

AE Waveguides

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Uses of AE Waveguides

AE sensors detect wave excitation on their active surface, which is almost always a ceramic wearplate. Some circumstances dictate that the sensor cannot be placed on the surface where the wave is to be detected. Waveguides extend the monitoring capabilities of a sensor by “guiding” a wave to the sensor. The most common uses for a waveguide:

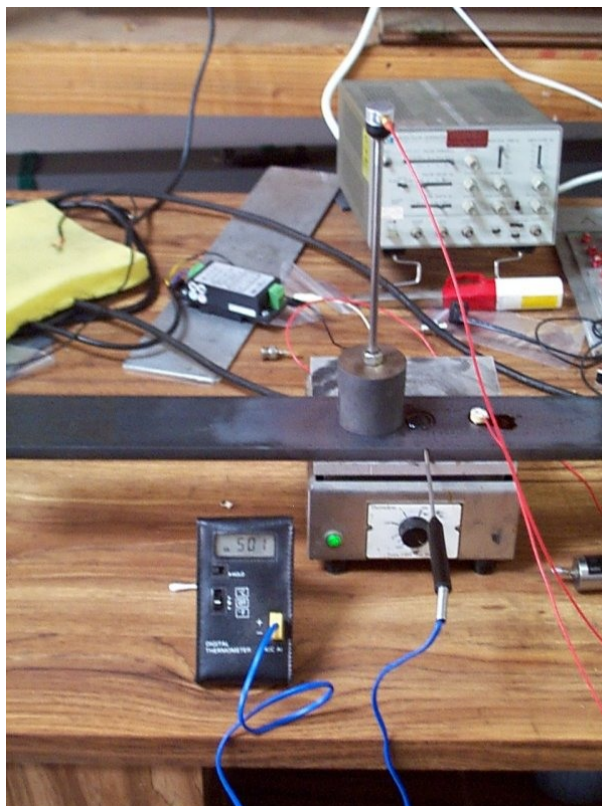
- Thermal standoff – the surface temperature of the test object is too hot for the sensor
- Monitoring in Fluids – waveguides can penetrate fluids to different depths to facilitate wave detection without sensor immersion
- Overcoming high attenuation – in materials with very high attenuation, such as fiber reinforced composites, specialized waveguides can direct waves along path through steel that attenuate signals at a much slower rate.

AE wave propagation is not limited to solids. At the end of this Report, the novel use a fluid column as a waveguide is described.

Design and Features of Waveguides

Waveguides are often stainless steel rods that attach at one end to a test part and the other end just underneath an AE sensor. The figure at right shows a waveguide on a test stand setup including steel bar, thermal plate and temperature measurement. A magnetic mounting accessory is used to keep the waveguide securely on the steel bar. The sensor is permanently mounted on the waveguide.

The length of the waveguide in this instance serves to isolate the AE sensor from the temperature of the structure. Stainless steel is often preferred because it has excellent corrosive resistance and has relatively good thermal isolation in rod form. Stainless steel also is a good mechanical impedance match for steel test objects.



The waveguide end that contacts the surface of the test object can be flat or pointed. If the waveguide is to be attached to the test object by welding, it should be flat ended. If the waveguide sensor has a small aperture, it can be pointed. A pointed ended waveguide will be better isolated from the surface temperature of the test object. One can expect less signal through a pointed tip waveguide than a flat tipped waveguide.

Off-the Shelf Waveguides and Customization

All DECI transducers can be supplied with an integral mounted waveguide and with magnetic hold-down. These waveguides are constructed from 1/4 inch diameter 304 stainless steel of various lengths depending on the surface temperature being monitored. The standard 10 inch long waveguide is adequate in most cases for temperatures up to 200 C. The magnet has a holding force of 80 pounds and is good for continuous operation up to 300 C. An internal spring maintains a contact force of 10 pounds on the waveguide. The waveguide is electrically isolated from the transducer to prevent ground loops from occurring when using long cables and is designed to provide a maximum amount of signal from the waveguide to the crystal in the transducer.

DECI has also customized AE waveguides for specific purposes. The DECI termite tracker is such an application. To detect termite activity in wood, a specialized waveguide to penetrate the wood was developed. A prototype of this waveguide is shown. The need for a solid waveguide is combined with the penetrating ability of a woodscrew in one device. The final version used for the termite tracker, optimized and verified for performance by experimental testing, may be viewed on www.deci.com



Pulsers on Waveguide

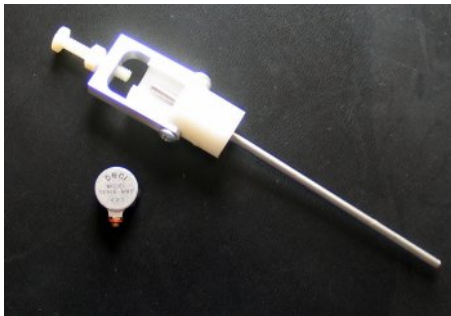
Just as AE sensors can act as pulsers, AE sensors on waveguides can act as pulsers as well. One of the common uses of AE pulsing is to check sensor coupling of large channel systems on structures (such as pressure vessels) over the course of time. This is especially important if the test is for on-going (continuous) AE monitoring. Some AE instruments feature automatic pulsing sequences to verify sensor coupling commonly called auto-calibration sequences. One should be aware in these scenarios that there is signal loss associated with using a waveguide in both directions (pulsing and receiving) and that waveguides are not designed to minimize the loss to outgoing (pulsed signals) to the degree that they serve to minimize incoming signal losses. Hence one should be aware

that pulse/receive losses (in auto-calibration) experience much higher losses through the waveguides and structural propagation distances than through the structure by itself. Sensor to sensor reception through pairs of waveguide coupled sensors may not be easily detectable without stronger than normal pulsing techniques.

