Online acoustic Wave (AE) Monitoring

and Testing of Tank Bottom Plate

1 Brief

1.1 Principle:

1.1.1 The leakage and thinning of the tank floor caused by corrosion under load will produce weak acoustic waves, which can be received and analyzed to obtain the corrosion state of the tank bottom plate.

The monitoring and testing described in this paper conforms to the standard JB/T 10764-2007 nondestructive testing of atmospheric pressure metal storage tank acoustic emission testing and evaluation method.

1.2 Application:

1.2.1 365 days of online monitoring and detection, the whole process of automatic analysis results, Internet of Things remote operation and use, mobile phone alarm push.
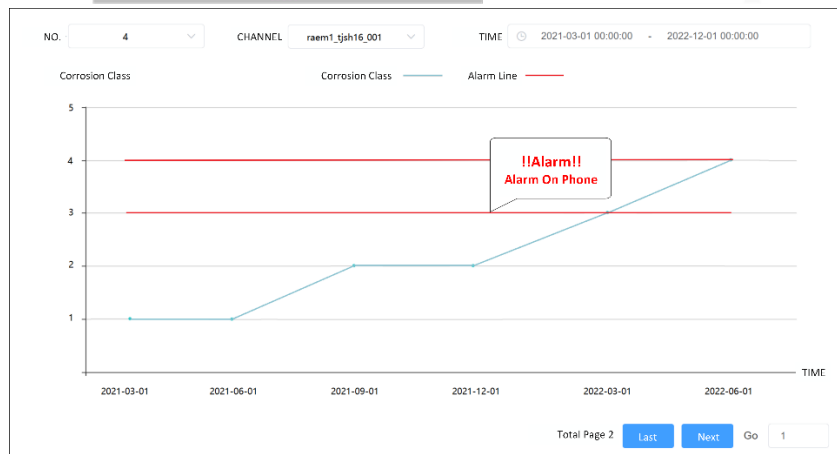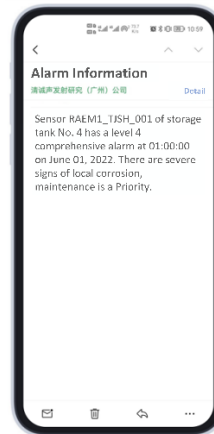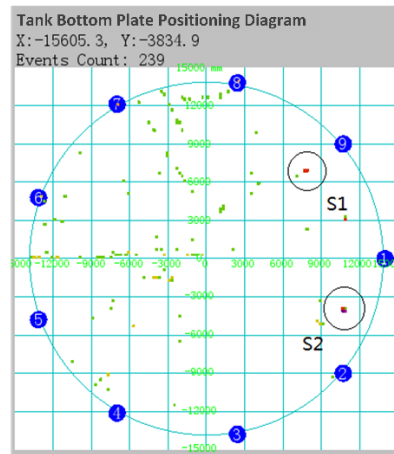

1.3 Advantages

- Automatically provide monitoring and diagnosis results
- Online and historical data screen display
- Online mobile alarm push

2 Solution - RAEM1 series remote acoustic wave (acoustic emission) monitoring system

2.1 A variety of data output communication modes (Wi-Fi, 4G, Ethernet, RS485, etc.) can be configured according to user requirements to achieve regular detection/local long-term monitoring and detection/remote long-term monitoring and detection or other application.

