



UniVert kN

Mechanical Test System

User Manual
version 1.0



Mechanical measurement and analysis of materials

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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	100~240 VAC, 50-60Hz
Current Rating	5 Amp
Environmental Conditions	Maximum Operating Temperature 40°C 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. Please see appendices below for instructions on set up and installation.




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.

	<p>This equipment must be set up and used in accordance with the procedures outlined in this manual. Operators of this equipment must be instructed in safe assembly and operating procedures to prevent injury and/or damage.</p>
	<p>The UniVert presents a pinch hazard to extremities. Keep hands clear of moving parts for the duration of the test.</p> <p>Ensure that the area around the moving actuator is clear before commencing test protocols.</p>
	<p>An optional heated media bath can be purchased and use along side the UniVert to perform tests at non-ambient temperatures. The heater plate for the media bath can reach extreme temperatures (i.e., temperatures exceeding 60°C/140°F).</p> <p>When handling equipment at these temperatures, you must use protective clothing, such as gloves.</p>

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 **Step 8: Terminate the Test Prematurely (optional)** in the **Setting Up & Starting a Test** section below for more details).

General Maintenance

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

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:

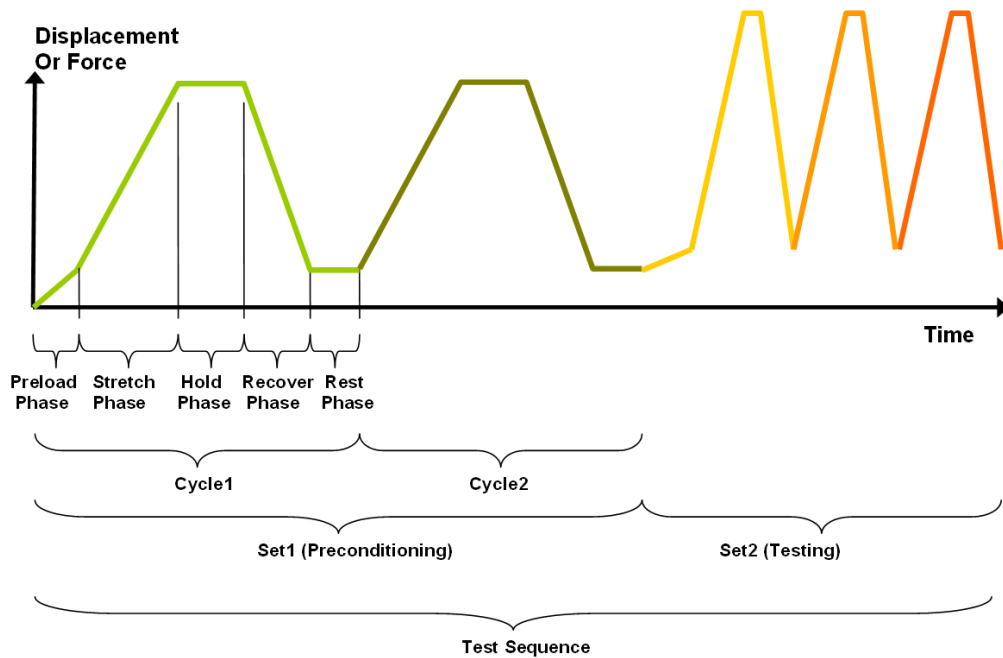
Preconditioning - Especially for biological specimens, the goal of preconditioning is to restore a specimen to its physiological or *in vivo* state. During the process of specimen storage and preparation, a specimen may swell, dry out, have its material fibers realign, or its molecules reorganize. It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

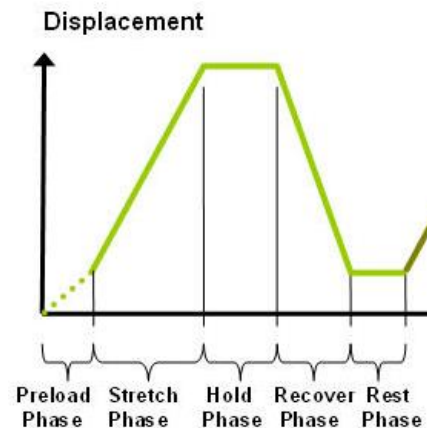
Preloading - Preloads are applied to bring a test to a well-defined starting point. Because the dimensions of a specimen may change as a result of a loading cycle (stretching of fibers, viscoelastic effects, plastic deformation, or localized material failure at the attachment points), the preload adjustment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

Control Functions

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

Under displacement control:

The **true strain function** applies the displacement at a true strain rate, which accounts for the current specimen length while the specimen is being stretched and continuously recalculates the velocity. The UniVert system approximates this with a series of linear segments.

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.

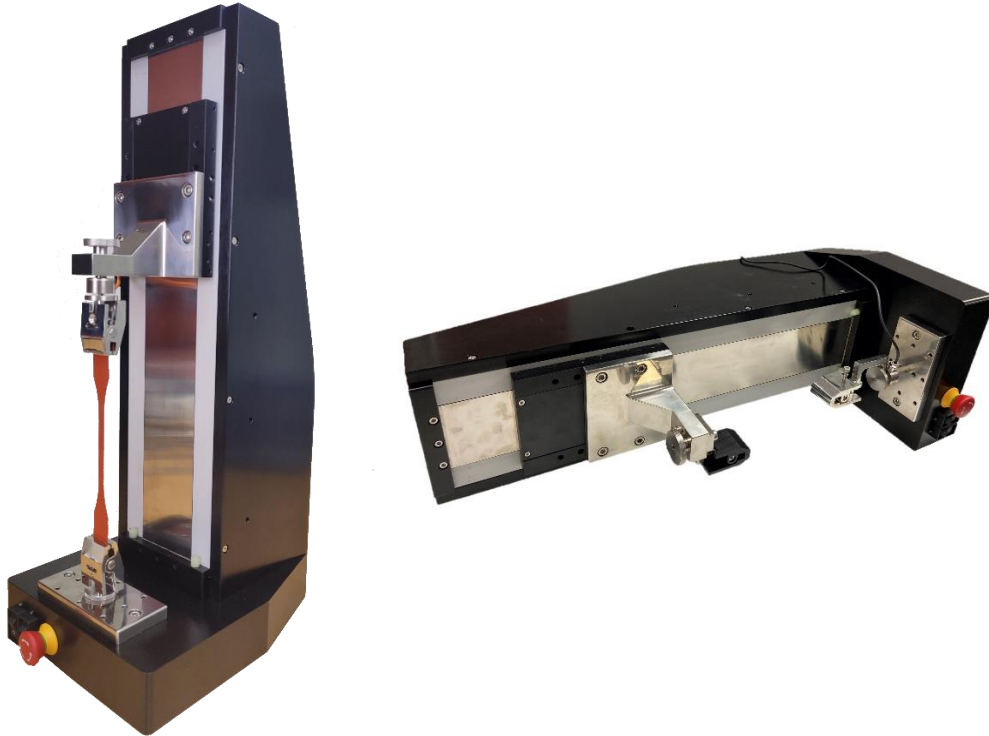
Test Modes and System Configurations

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.

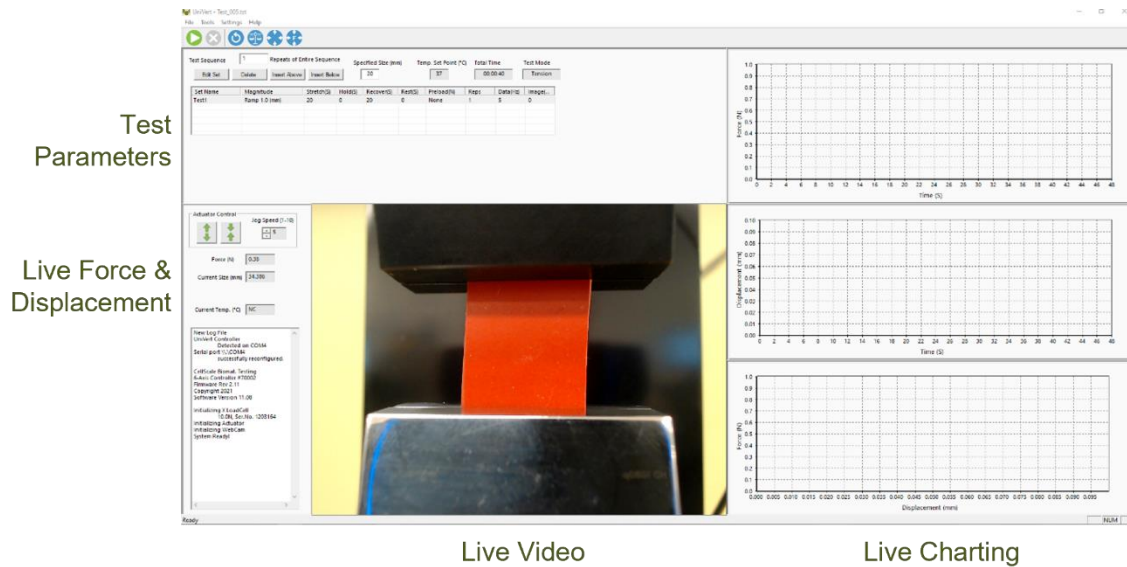
Compression Test - This test mode is used in combination with provided compression platens. In this mode, positive displacement is in the direction of decreased fixture separation and compressive forces are positive.

The UniVert can be used in two configurations: **vertical and horizontal** (see **Appendix C: Device Handling and Test Setup** 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.

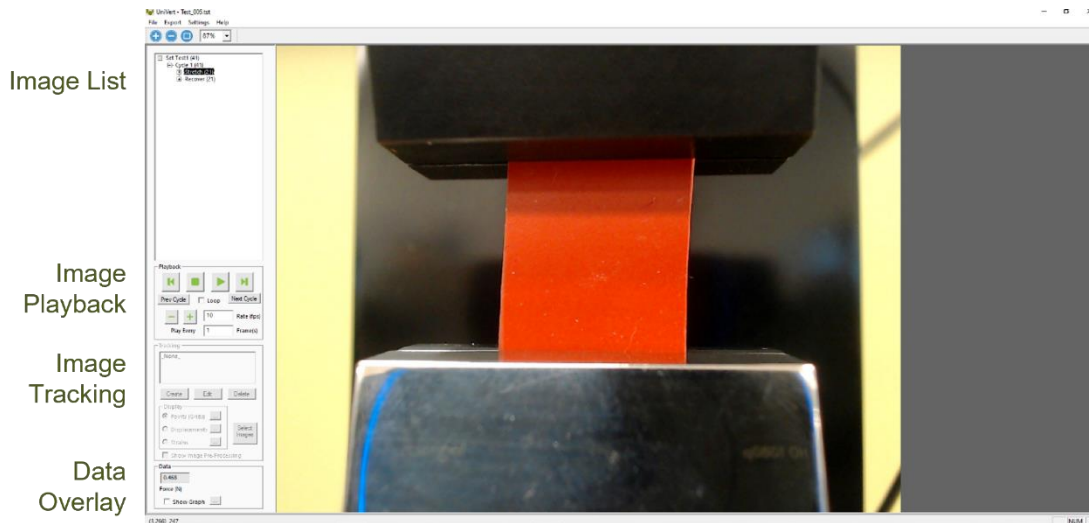


Software Overview

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 image review and analysis module is used to playback accelerated or decelerated test images, perform image analysis and tracking, and output movie files for presentation purposes. The screen layout for this module is shown below:



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 “Tracking” subfolder is initially empty. If tracking is done on any of the images in the test folder using the “Analyze and Review” software module, there will be data files that contain the tracking information stored in this directory.

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

While using the “Analyze and Review” software module, you may create additional data files such as text files (*.csv) containing tracking results, images with force data or tracking results overlaid (*.wmf), or movie files (*.avi). These additional files can be stored in the test directory or elsewhere on your computer’s main drive without interfering with the software application (once created, they must be opened by 3rd-party software).

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

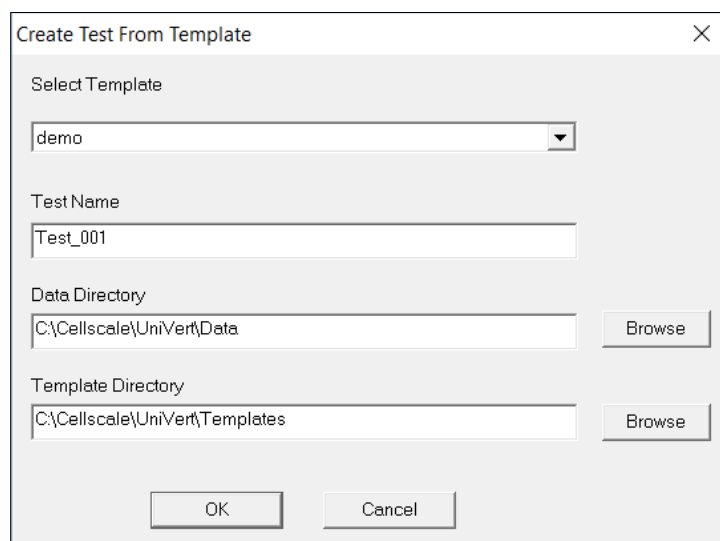
Overview

- 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)

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.



The screenshot shows a dialog box titled "Create Test From Template" with a close button (X) in the top right corner. The dialog contains the following fields and controls:

- Select Template:** A dropdown menu with "demo" selected.
- Test Name:** A text input field containing "Test_001".
- Data Directory:** A text input field containing "C:\Cellscale\UniVert\Data" and a "Browse" button to its right.
- Template Directory:** A text input field containing "C:\Cellscale\UniVert\Templates" and a "Browse" button to its right.
- Buttons:** "OK" and "Cancel" buttons at the bottom center.

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.

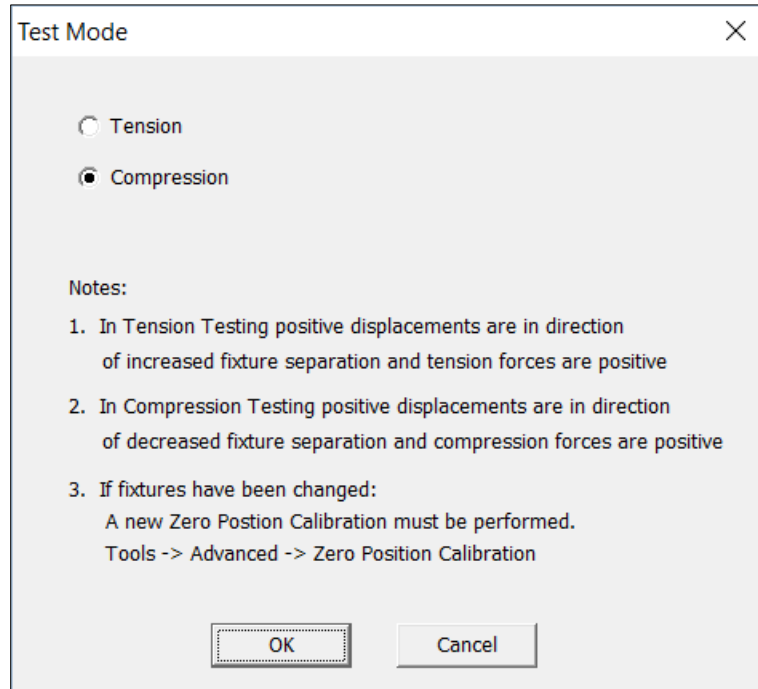
To reset the actuator, select *Reset Actuator* from the Tools menu, or press  on the toolbar.

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 C: Device Handling and Test Setup** 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)

[illegible]

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.

Set Parameter Editor

Name: (Example: "Precon1", "HoldA")

Magnitude

Control Mode:

Control:

Stretch Magnitude:

Preload

☒ Not Applied
☐ Applied on 1st Repetition Only
☐ ReApply On Every Repetition

Preload Magnitude (N):

Cycle

Stretch Duration (S): ☐ Do Not Stretch Repetitions:

Hold Duration (S): Data Output Frequency (Hz):

Recovery Duration (S): ☐ Do Not Recover Image Output Frequency (Hz):

Rest Duration:

[Edit Custom Load Function](#)

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	<p>Tests are performed under displacement or force control, however, you can select the following control modes to achieve specific testing objectives:</p> <ul style="list-style-type: none"> • 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	<p>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.</p>
Stretch Magnitude (Load Magnitude when in Force Control mode)	<p>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.</p> <p>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%.</p> <p>If you are using Force control mode, you can only specify the force in N.</p> <p>Watch the test results carefully to determine which magnitude setting best achieves your test goals.</p>
Preload	<p>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.</p>
Preload Magnitude	<p>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.</p>
Stretch Duration	<p>For evenly spaced images, it is recommended to choose a number that is an integer multiple of the Image Output Frequency.</p>
Hold Duration	<p>Hold Duration is typically set to 0, however it is useful for creep or relaxation testing.</p>
Recovery Duration	<p>Recovery Duration is typically set to the same value as the Stretch Duration.</p>
Rest Duration	<p>Rest duration is typically set to 0, however a non-zero value may be used to mimic <i>in vivo</i> conditions or for specialized testing.</p>
Repetitions	<p>Apply enough repetitions until the force deformation curves from one repetition to the next start to overlie each other.</p>
Data Output Frequency	<p>Typically set to the same frequency as the image output frequency.</p>
Image Output Frequency	<p>Typically set to 1Hz for cycles > 5 seconds and 15 Hz for cycles < 5 seconds.</p>

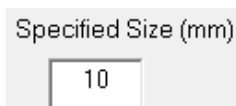
Step 6: Mounting a Specimen

Platen Mounted Specimens

1. Install the compression platens (see **Compression Test Setup** in **Appendix C: Device Handling and Test Setup** 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

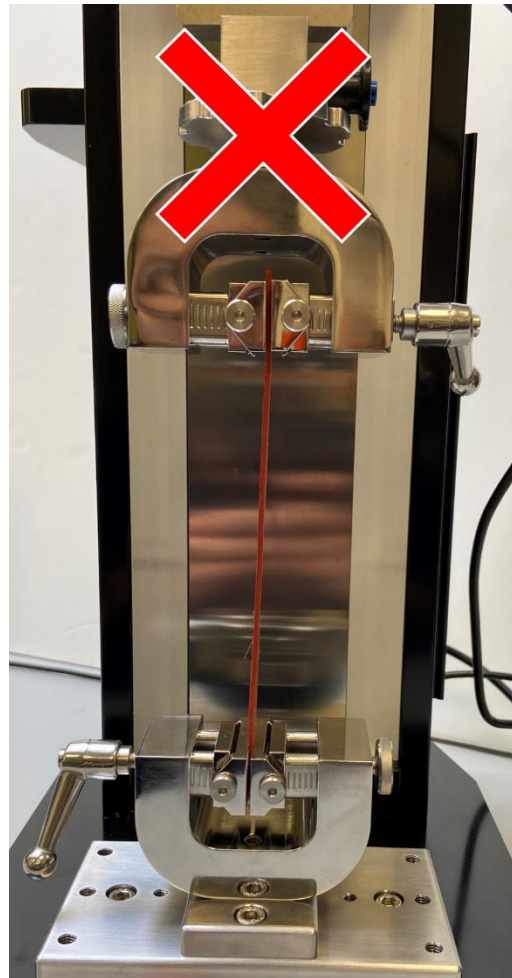
Make sure to center the specimen on the platen as much as possible to ensure accuracy in the force reading. Ideally, specimens will have two parallel flat sides and will make full contact with both platens. Although this is not always possible, flat testing surfaces will improve force distribution.

