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Neporušitvene preiskave - Akustična emisija - Določanje značilnosti opreme - 2. del: Preverjanje lastnosti delovanja

Non-destructive testing - Acoustic emission testing - Equipment characterisation - Part 2: Verification of operating characteristics

Zerstörungsfreie Prüfung - Schallemissionsprüfung - Charakterisierung der Prüfausrüsting - Teil 2: Überprüfug der Betriebskenngrössen

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English Version

Non-destructive testing - Acoustic emission testing - Equipment characterisation - Part 2: Verification of operating characteristics

Zerstörungsfreie Prüfung - Schallemissionsprüfung - Charakterisierung der Prüfausrüsting - Teil 2: Überprüfug der Betriebskenngrössen

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 138.

If this draft becomes a European Standard, 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.

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

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Contents

European foreword

This document (prEN 13477-2:2019) 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.

This document will supersede EN 13477-2:2010.

In comparison with the previous edition, the following technical modifications have been made:

— Improvement of Clause 3 “Terms & Definitions”;

— Improvement of Clause 5 “Sensor verification”;

— Improvement of Clause 6 “Pre-amplifier verification”;

— Improvement of Clause 7 “Acoustic emission signal processor verification”.

1 Scope

This document specifies methods for routine verification of the performance of acoustic emission (AE) equipment comprising one or more sensing channels. It is intended for use by operators of the equipment under laboratory conditions. Verification of the measurement characteristics is advised after purchase of equipment, in order to obtain reference data for later verifications. Verification is also advised after repair, modifications, use under extraordinary conditions, or if one suspects a malfunction. The procedures described in this document do not exclude other qualified methods, e.g. verification in the frequency domain. These procedures apply in general unless the manufacturer specifies alternative equivalent procedures. Safety aspects of equipment for use in potentially explosive zones are not considered in this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 1330-1:2014, *Non-destructive testing – Terminology – Part 1: List of general terms*

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

EN 1330-9:2017, *Non-destructive testing – Terminology – Part 9: Terms used in acoustic emission testing*

EN 13477-1:2001, *Non-destructive testing – Acoustic emission – Equipment characterisation – Part 1: Equipment description*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1330-1:2014, EN 1330-2:1998 as well as EN 1330-9:2017 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
acoustic emission signal processor
ASP
part of an AE channel for the conversion of the output of the pre-amplifier to digital signal parameters

Note 1 to entry: An AE signal processor may include additional support functions, e.g. pre-amplifier power supply, test pulse control, transient recorder and more.

3.2
arbitrary function generator
AFG
electronic device for generating programmable test signals (burst), various waveforms and DC

3.3
high accuracy digital voltmeter
HADVM
electronic device for precise measurement of the DC voltages used for stimulation of external parametric inputs

3.4
current measurement adapter
CMA1
electrical device for the convenient measurement of DC current consumption of a pre-amplifier, supplied by an AE signal processor

3.5
50 Ω terminator
coaxial plug (BNC style) with an internal 50 Ω resistor from inner wire to shield

3.6
high impedance
HiZ
reverse of "terminated by 50 Ω"

3.7
DC-blocker
BNC male to BNC female connector piece with a capacitor, 10 µF/50 V, non-polarized, between the inner wires of both connectors, feeding an ac signal through but blocking DC to prevent DC-current into an AFG or a 50 Ω terminator

3.8
designations for variables, constants, setpoints and acceptance criteria

Note 1 to entry: This document uses about 30 basic designation codes each identifying an item (or item-group) under verification. Designation-extensions for setpoints and acceptance criteria, increase the number of designations used to about 200. This section defines three structural elements that keep this large number of designations self-explanatory and easy to handle, the designation code, a setpoint-related extension, and an acceptance criteria extension.

