

P-Wave User Guide

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The P-wave Velocity station.

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Introduction

The P-wave velocity gantry measures the speed at which ultrasonic sound waves pass through materials that are placed between its transducers. The three orthogonal sets of piezoelectric transducers allow the velocity to be determined in the X-, Y-, and Z-directions (*Figure 1*) on working-half split-core sections. The P-wave bayonets (PWBs) measure the velocity along the core (Z-direction) and across the split-core face (Y-direction), and a P-wave caliper (PWC) measures the velocity perpendicular to the split-core face (X-direction). A laser measures the position of the top of the split-core section, and using this, along with the known distance to the transducers, calculates the position at which the velocity was measured (this is recorded as Offset in the LIMS Database). For discrete sample cubes, the velocity is measured along each of the three axes separately using the PWC. Mini-cores are measured along the axis of the cylinder (X-direction) using the PWC. For discrete samples cubes and mini-cores, all sample information, including offset, is entered by the user when the sample was taken.

Velocity data generated from these sensors are part of the physical properties suite of shipboard sample measurements.

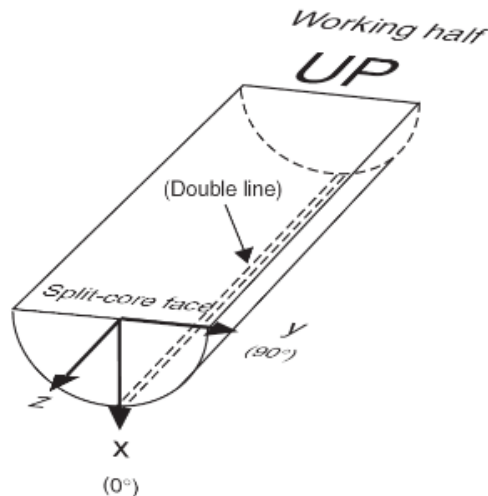


Figure 1. Section half measurement directions.

Method Theory

Measurement of *P*-wave velocity requires an estimate of the travel time and an accurate measurement of the ultrasonic *P*-wave path length through the sample.

Velocity is defined as follows:

velocity = pathlength/traveltime, or

$$v = dS/dt.$$

Traveltime measurement is estimated by an algorithm for graphical first arrival pick. An ultrasonic pulser generates a high-impulse voltage, which is applied to the ultrasonic transmitter and thereby induces oscillation of the crystal element within the transducer-specific frequency band. A trigger pulse from the pulser is then applied to the oscilloscope to record the waveform from the receiving transducer.

By measuring the acoustic traveltime of the waveform through a standard of known pathlength and velocity, the difference in expected travel time and actual travel time provides the instrumentation-specific time delay. Subtraction of the system delay time (+ liner material propagation time, if required) from the total traveltime gives the traveltime for the ultrasonic pulse through the sample.

Precise thickness of the sample, or path length, is derived from the readout of an Acuity AR700 laser displacement sensor. The laser offset correction is determined during the calibration process and requires that the system fully close the transducer caliper when the software is opened and activated.

Therefore, do not place a core section underneath the transducers when the software is started.

The chisel (bayonet) transducers are fixed at 82.32 mm for the z-axis (downhole) and 31.70 mm for the y-axis (see figure 1). As mentioned above, the x-axis caliper separation is derived from an Acuity AR700 laser.

Traveltimes for samples are calculated as follows:

x-axis = total traveltime – x-system delay time – liner traveltime (section-halves only)

y-axis = total traveltime – y-system delay time

z-axis = total traveltime – z-system delay time

Liner traveltime is calculated as the liner thickness (typically 2.7 mm) divided by the published liner material velocity (cellulose butyrate = 2140 m/s).- **W** **asn't this experimentally determined?- Currently we are using 2100m/s.**

The travel times for any measurement signal is based on either a user selected location on a graphical display of the first arrival wave (manual pick), or a software auto-pick feature, which attempts to determine the first arrival of the measurement signal. The auto-pick feature will search for the first instance of a signal stronger than a user set threshold value (milli-amps). Next it will take the absolute value of the signal and determine where the wave-form crosses the graph's x-axis the 2nd time. It will then subtract an assumed 1/2 of wave length, and display the pick location on the same graphical display. This should get the travel-time of the measurement signal. **Verification of the signal and pick location by the user is critical.**

P-Wave Measurement Overview

A temperature-equilibrated split core section-half in its liner is placed on the core track. The user positions the section half under the sensor, places a small piece of glad wrap on top of the core, and triggers the measurement from the software control panel. The measurement is taken continuously, with the recorded result representing the average of several thousand determinations. A barcode reader records all relevant sample information, which is used for the data upload into LIMS. A laser sensor measures the distance to the top of the section-half and determines the sampling interval from the known sensor offsets. Discrete measurements are discussed in the Caliper Measurement section below. When inserting the bayonets or closing the calipers into/on a sample, the graph should be monitored for signal quality.

Caliper Measurement

- The sample is placed between 2 flat, 1 inch diameter sensors that squeeze firmly onto the specimen to ensure good contact. De-Ionized (DI) Water is introduced between the sample and sensors to aid in signal propagation.
- One sensor acts as a transducer and the other as a receiver to record velocity measurements at a rate of 0.5 MHz.
- To measure discrete samples in multiple axis, the sample is rotated by the user to each axis (x-, y-, and z-axis) and measured separately.
- Calibration is performed with a single aluminum block with known thickness and velocity.

Bayonet Measurement

- Two pairs of piezoelectric transducers, set at 90° to each other, are inserted into the unconsolidated or semi soft section-half sediment. The sensors (black circles) must be at least partially buried in the material.
- One of each pair of sensors acts as transducer and the other as receiver to measure velocity in two directions simultaneously.
- Calibration is performed by inserting the probes into a container filled with distilled water of known temperature, and therefore known velocity.

Data Quality

Velocity data quality is affected by several variables. The signal quality and pick locations should be consistently monitored by the user during every measurement.

- Quality of the acoustic coupling between the core material and the sensor transducers. **Note:** Use water to increase the quality of the contact.
- Quality of the coupling between both the transducer and the core liner and between the core liner and sample. **Note:** Use water to increase the quality of the contact.
- Consolidation of the sediments; noncohesive sediments containing microcracks or gas voids cannot be measured accurately.

Apparatus, Reagents, & Materials

Hardware

The velocity track system consists of the following components (*Figure 2*):

- **Caliper transducers:** X-axis velocity measurements
- **Chisel-type transducers (bayonet transducers):** Y and Z axis velocity measurements

- **3 Linear actuators:** Each actuator controls the motion for one instrument
- **Laser Range Finder (AR1000 laser):** Used to determine offset of measurements on section halves
- **Displacement Laser (AR700):** Used to determine distance between caliper transducers during measurements
- **Two Signal Amplifiers:** One amplifier is common to all three instruments and is used to amplify the transducer signals. The second amplifier is used as a pre-amplifier for the receiving signal from the Caliper only. The Caliper returns a weaker signal than the Bayonets. By using this pre-amplifier the Caliper signal can be amplified without affecting the Bayonet measurements. If the signal is noisy or too weak, adjustments are made on only the gain dial.

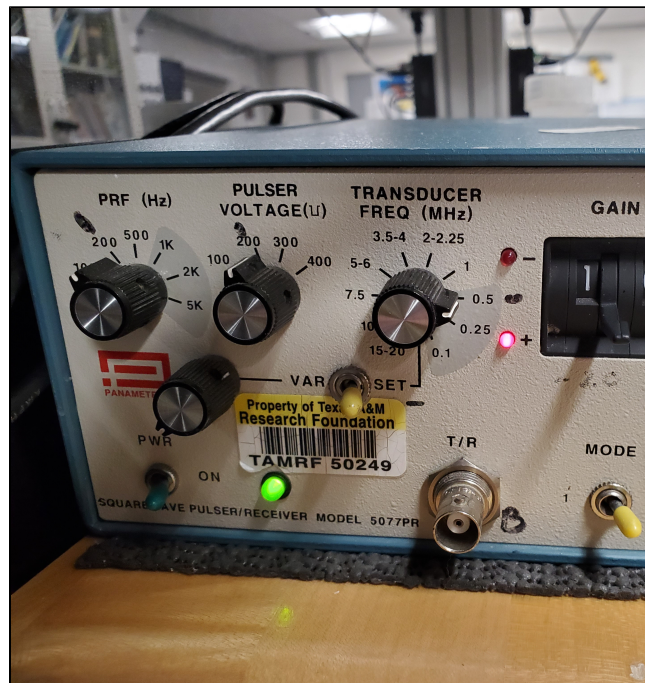
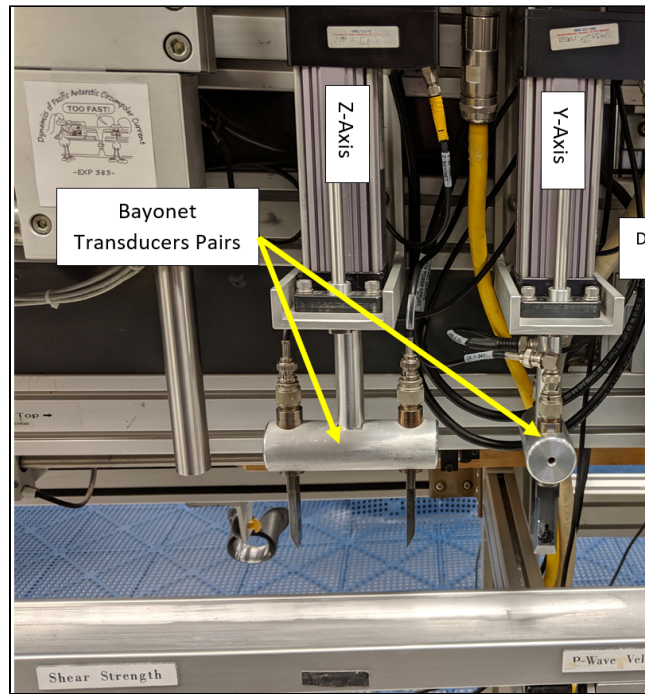


Figure 2: Bayonets, caliper and displacement laser

Caliper Transducers: Panametrics-NDT Microscan Delay Line Transducers

Specification	Value
Frequency (MHz)	0.5
Element diameter (mm)	25
Part number	M2008

Bayonet Transducers

Custom made.

