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APPLICATION REPORT

ACOUSTIC EMISSION TESTING OF OIL TANKERS.

INTRODUCTION: The detection and evaluation of under deck corrosion and early detection of potential cracking in the deck are of a oil tanker has long been a matter of importance, this paper discusses the results of recent studies sponsored by American Bureau of Shipping (ABS), Alaska Tank Company (ATC) and Mistras Group (PAC). This was completed on the first oil tanker that was 32 years old of the double wall design. The AE activity from corrosion products is driven by two main sources, the first is the electrolytic oxidization reaction process and then the presence of action of stress in the structure.
The detection and grading of corrosion in storage tank floors is a well proven technology with a history of several thousand tanks, however this test is a static test and ultra low frequency AE sensors are used to determine the severity and the location of the corrosion.
In the case of an oil tanker the noise generated from sources such as rain, high waves and general running conditions make it difficult to do a successful test using AE. at these low frequencies used for land based storage tanks. We therefore have to resort to higher frequency AE sensors and sacrifice the distance coverage that is obtained using low frequency sensors.
The recent improvements in AE equipment, high speed computers and software, specially the signature recognition software make it feasible to use AE and get good reliable results.

APPLICATION CONSTRAINTS: In order to conduct a meaningful test the following requirements were set:

a. Realtime data acquisition was needed during the voyage of the vessel.
b. The area with the maximum stresses was of main interest. Previous failures in oil tankers indicate that the mid ship section of the deck was subject to the highest stresses,
c. There are two conditions of high stress, when the tanks are empty and the ballast tanks are full this is known as the hogging condition during this the deck is in transverse tension (Port to Starboard) with further longitudinal stresses induced by the Wave action. The second is when the tanks are full and the ballast tanks are empty, the stresses are then transferred to the side walls of the ballast tank area (this application does not address this area, it is planned to conduct this test in the near future)
d. The AE sensors must be intrinsically safe and meet the Shipping safety codes.
e. The AE data collection instrumentation needs to be protected against heavy seas and rain, this requires the use of special bulk head entry equipment.
f. Sea conditions will vary and so will the stresses accordingly, the use of strain gage input data into the data set is a strong recommendation.

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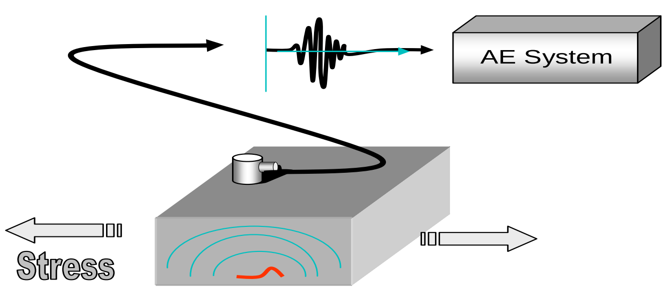
WHAT IS ACOUSTIC EMISSION (AE): Acoustic emissions are elastic energy waves that are spontaneously released by a material undergoing deformation. Acoustic emission testing is defined as a “passive” inspection method for monitoring the dynamic internal stress redistribution within a material that occurs when an external stress is imposed on a component. The stress can be a hydrostatic, pneumatic or thermal.

In an acoustic emission test a network of piezoelectric transducers are attached to a structure. These sensors convert mechanical energy such as elastic waves into an electric impulse that is transmitted by cables to the AE Instrumentation.

As the structure is stressed, the AE instrumentation collects data. Parameters from each emission are measured and then stored within the system data logger. Data from each sensor is stored on separate channels along with the exact time when events are detected. These data are analyzed both during and after the test.

Acoustic emission serves an important function in many industries. It is a global non-destructive examination technique that provides a measure of the structural severity of a defect. As such, it is complementary to other non-destructive examination methods such as radiography, ultrasonics, visual and magnetic particle, which are used for examination of local areas.