3.8.1
distinction of designations from text
distinction in which normal text is reproduced in standard font (e.g. Cambria 11 Pt.), in which designations are reproduced in bold italic font of style Times New Roman 11 Pt. in case it indicates a ***VARIABLE*** and in non-italic font of same style in case it indicates a **CONSTANT**, and in which, for optimized legibility, superscripts and subscripts are avoided in most cases

3.8.2
item under verification
IUV
general term and place holder for any designation code defined hereafter

3.8.3
designation code
abbreviation of an item under verification, consisting of one or two characters (sometimes more in order to identify further information) and optionally the number of a test pattern or the character ***"s"*** as place holder for the number of a test pattern

EXAMPLE 1 ***Rs*** identifies the measured risetime of pattern ***s***, see 7.6.4.

EXAMPLE 2 ***EA1*** identifies the measured energy value of the first test pattern of the amplitude dependent energy verification, see 7.6.6.1.

EXAMPLE 3 ***BGRMS*** identifies a measurement of RMS background noise, see 7.3.1, Formula (19).

3.8.4
setpoint related extensions of a designation code

3.8.4.1
'N
extension which, at the end of a code, identifies a nominal value of an IUV, defined by the manufacturer, the procedure, or calculated by a formula

EXAMPLE 1 ***A1'N*** defines the first nominal maximum amplitude setpoint of a series, in the unit dB_{AE}, to be stimulated, measured and verified against well-defined acceptance criteria, see 7.6.2.

EXAMPLE 2 ***EAs'N*** defines a series of nominal signal energies, in energy units, calculated by using a given formula, to be stimulated, measured and verified against well-defined acceptance criteria, see 7.6.6.1.

3.8.4.2
'S
extension which, at the end of a code, identifies an AE system setpoint

EXAMPLE 1 ***ATH1'S*** defines the threshold setpoint for the verification of ***A1'N***, in the unit as required by the AE system, usually the same as of ***A1'N.***

EXAMPLE 2 ***BPN'S*** defines a narrow-banded band-pass to be used in the AE signal processor, for measurements as defined in the procedure.

3.8.4.3
'T
extension which, at the end of a code, defines a test signal setpoint

EXAMPLE 1 ***AAH1'T*** defines the setpoint for the test signal amplitude in HiZ condition of the output of the arbitrary function generator AFG, for a signal to be used as stimulation of ***A1'N***, in the unit required by the AFG, usually in mV_{PP}.

EXAMPLE 2 ***S2-Sw'T*** defines the setpoint for the AFG to generate a sin^2-modulated sine-wave burst.

3.8.5
acceptance related extensions of a designation code

3.8.5.1
.MA
extension which, at the end of a code, defines the acceptable deviation of a measured value compared with the nominal value, specified in dB, by the manufacturer, see 7.6.2.1

3.8.5.2
.MP
extension which, at the end of a code, defines the acceptable deviation of a measured value compared with the nominal value, specified in %, by the manufacturer, see 8.1.2

3.8.5.3
.MB
extension which, at the end of a code, defines an additional acceptable deviation component, specified as a percentage of an absolute measurement range, or directly in µV, by the manufacturer, usually extending ***.MA*** or ***.MP,*** see 7.6.2.1 or 8.1.2

3.8.5.4
.U
extension which, at the end of a code, defines an upper acceptance limit, either derived by a formula from ***.MA***, ***.MP*** and/or ***.MB***, or directly specified by the manufacturer

EXAMPLE 1 ***As.U*** defines the upper acceptance limit for the deviation of an amplitude measurement in dB_{AE} from a nominal amplitude value, e.g. ***A1'N***, see 7.6.2.

EXAMPLE 2 ***BGIWP.U*** defines an upper limit for the internally generated system noise in µVP, specified by the manufacturer, see 7.2.

3.8.5.5
.L
extension which, at the end of a code, defines a lower acceptance limit, either derived by a formula from ***.MA***, ***MP*** and/or ***.MB***, or directly specified by the manufacturer, see 6.3.5

3.8.5.6
.DP
deviation percentage, i.e. absolute ratio of a measurement deviation to the acceptable deviation, expressed in %

Note 1 to entry: The acceptance criterion is met if ***.DP*** of IUP is lower or equal 100 %. This allows to very simply see whether an acceptance criterion is met and how near the acceptance limit is, by looking at this quantity only.

