

# Damage Monitoring and Testing Of Structural Parts

## 1 Introduction

### 1.1 Principle:

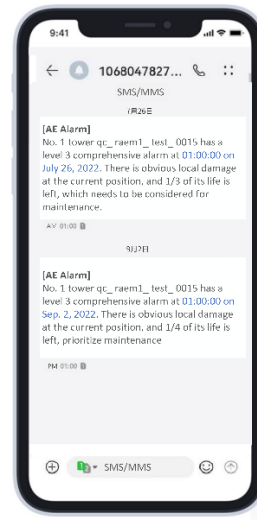
The damage process of structural materials such as crack, deformation and de-lamination are often accompanied by acoustic wave (acoustic emission). The acoustic wave is acquired and analyzed, and the type, degree and location of damage are judged by detector, so as to make a health evaluation on the integrity of structural parts.

### 1.2 Application:

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



The online Cloud platform automatically displays the results



Automatically alarm information

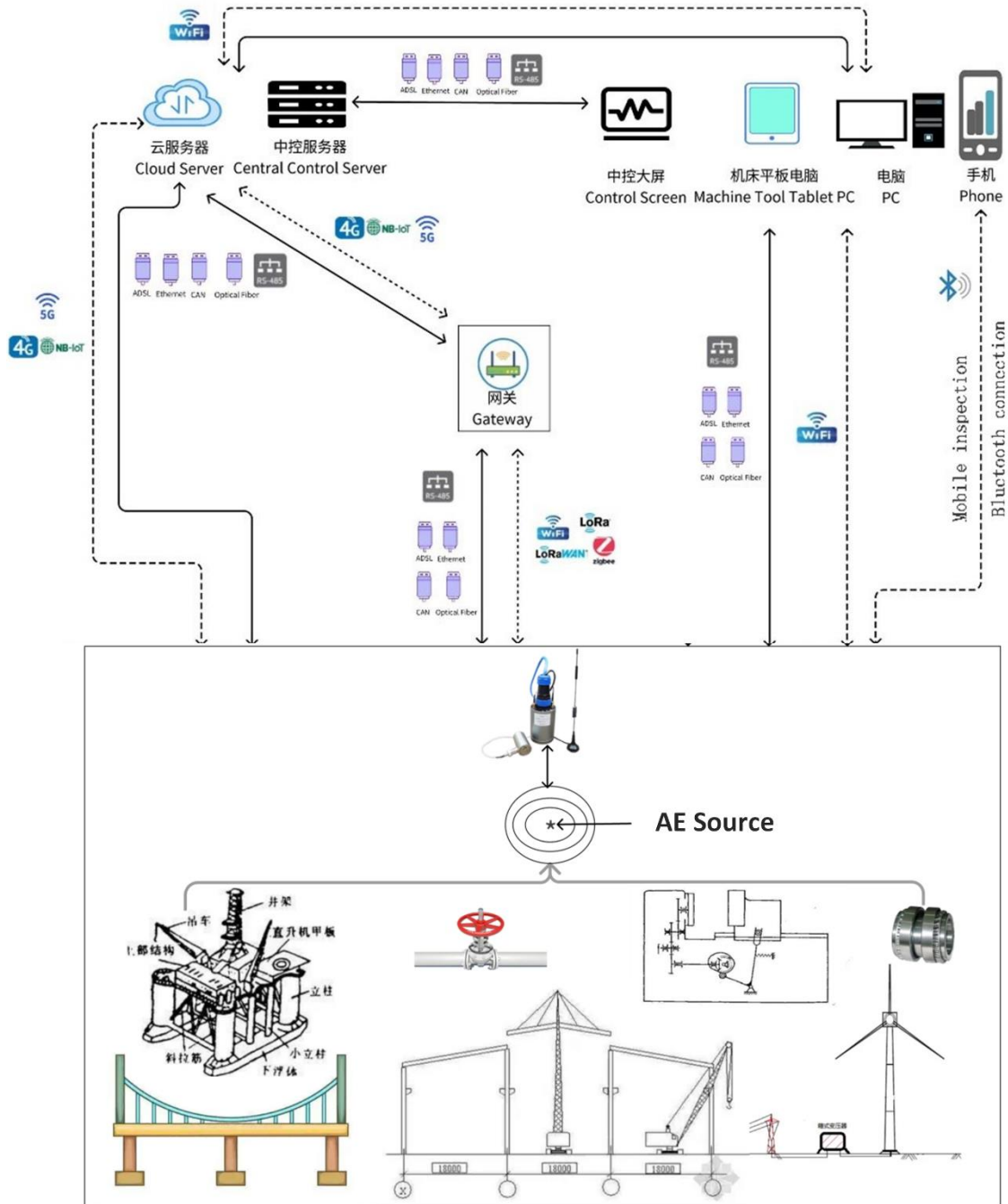
### 1.3 Advantages

- 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 It is suitable for damage monitoring and detection of structural parts of various materials, Such as all kinds of materials bridge, wind power, tools, storage tanks, operating platforms and other equipment structural parts of the damage monitoring and detection.

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



System diagram

2.2 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 detection/remote long-term monitoring detection and other application modes.

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

### 3 Main Hardware and Software Introduction

RAEM1 series remote Acoustic Wave (acoustic emission) monitoring system:

<b>System Composition</b>	RAEM1 collector, Platform, Client terminals
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(Multiple collectors can be composed of multi-channel monitoring system, real-time monitoring of large equipment)



#### 3.1 Configuration table

<b>Sensor</b>		GI140 Narrow band built-in preamp integration	
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<b>Collector</b>	Name		RAEM1 Collector
	Communication mode	Wired	RS-485
			CAN
			LAN
		Wireless	4G
	WIFI		
