The Use of a Floating Threshold for Online Acoustic Emission Monitoring of Fossil High Energy Piping

A common misconception about AE is that we can "tune in" to some discreet frequency the defect is emitting with which other noises on the structure will not interfere. In reality it is a balancing act between avoiding noise and remaining sensitive to those emissions we want to detect and quantify. If the signals we are looking for are buried in flow noise, there is no convenient way to extract them with today's AE systems (the D.O.D. has some good technology, but their prices are a little steep). Flow noise becomes an increasing problem below 300 KHz in online monitoring of steam lines, and emissions from valid sources (crack growth, oxide fracture) are very broadband in nature, extending up to 1 MHz. But since structural attenuation increases with sound frequency, the higher frequencies (>500 KHz) attenuate rapidly and are not detectable more than a few feet from the source. This dictates in general that we use highly sensitive resonant sensor designs with peak response in the range of 300-400 KHz.

The need for a "floating" or adaptive threshold has been well-documented in previous work funded by EPRI (RP 1893), and other utility sponsored work on reheat and main steam lines. Without the floating threshold the AE practitioner would have to set a fixed threshold on each channel according to the noise profile he saw during the setup period. Since noise profiles can vary with different flow and throttling conditions, this would be unacceptable for reasonable periods of online monitoring. The result of a threshold set too low would be saturation on one or more channels, effectively disabling the system during periods of high noise. A threshold set too high would be insensitive to detecting and locating valid emissions during periods of low noise.

The purpose of the floating threshold is to automate the process of setting the threshold on each channel to keep it acceptably above noise background variations, while still remaining as sensitive as possible to valid emission activity. This is accomplished mainly by electronic design of the threshold circuit. A typical approach used in the AET 5500 computer-based system is to measure the average noise level (rms millivolts) in each channel circuit and add that value to the level of the fixed threshold selected by the operator with software. E.g., a fixed threshold of 1.0 volts combined with an rms noise level of 200 mV would result in a floating threshold of 1.2 volts. So the fixed threshold selection becomes the effective "deadband" the system tries to maintain between the noise floor and the threshold. The other factor of importance is the response time of the floating threshold circuit, which is again an electronic design feature. The floating threshold circuit should not respond so quickly that occasional high energy transient emissions—the ones we seek to detect and quantify—are affected in their measurement. A threshold responding too quickly will truncate the signal and result in inaccurate feature measurements (counts, signal duration, and energy).

The floating threshold makes online monitoring a practical reality, but its use should be restricted by the proper selection of sensors and electronic bandpassing. Sensors with resonant frequency response between 300-400 KHz and high pass filtering above 250 KHz provide more natural immunity to flow noise, and limit the variation in threshold range dictated by background noise conditions.

