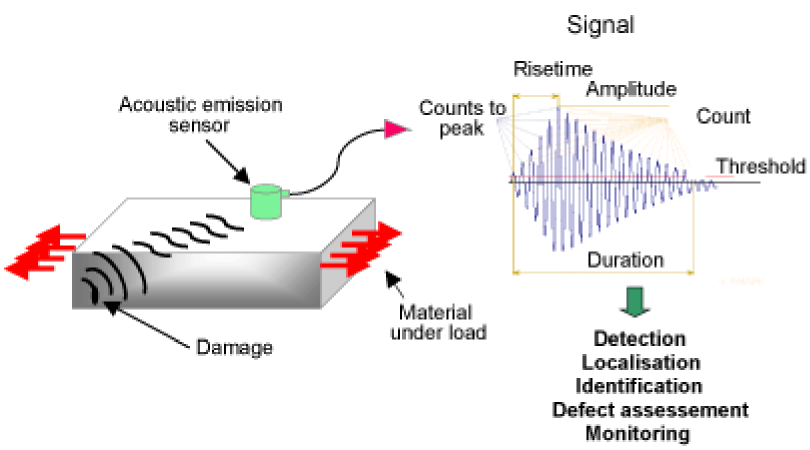
Acoustic Emission

How does it work?

When a load is applied to a solid structure (e.g. by internal pressure or by external mechanical means), it begins to deform elastically. Associated with this elastic deformation are changes in the structure's stress distribution and a storage of elastic strain energy. As the load increases further, some permanent microscopic deformation may occur, which is accompanied by a release of stored energy, partly in the form of propagating elastic waves termed 'Acoustic Emission' (AE). If these emissions are above a certain threshold level they can be detected and converted to voltage signals by sensitive **piezoelectric transducers** mounted on the structure's surface.

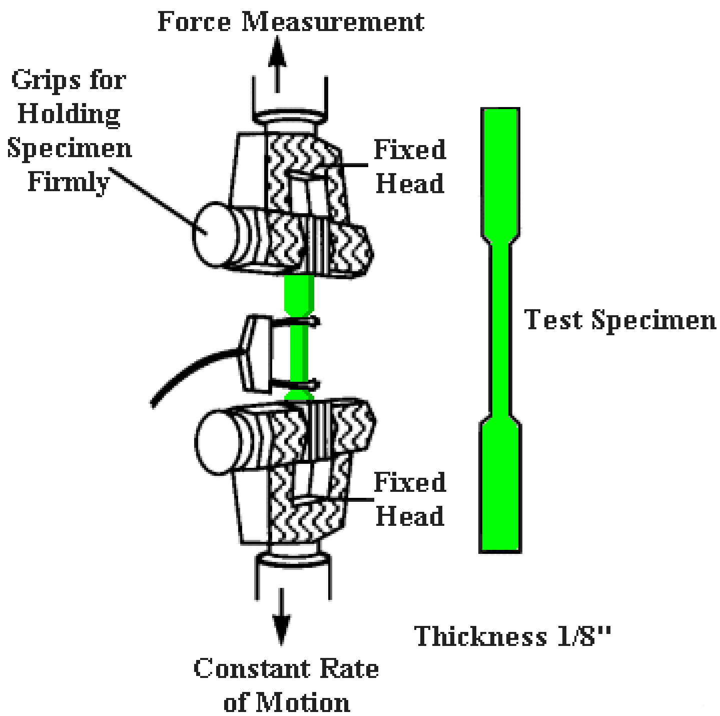


A typical AE system consists of signal detection, amplification, data acquisition, processing and analysis. Various parameters are used in AE to identify the nature of the source, including: count, duration, amplitude, rise-time, energy, frequency and RMS (Root Mean Square).

An important aspect of AE testing is signal processing. There is a need to separate genuine stress-wave emissions, originating from within the material, from external signals, such as environmental noise (rain, wind with sand particles), mechanical noise (movement of the component during testing), electric noise, etc. Much of this is achieved by careful electronic filtering of the received AE data but best practice is still to identify and remove as many sources of extraneous noise as possible prior to testing.