	Bluetooth (Mobile phone Bluetooth inspection)		
	LORA (Networking)		
<b>Terminal output</b>	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 Cloud Platform

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



QingCheng Cloud

Ali Cloud

Amazon Cloud

### 3.5 Parameter

<b>Channel</b>	Single, or multiple-channel	<b>Sample resolution</b>	16-bit
<b>Trigger</b>	Threshold or time trigger	<b>System noise</b>	Better than 30dB
<b>Sample rate</b>	Up to 2M points per second	<b>Dynamic range</b>	70dB
<b>Protection</b>	IP65	<b>Input bandwidth</b>	10kHz-1000kHz
<b>Supply</b>	12VDC	<b>Weight</b>	220g
<b>Analog filter</b>	Two high-pass filters: 30kHz, 125kHz; two low-pass filters: 80kHz, 175kHz; Factory default combinations: 30kHz~80kHz, 125kHz~175kHz.		

<b>Digital filter</b>	256-order FIR filter, in the frequency range of 0kHz~1000kHz, any value can be set as pass-through, high-pass, low-pass, or band-pass filters.
<b>Sensor</b>	Integrated sensor series (3 types of integrated preamp available): 28V40dB, 12V34dB, 5V26dB
<b>Data output</b>	Waveform, parameters, alarm ratings
<b>AE featured parameters</b>	Arrival time, amplitude, counts, energy, rising time, duration, RMS, ASL
<b>Storage capacity</b>	64G (expandable to 512G)
<b>Communication</b>	4G, Ethernet, Wi-Fi, RS485 (can customize communication means according to requirements, e.g., NB-IOT, LoRa)
<b>Temperature</b>	-20℃~60℃ (Wi-Fi: 0℃~60℃)
<b>Dimension</b>	Cylinder diameter $\phi$ 62mm, height = 100mm
<b>Installation</b>	magnetic base, which can be attached to the surface of magnetic absorption

## 4 Solutions & Case

### Case:

For a certain tower, focus on the welding seam to carry out online acoustic wave (acoustic emission) monitoring of structural parts damage, long-term monitoring of the tower defects in the production process, positioning and evaluation of expanded defects.

Check tower monitoring data for 18 months from monitoring.

