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QAWRUMS

Online Monitoring and Detection of Corrosion on Bottom Plate of Atmospheric Pressure Storage Tank

——Complies with standards JB/T 10764-2023, NB/T 47013-2015, ISO 24489

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Application Introduction

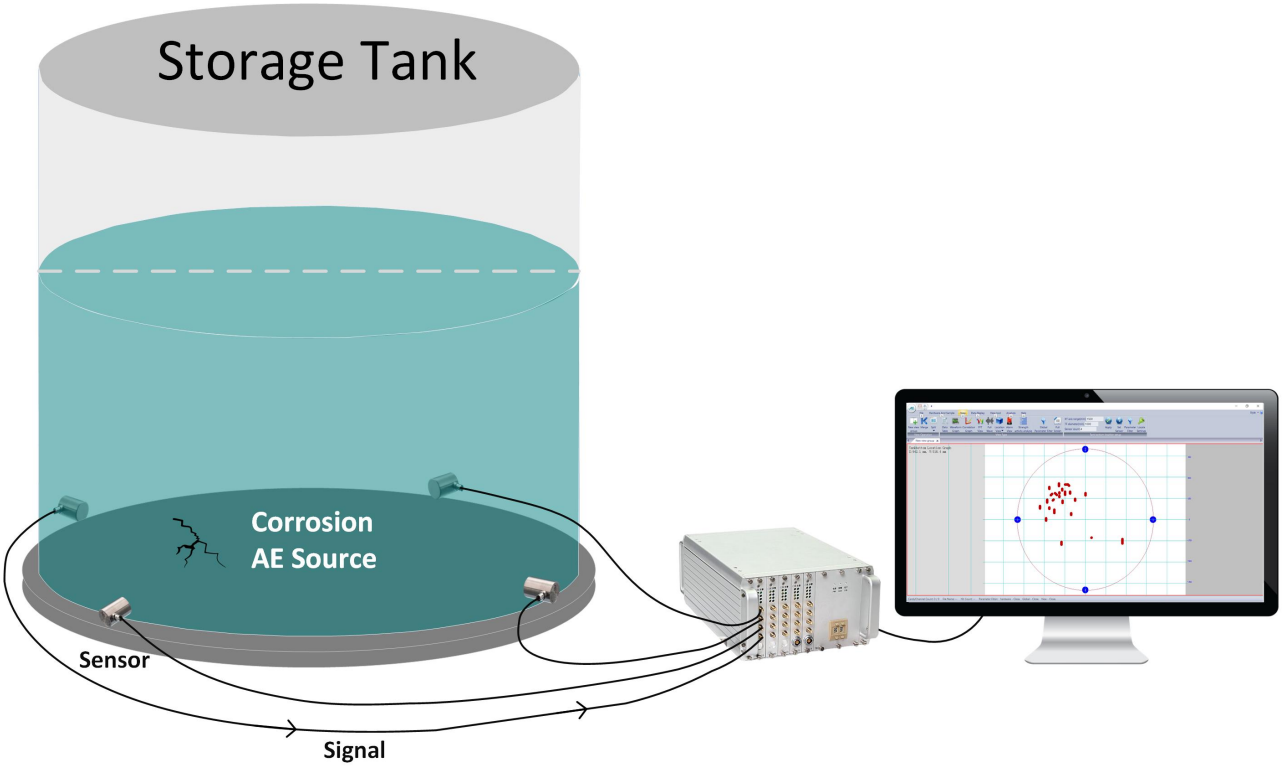
Tank corrosion primarily involves material degradation in different sections of the tank structure. For instance, the top plate may corrode due to differences between internal and external environmental conditions. Weld seams with defects such as pores, slag inclusions, or lack of penetration are susceptible to becoming corrosion initiation sites. Additionally, sediment accumulation and uneven settlement can lead to localized corrosion on the bottom plate.

