

BS 9690-1:2011



BSI Standards Publication

Non-destructive testing – Guided wave testing

Part 1: General guidance and
principles

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to ii, pages 1 to 20, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI and came into effect on 31 October 2011. It was prepared by Technical Committee WEE/46, *Non-destructive testing*. A list of organizations represented on this committee can be obtained on request to its secretary.

Information about this document

The purpose of this document is to define a standard for non-destructive testing (NDT) using guided stress waves.

Guided stress waves used for NDT are sonic or ultrasonic waves which travel along an object and are guided by its surfaces or shape, and whose wavelength is large compared to a characteristic dimension such as wall thickness. NDT using guided waves offers the possibility of performing rapid testing of 100% of the volume of the components in which they can travel and is therefore particularly suited to elongated objects such as pipes, tubes and rails. The nature of guided waves differs substantially from the ultrasonic waves used in conventional ultrasonic testing (UT), and therefore it is necessary to define guided wave testing (GWT) as a method in its own right and manage this branch of inspection under its own standard.

The standard has been written to incorporate flexibility to include different applications of guided waves, by separate parts of the standard, as the capability and needs arise.

Currently, BS 9690, *Non-destructive testing – Guided wave testing*, comprises the following parts.

Part 1: *General guidance and principles*.

Part 2: *Basic requirements for guided wave testing of pipes, pipelines and structural tubulars*.

However, it is anticipated that further parts of the standard will be introduced to cover the interpretation of measurements; the testing of advanced cases of pipes, pipelines and structural tubulars; and the application of GWT to other structures and components.

Presentational conventions

As a guide, this part of BS 9690 takes the form of guidance and recommendations. It should not be quoted as if it were a specification or a code of practice and claims of compliance cannot be made to it.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

1 Scope

This part of BS 9690 provides the general principles for guided wave testing.

The specific conditions of application and use of guided wave testing, which depend on the type of object tested, are described in documents which could include:

- a) product standards;
- b) specifications;
- c) codes;
- d) contractual documents;
- e) written procedures.

Unless otherwise specified in the referencing documents the minimum recommendations of this standard are applicable.

This standard does not define:

- 1) extent of testing;
- 2) optimum test parameters for specific applications; or
- 3) acceptance criteria.

2 Normative references

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

BS EN 473, *Qualification and certification of NDT personnel – General principles*

BS EN 1330-2, *Non-destructive testing – Terminology – Part 2: Terms common to the non-destructive testing methods*

BS EN 1330-4, *Non-destructive testing – Terminology – Part 4: Terms used in ultrasonic testing*

3 Terms and definitions

For the purposes of this British Standard, the terms and definitions in BS EN 1330-2 and BS EN 1330-4 apply, together with the following.

3.1 axial direction

principal direction of propagation of the guided waves, particularly in a pipe where this is parallel to the pipe axis

3.2 axial length

length of a discontinuity in the axial direction normally parallel to the direction of propagation of the guided waves

3.3 call level [distance amplitude correction (DAC) or time-corrected gain (TCG)]

DAC curve or TCG threshold above which indications are required to be reported

3.4 circumferential direction

direction of propagation or displacement perpendicular to the axis and parallel to a tangent to the surface at any point

NOTE Applicable to objects of circular cross section, such as pipes.

3.5 circumferential order

number of vibration nodes of a guided wave mode around the circumference

NOTE Applicable to objects of circular cross section, such as pipes.

3.6 corrosion

deterioration of a material, usually a metal, that results from a chemical or electrochemical reaction with its environment

3.7 cross section

total area of the wave guide perpendicular to the direction of propagation

NOTE The amplitude of a reflection is assumed, typically as a first approximation, to be proportional to the CSC.

3.8 cross section change (CSC)

equivalent cross section change calculated, assuming that an indication is purely caused by a change in the cross section of the object

NOTE Also referred to as “estimated cross section loss” (ECL). It is given as a percentage of the nominal cross section. The amplitude of a reflection can also be affected by stiffness changes and the axial dimensions of a feature.

3.9 cut-off frequency of guided wave mode

frequency at which the energy velocity changes from non-zero to zero

NOTE The definition differs from the term “cut-off frequency” in BS EN 1330-4, which relates to limits of the bandwidth of an ultrasonic signal.

3.10 data capture range

distance over which data are gathered in a particular direction

NOTE This is not necessarily the same as the diagnostic range.

