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Non-destructive testing — Long-range inspection of above-ground pipelines and plant piping using guided wave testing with axial propagation

Essais non destructifs — Vérification à large échelle des réseaux de canalisations hors sol et de la tuyauterie d'usine utilisant un essai d'onde guidée à propagation axiale

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Foreword

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The committee responsible for this document is IIW, *International Institute of Welding*, Commission V.

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Non-destructive testing — Long-range inspection of above-ground pipelines and plant piping using guided wave testing with axial propagation

1 Scope

This International Standard specifies a method for long-range testing of carbon and low-alloy steel above-ground pipelines and plant piping using guided ultrasonic waves with axial propagation applied on the entire circumferential pipe section, in order to detect corrosion or erosion damage.

The guided wave testing (GWT) method allows for fast inspection of above-ground pipelines, plant piping and cased road crossings, giving a qualitative screening and localization of probable corroded and eroded areas. GWT is typically performed on operating piping systems.

This International Standard is applicable to the following types of pipes:

a) above-ground painted pipelines;

b) above-ground insulated pipelines;

c) painted plant piping;

d) insulated plant piping.

NOTE Pipe sections within road crossings with external casings (without bitumen or plastic coating) are a special case of buried pipe where there is no soil pressure on the OD of the pipe. This International Standard applies to these cased road crossings.

Other types of pipes not included in the above list need dedicated approaches due to increased complexity.

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.

ISO 9712, *Non-destructive testing — Qualification and certification of NDT personnel*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
axial direction
direction along the main axis of the pipe

3.2
circumferential direction
direction around the circumference of the pipe

3.3
total pipe wall cross-section
TCS
area between the inner and outer diameters of the pipe in a plane perpendicular to the pipe axis

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3.4
cross-section change
equivalent cross-section change calculated assuming that an indication is purely caused by a change in the cross-section of the pipe wall

3.5
datum point
reference point for reporting a *test position* (3.16) and for correlating test results with the corresponding position on the test object

3.6
dead zone
length of pipe on either side of the *test position* (3.16) where reflectors of interest cannot be detected because they are covered by the transmitted pulse

3.7
flexural mode
non-symmetric bending type mode of guided wave propagation in pipes, with particle displacements in axial, circumferential and radial directions

3.8
focus
concentration of guided waves at a single axial and circumferential position, achieved either by hardware settings or by post-processing of a recorded set of signals (synthetic focus)

3.9
geometric feature
pipeline feature (e.g. weld, support, flange, bend, etc.) causing the reflection of guided waves because of a *cross-section change* (3.4) or other acoustic impedance variation

3.10
guided wave mode
distinct type of guided wave with a specific vibration pattern

3.11
longitudinal mode
symmetric compression type mode of guided wave propagation in pipes, with particle displacements predominantly in the *axial direction* (3.1)

3.12
primary mode
guided wave mode (3.10) which is chosen for the incident wave

3.13
probe ring
circumferential component, containing transducer elements with direct contact to the pipe

3.14
secondary mode
guided wave mode (3.10) which is different from the *primary mode* (3.12) and is generated by mode conversion at pipe features or discontinuities

3.15
test frequency
centre frequency of the pulses transmitted by the *probe ring* (3.13)

3.16
test position
axial position on the pipe where the *probe ring* (3.13) is placed

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3.17
test range
distance between the *test position* (3.16) and the furthest position for which the minimum acceptable sensitivity of the reference signal is achieved, in each direction (positive or negative)

3.18
torsional mode
symmetric twisting type mode of guided wave propagation in pipes, with particle displacements in the *circumferential direction* (3.2)

4 Test personnel

The personnel performing ultrasonic guided wave testing shall be qualified in accordance with ISO 9712 or with any another equivalent standard of the relevant industrial sector.

Training in the use of the specific equipment is required because there are significant differences between the available systems and diagnostic approaches.

5 General

Ultrasonic guided wave testing (GWT) uses elastic waves which are guided along the pipe wall and can travel long distances, thus providing rapid near complete coverage of the volume of the pipe wall.

The typical test setup is comparable to conventional ultrasonic pulse-echo testing: an ultrasonic instrument forces transducers in the probe ring to generate ultrasonic waves in the pipe wall which are reflected by discontinuities and received by the same probe ring. The time-of-flight of the received signal indicates the distance between the discontinuities and the probe ring. A single test with guided waves can cover a length of pipe of tens of meters.

Within this International Standard, GWT is performed as a screening method. The reflections returning from discontinuities and received by the ultrasonic instrument indicate the position of the discontinuity. However, they do not give detailed quantitative information about its morphology. Therefore, GWT is used to indicate any locations which need to be followed up with complementary detailed inspection. More information on the nature of guided waves is given in Annex A.

Within this International Standard, GWT typically uses a frequency range between 20 kHz and 500 kHz. If the performance of the test has been shown to have equal or better sensitivity to that obtained with the frequency range specified above, a frequency lower than 20 kHz can be used for GWT.

The successful application of guided ultrasonic waves requires the following:

a) selective pure mode transmission and reception;

b) wave modes which are non-dispersive in the frequency range used;

c) coverage of the full cross section of the pipe wall;

d) signals coming from each direction shall be distinguished.

The amplitude of a reflected ultrasonic guided wave signal from a discontinuity varies in a complex manner that depends on many factors such as test frequency, guided wave mode and the specific morphology of the discontinuity. It is often possible to correlate the size of the reflected signal with the overall cross-section change in the pipe wall resulting from wall loss, meaning that GWT can qualitatively group discontinuities into different severity groups such as indications of low, medium and high concern. However, usually the parameter of interest when testing piping systems with wall loss is the remaining wall thickness in areas with discontinuities, which GWT cannot accurately provide (see Annex A for more information).

It is recommended to perform ultrasonic guided wave testing using a range of frequencies to improve the accuracy of the test. Also, GWT ultrasonic instruments often employ advanced approaches like

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