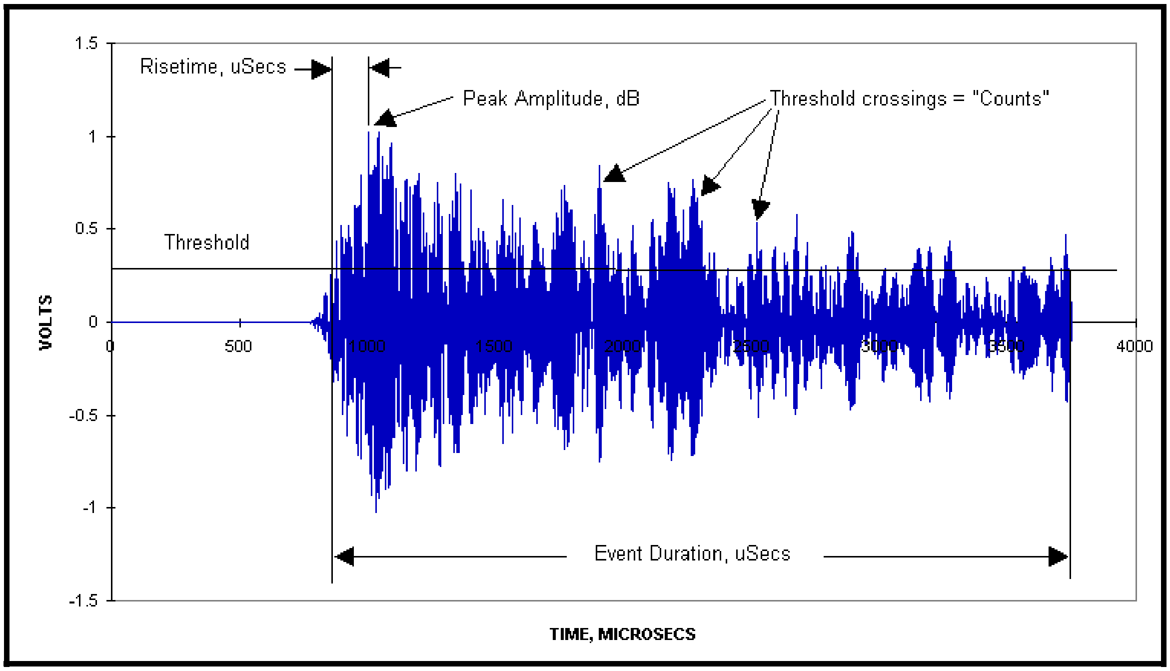


Figure 1. Definitions of Signal Measurements Made on AE Burst-type Signals.

Processing of the transient AE signal begins with the first threshold crossing by the signal. All signal measurements, including the signal arrival time, start at this point.

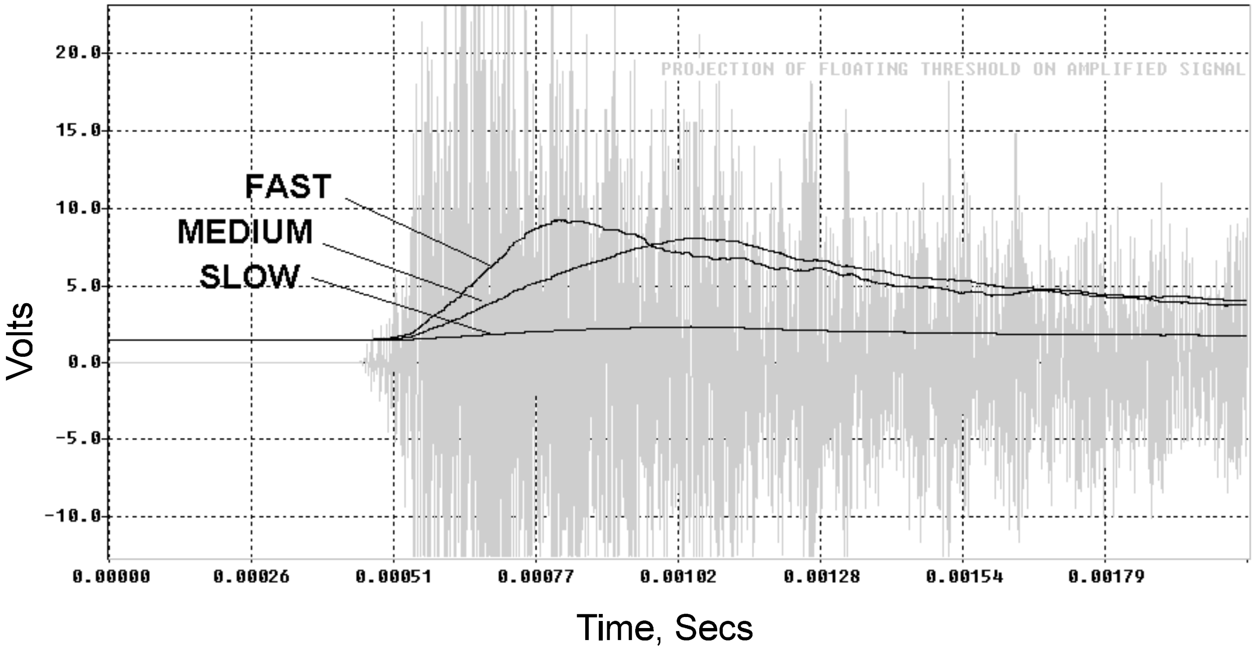


Figure 2. Floating Threshold Response to a Burst-type AE Signal With Different Response Times.

The floating threshold response to a high-energy transient signal should be slow so as not to affect signal feature measurements.

