CellScale
biomaterials testing

UniVert S

Mechanical Test System

User Manual

version 4.1

Mechanical measurement and analysis of materials

CellScale provides scientific and medical researchers with turn-key systems for measuring the mechanical properties of materials. We provide user-friendly software, an easy-to-use patented attachment system, and effective data analysis tools.

Our foundation was laid at one of the world's leading research institutions – the University of Waterloo. We understand research and aim to provide effective solutions at a reasonable price.

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General Information

The UniVert is a precision test instrument designed for the compressive and tensile testing and analysis of materials including polymers, biological specimens, and 3D-printed constructs. The UniVert system includes a test station and an integrated software interface to run and analyze test results.

Environmental and Electrical Specifications

Electrical Input	24 VDC
Current Rating	2.71 Amp
Environmental Conditions	Maximum Operating Temperature 25ºC 0% - 95% Relative Humidity
Installation Category	Category II
Pollution Degree	Degree 2
Data Connections	1 – USB for camera/PC communication (USB 3.0 for scientific camera) 1 – USB for controller/PC communication

System Assembly

Some basic assembly and setup is required. An unboxing and setup guide can be found in **Appendix A**. Load cell installation is detailed in **Appendix B** and software installation is described in **Appendix C**. Test setup and configurations are described in **Appendix D**. Camera setup is described in **Appendix E**.

Connections to Supply

Connect the power supply into a properly grounded 100-240VAC power source to ensure safe operation. Ensure that the power cord is easily accessible at all times. The use of an Uninterruptible Power Supply (UPS) is recommended to protect against data loss.

The mains supply voltage fluctuations should not exceed 10% of the nominal supply voltage.

Safety Warnings

This equipment must be used in accordance with the procedures outlined in this manual. Operators of this equipment must be instructed in safe operating procedures to prevent injury and/or damage.

Ensure that the area around the moving actuator is clear before commencing test protocols.

The UniVert presents a pinch hazard to extremities. Keep hands clear of moving parts for the duration of the test.

> ***System Alert***
>
> This equipment must not be disassembled by the user or modified in any way except that which is described in this manual.

Manual Operating Controls

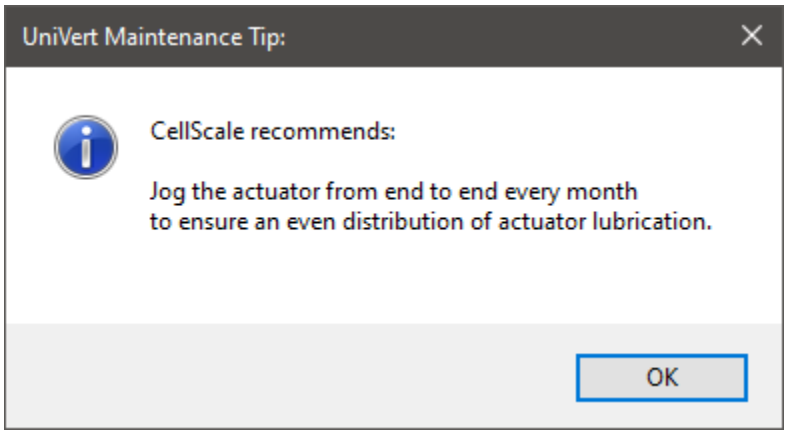
There are 3 manual switches on the front of the baseplate. In order of left to right, the main power switch, the heated bath switch (optional add-on), and the E-Stop switch. The E-stop will stop power to the motor and instruct the software to stop a test if one has been executed. If the E-stop has been depressed, it must be rotated to return it back to its original position.

The E-stop should only be used in emergency situations only since it will require a power cycle and actuator reset to set up a new test after it has been depressed (see **Setting Up & Starting a Test: Step 8** for more details).

General Maintenance

Clean the system as needed with mild detergent and water or alcohol based cleaning solutions.

It is recommended to jog the actuator from end to end at least once a month to distribute the lubricant along the ball screw. This is especially crucial if the tests protocols only involve short displacements, as it could wear down that portion of the ball screw over time.



To distribute the lubricant:

1. Remove all fixtures from the UniVert (i.e. compression platen or tension grips)
2. Using the Actuator Controls, click and hold the inward button to move the actuator downward until it reaches the bottom
3. Click and hold the outward button to move the actuator towards the top. It should stop at the limit switch.

Approvals and Certification

This product conforms to applicable CE standards.

Testing Terminology

The UniVert is designed to apply uniaxial compressive and tensile forces to a variety of materials. This includes soft metals, plastics, and composites as well as biological materials.

Multiphase Test Cycles

In order to properly characterize and test a specimen, it is often necessary to load it to different degrees and at different rates. There are three main reasons for doing this:

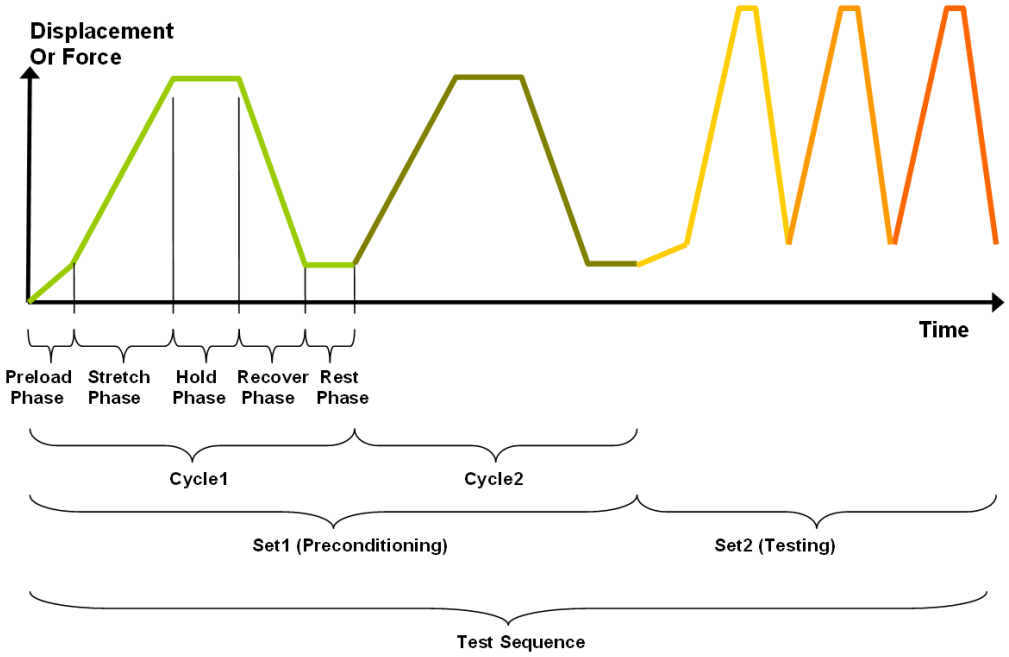
Preconditioning - Especially for biological specimens, the goal of preconditioning is to restore a specimen to its physiological or *in vivo* state. During the process of specimen storage and preparation, a specimen may swell, dry out, have its material fibers realign, or its molecules reorganize. It may take multiple preconditioning cycles for a specimen to be restored to its natural state.

Reproducing Physiological Conditions During Testing - By applying various loads and load rates, natural expansion and contraction of a specimen can be reproduced (for example, the pulse pressure in an organ). In as much as the physiological conditions can be recreated, the specimen can be tested in a more realistic state.

Varying Test Conditions - Variable loads and rates allow you to create a variety of test profiles to best study your specimen.

Phases, Cycles, and Test Sequences

As the following diagram demonstrates, each application and release of load on the specimen is called a ***test cycle***. The same test cycle can be repeated multiple times to achieve a certain goal (preconditioning, physiological conditioning, or testing); this is called a ***test set***. Finally, a ***test sequence*** is made up of multiple test sets.

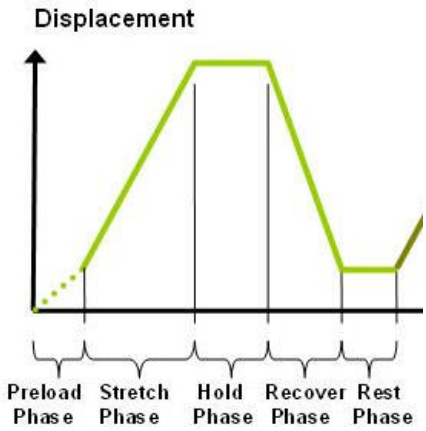


The above example describes the following:

- The entire diagram presents a full *test sequence*.
- Within that sequence, there are two *test sets*: the first set applies preconditioning to the specimen; the second set executes the actual test on the specimen.
- Within the first set (preconditioning), two identical *test cycles* are implemented to bring the sample to a satisfactorily preconditioned state.
- Finally, the second set (testing) is made up of three cycles.

Test Phases: The Smallest Unit of Testing

The test phase is the smallest unit of the test specification. There are five phases within a cycle. Each phase serves a specific purpose:



Preloading- Preloads are applied to bring a test to a well-defined starting point. Because the dimensions of a specimen may change as a result of a loading cycle (stretching of fibers, viscoelastic effects, plastic deformation, or localized material failure at the attachment points), the preload adjustment compensates for any of these changes in specimen geometry.

Stretching - During the stretch phase, a deformation is applied to the specimen. The deformation can be specified either in terms of force applied or displacement achieved. Note that in this context, the stretch phase refers to either stretching (for a tension test), or compression (for a compressive test).

Holding - The deformation can be held for a given duration. The duration for which it is held is dependent on the nature of the testing.

Recovering - The recovery phase is the time during which the force being applied to the specimen is removed. The duration of the recovery time is configurable and dependent on the nature of the testing.

Resting - Finally, the rest phase is the time between the end of one cycle and the beginning of the next. Some tests may specify a short recover time or no recover time, while others may specify a longer time. The duration is configurable and dependent on the nature of the testing.

Control Modes

There are two control modes which define the basic approach to a given test: displacement control and force control:

> Under **displacement control**, the displacement of the specimen is predefined. The UniVert stretches or compresses the specimen until the predefined displacement is achieved (specified in mm or %). The force required to achieve the displacement is an output of the test.
>
> Under **force control**, the force applied to the specimen is predefined. The UniVert stretches or compresses the specimen until the predefined force is achieved (specified in newtons [N]). The displacement required to achieve the force is an output of the test.

In addition, strain control from image feedback is available for UniVert systems with scientific camera packages. This control mode utilizes displacements based on a region within a specimen rather than global actuator displacements. For more information on this control mode and how to set up a protocol with this mode, see the **Strain Control from Image Tracking** section below.

Control Functions

The UniVert makes it possible to test specimens under several control functions:

Under displacement control:

> The **ramp function** applies the displacement at a constant nominal rate. This is equivalent to engineering strain or constant velocity.
>
> The **sinusoid function** applies the displacement according to a sinusoid with the desired displacement magnitude and duration. The UniVert system approximates this with a series of linear segments.

Under force control:

> The **ramp function** applies the force at a constant nominal rate. This is equivalent to engineering strain or constant velocity. The result of this test will depend on the material being tested and the force control settings.
>
> The **sinusoid function** applies the force according to a sinusoid with the desired force magnitude and duration.

Test Modes and System Configurations

There are three test modes that can be used when performing a test: tension, compression, and 3-point bending.

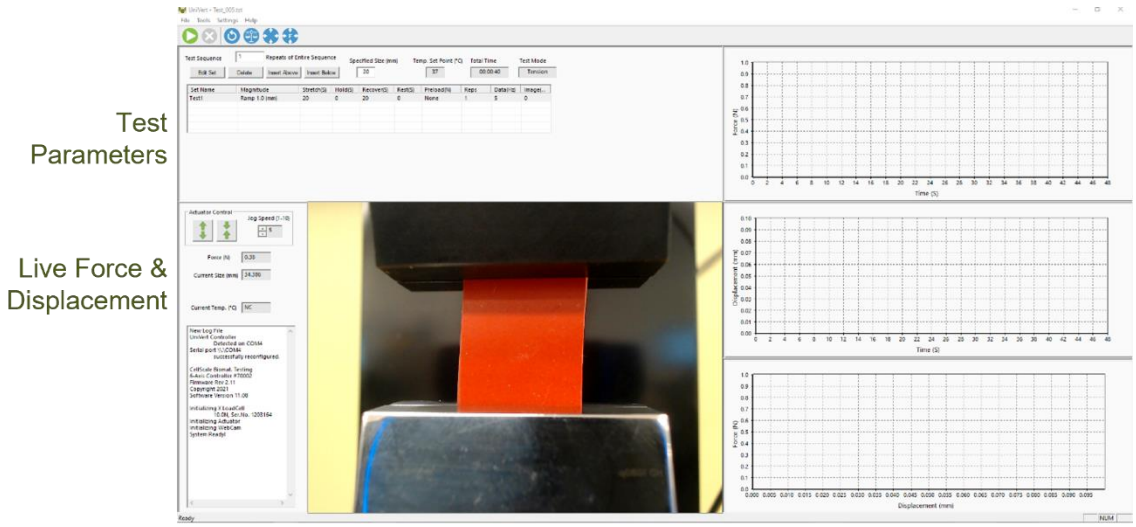
Tensile Test - This test mode is used in combination with provided specimen grips. In this mode, positive displacement is in the direction of increased fixture separation and tension forces are positive.

Compression Test - This test mode is used in combination with provided compression platens. In this mode, positive displacement is in the direction of decreased fixture separation and compressive forces are positive.

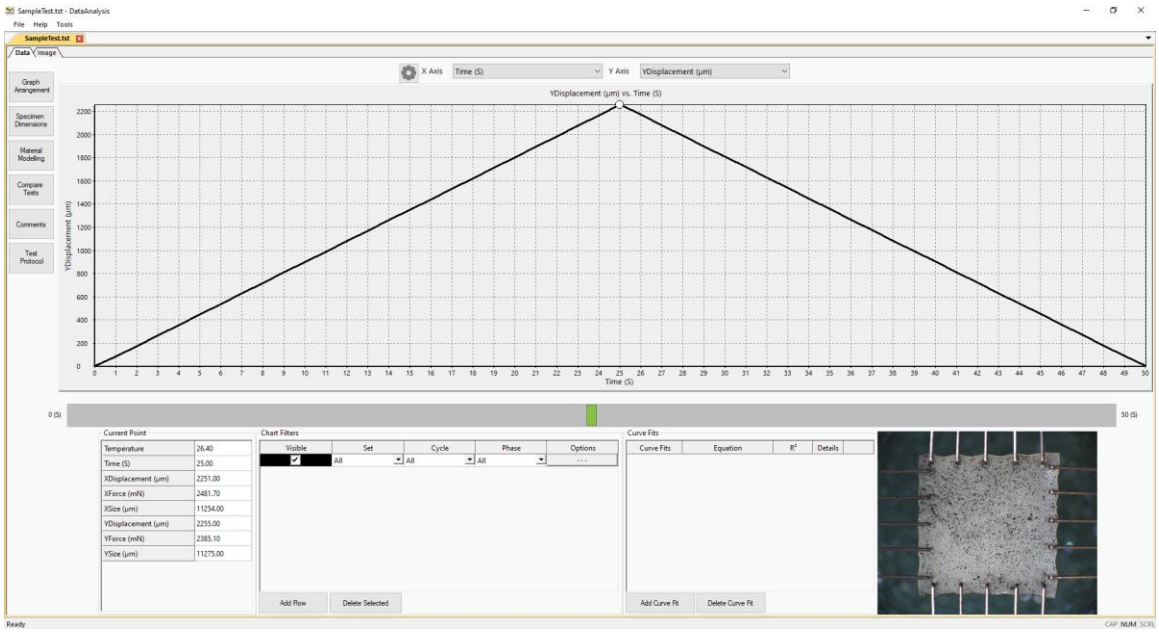
The UniVert can be used in two configurations: **vertical and horizontal** (see **Appendix D** for more details). The above test modes are all compatible in both configurations. For compression and 3-point bend testing, test samples will need to be supported to meet the height of the platens.

Software Overview

The software included with the UniVert device is called UniVert. It is divided into several modules: a data collection module and an image review and analysis module as well as test template review. The data collection module is used to set test parameters, enable specimen loading and testing, and monitor test progress. The screen layout for this module is shown below:



The Data Analysis software is an additional program used to review and analyze data and images collected by the UniVert. For more details, see the included Data Analysis user manual in the Documentation folder (*Cellscale>UniVert>Documentation*).



Output Files and Data Structures

For each test, the UniVert creates and saves three file types. The following table describes the three file types for a project named “Sample1”. Output from this test would be found in a “Sample1” output directory (a sub directory of the user specified data directory).

File Type	Description
.tst file	The Sample1.tst file that contains the exact protocol and settings used for the test.
.csv file	The Sample1Data.csv file that contains comma separated numerical data such as time, force, and displacement values.
.jpg files	Captured images such as Sample1.000010.3.jpg, which would correspond to an image captured at 10.3 seconds from the start of the test.

Each test folder will also contain 2-3 subfolders. The “Logs” subfolder contains a text file of the content of the text dialogue portion of the main screen (in the lower left-hand side). It is useful as reference to troubleshoot problems with your system, should they occur as well as track test progress.

The “Images” subfolder usually contains any recorded .jpg images from a test. These may also be stored in the main data folder.

Additional “Analysis” and “Tracking” folders will be created if the data file and/or images are reviewed and processed in the Data Analysis software module. These folders will store tracking information and other preference settings. For more information, see the Data Analysis user manual in the Documentation folder.

When working with the data, the user should be aware of a few details regarding the data output:

1. The output specimen size is based on the spacing between the grips or platens and does not account for the specimen material outside of the test region.
2. The software cannot calculate stress since the thickness of the specimen is not known. To calculate stress, you will have to manually measure the thickness of the material before or after the test is performed and apply this measurement to the output force data
3. Strains can be calculated using the output displacement values (which are based on the grip or platen motions). The specimen may actually be subjected to less strain than the calculated values due to attachment site effects. The image tracking module is useful for determining the actual strain values and variations within the specimen.

Setting Up & Starting a Test

Overview

Step 1: Start a New Test

Step 2: Reset the Actuator

Step 3: Specify Test Type

Step 4: Zero the Load Cell (occasional)

Step 5: Modify the Test Parameters (optional)

Step 6: Mount the Specimen

Step 7: Execute the Test

Step 8: Terminate the Test Prematurely (optional)

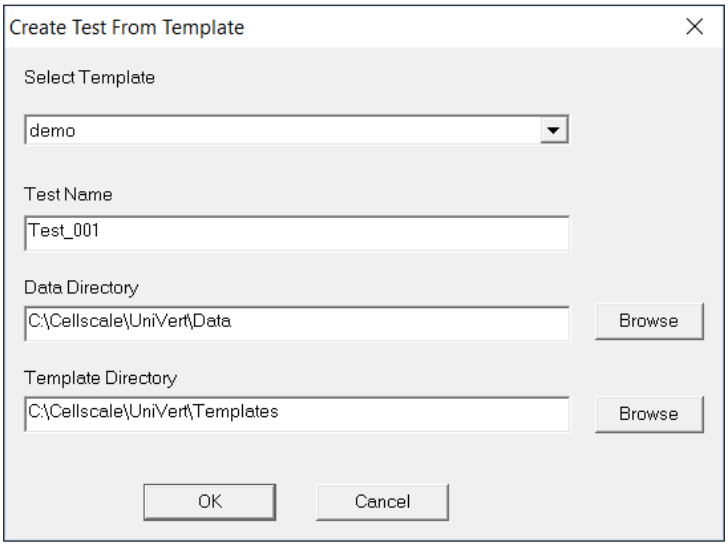
Step 9: Saving the Template (optional)

Step 10: End of Test Controls (optional)

If this is your first time setting up the UniVert system, please complete the steps in **Appendix A: Unpacking and Initial Setup** prior to executing a test.

Step 1: Start a New Test

Launch the UniVert software and then select *Collect New* from the File menu.



In the *Create Test From Template* dialog, perform the following steps:

1. Select a template that matches the type of test you wish to perform. See the below *UniVert Tip* on how to select and use a template. You can modify the template parameters in Step 5 below.
2. Name your test. The dialog will have a default test name. You can use the default or rename the test. Each time you start a new test, the default name will continue to increment the number at the end of the name (a 3 digit number).
3. If desired, you can change the location of the output data. The location of your output data and images is determined by specifying a *Test Name* and *Data Directory*. The template and data directories are user specific (computer login name). Each system user can store their files to a different default location. The system uses the last location selected as the default. Note that a local drive should always be used and data transferred to network or cloud location after a test is complete.

UniVert Tip: Selecting and Using Templates

How to create a Template: Designing an appropriate test sequence depends on both the type of material being tested and the specific material properties you are interested in measuring. When first testing a new material, you will have to experiment with the settings until the test yields meaningful data.

The system comes loaded with sample templates to help you get started. Selecting a template does not lock you into a specific test sequence or protocol – rather a template preloads a test sequence and settings, all of which can be changed before a test is run.

Once you have developed a test sequence with settings that are appropriate for the material you are testing, you should save these settings using “Save As Template” from the File menu. You can then select this template the next time you initiate a test.

Step 2: Reset the Actuator

We suggest performing a reset at the start of a new test session. This command sends the actuator to its fully retracted position and resets the displacement value. If you have stopped the previous test in mid cycle, then you should also reset the actuator. By resetting the actuator, you are ensuring that the displacement measurements taken by the UniVert are accurate (dependent on an accurate Zero Position Calibration – see System Calibration and Advanced Tools).

If you need to recalibrate the UniVert position, see the Zero Position Calibration or Custom Position Calibration portion in the System Calibration and Advanced Tools section. This is recommended if you are changing fixtures or configurations.

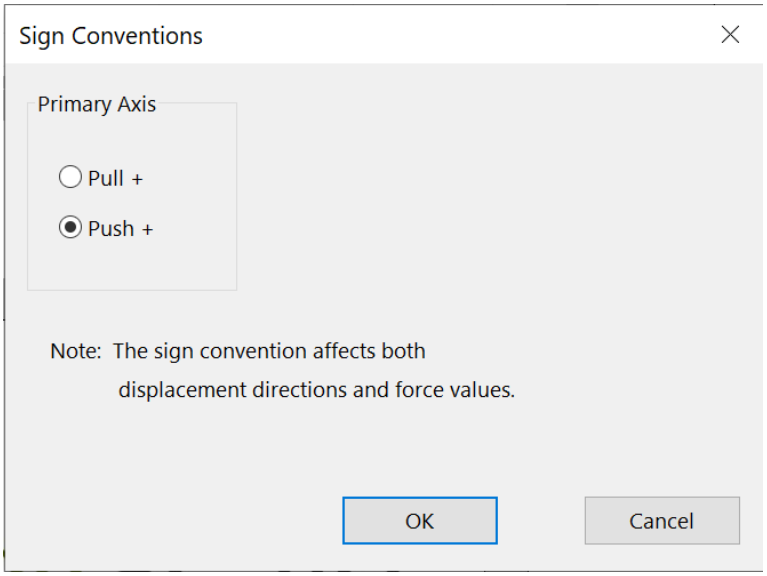
To reset the actuator, select *Reset Actuator* from the Tools menu, or press on the toolbar.

System Alert

You should **NOT** reset the actuator if the specimen is already loaded in tension. Doing so will damage your specimen and/or the load cell.

Step 3: Specify Test Type

Access *Test Mode* in the *Settings* menu to select the appropriate test mode and install the platens, grips, or 3-point bend attachments (see **Appendix D** for this procedure).



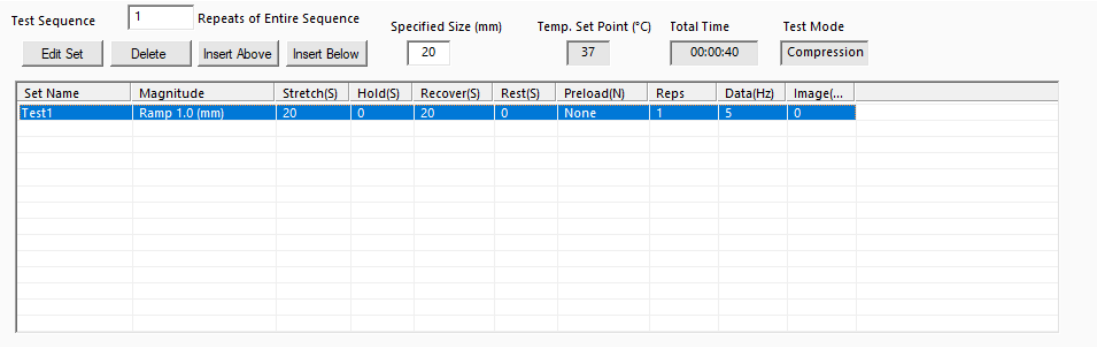
Step 4: Zero the Load Cell (occasionally)

While it is not necessary to zero the load cell with every test sequence, we suggest zeroing the load cell at the start of a new test session. With repeated use, the zero point of the load cell can drift. By zeroing the load cell, you are ensuring that the force measurements are accurate. The force offset can also be affected by changing the fixtures.

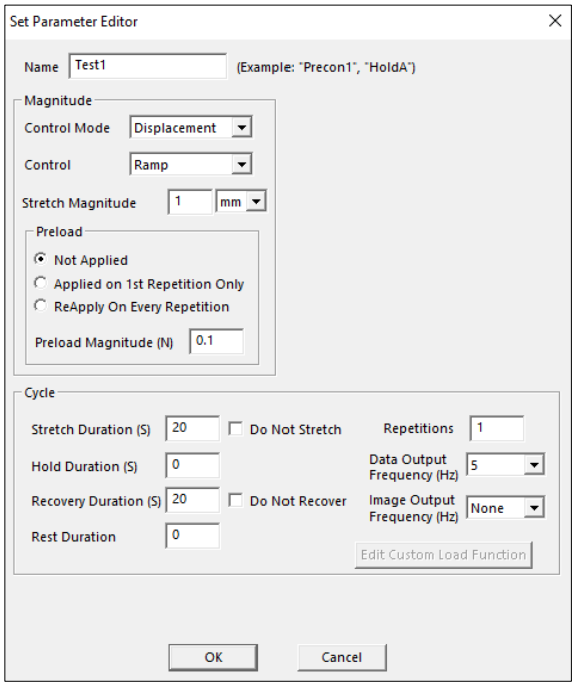
To zero the load cell, select *Zero Load Cell* from the Tools menu or press on the toolbar.

> ***System Alert***
>
> You should zero the load cell after attaching a platen or grip but before mounting a sample. If a specimen is already loaded when the load cell is zeroed, the force reading will include an offset load.

Step 5: Modify Testing Parameters (optional)



You can select and modify the parameters in the test sets by clicking on a row in the Test Sequence table and then pressing the *Edit Set* button (or by double clicking on the desired row). When you do so, the *Set Parameter Editor* dialog will appear.



Note that displacements are specified in either % strain, or mm. Force loads are specified in N, and durations are specified in seconds.

The following table describes each of the parameters:

Test Parameter	Description
Control Mode	Tests are performed under displacement or force control, however, you can select the following control modes to achieve specific testing objectives: • For creep testing, use force control with a long hold duration. • For stress relaxation testing, use displacement control with a long hold duration.
Control Function	True Strain, Ramp, or Sinusoid is typically selected for tests performed in displacement control mode. For tests performed in force control mode, Ramp or Sinusoid controls are selected.
Stretch Magnitude (Load Magnitude when in Force Control mode)	Selecting a stretch magnitude is dependent on the material you are testing. A sound approach is to begin with a small magnitude and iteratively move up to larger magnitudes. If you are using Displacement control mode, you can specify the displacement in either mm or as a percentage. For example, the displacement on a 5mm specimen can be expressed as either 0.5mm or 10%. If you are using Force control mode, you can only specify the force in N. Watch the test results carefully to determine which magnitude setting best achieves your test goals.
Preload	Preload is typically reapplied on every repetition during a preconditioning set as well as on the first repetition of a testing set. Specimen size is adjusted after a preload adjustment. Strain calculations are based on the specimen size after the last preload adjustment. If you are working with a material for which preload values have been suggested, you can set the value accordingly. Otherwise, zero is a good initial choice. The preload accuracy is directly influenced by the resolution/accuracy of the load cell you are using.
Preload Magnitude	As with stretch magnitude, the preload magnitude settings depend on the material you are testing. While Preload can be set at zero, typically you would set the preload magnitude somewhere between zero and 10% of the peak load you expect to achieve.
Stretch Duration	For evenly spaced images, it is recommended to choose a number that is an integer multiple of the Image Output Frequency.
Hold Duration	Hold Duration is typically set to 0, however it is useful for creep or relaxation testing.
Recovery Duration	Recovery Duration is typically set to the same value as the Stretch Duration.
Rest Duration	Rest duration is typically set to 0, however a non-zero value may be used to mimic *in vivo* conditions or for specialized testing.
Repetitions	Apply enough repetitions until the force deformation curves from one repetition to the next start to overlie each other.
Data Output Frequency	Typically set to the same frequency as the image output frequency.
Image Output Frequency	Typically set to 1Hz for cycles > 5 seconds and 15 Hz for cycles < 5 seconds.

Step 6: Mounting a Specimen

Platen Mounted Specimens

1. Install the compression platens (see **Appendix D** for more details)
2. Place the specimen on the bottom platen.
3. Jog the top platen to the correct position using the jog arrows in Actuator Control

Alternatively, the *Move Actuator to Specified Size* command may be used. Ensure the correct size value is entered before clicking .

UniVert Tip: Compression Specimen Mounting

Make sure to center the specimen on the platen as much as possible to ensure accuracy in the force reading. Ideally, specimens will have two parallel flat sides and will make full contact with both platens. Although this is not always possible, flat testing surfaces will improve force distribution.

Grip Mounted Specimens

Low Force Grips

1. Select a spring with an appropriate clamping force for the specimen being tested (see **Appendix G** for more details).
2. Jog the actuator using Actuator Control until the grips are sufficiently far apart or enter the desired size and select *Move to Specified Size* .

3. Attach the specimen to the top grip.
4. Using Actuator Control, lower the top grip (with specimen attached).
5. Open the bottom grip and lower the specimen between the grip surfaces. Release the bottom grip.

UniVert Tip: Specimen Thickness

Measuring the specimen thickness before and/or after a test is performed will allow stress calculations to be made from your output data.

High Force Grips

1. Select a spring with an appropriate clamping force for the specimen being tested (see **Appendix G** for more details).
2. Jog the actuator using Actuator Control or select Move to Specified Size until the grips are sufficiently far apart.
3. Loosen the M4 screw with a 3 mm hex key and squeeze the two halves of the top grip to clamp the sample. For higher clamping force, use the same hex key to tighten the locking screw against the back face of the grip.
4. Using Actuator Control, lower the top grip (with specimen attached).
5. Open the bottom grip and clamp the specimen between the grip faces. Use the 3 mm hex key to tighten the locking screw if higher clamping forces are required.

3-Point Bend Specimens

1. Choose the appropriate 3-Point Bend dowel for the type of test you wish to perform.
2. Install the 3-Point Bending test setup (See **Appendix D**)
3. Move the sliders into desired position and lock in place by tightening the 4-40 fastener to the rail using a 3/32” hex key.
4. Place the specimen on top of both lower dowels and begin testing.

System Alert: Load Cell Handling

It is important to handle load cells carefully. Here are some things to consider while handling a load cell:

- *The load cells are designed to handle overloads of up to 120% full scale value.* ***Overloading a load cell past this rating may cause permanent damage to the load cell.***
- *Avoid applying excessive torque and transverse forces to the load cells. Over tightening grips or platens onto the active end of the load cell may damage it.*
- *Accidentally crashing the platens or grips together will produce more force than most load cells can handle. Be careful and reduce actuator speed when jogging grips or platens close together.*
- *Generally, avoid dropping, tapping, and exerting unnecessary force to increase the life of the load cell*

Step 7: Execute the Test

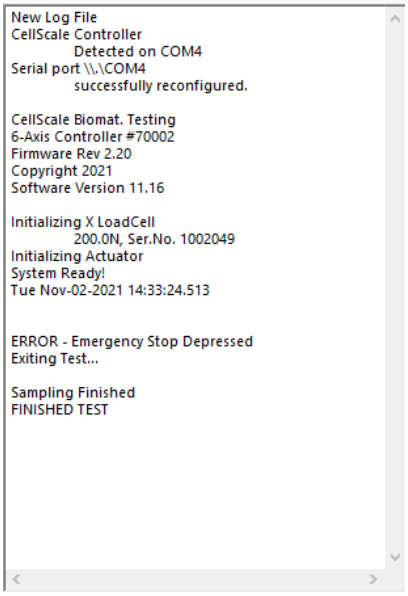
Select *Execute* from the File menu or press on the toolbar.

Step 8: Terminate the Test Prematurely (optional)

You can stop a test at any time by clicking on the toolbar, or by selecting *Stop* from the File menu. These are preferred methods of ending a test instead of powering down the equipment or using the E-Stop, as it allows the software to store the current actuator position.

At the end of the completed test (both normally and prematurely terminated) the actuators will maintain their current position.

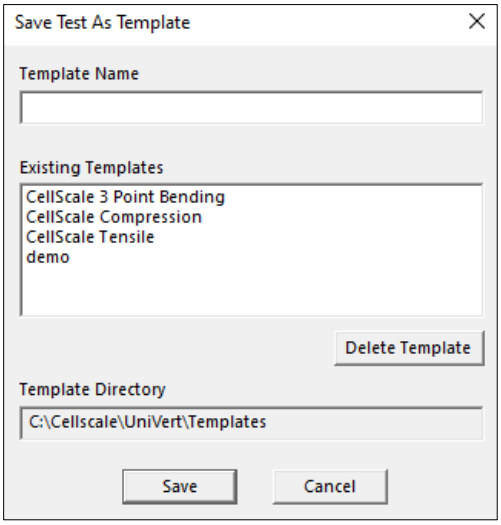
In an emergency, the Emergency Stop (E-Stop) button can be pressed to stop the motor from moving. This button will stop power to the UniVert acutator and allow it to be moved by hand. The displacement position cannot be stored if the E-Stop has been depressed.



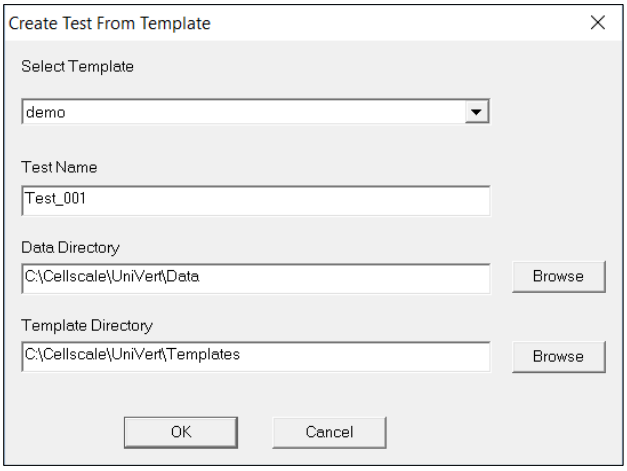
Once the UniVert is ready to be used again, twist the E-Stop to return it to its original position. A new test cannot begin until the E-Stop has returned to its original position. The actuator will need to be reset to restore the position. To reset the actuator, select *Reset Actuator* from the Tools menu, or press on the toolbar. An actuator reset is required before beginning a new test.

Step 9: Saving the Template (optional)

At the end of the test (or before beginning the test), you may save the test parameters entered as a new template. Select *Save as Template* from the *File* menu. The *Save Test as Template* window will appear. Set a template name and click Save.



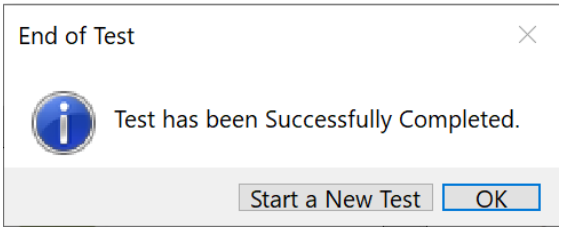
By default, the new template will be stored in the current template directory. You may change the template directory at the start of a new test in the *Create Test from Template* window.