Grip Mounted Specimens

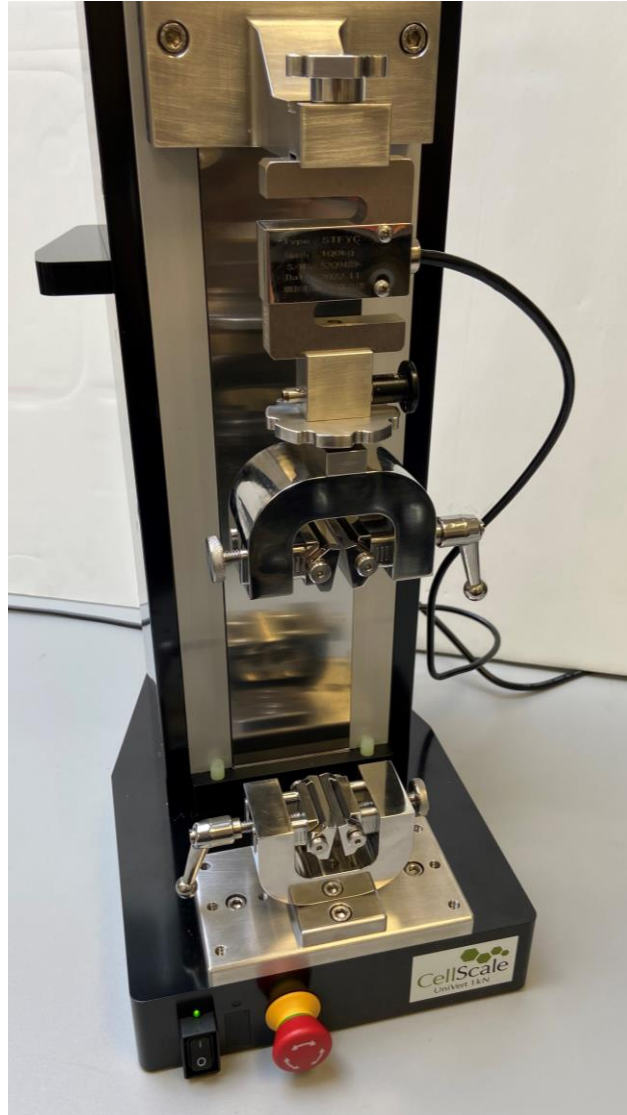
1. Select and install the appropriate grips for the load cell that will be used (see **Tension Test Setup** in **Appendix C: Device Handling and Test Setup** for more details)
2. Jog the actuator using Actuator Control until the grips are sufficiently far apart or enter the desired size and select *Move to Specified Size* .

Specified Size (mm)

3. Attach the specimen to the top grip.
 - a. For Medium Force grips, pinch the grip to open the jaws. Insert specimen and release the grip to clamp onto the specimen.
 - b. For High Force grips, loosen the locking screws to separate the grip face plates. Insert the specimen and tighten the locking screws until the grip face plates are clamping onto the specimen. Use the markings on the grip sliders to ensure the specimen is aligned vertically between both grips. This is to ensure the specimen is linear and the test executed will be uniaxial.



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

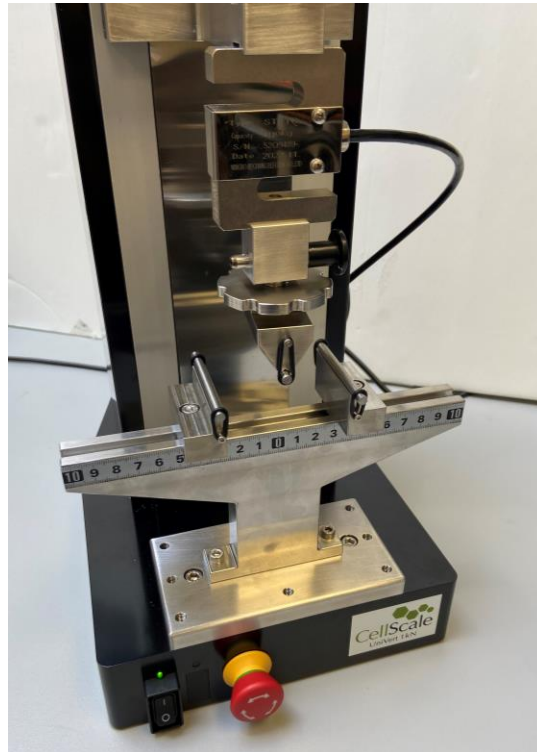


UniVert Tip: Specimen Thickness

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

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 **3-Point Bend Test Setup** in **Appendix C: Device Handling and Test Setup** for more details).
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)

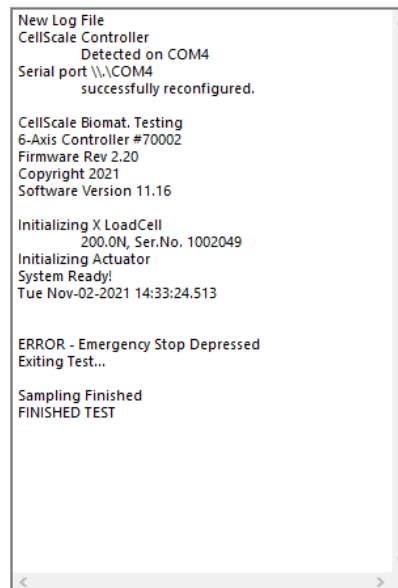
You can stop a test at any time by clicking  on the toolbar, or by selecting *Stop* from the File menu. These are preferred methods of ending a test instead of powering down the equipment or using the E-Stop, as it allows the software to store the current actuator position.


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

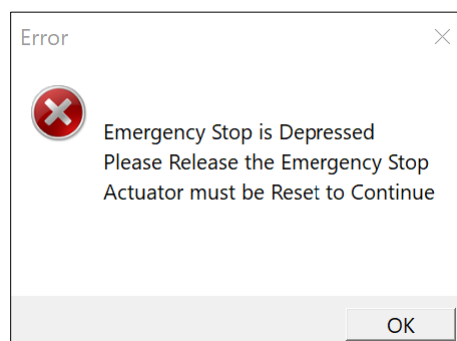
In an emergency, the Emergency Stop (E-Stop) button can be pressed to stop the motor from



moving. This button will stop power to the UniVert acuator and allow it to be moved by hand. The displacement position cannot be stored if the E-Stop has been depressed.

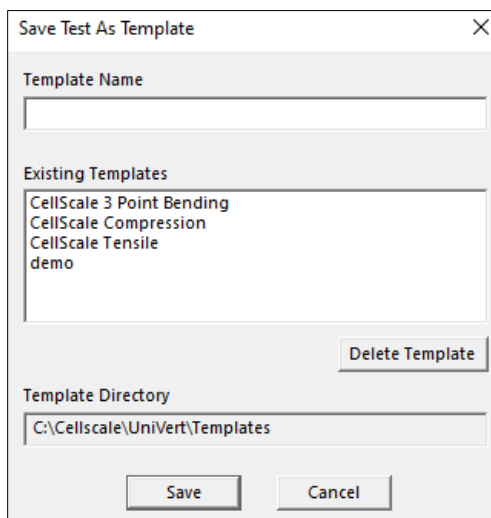


Once the UniVert is ready to be used again, twist the E-Stop to return it to its original position. A new test cannot begin until the E-Stop has returned to its original position. The actuator will need to be reset to restore the position. To reset the actuator, select *Reset Actuator* from the Tools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



Step 9: Saving the Template (optional)

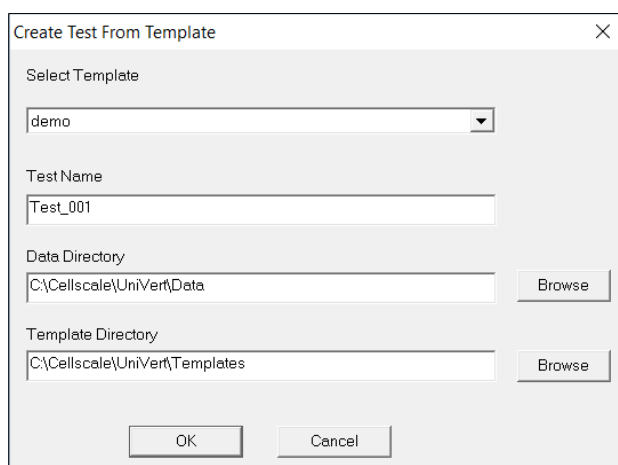
At the end of the test (or before beginning the test), you may save the test parameters entered as a new template. Select *Save as Template* from the *File* menu. The *Save Test as Template* window will appear. Set a template name and click Save.



The **Save Test As Template** dialog box contains the following elements:

- Template Name:** A text input field for naming the new template.
- Existing Templates:** A list box showing existing templates: "CellScale 3 Point Bending", "CellScale Compression", "CellScale Tensile", and "demo".
- Delete Template:** A button located below the existing templates list.
- Template Directory:** A text input field showing the current directory: "C:\Cellscale\UniVert\Templates".
- Buttons:** "Save" and "Cancel" buttons at the bottom.

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.



The **Create Test From Template** dialog box contains the following elements:

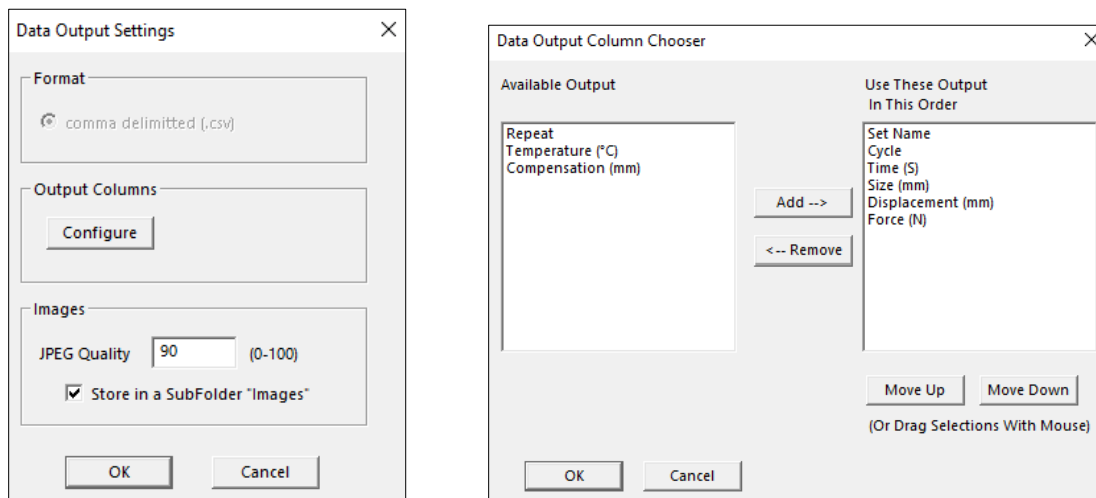
- Select Template:** A dropdown menu with "demo" selected.
- Test Name:** A text input field containing "Test_001".
- Data Directory:** A text input field showing "C:\Cellscale\UniVert\Data" with a "Browse" button to its right.
- Template Directory:** A text input field showing "C:\Cellscale\UniVert\Templates" with a "Browse" button to its right.
- Buttons:** "OK" and "Cancel" buttons at the bottom.

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.

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.

Advanced Settings

Show Warnings

☒ Before Reset Actuators

☐ Before Zero Load Cells

System Stiffness Compensation

☐ Enable Requires a Calibration (see Tools -> Advanced)

Note: To Save these settings to a Template
Select Save As Template from the File Menu.

OK Cancel

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 Error! Reference source not found. section under System Calibration and Advanced Tools for more details and steps on how to complete the calibration procedure.

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.

Motion Control Settings

Primary Axis

Max. Velocity (1-10)
(Force Control)

Acceleration (1-10)

Note: To Save Velocity and Acceleration settings to a Template
Select Save As Template from the File Menu.

☐ Enable Control Algorithm Settings Editing (Advanced) Reset to Hardware Defaults

Control Mode: Force

Algorithm: ☒ Adaptive ☐ PID

Kp:

Ki:

Kd:

Note: Improperly tuned PID settings may result in unstable behavior.

Apply Done

Max. Velocity (1-10 integer values) matches actuator jog speed. 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 (1-10 integer values). A default value of 7 is set in the sample templates provided. 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 ²	Time (s) to achieve 20mm/s	Travel (mm) to achieve 20mm/s
1	0.004	5.0000	50.0000
2	0.008	2.5000	25.0000
3	0.016	1.2500	12.5000
4	0.032	0.6250	6.2500
5	0.064	0.3125	3.1250
6	0.128	0.1563	1.5625
7	0.256	0.0781	0.7813
8	0.512	0.0391	0.3906
9	1.024	0.0195	0.1953
10	2.048	0.0098	0.0977

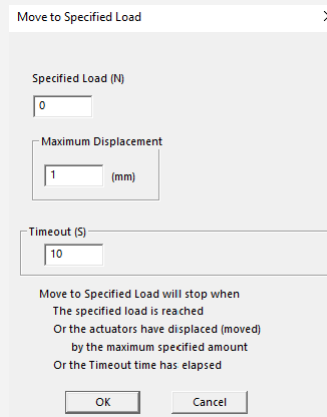
UniVert Tip: Testing Force Control Settings

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.



Move to Specified Load

Specified Load (N)
0

Maximum Displacement
1 (mm)

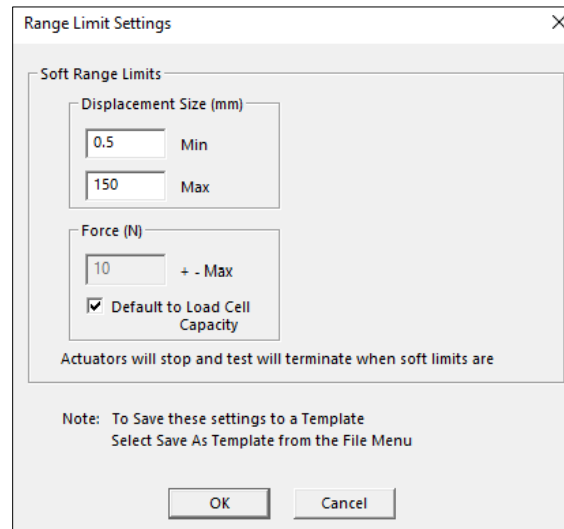
Timeout (S)
10

Move to Specified Load will stop when
The specified load is reached
Or the actuators have displaced (moved)
by the maximum specified amount
Or the Timeout time has elapsed

OK Cancel

Range Limits

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



The image shows a 'Range Limit Settings' dialog box with a close button (X) in the top right corner. It contains two main sections: 'Soft Range Limits' and a 'Note'. The 'Soft Range Limits' section has two sub-sections: 'Displacement Size (mm)' and 'Force (N)'. The 'Displacement Size (mm)' section has two input fields: 'Min' with the value '0.5' and 'Max' with the value '150'. The 'Force (N)' section has an input field with the value '10' and a label '+ - Max'. Below these is a checkbox labeled 'Default to Load Cell Capacity' which is checked. A text label below the checkbox states 'Actuators will stop and test will terminate when soft limits are'. The 'Note' section at the bottom states 'Note: To Save these settings to a Template Select Save As Template from the File Menu'. At the bottom of the dialog are 'OK' and 'Cancel' buttons.

Range Limit Settings

Soft Range Limits

Displacement Size (mm)

0.5 Min

150 Max

Force (N)

10 + - Max

☒ Default to Load Cell Capacity

Actuators will stop and test will terminate when soft limits are

Note: To Save these settings to a Template
Select Save As Template from the File Menu

OK Cancel

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 detail 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.

The **Graph Settings** dialog box is used to configure three live charting graphs. It contains three sections, one for each graph, with settings for the X-axis, Y-axis, and a 'Clear' checkbox.

Graph 1

- XAxis:** Time (S) (dropdown), Auto (dropdown), Mir 0 (text), Max 48 (text)
- YAxis:** Force (N) (dropdown), Auto (dropdown), Mir 0 (text), Max 1 (text)
- ☐ Clear Graph Between Sets

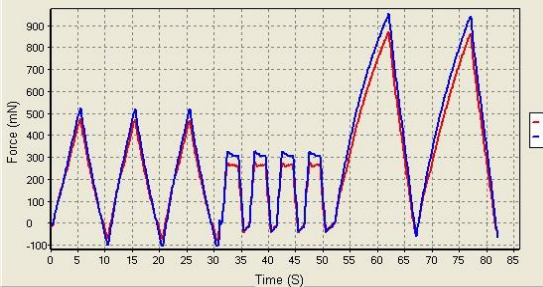
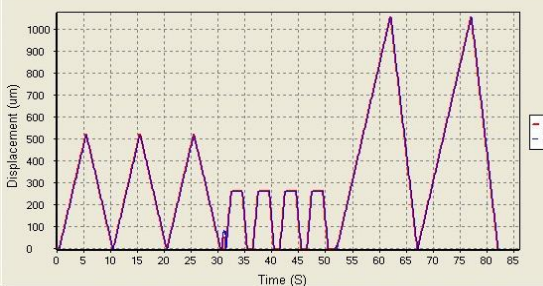
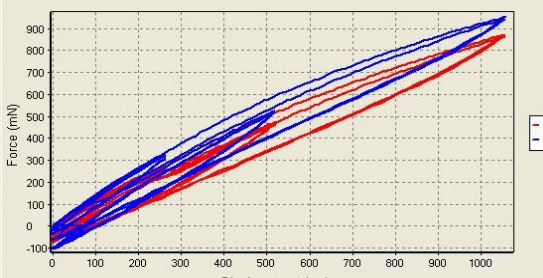
Graph 2

- XAxis:** Time (S) (dropdown), Auto (dropdown), Mir 0 (text), Max 48 (text)
- YAxis:** Displacement (mm) (dropdown), Auto (dropdown), Mir 0 (text), Max 0.1 (text)
- ☐ Clear Graph Between Sets

Graph 3

- XAxis:** Displacement (mm) (dropdown), Auto (dropdown), Mir 0 (text), Max 0.1 (text)
- YAxis:** Force (N) (dropdown), Auto (dropdown), Mir 0 (text), Max 1 (text)
- ☐ Clear Graph Between Cycles ☐ Clear Graph Between Sets

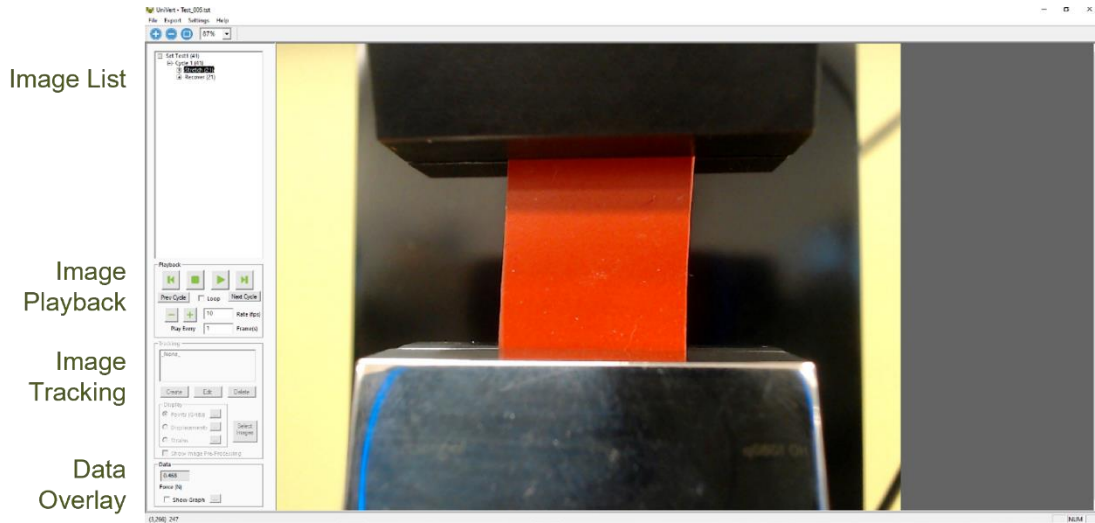
At the bottom are **OK** and **Cancel** buttons.

Graph	Data
<p>Force versus Time</p> <p>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.</p>	
<p>Displacement versus Time</p> <p>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.</p>	
<p>Force versus Displacement</p> <p>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.</p>	

Reviewing Test Results

Overview

The UniVert software has an integrated image analysis module which can be accessed by selecting *Analyze and Review Images* from the File menu, then selecting the appropriate test file. The test file is a text file with a .tst extension that contains information about the test parameters so that the software can display the images and data in a useful fashion.



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 tracking to be available, the advanced scientific camera package must be purchased.

Selecting Images

The Images are shown in a tree structure on the top left panel. The tree structure organizes the images by:

Set (line on the test parameter window)

Cycle (iteration of a given Set)

Phase (Preload/Stretch/Hold/Recovery/Rest phase of each Cycle)

Image (the one or more individual images from each Phase)

You can select which images to include in a playback set in one of several ways:

- Hold down the shift key and click on individual images
- Select entire sets, cycles, or phases (will playback all contained images)
- Select images which have data associated with a particular tracking set

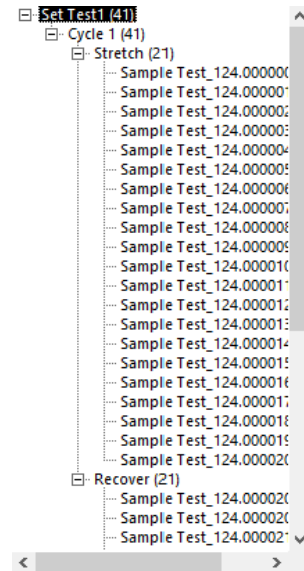
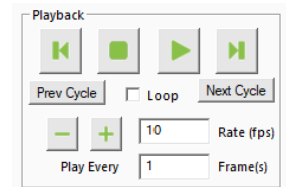


Image Playback Options

The controls on the left of the screen are broken into 2 sections: Playback and Tracking.

