

Product Acoustic Signature System (PASS)



Product Acoustic Signature System (PASS)



PASS Capabilities

▶ The PASS uses ultrasonic energy to non-invasively...

- detect contraband or compartments inside liquid-filled containers
- detect contraband that is cast inside or hidden inside compartmental cavities of a bulk solid commodity

...without opening or damaging the container




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PASS Capabilities

- ▶ In addition to detecting hidden objects inside sealed containers and bulk solid cavities, the PASS also has the ability to
 - identify a liquid inside a container
 - identify some bulk solid materials
 - rapidly sort liquids into groups of like and dislike
 - determine liquid fill levels in containers

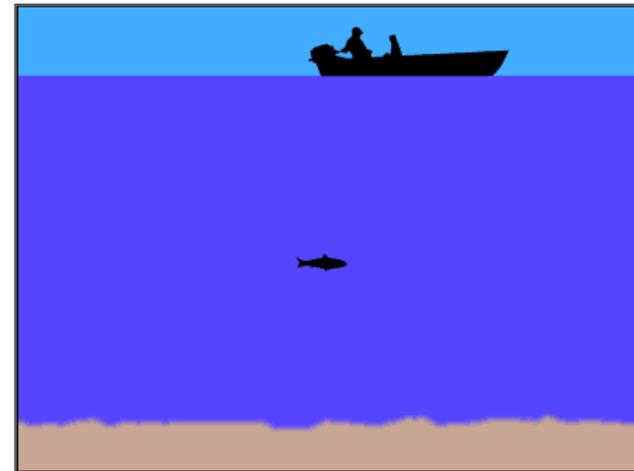


PASS Basic Theory of Operation

- ▶ The term 'ultrasound' is commonly associated with things such as bat echolocation and fish finders.
- ▶ Common theme: object detection
- ▶ The PASS uses ultrasound to accomplish the same task.

