Acoustic emission testing of corrosion at atmospheric and low pressure metallic storage tank floors

1. Scope

This document (according to ISO 24489 standard) 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 (AET) 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. General Principle

The proposed AE testing is intended to provide a non-intrusive screening assessment of active acoustic emission sources associated with tank bottom corrosion, leakage activity, or other structurally active sources detectable during the test period.

AE testing is a global monitoring method. It does not directly measure remaining wall thickness and does not replace follow-up local NDT such as UT thickness measurement, MFL floor scanning, vacuum box testing, or API 653 internal inspection where required. AE indications should be used to prioritize further inspection and maintenance decisions.

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.

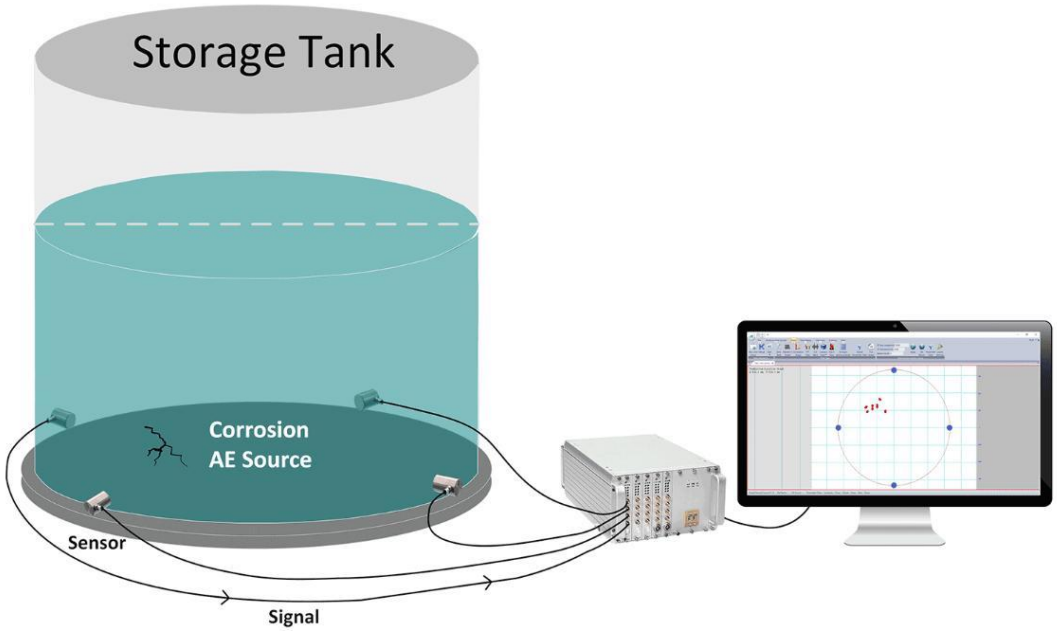
3. Applicable Standards and References

The work will be performed with reference to the following standards and documents, as applicable:

- ISO 24489:2024 — Non-destructive testing — Acoustic emission testing — Detection of corrosion at atmospheric and low-pressure metallic storage tank floors
- ASTM E1930/E1930M-17 — Standard Practice for Examination of Liquid-Filled Atmospheric and Low-Pressure Metal Storage Tanks Using Acoustic Emission

- ASTM E1316 — Standard Terminology for Nondestructive Examinations
- ASTM E650 — Standard Guide for Mounting Piezoelectric Acoustic Emission Sensors
- ASTM E2374 — Standard Guide for Acoustic Emission System Performance Verification
- ISO 12716 — Non-destructive testing — Acoustic emission inspection — Vocabulary
- EN 13477-2 — Acoustic emission testing equipment characterization / verification, where applicable
- Client site HSE rules, permit-to-work procedures, and hazardous area requirements

4. Test Methodology



4.1. Sensor Arrangement

A row of sensors is placed on the tank wall near to the tank bottom. The final number and position of sensors may be adjusted after review of tank geometry, site accessibility, noise conditions, and the applicable test procedure.

The sensors of the row shall be mounted at the same height, about 0.1m~0.5m above the bottom. It shall be ensured that they are above the height of the sediment in the tank.

Thick layers of sediment affect the sensitivity of AET.

If there are manholes, nozzles and welded structures between two adjacent sensors, the maximum spacing shall not exceed 13 m. But we recommend the sensor spacing doesn't exceed 11m. It is highly suggested to do the attenuation test on site to confirm the attenuation distance and then to decide the final sensor spacing.

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

If the tank is made of metal, the magnetic sensor holder can be used to hold the sensor fixed and tight on the tank wall.

