



**PRODUCT ACOUSTIC SIGNATURE SYSTEM
TECHNICAL DATA SHEET**

PRINCIPLES OF OPERATION

The gun-shaped Product Acoustic Signature System (“PASS”) contains an ultrasonic sensor head that is tethered to a personal digital assistant (PDA) and linked to a data library that consists of a listing of solids and fluids with their associated acoustic property data as a function of frequency and temperature. The technique governing how the PASS functions entails measurements of ultrasonic pulses in the range of 0.1 to 5 MHz that are launched into a container, easily penetrating many solid materials and liquid commodities. The PASS uses two interchangeable, broadband, ultrasonic transducers (200 kHz and 1 MHz nominal center frequencies) that can interrogate containers ranging in size from approximately 6 inches to over 96 inches in diameter. The return echoes from the injected ultrasonic pulses are analyzed in terms of time-of-flight and amplitude decay/frequency, in order to extract physical property measurements of the material being inspected. These parameters (acoustic velocity and attenuation coefficient) are used to sort and identify specific components in a sealed container. Mislabeled containers and intentionally corrupted fluids can be readily discerned. The presence or absence of an ultrasonic echo from the far wall of the container is used for determining fill level in storage containers and for locating cavities and packages hidden in outwardly innocuous commodity items such as shipping barrels and metal ingots. The ultrasonic velocity and the attenuation coefficient are temperature-dependent physical properties of the propagation medium. The PASS collects and passes ultrasonic data to the PDA platform in the form of digitized waveforms. On the PDA, an algorithm uses this information, along with the path length and temperature measurement input, to calculate the acoustic velocity and attenuation coefficient. These calculated results are automatically compared to the database and identification is attempted. The technical details of these calculations are transparent to the operator. The necessary information is automatically uploaded from the acoustic unit to the PDA platform when the operator depresses the trigger. Prior to interrogation, the user is required to input the container diameter and container temperature. This may include information from the manifest, the driver, and the conveyance. The inspection results are presented graphically for clear and immediate interpretation by the user. The results are then merged with the user input to form a file that may be saved, transmitted electronically or printed out on paper. The PASS liquid/material database resides on the PDA and can be readily updated with additional liquids or materials using data collected in the field or in the laboratory using the PSAMS technology. The PSAMS platform is used to acquire acoustic velocity and data on select fluids as a function of temperature and frequency.

SYSTEM COMPONENTS

The primary function of the acoustic unit is to provide a portable, handheld mechanism for contacting the ultrasonic transducer to the wall of the container or material commodity that is to be examined. The enclosure comprising the acoustic unit houses the primary electronics (pulser board, receiver board, 8-bit, 20 MHz analog-to-digital converter (ADC), 8-bit Ethernet board, and the PDA) as well as the transducer of choice for transmission and reception of the acoustic pulse. The trigger of the unit functions as the toggle switch for acquisition of acoustic data during testing. The function of the pulser board is to provide the appropriate excitation characteristics to the transducer of choice, (either high frequency or low frequency). In the high frequency mode, the transmit pulse consists of a 385 Volt, single, negative square wave pulse for broadband excitation. In the low frequency mode, the transmit



pulse consists of a 600 Volt peak-to-peak, 5 cycle sinusoidal wave tone-burst. The transducers are fitted with a robust, novel, dry-couplant membrane with a glycerol filled cavity that provides efficient coupling of acoustic energy without the need for wetting agents or gels. These membranes are easily replaced and can be refilled as well. The function of the receiver board is to provide a means for amplification and signal conditioning of the received acoustic signal response. The function of the ADC is to convert the analog RF signal response to a digitally sampled representation of the acoustic response. The function of the Ethernet board is to perform data transfer from the ADC to the PDA where the digitized acoustic signal response is used as input to various algorithms for determining inspection results. Results returned to the user occur in two stages. Initially the operator views a main screen to input parameters and when the trigger is depressed and the sound field enters the container, the ultrasonic waveform (signal response) is illustrated on the PDA. When the trigger is released, the PDA toggles back to the main menu screen where the database listing highlights the identified commodity.