Exlar Linear Actuator

Specification	Value
Maximum radial load (lb)	15
Resolution (revolution)	0.001
Accuracy (revolution)	±0.010
Operating temperature (°C)	0–55
Model Number	TLM20-0601-1-IFM-1BS-50-AR
Voltage (VDC)	48
Current (A)	5000 @ 10 rpm

Acuity 1000 Laser Distance Sensor

Specification	Value
Distance (m)	30
Laser	650 nm, 1 mW visible red
Accuracy	±0.12 inch (3.05 mm)
Resolution	0.004 inch (0.10 mm)
Operating temperature (°C)	–10–50
Linearity/accuracy (mm)	±3

Acuity AR700-4 Laser Displacement Sensor

Specification	Value
Model (P/N)	AR700-4 5mW (AP7020040)
Laser class	3R
Laser type	670nm 5mW visible RED diode
Span	101.6 mm
Resolution	5.1 microns
Operating temperature	0 to 50°C
Linearity/accuracy	±31 microns

Standards

Various standards are available for the P-Wave Gantry system (**Figure 3**). These include:

- Laboratory reagent water (distilled) (for the bayonet calibration), velocity = 1480 m/s at 20 degrees C
- Aluminum block of known length and velocity; velocity = 6295 m/s (for caliper calibration)
- Acrylic half-cylinders of variable thicknesses; the assumed Acrylic Velocity as of June, 2019 is 2730 m/s.
- Liner Velocity accepted value as of June 2019 is 2100 m/s with 40 m/s error

It is recommended that the check standard used be similar in size to the sample being measured.

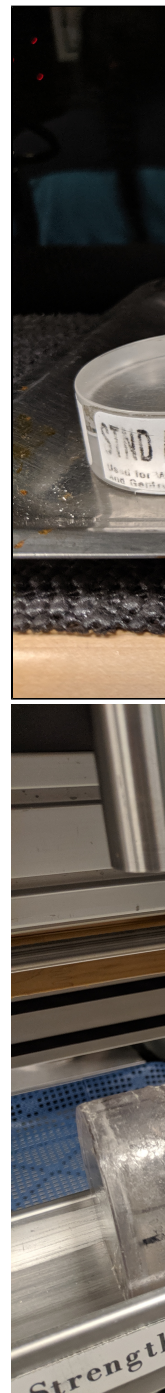


Figure 3. Velocity Standards.

Launching the IMS-Velocity application

The IMS-Velocity software can be launched from the Windows Start menu or from a desktop icon (**Figure 4**).

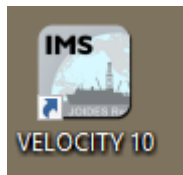


Figure 4. Velocity Desktop Icon

At launch, the program begins the following initialization process:

- Tests all instrument communications
- Reloads configuration values
- Homes the Caliper and Bayonets **Do Not** place samples on the track before launching the software.

CAUTION: When first opening the program, all 3 sensors will go through a communication initiation process where they will move down and up; the program will display a warning message first (Figure 5). However, make sure there are no samples or body parts underneath any of the sensors.

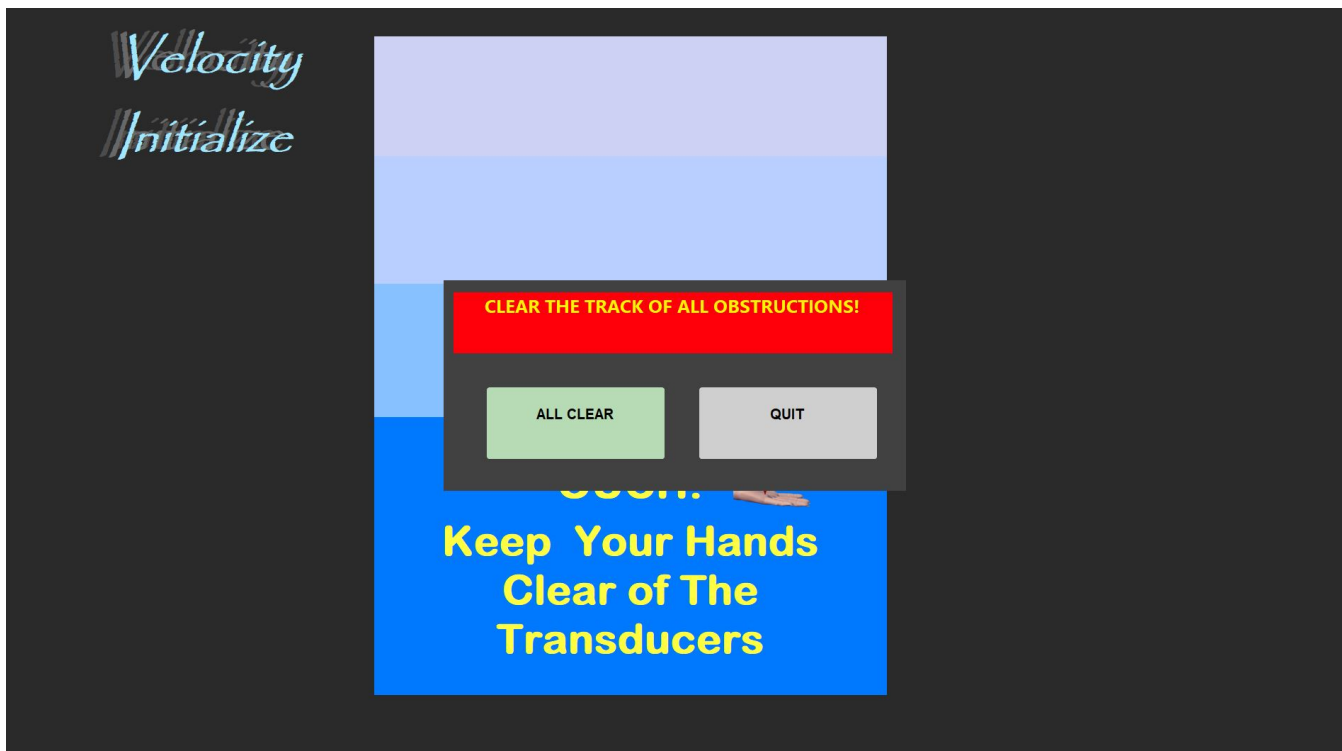


Figure 5. Track Initialization Warning

After successful initialization, the main IMS-Velocity window will appear (Figure 6).



Figure 6. Velocity IMS Main Window

The software home screen allows the user to modify a number of setup and acquisition parameters directly, as well as control the motion of the transducers.

The main window (Figure 7) includes:

1. **Sample type and Measurement Axis selection:** The user selects the type of sample, while simultaneously selecting the measurement axis via the pictured tiles, the current selection will be highlighted.
2. **Graphical Display Tabs:** The RAW, RAW STACKED, and RAW ZOOMED tabs will display the measurement signal without mathematical manipulation. They also display the auto-pick location as a vertical pink line. The ABS and ABS ZOOM tabs display the absolute value and the uncorrected auto-pick location, which should be between the 1st and 2nd hump. These displays are crucial for evaluating the signal quality and pick locations.
3. **Requested Stack and Threshold sliders:**
 - a. **Requested Stack:** The number of measurement signals the software will add together with the intent of increasing the signal to noise ratio. Each time it is adjusted a new set of signals will begin stacking. 100 stacks is a typical value.
 - b. **Threshold:** Voltage level (y-axis of the graphical display mV) that the stacked signal must attain for consideration in a auto-pick. If the threshold is too low, signal noise may be selected as the first arrival. If the threshold is too high, the first arrival may be missed and included with the signal noise.
4. **Mini Graphs:** VELOCITY graph displays the running average of the last 1,000 samples and the TORQUE graph display the torque applied by the actuators to the sample. The Distance graph displays the AR700 distance readings.
5. **Motion Control Buttons:** These control the up-down motion of the caliper and bayonets. The user may select to make slow or fast movements.
6. **Pause Button:** By selecting the pause button, the user will be able to make manual picks and have the velocity of that pick displayed.
7. **Save Data:** The save button is activated when an automatic velocity pick is within the velocity filter range or when a manual pick is made.



Figure 7: Main Velocity Window with annotated sections

A Quick Introduction to the IMS Program Structure

IMS is a modular program. Individual modules are as follows:

- INST plug-in: code for each of the instruments
- MOTION plug-in: code for the motion control system
- DAQ Engine: code that organizes INST and MOTION plug-ins into a track system

The Velocity system, specifically, is built with three INST modules (Caliper, Y-Bayonet, Z-bayonet), three MOTION modules (one for each instrument actuator) .

The IMS Main User Interface (IMS-UI) calls these modules, instructs them to initialize, and provides a user interface to their functionality.

Each module manages a configuration file that opens the IMS program at the same state it was when previously closed and provides utilities for the user to edit or modify the configuration data and calibration routines.

The three buttons on the left side of the IMS-UI window provide access to utilities/editors via dropdown menus as shown in **Figure 8**.

