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Operating Instructions

Shear Wave Transducers 250 kHz

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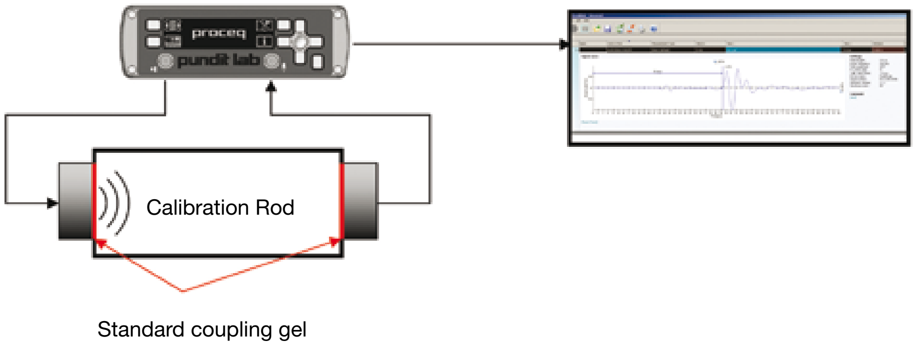
Made in Switzerland

... more than 50 years of know-how you can measure!

Measuring with Shear Wave Transducers

Calibration of the shear-wave transducer

1. Put a small amount of standard coupling gel on the transducers.
2. Firmly press the transducers on either side of the 25 µs calibration rod (Part No 710 10 028). Make sure that the coupling gel is properly distributed and that no air is trapped between the transducer and the calibration rod.
3. Select the 250 kHz transducer from the list of supported transducers (see Pundit Lab manual chapter 3 for more details).
4. Zero the instrument as described in the Pundit Lab manual chapter 2.1.



Please note the following issue when using shear wave transducers.

Performing measurements

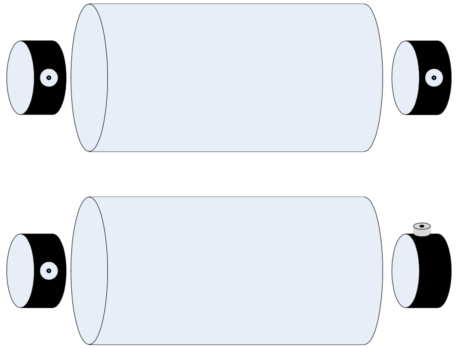
When performing measurements with the 250 kHz shear wave transducers it is crucial to use the special shear wave coupling paste, otherwise shear waves cannot be properly transmitted into the object under test. The shear wave coupling paste is a non-toxic, water soluble organic substance of very high viscosity.

Furthermore, it is necessary to use Pundit Link's waveform display in Live View mode in order to manually locate the onset of the shear wave echo. Since the latter is always preceded by a relatively weak P-wave signal.

The transit time determined by Pundit Lab automatic triggering, would correspond to the longitudinal instead of the shear wave.

Correct Transducer Alignment

When carrying out a measurement with shear wave transducers it is imperative that the two transducers are correctly aligned. This is because the shear waves are generated in one plane only.