3.8.5.7
.D0
default nominal value or typical value of a measurement, which can be provided by the manufacturer, otherwise by this document, and which is used to calculate the allowed deviation, if a precise nominal value ('N) is not defined

EXAMPLE 1 Shield crosstalk ***SC***. Assume ***SC.U*** is specified to −80 dB. The lower physical measurement limit for ***SC*** is at about −150 dB. This document uses on default ***SC.D0*** = −150. A measured value of −150 dB delivers then ***SC.DP*** = 0 %, a measured value of −80 dB, ***SC.DP*** = 100 %, see Subclause 5.3.3.

EXAMPLE 2 System noise ***BGIWP.U.*** Assume ***BGIWP.U*** = 20 µVP, ***BGIWP.D0*** = 0, and a realistic typical measurement value of ***BGIWP*** begins at 10 µVP. Then, ***BGIWP*** = 10 µVP leads to ***BGIWP.DP*** = 50 %, and 20 µVP to 100 %. If the manufacturer defines ***BGIWP.D0*** = 10, then ***BGIWP*** = 10 µVP leads to ***BGIWP.DP*** = 0 %, 20 µVP to 100 %: This parameter allows the manufacturer to adjust a range of *.DP*-result according to physical conditions, see 7.2.

4 Required test equipment

4.1 List of required equipment

The following minimum test equipment is required:

a) Test block;

b) Shielding test plate;

c) Hsu-Nielsen source, for sensor sensitivity verification;

d) Multimeter for DC voltage and DC current measurement during pre-amplifier verification;

e) Test signal generator, an arbitrary function generator (AFG) with the capability to deliver loadable arbitrary signals, sine-waves, rectangle waves, pulses, and DC for manual or automated verification of external parametric inputs. The output socket shall be isolated from protective earth, which is the usual case with standard AFGs. Key specifications for accuracy: AC amplitude: ± 1 % setting ± 1 mVPP at 1 kHz, frequency: 0,01 % setting, DC-offset: ± 1 % setting ± 2 mV;

f) High-accuracy digital voltmeter (HADVM) to measure the DC test signal from AFG in sufficient accuracy for the verification of the external parametric inputs. Key specifications for accuracy: DC voltage ± 0,0035 % reading ± 100 µV;

g) Variable attenuator, graduated in decibels, matching 50 Ω impedance on input and output; ± 0,15 dB;

h) DC-power-supply, for pre-amplifier supply, with a proper circuit to decouple and terminate the AE signal, if power is fed in over the signal wire. Can be substituted by a verified AE signal processor, see also k) and n);

i) RMS voltmeter, with known or settable time constant or time window. Can be substituted by a verified AE signal processor and appropriate software; Key specification: AC accuracy 20 kHz to 1 MHz: 0,2 dB;

j) Dual-channel storage oscilloscope, for detecting any artefact or non-plausibility in various setups;

k) Current measurement adapter (CMA1), if h) is substituted by a verified AE signal processor. Resistor accuracy: 1 %;

l) DC-blocker;

m) 50 Ω BNC terminator

n) Verified AE signal processor (two units), can be substituted by h) and i).

All electric/electronic test items shall be subject to the quality management system.

4.2 Test signal waveforms

4.2.1 Continuous sine-wave

This type of test signal shall be used to verify the frequency response and gain of the pre-amplifier and the continuous signal level accuracy of the AE signal processor.

