

MetaRock Laboratories, Inc. (MRL) has the capability to undertake research in specific properties of the rock mechanics field. Acoustic measurements of samples (both dry and saturated) can be conducted under both uniaxial and triaxial pressure vessels. Ultrasonic velocity measurements in rock samples are performed utilizing piezoelectric crystals (P&S) of 1MHz resonant frequency. Each transducer is excited independently utilizing a switch matrix as well as a high voltage short duration electrical pulsar. The applied electrical pulse transforms into mechanical pulse and propagates through the rock sample in the form of ultrasonic elastic wave, and is then received by the other end. The receiving transducer, at the opposite end of the rock specimen, is converted back to an electrical pulse and measured as an electrical waveform using a high precision digital oscilloscope. Using the end caps calibration data and the received waveform from each transducer (compressional or shear), the P-wave and S-wave arrival time is measured and velocities, dynamic properties are calculated.

The rock properties are analyzed for realistic reservoir conditions and the stress-induced anisotropy at high axial and radial loads are measured based on P-wave and S-wave velocity change and amplitude change respectively. A detailed report is developed for each sample, and submitted to the client documenting the analysis. Utilizing the integrated pore lines, the sample can be saturated using brine, water and/or oil as per client specifications. The standard of the transducer is proven in aluminum, stainless steel, iron and brass by measuring the velocity under ambient conditions (see table 1). The calculated velocity has been compared with the standard velocity

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of these specific metals and the data indicates a strong match.

Dynamic measurements are derived from the acoustic data. For isotropic medium, two dynamic elastic constants are obtained from the acoustic measurements. For transversely isotropic (TI) medium, five dynamic elastic constants are found from the acoustics. The elastic constants calculated from the dynamic measurements will indicate the changes in rock fabrics and other physical properties. The front face of the transducer's epoxy thickness is estimated based on the wavelength ($\lambda/4$) calculated using bench-top measurements.



1" Endcaps

1.5" Endcaps

Tests can be performed up to a 50000lbs axial load and a 15000psi confining load by utilizing our unique external **Ball Screw Press**, and external radial pumps respectively. The transducers designed by MRL are protected under stainless steel end-caps, and can withstand temperatures up to 300°C. The load cell is placed inside the pressure vessel to measure the actual differential and axial loadings, where the cell does not see the piston's friction.

During the transducer development process, great consideration is given with regards to beam angle/incident angle to allot for better signal concentration in the sample, and for more accurate sensitivity and resolution.

The loading and reloading can be performed without removing the samples from the pressure vessel to generate hysteresis loop.

A stainless steel metal case protecting the active element of a transducer is designed to provide better stress concentration and to eliminate back-wall reflections.

Dynamic parameters (bulk modulus, shear modulus, Young' modulus, P-wave velocity, S-wave velocity and Poisson's ratio) are calculated from the acoustic measurements to elucidate the stress-induced anisotropy in the rocks at elevated pressure and temperature conditions.