If you would like to set a new template directory, create a new folder in your Windows File Explorer and set this file path as the new directory in the *Create Test from Template* window. You may delete templates through the File Explorer. Moving templates between directories will need to be done through the Windows File Explorer.

Step 10: End of Test Controls (optional)

Once the test has been completed, you can choose to start a new test or use the system controls by selecting the “OK” button.



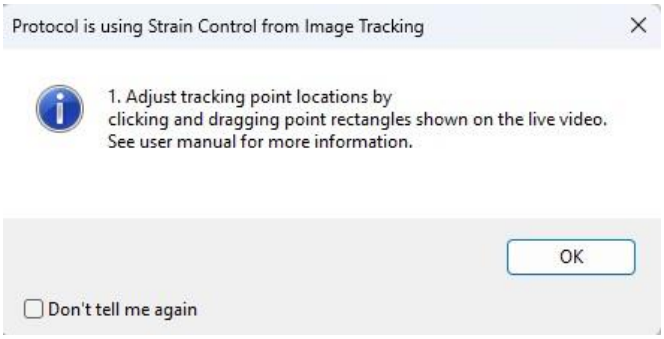
System controls include the top ribbon as well as Actuator Control. These controls can be useful if you need to release a specimen from the text fixtures at the end of a test.

Strain Control from Image Tracking

Strain control from image tracking is an alternate test control mode that can specify and control the test displacements based on a region within a specimen rather than the global actuator displacements. When deforming a specimen, strain values often vary near the attachment sites compared to the middle region of a specimen. This is especially evident when using BioRakes which tend to deform more around the rake tine puncture points compared to other parts of the specimen. Clamped specimens usually have lower strains around the clamps because the clamps prevent lateral deformations.

Controlling the applied strain in a region of a specimen is achieved by tracking image features in real time during test execution.

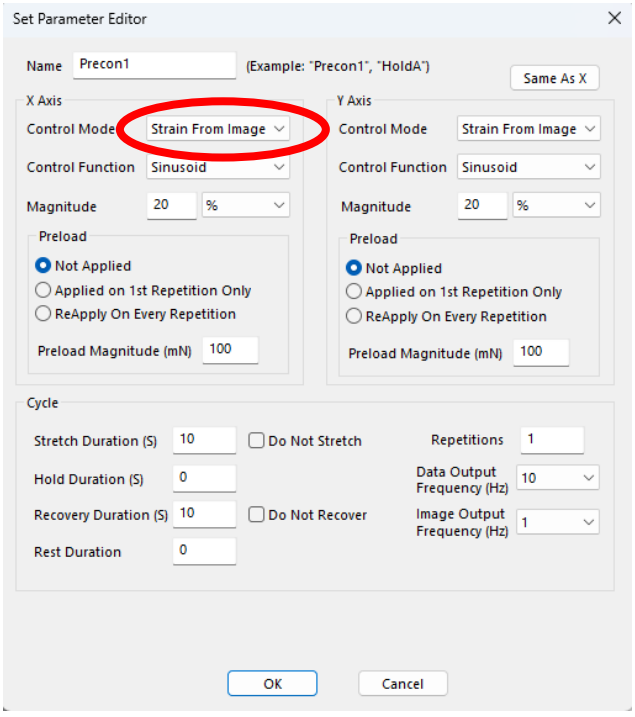
When a template with Strain Control from Image Tracking protocols is opened, the pop-up window shown below will appear to indicate so.



Specify Testing Parameters

To use strain control:

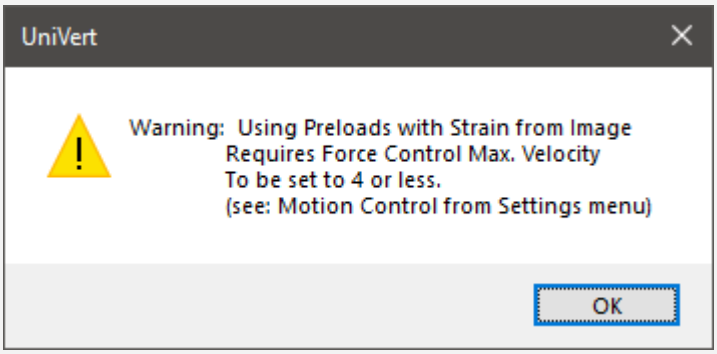
1. Double click or select Edit on the desired protocol line to open Set Parameter Editor
2. Select *Strain From Image* as the Control Mode. This mode will only be available if a scientific camera set up is connected.
3. Select Sinusoid or Ramp control function.
4. Magnitude is in % and is calculated as the change in length divided by the initial length at the start of the stretch phase. The initial length is updated after preloads.



System Alert: Preload with Strain from Images

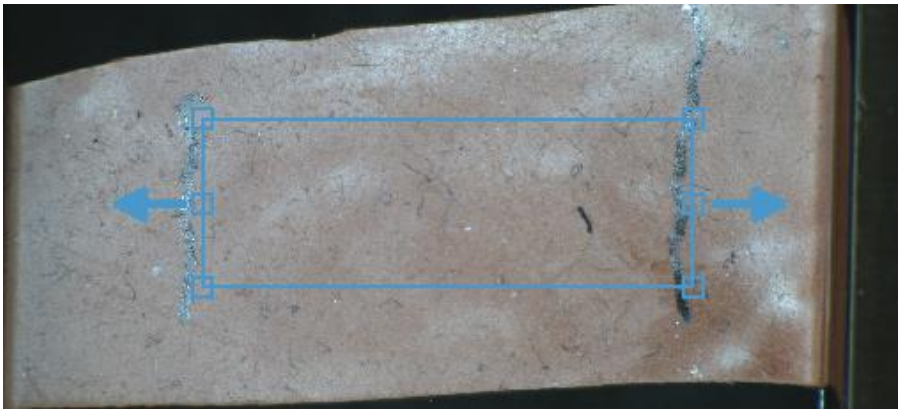
When using preloads with the strain from images control mode, the force control velocity parameter must be set to a value of 4 or lower. Higher velocity settings may result in failure to execute the preload due to the image tracking algorithm speeds.

If the force control velocity setting is greater than 4, it will automatically be reduced to 4 upon executing the test to ensure successful completion of the preloads and test protocol.



Selecting the Tracking Point Locations

A test protocol that is using strain control with image tracking will display a rectangle in the live video feed as follows:



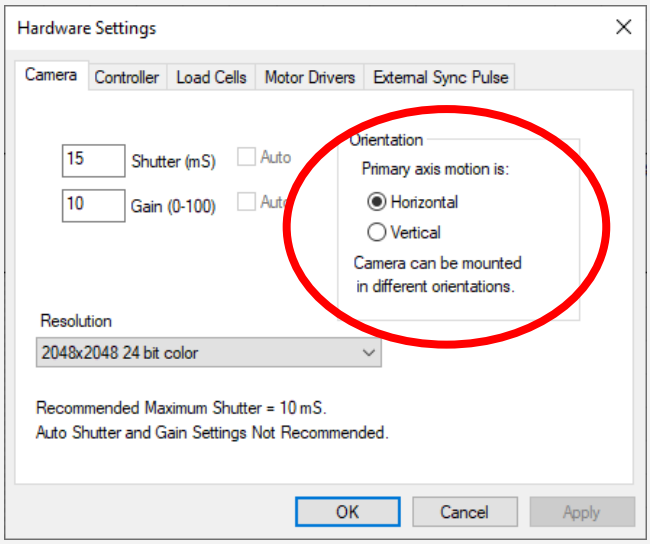
The small squares are the points that will be tracked. The location of the tracking points can be adjusted by clicking and dragging the corners of the box or the center tracking points on each side.

The average distance between all pairs of points is used for strain calculations. Tracking is performed using a digital image cross-correlation technique with updates at 20 Hz. For strain control using image tracking to be successful, there must be sufficient texture patterns or fiducial markers present in the images. Texture patterns can be added to specimens with marking pens or a light dusting of graphite or other contrasting powders on the specimen.

The colour of the tracking box and points can be adjusted in the Strain Control from Image Tracking Settings (see below).

System Alert: Selecting Correct Camera Orientation

Arrows must match primary axis motion direction. Arrows are determined by the camera orientation. The camera can be manually mounted in different orientations and must be correctly specified in the camera settings dialog. This can be done by selecting the Camera tab in the Hardware menu (under Settings in the ribbon menu).

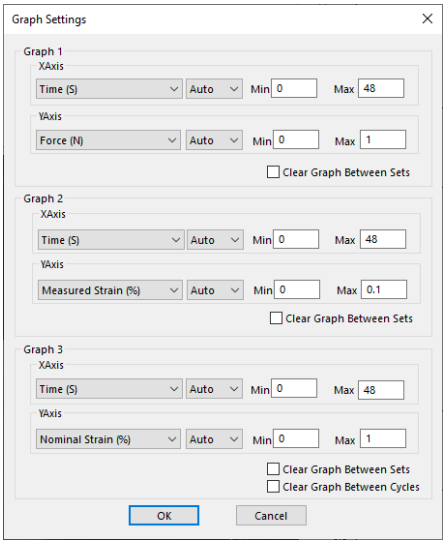


Configuring the Live Charting Graphs

The strains can be displayed on the live charting graphs when using the strain control from image tracking feature. The graphs can display measured strain or nominal strain.

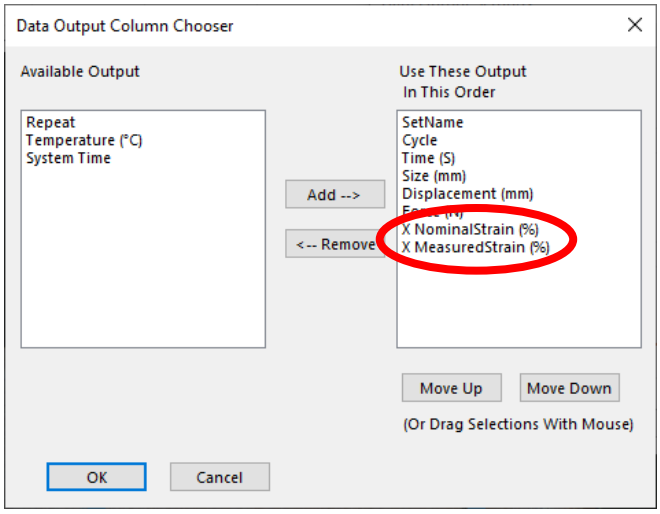
- Measured Strain is the calculated strain from the image tracking.
- Nominal Strain is calculated from the motion of the actuators.

The graph settings can be specified by selecting *Graphs* from the Settings menu.



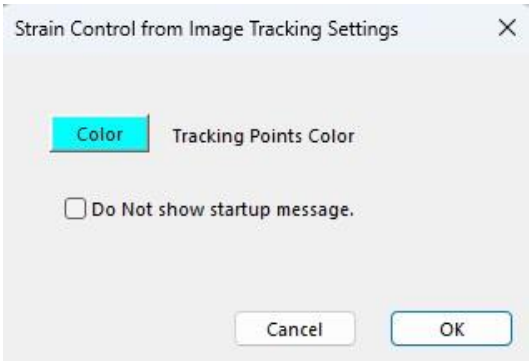
Configuring Output Data Files

Measured and Nominal strains are available as test output columns for the csv data file. From the Settings menu, select *Data Output.* Then click the *Configure* button to select the desired output columns.



Strain Control from Image Tracking Settings

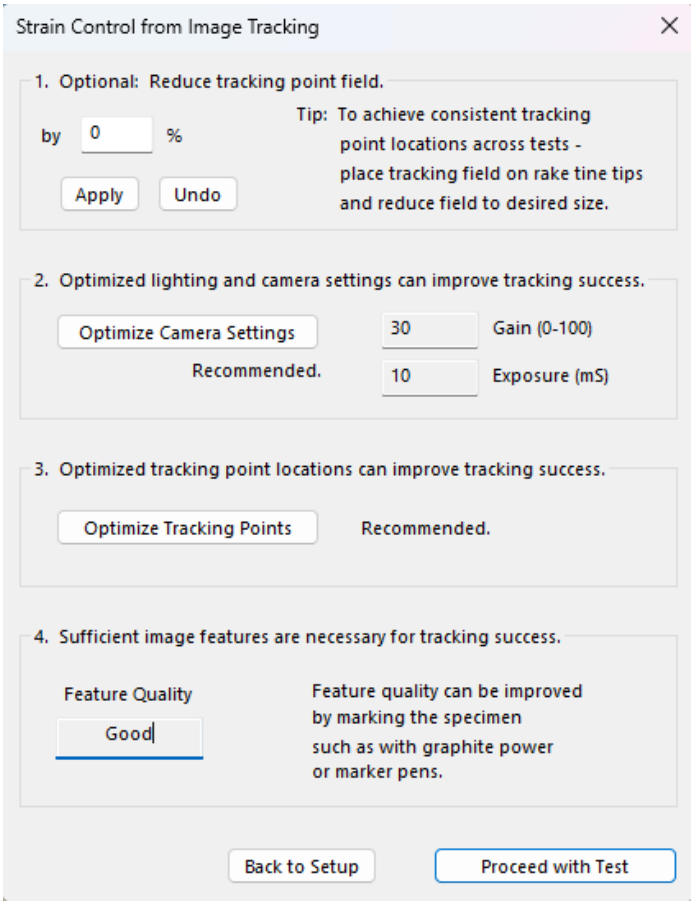
To access the settings for Strain Control from Image Tracking, select *Settings* in the top ribbon and *Strain from Image.* The colour of the tracking points can be modified as well as disabling/enabling the pop-up window at the beginning of each test.



Executing the Test

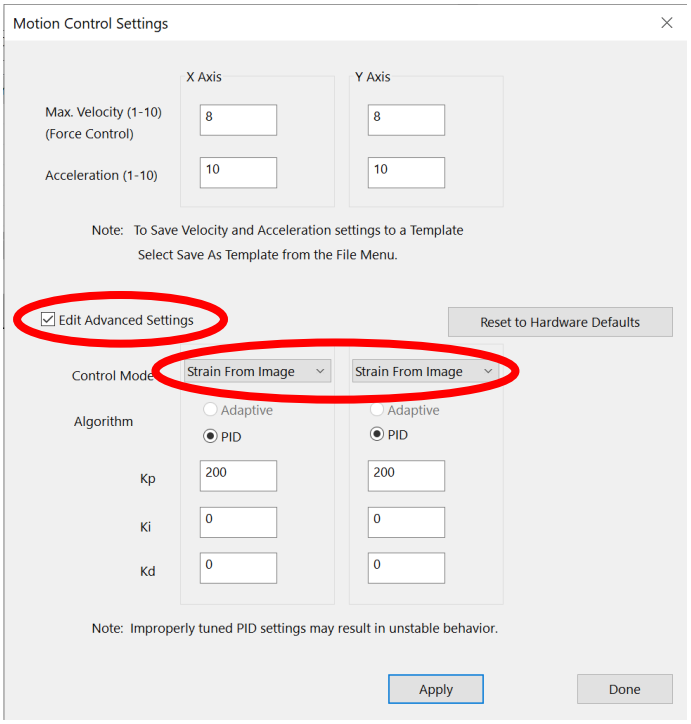
Upon executing a test, the dialog box shown below will appear. It gives options to automatically adjust camera settings and to automatically adjust tracking point locations. Optimized lighting and camera settings and adjusted tracking points locations may improve the success of tracking.

Click proceed with Test to execute the test. If the software is unable to continuously track a point, the test will automatically stop to prevent any damage to the system. If this occurs, more textured patterns or unique features may be required to generate better tracking points for the software to follow.



Advanced Controls

Strain control from image tracking is controlled with a PID control algorithm. The PID control parameters can be adjusted by selecting *Motion Control* from the *Settings* menu in the top ribbon.



Check the *Edit Advanced Settings* check box then select *Strain from Image* in the control mode drop down menu.

Increase the Kp value if the system is not responsive enough or cannot achieve the specified strains.

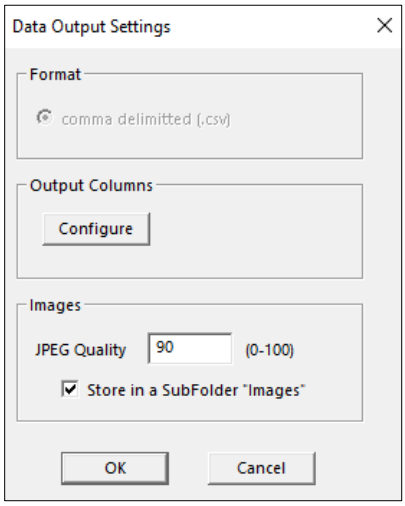
Decrease the Kp value if the system is producing unstable or oscillating results.

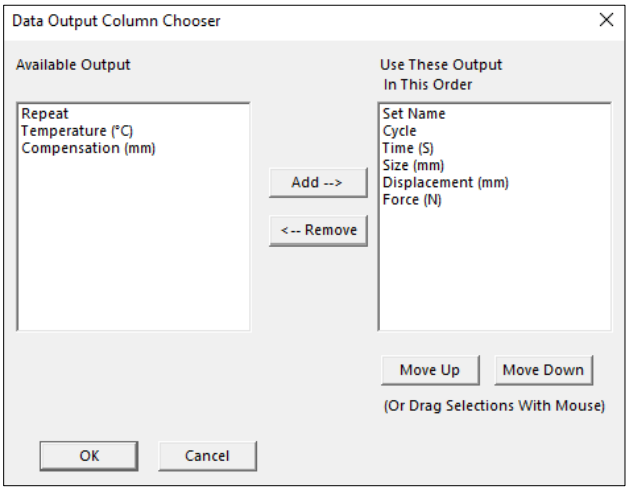
The hardware defaults should work under most conditions and can be restored with the *Reset to Hardware Defaults* button.

Additional Settings

Configuring Output Data Files

From the Settings menu, select *Data Output* to display the dialogue shown on the left. Click the *Configure* button to select which of the following columns to output.

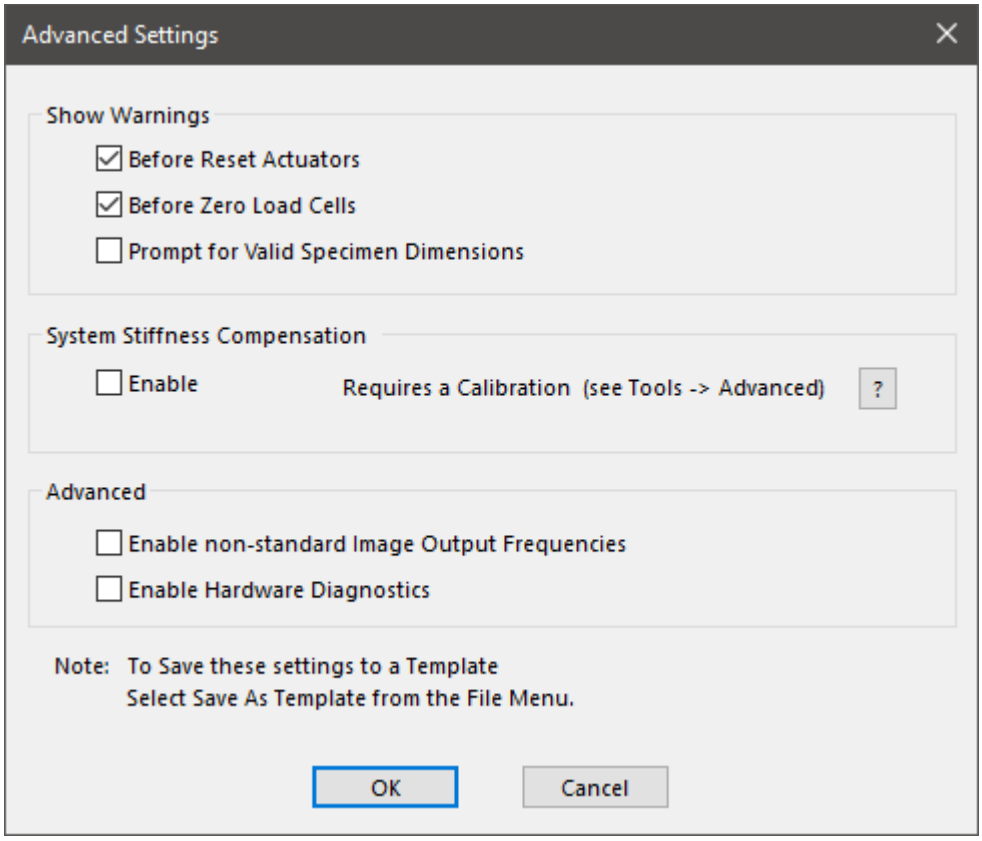




Output Column	Description
Set Name	User defined name of each set
Cycle	Cycle and Phase information
Time (S)	Time point in seconds a data point was recorded
Size (mm)	Specimen Gauge Length at any given time
Force (N)	Load Cell reading
Displacement (mm)	Reports the change in size relative to the initial size
Compensation (mm)	Reports overall compensation due to system stiffness (see the **System Calibration and Advanced Tools** section). Set to Off by default.
Temperature (°C)	Temperature readings of the media bath from the probe (if applicable)

Advanced Settings

Advanced Settings are available by selecting *Advanced* from the *Settings* menu. All these settings are specific to the test template selected unless otherwise noted.



Show Warnings

By selecting the check boxes, a warning dialogue will appear before either action button (i.e. Reset Actuators or Zero Load Cells).

Resetting the actuators with a sample attached may damage the specimen, fixtures, and/or load cells. To avoid resetting the actuators with a sample attached, a warning dialogue will appear after “Reset Actuators” is selected, prompting the user to proceed.

System Stiffness Compensation

System Stiffness Compensation can be used to compensate displacement readings that occur in the UniVert system during testing typically at high loads with low displacements. Under most loading conditions these displacements are negligible and system stiffness compensation is not required.

If you find this is necessary for your testing, check the enable button and see the **System Stiffness Compensation** section under System Calibration and Advanced Tools for more details and steps on how to complete the calibration procedure**.**

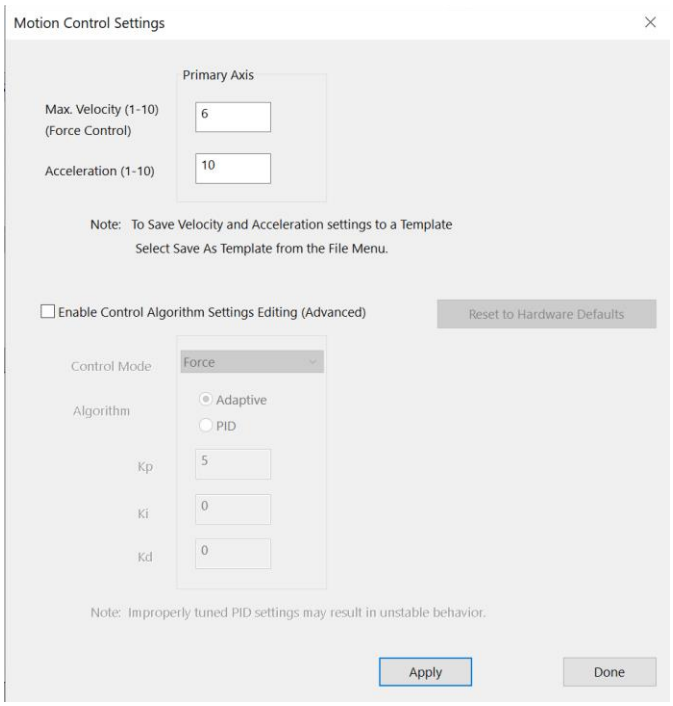
Advanced

Checking the “Enable non-standard Image Output Frequencies” will enable Image Output Frequencies options between 1 and 20 in the Parameter Editor. It is important to note, the scientific camera will not be running at those frame rates natively. The camera will operate at its highest frame rate (45 fps) and the nearest frame to the selected frequency interval will be selected. This could result in an output image frame that does not exactly match the desired frequency output. This setting can be saved to a template.

Checking the Enable Hardware Diagnostics will enable an LED light on the main controller circuit board to flash continuously. By default, the LED is not enabled as it can cause discernable noise on load cell signal communications within the circuit board. This checkbox should only be used for troubleshooting purposes only. **This setting will not be saved to a template and must be checked for each test if required.**

Motion Control Settings

Motion Control Settings affect the rate and stability at which forces are achieved in force-controlled procedures. These settings apply to preloads as well as Force Control Modes. Changes to these settings are saved to the test template.



Max. Velocity

Maximum velocity setting can be set to an integer value between 1 and 10 (see chart below for corresponding velocity values). The velocity integer matches actuator jog speed on the UniVert software home screen. Typically for stiffer or smaller specimens (i.e. requires a short displacement to achieve desired force), use a lower velocity setting as this will allow for smoother force-controlled protocols. It may take a few trials to optimize your test protocols and settings for your experiment.

Velocity Jog Integer	mm/s
1	0.039063
2	0.078125
3	0.15625
4	0.3125
5	0.625
6	1.25
7	2.5
8	5
9	10
10	20

Acceleration

Acceleration setting can be set as an integer value between 1 and 10 (see chart below for corresponding acceleration values). Changes made to the acceleration will affect tests under both force and displacement control. Reducing this value may help smooth force-controlled tests under low loads or displacement-controlled tests at high speeds. Tests run with lower accelerations will have softer transitions at direction or speed changes but may take longer than specified to achieve specified testing cycles.

Acceleration value	m/s/s	Time (s) to achieve 20mm/s	Travel (mm) to achieve 20mm/s
1	0.002	10.000	100.0
2	0.004	5.000	50.0
3	0.008	2.500	25.0
4	0.016	1.250	12.5
5	0.032	0.625	6.3
6	0.064	0.313	3.1
7	0.128	0.156	1.6
8	0.256	0.078	0.8
9	0.512	0.039	0.4
10	1.024	0.020	0.2

Inertial Force Effects

At higher accelerations or when using heavier fixtures (relative to load cell capacity), inertial forces become more prominent and can impact force readings in test results. The table below outlines the inertial forces (mN) as a function of the corresponding fixture weight and acceleration selected.

Accel #	Accel (m/s/s)	UniVert S/S2 Fixture Weight (g)					
		A	B	C	D	E	F
		8	6	17	50	93	160
1	0.002	0.0	0.0	0.0	0.1	0.2	0.3
2	0.004	0.0	0.0	0.1	0.2	0.4	0.6
3	0.008	0.1	0.0	0.1	0.4	0.7	1.3
4	0.016	0.1	0.1	0.3	0.8	1.5	2.6
5	0.032	0.3	0.2	0.5	1.6	3.0	5.1
6	0.064	0.5	0.4	1.1	3.2	6.0	10.2
7	0.128	1.0	0.8	2.2	6.4	11.9	20.5
8	0.256	2.0	1.5	4.4	12.8	23.8	41.0
9	0.512	4.1	3.1	8.7	25.6	47.6	81.9
10	1.024	8.2	6.1	17.4	51.2	95.2	163.8

Fixture	Fixture Name	Material	Compatible Load Cell Capacity
A	Low Force Compression Platen	Plastic	0.5 – 4.5N
B	Low Force Tension Grip	Plastic	0.5 – 4.5N
C	Medium Force Compression Platen	Plastic	10 – 20N
D	Medium Force Tension Grip	Plastic	10 – 20N
E	Medium Force Compression Platen	Stainless Steel	50 – 200N
F	Medium Force Tension Grip	Stainless Steel	50 – 200N

Note the fixture weights in the table above are approximate. You may calculate inertial forces for your own fixtures (included or custom) using Newton's second law of motion, F = m*a, where:

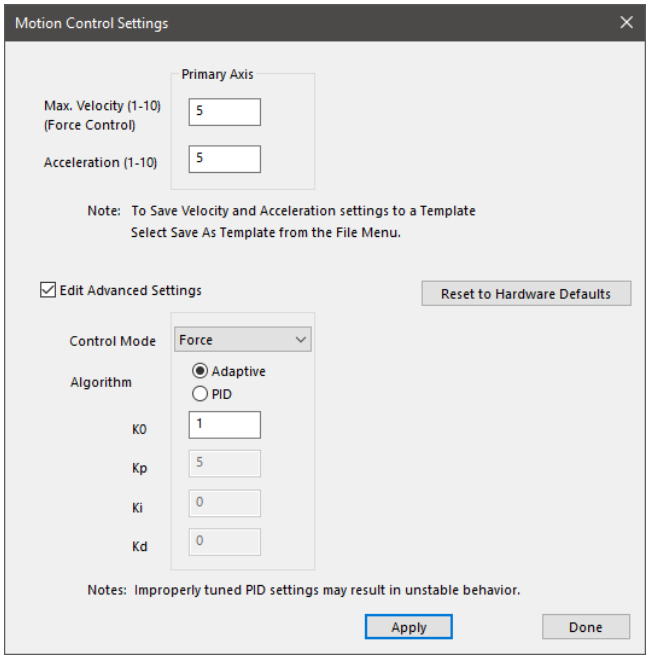
- F is the inertial force in mN
- m is the fixture weight (mass) in grams
- a is the acceleration selected in m/s/s (see acceleration table for reference)

The inertial forces listed above are for linear ramp control with the UniVert in vertical orientation. When using the UniVert in horizontal orientation, inertial forces can be more evident due to vibrations/resonance as a result from the cantilevered fixtures off the load cells. Changing the test protocol to use sinusoidal control can help mitigate inertial forces as it reduces accelerations between direction changes of the actuator (e.g. when the test protocol changes from stretch to recover).

Control Algorithm Settings Editing (Advanced)

This setting offers the option to change from the programmed adaptive control algorithm to a custom algorithm. We recommend using the adaptive algorithm that has already been optimized for the device, as improperly tuned PID settings may result in unstable behavior. We suggest only advanced users with specialized tests modify these PID settings. Contact CellScale for more information regarding these settings.

For adaptive control, an initial gain value (K0) can be modified. This value must be greater than zero, and it is set to 1 by default. The force control may undershoot or overshoot its target when testing very soft or stiff specimens, respectively. The K0 value can be reduced to adjust for overshooting and increased to adjust for undershoot.



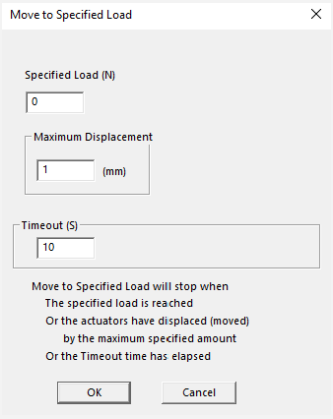
UniVert Tip: Testing Force Control Settings

It is important to have appropriate Force Control Settings that match the materials you are testing.

To safely test Force Control Settings: press *on the tool bar, or from the Tools menu select Move Actuators to Specified Load. The dialogue shown on the right will appear. The UniVert will attempt to achieve the specified load (force) but will stop when the specified load is reached, the actuator has displaced by the maximum specified amount, or the timeout time has elapsed.*

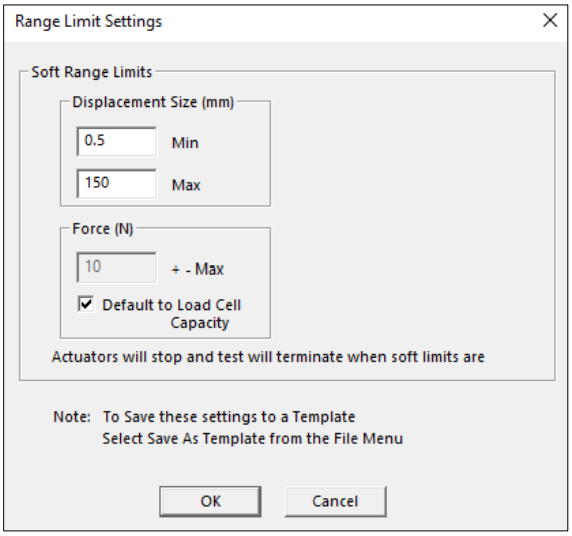
If the actuator oscillates around the specified loads but never achieves them try decreasing the velocity.

If the actuator reaches the specified load too slowly, try increasing the velocity.



Range Limits

Range limits can be accessed by selecting *Range Limits* from the Settings menu.



Soft Range Limits

To avoid collisions or sample destruction, it is useful to assign reasonable travel limits to the actuators. This is especially important during force control or preloading, where if specified loads cannot be reached, the actuators will keep moving until they reach the soft limits.

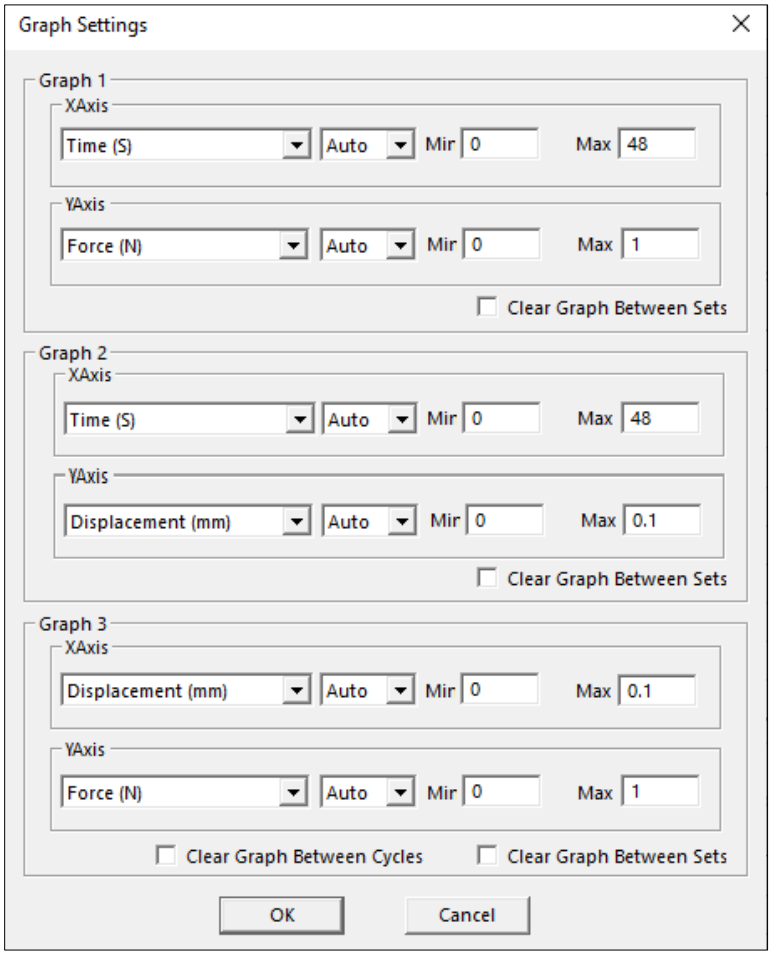
- **Min and Max Displacement**, in mm, set the minimum and maximum positions to which the grips or platens can move. These settings require adjustment especially when the fixtures are changed.
- **Max Force**, in N, sets the maximum value of force at which a test will be automatically stopped. The default value is set to the capacity of the load cells. Setting this value may be useful to prevent sample destruction or overloading of the load cells.

