CellScale
biomaterials testing

UniVert

Mechanical Test System

User Manual

version 1.7

Mechanical measurement and analysis of materials

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

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CellScale
biomaterials testing

Sales and Support
CellScale Biomaterials Testing
11–564 Weber St. N.
Waterloo, Ontario, Canada N2L 5C6
Phone: 519.342.6870

Table of Contents

1. General Information

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

Environmental and Electrical Specifications

Electrical Input	100-240VAC, 50-60Hz
Current Rating	1.67 Amp
Environmental Conditions	Maximum Operating Temperature 25ºC 0% - 95% Relative Humidity
Installation Category	Category II
Pollution Degree	Degree 2
Data Connections	1 – USB 2.0 for camera/PC communication 1 – USB 2.0 for controller/PC communication

System Assembly

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

Connections to Supply

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

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

Safety Warnings

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

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

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

> ***System Alert***
>
> *This equipment must not be disassembled by the user or modified in any way.*

Manual Operating Controls

There is a single power switch on the front of the control unit to turn on the UniVert.

General Maintenance

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

Approvals and Certification

This product conforms to applicable CE standards.

2. Testing Terminology

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

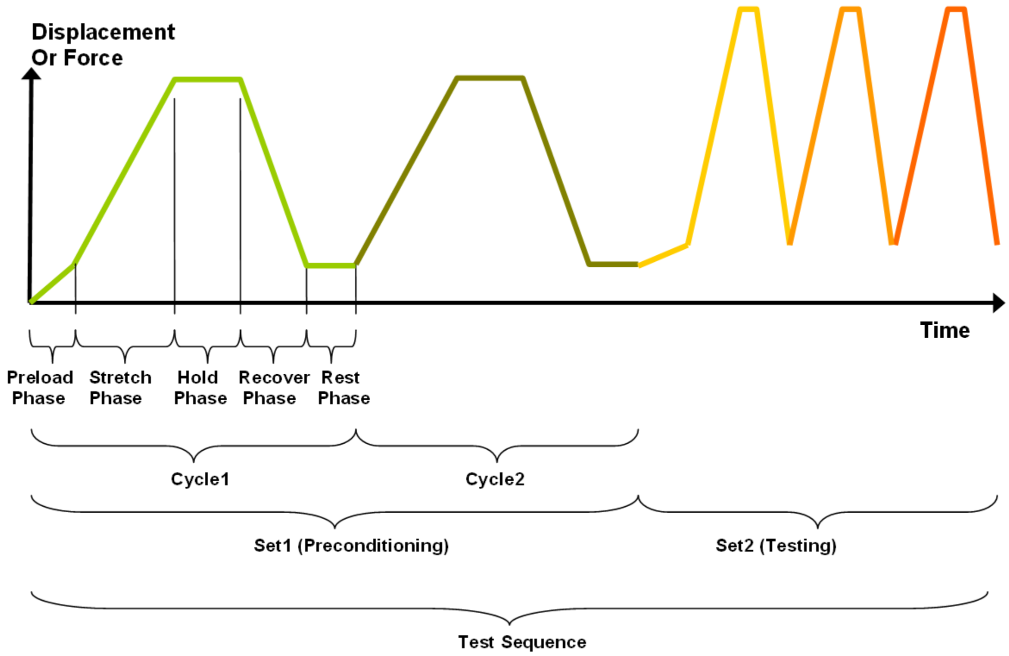
Multiphase Test Cycles

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.



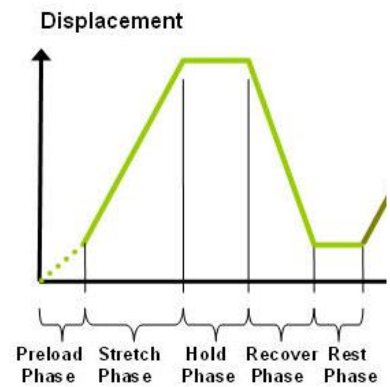
The above example describes the following:

- 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.

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, 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. 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. 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:

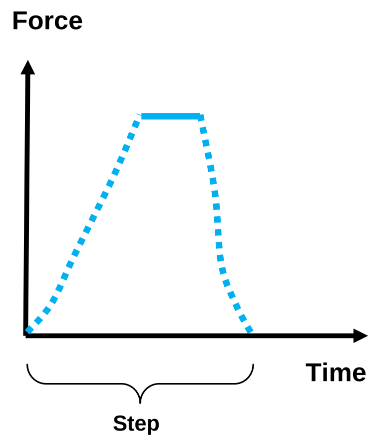
The **true strain function** applies the displacement at a true strain rate, which accounts for the current specimen length while the specimen is being stretched. The UniVert system approximates this with a series of linear segments (default = 10).

The **ramp function** applies the displacement at a constant nominal rate. This is equivalent to engineering strain or constant velocity.

The **sine 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 **step function** achieves and maintains the desired force as quickly as possible. The amount of time it takes to achieve the desired force depends on the material being tested and the force control settings.



Test Modes

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

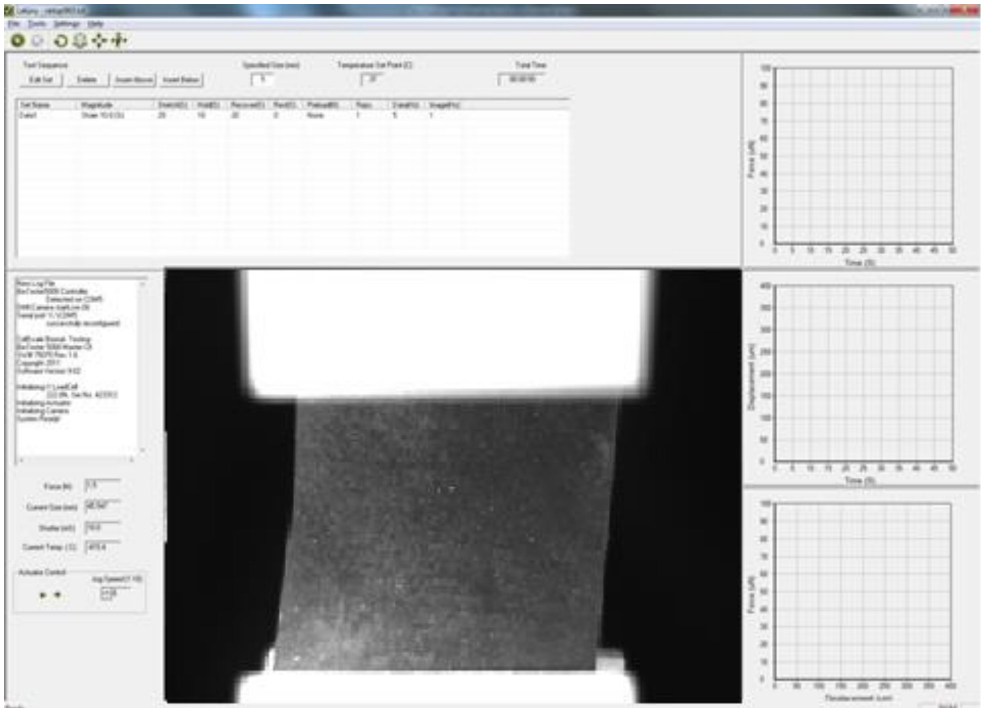
Tensile Test - This test mode is used in combination with provided specimen grips. In this mode, positive displacement is in the direction of increased fixture separation and tension forces are positive.

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.

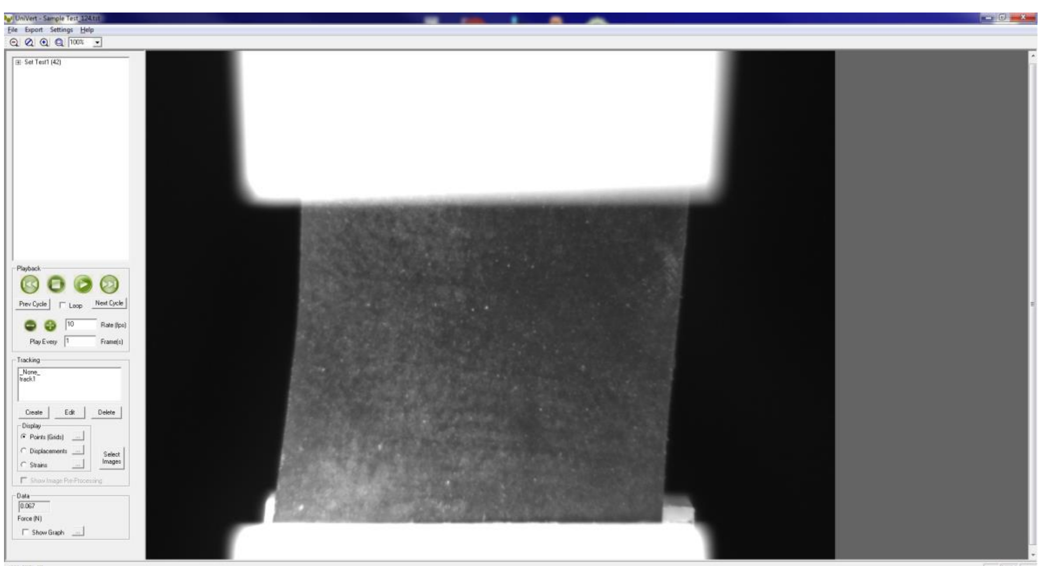
3-point Bend Test - This test mode uses the same displacement and force convention as compression testing but is applied to a 3-point bend setup.

3. Software Overview

The software included with the UniVert device is called UniVert. It is divided into two modules, a data collection module and a review and analysis module. 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 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 subfolders. The “Logs” subfolder contains a text file of the content of the text dialogue portion of the main screen. It is useful as reference to troubleshoot problems with your system, should they occur.

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.

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 hard drive without interfering with the software application (once created, they cannot be opened by the UniVert application).

When working with the data, you 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.
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.

4. Setting Up & Starting a Test

Overview

Setting up and running a new test is a simple process made up of both mandatory and optional steps. The following list presents all of the steps, while the rest of this chapter describes each of the steps in detail.

Step 1: Start a New Test

Step 2: Reset the Actuator

Step 3: Specify Test Type

Step 4: Move the Actuator to a Specified Size

Step 5: Zero the Load Cell (occasional)

Step 6: Modify the Test Parameters (optional)

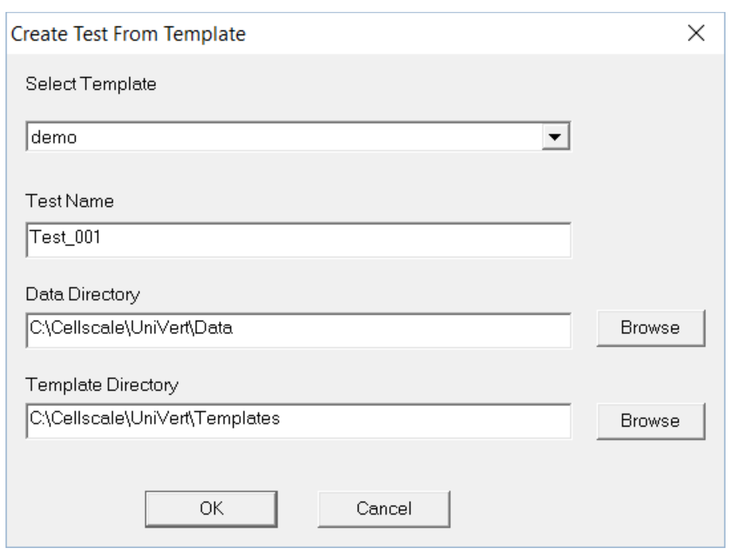
Step 7: Mount the Specimen

Step 8: Execute the Test

Step 9: Terminate the Test Prematurely (optional)

Step 1: Start a New Test

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



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

1. Select a template that matches the type of test you wish to perform. See the *UniVert Tip* on how to select and use a template. You can modify the template parameters in Step 4, 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.

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.

> ***UniVert Tip: Selecting and Using Templates***
>
> *How to select a template: Designing an appropriate test sequence is an art that 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 should expect to have to experiment with the settings until the test yields meaningful data.*
>
> *The system comes loaded with example templates to help you get started. Selecting a template does not lock you into a specific test sequence or protocol – rather a template defines a test sequence and settings, all of which can be changed before a test is run. Once you have developed a test sequence and 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 your template the next time you initiate a test.*

Step 2: Reset the Actuator

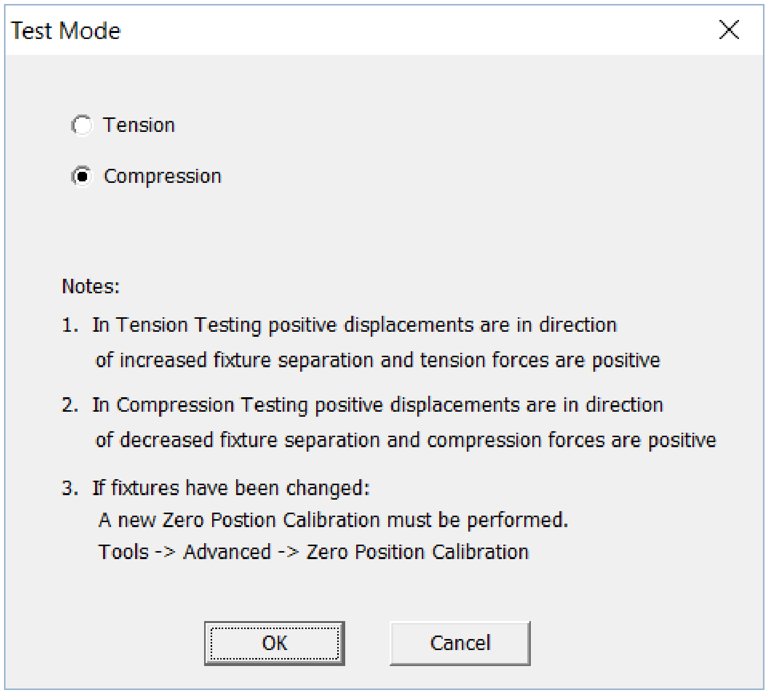
We suggest performing a reset at the start of a new test session. This command sends the actuator to its fully retracted position and resets the displacement value. If you have stopped the previous test in mid cycle, then you should also reset the actuator. By resetting the actuator, you are ensuring that the physical measurements taken by the UniVert are accurate.

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

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

Step 3: Specify Test Type

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



Step 4: Move the Actuator to a Specified Size

After the actuator has been reset, it will remain in the fully retracted position and must be moved to a specified (reference or starting) position.

To move the actuator to the specified position, select *Move Actuator to Specified Size* from the Tools menu, or press  on the toolbar. This size may be entered in the “Specified Size” dialogue.

Step 5: 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.

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

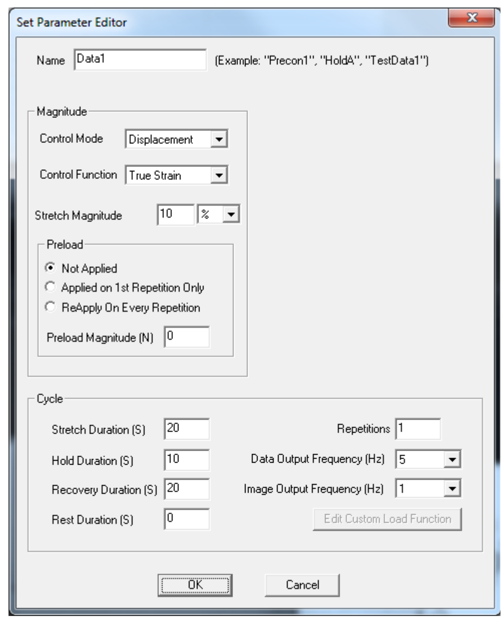
> ***System Alert***
>
> *You should zero the load cell after attaching a platen or grip but before mounting a sample. If a specimen is already loaded when the load cell is zeroed, the force reading will include an offset load.*

Step 6: Modify Testing Parameters (optional)

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

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

The following table describes each of the parameters.



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

UniVert Tip: Idle Current

Idle current (holding current) can be applied to the motors. The motors have a holding force in the de-energized state of approximately 100N. If forces in excess of 100N are expected it is recommended that idle current is used to prevent position loss during velocity and direction changes when the motors are de-energized for a very short time. When idle current is activated the motors will produce **more noise**, even when the actuator is at rest. This setting may be accessed by selecting *Hardware* from the Settings menu.

Step 7: Mounting a Specimen

Platen Mounted Specimens

1. Select an appropriate riser to accommodate the size of the specimen (see **Appendix D**).
2. Place the specimen on the bottom platen.
3. Jog the top platen to the correct position using the jog arrows in Actuator Control

Alternately, the *Move Actuator to Specified Size*  command may be used.

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

Grip Mounted Specimens:

Low Force Grips

1. Select an appropriate riser to accommodate the size of the specimen (See **Appendix D**).
2. Select a grip with appropriate clamping force for the specimen being tested (see **Appendix E** for more details).
3. Jog the actuator using Actuator Control or select *Move to Specified Size*  until the grips are sufficiently far apart and attach the specimen to the top grip.
4. Using Actuator Control, lower the top grip (with specimen attached).
5. Open the bottom grip and lower the specimen between the grip surfaces. Release the bottom grip.

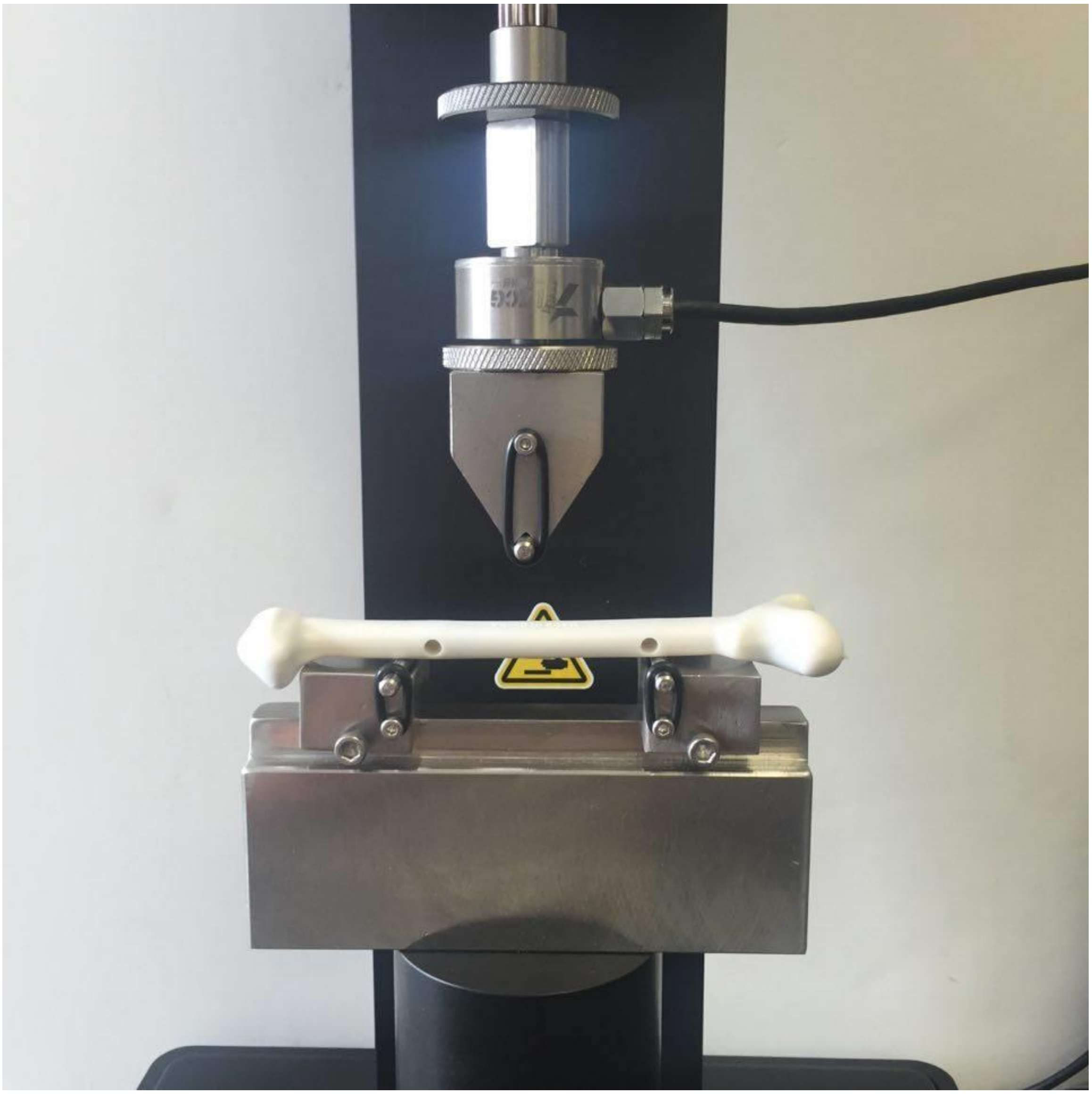
High Force Grips

1. Select an appropriate riser to accommodate the size of the specimen (See **Appendix D**).
2. Select a grip with appropriate clamping force for the specimen being tested (see **Appendix E** for more details).
3. Jog the actuator using Actuator Control or select Move to Specified Size until the grips are sufficiently far apart and attach the specimen to the top grip using the 9/64 hex key provided.

4. Using Actuator Control, lower the top grip (with specimen attached).
5. Open the bottom grip and lower the specimen between the grip surfaces. Grip the specimen by tightening the grip using the 9/64 hex key again.