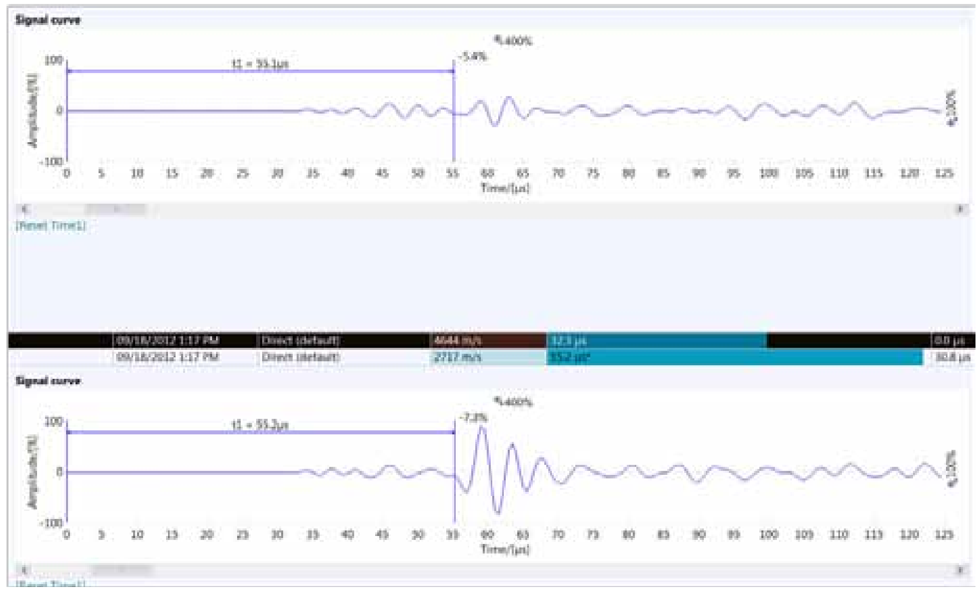
BNC connectors correctly aligned

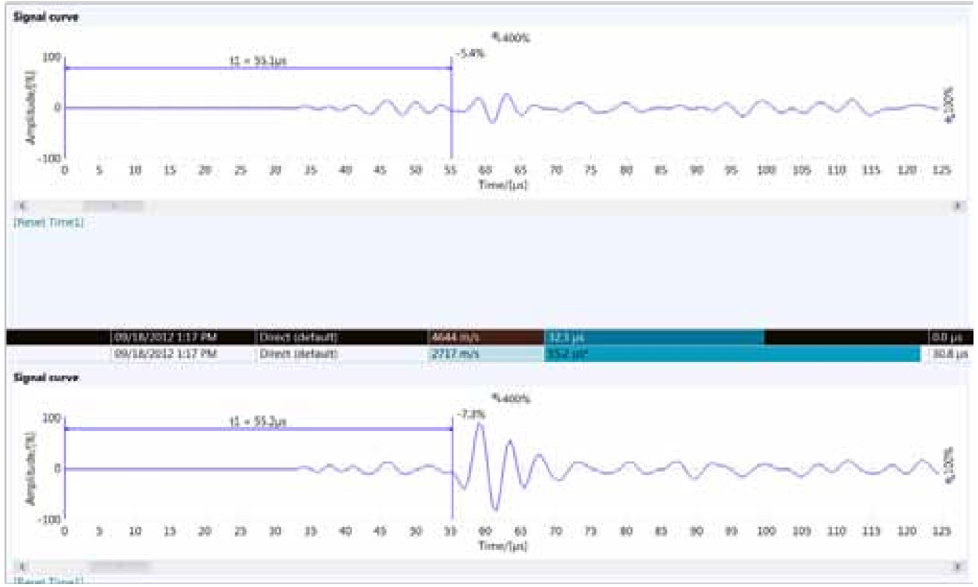
Misaligned Transducers

The worst case occurs when the transducers are aligned at right angles to each other.

In this case the shear wave signal is not picked up at all by the receiver transducer. The PunditLink waveforms shown below shows the same measurement with

- misaligned transducers (above) – almost no S-wave component
- and correctly aligned transducers (below) – very strong S-wave component





The shear wave signal arrives after 55 µs. Rotating the transducers while performing a measurement and watching how the shear wave component increases and decreases allows the user to accurately pinpoint the trigger point of the shear wave.

Recommendations

- If possible, always measure the P-wave first. This will give an indication of where to look for the S-wave (roughly twice the P-wave transmission time).
- Begin with a low amplification setting to ensure that the received signal is not saturated.
- Check the transducer alignment, by lining up the BNC connectors.
- Try rotating the receiver transducer through 90°C. This will allow you to see the shear wave component increasing and decreasing.

Using P and S wave measurements to determine Poisson's Ratio and Modulus of Elasticity

This table taken from Wikepedia shows how elastic properties of materials may be determined, provided that two are known.

v • d • e **Elastic moduli for homogeneous isotropic materials** [hide]

Bulk modulus (K) • **Young's modulus** (E) • Lamé's first parameter (λ) • Shear modulus (G) • Poisson's ratio (ν) • P-wave modulus (M)

Conversion formulas [hide]

Homogeneous isotropic linear elastic materials have their elastic properties uniquely determined by any two moduli among these, thus given any two, any other of the elastic moduli can be calculated according to these formulas.