3.11 datum

reference point for reporting a test position and for correlating test results with actual position on the test object, normally a localized physical feature on, or in a fixed relationship to, the test object

NOTE In the case of a pipe this can be a weld, flange or any other suitable permanent feature. The distance from the datum to the test position is also reported.

3.12 dead zone

distance along the test length of object on either side of the test position, and equal to or slightly greater than the length of the transmitted pulse, where reflectors of interest cannot be detected

NOTE This definition differs from that in BS EN 1330-4, in which the term relates to distance from the scanning surface.

3.13 diagnostic range

axial length of the test object (excluding the dead zone), measured from the test position, for which the amplitude of the call level lies above the maximum usable sensitivity line

NOTE Also known as the “end of test”.

3.14 dispersion

frequency dependence of the acoustic properties of a guided wave, such as velocity and attenuation

3.15 dispersion curve

graph of the variation of an acoustic property of a guided wave, for example the group velocity, as a function of frequency

NOTE Dispersion curves can be shown for any number of guided wave modes in the same graph.

3.16 energy velocity

velocity with which the energy of a guided wave signal propagates

NOTE See also "group velocity".

3.17 envelope (signal)

outline A-Scan trace bounding the oscillations in each pulse of ultrasound, obtained by a smoothing process

NOTE See also "result trace" (3.35).

3.18 feature

geometric change or addition to the uniform base material of the test object which does not constitute a discontinuity

3.19 focusing**3.19.1 focus**

deliberate concentration of guided wave modes at a single circumferential and axial position

3.19.2 synthetic focus

post-processing of a recorded data set to concentrate guided wave modes at a single circumferential and axial position

3.20 guided wave (GW)

sonic or ultrasonic waves which travel along an object and are guided by its surfaces or shape, and whose wavelength is large compared to a characteristic dimension such as wall thickness

3.21 guided wave testing (GWT)

testing of a large volume of material from a test location utilizing the long distance propagation characteristics of guided waves

3.22 interpretation

process of identifying discontinuities from indications in the result trace and other displays

3.23 leakage

attenuation of the guided wave caused by the transmission of energy into a surrounding material

3.24 magnetostrictive transducer

transducer which generates and receives signals via the coupling of a changing electromagnetic field to an elastic strain field, using the magnetostrictive effect

NOTE This is best achieved using a specific magnetostrictive material in order to maximize the coupling behaviour.

3.25 maximum usable sensitivity line

line overlaid on the test data, which is a factor of 2 (6 dB) greater in value compared with the noise line at all points

NOTE This represents the lowest level at which responses may be reported without significant risk that they may arise from noise signals.

3.26 mode

specific kind of wave

NOTE Many kinds of guided waves are possible, and they are distinguished by reference to the nature of their displacements. Longitudinal modes have displacements predominantly in the axial direction; torsional modes have displacements in the circumferential direction. Axisymmetric (often simply called symmetric) modes have displacements which are uniform around the circumference; flexural modes have displacements which are not uniform around the circumference.

3.27 guided wave mode

distinct type of guided wave with a specific vibrational pattern

NOTE A variety of modes might exist in any given geometry of object. In the case of a pipe there are three families of modes: torsional, longitudinal and flexural. Each of these mode families has a particular vibrational behaviour, with the modes within a family being similar to each other.

3.28 nominal wall thickness

nominal reference wall thickness of the test object as per specification, not necessarily the actual wall thickness

3.29 noise line

line overlaid on the test data which describes the variation in noise amplitude along the test range, after removing the influence of high amplitude responses from pipe features or discontinuities

NOTE The basis for determination of the noise level (peak, root mean square, moving average, etc.) is stated in the report.

3.30 phase velocity

propagation velocity of a point of constant phase of a wave

NOTE This can be observed for example as the velocity of the crest of a wave. The phase velocity is equal to the group velocity in cases when there is no dispersion.

3.31 pitch-catch configuration

type of test in which pulses are emitted by one transducer device and reflections are received by another

3.32 primary mode

single mode which is generated selectively in the test object as the incident wave for the test

3.33 propagating mode

guided wave mode whose energy velocity is non-zero

3.34 pulse length

axial length of a transmitted pulse in the material under test

3.35 result trace

plot of the guided wave signal envelopes as a function of distance

NOTE This includes A-Scans, C-Scans, etc. In the case of a pipe, the result trace may include both symmetric and non-symmetric components.