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Non-destructive testing — Acoustic emission testing — Detection of corrosion at atmospheric and low-pressure metallic storage tank floors

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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 document 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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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 atmospheric metal storage tanks have been gaining wider usage alongside marked improvement of acoustic emission testing technologies. The effectiveness of any application of acoustic emission testing depends upon proper and correct use of the acoustic emission instruments and test techniques.

In addition, existing international acoustic emission standards lack a specification of a classification system with the associated recommendations for maintenance.

The purpose of this document is to provide requirements for the testing equipment, testing procedures and classification system for acoustic emission testing for corrosion of atmospheric metal storage tank floors.

Non-destructive testing — Acoustic emission testing — Detection of corrosion at atmospheric and low-pressure metallic storage tank floors

1 Scope

This document describes the testing methodology based on acoustic emission (AE) for atmospheric and low-pressure (less than or equal to 50 kPa on top of the tank) metallic storage tank floors and the classification system to be used for test results.

This document applies to acoustic emission testing (AT) for corrosion severity of atmospheric metal storage tank floors.

The technique is limited to tank floors made of construction steel and relies on an active corrosion process. It applies only in cases where corrosion of the floor is the governing damage mechanism. Good results will be obtained providing corrosion conditions have not changed.

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

EN 13477-2, *Non-destructive testing — Acoustic emission testing — Equipment characterisation — Part 2: Verification of operating characteristic*

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 terminology databases for use in standardization at the following addresses:

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

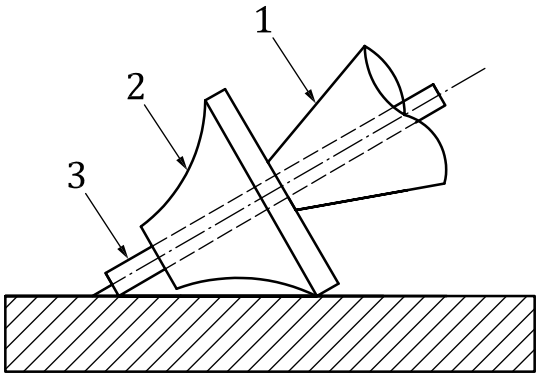
— IEC Electropedia: available at https://www.electropedia.org/

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

[SOURCE: EN 1330-9:2017, 2.5.1]

3.2
Hsu-Nielsen source
device to simulate an acoustic emission event using the fracture of a brittle graphite lead in a suitable fitting

Note 1 to entry: Hue-Nielsen source is according to Figure 1.



Key

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

Figure 1 — Hsu-Nielsen source

4 General principles

During the operation of atmospheric metallic storage tanks, the tank floor is potentially subjected to a corrosive environment and due to the ongoing corrosion process AE waves are generated.

Elastic waves are generated by AE events from the corrosion process itself or peeling and cracking of corrosion products on the tank floor and are transmitted to the surface of the tank wall predominantly through the storage medium.

The purpose of AT of storage tank floors is to detect the AE signals related to the corrosion process with AE sensors mounted in the lower part of the tank wall.

By receiving and analysing these signals, the severity of the tank floor corrosion condition can be determined and assessed.

5 Qualification of test personnel

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 Test equipment

6.1 Acoustic emission testing system

An AT system consists of an AE instrument including software, AE sensors, preamplifiers, interconnecting cables and mounting devices holding the sensors.

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

6.2 Acoustic emission sensors

The requirements for AE sensors are as follows:

a) The main response frequency of the sensors shall be between 20 kHz and 80 kHz.

b) The minimum sensitivity shall be equivalent to or greater than 60 dB referred to 1 Vs/m in surface wave sound field setting or in longitudinal wave setting.

c) Sensors shall be shielded against radio frequency and electromagnetic noise interference by proper shielding practice or by differential element design, or both.

d) The metallic housing of each AE sensor shall be electrically isolated from the metallic test object.

e) 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.

f) To get sufficient sensitivity, a Hsu-Nielsen source at a distance of 100 mm from the sensor shall generate a peak amplitude of at least 80 dB_{AE}.

g) The verification of the sensors shall be performed according to sensor-specific manuals provided by the manufacturer.