Acoustic Emission (AE) technology can be used to locate and classify tank corrosion levels. It complies with the Chinese national standard JB/T 10764-2023 “Non-destructive Testing--Acoustic Emission Testing and Evaluation of Atmospheric Pressure Metal Storage Tanks”, NB/T 47013-2015 “Nondestructive Testing of Pressure Equipment”, and the international standard ISO 24489.

It is suitable for acoustic emission detection and evaluation of the bottom plates of newly manufactured and in service vertical tanks with gas or liquid media and working pressure of atmospheric pressure or low pressure less than 0.1MPa.

❖ Principle

The corrosion of the bottom plate of the atmospheric pressure storage tank causes leakage, seepage and thinning, which generates acoustic wave signals that are transmitted to the tank wall through the medium or the bottom plate. The sensor array on the tank wall passively receives the acoustic wave signals of the corrosion of the bottom plate of the tank, which are analyzed and processed by the collector and transmitted to the PC/server/cloud platform. The SWAE software can show the bottom floor corrosion location map so that users can use the cluster analysis and intensity and activity ratings to evaluate and classify the corrosion results.



❖ Compared with other NDT technologies

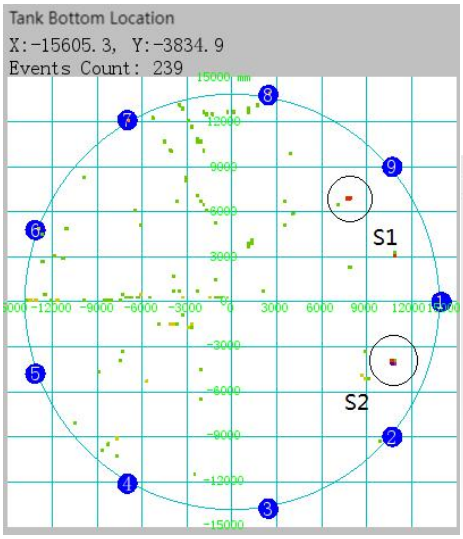
Technology	Area	Pros and Cons
Acoustic emission testing	Bottom plate, tank body	**Non-stop Online Detection** Allows real-time detection without production shutdown; efficient, low-cost, and provides clear, reliable results.
Magnetic flux leakage testing	tank wall	**No Surface Grinding Required** However, surface debris such as iron chips or oxide scale may cause false indications.
Ultrasonic Testing with Crawler	tank wall	**No Scaffolding Needed** Limited by tank wall structures (e.g., wind girders may obstruct access).
X-ray testing	tank wall weld	**Clear Defect Indications** Subject to structural constraints—requires personnel to enter the tank for operation.
Infrared imaging	tank body	**Fast Detection with Visual Results** Offers quick inspection and intuitive outcomes; however, image contrast is low, and the method is costly.
Eddy current testing	tank wall	**Easy Operation and High Speed** Suitable only for surface and near-surface defects in metals, not for deep internal flaws.
Phase-controlled array testing	tank wall weld	**High Detection Rate for Thin-wall Weld Seams** Requires grinding of the inspection area and scaffolding for work at height.