The PASS employs a modular design that incorporates a battery powered base unit (acoustic “gun” with various measurement peripherals), including high frequency transducer. The current operations platform is a commercially available Windows Mobile-based personal digital assistant (PDA). The PDA controls all peripherals through a common graphical users interface (GUI) and contains a system library of liquids and materials. This system library, or database, can be updated with additional liquids and materials. The control unit uses a sunlight readable, backlit LCD display with a touch-screen interface and provides connectivity for an Ethernet connection, a USB port, a keyboard, and can also be docked to a PC. The PDA platform provides a means to upload/download information and share critical examination results with inspectors at other ports-of-entry through normal communications infrastructure (internet, LANs, etc.). The PDA provides quick start-up times and a familiar Windows-Mobile environment. The function of the PDA is to provide a platform for ultrasonic examination parameter control and data analysis. The PDA provides the platform for invoking the necessary software for operational control of the acoustic unit as well as a platform for immediate analysis of acoustic data acquired from a container or bulk-solid commodity. This unit provides the inspector with both visual and audible indicators to enhance his/her capability to rapidly inspect a large number of items and make an immediate decision regarding disposition. The 12-Volt, 2-amp rechargeable battery allows the unit to be used for 8-10 hour periods of time without interruption.

TECHNICAL SPECIFICATIONS FOR SENSOR DEVICE

Pulser Board (1 MHZ High Frequency)

Type: Square Wave (single negative pulse)
Pulse Voltage: 385 Volts
Pulse Width: Variable 50 ns to 700 ns (50 ns increments)

Pulser Board (200 KHZ Low Frequency)

Type: 5 Cycle Sinusoidal Tone Burst (present setting)
Burst Frequency: 200 kHz
Pulse Voltage: 600 Volts peak-to-peak
Of Cycles: Variable (1 to 32 cycles)
Rep. Rate: 25 Hz

Receiver Board (Pre-amplifier)

Input Noise: <27 μ V rms referred to input
Gain: 12 dB to 52 dB
Variable over the range 20 dB to 80 dB
Freq. Response: 100 KHz to 5 MHz



ADC Board (Analog to Digital Converter)

Resolution: 8 bits
Sample Rate: 20 MHz
Waveform Size: 16 Kbytes (samples per waveform)

Ethernet Board (PICO WEB)

Data Acq. Res.: 8 bits
Speed: High Speed (maximum of 238 Kbytes per second)
Protocol: User Datagram Protocol (UDP) for waveform transfer
TCP/IP for passing control data

Microprocessor

Atmel single-chip AT90S8515 w/ low-power RISC processor, 8 KB of flash program memory, 512 bytes of EEPROM, 512 bytes of RAM, 32 I/O lines and built-in UART.

<i>Sensor Unit Weight:</i>	3.5 lbs
<i>Dimensions of Sensor Unit:</i>	10.5" x 10.5" x 3.5"
<i>Processing Unit Model:</i>	HP iPAQ Pocket PC HX2400 Series
<i>Processing Unit Power Requirements:</i>	5V 2 A DC (internal Lithium battery)
<i>Sensor Unit Power Requirements:</i>	12V 2 Amp Hours DC
<i>Total Case Weight (all components):</i>	15.0 lbs
<i>Dimensions of Case:</i>	19 1/8" x 15 7/16" x 7 9/16"
<i>Recharge Time12V battery pack:</i>	4hours
<i>Communication:</i>	TCP/IP
<i>Processing Unit OS:</i>	Windows Mobile Version 5
<i>Display:</i>	3.5" transfective TFT RGB color 240 x 320 pixels
<i>Recharge Power:</i>	120V AC
<i>Operating Frequencies:</i>	1.0 MHz
<i>Transducer:</i>	1 MHZ (high), 220KHZ (optional low)
<i>Target Size Limits:</i>	6" (minimum) to 96" (maximum)