The playback buttons allow the user to review the images taken during a test.



Next/Prev	Display next or previous image (as dictated by "Play Every" parameter).
Play/Stop	Start and stop the playback.
Prev/Next Cycle	Jumps to a corresponding image and phase in the next or previous cycle. Useful when reviewing sets that have multiple cycles.
Loop	Sequences can be played continuously in a loop or only once.
Playback Rate	+/- changes the speed of the playback. A playback rate can also be manually entered in the display box.
Play Every	Allows the user to skip some frames to expedite playback.

Image Tracking: Overview

Image tracking is a function that can be used to quantify the motions of image features (specimen texture and fiducial markers). This can be useful for studying localized specimen deformations, verifying strain magnitudes, and comparing the results of one test to another.

The image tracking engine is based on a template matching algorithm. This algorithm starts by defining a “patch” of pixels (called a template) surrounding the selected source point on the source image. It then determines the optimal location for this template on a target image within a specified search region.

The algorithm defines the location of the tracked point on the target image as the center of the optimally located template.

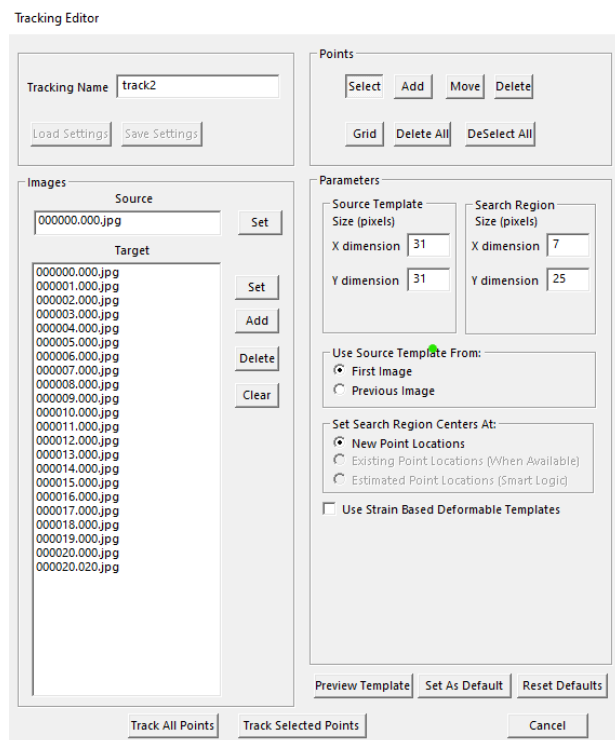
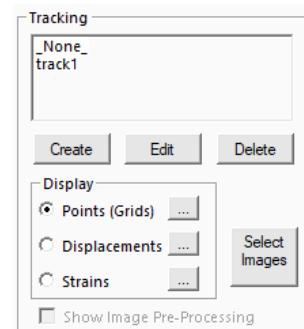
To track an image, follow these steps:

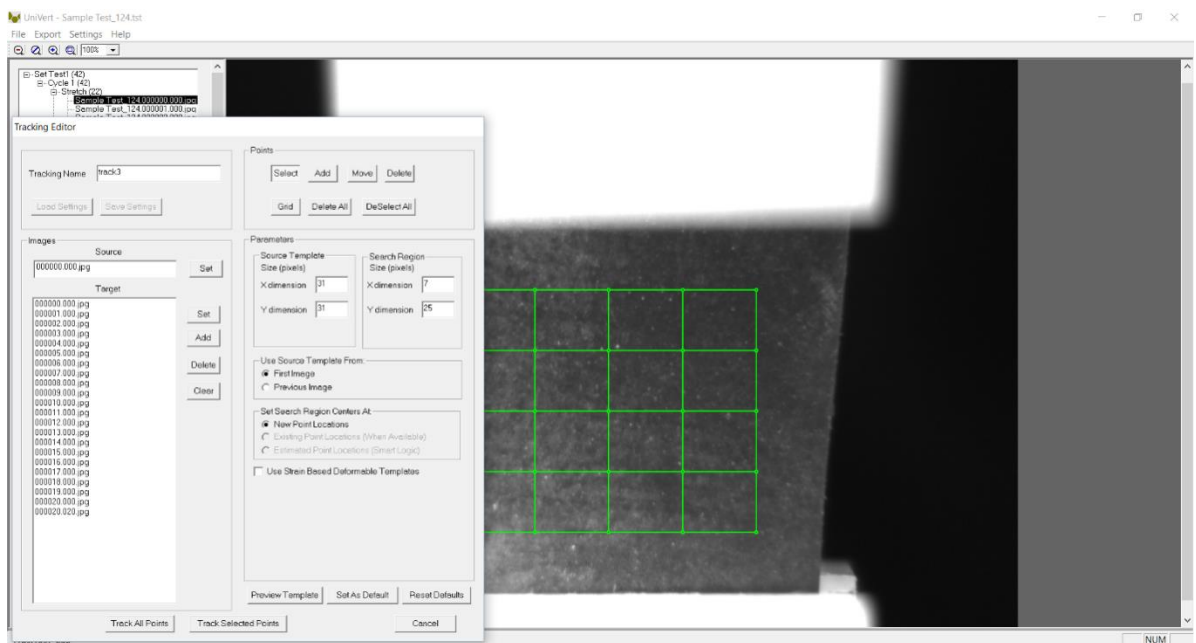
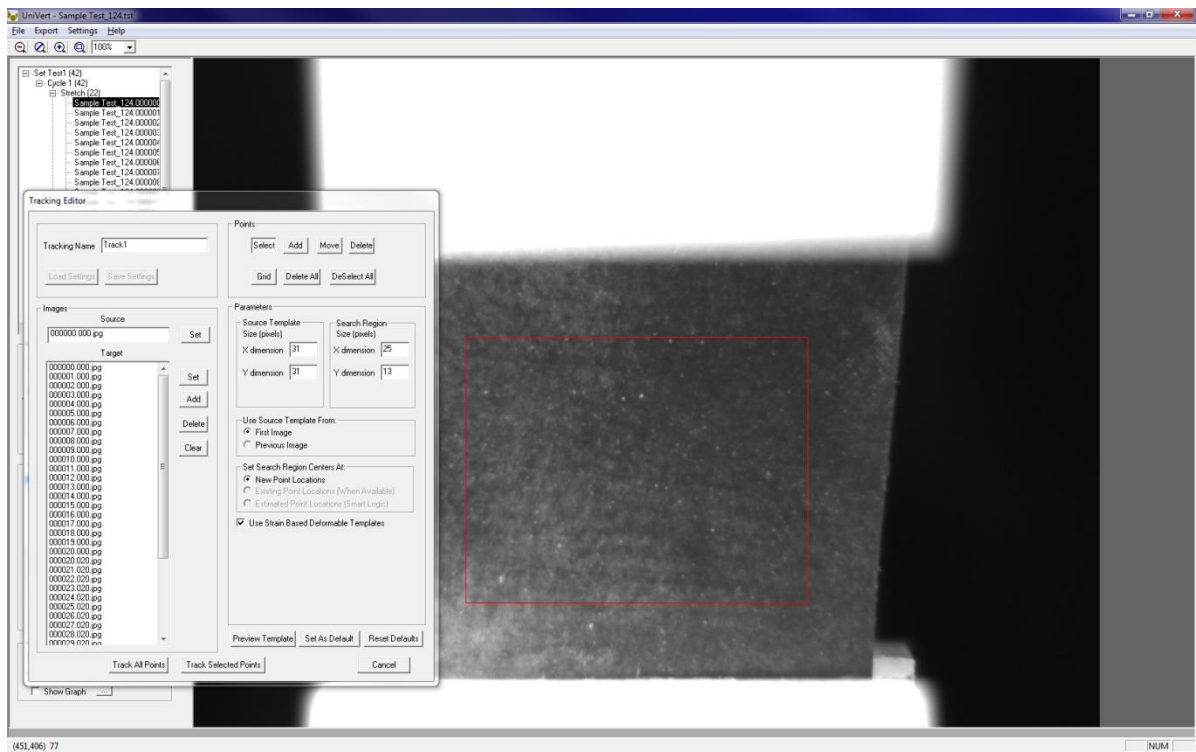
1. Click the *Create* button in the tracking window, shown above. This brings up the Tracking Editor dialog box.
2. Enter a Tracking Name.
3. Select *Source Image* in the test image list tree and click *Set* to the right of the Source box.
4. Select the *Target Images* in the test image list tree, and click *Set* to the right of the Target box. The target image list will automatically be sorted to remove duplicates and be put in sequential order.
5. Generate source points on the source image by performing the following steps:
 - a. Manually click source point locations on the source image with the *Add* button depressed.

OR

- b. Draw a box on the source image with the *Select* button depressed, then click the *Grid* button and define a grid of points.

The displayed image will automatically change to the source image when either the *Add* or *Grid* buttons are depressed.





6. Modify search parameters:

Source Template	The optimal source template is difficult to predict, but in general it is advantageous for the template to be large enough that it contains at least one feature, but not so large that it contains multiple features. Typical values for this parameter are between 15 and 55, with 35 being a good starting point for most users. Noticeable light/dark (grayscale) contrast is critical for the source template.
Search Region	The search region needs to be large enough that the optimal location for the template is found. In general, no part of the specimen moves more than the grips or platens, so the motion of these is a good guideline for how large the template needs to be. For example, if they move 50 pixels over the 10 frames you are interested in, it is unlikely that any part of the specimen is moving more than 5 pixels/frame and so a good value for the search region parameter would be 11 (5 pixels each way, plus the center pixel).
Use Source Template From	<p>First Image tracks all images against the first in the series (1→2, 1→3, 1→4...).</p> <p>Previous Image tracks each subsequent image against the image before it (1→2, 2→3, 3→4...).</p> <p>First Image Tracking tends to have poorer correlation than Previous Image Tracking because the current image is usually closer in content to the previous image than it is to the first image in the sequence. Previous Image Tracking tends to have good correlation for each individual step, but is prone to error accumulation since each step is independent. The best method for a given data set will depend on the number of images and the content of the images. Sometimes it is best to use Previous Image Tracking but to only use every other image or every n^{th} image rather than all the images available. Sometimes it is best to use First Image Tracking and use every image but set the source image in the middle of the image series rather than at the beginning.</p>
Set Search Region Centre	<p>New Point Locations The location of the center of the search region is set to the same location of that point in the previous image (even when the source template is from the first image).</p> <p>Existing Point Locations The search region center location is set to the previously tracked location of that point. When no previously tracked point exists, the location is chosen in the same way as New Point Locations.</p>
Use Strain Based Deformable Templates	When this option is checked, the source template will be scaled according to strains calculated from the Size parameters from the test data. In other words, the source template will be deformed according to the displacement of the grips or platens at that point in the test. Best tracking results are often obtained when using this option. However, this option may not be the best for simple uniaxial tests or tests where the specimen deformation is non-uniform.

7. Perform tracking with either *Track All Points* or *Track Selected Points*.

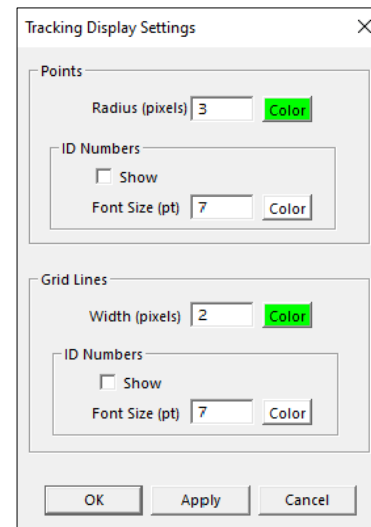
Image Tracking: The Points Display Option

The *Points* option displays the points in their current location (i.e. their location on the currently displayed image) with or without gridline connecting points that were generated using the grid function.

Clicking the *Details* icon brings up the window shown to the right. Options include changing the point radius or color, showing ID numbers, and showing gridlines with or without ID numbers.

Gridline ID numbers are associated with each grid square (cell), while Point ID numbers are associated with the points themselves.

Tracking display settings default to the last used settings.



The 'Tracking Display Settings' dialog box contains the following controls:

- Points Section:**
 - Radius (pixels): 3
 - Color: Green
 - ID Numbers:
 - Show: ☐
 - Font Size (pt): 7
 - Color: Green
- Grid Lines Section:**
 - Width (pixels): 2
 - Color: Green
 - ID Numbers:
 - Show: ☐
 - Font Size (pt): 7
 - Color: Green
- Buttons: OK, Apply, Cancel

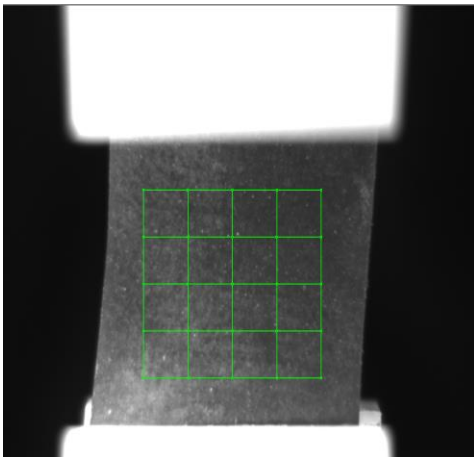


Figure 1: Initial tracking grid displayed as points.

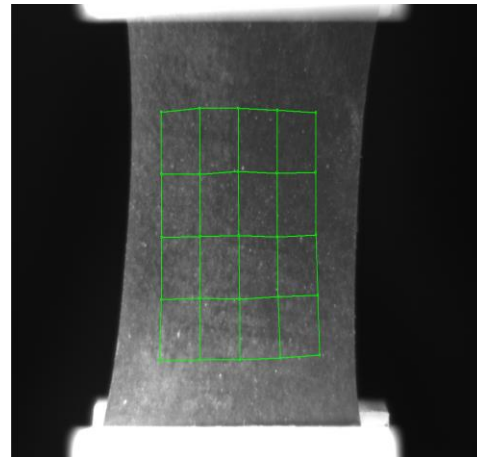


Figure 2: Tracking to 33% strain displayed as points.

Image Tracking: The Displacement Option

The *Displacement Option* displays the points in their current location as well as graphically representing their motion through time.

Clicking the *Details* icon brings up the window shown to the right. This dialogue allows the user to change the reference image, change the type of connecting line, and change the line appearance.

Displacement connecting lines directly connect the reference and current points via a vector or a path. The path option provides more information but can result in slow playback speeds for sets with many points and/or many images.

The *Flow* option generates a direction vector based at the current location and oriented in the direction of motion relative to the reference image. This can be useful because the length of this vector can be scaled to better visualize small displacements.

Tracking displacement settings default to the last used settings.

Tracking Displacement Settings

Reference Image

Display As
☒ Displacements (Tail at Reference Location)
 ☒ Vector (single line segment) (fast)
 ☐ Path (many segments) (slow)
☐ Flow (Tail at Current Location)
 Scale Factor

Appearance
 Line Width (pixels)
 Head Radius (pixels)
☐ Show Points (Grids)

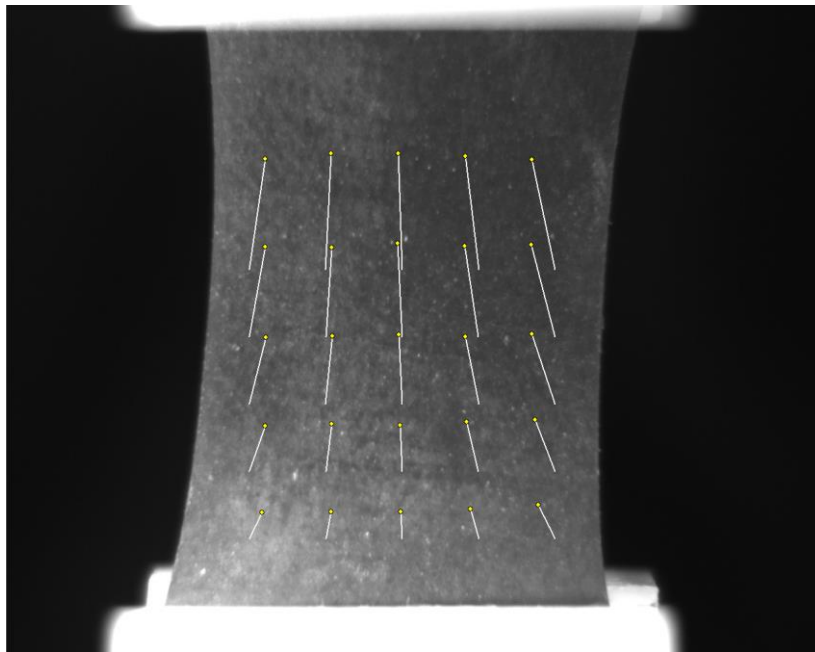


Figure 3: Tracking to 33% strain displayed as displacement.

Image Tracking: The Strains Option

The Strains Option can only be used in conjunction with a grid of points (as opposed to individually placed points). This option calculates the regional strains inside every grid box and displays this data as an ellipse. One can imagine this is what would happen to a grid of circles drawn on the surface of the specimen at the beginning of the test.

Clicking the details icon brings up the window shown to the right. This dialogue allows the user to change the reference image as well as the appearance of the circles and text.

Showing text for E1, E2 will result in the text showing the principal strains along the major and minor axis of the ellipse. Showing text for Ex, Ey will result in text showing the strains along the X and Y directions regardless of the ellipse orientation.

A 4-point or 16-point average can be used to calculate the strain inside each grid box (each individual grid box or each box plus additional surrounding grid points).

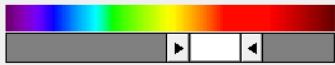
Tracking strain settings default to the last used settings.

Tracking Strain Settings

Reference Image

Options

 E1, E2 = Principal Strains
 Ex, Ey = Coordinate Strains ☐ Show Points (Grids)
 R = Principal Angle (Deg)

Color Grid By Strain Values
☒ Show

☒ Auto Mir 1 Max 2

Strain Ellipses
☒ Show Scale Factor 1
 Line Width (pixels) 1

Text (% Strain)
☐ Show Font Size (pt) 10

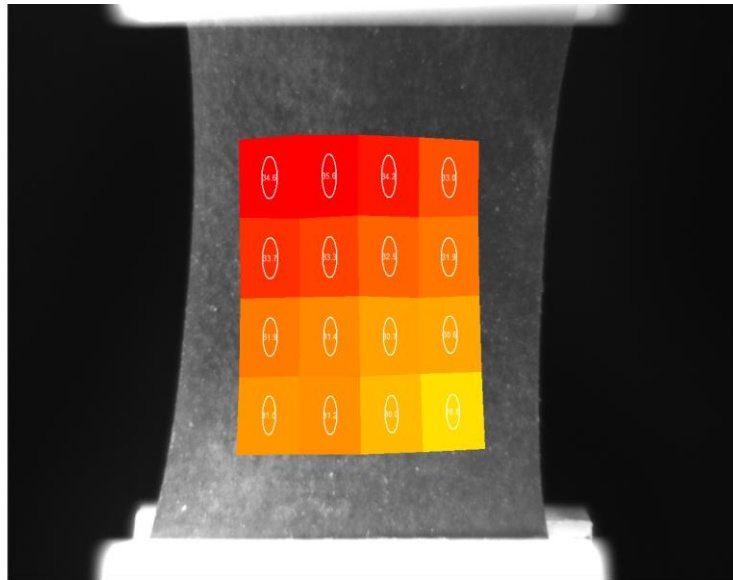
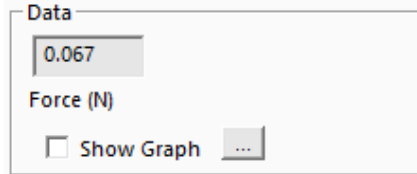


Figure 4: Tracking to 33% strain displayed as strain ellipses with text showing x% strain.

Data Overlay

Data associated with each image is displayed below the tracking controls on the left side of the main window. Checking the *Show Graph* box displays this data as a graph overlaid on the images



Clicking the details icon displays the window shown to the right. The dialogue allows the user to change the size and appearance of the overlaid graph. The data points associated with the current image are marked on the graph with green circles. The overlaid data graph will be drawn on top of any image tracking displays (when they overlap).

Data Overlay settings default to the last used settings.

