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Non-destructive testing — Acoustic emission testing — Metallic pressure equipment

Essais non destructifs — Essais d'émissions acoustiques — Équipements sous pression métalliques

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 135, *Non-destructive testing*, Subcommittee SC 9, *Acoustic emission testing*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Industrial applications of acoustic emission testing for pressure equipment are expanding along with remarkable improvement of acoustic emission testing technologies. The effectiveness of any application of acoustic emission testing depends upon proper and correct usage of the acoustic emission instruments and testing techniques. In addition, the existing international acoustic emission standards lack specification of a classification system with associated recommendations for maintenance.

The purpose of this document is to provide requirements for testing equipment, testing procedures and the classification system for acoustic emission testing of pressure equipment in the field of industrial non-destructive testing. The establishment of this document can address the lack of an ISO standard for acoustic emission testing for pressure equipment. The main parties who might benefit from this document are testing organizations and owners/users of pressure equipment.

Non-destructive testing — Acoustic emission testing — Metallic pressure equipment

1 Scope

This document specifies an acoustic emission testing (AT) technique for metallic pressure equipment and the classification and evaluation of results.

This document applies to acoustic emission (AE) detection and monitoring of active sources of newly manufactured and in-service metallic pressure equipment.

This document does not apply to leak detection and in-service monitoring using AE.

This testing method is not intended to be a stand-alone method for testing and evaluation of the pressure equipment. Other non-destructive testing (NDT) methods may be used to verify and supplement the AT results.

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.

ISO 12714, *Non-destructive testing — Acoustic emission inspection — Secondary calibration of acoustic emission sensors*

ISO 12716, *Non-destructive testing — Acoustic emission inspection — Vocabulary*

ISO/TR 13115, *Non-destructive testing — Methods for absolute calibration of acoustic emission transducers by the reciprocity technique*

EN 14584:2013, *Non-destructive testing —Acoustic emission testing — Examination of metallic pressure equipment during proof testing — Planar location of AE sources*

EN 15495, *Non-destructive testing — Acoustic emission — Examination of metallic pressure equipment during proof testing — Zone location of AE sources*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12716 and the following apply.

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

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

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

3.1
acoustic emission testing
AT
testing of a test object during controlled stimulation using acoustic emission instrumentation to detect and analyse sources of acoustic emission

3.2
acoustic emission source
AE source
spatial element in the material where transient elastic waves are generated by the release of energy

3.3
acoustic emission source location
AE source location
determination of the spatial position of an *AE source* (3.2) at the test object based on the arrival time measurement using an array of sensors

Note 1 to entry: Several approaches to AE source location are used, including zonal location, computed location and continuous location. The spatial element can be represented by one or more location clusters in planar or linear location when using computed location method based on time difference or by a location zone when using zone location

3.4
activity of acoustic emission source
activity of AE source
total number of AE events obtained from one or more location clusters or zones assigned to one AE source at a certain spatial area of the test object

3.5
intensity of acoustic emission source
intensity of AE source
characterization of the *AE source* (3.2) by using intensity related parameters from one or more location clusters or zones assigned to one AE source at a certain spatial area of the test object

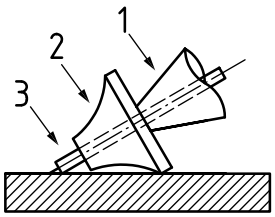
Note 1 to entry: Intensity of AE source for burst related parameters are, e.g. peak amplitude, energy, ring-down counts

3.6
active discontinuity
discontinuity which is generating transient elastic waves under controlled stimulation

3.7
pressure equipment
steam boilers, pressure vessels, piping, safety valves and other components and assemblies subject to pressure loading

3.8
Hsu-Nielsen source
device to simulate an AE event using the fracture of a brittle graphite lead in a suitable fitting

Note 1 to entry: Device given in Figure 1



Key

1	pencil
2	guide ring
3	graphite lead
hardness grade	2H
diameter	0,5 mm

length 3 mm ± 0,5 mm

Figure 1 — Hsu-Nielsen source

3.9
acoustic emission detectability parameter
K_{AE}
difference between the evaluation threshold and the system testing threshold in units dB

4 General principles

The main purpose of AT on pressure equipment is to detect and to locate AE sources within the volume or at the surface of the parent metal or welds.

a) The AT shall comprise 100 % of the pressure-bearing shell. Only in exceptional cases and when not directly affecting the safe pressurization of the equipment, the AT may be limited to specific parts agreed upon with the owner/operator at the time of enquiry or order.

b) The AT shall be done during the loading process, which includes the pressure loading, load holding unloading and reloading.

c) The AE sensors shall be arranged on the surface of pressure equipment under test in order to detect the transient elastic waves released by AE sources and transform them into electric signals.

d) These electricals signals shall be conditioned and transmitted to an AE instrument for measuring, recording, interpretation and evaluation.

5 Personnel qualification

The AT shall be performed by competent personnel. In order to ensure that this is the case, it is recommended that the personnel meet the requirements of ISO 9712 or equivalent.

6 Testing equipment

6.1 Acoustic emission testing system

An AT system employs an AE instrument, AE sensors, preamplifiers, and interconnecting cables.