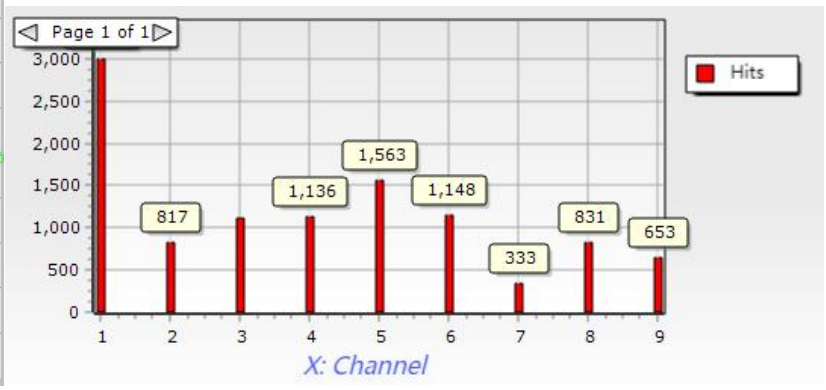
❖ Technical Advantages

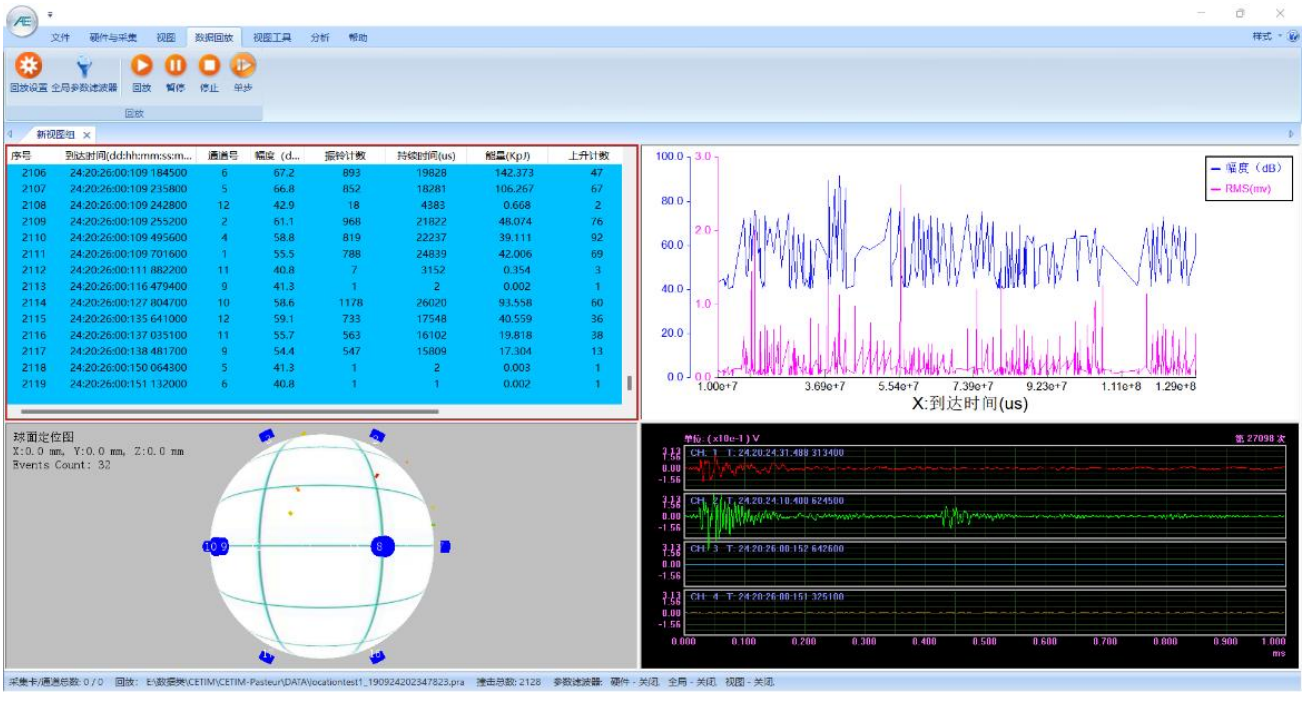
- **Non-stop non-destructive inspection:** no opening or cleaning the tanks. Just install sensors on the outside walls and the system can real-time analyze the areas of corrosion and/or leaking wirelessly.
- **Comply with the standards:** Chinese national standard JB/T 10764-2023 “Non-destructive Testing--Acoustic Emission Testing and Evaluation of Atmospheric Pressure Metal Storage Tanks”, NB/T 47013-2015 “Nondestructive Testing of Pressure Equipment”, and the international standard ISO 24489.
- **Data connection:** Real-time transmission of acoustic emission parameters (amplitude, ASL, energy, RMS, etc.), original waveform, and remote device configurations and modifications.
- **Communication protocol:** Support TCP/IP, MQTT, Protobuf, user-defined protocol access to customer private cloud platform

❖ Data Deep Analysis

SWAE analysis software provides various graphic views to assist in in-depth research on tank corrosion, such as location maps, correlation graphs, data tables, frequency domain FFT views, etc. It is suitable for SAEU3H benchtop multi-channel AE system and RAEM1-6 multi-channel remote unattended monitoring system, and can perform data collection, display and post analysis.