6.3 Acoustic emission signal cables

The requirements for AE signal cables used to connect AE sensors and preamplifiers are as follows:

a) Signal cables connecting sensors and preamplifiers shall be shielded against electromagnetic interference.

b) Cable length shall not exceed 1 m, unless the length-depending signal loss is considered and acceptable.

This requirement may be omitted where the preamplifier is integrated in the shielded sensor housing.

6.4 Couplant

The used couplant shall provide an effective coupling quality so that the sensor tracks the motion of the surface.

6.5 Preamplifiers

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

The requirements for preamplifiers 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 sensitivity changes greater than 3 dB over this range.

c) The preamplifiers response frequency shall match that of the sensors, and the gain of the preamplifiers, usually 34 dB, 40 dB or 46 dB, shall not cause saturation of the measurement chain.

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 requirements for power-signal cables providing power to the preamplifier and conducting the amplified signal to the main processor are as follows:

a) The cables shall be shielded against electromagnetic noise.

b) Signal loss shall be no more than 1 dB per 30 m of cable length. 150 m is the recommended maximum cable length to avoid excessive signal attenuation.

c) The signal loss of cables depends on type of cable, frequency and length. 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.

6.7 Filters

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

6.8 Acoustic emission instrument

The requirements for the AE instrument 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 not be less than 10 times the sensors' centre response frequency.

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

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

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

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

h) The measurement inaccuracy for the external parametric inputs, such as pressure, liquid level and temperature, shall not exceed 2 % of the full range.

i) The resolution of rise time, duration and arrival time for each channel shall be less than or equal to 1 µs.

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

k) The electronic noise levels shall be equal to or less than 20 dB_{AE} in the frequency range from 20 kHz to 80 kHz.

l) The usable dynamic range shall be at least 65 dB.

m) The AE instrument shall be capable of processing, storing and displaying at least 20 hits per second at all channels.

n) The delay and display from the arrival of the AE hits shall not exceed 10 seconds.

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

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

q) A warning shall occur when the storage space runs low.

r) During data acquisition, AE software shall be capable of displaying the following diagrams:

   1) any AE parameter versus time;

   2) one AE parameter versus another AE parameter;

   3) tank floor circular planar locations.

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

6.9 Maintenance and verification of test equipment

The performance of the AT system shall be verified at specified intervals in accordance with EN 13477-2.

7 Actions before testing

7.1 General information

Prior to the specification of the test, the following information shall be provided:

a) the purpose of the test;

b) details of the storage tank to be tested;

c) the requirements for surface preparation;

d) the acceptance criteria, if specified;

e) the requirements in relation to the test report;

f) details of the qualification of test personnel.

7.2 Documents

Before performing an AE test, the following documents shall be provided for the storage tank to be tested, as a minimum:

a) design and fabricating documents of the storage tank, e.g. product certification, quality certification document, as-built drawing;

b) operation recording documents of the storage tank, e.g. type of liquid, the normal product and number of years with this product, the highest level of liquid, range of operating temperature and abnormal conditions;

c) previous test reports;

d) other documents, e.g. drawings and records showing repairs or modifications.

7.3 Site inspection

Prior to testing, a site inspection shall be carried out to find all interference factors, such as mechanical impact, electromagnetic interference and vibration.

The interference of these factors shall be eliminated or sufficiently reduced during on-site AT.

7.4 Preparation of test instruction and record sheet

The test instruction (see 10.2) and record sheets (see 10.3) shall be prepared in accordance with the NDT procedure, storage tank and site conditions.

The instrument, applicable sensors and surface conditions of the storage tank shall be specified.

7.5 Sensor mounting

The first row of sensors is placed on the tank wall near to the tank floor, and it shall be ensured that they are above the height of the sediment in the tank. Thick layers of sediment affect the sensitivity of AT.

A second row of sensors (guard sensors) shall be mounted when noise from higher up in the tank (e.g. condensation) can be expected.

The second row of sensors shall be below the liquid level, usually at about 3 m height above the first row.

The sensors of each row shall be mounted at the same height.

Care shall be taken that the sensitivity of the sensors is similar.

The maximum spacing of adjacent sensors shall not exceed 15 m.

If there are manholes, nozzles and welded structures between two adjacent sensors, the maximum spacing shall not exceed 13 m.

It is recommended that six to eight sensors are installed per row for a tank with a diameter of less than 25 m.