Comprehensive Level (5): intact (level 1); 1/2 life remaining (level 2), 1/3 life remaining (level 3), 1/4 life remaining (level 4), 1/5 life remaining (level 5)

Tower 1	Month 3	Month 6	Month 9	Month 12	Month 15	Month 18
Counts	158881	220201	346871	387122	469630	634722
Comprehensive Level	1	1	2	2	3	4

### 4.1 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.

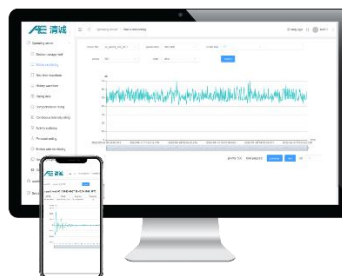


FIG. 1:1 Tower No. 1 Channel (qc raem1 test 0015)

Corresponding levels at the 3rd, 6th, 9th, 12th, 15th and 18th months are respectively: 1, 1, 2, 2, 3, 4

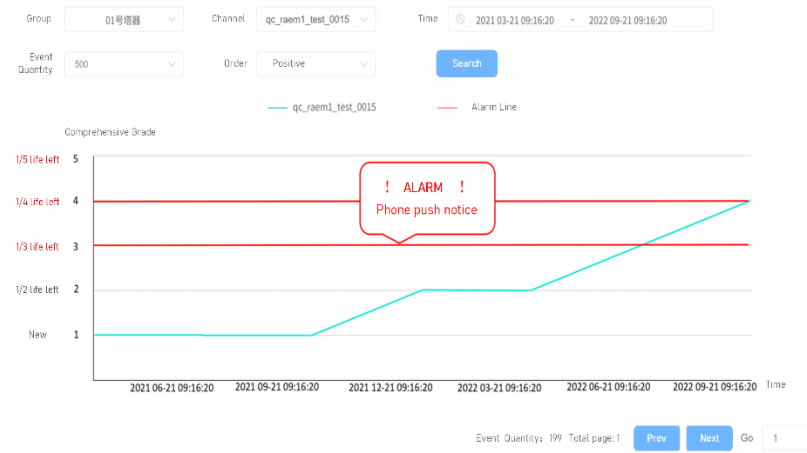


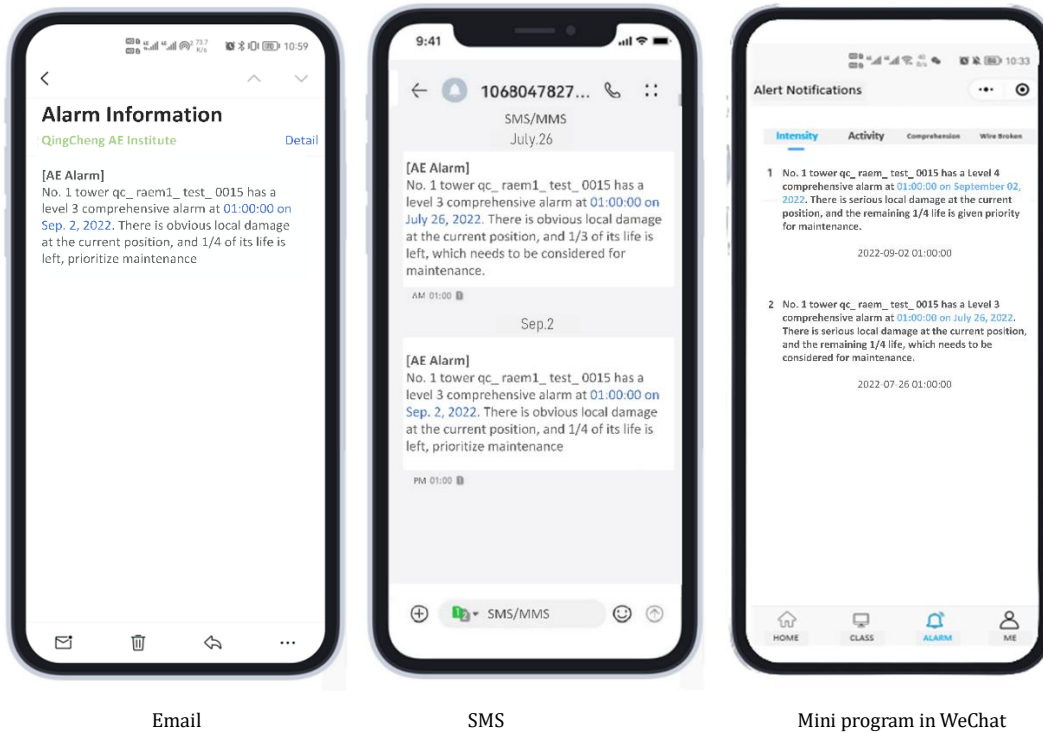
Figure 2:1 Multi-channel Counts display of tower No. 1



## 4.2 Mobile phone push

4.2.1 When the alarm limit is reached, the phone pushes the alarm information. Alarm methods: small program, email, SMS, APP.