4.2. Before Installation

For storage tanks with insulation layers or double tank layers, a hole can be drilled in the insulation or outer tank layer where the acoustic emission sensor is installed, so that the acoustic emission sensor can directly contact the surface of the inner storage tank wall.

The tank wall surface in contact with the sensor should be clean and free of impurities to ensure good coupling. Paint or coatings, geometric discontinuities, or surface roughness on the tank wall surface can cause acoustic emission signal loss and should be removed before installation.

4.3. Testing Procedures

Installation and system connection -> sensitivity test -> background noise test -> attenuation test -> velocity test -> simulation/source calibration test -> official testing -> possible second sensitivity test for verification.

4.4. Data Acquisition

AE data will be recorded while the tank is under stable liquid level and stable operating conditions. During the test period, the following should be avoided as much as possible:

- Product transfer in or out of the tank
- Operation of nearby high-noise pumps or mechanical equipment
- Hammering, grinding, welding, scaffolding work, or other mechanical impacts
- Heavy rain, strong wind, or other abnormal environmental noise
- Movement of vehicles or heavy equipment close to the tank

The recommended AE monitoring time is typically 2–4 hours of stable acquisition per tank, subject to actual noise condition and test procedure requirements.

4.5. Data Analysis

The analysis will include:

- AE hit/event activity
- Amplitude, energy, counts, duration, and frequency-related parameters
- Source location results
- Identification of concentrated AE source areas
- Assessment of noise versus relevant AE activity
- Classification of tank bottom AE activity level
- Recommendations for follow-up inspection, if required

5. Product Introduction

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

5.1. Acoustic Emission Sensor

In the ISO 24489 standard, the main response frequency of the sensors shall be between 20 kHz and 80 kHz. So we recommend the GI40 sensor, frequency range of 15kHz to 70kHz, resonant at 40kHz, built-in 40dB 28V preamp.
(https://aendt.com/acoustic/products/Sensors/IntegralPreamplifierSensors/2022/1122/116.html)

If you have requirements of explosion-proof, or water-proof, or high temperature or other special requirements, please let us know and choose other suitable sensors.

5.2. Couplant

Couplant is required to use in between the sensor and the surface to be measured. The used couplant shall provide an effective coupling quality so that the sensor tracks the motion of the surface.

Common couplant for acoustic emission testing can be vacuum grease, Vaseline, butter, quick-drying glue and other ultrasonic couplant. Due to transportation and export requirements, we cannot export the couplant. So customers will need to source the couplant locally in their country.

https://aendt.com/acoustic/products/Accessories/2022/1123/147.html

5.3. Acoustic Emission Signal Cables

The AE signal cable is used to connect AE sensor to preamp or the DAQ. When the AE sensor with built-in preamp is used, like GI40, the signal cable length can be any length. But the longer the more signal loss/attenuation.

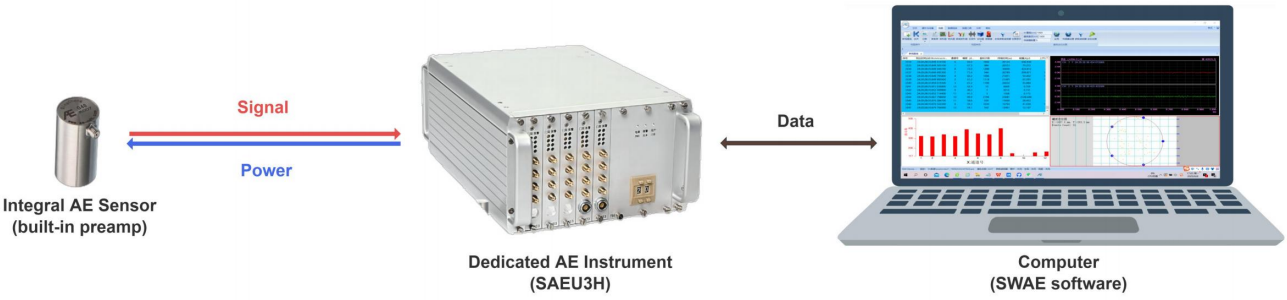
5.4. Acoustic Emission Instrument

The acoustic emission instrument should have enough AE channels. The sensors after preamplifier are all connected to the AE instrument for signal recording, processing, analysis and transmission.

There are two types of AE instruments that can be used for corrosion detection of storage tanks, the **SAEU3H** multi-channel AE system and the **RAEM1-6** acoustic emission system respectively. Choose one type as your AE processor system. **Our recommended system is RAEM1-6 because of its cost-effectiveness and system flexibility between detection and monitoring**.