实线(Solid line): 有线连接(wired connection)
虚线(Dotted line): 无线连接(wireless connection)
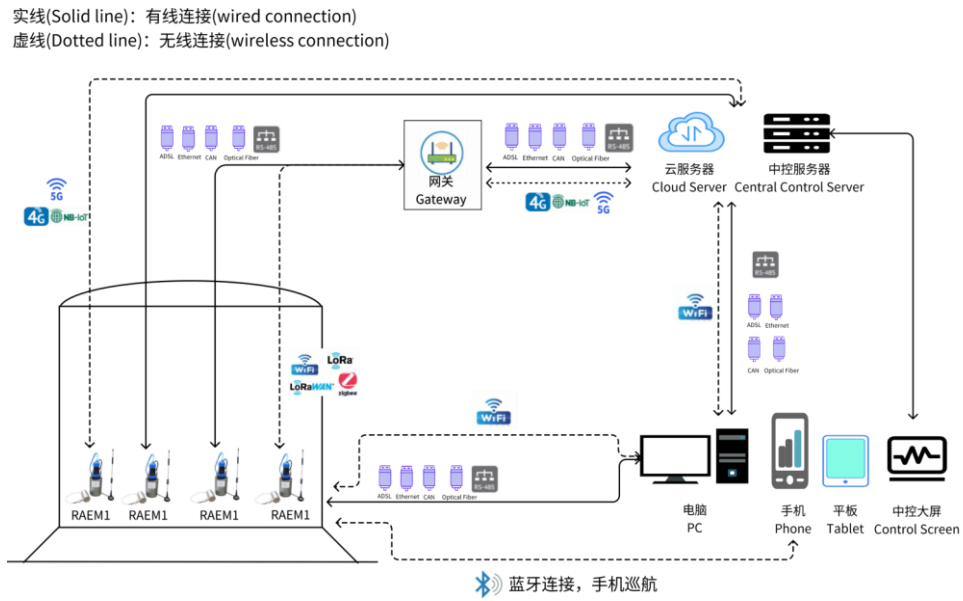
System diagram

Note: The above systems have the functions of mobile app Bluetooth communication inspection and on-site debugging setting

2.2 Remote on-line intelligent acoustic Wave (AE) monitoring system for tank bottom plate

2.2.1 It is suitable for the acoustic wave (acoustic emission) detection and evaluation of the bottom plate of newly manufactured vertical storage tank whose working medium is gas or liquid and working pressure is normal pressure or low pressure less than 0.1MPa.

3 Main Hardware and Software Introduction

RAEM1 series remote Acoustic Wave (AE) monitoring system:

System composition	RAEM1 collector, Platform, Client terminal

（Multiple collectors can be composed of multi-channel monitoring system, real-time monitoring of large equipment）
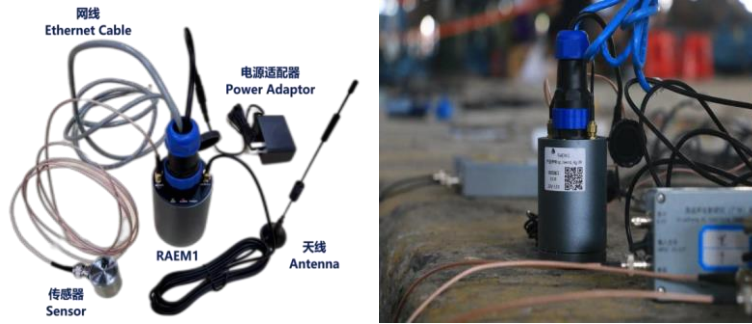
3.1 Configuration table

Sensor			GI40 Narrow band built-in preamp integration
			GI150 Narrow band built-in preamp integration
Collector	Name		RAEM1 Collector
	Communication mode	Wired	RS-485
			CAN
			LAN
		Wireless	4G
			WIFI
			Bluetooth (Mobile phone Bluetooth inspection)
			LORA (Networking)
Terminal output	Phone		APP
			mini program
			SMS
			Email
	Cloud platform		Qingcheng IoT cloud platform
			Ali cloud platform
			Amazon cloud platform
	Software		SWAE Software
			RAME Software

3.2 RAEM1 Collector

RAEM1 intelligent Acoustic Wave (AE) collector integrates sensor, acquisition board, data communication (Bluetooth, etc.), battery power supply and wireless clock synchronization.

3.3 Sensor

GI40 or GI150 series sensors convert mechanical signals into electrical signals and input Acoustic Wave (AE) acquisition and analysis system.

GI40 Sensor　　　　　　　　GI150 Sensor

3.4 Platform

Cloud server, local area network, PC, mobile phone, etc.