All the sensors shall be numbered and indicated in the schematic diagram of the tank.

The mounting of sensors shall meet the following requirements:

a) The sensors shall be installed according to the specified sensor array.

b) The place for the mounting of a sensor on the tank shall be smooth and showing the metallic lustre. The coating can be kept when it is smooth and compacted and measured attenuation is acceptable.

b) Efficient couplants, such as vacuum grease or vaseline, are recommended.

d) Firm fixing of the sensors onto the tank shall be performed by a magnetic holding device, adhesive tape or other devices and mounting materials that provide equivalent sensor adhesion over the test duration.

e) For tanks with interlayer or insulation, removal of insulation or interlayer material at sensor position to allow sensor mounting directly onto the tank surface is the preferred solution.

f) AE waveguides (rods) may be used when feasible for the intended purpose of the test.

7.6 Setting of the acoustic emission instrument

7.6.1 First steps

Connect the sensors and preamplifiers with the corresponding channel input of the AT system by cables, turn on the AE instrument and wait until the instrument is in proper working condition.

Roughly set the instrument and then complete the set-up of the AT system by performing the steps in 7.6.2 to 7.6.4.

7.6.2 Simulation of acoustic emission sources

Simulated AE sources are used to determine the sensitivity of each channel.

The requirements and recommendations for simulated AE sources are as follows:

a) They should be capable of producing a transient elastic wave having a peak amplitude representative of the AE signals.

b) Using a Hsu-Nielsen source is recommended. An electronically induced event or equivalent may be used.

c) The detected peak amplitude of the simulated event shall be at a fixed distance from the sensor, typically 100 mm ± 5 mm, and the responsive value shall be the average of more than three events.

7.6.3 Determination of sound velocity

The sound velocity of the medium in the tank shall be measured for computed time-difference location methods.

If the sound velocity of this medium has been obtained before, it can be set directly.

The sound velocity setting can also directly use the velocity of sound propagation of the medium in the tank.

Table 1 shows the sound velocity of common media in atmospheric storage tanks at room temperature.

Table 1 — Sound velocity of common media in atmospheric storage tanks

Serial number	Storage medium	Sound velocity at room temperature m/s
1	Crude oil	1 290
2	Water	1 500
3	Gasoline	1 250
4	Diesel	1 250
5	Lubricating oil	1 530

7.6.4 Background noise

The given background noise at the test site limits the sensitivity of the test. A high background noise level requires to raise the threshold of the AT system. Thus, a high background noise induces a low test sensitivity.

If the background noise is close to or larger than the AE signals caused by the corrosion of the tank floor, the background noise shall be reduced sufficiently. Otherwise, it is not meaningful to perform AT.

Common sources of background noise include friction (e.g. between floating roof and tank wall), collision (e.g. between loose tank accessory and tank wall), vibration (e.g. of pipes in operation at or close to the tank), leakage at pipe or hose connections, leakage of the tank wall or the tank floor or the gate valves, heaters or mixers in operation, movement of mechanical liquid level indicators or other components inside the tank, bubbles (e.g. due to degassing of the storage product), internal condensation (e.g. of warm gas phase at cold fixed tank roof), precipitation, hail, wind, direct sunlight leading to thermal expansion, electromagnetic interference (EMI) or radio frequency interference (RFI).

7.6.5 Sensitivity check and threshold

The requirements for the sensitivity check are as follows:

a) The sensitivity check for all channels shall be done before and after the test.

b) The average peak amplitude of any sensor shall be within ± 3 dB of the average of all sensors.

c) The threshold of the AT system shall be set to a quantity within the acceptable range.

Setting the threshold to the lower limit of the acceptable range results in the maximum allowable hit rate $\dot{N}_h$, which is defined by Formula (1).

$$\dot{N}_h = \frac{v}{d} \tag{1}$$

where

$\dot{N}_h$ is maximum allowable hit rate (hits/s);

v is sound velocity of the given storage product (m/s);