	(λ, G)	(E, G)	(K, λ)	(K, G)	(λ, ν)	(G, ν)	(E, ν)	(K, ν)	(K, E)	(M, G)
$K=$	$\lambda+\frac{2G}{3}$	$\frac{EG}{3(3G-E)}$			$\frac{\lambda(1+\nu)}{3\nu}$	$\frac{2G(1+\nu)}{3(1-2\nu)}$	$\frac{E}{3(1-2\nu)}$			$M-\frac{4G}{3}$
$E=$	$\frac{G(3\lambda+2G)}{\lambda+G}$		$\frac{9K(K-\lambda)}{3K-\lambda}$	$\frac{9KG}{3K+G}$	$\frac{\lambda(1+\nu)(1-2\nu)}{\nu}$	$2G(1+\nu)$		$3K(1-2\nu)$		$\frac{G(3M-4G)}{M-G}$
$\lambda=$		$\frac{G(E-2G)}{3G-E}$		$K-\frac{2G}{3}$		$\frac{2G\nu}{1-2\nu}$	$\frac{E\nu}{(1+\nu)(1-2\nu)}$	$\frac{3K\nu}{1+\nu}$	$\frac{3K(3K-E)}{9K-E}$	$M-2G$
$G=$			$\frac{3(K-\lambda)}{2}$		$\frac{\lambda(1-2\nu)}{2\nu}$		$\frac{E}{2(1+\nu)}$	$\frac{3K(1-2\nu)}{2(1+\nu)}$	$\frac{3KE}{9K-E}$	
$\nu=$	$\frac{\lambda}{2(\lambda+G)}$	$\frac{E}{2G}-1$	$\frac{\lambda}{3K-\lambda}$	$\frac{3K-2G}{2(3K+G)}$					$\frac{3K-E}{6K}$	$\frac{M-2G}{2M-2G}$
$M=$	$\lambda+2G$	$\frac{G(4G-E)}{3G-E}$	$3K-2\lambda$	$K+\frac{4G}{3}$	$\frac{\lambda(1-\nu)}{\nu}$	$\frac{2G(1-\nu)}{1-2\nu}$	$\frac{E(1-\nu)}{(1+\nu)(1-2\nu)}$	$\frac{3K(1-\nu)}{1+\nu}$	$\frac{3K(3K+E)}{9K-E}$	

By measuring a P-wave transmission time and an S-wave transmission time with Pundit Lab, we are able to determine the P-wave modulus (M) and the Shear modulus (G).

P-wave modulus (M):

$M=\rho\rho V_p^2$

Where ρis the density of the material and Vp is the pulse velocity of the P-wave.

Shear-modulus (G):

$G=\rho V_s^2$

Where ρ is the density of the material and Vs is the pulse velocity of the S-wave.

Using the equations above we can determine Poisson's Ratio (•):

$$\nu=\frac{M-2G}{2M-2G}=\frac{\rho V_p^2-2\rho V_s^2}{2\rho V_p^2-2\rho V_s^2}=\frac{V_p^2-2V_s^2}{2V_p^2-2V_s^2}=\frac{V_p^2-2V_s^2}{2(V_p^2-V_s^2)}$$

So Poisson's ratio can be determined simply by measuring the P-wave velocity and the S-wave velocity and it is not even necessary to know the density of the material.

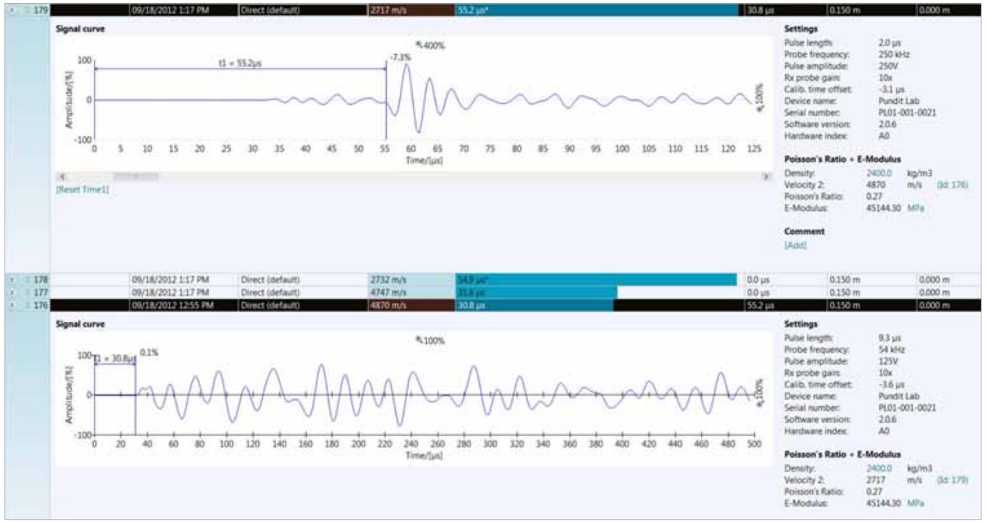
Once Poisson's ratio is known, the elastic modulus can be calculated from the equation: $E=2G(1+\nu)$

For this it is necessary to know the density of the material.