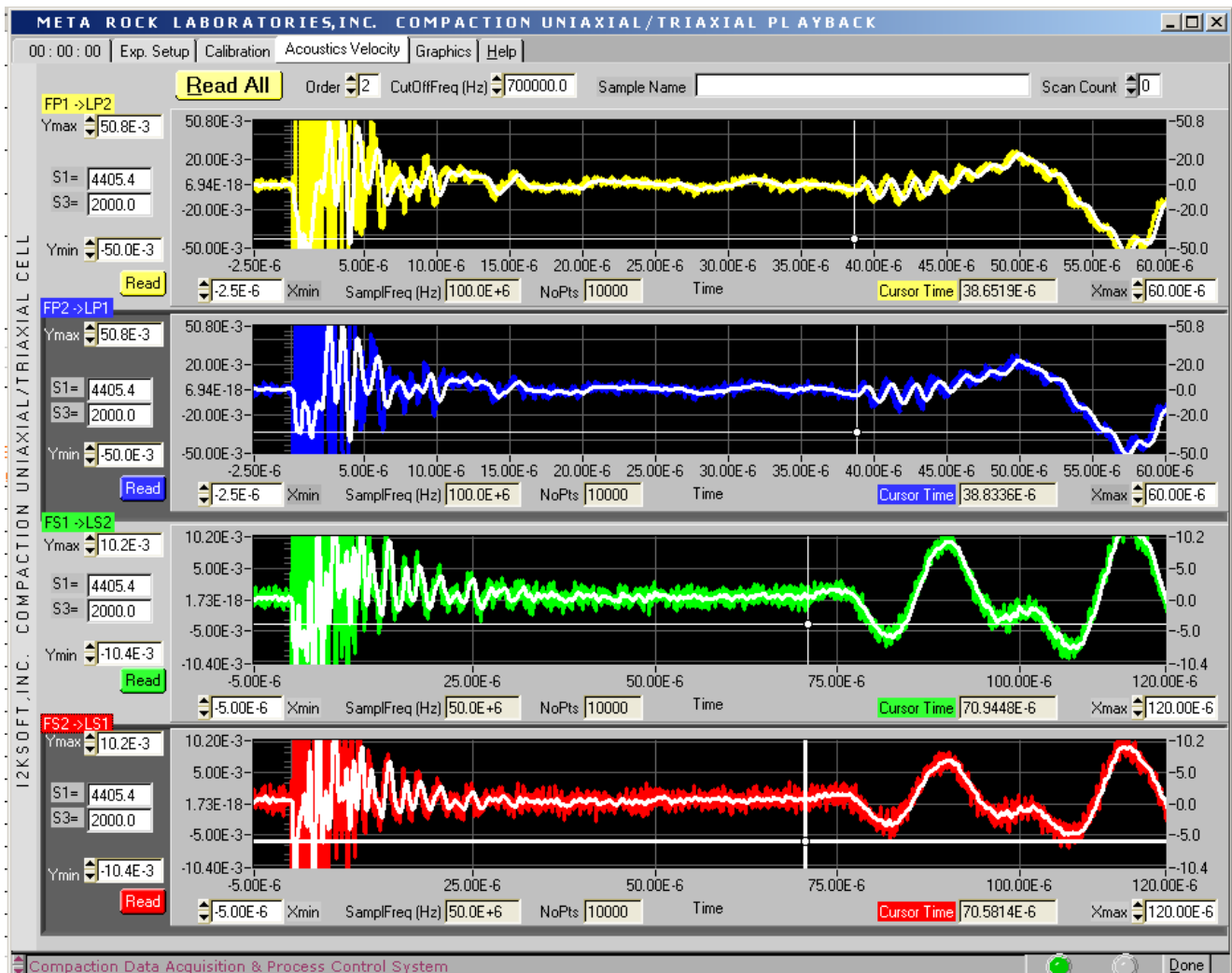


Table 1: Comparison of calculated and industrial velocity range of various metals under ambient condition (Manual arrival detection)

METALS	METAROCK P-VELCOTIY, m/sec	METAROCK S-VELCOTIY, m/sec	INDUSTRY STANDARD P-VELCOTIY, m/sec	INDUSTRY STANDARD S-VELCOTIY, m/sec
ALUMINUM	6293	3144	6300 - 6350	3060 - 3130
STAINLESS STELL-P-14 GRADE	5730	3143	5750 - 5890	3100 - 3200
BRASS	4252	2150	4300 - 4400	2000 - 2120
IRON	4743	2620	5000 - 5150	3000 - 3240

Table 2: Comparison of calculated and industrial velocity range of various metals under ambient condition (Automatic arrival detection)

METALS	METAROCK P-VELCOTIY, m/sec	METAROCK S-VELCOTIY, m/sec	INDUSTRY STANDARD P-VELCOTIY, m/sec	INDUSTRY STANDARD S-VELCOTIY, m/sec
ALUMINUM	6315	3156	6300 - 6350	3060 – 3130
STAINLESS STELL-P-14 GRADE	5852	3226	5750 - 5890	3100 – 3200
BRASS	4285	2214	4300 - 4400	2000 – 2120
IRON	4798	2864	5000 - 5150	3000 – 3240