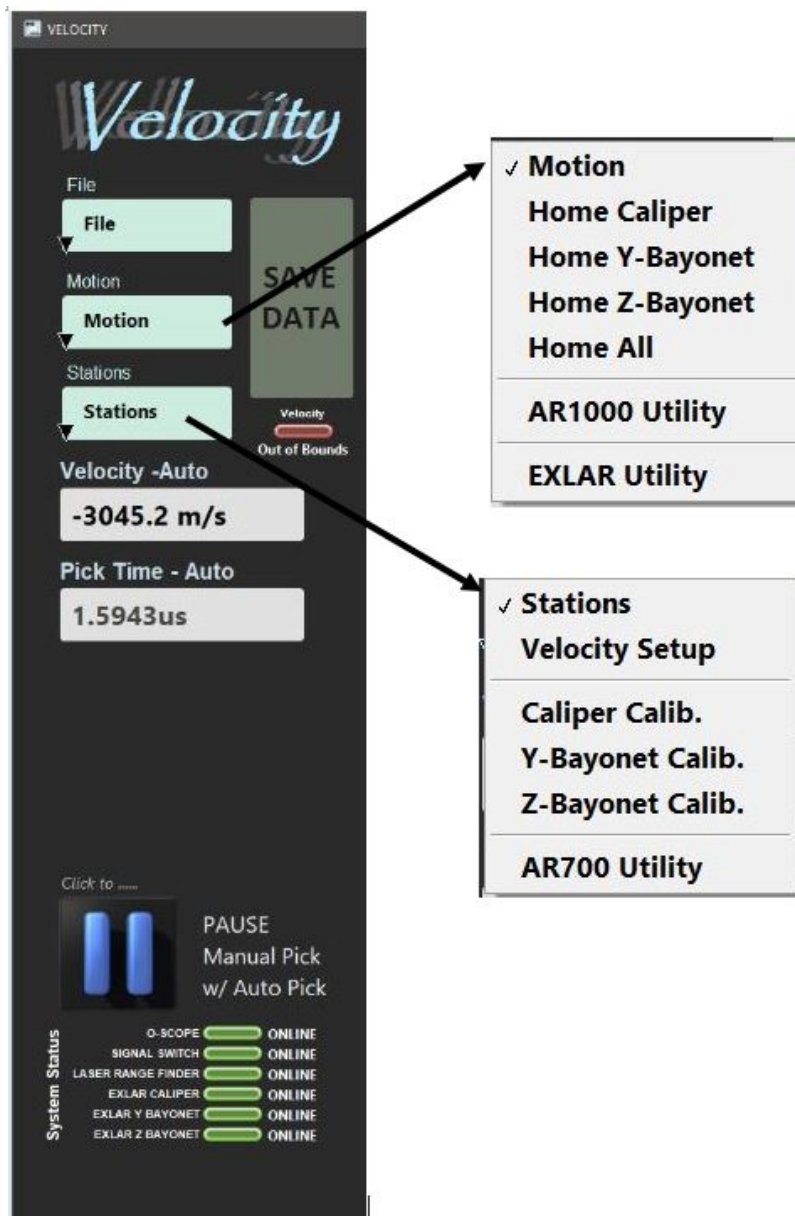


Figure 8. IMS Control Panel Drop Down Menus

Initial Instrument Setup

Configuration values should be set during initial setup and configuration by the physical properties technician. There should be no need to change these values unless the configuration files is corrupted. This window allows the user to view and modify the physical configuration values for the Velocity system, as well as the liner correction values and the velocity filter settings.

Velocity Instrument General Setup

To open the Velocity instrument setup window (Figure 9), select **Stations > Velocity Setup** from the IMS panel menu (Figure 8).

1. Ensure the values in the window are set as shown in Figure 9.
 - a. **Caliper and Bayonet Offsets:** physical offset from the laser zero point to the center of the transducer pair for the three stations (caliper, bayonet Y, bayonet Z). This measurement will not change unless the station location is physically changed.
 - b. **Axis Separation:** physical distance between the bayonet transducer pairs. This measurement should never change unless the bayonets holders are physically changed. The X-Axis is not shown because its separation is determined during calibration and measurement by the AR700 laser

- c. **Liner Correction:** the liner delay value as determined experimentally based on the liner thickness and velocity measurements on the liner material.
 - d. **Velocity Disable "Save" Filter:** when the filter is enabled, the save feature is inactive for any automatic velocity picks outside of the velocity range set.
2. Click **Ok** to accept to save the changes and write them to the configuration file. Click **Cancel** to revert to previous values. NOTE: Only one configuration file exists in the IMS folder. Every save will overwrite the config file.

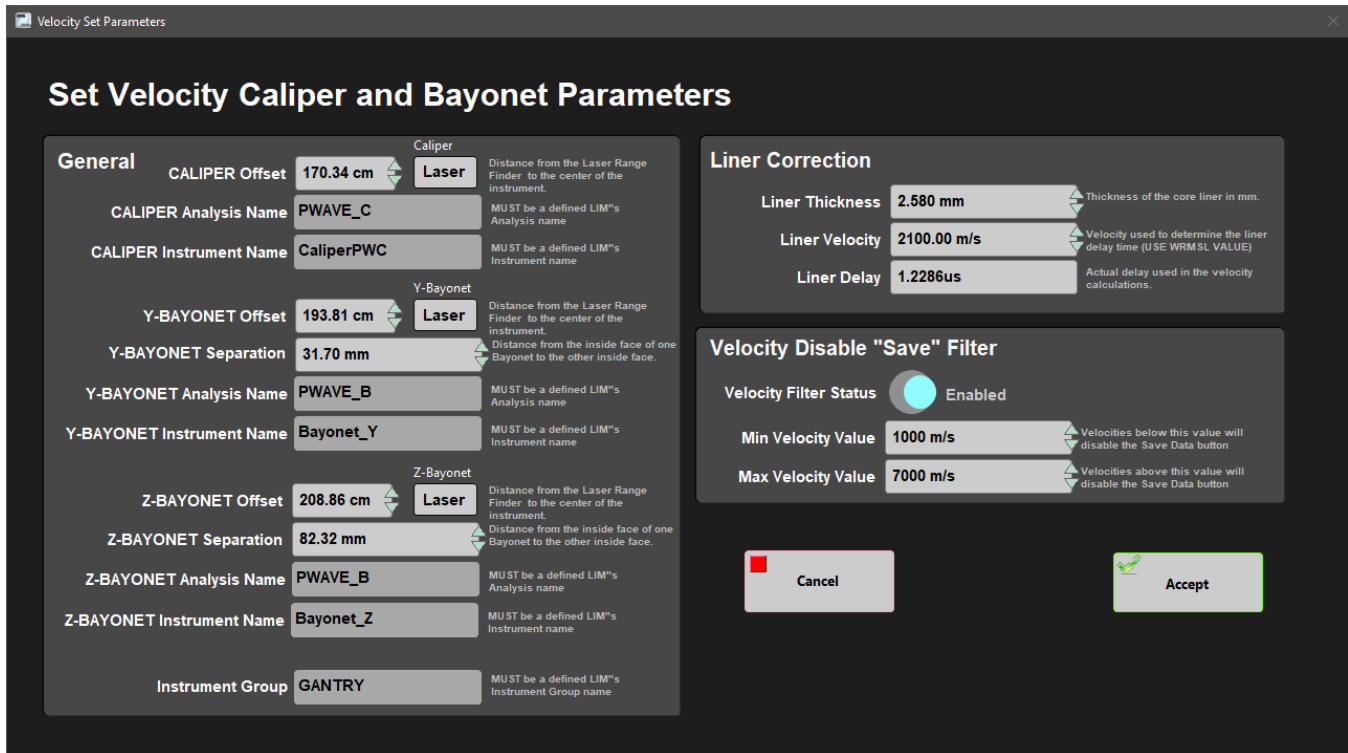


Figure 9. Velocity Parameters Window

Instrument Calibration

The bayonet and caliper transducers must be calibrated and the system delay determined whenever a check standard is out of range, +/-2.0% of the expected velocity. There is a separate utility for each one:

- The *bayonet* transducers are calibrated by back-calculating the system delay from the total traveltime, for the *y*- and *z*-axes, from the transducer separation value and theoretical velocity of distilled water at the temperature of the water bath.
- Calibration of the *caliper* requires the transducer and system delay to be calibrated concurrently. The transducer separation is measured with a displacement laser.

System delay is derived from the separation for the different calibration standards and traveltime is derived from a traveltime pick algorithm. **As the current transducers have pliable plastic pole faces the system delay is on the order of 25 μ s, closing the calipers too hard produces unwanted variation (NOT ANYMORE???)**.

The calibration uses the derived velocity of the standard material to test for acceptance or rejection of the data. Aluminum and acrylic, materials used as calibration standards for the caliper, have a published sound speed of 6295 m/s and 2730 m/s, respectively.

Caliper Calibration (Present - Since IMS v11.1)

The Caliper Calibration Utility calibrates the laser offset and the delay of the system at the same time.

Measurements are taken at standards with the same velocity but with different heights. The operator can choose the number of standards used and the material. A linear correction is applied to calibrate the laser offset, while the system delay and velocity is calculated from the time measurements (??).

By convention a set of six acrylic standards with increasing sizes (15.07, 20.00, 30.03, 34.99, 34.90 and 45.01 mm) are used. They will be measured one by one, following next steps and the same procedure as an ordinary sample.

To open the Caliper Calibration Utility select: **Stations > Caliper Calib.** from the IMS panel menu. The Caliper Calibration window will open (**Figure X1**).