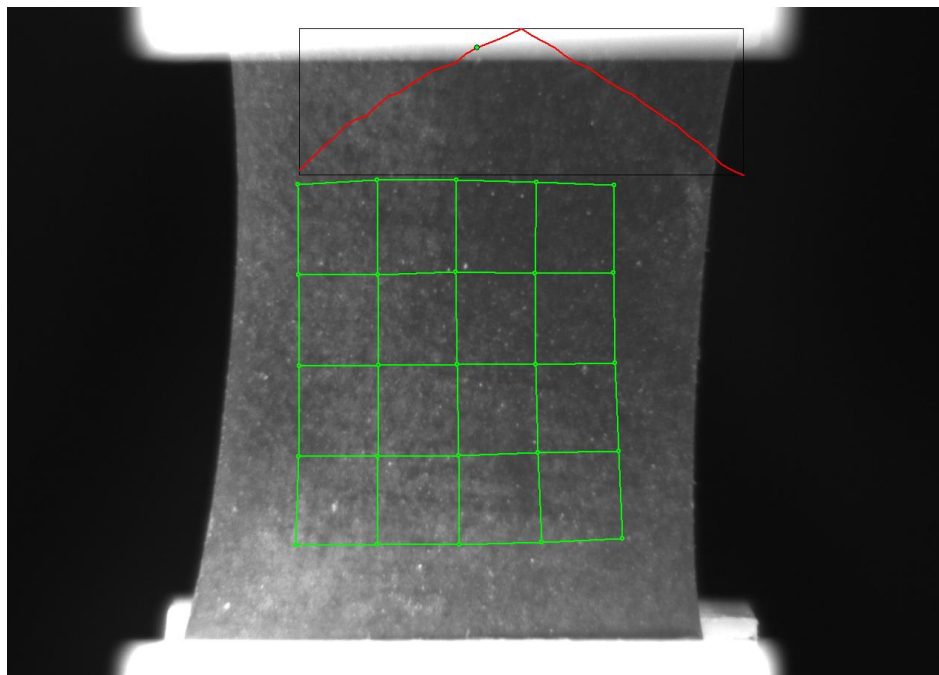
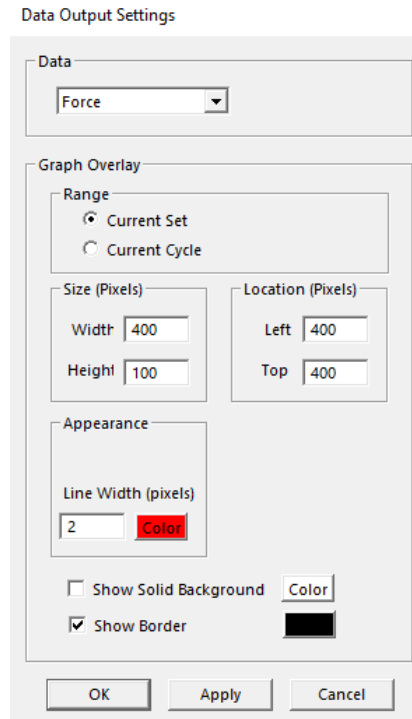


Figure 5: Tracking to 33% strain with overlaid force graph.

Exporting Tracked Data

Tracked grid point coordinates and calculated grid strains can be exported to a .csv file. From the Export menu, select *Data Points* to display the dialogue shown on the right. The image list is automatically set to the currently selected images in the test image list tree. This image list can be changed by selecting new images in the test image list tree and pressing the set button. When exporting strains data from *Selected Tracking Points*, all four points of a grid cell need to be selected for data from that cell to be exported.

Exported data is labeled with associated ID numbers (grid point ID numbers for exported coordinates and grid cell ID numbers for exported strain values). To display ID numbers on tracking grids, see Image Tracking: The *Points Display Option*. In the following example (Figure 6), grid point ID numbers are shown in yellow and grid cell ID numbers are shown in white.

The exported .csv file is written to the test directory.

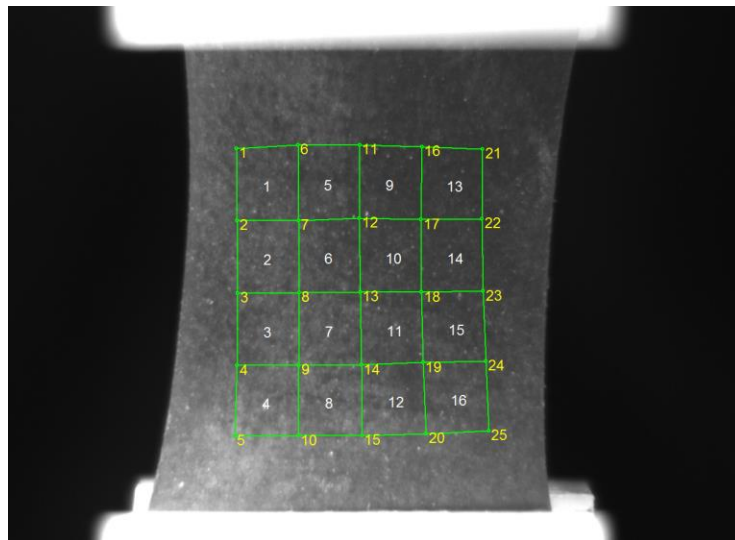
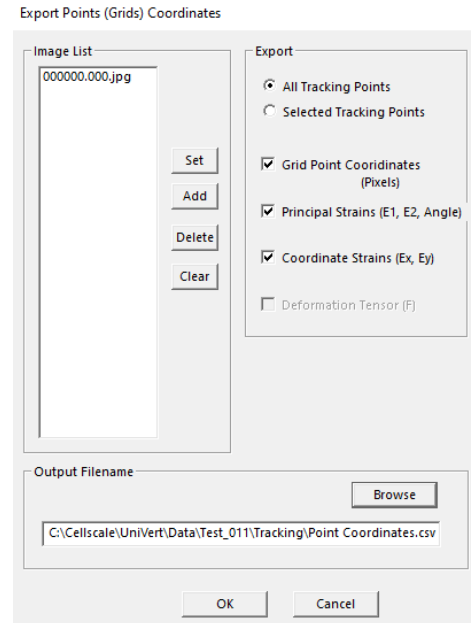


Figure 6: Tracking Grid showing ID Numbers

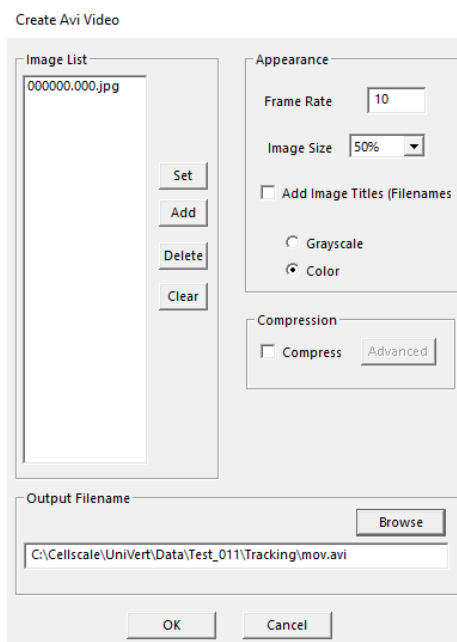
Grid Point	Coordinates (pixels)									
FileName	Time(S)	X5	Y5	X6	Y6	X7	Y7	X8	Y8	X9
2nd Goos	181.4	588	323	588	426.667	588	530.333	588	634	69
2nd Goos	182.4	587.125	318.75	586.75	424.75	586.875	531.625	586.625	636.875	692.62
2nd Goos	183.4	586.5	314.75	586.25	423.5	586.125	532.375	585.375	639.25	693.62
2nd Goos	184.4	585.375	310.5	585.25	421.625	585.375	532.625	584.375	642	694.37
2nd Goos	185.4	584.375	306.875	584.125	420	584.125	533.125	583.125	645.625	695.12
2nd Goos	186.4	583.625	303.125	583.125	418.875	583.25	534.75	582.5	649	695.87
2nd Goos	187.4	582.5	299.125	582.5	417.5	582.125	535.75	581.25	652	696.7
2nd Goos	188.4	581.5	295.25	581	416	581	536.25	578.625	655.875	697.62
2nd Goos	189.4	580.5	291.125	579.875	414.875	579.75	537.5	577.375	658.875	698.62
2nd Goos	190.4	579.375	286.625	578.75	413.25	578	539	576.5	662	699.
2nd Goos	191.4	578.25	283.5	577.5	412	577.25	539.75	574.25	665.75	700.
2nd Goos	191.5	578.25	283	577.5	412	577.125	540.125	576.875	665.125	700.62
Coordinate Strain X - Values (16 point least squares average) (Grid Cells are numbered from the top left corner -										
FileName	Time(S)	StrainX_4	StrainX_5	StrainX_6						
2nd Goos	181.4	0	0	0						
2nd Goos	182.4	0.02448	0.02443	0.02512						
2nd Goos	183.4	0.04696	0.04739	0.0492						
2nd Goos	184.4	0.06915	0.06983	0.07204						
2nd Goos	185.4	0.08994	0.09044	0.09307						
2nd Goos	186.4	0.10994	0.11052	0.11394						
2nd Goos	187.4	0.13117	0.13203	0.13574						
2nd Goos	188.4	0.15236	0.15373	0.15853						
2nd Goos	189.4	0.17472	0.17701	0.18233						
2nd Goos	190.4	0.19704	0.19955	0.20549						
2nd Goos	191.4	0.21951	0.222	0.22825						
2nd Goos	191.5	0.22055	0.2223	0.22813						
Coordinate Strain Y - Values (16 point least squares average) (Grid Cells are numbered from the top left corner -										
FileName	Time(S)	StrainY_4	StrainY_5	StrainY_6						
2nd Goos	181.4	0	0	0						
2nd Goos	182.4	0.01942	0.02171	0.02187						
2nd Goos	183.4	0.04246	0.04261	0.03932						

Figure 7: Sample Exported Data.

Exporting Images and Movies

The current Image view, including all displayed tracking grids, tracking data and overlaid data can be exported as a metafile by selecting *Current Image* from the *Export* menu. Alternately, the current image view can be copied to the clipboard by pressing *Ctrl-C* on the keyboard.

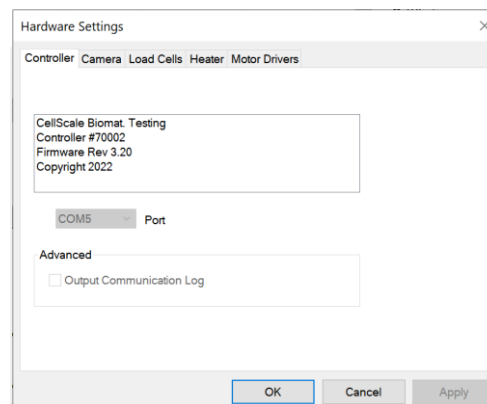
To export a series of image views, including all displayed tracking grids, tracking data and overlaid data as an .avi movie, select *Movie* from the *Export* menu. The dialogue shown on the right will be displayed. The image list is automatically set to the currently selected images in the test image list tree. This image list can be changed by selecting new images in the test image list tree and pressing the Set button. Options are available for setting the frame rate or image size (resolution), adding filenames, and choosing color or grayscale output. File compression options are also available.



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.



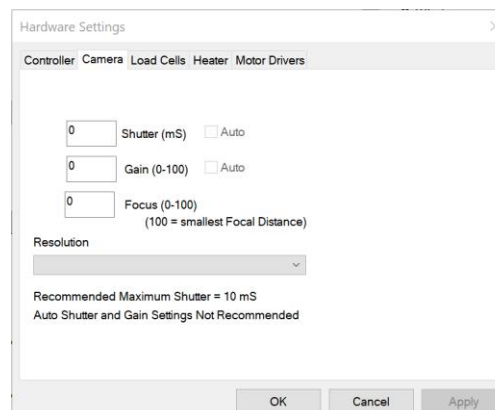
Camera

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).

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* (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.

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 low forces (1N, 2.5N, 4.5N), medium forces (10N, 20N, 50N, 100N, 200N) and high forces (500N, 1kN). Each load cell has a unique calibration factor which is stored in a chip contained in the load cell connector. For low and medium force load cells, an additional calibration check 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



Hardware Settings

Controller Camera Load Cells Heater Motor Drivers

Primary Axis

Full Scale (N)
10

Cal. Factor (mV/V)
25.23

Serial Number
1203165

OK Cancel Apply

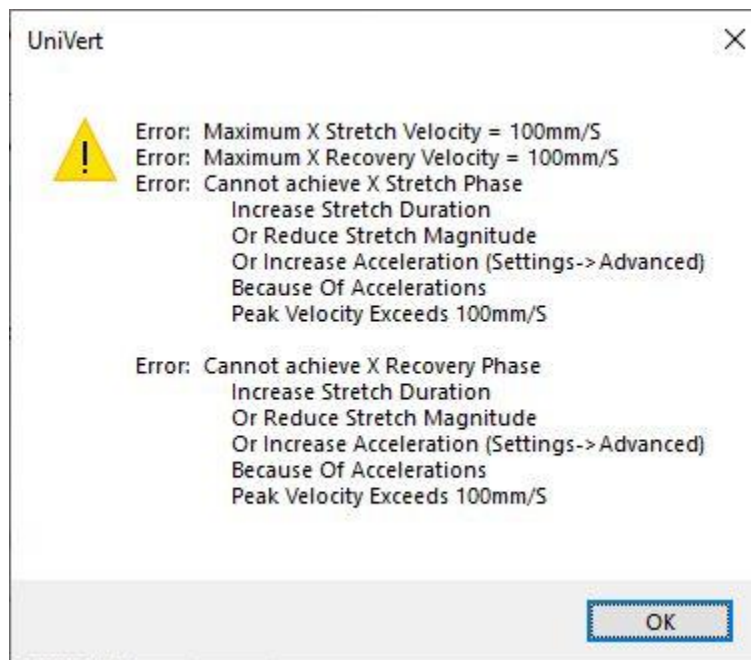
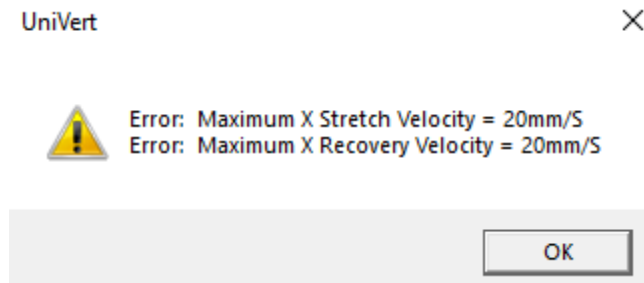
The load cells are sampled at 100Hz, with hardware providing an 8-sample averaging to reduce noise in the data. Further sample averaging can be implemented by selecting *Advanced* from the Settings menu.

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 recommended (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.

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 Settings** 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.

Hardware Settings

Controller: Camera Load Cells **Heater** Motor Drivers

37 Setpoint (°C)

Warnings

☐ Show Warnings if Temperature Not within Setpoint Tolerance

1 Tolerance (°C)

Control Settings (PID)

Kp	Ki	Kd
1.7	0.007	0

OK Cancel Apply

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 bath's heater plate (located at rear for vertical bath and bottom for horizontal bath) when the heater is on, it can become very hot! Only handle hot equipment with protective clothing, such as gloves.

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 calibrated and programmed in house during manufacturing and quality assurance.

For load cells under 200N, calibration can be performed in the field. A set of calibration weights (not included with system) is required to complete this process. When the load cells are set up for the first time, changed, or moved it is advisable to perform a load cell calibration. See the steps below on how to calibrate the load cells.

Due to high-capacity requirements for load cells over 200N, it is not recommended to use test weights to perform a calibration. CellScale offers calibration services for our load cells. Please contact us at www.cellscale.com for more information.

1. Attach the load to the moving bracket with the Fixture Adapter facing upwards.



2. Attach the upper compression platen to the load cell with the Quick Release Pin and Fixture Locking Disc.



3. Remove any fixtures that may be attached to the Mounting Plate.
4. Carefully jog the actuator downward until the load cell is near the base plate of the UniVert.



5. From the Tools menu select *Load Cell Calibration*

Load Cell Calibration (Free Weights)

1. Select Axis
Primary

2. Zero Load Cells
Zero Load Cells

3. Choose Units
Grams

Jog Speed (1-10)
5

4. Apply Weights
Enter Weight (g)
0
Read Load Cell
Read
FullScale Load (g)
1000
Serial Number
1203165
For best Results:
Apply at least 2 different weights covering most of the load cell range

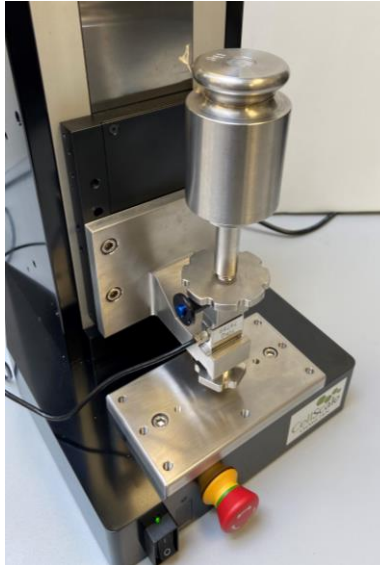
5. Calculate
Run
Calculated Calibration Factor (mV/Vexcitation fullscale)
0
R-Squared
0

6. Apply Calibration Factor
Factory Calibration Factor
1.50178568
Current Calibration Factor
1.50178568
Use Calculated Calibration
Use Factory Calibration
Continue with Current Calibration

Note: Soft Range Limits for Force are template specific.
You may wish to adjust Force Soft Limits when changing load cells.
Soft Range Limits can be set by selecting Range Limits from the Settings menu.

Done


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 **25%-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. If desired, repeat steps 7 and 8 for multiple weights covering most of the load cell range. However, at least 2 weights within the load cell range is recommended.
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
 - b. *Use Factory Calibration* will restore the factory calibration factor
 - 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

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.*

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.

Current Size (mm)	25.192
-------------------	--------

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.

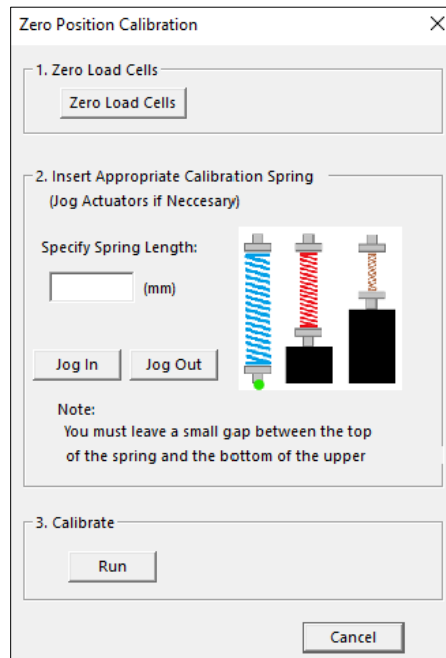
An actuator zero position is preset during manufacturing and quality check. However, the zero position should be re-calibrated on initial system setup and whenever the grips, platens, or load cells are changed. Changing these components will always alter the zero position slightly.

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 fixtures. The calibration utility slowly moves the fixtures to lightly compress the spring to a set load. It then assigns a set position based on the initial size of the spring, amount of displacement, and the spring constant.

To calibrate the zero position, follow these steps:

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



Zero Position Calibration

1. Zero Load Cells

Zero Load Cells

2. Insert Appropriate Calibration Spring
(Jog Actuators if Necessary)

Specify Spring Length:

(mm)

Jog In Jog Out

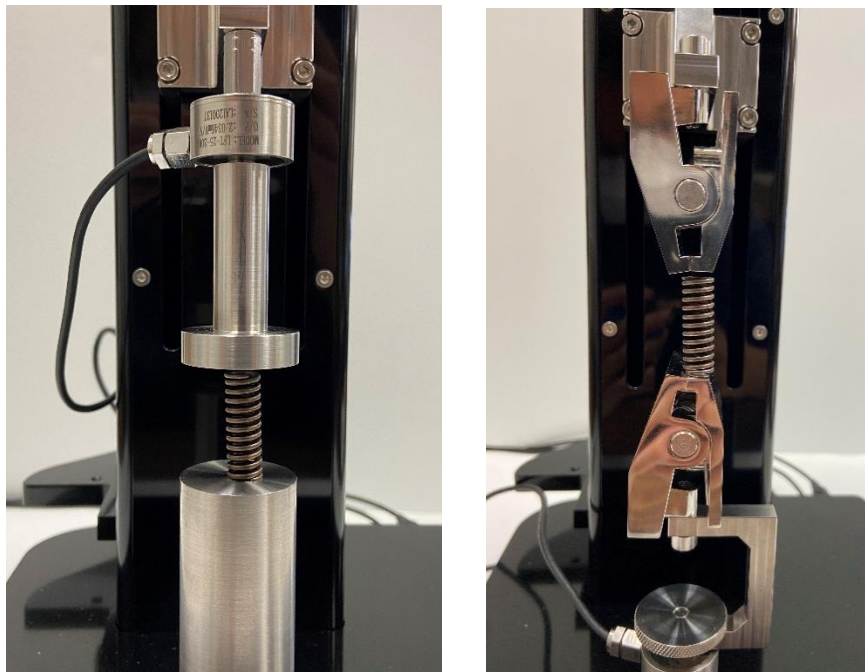
Note:
You must leave a small gap between the top of the spring and the bottom of the upper

3. Calibrate

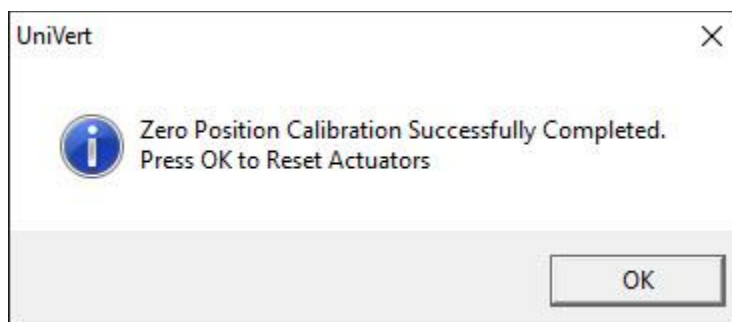
Run

Cancel

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.

