SLOVENSKI STANDARD
oSIST prEN 16696:2014

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Neporušitveno preskušanje - Akustična emisija - Preskušanje tesnosti

Non-destructive testing - Acoustic emission - Leak detection by means of acoustic emission

Zerstörungsfreie Prüfung - Schallemission - Dichtheitsprüfung mittels Schallemission

Essais non destructif - Émission acoustique - Détection de fuite par émission acoustique

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

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

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Foreword

This document (prEN 16696:2013) has been prepared by Technical Committee CEN/TC 138 “Non-destructive testing”, the secretariat of which is held by AFNOR.

This document is currently submitted to the CEN Enquiry.

1 Scope

This European Standard specifies the general principles required for Leak Detection by the acoustic emission (AE) testing. The Standard is addressed to the application of the methodology on structures and components, where a leak flow as result of pressure differences appears and generates AE.

It describes phenomena of the AE generation and influence of the nature of fluids, shape of the gap, wave propagation and environment.

The different application methods, instrumentation and presentation of AE results will be discussed. It also includes the guidelines for the preparation of application documents, which describe specific requirements for the application of the AE method.

Different application examples will be given.

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

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 473, *Non-destructive testing — Qualification and certification of NDT personnel — General principles*

EN 1330-1, *Non-destructive testing – Terminology – Part 1: 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*

EN 13477-1, *Non-destructive testing — Acoustic emission — Equipment characterisation – Part 1: equipment description*

EN 13477-2, *Non-destructive testing – Acoustic emission — Equipment characterisation – Part 2: verification of operating characteristics*

EN 13554, *Non-destructive testing — Acoustic emission — General principles*

EN ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

3 Terms and definitions

For the purpose of this document, the terms and definitions given in EN 1330-1, EN 1330-2 and EN 1330-9 apply.

The definitions of “leak”, “leakage rate”, “leak tight” are those defined in EN 1330-8 “Terms used in leak tightness testing”.

4 Personnel qualification

It is assumed that acoustic emission testing is performed by qualified and capable personnel. In order to prove this qualification, it is recommended to certify the personnel in accordance with EN 473.

5 Principle of acoustic emission method

5.1 The AE phenomenon

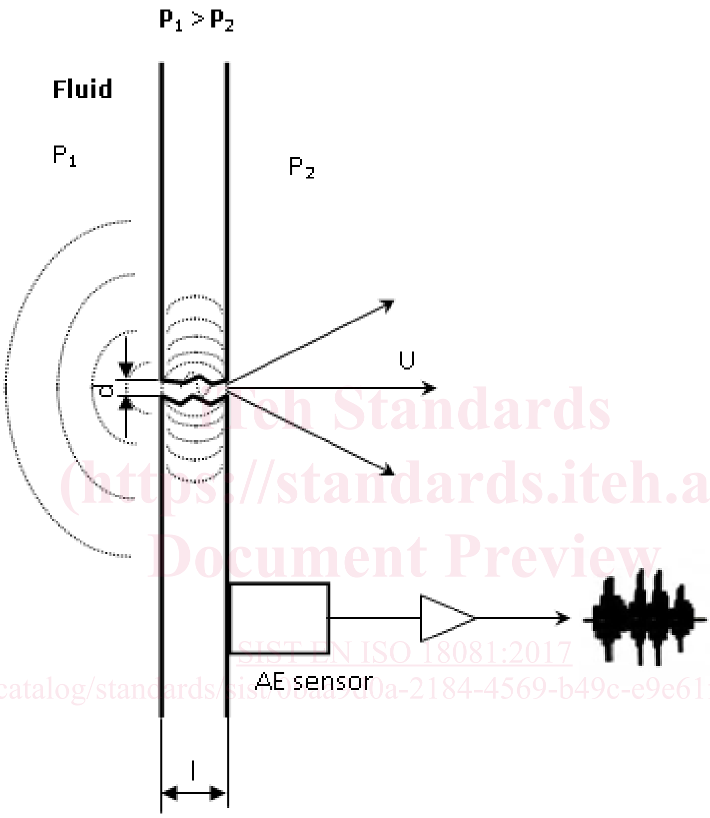

Figure 1 — Schematic principle of acoustic emission and its detection

The continuous acoustic emission in the case of leak looks like an apparent increase in background noise. (Transients from pressure fluctuations are very different resulting in broad band acoustic emission) Temporal variations of pressure fluctuations are very different; the frequency spectrum of acoustic noise generated is then very large.

Table 1 — Influence of the different parameters on the AE activity

	Parameter	Higher activity	Lower activity
5.2	Test media	gas two phase	liquid
	Viscosity	low	high
	Type of flow	turbulent	laminar
	Fluid velocity	high	low
5.3	Pressure difference	high	low
5.4	Shape of leak	crack like	hole
	Length of leak path	long	short
	Surface of leak path	rough	smooth

5.2 Influence of different media and different phases

The detectability of the leak depends on the fluid type and its physical properties. These will contribute to the dynamic behaviour of the leak flow (laminar, turbulent) (see Table 1).

