defence Industries Association of Europe - Standardization (ASD-STAN).

After enquiries and votes carried out in accordance with the rules of this Association, this Standard has received the approval of the National Associations and the Official Services of the member countries of ASD, prior to its presentation to CEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2012, and conflicting national standards shall be withdrawn at the latest by March 2012.

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1 Scope

This European Standard specifies the method of performing ultrasonic testing. The general requirements are given in EN 4050-1.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 4050-1, *Aerospace series — Test method for metallic materials — Ultrasonic inspection of bars, plates, forging stock and forgings — Part 1: General requirements*

EN 4050-4, *Aerospace series — Test method for metallic materials — Ultrasonic inspection of bars, plates, forging stock and forgings — Part 4: Acceptance criteria*

3 General

3.1 Implementation

Implementation shall be as required by the relevant technique, inspection schedule or order.

3.2 Test procedures

The equipment to be used, its performance, the scanning plan and the acceptance standard shall be as defined in the relevant test procedure, inspection schedule or order for each item.

3.3 Calibration of the flaw detector time base

The time base shall be calibrated and care shall be taken to ensure that interface and target echoes can be readily identified.

3.4 Scanning speed and pitch

To ensure efficient inspection of the entire volume of the material, the scanning speed and pitch shall be established taking into account the test beam diameter, the acceptance standard and the pulse repetition frequency. Account shall also be taken of whether a manual or automatic system of flaw detection is used.

3.5 Scanning index

The scanning index shall be such that the reference reflector always produces at least two indications on two successive pulses. The two signals shall not be more than 6 dB lower than the maximum indication of the reference reflector measured in the static conditions.

3.6 Wave modes

There are different ultrasonic wave modes, namely:

— longitudinal;

— shear;

— surface;

— lamb waves.

The wave mode shall be as specified in the relevant technique or inspection schedule.

3.7 Sensitivity corrections

Corrections for distance/amplitude effects, attenuation, shape effects and specified acceptance standard shall be made to attain the desired level of sensitivity in the part being examined.

3.8 Flaw size and position recording

The inspection system shall generate and contain sufficient information to enable flaw size and position to be derived with respect to the scanning sequence and reference data from the equipment.

4 Performance characteristics of the inspection system

4.1 Requirements

In order to meet the specific requirements for each test item of the procedural document for each part number and for optimum and reproducible inspection, it is essential that the characteristics and performance data of all the equipment are measured and recorded. This is defined in the three following sections:

— the probe and flaw detector that are used in establishing the working sensitivity and for evaluating flaws;

— periodic control checks carried out on the facility;

— specific operating and control instructions unique to each facility; this latter point is particularly directed to automatic and semi-automatic facilities.

Table 1 lists the requirements for identification and performance measurement of the equipment which is to be used in establishing the working sensitivity, inspecting and evaluating flaws.

As there may be differences between equipment performances, when used on manual or automatic modes, the corresponding calibration shall be carried out. The methods of deriving these basic data are detailed in the following paragraphs.

4.2 Ultrasonic test set

The ultrasonic test set used shall operate in the pulse-echo mode and, if required, shall also be capable of operating in the through-transmission mode. Gain calibrated in steps of 1 dB max. shall be used (steps of 2 dB may be agreed).

When required a means of reducing the back-wall echo shall be provided, but the possibility of flaw detection shall remain unimpaired.

Equipment featuring distance amplitude correction shall be used.

Equipment shall be calibrated.

5 Measurement of material characteristics

5.1 Attenuation

The attenuation in the part under test shall be measured for application to working sensitivity and flaw evaluation. The attenuation factor shall preferably be measured by comparison with a reference test block, the acoustic impedance and geometry of which are similar to that of the product to be inspected and the attenuation of which has been previously evaluated using the same probe/flaw detector combination.

This measurement shall be made using the same operating conditions and probe/flaw detector combination, limited to sections with parallel faces, diametrically opposing faces, and for grain flow correction.