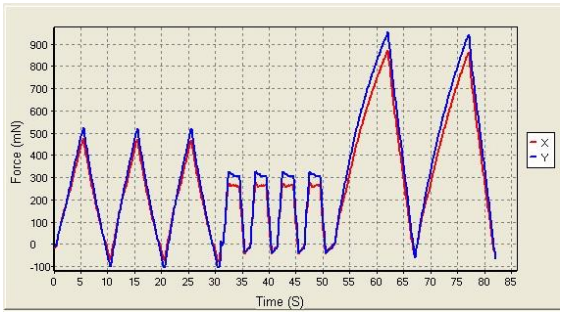
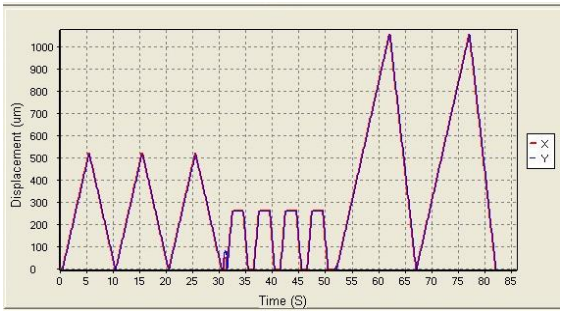
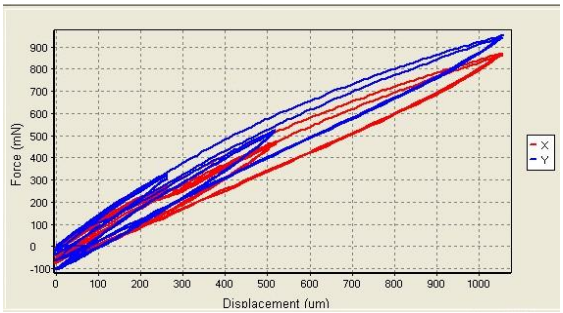
Configuring the Live Charting Graphs

The three graphs on the right side of the screen provide real-time user feedback during a test. These graphs are intended to be used for qualitative feedback, not for detailed analysis.

The graphs are updated at a maximum frequency of 10Hz; certain short-duration tests may not show all the details that is present.

The graph settings can be specified by selecting *Graphs* from the *Settings* menu. Auto scaling allows the axis min and max to start at the specified values but expand if the data values are larger or smaller than the initial limits.



Graph	Data
Force versus Time This graph shows how the measured forces are changing with time. Peak loads per cycle and force relaxation are all easily seen in this type of graph. Force is proportional to nominal (engineering) stress.	
Displacement versus Time This graph shows how the grips or platens are moving with time. The phases of the test sequence and size adjustments due to preloading are readily apparent in this type of graph.	
Force versus Displacement This graph displays a qualitative representation of the material behavior. Viscoelastic effects (like hysteresis) and material response to different loading phases are apparent in this graph. This graph is proportional to a nominal (engineering) stress-strain graph.	

Sign Convention

This setting is used to set the direction and force reading values for the test. For the UniVert device, Pull + refers to a Tension test and Push + refers to a Compression test. For example, If pull + is set for a tension test, the displacement parameters will result in the actuator to move upwards in order to stretch the specimen.

For more details on which sign convention to select, see **Appendix D: Test Setup**.

Specimen Failure Detection

The Specimen Failure Detection setting will automatically stop a test if the specimen has failed (e.g. torn, crushed, broken). This prevents the UniVert system from continuing to execute the remainder of the protocol if the specimen has failed.

First, select the axis which a failure will be detected. The force readings from this axis will determine when a failure has been detected. Additional axes will be available if you have UniVert Plus model equipped with an auxiliary axis (e.g. Torsion, Inflation, or Shear).

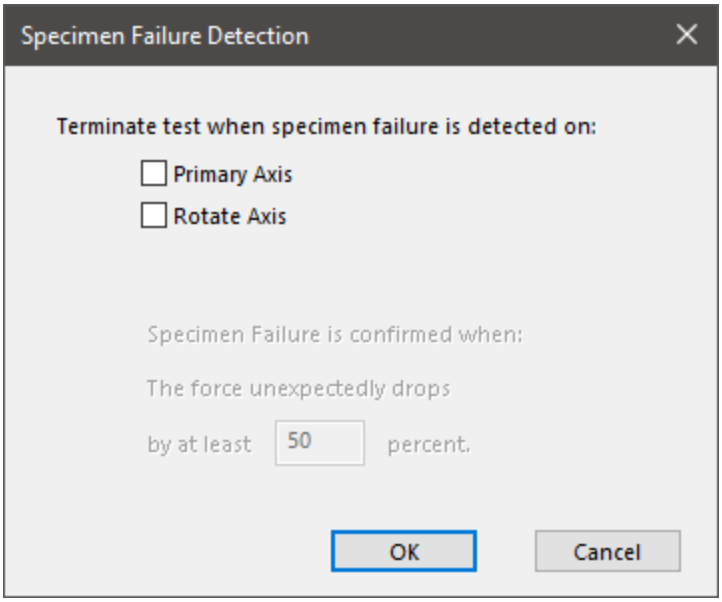
Next, enter a percentage by which the force must drop to for specimen failure to be detected and stop the test.

The following 3 criteria must be met for a specimen failure to be detected:

1. **The force reading drops by at least the determined amount**. This is relative to the maximum force reading during the current phase. For example, if failure detection is set to 50% and the maximum force reading is 20N, the test will stop when the force drops to 10N. The value considered as the maximum force reading is reset after each phase.

2. **The displacement is increasing.** This is relative to the sign convention (i.e. test mode) selected. Generally, the displacement increases during deformation phase (i.e. stretch or compress). For example, in a Pull+ (Tension) test, an increasing displacement occurs during the stretch phase when the actuator is moving away from the baseplate.

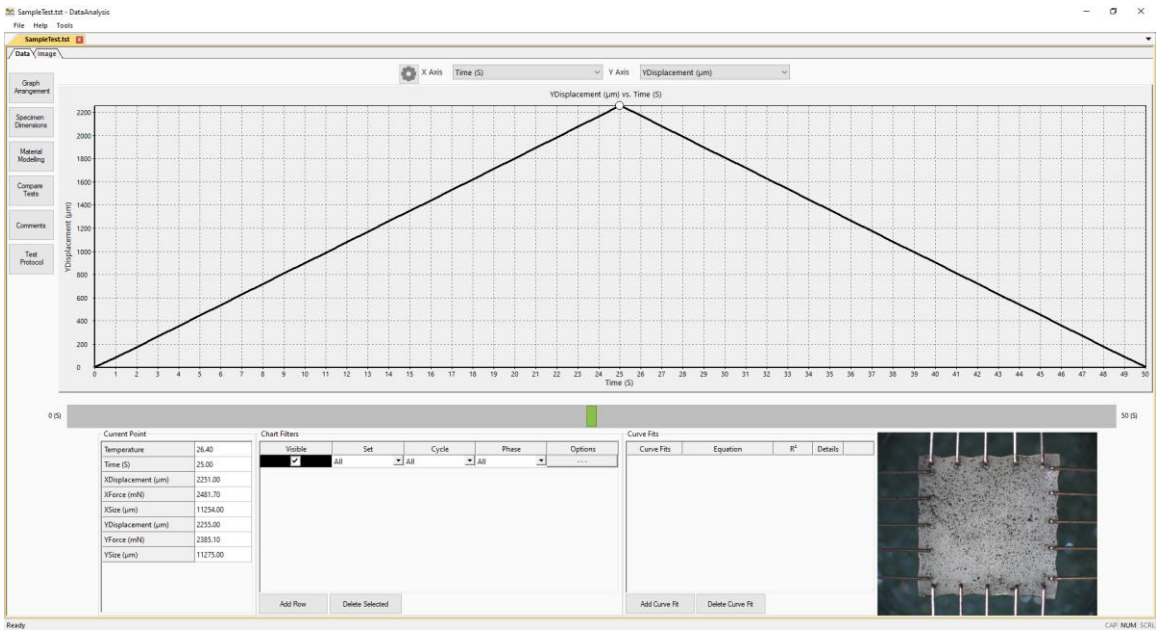
3. **The force reading must be greater than 1% of the load cell's capacity**. This is to prevent a failure detection from occurring due to noise on the load cell signal connection. It is possible specimen failure is not detected if the force readings of the test are very low relative the to the load cell's maximum capacity. Adjust the force drop percentage accordingly and use a lower capacity load cell if necessary.



Reviewing Test Results

The UniVert includes an additional software, Data Analysis, to review and analyze data collected from the device. This includes graphing, curve fitting, material modeling and image processing to determine detailed strain maps. Image analysis functionality is only available to UniVert systems equipped with the Scientific Camera package (see **Appendix E: Camera Setup** for more details).

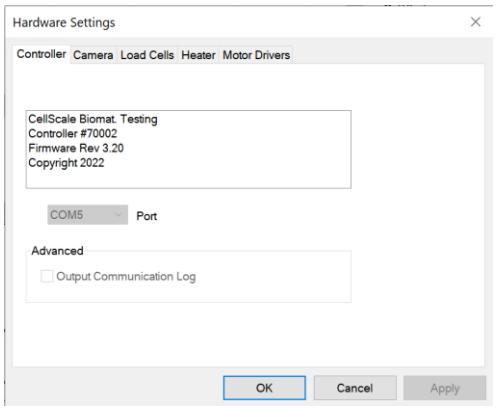
To open the Data Analysis program, select *File>Analyze and Review Images* from the UniVert software home page. More details about Data Analysis can be found in its user manual located in the Documentation folder (*Cellscale>UniVert>Documentation*).



System Hardware Settings

Controller

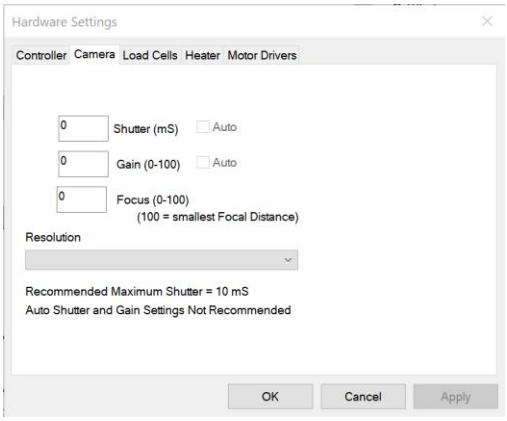
The UniVert uses an integrated control board rather than a group of PC controlled device drivers. This minimizes communication lag and allows the device to operate asynchronously with the PC. The control board details can be seen by selecting *Hardware* from the *Settings* menu, which brings up the window shown to the right.



Camera

The UniVert software can be equipped with the standard webcam package, the scientific camera package, or no camera at all. The software will automatically detect which camera configuration is in use.

Webcam



The basic UniVert system comes with a Logitech HD 1080p webcam intended to be used for recording images for image playback and review. This camera and software associated with it **does not** support image tracking.

For image review purposes the webcam will capture images at up to 5 frames per second and obtain a resolution of 1900 pixels by 1080 pixels. Images captured by the webcam are written to a buffer. The test controller extracts images from this buffer at the specified frequency specified in the *Set Parameter Editor* (5Hz, 1Hz, 0.1Hz, 0.01Hz, or 0.001 Hz) These images are written to the output directory. The file name is the ideal capture time. The actual capture time may differ from the ideal capture time by as much as 1/30 of a second since the images are extracted from a buffer.

The test software creates an image capture log file in the output directory should this difference be significant. This log stores the actual capture time and the idealized capture time.

The webcam can be focused using the focus control in the *Camera* tab under *Hardware* in the Settings menu. The focal distance is set by entering a value between 0-100 (The higher the value, the smaller the focal distance).

The shutter and gain control on the webcam are controlled automatically.

Scientific Camera Package

The advanced scientific camera package is not included with the base UniVert system and is available as an added feature. This advanced option provides high quality images suitable for image tracking and the associated software is enabled with the image tracking feature (See the **Reviewing Test Results** section above or the Data Analysis software user manual).

The camera uses a 2/3" CMOS image sensor to obtain a resolution of 2048 pixels by 2048 pixels. The camera shutter and gain can be controlled by accessing the *Camera* tab in *Hardware Settings*.

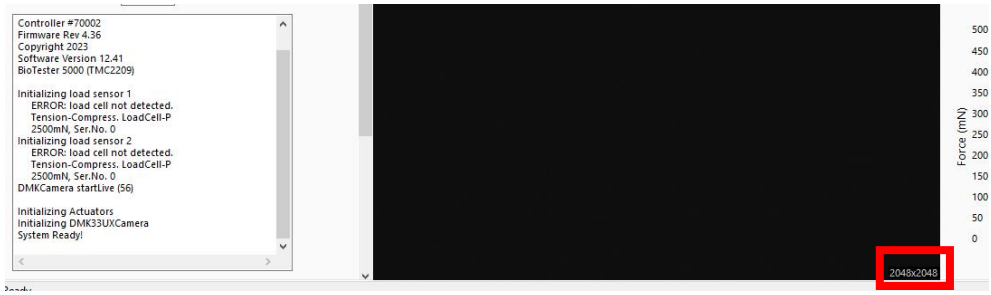
The scientific camera captures images at 15 frames per second during every test and writes these images to a buffer. The test controller extracts images from this buffer at the frequency specified in the *Set Parameter Editor* (50Hz, 25Hz, 15Hz, 5Hz, 1Hz, 0.1Hz, 0.01Hz, or 0.001Hz). These images are written to the output directory. The file name is the ideal capture time. The actual capture time may differ from the ideal capture time by as much as 1/30 of a second since the images are extracted from a buffer.

The test software creates an image capture log file in the output directory should this difference be significant. This log stores the actual capture time and the idealized capture time.

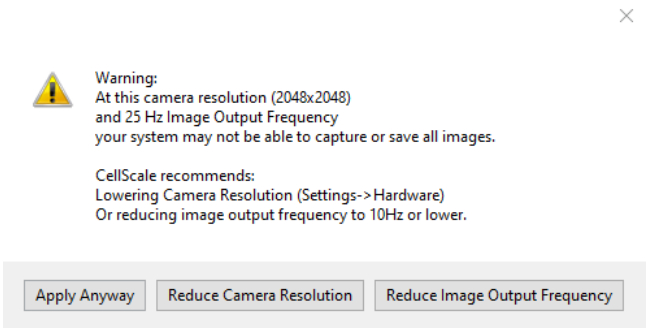
The camera default shutter and gain are specific to each test template and can be set by selecting the *Camera* tab in *Hardware* from the *Settings* menu. The recommended maximum shutter speed is 10mS. Typically, the camera iris is left fully open and the shutter and then the gain are adjusted to achieve the desired image brightness.

Changing Camera Image Resolution – Only with Scientific Camera Package

The default resolution of the camera is 2048x2048, the current image resolution is written at the bottom of the screen.

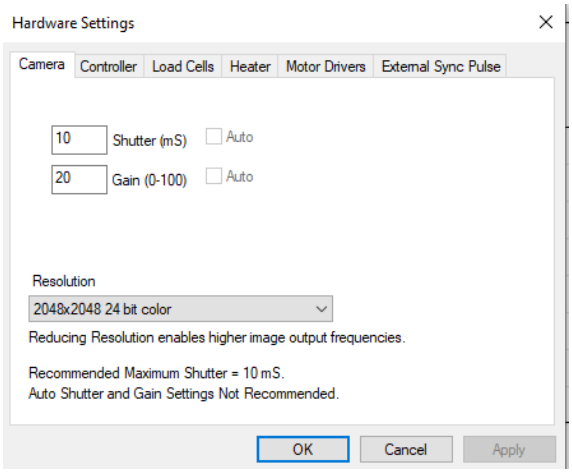


If you would like to capture images at a higher frequency (25Hz or 50Hz) you can reduce this resolution to 1024x1024. When you select the higher frequency, you will get the below prompt where you can reduce the image output frequency, Reduce Camera Resolution or for 25Hz you can leave it the same but note that images may be missed on long tests or if your computer cannot keep up.



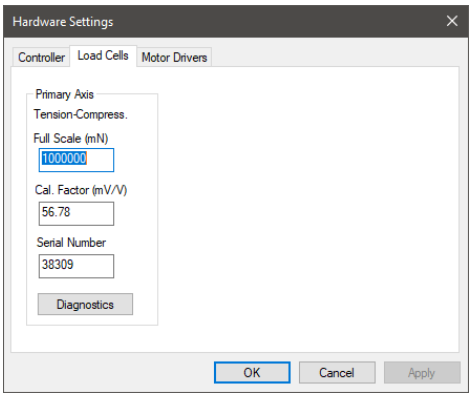
Selecting “Reduce Image Output Frequency” will return you to the Set Editor, selecting “Reduce Camera Resolution” will bring you to the hardware settings window for the camera where you can change the resolution.

To change this setting, you can access the camera settings from the Settings-> Hardware from the top menu



Load Cell

The load cells are semiconductor strain gauge based. They have accuracy equal to 0.2% of the rated full-scale load. Load cells are available in 0.5N, 1N, 2.5N, 4.5N 10N, 20N, 50N, 100N, and 200N sizes. Each load cell has a unique calibration factor which is stored in a chip contained in the load cell connector. A calibration using test weights can also be carried out by the user.



While the load cells should not have significant hysteresis or thermal drift, temperature changes or prolonged loading can introduce small offsets. It is recommended that the zero-load state be redefined before beginning a test. This can be done by selecting *Zero Load Cells* from the Tools menu or selecting .

The load cells are sampled at 100Hz, with hardware providing an 8-sample averaging to reduce noise in the data. Further sample averaging can be implemented by selecting *Advanced* from the Settings menu.

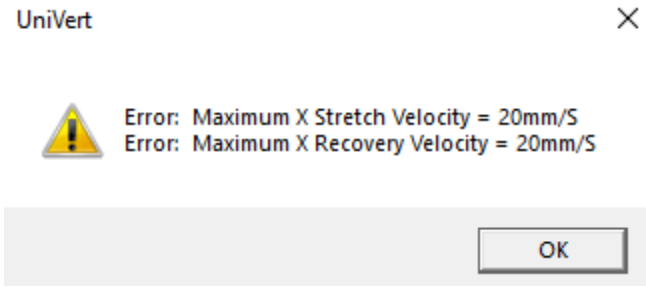
Each load cell is calibrated and has a specific calibration factor which is stored on a chip in the load cell connector. Field calibration using weights of known mass is possible (see the **System Calibration and Advanced Tools** section of this manual). The range and calibration factor can be viewed by selecting *Hardware* from the Settings menu but are not editable in this menu.

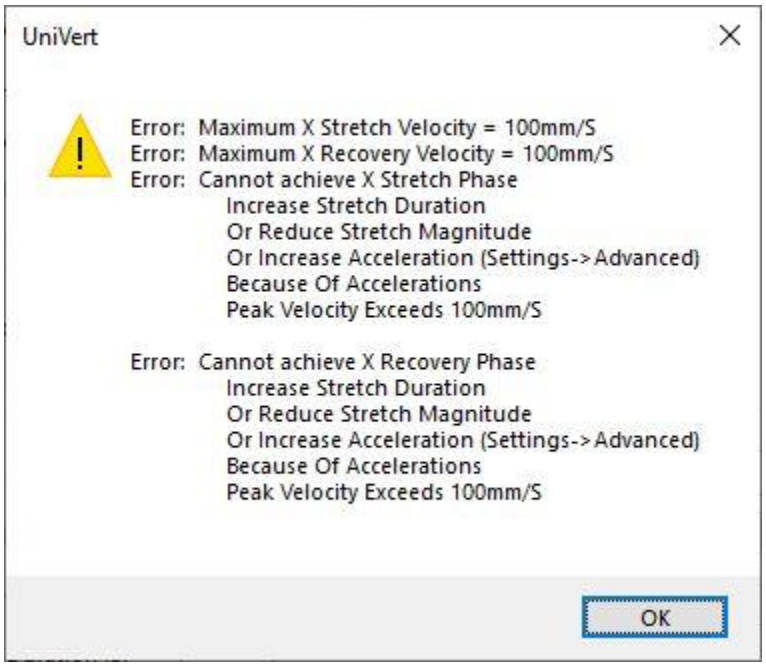
Warning: Permanent load cell damage can occur if 120% of the full scale value is exceeded. Handle the load cell with care and make sure to select appropriate test protocols to avoid overloading.

Note: The Diagnotics button is only intended to be used for troubleshooting with CellScale’s Technical Support Team. If you suspect your load cell may be damaged, contact support@cellsacle.com.

Actuator and Motor

The actuator is driven by a stepper motor under closed loop control. The motor moves a ball screw-driven carriage attached to the load cell and test fixtures. The actuator has a peak velocity of 20mm/s for the standard UniVert and 100mm/s for the UniVert S2 – High Performance. To prevent excessive velocities and accelerations, the control software will issue warnings if entries in the *Set Parameter Editor* result in accelerations or velocities that are out of range. Excessive thrust loads should only occur if mechanical interference obstructs the movement of the actuator. It is advisable to reset the actuators occasionally. The acceleration and velocity parameters can be modified in the *Advanced Settings* window if necessary for your materials or experiments (see the **Advanced System Settings Dialogue** section for more details).

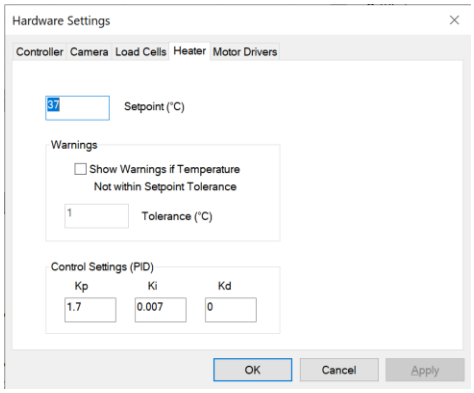




If the Emergency Stop (E-Stop) button has been depressed, power to the actuator will be cut. The motor carriage can be moved manually if necessary. However, the position of the motor will be compromised, and an actuator reset will be required before executing another test.

Heater

To activate the fluid chamber heater, the unit must be powered on, and the heater cable must be connected (the computer and software do not need to be on yet). Turn on the heater toggle switch (below amber LED light), the heater will warm the fluid to the last used temperature set point. The temperature set point can be changed by selecting *Hardware* from the *Settings* menu.



Typically, the heater will take 30 to 60 minutes to warm a full fluid chamber from room temperature to 37°C and will take up to 90 minutes to stabilize at this temperature. To reduce this time, it is encouraged to use pre-heated media.

When Show Temperature Warnings is enabled and the Current Temperature is not at the Temperature Set Point plus or minus the specified tolerance -- a red indicator button will be displayed next to the Current Temperature live output and a warning dialogue will appear when you execute the test.

The Control Settings (PID) section displays the programmed settings for the temperature control of the heated bath. These have already been optimized for the UniVert heated bath. This section only displays the setting values (i.e. cannot be edited) to ensure the correct values have been programmed.

System Alert

In the event of a dislodged or faulty temperature sensor, or if there is a lack of fluid in the fluid chamber, the system is designed to reach a maximum temperature of less than 80°C.

Caution: Avoid touching the chamber's metal back panel when the heater is on, it can become very hot!

UniVert Tip: Preheat Fluid

You can add preheated fluid to the fluid chamber to reduce warm up time.

System Calibration and Advanced Tools

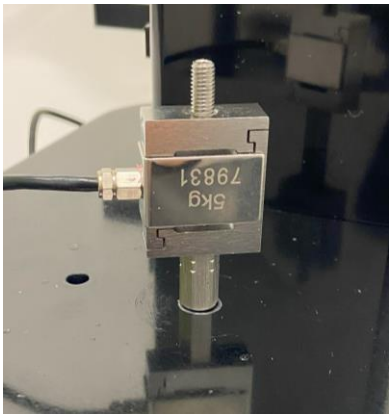
Load Cell Calibration

The load cells are preset with a calibration factor during manufacturing and quality check. It is recommended to use this factory calibration. However, calibration in the field is possible. When the load cells are set up for the first time, changed, or moved it is advisable to perform a load cell calibration check to ensure the factory calibration is still correct. This process will require a set of calibration weights (not included with system). Load cells can be calibrated attached to the UniVert system or with the Calibration Plates.

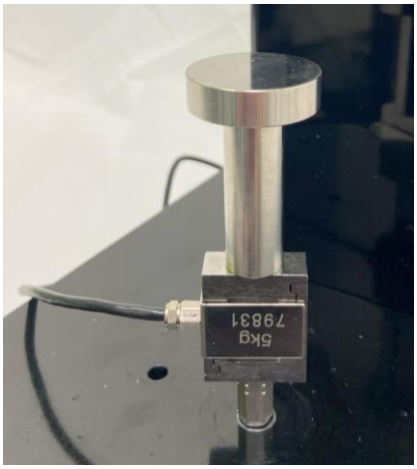
If you are planning to overwrite the factory calibration value, we recommend using at least 3 different weights spanning from 10%-90% of the full scale of the loadcell to ensure a correct calibration factor is found.

Attached to System

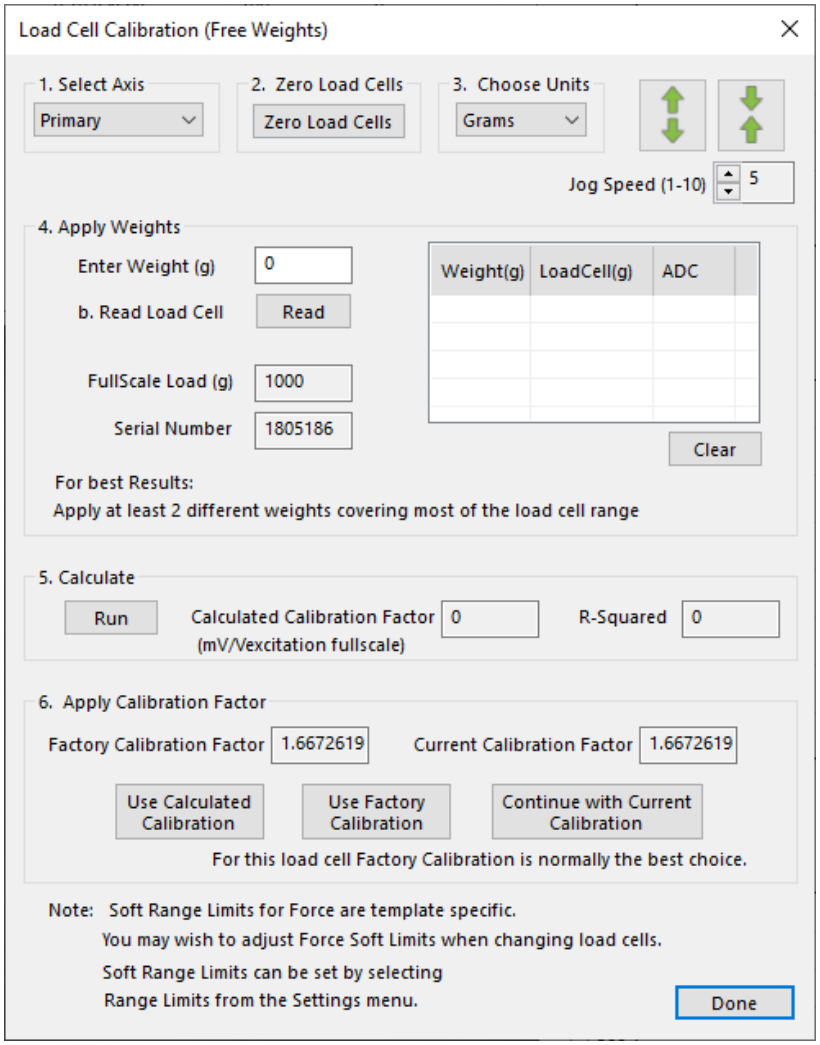
1. Attach the load cell to the fixed end of the UniVert (i.e. on the baseplate) with an M5x16 SHCS and 4mm hex key. Ensure the measuring end of the load cell is facing away from the system (See **Appendix B**).



2. Affix the calibration platen to the load cell.

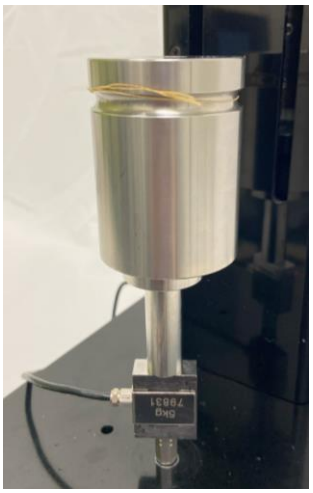


3. Reset the actuator to move the test fixtures out of the way.
4. From the Tools menu select *Load Cell Calibration*



5. **Zero the load cell** to remove the weight of the platen from the calibration values measured.
6. Select the desired units to measure in. When using free weights this will always be in grams.
7. Measure the zero-load condition for the first calibration point (no calibration weight)
    a. Enter “0” in the *Enter Weight* dialogue
    b. Click *Read*

8. Gently place a test weight onto the platen. This weight should be between **10%-90%** of the load cell full scale value to ensure accurate calibration. Centre the weight on the load-bearing surface to ensure in-line loads and use weights corresponding to the load cell capacity range. **Do not overload the load cell.**



9. Take a measurement of the calibration test weight.
    c. Enter the weight in grams in the *Enter Weight* dialogue
    d. Click *Read*
10. Repeat steps 8 and 9 with at least 2 additional weights covering most of the load cell range. This will ensure a precise calibration factor is calculated.
11. Click “Run”.
12. Check the *R Squared* for reasonable values. The *R Squared* is calculated based on a linear plot of the measured weights in the previous section. Ideally, this value should be as close to 1 as possible.
13. Select which calibration factor to program to the load cell:
    a. *Use Calculated Calibration* will apply the new calculated value from the free weights applied in previous steps. **This is recommended only if you are using NIST certified weights or using a Version 1 of the loadcell (6-position connector, shown below).**

b. *Use Factory Calibration* will restore the factory calibration factor. **For Version 2 of the load cells (4-position connector and in-line box, shown below), we recommend using the factory calibration factor and using the test weights as a check.**

c. *Continue with Current Calibration* will keep the calibration factor that is currently programmed to the load cell. This could be the factory calibration factor if a new one has not been programmed.

14. Click “Done” to close the window

Note: Only take one reading per calibration weight used. Multiple readings of a single load value can cause an error in the calibration algorithm

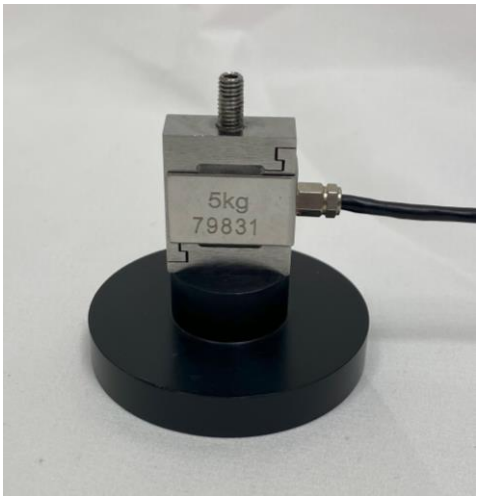
Be sure to zero ***the load cell again once the UniVert is in the desired testing configuration***

Calibration Plates

Alternatively, the load cells can be calibrated detached from the UniVert fixtures.

1. Carefully remove the load cell being calibrated if it is attached to the UniVert fixtures. However, ensure the cable is still connected to the UniVert.

2. Attach the two provided calibration plates to both ends of the load cell.



3. Orient the setup such that the measuring end of the load cell is facing up and continue with the standard calibration procedure described above.

Note: Calibration plates are only compatible with regular UniVert load cells. Low force load cells may only be calibrated while attached to the UniVert device.

System Alert: Load Cell Handling

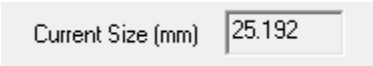
It is important to handle load cells carefully. Here are some things to consider while handling a load cell:

- *The load cells are designed to handle overloads of up to 120% full scale value. Overloading a load cell past this rating will cause permanent damage or failure.*
- *Avoid applying torque and transverse forces to the load cells. Over tightening grips or platens onto the active end of the load cell may damage it.*
- *Accidentally crashing the platens or grips together will produce more force than most load cells can handle. Be careful and reduce speed when jogging grips close together.*

Generally, avoid dropping, tapping and exerting unnecessary force to increase the life of the load cell.

Zero Position Calibration

The actuator position is indicated in the *Current Size* dialogue on the left-hand side of the screen.



This is the current separation of the edges of the clamps or platens. For this measurement to have meaning, a zero position must be defined. This is a position where the grip or platen tips would just touch each other.

The *Move to Size* command is also dependent on a correctly defined zero position.

An actuator zero position is preset during manufacturing and quality check. However, the zero position should be re-calibrated on initial system setup and whenever the grips, platens, load cells, or risers are changed. Changing these components will always alter the zero position slightly.

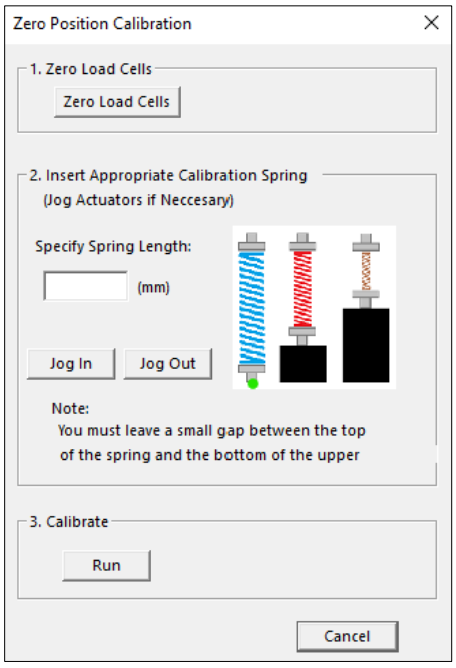
There is a software utility to automatically calibrate the zero position using a spring of known length provided with the UniVert system.

The calibration spring is placed between the grips or platens. The calibration utility slowly moves the grips or platens together until a small load is detected when contact with the spring occurs. It then assigns this position as the size of the calibration spring being used.

Note this calibration method should only be used for vertical configurations. For horizontal configurations, use the Custom Position Calibration outlined in the following section. Using Zero Position Calibration in the horizontal configuration could introduce off-axis loading on the load cell. This could result in inaccurate calibration or even damage to the load cell.

To calibrate the zero position, follow these steps:

1. Open the Zero Position Calibration utility by selecting *Zero Position Calibration* in the Tools menu.



2. Place the provided calibration spring on the bottom platen or grip.

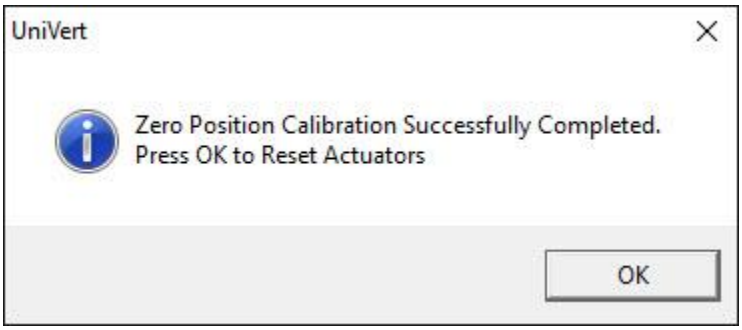
3. Zero the load cell using the *Zero Load Cells* button.

4. Specify the spring length (mm). This figure is provided for each spring included in the UniVert system.

5. Using the jog buttons, move the actuator such that there is a small gap between the top of the spring and the bottom of the upper platen or grip. Do not contact the top of the spring. Using a slow jog speed (below 5) is advisable for this reason.

6. Select *Run* and let the calibration utility proceed. The software will calibrate the zero position automatically.

7. Press OK to Reset Actuators and complete the calibration.

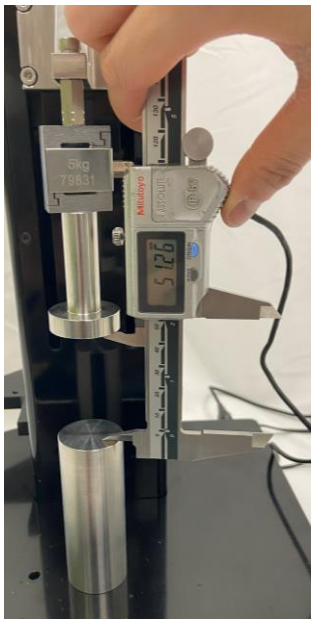


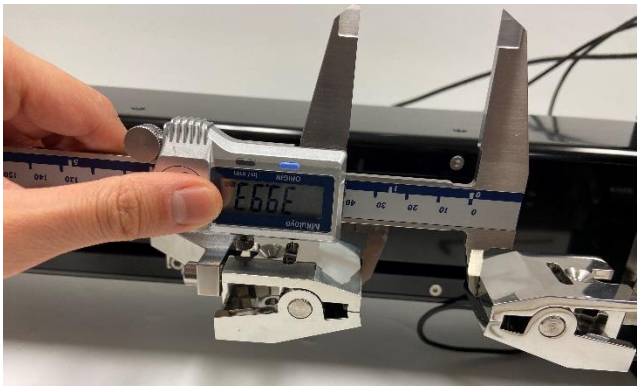
Custom Position Calibration

Alternatively, the UniVert position can be defined with the use of digital or vernier calipers.