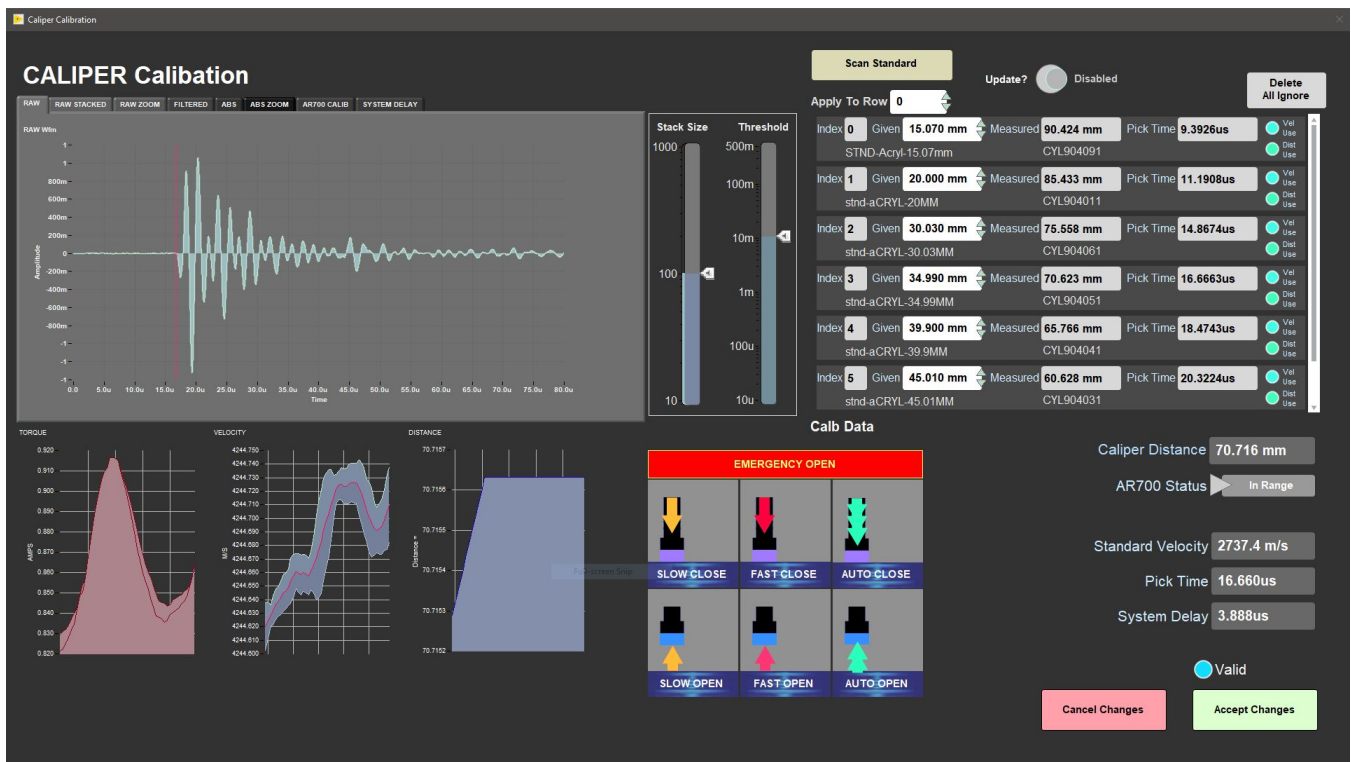


Figure 1X. Caliper Calibration window.

1. On **Apply To Index** box, select the row where the standard measurement info will be filled. Rows are numbered by index, starting with index 0.
2. To insert the standard info, select **Scan Standard** button. The Standard Info window will pop up (Figure X2). Scan the label, on the standard or on the board at the left of the monitor, and click **Accept**. To delete the info of the standard click **Cancel**.

If you are measuring a standard that already exists, you can skip this step.

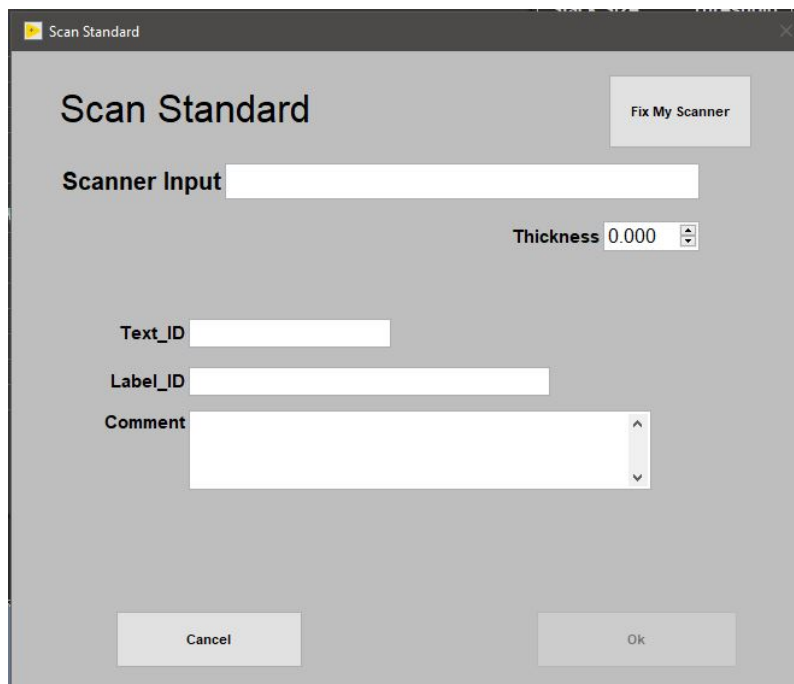


Figure 2X. Scan Standard window.

3. Place the standard between the transducers and close the caliper. Don't forget to place a drop of water on the lower transducer and on the top of the standard. Standards maximum height allowed is 60.0 mm.

4. Verify the software is picking the first arrival wave in the *Raw Stacked* graph tab. You can adjust the threshold scale bar to achieve the proper pick location (**Figure X3a**). Observe the graph to verify the system is getting a clean signal. If you are not getting a clean signal, follow the steps in the trouble shooting section of this guide. Also, verify the auto-pick location in the Absolute Value tab (ABS or ABS Zoom). This pick should be at the zero crossing after the first significant wave form above noise (**Figure X3b**).

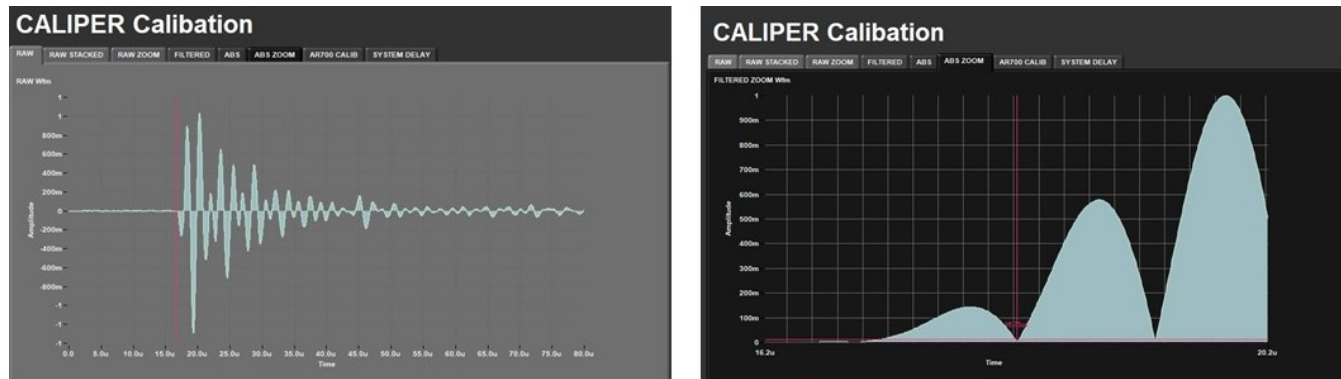


Figure X3. Caliper Calibration Windows. Raw data graph tab (left) and the ABS zoom graph tab (right).

5. **Enable** the button **Update?** to see the new values. If you want to set the value, place this option on **Disable**.

6. Repeat steps 1 to 4 until the required values are updated.

7. The operator can decide which values will be used to calculate laser offset and delay. By default all measurements are used, to remove them turn off **Vel Used** and/or **Dist Used** buttons on each row.

8. When values meet the expectations, click **Accept Changes** (Acrylic velocity= 2730 m/s ± 2.0 %, aluminum velocity= 6295 m/s ± 2.0 %). To leave the utility without saving the calibration, select **Cancel Changes**.

To reset all the values, select **Delete Ignore All** button.

9. To check the calibration measure the velocity of a standard to verify if it is within the expected error margin. On the main window select one of the **Caliper Discrete Sample** options to make the measurement, to discount the liner correction.

To calculate the laser offset, the zero contact position offset was determined for the transducer and a small slope correction values (**Figure X4**).

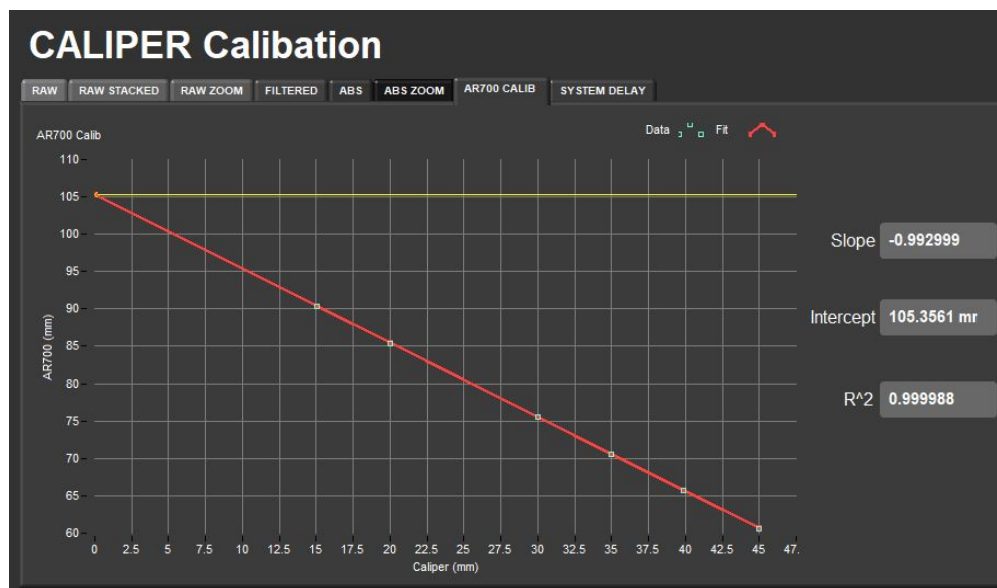


Figure X4. Laser (AR700) offset calculation.