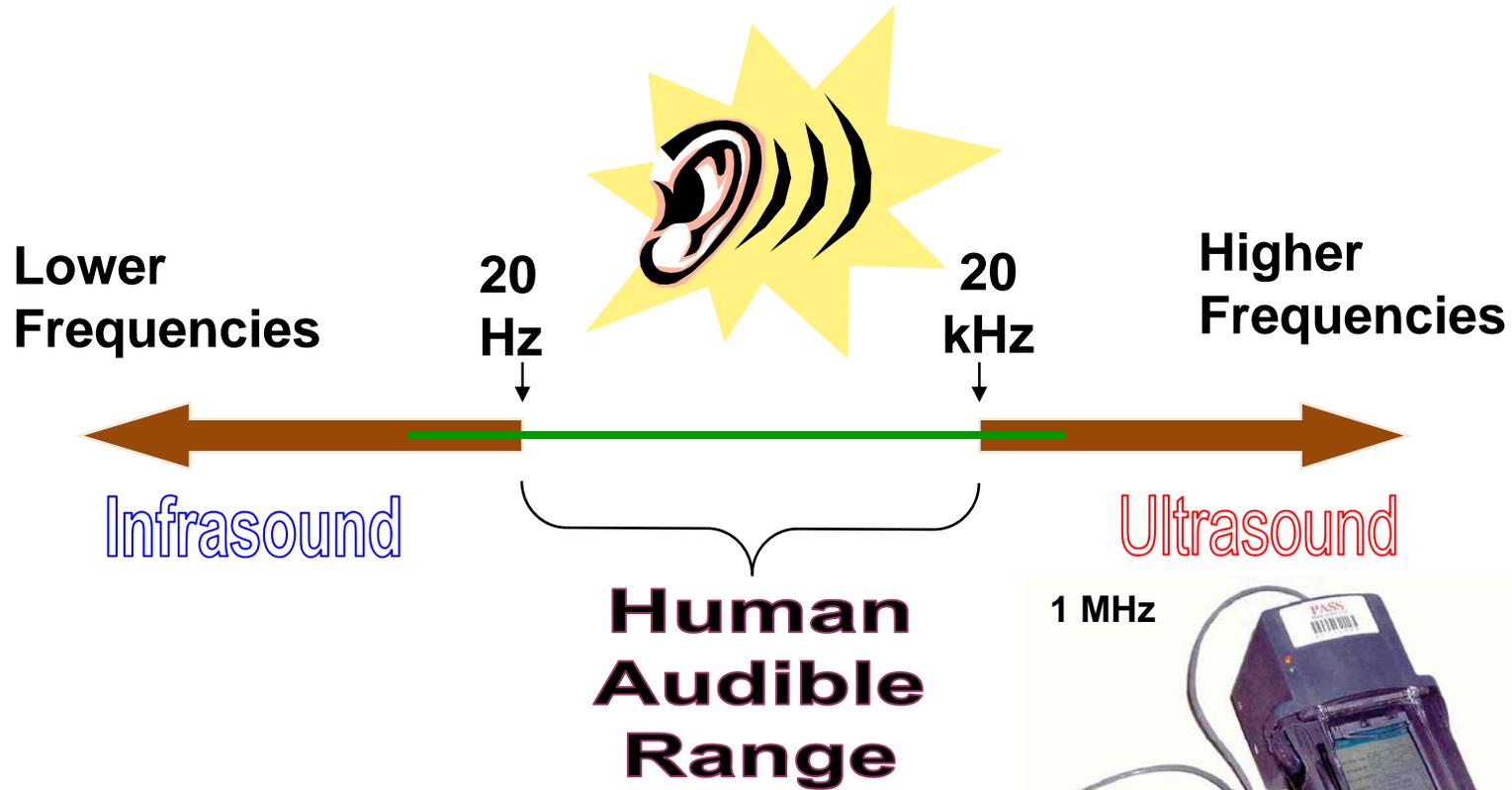


Courtesy of bats4kids.com



Courtesy of Johnson Outdoors, Inc.

