

Pressure Vessels/ Storage Tanks: Testing and Monitoring System

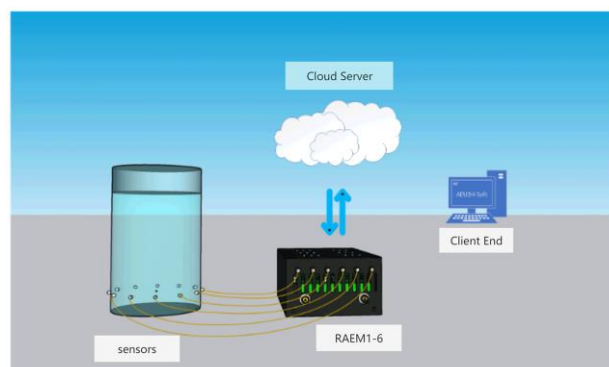
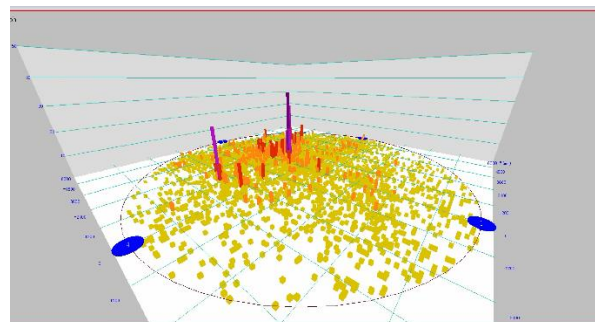
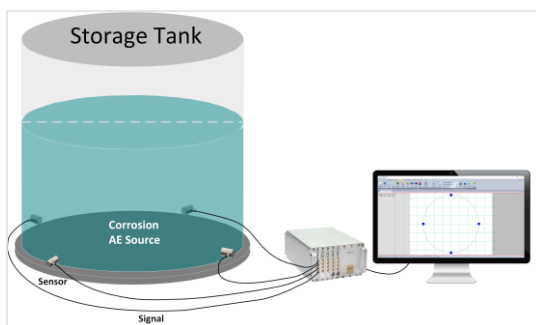
Using Acoustic Wave (Acoustic Emission)

1 Brief

Storage tanks, pressure vessels and boilers are required to take regular inspections and testing to ensure the safety of continuous operations and the integrity of the vessels in case of corrosion, cracks and leaks.

The national and industrial standards of the pressure vessels inspection include some non-destructive testing methods, for example, radiographic testing, ultrasonic testing, eddy current testing and magnetic particle testing. However, another NDT technology, acoustic emission testing (AET) has unique advantages of non-stop operations or no need to drain or open the vessels, which makes the AET a faster and cost-effective technology for:

- Tank inspection
- Storage tank monitoring
- Pressure vessel detection and monitoring





2 Solution – SAEU3H AE testing system/ RAEM1-6 remote acoustic wave (acoustic emission) monitoring system

2.1 Principle

- 2.1.1 When there are the cracks, corrosion or leak, the storage tanks or pressure vessels generates acoustic elastic waves that can be captured by the acoustic emission sensors following by processing and analysis to locate the sources.

2.2 Hardware introduction

According to the customers' requirements, we provide two kinds of AET systems to meet regular detection requirements and long-term monitoring needs.

	Periodical Detection	Long-term Monitoring
Photo		
Detection system	SAEU3H acoustic emission detection system	RAEM1-6 acoustic emission monitoring system
Operation system	Windows	Linux
Channels	Multi-channels, cascadable to 100+ channels	From 6 channels, cascadable to 1000+ channels
Acoustic emission sensors	GI40/G40 for tank bottom corrosion; GI150 for tank body cracks	GI40/G40 for tank bottom corrosion; GI150 for tank/vessel body cracks
Sampling rate	10M/s, 16-bit	2M/s, 16-bit
Waveform collection	Support	Support
Analog filters	High-pass filters: 20kHz, 100kHz, 400kHz Low-pass filters: 100kHz, 400kHz, 1200kHz	High-pass filters: 30KHz, 125KHz Low-pass filters: 80KHz, 175KHz
Digital filters	1KHz-2.5MHz	1KHz~1.0MHz
Advantages	USB3.0 high-speed data transmission, good expansion ability, stable performance, accurate defect location function. Suitable for regular detection.	Based on Linux operating system, stable performance, wireless communication capability, suitable for long-term remote unattended monitoring.

