

***Prevent Failures of Fiber Reinforced Plastic Structures Using Diagnostic Acoustic Emission Technology***



Integrity Diagnostics provides inspection and monitoring services of **fiber reinforced plastic** structures and pressure equipment **during operation** using **Diagnostic Acoustic Emission (DAE)** technology. DAE allows detection of delamination growth, matrix cracking, and fiber breakage under real operational stress conditions. During operation, operational issues causing flaw initiation and development are often identified. DAE detects internal and surface breaking flaws with no limitation while effectively locating flaws along the piping or vessels. Periodic or continuous monitoring of revealed flaws alerts when repair or replacement is required.

**Proven experience** of Integrity Diagnostics includes inspection and monitoring of wide range of fiber reinforced plastic structures in different countries, particularly:

- FRP piping (water, acid and other)
- FRP pressure vessels
- FRP storage tanks
- Aerospace composite overlap pressure vessels with metal liners
- FRP structures

**DAE Unique Advantages – Increased Safety with Excellent Money Saving**

- 100% examination of structure
- No need to evacuate product or clean
- Reliable detection of flaws, leaks, and evaluation of flaw propagation rate
- Differentiating between developing and non-developing flaws
- Quantitative long-term monitoring of flaws
- Prioritization of structures for maintenance and repair

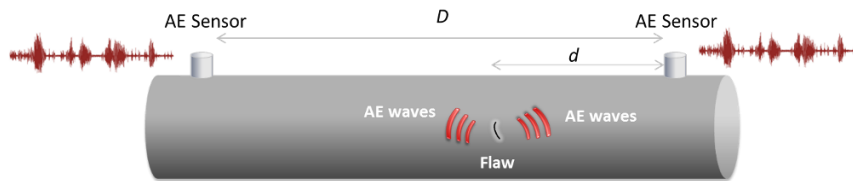




Acoustic Emission monitoring of FRP piping

### What is Acoustic Emission?

Acoustic emission is a phenomenon of sound and ultrasound (stress) wave radiation in materials that undergo deformation or fracture processes.



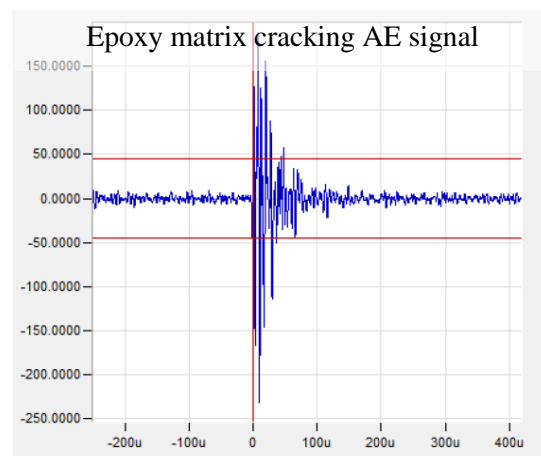
$$d = \frac{1}{2}(D - \Delta T \cdot V)$$

$d$  = distance from first hit sensor

$D$  = distance between sensors

$V$  = wave velocity

**Crack, delamination growth, fiber breakage** in stressed composite materials results in a fast release of potential energy in form of stress waves with frequencies typically between 50 kHz and 1 MHz. These waves propagate along the structure for distances of several feet and are detected by piezoelectric sensors. Special analysis of detected AE waves is then performed to locate acoustic emission flow sources, identify flaw type, evaluate rate of flaw propagation and its sensitivity to load/stress/operational changes.





Multi-channel AE System



AE sensors during monitoring of Reverse-Osmosis  
FRP pressure vessel

## Acoustic Emission Standardization

Acoustic Emission is one of the standard non-destructive test methods with several dozen standards, procedures, and test methods issued by various international organizations such as ASTM, ASME and others. Here are some standards, codes and documents related to use of Acoustic Emission technology:

### ASME

1. ASME **STP-PT-021** – Non Destructive Testing and Evaluation Methods for Composite Hydrogen Tanks.
2. ASME **STP-PT-023** – Guidelines for In-service Inspection of Composite Pressure Vessels.
3. ASME Standard: **Section X, Fiber-Reinforced Plastic Pressure Vessels.**
4. ASME Standard: **Section V, Article 11, Subsection A, Section V, Boiler and Pressure Vessel Code, Acoustic Emission Examination of Fiber-Reinforced Plastic Vessels.**
5. ASME Standard: **Section V, Article 13, Boiler & Pressure Vessel Code, Continuous Acoustic Emission Monitoring.**

### ASTM

1. ASTM **E 1067** Standard Practice for Acoustic Emission Examination of Fiberglass Reinforced Plastic Resin (FRP) Tanks/Vessels.
2. ASTM **E 1118** Standard Practice for Acoustic Emission Examination of Reinforced Thermosetting Resin Pipe (RTRP).
3. ASTM **E 2191** Standard Practice for Examination of Gas-Filled Filament-Wound Composite Pressure Vessels Using Acoustic Emission
4. ASTM **E 1888 / E 1888M** Standard Practice for Acoustic Emission Examination of Pressurized Containers Made of Fiberglass Reinforced Plastic with Balsa Wood Cores.
5. ASTM **E 2478** Standard Practice for Determining Damage-Based Design Stress for Fiberglass Reinforced Plastic (FRP) Materials Using Acoustic Emission.
6. ASTM **E 2076** Standard Test Method for Examination of Fiberglass Reinforced Plastic Fan Blades Using Acoustic Emission.
7. ASTM **E 2661 / E 2661M-10** Standard Practice for Acoustic Emission Examination of Plate-like and Flat Panel Composite Structures Used in Aerospace Applications.
8. ASTM **WK29034 (in preparation)** New Practice for Examination of the Composite Overwrap in Filament Wound Pressure Vessels Used in Aerospace Applications by Nondestructive Testing.
9. ASTM **E 1211** Standard Practice for Leak Detection and Location Using Surface-Mounted Acoustic Emission Sensors.
10. ASTM **E 569** Standard Practice for Acoustic Emission Monitoring Of Structures during Controlled Stimulation.
11. ASTM **E 1316** Terminology for Nondestructive Examinations.
12. ASTM **E 2374** Guide for Acoustic Emission System Performance Verification.