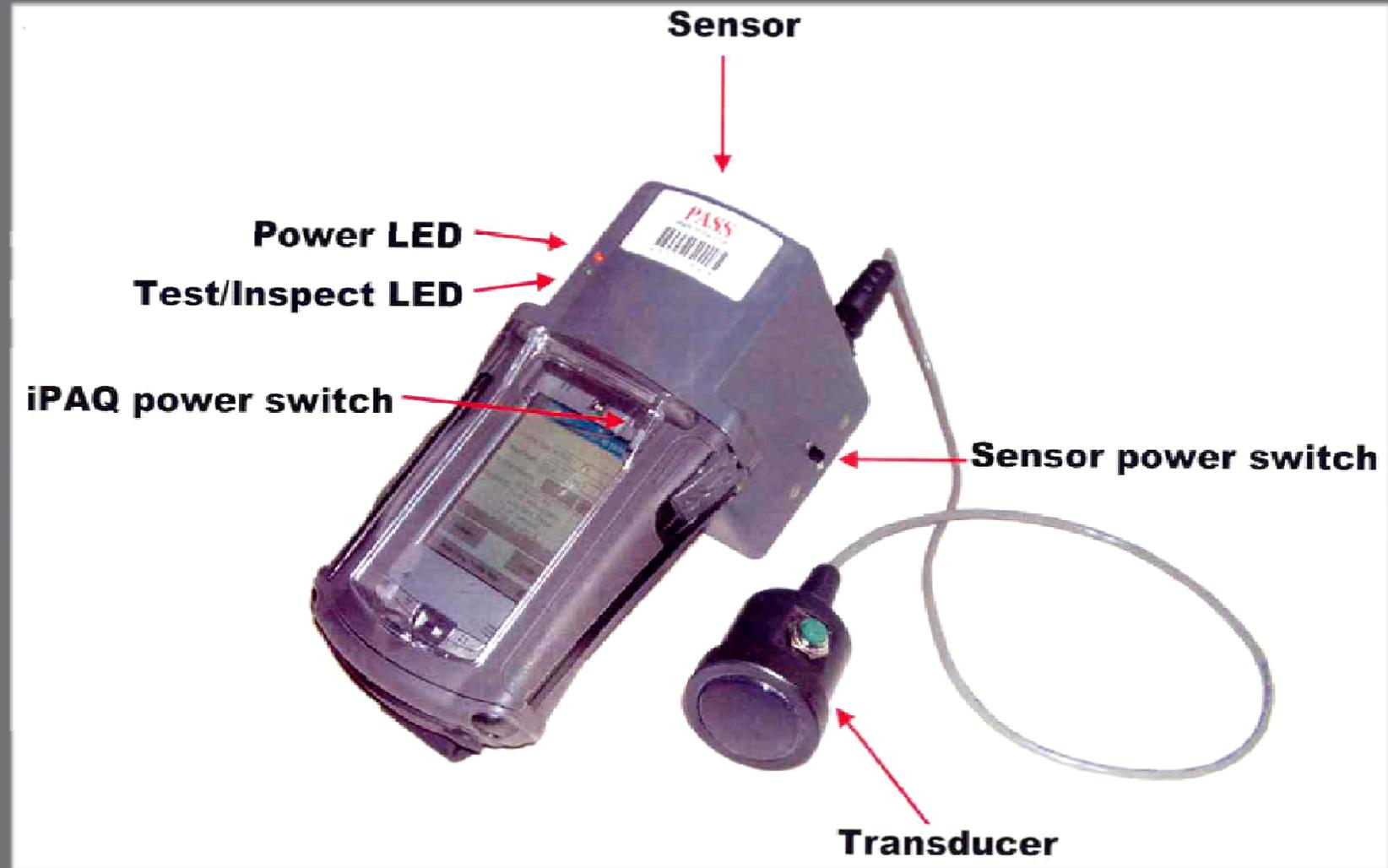
PASS Basic Theory of Operation




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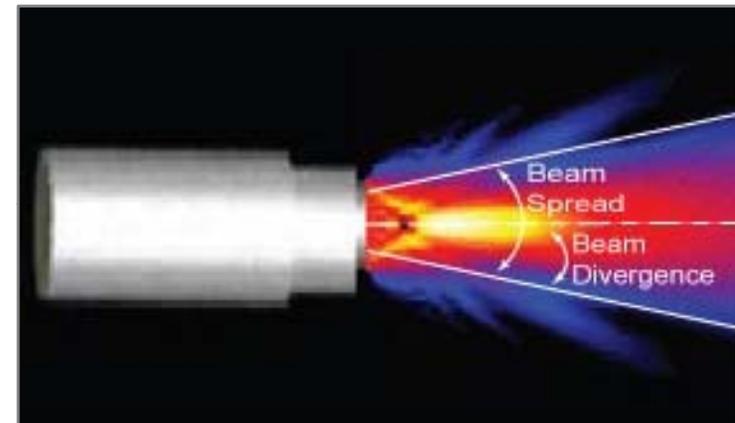
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PASS Basic Theory of Operation



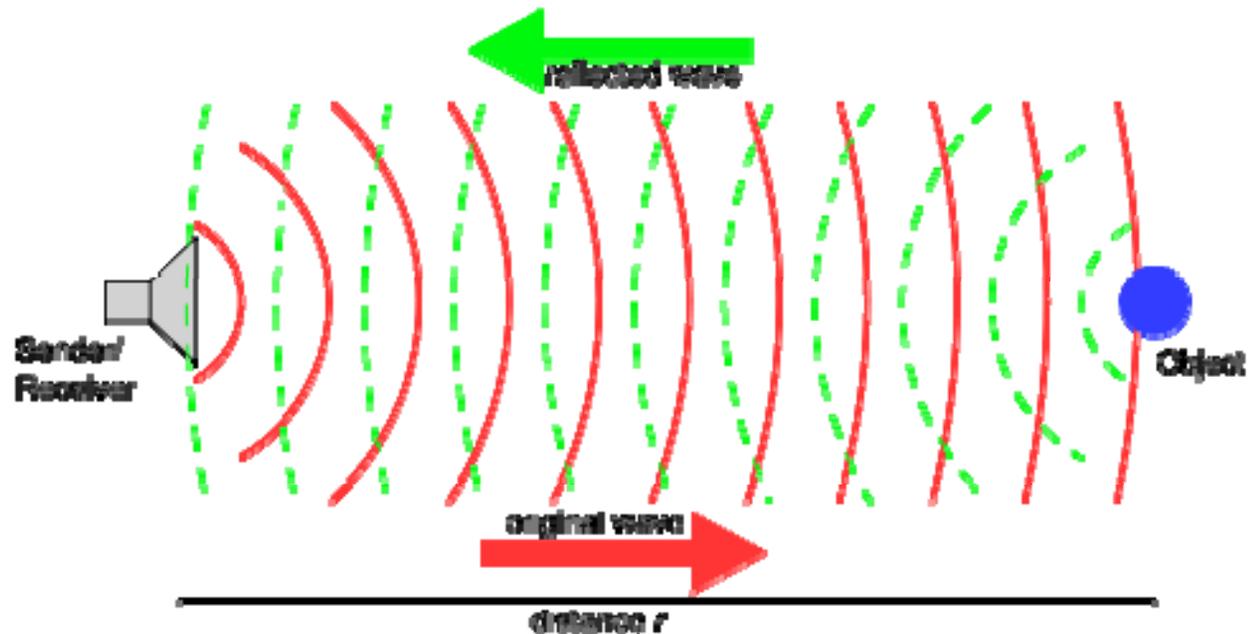
PASS Basic Theory of Operation

- ▶ An ultrasonic sound field is emitted by the PASS transducer when the green button is pushed.
- ▶ When the transducer is placed against a container wall, the sound field penetrates the wall and enters the container.
- ▶ The transducer *sends and receives* ultrasonic signals.