The SAEU3H is a conventional AE acquisition instrument based on the Windows system. It requires connecting to a computer for controlling, storage, display and analysis. SAEU3H only has multiple of 4 channels (because each AE board has fixed 4 channels on), like 4, 8, 12 channels.

https://aendt.com/products/multichannel-systems/254.html



The RAEM1-6 is based on the Linux system which makes it standalone, stable and reliable even in the remote unattended monitoring applications. RAEM1-6 can work with the windows PC as the benchtop instrument and send data to SWAE software for the display and analysis, just as the SAEU3H. But it can also work as a standalone remote long term monitoring system which sends the data to PC/cloud/servers etc via wirelessly transmission (WiFi/4G). RAEM1-6 has flexible channel numbers, minimum of 2 channels and maximum of 6 channels per case. Two or more cases of RAEM1-6 can cascade together to a bigger system.

https://aendt.com/products/ae-detection-system/190.html

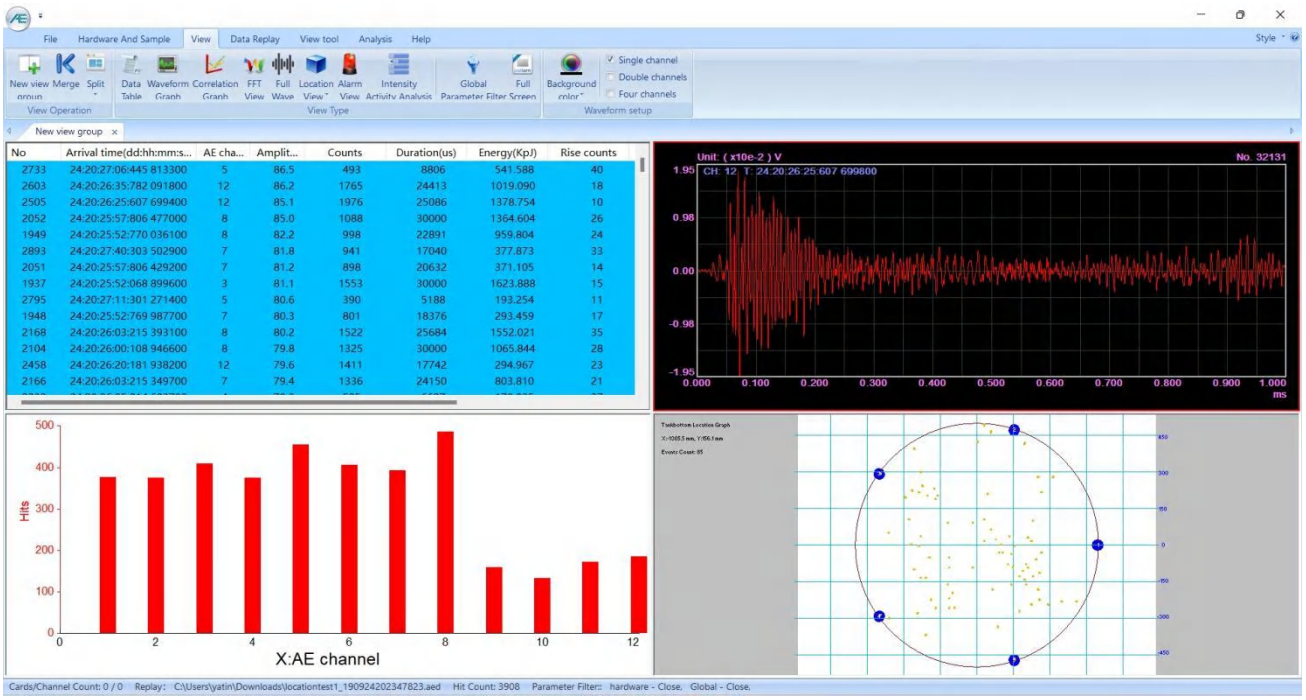
Specifications

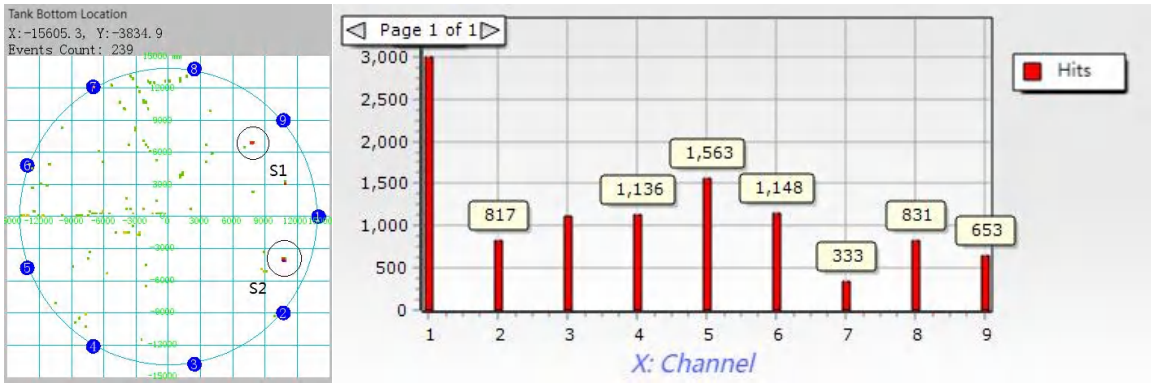
	SAEU3H	RAEM1-6
		
Channel	4 channels per AE board. There are chassis for 4/20/48 channels. Cascade chassis for 128 channels.	Flexible to order any number of channels. Each chassis can install up to 6 channels. Cascade chassis for unlimited channels

Sample Mode	Threshold	Threshold/time/continuous
Sample Rate	Max 10MS/s per channel, 16-bit	Max 2MS/s per channel, 16-bit
System Noise	<15dB (no load)	< 30dB
Dynamic Range	85dB	70dB
Input Frequency	1kHz to 2.5MHz (-3dB bandwidth)	10kHz to 800kHz (-3dB, pass-through)
Analog Filter	High-pass filter: 20kHz, 100kHz, 400kHz; Low-pass filter: 100kHz, 400kHz, 1200kHz; any combination of the two filters to be set in the software; each channel is independent	Software selectable (kHz): 20-100kHz/ 20-400kHz/ 70-100kHz/ 70-400kHz/ Pass-through/ Bypassed
Digital Filter	From 1KHz-2.5MHz frequency range, any value can be set as the pass-through, high-pass, low-pass, band-pass filter	Set any value in between 0 to 1000 kHz frequency range as pass-through/ high-pass/ low-pass/ band-pass filter