To calculate material velocity and the system delay value the pick time is measured during the calibration (**Figure X5**).

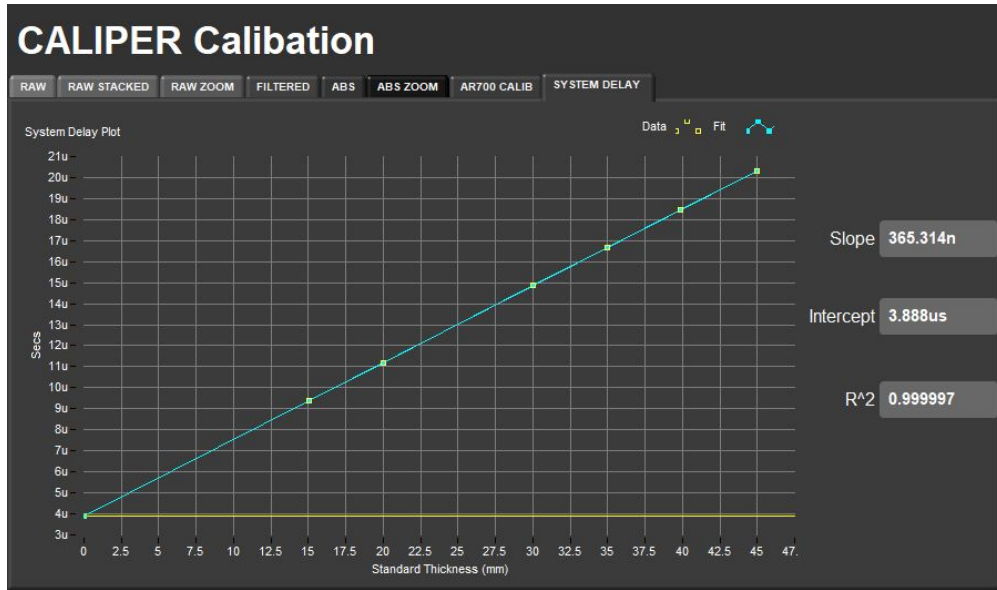


Figure X5. System Delay regression line.

Caliper Calibration (**CURRENTLY NOT BEEN USED**, Used before IMS v11.1)

To open the Caliper calibration window (**Figure 10**), select **Stations > Caliper Calib.** from the IMS panel menu (**Figure 8**).

Calibration requires correcting the displacement laser's offset and determining the system delay. Calibration is completed with an aluminum block of the following approximate dimensions; 50.80 x 76.25 x 30.58mm (**Figure 3**).

To calibrate the caliper:

1. Open the Caliper Calibration window
2. Place a drop of water on the lower transducer
3. Place the aluminum standard on the lower transducer along an axis of known dimension. Commonly the 50.80 mm axis is used as it is closest in thickness to a section-half.
4. Verify the Aluminum width on the right side of the window matches the block width, i.e. 50.80 mm.
5. Place a drop of water on top of the aluminum block.
6. Use the Close Slow or Close Fast buttons to close the caliper on the aluminum block. Do not over close the transducers as a greater force will vary the physical distances of the caliper system.
7. Verify the software is picking the first arrival wave in the *Raw Stacked* graph tab. You can adjust the threshold scale bar to achieve the proper pick location (**Figure 10**). Observe the graph to verify the system is getting a clean signal. If you are not getting a clean signal, follow the steps in the trouble shooting section of this guide. Also, verify the auto-pick location in the Absolute Value tab (ABS or ABS Zoom). This pick should be at the zero crossing after the first significant wave form above noise (**Figure 10**).
8. Select **Laser Offset Correction** and verify the distance shown corresponds to the aluminum width.
9. Verify the aluminum velocity is properly set (6295m/s)
10. Select **Determine System Delay**
11. Verify the velocity shown on the screen is now 6295 m/s plus or minus 25 m/s.
12. If the displayed velocity is correct, select Accept changes. To leave with out saving the calibration, select Cancel Changes.
13. As a check on your calibration, measure the velocity of the aluminum block and an acrylic standard to verify it is within an expected error margin, +/- 2.0%. The assumed Acrylic Velocity as of June, 2019 is 2730 m/s. It is recommended to use an acrylic standard of a similar thickness to what the user will be measuring, i.e. a core section or cube sample. Ensure one of the discrete caliper sample types is selected for this measurement to discount the liner correction.

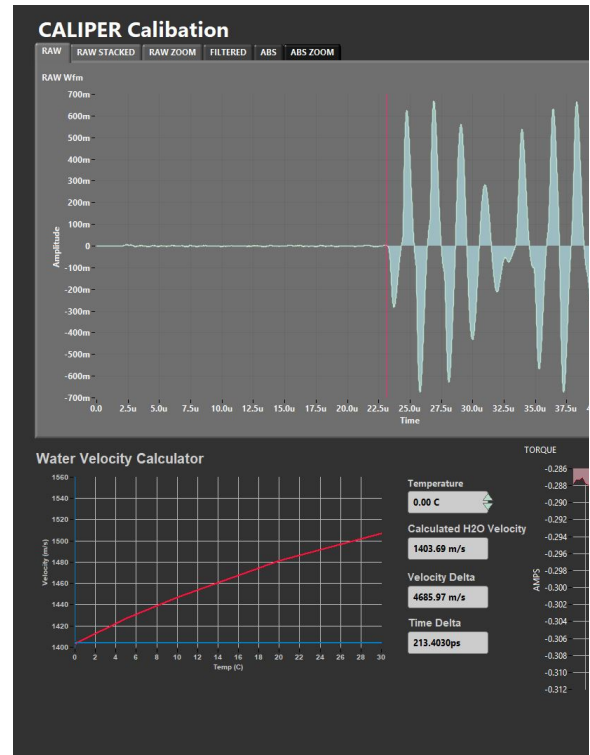


Figure 10. Caliper Calibration Windows. Raw data graph tab (left) and the ABS zoom graph tab (right)

Bayonet Calibration

Because the distance between the bayonets is fixed, only the system time delay needs to be calculated. This is achieved by measuring the velocity in water of known temperature, the difference between the known and measured value is due to system delay.

To open the Bayonet calibration window (**Figure 11**), select **Stations > Y-Bayonet Calib. or Z-Bayonet Calib.** from the IMS panel menu (**Figure 8**).

To calibrate the bayonets:

1. Fill the bayonet calibration liner with DI water (**Figure 12**). The water level must be high enough that the black transducer pads on the bayonets can be placed below the water line without touching the liner itself. The water should be at room temperature if possible.
2. Place the liner below the bayonets.
3. Open the bayonet calibration window for the selected axis
4. Verify the bayonet separation value. If the value is incorrect, return to the Velocity Setup window (**Figure 9**) to edit the value.
5. Use a thermometer to measure the temperature of the water in the calibration liner
6. Enter the temperature value in the *Temperature* field next to the Water Velocity Calculator (lower left of the window). The screen displays a plot of theoretical velocity of water vs. temperature.
7. Use the Insert slow or Insert fast buttons to lower the bayonets into the water until the black transducer pads are submerged. Use care when lowering the Y-bayonet to ensure you do not contact the core liner.
8. Verify the software is picking the first arrival wave in the Raw Stacked graph tab. You can adjust the threshold scale bar to achieve the proper pick location (**Figure 11**) as long as the signal is not too noisy. Also, verify the auto-pick location in the Absolute Value tab (ABS or ABS Zoom) (**Figure 11**). This pick should be at the zero crossing after the first wave form above noise (**Figure 11**). An algorithm calculates the temperature-corrected velocity of the water bath and displays the result in the *Corrected Velocity* field.
9. Select **Determine System Delay**. The computer calculates the system delay based on the separation distance and theoretical velocity of water.
10. Compare the corrected velocity to the calculated H2O velocity value. If the values are not within range, redo the calibration.
11. Select Accept Changes to save the calibration or select Cancel Changes to leave without saving the calibration.
12. As a check on your calibration, measure the velocity of the water to verify it is within an expected error margin, +/- 2.0%. Ensure the proper sample type is selected when verifying the calibration.



Figure 11. Y-bayonet and Z-bayonet Calibration windows. Y-bayonet raw graph tab (left), Z-bayonet raw graph tab (center), Y-bayonet ABS Zoom graph tab (right).