QingCheng Cloud　　　Ali Cloud　　　Amazon Cloud

3.5 Parameter

Channel	Single, or multiple-channel	Sample resolution	16-bit
Trigger	Threshold or time trigger	System noise	Better than 30dB
Sample rate	Up to 2M points per second	Dynamic range	70dB
Protection	IP65	Input bandwidth	10kHz-1000kHz
Supply	12VDC	Weight	220g
Analog filter	Two high-pass filters: 30kHz, 125kHz; two low-pass filters: 80kHz,175kHz; Factory default combinations: 30kHz~80kHz, 125kHz~175kHz.		
Digital filter	256-order FIR filter, in the frequency range of 0kHz~1000kH, any value can be set as pass-through, high-pass, low-pass, or band-pass filters.		
Sensor	Integrated sensor series (3 types of integrated preamp available): 28V40dB, 12V34dB, 5V26dB		
Data output	Waveform, parameters, alarm ratings		
AE featured parameters	Arrival time, amplitude, counts, energy, rising time, duration, RMS, ASL		
Storage capacity	64G (expandable to 512G)		
Communication	4G, Ethernet, Wi-Fi, RS485 (can customize communication means according to requirements, e.g., NB-IOT, LoRa)		
Temperature	-20℃~60℃ (Wi-Fi: 0℃~60℃)		
Dimension	Cylinder diameter φ62mm, height = 100mm		
Installation	magnetic base, which can be attached to the surface of magnetic absorption		

4 Solutions & Case

Corrosion state analysis and rating of multiple tank data

4.1 The test data results of 6 storage tanks of the same size and with the same medium under the service condition and pressure holding for 1 hour are shown in the table

	Tank 1	Tank 2	Tank 3	Tank 4	Tank 5	Tank 6
Total Hits	20348	868	9617	203876	8984	968
Total location event	2340	178	239	25600	268	180
Max. Hits	7834	360	3000	68876	3400	420
Min. Hits	456	378	333	321	487	365
Corrosion status class	III	I	II	IV	II	I
Corrosion status assessment	Obvious signs of local corrosion	No signs of local corrosion	Slight signs of local corrosion	Severe signs of local corrosion	Slight signs of local corrosion	No signs of local corrosion
Suggestions for maintenance	Consider maintenance	Maintenance free	Maintenance will not be considered in the near future	Maintenance is a priority	Maintenance will not be considered in the near future	Maintenance free

4.1.1 According to standard JB/T 10764-2007 Non-destructive testing Acoustic Emission Testing and evaluation methods for atmospheric metal storage tanks Article 10 Test results and evaluation Table 3 Classification of acoustic emission sources for tank bottom plate based on regional positioning analysis, K=500 (regional positioning of Hit number). The detailed levels of each tank are obtained as shown in the table above.

4.1.2 According to the review of storage tank data, historical operation records and other data, it is judged that No. 2 and No. 6 storage tanks are in good condition (level I) and do not need maintenance; Tank No. 4 is a tank with severe floor corrosion (greater than Grade III) and is a top priority for maintenance. The same method can be used to analyze the whole process of tank loading and the specific process of pressure boost and pressure maintenance. For example, in the case in the above table, the total Hit number K=1000 and the total positioning event E=200, the same rating result can be obtained.

4.2 For a storage tank, the test data of 1-hour pressure retention tested every 3 months are shown in the table:
（The first acoustic emission test will be conducted after 1 year and 3 months after the completion of the storage tank, and the test will be conducted every 3 months thereafter）

Tank 4	3 months	6 months	9 months	12 months	15 months	18 months
Total Hits	868	968	8984	9617	20348	203876
Total location event	178	180	268	239	2340	25600
Max. Hits	360	420	3400	3000	7834	68876
Min. Hits	378	365	487	333	456	321
Corrosion status class	I	I	II	II	III	IV
Corrosion status assessment	No signs of local corrosion	No signs of local corrosion	Slight signs of local corrosion	Slight signs of local corrosion	Obvious signs of local corrosion	Severe signs of local corrosion
Suggestions for maintenance	maintenance free	maintenance free	Maintenance will not be considered in the near future	Maintenance will not be considered in the near future	Consider maintenance	Maintenance is a priority

4.2.1 10764-2007 Nondestructive testing Acoustic Emission Testing and evaluation methods for atmospheric metal storage tanks Article 10 Test results and evaluation Table 3 Classification of acoustic emission sources for tank bottom plate based on regional positioning analysis, K=500 (regional positioning of Hit number). The level of detection obtained is shown in the table above.