2.3 AE 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 Solutions & Case

Corrosion state analysis and rating of multiple tank data

3.1 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

3.1.1 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.

3.1.2 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.

3.2 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	Id	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

3.2.1 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.

3.2.2 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.

3.2.3 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.

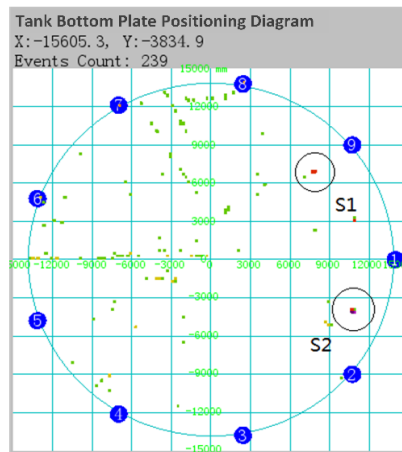
3.3 SAEU3H Software

The acoustic emission data can be analysis by using SWAE software after data acquisition, or directly sent to SWAE software for real-time analysis and processing.

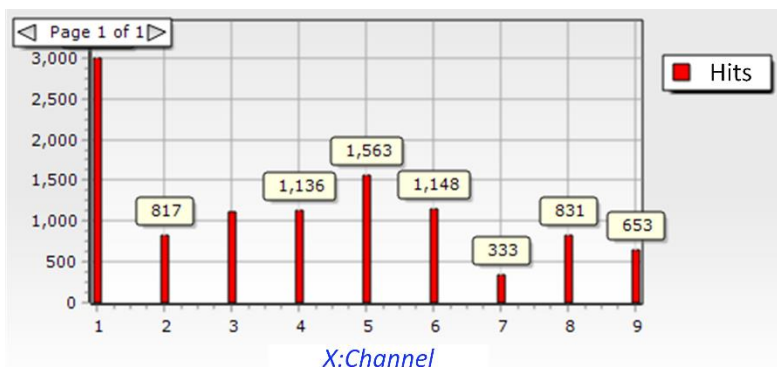
3.3.1 Case: 1-hour data of pressure retention.

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

Slight local corrosion is present. Through SWAE 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 Practical Cases Study

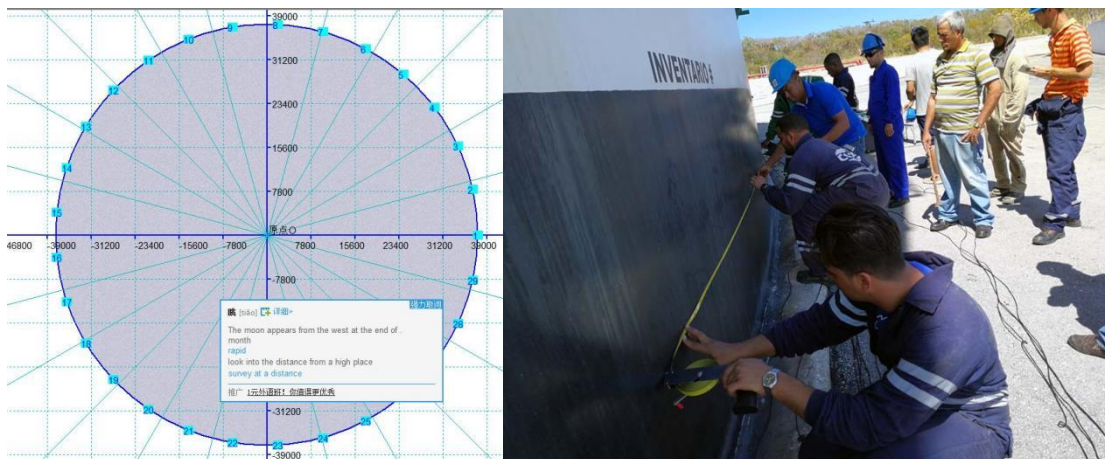
- There are many accidents of tank floor thinning and perforation leakage due to corrosion. According to statistics, tank failures due to corrosion account for more than 60% of all tank failures.
- It is of great significance for safe production, resource conservation and environment protection to adopt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



4.1 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.