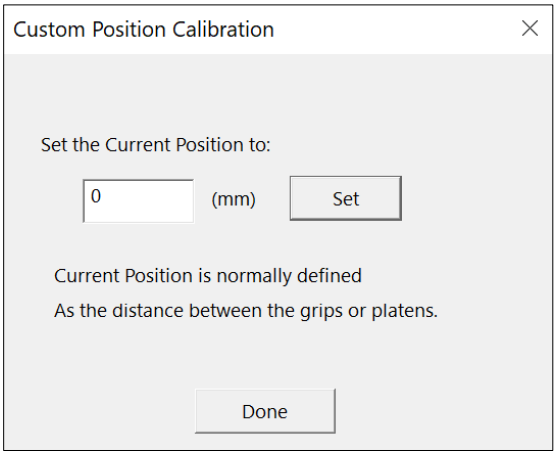
To set a custom position:

1. Jog the fixtures so their distance is within the reading range of the calipers.
2. Measure the distance between the fixtures with the calipers. Ensure the calipers are reading in millimeters.





3. Open the *Custom Position Calibration* utility in the *Tools* menu



4. Enter the distance read out by the calipers (in mm) and press *Set* to define a new custom position

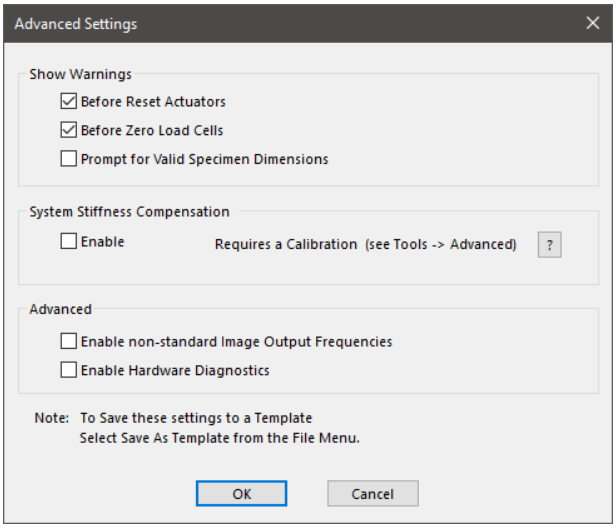
System Stiffness Compensation

System Stiffness Compensation can be used to compensate for the small displacements that occur in the system during testing due to flexion and load cell compression/tension. These displacements arise from any strains in the load cell and any bending or deformation of the system during loading. Under most loading conditions, these displacements are negligible and system stiffness compensation is not required. System stiffness compensation plays a more significant role when testing stiff specimens that achieve high loads at low displacements.

System Stiffness Compensation can be enabled or disabled under the Advanced Settings dialogue (*Advanced* from the *Settings* menu).

Note: This calibration procedure is not required for UniVert systems with serial number UV55311 or greater (purchased in Feb 2024 or later). Both the system and all load cells associated with the device have been factory calibrated. The factory calibrated compensation values can be enabled through the Advanced Settings window at your discretion.

When enabled, output displacement and size data in the .csv data output file will be modified. For example, in a test where a 10 mm specimen is being compressed by 1mm at 100N of force the system may be displaced by 0.1mm. In this case when the actuators have moved 1 mm the specimen will only have been deformed by 0.9 mm and the other 0.1 mm will have gone into deforming the load cell and system. The output will show a displacement of 0.9 mm (rather than 1.0) and a specimen size of 9.1 mm (rather than 9 mm).



Note: The system stiffness compensation does not affect or alter the applied loads or displacements only the reported values in the output .csv files.

The amount of compensation being applied to the displacement and size columns of the output data file can also be shown as an additional output column (see the **Additional Settings** section).

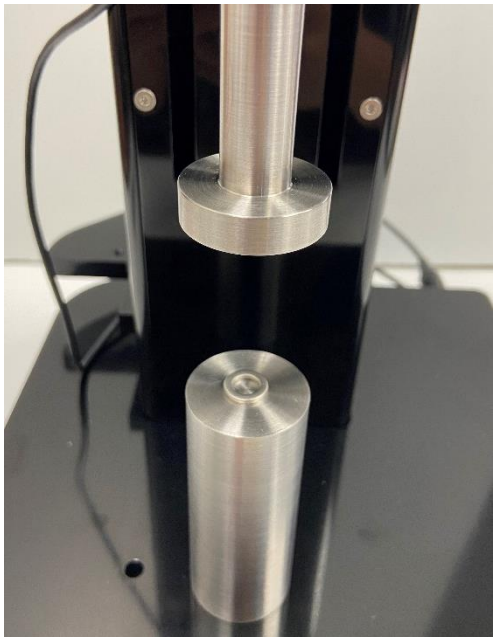
UniVert Tip: When to Apply System Stiffness Compensation

Typically, System Stiffness Compensation will not be required. It may be useful, however, when testing stiff specimens that achieve high loads at low displacements. Most of the system deformation comes from the load cells which typically strain linearly by up to about 200 μm at full scale load. One can estimate the amount of system deformation by multiplying 200 μm by the percent of load cell range that is used. For example, when a load cell is at 50% of its full-scale load (a 200N load cell at 100N, or a 10N load cell at 5N) the system deformation is estimated to be about 100 μm. To determine the effect of this displacement on your test you can divide this estimated system deformation by the maximum displacement in your test.

For example, in a test with 10mm of displacement: $\frac{100\ um}{10\ mm} = \frac{0.1\ mm}{10\ mm} = 1\%$

We recommend using system stiffness compensation if the system deformation is more than 10% of the applied deformation.

If system stiffness compensation is enabled and factory calibrated values are not programmed, a calibration must be performed to determine the correct compensation factor. This factor depends on the load cell being used and a new calibration must be completed each time the load cell is changed. There is a software utility to automatically perform this calibration. Before starting the software utility, attach the compression platens to the UniVert system. Also, place the Stiffness Compensation spacer that is provided (a small washer) onto the exact center of the lower platen.



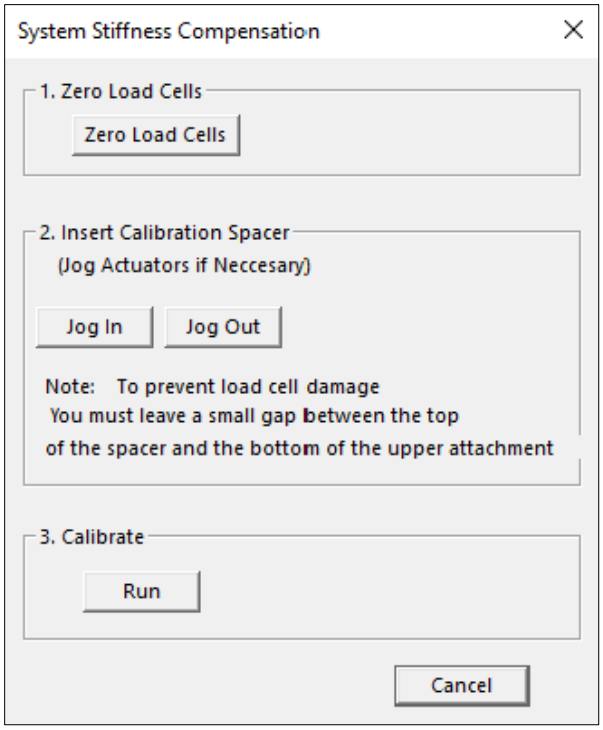
After placing the calibration spacer, slowly jog the platens together until there is a very small gap between the upper platen and the spacer. If this gap is too large, the software utility will take a very long time to run. However, do not allow the upper platen and the spacer to come in contact. **If the platens crash together the load cell will likely be damaged.**

UniVert Tip: Jog Slowly to Protect Load Cells

Jog the platens together at a slow speed to prevent crashing them together and damaging the load cell. Use lower jog speeds the closer the platens are to each other.

To perform system stiffness compensation calibration, follow these steps:

1. Open the System Stiffness Compensation utility by selecting Advanced → System Compensation from the Tools menu.
2. Zero the load cells.
3. Use the jog buttons to decrease the gap above the spacer. Do not contact the top of the calibration spacer.
4. Click Run to start the calibration and set the stiffness compensation value.
5. Press OK to Reset Actuators and complete the calibration.
6. The calculated system stiffness compensation value will be displayed in the message window.



The calibration utility will slowly drive the platens together until the full-scale load is reached on the load cell. Resulting load displacement data is typically very linear and a best-fit slope is used to determine the calibration factor. Compensation is calculated in compression but is assumed to act linearly in both tension and compression.

Snap Image Feature

Located under *Tools>Snap Image.*

This feature allows the user to capture a single image during the setup phase. This can be useful for documenting specimen loading activity and neutral (non-contact) beam position.

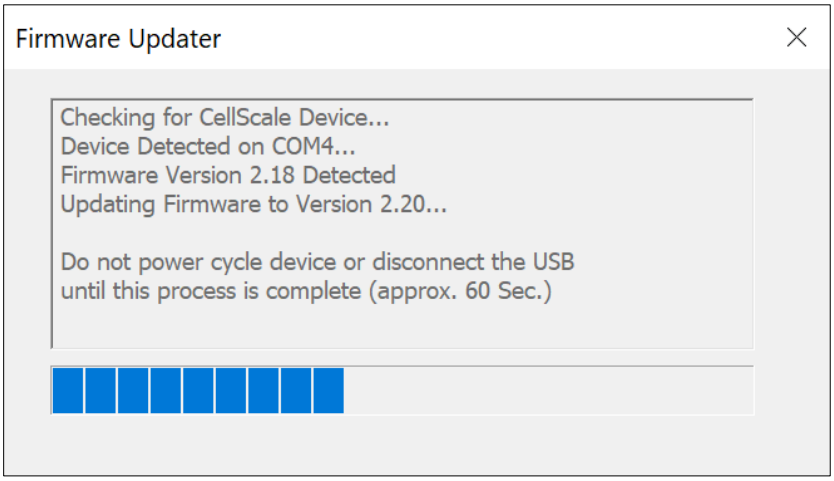
Update Firmware

Periodic firmware updates may be issued by CellScale for the UniVert. When a new firmware or software is available, you may download it from our website (www.cellscale.com/downloads).

To update the firmware:

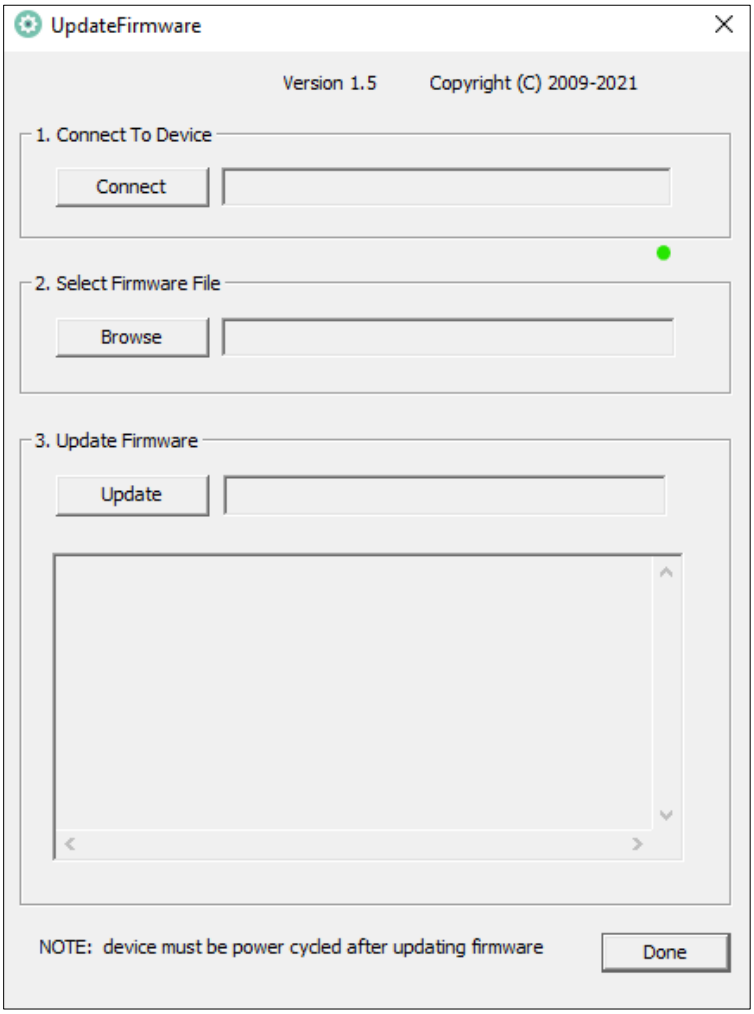
1. Connect the UniVert to the PC via USB and turn on power to the UniVert
2. Open the *UpdateFirmware.exe* program located in *Univert>Software>Utilities>Update Firmware*
3. The program will automatically update the firmware of the UniVert
4. Power cycle the system after the firmware is successfully updated before using the UniVert software again

The firmware version is checked and the automatic updater is also run when installing a new version of the software.



If the automatic firmware update software does not work, please follow the manual steps below:

1. With the UniVert connected to the PC and turned on, launch the manual firmware update software located in *UniVert>Utilities>Update Firmware>Advanced*.
2. Click the *Connect* button.
3. Load the firmware file using the *Browse* button. The file will be a .bin extension.
4. Execute the update using the *Update* button.
5. Power cycle the system after the firmware is successfully updated before using the UniVert software again.



Troubleshooting

Communication Errors: Read File or Write File

When communication errors occur the live message window will display a *ReadFile* or WriteFile failed message. Communication errors can occur if:

- The UniVert is not powered up.
- USB cables between the computer and UniVert are disconnected.
- The supply power surges or is interrupted.

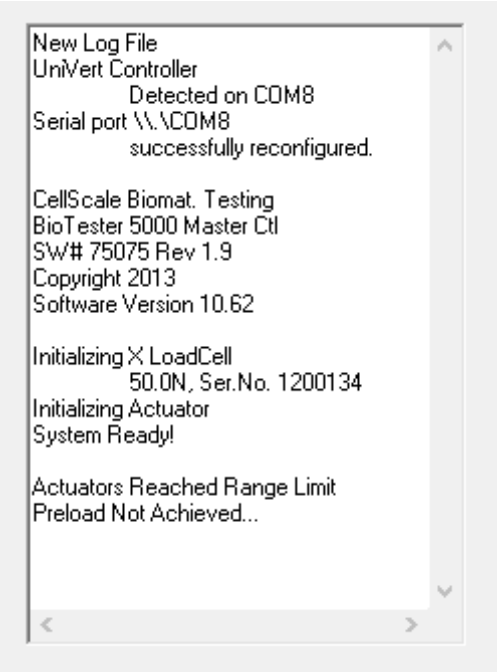
When a communication error occurs, close UniVert software, check connections, power cycle the UniVert Device, and restart the UniVert software. Be sure to reset the actuators before setting up a new test.

> ***UniVert Tip: Preventing Power Disruptions***
>
> We recommend plugging the UniVert (and host computer) into an uninterruptable power supply (UPS) or battery back-up.

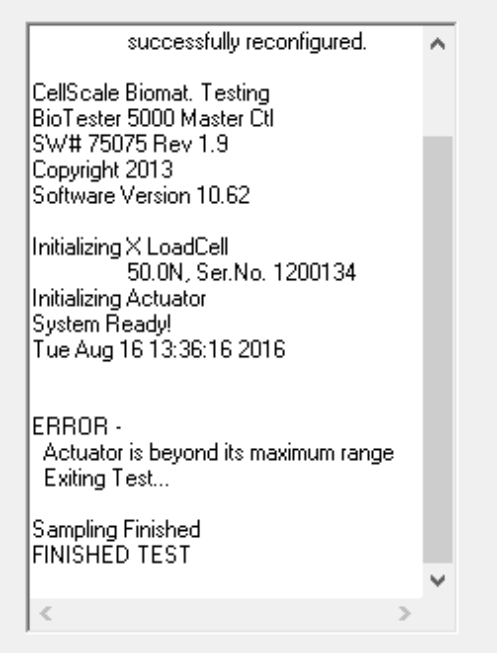
Actuator Limits

When changing between horizontal and vertical configurations, it is possible to reach the lower range limit of the actuator. Hitting the physical range limit may affect the accuracy of the Current Size reading. To avoid this, there are several software warnings which occur under these circumstances:

Moving the actuator out of range with *Move to Force* :
If the actuator is moved past the range limit when using *Move to Force* the UniVert software will display an error message (shown below). It is recommended to perform an actuator reset before continuing testing. You may need to adjust the range limits by selecting *Range Limits* in the *Settings* menu to accommodate your specimen.



Reaching the actuator limit during a test:
If the actuator is moved past the range limit during a test, the UniVert software will terminate the test and display an error message:

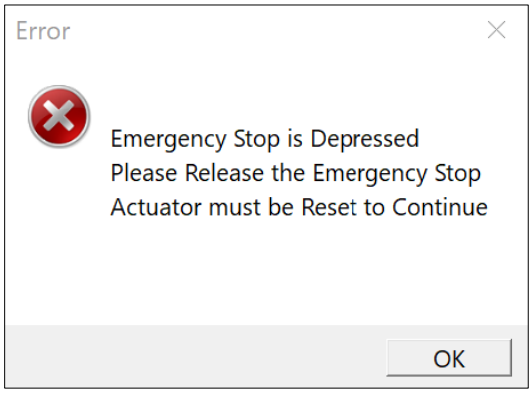


UniVert Tip: Zero Position Calibration

Perform a zero position calibration (see the **System Calibration and Advanced Tools** section) when the load cell, grips, or risers are changed. A correct zero position will ensure that the failsafe features for the actuator limits (described above) will work as intended.

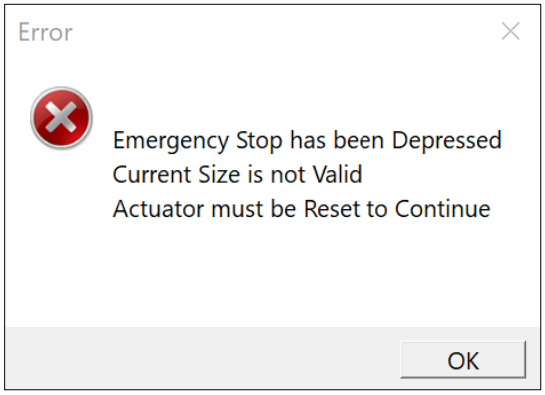
Emergency Stop

If the Emergency Stop (E-Stop) has been depressed, a new test cannot begin until it has returned to the disengaged position. Twist the red E-Stop button on the UniVert controller in either direction and this will allow the switch to pop out again.



This switch is intended to be used only in case of **EMERGENCY** as the actuator will lose its position when the E-Stop has been depressed. Once the E-Stop has been returned to its original position after the being activated, power cycle the UniVert and reset the actuators to restore the position accuracy.

A test cannot begin until an actuator reset has been completed after the E-stop is returned to its original position.



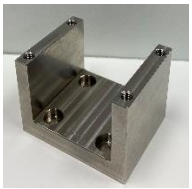
Appendix A: Unpacking and Initial Setup

The system components listed below may be unpacked and laid out before system setup. A clearance space (L x W x H) of 25cm x 35cm x 60cm and 60cm x 35cm x 25cm is required for vertical and horizontal configuration setup respectively.

Tools

Hex keys (2.5mm, 3mm, 4mm, and 5mm)

Components

Item Name	Item	Quantity
UniVert Main Unit		1
Pivot Wings		2
Motor Bracket A* (Installed on device)		1
Motor Bracket B		1
Horizontal Bracket (No Load Cell)		1

M5 Tension Load Cell Bracket		1
M3 Tension Load Cell Bracket		1
Load Cell		1
Calibration Plates		2
Light Grip Springs		3
Medium Grip Springs		3
Heavy Grip Springs		3
M3 Compression Platen (Plastic)		1

M5 Compression Platen (Stainless Steel)		1
M5 Compression Base Riser - Tall		1
M5 Compression Base Riser – Short		1
M3 Specimen Grip (Plastic)		1
M5 Specimen Grips (Stainless Steel)		2
M5 Locking Discs		2
M3 Locking Discs		2

M5 Coupling Nut		1
M5 to M3 Thumbnut		1
M5 Stand Off		1
Calibration Spring		1
Sample Test Specimens		4
Stiffness Compensation Spacer		1
Camera		1

Tripod		1
24V Power Supply		1
USB Cable		1

Fasteners

Size	Purpose	Quantity
M4x12 SHCS	Mount Pivot Wings to Main Unit	4
M4x8 SHCS	Attach Motor Bracket B to Motor Bracket A	4
M5x12 SHCS	Attach Horizontal Fixtures (M5) (see **Appendix D** for more details) Mount loadcell or fixtures to Motor Bracket B	4
M3x12 SHCS	Attach Horizontal Fixtures (M3) (see **Appendix D** for more details)	1
M5x16 SHCS	Mount fixtures to baseplate	1
M4x25 FHCS	To increase clamping force of M5 Specimen Grips	2

Initial Setup

Step 1: Unpack the main unit and the accessories

Set aside the main unit, Pivot Wings, 4 x M4x8 SHCS, Motor Bracket B, 4 x M4x8 SHCS, and 3mm hex key

Step 2: Attach Motor Bracket B to Motor Bracket A

Attach the Motor Bracket with 4 x M4x8 SHCS using the 3mm hex key

Step 3: Attach the Pivot Wings to the main unit

Attach both Pivot Wings to the side of the UniVert with 4 x M4x8 SHCS using a 3mm hex key

Step 4: Install the UniVert software

See **Appendix C: Software Installation** for more information.

Step 5: Attach the load cell

See **Appendix B: Load Cell Installation** for this procedure.

Step 6: Attach platens or grips to the load cell

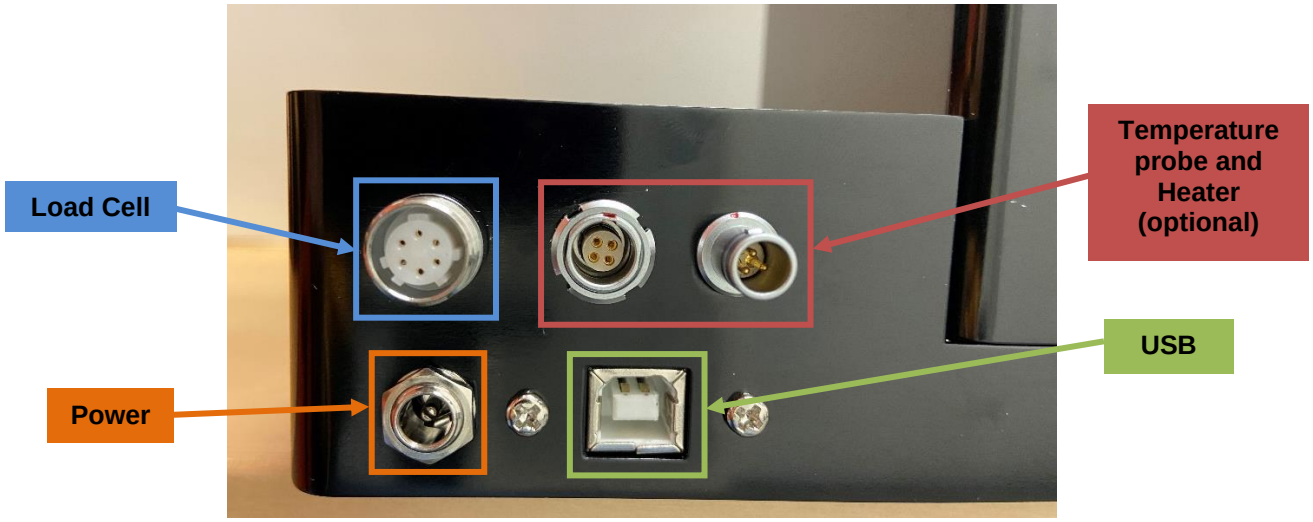
See **Appendix D: Test Setup** for this procedure

Step 7: Connect all necessary cables to the UniVert

A 24V brick power supply powers the UniVert system via a barrel connector on the back of the control box. The UniVert control box is connected to the PC via a USB connection.

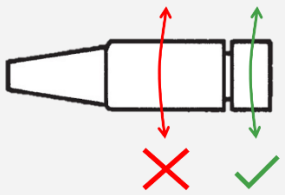
The load cell connector has a keyway inside the connector and a locking ring to ensure proper connection. To connect a load cell, align the keyway, push the connector in, and turn the threaded locking ring until tight. Note that this may require several turns to lock in place.

The temperature probe and heater connectors also have a keyway. Align the red marks on both the panel connector and cable connector. These connectors will only be present if a Media Bath package is purchased with the UniVert (see **Appendix F** for more detail on how to set up the media bath).



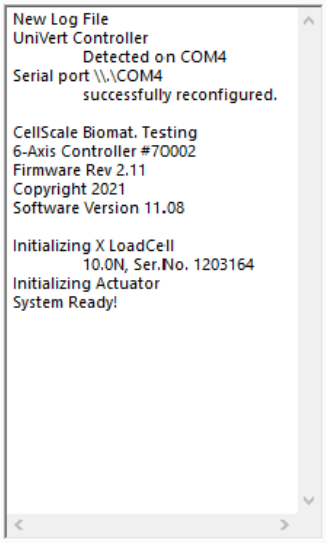
System Alert: Load Cell connector

*Only twist the silver threaded coupling when attaching and detaching the load cell connector. **DO NOT** twist the black rubber housing when the connector is mounted to the control box. This can damage the internal wiring and connectivity of the load cell.*



Step 8: Launch the software and begin a test to ensure the UniVert connects to the PC

Run UniVert.exe and start a new test (*File* > *Collect New)*. The software will output information on the initialization of the camera, load cell, and actuator. The software will output *System Ready!* when all systems have loaded and the UniVert is ready for testing.



Step 9: Calibrate the Load Cell

See the **System Calibration and Advanced Tools** section of this User's Manual for more information.

Step 10: Set the Actuator Zero Position

See the **System Calibration and Advanced Tools** section of this User's Manual for more information.

Step 11: Begin Testing

It is recommended that the User's Manual be thoroughly reviewed before beginning testing using the UniVert system. Procedures for loading samples, setting up tests, carrying out tests, and reviewing results are described in detail.

Auxiliary Axis

UniVert Plus systems are equipped with additional connections for another test axis.

Torsion Axis

The Torsion test axis allows for rotational displacement and torque force measurements. For more information about the function and installation of the Torsion axis, please refer to the ***UniVert Torsion Axis User Manual*** located in the Documentation folder (*C:\Cellscale\UniVert\Documentation*).

Inflation Axis

The Inflation test axis allows for specimen inflation and pressure measurements. For more information about the function and installation of the Inflation axis, please refer to the ***UniVert Inflation Axis User Manual*** located in the Documentation folder (*C:\Cellscale\UniVert\Documentation*).

Shear Axis

The Shear test axis allows for lateral (perpendicular to primary axis) displacements and shear force measurements. For more information about the function and installation of the Shear axis, please refer to the ***UniVert Shear Axis User Manual*** located in the Documentation folder (*C:\Cellscale\UniVert\Documentation*).

Appendix B: Load Cell Installation

In order to avoid load cell damage, proper installation is required. Follow these steps when installing for the first time or changing load cells:

- If your load cells have a cylindrical body with a 6-pin connector, follow steps outlined in the Legacy Load Cell section.
- If your load cells have a rectangular body with a 4-pin connector, follow steps outlined in the Current Load Cell section.

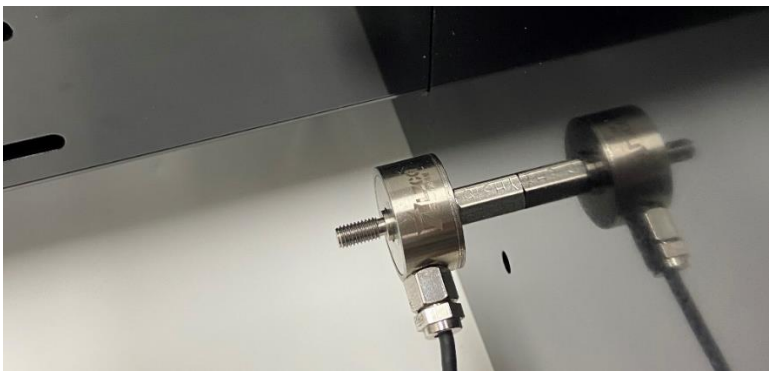
Legacy Load Cell

1. Identify the active end of the load cell (see below image). This is the **MEASURING END** of the load cell which results in a force reading. This end is covered with a small plate not continuous with the rest of the load cell body.

2. Attach the appropriate thumbnut/coupling to the **NON-MEASURING END** of the load cell (M5 or M3 depending on the load cell).

3. Attach the load cell and thumbnut/coupling assembly to the UniVert device:

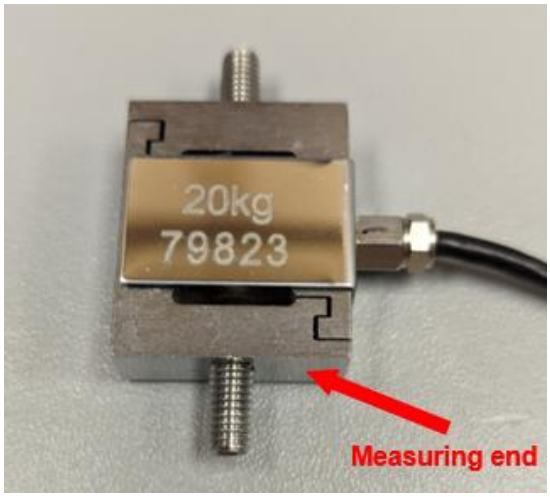
    - For vertical configuration attach the load cell to Motor Bracket B with an M5x12 SHCS using a 4mm hex key
    - For horizontal configuration, mount it to the baseplate of the UniVert with an M5x16 SHCS using a 4mm hex key.



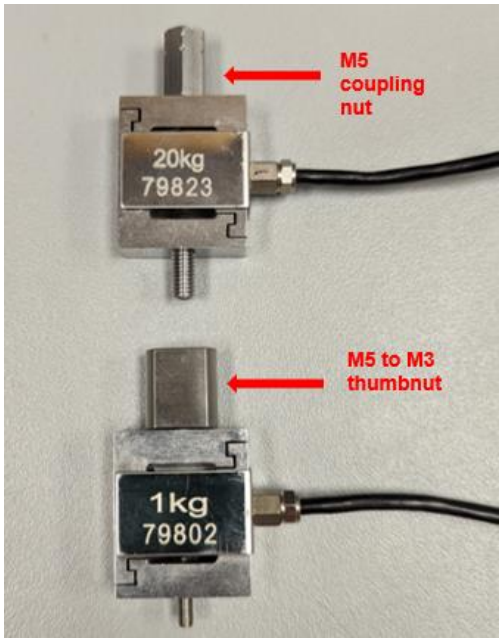
4. The measuring end of the load cell should be exposed, and the non-measuring end attached to the thumbnut/coupling and then to the UniVert. The test fixtures are ready to be mounted to the load cell.

Current Load Cell

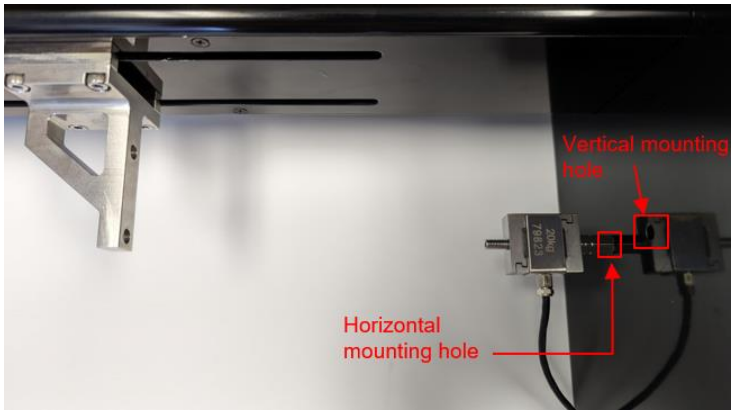
1. Identify the active end of the load cell (see below image). This is the **MEASURING END** of the load cell which results in a force reading.



2. Attach the appropriate thumbnut/coupling to the **NON-MEASURING END** of the load cell (M5 or M3 depending on the load cell). In the image below, the top load cell uses an M5 screw, and thus requires the M5 coupling nut. The bottom load cell uses an M3 screw, and thus requires the M5 to M3 thumbnut.



3. Attach the load cell and thumbnut/coupling assembly to the UniVert device:
    - For vertical configuration attach the load cell to Motor Bracket B with an M5x12 SHCS using a 4mm hex key
    - For horizontal configuration, mount it to the baseplate of the UniVert with an M5x16 SHCS **in the horizontal mounting hole** using a 4mm hex key.



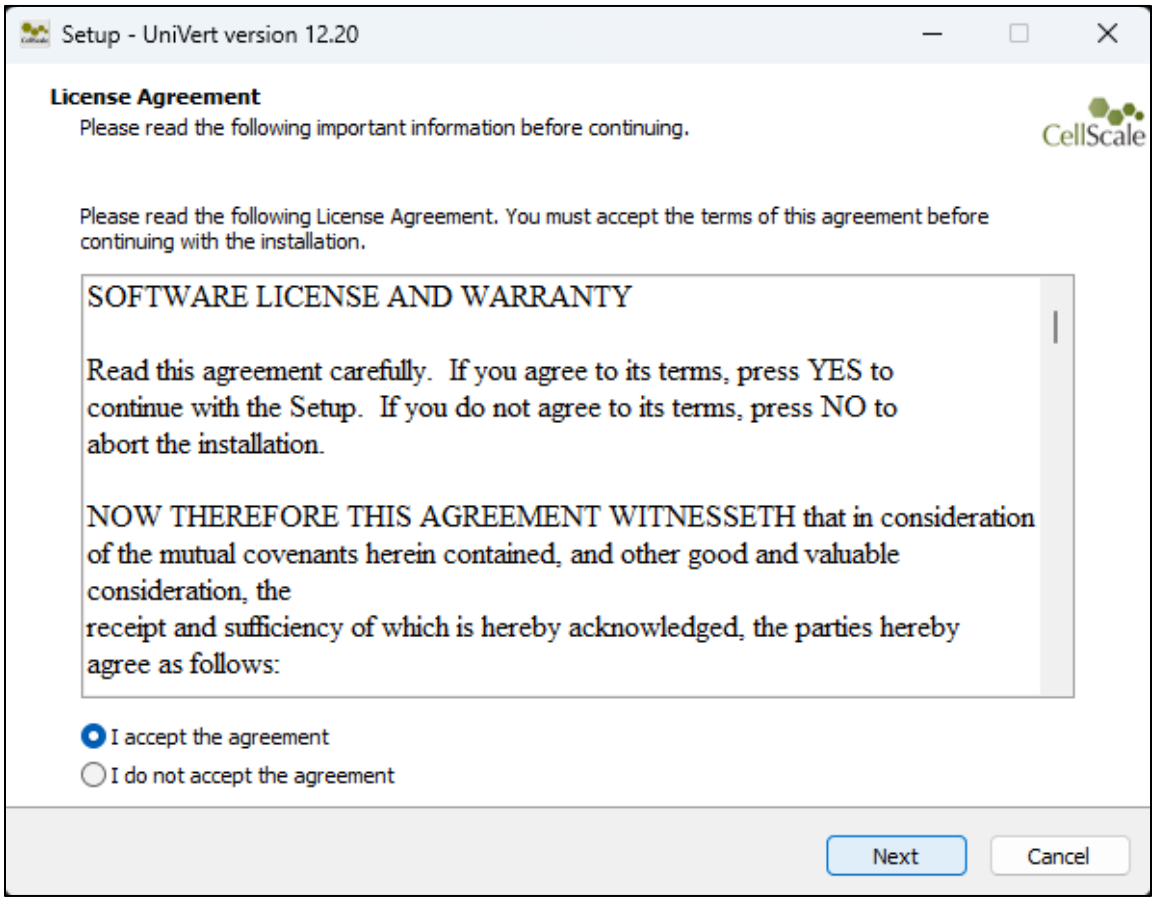
4. The measuring end of the load cell should be exposed, and the non-measuring end attached to the thumbnut/coupling and then to the UniVert. The test fixtures are ready to be mounted to the load cell.