4.2.2 According to the data of the No.1 tower of the cloud platform, the level 3 alarm line was touched in July 2022, and the level 4 alarm line was touched in September 2022. Mobile phone receives alarm push synchronously.



Email

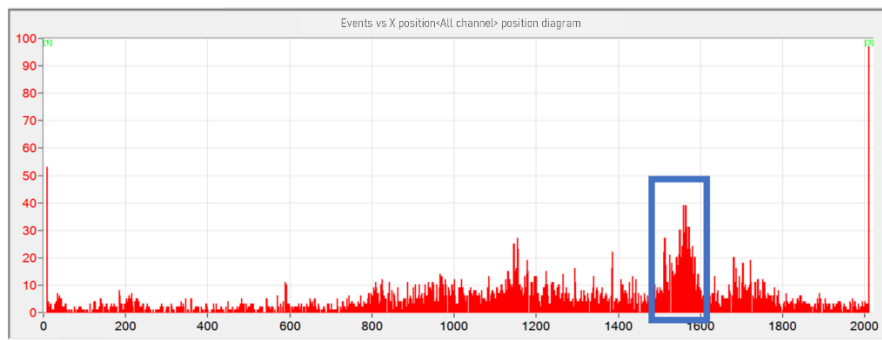
SMS

Mini program in WeChat

#### 4.3 SWAEU3H Software

4.3.1 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.

**Operation:** Obtain the data set of effective damage source signals, and conduct statistical analysis on the data of effective signals, such as linear positioning of the damage location.



4.3.2 Automatic detection and rating, remote viewing, active push alarm:

4.3.2.1 **Data is automatically acquired at the set interval.** Set K value as the automatic rating criterion, automatic data processing, automatic analysis to obtain the acoustic emission detection level of each tower.

4.3.2.2 The tower's rating and other specific data can be viewed at any place by accessing the cloud Internet of Things platform with a computer or mobile phone.

4.3.2.3 **Set the alarm level.** For example, when the comprehensive level 3 is set in the case, the alarm

will be automatically reported. When the level 3 is reached, the alarm information will be actively pushed to the specified mobile phone number and reminded to take maintenance and other measures.

## 5 Practical Cases Study



- The deformation and crack propagation of materials under stress are the important mechanism of structural failure.
- Acoustic wave (acoustic emission) nondestructive testing technology can infer the damage situation and development, and predict the damage occurrence and development trend of structural parts.

### 5.1 G50 Online crack detection of steel plate in Yichang Yangtze River Highway Bridge of Hu-Chongqing Expressway

Acoustic emission (AE) on-line monitoring of steel plate cracks on bridge deck of G50 Shanghai-Chongqing Expressway Yichang Yangtze River Highway Bridge