This combination together with mounting devices for holding the sensors forms the AT system.

All essential parts of the system shall be specified in a written AT instruction agreed between purchaser and supplier at the time of enquiry or order (see 10.2).

6.2 Acoustic emission sensors

It is recommended to use sensors in the frequency range between 100 kHz and 400 kHz.

A lower frequency range for sensors can be advantageous in case of high attenuation.

The requirements are as follows.

a) The minimum sensitivity shall be equivalent or greater than 60 dB referred to 1 V/(m·s^{-1}).

b) Sensors shall be shielded against electromagnetic interference by proper shielding practice or by differential element design, or both. The metallic case of each AE sensor shall be electrically isolated from a metallic test object.

c) The AE sensors shall be stable over the response frequency and temperature range of use, and shall not exhibit sensitivity changes greater than 3 dB over this range.

d) The verification of the sensors should be performed according to ISO 12714 or with ISO/TR 13115 when applicable.

e) AE sensors mounted on the surface of pressure equipment shall be electrically insulated from each other.

6.3 Acoustic emission signal cables

The AE signal cables connecting sensors and preamplifiers shall be shielded against electromagnetic interference. Its length shall not exceed 1 m, unless the length-depending signal loss is considered and acceptable. This may be omitted where the preamplifier is mounted inside the shielded sensor housing.

6.4 Couplant

The couplant shall aid to keep good surface motion tracking and minimum acoustic impedance transfer effect during testing.

6.5 Preamplifiers

The preamplifiers may be separate or may be mounted inside the sensor housing.

The requirements are as follows.

a) The RMS voltage of preamplifiers circuit noise shall be less than 7 µV.

b) The preamplifiers shall be stable over the response frequency and temperature range of use, and shall not exhibit gain changes greater than 3 dB over this range.

c) The preamplifiers response frequency shall match with that of the sensors, and the gain of the preamplifiers, usually 40 dB or 34 dB, shall not cause saturation of the measurement chain up to a 100 dB_{AE} signal peak amplitude.

d) If the preamplifiers are of differential design, a minimum of 40 dB of common-mode rejection shall be provided.

6.6 Power signal cables

The signal loss of cables depends on type of cable, frequency and length. The requirements are as follows.

a) The cable providing power to the preamplifier and conducting the amplified signal to the main processor shall be shielded against electromagnetic noise.

b) Signal loss shall be no more than 1 dB per 30 m of cable length.

c) With cable length above 30 m, the resulting attenuation and the voltage drop-off of the DC-supply shall be evaluated and considered in the data analysis.

d) 150 m is the recommended maximum cable length to avoid excessive signal attenuation.

6.7 Filters

The response frequency of filters in the preamplifiers and the AE instrument shall match with that of the AE sensors.

6.8 Acoustic emission instrument

The requirements for AE instruments are as follows.

a) The AE instrument shall have enough AE channels to cover the area to be tested.

b) For each channel, the AE instrument shall display and record arrival time, threshold, peak amplitude, ring-down count, energy, rise time, and duration for each hit as a minimum.

c) The individual sampling frequency of each channel for acquisition of waveforms shall be not less than 10 times the sensors' centre response frequency.

d) The measurement inaccuracy for threshold above 40 dB_{AE} shall not exceed ±1 dB.

e) The measurement inaccuracy for ring-down counts shall not exceed ±5 %.

f) The AE instrument shall be capable to process, store and display at least 20 hits per second and per channel.

g) The delay and display from the arrival of the AE hits shall not exceed 2 seconds.

h) An alarm shall occur if the hit rate exceeds the capability of the instrument.

i) A warning shall occur when the storage space runs short.

j) The measurement inaccuracy for peak amplitudes above 40 dB_{AE} shall not exceed ±1 dB.

k) The usable dynamic range shall be a minimum of 65 dB.

l) The measurement inaccuracy for energy above 40 dB_{AE} shall not exceed ±5 %.

m) The resolution of the rise time, duration and arrival time for each channel shall not exceed 1 µs.

n) The error of arrival time measurement between all channels shall be not more than 2 µs.

o) The electronic noise levels shall be equal to or below 20 dB_{AE} in the frequency range from 100 kHz to 400 kHz.

p) It is preferred that the instrument is able to receive and record also external electric signals, such as pressure and temperature. The measurement inaccuracy for the external parametric inputs shall not exceed 1 % of the full range.

q) During data acquisition, AE software shall be capable to display the following diagrams:

   1) any AE parameter versus time or load;

   2) one AE parameter versus another AE parameter;

   3) linear, planar and/or zone locations.

r) The update time for all real-time testing diagrams shall be not more than 5 s.

s) The AE analysis software shall provide functions to replay and to analyse the recorded AT data.

   1) Linear and planar location algorithms shall be provided by the AT system manufacturer. Event location in this regard is based on Δt measurements and processes the sensor positions as well as the speed of sound. Application of linear location requires at least two sensors, and application of planar location requires at least three sensors.

   2) Zone location is based on arrival sequence of channels. The event shall be assigned to the first hit sensor location.