3-point Bend Specimens

1. Use the 80mm riser to ensure the sample is in the range of the actuator (see **Appendix D**)
2. Choose an appropriate sized 3-Point Bend dowel for the type of test you wish to perform.
3. Install the 3-Point Bending test setup (See **Appendix D**)
4. Move the sliders into desired position and lock in place by tightening the M3 fastener to the rail.
5. Place the specimen on top of both lower dowels and begin testing.



Step 8: Execute the Test

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

Step 9: 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. This is preferred over powering down the equipment, as it allows the software to store the current actuator position.

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

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.

System Alert: Load Cell Handling

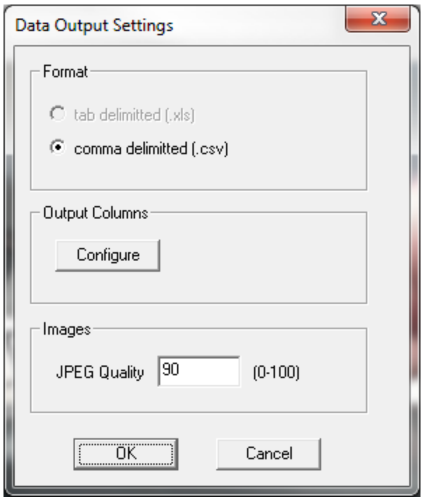
It is important to handle load cells carefully. Here are some things to consider while handling a load cell:

- *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.*
- *Accidently 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 the load cell.*

5. 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.



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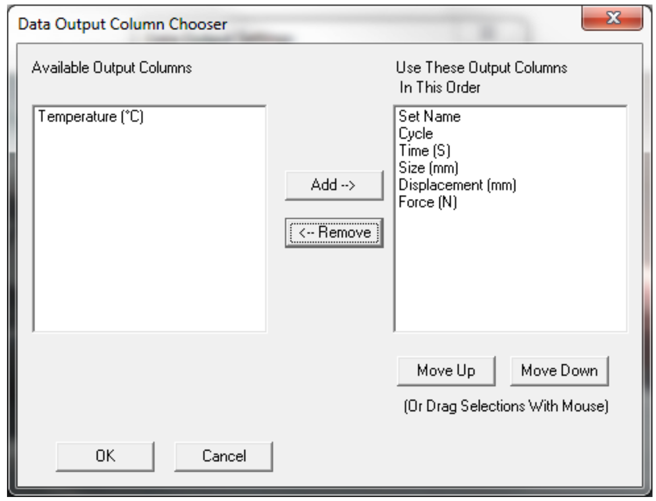
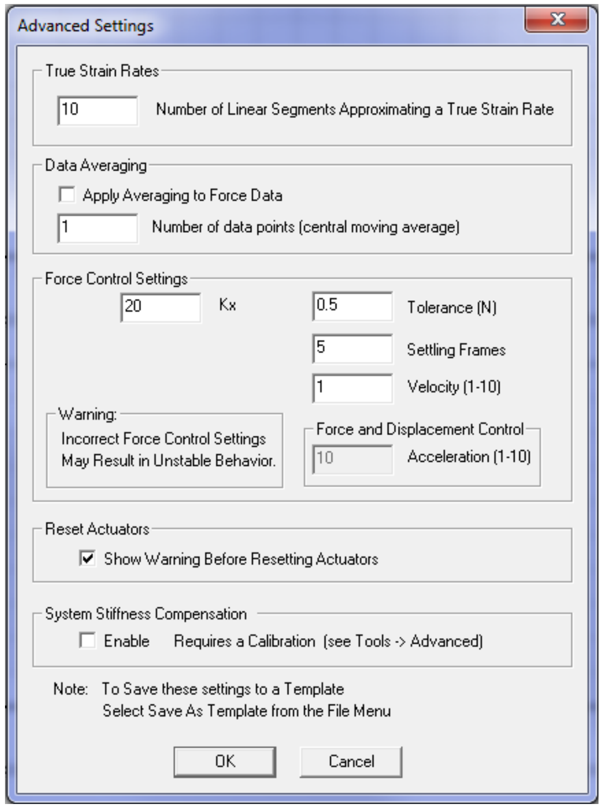


Output Column	Description
Set Name	User defined name of each set
Cycle	Cycle and Phase information
Time (S)	Time in seconds
Size (mm)	Specimen Gage Length
Force (N)	Load Cell reading
Displacement (mm)	Reports the change in size relative to the initial size
Compensation (mm)	Reports overall compensation due to system stiffness (see Section 8). Off by default.

Advanced System Settings Dialogue

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



True Strain Rate

Unlike nominal or engineering strain rate, a plot of velocity versus time for a true strain rate test would be non-linear. The degree of non-linearity increases with increasing strain. The UniVert approximates this non-linear curve with a series of linear segments. Typically, 10 line segments is a sufficiently close approximation. More segments can be used, but you should bear in mind that the actuator velocity can only be updated every 250ms.

Data Averaging

The load cells are sampled at 100Hz with hardware using a central moving average of 8 samples. Further data averaging can be applied to smooth noisy data.

Force Control Settings

Force 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.

Kx (Default = 100, integer values) is a proportional gain tuning parameter. It controls the sensitivity or the amount of corrective action that is applied to the difference between the current and target force values. At low gain values the system may be safe and stable but may be sluggish in response to changing conditions. If the proportional gain is increased the system becomes more responsive and loads are achieved more quickly. If Kx is set too high, an unstable oscillating system may result and forces may never be achieved. The optimal value for these settings depends on the properties of the material being testing.   For stiff materials, values may range between 10 and 50. For soft materials, values may range between 50 and 500.

Tolerance (N) (Default = 0.1) controls how close to the specified force the actual load values need to be. For example, a specified force of 10N with a Tolerance of 0.1 N will be considered achieved when the loads are between 9.9 and 10.1 N. Keep in mind the accuracy of the load cell being used when choosing the value for this parameter. The load cells typically fluctuate by about 0.1% of their full scale during the course of a test. For a 10N load cell this is about 0.01N but for a 200N load cell, this is about 0.2N. This value should usually be 0.2-0.5% of full scale to ensure stable operation.

Settling Frames (Default = 5) controls how many successive load samples (sampled at 100 Hz) need to be within the Tolerance criteria for the force to be considered achieved. For example, a specified force of 10N with a Tolerance of 0.1 N and Settling Frames = 5 will be considered achieved when the loads are between 9.9 and 10.1 N for 5 successive data samples at 100Hz.

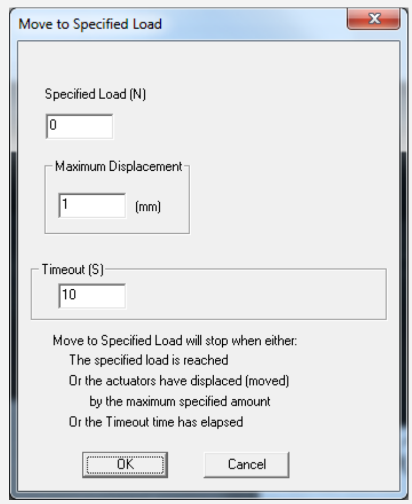
Velocity (1-10 integer values) matches actuator jog speed. Typically for stiffer materials, this value should be between 6 and 8 and for soft materials, this value should be between 8 and 10.

Acceleration (1-10 integer values). Typically this should be set to the default value of 10 (maximum acceleration). 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 testing cycles.

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 reducing Kx and/or decreasing the velocity.

If the actuator reaches the specified load too slowly, try increasing Kx and/or increasing the velocity.

Reset Actuators

Resetting the actuators with a sample attached may damage the specimen, BioRakes, 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. This feature can be disabled by de-selecting “Show Warning Before Resetting Actuators”.

Range Limits

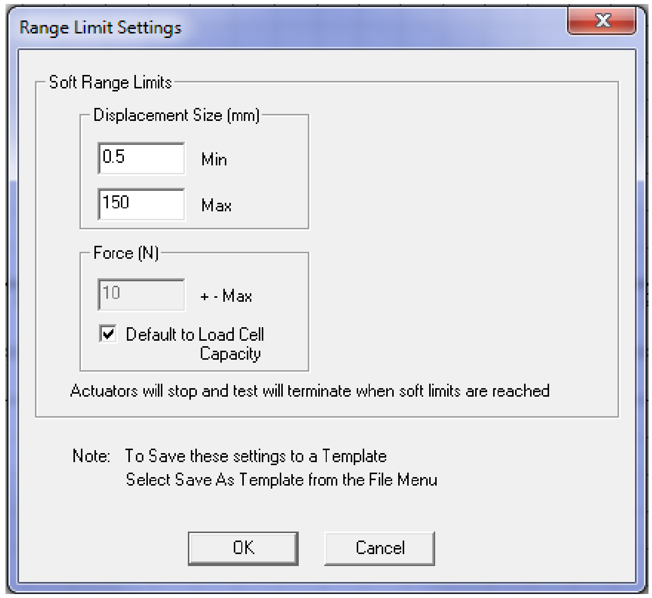
Range limits can be accessed by selecting *Range Limits* from the Settings menu.

Soft 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 are allowed to move. These settings require adjustment especially when the riser is 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.

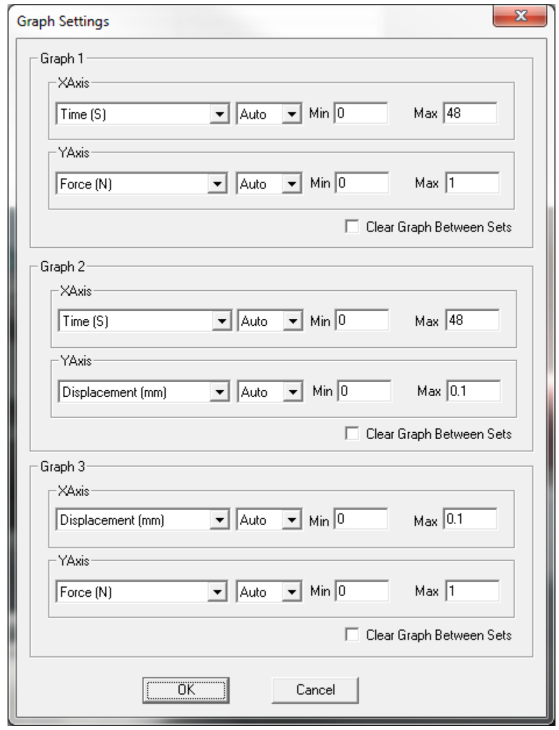


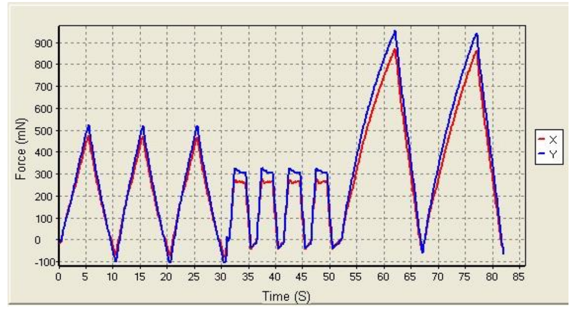
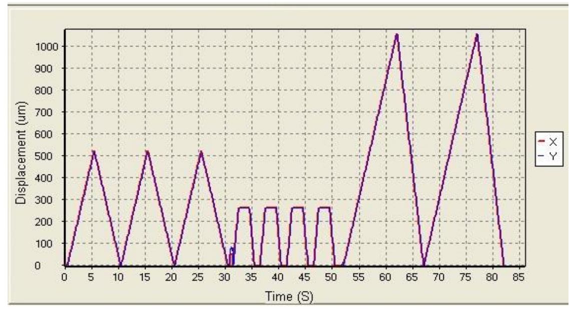
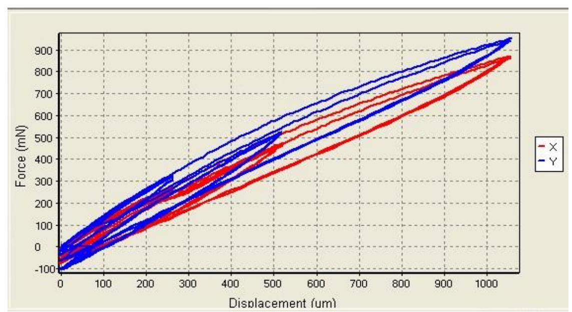
Configuring the Live Charting Graphs

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 actually present.

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

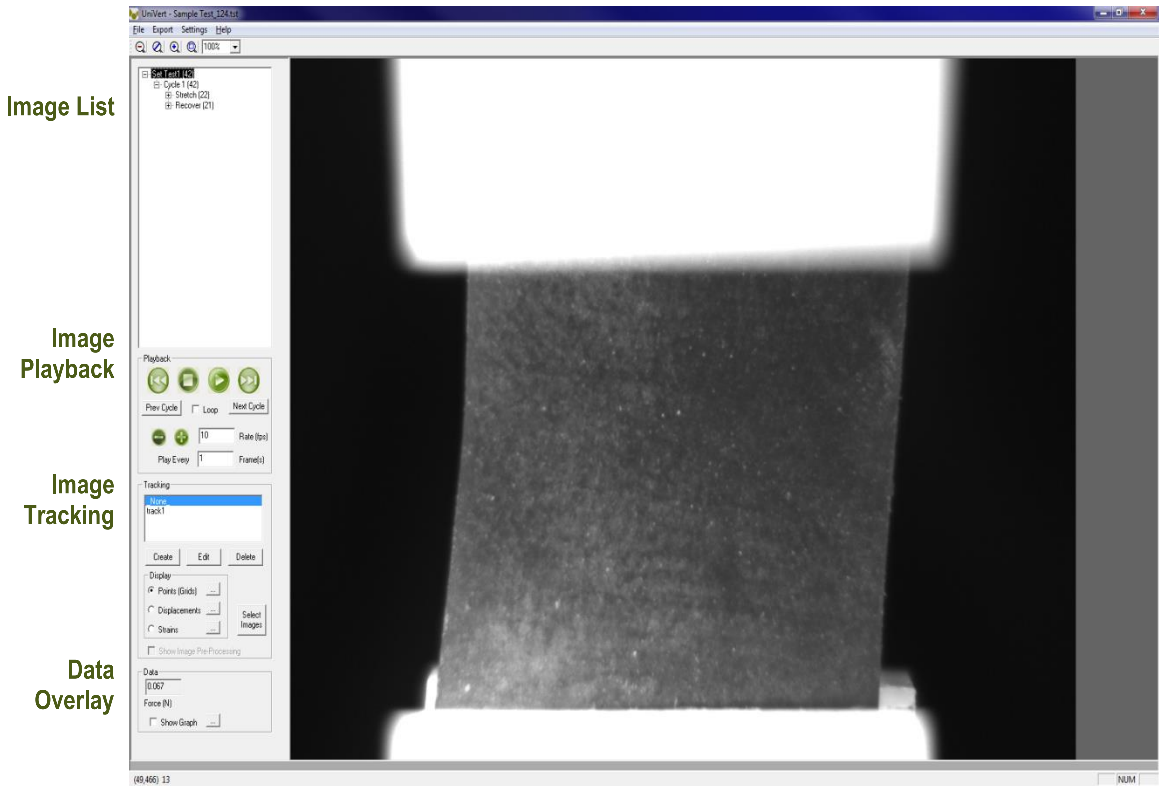


Graph	Data
Force versus Time This graph shows how the measured forces are changing with time. Peak loads per cycle and force relaxation are all easily seen in this type of graph. Force is proportional to nominal (engineering) stress.	
Displacement versus Time This graph shows how the grips or platens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

6. 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.

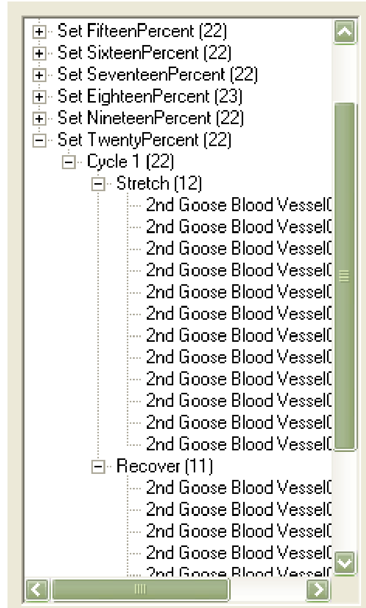


The basic UniVert system comes with a Logitech HD 1080p webcam intended to be used for recording images for image playback and review. This camera and software associated with it **does not** support image tracking.

For image tracking to be available, the advanced scientific monochrome camera 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)

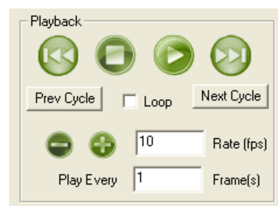
Image (the one or more individual images from each Phase)

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

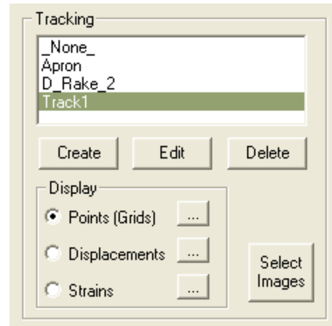
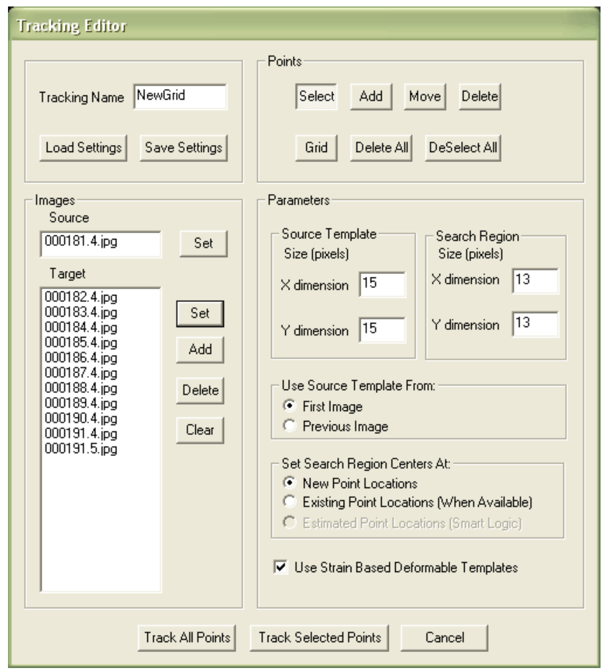


Image tracking is a function that can be used to quantify the motions of image features (specimen texture and fiducial markers). This can be useful for studying localized specimen deformations, verifying strain magnitudes, and comparing the results of one test to another.

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.

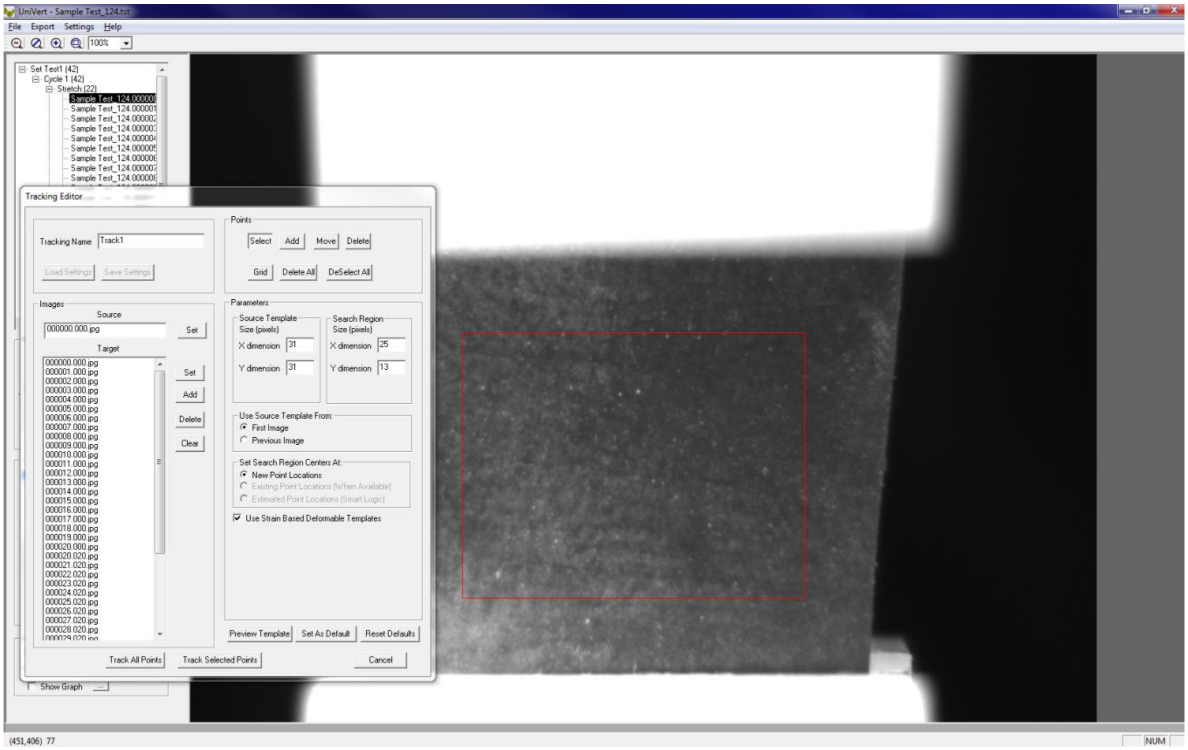
The algorithm defines the location of the tracked point on the target image as the center of the optimally located template.

