SLOVENSKI STANDARD
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Neporuġitveno preskuġanje - Akustiḷ na emisija - Karakterizacija opreme - 1. del: Opis opreme

Non-destructive testing - Acoustic emission - Equipment characterisation - Part 1: Equipment description

Zerstörungsfreie Prüfung - Schallemissionsprüfung - Gerätecharakterisierung - Teil 1: Gerätebeschreibung

Essais non destructifs - Emission acoustique - Caractérisation de l'équipement - Partie 1: Description de l'équipement

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This European Standard was approved by CEN on 28 December 2000.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Foreword

This European Standard has been prepared by Technical Committee CEN/TC 138 "Non-destructive testing", the secretariat of which is held by AFNOR.

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of an identical text or by endorsement, at the latest by July 2001, and conflicting national standards shall be withdrawn at the latest by July 2001.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association . This European Standard is considered to be a supporting standard to those application and product standards which in themselves support an essential safety requirement of a New Approach Directive and which make normative reference to this European Standard.

This standard about “Non destructive testing - Acoustic emission - Equipment characterisation” consists of the following parts:

Part 1: Equipment description

Part 2: Verification of operating characteristics

Part one of this standard gives a description of the main components of an AE monitoring system.

Part two of this standard gives methods and acceptance criteria for verifying the electronic performance of an AE monitoring system. These methods and acceptance criteria are used to routinely check and verify the performance of an AE monitoring system composed of one or more channels during it's life time.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European standard describes the main components that constitute an acoustic emission (AE) monitoring system comprising:

- detection,
- signal conditioning,
- signal measurement,
- analysis and output of results.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normatives references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies (including amendments).

EN 1330-1, *Non destructive testing - Terminology - Part 1: List of general terms*

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

EN 1330-9, *Non destructive testing - Terminology - Part 9: Terms used in acoustic emission testing*

3 Terms and definitions

For the purpose of this standard the definitions given in EN 1330-1, EN 1330-2, EN 1330-9 and IEC 60050 International Electrotechnical Vocabulary and the following apply:

average signal level (ASL)
rectified, time averaged AE signal.

4 Detection

A piezoelectric sensor is the most commonly used device for detecting acoustic emission. It provides the most effective conversion of elastic waves (acoustic emission) into an electrical signal in the frequency range most commonly used for AE detection, 20 kHz - 1 MHz. In its simplest form it consists of a piezoelectric crystalline or ceramic element, mounted in a protective case. The sensor detects a combination of wave types: compressional, shear, surface (Rayleigh), plate (Lamb), arriving from any direction.

4.1 Sensing element

The sensing material affects the conversion efficiency, operating temperature range and cable drive capability. Lead zirconate titanate (PZT), a ceramic, is the most commonly used material. It can be manufactured in a wide range of sizes and shapes.

The size, shape and containment affect the sensitivity, directionality, frequency response and wave-mode response. Several elements may be combined to achieve a desired performance.

4.2 Sensor case

The sensor case (usually metallic) determines the overall size and mechanical characteristics of the sensor. It may have an integral cable or a connector. The case provides a total electrical screening of the sensing element and is usually common to one pole of the sensing element. A faceplate of ceramic or epoxy between the sensor element and test object provides electrical isolation from the structure to avoid ground loop and induced electromagnetic noise.

Depending on the method of assembly, the sensor can be made single ended or differential.

In a single-ended device, the screen of a coaxial cable is connected to the sensor case and to one side of the sensing element.

In a differential device, a screened twisted pair cable is used and the sensing element is usually split or machined so that the screen does not conduct the electrical output signal. Differential sensors have normally improved immunity to electromagnetic noise compared with single-ended sensors.

The case may contain a low noise preamplifier. Incorporating the preamplifier inside the sensor case, eliminates the cable link between the sensor element and the preamplifier. This reduces signal loss and improves immunity to electromagnetic noise. The drawbacks are that the sensor case becomes larger, the maximum temperature rating is limited by the electronics, and the preamplifier is not interchangeable, see also 5.1.

4.3 Sensor characteristics

4.3.1 Frequency response

Piezoelectric acoustic emission sensors are either resonant with a peak in a certain frequency range, i.e. the frequency content of the transient signal is mostly determined by the resonant frequency of the sensing element, or broad-band with a rather flat frequency response if properly damped. The response of a sensor is given in terms of its output voltage versus frequency for a standard mechanical stimulus. Due to the inertia of piezoelectric sensors their response will be different to continuous and transient stimuli. Most piezoelectric devices will be characterised by surface velocity (volts per metre per second) as a function of frequency for a transient input. An exception is the "flat response" device which is often characterised in terms of surface displacement (volts per unit displacement). Continuous signal response may be characterised in the same way or in pressure terms (volts per microbar).