How AE Works



- Today’s systems typically use a DSP (Digital Signal Processing Chip)
- The System will:
  - Filter out superfluous noise
  - Extract the desired features
  - Graph features
  - Set-off an alarm if needed
  - Print and Store data

TECHNIQUE: The following sequence of events best describe the way the test was conducted.

a. Selected members from ABS, PAC and ATC did an onboard inspection on the prospective tanker selected for the test and did a walk down and discussion with the Captain and the Chief Engineer of the tanker.

b. A detail scope of work was drawn up and agreed to by all parties. PAC would supply all the AE equipment cables and bulk head fittings.

c. A suitable date was selected and the inspection crew boarded the tanker at Port Angeles during an inspection stop when the tanker in question had no load or ballast ready for the voyage to Valdez Alaska.

d. While the Tanker was in dock the AE sensors cables and equipment was placed on the deck (sensors) and the computer in Cargo load control room, strain gage parametric input was linked up and we were ready to commence the voyage. There where no delays incurred by the AE crew.

e. AE Monitoring was done during the loading of the ballast tanks (while the tanker was heading out to sea).
f. A separate data files were generated to enable the evaluation of ballast loading condition and the voyage conditions.
g. Owing to equipment constraints (number of AE sensors available for the test) the test was conducted with three sensor location set up’s
h. During the voyage the weather conditions varied from cloudy to rainy to dry and the sea state at the start of the voyage varied from 3 feet waves to very calm conditions. We had hoped that we would encounter rougher seas but the conditions we had proved a very good base line for data collection.
i. At no stage did we have any data saturation, the AE data collection instrumentation able to handle all of the conditions experienced during the voyage.
j. Just prior to our arrival at Valdez we where able to dismantle the AE equipment and pack.

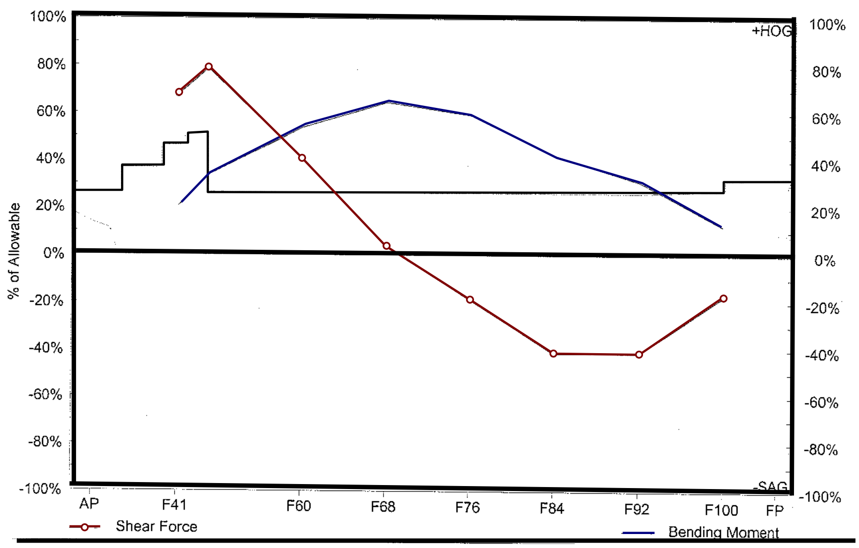


Figure 1. Typical stress distribution during the hogging condition, higher bending Bending moment with lower shear force.