With a point contact pulser, the acoustic energy can be focused through the contact point, which is usually much smaller than the sensor aperture. This can be important in specific applications.

Waveguide Accessories

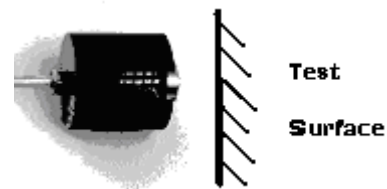
Although a waveguide may be as simple as a rod, it needs to attach to structure to be monitored and to the AE sensor. In both cases there are specialized accessories which are popular to add to the basic waveguide.



Choices for mounting sensors to the waveguides changed dramatically once DECI introduced the WGADT adaptor. For mounting AE sensors to waveguides supplied by DECI, this adapter is now highly recommended and is usually selected by customers when making waveguide purchases. This adaptor is a removable and reusable fixture that provides for secure and consistent sensor-waveguide contact. The methods commonly used before the

WGADT are still available including: fixtures welded to the waveguide; and permanently coupling the sensor to the waveguide (integral sensor-waveguide solutions).

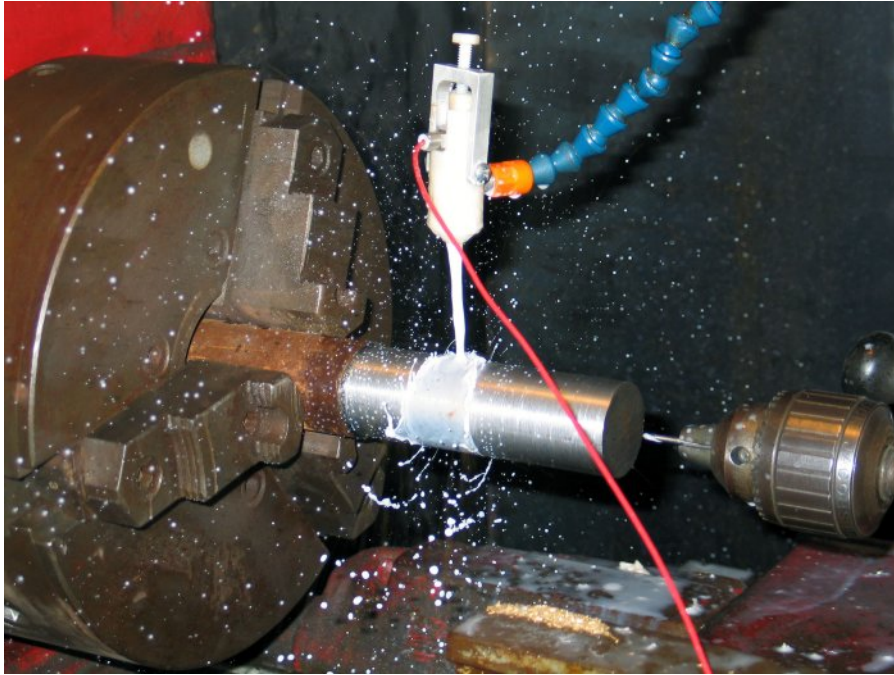
Structural mounting accessories are also popular. Magnetic hold-downs designed to hold DECI waveguides are commonly ordered. The same three features that make the WGADT common (removeable, reusable and secure) apply to this method. The hold-down approach, as shown, includes a magnet that attaches to the test objects surface. The waveguide is secured to the surface through spring loading from the magnet itself.



Another common approach is to weld the waveguide directly to the structure. This approach, while secure, can limit the waveguides reuse depending on how the waveguide is detached. Welding waveguides to a test object make great sense for permanent mounting scenarios.

Waterjets (Fluid Columns) for Guiding Waves

Waterjets are used in many machining operations to cool test parts, especially moving test parts. These waterjets are fluid columns that can conduct AE waves from parts being machined to an AE sensor on a nozzle, or better still, within the fluid column itself. DECI investigations have shown that when the sensor is to be placed in the water column, a position inside the nozzle is desirable.



This picture shows a lathe tool about to be monitored with an AE sensor through a water column. The red microdot cable is connected to a DECI AE sensor within a special fixture made for this experiment. The water jet enters the fixture from the blue line where the water surrounds the AE sensor and exits through a nozzle with forced flow toward the test piece. When the lathe tool at right breaks, AE with high Modal Ratios are detected after propagating through the test piece, up the water column and into the AE sensor. Some advantages of this method of detection include:

- Steady propagation, regardless of part movement
- Thermal isolation
- Strong Acoustic Coupling to moving parts

Other experiments with milling tools were made where the tool was pressed into a cylindrical part until the tool breaks. Not only are the breaks readily detected by an AESmart system, precursors to the break are also detectable for most cases. High Modal Ratios are detected, an indication that while mode conversion of both higher frequency extensional waves and lower frequency flexure waves mode convert into fluid waves, the break events have exceptionally high Modal Ratios. As noise events are prevalent, the Modal Ratio is required and effective in filtering data to obtain the tool break signal.