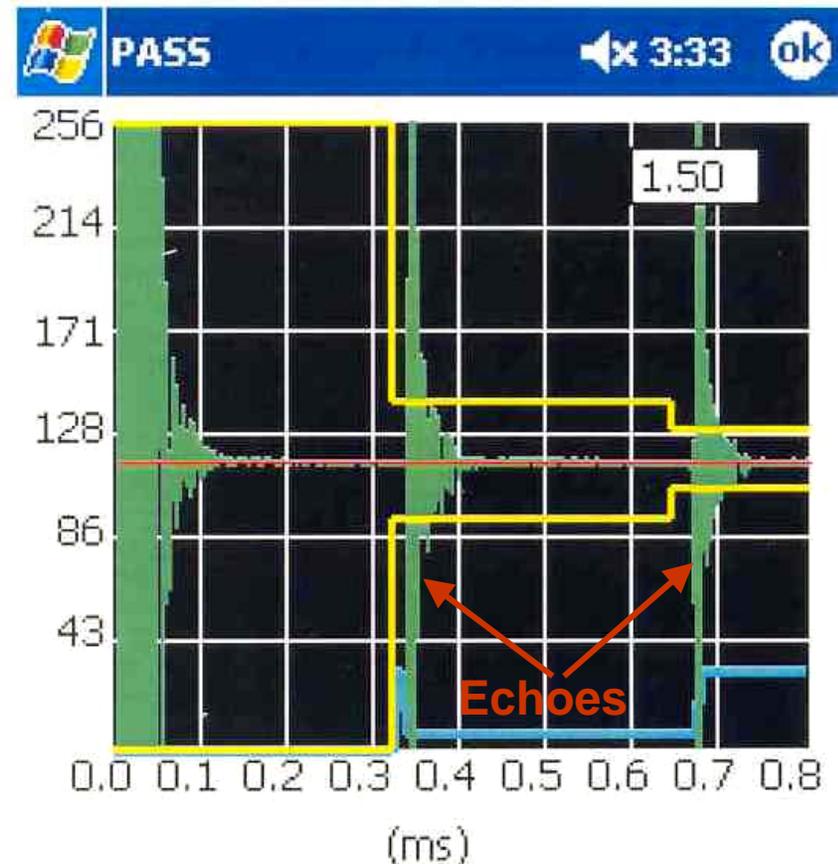
PASS Basic Theory of Operation

- ▶ Ultrasonic energy travels through the medium and is reflected back to the sensor when it meets a boundary.
 - Liquid-solid
 - Liquid-air
 - Solid-liquid
 - Solid-air



PASS Basic Theory of Operation

- ▶ On the PASS device, a boundary is represented by an echo on an amplitude vs. time graph.
- ▶ The boundary can be the other side of the container or a hidden object.



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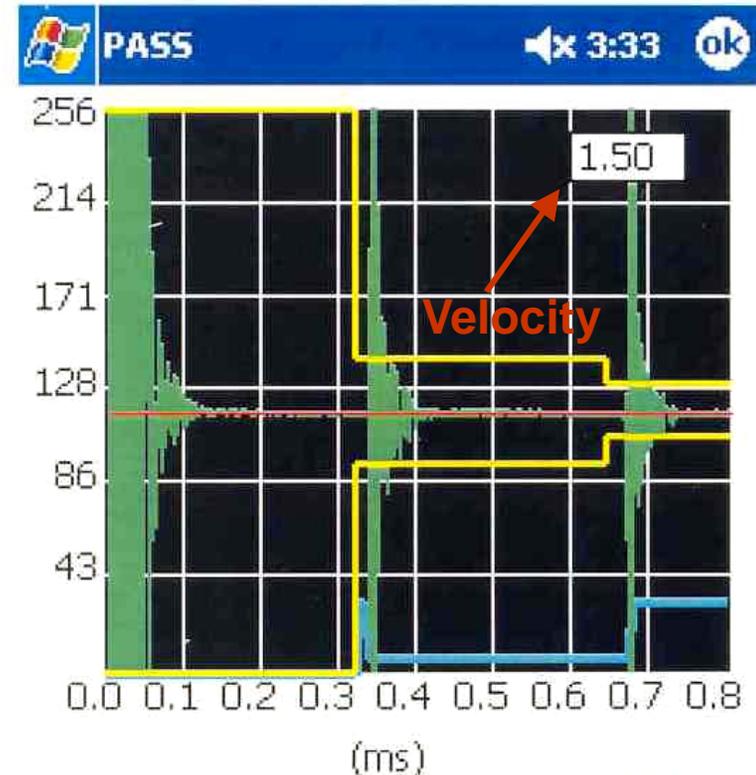
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PASS Basic Theory of Operation

- ▶ The arrival times of the echoes will be your guide.
- ▶ The arrival times let you know how long it takes the ultrasonic signals to reach and be reflected by a boundary.
- ▶ Arrival times will depend on
 1. How far away the boundary is from your measurement point (the largest factor),
 2. and the nature of the fluid or solid the ultrasonic signal is traveling through before it reaches the boundary.

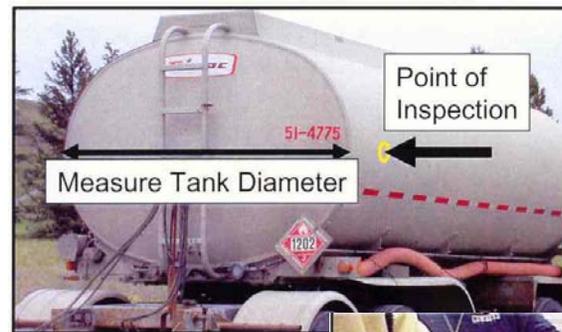
PASS Basic Theory of Operation

- ▶ The velocity value that is in the corner of the graph will also be your guide.
- ▶ The velocity value is directly related to the arrival times of the echoes as well as the container dimension...



