SLOVENSKI STANDARD

SIST-TP CEN/TR 15134:2006

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Neporuġitveno preskuġanje ï Avtomatsko ultrazvoļ no preskuġanje ï Izbor in uporaba sistemov

Non-destructive testing - Automated ultrasonic examination - Selection and application of systems

Zerstörungsfreie Prüfung - Automatisierte Ultraschallprüfung - Auswahl und Anwendung von Systemen

Essais non destructifs - Examen automatisé par ultrasons - Sélection et application des systemes

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Non-destructive testing - Automated ultrasonic examination - Selection and application of systems

Essais non destructifs - Examen automatisé par ultrasons - Sélection et application des systèmes

Zerstörungsfreie Prüfung - Automatisierte Ultraschallprüfung - Auswahl und Anwendung von Systemen

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Contents

Page

Foreword

This CEN Technical Report (CEN/TR 15134:2005) has been prepared by Technical Committee CEN/TC 138 "Non-destructive testing", the secretariat of which is held by AFNOR.

1 Scope

Automatic ultrasonic scanning inspection systems are becoming more and more popular. There is a growing dependence on these systems, the data (both ultrasonic signals and probe location) and the automatic or manual evaluation of the data.

Stationary and mobile test systems are discussed, as used for pre-service testing (testing during manufacture) and in-service testing (testing after manufacture, including regular safety assurance testing).

The information in this Technical Report covers all tests and testing on all component parts or complete manufactured systems for either correctness of geometry, material properties (quality or defects) and fabrication methodology (e.g. welds).

This Technical Report can be used for training purposes.

This Technical Report is aimed at suppliers and users of automatic scanning systems.

The scope of this Technical Report is to permit the user, along with a customer specification or test description and any national or international standards or regulations to specify:

- ultrasonic probes, probe systems and mechanical controlling sensors;
- manipulation systems including controls;
- ultrasound electronic sub-systems;
- data storage and display systems;
- evaluation and assessment methods or techniques

with regard to their performance and suitability for purpose.

This Technical Report also defines a means of verifying the performance of any specified system.

This includes:

- tests during the manufacturing process on parts and completed items (stationary testing systems)

and also

- tests with mobile systems.

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.

EN 1330-2:1998, *Non-destructive testing - Terminology - Part 2: Terms common to the non-destructive testing methods.*

EN 1330-4:2000, *Non-destructive testing - Terminology - Part 4: Terms used in ultrasonic testing.*

3 Terms and definitions

For the purposes of this Technical Report, the terms and definitions given in EN 1330-2:1998 and EN 1330-4:2000 apply.

4 Basic system description

4.1 Systems

There are two major applications for automated ultrasonic inspection systems:

- for the detection and evaluation of material defects (e.g. cracks, porosity, geometry);
- for the measurement and evaluation of material properties (e.g. sound velocity, scattering).

Essential components of an automatic inspection system are:

- mechanically positioned and controlled ultrasonic probes and/or test objects;
- automatic data acquisition for the ultrasound signals;
- acquisition and storage of transducer location in relation to ultrasonic signals;
- test results.

A system usually consists of several individually identifiable components. These are:

- manipulators for probes or test objects;
- probes and cables;
- couplant supply and removal;
- ultrasonic sub-system;
- data acquisition and processing;
- data evaluation and display;
- system control.

The complexity of a system depends on the scope of the test and application of the system.

Test systems may be divided into stationary and mobile.

Examples of stationary systems are:

- continuous inspection of steel products, e.g. billets, plate material, tubes, rails;
- component testing, e.g. steering knuckles, rollers, balls, bolts, pressure cylinders;
- composite materials e.g. aerospace structures , e.g. complete wings made of composite materials, CRFP and GFRP components;
- random sample control (batch test) for process accompanying checks, e.g. testing for hydrogen induced cracking in steel samples.

Examples of mobile systems are:

- pre-service and in-service inspection of components, e.g. valves, vessels, bolts, turbine parts;
- pre-service and in-service inspection of vehicles;
- pre-service and in-service inspection of pipelines e.g. oil or gas pipelines;

- inspection of railway tracks.

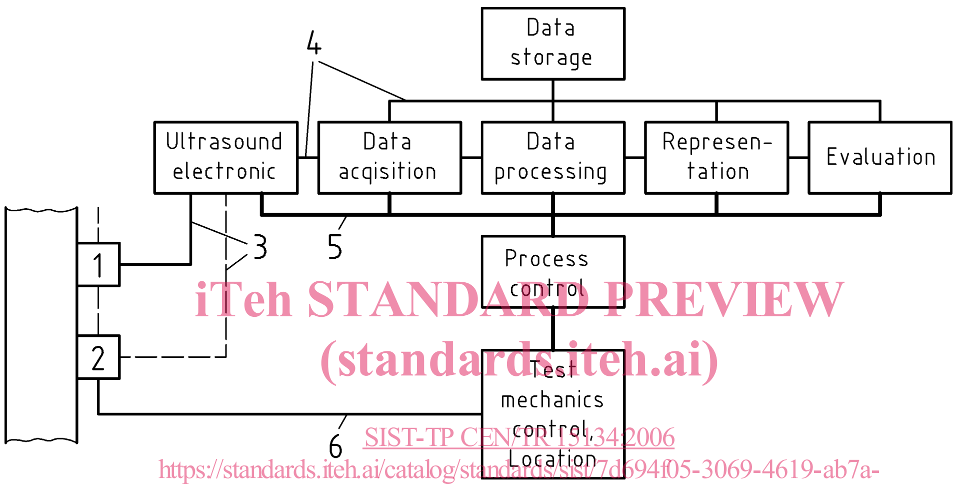
The test systems can be single or multichannel systems.

