BS EN 15856:2010

Non-destructive testing — Acoustic emission — General principles of AE testing for the detection of corrosion within metallic surrounding filled with liquid

ICS 19.100

National foreword

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A list of organizations represented on this committee can be obtained on request to its secretary.

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Essais non destructifs - Emission acoustique - Principes généraux des contrôles par émission acoustique pour la détection de la corrosion dans une enceinte métallique remplie de liquide

Zerstörungsfreie Prüfung - Schallemissionsprüfung - Allgemeine Grundsätze der Schallemissionsprüfung zum Nachweis von Korrosion innerhalb von mit Flüssigkeit gefüllten metallischen Umschließungen

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Management Centre: Avenue Marnix 17, B-1000 Brussels

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Foreword

This document (EN 15856:2010) 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of an identical text or by endorsement, at the latest by July 2010, and conflicting national standards shall be withdrawn at the latest by July 2010.

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1 Scope

This European Standard describes acoustic emission testing (AT) on metallic surroundings filled with liquids for the detection of corrosion processes that are active at the time of the test. It is applicable to metallic storage tanks, such as those used in the chemical and petrochemical industry.

The results provide a qualitative statement regarding the condition of the test object and a recommendation regarding the maximum allowable duration of the follow-on service period, based on the AT indications and additional information in order to characterize the AT indications.

In the case of flat bottomed storage tanks (FBST) the procedure described within this standard provides testing of the complete bottom, the tank shell up to the filling height and in case of a floating roof tank also the roof sheets in contact with the stored liquid.

As for every application of acoustic emission testing, the measured data contain information regarding active sources. An ongoing corrosion process, such as general corrosion and localized corrosion defined in EN ISO 8044, leading to progressive loss of wall thickness will be detected. A corrosion process which has stopped does not produce acoustic emission and will therefore not be detected at the time of test.

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

EN 1330-1:1998, *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 1330-9:2009, *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 8044:1999, *Corrosion of metals and alloys — Basic terms and definitions (ISO 8044:1999)*

EN ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories (ISO/IEC 17025:2005)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1330-1:1998, EN 1330-2:1998, EN 1330-9:2009 and EN ISO 8044:1999 apply.

4 Personnel qualifications

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 General

5.1 Introduction

Evaluation of the AE data shall be done according to an established grading system, providing grades relating to the rate of degradation of the component under test as a result of corrosion.

The recommended duration of the service period following the test is with respect to the service condition prior to and at the time of the test. This recommendation is invalid, if the storage product or any other major service parameter has been altered.

The final test result shall not be affected by external or internal noise sources. The testing service provider has to communicate the demands regarding tank preparation to the tank operator. Proper support by the plant personnel for identification and elimination of noise sources shall be ensured.

5.2 Test preparation

AE originating from corrosion propagates through both the liquid and the structure. Where corrosion testing of tanks utilises wave propagation through the liquid stock product, the minimum filling level of the tank to be tested shall exceed the highest position of sensors mounted onto the tank shell at least by 1 m.

When testing flat bottomed storage tanks (FBST) the tank operation shall be static before the test in order to reduce internal noise to a minimum. No product shall be fed into or taken out of the tank, no internal circulation shall take place and, if operated, the heater shall be shut down. The necessary time period varies depending on the tank size and the stock product. Twenty-four hours is usually sufficient.

5.3 Sensors

When wave propagation through the liquid is used, the sensor frequency band is usually in the range from 20 kHz to 80 kHz. When wave propagation through the metal is used, the sensing frequency band is usually in the range from 100 kHz to 300 kHz.

The equipment surface below the sensors shall be prepared to ensure the maximum coupling efficiency. The sensor couplant shall be as specified in the written test instruction. The sensors may be directly attached to the structure using magnetic devices or suitable adhesive.

The effectiveness and reliability of the acoustic couplant shall be verified. The characteristics of the type of the acoustic couplant used shall not affect the structure adversely.

5.4 Source location

The location of AE sources is based on delta t measurement. In case of tank floor testing two rows of sensors and wave propagation through the liquid shall be used.

When evaluating the floor condition regarding active corrosion, the location error is normally within 10 % of the tank diameter. The location error is smaller near the centre area and increases as the AE source approaches the annular ring.

If the height of first row sensors (see 7.1) is changed as a result of the presence of sludge or internal structure, then the location error increases, especially near to the annular ring.

The same principle applies to the evaluation regarding active corrosion of the floating roof. The location error of the roof testing is normally within 15 % of the tank diameter. The error increases when the distance of the second row of sensors from the floating roof increases.

Waves propagate through liquid and metal from the source to the sensors and perhaps also on different paths. Therefore the planar location error on the tank shell is normally within 15 % of the sensor spacing.

5.5 Preliminary information

The tank operator shall provide information necessary for performing the test. This shall include the following, as relevant and available:

a) Customer nominated on-site test co-ordinator;

b) Tank information: identification, manufacturer, year of manufacturing, serial number, capacity, shell height, diameter, thermal insulation, stock product, roof type, bottom type, foundation, internal coating, internal installation, cathodic protection, tank history including NDT and repairs, assembly drawings with sufficient details of the structure;

c) AE test information: intended date and expected conditions such as stock product, temperature, filling height, sludge level, water bottom;

d) Potential external and internal noise interference sources.