4.2.2 Triangular-modulated sine-wave

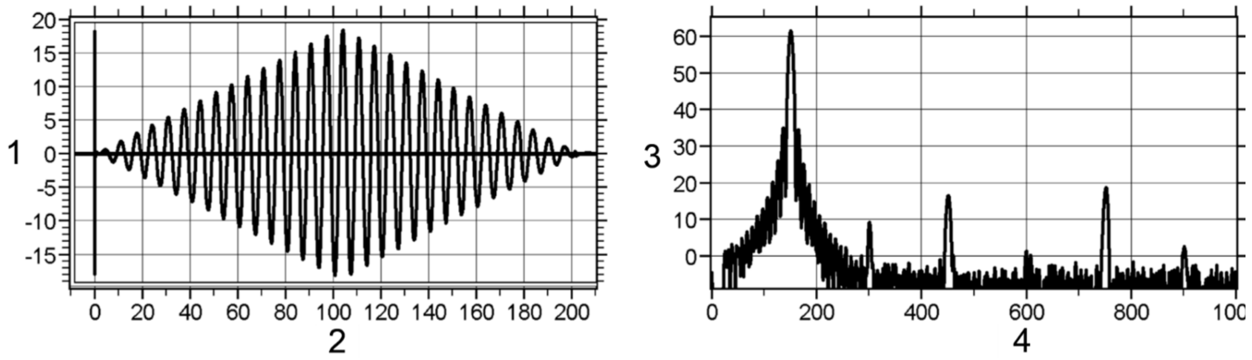
This type of wave simulates an AE burst signal, see Figure 1. It is defined by the following parameters:

a) A amplitude;

b) R rise-time;

c) D duration;

d) f carrier frequency.



a) Time domain

b) Frequency domain (FFT)

Key

1 amplitude in mV

2 time in µs

3 amplitude in dB

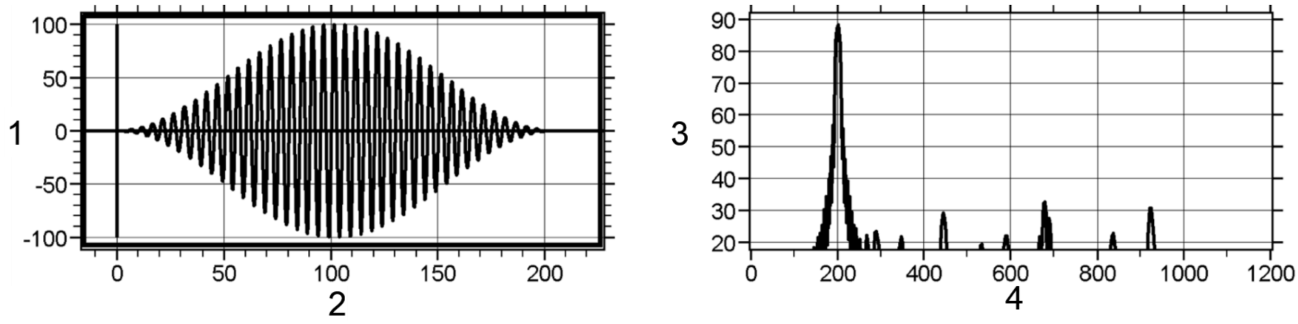
4 frequency in kHz

Figure 1 — Triangular-modulated sine-wave

The measured rise time may be shorter than the visible rise time of the test signal because rise time measurement starts at the time of the first threshold crossing. Table 1 shows the theoretical dependency of this threshold crossing delay on the difference between maximum amplitude and threshold setpoint in an AE channel. In practice, the used band-pass filter may further modify the exact value of the threshold crossing delay. The amplitude scaling of the FFT in dB refers to 1 µV_{peak}, (0 dB_{AE}), if the input is a continuous sine-wave.

4.2.3 Sin²-modulated sine-wave

A sin²-modulated signal (see Figure 2) can be used as an alternative to a triangular modulated sine-wave. Due to its smooth begin, maximum and end, its spectrum is very pure and the influence of filter overshoot and filter ring-down behaviour is reduced. This signal can be used to obtain the frequency response of the band-pass of a pre-amplifier or AE signal processor by burst maximum-amplitude measurement.