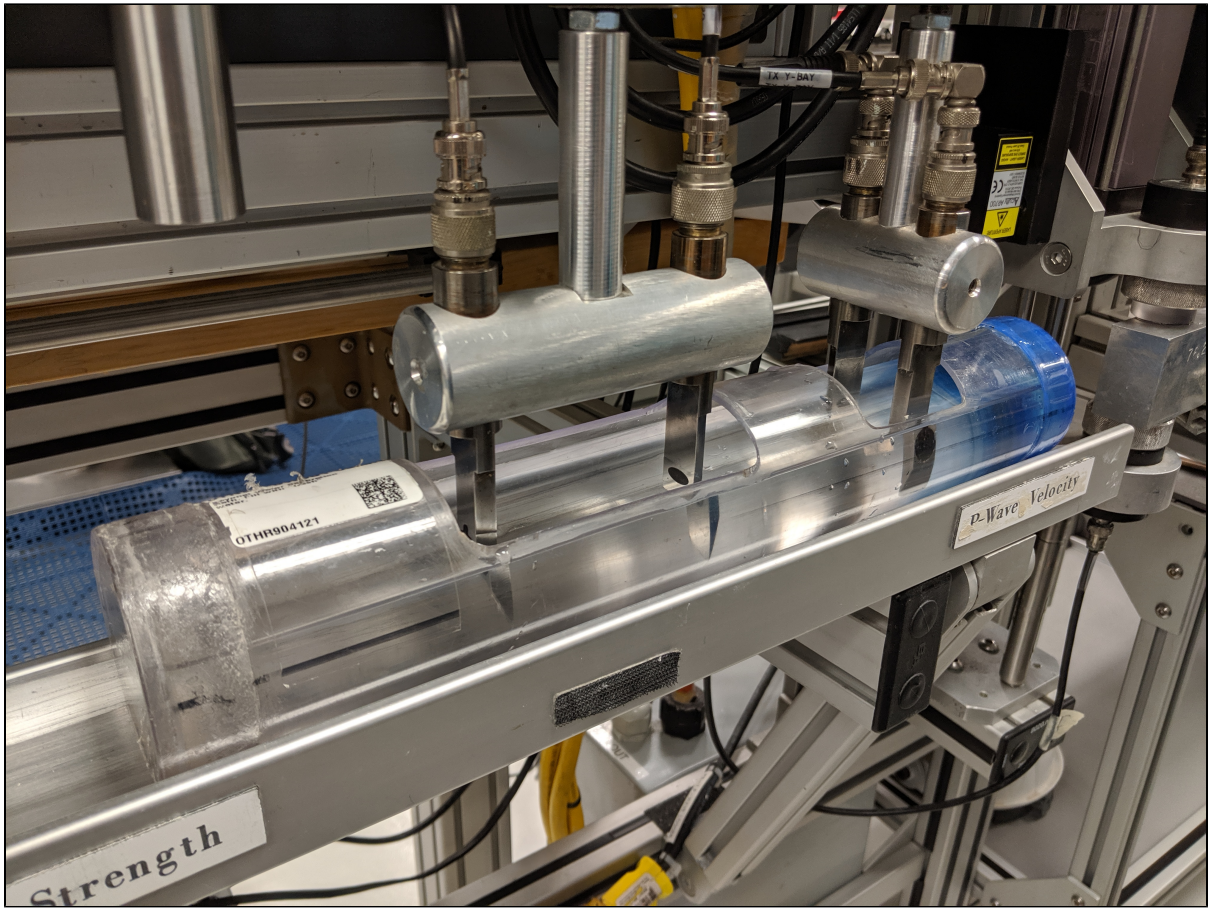


Figure 12. Bayonet Water Standard

Measurement Preparation

Sample Preparation Overview

- On semi-lithified and lithified samples, loose material may be present on the core cut surface. Before placing the working half in the core tray, make sure the surface is clean (lightly brush away any material with a Kimwipe or paper towel).
- Place the core section in the tray and make sure it is as flat as possible. The blue end cap should point forward (toward the AR1000 laser).
- For section-half measurements, place a small piece of Glad Wrap over the desired Caliper measurement location. This will keep the transducers clean and allow the user to add a small amount of water between the core and transducers.

Instrument Preparation

- Clean transducers of any residue with water and paper towels.

Sample Analysis

Caliper Measurements

The caliper can be used to measure section half and discrete cube samples. Before measuring samples, be sure the samples are properly prepared and the system is calibrated. Retaining the correct "up" direction is critical for axis determination, and for other systems like P-mag orientation; make sure the sample has the "up" direction marked on it.

Section halves measured on the Caliper station are working half sections placed on the track with the blue end cap (top of section) toward the AR1000 laser. The laser measures the distance to the top of the section and the software calculates the offset to the measurement based on the known section length.

Discrete samples measured on the Caliper station are hard material that has been cut from the core as cubes, minicores, or slabs. Because the material can be measured in various orientations, the user must select the measurement axis. Traveltime is calculated as total traveltime minus x-system delay time. Discrete sample measurements are not corrected for the core liner. The offset recorded in LIMS is the top offset of the discrete sample. The AR1000 laser is not used for discrete measurements. The transducer separation is measured with the displacement laser, as it is for the sample half measurement. For discrete samples the axis of measurement is selected for each measurement.

Section Half Measurement Procedure

1. Place section half below the caliper. Take care to not drag the core against the bayonets while placing the core on the track.
2. Place a drop of distilled water below the section on the transducer and on top of a piece of Glad Wrap on top of the section to improve contact between the caliper and section. Note: Placing Glad Wrap is not required. This is only to improve signal quality.
3. Select the proper instrument and measurement axis button (Caliper SHLF X-axis)
4. Close the transducer onto the core until contact is made. Do not over close the caliper on the section half.
5. Verify the automatic velocity pick in the Raw Stacked graph tab (**Figure 10**). You can adjust the threshold scale bar to achieve the proper pick location as long as the signal is not too noisy. The user may want to verify the auto-pick location in the Absolute Value tab (ABS or ABS Zoom). This pick should be at the zero crossing after the first wave form.
6. Select Save Data. A sample information window will appear (**Figure 13**).
7. Verify the measurement offset.
 - a. If the offset is incorrect, select cancel. The laser range finder sometimes struggles to return a proper offset if the end cap is not opaque or if the core is not flat on track. Try adding a post it note or opaque end cap to the section half if the laser returns the wrong offset. Select Save Data again.
8. Once the measurement offset is verified, scan the section half barcode label to populate the fields of the sample information box.
9. Select Save Data.

This procedure can also be used for whole rounds or pieces of section halves, but this is rarely used. The software assumes that the whole round piece or section half piece is not within a core liner and will not correct for a liner velocity. Scan the section half label when entering the sample ID information. **Offset information is not currently displaying properly in LIMS for these measurements (June 27, 2019). Piece measurements are displayed in LIMS under discrete measurements and whole round measurements are displayed in the section report.**

Figure 13. Section Half Caliper Measurements Sample Information Window

Discrete Sample Measurement Procedure

For each axis to be measured:

1. Place a small drop of water on the lower caliper transducer
2. Place the discrete sample on the caliper and add a drop of water to the top of the sample
3. Select the proper instrument and measurement axis button (Caliper X-Axis, Caliper Y-Axis, Caliper Z-Axis).
4. Lower the upper caliper transducer onto the specimen. Do not apply unnecessary force on the specimen as it may fracture, or cause physical variation in the caliper system and measurement.
5. Verify the automatic velocity pick in the Raw Stacked graph tab (**Figure 10**). You can adjust the threshold scale bar to achieve the proper pick location, or pause the system to do a manual pick. The user may want to verify the auto-pick location in the Absolute Value tab (ABS or ABS Zoom). This pick should be at the zero crossing after the first wave form.
6. Select Save Data. The sample information window will open (**Figure 14**). Note that the measurement offset will not be populated. The laser range finder is not used for discrete measurements.
7. Scan the discrete sample barcode label to populate the fields of the sample information box. The sample's top off set in the section-half will be used as the measurement location.
8. Select Save Data.

If the material to be measured is a whole piece removed from the liner (rarely used), select Caliper Piece X-Axis in Step 3. The measurement offset field in the sample information window is selectable. Scan a section half label and enter the offset of your measurement from **TOP OF CORE?** **Currently Piece Measurements offset do not work**

Figure 14. Discrete Caliper Measurements Sample Information Window

Bayonet Measurements

Before measuring samples, be sure the samples are properly prepared and the system is calibrated.

1. Place section half below the bayonets. Take care to not drag the core against the bayonets while placing the core on the track.
2. Select the proper instrument and measurement axis button (Y or Z bayonet)
3. Lower the selected bayonets into the section half until the black transducers are below the sediment surface. A piece of glad wrap can be placed on the cut surface before inserting the bayonets, with water then added to aid in signal propagation. The glad wrap is to prevent water from being absorbed into the material.
4. Verify the automatic velocity pick in the Raw Stacked graph tab (**Figure 11**). You can adjust the threshold scale bar to achieve the proper pick location, or pause the system to do a manual pick. The user may want to verify the auto-pick location in the Absolute Value tab (ABS or ABS Zoom). This pick should be at the zero crossing after the first wave form above noise.
5. Select Save Data. A sample information window will appear (**Figure 13**).
6. Verify the measurement offset.
 - a. If the offset is incorrect, select cancel and select Save Data again. The laser range finder sometimes struggles to return a proper offset if the end cap is not opaque or if the core is not flat on track. Try adding a post it note or opaque end cap to the section half if the laser returns the wrong offset.
7. Once the measurement offset is verified, scan the section half barcode label to populate the fields of the sample information box.
8. Select Save Data

Manual Pick

In some cases, a user may wish to make a manual pick. This usually occurs because the automatic pick is unsuccessful, often due to a noisy signal. Often, the Save Data option will not be available for a bad automatic velocity pick, because the values are outside of the velocity filter range. **Figure 15a** shows an example of a situation in which adjusting the threshold value could not overcome a large peak at the start of the measurement. Using the manual pick, the user is able to override the computers pick. Both the automatic velocity pick and manual pick are recorded in LIMS. This option is available for all measurements on the Velocity-Gantry track.

IMPORTANT: It is important that all users, on both shifts, agree ahead of time on the proper manual pick location. If they do not, each user is likely to induce a small offset in velocity due to inconsistent pick locations; the zoom tools in the lower left of the graph may help better locate the wave forms. It is obvious from the graph in **Figure 15b** that a first arrival location is not as straight forward as one might assume. **The manual pick location should be relatively obvious so anyone can see it above the noise, because noise is likely to be high when auto-pick doesn't work. Then any necessary offset to correct can be applied in post processing.** The agreed upon manual pick location and any offset correction in first arrival should be documented in the scientists' methods section.

To make a manual pick:

1. Place sample in the selected instrument
2. Once a signal is visible on the graphical display, select the Pause button in the lower left corner of the main window (**Figure 7**).
3. The manual pick tab will be displayed on the screen (**Figure 15**).

- Slide the red line along the x-axis to the desired pick location. The line should be placed at the first arrival. To help select the first arrival, the plot can be zoomed in using the graph palette zoom function in the lower left corner of the graphical display. **What is the proper method of selecting? First positive peak? (See my suggestion in red above)**
- Verify the Velocity-manual value is reasonable for the material measured.
- Select Save Data. The sample information window will open.
- Scan the sample barcode label and save the data to the LIMS database.

To exit the manual pick and return to the automatic velocity pick, press the Play button.