In contrast to turbulent flow the laminar flow doesn't in general produce detectable acoustic emission signals.

Acoustic signals of leakage are generated by

— turbulent flow of the escaping gas or liquid,

— fluid friction in the leak path,

— cavitations, during two-phase flow (gas coming out of solution) through a leaking orifice,

— the pressure surge generated when a leakage flow starts or stops,

— backwash of particles against the surface of equipment being monitored,

— gaseous or liquid jet,

— pulsating bubbles,

— explosion of bubbles,

— shock-bubbles on the walls,

— vaporisation of the liquid (flashing).

The duration of an event of cavitation in water is estimated at several tens of microseconds, which implies an emission wavelength in a frequency spectrum about several kHz to several MHz.

Cavitation results in a discrete emission whose energy is at least than one order of magnitude from that caused by turbulence.

The content in gas or air strongly influences the early stage of cavitation.

When it rises, it makes the leak detection easier but at the same time the noise level tends to decrease because of wave attenuation by air bubbles

The acoustic waves generated by leaks can propagate by the walls of system as well as through any fluids inside. The vibration at ultrasonic frequencies of fluid molecules produced by turbulence that occur in the transition from laminar to turbulent flow within the leak path and as they escape from an orifice is the source of the acoustic waves.

The acoustic waves produced by the above mentioned factors are used for leak detection and location.

5.3 Influence of pressure differences

The pressure difference is the primary factor affecting leak rate. However, the presence of leak paths may depend on a threshold value of fluid temperature or pressure. Both pressure dependent leaks and temperature dependent leaks have been observed, but in extremely limited number. Pressure-dependent or temperature-dependent leaks denote a condition where no leakage exists until threshold pressure or temperature is reached. At this point, the leakage appears suddenly and may be detectable. When the pressure or temperature is reversed, the leakage follows the prescribed course to the critical point at which leakage drops to zero. Temperature and pressure are not normally applied in the course of leak testing for the purpose of locating such leaks. Instead, they are used to force existing discontinuities to open, so as to start or increase the leakage rate to point of detection.

An example of this effect is the reversible leakages at seals below the service temperature and/or service pressure.

AE waves emitted by a leak will normally have a characteristic frequency spectrum depending on the pressure difference and shape of the leak path. Therefore the detectability of the leak depends on the frequency response of the sensor and this shall be taken into account when selecting the instrumentation.

5.4 Influence of geometry of the leak path

The AE intensity from a natural complex leak path (e.g. pinhole corrosion, fatigue or stress corrosion cracks) is generally greater than that produced by leakage from a standard artificial source such as a drilled hole used for verification. The main parameters defining the complexity are the cross section, length and surface roughness of the leak path.

5.5 Influence of wave propagation

Acoustic emission signals are response of a sensor to sound waves generated in solid media. These waves are similar to the sound waves propagated in air and other fluids but are more complex because solid media are capable of resisting shear force.

Waves that encounter a change in media in which they are propagating may change directions or reflect. In additions to reflection, the interface causes the wave to diverge from its original line of flight or refract in the second medium. Also the mode of the wave may be changed in the reflection and/or refraction process.

An incident wave upon an interface between two media will reflect or refract such that directions of the incident, reflected and refracted waves all lie in the same plane. This plane is defined by the line along which the incident wave is propagating and the normal to the interface.

Below are presented important factors to AE technology:

a) wave propagation has the most significant influence on the form of the detected signal;

b) wave velocity is key to computed source location;

c) attenuation governs the sensor spacing that is needed for effective detection.

The wave propagation influences the received waveform in the following ways.

— Reflections, refractions and mode conversions on the way from source to sensor result in many different propagation paths of different lengths.

— Multiple propagation paths on the way from source to sensor - even in the absence of reflecting boundaries may be caused by the structure itself. For example, spiral paths on a cylinder.

— Separation of different wave components (different modes, different frequencies) travelling at different velocities.

— Attenuation (volumetric dispersion, absorption as well as attenuation due to the first and third effects listed above).

The attenuation is influenced by liquids inside a system or pipe, which will assist in the propagation of acoustic waves, while liquids outside (such as moisture in the soil) have a tendency to reduce detectable signal the propagation of the acoustic waves. This effect will depend on the relative acoustic impedances of the different materials.

6 Applications

Acoustic emission testing provides many possibilities to detect leaks from pressurised volumes in industry and research fields. AT is used in following areas:

a) pressure vessels

b) pipe and piping systems

c) storage tanks

d) boiler drums

e) boiler tubes

f) autoclaves

g) heat exchangers

h) containments

i) valves

j) safety valves

k) pumps

l) vacuum systems