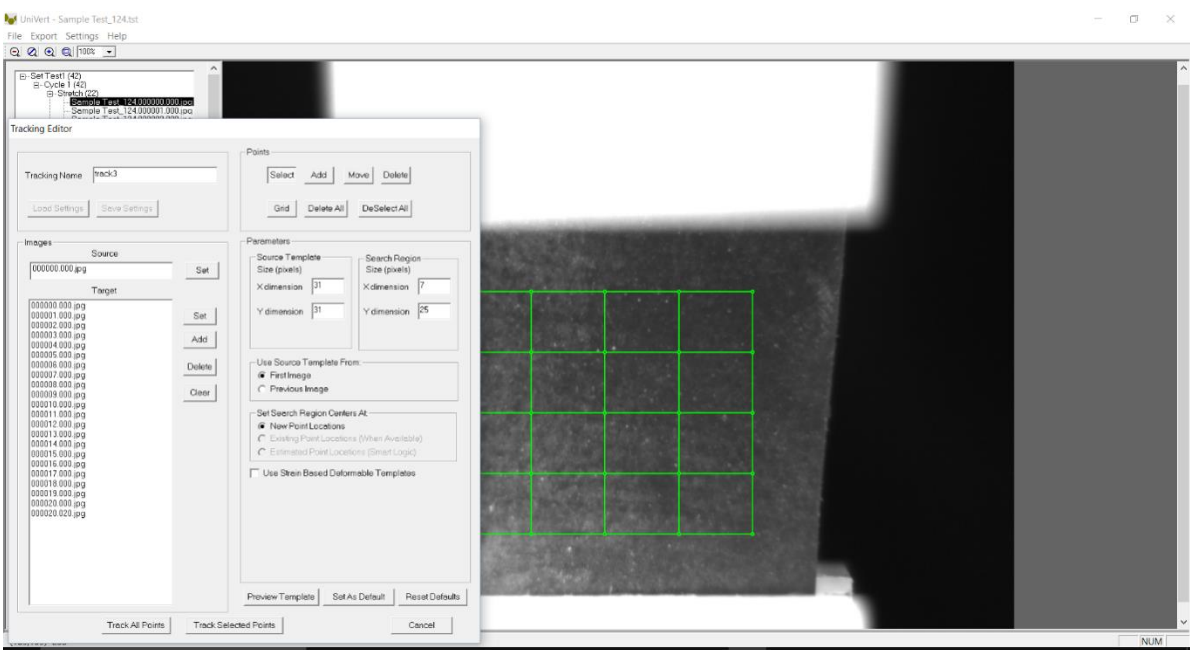
To track an image, follow these steps:



1. Click the *Create* button in the tracking window, shown above. This brings up the Tracking Editor dialogue box.
2. Enter a Tracking Name.
3. Select *Source Image* in the test image list tree, and click *Set* to the left of the Source box.
4. Select the Target Images in the test image list tree, and click *Set* to the left 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.
    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.


UniVert - Sample Test_124.tst
File Export Settings Help
100%
Set Test1 (42)
Cycle 1 (42)
Stretch (22)
Tracking Editor
Tracking Name Track1
Load Settings Save Settings
Points
Select Add Move Delete
Grid Delete All DeSelect All
Images
Source
000000.000.jpg
Set
Target
Set
Add
Delete
Clear
Parameters
Source Template Size (pixels)
X dimension 31
Y dimension 31
Search Region Size (pixels)
X dimension 25
Y dimension 13
Use Source Template From:
First Image
Previous Image
Set Search Region Centers At:
New Point Locations
Existing Point Locations (When Available)
Estimated Point Locations (Smart Logic)
Use Strain Based Deformable Templates
Preview Template Set As Default Reset Defaults
Track All Points Track Selected Points Cancel
Show Graph
(451,406) 77
NUM


UniVert - Sample Test_124.tst
File Export Settings Help
100%
Set Test1 (42)
Cycle 1 (42)
Stretch (22)
Tracking Editor
Tracking Name track3
Load Settings Save Settings
Points
Select Add Move Delete
Grid Delete All DeSelect All
Images
Source
000000.000.jpg
Set
Target
Set
Add
Delete
Clear
Parameters
Source Template Size (pixels)
X dimension 31
Y dimension 31
Search Region Size (pixels)
X dimension 7
Y dimension 25
Use Source Template From:
First Image
Previous Image
Set Search Region Centers At:
New Point Locations
Existing Point Locations (When Available)
Estimated Point Locations (Smart Logic)
Use Strain Based Deformable Templates
Preview Template Set As Default Reset Defaults
Track All Points Track Selected Points Cancel
NUM

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.
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	**First Image** tracks all images against the first in the series (1→2, 1→3, 1→4…). **Previous Image** tracks each subsequent image against the image before it (1→2, 2→3, 3→4…). 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.
Set Search Region Centre	**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). **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.
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*.

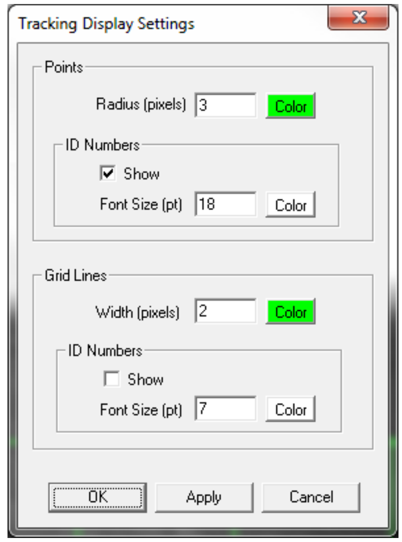
Image Tracking: The Points Display Option

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.



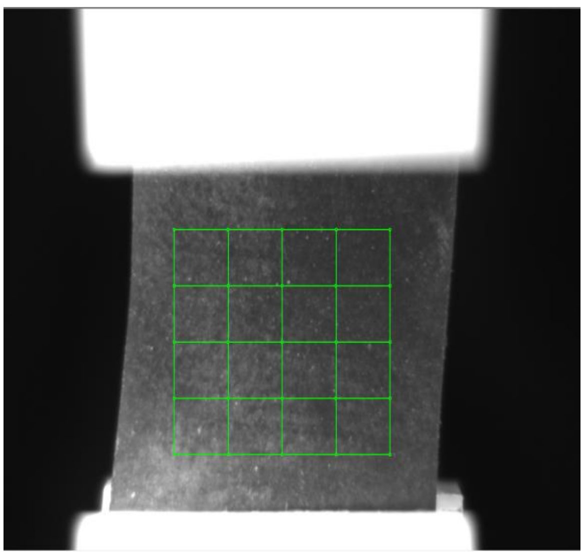


Figure 1: Initial tracking grid displayed as points.

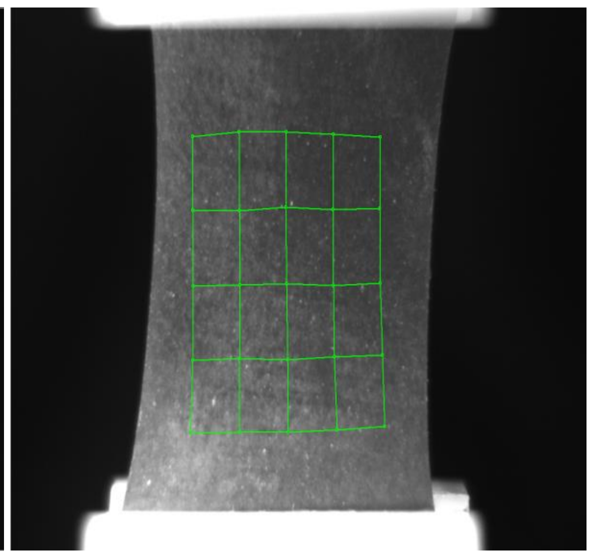


Figure 2: Tracking to 33% strain displayed as points.

Image Tracking: The Displacement Option

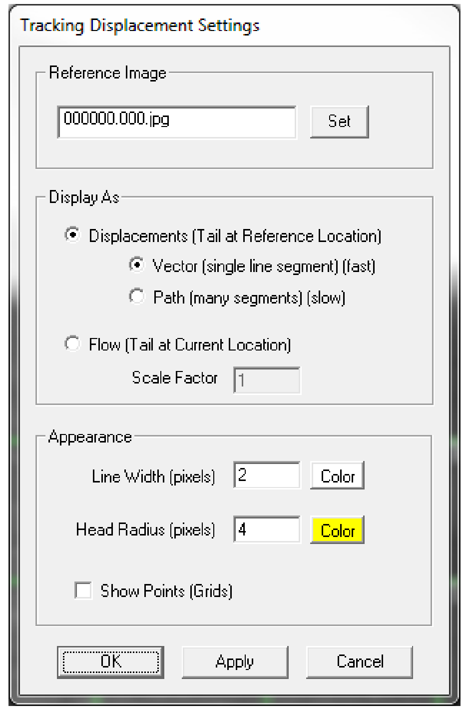
The *Displacement Option* displays the points in their current location as well as graphically representing their motion through time.

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.



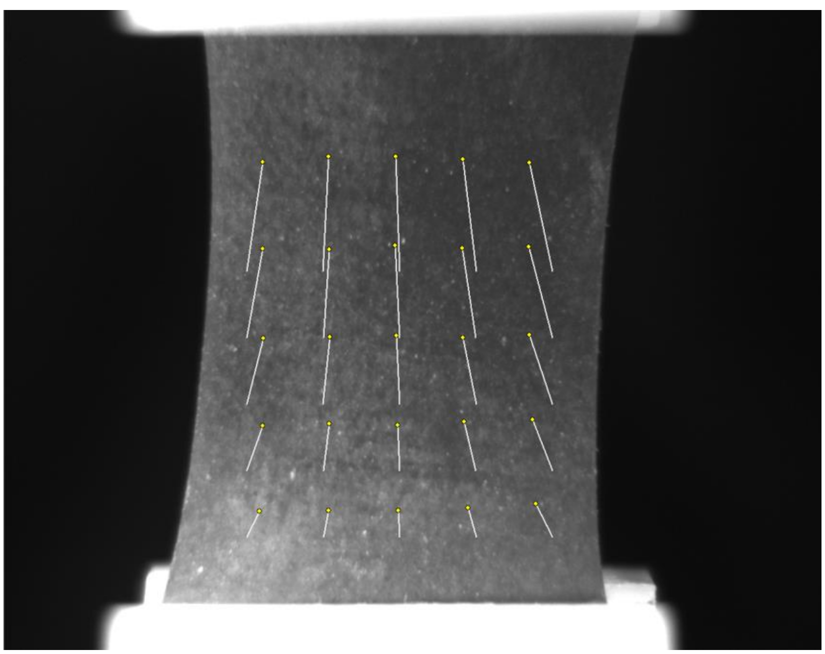


Figure 3: Tracking to 33% strain displayed as displacement.

Image Tracking: The Strains Option

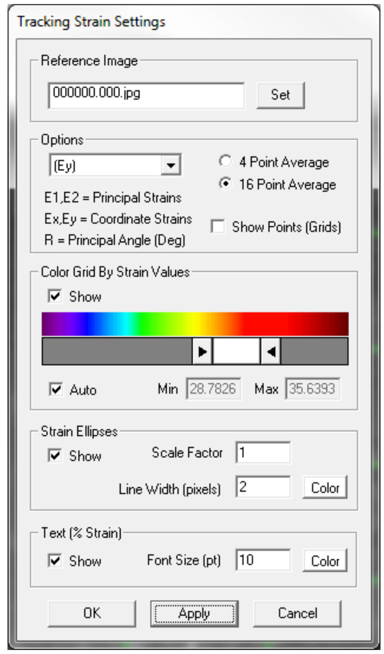
The Strains Option can only be used in conjunction with a grid of points (as opposed to individually placed points). This option calculates the regional strains inside every grid box and displays this data as an ellipse. One can imagine this is what would happen to a grid of circles drawn on the surface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



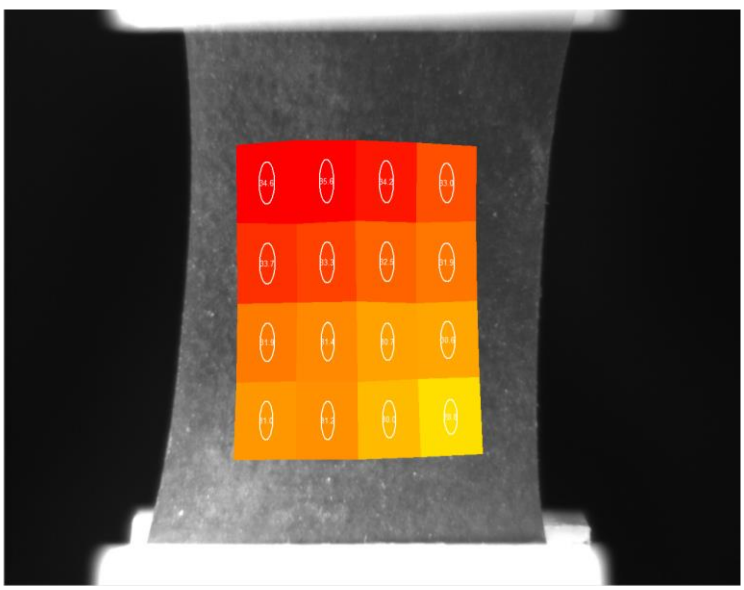
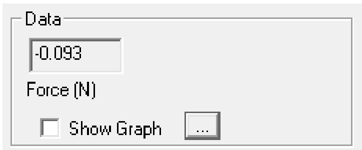
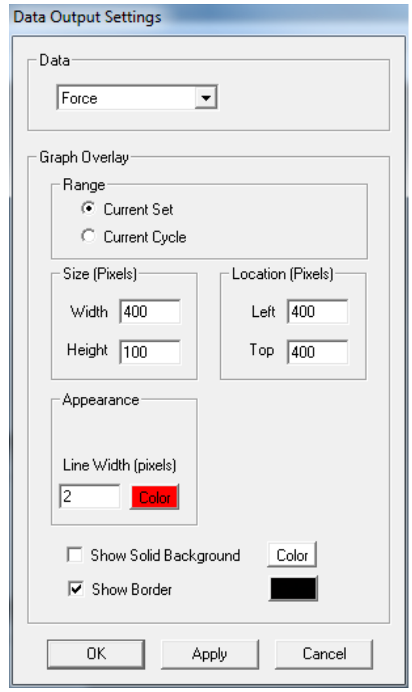


Figure 4: Tracking to 33% strain displayed as strain ellipses with text showing x% strain.

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.

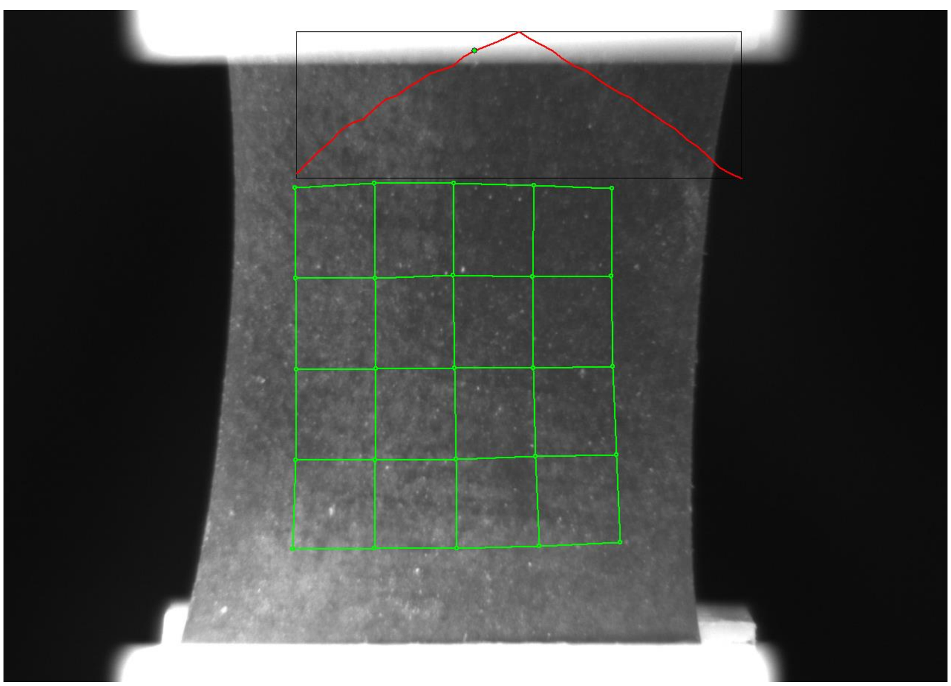
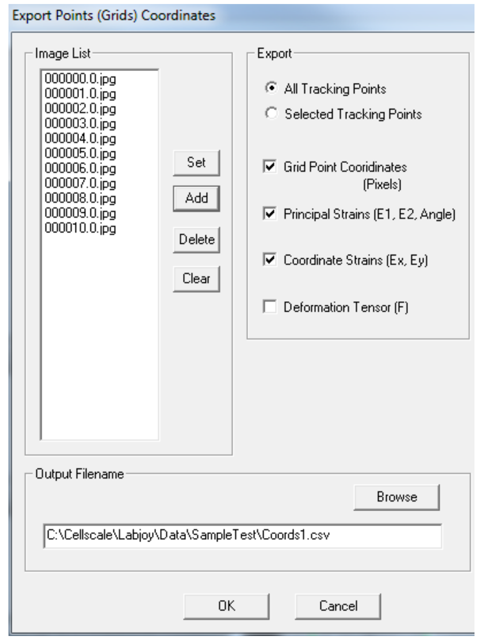


Figure 5: Tracking to 33% strain with overlaid force graph.

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.

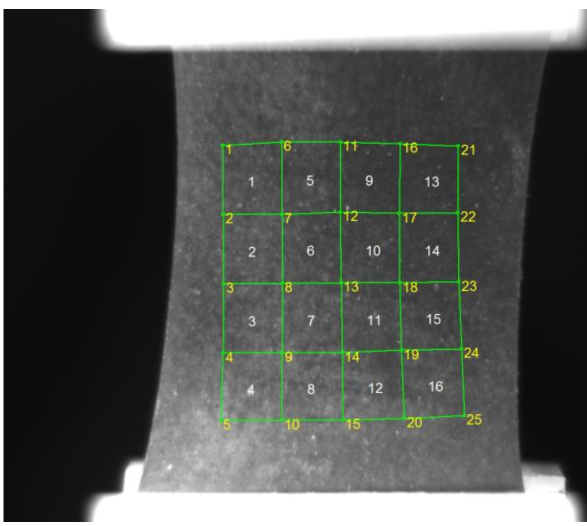
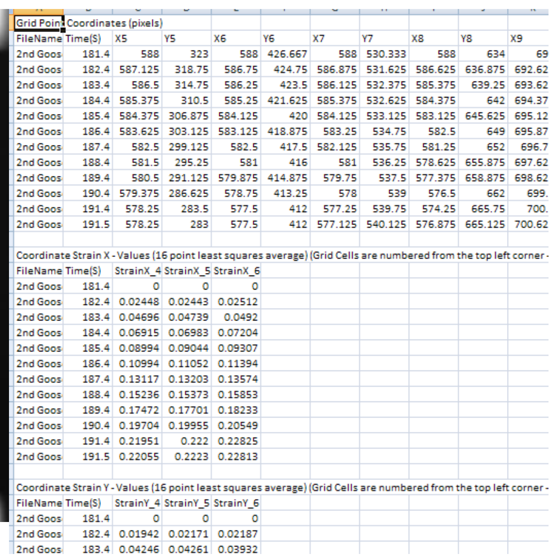


Figure 6: Tracking Grid showing ID Numbers.



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 -

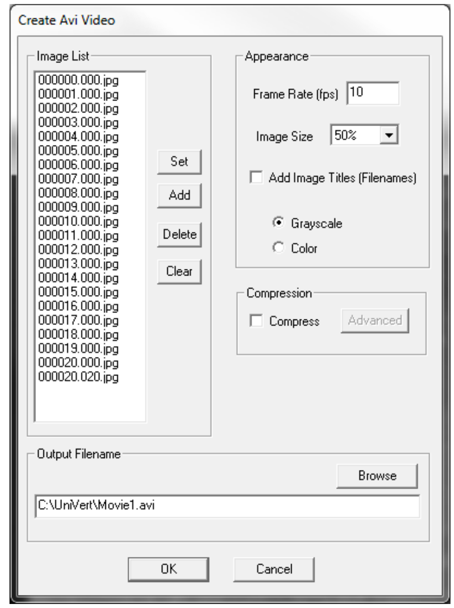
FileName	Time(S)	StrainY_4	StrainY_5	StrainY_6
2nd Goos	181.4	0	0	0
2nd Goos	182.4	0.01942	0.02171	0.02187
2nd Goos	183.4	0.04246	0.04261	0.03932

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.

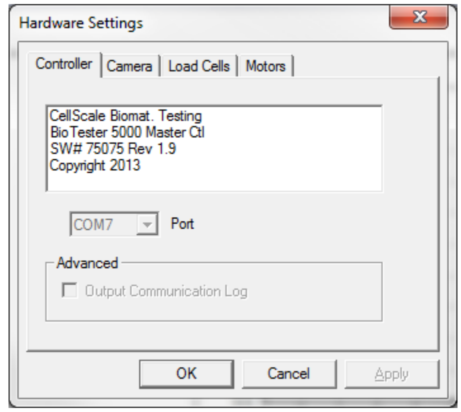
To export a series of image views, including all displayed tracking grids, tracking data and overlaid data as an .avi movie, select *Movie* from the *Export* menu. The dialogue shown on the right will be displayed. The image list is automatically set to the currently selected images in the test image 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.