Calculation Poisson's Ratio and Modulus of Elasticity in PunditLink

The measurement with the P-wave transducer is not described here as it is a standard direct measurement as described in the Pundit Lab manual. If using a separate P-wave transducer, it is recommended to measure with that transducer first. Alternatively, it is possible to measure both the P and S-wave component by using the S-wave transducer only.

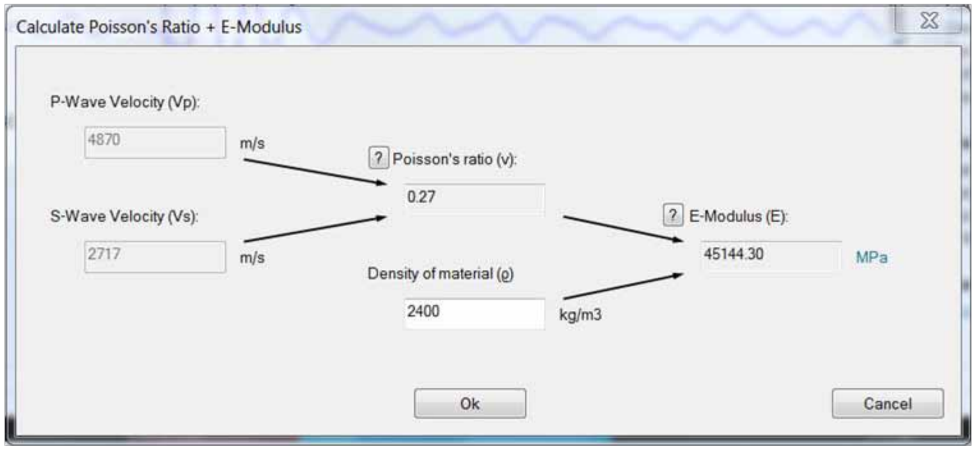
Practical Example made on a concrete block: Density of the concrete block is 2400 kg/m3.



The upper measurement shows the S-wave transmission time is 55.2 µs.
The lower measurement shows the P-wave transmission time, 30.8µs.

Select both measurements in PunditLink so that they are highlighted then select:
"Calculate/Poisson's Ratio + E-modulus"

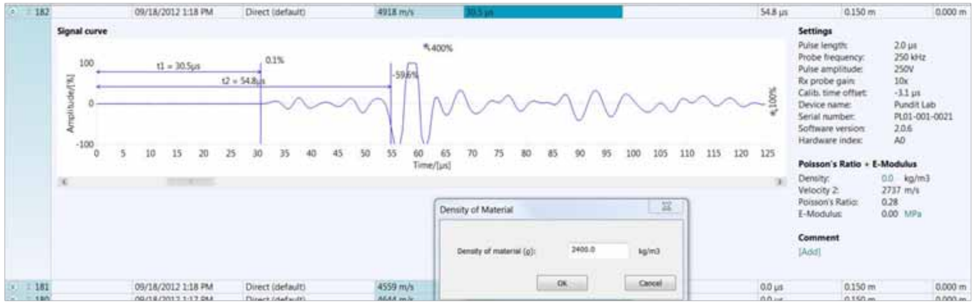
The following window will be shown in which you must enter the density of the material under test



The calculation of Poisson's rate and E-modulus is done automatically.

Alternative method

Alternatively it is possible to use only an S-wave transducer as this type of transducer also has a P-wave component.



The P-wave cursor will appear automatically. It is possible to activate a second cursor by clicking on the Amplitude axis with the CTRL button held down. This allows you to drag the second cursor to the shear wave trigger point "t2".

To obtain the E-modulus you must enter the density, by clicking on the blue Density figure in the column to the right of the graph. Enter the density in the pop-up window as shown and the E-modulus will be calculated automatically.

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