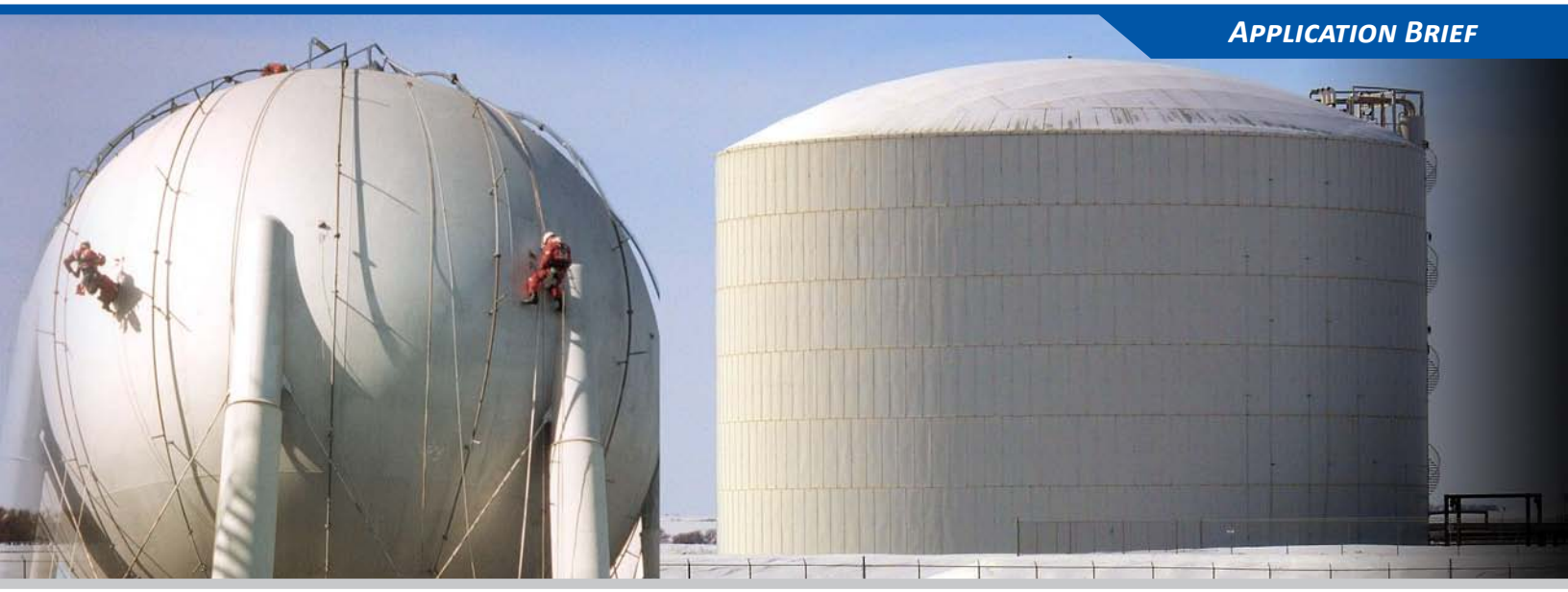
MISTRAS
Asset Protection Solutions | Services Division

APPLICATION BRIEF



In-Service Testing of Refrigerated Storage Tanks & Spheres with AE

BACKGROUND

Acoustic Emission (AE) testing was developed for a wide range of applications including the assessment of structural integrity on pressure vessels and storage tanks.

Acoustic emission is the elastic energy released by materials when they undergo deformation. In metals, emission can be caused by a number of mechanisms including stress corrosion cracking, weld cracking, etc. Its use on product storage equipment has been on tanks & spheres containing high-risk products such as ammonia, butane and propane.

The method is written into the ASME Boiler and Pressure Vessel Code (Section V Article XII) and is also extensively used to test other pressurized equipment and atmospheric equipment.

TEST PROCEDURES

For storage tanks, the method assesses wall and bottom-knuckle integrity. High frequency AE sensors are typically attached at a 4-6 meter spacing over the entire test area. For double wall tanks or tanks where the insulation is very thick, the sensors are mounted on waveguides.

The fluid level in the tank is then increased while monitoring for acoustic emission. The increase will depend on the history of product in the tank as well as the level of certification required.

For spheres, the method assesses shell integrity and leg to shell attachment welds. Just as with tanks, high frequency AE sensors are attached at typically a 4-6 meter spacing. If there is thick insulation, the sensors are mounted on waveguides.

The test is a two step procedure; First the fluid level in the vessel is increased while monitoring for acoustic emission. The increase will depend on the history of product in the sphere as well as the level of certification required. Next, the pressure in the sphere is increased to 10 % over the maximum it has experienced during the previous six months.