FIG. 1 Yichang Yangtze River Bridge



Figure 2 Sensor installation



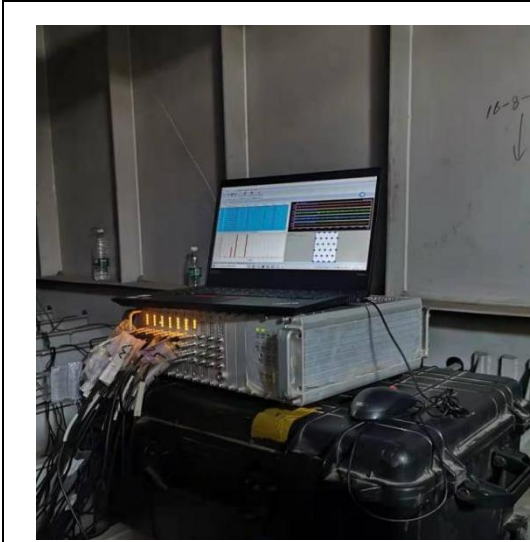


Figure 3 Signal acquisition by the host

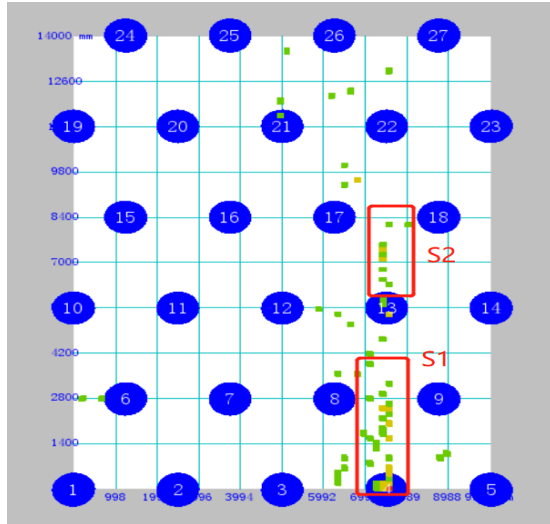


FIG. 4 Detection results

## 5.2 Inspection of 1000 cubic spherical tanks of Yangzi Petrochemical



- In the process of inspection in April 2001, a large number of cracks were found on the inner surface of the fusion line of the butt weld, so dehydrogenation treatment, welding repair and overall stress relief treatment were carried out. After passing the hydraulic test, it has been used until now.
- Our company carried out acoustic emission detection on 1000m<sup>3</sup> liquefied gas spherical tank, adopting two methods of overall monitoring and local monitoring. A total of 23 effective acoustic emission sources were found, among which 21 had cracks and defects in the reinspection.

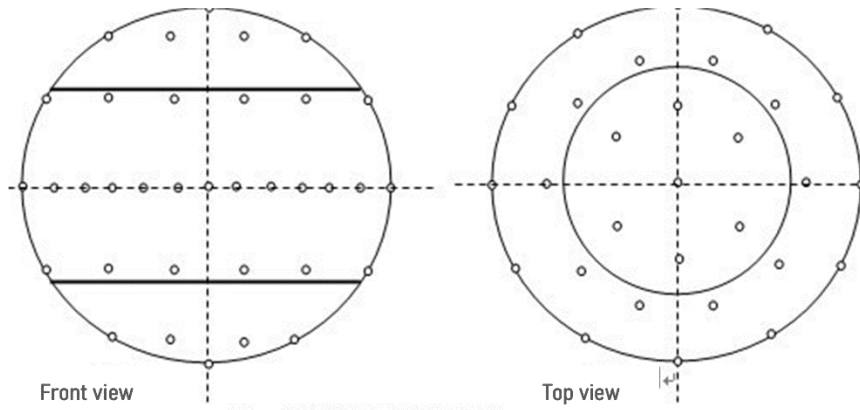


Fig.1 Sensor installation diagram

- Local monitoring: A total of 32 sensors (two layers in total) are distributed around the upper and lower annular cracks and arranged in a circular shape. The specific positions of the probes on the container are shown in Figure 2.

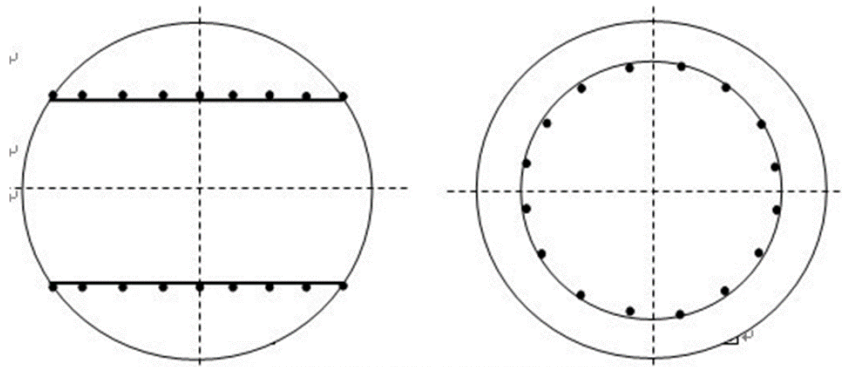


Fig.2 Local monitoring sensor installation diagram

- The pressure test procedure of acoustic emission detection adopts the process of two pressure cycles, and adopts the way of filling clean water to boost pressure, in accordance with the requirements of GB/T18182-2000 and combined with the actual situation of the spherical tank site.