4.2.2 The results of the first and second tests correspond to grade I, which are intact storage tanks without any damage to tank bottom plate such as corrosion. The third and fourth results are 3400 and 3000, which are grade II with slight local corrosion. At the 5th monitoring, obvious corrosion (level III) is found and maintenance needs to be considered; By the sixth monitoring, a tank with severe tank floor corrosion (Level IV) was identified, requiring the highest priority for maintenance.

4.2.3 The same method can be used to analyze the whole process of tank loading and the specific process of pressure boost and pressure maintenance. For example, in the case in the above table, the total Hit number K=1000 and the total positioning event E=200, the same rating result can be obtained.

4.3 Cloud Platform display：

Users can perform remote configuration and monitoring through the cloud platform, and upload data to the cloud platform for display and analysis.

FIG. 1: No. 4 tank No. 1 Channel (RAEM1_TJSH_001),

corresponding levels in the 3rd, 6th, 9th, 12th, 15th and 18th months are: I, I, II, II, III, IV respectively
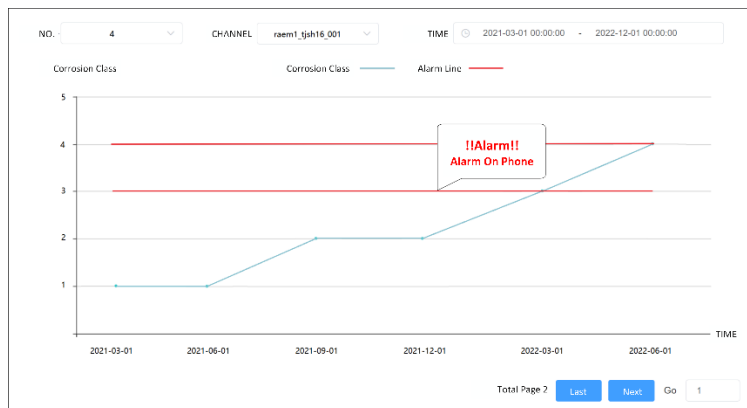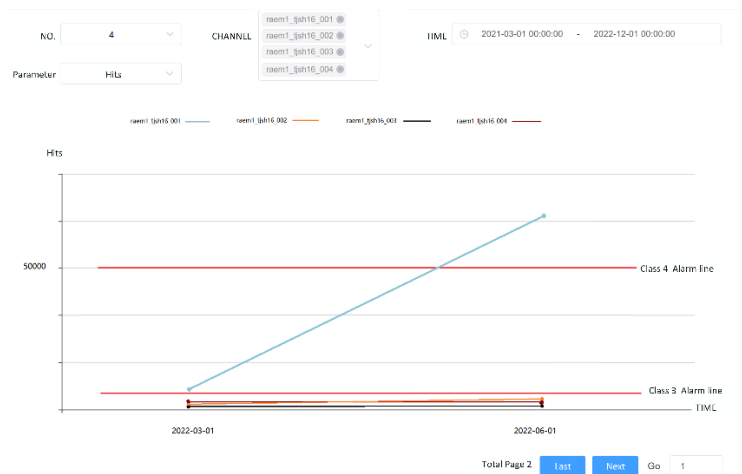

FIG. 2: All parameter values in all channels of No. 4 tank:

4.4 Mobile phone push

When the alarm limit is reached, the phone pushes the alarm information. Alarm methods: small program, email, SMS, APP.
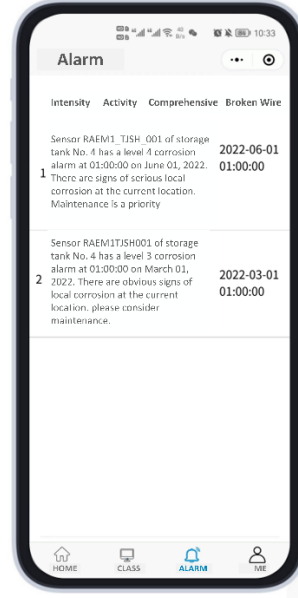
According to the data of the No.4 storage tank of the cloud platform, obvious corrosion (level III) was found in the 5th monitoring, and severe tank bottom corrosion (Level IV) was found in the 6th monitoring. The mobile phone synchronously receives alarm notifications, including tank grade, status and repair suggestions.
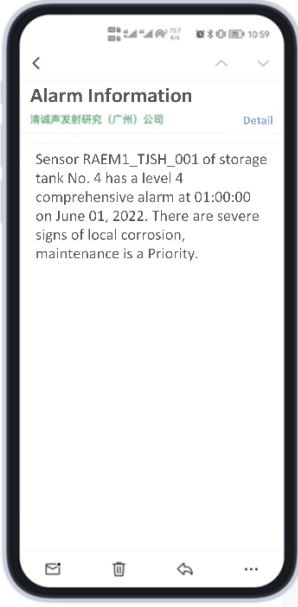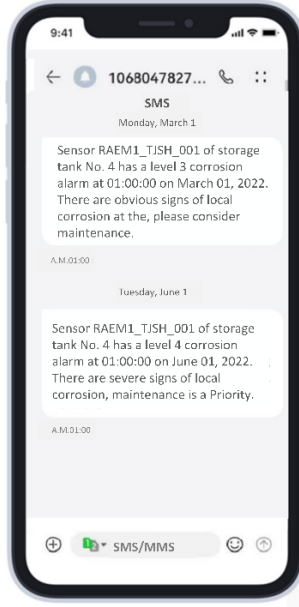

| Email | SMS | Mini program in WeChat |

4.5 SAEU3H Software

The data can be downloaded from the cloud for in-depth analysis using SWAEU3H software of Qingcheng, or directly sent to SWAEU3H software for real-time analysis and processing.
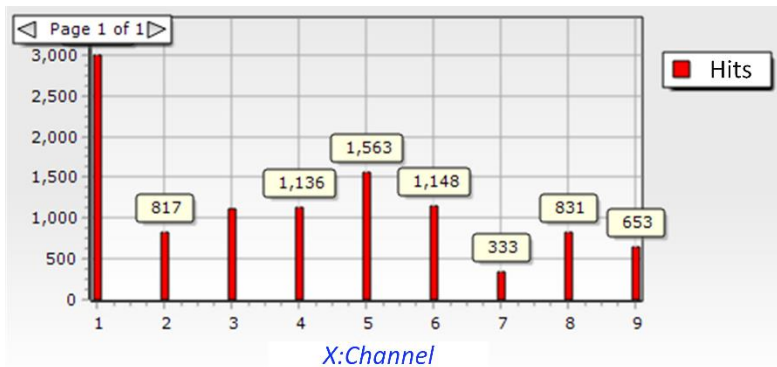
4.5.1 **Case:** 1-hour data of pressure retention.

Total Hit number: 10617, maximum 3000 (Channel 1), minimum 333 (Channel 7), total location number: 239.

Slight local corrosion is present. Through Qingcheng's SWAEU3H software, you can view the data and locate the corrosion site.
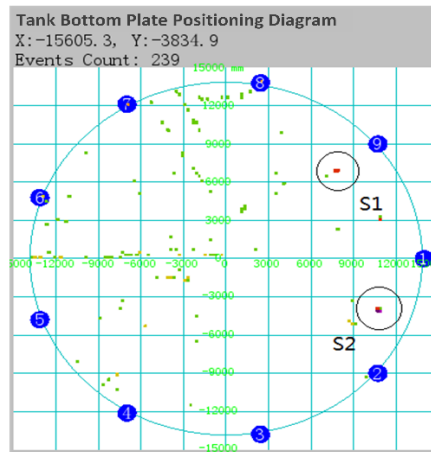
Tank bottom plate positioning diagram (time difference positioning)