7. 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.

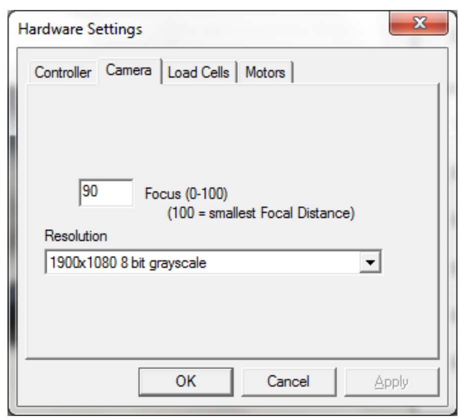


Camera

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 Package

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 monochrome images suitable for image tracking and the associated software is enabled with the image tracking feature (See Section 6: Image Tracking).

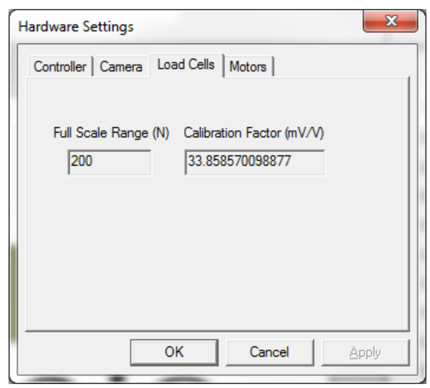
The camera uses a ½" monochrome CCD sensor to obtain a resolution of 1280 pixels by 960 pixels. The camera shutter and gain can be controlled by accessing the *Camera* tab in *Hardware Settings*.

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.

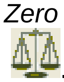
The test software creates an image capture log file in the output directory should this difference be significant. This log stores the actual capture time and the idealized capture time.

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 gain are adjusted to achieve the desired image brightness.

Load Cell



The load cells are semiconductor strain gage-based. They have accuracy equal to 0.2% of the rated full scale load. Load cells are available in 10N, 20N, 50N, 100N, and 200N sizes. Each load cell has a unique calibration factor which is stored in a chip contained in the load cell connector.

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

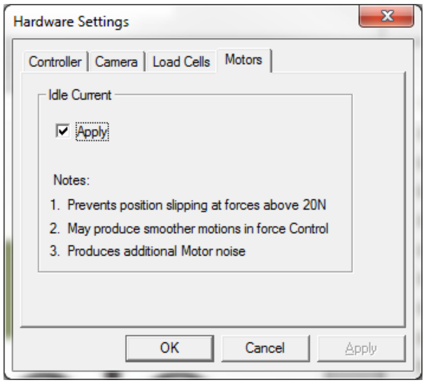
The load cells are sampled at 100Hz, with hardware providing an 8 sample averaging to reduce noise in the data. Further sample averaging can be implemented by selecting *Advanced* from the Settings menu.

Each load cell is calibrated and has a specific calibration factor which is stored on a chip in the load cell connector. Field calibration using weights of known mass is recommended (see **Section 8** of this manual). The range and calibration factor can be viewed by selecting *Hardware* from the Settings menu, but are not directly user controlled.

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 open loop control. The motor moves a lead screw-driven shaft attached to the load cell and then the platens or grips. The actuator has a peak velocity of 20mm/s. 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.



Idle current (holding current) can be applied to the motors. The motors have a holding force in the de-energized state of approximately 100N. If forces in excess of 100N are expected it is recommended that idle current is used to prevent position loss during velocity and direction changes when the motor is de-energized for a very short time duration. Turning idle current on may produce smoother motions in force control (since the motors are frequently stopping and starting). When idle current is activated the motors will **produce more noise**, even when the actuator is at rest.

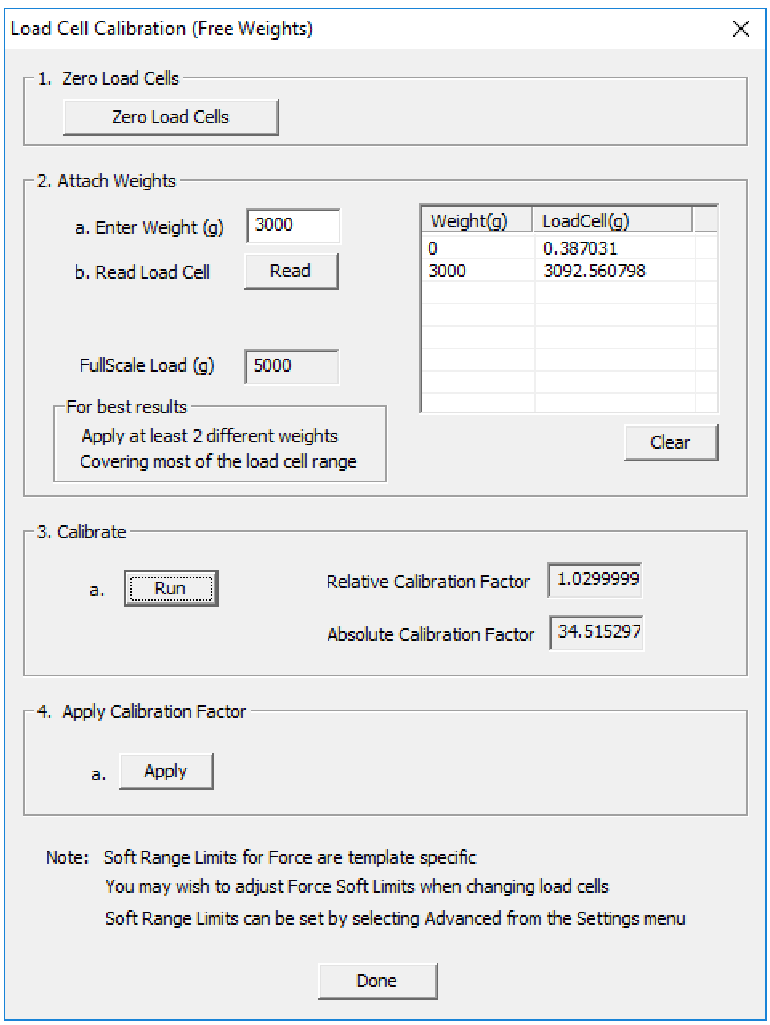
8. System Calibration and Advanced Tools

Load Cell Calibration

The load cells are preset with a calibration factor at the production facility. However, calibration in the field is recommended. When the load cells are set up for the first time, changed, or moved it is advisable to perform a load cell calibration. The user must obtain a set of calibration weights for this purpose.

This calibration can be performed using the following steps:

1. Attach the compression platen to the load cell
2. Reset the actuator 
3. Place the unit upside down on a flat, sturdy surface.
4. From the Tools menu select *Load Cell Calibration*



5. **Zero the load cell** to remove the weight of the platen from the calibration values measured
6. Measure the zero load condition for the first calibration point (no calibration weight)
    a. Enter “0” in the *Enter Weight* dialogue
    b. Click *Read*
7. 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.**
8. Take a measurement of the calibration test weight.
    c. Enter the weight in grams in the *Enter Weight* dialogue
    d. Click *Read*
9. If desired, repeat steps 7 and 8 for multiple weights covering most of the load cell range. However, at least one weight of at least 50% of the load cell range is recommended.
10. Click “Run”.
11. Check the *Relative Calibration Factor* and *Absolute Calibration Factor* for reasonable values. The Relative Calibration Factor is a ratio of the new calibration factor to the previous calibration factor. Ideally, this value should be between 0.99-1.01. The Absolute Calibration Factor is the actual calibration factor in mV/V. This value should be between 25-45.
12. Click “Apply”
13. Click “Done”

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 re-zero the load cell in the upright testing position 

Alternate Method

When calibrating load cells with large full scale values (100N, 200N) the calibration weight required may not fit inside the UniVert main unit when it is placed upside down. In this case, follow these steps:

1. Carefully remove the load cell being calibrated.

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

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

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.*
- *Accidently crashing the platens or grips together will produce more force than most load cells can handle. Be careful and reduce speed when jogging grips close together.*
- *Generally avoid dropping, tapping and exerting unnecessary force to increase the life the load cell.*

Zero Position Calibration

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

This is the current separation of the edges of the clamps or platens. In order 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.

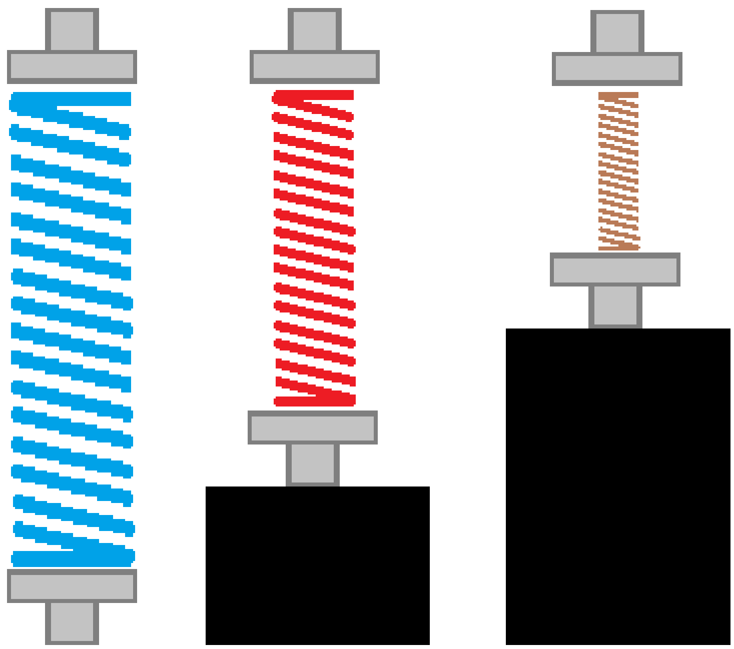
An actuator zero position is preset at the production facility before the UniVert unit is shipped. However, the zero position should be re-calibrated on initial system setup and whenever the grips, platens, load cells, or risers are changed. Changing these components will always alter the zero position by a certain amount.

There is a software utility to automatically calibrate the zero position using a spring of known length provided with the UniVert system. Three different springs are provided with the system to accommodate different sized risers.

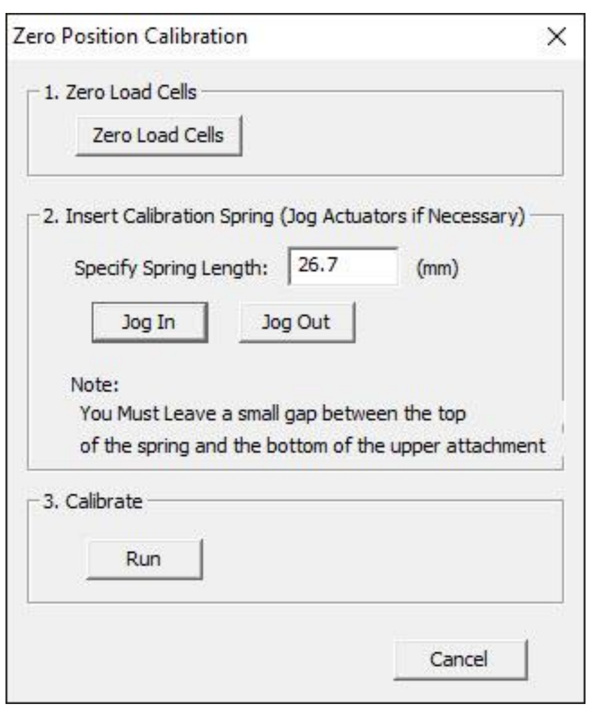
The calibration spring is placed between the upper and lower grips or platens. The calibration utility slowly moves the grips or platens together until a small load is detected when contact with the spring occurs. It then assigns this position as the size of the calibration spring being used.

To calibrate the zero position, follow these steps:

1. Before starting a center position calibration, choose an appropriate calibration spring (provided with the UniVert system). Use the bronze calibration spring with the 80mm riser, the red calibration spring with the 40mm riser, and the blue calibration spring when no riser is used.



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



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

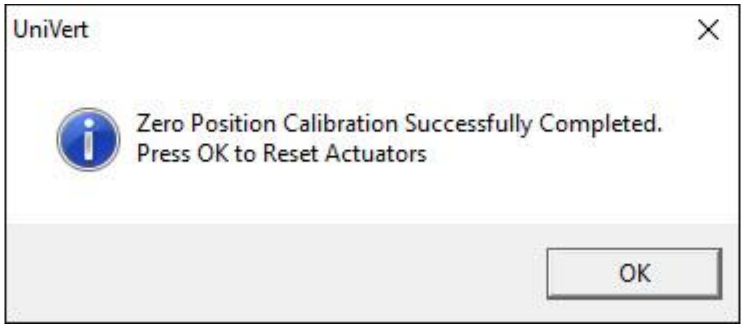
4. Zero the load cell using the *Zero Load Cells* button

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

6. 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.

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

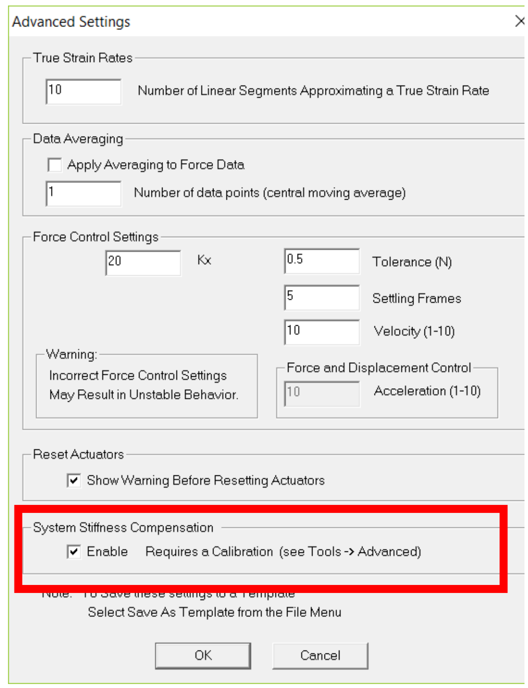
8. Press OK to Reset Actuators and complete the calibration



System Stiffness Compensation

System Stiffness Compensation can be used to compensate for the small displacements that occur in the system during testing. 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.

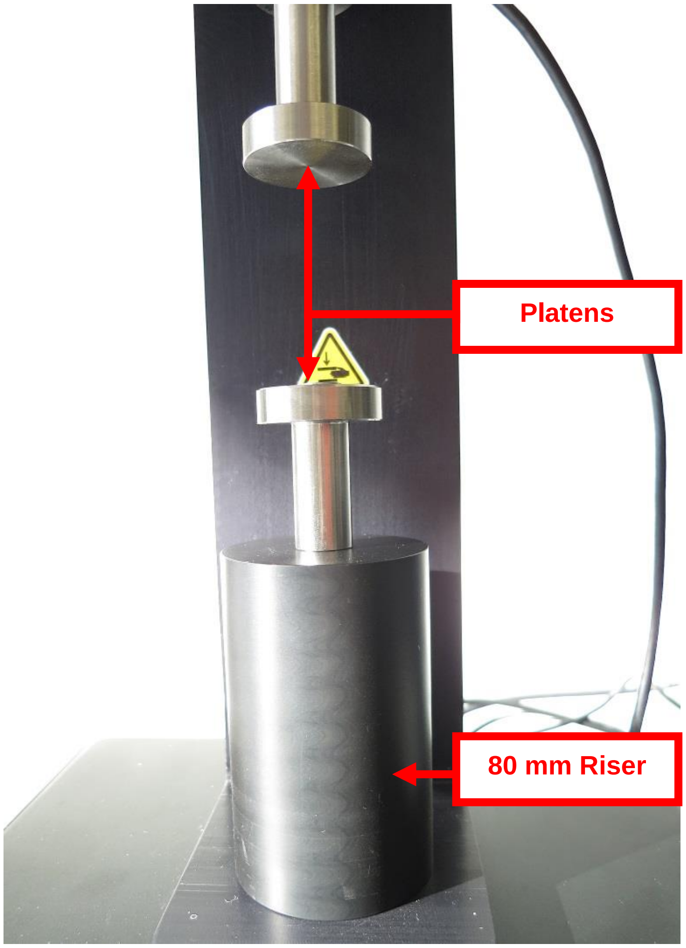
The amount of compensation being applied to the displacement and size columns of the output data file can also be shown as an additional output column (see Section 5).

UniVert Tip: When to Apply System Stiffness Compensation

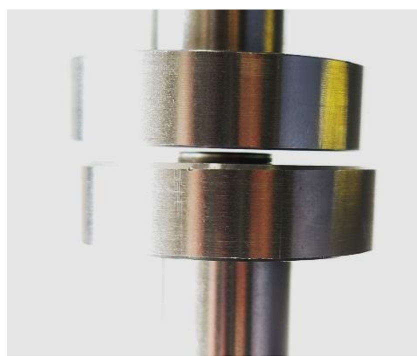
Typically, System Stiffness Compensation will not be required. It may be useful, however, when testing stiff specimens that achieve high loads at low displacements. Most of the system deformation comes from the load cells which typically strain linearly by up to about 200 µm at full scale load. One can estimate the amount of system deformation by multiplying 200 µm by the percent of load cell range that is used. For example, when a load cell is at 50% of its full scale load (a 200N load cell at 100N, or a 10N load cell at 5N) the system deformation is estimated to be about 100 µm. To determine the effect of this displacement on your test you can divide this estimated system deformation by the maximum displacement in your test. For example, in a test with 10mm of displacement: $\frac{100\,um}{10\,mm} = \frac{0.1\,mm}{10\,mm} = 1\%$

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

If system stiffness compensation is enabled, 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 80 mm riser and 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, jog the platens together until there is less than a 1 mm 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 are crashed together the load cell will likely be damaged.

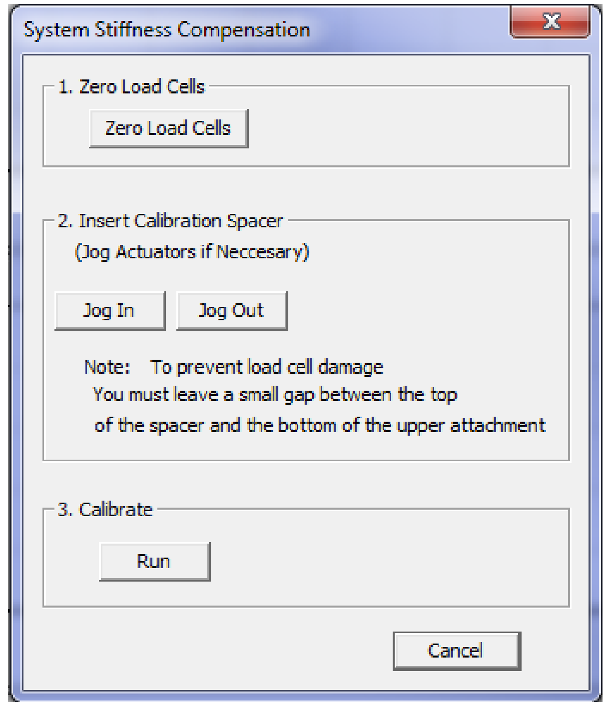


UniVert Tip: Jog Slowly to Protect Load Cells

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. Typical compensation factors are shown in the table below:

Load Cell	Typical Compensation (µm/N)
10 N	11.8
50 N	2.4
100 N	1.9
200 N	1.2

Snap Image Feature

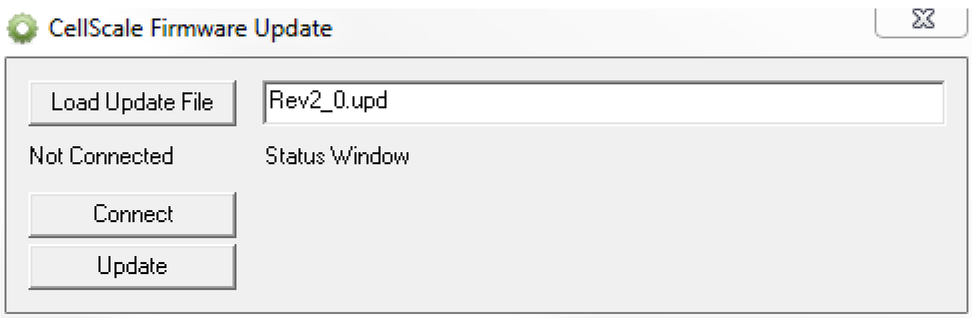
Located under *Tools>Snap Image.*

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.

1. With the UniVert connected to the PC and turned on, launch the firmware update software located in the Windows start menu under *UniVert>Utilities*.
2. Load the firmware file using the *Load Update File* button.
3. Click the *Connect* button.
4. Execute the update using the *Update* button.



9. Troubleshooting

Communication Errors: Read File failed with error 6.

When communication errors occur the live message window will display a *ReadFile* 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.