### 5.3 Acoustic (acoustic emission) diagnosis of hammer cracking during diamond synthesis



- In the process of synthetic diamond, the cuboid core material is loaded by six hammers. When one of the hammer loading surfaces is cracked, if the machine cannot be stopped in time, the six hammer will collide with each other and all of them will be scrapped. Before, the human ear inspection was carried out by the whole manual, and when the abnormal acoustic was heard,

the machine would run to stop the machine, which had low efficiency and high missed detection rate. Therefore, the acoustic emission online monitoring technology was introduced to monitor the synthesis process of the press in real time, send an alarm to the cracking signal, and trigger the shutdown mechanism of the synthetic press.

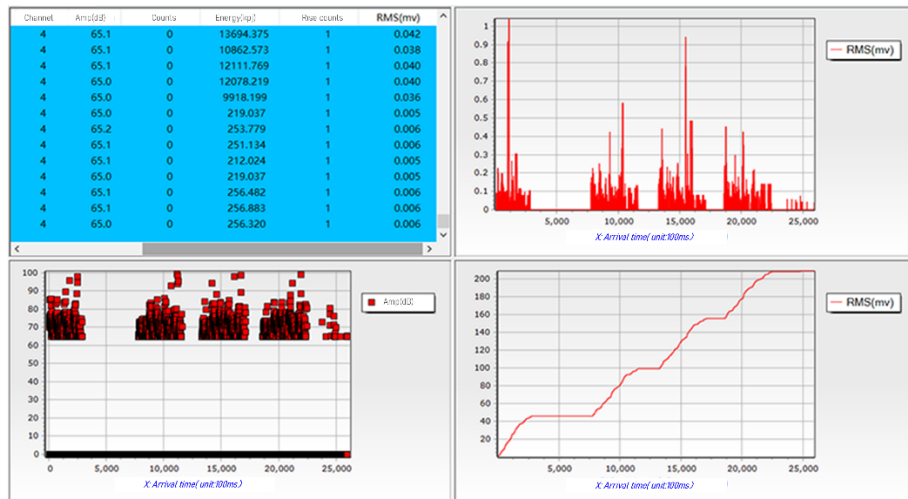
- The dynamic range of detection can be improved effectively by using analog and digital filters to dedryness. Using the unique event generation mechanism of acoustic emission and spatial filtering, the location of source can be accurately identified and the cracking signal of the hammer can be judged.

#### 5.4 Monitoring of the main shaft bearing of the lift winch

- The instrument layout is battery powered, and a communication module is added to upload the alarm signal to the cloud server and push it to the mobile phone.



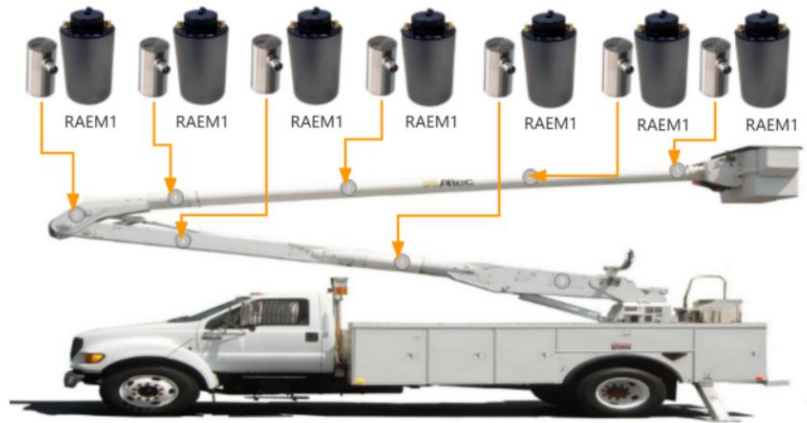
Monitoring site diagram



Data display diagram

#### 5.5 Acoustic wave (acoustic emission) detection of the curved arm high-altitude working platform

- The fault of the cantilever high-altitude working platform usually occurs in FRP, or the crack fracture of the metal cantilever, and the unbalanced toppling of the platform.