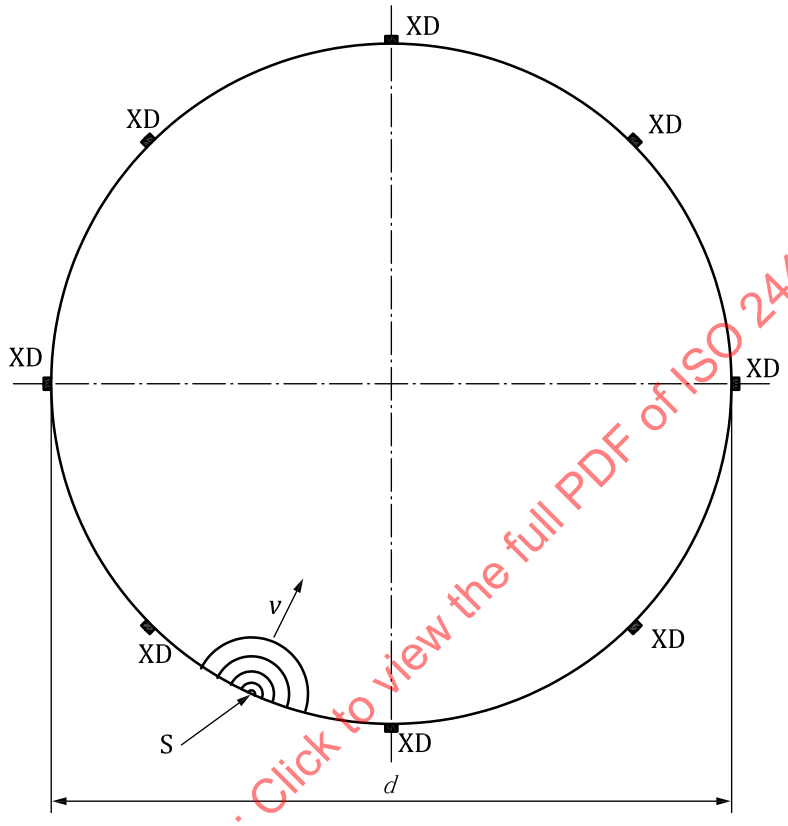
d is diameter of the tank (m).

The maximum allowable hit rate is the inverse of the time period needed for a sound wave pulse emitted at the edge of the tank floor to travel the distance of a tank diameter through the liquid storage product from one side of the tank to the opposite side, as illustrated in Figure 2.

As an example, the maximum allowable hit rate results in 60 hits/s with a tank diameter of 25 m and sound velocity of 1 500 m/s.

It is advisable that the actual hit rate on each channel does not exceed 10 % of the maximum allowable hit rate. This ensures that the series of AE signals related to one AE event is well separated from the next series of AE signals related to the AE event right after the previous one.

Setting the detection threshold just above the upper limit of the acceptable range results in an invalid test, where the detectability for the considered corrosion phenomenon is not met.



Key

d diameter of the tank
v sound velocity of the liquid storage product
S AE source at the tank floor near the tank wall
XD AE sensor at the cylindrical tank wall

Figure 2 — Top view on a tank floor with 8 sensors mounted onto the tank wall for each sensor row

8 Performing the test

8.1 Storage tank liquid level and condition

The requirements for storage tank liquid level and tank condition are as follows:

a) During the test the product in the tank shall be the operating product.

b) The inlet and outlet valves and other sources of interference, such as agitators and heating facilities, shall be closed.

c) The liquid level shall be at least 1 m above the level of the second row (guard) sensors. The maximum filling level is recommended.

d) Before the test, the liquid level shall be kept stable for at least 6 h for small unheated tanks, 12 h for unheated tanks located in field or production sites, 24 h for crude oil and/or heated tanks and 12 h for all other tanks.

8.2 Interfering acoustic emission sources

Interfering AE sources such as those listed in 7.6.4 can be encountered during the test and can affect the test results.

The AT shall be suspended when large signals are detected from those sources. The testing can be continued when those signals have been investigated and excluded.

8.3 Data acquisition and observations during acoustic emission testing

The requirements for data acquisition and observations during AT are as follows:

a) The data acquisition shall include the parameters given in 6.8 b).

b) The arrival times of signals shall be collected when using source location based on the time difference between channels.

c) The trend of the AE hits and/or AE events versus time shall be observed during the test.

d) For an area bristling with located AE events, check whether there is external interference.

e) A minimum of 1 h of data acquisition under suitable conditions is required.

f) If signal waveforms need to be acquired additionally, then this data acquisition shall cover at least 30 min.

g) During the test the background noise shall be monitored. Periods of obvious noise interference shall be marked.