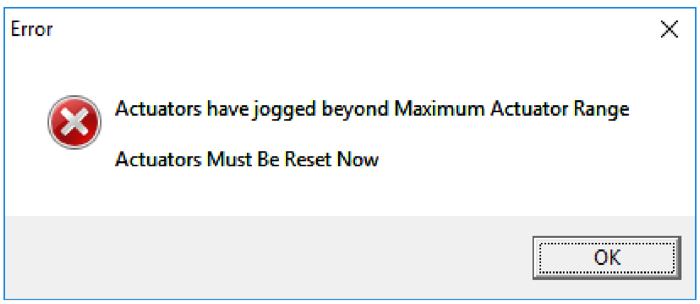
> ***UniVert Tip: Preventing Power Disruptions***
>
> *We recommend plugging the UniVert (and host computer) into an uninterruptable power supply (UPS) or battery back-up.*

Actuator Limits

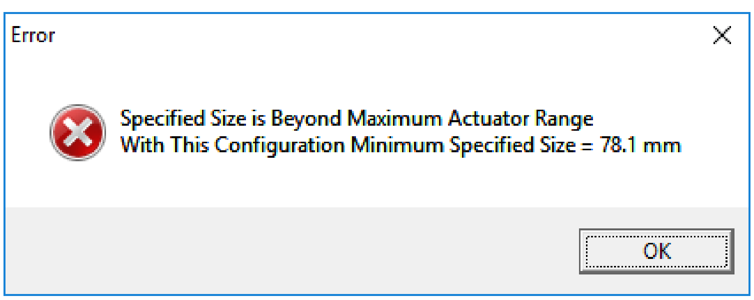
While using a test setup with a 40mm riser or no riser beneath the bottom grip or platen, it is possible to reach the lower range limit of the actuator. Hitting the physical range limit may affect the accuracy of the Current Size reading. To avoid this, there are several software warnings which occur under these circumstances:

Jogging the actuator out of range:

If the actuator is manually jogged out of the actuator range, a software warning will prompt for the actuators to be reset:

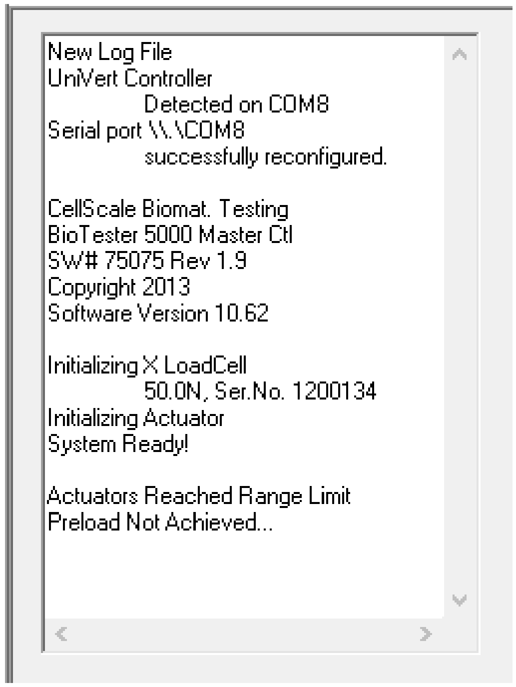


Moving the actuator out of range with *Move to Size*  ***:***
The UniVert software will not allow actuators to be moved to a size outside of the actuator range limit. An error message will warn the user of the invalid position and display the minimum specified size:

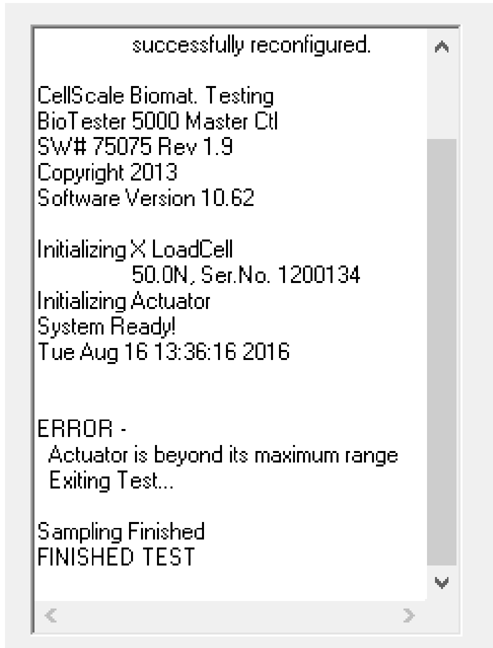


Moving the actuator out of range with *Move to Force*  **:**

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.



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 Section 8) 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.

Appendix A: Unpacking and Initial Setup

The UniVert has been packed securely to protect it during shipping. In addition, system accessories have been packed in a separate box. The system components listed below may be unpacked and laid out before system setup. A space 30cm x 30cm with 50cm overhead clearance is required for setup.

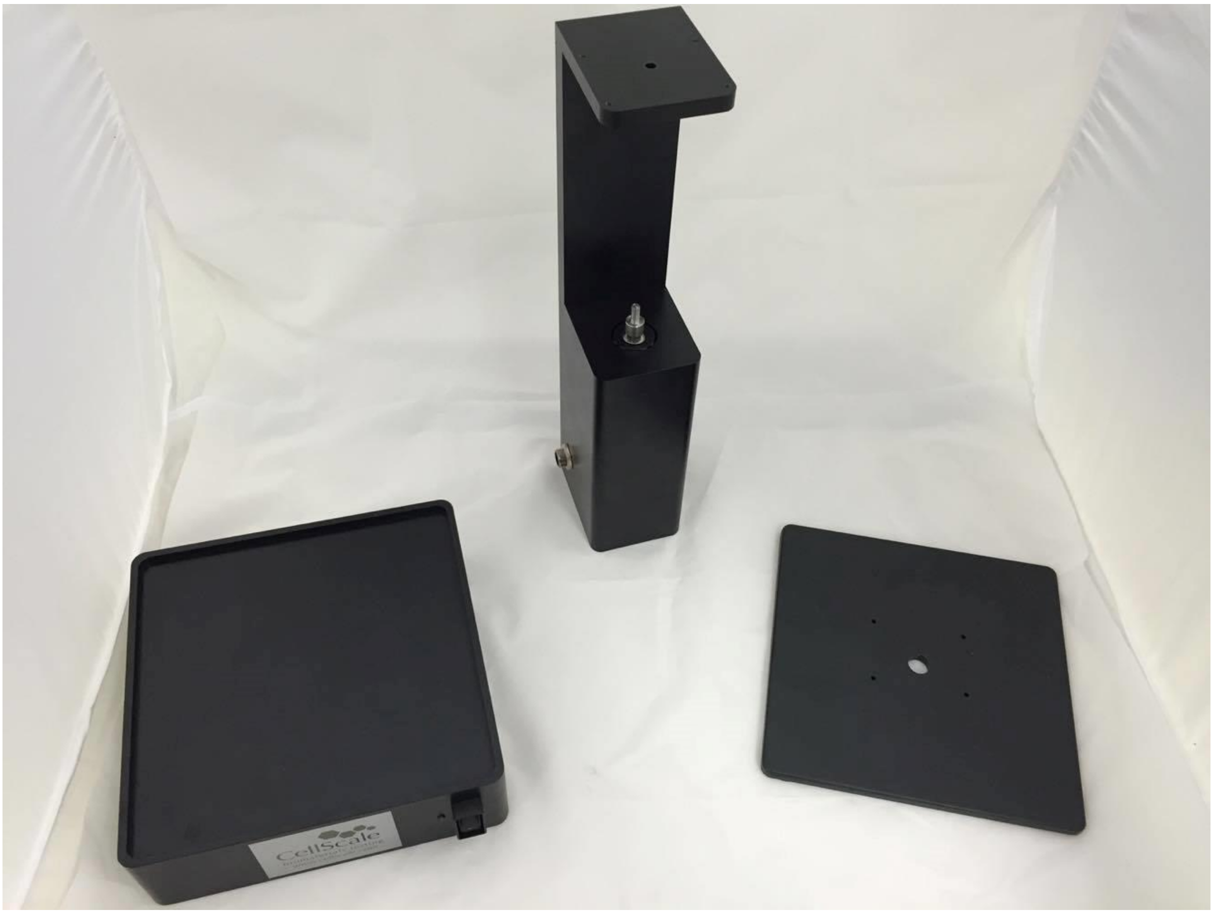
Tools

Metric hex wrenches: 1.5mm, 2.5mm, and 4mm

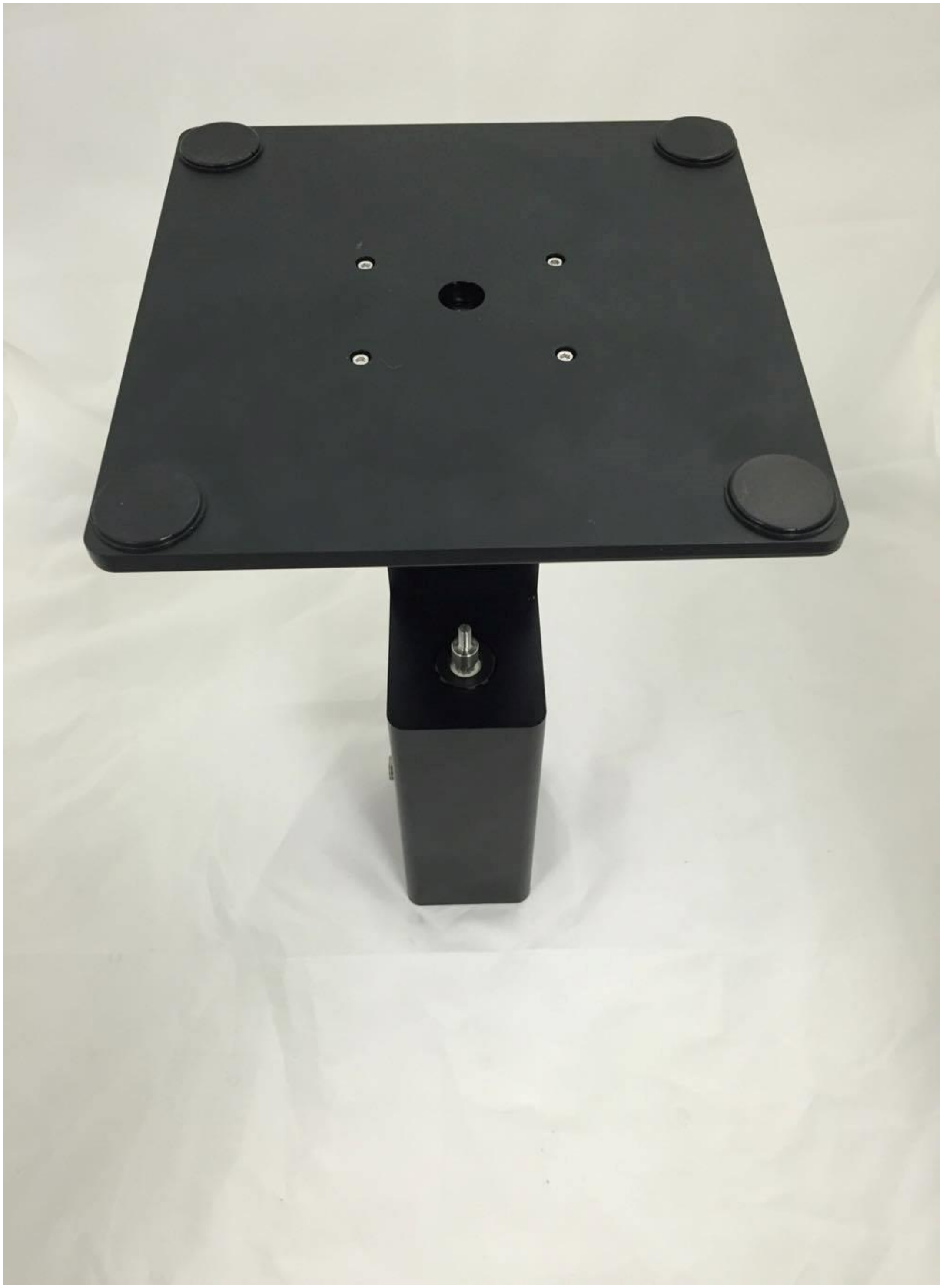
Components and Fasteners

1	UniVert Main Unit	1	Camera
1	Control Box	1	Tripod
1	Base Plate	1	Actuator Cable
1	Load Cell	1	24V Power Supply
2	Calibration Plates	1	6’ (1.8m) USB Cable
1	3-Point Bend Rail	1	M6 to M3 Thumbnut
1	3-Point Bending Block	1	M6 to M5 Thumbnut
2	3-Point Bend Slider	4	M3x10 Socket Head Cap Screw
4	3-Point Bend O-Ring (Small)	6	M2x6 Socket Head Cap Screw
2	3-Point Bend O-Ring (Large)	4	M3x8 Socket Head Cap Screw
3	3-Point Bend Dowel (Small)	1	M5x14 Socket Head Cap Screw
3	3-Point Bend Dowel (Large)	1	M5x55 Socket Head Cap Screw
3	Grip Spring (Light)	1	M5x100 Socket Head Cap Screw
3	Grip Spring (Medium)	1	40mm Riser
3	Grip Spring (Stiff)	1	80mm Riser
1	M3 Compression Platen (Plastic)	1	Bronze Calibration Spring
1	M5 Compression Platen (Plastic)	1	Red Calibration Spring
2	M5 Compression Platen (Steel)	1	Blue Calibration Spring
1	M3 Low Force Specimen Grip	1	Calibration Spacer
2	M5 Low Force Specimen Grips	1	Set of extra components
2	M5 High Force Specimen Grips	4	Sample Test Specimens
1	M6 Locking Disc	1	Stiffness Compensation Spacer
1	M5 Locking Disc		
1	M3 Locking Disc		

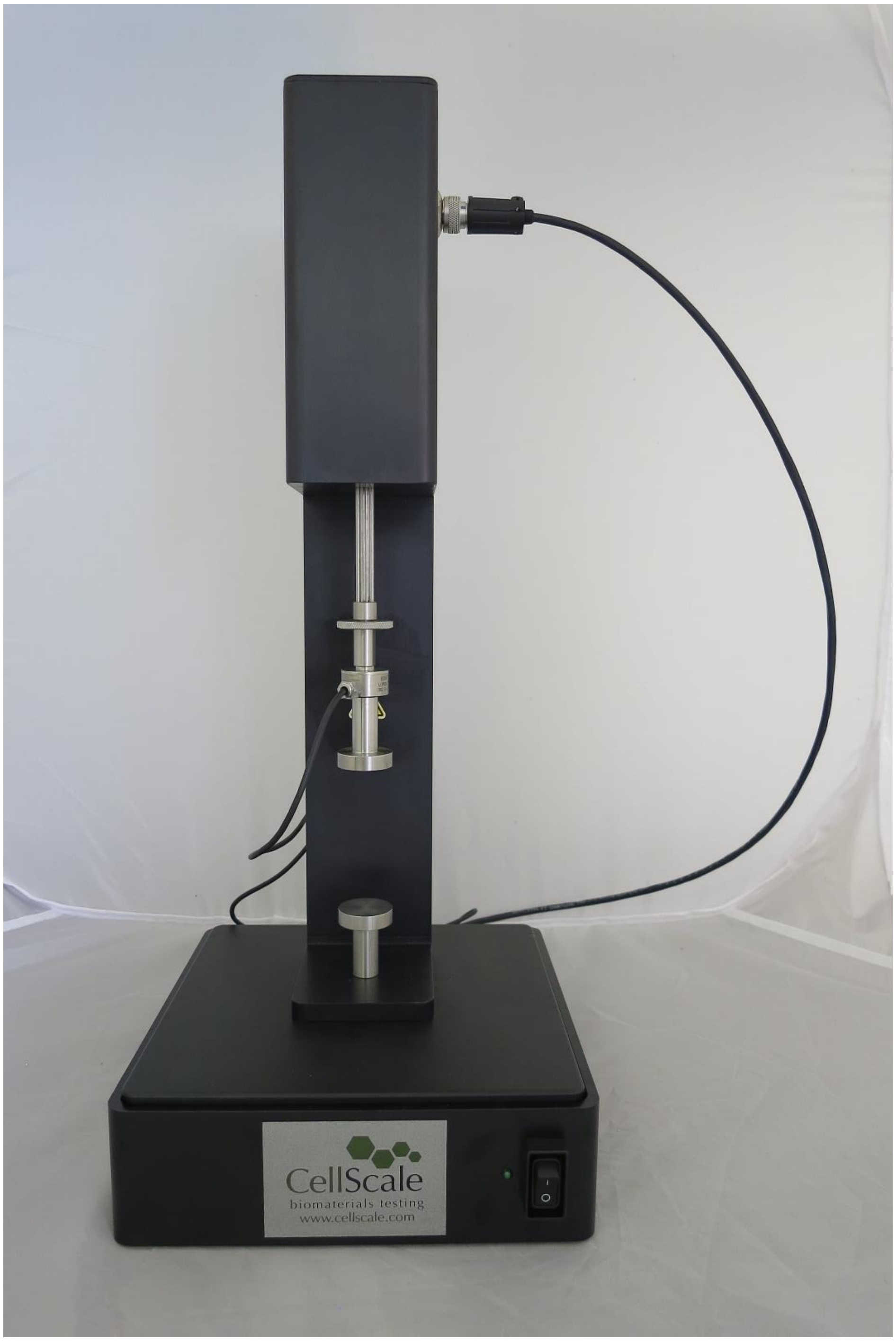
Step 1: Unpack all components and have them ready for assembly.



Step 2: Attach the base plate to the main unit
(4 x M3x8 fasteners)



Step 3: Set the UniVert main unit on the control box and connect the actuator cable to the main unit.



Step 4: Install the UniVert software.

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

Step 5: Attach the load cell.

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

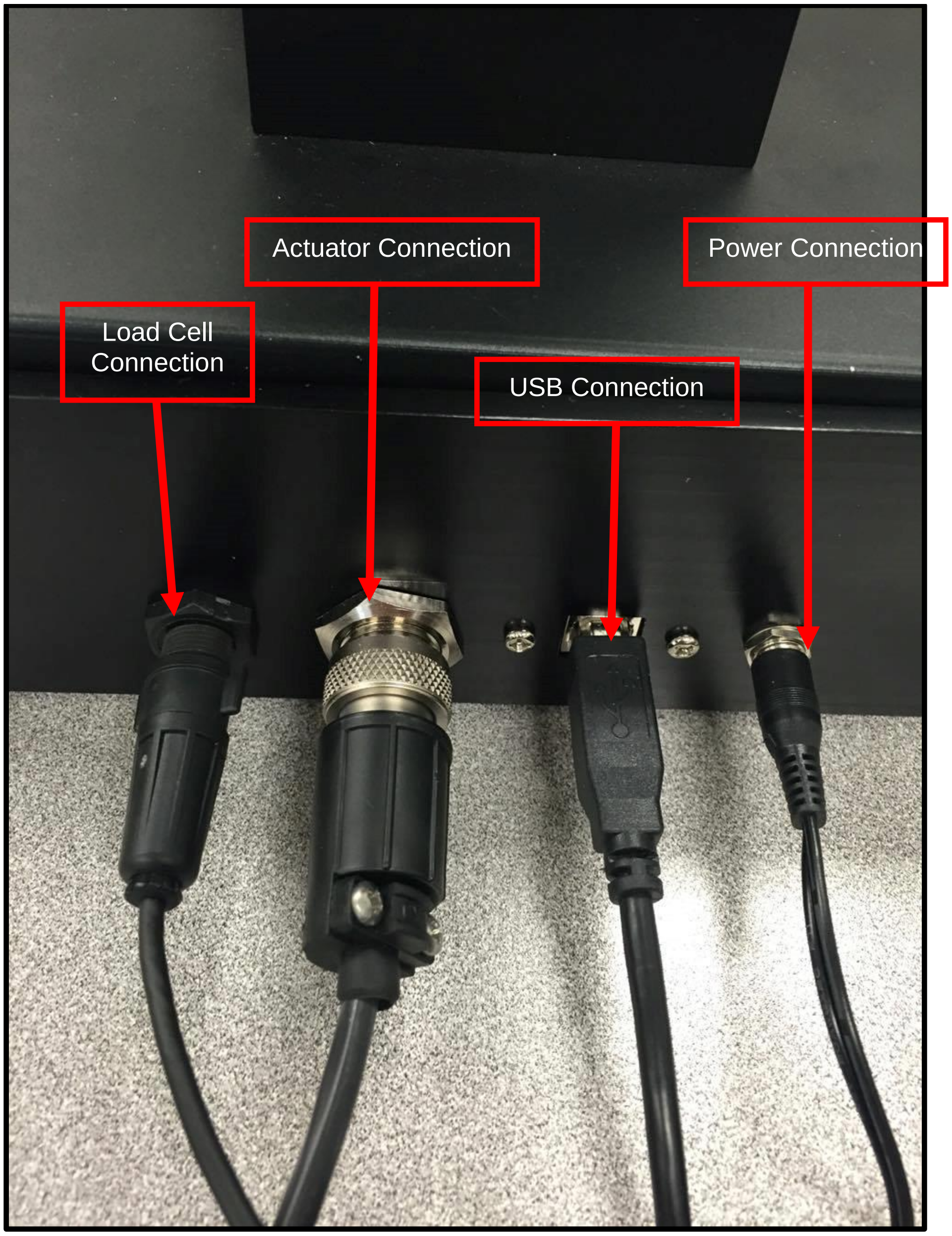
Step 6: Attach platens, grips, or 3-point bending components to the load cell

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

Step 7: Connect the UniVert controller and camera USB cables to the PC. Connect the power adapter, load cell cable, USB cable, and actuator cable to the control box

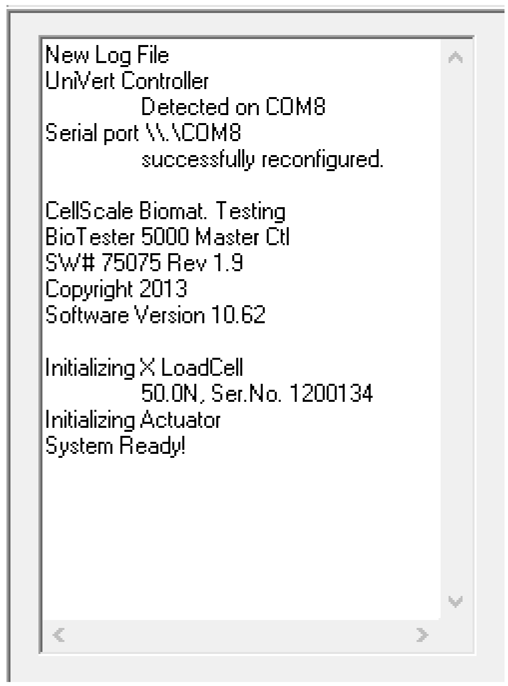
A 24V brick power supply powers the UniVert system via a barrel connector on the back of the control box. The UniVert control box is connected to the PC via a USB 2.0 connection.