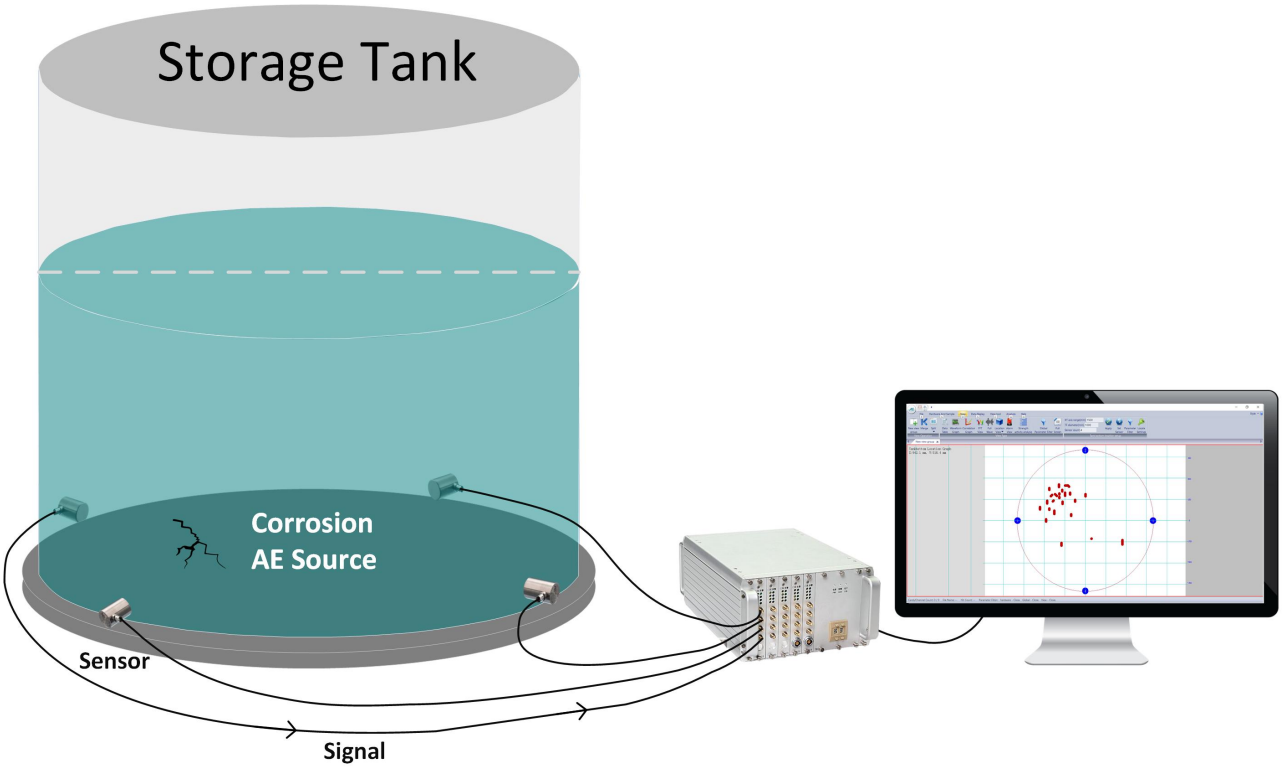




Solutions

1) SAEU3H Acoustic Emission Detection System for Tank Bottom

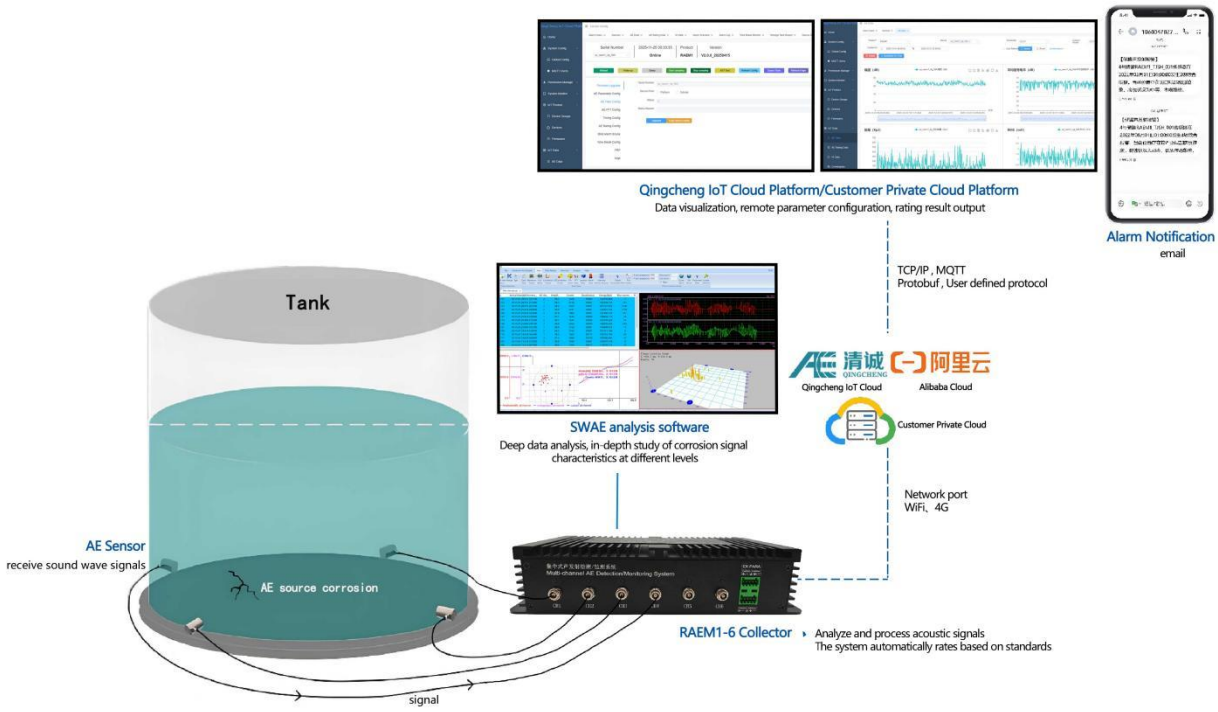
When corrosion defects on the tank bottom plate cause the corrosion products to peel off or detach, acoustic wave signals are generated. Similarly, leakage from the bottom plate creates acoustic emission signals due to fluid flow. These signals are captured by a sensor array installed at the lower part of the tank wall and processed by the SAEU3H instrument. The system can generate the data and transmit to SWAE desktop software for analysis and evaluation of the corrosion status and areas of the bottom plate in accordance with industry standards (JB/T 10764-2023, NB/T 47013-2015, ISO 24489).



2) RAEM1-6 Acoustic Emission Monitoring System for Tank Bottom

The acoustic wave signals generated by tank bottom plate corrosion or leakage are collected by sensors and analyzed by the RAEM1-6 acquisition unit. The data is then transmitted via 4G/WiFi/LAN to SWAE analysis software or the cloud platform (private cloud/Qingcheng Cloud) or a specific IP address. The system can generate the AE parameters and waveform for analysis and evaluation of the corrosion status and areas of the bottom plate in accordance with industry

standards (JB/T 10764-2023, NB/T 47013-2015, ISO 24489).