Channel - Hits correlation graph (area location)

4.5.2 Automatic detection and rating, remote viewing, active push alarm, meet the standard:

4.5.2.1   Data is automatically detected at the set time. After setting the K value according to the standard content, the K value can be used as an automatic rating criterion for automatic data processing and automatic analysis to obtain the corrosion status level of each tank according to the requirements of the standard content.

4.5.2.2   The corrosion status level of the storage tank and the specific data can be checked at any time by accessing the cloud Internet of Things platform with computer and mobile phone client anywhere.

4.5.2.3   If the alarm level is set, such as level IV alarm, it will push the alarm information to the specified mobile phone number after the detection is automatically completed 18 months later in the above case, reminding the need to take measures such as immediately opening the can for inspection.

5   Practical Cases Study

- There are many accidents of tank floor thinning and perforation leakage due to corrosion. According to statistics, tank failures due to corrosion account for more than 60% of all tank failures.
- It is of great significance for safe production, resource conservation and environment protection to adopt effective storage tank inspection method.

## 5.1   A case study of acoustic emission detection training in the bottom detection of CUPET tanks

- From March 6 to March 12, 2017, in the oil storage tank farm of the port of Matanzas, Cuba, the test was carried out according to the Chinese Machinery industry standard JB/T 10764-2007 Method for Acoustic Emission Detection and Evaluation of Atmospheric Metal Storage Tanks.
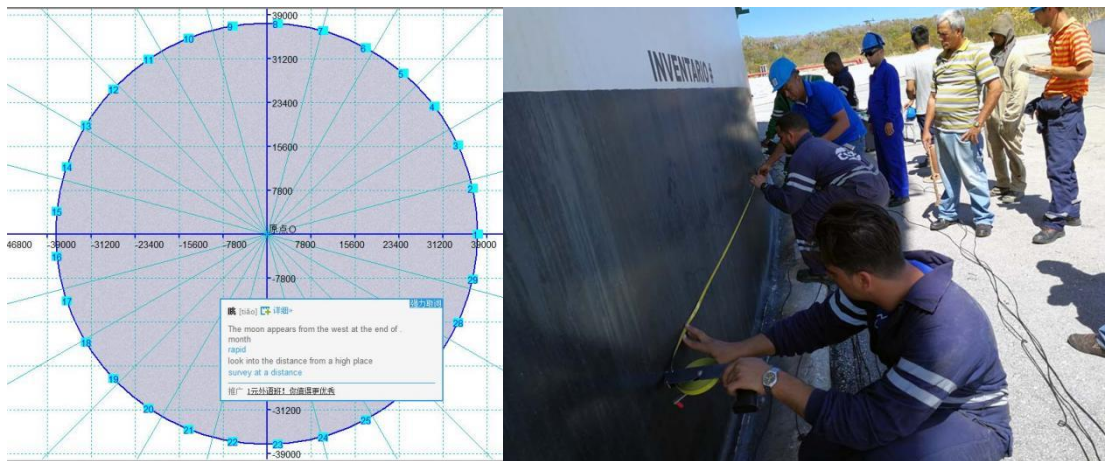
Tank No. TK-56 (put into use in 2012), diameter 74 meters, design liquid level 10.8 meters, material A516-Gr70