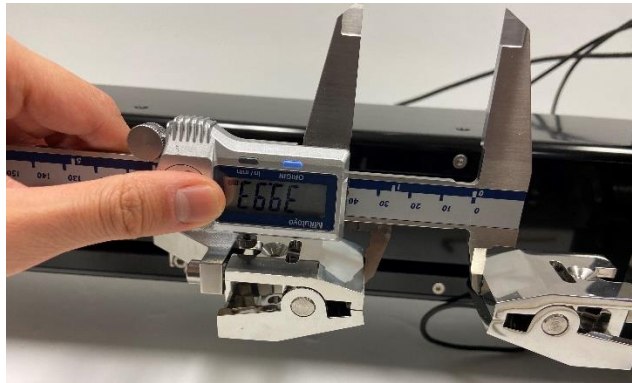
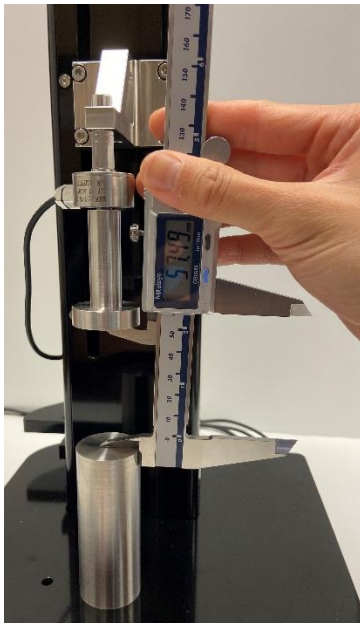


Custom Position Calibration

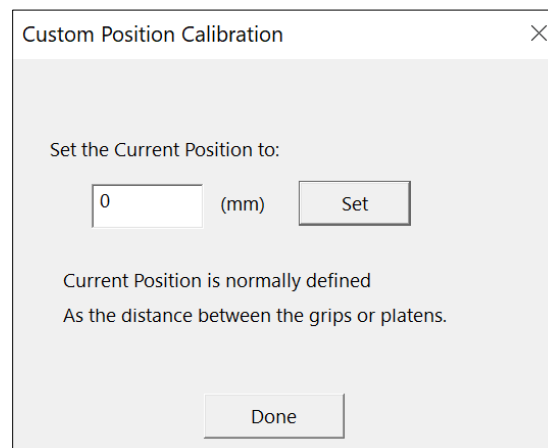
Alternatively, the UniVert position can be defined with the use of digital or vernier calipers.

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).

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 displacing 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).

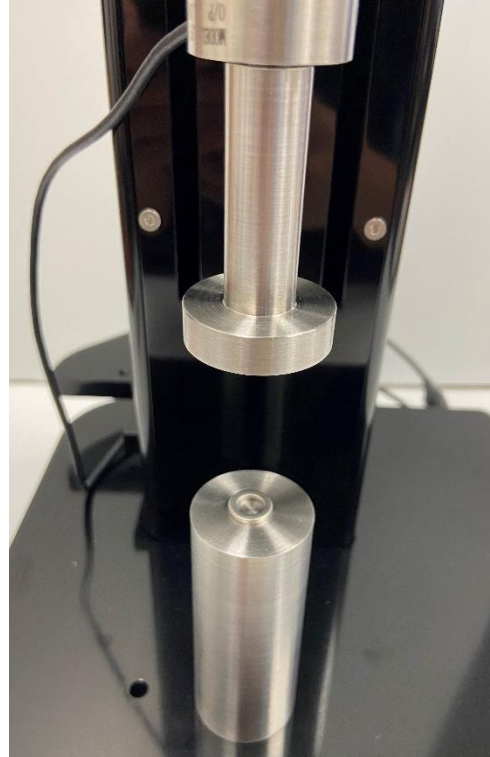
UniVert Tip: When to Apply System Stiffness Compensation

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: $\frac{100 \mu\text{m}}{10 \text{ mm}} = \frac{0.1 \text{ mm}}{10 \text{ mm}} = 1\%$

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

If system stiffness compensation is enabled, 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.



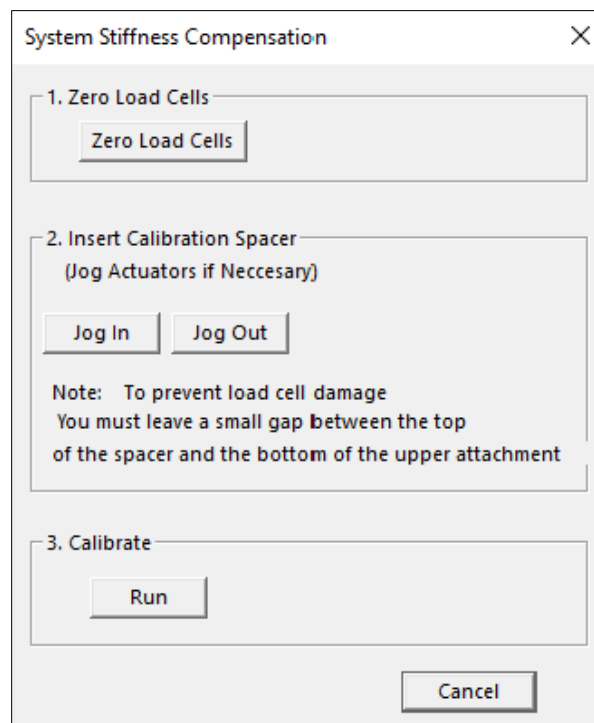
After placing the calibration spacer, slowly jog the platens together until there is a very small gap between the upper platen and the spacer. If this gap is too large, the software utility will take a very long time to run. However, do not allow the upper platen and the spacer to come in contact. **If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

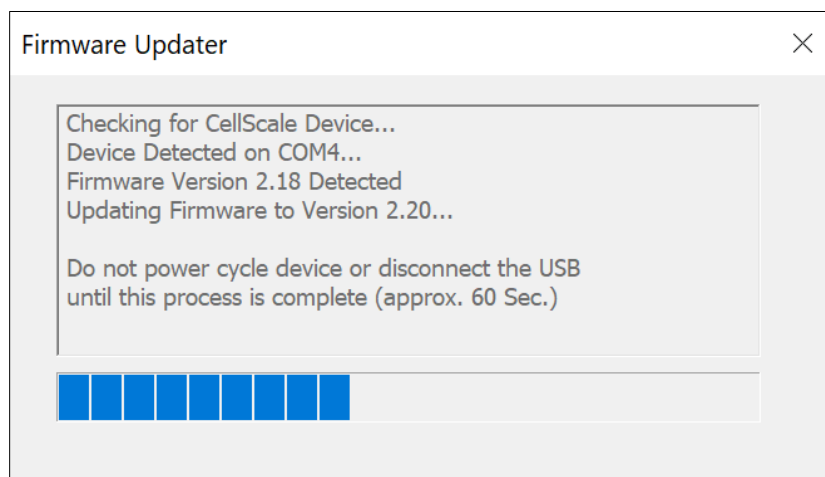
This feature allows the user to capture a single image during the setup phase. This can be useful for documenting specimen loading activity and neutral (non-contact) beam position.

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).

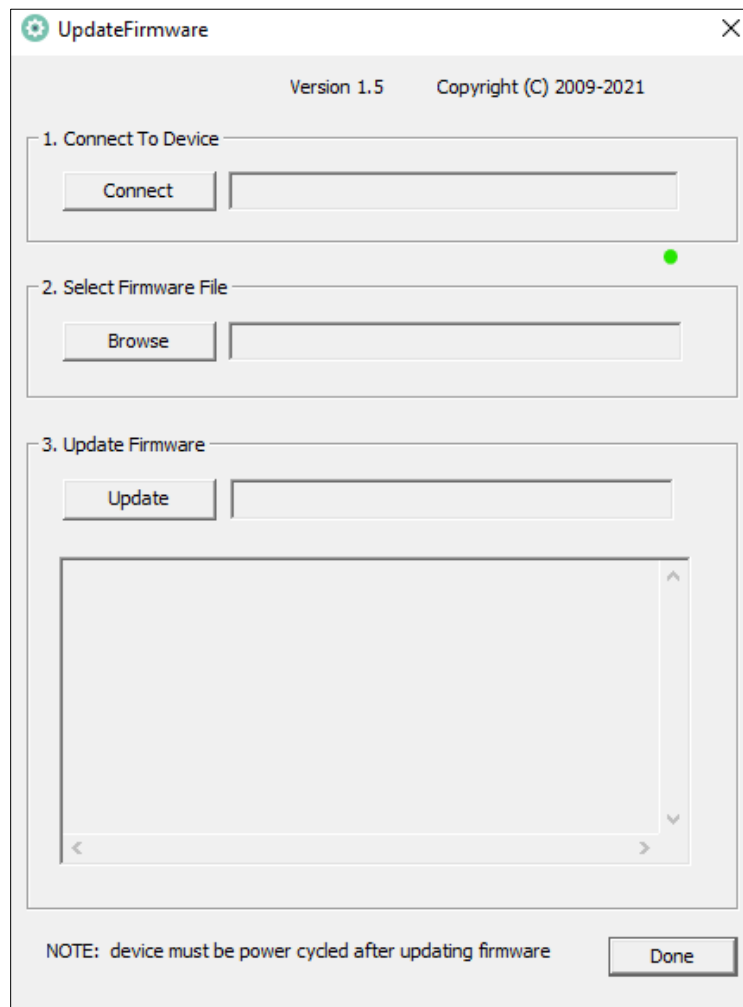
To update the firmware:

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



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

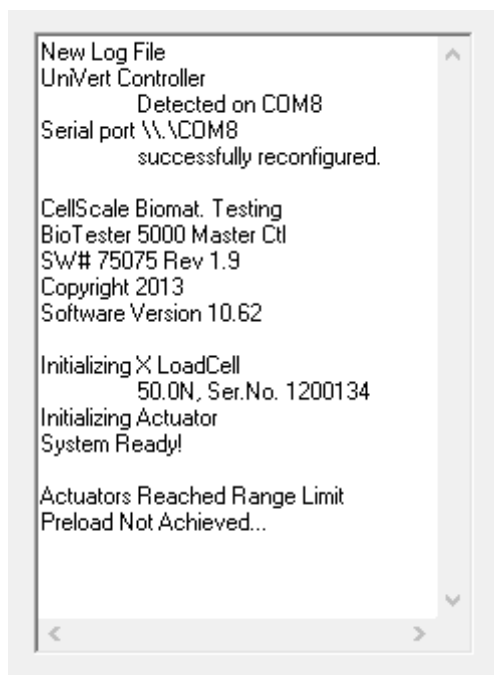
We recommend plugging the UniVert (and host computer) into an uninterruptable power supply (UPS) or battery back-up.

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:

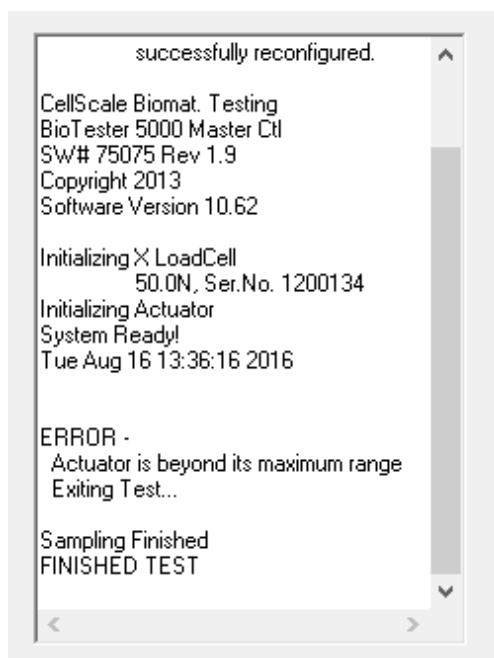
Moving the actuator out of range with *Move to Force* :

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:

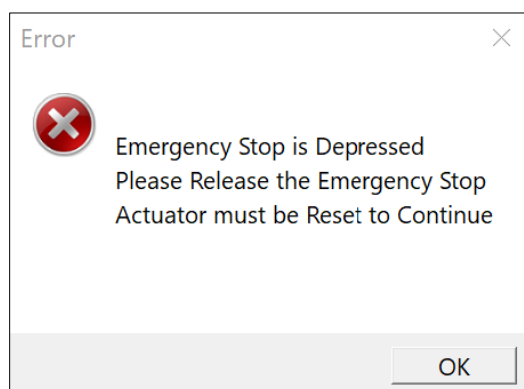
**UniVert Tip: Zero Position Calibration**

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

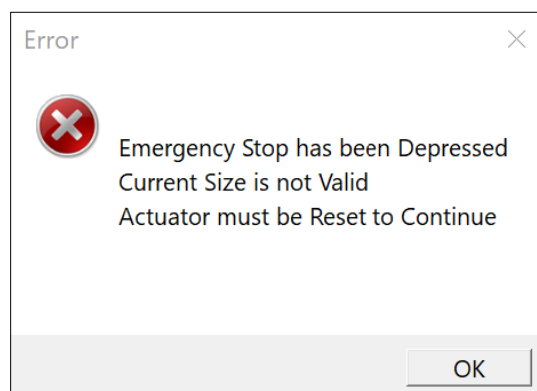


If the Emergency Stop (E-Stop) has been depressed, a new test cannot begin until it has returned to the disengaged position. Twist the red E-Stop button on the UniVert controller in either direction and this will allow the switch to pop out again.



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.



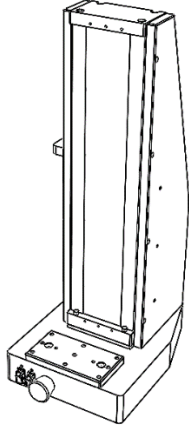
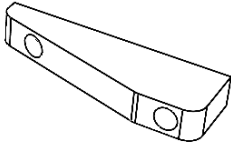
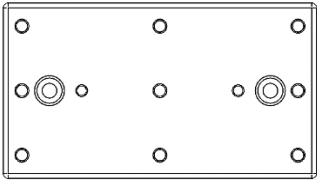
Appendix A: Unpacking and Initial Setup

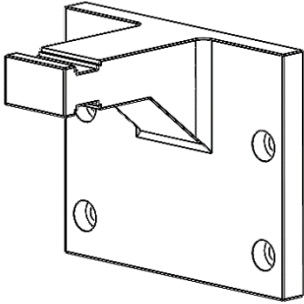
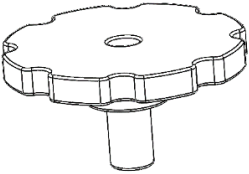



The system components listed below may be unpacked and laid out before system setup. A clearance space (L x W x H) of 25cm x 35cm x 60cm and 60cm x 35cm x 25cm is required for vertical and horizontal configuration setup respectively.

Tools

Hex keys (2mm, 2.5mm, 3mm, 4mm, and 5mm)

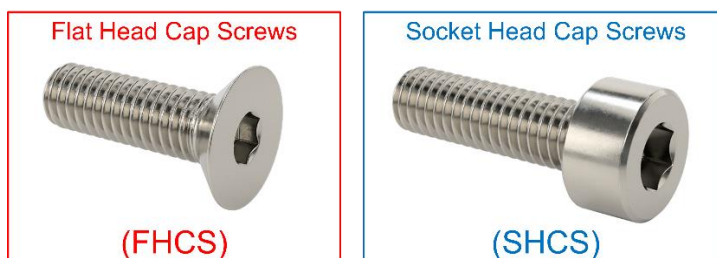
Main System Components

Item Name	Item	Quantity
UniVert Main Unit		1
Pivot Wedge		1
Mounting Plate		1

Motor Bracket		1
M6 Thumb Nut		1
Calibration Spring		1
Sample Test Specimens		4
Stiffness Compensation Spacer		1

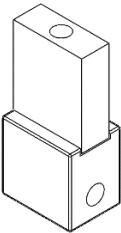
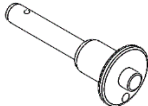

Camera		1
Tripod		1
24V Power Supply		1
USB Cable		1


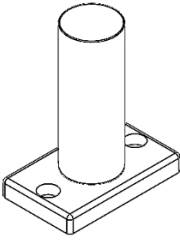
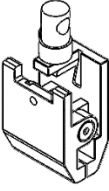
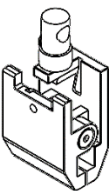
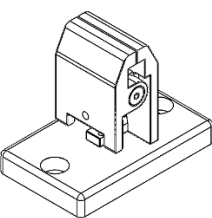
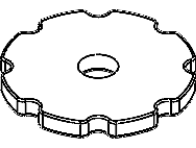
Main System Fasteners

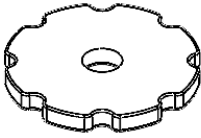


Size	Purpose	Quantity
M4x10 SHCS	Mount Pivot Wedge to Main Unit	2
M6x12 SHCS	Attach Motor Bracket to Motor	4
M6x12 SHCS	Attach Mounting Plate to Main Unit	2

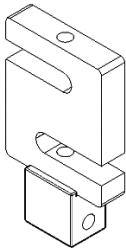
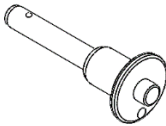
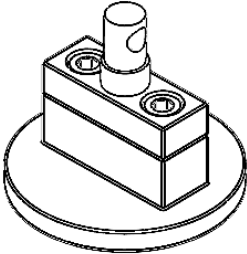
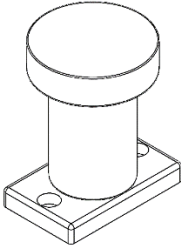
Medium Force (10 – 200N) Accessories

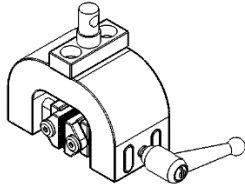
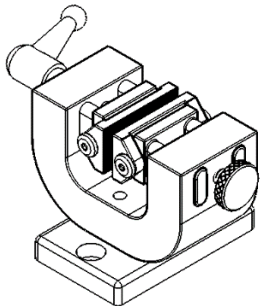
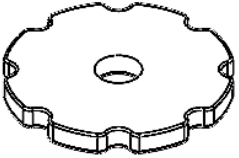
Item Name	Item	Quantity
Load Cell with Fixture Adapter (10 – 200N Range)		1
Quick Release Pin		1
Plastic Upper Compression Platen (For 10 – 20N Load Cell)		1

Stainless Steel Upper Compression Platen (For 50 – 200N Load Cell)		1
Lower Compression Platen		1
Plastic Medium Force Upper Specimen Grip (For 10 – 20N Load Cell)		1
Stainless Steel Medium Force Upper Specimen Grip (For 50 – 200N Load Cell)		1
Medium Force Lower Specimen Grip		1
Plastic Fixture Locking Disc (For 10N – 20N Load Cell)		1

Stainless Steel Fixture Locking Disc (For 50N – 200N Load Cell)		1
---	---	---

High Force (500N – 1kN) Accessories

Item Name	Item	Quantity
Load Cell With Fixture Adapter (500N – 1kN)		1
Quick Release Pin		1
Upper Compression Platen		1
Lower Compression Platen		1

<p>High Force Upper Specimen Grip</p>		<p>1</p>
<p>High Force Lower Specimen Grip</p>		<p>1</p>
<p>Fixture Locking Disc</p>		<p>1</p>

Unpacking Steps

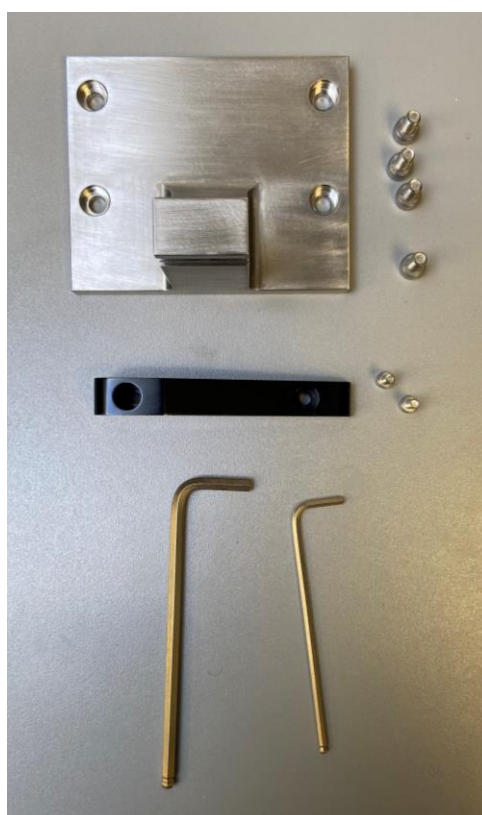
Step 1: Unpack the main unit and the accessories

Remove the top layer of packaging foam from the box. With the assistance of a second person, carefully lift the device from the box using the grab handles. Place the device upright on your work surface as shown below.