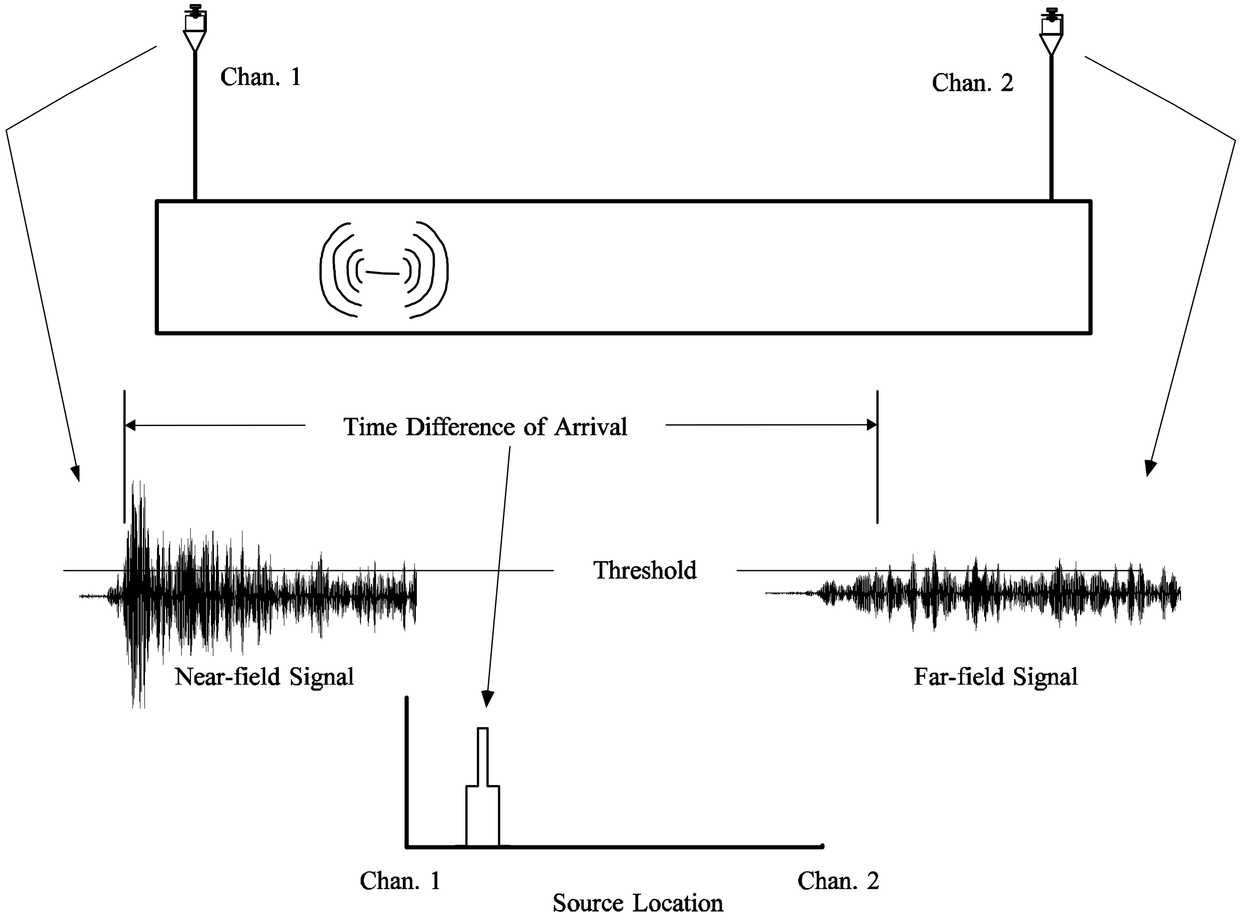


Figure 3. Linear Source Location on Pipe Structures.

A source of emission such as a growing crack emits discreet bursts of emission that propagate with known velocity in the structure. By knowing the spacing of the sensors and the sound velocity, the "time difference of arrival" allows computation of the source position with respect to the two adjacent sensors. However, the signals may look different at each sensor due to waveform spreading and structural attenuation. The example above shows the source closer to channel 1. The near-field signal has a sharper leading edge and higher amplitude than the far-field signal, which has undergone substantial attenuation and dispersion. The arrival time at the near-field sensor is less susceptible to distortion due to differences in noise levels, signal amplitude, or threshold selection. The far-field signal is much more susceptible to these conditions, and the resulting time difference of arrival can be affected. The source location dispersion is therefore greater as the true location of the source is closer to one of the sensors. Source location dispersion at the center of the array between sensors is less, since both sensors see the signal with close to the same waveform shape.