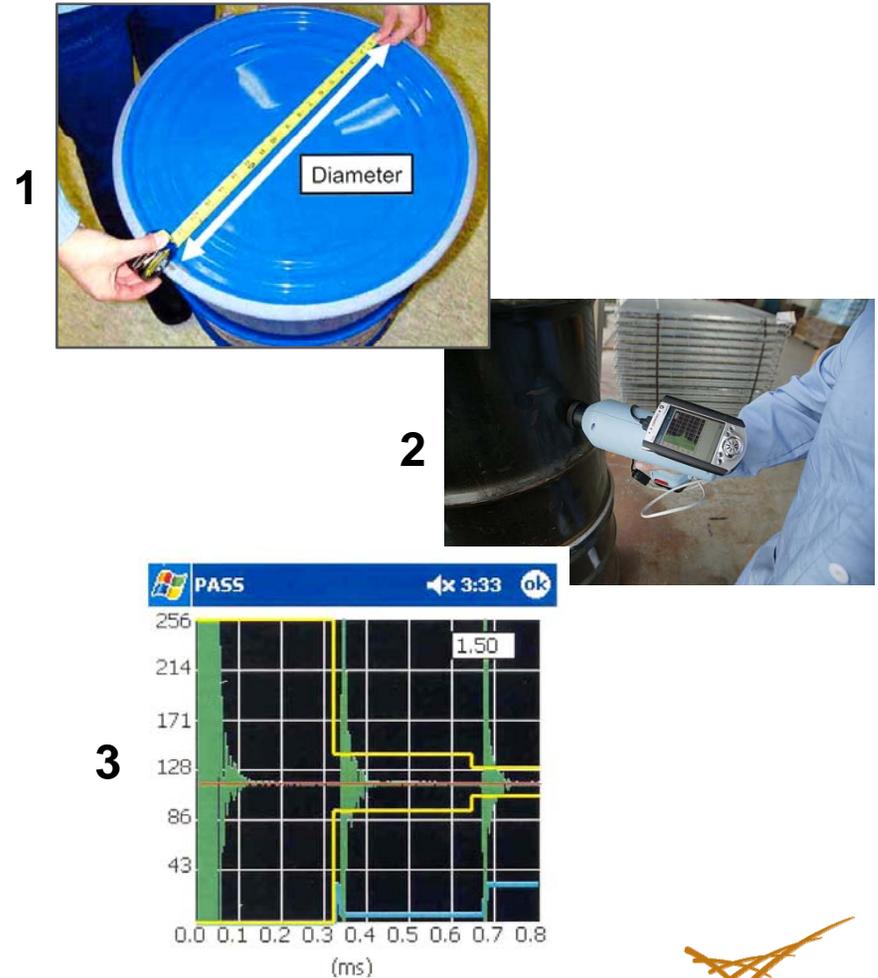
PASS Basic Theory of Operation

- ▶ Before using the PASS to detect contraband or identify a fluid or solid, the dimension of the container across which the transducer is pointed must be measured and entered into the PASS software.



PASS Basic Theory of Operation

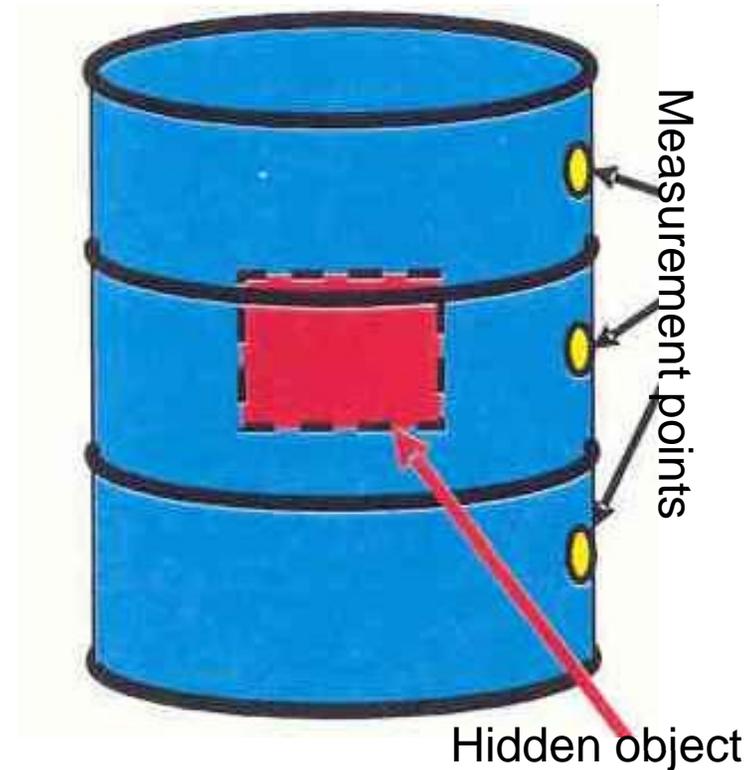
- ▶ With the container dimension you input and the arrival times of the echoes, the PASS software calculates the ultrasonic velocity that is displayed on the graph.



