Aboveground Storage Tank Floor Corrosion Condition Assessment

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Fecha de recepción del artículo 13/11/2009*: Fecha de aceptación del artículo:* 13/12/2009

Abstract

The floors of aboveground storage tanks remain a most difficult part of the vessel to inspect for corrosion damage. Generally, this section of the tank is inaccessible from the outside for conventional nondestructive testing (NDT) and the costs of opening the vessel and preparing it for an internal inspection including cleaning, purging and loss of production availability create a significant financial burden for the tank owner or operator. An advanced NDT method with the capability of assessing the condition of the tank floor without opening the tank is acoustic emission (AE) monitoring[1]. The AE method requires installation of sensors on the outside wall of the tank and monitors the floor passively for corrosion damage and its extreme case of leaking at substantially lower cost. AE monitoring is a front-line inspection method that complements the internal inspection techniques. When it is integrated as an input to a risk-based maintenance program, it provides both an enhanced level of tank reliability and significant cost savings over time-based periodically scheduled internal inspections[2,3]. This paper provides an overview of the AE inspection method as applied to tank-bottom plate condition assessment, a brief description of its use in a risk-based maintenance program including a case study of the practical use of AE monitoring for tank bottom inspection.

Key Words

Emisión Acústica, Tanques Atmosféricos, Corrosión, Análisis de riesgo, detección de fugas.

Introduction

Acoustic emissions are stress waves produced by sudden release of the elastic energy in stressed materials. Classic acoustic emission sources include defect-related deformation processes such as crack growth and plastic deformation that release of elastic energy some of which is converted to stress wave propagation in and on the surface of structural element. Leaking gases and liquids also cause acoustic emission. In the case of aboveground storage tanks (ASTs), the sources of interest are the *fracturing of corrosion product* as an indication of corrosion emission from leaks.

Sensors, typically piezoelectric, mounted on the external surface of the shell of the tank near its base detect these stress waves and output an electrical waveform that contains information about the source of emission.

Acoustic emission signals originate in the material itself from active or propagating defects whereas most other methods such as radiography and ultrasonic testing detect geometrical discontinuities, active or not. Emission from defects is excited by applying a load. Most AE tests are carried out under controlled stimulation using systematically increasing mechanical or thermal loading. In the case of AST floors, the fluid load in the tank is used to excite the emission and monitoring is carried out over a prescribed time interval. The remote monitoring capability allows the whole volume of the structure to be inspected globally and non-intrusively as the emissions travel from the active defect through the liquid in the tank to the remote sensors on the outside of the tank. It is not necessary to scan the structure point by point or scanning the structure looking for local defects. This leads to major savings in testing time and the global AE inspection is used to identify areas with structural damage or deterioration and other NDT methods are then used to identify and fully characterize them, if necessary, in terms of shape, orientation and size[3]. This capability has been designated by the authors as ASTIA™, Aboveground Storage Tank Integrity Assessment.

Astia procedure

The ASTIA™ procedure involves AE monitoring of the tank for a period of one hour to identify damage and prioritize these tanks for maintenance or/and complementary NDT. A ring of AE sensors is mounted equidistant around the outside circumference of the tank wall at approximately one meter up from the bottom, and are monitored in the frequency range of 20 – 100 KHz. Following a period of conditioning of 12 to 24 hours to minimize ambient noise during which valves are closed and heaters/agitators turned off the tank floor is monitored for the fracture of corrosion products and leakage that are active during a one-hour test period. Time of arrival differences at the sensors in the array on the outer shell are used to compute the location of the emission. Each channel has the capability to measure amplitude, adjust thresholds, filter signals outside the range of interest, and store digital records of all AE signals.

Use of the AE data

ASTIA is a system which can separate 'good' tanks from 'bad' and so direct maintenance to where it's most needed. Basic input from a maintenance management point of view is the overall condition of the floor expressed as an overall tank grading. The grading is developed first by analyzing the acoustic emission data accumulated during a one-hour monitoring period to identify and locate overall corrosion and potential leak activity. Special filters separate corrosion and leak data from the total data set and the location of these data are diaplayed on a plan view of the tank bottom. After the analysis and interpretation, the acoustic activity is expressed as:

- "Overall Corrosion grading" that is graded A to E Table 1.
- "Potential leak grading" that is graded 1 (Very minor) to 5 (highly active)

Potential leak grades 1 through 5 are based on the number of active acoustic emission events emitted from any one cluster of acoustic emission activity. The data is characteristic of severe localized corrosion damage, grade 1 indicating no or minor damage and 5 indicating a highly active location. Not actual leakage, but a future "potential leak" location.

Table 1. ASTIA Overall tank floor corrosion condition grading guideline

Overall Corrosion Grading	Floor Condition
A	Very minor/No Damage
B	Minor Damage
C	Intermediate damage
D	Active damage
E	Highly active damage

The combination of the overall corrosion grade with the "potential leak" grade, (PLG) gives the tank owner the composite grade and thus, a reference on the time recommended before the next inspection, based on the risk matrix In Table 2.