The load cell and actuator connectors have a keyway inside the connector and a locking ring to ensure proper connection. To connect a load cell or actuator cable align the keyway, push the connector in, and turn the locking ring until tight. Note that the load cell connector only requires about ¼ turn to lock in place while the actuator cable has a threaded connection and requires several turns to lock in place.



Step 8: Launch the software and begin a test to ensure the UniVert loads up normally.

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



Step 9: Calibrate the Load Cell

See **Section 8** of the User's Manual for more information.

Step 10: Set the Actuator Zero Position

See **Section 8** of the User's Manual for more information.

Step 11: Begin Testing

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

Appendix B: Load Cell Installation

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

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

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

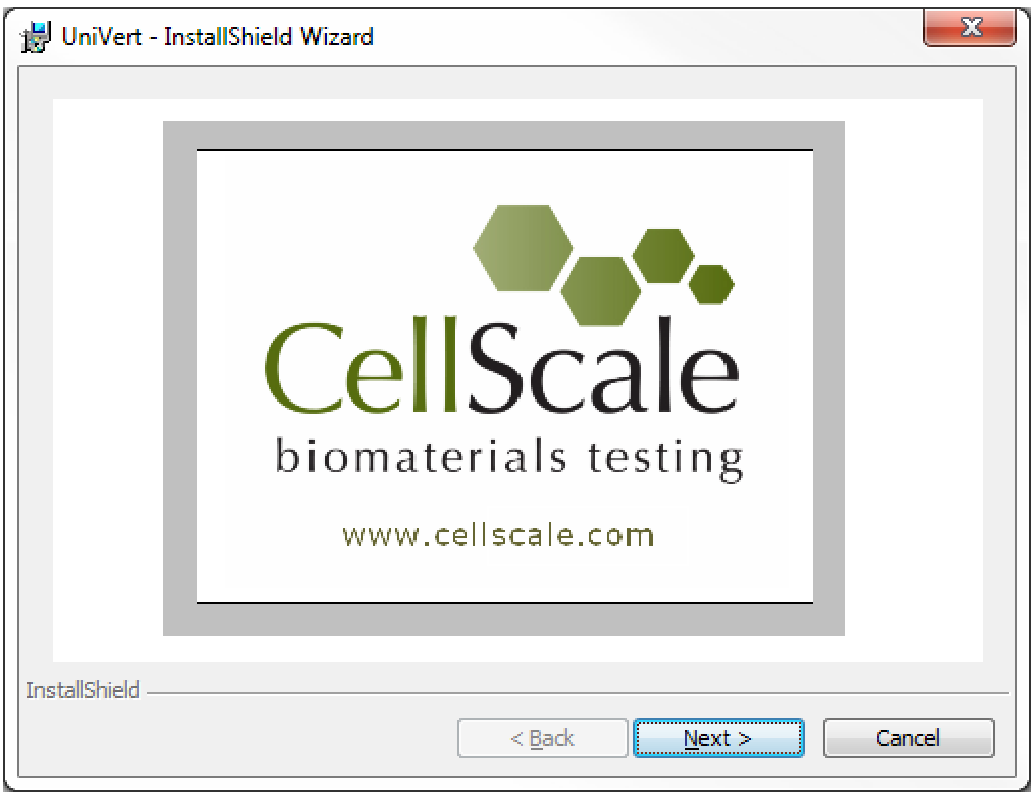
3. Screw the load cell/thumbnut combination onto the actuator. **At this point the measuring end of the load cell should be facing down, and the non-measuring end attached to the thumbnut and actuator.**

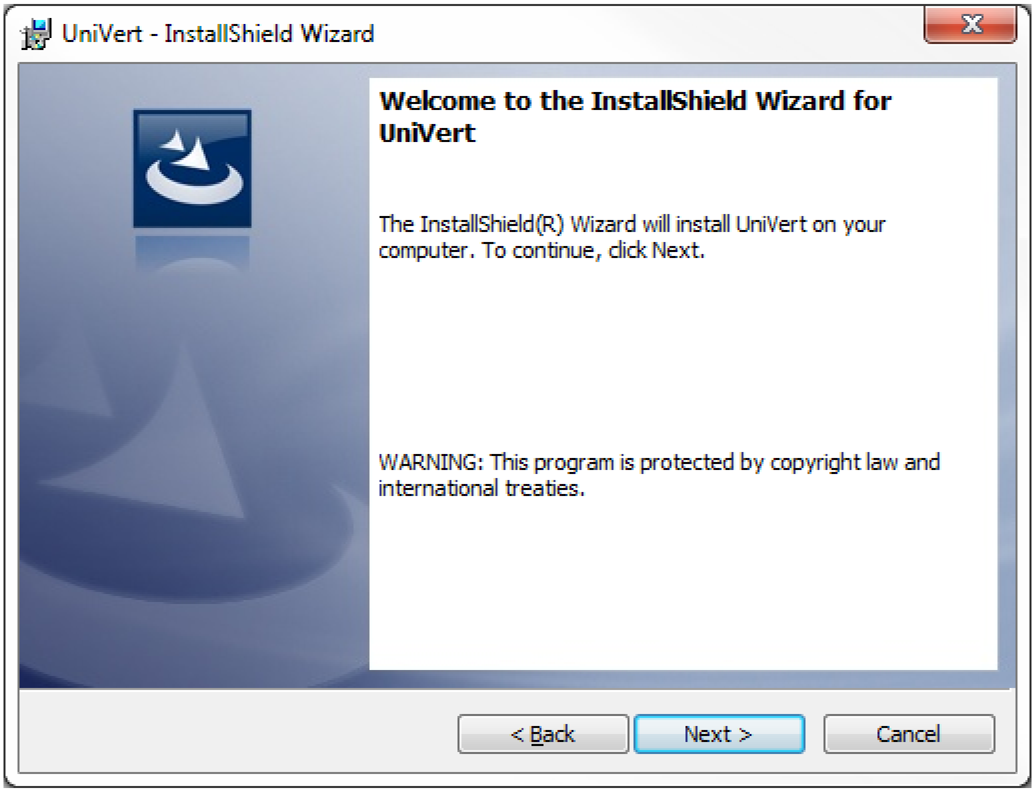
   An M6 locking disc may be used between the thumbnut and actuator so the rotational position of the load cell can be changed while maintaining snug attachment.

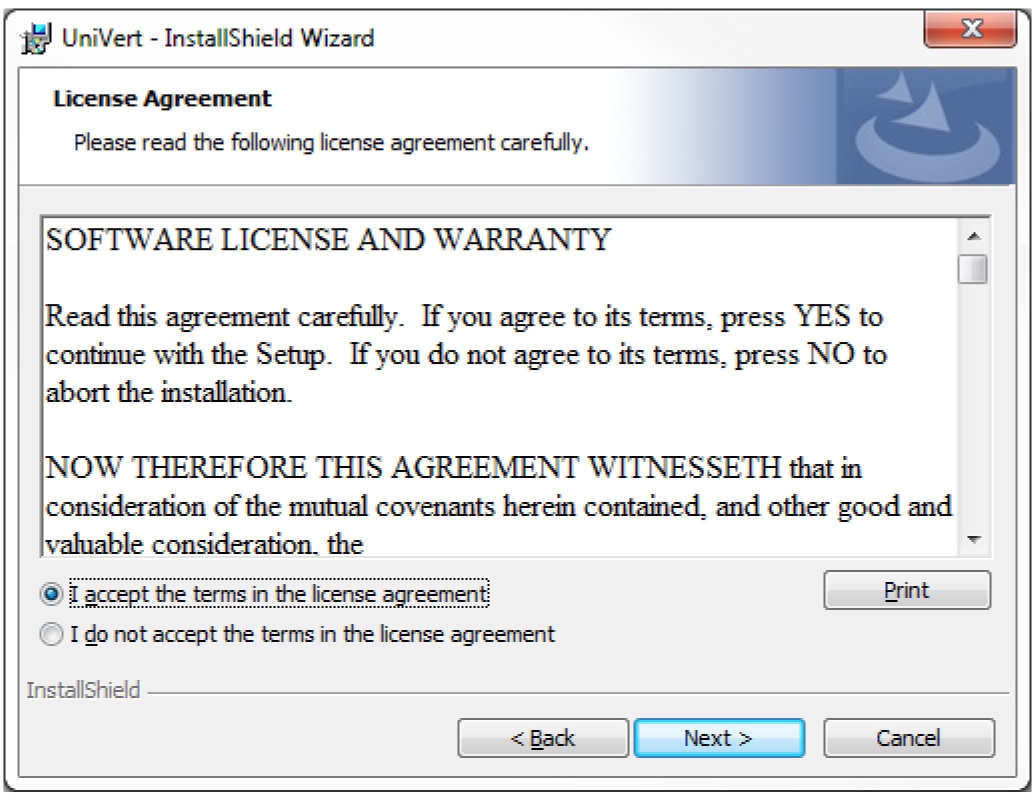
Appendix C: Software Installation

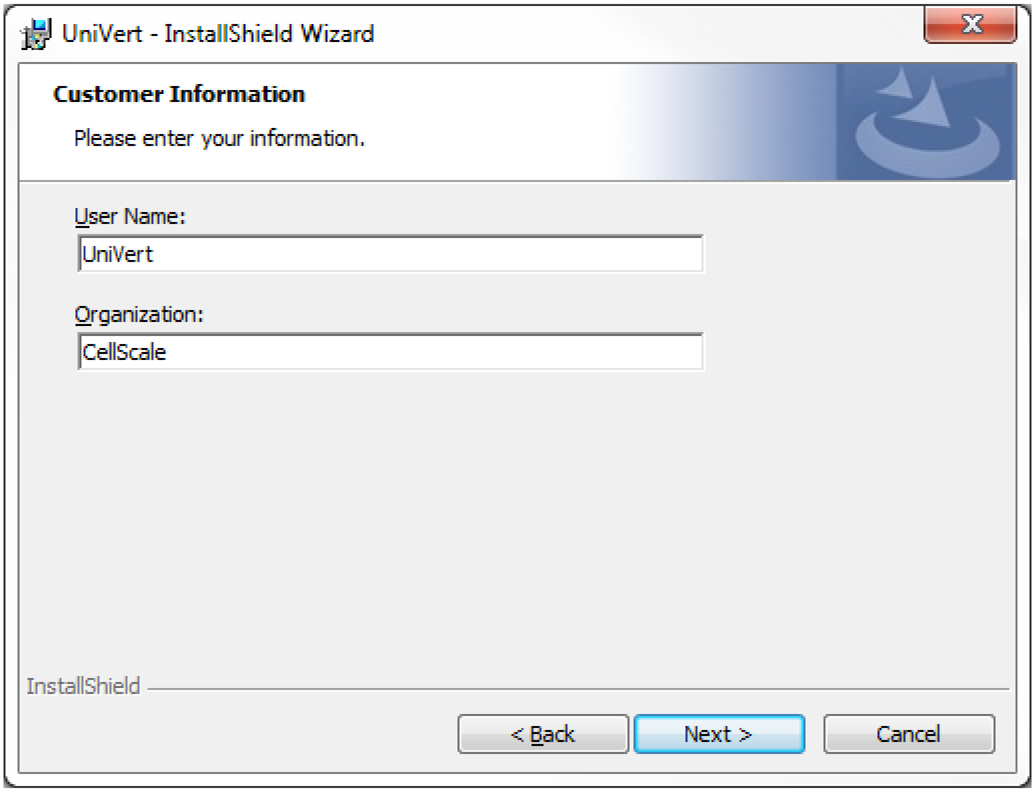
A Windows based PC (Windows 7 or above) with at least 2 USB 2.0 ports is required to operate the UniVert. A label on the cover of the manual contains a web address to download the UniVert software installation package. These files contain the software installer for the user interface and control software for the UniVert.

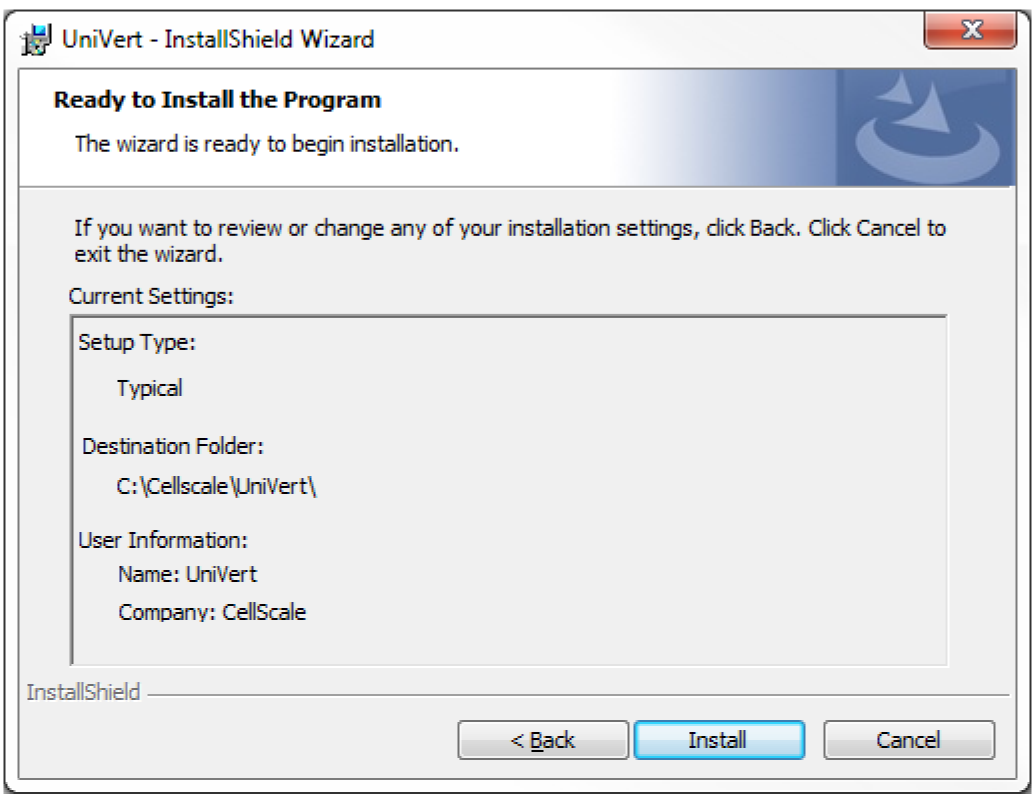
To install the software, go to the provided web address and download the compressed installation package. Transfer this file to the computer which will be running the UniVert. Right click on the folder and select *Extract All…* to unzip. After this is complete, go to the uncompressed installation folder and select *setup.exe*. Details of typical dialogue boxes are shown below.

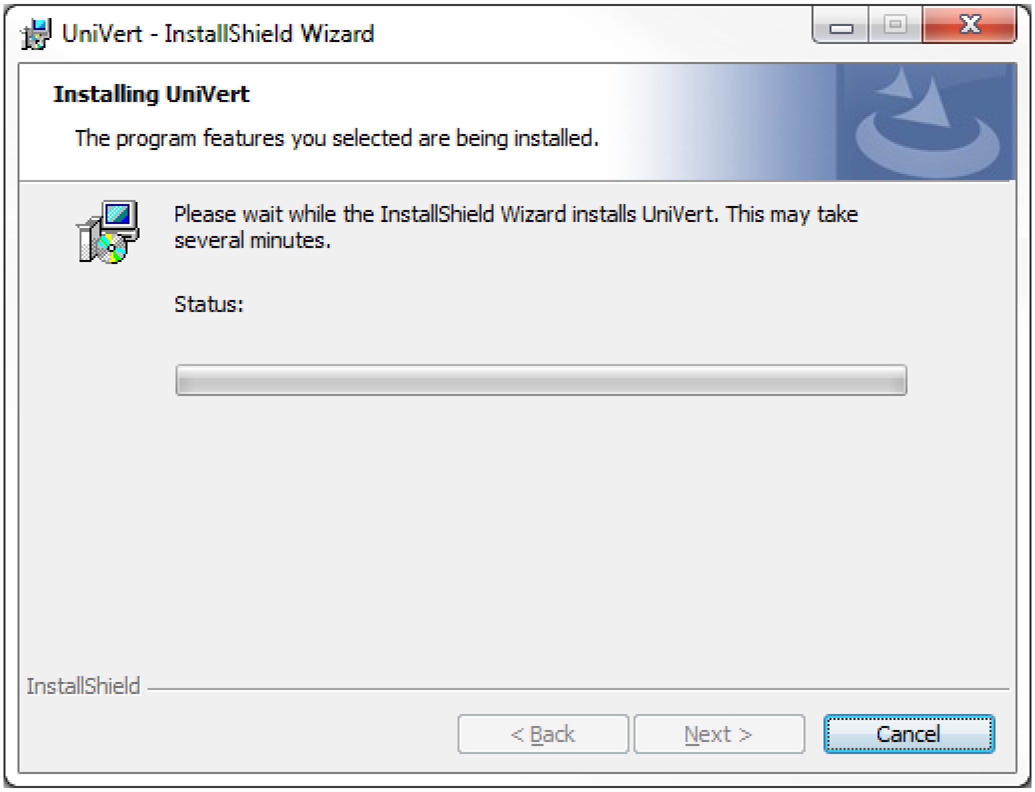


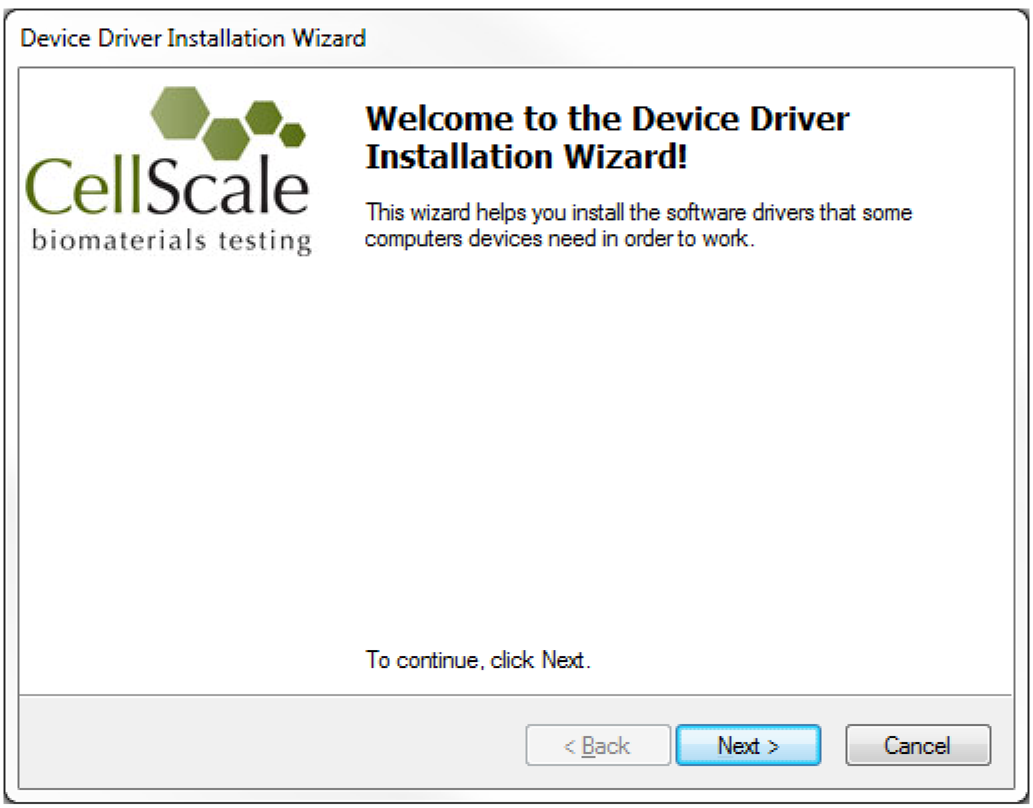

UniVert - InstallShield Wizard
Welcome to the InstallShield Wizard for UniVert
The InstallShield(R) Wizard will install UniVert on your computer. To continue, click Next.
WARNING: This program is protected by copyright law and international treaties.
< Back
Next >
Cancel