5.6 Written instruction requirements

The AE test organisation shall provide a written test instruction, which shall include but not necessarily be restricted to the following:

a) explicit indication of the purpose of the test and limitations if any;

b) sensor type, frequency and manufacturer;

c) method of sensor attachment;

d) type of acoustic couplant used;

e) type of surface preparation;

f) type of AE equipment used with the main characteristics;

g) energy measurement method to be used;

h) number of sensors required and the sensor arrangement;

i) description of equipment verification procedure;

j) description of in-situ verification;

k) description of test performance;

l) recorded data and recording method;

m) available on-line presentation of data;

n) cluster parameters (e.g. shape, size, minimum number of located events);

o) post-test analysis procedure;

p) final report requirements;

q) qualification/certification of the personnel.

The test instruction shall be prepared in accordance with EN 473 and EN 13554.

6 Instrumentation

An AE system consists of sensors and equipment for signal conditioning and processing and for displaying and recording data according to EN 13477-1.

The AE instrument shall be capable of measuring at least the following parameters on every channel:

a) AE burst count;

b) appropriate parameter indicating the background noise;

c) burst signal peak amplitude;

d) burst signal duration;

e) burst signal rise time;

f) burst signal energy;

g) arrival time.

In addition to the acquired burst signal parameters, waveform data of each detected hit on any available AE channel enables evaluation by signal frequency analysis.

The test instrumentation shall:

h) store all the acquired data; and

i) provide an on-line location display

for preliminary on-site reporting on the performed test.

The AE system performance check (including sensors) shall be performed according to EN 13477-2.

7 Testing

7.1 Sensor positions

For use of wave propagation through liquid, e.g. testing flat bottomed storage tanks (FBST), the following applies:

The number of sensors necessary for a certain tank diameter is derived from the requirement, that the distance between the sensors distributed equally around the circumference shall not exceed 15 m. Due to the fact that manholes, nozzles, welds and other structural details have to be taken into account when selecting the sensor positions, a reduced maximum distance of 13 m has proven to be applicable. With this value it is possible to shift positions as required by the structure and to stay within the limit of 15 m. The number of sensors applied shall not be less than six per row.

The distance of a sensor to a weld or a reinforcing plate shall not be less than 200 mm.

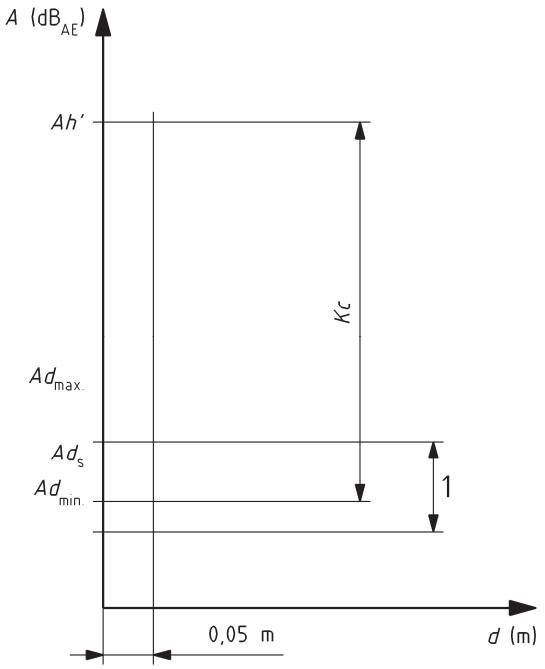
The first row of sensors shall be set at a level of approximately 1 m above the bottom. The second row of sensors is usually set at a level of 4 m to 6 m with positions directly above the first row sensors but more than 1 m below the liquid level. With this sensor arrangement it is possible to identify AE sources located at higher positions (corrosion of floating roof, drops of condensed product from fixed roof onto the surface of the liquid, etc.) and exclude these AE sources from the floor evaluation.

If the sludge level of the tank affects the wave propagation significantly, then both levels of the sensor rows may be raised to decrease the wave propagation path within the sludge. This shall be agreed by the tank operator because the location error might be larger in such a case.

7.2 Test detection threshold

The test instruction shall specify a standard detection threshold Ad_s, a maximum detection threshold Ad_{max} and a Hsu-Nielsen reference factor K_C.

K_C, a value in decibels (dB), added to Ad_s in dB_{AE}, defines the minimum peak amplitude Ah' a Hsu-Nielsen source at 0,05 m from centre of sensor shall produce. The test detection threshold Ad_T will normally be lower than or equal to Ad_s. The minimum detection threshold Ad_{min} is characterised by the first occurrence of significant event overlap. If Ad_{min} is greater than Ad_s, Ad_T may be increased up to Ad_{max}. The actual value of Ad_T shall be taken into account for data evaluation. The test organisation shall provide evidence that the given range of test detection threshold together with all instrumentation and test settings is capable of detecting active corrosion under test conditions. Figure 1 shows how the above defined parameters establish the range of test detection threshold.