9 Interpretation of test results

9.1 General requirements

The general requirements for the interpretation of test results are as follows:

a) On completion of the test, the test results shall be documented in a test report.

b) A schematic of the positions of the identified AE sources at the tested tank floor shall be drawn.

c) Classification for the corrosion status and recommendations for maintenance shall be done using a system as given in 9.3.

d) Established procedures shall be used, including the sensitivity levels and acceptance criteria for the classification.

9.2 Data processing

The requirements for data processing are as follows:

a) The noise observed during the AT shall be determined and excluded from the evaluation.

b) Using software filters or graphic data display analysis methods, the AE signals with non-correlated corrosion shall be separated from relevant AE signals and indicated in the test record.

c) If waveform acquisition is used, waveform analysis methods, such as frequency spectrum and wavelet analysis, can be used to identify corrosion and noise signals and further remove noise signals.

9.3 Classification system for the corrosion status and recommendations for maintenance

The assessment of the tank floor is based on the activity and the localization of the corrosion sources.

The corrosion class is assessed by four different classes, as shown in Table 2.

The recommended maintenance and the time period until the next AT are also given in Table 2, based on the risk management and safety assurance of the tank during operation.

a) For corrosion class IV, the user is advised to open the tank for immediate maintenance or use other methods to assess the risk of continuing operation without maintenance.

b) For corrosion class III, the user is advised to prioritize maintenance or perform the next AT within 12 months.

c) For corrosion class II, the user is advised to consider maintenance or perform the next AT within 36 months.

d) For corrosion class I, no maintenance is advised but the next AT should be performed within 60 months.

Table 2 — Classification system for corrosion status of the tank floor

Corrosion class	Definition	Corrosion status	Recommendations for maintenance	Time to next AT without maintenance months
I	No significant activity	No corrosion	No maintenance advised	60
II	Weak active tank floor	Questionable	Consider maintenance	36
III	Active tank floor	Serious	Priority maintenance	12
IV	Very active tank floor	Critical	Top priority maintenance	—

The testing organization applying the classification method is responsible for meeting the classification system described in Table 2.

Annex A describes the classification method based on time-difference location analysis and gives an example. Annex B describes the classification method based on overall floor condition analysis and gives an example.

10 Documentation

10.1 General

The documentation consists of the written test instruction, the test records and the test report.

10.2 Written test instruction

The organization performing the AT shall prepare the written test instruction on the basis of the respective NDT procedure.

The NDT procedure for the application and the use of AT for atmospheric and low-pressure metallic storage tank floors shall be according to the following:

— this document, i.e. ISO 24489:2024;

— product standards;

— specifications;

— codes of practice.

The written test instruction shall be derived from these documents and shall describe all the essential parameters as well as the precautions to be observed.

The following shall be included in the written test instruction:

a) the purpose of the test;

b) a description of the storage tank to be tested, including geometry and dimensions, materials, design and operating parameters;

c) the application documents;

d) details of the qualification of the test personnel;

e) the AT equipment, including the AE instrument, sensors, preamplifiers and cables;

f) the testing software used;

g) details of surface preparation;

h) a description of the test and the sequence of the steps when performing the test;

i) the arrangement of the sensors, the mounting method and the type of couplant;

j) determination of the background noise, the sensitivity of sensors and sound velocity;

k) the testing process, data analysis and interpretation;

l) the verification intervals for the AE instrument and the sensors;

m) the evaluation of test results;

n) other information to be included in the test report;

o) dated signature of preparing, reviewing and approving personnel.

10.3 Test records

The requirements for test records are as follows:

a) The test records shall include at least the contents given in 10.4.

b) The test records and the AT data shall be stored for a minimum of 60 months.

10.4 Test report

The requirements for the test report are as follows:

a) The format of the test report shall be agreed at the time of enquiry and order.

b) The test report shall contain sufficient information to enable the test to be repeated at a future date.

c) At least the following shall be included:

   1) date and place of the test;

   2) information about the metallic storage tank, including name, serial number, manufacturer, temperature, medium, maximum level of liquid, material, nominal wall thickness and geometry;

   3) level of liquid during AT;

   4) a reference to this document, i.e. ISO 24489:2024;

   5) the written test instruction;

6) identification of the AE test system, in particular all details necessary for the complete identification of the type of instrument used;

7) type of sensors used, the arrangement of the sensors, the mounting method and the type of couplant;

8) instrument settings used;

9) artificial AE source used as reference;

10) results of the test;

11) any deviation from the test instruction;

12) organization responsible for performing the test;

13) name and qualification of the person who performed the test;

14) dated signature of the person who performed the test or the name and signature of another authorized person.