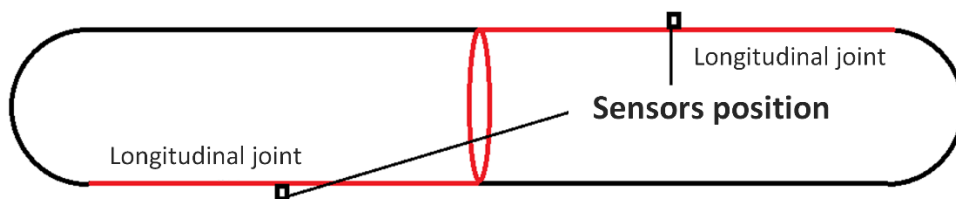


- The acquisition module is arranged at the part that needs to be detected on the high-altitude operation platform of the curved arm, and the collected data is uploaded to the cloud platform. Through certain algorithms, it can determine whether there is a fault or hidden danger, judge the severity of the fault and determine the fault location, and push the alarm message to the client to avoid the occurrence of major accidents.

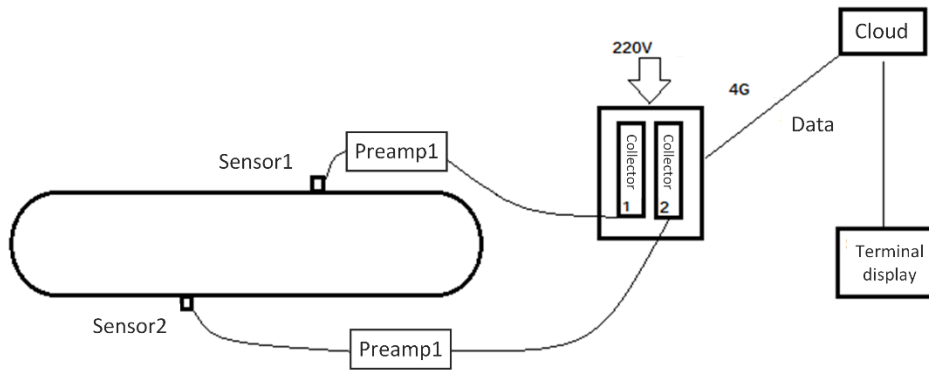


### 5.6 Acoustic wave (acoustic emission) monitoring scheme for high temperature pipeline welds

- For the monitoring of two longitudinal cracks on the container, two RAEM1 single-channel acoustic wave (acoustic emission) monitoring modules are used. Each module contains a high temperature sensor (350°C) with a resonance of 150KHz for crack detection, a broadband 40dB amplifier and a collector.
- Partial insulation layer is broken in the middle of each monitored weld, and the acoustic emission sensor is attached near the weld and fixed. The sensor, amplifier and acoustic emission collector are connected through coaxial cable, and then the insulation layer can be restored. The acoustic emission collector needs 12V DC power supply, and the location of the collector can be determined according to the actual situation on site.



Sensor layout diagram



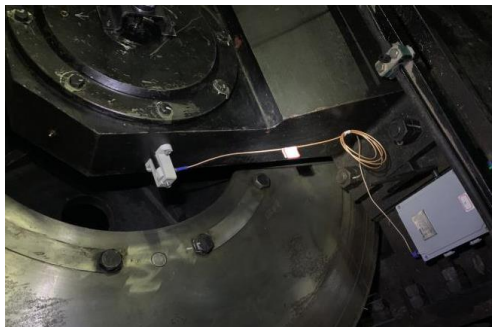
System connection diagram

● **Implementation:**

- ✓ 24/7 monitoring of the occurrence and expansion of defects in the running state of the container;
- ✓ Make use of the development trend changes of signals generated by defects to provide assessment basis for the safety state of container operation;
- ✓ Based on the processing of a large number of operation data, set the safe operation state warning of the container, and automatically alarm when the defect activity reaches a certain level;
- ✓ Evaluate the safety status of containers according to defect signal development during the operation of containers over their life, and scientifically extend the service life of containers.

6 Conclusion

- The acoustic wave (acoustic emission) monitoring and detection of structural damage are realized, and the damage level is pushed to the user. Users can timely carry out corresponding maintenance according to the grade, so as to prolong the service life of structural parts and prevent accidents and losses caused by the failure of equipment structural parts.



**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.