Following the test, the AE data is processed to remove any extraneous noise. The severity of emission is then assessed against a database. This method gives a clearly-defined grading system with interpretation and recommendations

In some cases, it is possible to obtain a more precise indication of the emission source by analyzing arrival times for the stress waves at each sensor in the same way that earthquakes are located. For this to be possible, the stress waves must be energetic enough to reach three sensors. This is most likely the case where cracking is the source.

Grade	***Interpretation***	***Recommendation***
A	Very minor source	None
B	Minor source	Visual external inspection
C	Source further	Evaluation/possible NDT
D	Active source	Immediate follow-up NDT
E	Intense source	Immediate action

AMMONIA SPHERE RECERTIFICATION EXAMPLE

Business need

- Recertify 60 year old sphere
- No previous inspections and minimal construction drawings
- Perform work on line without internal inspection or insulation removal

Services Provided

- FEA of sphere - determine location of high stress areas
- Surface inspection of those areas
- Leak Before Break Analysis
- PMI of material
- Phased Array Inspection of “T” joints
- Hardness testing
- UT Thickness measurements in selected areas
- AE in service test
- Phased array inspection of defects found in AE test
- Fitness for Service per API 579
- 24/7 Online monitoring of defects

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BENEFITS OF AE TESTING

Global Monitoring - Sensors detect AE signals from considerable distances, making this method ideal for global monitoring of large vessels and systems. Identified problem areas can then be inspected using other NDT methods.

Minor Disturbance of Insulation - Only small holes in insulation are required for sensor mounting. Waveguides are used to contact the surface. Sensors are then mounted outside the insulation.

On-Line Testing – Opening a tank introduces oxygen into the tank. When the tank is put back into service the stress corrosion cracking process starts all over again. For most storage vessels, on-line testing is possible either by filling it with product, introducing gas into the vapor space, controlling the temperature or other process parameters.

Cost Reduction – In ammonia applications, it can cost up to $1,000,000 just for a nitrogen purge. The cost increases further when you add thousands of dollars for scaffolding and the cost of traditional ultrasonic or other inspection, not to mention lost production time. The use of AE can reduce plant maintenance costs considerably, while increasing the information available about plant integrity. Plant downtime for inspection is also minimized.

Rapid Inspection - The actual AE test takes a matter of hours, and in some cases, considerably less. No comparable method can provide 100% volumetric inspection in the same amount of time.

Permanent Record of Test - Data is digitized and stored on disk, providing a permanent record of the test that can be reanalyzed at any time.

ADDITIONAL ENGINEERING SERVICES

Finite Element Analysis (FEA) - determines the area(s) of high stresses in the storage tanks so that sensors may be strategically placed to ensure complete coverage in the areas.

Leak before Break Analysis (LBB) - a methodology that means that a leak will be discovered prior to a fracture occurring in service.

Fitness for Service (FFS) - Fitness for service assessment is performed to ensure the tank will operate safely and reliably for some desired future period

Risk Assessment (RBI) - Based on the results of the testing determine the risk associated with operating the tank

Continuous, Online Monitoring - Should there be concern about the tank integrity, 24/7 continuous on line monitoring with Acoustic Emission can be performed.

CASE HISTORIES

Ammonia tank 1: There was no indication of structurally significant defects. The vessel was left in-service and is retested on a periodic basis. The savings compared with decommissioning and internal entry are significant.

Ammonia tank 2: On-line AE testing kept this tank in-service many years past its normal inspection interval.

Ammonia tank 3: This tank was monitored with a total of 128 sensors, showing the unusual characteristic of emitting around the knuckle area as the fluid level was reducing at low level. Careful inspection around that area revealed many corroded and cracked hold-down bolts. Many of these tanks, fabricated from higher strength steels, tend to deform into a "sphere" shape at low fluid levels due to vapor pressure (millibars). This puts tensile stresses on the hold-down bolts that are being over stressed for their physical condition, resulting in acoustic emission.

30m Propane tank: This tank was monitored during a water test, following refurbishment. 64 sensors were used and several AE sources were detected and located. X-rays of these areas were reviewed and in all cases, defects were clearly visible. Since the flaws were located in stiffening-ring welds and were not active at higher stresses, the decision was made to leave them.

Thousands of X-rays are generated during manufacture or major repair of these tanks. It is not uncommon to discover defects in these X-rays after reviewing the location of AE sources.

CONCLUSIONS

The Acoustic emission method of tank inspection can offer considerable financial, safety and environmental benefits by providing information on tank integrity without draining or incurring extensive down time. The tests are non-invasive and pose no threat to the integrity of the tank. When used as part of a predictive maintenance program for tanks and spheres, they allow maintenance resources to be targeted to the areas with problems, thereby minimizing costs while focusing on problem tanks.

When ammonia tanks are taken out of service for inspection and repair, oxygen enters the tank and this tends to restart the stress corrosion cracking process once again.

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