Annex A
(informative)

Classification method based on time-difference location analysis and an example

A.1 Classification method based on time-difference location analysis

A square or circular location cluster is defined as the assessment area by the length or diameter of maximum 10 % of the tank floor diameter.

Recommendations for time-difference location analysis and classification of AE sources are as follows:

a) The analysis of all location clusters within the tank floor should be performed and the number of AE events generated per hour from those location clusters should be calculated.

b) According to the time-difference location results, the AE source levels of each location cluster should be classified and evaluated based on a classification system covering the range from "few AE events detected" to "huge number of AE events detected", as shown in Table A.1.

c) According to the evaluation results of AE events in the location cluster area, the corrosion class of the tank floor in the assessment area should be classified and evaluated from class I to class IV, as shown in Table A.1.

Table A.1 — Evaluation and classification of AE sources based on the time-difference location analysis

AE source level	Number of located events per hour in the assessed area E	Evaluation of AE events in location cluster area	Evaluation of corrosion class of the tank floor in the assessment area
I	$E \leq a$	Few	I
II	$a < E \leq b$	Medium	II
III	$b < E \leq c$	Large	III
IV	$E > c$	Huge	IV

The values of a, b and c in Table A.1 should be obtained by AT and verification on a series of storage tanks with the same specifications and operating conditions. The AT results should be verified by opening the tank, performing other non-destructive testing (NDT) or by cutting severely-corroded parts of the tank floor and inspecting the parts by visual testing (VT) or other methods.

A.2 Example for the tank floor classification of a 50 000 m^3 storage tank

A.2.1 50 000 m^3 storage tank

The storage tank is a heated crude oil floating roof tank with diameter 60,16 m and height 19,53 m. It has been operated for 20 years.

A.2.2 Test equipment and mounting of sensor array

Fourteen AE sensors were evenly mounted on the wall of the tank about 0,3 m above the tank bottom.

The maximum height of the solid deposits in the tank was 0,1 m.

The sensors have built-in preamplifiers, magnetic holder and the 30 kHz centre frequency.

The used couplant was vacuum grease.

The liquid level was 52 % of maximum level.

The inlet and outlet valves and heating facilities were closed 24 hours before the test.

A.2.3 Data acquisition and processing

The determined background noise was 40 dB_{AE}.

The acquisition threshold was set to 46 dB_{AE}.

The data acquisition lasted for 2 hours.

Figure A.1 shows the representation of the time-difference based AE source location.