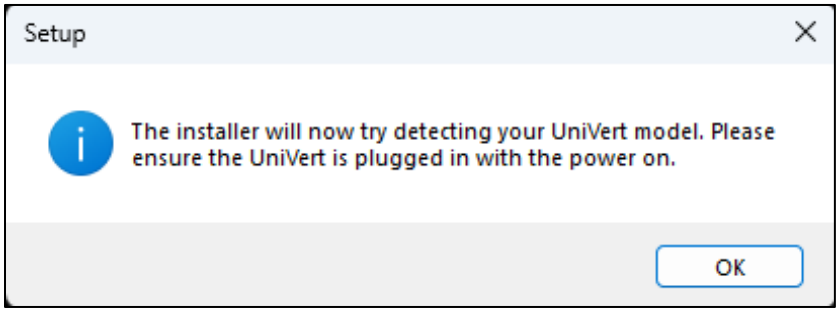
Appendix C: Software Installation

A Windows based PC (Windows 10 or above) with at least 1 USB ports is required to operate the UniVert (2 USB ports are required for the imaging feature). Go to www.cellscale.com/downloads to download the latest UniVert software package. The package contains the software installer for the user interface and control software for the UniVert.

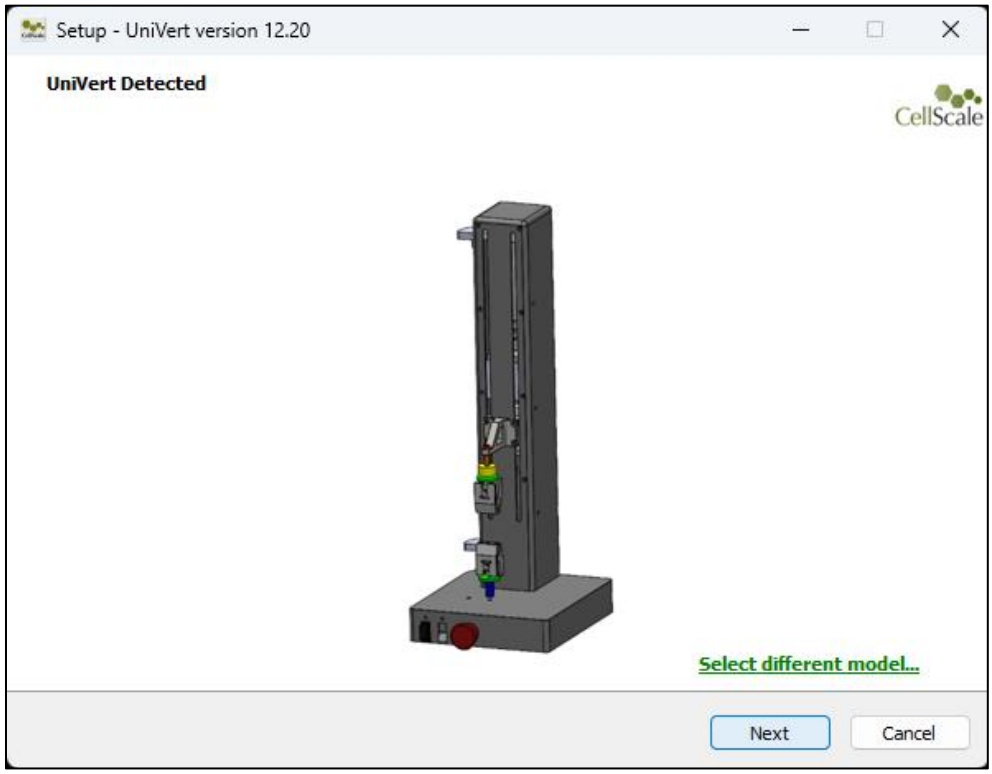
To install the software:

1. Go to the provided web address and download the compressed installation package.
2. Transfer this file to the computer which will be running the UniVert device.
3. After this is complete, go to the uncompressed installation folder and select *UniVert Installer.exe*. Details of typical dialogue boxes are shown below.

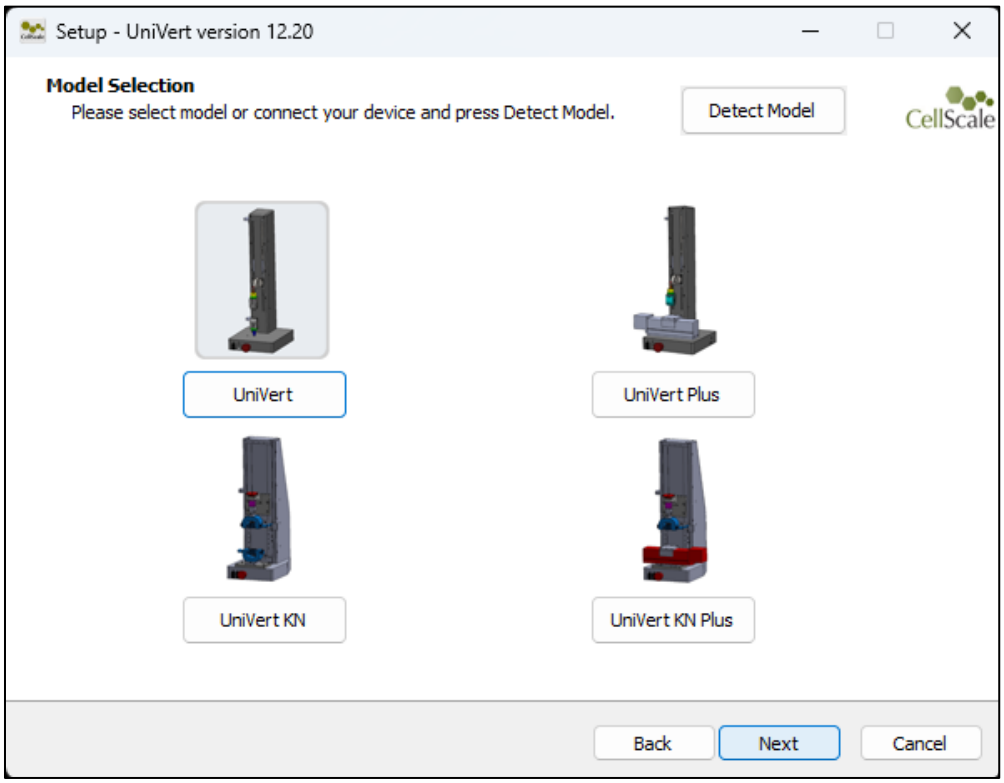


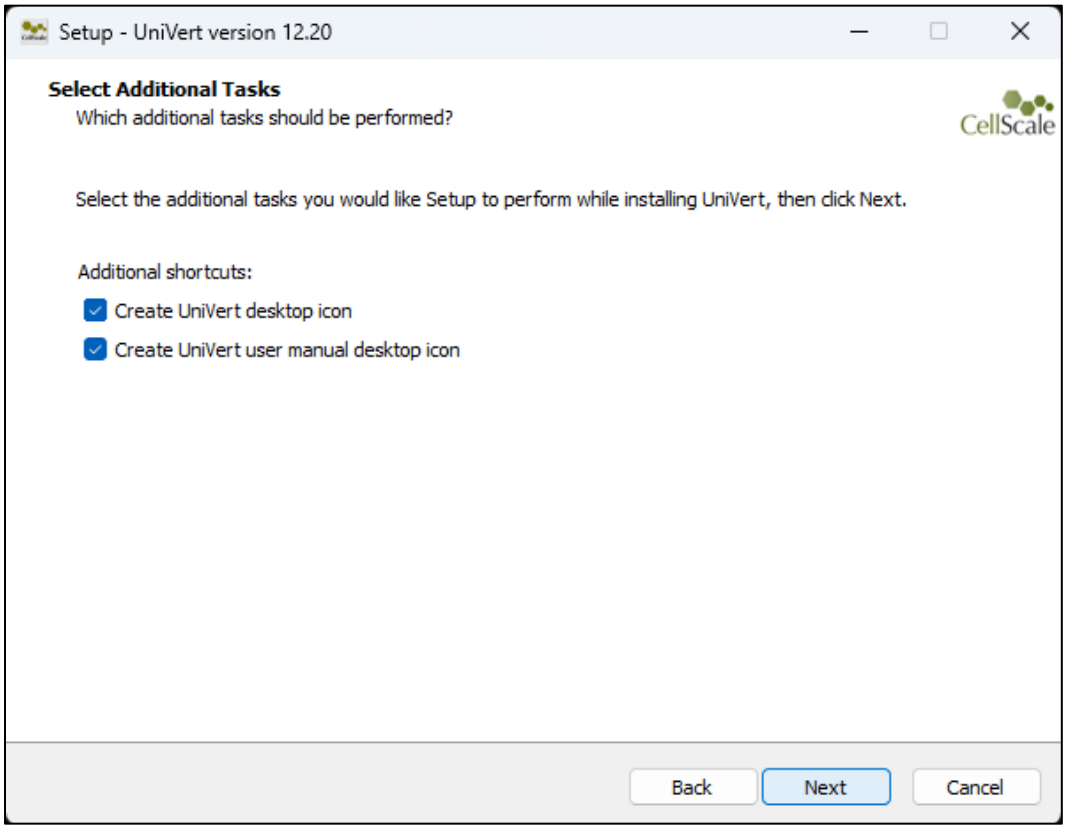


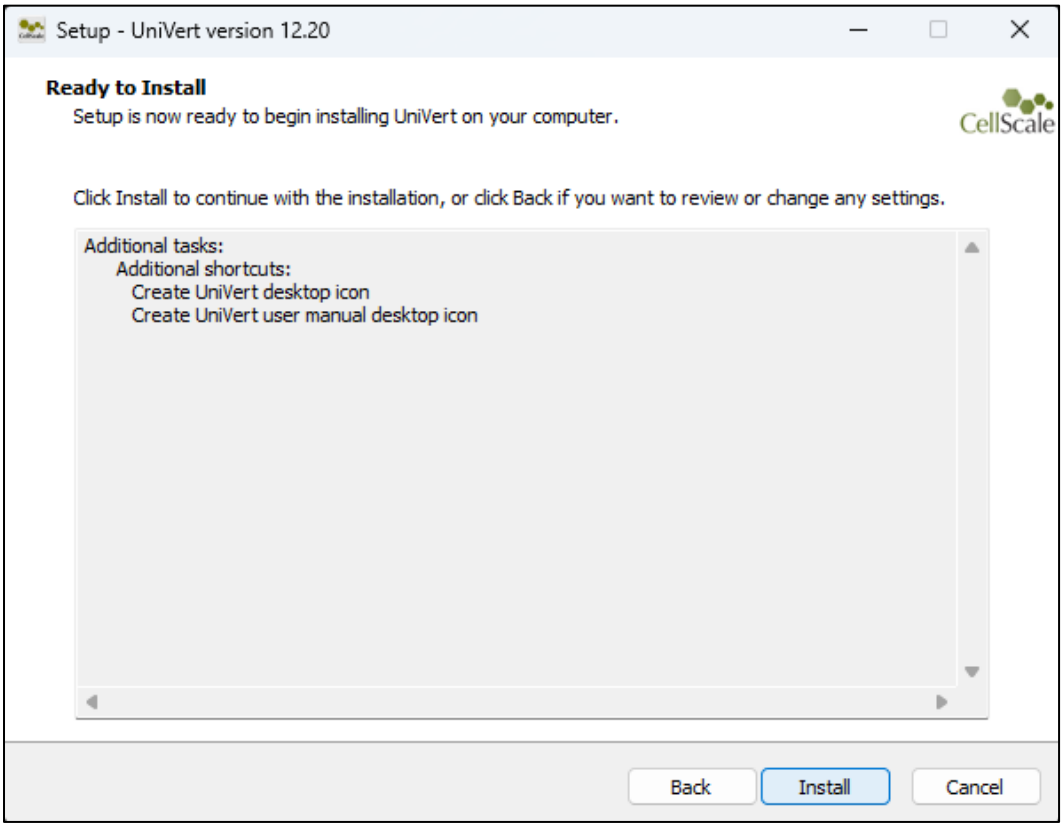
If your UniVert is detected this screen will popup:

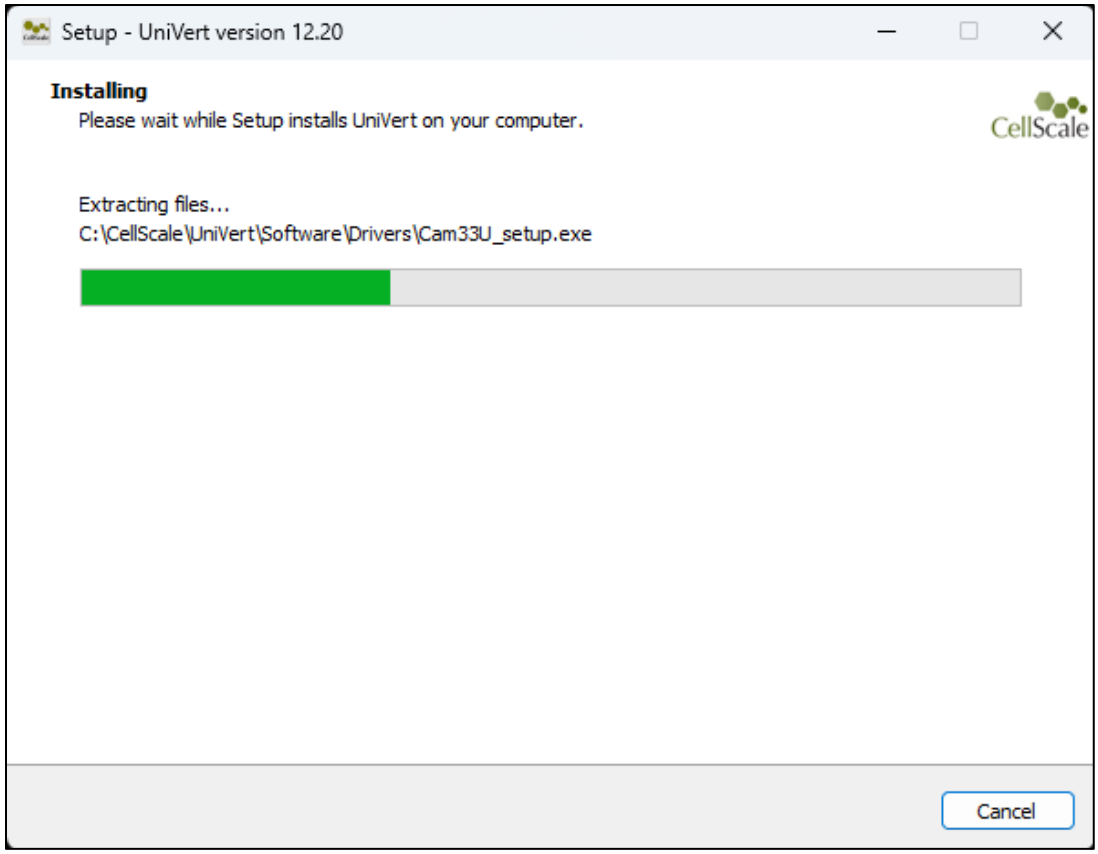


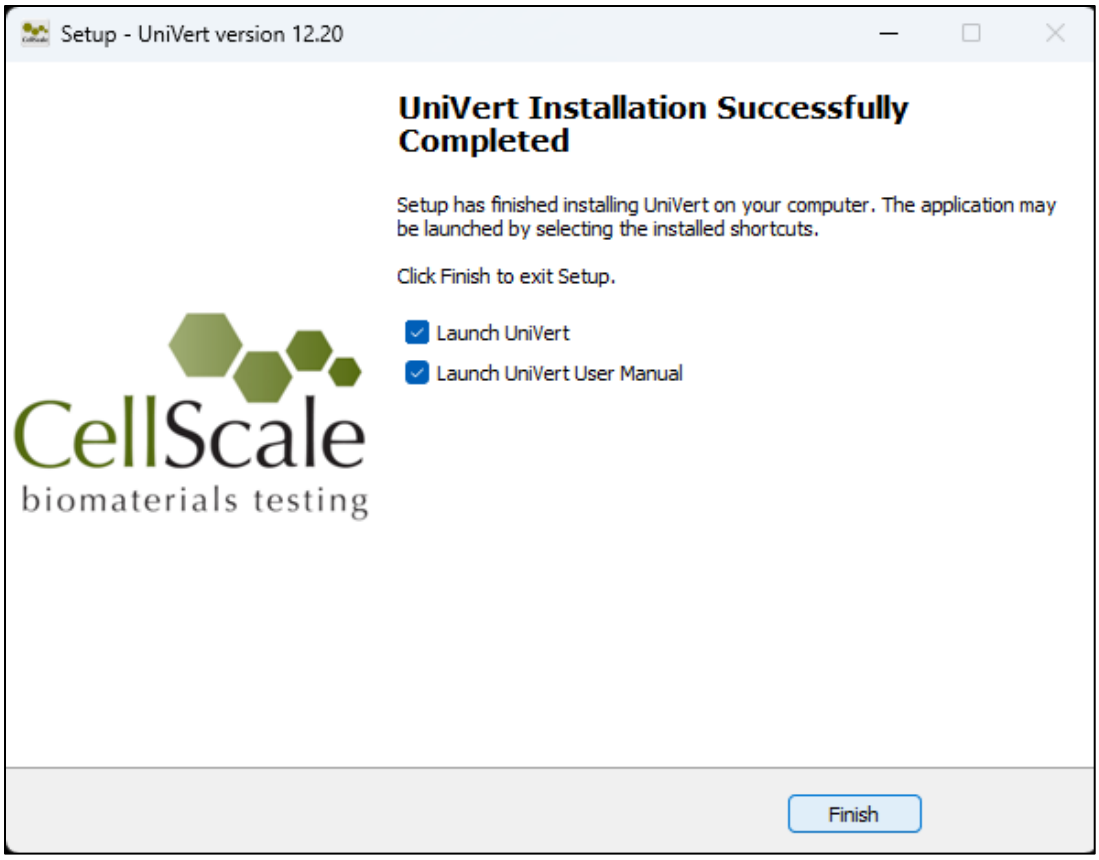
If UniVert is not detected, then you will be taken to a model selection screen where you can select your UniVert model. To install the correct user manual and templates please select the appropriate model.




Setup - UniVert version 12.20
Select Additional Tasks
Which additional tasks should be performed?
CellScale
Select the additional tasks you would like Setup to perform while installing UniVert, then click Next.
Additional shortcuts:
Create UniVert desktop icon
Create UniVert user manual desktop icon
Back
Next
Cancel

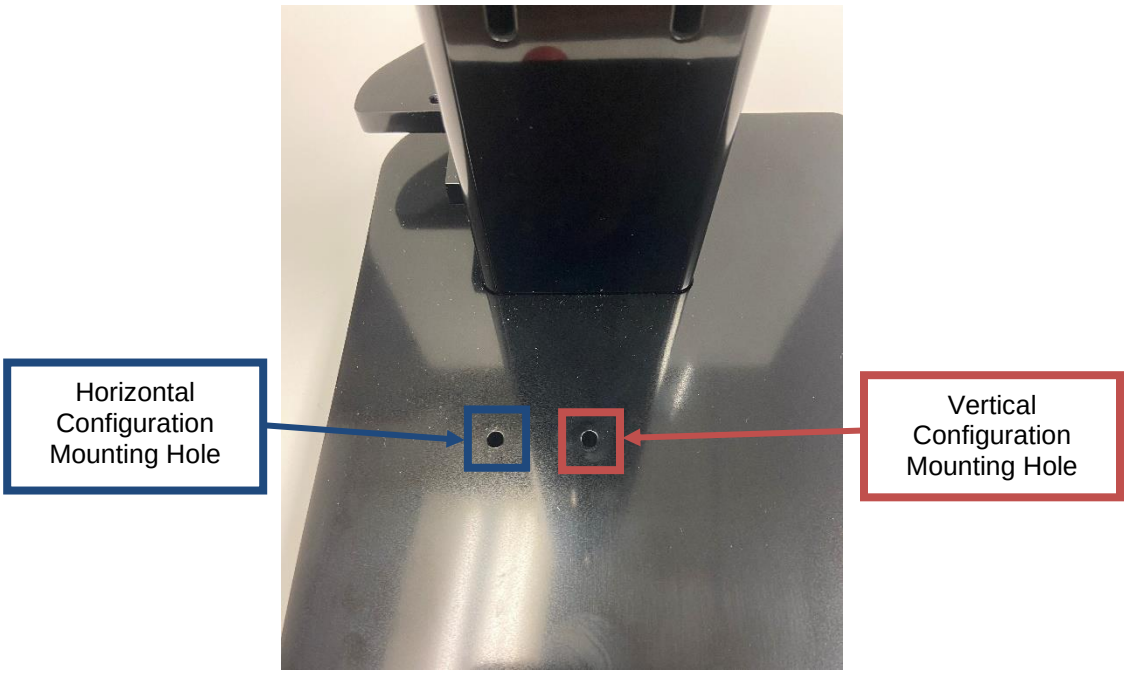

Setup - UniVert version 12.20
Ready to Install
Setup is now ready to begin installing UniVert on your computer.
CellScale
Click Install to continue with the installation, or click Back if you want to review or change any settings.
Additional tasks:
Additional shortcuts:
Create UniVert desktop icon
Create UniVert user manual desktop icon
Back
Install
Cancel


Setup - UniVert version 12.20
Installing
Please wait while Setup installs UniVert on your computer.
CellScale
Extracting files...
C:\CellScale\UniVert\Software\Drivers\Cam33U_setup.exe
Cancel


Setup - UniVert version 12.20
UniVert Installation Successfully Completed
Setup has finished installing UniVert on your computer. The application may be launched by selecting the installed shortcuts.
Click Finish to exit Setup.
Launch UniVert
Launch UniVert User Manual
CellScale
biomaterials testing
Finish

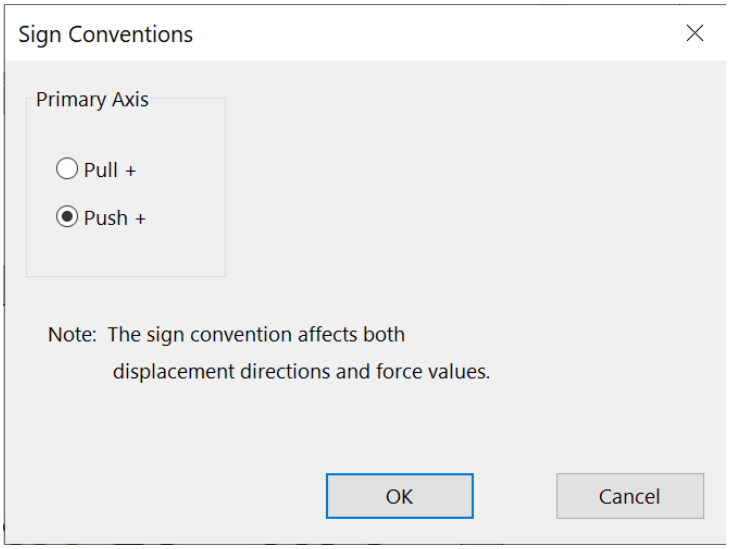
Appendix D: Test Setup

When using the UniVert in the vertical configuration, use the rightmost mounting hole on the baseplate for test fixtures. For the horizontal configuration, use the leftmost mounting hole on the baseplate for test fixtures.



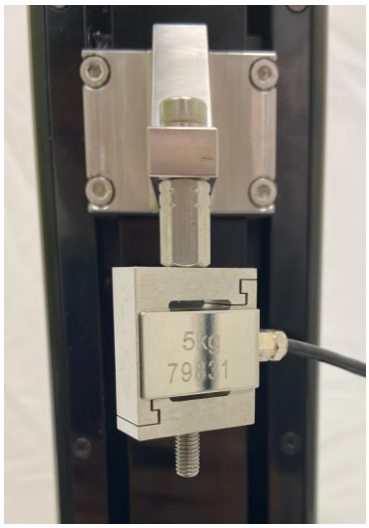
Tension Test Setup

Set the test mode to Tension (*Settings>Sign Convention>Pull* +) in the software. This setting is specific to the test template being used and can be saved to a template.

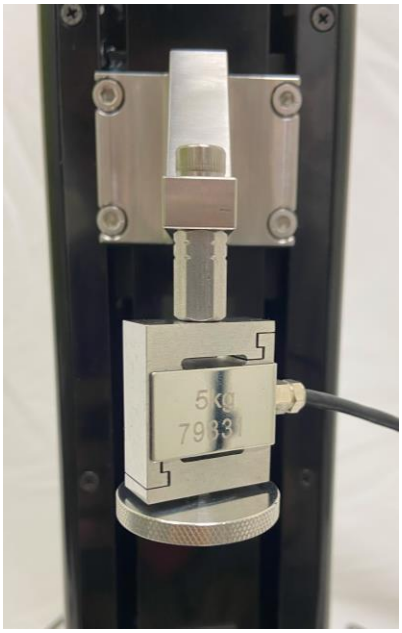


Vertical Configuration

1. Install the desired load cell (see **Appendix B**) to Motor Bracket B.



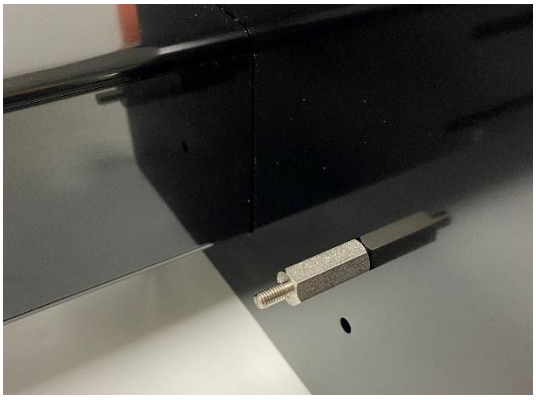
2. Screw a locking disc onto the measuring end of the load cell. Select either an M5 or M3 locking disc based on the load cell.



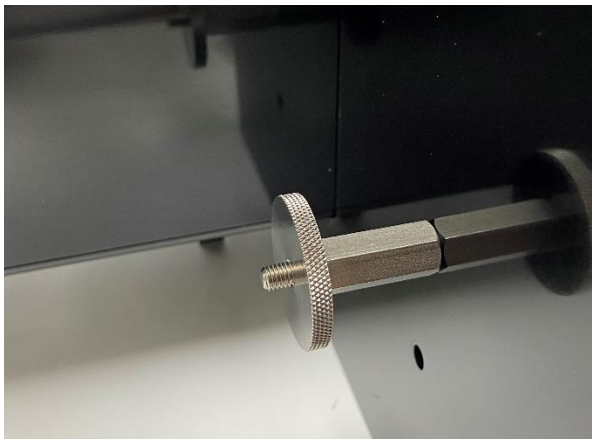
3. Screw the appropriate grip onto the measuring end of the load cell after the locking disc. Tightening the locking disc against the grip allows the grip to be secured to the actuator at any rotational position.

Finger tighten all components (ie. avoid using a wrench). Beware of exerting excessive off-axis and torquing forces to avoid damage to the load cell.

4. Attach the M5 stand off to the base with an M5x16 SHCS screw using a 4mm hex key. Use the mounting hole furthest from the power switch. This may be easier to do with the UniVert in the horizontal configuration.



5. Attached the M5 locking disc and grip to the stand off.

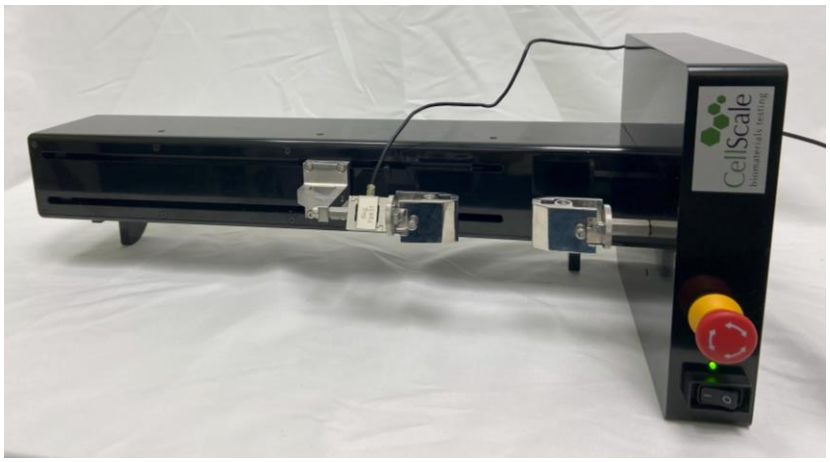


6. Attach the remaining grp to the M5 Stand Off and align the two grips until they are parallel. Loosen the locking discs to adjust the grips. Once they are aligned, hold the grips in place while tightening the locking discs.

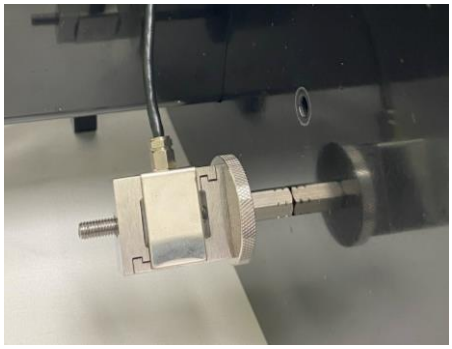
7. A position calibration is required after changing grips or platens. See the **System Calibration and Advanced Tools** section of this manual for more details.

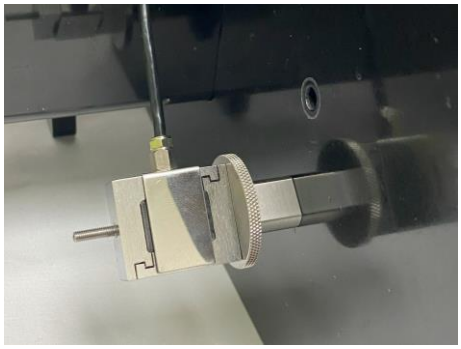
Horizontal Configuration

Note the steps below outline the horizontal configuration that is required for the Horizontal Media Bath. If you do not have or want to use the Horizontal Media Bath for your test, you may use the vertical configuration set up with the UniVert tilted 90° on its side to use the device horizontally if this is more convenient for your test set up.

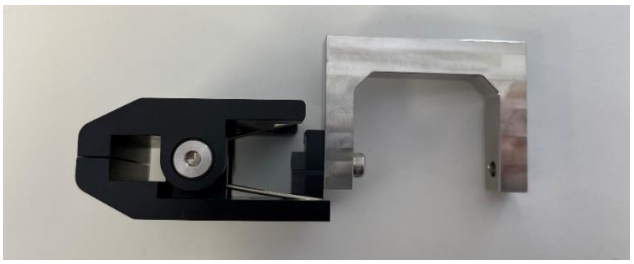


1. Install the load cell (see **Appendix B**) to the fixed end of the UniVert with an M5x16 SHCS using a 4mm hex key. Use the mounting hole closest to the power switch. Note that for the horizontal configuration, an additional locking disc should be added between the load cell and thumbnut.

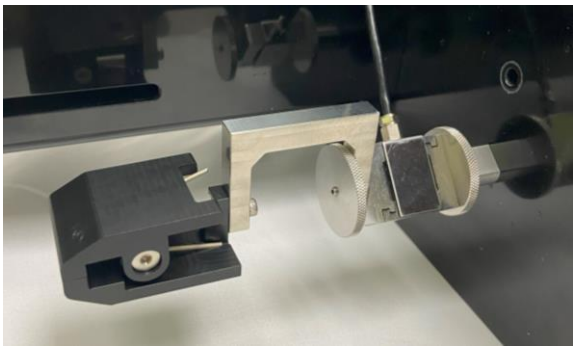


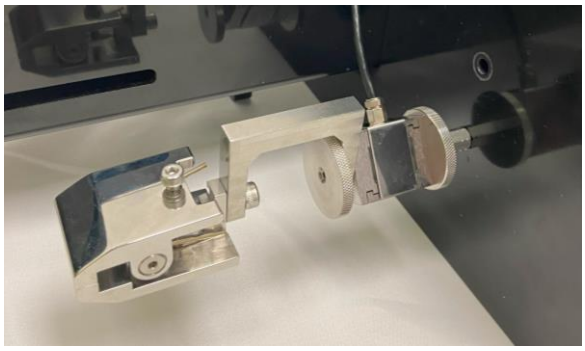


2. Install the grip to the Tension Load Cell Bracket
    - For an M5 threaded load cell, use the stainless steel M5 grip, M5 Tension Load Cell bracket, M5x12 SHCS, 4mm hex key and M5 Locking Disc.
    - For an M3 threaded load cell, use the plastic M3 grip, M3 Tension Load Cell Bracket, M3x12 SHCS, 2.5mm hex key, and M3 Locking Disc.



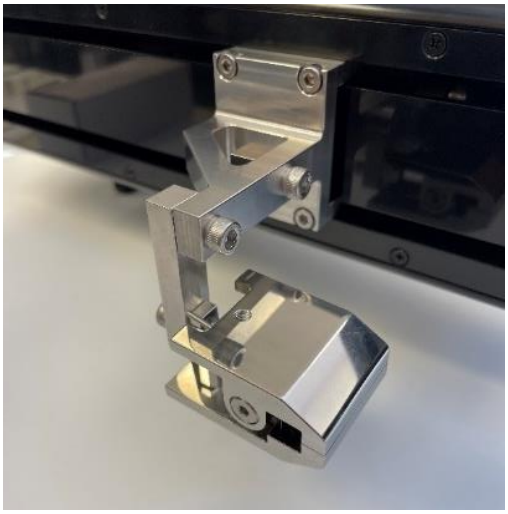
3. Install the Tension Load Cell Bracket to the load cell and affix it with the corresponding locking disc. The size of both these fixtures (M5 or M3) will depend on the load cell selected.



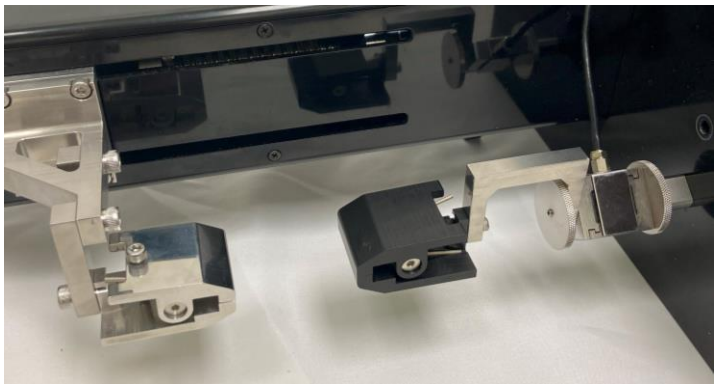


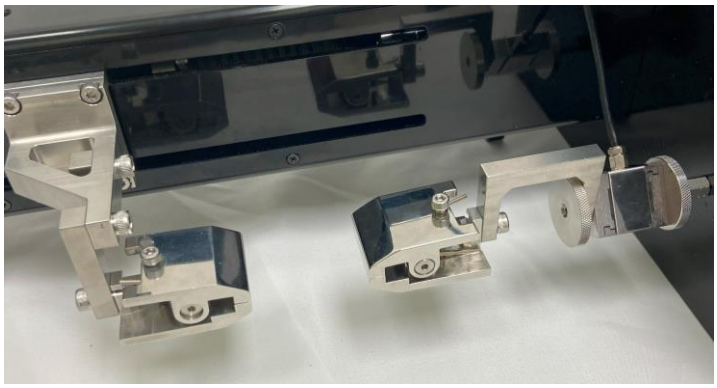
4. Attach the moving grip to the Horizontal Bracket (No Load Cell) with an M5x12 SHCS using a 4mm hex key.