The infusion of background flow noise can compromise the correct location of signals by altering the apparent time of arrival of signals, or by creating a spurious signal arrival. The next series of figures address how a floating threshold can help maintain the integrity of signal arrival times and mitigate detection of noise signals.

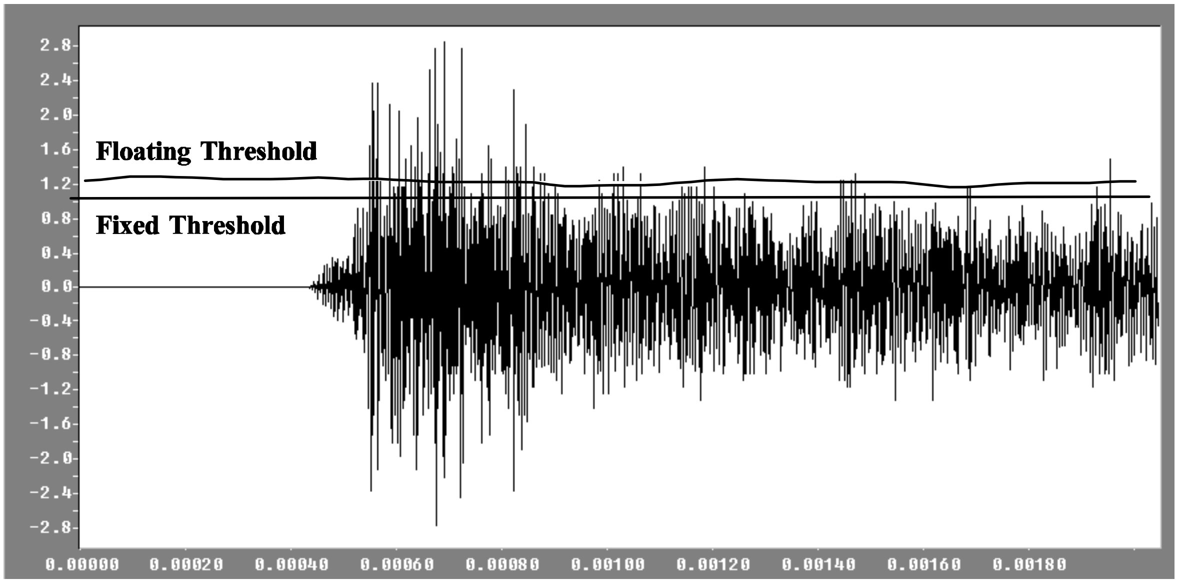


Figure 4A. Near-field AE Signal Without Flow Noise

The near-field AE signal arrival time is unaffected by the threshold type due to the closeness of the threshold values and the sharp profile of the signal leading edge.