❖ Data Acquisition System

1) SAEU3H Acoustic Emission Detection System

The SAEU3H Multi-Channel Integrated Acoustic Emission Testing System is a data acquisition unit (DAQ). The complete system should work with AE sensor, preamp and the SWAE software on a Windows based computer. The SAEU3H contains multiple AE boards, each with four independent AE channels. Depending on requirements of channels, the system can be configured by selecting different chassis and the number of AE boards to form the suitable AE systems. Multiple chassis can be cascaded to build large acoustic emission systems.

48-channel System

20-channel System

4-channel System

2) RAEM1-6 Acoustic Emission Detection & Monitoring System

The RAEM1-6 is a multi-channel intelligent IoT acoustic emission monitoring system that integrates automated signal acquisition, processing and analysis, clock synchronization, and wired/wireless communication. With high reliability for 24/7 continuous standalone operation and wireless transmission capability, it is suitable for long-term, continuous, unattended automatic monitoring applications, such as structural health monitoring of bridges and corrosion monitoring of storage tanks.

❖ Data Acquisition System Specs

	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, parameter ratings

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 (LxWxH, 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

❖ Sensors

	GI150	GI40
		
Resonant Frequency	150KHz	40KHz
Frequency Range	60KHz~400KHz	15KHz~70KHz
Sensitivity	＞75dB	＞75dB
Built-in Preamp	40dB28V	40dB28V
Connector	BNC	BNC
Protection Degree	IP62	IP62
Temperature	-20℃～50℃	-20℃～50℃
Dimension(ΦxH, mm)	Φ30×36.5	Φ30×57
Target Defects	Cracks	Corrosion, leak

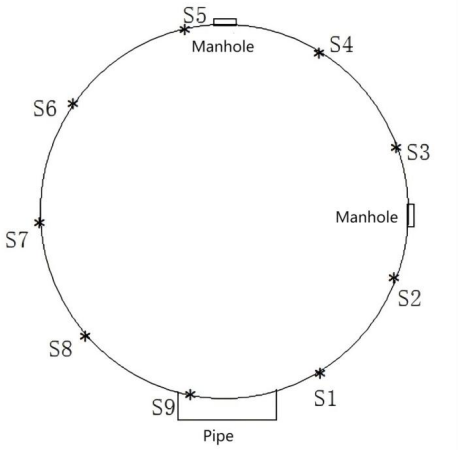
Application Cases

❖ Case 1: AE Detection of Storage Tanks at Xingsan Joint Station

The storage tank had a volume of 5000 cubic meters, a diameter of 22.7 meters, and an effective height of 16.14 meters. It stored crude oil. The tank walls were coated with anti-corrosion paint and insulated with composite aluminum-magnesium silicate felt and sheet metal protective plates.

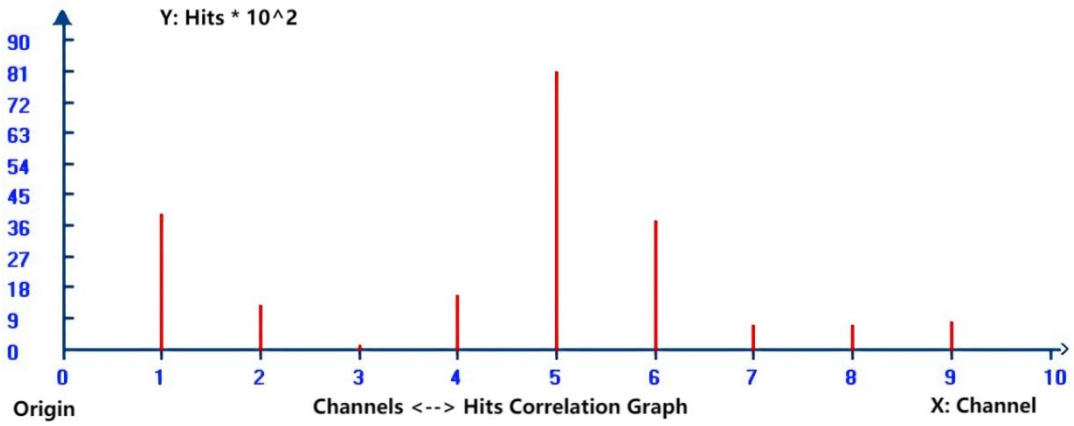
Acoustic emission sensor arrangement: Nine sensors were evenly distributed around the outer wall approximately 50 centimeters above the bottom plate, avoiding structural discontinuities such as pipes and manholes, with a horizontal spacing of approximately 7.8 meters.