Be careful when handling the device as it weights approximately 40lb (18kg). See **Appendix C: Device Handling and Test Setup** for more details on device handling.

Remove and dispose of the temporary grab handles using a 5mm hex key.

Unpack the remaining accessories. Set aside the main unit, 2x M4x10 SHCS, Pivot Wedge, 4 x M6x12 SHCS, Motor Bracket, 3mm hex key and 5mm hex key.



Step 2: Attach Motor Bracket to Motor

Attach the Motor Bracket with 4 x M6x12 SHCS using the 5mm hex key.

To increase stroke length slightly, you may mount the Motor Bracket with the crosshead facing upwards and/or use the upper set of mounting holes.

***Step 3: Attach the Pivot Wedge to the main unit***

Attach the Pivot Wedge to the side of the UniVert with 2 x M4x10 SHCS using a 3mm hex key.



Step 4: Install the UniVert software

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

Step 5: Set up the load cell and test fixtures

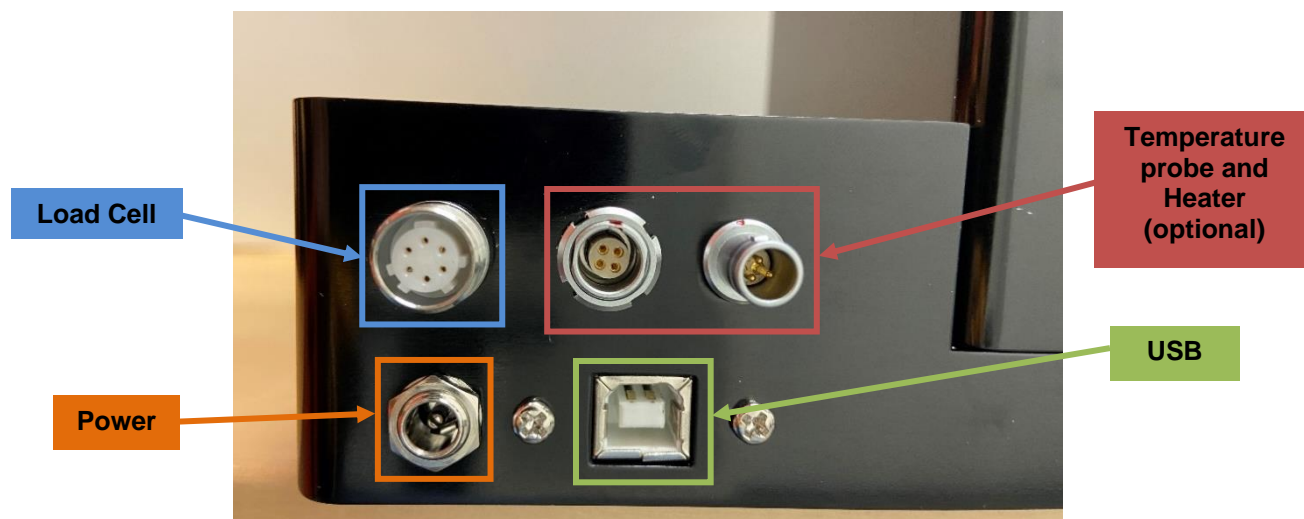
See **Appendix C: Device Handling and Test Setup** for this procedure.

Step 7: Connect all necessary cables to the UniVert

A 24V 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.

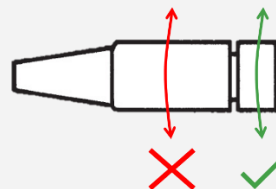
The load cell connector has a keyway inside the connector and a locking ring to ensure proper connection. To connect a load cell, align the keyway, push the connector in, and turn the threaded locking ring until tight. Note that this may require several turns to lock in place.

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 E: Media Bath Setup** for more detail on how to set up the media bath).



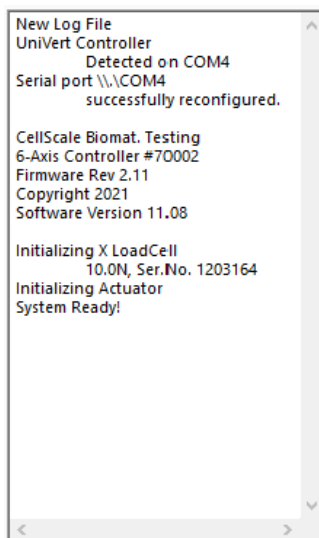
System Alert: Load Cell connector

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: Set the Actuator Zero Position

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

Step 10: Begin Testing

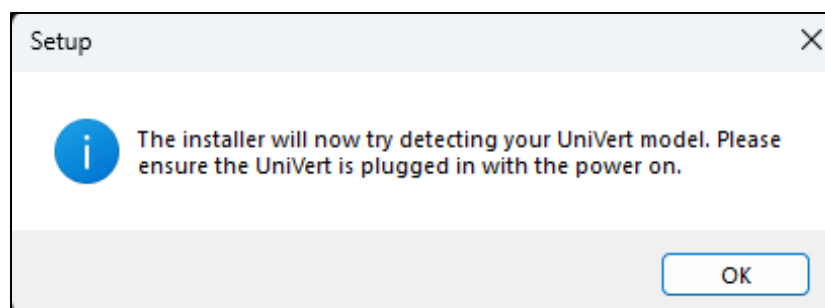
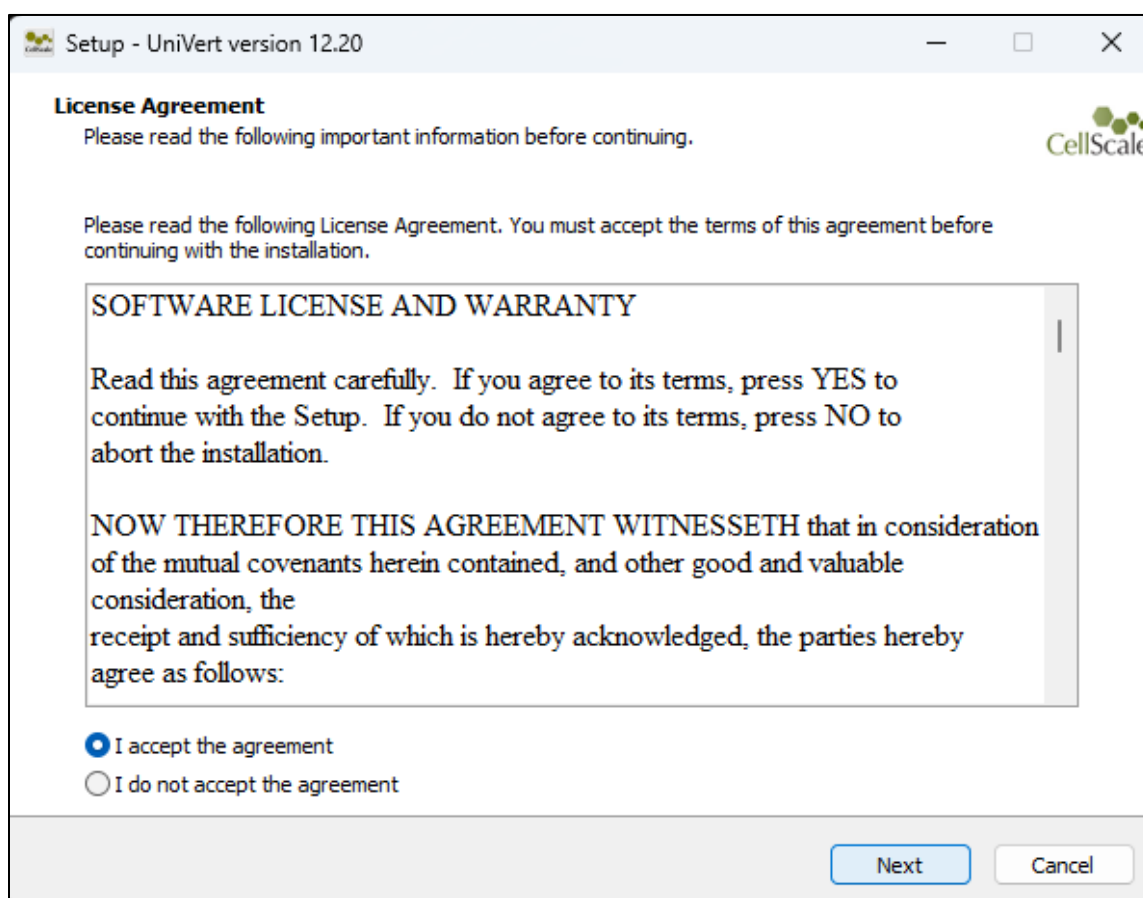
It is recommended that the User's Manual be thoroughly reviewed before beginning testing using the UniVert system. Procedures for loading samples, setting up tests, carrying out tests, and reviewing results are described in detail.

Appendix B: Software Installation

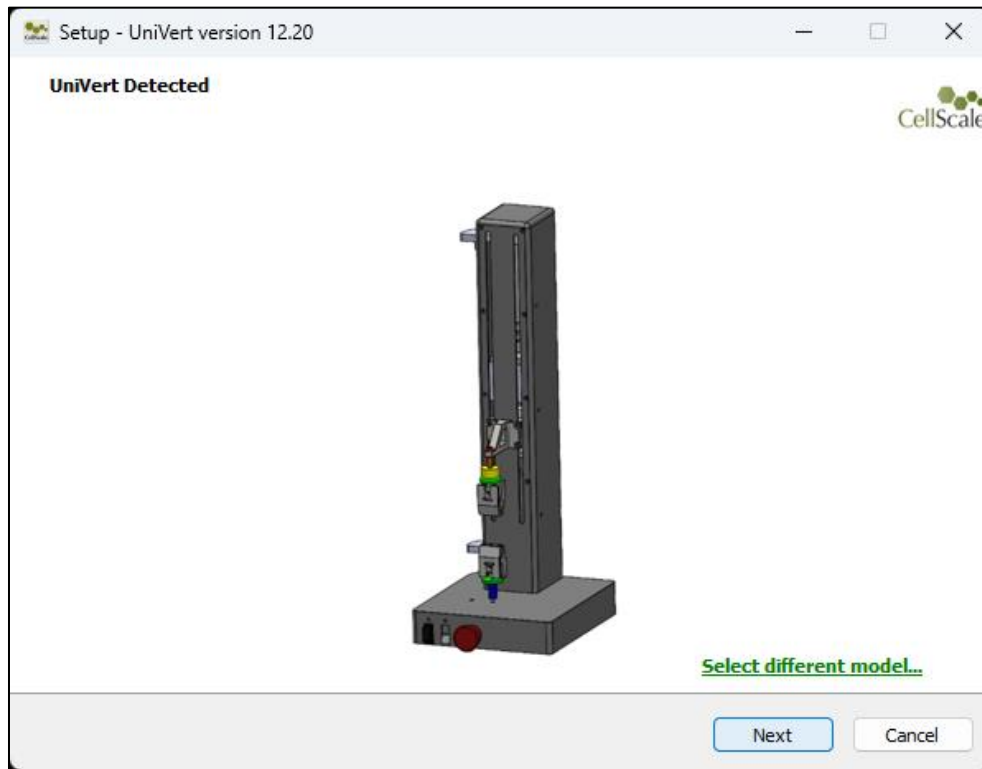
A Windows based PC (Windows 10 or above) with at least 1 USB ports is required to operate the UniVert (2 USB ports are required for the imaging feature). Go to www.cellscale.com/downloads to download the latest UniVert software package. The package contains the software installer for the user interface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

To install the software:

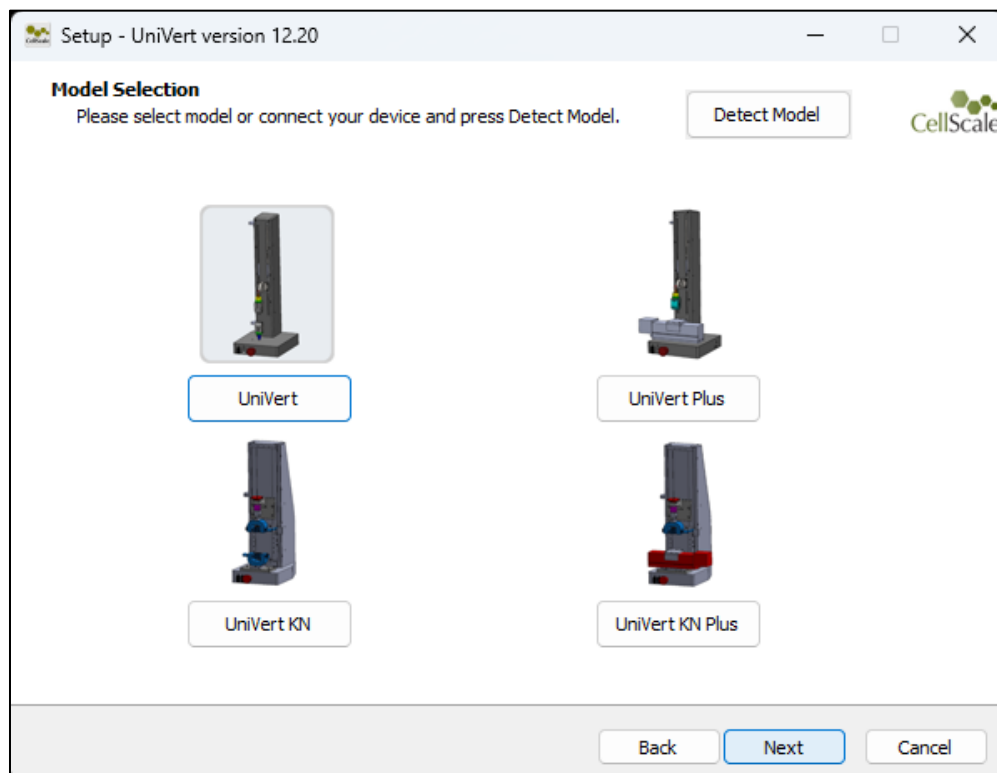
1. Go to the provided web address and download the compressed installation package.
2. Transfer this file to the computer which will be running the UniVert device.
3. After this is complete, go to the uncompressed installation folder and select *UniVert Installer.exe*. Details of typical dialogue boxes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

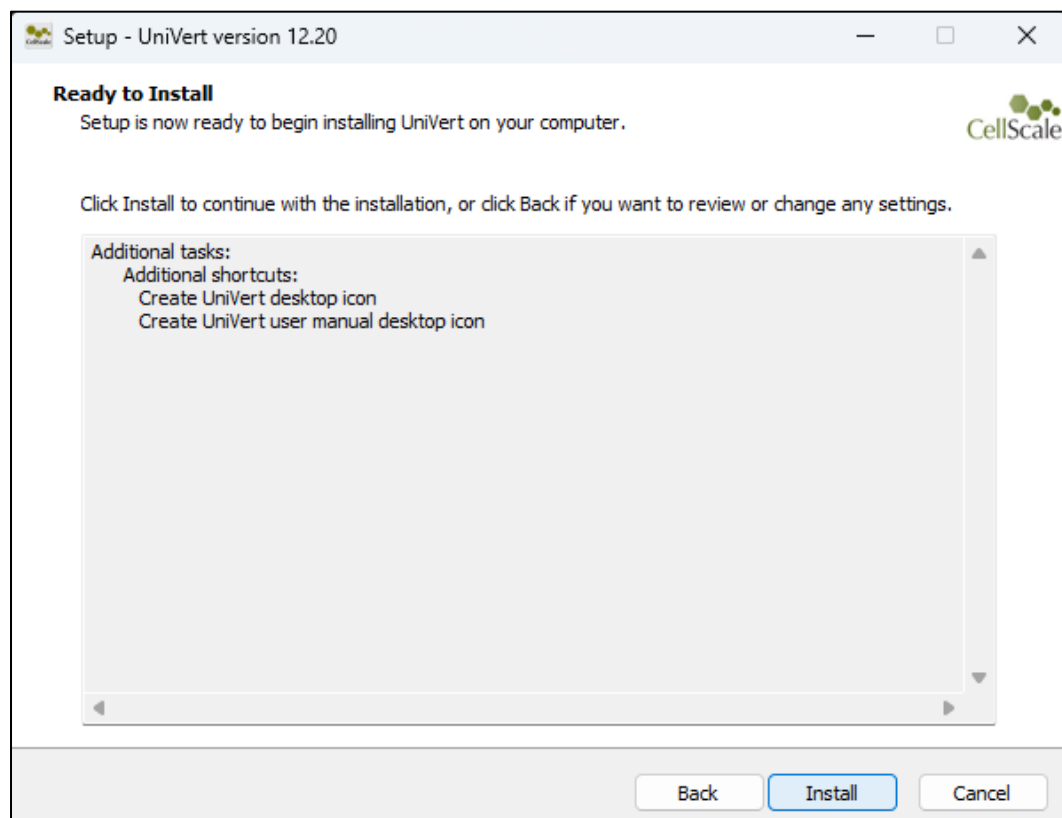
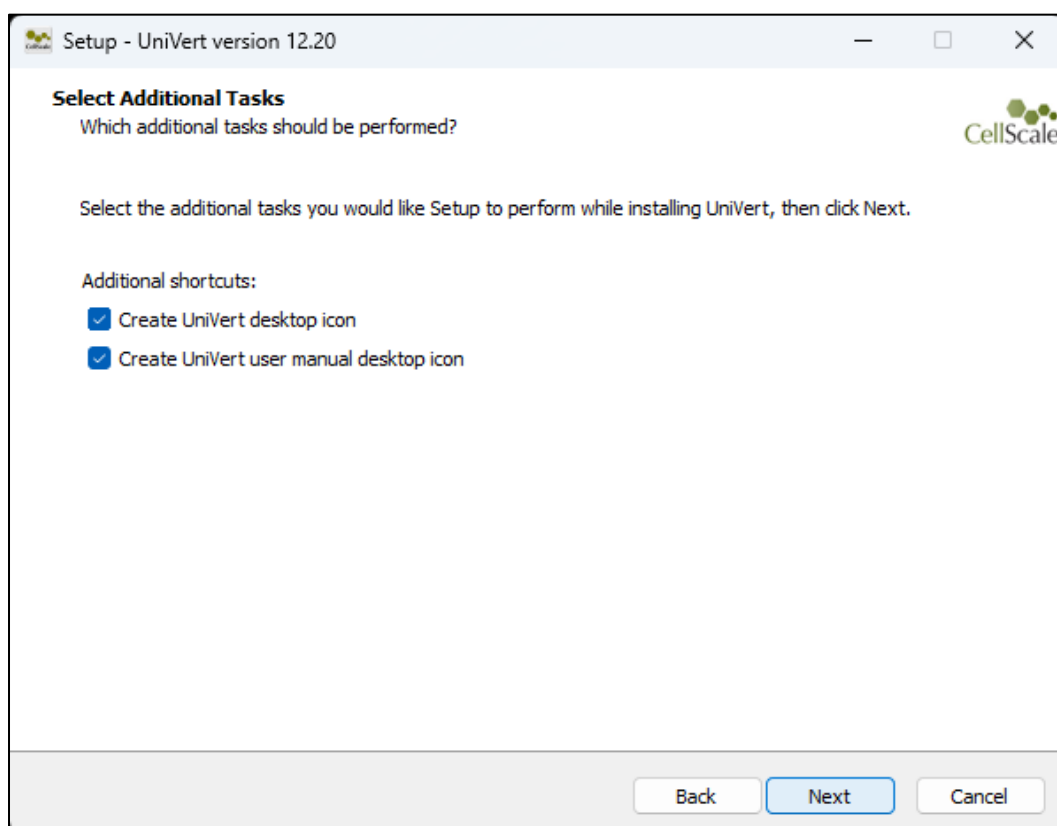