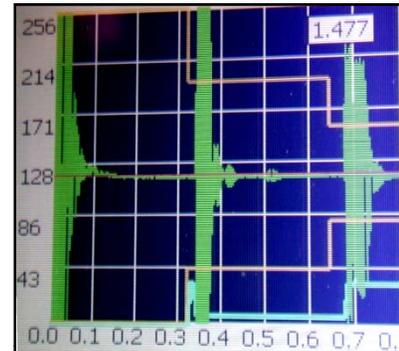
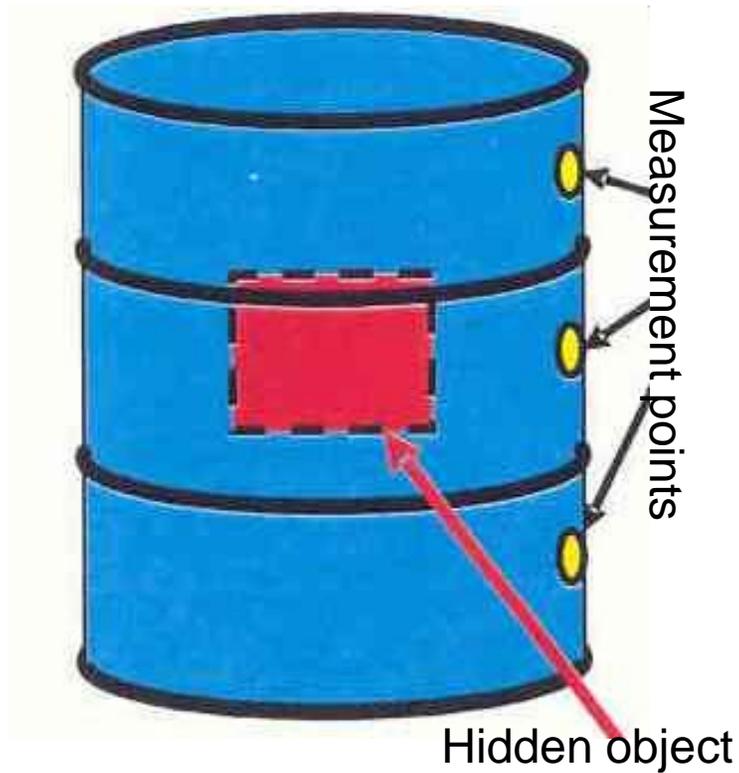
$$\underline{\text{Velocity} = \text{Distance} / \text{Time}}$$

PASS Basic Theory of Operation

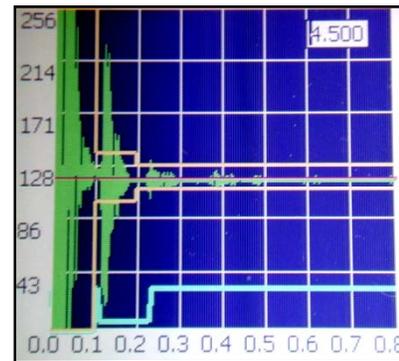
- ▶ When measurements are being made across the same container dimension, and the arrival times of the echoes change (and thus the velocity), this indicates a change in container contents.