Tank

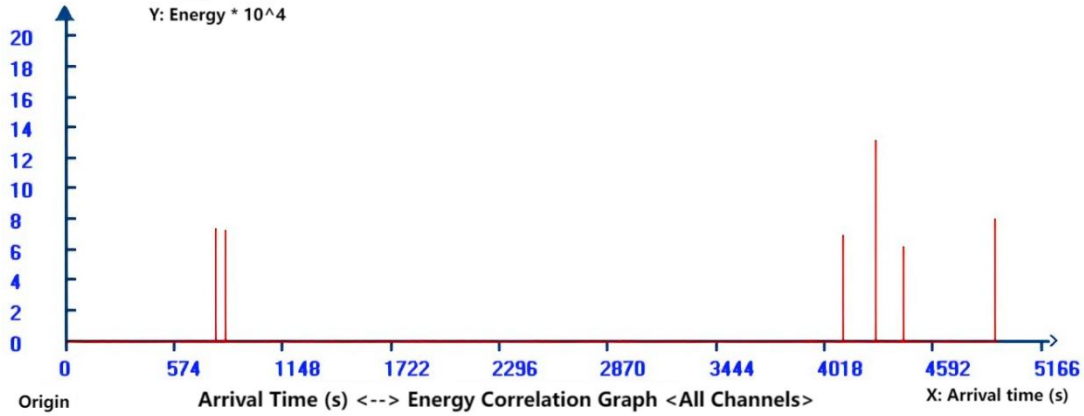


Sensor Arrangement Map

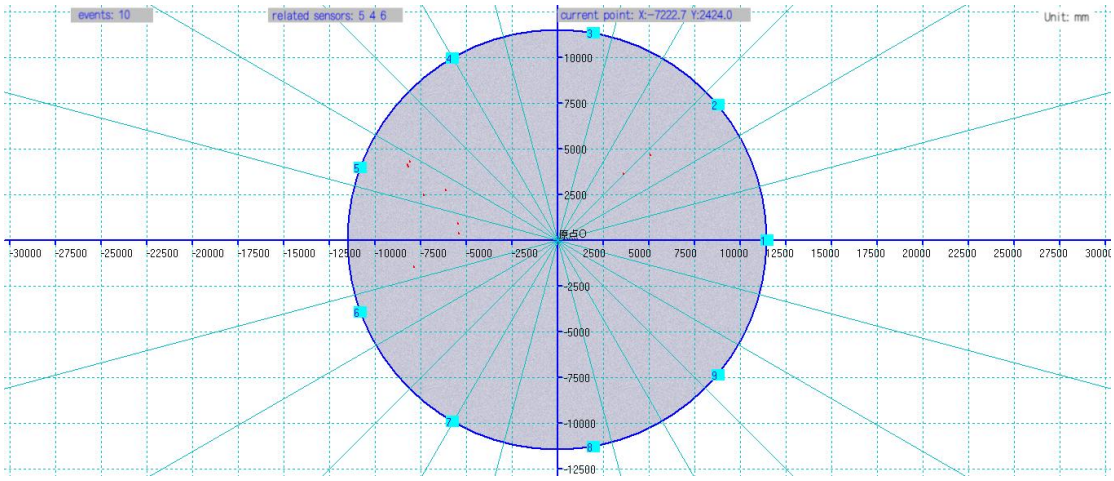
Data acquisition and analysis: Conducted acoustic emission testing on the storage tank for 2 hours.