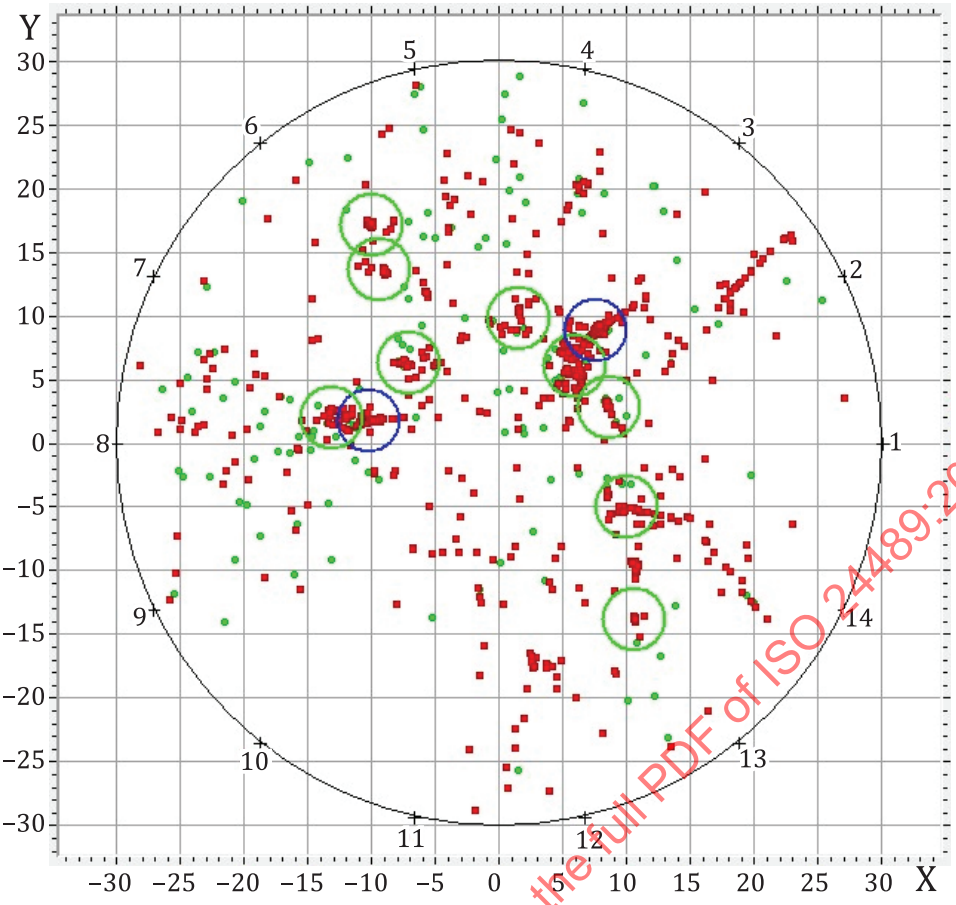
Figure A.2 shows the distribution of AE hits in each channel.

Sensor no. 6 was located near the six nozzles of the heating coils with valves. Since one valve cannot be completely closed, occasionally an AE signal caused by a water hammer was generated.

A.2.4 Acoustic emission testing results evaluated by time-difference location analysis

The AT results evaluated by time-difference location analysis are shown in Figure A.1.

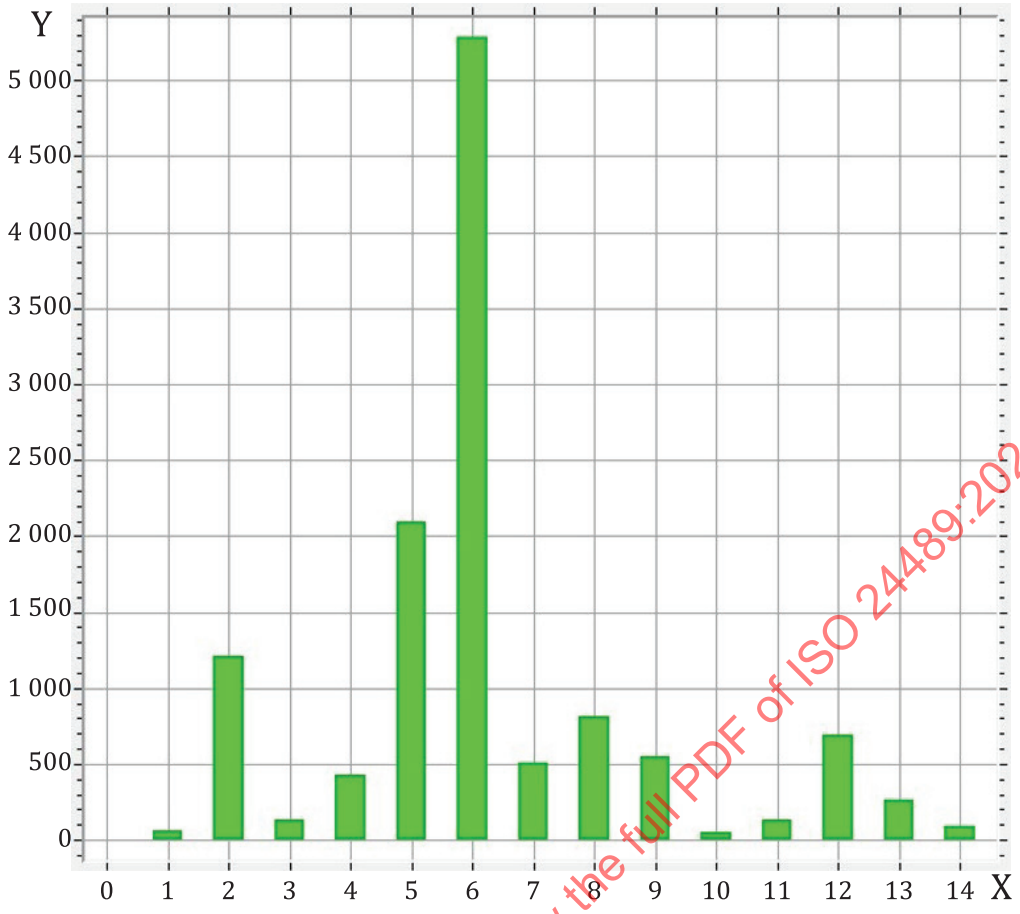
The *a, b* and *c* values based on the time-difference source location and the evaluation results are shown in Table A.1.