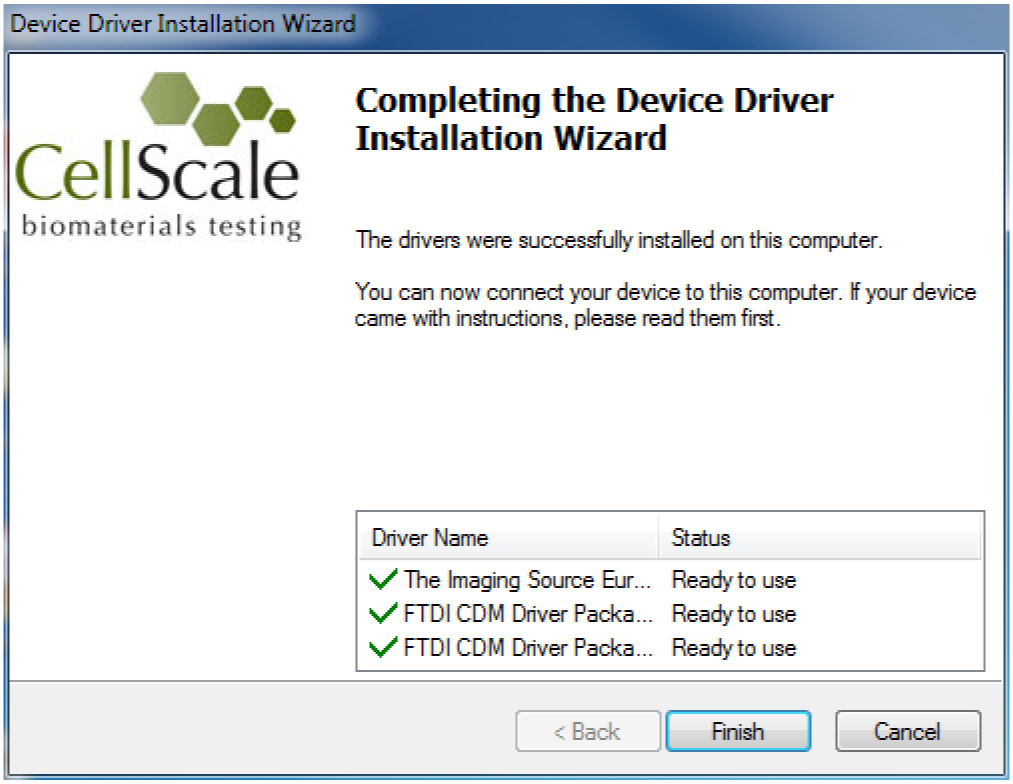

UniVert - InstallShield Wizard
License Agreement
Please read the following license agreement carefully.
SOFTWARE LICENSE AND WARRANTY
Read this agreement carefully. If you agree to its terms, press YES to continue with the Setup. If you do not agree to its terms, press NO to abort the installation.
NOW THEREFORE THIS AGREEMENT WITNESSETH that in consideration of the mutual covenants herein contained, and other good and valuable consideration, the
I accept the terms in the license agreement
I do not accept the terms in the license agreement
Print
InstallShield
< Back
Next >
Cancel

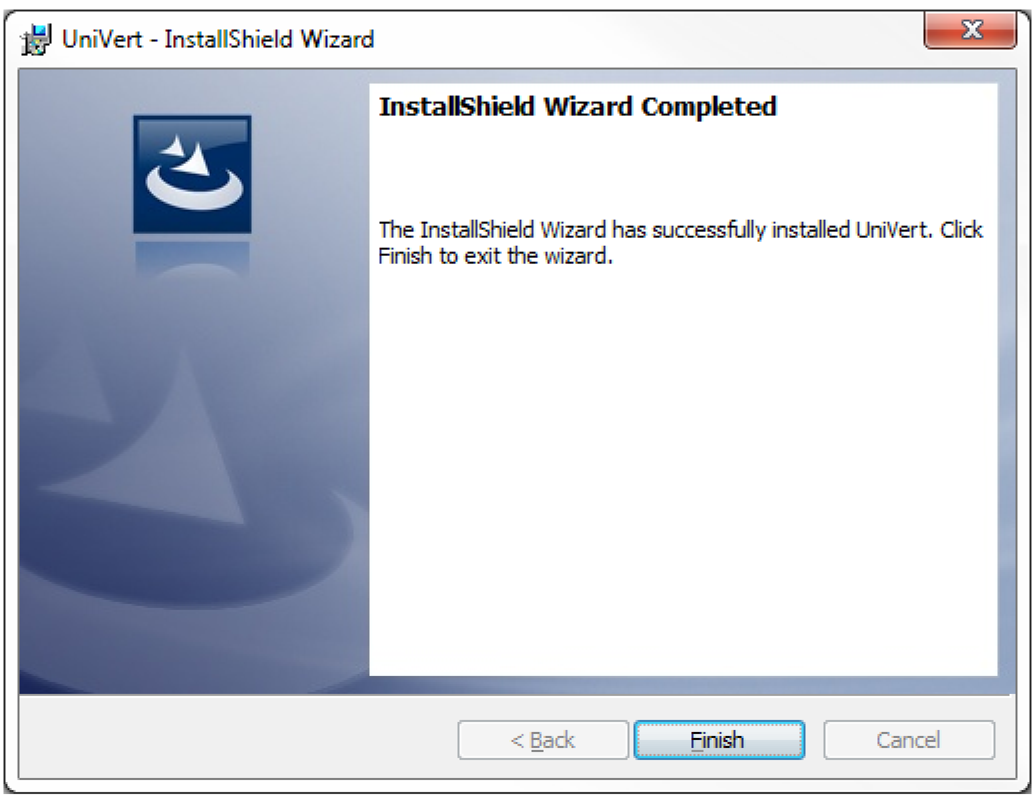

UniVert - InstallShield Wizard
Customer Information
Please enter your information.
User Name:
UniVert
Organization:
CellScale
InstallShield
< Back
Next >
Cancel

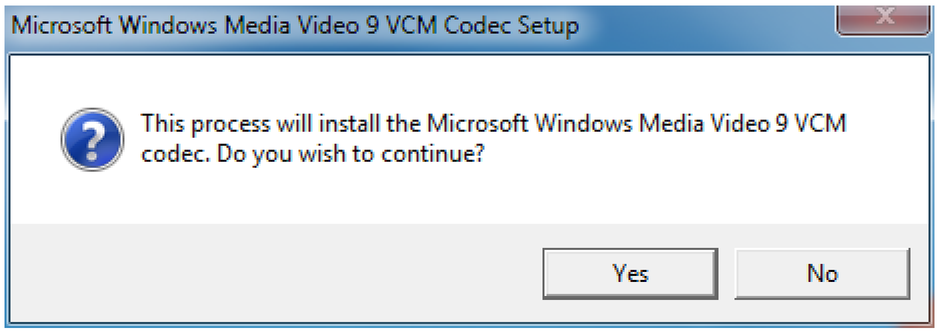

UniVert - InstallShield Wizard
Ready to Install the Program
The wizard is ready to begin installation.
If you want to review or change any of your installation settings, click Back. Click Cancel to exit the wizard.
Current Settings:
Setup Type:
Typical
Destination Folder:
C:\Cellscale\UniVert\
User Information:
Name: UniVert
Company: CellScale
InstallShield
< Back
Install
Cancel

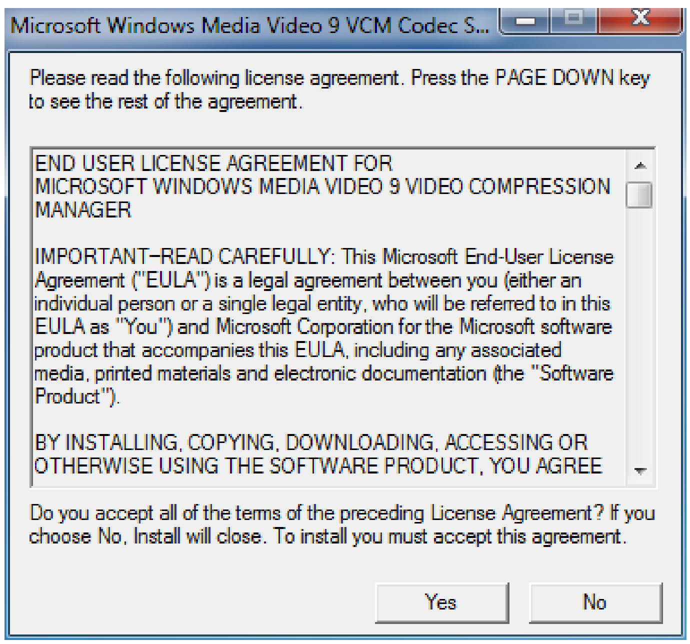

UniVert - InstallShield Wizard
Installing UniVert
The program features you selected are being installed.
Please wait while the InstallShield Wizard installs UniVert. This may take several minutes.
Status:
InstallShield
< Back
Next >
Cancel

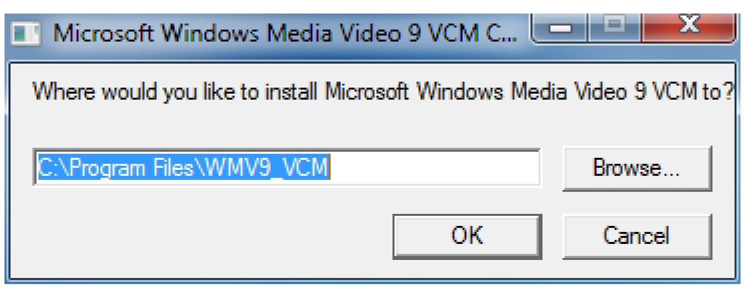

Device Driver Installation Wizard
CellScale
biomaterials testing
Welcome to the Device Driver Installation Wizard!
This wizard helps you install the software drivers that some computers devices need in order to work.
To continue, click Next.
< Back
Next >
Cancel

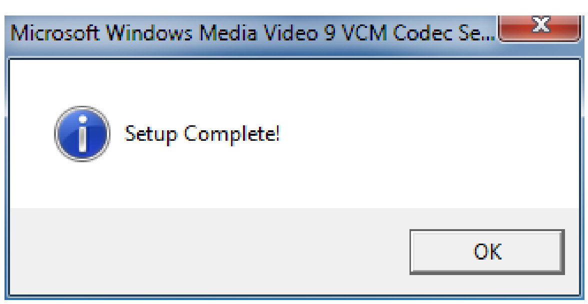

Device Driver Installation Wizard
CellScale
biomaterials testing
Completing the Device Driver Installation Wizard
The drivers were successfully installed on this computer.
You can now connect your device to this computer. If your device came with instructions, please read them first.
Driver Name
Status
The Imaging Source Eur...
Ready to use
FTDI CDM Driver Packa...
Ready to use
FTDI CDM Driver Packa...
Ready to use
< Back
Finish
Cancel


UniVert - InstallShield Wizard
InstallShield Wizard Completed
The InstallShield Wizard has successfully installed UniVert. Click Finish to exit the wizard.
< Back
Finish
Cancel


Microsoft Windows Media Video 9 VCM Codec Setup
This process will install the Microsoft Windows Media Video 9 VCM codec. Do you wish to continue?
Yes
No


Microsoft Windows Media Video 9 VCM Codec S...
Please read the following license agreement. Press the PAGE DOWN key to see the rest of the agreement.
END USER LICENSE AGREEMENT FOR MICROSOFT WINDOWS MEDIA VIDEO 9 VIDEO COMPRESSION MANAGER
IMPORTANT–READ CAREFULLY: This Microsoft End-User License Agreement ("EULA") is a legal agreement between you (either an individual person or a single legal entity, who will be referred to in this EULA as "You") and Microsoft Corporation for the Microsoft software product that accompanies this EULA, including any associated media, printed materials and electronic documentation (the "Software Product").
BY INSTALLING, COPYING, DOWNLOADING, ACCESSING OR OTHERWISE USING THE SOFTWARE PRODUCT, YOU AGREE
Do you accept all of the terms of the preceding License Agreement? If you choose No, Install will close. To install you must accept this agreement.
Yes
No


Microsoft Windows Media Video 9 VCM C...
Where would you like to install Microsoft Windows Media Video 9 VCM to?
C:\Program Files\WMV9_VCM
Browse...
OK
Cancel

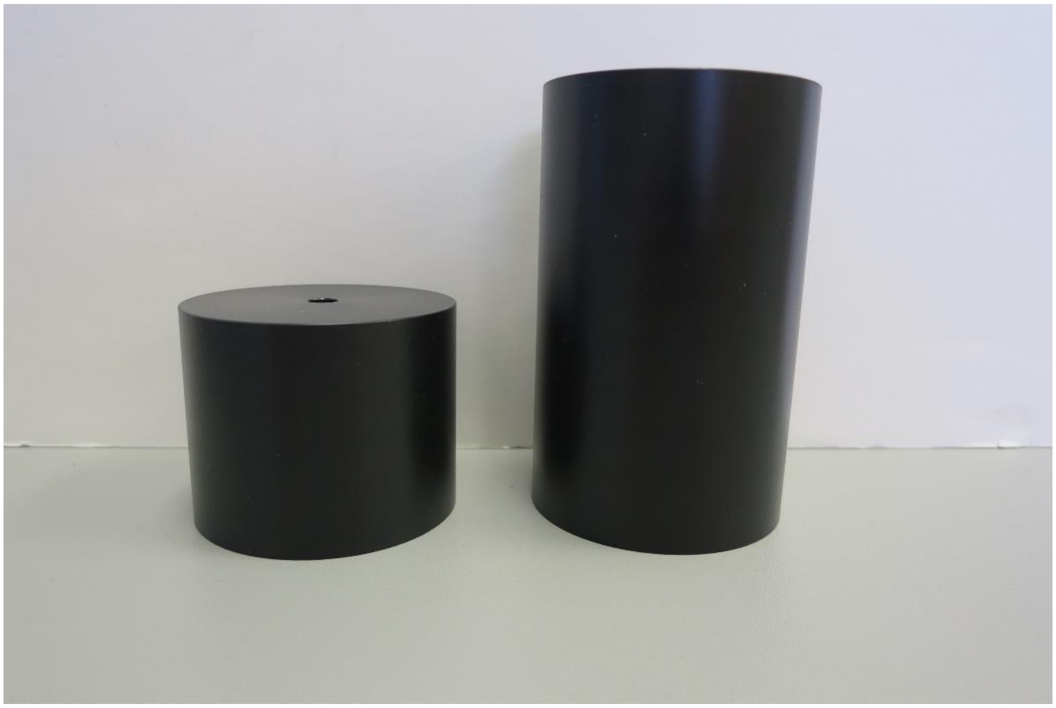

Microsoft Windows Media Video 9 VCM Codec Se...
Setup Complete!
OK

Appendix D: Test Setup

Choosing and installing a Riser for the Bottom Grip, Platen, or 3 Point Bend Block

40mm and 80mm risers are included with the UniVert system. These are placed between the bottom of the main unit and the lower platen, grip, or 3-point bending block. The risers are used to set the available specimen size for testing. Due to the limitations of maximum stroke of the actuator, each riser (or no riser) will have correspond to a minimum sample size.

- Using a 40mm riser requires a minimum sample size of about 40mm.
- Using **NO** riser requires a minimum sample size of about 80mm.



> ***UniVert Tip: Choosing an appropriate riser***
>
> *The UniVert system can accommodate large samples when using the 40mm riser or no riser. Use a 40mm riser or no riser for large samples or tests that require large displacements.*

After selecting a riser follow these installation steps:

1. Carefully place the UniVert motor housing on its side.

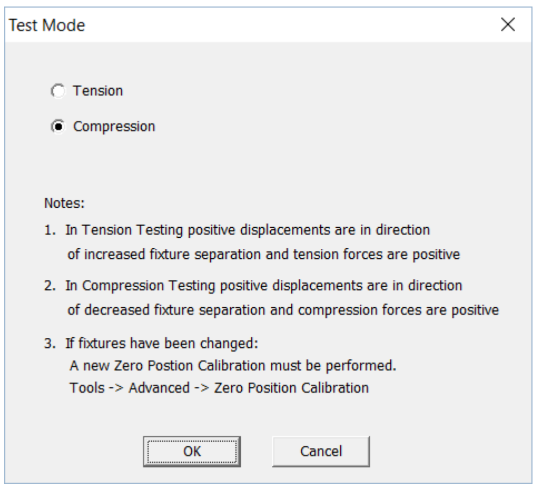
2. Select the **M5x100** fastener for an 80mm riser, the **M5x55** fastener for a 40mm riser or an **M5x14** fastener when not using a riser. (Note: Two M5 washers must be used when using the M5x100 fastener and the 80mm riser.)

3. Thread the appropriate fastener through the bottom of the base plate and slide the corresponding riser on top.

4. Continue with a test setup procedure using the grips, platens, or 3-point bend blocks. This is outlined below.

Tension Test Setup

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



2. Install the desired load cell (see **Appendix B**) and select the appropriate riser (see above)

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

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

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

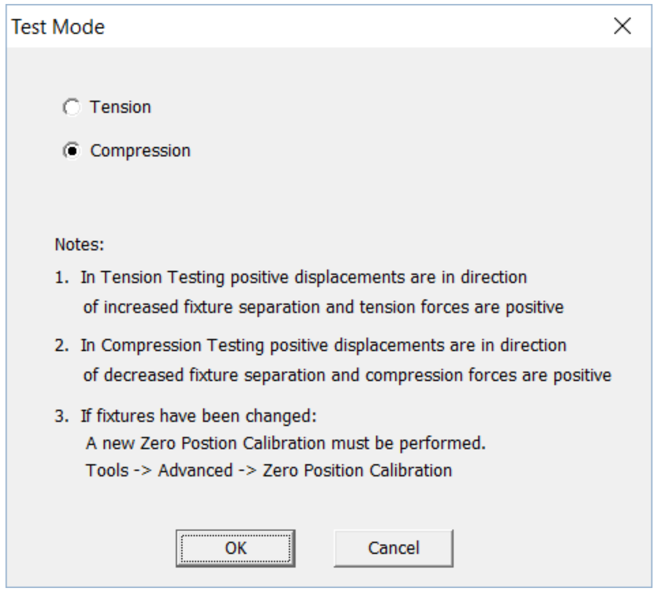
5. Choose an appropriate riser and attach the bottom grip. Use an **M5x14** fastener for a test setup with **NO** riser, a **M5x55** fastener for a 40mm riser, and an **M5x100** fastener for the 80mm riser. (Note: Two washers will be needed on the M5x100 fastener when using the High Force Grips)

6. Align the two grips until they are parallel.

7. A Zero Position Calibration is required after changing grips or platens. See **Section 8** of this manual for more details.

Compression Test Setup

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

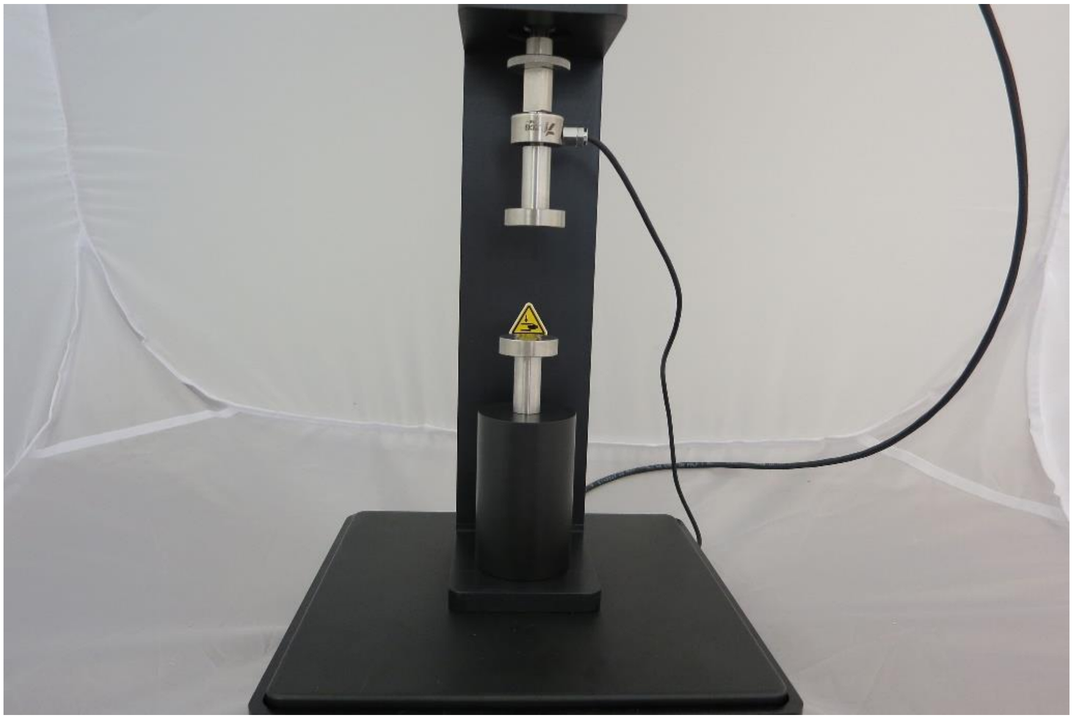


2. Install the desired load cell (see **Appendix B**)

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

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

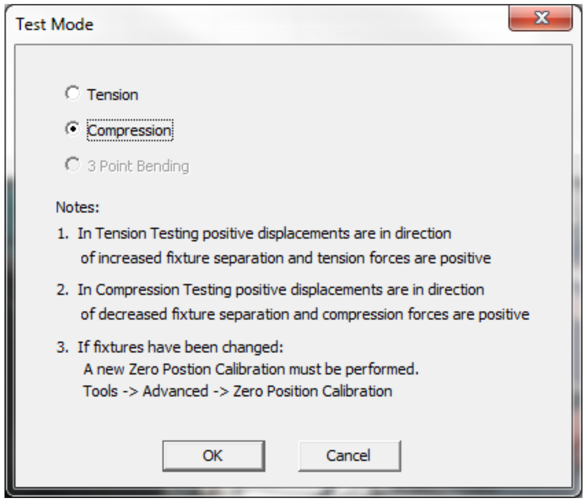
4. Choose an appropriate riser and attach the bottom platen. Use an **M5x14** fastener for a test setup with **NO** riser, a **M5x55** fastener for a 40mm riser, and an **M5x100** fastener for the 80mm riser.