Phantom Power Output to Preamp	28V or 5V or 0V phantom power through coaxial cables to the preamplifier in software	Hardware fixed only one type of phantom power to preamp: 28V or 12V or 5V
Data Output	Waveform, parameters	Waveform, parameters
AE Featured Parameters	Arrival time, amplitude, counts, duration, energy, rise counts, rise time, RMS, ASL, 12 external parametric, center frequency, peak frequency, 5 partial powers	Arrival time, amplitude, counts, duration, energy, rise counts, rise time, RMS, ASL, 12 external parametric, center frequency, peak frequency, 5 partial powers
Internal Capacity	1GB per AE board	/
Transmission	USB3.0	Ethernet, additional WiFi/4G
External Input	Each AE board supports 4 external inputs; Up 12 external inputs in a system. Input range from ±10V. Maximum sample rate of 1MHz; able to external input trigger	Up to 4 external inputs; input range from ±10V. Maximum sample rate of 1MHz; able to external input trigger
Alarm Output	Switches or lights can be used to output alarm signals	2 channels
Temperature	-10℃~45℃	-20~60℃
Input Power	100~240VAC, 50-60Hz (4-channel chassis: 12VDC)	12VDC
Dimension (L x W x H, mm)	4-channel chassis: 320 x 125 x 50 20-channel chassis: 363 x 225 x 150 48-channel chassis: 368 x 363 x 150	232 × 125 × 52
Weight (kg)	1.3 / 3.7 / 5.16	1.25

5.5. Analysis Software

We provide SWAE, the Windows software for data display and analysis. The software is included in the hardware purchase. And there is no license or limitations to use. Future updates are available upon request.





6. Project Specific Configuration

The requested work is for AE testing of the above-ground metallic storage tank:

Item	Tank #01
Inner Tank Diameter	mm
Height	m
Content	
Material	
Outer Tank Diameter	mm

6.1. Product List

The channel number for tank bottom corrosion testing is based on the tank diameter.

	Model	Quantity	Note
AE Sensor	GI40		Resonant frequency at 40kHz, 15-70kHz range, Built-in preamp 40dB28V
DAQ	RAEM1-6 (min 2, max 6-channel)		Ethernet cable transmission by default. Optional wireless: WiFi or 4G.
Signal cable			BNC-SMA, ?? meter
Sensor holder	Magnetic holder		
Software	SWAE		Included in the hardware purchase
Cascade cable	RS485		Cascade two RAEM1-6 together