Table 2. Tank Bottom Risk Matrix

	Overall Corrosion Grading				
PLG	A	B	C	D	E
1	I	I	II	II	II
2	I	I	II	II	III
3	II	II	III	III	III
4	II	III	III	IV	IV
5	III	III	IV	V	V

When no full off-line inspection or maintenance is planned, recommendations are expressed in Table 3 in terms of the AE retest interval, varying from ½ to 4 years with increasing AE grade.

Table 3. ASTIA Follow-up Recommendation

Composite Grade	Next Inspection (Years)
I	4
II	2
III	1
IV	0.5
V	Require Internal Inspection

In terms of follow-up recommendations it is mentioned that the AE information should always be combined with the other (historical) information available. When no full off-line inspection or maintenance is planned, recommendations for AE retest intervals are given, varying from 4 to ½ year for increasing AE grade.

Beyond direct classification of condition in terms of AE data, the latter data provide valuable input into more detailed risk-informed, inspection-based maintenance management (RIM™) decision making on whether to repair the damage/defect, replace the tank bottom plate or re-monitor

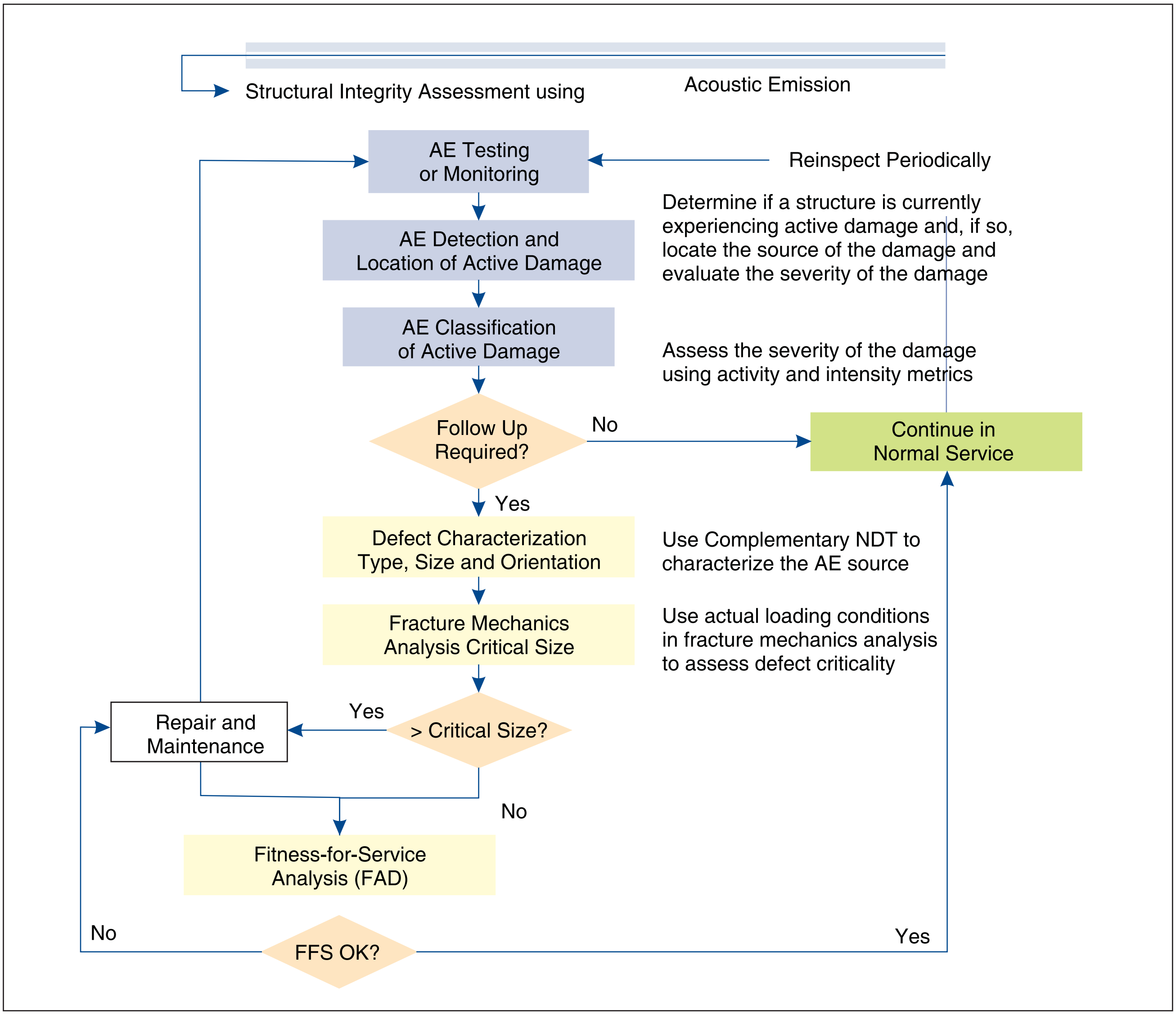

Figura 1. Structural Integrity Assessment using AE

at a later date. This strategy of short-term AE testing of ASTs, allows both early detection of significance and intensity of the damage, and aids the development of cost-effective priority based maintenance procedures depending on actual damage and its significance for structural integrity of the storage tanks. AE complemented by in-service history and experience and integration of this information with Fracture Mechanics (FM) and Fitness-For-Service (FFS) assessment provides a sound basis for responsible care of the tanks[4,5,6]. Figure 1, illustrates how AE provides an initial input into a comprehensive structural integrity assessment program for ASTs.