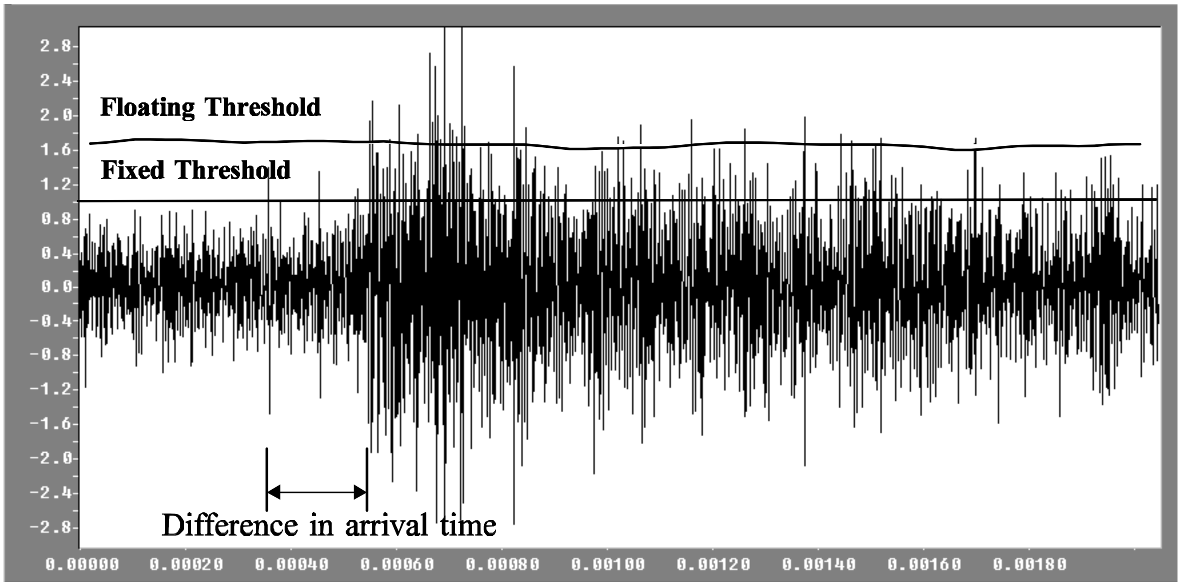


Figure 4B. Near-field AE Signal With Flow Noise

The near-field AE signal infused with flow noise is less definitive in shape, and more susceptible to arrival time differences due to noise. The floating threshold preserves the correct arrival time from the original signal in Figure 4A.

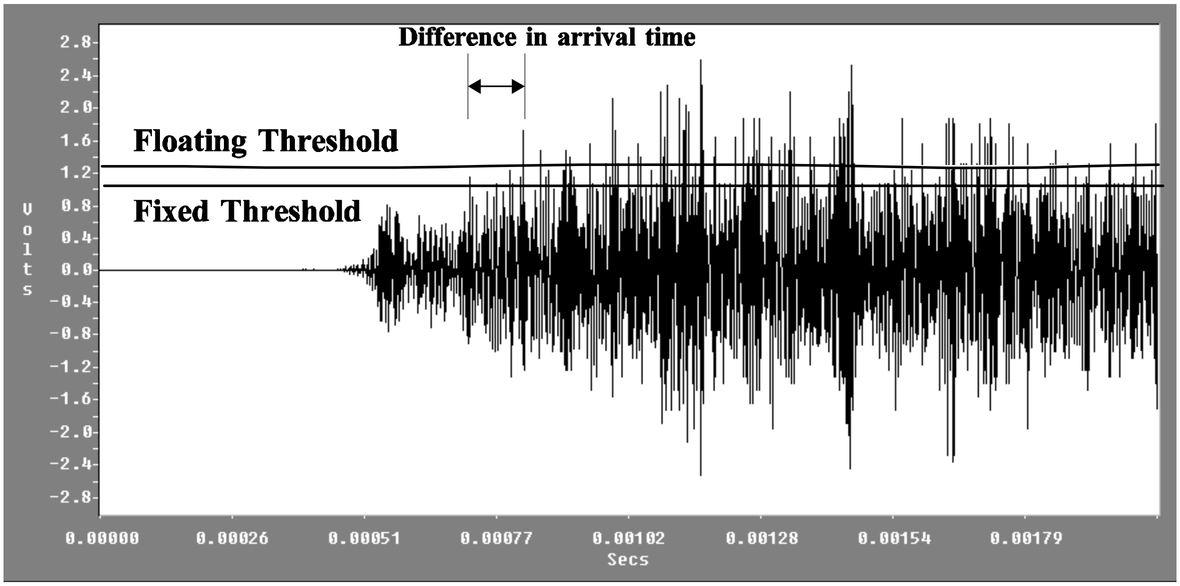


Figure 5A. Far-field AE Signal Without Background Noise.

The difference in arrival time is not significant between the two threshold types for this far-field AE signal which is unaffected by background flow noise.