5. Attach the assembly from the previous step to the Motor Bracket B with 2 x M5x12 SHCS using a 4mm hex key.



6. Align the grips until they are parallel by loosening the M5 screws and rotating the grip/assembly. When aligning the load cell/grip assembly, **only handle the assembly by the body of the load cell**. This is to prevent overloading or damaging the load cell.



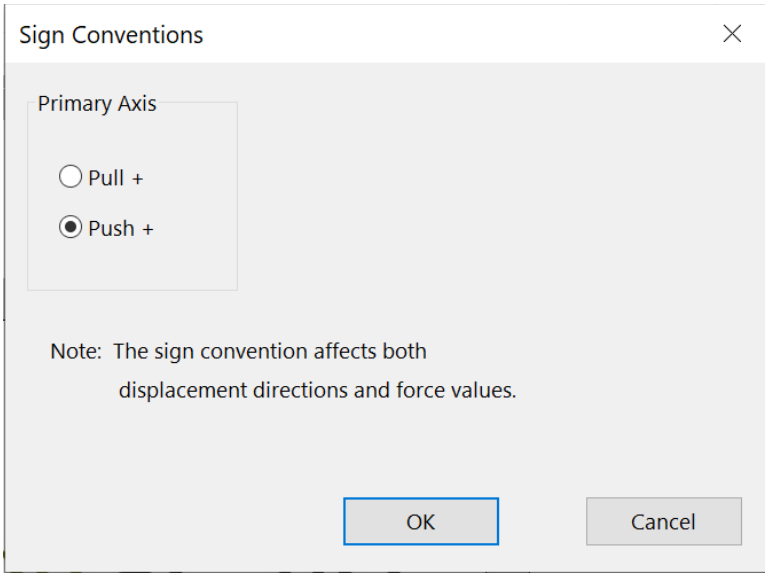


7. A position calibration is required after changing grips or platens. See the **System Calibration and Advanced Tools** section of this manual for more details.

8. To prevent overloading and off-axis loading on the load cells, mount samples by pinch both the sides of the grip. Tilt the UniVert device away from you for more working room.

Compression Test Setup

Set the test mode to compression (*Settings>Sign Convention>Push +*). This setting is specific to the test template being used and can be saved to a template.



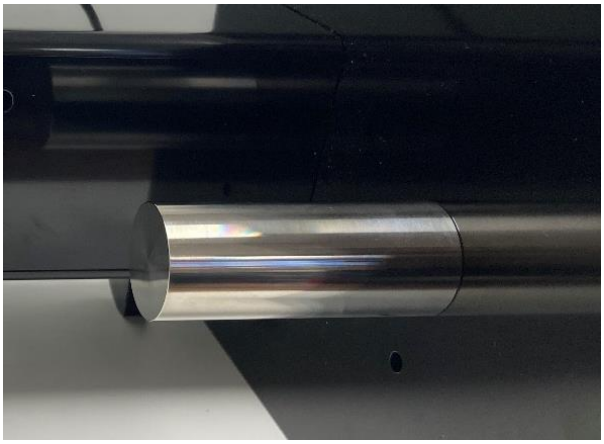
Vertical Configuration

1. Install the desired load cell (see **Appendix B**) to the Motor Bracket B of the UniVert.

2. Attach the compression platen directly to the measuring end of the load cell. Choose an M5 or M3 platen depending on the load cell.

Finger tighten all components. Beware of exerting excessive off-axis and torquing forces to avoid damage to the load cell.

3. Attach the M5 Compression Base Riser – Tall to the baseplate with an M5x16 SHCS using a 4mm hex key. Use the mounting hole furthest away from the power switch. This will be easier to do when the UniVert is lying in the Horizontal configuration.



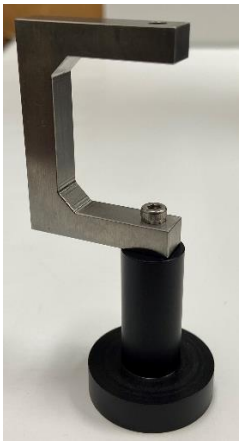
4. A position calibration is required after changing grips or platens. See the **System Calibration and Advanced Tools** section of this manual for more details.

Horizontal Configuration

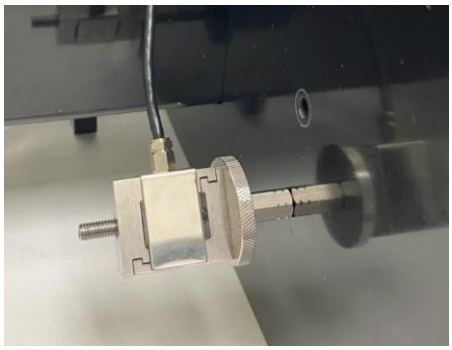
Note the steps below outline the horizontal configuration that is required for the Horizontal Media Bath. If you do not have or want to use the Horizontal Media Bath for your test, you may use the vertical configuration set up with the UniVert tilted 90° on its side to use the device horizontally if this is more convenient for your test set up.

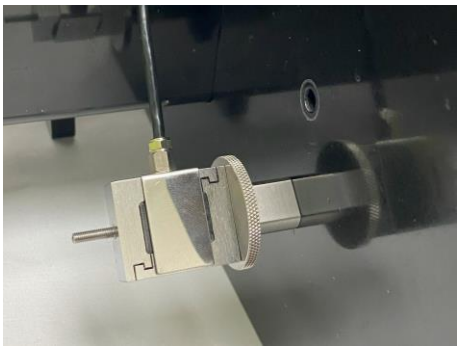
In addition, the test sample will need to be supported by a supplementary riser (not included with the UniVert) to use the compression test setup in the horizontal configuration.

1. Install the compression platen to the Tension Load Cell Bracket
    a. For an M5 threaded load cell, use the stainless steel M5 platen, M5 Tension Load Cell bracket, M5x12 SHCS, 4mm hex key and M5 Locking Disc.
    b. For an M3 threaded load cell, use the plastic M3 platen, M3 Tension Load Cell Bracket, M3x12 SHCS, 2.5mm hex key, and M3 Locking Disc.

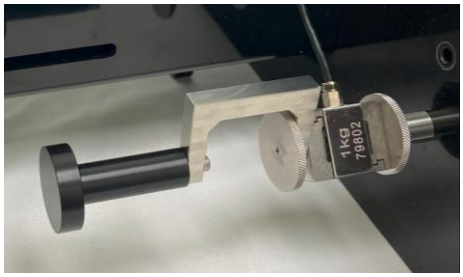


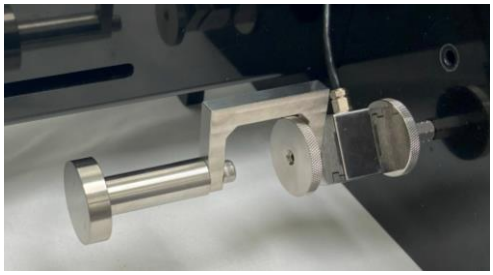
2. Install the load cell assembly (see **Appendix B**) to the fixed end of the UniVert with an M5x16 SHCS and 4mm hex key. Use the mounting hole closest to the power switch. Note that for the horizontal configuration, an additional locking disc should be added between load cell and thumbnut.





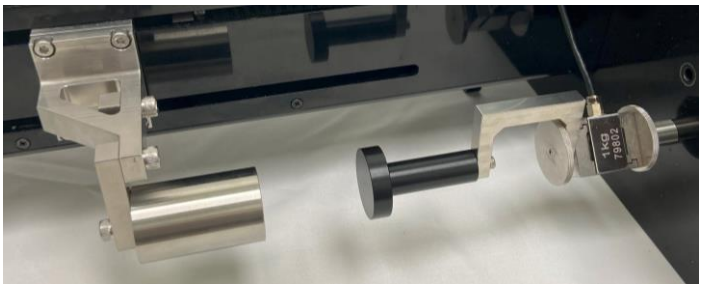
3. Install the Tension Load Cell Bracket to the load cell and affix it with the corresponding locking disc. The size of both these fixtures (M5 or M3) will depend on the load cell selected.

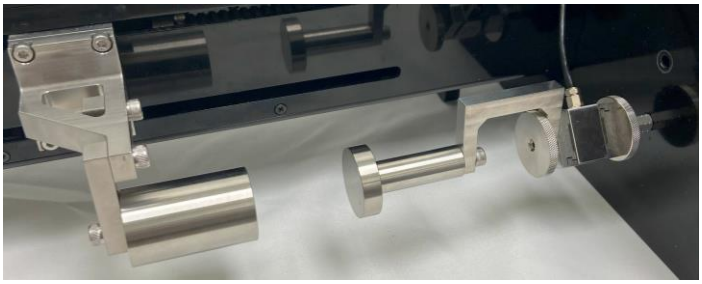




4. Attach the M5 Compression Base Riser – Short to the Horizontal Bracket (No Load Cell) with an M5x12 SHCS

5. Attach the assembly from the previous step to the Motor Bracket B with 2 x M5x12 SHCS



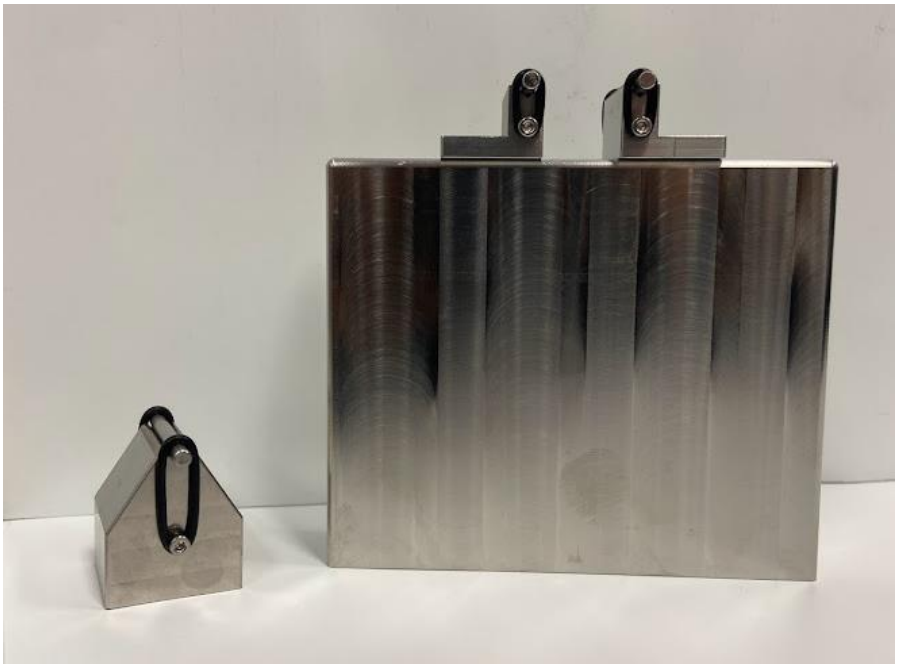


6. A position calibration is required after changing grips or platens. See the **System Calibration and Advanced Tools** section of this manual for more details.

3-Point Bend Test Setup

1. Set the test mode to compression (*Settings>Sign Convention>Push +)*
2. Install the desired load cell for vertical configuration (see **Appendix B**)
3. Attach a locking disc to the measuring end of the load cell.

4. Assemble the 3-Point Bending Block and sliders:
    - Attach M2x6 fasteners on the sides of the sliders and bending blocks
    - Place 4-40 - 5/16” fasteners through the hole and the square nuts. Place the square nuts through the groove of the bottom block.
    - Use the large O-Rings and small O-Rings as illustrated below to hold the 3-point bending dowels in place (Note: Choose a dowel size appropriate for the test being performed. Small and Large dowels are provided with the 3-Point Bend package).

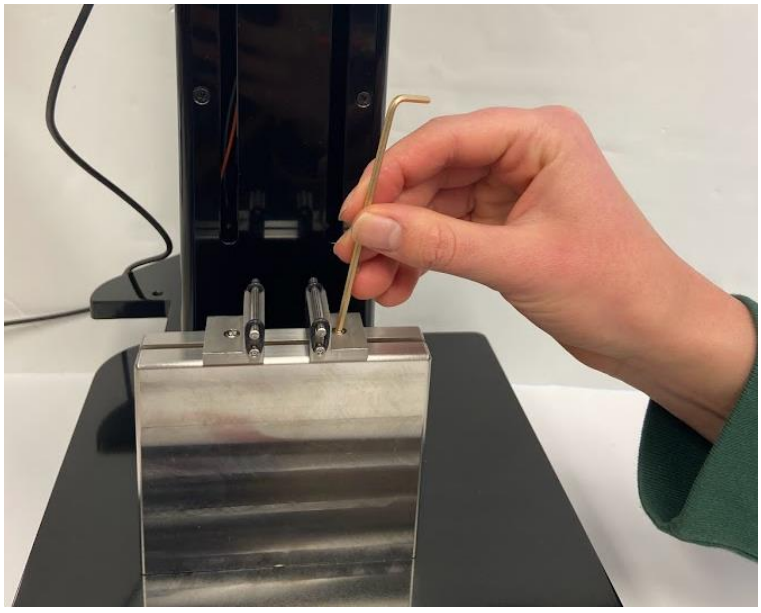


5. Screw the bending block onto the measuring end of the load cell and tighten it in the correct position using the locking disc.

Finger tighten all components. Beware of exerting excessive off-axis and torquing forces to avoid damage to the load cell.

6. Attach and align the 3-Point bend rail onto the baseplate with 2x M5x25 SHCS. This may be easier to do with the UniVert in horizontal configuration and tilted back.

7. Secure both sliders on the rail in the desired position by tightening the fasteners with a 3/32” hex key.



8. A Custom Position Calibration is required after changing fixtures (see the **System Calibration and Advanced Tools** section) Use the calipers to measure between the bottom of the top block and the top surface of the bottom block. This will prevent negative displacement readings.

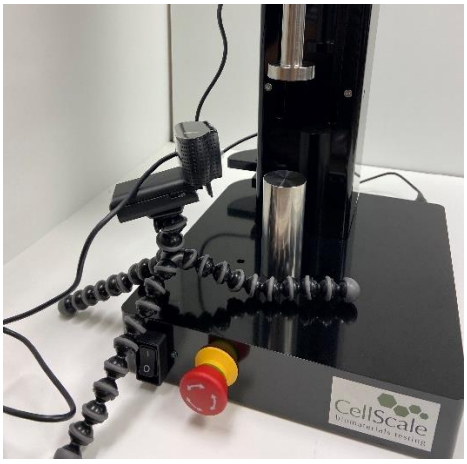
Appendix E: Camera Setup

Webcam

The webcam included with the UniVert system is used for recording images at up to 5Hz. The UniVert will function with or without the camera plugged in. To setup the camera, follow these steps:

1. Before starting the UniVert software, plug the webcam into a USB port.
2. Thread the tripod into the mounting hole on the bottom of the camera.

3. Set the camera in the desired recording position using the flexible tripod.



4. Refer to the **System Hardware Settings** section for additional camera settings.

Scientific Camera

The scientific camera, an optional add-on to the UniVert system, is used for recording images at up to 15Hz and is compatible with the image tracking feature in the UniVert software. First, set up the camera positioning system. The components and tools required are:

- Rail
- 2 x M6x6 SHCS
- Rail Carrier
- Mounting Post
- Post Holder
- Post Collar
- 5mm hex key

1. Place the UniVert in the horizontal configuration.

2. Install the camera rail with 2 x M6x6 SHCS using a 5mm hex key, in the desired location along UniVert tower.

3. Thread the Post Holder to the Rail Carrier.

4. Slide the Rail Carrier onto the Rail and tighten the thumbnut at the back securely.

5. Insert the Mounting Post in the Post holder. Ensure the M6 threaded hole is facing outward.

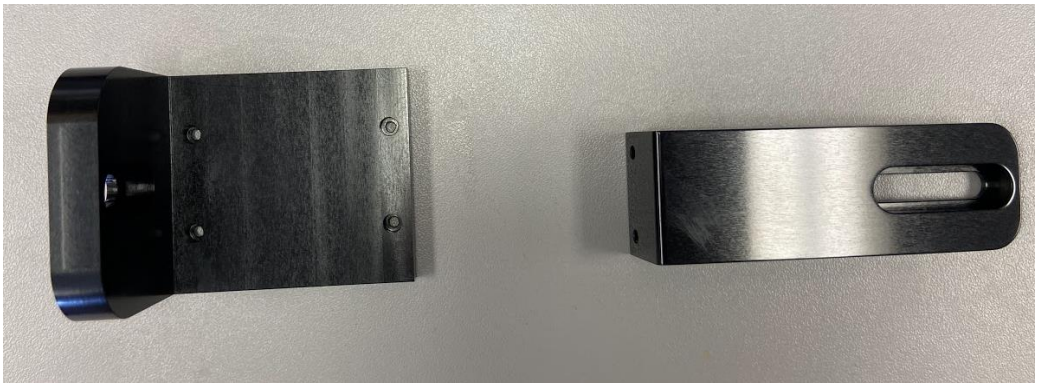
6. Attach the Post Collar to the Mounting Post. This is to ensure the post remains at the same height when adjusting the rotation with the Post Holder thumbnut.

Next attach the camera assembly to the positioning system. The components and tools required are:

- Camera
- Camera Bracket
- Lens
- USB 3.0 cable
- M3x6 SHCS
- 2.5mm hex key
- M6x6 SHCS
- 5mm hex key
- Lighting gooseneck and power supply
- Only for Camera Bracket shown below:
    - Mounting Plate
    - 4 x M2x6 SHCS
    - 1.5mm hex key

1. Remove the lens caps from both the camera and lens, and gently thread the lens onto the camera.

2. Attach the camera to the Camera Bracket:
    a. If the camera bracket provided matches the left one shown below, continue to step 3.
    b. If the camera bracket provided matches the right one shown below, skip to step 5.

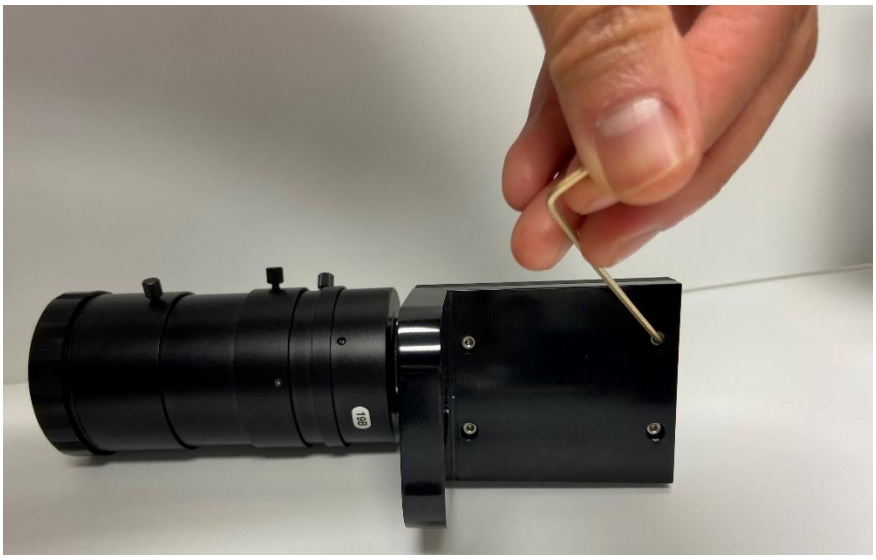


3. Attach the Camera to the Mounting plate first with 2x M3x6:

    a. For use in the Vertical configuration, attach the camera as follows:

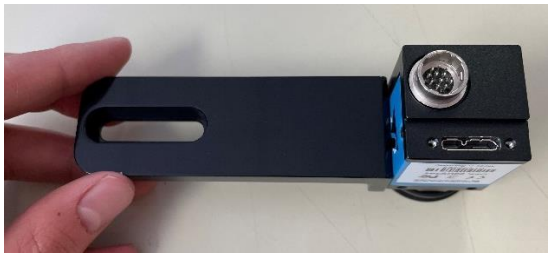
    b. For use in the Horizontal configuration, attach the camera as follows:

4. Attach the Camera Bracket onto the camera assembly with 4 x M2x6 SHCS using a 1.5mm hex key. Continue to Step 6 to mount this assembly to the Camera Mounting Post.



5. Attach your bracket directly to the camera with 2x M3x6 SHCS:

    a. For use in the Vertical configuration, attach the camera as follows:



    b. For use in the Horizontal configuration, attach the camera as follows:

6. Attach the Camera Bracket to the Mounting Post with M6x6 SHCS using a 5mm hex key. Both style of brackets mount to the Mounting Post in the same manner.

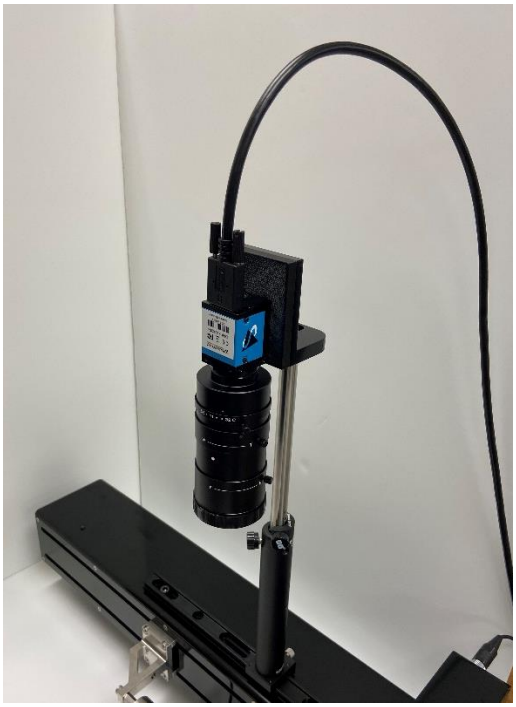
7. Prepare the components for the lighting gooseneck:
    a. 2x goosenecks
    b. 1x base
    c. 1x 5V power supply

8. To set up the lighting gooseneck:
    a. Attach the lights to the base. Ensure the keyway matches and they are well seated. Fasten them in place by tightening the locking nuts.

    b. Plug in the provided 5V power supply to the base

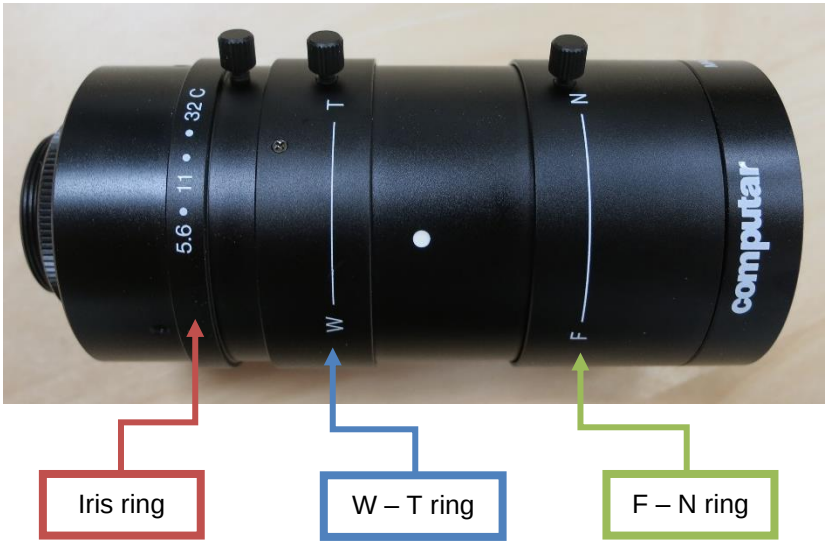
    c. Turn the lights on and adjust the brightness with the slider on the base
    d. Position the goosenecks towards the specimen when ready for testing

9. Attach the USB cable to the Camera, securing the USB locking screws, and plug the other end into a **USB 3.0** (or higher) port on the PC. These are the typically labeled SS and/or have a blue plastic tab on the connector.



Lens Adjustments:

1. The image brightness can be adjusted using the Iris Ring on the lens. It is recommended to leave the Iris Ring fully open and control image brightness with the Hardware Settings in the software (see the **Reviewing Test Results** section).
2. Obtain desired magnification level by manually adjusting the W – T ring on the lens.
3. Bring the image to optimum focus by manually adjusting the F – N ring on the lens.
4. Use the set screws on each of the lens rings to lock them at the desired settings.



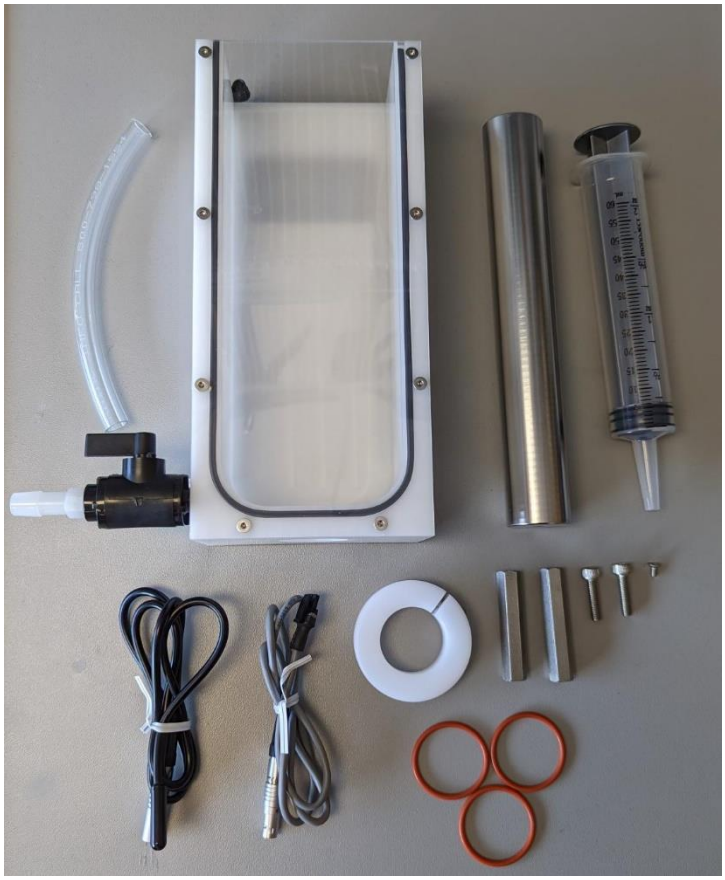
Appendix F: Media Bath Setup

The media bath allows specimens to remain submerged in a temperature-controlled fluid.

Vertical Media Bath

The components and tools required to set up the vertical media bath are:

- Media chamber with attached heating plate
- Fluid chamber valve and spout
- PVC tubing (for draining chamber)
- Syringe
- 200mm mounting standoff
- Standoff collar
- Heater cable
- Temperature probe (mounting clip is attached to media chamber)
- M5x20 SHCS (1 + extra)
- Media chamber O-rings (extra)
- M3x6 FHCS (extra)
- M5x20 Set screw (1 + extra)
- Long M5 coupling nut
- Long M5-M3 coupling nut



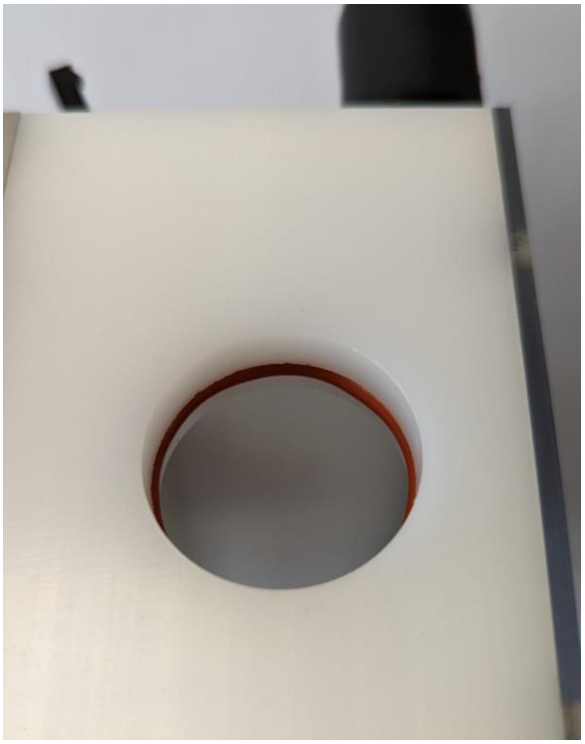
Load Cell Warning:

Load cells cannot be submerged. Take care not to accidentally damage your load cell when preparing a sample or conducting a test.

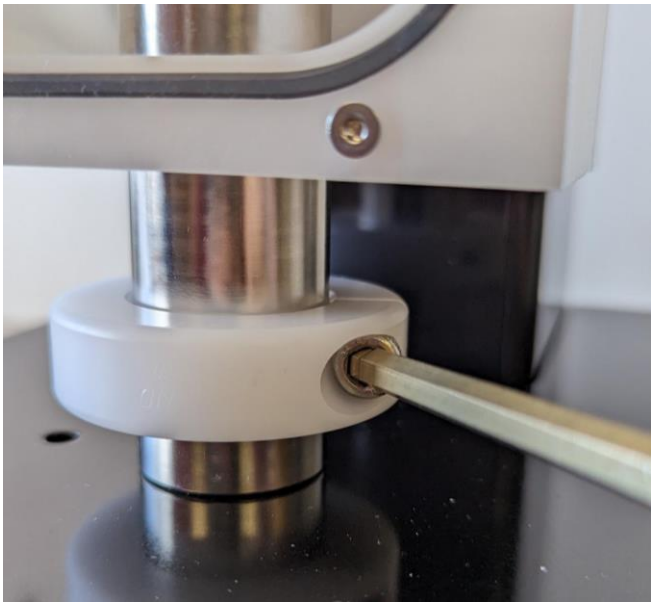
1. Fasten the compression platen to the main body using the provided M5x20 SHCS and a 4mm hex key.

2. Place the white collar over the compression platen, but do not tighten it yet.

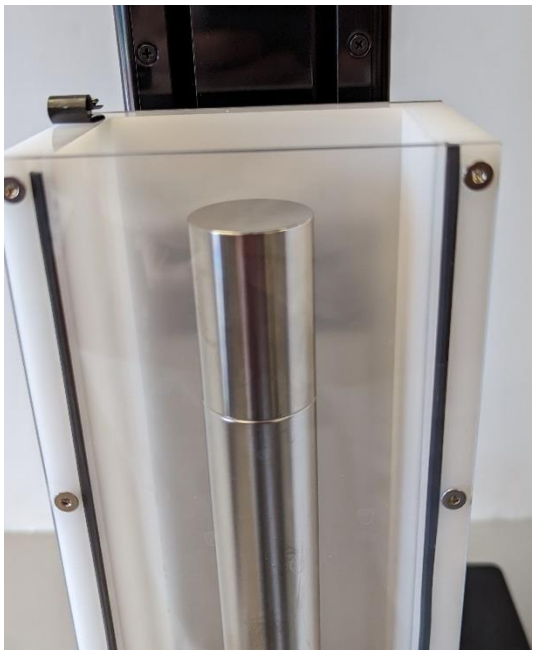
3. Ensure that the O-ring in the media chamber is snug and not broken (if it damaged, it can be removed and replaced with another of the provided O-rings).



4. Tighten the M6 SHCS in the white collar using a 5mm hex key to fasten the media chamber at the desired height.



5. For compression testing, attach the desired compression standoff to the protruding set screw in the 200mm standoff.



   a. Attach the desired load cell to the coupling nut provided. The coupling nut used will depend on the size of the threads (M5 or M3) on the given load cell, as well as the testing protocol (e.g., magnitude of displacement). The image below depicts a long coupling nut being used.

b. Attach the load cell assembly from the previous step to the Motor Bracket B on the UniVert with M5x12 SHCS and jog the moving end near its upper limit. This will allow for more room when installing the bath to the baseplate. Attach the appropriate compression platen (steel or plastic).

6. For tension tests, place an M5 locking disc and a stainless steel grip on the 200mm mounting standoff. Tighten the locking disc so that the grip faces the proper orientation. The media chamber may need to be adjusted to properly mount and secure the testing sample.

a. Attach the desired load cell to the coupling nut provided. The coupling nut used will depend on the size of the threads (M5 or M3) on the given load cell, as well as the testing protocol (e.g., magnitude of displacement). The image below depicts a long coupling nut being used.

b. Attach the load cell assembly from the previous step to the Motor Bracket B on the UniVert with M5x12 SHCS and jog the moving end near its upper limit. This will allow for more room when installing the bath to the baseplate. Attach the appropriate locking disc (M3 or M5) and the corresponding grip. Tighten the locking disc so that both grips are aligned.

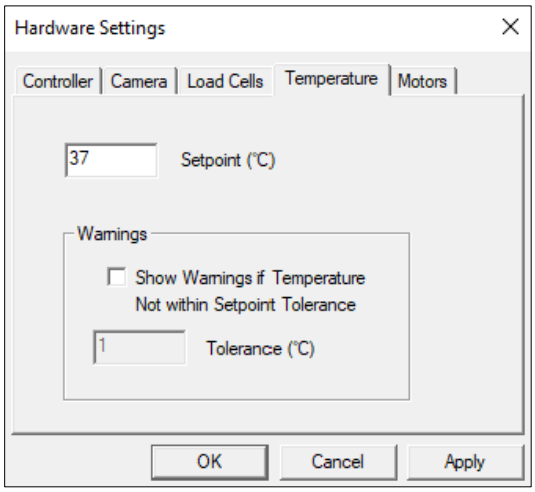
Properly sealing the media chamber:

Ensure that the handle on the plug is facing the back of the Univert system. This is the closed orientation. Attach the PVC tubing to allow for easier draining of the media chamber once testing is completed

7. Attach all connections for heater and temperature sensor

8. Remove the D-clip on the media bath using a 2.5mm hex key and slide the temperature probe into the clip. Fasten the clip once again into the wall of the media bath.

9. To activate the fluid chamber heater, turn on the main power switch of the UniVert followed by the heater switch (if present on your device – see below). At this point, the heater will warm the media to the last used temperature set point. The temperature set point can be changed by selecting Hardware from the Settings menu. If the plate does not feel warm after a few minutes, ensure the heater plate cable is plugged in.

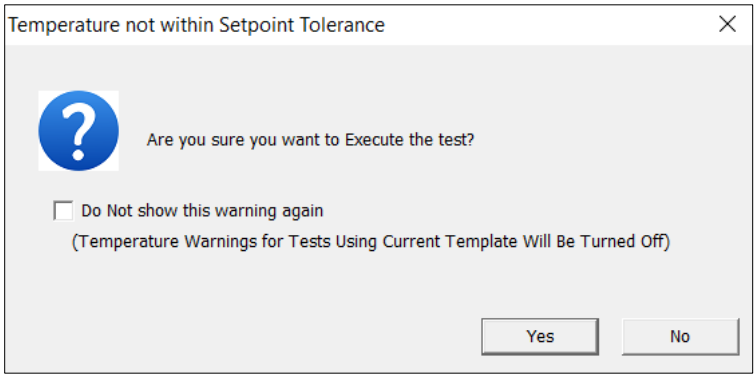


a. If your UniVert has 2 switches on the front panel, the second switch on the left (below the orange LED indicator light) is used to toggle the heater on/off if the cable is plugged in.

b. If your UniVert only has 1 switch on the front panel (i.e., the main power switch), the heater will automatically turn on with the main power if it is plugged in. If you do not want the heater plate to be on during your test, leave the heater plate unplugged from the main device.