Key

X	Loc.[m]
Y	Loc.[m]
●	D[μs] < 1 000,0
■	D[μs] > = 1 000,0
○	≥ 20
○	≥ 100

Figure A.1 — AE location sources of tank floor



Key

X channel
Y hits
no filter

Figure A.2 — Distribution of AE hits

A.2.5 Evaluation of corrosion status and recommendations for maintenance

According to Table A.2, the corrosion class of the tank is determined to be class III comprehensively and it is recommended that priority maintenance is performed.

Table A.2 — Evaluation of AT results by time-difference location

AE source level	Number of located events per hour in the assessed area E	Number of AE location clusters detected	Evaluation of corrosion class of the tank floor in the assessment area
I	$E \leq 10$	Area except level II, III and IV	I
II	$10 < E \leq 50$	9	II
III	$50 < E \leq 300$	2	III
IV	$E > 300$	0	IV

NOTE 1 The source area is circular and its diameter is 8 % of the tank diameter.

NOTE 2 According to the AT results of 36 atmospheric storage tanks with a volume greater than or equal to 50 000 m^3, the magnetic flux leakage testing results of the bottom plate after opening the tank and the plate cutting verification of the severely corroded parts, the values of a, b and c are determined to be 10, 50 and 300, respectively.

If the storage tank users do not want to perform maintenance at that time, the AT may be carried out again in 12 months to determine the corrosion development status of the storage tank, see Table A.3.

Table A.3 — Recommendations for maintenance and next AT

Corrosion class	Corrosion status	Recommendations for maintenance	Time to next AT without maintenance months
III	Serious corrosion	Priority maintenance	12

Annex B
(informative)

Classification method based on overall floor condition analysis and an example

B.1 Classification method based on overall floor condition analysis

B.1.1 General

This method for determining the corrosion status first evaluates the overall floor condition. This overall class is then adjusted by evaluation of potential local damage concentrations using Δt-location clusters. The adjusted class defines the corrosion class.

The limits between classes should be obtained empirically by AT on large numbers of tanks followed by internal inspection to relate the corrosion damage to the classes.

The written instruction should define the limits between the classes for both the overall condition classes and the potential local damage classes.

B.1.2 Overall floor condition evaluation

The basis for the overall class should be the total number of hits of all channels from floor corrosion. This number is obtained after filtering the data and after removal of the top row data.

This number should then be normalized to:

a) one-hour test data, adjusted for the time taken out in the filtering process;

b) a standard number of channels;

c) a target evaluation threshold.

The standard number of channels and target evaluation threshold should be defined in the written instruction.

The normalized number of hits determines the overall floor condition class, as in Table B.1.

Table B.1 — Evaluation and classification of AE sources based on overall floor condition analysis

AE source level	Normalized number of hits H	Evaluation of AE source	Evaluation of corrosion status of the tank floor
A	$H \leq$ d	None or minor	No corrosion
B	d < $H \leq$ e	Few	Slight corrosion
C	e < $H \leq$ f	Medium	Medium corrosion
D	f < $H \leq$ g	Large	Serious corrosion
E	$H >$ g	Huge	Critical corrosion

The values of d, e, f and g in Table B.1 should be obtained by AT and independent verification on a series of storage tanks with the same specifications and operating conditions. The AT results should be verified by opening the tank, performing other NDT or cutting severely-corroded parts of the tank floor and testing the parts visually (VT) or by other methods.