Keys

1	range of A_T
Ah'	minimum peak amplitude response to a Hsu-Nielsen source at 0,05 m from centre of sensor,
Ad_s	standard detection threshold,
Kc	Hsu-Nielsen reference factor,
Ad_{max} , Ad_{min}	maximum, minimum test detection threshold

Figure 1 — Range of test detection threshold A_T

7.3 Background noise

After proper mounting of the necessary sensors according to 5.3 and 7.1, the background noise level of the tank shall be monitored for every channel. The test detection threshold shall ensure that AE burst data is collected during the testing time, as free as possible from extraneous noise. If noise interference is indicated, appropriate measures shall be taken in order to identify and eliminate noise sources. If a test detection threshold greater than Ad_{max} would be required, the test shall be suspended. If noise sources can be identified and eliminated then the test may continue, in all other cases the tank shall be regarded as not to be tested.

7.4 In-situ verification

Prior to the test, the correct functioning of all sensors and instrumentation shall be checked using a Hsu-Nielsen source at a distance of 0,05 m from centre of each sensor.

If the Hsu-Nielsen source leads to saturation of the measuring chain, then appropriate measures shall be taken (e.g. using an attenuating element).

Results shall be recorded together with sensor serial number and position. The average peak amplitude of four signals from any sensor shall be equal or above Ah', calculated according to Equation (1), and within $\pm$ 3 dB of the average of all sensors.

$$Ah' = Ad_s + K_C \quad (1)$$

where

Ah' is the minimum peak amplitude of the Hsu-Nielsen source at a distance of 0,05m from centre of sensor;

Ad_s is the standard detection threshold;

K_C is the Hsu-Nielsen reference factor.

Table 1 — Example for values of the necessary parameters defined in the written test instruction or obtained by calculation.

Parameter	Value	Remark
K_C	65 dB	Test instruction
Ad_s	30 dB_{AE}	Test instruction
Ad_{max}	42 dB_{AE}	Test instruction
Ah'	95 dB_{AE}	Equation (1)
Ad_{min}	24 dB_{AE}	Test object

Since high sensitivity is essential for the test, care shall be taken to ensure proper sensor coupling to the structure.

7.5 Apparent acoustic emission velocity

The apparent acoustic emission velocity for each of the used location algorithms shall be calculated. Time of flight measurements of a wave generated by a Hsu-Nielsen source or a pulser between two sensors, together with the distance between these sensors, are suited to derive the apparent acoustic emission velocity in the liquid stock product or the metallic shell.

7.6 Performing the test

The time of test shall be chosen with respect to internal and external noise sources in order to minimise their effect on the test result. The ideal ambient conditions are: no rain, no wind and no direct sunlight. It may be necessary to perform the test during night time.

A minimum of one hour of data acquisition under suitable conditions is necessary for test evaluation. If signal waveforms are acquired additionally, then these data shall cover at least 30 min. During the test the background noise shall be monitored. Periods of obvious noise interference shall be marked and excluded from evaluation and consequently a sufficient period of time shall be added to the test duration.

Several periods of data acquisitions of one hour each in general improve the data base used to evaluate the test.

8 Interpretation of results

8.1 Data evaluation

During data evaluation care shallbe taken that acquired random noise does not influence the result.

AE events shall be identified by analysing the arrival time differences of the detected hits. With the help of the apparent acoustic emission velocity the position of each found locatable AE event shall be calculated. Located AE events close to each other are regarded as a single cluster and represent an AE source.

In case of tank floor evaluation, the second row sensors are used as guard-sensors, therefore AE sources located at higher positions are rejected.

8.2 Tank grading

The activity of the found sources (number of AE events per one hour within the reference area of the cluster) and the general AE activity of the structure shall be used for obtaining the test grading.

The applied grading system shall cover the range from "no AE source found" to "severe AE source found" and shall address intermediate conditions according to AE source activity. In the case where no AE sources are detected, the maximum service period shall be recommended. If severe AE sources are found, the opening of the tank for inside inspection in order to clarify the AE indications shall be recommended.

9 Documentation

The final report should include the following:

a) test instruction and revision number;

b) name(s) of test operator(s);

c) date and place of the test site;

d) type of AE instrumentation;

e) description of the tank;

f) number of sensors and locations;

g) test detection threshold;

h) stock product and level;

i) scope of test;

j) maps of the structure showing the AE sources identified during the test;

k) description of the AE sources;

l) tank grading;

m) recommendation for the duration of the following service period obtained from the tank grading.

The report should be in accordance with EN ISO 17025.

10 Safety regulations

The testing team shall obey strictly the safety regulations implemented by the tank operator. Among others this concerns the personal safety equipment, the requirements on the testing equipment and the working permission. The measures that have to be taken before entering the tank yard or the tank roof shall be clarified by the tank operator. Manipulations on tank installations are restricted to personnel of the tank operator only.

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Headquarters 389
Chiswick High Road,
London, W4 4AL, UK
Tel +44 (0)20 8996 9001
Fax +44 (0)20 8996 7001
www.bsigroup.com/
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