DIGITAL WAVE

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Manufacturer of Ultrasonic Cylinder and Modal Acoustic Emission Test Equipment

MAE™

Modal Acoustic Emission (MAE) Equipment and Testing Services

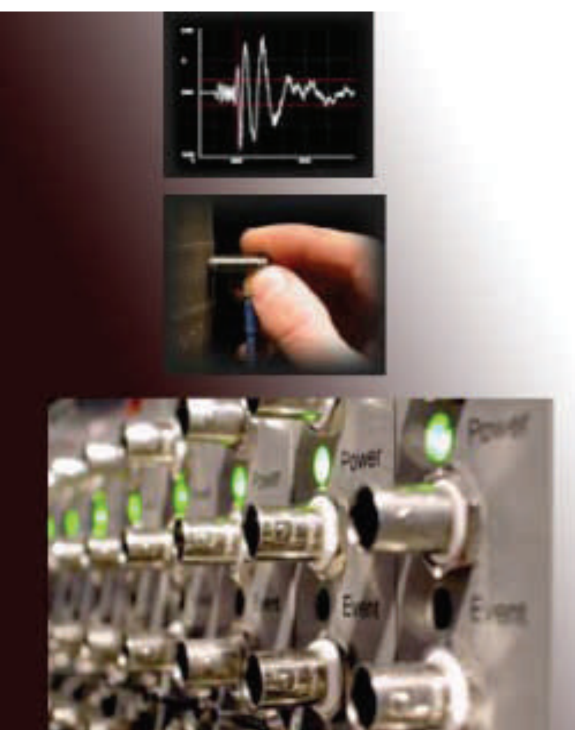
- Locates cracking in structural components, pressure vessels, tube trailers, above ground storage tanks (AST's), aircraft, spheroids, lab specimens and many other applications.
- Detects fiber breaks and delaminations in composites.
- Differentiates between fracture signals and extraneous noise.
- Software performs waveform analysis automatically.
- More precisely identifies crack location than traditional technology.
- Modal AE is used by numerous governmental, manufacturing, engineering and educational facilities.
- Digital Wave will provide MAE inspections of pressure vessels globally.

What is Modal Acoustic Emission (MAE)?

Modal AE is a relatively new nondestructive testing (NDT) method which represents the latest development in the field of acoustic emission. It determines the types of acoustic emission sources in plates, rods, shells, and other thin-walled (up to about 2 inches thick) materials using the shape of the wave mode rather than just counting events with traditional technology.

The basic concepts of Modal AE are easy to understand and use in practical applications. Modal AE has three basic objectives:

- Determining the nature of wave modes
- Accurate source location
- Verifying theoretical models to identify sources of emission



Analysis methods range from basic visual recognition of the wave modes to advanced computational wave propagation, signal processing, and source location techniques.

Using our technology, we provide these advanced services throughout the world. Customer include NASA, ATK, Knoll Atomic Power Lab, Boeing, FPC, US Navy, Los Alamos National Laboratory and numerous universities just to name a few.

Inspections At "The Speed of Sound"

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Basic Concepts

Modal AE uses a high fidelity sensor to capture all of the sound in the test specimen. The sensor is coupled to the specimen under test and then connected to an appropriate broadband preamplifier. As with other types of modal analysis, determining the shapes of the modes and their frequency content is a main analysis objective. Just as vibrational modes have definite shapes, traveling modes also have definite shapes. In modal AE, this information is used to decide whether a signal is due to material fracture or extraneous noise. Unlike stationary wave modes or, more commonly, vibrations, traveling wave modes have definite velocities associated with the progress of the modes across a specimen. Using this information, source position can be triangulated. Structural vibrations can be quite complex and consist of many frequencies; a wave mode, likewise, can be quite complex. Furthermore, the pattern changes as the mode propagates. This phenomenon known as dispersion, which means that each frequency in a mode interferes constructively and destructively; thus, the mode shape changes as it propagates.

The shape is a function of both position and time. Fortunately, the dispersion characteristics of the relevant modes can be predicted by theory and programmed on a computer. Plotting dispersion curves requires only the input of material properties and plate thickness. Automatic source location routines are independent of threshold and gain settings used during the test, and automated mode recognition routines reduce the effort required to locate and identify sources.

Applications of Modal AE

Modal AE can be applied to laboratory specimens or large production structures with no change in the testing procedure or analysis. In metals, this method has been used successfully to detect and locate cracking in small test specimens loaded in tension, compression, shear or fatigue, as well as in pressure vessels during pressurization, leaks aboveground storage tanks (ASTs) and in large aircraft and spacecraft structural components during spectrum fatigue loading. Modal AE allows the researcher to determine the type of failure (e.g. fiber bundle breakage or matrix cracking) occurring in composite materials, based on the frequency content and wave mode shape detected.

Benefits of Modal AE

Basic relationships between AE sources and wave mode excitation have been established for several common material failure mechanisms such as matrix cracking and delamination. Source location based on a given mode and mode frequency is far more accurate than ever before. Various types of noise, ever present in the real world, are distinguished from wave mode by examining the wave propagation characteristics of measured signals and comparing them with theoretical computation. Modal AE analysis, being well-grounded on first Principles of Physics, means that knowledge is sure. Theory can then be used to connect laboratory results to field applications.

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History

Knowledge of the modal nature of wave motion in finite or bounded structures has a long history, but its application to acoustic emission is relatively recent. Modal AE was first applied to composite material laboratory specimens where it was shown that transverse matrix cracks produce a definite wave mode which can easily be measured and counted. This was followed by fatigue testing of 7075 aluminum specimens where crack growth can be positively determined despite the presence of fastener fretting and test machine noise. Modern modal AE testing was stimulated by the introduction of the first modal AE instrument, the Fracture Wave Detector, by Digital Wave in 1992. Modal AE is now a rapidly growing subject of study worldwide.

Distinguishing Between Fracture and Noise

Detecting the onset and growth of cracks can provide great insight into new material design, quality assurance, and structural monitoring. Modal AE allows the researcher to classify individual fracture events as they occur.

In most materials, crack growth produces broadband stress waves that propagate through the material. These waves produce surface displacements on the order of nanometers and in the frequency range of 10 to 2000 kHz. Therefore, modal AE instrumentation must be broadband and very sensitive. Unfortunately, sensors of this design also detect many sources of unwanted background noise, which the instrument must distinguish from fracture occurrences.

Typical field and environmental noise can include electromagnetic interference (EMI), loose fixturing, stiffeners, fretting, mechanical or hydraulic vibration, etc. This noise can overload the data acquisition, causing fracture signals to be missed. Because the noise signals can be random in amplitude, signals of low (or high) amplitude cannot simply be ignored. A simple frequency check can be ambiguous; thus, it can become quite time consuming to look for a relatively small percentage of fracture waveforms out of a large data set.

In order for a software program to distinguish between fracture waves and extraneous noise, criteria must be established. Fracture waveforms have a characteristic shape and frequency content that depend on the source and material propagation. There are some significant signal characteristics that are useful for qualifying fracture waveforms (e.g., the dominance of a higher frequency band over a lower frequency band).

Stripped down to its most basic level, modal AE analysis consists of identifying fracture signals while discounting signals caused by extraneous noise. A trained engineer can identify these signals by sight; in many tests, however, data sets are too large to handle waveform by waveform. To mitigate this, Digital Wave has developed a software package that can perform a great deal of waveform analysis *automatically*.

It has long been known that fracture emissions are broadband and that there is additional information in the complete waveform. Now, with Digital Wave's revolutionary technology, the researcher has the tools to reduce data analysis to a realistic, manageable level.