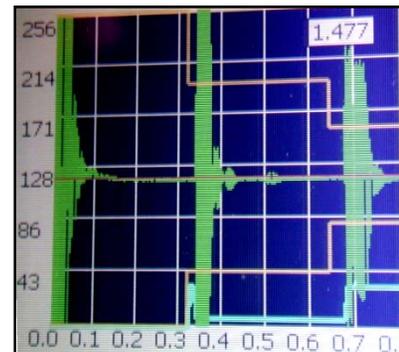
PASS Basic Theory of Operation



Top

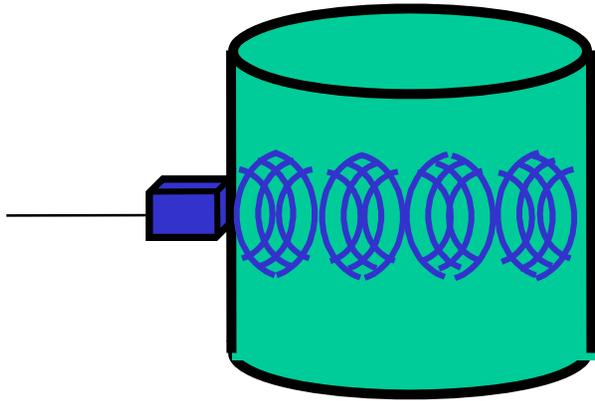


Middle

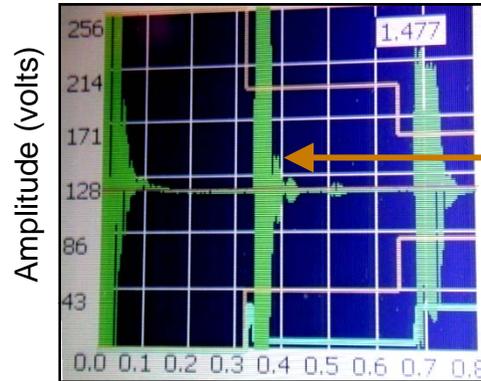


Bottom

PASS Basic Theory of Operation

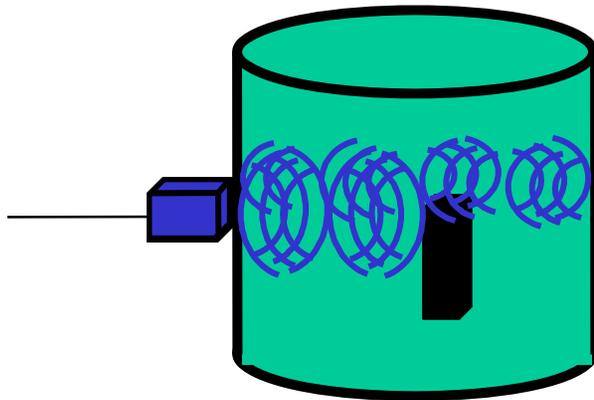


Echo Signal: **No Obstruction**

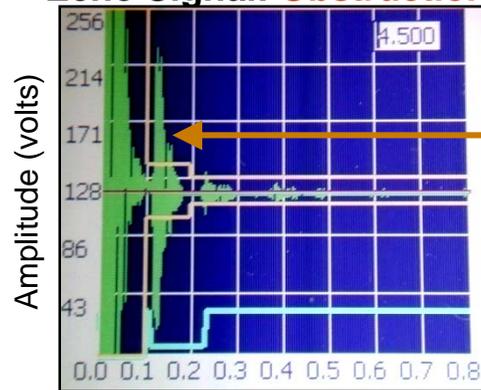


Echo from far side of container

Time (ms)



Echo Signal: **Obstruction**



Echo from obstruction

Time (ms)

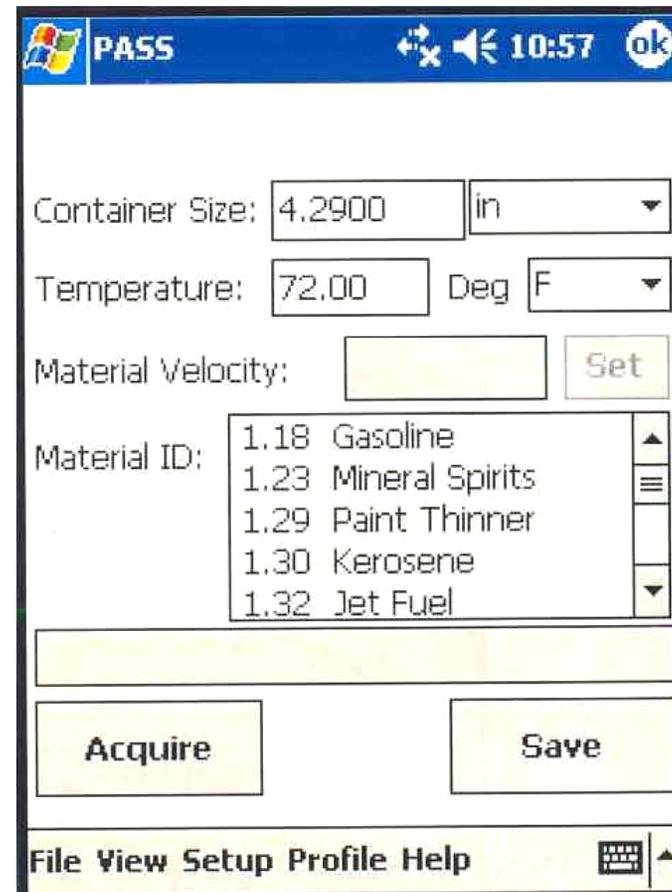


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PASS Basic Theory of Operation

- ▶ In addition to being your guide during contraband detection, the velocity can be used to identify liquids and bulk solids.
- ▶ The PASS has a database with 52 items in its collection
 - 19 liquids
 - 33 solids



The screenshot shows the PASS software interface. At the top, there is a blue header bar with the PASS logo, a close button, a volume icon, the time 10:57, and an OK button. Below the header, there are several input fields and a list:

- Container Size: 4.2900 in
- Temperature: 72.00 Deg F
- Material Velocity: [empty field] Set
- Material ID: A list with the following items: 1.18 Gasoline, 1.23 Mineral Spirits, 1.29 Paint Thinner, 1.30 Kerosene, 1.32 Jet Fuel. The list has up, down, and menu icons on the right side.

At the bottom of the main area, there are two buttons: "Acquire" and "Save". Below these buttons is a footer bar with the text "File View Setup Profile Help" and a keyboard icon.

PASS Basic Theory of Operation

- ▶ Velocity of sound through fluids and solids acts as a “fingerprint.”
- ▶ Therefore, fluids and solids can be identified by the rate at which sound travels through them.