Sections of material with non parallel faces can be assessed for material attenuation based on figures obtained from a nearby parallel sided section.

5.2 Structure noise (grass)

Structure noise (grass) limits the ability to detect flaws. Grass may therefore need to be measured in order to determine to what level a part can be inspected.

The flaws to be detected shall rise 6 dB or more above the structure noise.

The measurement of structure noise shall be carried out at the same equipment settings and by that method used for inspection.

6 Flaw recognition level

The flaw echo amplitude as seen on the flaw detector screen during inspection may have been diminished by the effects of attenuation, depth, flaw tilt, scanning pitch and pulse repetition frequency.

To ensure that rejectable flaws are not ignored because of their diminished response, it is necessary to establish a monitor threshold level above which all indications shall be evaluated.

This shall be carried out in accordance with the relevant technique, or inspection schedule.

When using the manual contact technique an additional gain of $+6$ dB may be added to correct this diminution.

7 Setting-up procedure

7.1 Choice of probe

The choice of probe for inspection will depend upon a number of factors governed largely by the component to be inspected and the acceptance standard to be applied.

7.2 Choice of inspection frequency

The inspection frequency chosen shall be such as to ensure that a signal-to-noise ratio of 6 dB or greater shall be attained in accordance with the flaw detection capability.

7.3 Choice of water gap (immersion technique)

Inspection water gap shall be defined and maintained according to the relevant technique test procedure taking into account the need to optimise either near surface resolution or sensitivity, or to obtain the best compromise of the two.

Where of significant magnitude, water attenuation effects shall be taken into account, as agreed between manufacturer and purchaser.

The distance (L) between transducer and part is related to the thickness (t) of the given part, velocity of sound in water (v_w) and velocity of sound in the material of the part (v_{part}) and is given in $L/t \geq v_w/v_{part.}$

7.4 Type of coupling (contact technique)

The coupling conditions for the material under test and the standard test block shall be the same.

For inspection by the contact method clean tap water, oil, glycerine or cellulose gum may be used as the couplant. The acoustic impedance, viscosity and surface wetting of the couplant shall maintain good ultrasonic energy transmission into the test material and low attenuation of the sound beam.

When used, the type and thickness of the protecting membranes of the probes shall allow adequate sensitivity.

7.5 Basic reference sensitivity

7.5.1 General

The basic reference sensitivity is used to establish the working sensitivity by the addition of the material standard, of those characteristics attributable to the part, that is: transmissivity at interface and attenuation.

This specification contains two methods of establishing the basic reference sensitivity, working sensitivity and the evaluation of flaws. These represent the methods currently in use. It shall be recognised that these methods are not necessarily mutually interchangeable or comparable.

7.5.2 Distance gain size (DGS) method

The method as described applies to plane unfocused and narrow frequency band probes only.

7.5.2.1 Reference sensitivity

The DGS method is implemented using the general diagram (Figure 1). Sensitivity is determined from the back echo. In the event where it is not possible to obtain a back echo on the part, the use of a block to obtain a back echo is permitted, if the material of the block has similar characteristics to those of the product to be inspected.

7.5.2.2 Working sensitivity

The working sensitivity is achieved by adding the loss due to material attenuation to the reference sensitivity. Where the acceptance standard differs from the 1,2 mm flat bottom hole standard, a corresponding adjustment in gain is required.

7.5.2.3 Flaw evaluation

Flaw evaluation is carried out using the DGS diagram as illustrated in Figure 2.

The flaw shall be positioned between 1,5 N and 3 N distance.

Additional corrections shall be made due to water attenuation.

The amplitude of the flaw shall be maximised by probe manipulation and compared with the amplitude of the reference plate back wall echo using the same derived water distance.

Local attenuation corrections are made to this figure: knowing the effective probe diameter, the equivalent flat bottom hole diameter is calculated from the S size factor of the diagram.

Detailed operating instructions for flaw evaluating by the DGS method shall be defined in the relevant inspection operation sheet.