The manipulator complexity of the system depends on the examination task.

The complexity of the data acquisition and evaluation system depends on the number of test channels, the test velocity and the test requirements.

4.2 System schematic

The essential components of an automatic scanning system are shown in Figure 1. More detailed descriptions can be found elsewhere in this document. A detailed description of the individual functions is given in Clause 5.



Key

1 probe 1
2 probe 2
3 signal lines
4 data lines
5 control line
6 control line/location data

Figure 1 — System schematic

The probe position shall be known and be recorded together with the ultrasonic data. This can be achieved by using encoders, ultrasound or video techniques.

If the probe motion is in one axis only, the probe position can be determined by measuring elapsed time compared to the motion velocity.

The most simple ultrasonic system consists of one probe, see Figure 2.

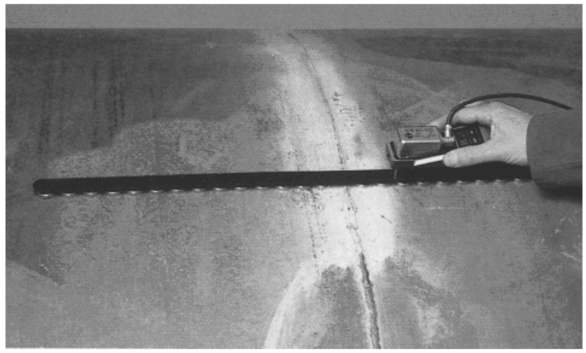


Figure 2 — Simple system with one probe

In order to fulfil any test requirement the system can include several hundred probes e.g. in a pig for pipeline testing, see Figure 3.

The ultrasonic sub-system is the main component of the overall system. Figure 4 shows a block diagram of the basic electronic components of the ultrasonic sub-system. Depending on the required complexity, the ultrasonic sub-system can be made from one module for a single channel system or multiple modules for multi-channel systems. These can be self-contained modules, computer plug-in cards or rack mounted systems.

Figure 3 — The probe assembly of an intelligent pig for use on a 40 inch diameter pipeline

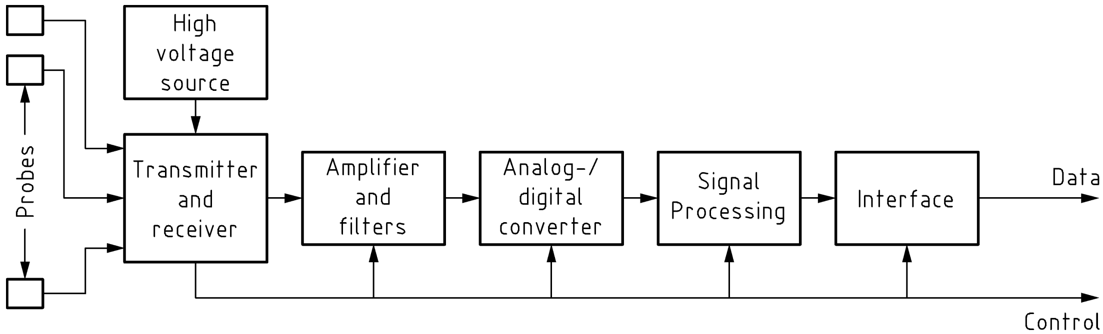


Figure 4 — Block diagram of the electronics of the ultrasonic sub-system

Some digital systems used for testing provide acquisition and storage of the full RF ultrasonic signals. This method offers the most information compared to other acquisition methods.

In order to reduce the testing time, data processing and storage requirements, other methods use data reduction techniques such as peak testing. For many applications this provides a perfectly adequate level of data for the purposes of the inspection.

Methods for data reduction are described in 6.6.4.2.

The data, which are transferred from the ultrasonic unit to the data acquisition unit, is referred to as measurement data.

In the data processing unit the measurement data is processed in a way, which permits it to be visualized on a display for the interpreter (user) performing the evaluation.

The data can be assessed and the test verified automatically during automatic component testing.

In certain areas, the evaluation has to be performed by experienced test personnel, e.g. welds on vessels and pipelines or safety-critical components in aerospace. In these cases, the data processing unit has to provide images from the measurement data as a projection or sectional image. Other tasks are possible by filtering the data to remove unwanted information. This can be achieved by software in a computer or by special hardware.