- The loading history of nearly a month shows that the highest liquid level has reached 10.6 meters, and the liquid level is planned to rise to 10.8 meters in this test. According to the circumference design of the probe position, the actual number of channels used is 29 channels, sensor spacing is about 8 meters.
- At last, a comprehensive test was carried out for the storage tank group of Cubana National Oil Company. According to the distribution of the number of Hits, the specific implementation plan of can opening reinspection was determined, and the qualification standard of subsequent annual inspection was formulated according to the results of an opening.
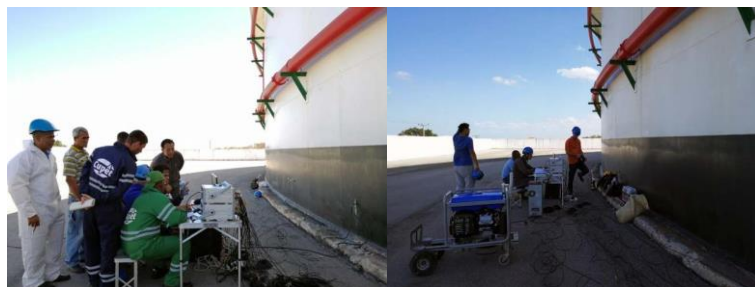
5.2 Acoustic wave (acoustic emission) detection of storage tank in Zhongyuan Oil field

Appearance of atmospheric tank to be tested

- Entrusted by the Oil and Gas Storage and Transportation Management Office of Zhongyuan Oilfield, our company conducted acoustic wave (acoustic emission) inspection on 20000m3 storage tank of Zhongyuan Oilfield in August 2006.

5.3 Jiangxi Special Inspection Institute - Jiujiang Petrochemical Tank bottom inspection

Appearance of storage tank

|	
Sensor Installation	Preamplifier
Host acquisition signal	Field drawing
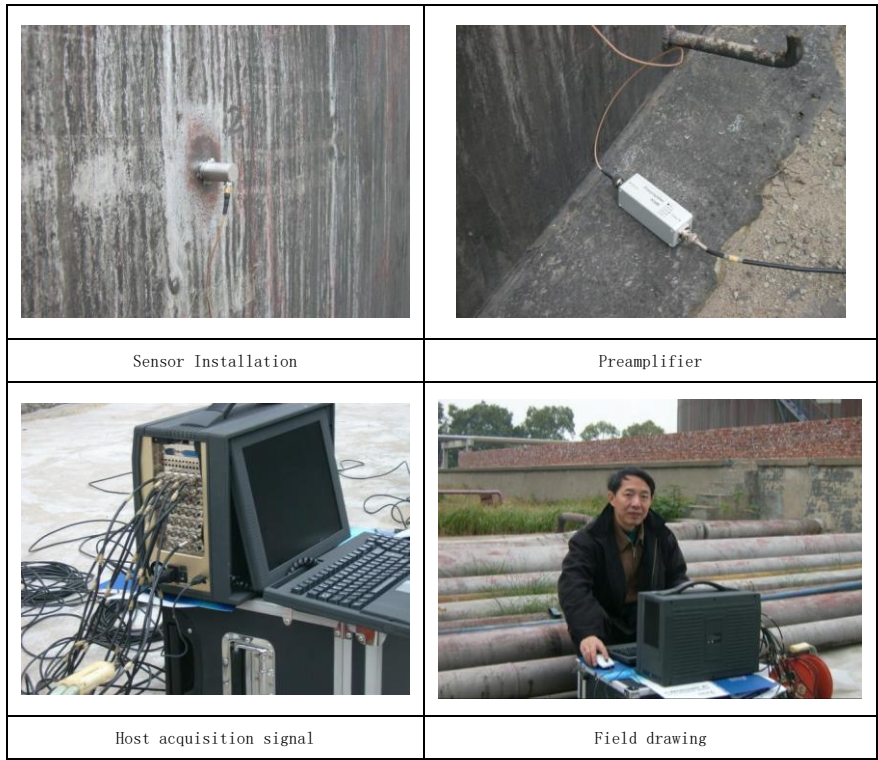
5.4 Acoustic wave (acoustic emission) on-line detection of storage tank at a joint station of Special Oil Company