The screenshot shows the PASS software interface with the following fields and options:

- Container Size: 4.2900 in
- Temperature: 72.00 Deg F
- Material Velocity: [Empty field] Set
- Material ID: 1.18 Gasoline, 1.23 Mineral Spirits, 1.29 Paint Thinner, 1.30 Kerosene, 1.32 Jet Fuel
- Buttons: Acquire, Save
- Footer: File View Setup Profile Help

PASS Basic Theory of Operation

- ▶ What are the main factors that influence the velocity of sound through a fluid or solid?
 - The density of the fluid or solid
 - The elasticity of the fluid or solid
 - Temperature

$$c_{\text{solids}} = \sqrt{\frac{E}{\rho}}$$

c=velocity

E=Young's modulus

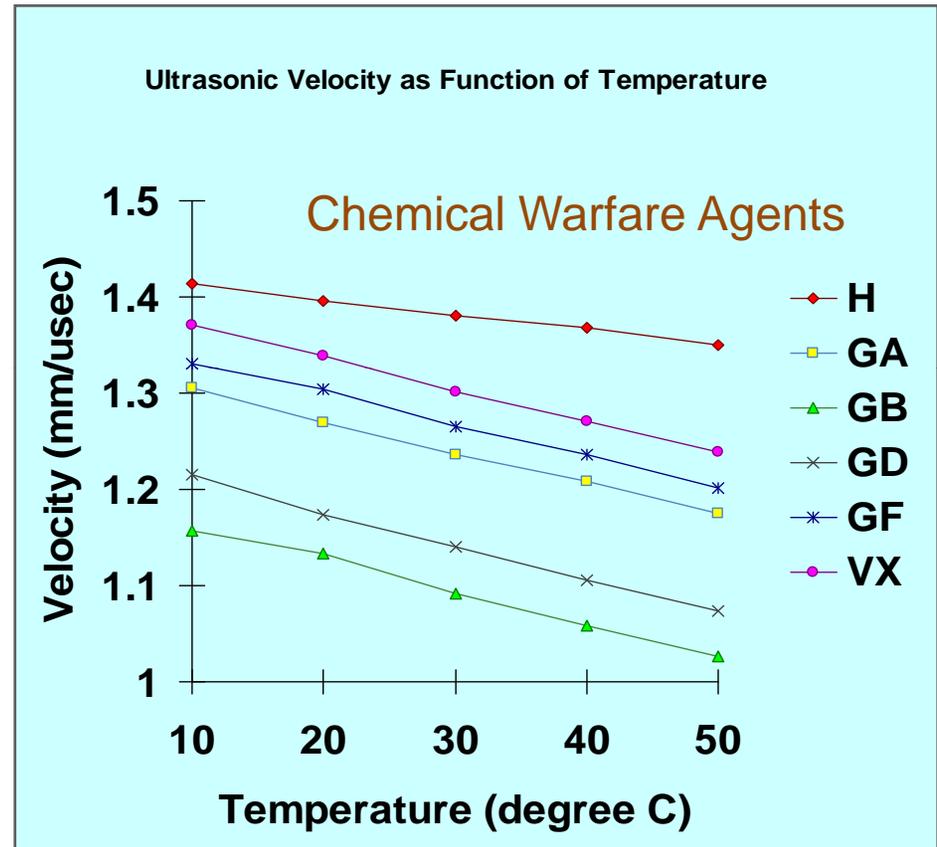
K=bulk modulus

ρ =density

$$c_{\text{fluid}} = \sqrt{\frac{K}{\rho}}$$

PASS Basic Theory of Operation

- ▶ Ultrasonic velocity through a fluid or solid will change slightly with temperature.
- ▶ Estimate the temperature of the fluid or solid you are inspecting and enter it into the PASS software.



PASS Features

Material ID Mode

- ▶ Use this mode to identify a fluid or solid.
 - If you know what the liquid or solid is that you are measuring with the PASS, first look it up in the PASS material database and see if it is listed.
 - If the liquid or solid is in the material database, the PASS will be able to identify it.



PASS Features

- ▶ If you are inspecting a **bulk solid** or a **fluid** that is in the PASS database, the PASS will identify the item you are inspecting.
- ▶ If the bulk solid or fluid you are inspecting is not in the database, the PASS may identify a close match or nothing at all.

A screenshot of the PASS software interface. The title bar shows 'PASS' and the time '10:57'. The interface includes several input fields and a list of materials.

Container Size: 4.2900 in

Temperature: 72.00 Deg F

Material Velocity: [] Set

Material ID:

| | |
|------|-----------------|
| 1.18 | Gasoline |
| 1.23 | Mineral Spirits |
| 1.29 | Paint Thinner |
| 1.30 | Kerosene |
| 1.32 | Jet Fuel |

Buttons: Acquire, Save

Footer: File View Setup Profile Help

PASS Features

Alarm Mode

- ▶ Use this mode to make one reference measurement against which subsequent measurements will be compared to either verify consistency or to detect inconsistency.
 - Example: Checking consistency within one container or among several of the same containers.



PASS Features

Contraband Mode

- ▶ Use this mode to detect contraband or hidden compartments.
- ▶ When the liquid or solid being inspected is known and the item is in the PASS material database, this mode can be used to measure a dimension of the container.
 - The user can determine whether or not the dimension determined by the PASS makes sense.
 - If it doesn't, the container may contain contraband.
 - Example: A 24" diameter drum is determined to be a 10" diameter drum according to the PASS.



PASS Features

Container Profiles

- ▶ The PASS can save a profile for a container (the container dimension and the gain and A/D clock settings), which can later be recalled.
- ▶ This feature is convenient for containers that are inspected frequently. Instead of re-measuring the container dimension and inputting the gain and A/D settings each time, the user simply recalls the profile and these values are automatically entered.