5. A Zero Position Calibration is required after changing grips or platens. See **Section 8** of this manual for more details.

3-Point Bend Test Setup

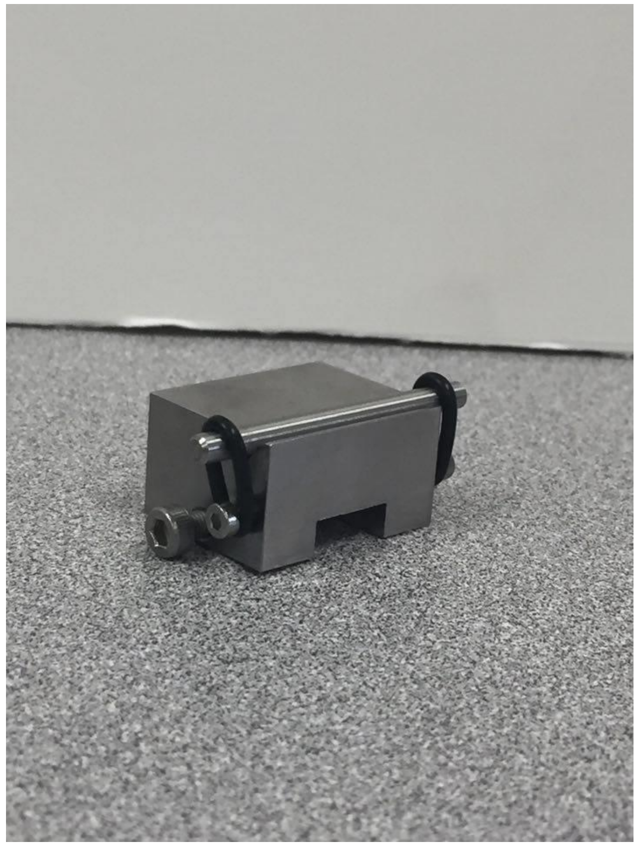
1. Set the test mode to compression (*Settings>Test Mode>Compression*).



2. Install the desired load cell (see **Appendix B**)

3. Attach a locking disc to the measuring end of the load cell.

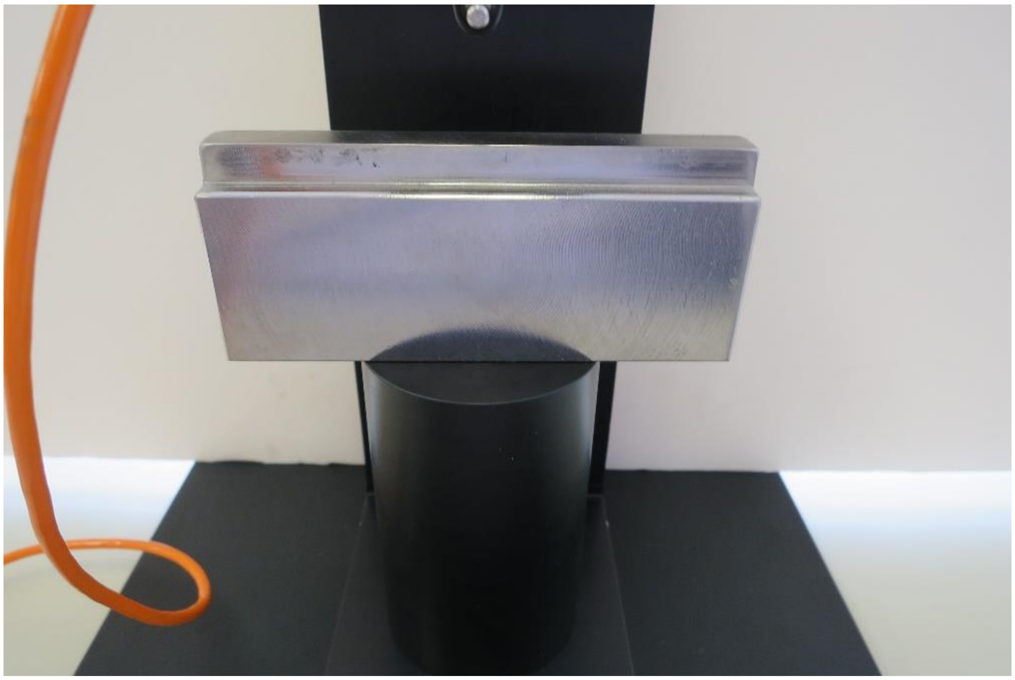
4. Assemble the 3-Point Bending Block and sliders using M2x6 fasteners, M3x10 fasteners, large O-Rings and small O-Rings as illustrated below (Note: Choose a dowel size appropriate for the test being performed).



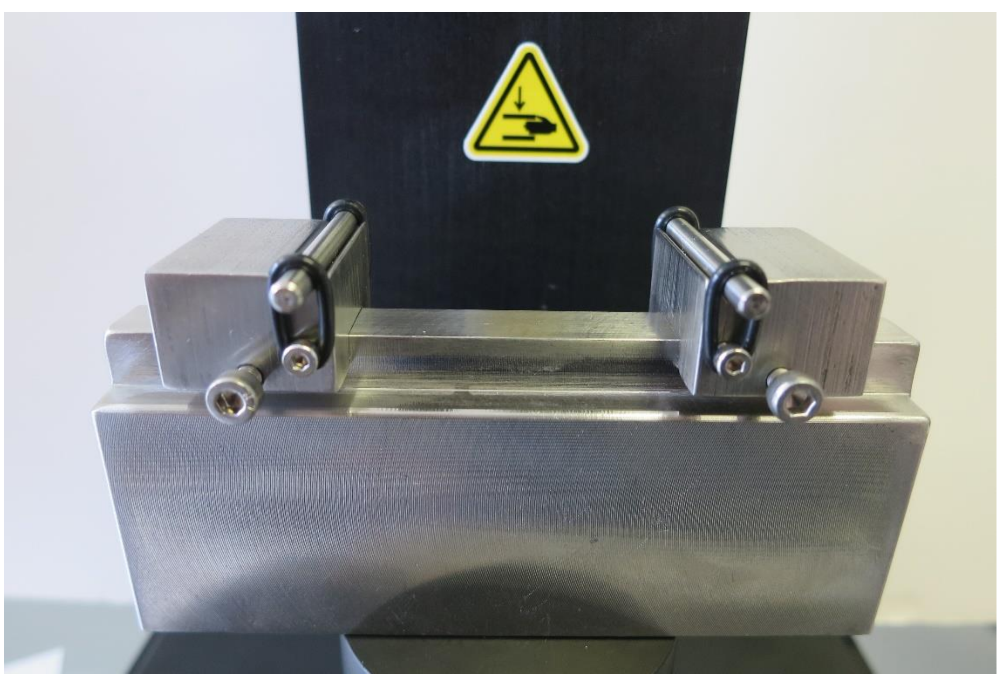
5. Screw the bending block onto the measuring end of the load cell and tighten in the correct position using the locking disc.

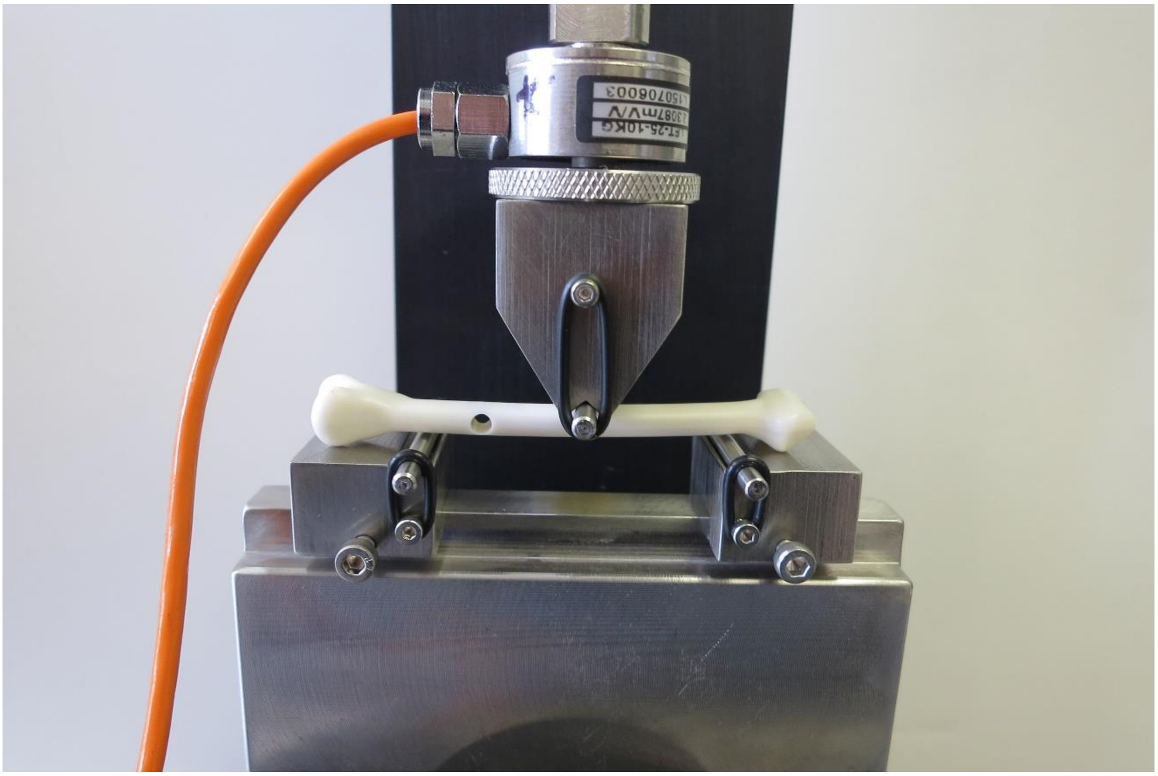
Finger tighten all components. Beware of exerting excessive off-axis and torqueing forces to avoid damage to the load cell.

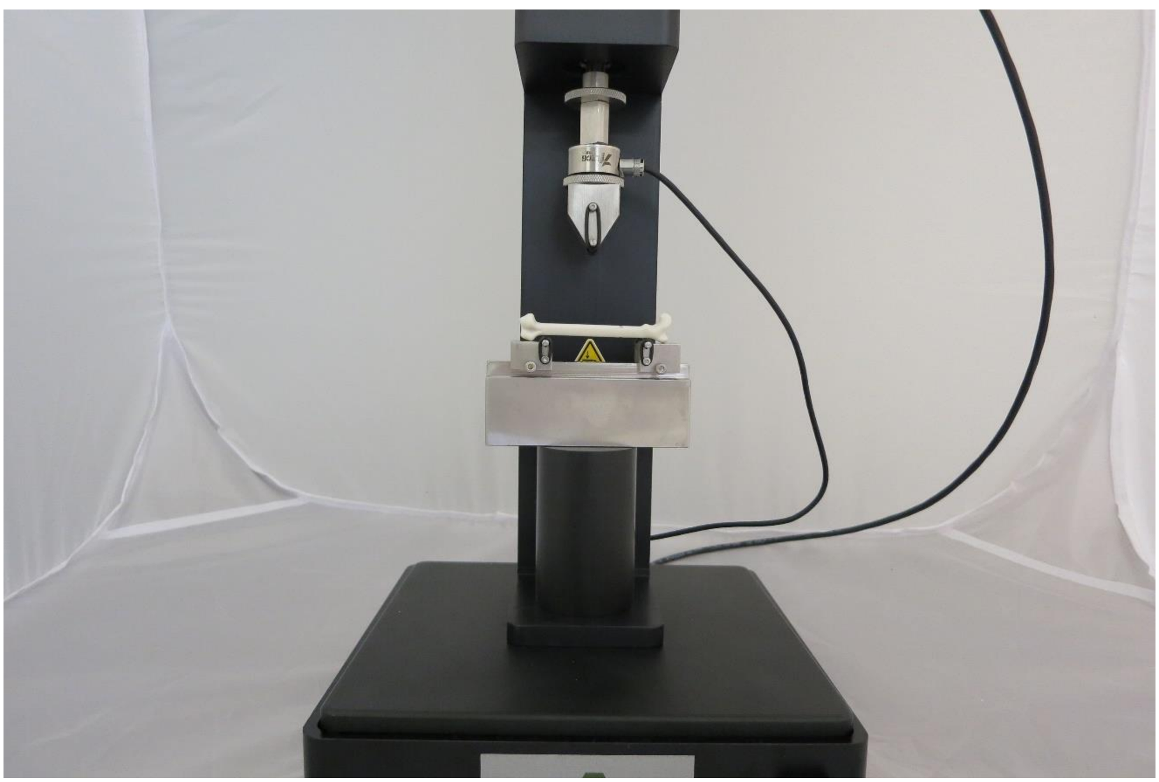
6. Attach and align the 3-Point bend rail onto the bottom of the motor housing using an **M5x100** fastener and 80mm riser.



7. Secure both sliders onto the rail in the desired position by tightening the fasteners.







Appendix E: Camera Setup

Webcam

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

1. Before starting the UniVert software, plug the webcam into a USB port.

2. Thread the tripod into the mounting hole on the bottom of the camera.

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

4. Refer to Section 7: System Hardware Settings for additional camera settings.

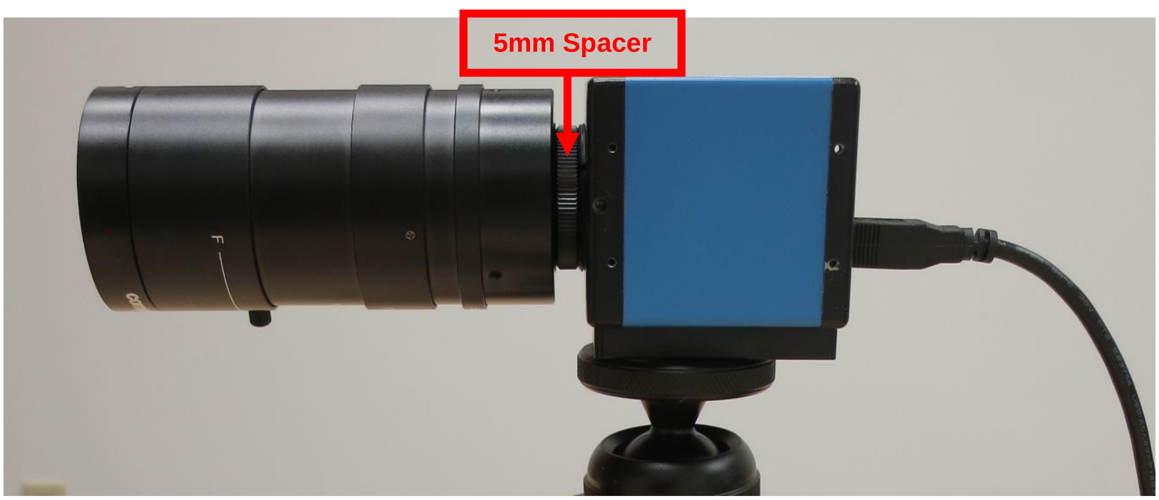
Scientific Camera

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 of the software. To setup the camera, follow these steps:

1. Before starting the UniVert software, plug the camera into a USB port. Have the UniVert software open while performing camera setup so that the live video can be monitored.

2. Thread the tripod into the mounting hole on the bottom of the camera.

3. Thread the lens onto the camera with a 5mm spacer in place (already attached to the camera upon system delivery)



4. Place the ringlight on the end of the lens. Lock it in place using the thumb screws. Brightness level can be controlled by the dial on the power supply.

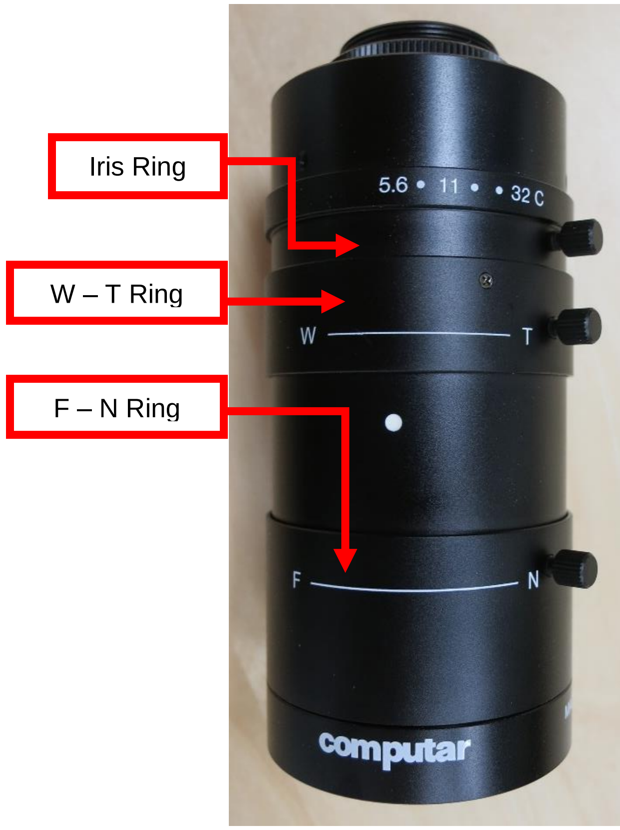
5. Bring the camera to the desired height by adjusting the separation of the tripod legs. Note that working distance from specimen to lens should be at least 15cm.

6. 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 ringlight and the Hardware Settings in the software (see Section 7).

7. Obtain desired magnification level by manually adjusting the W – T ring on the lens.

8. Bring the image to optimum focus by manually adjusting the F – N ring on the lens.

9. Use the thumb screws on each of the lens rings to lock them at the desired settings.

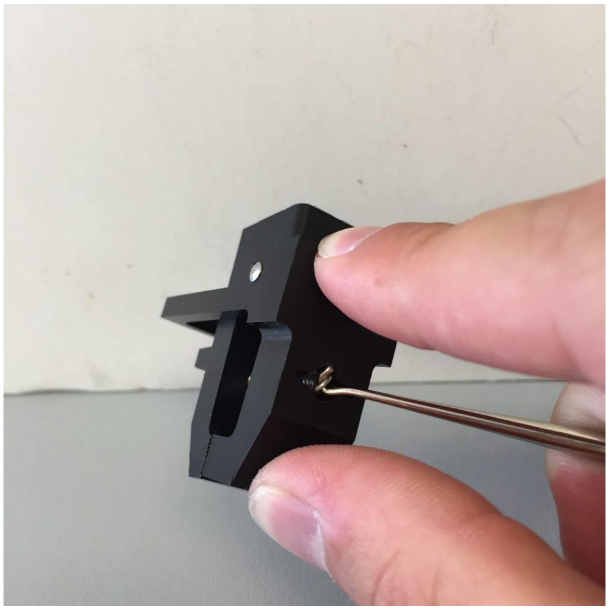


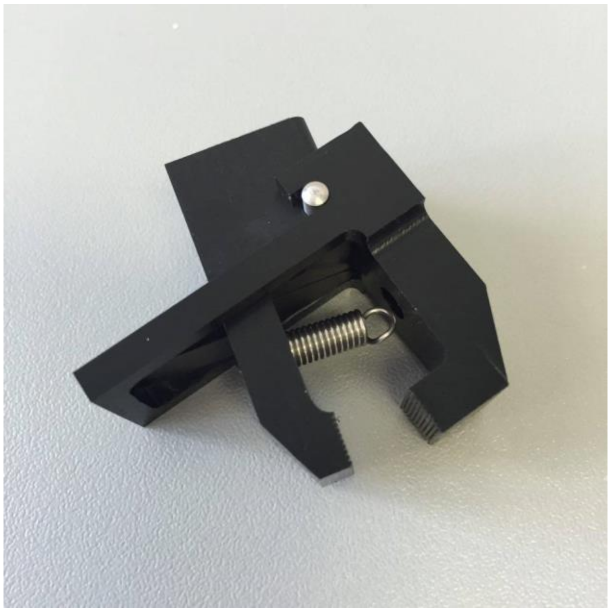
Appendix F: Changing Grip Springs

The grips used for tension testing come in three different gripping strengths to suit different materials and tests. Replacement springs of varying stiffness are provided with the UniVert and these may be switched at any time using the hook tool provided. The light, medium and heavy springs will provide **1.5N**, **6N**, and **15N** of gripping force respectively.

To change a grip spring follow these steps:

1. Using the hook tool provided, pull on the spring and remove the metal dowel holding the grip spring in place. The spring is free to be removed after this step.





System Alert

A fully installed spring experiences a high amount of tension. When the springs are disengaged, be sure not to let the hook tool slip or the spring may be released at high velocity. ***The use of safety glasses is recommended.***

2. Replace the old spring with a new spring of the desired tension.
3. Secure one side of the spring onto the grip with a metal dowel.
4. With one hand use the hook tool to pull the other side of the spring into place and secure with another metal dowel (Note: This step may be easier with two people)