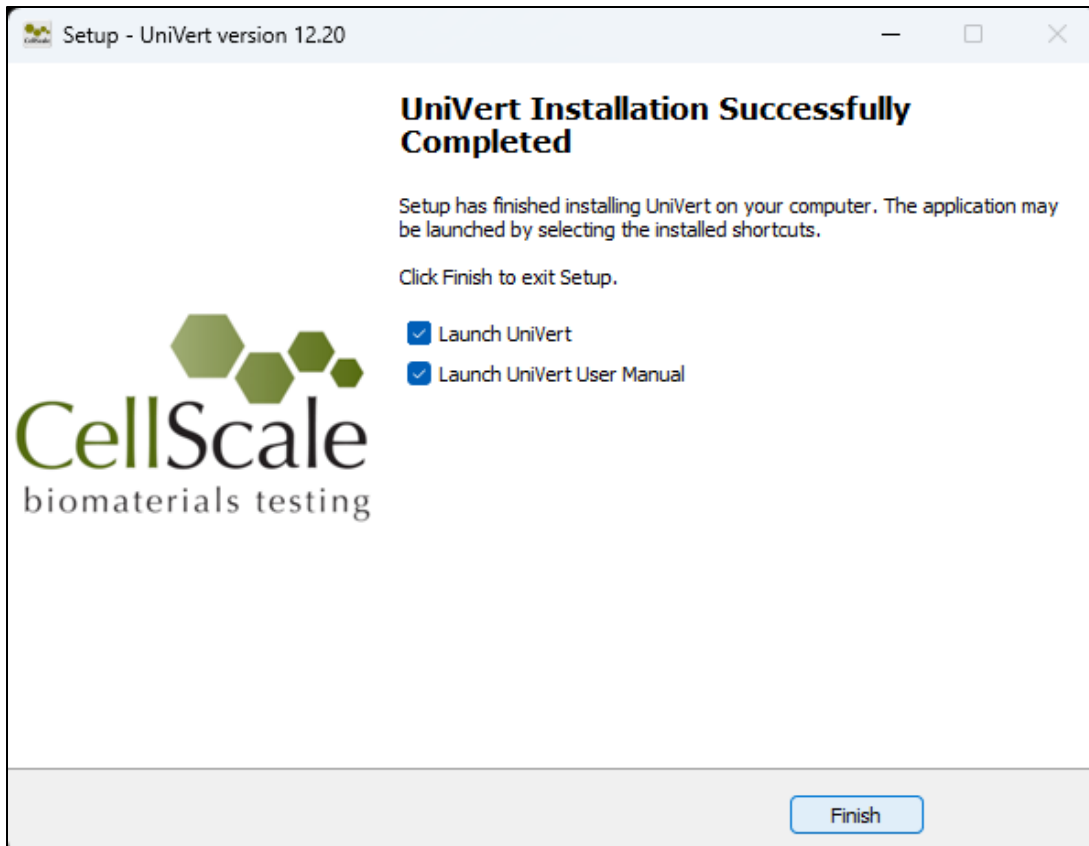
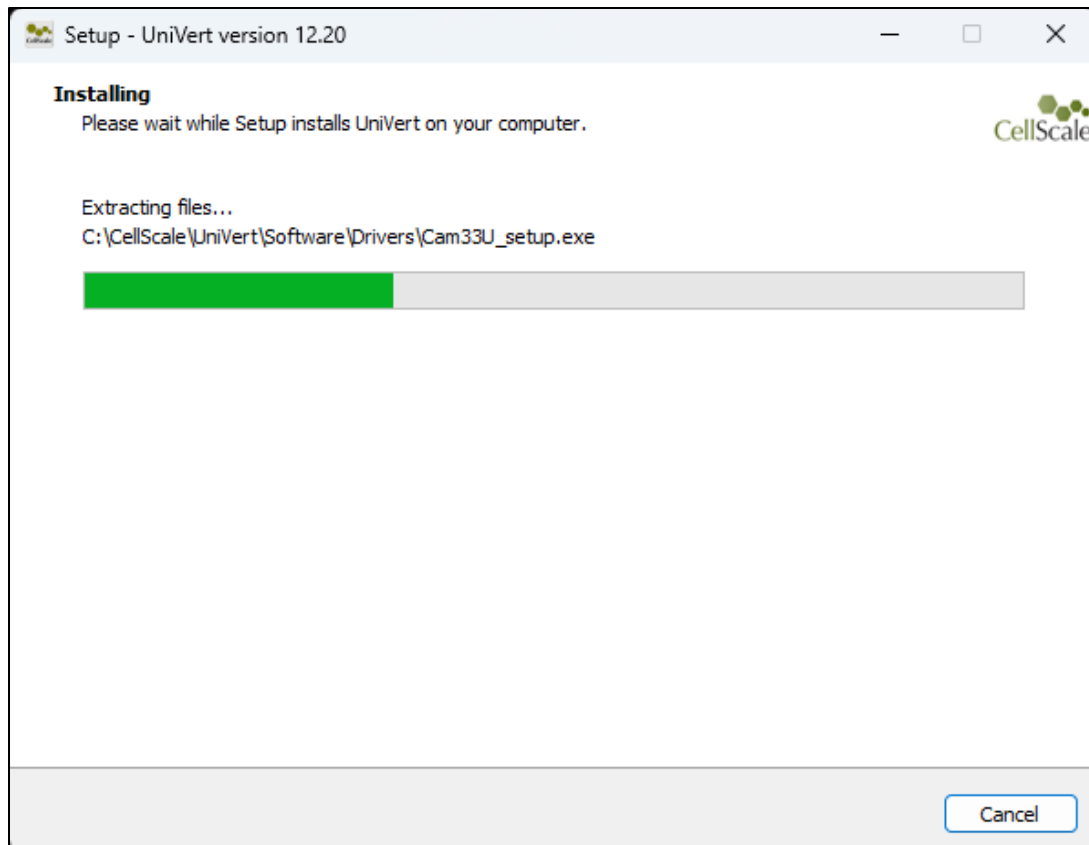
If your UniVert is detected this screen will popup:



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.







Appendix C: Device Handling and Test Setup

The UniVert can be used in vertical or horizontal configurations. The UniVert base plate includes a mounting plate with a series of threaded holes to attach various test fixtures/accessories. Generally, the centre row of holes will be used for in-line axial testing.

If a Media Bath is used, see **Appendix E: Media Bath Setup** on proper load cell and fixture attachment as they will vary from the section below.

Device Handling

The UniVert kN system without fixtures or accessories weights approximately 40lb (18kg) and should be handled with the assistance of a second person. Handling can include moving the UniVert to a new location or tilting the device between vertical and horizontal configurations.

To orient the UniVert between vertical and horizontal configuration:

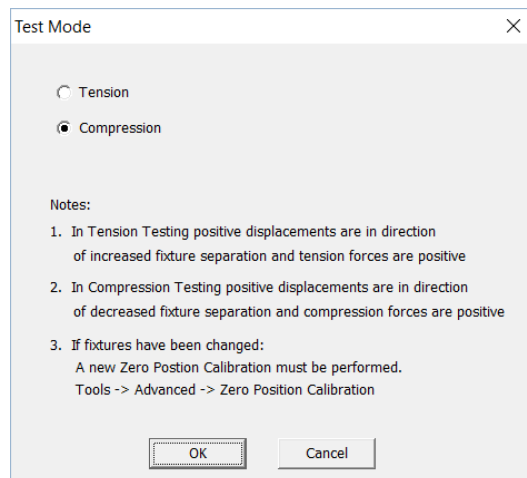
1. Ensure there is enough room on your work bench to place the device horizontally or enough overhead space to plate the device vertically.
2. One person should support the device at the base plate while the second person tips/lifts the tower of the UniVert into the desired orientation.
 - a. From vertical to horizontal configuration: tilt the UniVert to the left (when facing the front panel) until it is supported by the Pivot Wedge.
 - b. From horizontal to vertical: lift the UniVert towards the right until the base plate is against your work bench.

To move/carry the UniVert to another location:

1. Ensure there is enough room at the new desired location for the UniVert before moving the device.
2. Orient the UniVert to its horizontal configuration (see steps above).
3. Support both the tower and baseplate end of the UniVert. One person on either side of the device.
4. Carefully lift the UniVert to move it to the new location.
5. Be careful when setting the device back down as to not crush your fingers or hands between the device and work bench.
6. If desired, orient the UniVert back to the vertical orientation (see steps above).

Tension Test Setup

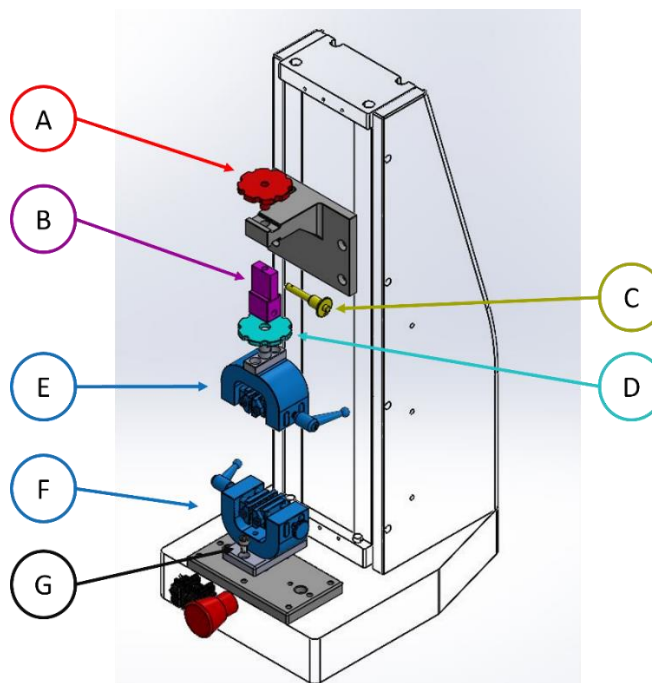
Set the test mode to Tension (*Settings>Test Mode>Tension*) in the software. This setting is specific to the test template being used and can be saved to a template.



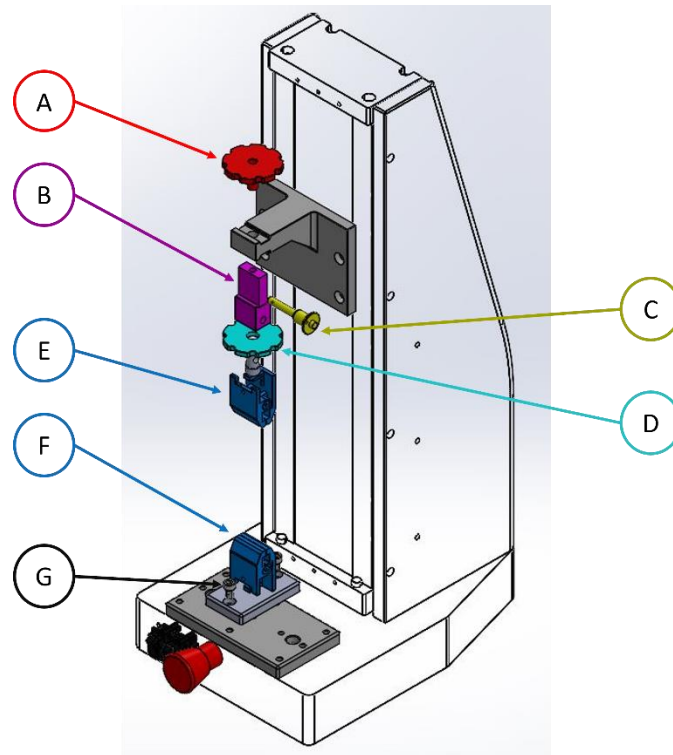
The following components are required for tension test setup:

- a) M6 Thumb Nut
- b) Load Cell with Fixture Adapter
- c) Quick Release Pin
- d) Fixture Locking Disc
- e) Upper Specimen Grip
- f) Lower Specimen Grip
- g) M6x10 SHCS
- h) 5mm hex key

For High Force Set up:



For Medium Force Set up:



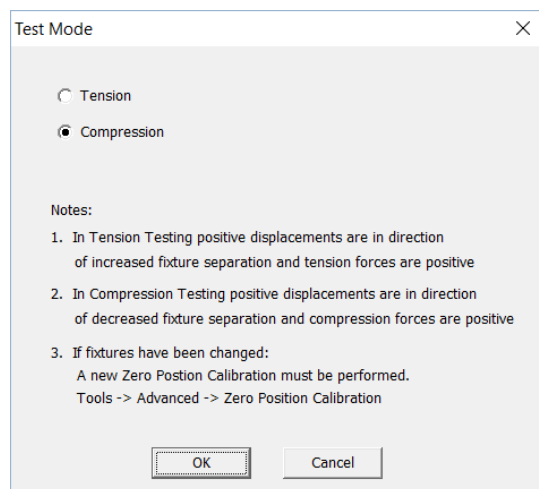
1. Thread the Fixture Locking Disc onto the desired Upper Specimen Grip's mounting pin.
2. Place the Fixture Adapter (pre-installed on load cell) onto the mounting pin of the desired grip.
3. Insert the Quick Release Pin through the Fixture Adapter.
4. Tighten the Fixture Locking Disc against the Fixture Adapter to secure the grip to the load cell.
5. Position the assembly from the previous step in the groove of the Motor Bracket.
6. Place the M6 Thumb Nut through the Motor Bracket and secure it to the load cell

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.

7. Attach the Lower Specimen Grip to the Mounting plate with 2x M6x10 SHCS and 5mm hex key
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.

Compression Test Setup

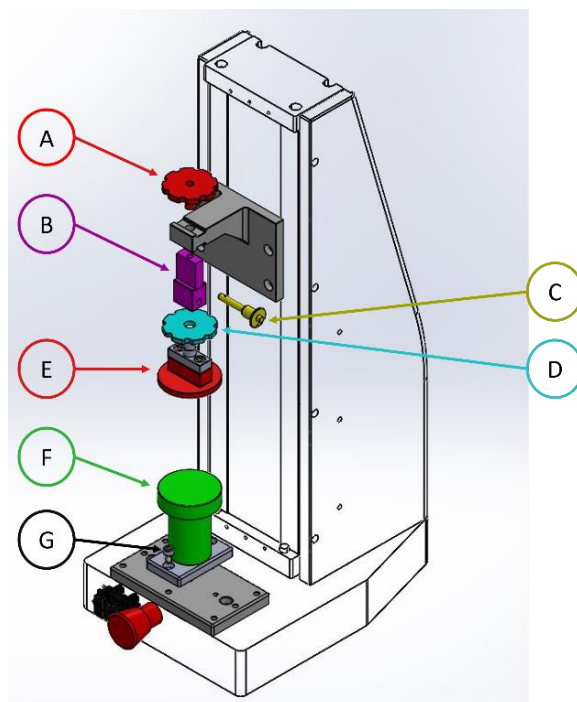
Set the test mode to compression (*Settings>Test Mode>Compression*). This setting is specific to the test template being used and can be saved to a template.



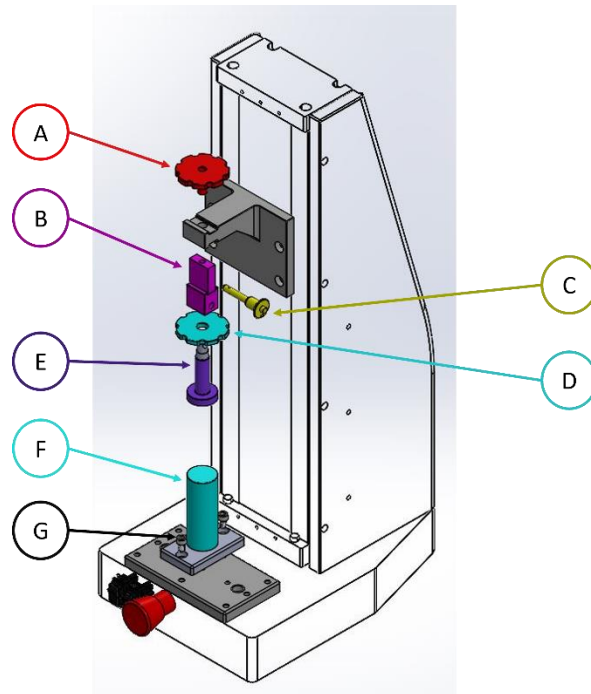
The following components are required for tension test setup:

- a) M6 Thumb Nut
- b) Load Cell with Fixture Adapter
- c) Quick Release Pin
- d) Fixture Locking Disc
- e) Upper Compression Platen
- f) Lower Compression Platen
- g) M6x10 SHCS
- h) 5mm hex key

For High Force Set Up:



For Medium Force Set Up:



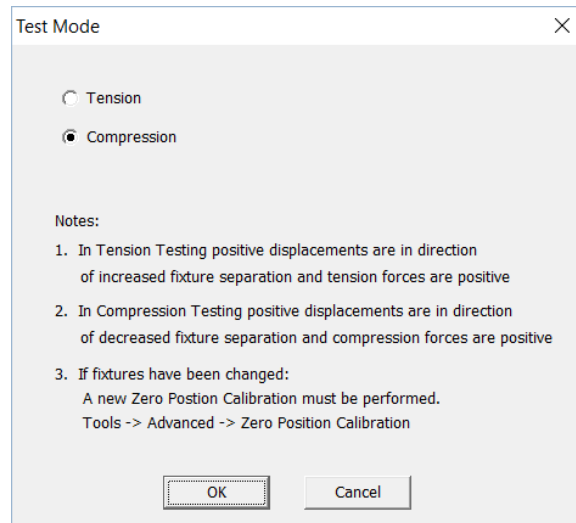
1. Thread the Fixture Locking Disc onto the desired Upper Compression Platen's mounting pin.
2. Place the Fixture Adapter (pre-installed on load cell) onto the mounting pin of the desired grip.
3. Insert the Quick Release Pin through the Fixture Adapter.
4. Tighten the Fixture Locking Disc against the Fixture Adapter to secure the grip to the load cell.
5. Position the assembly from the previous step in the groove of the Motor Bracket.
6. Place the M6 Thumb Nut through the Motor Bracket and secure it to the load cell

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.

7. Attach the Lower Compression Platen to the Mounting plate with 2x M6x10 SHCS and 5mm hex key
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.

3-Point Bend Test Setup

1. Set the test mode to compression (*Settings>Test Mode>Compression*)

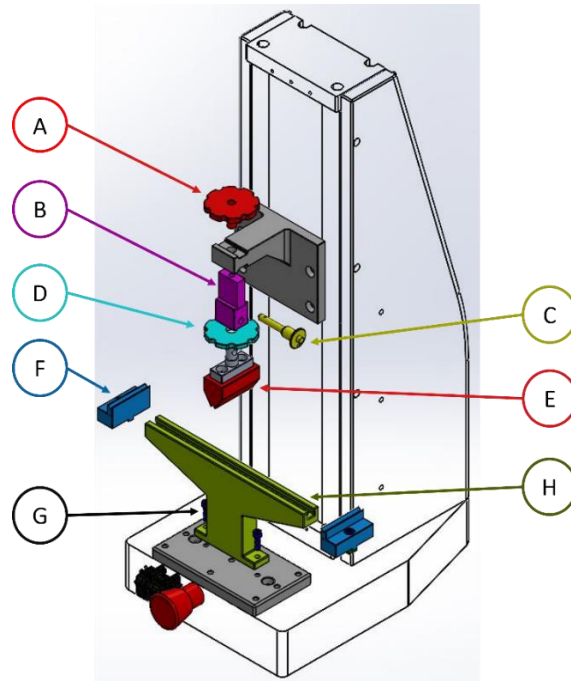


2. Assemble the 3-Point Bending Fixtures:
 - a) Attach M2x6 fasteners on the sides of the sliders and bending block
 - b) Place M5x16 SHCS fasteners through the hole and the square nuts. Place the square nuts through the groove of the 3-point bend rail.
 - c) Use the large O-Rings and small O-Rings as 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).