4.3.2 Directionality

The directionality is a measure of the uniformity of the device response to signals coming from any direction along the surface of the object to which the device is attached. It is usually called the polar response and quoted as a deviation about the mean in dB. Sensors may be intentionally directional to preferentially monitor a specific area.

4.3.3 Wave mode response

Sensors may be made responsive to a particular wave mode, such as: shear, compressional or other waves.

4.3.4 Operating temperature

This depends on the construction materials and the characteristics of the sensor element. It shall be used within the temperature range specified by the manufacturers.

5 Signal conditioning

Included in this section is preamplification, cables and post amplification.

5.1 Preamplifier

The main preamplifier characteristics are the input impedance, noise, gain, bandwidth, filter characteristics such as roll-off rate, output impedance, operating temperature range, common-mode rejection ratio (CMRR) and dynamic range.

Preamplification can be of voltage or charge. Voltage preamplification converts the sensor output, usually a high impedance low-level signal, to a low impedance high-level signal for the transmission over long signal lines to the measurement instrumentation, which may be up to several hundred metres away.

A typical preamplifier has a high input impedance, 40 dB gain and 50 Ω output impedance to drive a coaxial cable. The D.C. power supply to the preamplifier is commonly supplied on the same cable as the signal output and decoupled at each end using a filter network.

The preamplifier input may be single-ended, differential or switchable to fit different sensor types. For some industrial applications, preamplifiers are an integral part of the AE sensor, providing greater ruggedness, reliability, reduced signal loss due to cable impedance and reduced susceptibility to electromagnetic noise.

The design of the preamplifier may allow the sensor to be used as a pulser transducer for calibration purposes.

Charge preamplification eliminates the effect of cable capacitance on the signal but is not widely used.

5.2 Cables

5.2.1 Sensor to preamplifier cable

This is the most important cable in the system and should be of low-capacitance, (< 100 pF/m), fully screened, and kept as short as possible (< 1 m) where voltage preamplification is used.

5.2.2 Preamplifier to instrument cable

This is normally a screened coaxial 50 Ω impedance cable matched to the preamplifier and measurement instrument. Care shall be taken to avoid crosstalk problems with multi-conductor cables, particularly if individual conductors are used to transmit a wide band pulser signal for periodic calibration during a test.

5.2.3 Screen

A single-point ground for all the screens is normally used at the measurement instrumentation. The screens of the cables shall not form ground loops.

5.3 Post-amplification and frequency filtering

Post-amplification and further analogue filtering is used at the measurement instrumentation to increase the signal level and remove unwanted low or high frequency signals for measurement purposes. The input impedance, dynamic range, filter characteristics, gain or attenuation are relevant to this section. The input stage usually provides D.C. power for the preamplifier and, sometimes, may control pulser operation.

6 Signal measurement

6.1 Continuous signal

A continuous signal is characterised by the measurement of RMS (Root Mean Square) or ASL (Average Signal Level) with a particular time constant. Continuous signal measurement systems are used where there is no requirement to identify and characterise individual emissions (bursts), e.g., process monitoring and leak detection. The measured characteristics and their dynamic range define this type of system.

6.2 Burst signal

Burst signal measurement systems identify and characterise individual acoustic emissions on the basis of their time above an amplitude threshold.

The parameters of each burst signal may comprise any or all of the following, depending on the type of system and its user set-up:

- peak amplitude;
- time to peak amplitude;
- arrival time;
- rise-time,
- duration;
- ringdown count;
- count to peak amplitude;
- energy;
- average frequency;
- RMS level;
- ASL;
- detection threshold level;
- others.

External slow-varying parameter data, such as pressure, temperature, load or strain may also be acquired as part of the data set. These parameters may be sampled at the precise time of the AE and or on a time interval basis.

All these values define an AE data set.

The rate at which a system acquires discrete bursts is defined by two parameters:

- the peak acquisition rate, which is sustainable for a short defined period of time,
- the continuous acquisition rate, which is sustainable for an indefinite period of time.

6.3 Waveform

The complete characterisation of an AE "burst" is obtained by digitisation and storage of the waveform when it exceeds a set amplitude threshold. The difficulty in using this method is the storage capacity required, typically 100 times that of systems measuring only the primary characteristics of the signal, and the rate at which data can be transferred to the storage medium.

AE waveform capture is usually triggered periodically by certain characteristics of an AE data set.

Important features of waveform capture systems include their dynamic range, bandwidth, sampling rate, type and capacity of buffering and data transfer rate to disk.