10. Typically, the heater will take 30 to 60 minutes to warm a full fluid chamber from room temperature to 37°C and will take up to 90 minutes to stabilize at this temperature. Using pre-heated media will help reduce the time needed to reach temperature.

11. When Show Temperature Warnings is enabled and the Current Temperature is not at the Temperature Set Point (plus or minus the specified tolerance) - a red indicator button will be displayed next to the Current Temperature live output and a warning dialogue will appear when you execute the test.

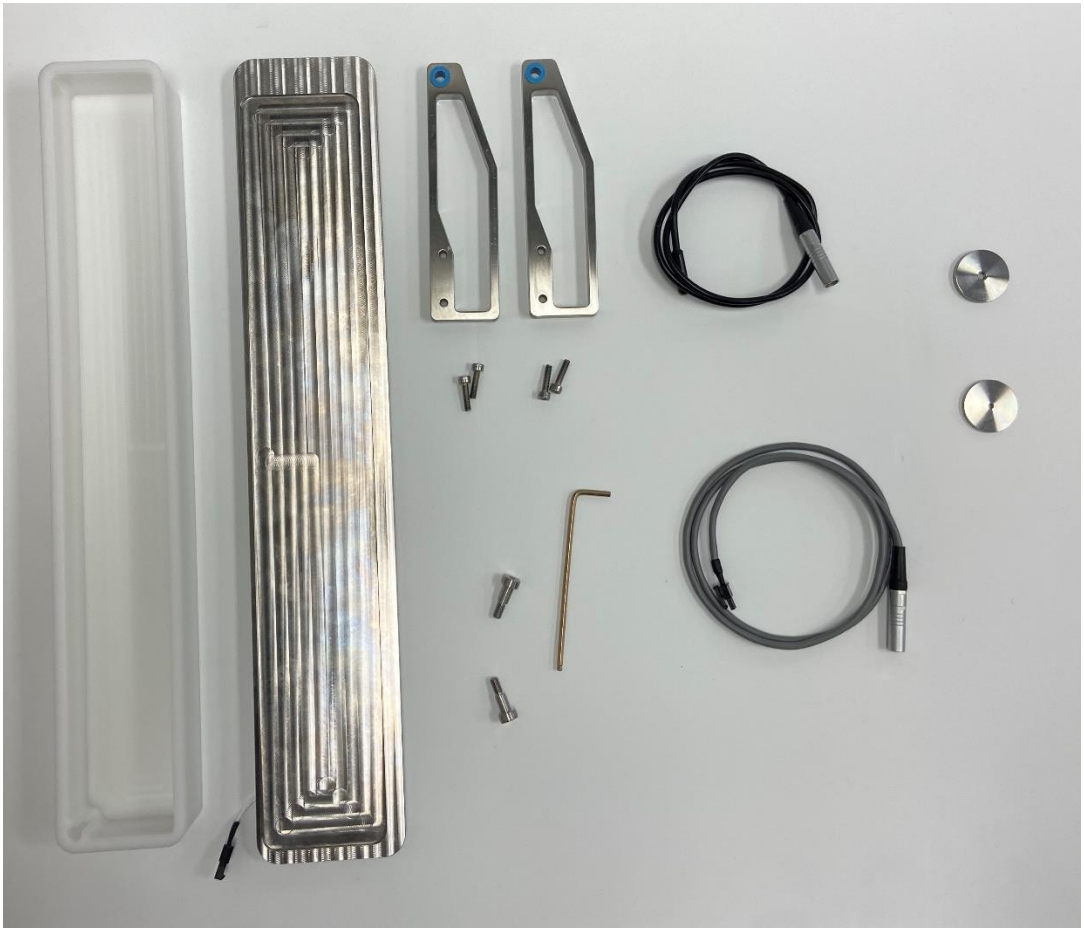


12. Once your test is complete, use the supplied syringe to remove the media from the chamber. Ensure the bath is **completely empty** before removing the back plate from the polycarbonate chamber.

Horizontal Media Bath

The components and tools required to set up the horizontal media bath are:

- Plastic Fluid Dish
- Heater Plate
- Heater Pivot Wings with sleeve bearings
- 4x M4x16 SHCS
- Shoulder screws
- 3mm hex key
- Temperature probe
- Heater cable
- Extra M5 or M3 Locking Discs

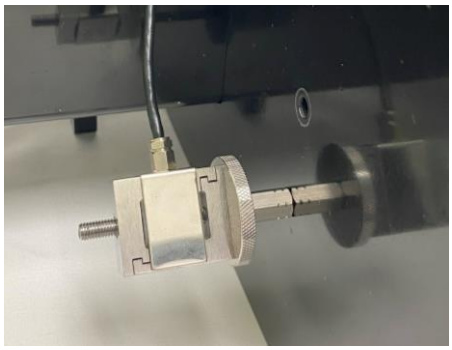


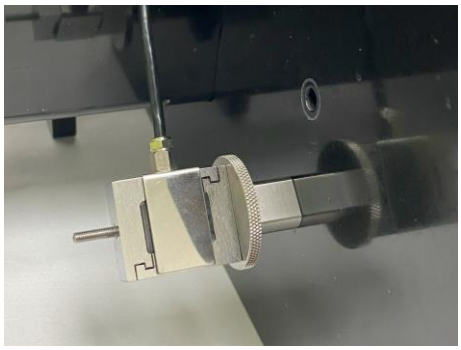
1. Attach the Heater Pivot Wings to the Heater plate with 4 x M4x16 SHCS using a 3mm hex key. Ensure the Heater Pivot Wings are facing in the opposite direction to the electrical connector (as illustrated below).

2. Mount the Heater Plate and Heater Pivot Wings assembly to the UniVert system with the supplied shoulder screws and 3mm hex key. This will be easier to do with the UniVert in the vertical configuration.

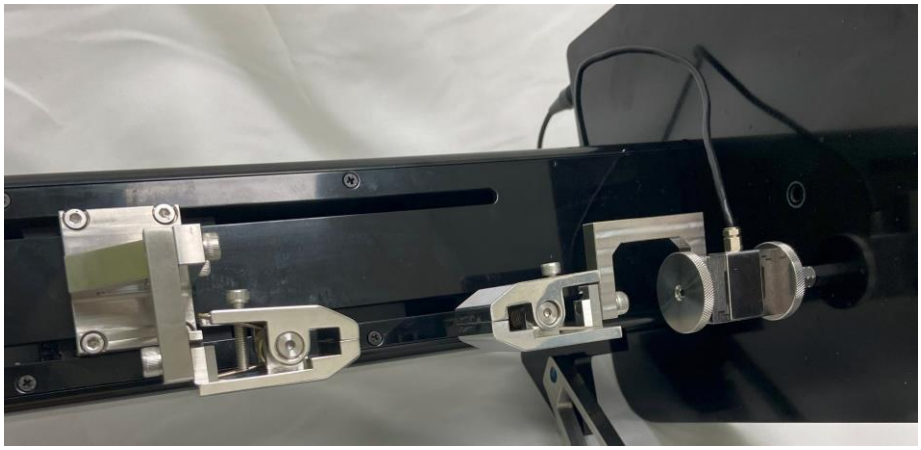
3. Place the UniVert back in its horizontal configuration. Be careful when doing so as the heater plate will swing freely.

4. Attach the additional locking disc between the desired load cell and corresponding coupling.

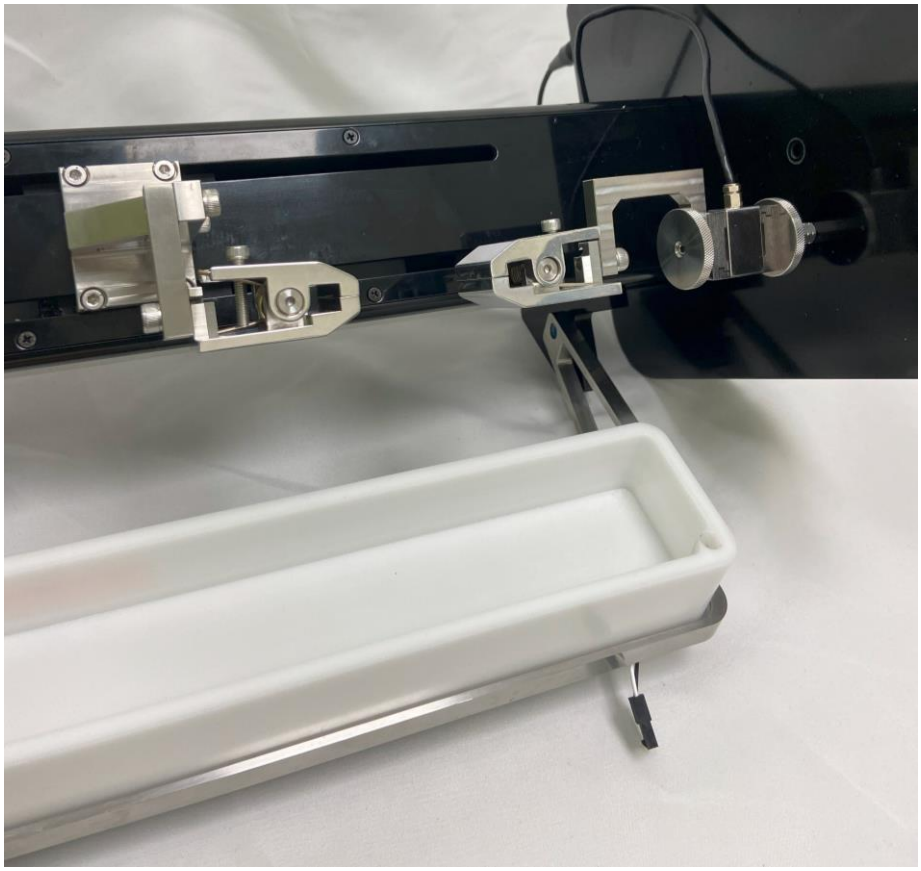




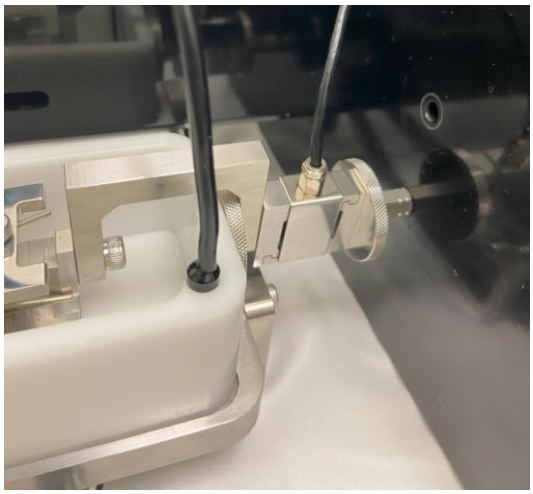
5. Attach the desired fixtures to the load cell in the Horizontal Configuration (see **Appendix D** for more details). Tilt the UniVert back as this will allow for more room when fastening the fixtures.



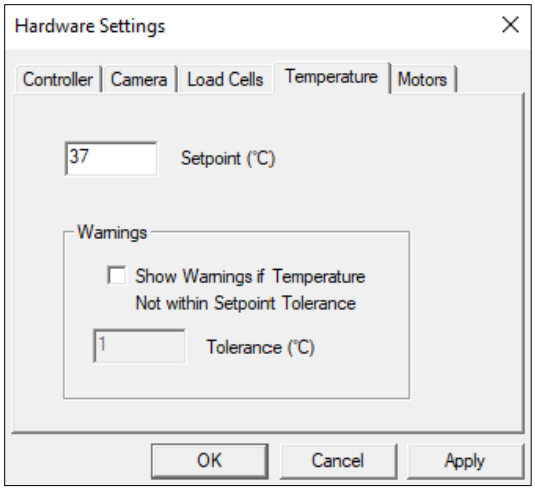
6. Place the fluid dish on the Heater Plate and attach all the connections for the heater and temperature probe.



7. Secure the temperature probe into the corner of the fluid dish



8. To activate the fluid chamber heater, turn on the main power switch of the UniVert followed by the heater switch (if present on your device – see below). At this point, the heater will warm the media to the last used temperature set point. The temperature set point can be changed by selecting Hardware from the Settings menu. If the plate does not feel warm after a few minutes, ensure the heater plate cable is plugged in.

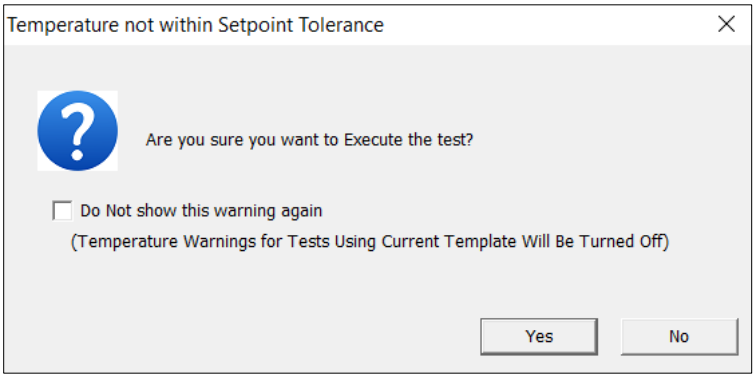


a. If your UniVert has 2 switches on the front panel, the second switch on the left (below the orange LED indicator light) is used to toggle the heater on/off if the cable is plugged in.

b. If your UniVert only has 1 switch on the front panel (i.e., the main power switch), the heater will automatically turn on with the main power if it is plugged in. If you do not want the heater plate to be on during your test, leave the heater plate unplugged from the main device.

9. Typically, the heater will take 30 to 60 minutes to warm a full fluid chamber from room temperature to 37°C and will take up to 90 minutes to stabilize at this temperature. Using pre-heated media will help to reduce this time needed to reach temperature.

10. When Show Temperature Warnings is enabled and the Current Temperature is not at the Temperature Set Point (plus or minus the specified tolerance), a red indicator button will be displayed next to the Current Temperature live output and a warning dialogue will appear when you execute the test.



Appendix G: Grip Modifications

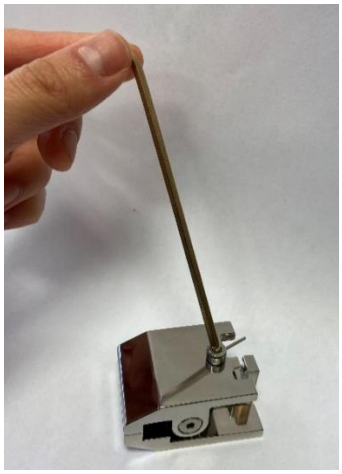
The grips used for tension testing come in three different gripping strengths to suit different materials and tests. Replacement springs of varying stiffness are provided with the UniVert and these may be switched at any time using the jig provided. The light, medium and heavy springs will provide **10N**, **20N**, and **40N** of gripping force, respectively.

Changing Grip Springs

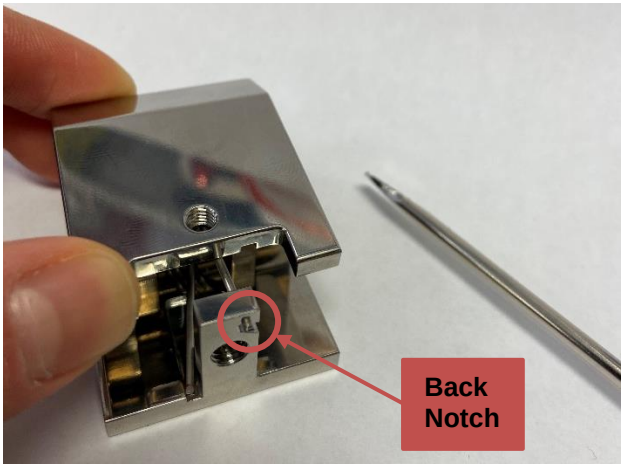
Current Generation Grips

1. Gather the required tools:
    - Grip
    - Desired spring
    - 3/32” hex key
    - 3mm hex key
    - Flat heat screwdriver
    - Safety glasses (recommended)

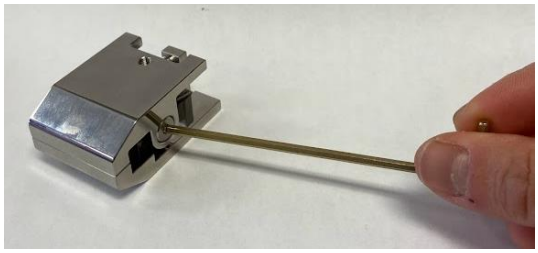
2. Remove the M4 locking screw with the 3mm hex key



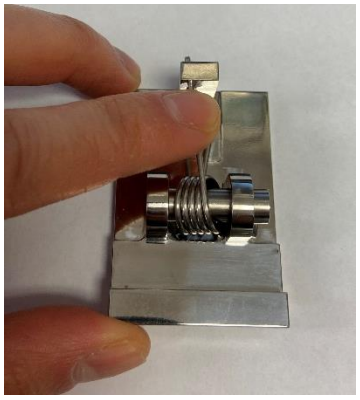
3. Push down on the front of the grip and lock the spring in back notch using the flat head screwdriver



4. Remove the dowel screws on either side with the 3/32” hex key, and remove the top piece of the grip



5. Gently push down on the top spring arm to release it from the back notch



6. Tilt the grip to the side to remove the dowel and spring

7. Position the desired spring in the center of the grip and place the dowel back in place

8. Push the spring arm down and lock it into the back notch

9. Place the top piece of the grip over top and use the 3/32” hex key to fasten the dowel screws on either side

10. Push down on the top of the grip to release of the spring arm from the back notch. Use a flat head screwdriver if necessary

11. Use the 3mm hex key to place the M4 locking screw back in place

Previous Generation Grips

1. Gather the required tools:
    - Grip jig
    - Screwdriver
    - Grip
    - Safety glasses (recommended)

2. To remove the current spring, press both halves of the grip and place it inside the provided jig to keep the grip slightly open.

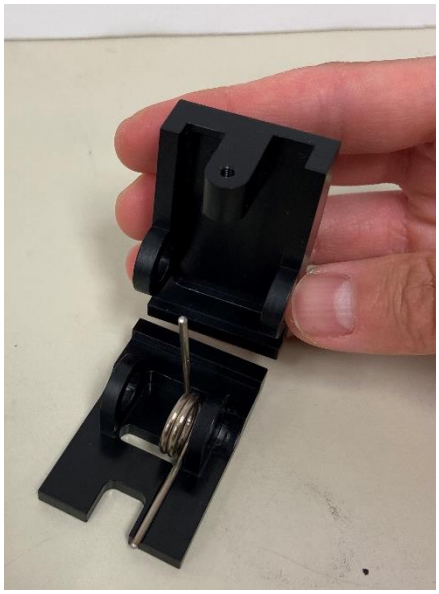
3. Use a screwdriver to push the dowel out of the grip.

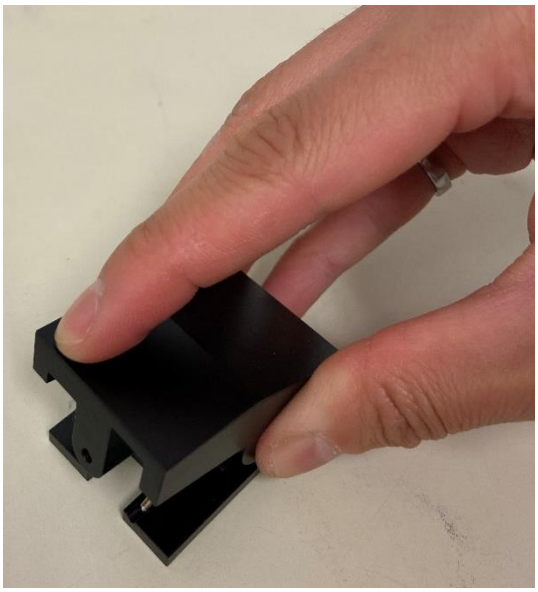
4. Carefully take the grip halves and spring out of the jig. It may be easier to use two hands for this step. Use one hand to squeeze the grip and the other to palm over the assembly to contain all the parts as it is removed from the jig.

> ***System Alert***
>
> *A fully installed spring experiences a high amount of stored energy. When removing the grip and spring from the jig, be sure to maintain pressure on both halves of the grip.* ***Safety glasses are recommended when changing grip springs.***

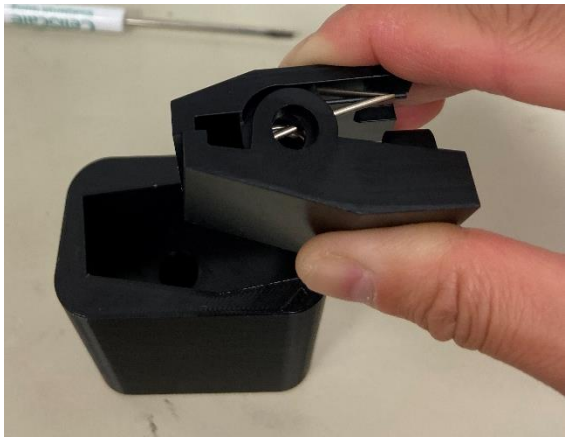
5. Remove the dowel from inside the jig
6. Place the desired spring into the groove in the top half of the grip.

7. Align the clamping face of the bottom half of the grip to the top and carefully press it down to compress the spring.

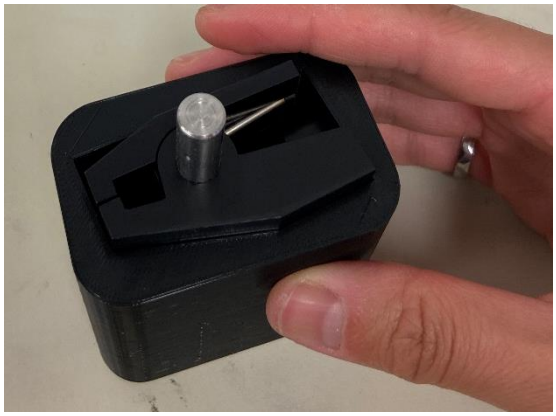




8. Place the grip and new spring into the jig. Again, using two hands may make this step easier. Use one hand to maintain pressure on the spring, and the other to palm over the assembly to keep all components together.



9. Press the dowel into the grip

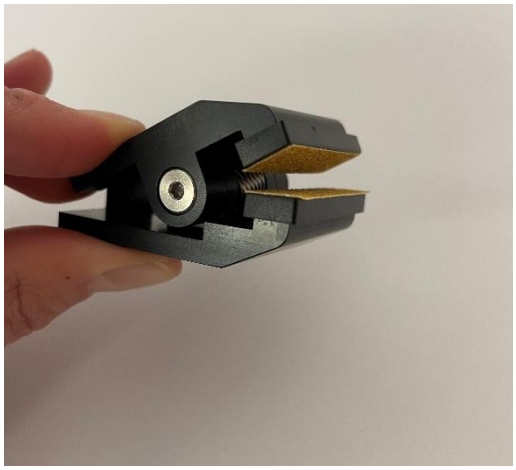


10. Remove the grip from the jig by pinching the grip while pulling up

> ***UniVert Tip: High Force Grips***
>
> Tighten the M4 locking screw on the high force grips (stainless steel) with a 2.5mm hex key to increase clamping force if the heavy springs are not enough. **Do not use excessive force when tightening the screw.** Overtightening could strip the screw hex head or damage the specimen.

Changing Jaw Coverings

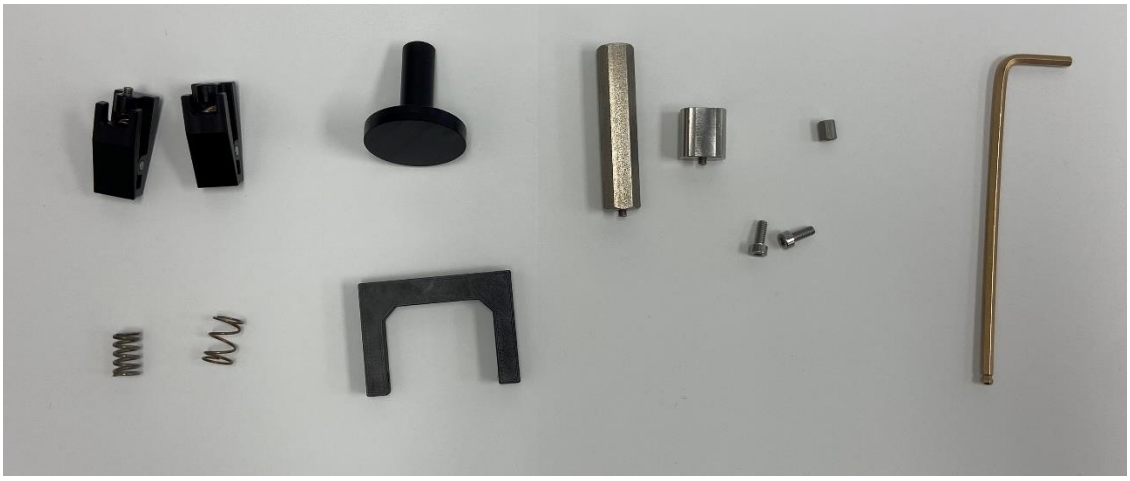
The current generation grips have jaw coverings available in a soft silicone or hard plastic with sandpaper. The coverings are easily interchangeable by sliding the coverings on and off the grip jaws while the grip is open. These coverings are optional and are best used if they provide a stronger grip on the test sample.



Appendix H: Low Force Load Cells

Low force load cells are an optional add-on to the UniVert system. They are available in 0.5N, 1N, 2.5N, and 4.5N capacities. These load cells have M3 female threads and will require a special set of fixtures. Components and tools required to use a low force load cell include:

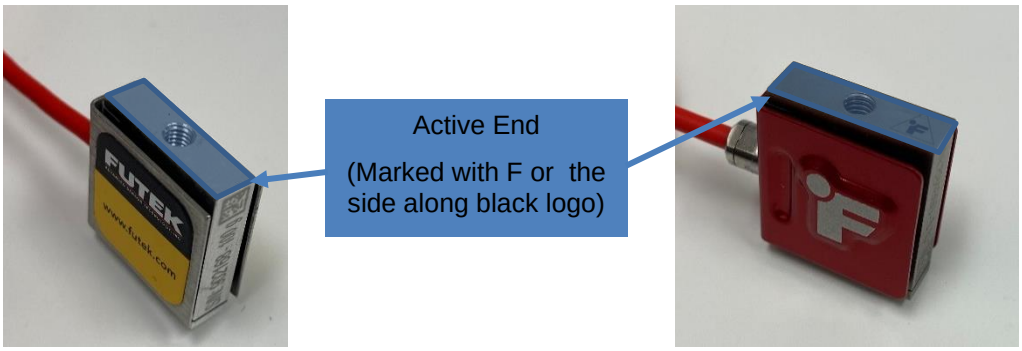
- Low force grips (M3 male thread and M5 female thread)
- Light springs
- Medium springs (assembled in grips)
- Heavy springs
- Low force compression platen (M3 male thread)
- Plastic M3 Tension Load Cell Bracket
- M5 to M3 stand off (long)
- M5 to M3 stand off (short)
- M3 Coupling nut
- 2x M3x8 SHCS
- 2.5mm hex key



Load Cell Overload Warning:

When using a 0.5N or 1N load cell, the zero-position calibration spring cannot be used. The procedure causes the system to exert 1N of force on the spring to determine its position. This action risks overloading load cells of this sensitivity. Instead, use calipers or a ruler to record the displacement between the compression platen and riser when conducting this calibration, and input this information under *Tools* → *Custom Position Calibration*.

All test fixtures should be mounted to the measuring end of the load cells. The active measuring end of the low force load cells are shown below.

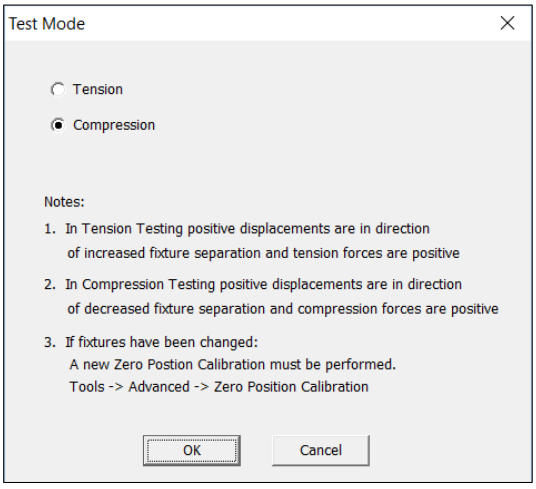


Due to their low capacity and sensitivity, **be careful when handling these load cells**. Only handle the load cell by their sides and only use the low force fixtures to avoid overloading the load cells.

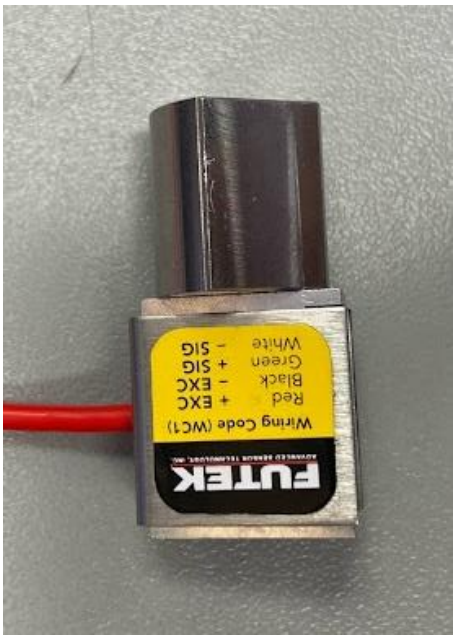
Tension Test Setup

The low force grips are required to be used with the low force load cells. Replacement springs of varying stiffness are provided with the low force grips. The light, medium and heavy springs will provide **12N**, **24N**, and **60N** of gripping force, respectively.

1. Set the test mode to Tension (*Settings>Test Mode>Tension*). This setting is specific to the test template being used and can be saved to a template.



2. Attach the M5 to M3 stand off to the non-measuring end of the low force load cell.
    - For vertical configuration, use the longer stand off
    - For horizontal configuration, use the shorter stand off



Vertical Configuration

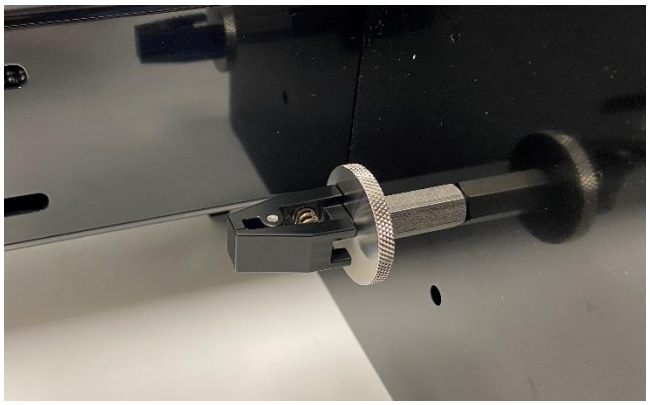
1. Attach the load cell assembly to the Motor Bracket B with an M5x12 SHCS using a 4mm hex key

2. Ensure the measuring end of the load cell is exposed and attach the M3 (male thread) grip directly to the measuring end of the load cell.

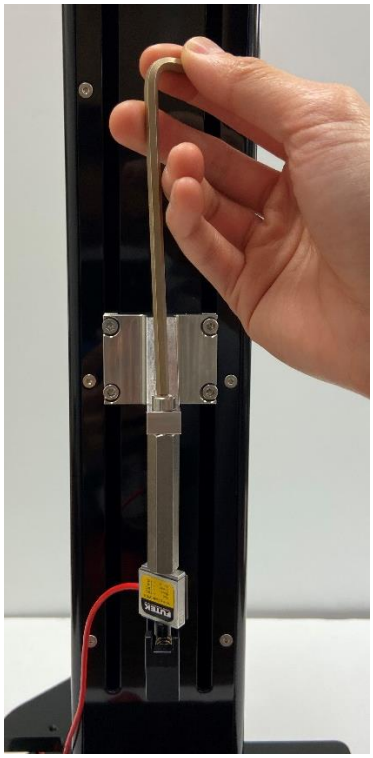
Finger tighten all components. Beware of exerting excessive off-axis and torquing forces to avoid damage to the load cell.

3. Attach the M5 stand off to the baseplate of the UniVert with an M5x16 SHCS using 4mm hex key. This may be easier to do with the UniVert in the horizontal configuration.

4. Attach the M5 locking disc and M5 grip to the M5 stand off.



5. Align the grips to be parallel by loosening the M5 screw/locking disc and rotating the load cell assembly/grip. Only handle the load cell assembly by the coupling or the sides of the loadcell. Twisting the grip while it is attached to the load cell can result in overloading.



6. A Zero Position Calibration is required after changing grips or platens. See the **System Calibration and Advanced Tools** section of this manual for more details.

UniVert Tip: Mounting Low Force Load Cells to the Fixed End - Tension

At velocities 3mm/s and slower, the UniVert uses smoother displacement commands to minimize vibrations induced from the actuator and fixtures. However, these commands cannot be used for velocities 3mm/s and faster since the desired velocities would be unachievable. The induced vibrations are generally negligible; however, due to the high sensitivity of low force load cells some of these vibrations can still be noticeable and may impact your test results.

If any test protocol lines in your template exceed 3mm/s or your force readings are not smooth, we suggest mounting the low force load cell assembly to the fixed end of the UniVert for Vertical configurations.

To set up your Low Force Load Cell on the fixed end, simply take your load cell assembly and mount it to the base place with an M5x16 SHCS and 4mm hex key. Attach the remaining grip assembly to the moving end with an M5x12 SHCS and 4mm hex key.

Horizontal Configuration

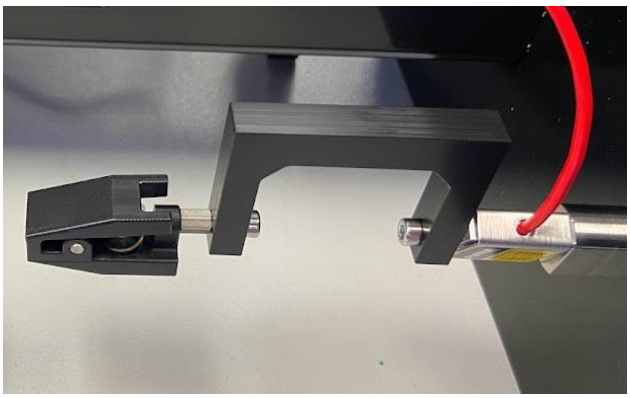
Note the steps below outline the horizontal configuration that is required for the Horizontal Media Bath. If you do not have or want to use the Horizontal Media Bath for your test, you may use the vertical configuration set up with the UniVert tilted 90° on its side to use the device horizontally if this is more convenient for your test set up.

1. Attach the grip to the M3 coupling nut and affix it to the Plastic M3 Tension Load Cell Bracket with an M3x8 SHCS using 2.5mm hex key.

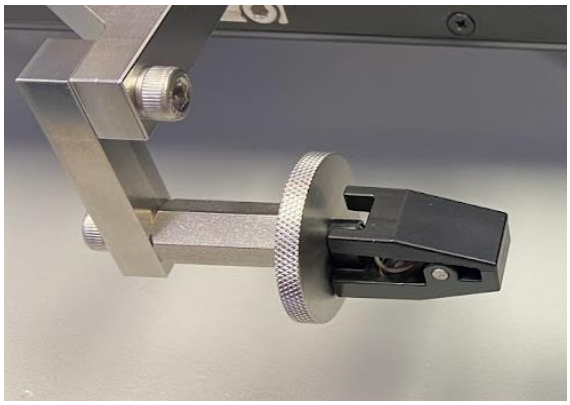
2. Attach the load cell to the above assembly with an M3x8 SHCS using a 2.5mm hex key

Finger tighten all components. Beware of exerting excessive off-axis and torquing forces to avoid damage to the load cell.