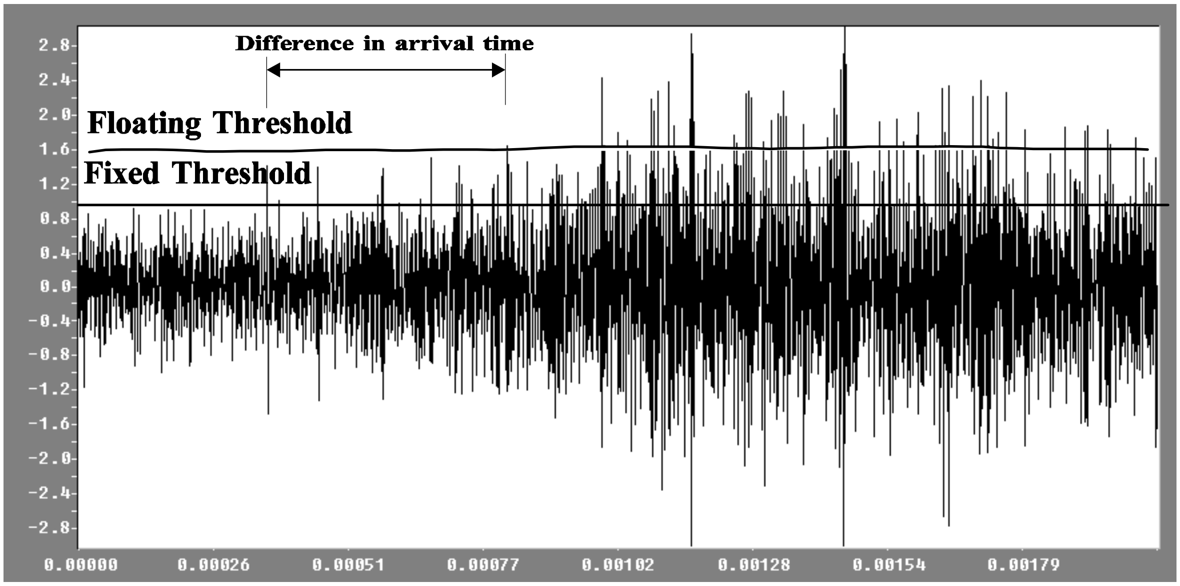
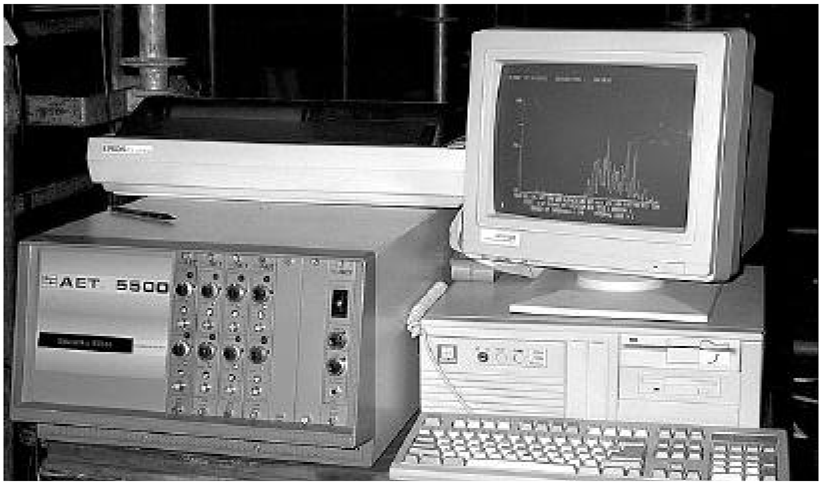


Figure 5B. Far-field AE Signal With Background Noise.

The difference between the arrival times for a fixed and floating threshold can be dramatically different for the same far-field signal that has been infused with a moderate level of flow noise. The floating threshold preserves close to the original arrival time of the signal from Figure 5A.

The floating threshold has been demonstrated successfully in a number of online tests using the AET 5500 system:

Utility	**Plant**	**Structure**	**Condition**	**Year**
Philadelphia Electric	Cromby	Reheat line segment	Offline steam injection and startup.	1989
Houston Light & Power	P. H. Robinson	Full reheat line.	Startup sequence.	1990
Duquesne Light	Cheswick	Reheat lines.	Startup and online.	1991
San Diego Gas & Electric	Encina	Main Steam Wye-blocks.	Startup and online.	1992
Virginia Power	Mt. Storm	Main steam line segments.	Startup and online.	1993
Pacific Gas & Electric	Potrero	Reheat Lines	Startup, online, cooldowns	1989, 1991, 1992, 1994



The AET 5500 computer-based system is utilized by AEC in online monitoring of high energy fossil piping.

For more information on this and other topics related to acoustic emission testing of high energy piping, contact:

Acoustic
Emission
Consulting

John M. Rodgers
8554 Gunner Way
Fair Oaks, CA 95628
Phone/Fax (916) 965-4827