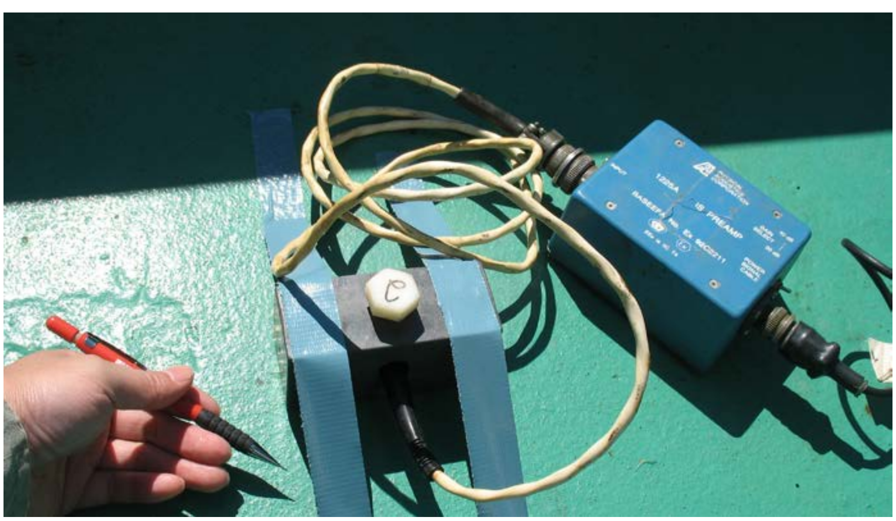


Figure 2. Intrinsically safe AE sensor mounted on the deck using Epoxy and Magnetic hold down. Calibration with 0.3 mm 2H pencil break method.

EQUIPMENT USED FOR THE PROJECT: The following is a list of the equipment used for the project.

a. AE data analysis instrumentation was a 24 channel PAC DISP system with the latest wave form boards and AEWIN software.
b. AE sensors where PAC R15 IS (150 kHz) intrinsically safe.
c. AE preamplifiers intrinsically safe. With special- 600 feet IS cables.
d. Zener barriers.
e. RGP type bulk head entry plug water proof.
f. NDT Automation LSI Ultrasonic 19inch scanning system complete with computer for follow up corrosion mapping.

Figure 3. RGP water proof Bulk head entry.

Figure 4. PAC DISP AE work station located in the cargo control room.

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Figure 5. View of the Tanker deck from the control deck. The area of interest is in the center of the picture.

RESULTS OF THE AE DATA: The following results where recorded during the voyage and show the various stages of the data analysis.

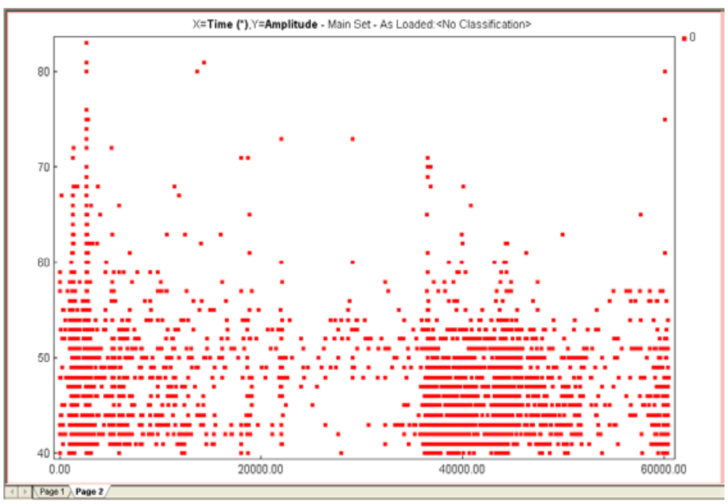

Figure 6. Sample of the raw data before any filtering or signature profiling was done.

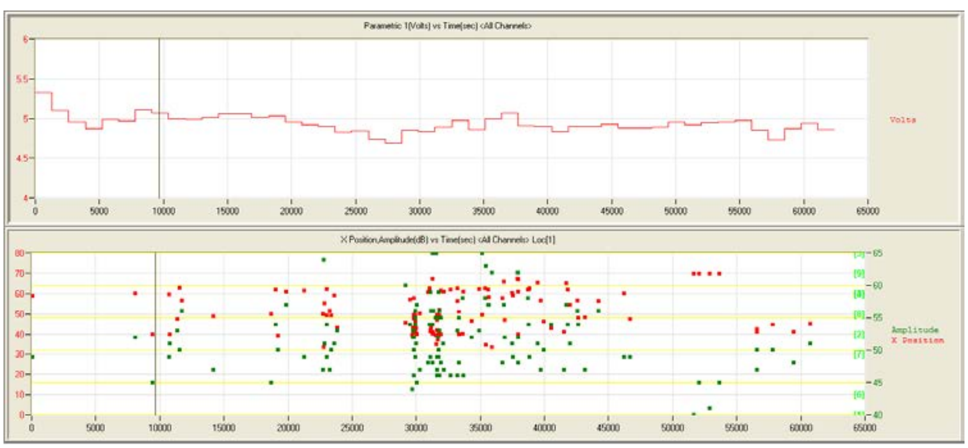

Figure 7. After filtering the data removing activity from rain and mechanical rubbing. The top graph is the recording of the strain gage data and the bottom graph is the AE events recorded, note the increase in events with increase in stress.