3. Attach the load cell assembly to the baseplate with an M5x16 SHCS using a 4mm hex key



4. Attach a M5 locking disc to the M5 stand off and attach the M5 low force grip to this assembly



5. Attach the assembly from the previous step to the Horizontal Bracket (No Load Cell) with an M5x12 SHCS and 4mm hex key
6. Mount the assembly from the previous step to Motor Bracket B with 2 M5x12 SHCS and a 4mm hex key.

7. Align the grips to be parallel:
    - For the fixed end (i.e. side with load cell), loosen the M5 screw in the baseplate to rotate the load cell assembly.
    - For the moving end, loosen the M5 locking disc and rotate the grip.

8. A Zero Position Calibration is required after changing grips or platens. See the **System Calibration and Advanced Tools** section of this manual for more details

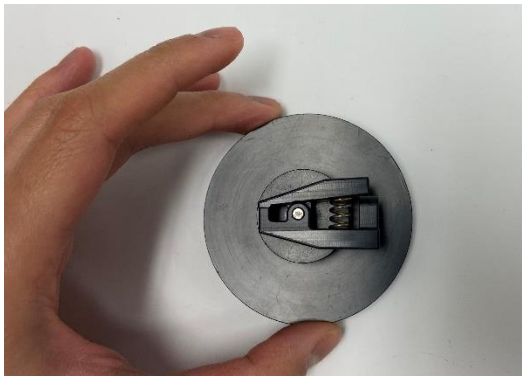
Changing Grip Springs

The grips come with three different gripping strengths to suit different materials and tests. The light, medium and heavy springs will provide **12N**, **24N**, and **60N** of gripping force, respectively.

To change a grip spring follow these steps:

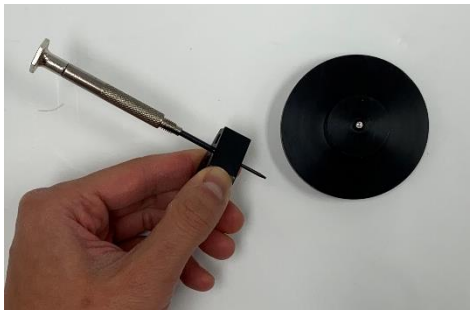
1. Gather the required tools:
    - 2.5 mm hex key
    - Grip
    - Spring
    - Calibration Plate
    - Safety glasses (recommended)
    - Small mallet and small screwdriver (optional)

2. To remove the current spring, hold the grip with the pivot hole and dowel over top the M5 hole of the Compression Plate.



3. Use the 2.5mm hex key to push the dowel out. Alternatively, a small mallet and/or a small screwdriver can be used instead or to assist in this step.

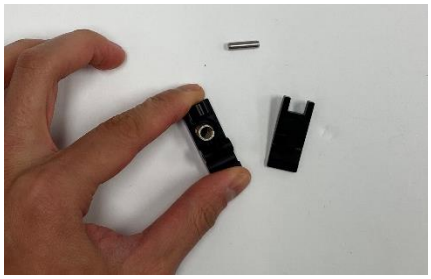
4. Carefully separate the grip halves and remove spring out. The hex key or screwdriver will have likely taken the place of the dowel in the pivot hold of the grip. Carefully hold the grip with one hand while removing the hex key or screwdriver.



> ***System Alert***
>
> *A fully installed spring experiences a high amount of stored energy. When removing the spring from the grip, be sure to maintain pressure on both halves of the grip.* ***Safety glasses are recommended when changing grip springs.***

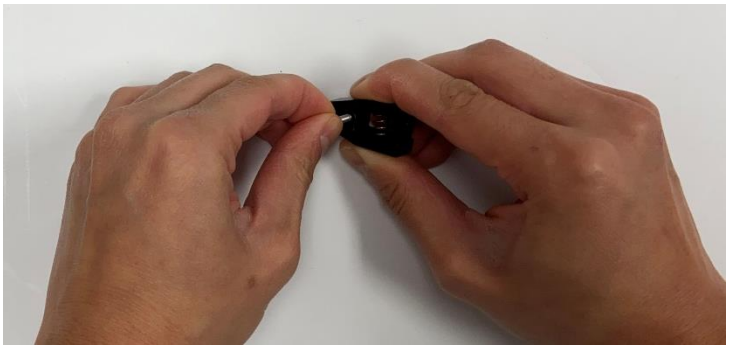
5. Remove the dowel from inside the Compression Platen.

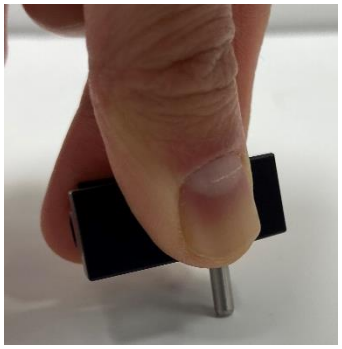
6. Place the desired spring into the cutout of the bottom half of the grip.

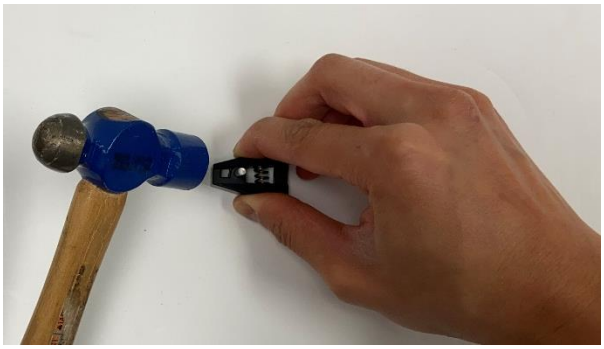


7. Align the clamping face of the top half of the grip to the bottom and carefully press it down to compress the spring.

8. Ensure the pivot hole of the grip halves are aligned and press the dowel into the grip. If needed, gently tap the dowel against the surface of the table or with a small mallet while holding the grip securely.



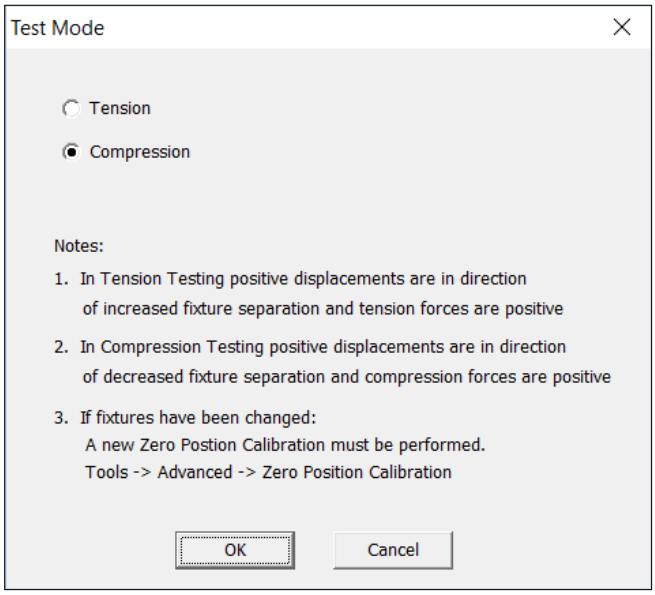




Compression Test Setup

The low force compression platen is required to be used with the low force load cells. Note the test sample will need to be supported by a supplementary riser (not included with the UniVert) to use the compression test setup in the horizontal configuration.

1. Set the test mode to compression (*Settings>Test Mode>Compression*). This setting is specific to the test template being used and can be saved to a template.



1. Attach the M5 to M3 stand off to the non-measuring end of the low force load cell.
    - For vertical configuration, use the longer stand off
    - For horizontal configuration, use the shorter stand off

Vertical Configuration

1. Attach the load cell assembly to the Motor Bracket B with an M5x12 SHCS using a 4mm hex key

2. Ensure the measuring end of the load cell is exposed and attach the Low Force compression platen directly to the load cell

Finger tighten all components. Beware of exerting excessive off-axis and torquing forces to avoid damage to the load cell.

3. Attach the M5 Compression Base Riser – Tall to the baseplate of the UniVert with an M5x16 SHCS using 4mm hex key. This may be easier to do with the UniVert in horizontal configuration.

4. A Zero Position Calibration is required after changing grips or platens. See the **System Calibration and Advanced Tools** section of this manual for more details.

UniVert Tip: Mounting Low Force Load Cells to the Fixed End - Compression

At velocities 3mm/s and slower, the UniVert uses smoother displacement commands to minimize vibrations induced from the actuator and fixtures. However, these commands cannot be used for velocities 3mm/s and faster since the desired velocities would be unachievable. The induced vibrations are generally negligible; however, due to the high sensitivity of low force load cells some of these vibrations can still be noticeable and may impact your test results.

If any test protocol lines in your template exceed 3mm/s or your force readings are not smooth, we suggest mounting the low force load cell assembly to the fixed end of the UniVert for Vertical configurations.

Important Note: In compression test mode, the weight of your sample should not exceed the capacity of your load cell since it will be resting on the load cell throughout the entire test.

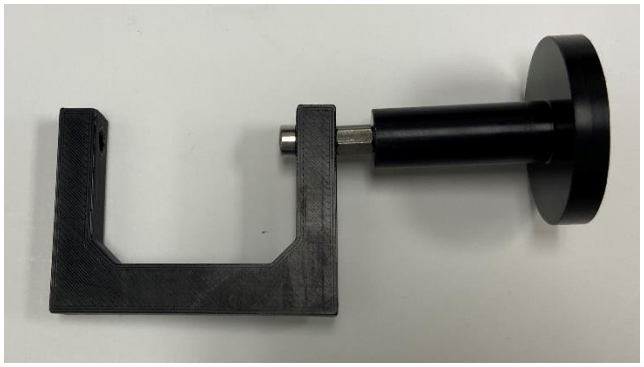
To set up your Low Force Load Cell on the fixed end, simply take your load cell assembly and mount it to the base place with an M5x16 SHCS and 4mm hex key. Attach the remaining compression platen to the moving end with and M5x12 SHCS and 4mm hex key.

Horizontal Configuration

Note the steps below outline the horizontal configuration that is required for the Horizontal Media Bath. If you do not have or want to use the Horizontal Media Bath for your test, you may use the vertical configuration set up with the UniVert tilted 90° on its side to use the device horizontally if this is more convenient for your test set up.

In addition, the test sample will need to be supported by a supplementary riser (not included with the UniVert) to use the compression test setup in the horizontal configuration.

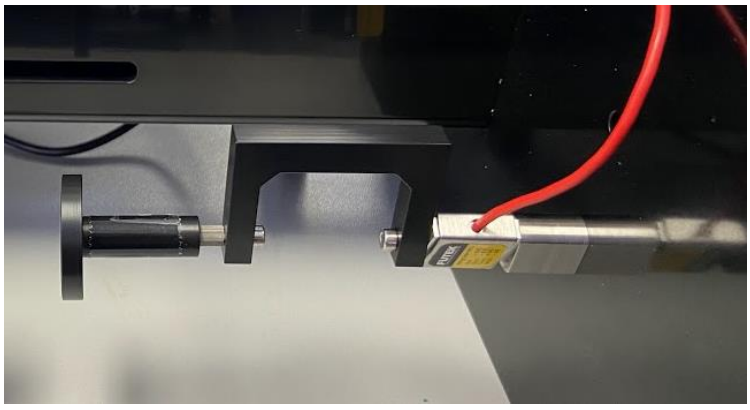
1. Attach the Low Force Compression Platen to the M3 coupling nut and affix it to the Plastic M3 Tension Load Cell Bracket with an M3x8 SHCS and 2.5mm hex key



2. Attach the load cell to the above assembly with an M3x8 SHCS and 2.5mm hex key

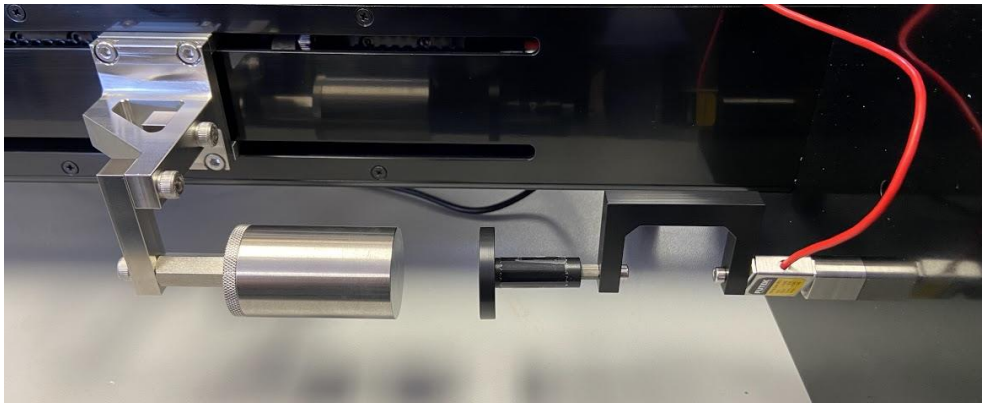
Finger tighten all components. Beware of exerting excessive off-axis and torquing forces to avoid damage to the load cell.

3. Attach the load cell assembly to the baseplate with an M5x16 SHCS using a 4mm hex key



4. Attach the M5 Compression Base Riser – Short to the M5 stand off
5. Attach the above assembly to the Horizontal Bracket (No Load Cell) with an M5x12 SHCS and 4 mm hex key

6. Mount the above assembly to the Motor Bracket B with 2 x M5x12 SHCS using a 4mm hex key.

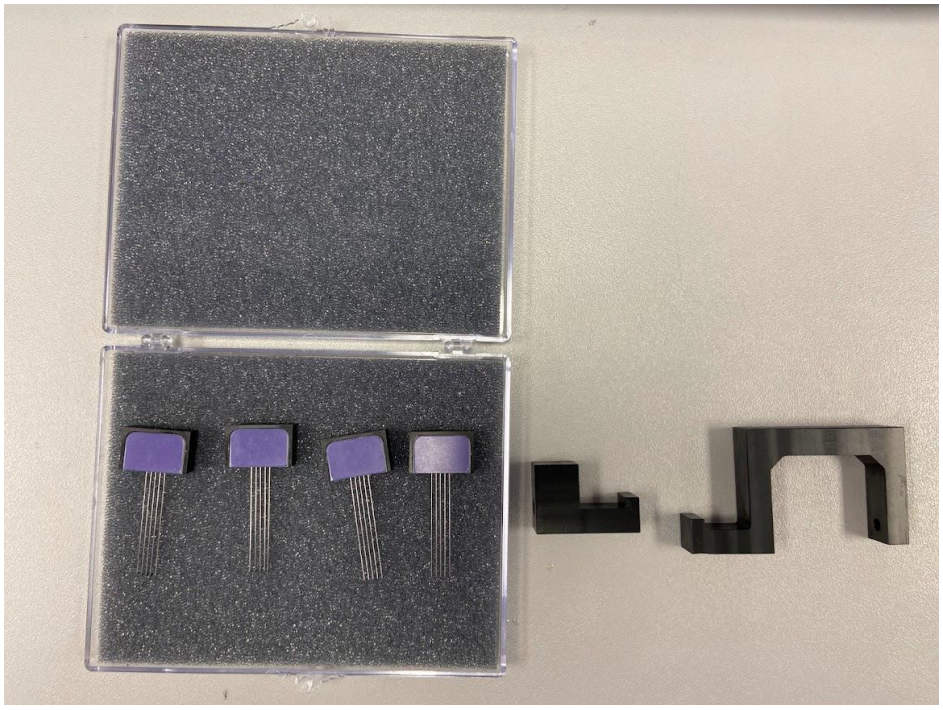


7. A Zero Position Calibration is required after changing grips or platens. See the **System Calibration and Advanced Tools** section of this manual for more details.

Appendix I: BioRake Brackets

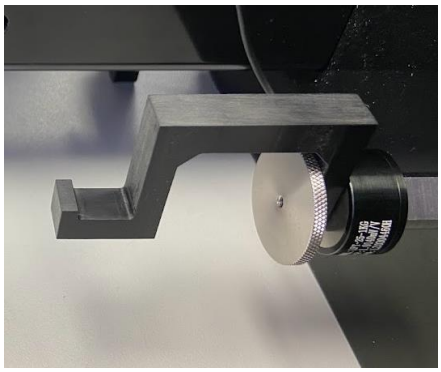
BioRake and BioRake Brackets are an optional add-on to the UniVert and can only be used with load cells 20N or lower (M3 thread). The tools and components required to use the BioRakes with the UniVert include:

- BioRakes
- BioRake Bracket - Load cell
- BioRake Bracket - No Load cell
- Sample Mounting Blocks and Backing Material

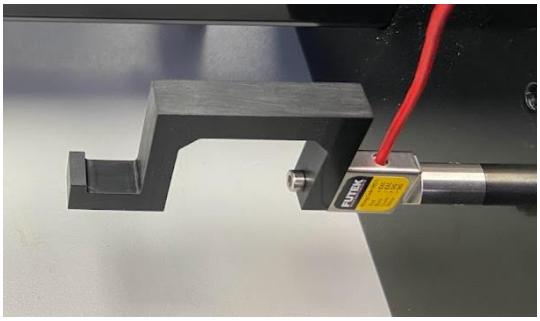


1. Set up the desired load cell as per **Appendix B** for standard load cells or **Appendix H** for Low Force load cells.

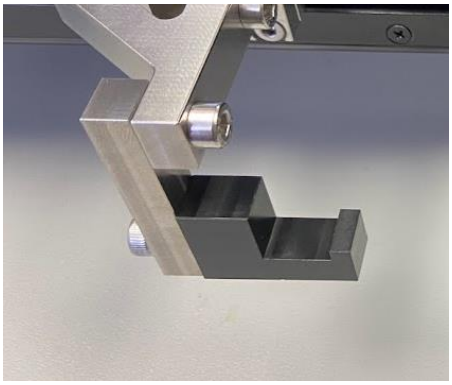
2. Attach the BioRake Bracket – Load Cell to the load cell:
    a. For standard load cells, use a locking disc to fasten the bracket.



    b. For low force load cells, use a M3x8 SHCS and 2.5mm hex key to fasten the bracket.

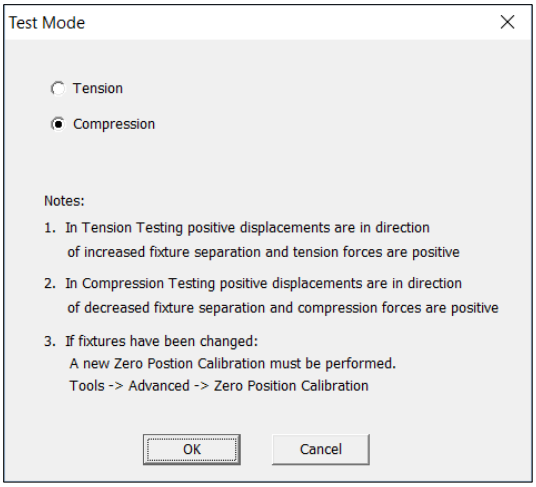


3. Attach the BioRake Bracket – No Load Cell to the Horizontal Bracket – No Load Cell with a M5x12 SHCS and 4mm hex key.

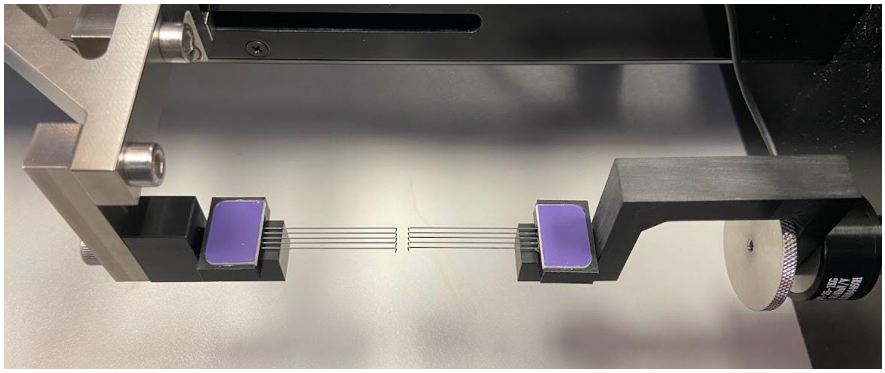


4. Open the software and select *Collect New.*

5. Set the test mode to Tension (*Settings>Test Mode>Tension*). This setting is specific to the test template being used and can be saved to a template.

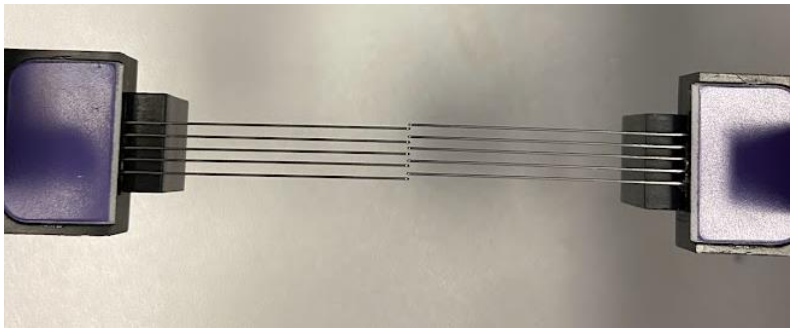


6. Place the BioRakes on the brackets and use the jog command to bring the BioRake tips close together.

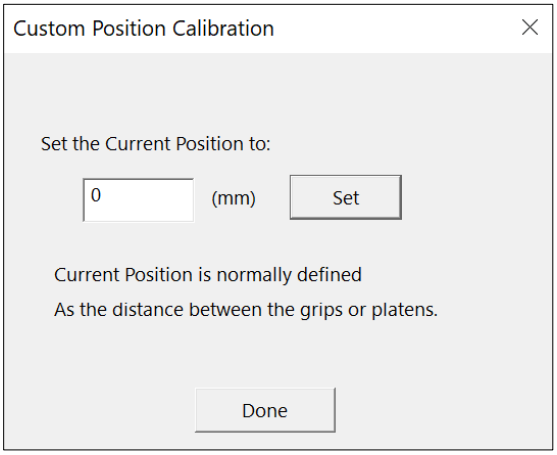


7. Loosen and re-tighten the M5 fasteners or M3 locking disc to align the BioRakes such that they are horizontally aligned (i.e. parallel when looking from above) and vertically aligned (i.e. parallel when looking from the side)

8. To set the zero position:
    a. Set one of the BioRakes slightly offset from the other
    b. Jog the BioRakes closer together until the rakes are just intertwined

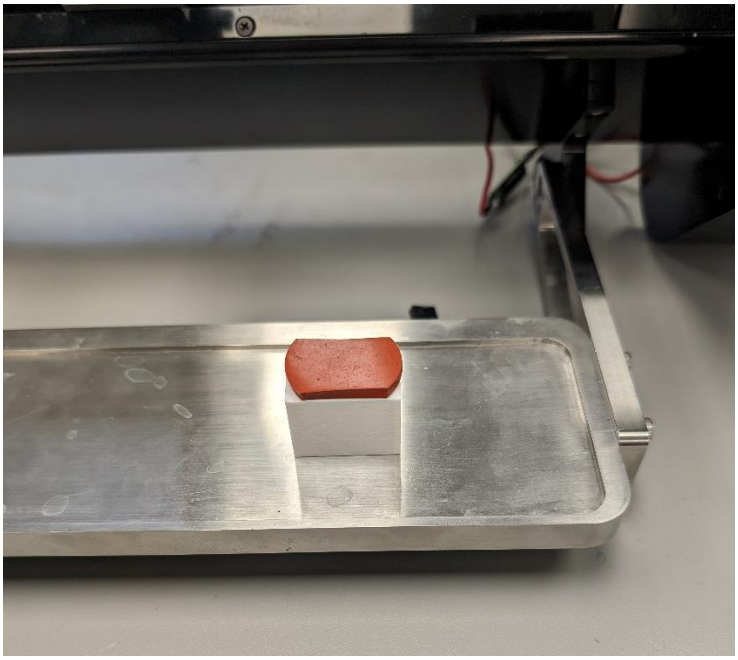


    c. Open the *Custom Position Calibration* in the *Tools* menu
    d. Set this position as 0 mm in the *Custom Position Calibration* menu

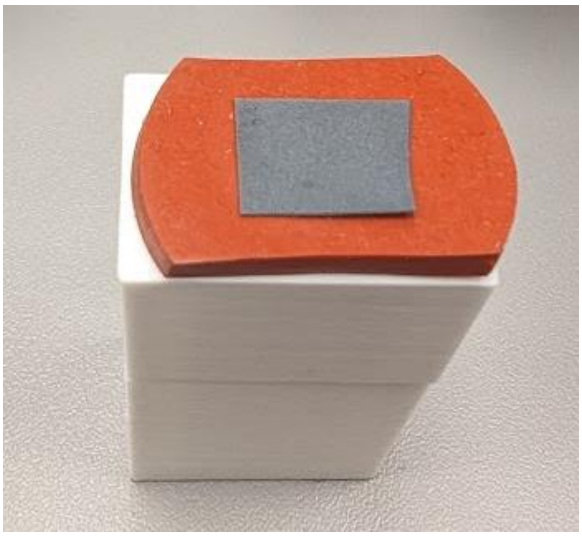


9. The BioRakes are now ready to have a sample mounted. To do this you will need the sample mounting block(s) and the backing material.
    a. When mounting a sample **without** the horizontal media bath, both mounting blocks will need to be stacked on top of one another with the backing material on top. The total height should be 58mm.

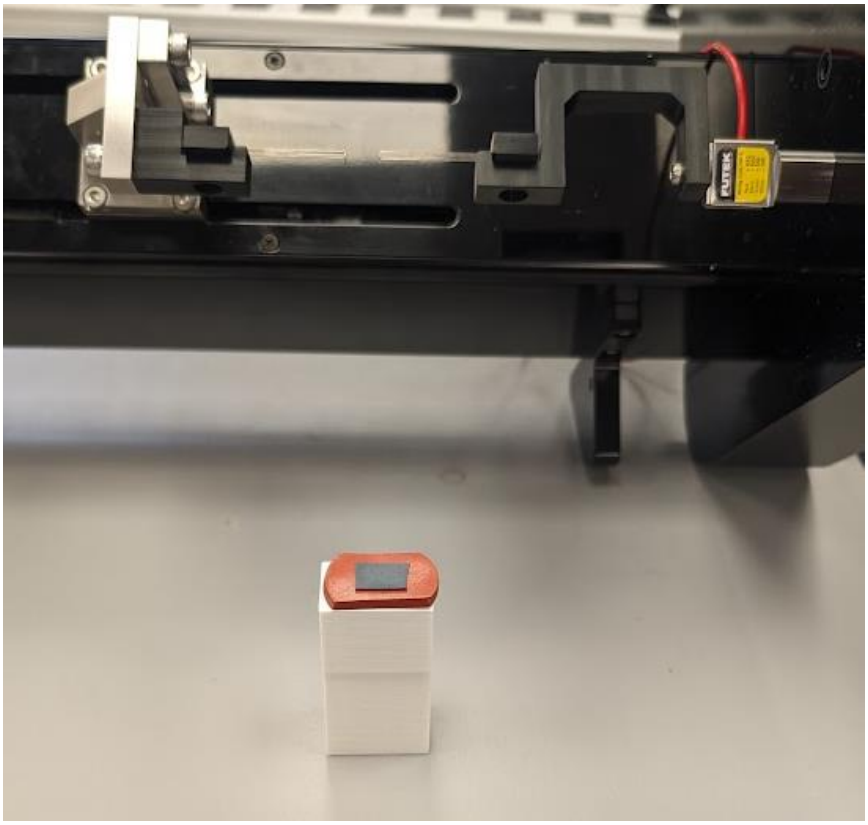
b. When mounting a sample **with** the horizontal media bath, only the shorter of the two blocks will be required. Place the backing material on top. It should be oriented in the shortest height (23mm tall).



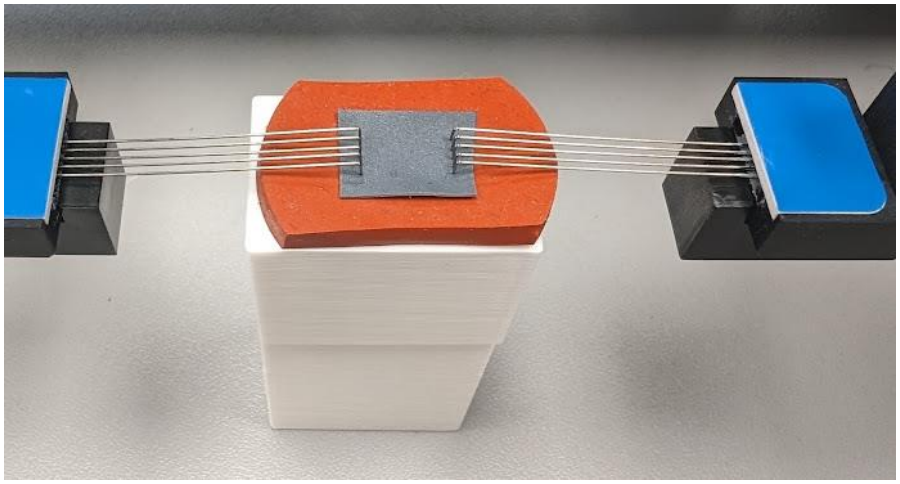
10. Your sample can now be placed on top of the backing material.



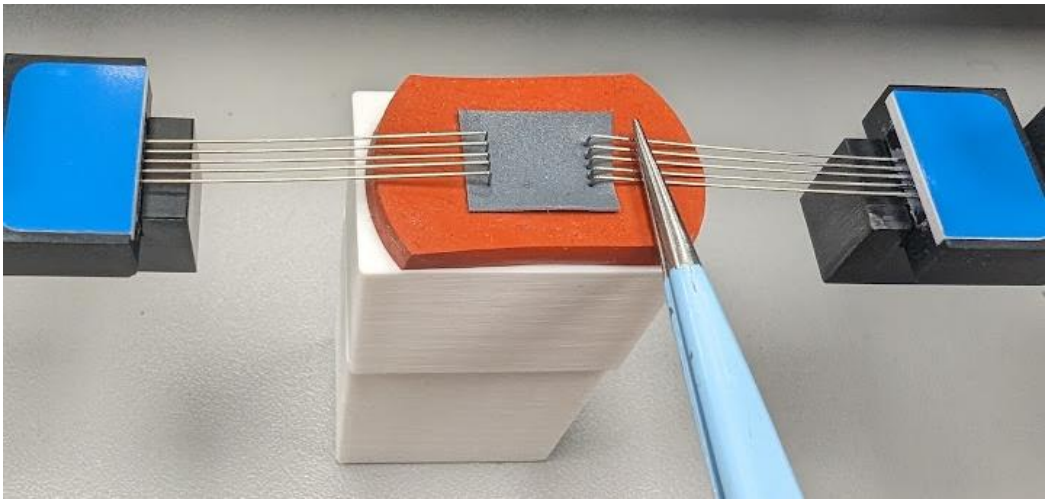
11. Tilt the UniVert and align the sample mounting platform under the BioRake tines.

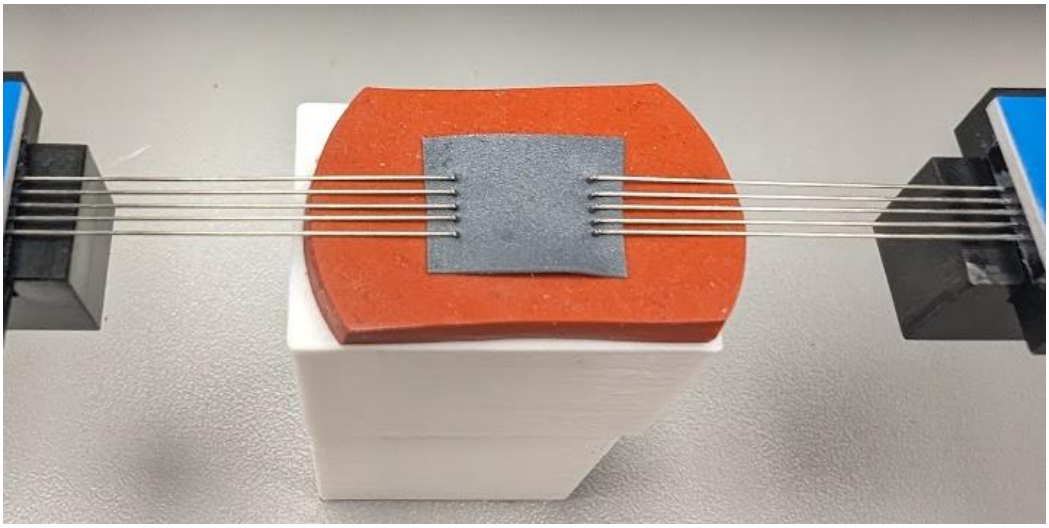


12. Now set the UniVert back down with the rakes over your sample

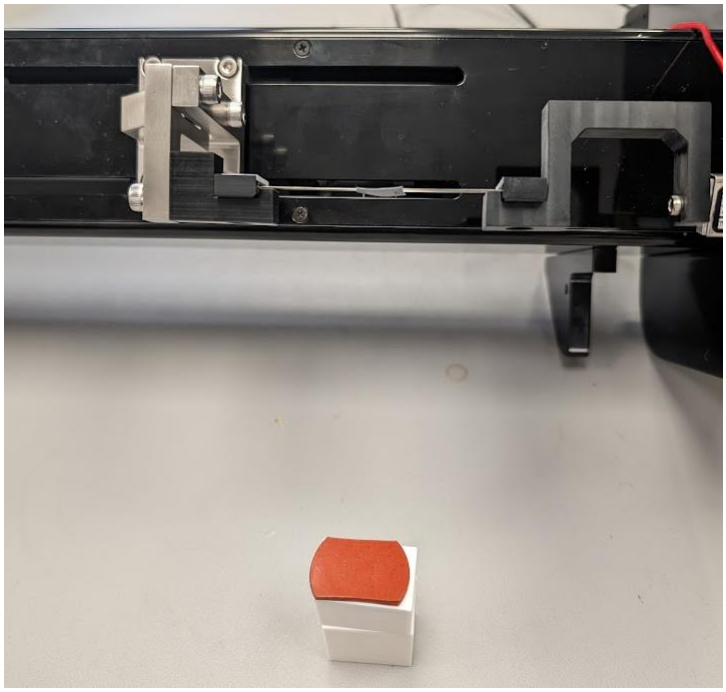


13. Push down on the tines on both sides to puncture and secure the specimen in place.

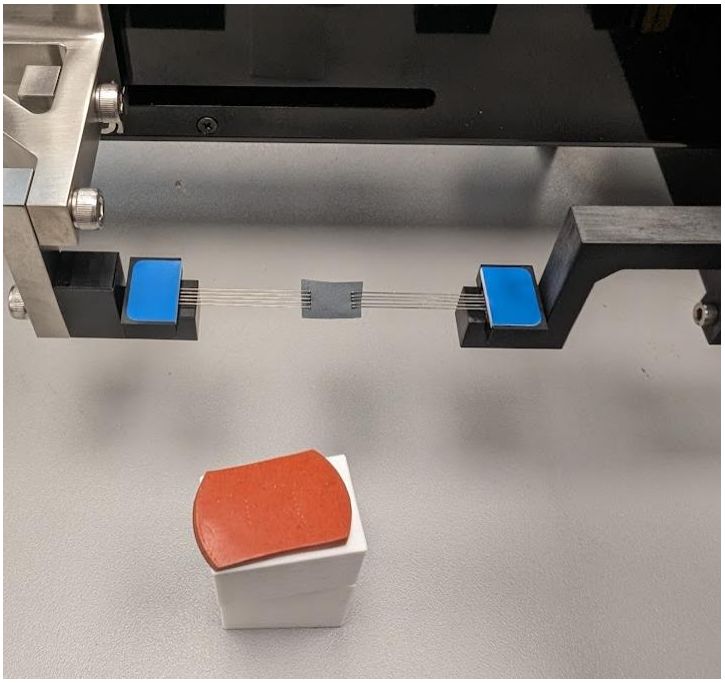




14. Tilt the UniVert back again to remove the sample mounting block and backing material.



15. Set the UniVert back down and the test can now be started.



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