NOTE If this method is applied on curved surfaces, additional correction factors will need to be taken into account.

7.5.3 Flat bottom holes (FBH)

7.5.3.1 Reference sensitivity

The basic reference sensitivity is derived from one of a series of drilled targets in an appropriate material, either FBH and shall take into account material under test and material acceptance standard.

These targets shall be referenced when appropriate to a master standard and shall have correction factors, due to variation of their geometry.

Using the inspection water gap (immersion technique), a distance/amplitude curve is plotted from these targets and suitably corrected.

The relevant technique sheet shall define the method by which the hole used to establish the working sensitivity has to be selected. The echo from this hole shall be brought to the reference height on the flaw detector screen graticule.

7.5.3.2 Working sensitivity

The working sensitivity is derived from the basic reference sensitivity, taking into account attenuation, thickness and shape of the part under test and material acceptance standard. According to local variations of these parameters, it may be necessary to use several working sensitivities on the same part.

7.5.3.3 Flaw evaluation

Maintaining the inspection water gap (immersion technique), the flaw amplitude shall be maximised by probe manipulation.

A comparison shall be made between the maximised flaw amplitude and the amplitude of either:

a) the point equivalent in depth taken from the FBH distance amplitude curve

b) a hole in the actual test block having the same depth as the flaw within the following tolerances:

- up to 6 mm depth: ± 1,5 mm
- above 6 mm to 10 mm depth: ± 2 mm
- above 10 mm to 50 mm depth: ± 5 mm
- above 50 mm to 70 mm depth: ± 10 mm
- above 70 mm to 100 mm depth: ± 15 mm

— above 100 mm to 200 mm depth: ± 25 mm

Where hole and flaw depth do not correspond, a correcting factor is required, (e.g. linear interpolation).

The result of this comparison shall be corrected for the alloy under test and local attenuation.

If the contact technique is used, the procedure shall be analogous.

8 Monitored systems

8.1 General

Monitored systems are to be preferred in order to ensure more reliable flaw detection.

8.2 Description

When these systems are used, it shall be demonstrated that these aids are effective in achieving required process capability.

A backwall echo monitor shall be provided where practical to ensure that a drop in signal height of n dB/mm or % screen height is recorded. Number n shall be agreed upon between the manufacturer and purchaser.

8.3 Monitored area and threshold level

The near and far surface resolution of the gate system shall be measured. This shall not exceed the material allowance on the part.

The threshold level shall be set in order to achieve the required class of the material standard.

8.4 Dynamic response

A calibration procedure shall be developed which guarantees that the total system is capable of carrying out this designated function under dynamic operation conditions.

9 Equipment requirements

9.1 Immersion technique facilities

The immersion technique facilities used, shall comply with the following prescribed requirements.

The reproducibility of the results shall be ensured by regular calibration to specified tolerances.

The mechanical, electrical and electronic elements shall be appropriate and shall be of adequate precision.

9.2 Contact technique facilities

The equipment used shall guarantee reproducibility of the set conditions.

For mechanical techniques uniform and exact movement of the probe shall be possible. Suitable guides shall be used and probe movement shall be of adequate precision.

NOTE It is preferred that the contact technique is used in conjunction with a mechanised scanning system that ensures full coverage of the required area. It should be noted that for certain classes of material, a manual “scan” is not permitted (see EN 4050-4).

9.3 Probe/flaw detector combination

The ultrasonic performance achieved is a result of the combination of a specific flaw detector, probe and connecting cable. The measurement of the performance data shall apply to such a combination when measured together, and not as separate elements.

Table 1 details the basic requirements for identification and performance measurement of the equipment.

NOTE Where for example probes are to be procured, it is advisable to state the type of instrument to be used.

The relevant procurement specification or process specification shall define all the important parameters by which the system performance is measured, recorded and procured.