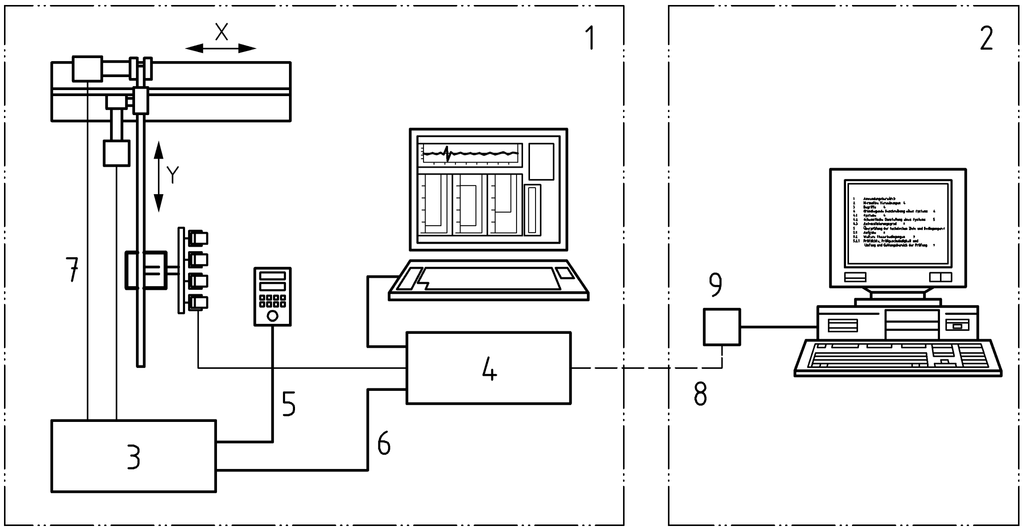
Data can be stored at different points during the measurement signal processing as shown in Figure 1. If this is a simple go/no go test only the test result need be recorded. In contrast, during testing of safety critical components the measurement data is stored together with any assessment result.

The control and synchronisation of the individual system components is achieved by the system control, this ensures that the proper test sequence is performed.

The system control also synchronises the storage of the probe location data and ultrasonic data.

In-process inspection can provide automatic sorting or marking of defective parts.

A practical example for a basic automatic scanning system is shown in Figure 1. The set-up of a multi-channel test system is shown in Figure 5. This has an XY manipulator and can be used for testing vessels and pipes.



Key

1 testing location
- on-line survey
- data acquisition

2 evaluation location
- test planning
- data acquisition
- display
- assessment
- documentation

3 manipulator control
4 ultrasound electronics
5 probe cable
6 position data
7 motor control, encoder signals
8 optional network link to ultrasound device
9 network

Figure 5 — Set-up of a multi-channel test system

4.3 Levels of automation

Various levels of automated inspection are possible, ranging from simple mechanical assisted probe movement through to fully automated examination of data, marking or sorting of test objects.

5 Examination of technical objectives and conditions

5.1 Task

The examination task defines the discontinuities or material properties that the test is intended to detect or to measure.

The specification shall be designed within practical and economical viable limits with due consideration to the test object.

Any existing relevant normative documents shall be taken into consideration.

The technical limit of the test system is governed, by amongst other things, the following parameters:

- the overall signal-to-noise ratio in the ultrasound sub-system;
- the band width of the probe(s) and ultrasound sub-system;
- the positional resolution of the probes.

The most important factor in all automatic scanning methods is the system's dynamic lateral resolution. The scanning pattern and speed shall be designed in accordance with the beam profile dimensions as determined by a relevant reflector.

5.2 Other controlling conditions

The following conditions shall be considered:

- the requirements governed by the material properties, e.g. surface conditions and coupling requirements;
- standards, directives and other specifications;
- the application limitations, e.g. test environment, access, weather conditions, power restrictions.

5.2.1 Testing density, test speed and extent and coverage of testing

High speed testing is typical in automated scanning. This generates large amounts of data. If this is to be automatically assessed processing speed is a key issue.

There is a relationship between the distance between measurement points, speed of probe motion, pulse repetition rate and data acquisition speed. This relationship shall also consider the number of channels.

If the probe is moved in a direction x and measurement data are required equidistantly (either amplitude or time-of-flight) the following condition shall be satisfied:

$$v < (\Delta x \; * f\,) \,/\, n \qquad (1)$$

where :

v = relative speed between probe and test specimen (mm/s)

Δx = distance between measurement points (mm)

f = pulse repetition rate (Hz)

n = number of pulses required per measurement point.

If the complete A-scan has to be acquired at each spot the following equation applies:

$$v \leq \Delta x \,/\, t_s \qquad (2)$$

where :

v = relative speed between probe and test specimen (mm/s)

Δx = distance between measurement points (mm)

t_s = acquisition and storage time of an A-scan

Normally, the transfer time of an A-scan to a storage medium (e.g. hard disk) is longer than the duration (length) of an A-scan. In this case t_s shall be equal to the slowest process step in the system.

5.2.2 Environmental considerations

Special consideration shall be given when the design is to be used in harsh environments e.g.:

- ionising radiation;
- extreme temperature of the test object or the environment it is in;