Figure 15a. Manual Pick Graphical Display

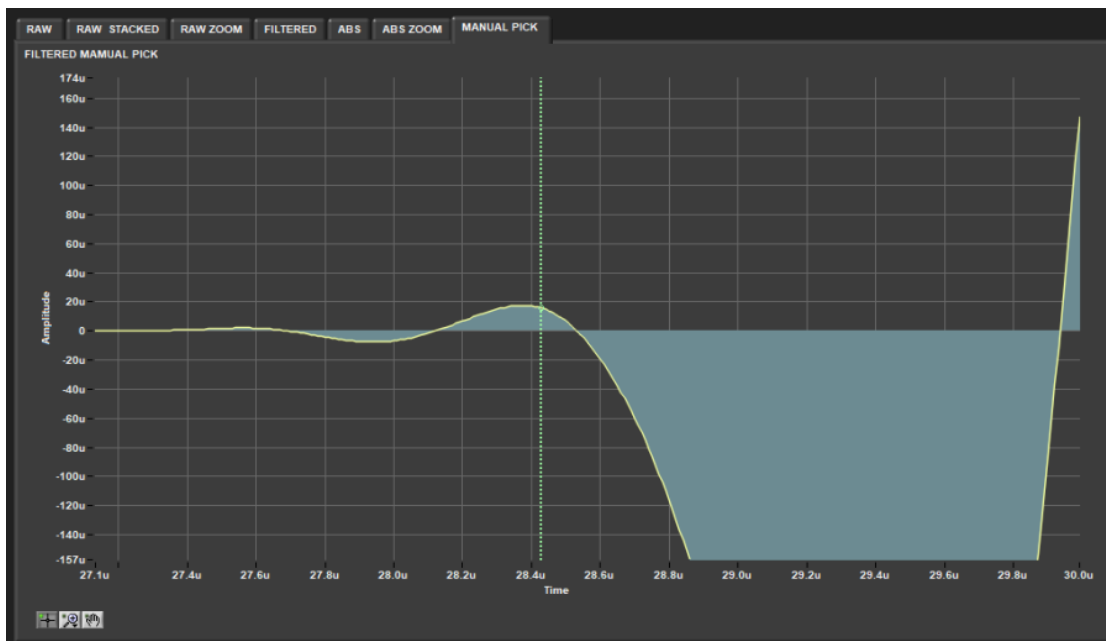


Figure 15b. Zoomed Manual Pick Graphical Display

Utilities

The Velocity software include utilities for homing the instruments and testing the AR700 and AR1000 lasers.

Motion Utilities

The available motion utilities are found under the **Motion** menu from the IMS panel menu (Figure 8). The user may home each instrument separately using the **Home Caliper**, **Home Y-Bayonet**, **Home Z-Bayonet** options or home both bayonets and the caliper at the same time using the **Home All** command.

AR1000 Laser Utility

To open the AR1000 utility window (Figure 16), select **Motion > AR1000 Utility** from the IMS panel menu (Figure 8). This utility is useful when a user is trying to determine if the laser is correctly reading the distance to the center of each instrument.

If the mean distance shown does not agree with the instrument offset in the Velocity Setup Window (Figure 9), the offsets reported in the database will be incorrect.

The utility immediately begins reading the AR1000 laser output and averaging the values collected once the utility is opened.

To check the instrument offsets, place an object in the center of the instrument in question, i.e. the caliper. The object surface should be at the center of the instrument. An end cap works well as long as it is opaque. Verify that the Mean Distance displayed on the screen matches the offset in the Velocity Setup window (Figure 9). A tape measure can also be used to independently verify the offset value.

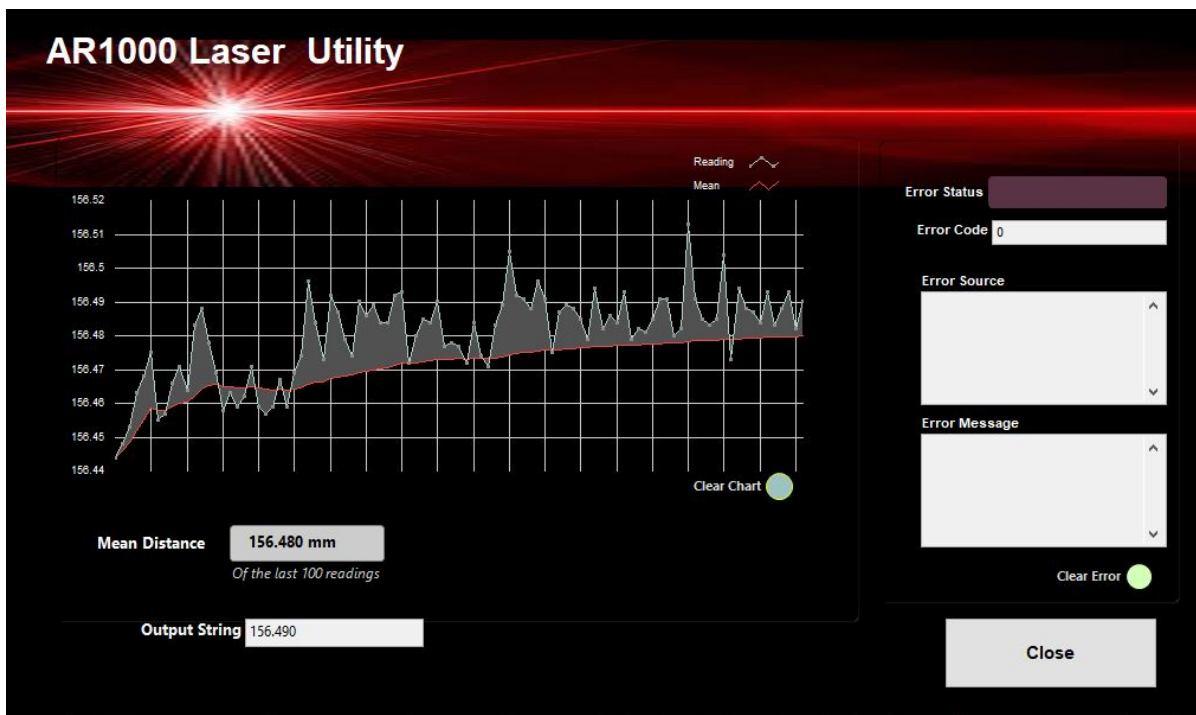


Figure 16. AR1000 Laser Utility

AR700 Displacement Laser Utility

To open the AR700 utility window (Figure 17), select **Stations > AR700 Utility** from the IMS panel menu (Figure 8).

Use this utility to determine if the AR700 displacement laser is returning accurate distances. The readings from this laser are used as the distance values in the velocity calculations. Inaccurate readings from the laser will cause error in the velocity readings.

The AR700 is mounted on the Caliper actuator. The more the Caliper is closed, the smaller the laser distance returned. It is recommended that the objects used for testing are similar in size to the samples being measured.

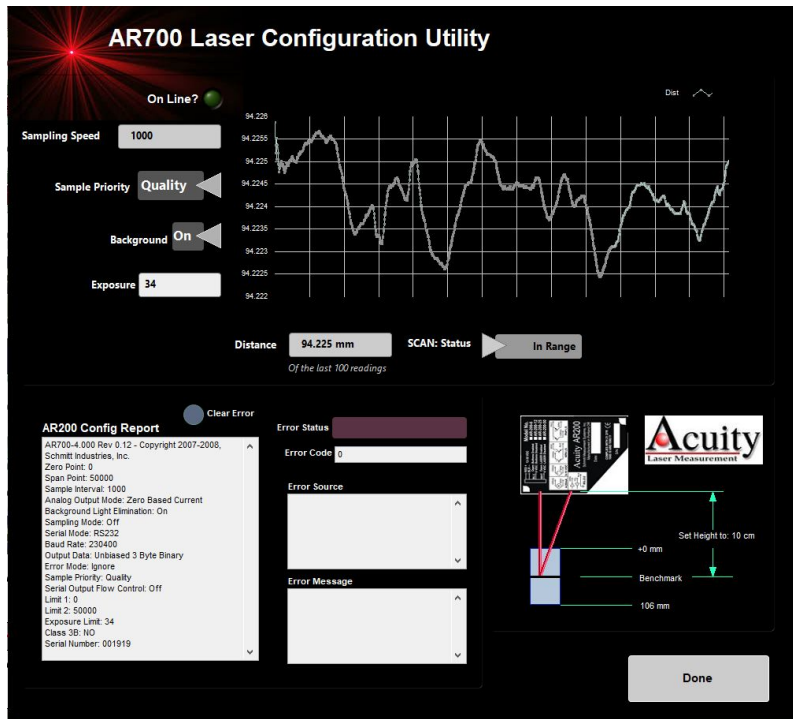


Figure 17. AR700 Displacement Laser Utility

EXLAR Utility

This utility allows to control the movement and change the parameters of the three Exlar actuators: Bayonet Z, bayonet Y and Caliper.

To open it, on the main window, go to: Motion > EXLAR Utility. TRITEX Utility window will open (**Figure X6**).

LIMS Integration

Data Upload Procedure

Data is automatically saved to the C:/Data/In folder on the computer. The MegaUploadatron application locates these files and uploads them to LIMS. Once the upload is completed the data is moved to C:/Data/Archive.

Data File Formats

The files generated by the Velocity Gantry system are:

- **Velocity.ini:** A file containing the configuration information for each instrument on the Velocity Gantry track and the most recent calibration information for each instrument
- **.pwc:** A file containing an individual measurement on the Caliper or Bayonets. Data includes distance between calipers (mm), travel time (us), the measurement offset on the section (cm) (no offset included for discretets), the calculated velocity (m/s), the time stamp of the measurement, the system delay, and the liner time correction. The name and location of all associated files are also listed within this file.
- **.lvm:** A file containing the transducer signal data for the given measurement. The signal and time (us) are provided.

Data Available in LORE

The data is available in LORE in the Standard and Expanded reports for the Caliper and Bayonets. The expanded reports include the linked original data files and more detailed information regarding the measurement.