10 Periodic control checks

Internal procedures shall specify the control checks to be carried out covering the fields:

— shift and part number changes;

— flaw detector;

— probe and flaw detector combination;

— mechanical facility;

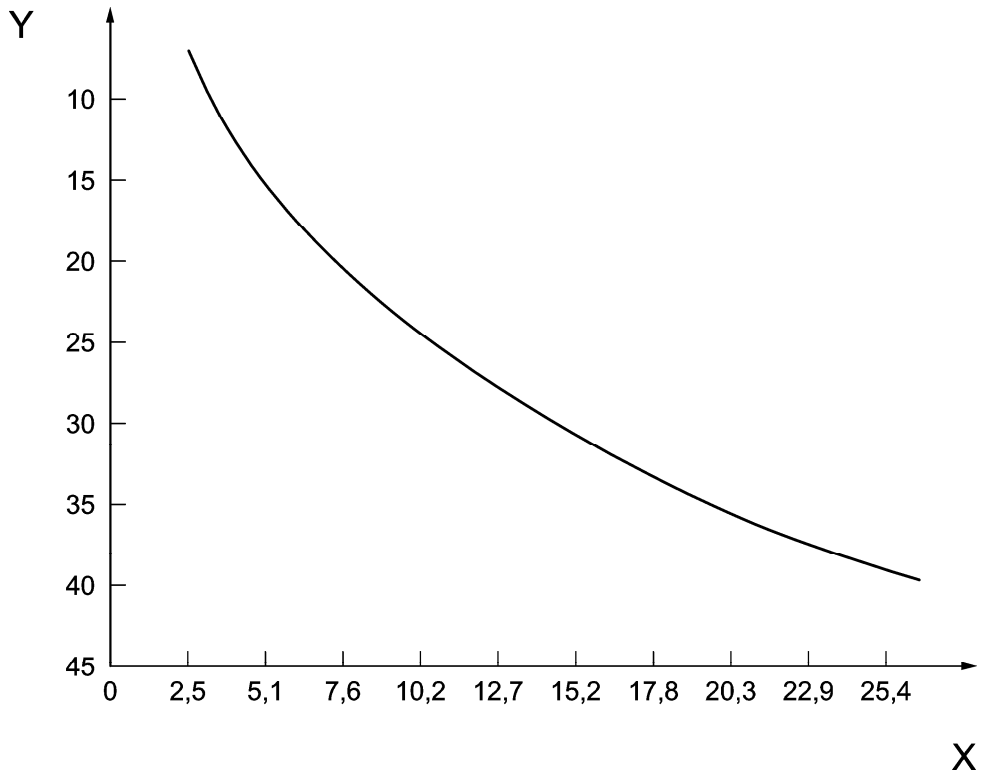
— ultrasonic/electronic aspects of automatic scanning.

The procedures shall specify the method of carrying out the checks, recording of results and the periodicity.

Table 1 — Requirements for identification and performance measurement of the equipment

	Probe	Manufacturer		
		Type		
		Nominal diameter		
		Serial number		
		Focal length		
		Focal spot diameter		
		Crystal material nature		
		Frequency		
	Connecting cable	Type (included serial number)		
		Impedance		
		Cable length		
	Flaw detector	Manufacturer		
		Type		
		Serial number		
		Amplifier	Type	
			Serial number	
			Frequency setting	
		Pulser	Pulse energy	
			Pulse length	
			Pulse shape	
	Probe + cable + flaw detector combination	"N" distance		
		"Nh" distance		
		Working range in the appropriate material		
		Preferred water gap		
		Frequency (measured)		
		Effective diameter (crystal)		
		Test beam diameter		
		Quality acceptance standard		
		Near surface resolution		
		Q factor		
		Probe capacitance		