a) Time domain **b) Frequency domain (FFT)**

Key

1 amplitude in mV

2 time in µs

3 amplitude in dB

4 frequency in kHz

Figure 2 — Sin²-modulated sine-wave

The signal shown in Figure 2 corresponds to the following formulae:

$$U[N] = UP \times \sin(N \times 2 \times \pi / \mathrm{SpSW}) \times \sin^2(N \times \pi / (\mathrm{SpSW} \times \mathrm{SWpB})) \quad (1)$$

$$N = 0 \text{ to } (\mathrm{SpSW} \times \mathrm{SWpB}), \text{ in integer steps} \quad (2)$$

where

N	number of each sample in time order;
SpSW	Samples per sine-wave (48 in Figure 2);
SWpB	Sine-waves per burst (41 in Figure 2);
U[N]	Voltage of sample ***N***;
UP	Maximum-amplitude (100 mV in Figure 2) of the simulated burst.

The resulting carrier frequency ***FC*** is a function of the sample time interval ***TS***:

$$FC = 1/(TS \times \mathrm{SpSW}) \quad (3)$$

or the time interval ***TS*** for a certain carrier frequency is

$$TS = 1/(FC \times \mathrm{SpSW}) \quad (4)$$

EXAMPLE in Figure 2 the time interval results in: ***TS*** = 1/(200 kHz × 48) = 104,167 ns

NOTE The duration ***D*** (in µs) of the burst is **SWpB** x ***FC*** (in MHz), e.g. 205 µs at **SWpB** = 41 and ***FC*** = 0,2 MHz.

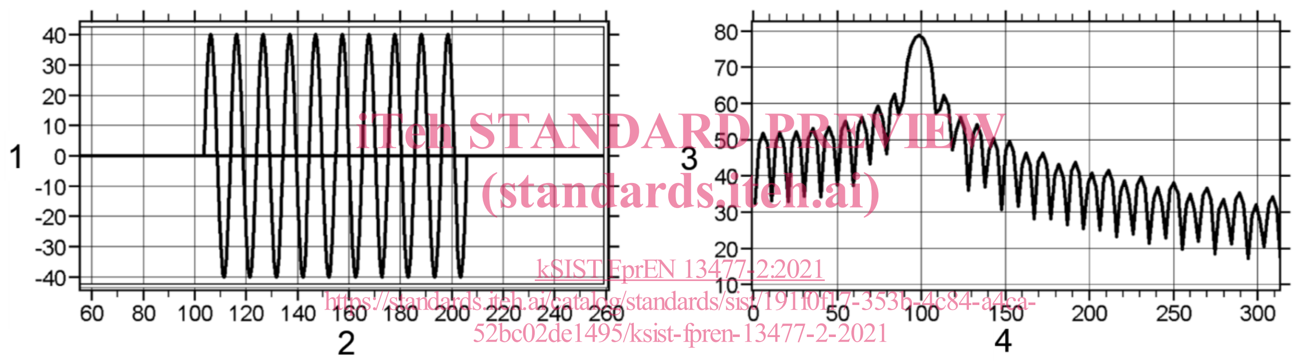
Similar to the triangular modulated sine-wave, the rise time measured by an AE signal processor is shorter than the visible rise time of the test signal, because rise time measurement starts at the time of the first threshold crossing. This so-called “first threshold crossing delay” depends on the difference of maximum amplitude and detection threshold in dB. Theoretical values are listed for the two modulated test signals in Table 1. In practice, the used band-pass filter may further modify the exact value of the first threshold crossing delay.

Table 1 — First threshold crossing delay versus amplitude-to-threshold ratio for a sin²- and triangular-modulated test signal

Threshold	Sin²-modulated first threshold crossing delay in % of linear signal rise time	Triangular -modulated first threshold crossing delay in % of linear signal rise time
A – 20 dB	19,7	11,0
A – 25 dB	15,0	6,0
A – 30 dB	12,3	3,5
A – 35 dB	8,3	3,0
A – 40 dB	7,6	1,0

4.2.4 Rectangular-modulated sine-wave

This type of signal is defined by the characteristics A, D and f (see 4.2.2 and Figure 3).