- The storage tank is an external vaulted storage tank with a volume of 10,000 cubic meters, a diameter of 27.75 meters, an effective height of 14.8 meters, a storage medium of crude oil, a safe level of 12.5 meters, and an initial level of 17.8 meters. The wall of the tank is coated with anti-corrosion paint, insulation board and metal sheet protection board.
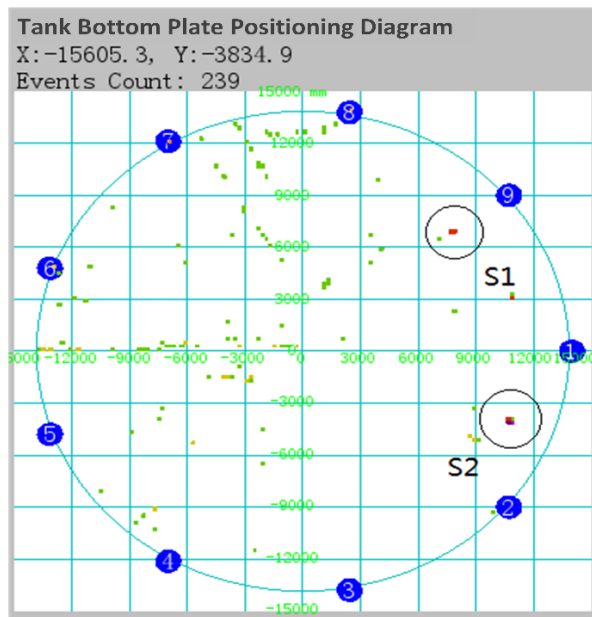

Site sensor partial installation diagram
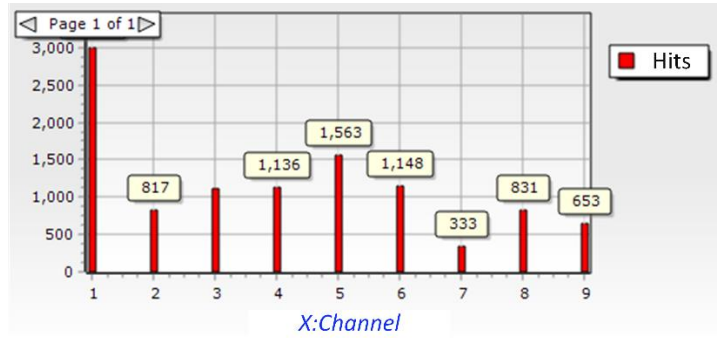
Data analysis FIG. 1
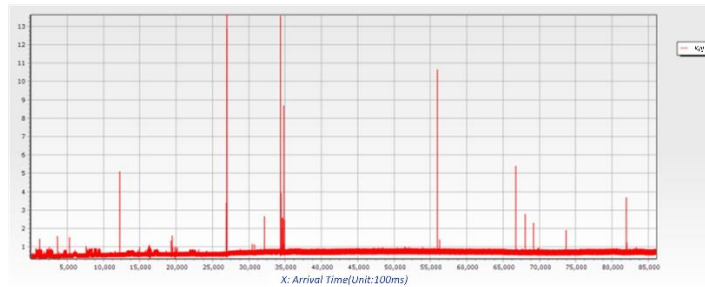
Time-energy statistical diagram

Time difference location map

6   Conclusion

According to the standard (JB/T 10764 -- 2007 Nondestructive testing acoustic emission detection and evaluation method for atmospheric metal storage tank), the acoustic emission monitoring and detection of storage tank bottom plate are realized and the corrosion status level of storage tank bottom plate is given according to the standard. Users can make maintenance arrangements according to the standard content, timely maintenance to avoid accident losses, reduce unnecessary can opening maintenance and reduce operating costs.

Advantages:

- No wiring at all
- Built-in battery power supply, continuous operation for more than 4 hours, suitable for regular testing
- It can also be powered by cable, so that long-term automatic monitoring and detection can be achieved
- Built-in sensor, with a center frequency of 40kHz and a frequency range of 15kHz~70kHz, can meet the requirements for tank detection, and the sensor can also be replaced.
- Built-in high-precision wireless synchronous clock, synchronous clock is less than 10us, can do time difference positioning rating
- Compact, with magnet at the bottom, easy to install on site.
- Data can be transferred to the computer for in-depth analysis and uploaded to the cloud platform for automatic rating.