The frequency of the stress waves emitted is normally in the range 30 kHz to 1 MHz. Triangulation and other techniques can give positional information and localise the sources of the emissions.

Acoustic emission refers to the generation of transient waves during the rapid release of energy from localized sources within a material. The source of these emissions is closely associated with the dislocation accompanying plastic deformation and the initiation and extension of fatigue cracks in material under stress. Other sources of acoustic emission are: melting, phase transformation, thermal stress, cool down cracking and the failure of bonds and fibres in composite materials.



Acoustic Emission how does it work

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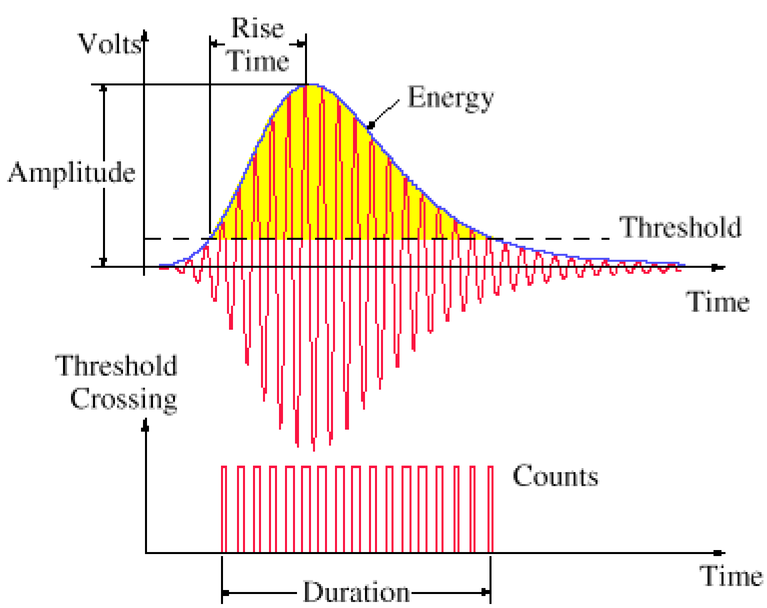
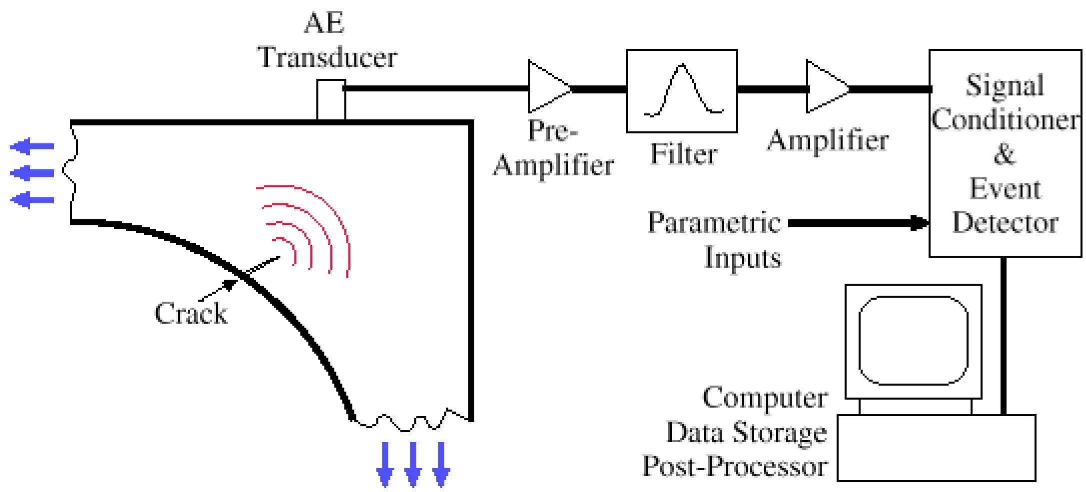
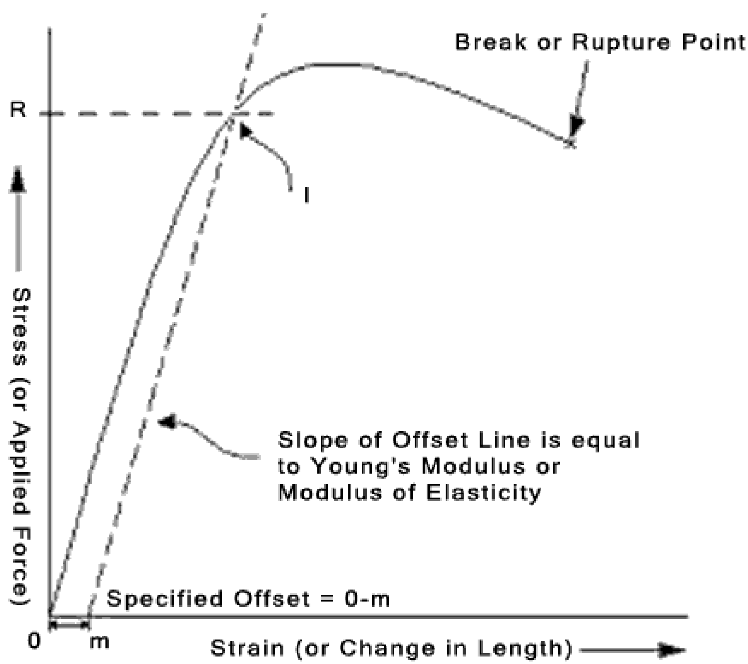
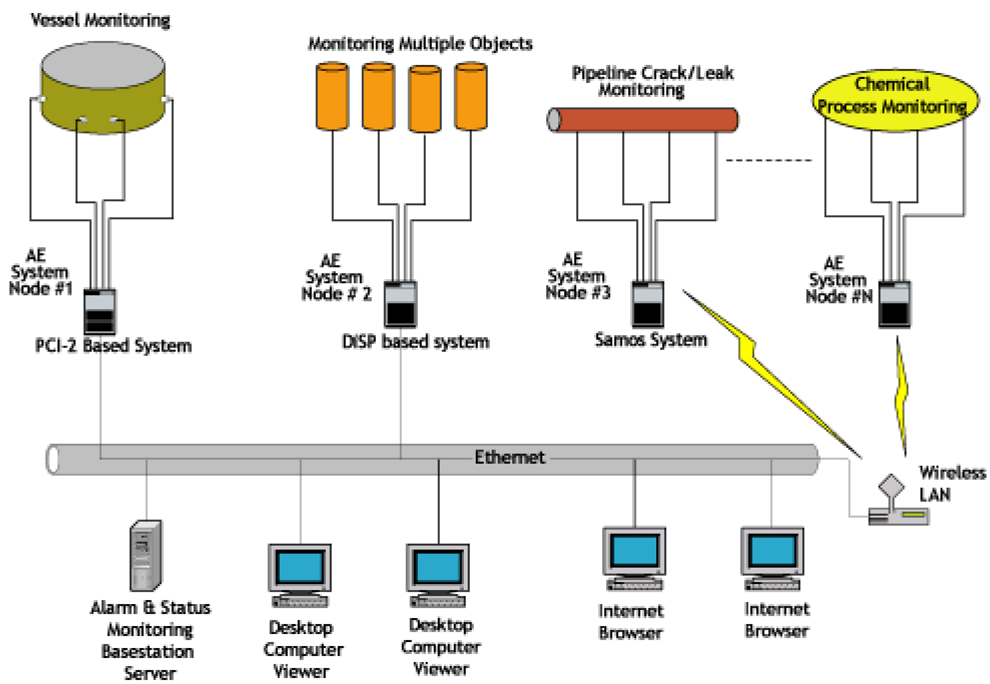






Modules of Elasticity

Acoustic Emission System



What will it find?