4.2 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.



4.3 Jiangxi Special Inspection Institute - Jiujiang Petrochemical Tank bottom inspection

	
Appearance of storage tank	
	
Sensor Installation	Preamplifier
	
Host acquisition signal	Field drawing

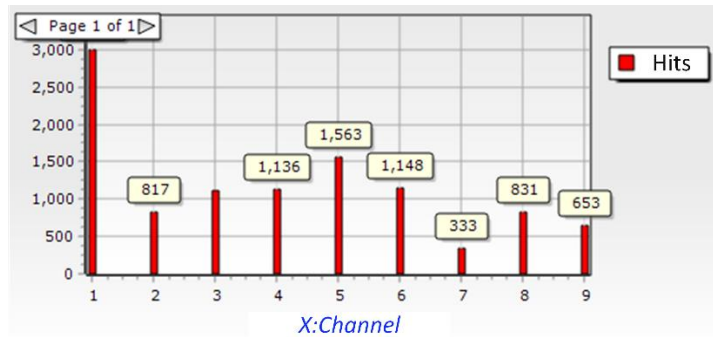
4.4 Acoustic wave (acoustic emission) on-line detection of storage tank at a joint station of Special Oil Company



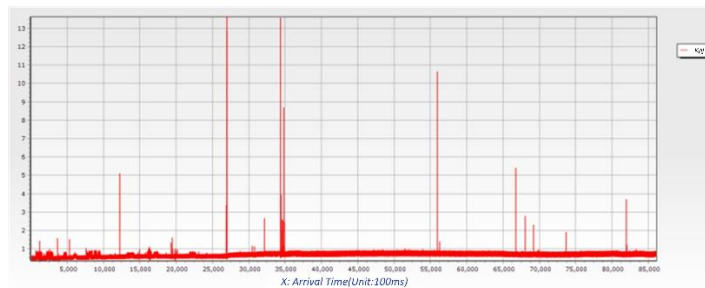
- The storage tank is an external vaulted storage tank with a volume of 10,000 cubic meters, a diameter of 27.75 meters, an effective height of 14.8 meters, a storage medium of crude oil, a safe level of 12.5 meters, and an initial level of 17.8 meters. The wall of the tank is coated with anti-corrosion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



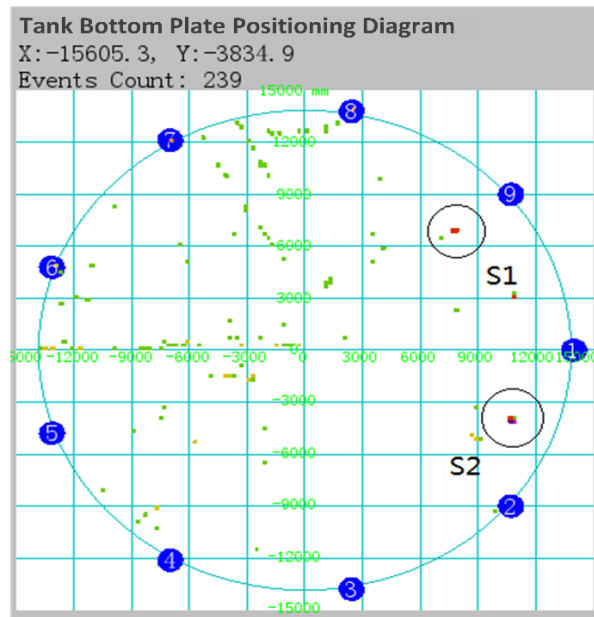
Site sensor partial installation diagram



Data analysis FIG. 1



Time-energy statistical diagram



Time difference location map

5 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.