Case Study

The 10000 m^3 capacity tank in Figure 2 had a visible leak from the tank bottom plate. Sensors were installed around the circumference on the tank walls at 75cm above the bottom to monitor for corrosion damage and leaking for a period of one hour. A plan view of the tank floor in Figure 3 shows the distribution of AE corrosion and leakage events observed during the test. There is a large cluster that reveled after software filtering the leakage location. Figure 4 shows a large number of events at the same place of the cluster, which is the area where the leak was coming from. There are other three clusters related to corrosion.

Figure 2. Visible Leak

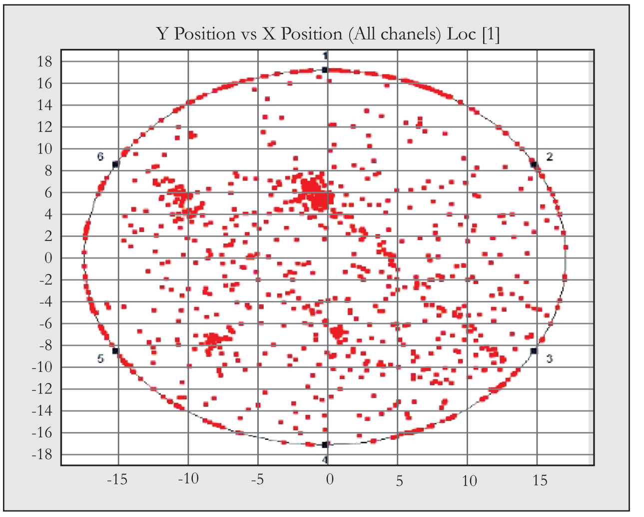

Figure 3. AE events on plan view of the tank floor

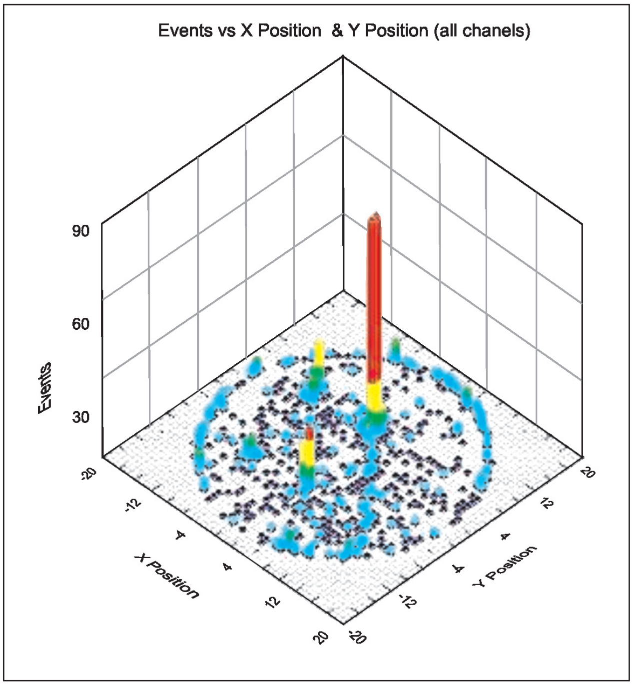

Figure 4. AE activity as a function of location on the tank floor.

Concluding remarks

ASTIA™ has been used successfully on a large number of aboveground storage tanks to assess floor condition and to identify corrosion damage and leaks. Its role in inspection-based maintenance management is as a screening technique for front-line input to risk-informed decision making. The statistical correlation between AE grading and inspection follow-up has in the ASTIA™ experience to date shown a 100% correlation between A-grades and confirmation by follow-up inspection that no repair was required. Increasing AE severity indications correlate well with more damage and larger repair requirements as in the leaking tank outlined herein. This correlation is enhanced using in-service tank maintenance history and AE grading as input to the decision making on recommended follow up actions and prioritizing tanks for allocation of maintenance resources.

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