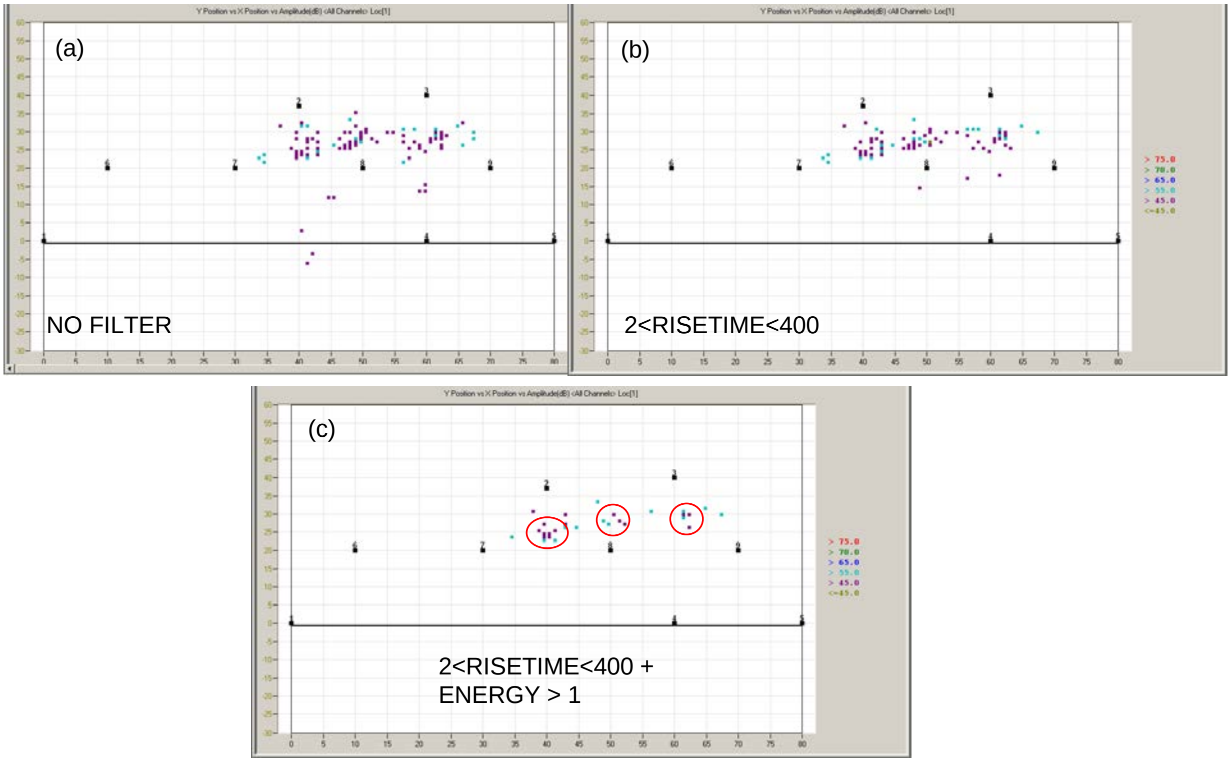

Figure 8. This is the location data of the AE events on the Port side of the Oil Tanker Deck. Note that the first graph top left has not been filtered, the second has a Rise time filter only and the bottom graph has both Rise time and Energy filter. All data was filtered using the Noesis program.

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LSI ULTRASONIC FOLLOW UP: It was important to both confirm and to evaluate the AE results to do this a special LSI (Large Structure Inspection) Ultrasonic scanning system was used with the following results.