Sources of acoustic emission are:

- Plastic deformation, dislocation motion, rupture of the inclusion, phase transformation, twin/slip deformation;
- Different stages of crack propagation (static, fatigue, stress corrosion). AE is sensitive enough to detect newly formed crack surface down to a few hundred square micrometers and less.
- The weld defects: lack of penetration and fusion, cracks, inclusion and porosity;
- Corrosion: localised corrosion / pitting corrosion. Detecting and monitoring of active corrosion, hydrogen embrittlement, corrosion fatigue, and intergranular stress corrosion cracking. Hydrogen embrittlement; dissolution of metal; hydrogen gas evolution; the breakdown of thick surface-oxide films;
- Friction;
- Mechanical impact;
- Leaks (liquid or gas);
- External noise (mechanical, electrical, and environmental).

What kind of Materials can be monitored by AE?

Acoustic emission can be used in non-destructive monitoring of different kinds of materials such as:

- Metals: steels, stainless steel, carbon steel, alloy, ferritic steel, aluminium, aluminium alloys, magnesium alloys, and others (e.g., copper and its alloys, uranium alloys, titanium, and zirconium alloys);
- Composite materials and polymer: sandwich composite, glass-reinforced plastic (GRP) and carbon fibre;
- Concrete, reinforced concrete;
- Rocks;
- Woods.

Where is it used?

- Pressure equipment: Fundamental research and development efforts in the control of the damage in materials by acoustic emission have grown in the last twenty years. This technique has become a reliable and standard method of non-destructive testing for pressure vessels. AE is used to monitor flaws, corrosion, and leakage in pressure vessels, LPG, tanks, piping systems, steam generators;
- For Creep monitoring
- For Strain Measurements
- Fatigue detection
- Condition Monitoring in In-Service Inspection of Pressure Vessel's.
- Aircraft and aerospace: aerospace structures, wings, bulkhead, fuel tanks, Rocket engine, real time monitoring;
- Petrochemical and chemical: storage tanks, reactor vessels, offshore and onshore platforms, drill pipe, pipeline;
- Marine: corrosion, composite shell, engine and power plant;
- Civil engineering: bridges, dams, suspension cable bridges, concrete structure reinforced by composite;
- Research and development: acoustic emission is a good technique to monitor and study the damage in materials and their mechanical properties (new materials, smart materials, Shape memory alloys (SMA)).

What are its advantages?

Acoustic emission testing offers a distinct advantage over more conventional non-destructive techniques:

- Real time monitoring in service structures;
- Cost reduction;
- Time reduction;
- High sensitivity;
- Defect localisation;
- Global structures monitoring;
- Control of non accessible zones;
- No intentional injection of an acoustic signal into the component under test are needed;
- Can be used with other destructive and non destructive techniques.
- There is no health hazardous

What are its disadvantages?

- Highly skilled operator’s required or monitoring system.
- Locating the emission sources can often be a difficult and frustrating process. Emitters can be large or small, conspicuous or inconspicuous, or completely hidden.
- The commonest ones were simple delaminations, usually located in the secondary bonds or around corners having extremely short radii.
- Test failure was most frequently attributable to extraneous noise from such causes as the cracking resin paste, so operator should know the material metallurgy before testing.

How to overcome

By studying the test data, a skillful A.E. technician should be able to see patterns that indicate an emitter's general location. Using this information, performing a careful visual examination of the vessel's interior and exterior surfaces is the next logical step. An examination performed using a strong black light can sometimes be helpful in locating deeply hidden indications, which can then be verified with **ultrasound**. It should be noted that the success of **visual examination** is adversely affected by the presence of a pigmented exterior coating, or of any resin additive that causes laminate to become opaque.

Once located, all repairable indications should be removed, and any new laminate must be given the opportunity to cure adequately before pressurization is again attempted. After the indications and other sources of noise have been properly removed, the likelihood of passing a second test should be excellent.

Conclusion

AE is a developing technology, a field in which there is ongoing research. It is a valuable tool for analysis that will grow in acceptance as its adoption increases.

Because of problems associated with tests, negative opinions do develop. Whenever possible, AE technicians should work closely with manufacturers to eliminate those conditions that can lead to test failures. Successfully doing so will help to eliminate the expense and inconvenience of repeated testing, increase understanding, and improve relationships. The positive long term benefit of this action can be enjoyed by all.

SUNIL B.GAVADE
Mumbai Mobile No:+091-91-9768700717
E-mail: sbgavade@gmail.com