P-Wave Velocity, Caliper System (PWC) Standard Report

- **Exp:** expedition number
- **Site:** site number
- **Hole:** hole number

- **Core:** core number
- **Type:** type indicates the coring tool used to recover the core (typical types are F, H, R, X).
- **Sect:** section number
- **A/W:** archive (A) or working (W) section half.
- **Offset on section (cm):** position of the sample being measured relative to the top of a section or section half.
- **Offset (cm):** position of observation made on a sample (typically a section half), measured relative to the top of the sample.
- **Depth CSF-A (m):** location of the observation expressed relative to the top of a hole.
- **Depth [other] (m):** location of the observation expressed relative to the top of a hole. The location is presented in a scale selected by the science party or the report user.
- **P-wave velocity x|y|z|unknown (m/s):** velocity of pressure wave through sample along the noted axis.
- **Caliper separation (mm):** displacement between the faces of the transducers in contact with the sample, associated with the velocity observation in the specified axis.
- **Sonic traveltime (µs):** traveltime of the sonic wave from transducer to transducer through the sample, associated with the velocity observation in the specified axis.
- **P-wave velocity x|y|z|unknown [manual] (m/s):** velocity of pressure wave through sample in the noted axis, calculated using the manually picked traveltime.
- **Sonic traveltime [manual] (µs):** manually picked traveltime of the sonic wave from transducer to transducer through the sample, associated with the velocity observation in the specified axis.
- **Timestamp (UTC):** point in time at which the data was uploaded on the Gantry.
- **Instrument:** an abbreviation or mnemonic for the P-wave sensing device used to make these observations (CaliperPWS).
- **Instrument group:** abbreviation or mnemonic for the data collection device used to acquire this observation (Gantry).
- **Text ID:** automatically generated unique database identifier for a sample, visible on printed labels.
- **Test No:** Unique number associated with the instrument measurement steps that produced these data.
- **Comments:** observer's notes about a measurement, the sample, or the measurement process.

P-Wave Velocity, Bayonet System (PWB) Standard Report

- **Exp:** expedition number
- **Site:** site number
- **Hole:** hole number
- **Core:** core number
- **Type:** type indicates the coring tool used to recover the core (typical types are F, H, R, X).
- **Sect:** section number
- **A/W:** archive (A) or working (W) section half.
- **Offset on section (cm):** position of the sample being measured relative to the top of a section or section half.
- **Offset (cm):** position of observation made on a sample (typically a section half), measured relative to the top of the sample.
- **Depth CSF-A (m):** location of the observation expressed relative to the top of a hole.
- **Depth [other] (m):** location of the observation expressed relative to the top of a hole. The location is presented in a scale selected by the science party or the report user.
- **P-wave velocity x|y|z|unknown (m/s):** velocity of pressure wave through sample along the noted axis.
- **Caliper separation (mm):** displacement between the faces of the transducers in contact with the sample, associated with the velocity observation in the specified axis.
- **Sonic traveltime (µs):** traveltime of the sonic wave from transducer to transducer through the sample, associated with the velocity observation in the specified axis.
- **P-wave velocity x|y|z|unknown [manual] (m/s):** velocity of pressure wave through sample in the noted axis, calculated using the manually picked traveltime.
- **Sonic traveltime [manual] (µs):** manually picked traveltime of the sonic wave from transducer to transducer through the sample, associated with the velocity observation in the specified axis.
- **Timestamp (UTC):** point in time at which the data was uploaded on the Gantry.
- **Instrument:** an abbreviation or mnemonic for the P-wave sensing device used to make these observations (CaliperPWS).
- **Instrument group:** abbreviation or mnemonic for the data collection device used to acquire this observation (Gantry).
- **Text ID:** automatically generated unique database identifier for a sample, visible on printed labels.
- **Test No:** Unique number associated with the instrument measurement steps that produced these data.
- **Comments:** observer's notes about a measurement, the sample, or the measurement process.

Health, Safety, & Environment

Safety

- Keep extraneous items and body parts away from the moving parts.
- The track system has a well-marked yellow and red emergency stop button (**Figure 18**) to halt the system if needed. Pressing this emergency stop will prevent all actuator motion on the Velocity track, however, it will lock the actuators in their position at the time it is pushed.
- Do not look directly into the laser light source (class 2 laser product).
- Do not direct the laser beam at other people.
- Do not attempt to work on the system while a measurement is in progress.
- Do not lean over or on the track.
- Do not stack anything on the track.
- This analytical system does not require personal protective equipment.



Figure 18. Emergency Stop on the Velocity Track

Maintenance & Troubleshooting

Common Issues

The following are common problems encountered when using the P-wave Velocity Gantry and their possible causes and solutions. For information about the laser Measurement and Operation software, read [Gantry NI Max setup.docx](#). Vp [GIESA Gantry Laser Operation manual.\(Is this Old?\)](#)

Issue	Possible Causes	Solution
Laser sensor: no laser light/no laser range data	Sampling is turned off	Turn sampling on through laser <i>Measurement and Operation</i> software
	Power supply voltage too low	Check power supply input voltage through laser <i>Measurement and Operation</i> software
Laser sensor: Serial port not responding	Power supply voltage too low	Check power supply input voltage through laser <i>Measurement and Operation</i> software
	Baud rate incorrect or unknown	See Acuity manual 3.5.1; laser <i>Measurement and Operation</i> software
Laser sensor: Error code (Exx) transmitted on serial port		See Acuity manual 5.3; laser <i>Measurement and Operation</i> software
Exlar actuator: No response	I/O error	Check drive or Expert software for faults Use MOTION1/MOTION2/JOG commands. Use arrow up to upload parameters
	Power interruption	Check wiring
Exlar actuator: Behaving erratically	Drive improperly tuned	Check gain settings Use MOTION1/MOTION2/JOG commands. Use arrow up to upload parameters
	Too much load on motor	Check for load irregularity or excess load

Exlar actuator: Cannot move load	Too much load or friction	Check load and friction sources
	Excessive side load	Check side load
	Misalignment of output rod to load	Check alignment of rod and load
	Current limit on drive too low	Check current on drive
	Power supply current too low	Check power supply current
Exlar actuator: Housing vibrates when shaft in motion	Loose mounting	Tighten mounting screws
	Drive improperly tuned	Check gain settings
Exlar actuator: Output rod rotates during motion	Rod rotation prevents proper linear motion	Install anti-rotation assembly
Exlar actuator: Overheating	Ambient temperature too high	Check ambient temperature
	Actuator operation outside continuous ratings	Check operation settings
	Amplifier poorly tuned	Check gain settings
Caliper Freezes in place	Put too much force on object and passed the current limit	Open Exlar utility and press sync to coordinate the software settings and the actuator.
Auto Open/Auto Close Buttons cause caliper to freeze	The rev/sec may be incorrect for the caliper	Check Exlar utilities window. Change 22 rev/sec on Motion 1 and 3 to 21 rev/sec

Resetting the AR700 Laser Baud Rate

A common issue with the Caliper system is the AR700 laser baud rate. If power is lost to the Laser it may default to an incorrect baud rate when turned back on. See the [Gantry NI Max setup.docx](#) or find the AR700 Vendor Manual in the [Lab Notebook: Physical Properties](#) page under *Resources: General* section.

Scheduled Maintenance

After Every Sample

Clean contact sensors with tissue, cloth, or paper towel and water.

Start of Expedition/As Needed

Remove the caliper transducer caps (clear acrylic) from the caliper by unscrewing the aluminum retaining ring. With a Kimwipe, remove all old Couplant fluid and water. Thinly coat the transducer's surface, or the cap for the upper transducer, with Couplant B, and re-screw the retaining ring. Re-calibrate after each time, paying attention to the signal quality.

Clean dust from the laser sensor lens using compressed air or delicate tissue wipes. Do **not** use **organic cleaning solvents** on the sensor lens.

Check that lower transducer for caliper is making contact with core liner as sections are measured.

Transducer cap maintenance?? Method for polishing? When to replace.

Annually

Coat (not pack) the following parts of the actuators with grease:

- Angular contact thrust bearings
- Roller screw cylinder
- Roller screw assembly in the actuators

Examine the cable management system for abraded cables or other indications of wear.

Vendor Contact/Consumable Parts

Panametrics transducer

Olympus (www.olympusndt.com)

- Transducer: NDT M2008

Transducer couplant

- Couplant B (DO NOT USE COUPLANT A)

Laser displacement sensor (AR1000)

Acuity Laser Measurement
www.acuitylaser.com
702-616-6070

Barcode reader (MS-4)

Microscan
www.microscan.com
helpdesk@microscan.com
800-251-7711

Actuator (TLM 20)

Tritex
www.exlar.com

Related Documentation and Links

- Vp GIESA Gantry Laser Operation manual
- Olympus Panametrics-NDT Ultrasonic Transducers
- Acuity Laser Measurement AccuRange AR1000™ Laser Distance Sensor User Manual
- Acuity Laser Measurement AR1000 Laser Distance Sensor: Quick Start Guide
- Acuity Laser Measurement AR1000 Laser Distance Sensor Data Sheet
- Exlar Tritex Linear & Rotary Actuator Installation, Operation, and Service Manual
- Exlar Tritex Technical Notification 4/12/07

Communication and Control Setup

Data communication and control is USB based and managed via National Instrument's Measurement & Automation Explorer (NI-MAX). When you open NI-MAX and expand the Device and Interface section. The correct communications setup can be found at [IMS Hardware Communications Setup](#).

Credits

This document was written June 2019 by B. Novak and A. de Loach with contributions from G. Acton in the IODP wiki. Portions of the manual were taken from the Archived P-Wave Velocity Gantry User Guide written by T. Cobine in 2009.

Archived versions

- [P-Wave User Guide 2020 \(*.pdf\)](#)
- [P-Wave Velocity Gantry: User Guide](#): Word file written by T. Cobine (2009-01-17), reviewed by H. Barnes and T. Gorgas, and approved by D. J. Hout