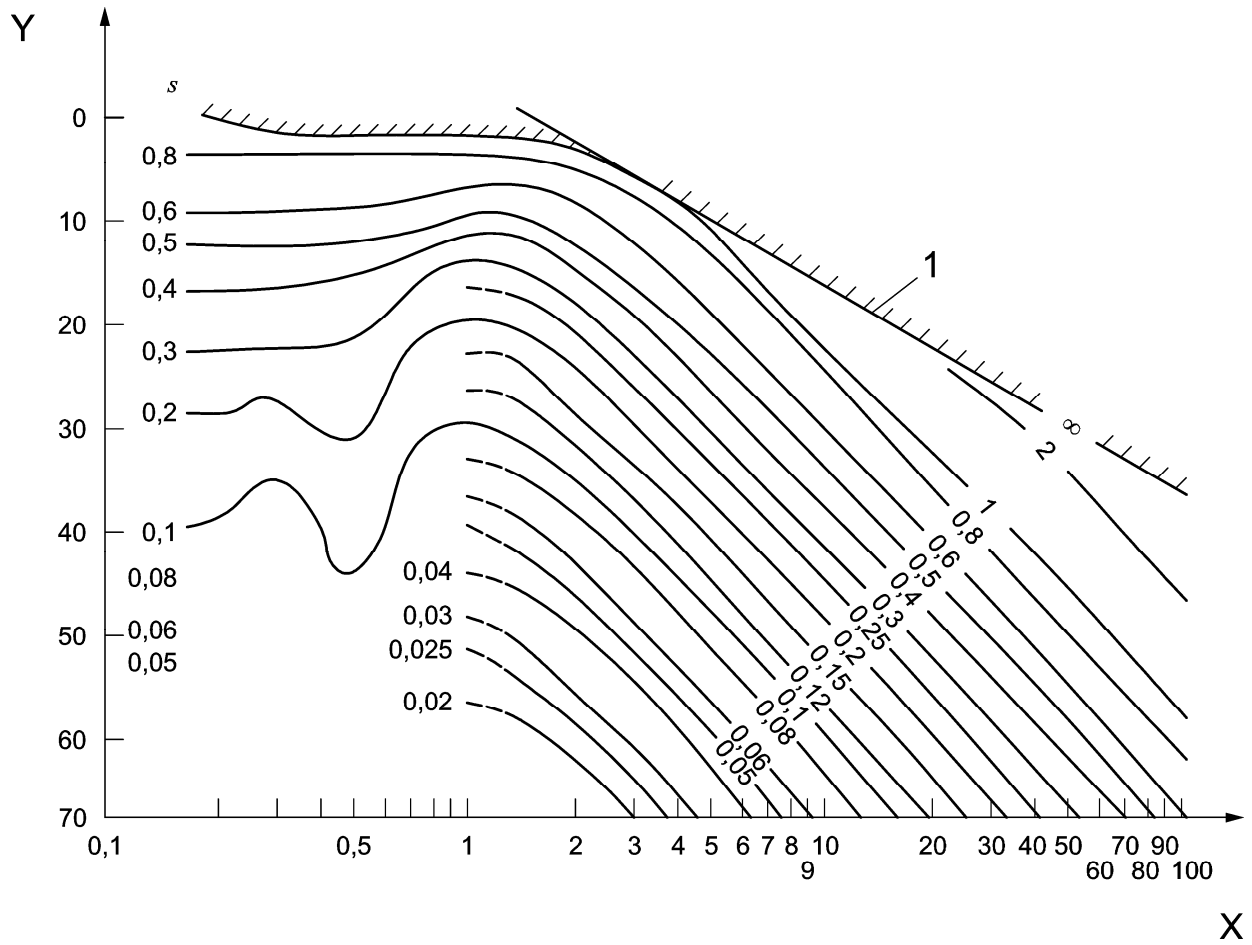
Performance data Identification and nominal characteristics



Key

X effective probe diameter; in mm
Y attenuation; in dB

Figure 1 — Curve showing attenuation in dB from back plate for increasing probe diameter (for 1,2 mm FBH)



Key

X distance (near zone)
Y amplification; in dB
S equivalent FBH-Ø/effective probe-Ø
1 backwall echo

Figure 2 — DGS Diagram

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