a) Time domain **b) Frequency domain (FFT)**

Key

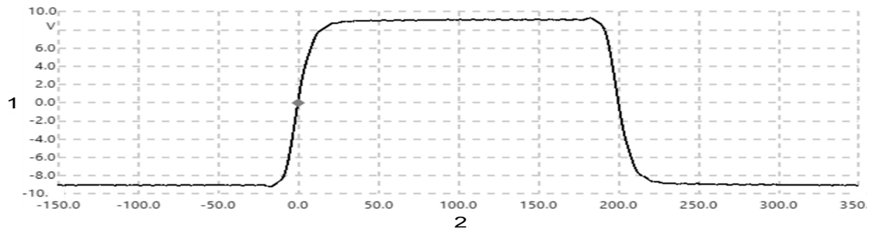
1 amplitude in mV
2 time in µs
3 amplitude in dB
4 frequency in kHz

Figure 3 — Rectangular-modulated sine-wave

4.2.5 Pulse

This test signal shall be used to check the measurement of ***Δt***. It is defined by the characteristics ***A*** (amplitude) and ***D*** (pulse duration). Figure 4 shows a pulse of 18 V_{PP} amplitude and 200 ns pulse duration at the output of an AFG. The amplitude setpoint was 9 V_{PP}. At unterminated output the amplitude is twice of the setpoint.

Such a pulse, fed into a piezoelectric emitter, can also be used to stimulate reproducible AE events into a test block (see 4.3).



Key

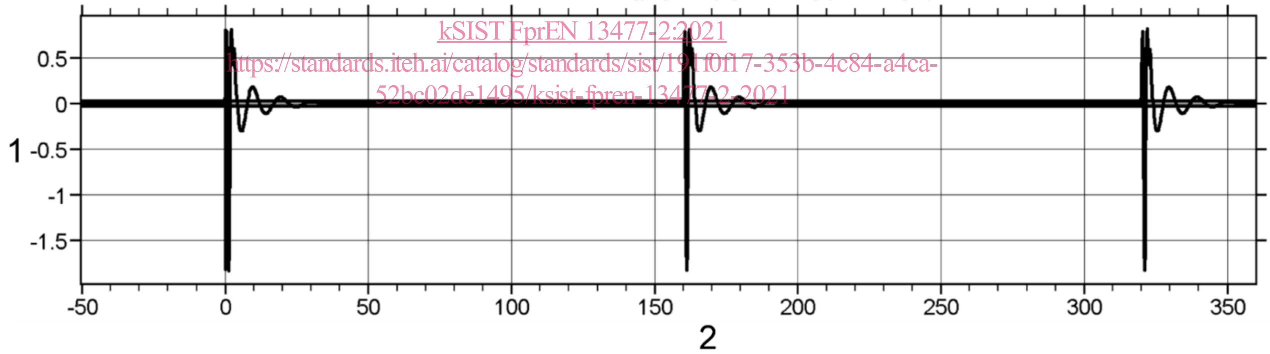
1 amplitude in V

2 time in ns

Figure 4 — Pulse signal

4.2.6 Repetitive signals

These signals are used to verify the signal processing rate. It is a series of pulses as described in Subclause 4.2.5. It is defined by ***A*** (amplitude), ***D*** (pulse duration) and ***f*** (repetition frequency), typically 1 Hz – 10 kHz. Figure 5 shows an example with 1/***f*** = 160 µs, taken after the band-pass filter of an AE signal processor. The maximum reasonable repetition frequency is limited by the ring-down effect of the band-pass filter, if a pulse causes multiple threshold crossings.



Key

1 amplitude in mV

2 time in µs

Figure 5 — A series of transient signals (pulses) behind the band-pass, 160 µs apart

4.3 Test Block

This can take different forms, e.g. a metallic block, or a plate, or an acrylic rod. Once chosen, the dimensions, construction material, source position (Hsu-Nielsen source or piezoelectric emitter), sensor mounting position and usage shall be controlled to ensure reproducibility of results.

The surface in contact with the sensor shall be flat and smooth. The test block shall be isolated acoustically from the work bench to avoid interference from external noise sources.