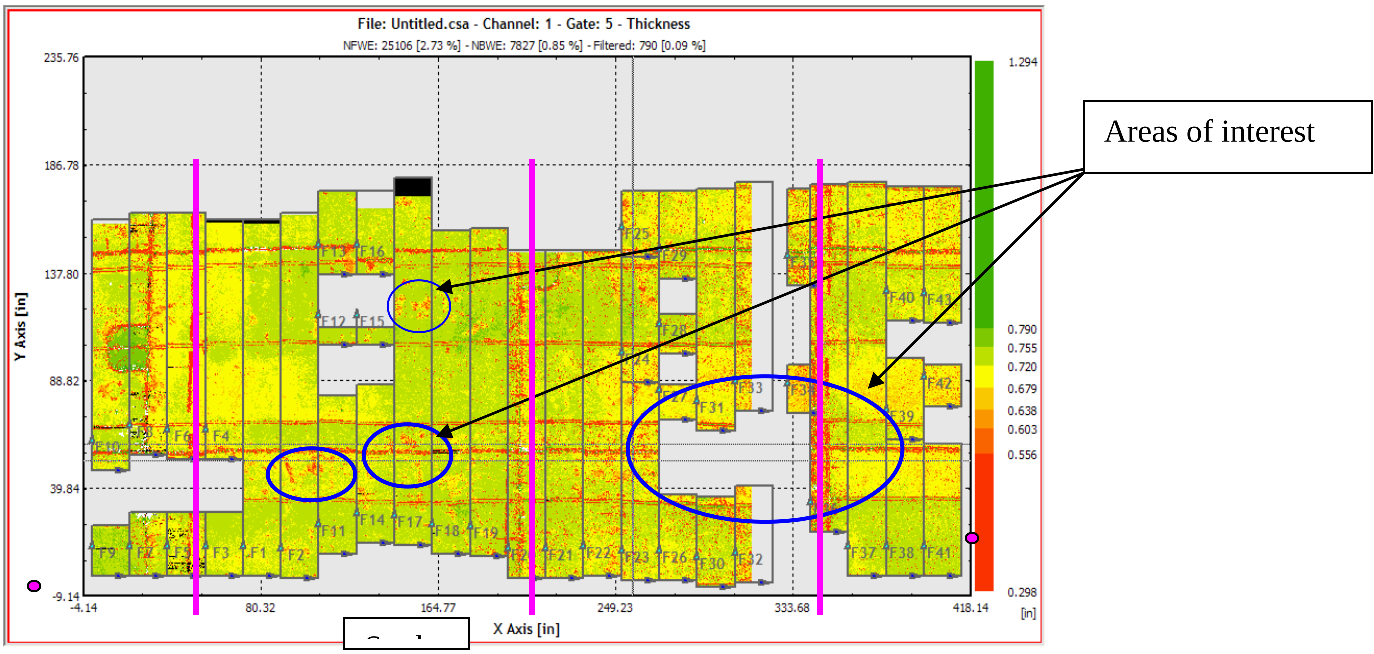

Figure 9. Corrosion mapping of the area of interest the blue circles are the locations detected by the AE field test. Green indicates thicker wall and the light yellow a thinner wall, red indicates the presence of corrosion reduced wall thickness. Horizontal red lines are the welds on the deck plate.

The nominal wall thickness of the deck in this area was 0.75 inch (19mm) and small areas of approximately 2 square inches (50mm) had corroded thicknesses of as low as 0.539 inches (13.69mm).in the areas of interest detected by the AE test and confirmed by the ultrasonic results.

CONCLUSIONS AND RECOMMENDATIONS: From the results of this study it can be concluded that the use of AE to detect the presence of significant corrosion, is both viable and economic, no interruption of the operation of the ship or its crew was experienced during this study. This approach to inspection of the deck area of oil tankers can prove to be far more reliable than the current method of taking the ship out of service for a period of time for the CAIP program. Currently when deck measurements are done five thickness measurements are taken one in each corner of the plate and one in the center and the average of these is used to determine the condition of the deck. It is a proven fact that corrosion is a random occurrence and serious wastage can go undetected.

For further information about the applications described in this document, or any other application you may require, contact. AMERAPEX NDT LLC. by telephone at 713 263 0900 or Fax 713 263 0922 or by e-mail to info@amerapex.com