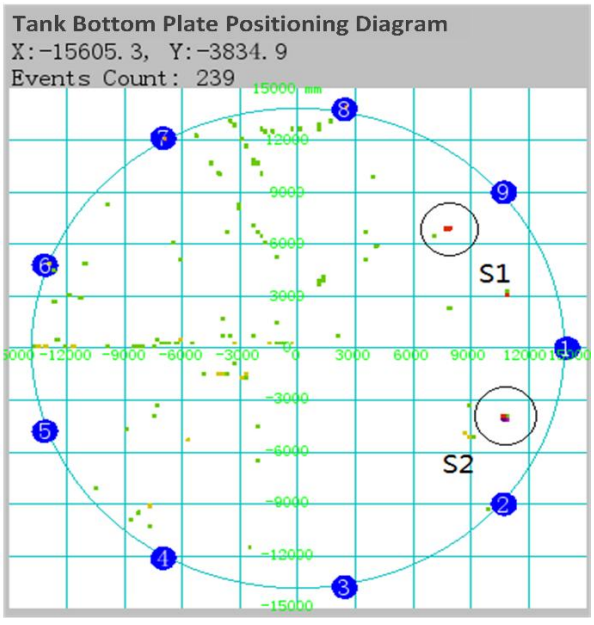
Tank #2 Channel - Hits Correlation Graph



Tank #2 Arrival time - Energy Correlation Graph



Tank #2 TDOA Location Map for 2h



Location Map During Pressure Maintaining

❖ Case 2: Weld Propagation Detection in Main Absorption Tower

In 2020, acoustic emission monitoring was employed on two absorption towers, 121-C-101 and 121-C-102, for long-term online monitoring of defects in the main absorption tower. The characteristics of the defect acoustic sources were analyzed to determine their activity status and to assess the location of expanding defects.

Sensor Installation: Each weld seam was covered by three acoustic emission sensors. The three sensors were located at both ends and the middle of the weld seam, arranged in an array 2 cm away from the weld seam on both sides.


The monitoring of acoustic emission signals had certain characteristics, with a 24-hour cycle. Based on the difference between interference signals and crack activity signals, a parametric filtering method was used to filter out all data from the decoking process. A dataset of valid signals was obtained, and statistical analysis was performed on this valid signal data.

❖ Case 3: Online Monitoring of Coke Tower

From January 4th to 6th, 2023, experimental data collection and analysis were conducted on the C-101C tower throughout its entire production cycle, aiming to explore an effective, accurate, and feasible online monitoring method for alternating fatigue vessels. The on-site 12V lithium battery provided power for approximately 34 hours. Signal acquisition for the entire coking tower production cycle was completed from 15:00 on January 4th to 1:00 on January 6th, 2023.

Sensor Installation: Monitoring focused primarily on the first and second main welds of the tower body. Waveguide rods were used for auxiliary sensor installation. The waveguide rod length was determined by ensuring the temperature at the non-welded end of the waveguide rod dropped

below 60℃. The minimum waveguide rod length was greater than the insulation layer thickness. Waveguide rods could be installed using welding or high-temperature adhesive bonding.

❖ Case 4: AE Detection of Storage Tanks at Special No. 1 Joint Station

There was the acoustic emission testing of the internal and external domed storage tanks at the Special Oil Company's Special No. 1 Joint Station. The tank type was an external domed tank with a volume of 10,000 cubic meters, a diameter of 27.75 meters, an effective height of 14.8 meters, and stored crude oil. The safe liquid level was 12.5 meters, and the initial detection liquid level was 17.8 meters. The tank wall was coated with anti-corrosion paint and had insulation panels and metal sheet protective plates.

❖ Supports

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