Testing Fiber Reinforced Plastic Tanks with Acoustic Emission

NDT options for composite tanks and vessels are limited. Visual inspection is commonly performed, but it may not identify delaminations, the condition of the laminate, secondary bonds and so forth.

Acoustic emission testing can determine tank condition from a simple fill test. The method was developed in the early 80's to address a growing problem with catastrophic failures of fiberglass tanks. The procedure has since been adopted by bodies such as ASME (section V, article 11) and ASTM (E-1067).

Acoustic Emission and Composites

Acoustic Emission is high frequency sound produced by crazing, cracking, delamination and other defects when a load is applied. In this case, the load arises from the hydrostatic head of liquid when the tank is filled.

This means the AE test method is sensitive to typical damage occurring in a tank while in service.

AE testing may also be used to test new tanks and check for damage from transportation or installation.

Although an AE test can detect damage and give a measure of its severity, it does not determine the size or exact position of individual defects. The main purpose and benefit of an AE test is to determine if there is a structural problem, approximately where it is and give a measure of its severity.

Brief Description

High frequency (150 kHz) acoustic sensors and specialized instrumentation detect AE activity as a vessel is filled to its maximum operating level. AE data is monitored during the fill to identify any major problems. Further analysis after the test determines whether there are any areas of concern.

AE sources are graded from the least to most severe ('A' to 'D') intensity levels. This is weighed with other factors such as the quality of the data and its correlation with level and time. This allows non-structural sources of AE activity such as fill noise to be screened out such that only AE sources showing a response to the applied load are reported.

Tank Conditioning

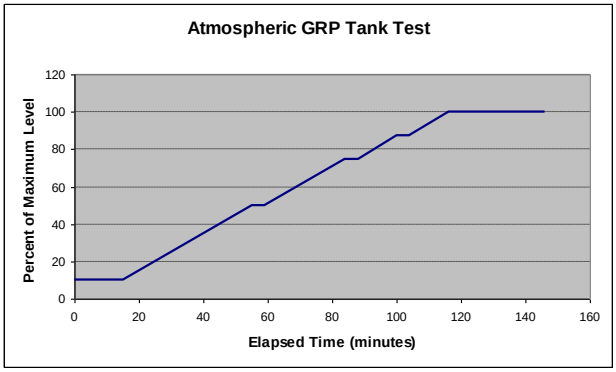
In-service tanks must be conditioned before testing. The table shows the time a tank must be kept at reduced level before testing.

Percent of Maximum Operating Level	Time at Reduced Level
10 or less	12 hours
20	18 hours
30	30 hours
40	2 days
50	4 days
60	7 days

For example, if a tank's level is reduced to 20% of its maximum, the conditioning time before testing is 18-hours.

Test Load

Atmospheric tanks are tested by filling to their maximum operating level as shown in the plot. Testing is best done with the normal contents but water or may be used with adjustments for differences in specific gravity.



The tank is filled from the start level (50% or less) to the test level. This is usually determined from the tank's maximum operating level for the last year. Load holds (4-minutes each) are incorporated at 50%, 75% and 87.5% with a final hold of 30 minutes at the 100% level. The time taken depends on the size of tank and fill rate, 3-4 hours is typical.

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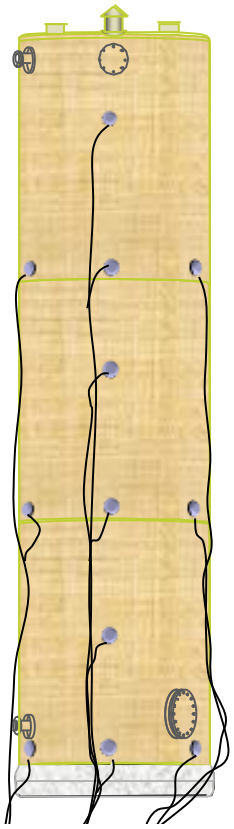
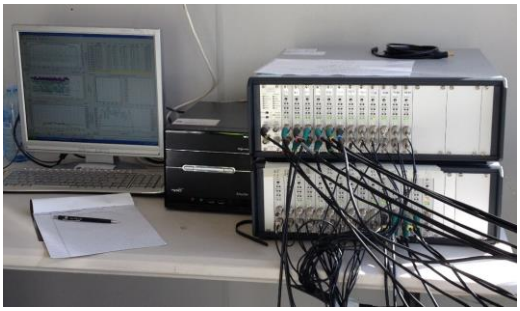
It is important to eliminate extraneous noise sources connected directly to the tank. Filling from a nozzle below the liquid level is particularly important. General plant noise is usually not a problem.

Test Procedure

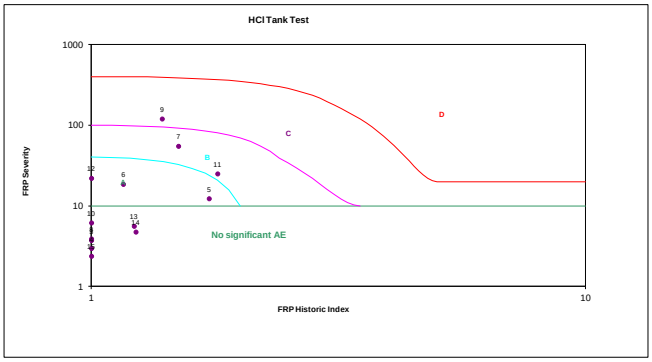
A typical AE test starts by positioning the test equipment, housed in a van or trailer, near the tank, and connecting to 110V power. Sensor positions are marked out and sensors attached to the vessel using tape, glue or other means. Coaxial cables are routed back to the instrument from each sensor. The final stage of the setup is to check the sensitivity of each sensor and instrument channel.



Most FRP tanks (say 3m (10') diameter by 4m (13') high) will require about 16-sensors. Setting up takes 4-6 hours after staging the equipment and receipt of all permits.



Intensity Analysis



Capabilities

- Straightforward test, often completed in a day, minimum disruption to operations. Well established evaluation criteria.
- Provides information about a tank's response to service loads. Detects the effects of defects and damage occurring in-service.
- Gives a measure of the severity of any damage in terms of acoustic emission intensity:
  - **A – Minor:** note for future reference
  - **B – Intermediate:** requires further evaluation. This may be additional analysis, retest or other NDT examination of the area.
  - **C – Possible significant defect:** Immediate inspection of the area. Consider operating at reduced level depending on findings and test more frequently.
  - **D – Possible major defect:** no further operation of the tank until a full examination has been carried out. Major repair or replacement may be required.
- Permanent record of test data, ability to monitor changes in condition over time.

Limitations

- Qualitative assessment only. Does not give an exact measure or location of damage.
- Requires good test conditions, susceptible to rain, wind and other noise sources in direct contact with the vessel.
- Flaws in unstressed areas such as the floor and those that are structurally insignificant will not generate AE.

Preparation

- Plan the test including the conditioning period access and filling arrangements.
- Provide construction details and operating, inspection and repair history.

Services Required

- 110V or 240V AC electrical power.
- Access to the tank for sensor and cable installation.
- Arrangements to fill the vessel and measure the level during the test.

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