3. Gather the following components for the 3-point bend set-up:

- a) M6 Thumb Nut
- b) Load Cell with Fixture Adapter
- c) Quick Release Pin
- d) Fixture Locking Disc
- e) Upper 3-Point Bend Block
- f) 3-Point Bend Sliders
- g) Lower 3-Point Bend Rail
- h) M5x16 SHCS
- i) 4mm hex key



4. Attach the 3-Point Bending Block to the load cell:

- Place the Fixture Locking Disc to the mounting pin of the 3-Point Bend Block
- Insert the 3-Point Bend Block to the load cell Fixture Adapter
- Insert the Quick Release Pin
- Tighten the Fixture Locking Disc

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

5. Mount the assembly from the previous step to the Motor Bracket:

- Align the load cell in the groove of the Motor Bracket
- Insert the M6 Thumb Nut
- Tighten the thumb nut to secure the load cell assembly to the UniVert

6. Mount the 3-Point Bend Rail to the base plate with 2x M5x12 SHCS and 4mm hex key

7. Secure both sliders on the rail in the desired position by tightening the fasteners with a 4mm hex key.

Appendix D: 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.

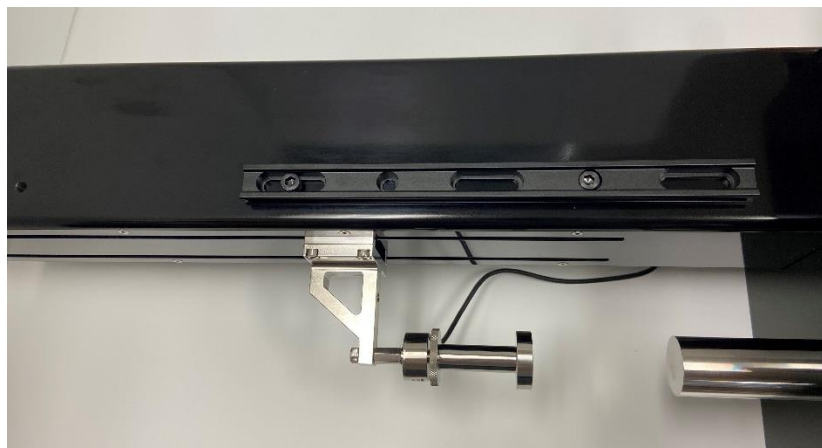
Scientific Camera

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
- M3x8 SHCS
- 2.5mm hex key
- M6x6 SHCS
- 5mm hex key
- Ring light and power supply

1. Remove the lens caps from both the camera and lens, and gently thread the lens onto the camera.
2. Attach your bracket directly to the camera with 2x M3x8 SHCS:
 - a. For use in the Vertical configuration, attach the camera as follows:



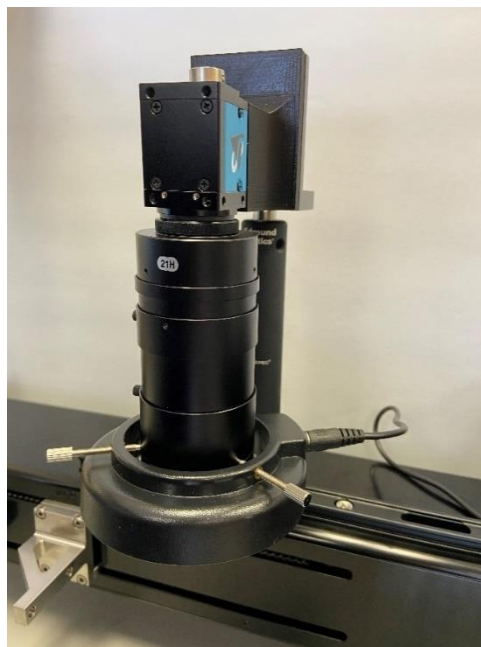
- b. For use in the Horizontal configuration, attach the camera as follows:



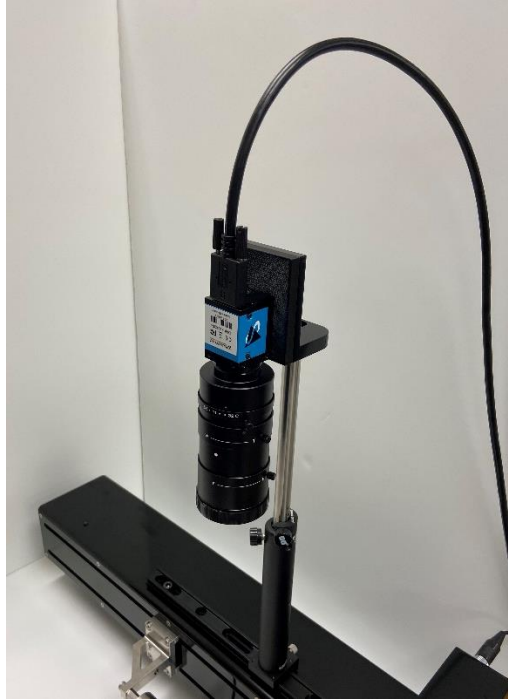
3. Attach the Camera Bracket to the Mounting Post with M6x6 SHCS using a 5mm hex key. Both style of brackets mount to the Mounting Post in the same manner.



4. Attach the ring light to the lens by tightening the set screws and connect its provided power supply.

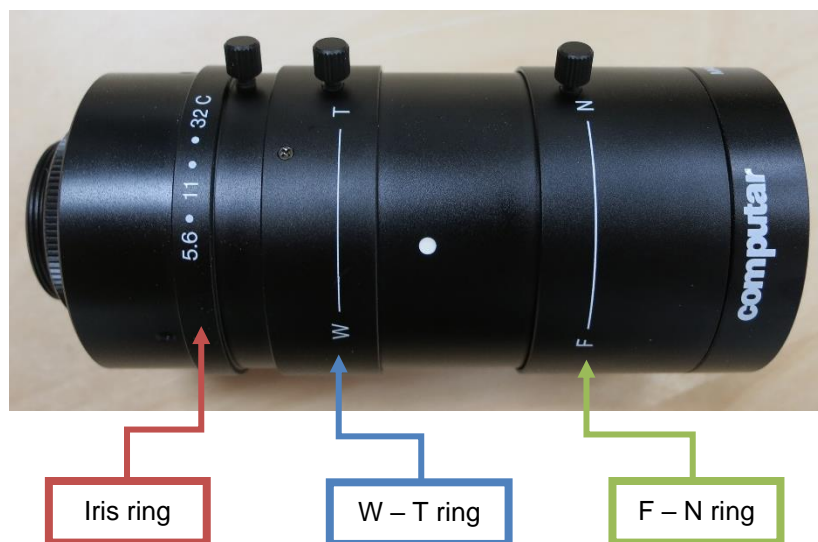


5. Attach the USB cable to the Camera, securing the USB locking screws, and plug the other end into a **USB 3.0** (or higher) port on the PC. These are the typically labeled SS and/or have a blue plastic tab on the connector.



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 E: Media Bath Setup

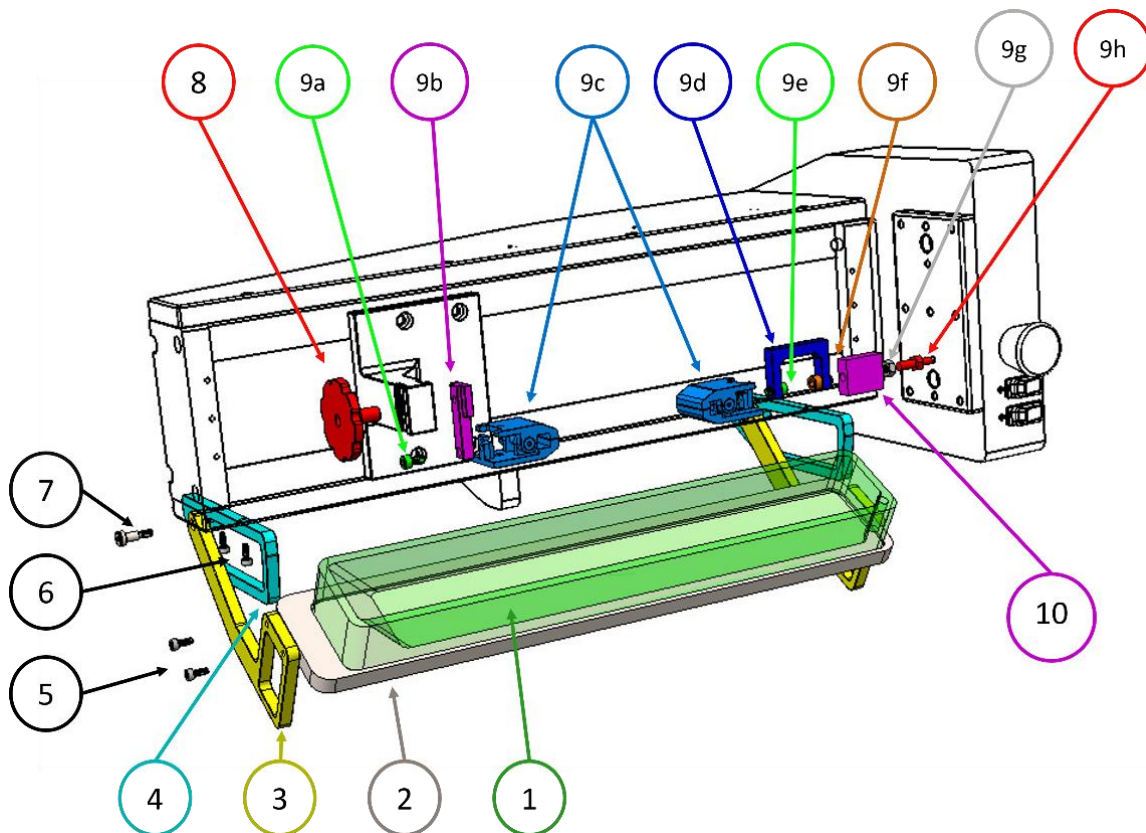
The media bath allows specimens to remain submerged in a temperature-controlled fluid.

Horizontal Media Bath

The Horizontal Media bath is intended to be used only for tension test set ups with forces 200N and below. The Vertical Media bath option will be required for compression tests or tension tests greater than 200N.

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

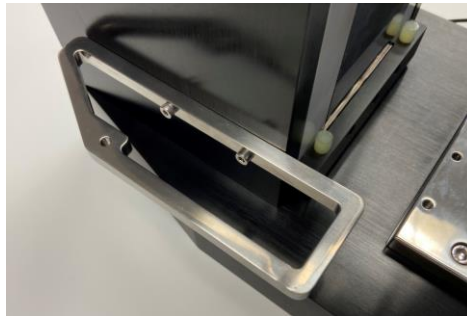
- | | |
|---|---|
| 1) Plastic Fluid Dish | d) M3 or M5 Tension Load Cell Bracket |
| 2) Heater Plate | e) M5x12 SHCS or M3x12 SHCS |
| 3) Heater Plate Support Brackets | f) M6x12 SHCS |
| 4) Horizontal Pivot Brackets | g) M6 Nut |
| 5) 4x M4x16 SHCS | h) M5 to M6 Thread Adapter |
| 6) 4x M4x12 SHCS | 10) Load Cell (without Fixture Adapter) |
| 7) Shoulder screws | 11) Temperature probe |
| 8) M6 Thumb Nut | 12) Heater cable |
| 9) Horizontal bath test fixtures and fasteners: | 13) Syringe |
| a) M5x12 SHCS | 14) 3mm hex key |
| b) Tension No Load Cell Bracket | 15) 4mm hex key |
| c) Specimen Grips | 16) 5mm hex key |
| | 17) Wrench |



1. Remove the Fixture Adapter from the desired load cell by removing the M6 screw with a 5mm hex key.
2. Attach the Heater Plate Support Brackets to the Heater plate with 4 x M4x16 SHCS using a 3mm hex key.



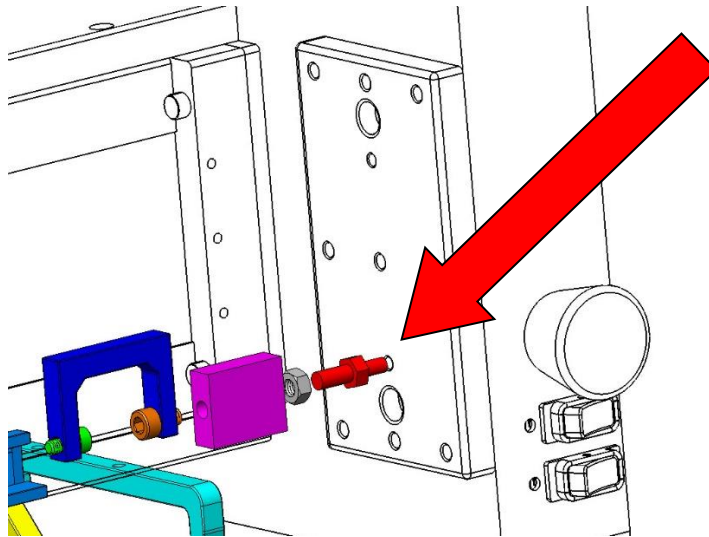
3. Mount the Horizontal Pivot Brackets to the Main Unit with M4x12 SHCS and 3mm hex key.



4. Mount the Heater Plate assembly to the Horizontal Pivot Brackets with the supplied shoulder screws and 3mm hex key.



5. Tilt the UniVert to the horizontal configuration (see **Appendix C: Device Handling and Test Setup** for more details).
6. Mount the Tension No Load Cell Bracket to the Motor Bracket with the M6 Thumb Nut.
7. Attach the M5 stainless steel grip to the Tension No Load Cell Bracket with M5x10 SHCS and 4mm hex key.
8. Thread the M6 nut on the M5 to M6 thread adapter.
9. Mount the assembly from the previous step to the M5 threaded hole of the mounting plate.



10. Carefully thread the load cell to the thread adapter and gently tighten the M6 Nut against the load cell body with the provided wrench to secure the load cell in place.
11. Attach the remaining tension grip to the Tension Load Cell Bracket:
 - a. For 10N-20N load cells, attach the M3 plastic grip to the M3 Tension Load cell Bracket with an M3x10 SHCS and 2.5mm hex key.
 - b. For 50N-200N load cells, attach the M5 stainless steel grip to the M5 Tension Load Cell Bracket with and M5x10 SHCS and 4mm hex key.
12. Mount the grip assembly to the load cell and secure it in place with a M6x10 SHCS and 5mm hex key.

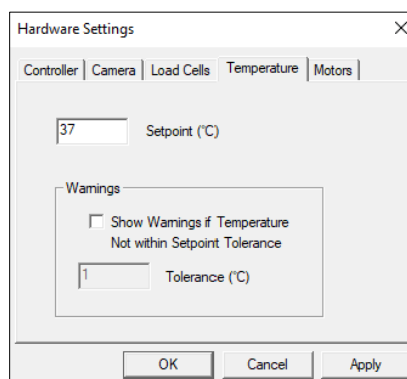
13. Place the fluid dish on the Heater Plate and attach all the connections for the heater and temperature probe.



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

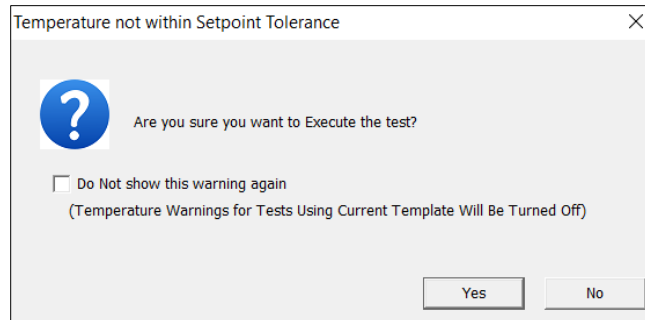


15. To activate the fluid chamber heater, turn on the main unit followed by the heater switch. At this point, the heater will warm the media to the last used temperature set point. The temperature set point can be changed by selecting Hardware from the Settings menu.



16. 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.

17. 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.



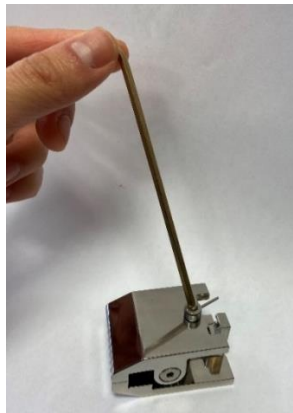
Appendix F: Grip Modifications

Medium Force Grips (10N – 200N)

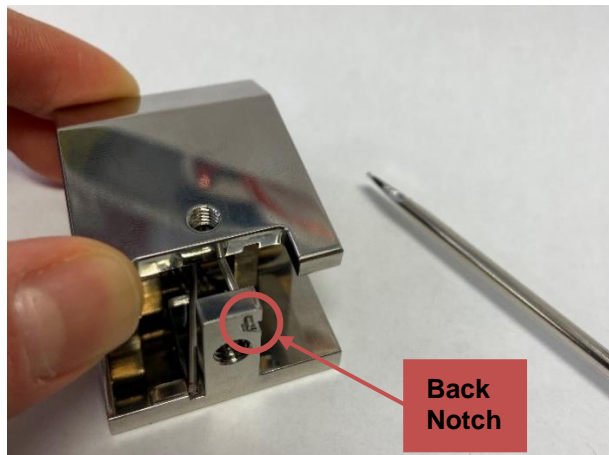
Changing Grip Springs

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

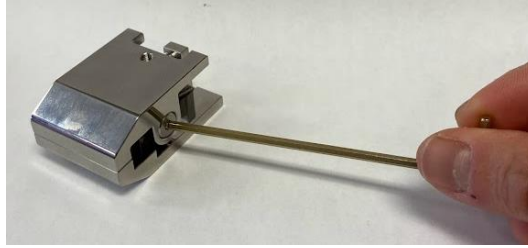
1. Gather the required tools:
 - Grip
 - Desired spring
 - 3/32" hex key
 - 3mm hex key
 - Flat heat screwdriver
 - Safety glasses (recommended)
2. Remove the M4 locking screw with the 3mm hex key.



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.



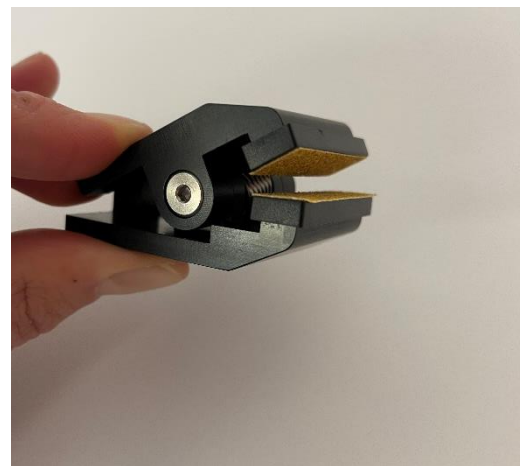
8. Push the spring arm down and lock it into the back notch.
9. Place the top piece of the grip over top and use the 3/32" hex key to fasten the dowel screws on either side.
10. Push down on the top of the grip to release of the spring arm from the back notch. Use a flat head screwdriver if necessary.
11. Use the 3mm hex key to place the M4 locking screw back in place.

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

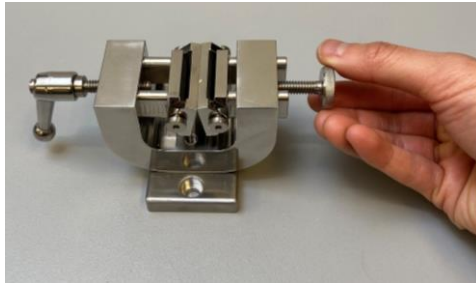
The medium force grips have jaw coverings available in a soft silicone or hard plastic with sandpaper. The coverings are easily interchangeable by sliding the coverings on and off the grip jaws while the grip is open. These coverings are optional and are best used if they provide a stronger grip on the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



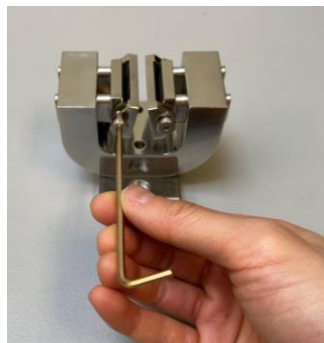
High Force Grips (500N – 1kN)

The high force grips have interchangeable faceplates available in the following patterns: flat, horizontal, diamond, or custom. See steps below to change between faceplates:

1. Remove the thumbnut and threaded lever from either side of the grip.



2. Use a 2.5mm hex key to remove the shoulder screws on either side of the faceplates.



3. Remove the face plate and replace it with the desired faceplate.



4. Insert the shoulder screws back in place and tighten the screws with the 2.5mm hex key.
5. Thread the lever and thumbnut back in place.