Nanomechanics, Inc.
iNano Indentation System Operating Instructions

SKYD-0892-0
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1.0 Introduction

1.1 About Nanomechanics

A word about us: Nanomechanics, Incorporated is comprised of scientists and engineers with unparalleled expertise in Materials Science, Precision Mechanical Design, and Advanced Instrumentation Software. Over the last 20 years, our staff has stayed at the forefront of technology focused on nano-scale mechanical testing. We take a comprehensive approach to developing quality solutions for our customers.

We are dedicated to improving technologies in mechanical testing, force and displacement measurements, and evaluating the mechanical performance of materials. We do this through the research and development of test techniques and data management, design and manufacturing, and through our state-of-the-art analytical services laboratory. Our engineers specialize in nanomechanical transducer design, testing techniques, data acquisition, system integration, and software development.

Our principle mission is to enable our customers to evaluate and understand the mechanical performance of their materials on the micro- and nano-scales. With field experts in nanomechanical testing, data acquisition, and system integration, we are well positioned to provide the operator with the most accurate results along with leading edge characterization.

1.2 Contacting Us

Getting More Information about Nanomechanics, Inc. and Our Products

To find out more about Nanomechanics, Inc. and our products, visit the NanoMechanics, Inc. website at http://www.insem.com/.

An online Contact Us form can be obtained at this link – one of our application engineers will contact you regarding your request within 24 hours.

For direct contact by phone, call 1-877-386-6262.

Additionally, you may email us at: info@insem.com.
Our mailing address is:

Nanomechanics, Inc.
105 Meco Lane, Suite 100
Oak Ridge, TN 37830 USA

You can find us on social media at:

Facebook:
https://www.facebook.com/pages/Nanomechanics-Inc/124992837512793

Twitter:
https://twitter.com/Nanomechanics

LinkedIn:

YouTube – our channel on YouTube is titled NanoInSEM:
http://www.youtube.com/user/NanoInSEM

YouTube – Nanomechanics, Inc. Introduction to InSEM:
http://www.youtube.com/watch?v=KwiVZ6t2O2M

Contacting Technical Support and Sales Support

What you will need before you call

Before calling for technical support, have the following information on hand:

- Machine number
- Software Version (See Section 6.3.3.1)
- Description of problem
- Data from Operational Check (see Section 4.1)
- Method
- Tip (Type, Geometry)
- Sample Information

Technical Support email: support@nanomechanicsinc.com

Technical Support phone: 877-386-6262
A note to our overseas customers

Overseas customers should contact their local representative first.

To access a list of representatives, you may email us at info@insem.com, or go to the Contact Us (http://www.nanomechanicsinc.com/distributors) page on our website.

Training Classes

Nanomechanics, Inc. offers periodic training classes for our products as well as training by request. Basic training is provided when your system is installed. For more information regarding our training services, visit our website training information page:

http://www.nanomechanicsinc.com/training

1.3 Unpacking

Unpacking and Installing the iNano

The iNano is a “self-installed” system, meaning that in almost all cases, the user can unpack and install the system without the requirement of an on-site installation by Nanomechanics personnel.

Refer to the unpacking and installation instructions in document SKYD-0758-0 iNano Indentation Unpacking System, which is located in the “Open Me First” box of the iNano shipment.
2.0 About the iNano

2.1 Overview of the System

About the iNano:

The iNano can be best described as a “mechanical properties microprobe.” Simply speaking, it is a device for measuring the mechanical properties of materials, structure, or devices. The iNano applies highly resolved forces and measures sub-nanometer displacements and stiffness. Utilizing the force and displacement data, along with the stiffness, the properties of a specimen can be determined through a variety of analytic models.

The iNano consists of a number of subsystems:

- Computer (CPU)
- Isolation Cabinet
- Microscope
- Gantry
- Motion System
- Sample Tray
- InQuest Controller
- InForce 50 Head
- InView Software

The iNano operates in the following manner: The user mounts specimens to “pucks” which are then loaded into a sample tray, which is in turn loaded into the iNano. By operating the InView software on the CPU, the user can utilize the motion system to move the specimens under the microscope, and select target locations for tests to be performed. After a test method is selected and the desired test locations are chosen, the tests are performed automatically. When the tests are done, the data is presented in the Review Data program of the InView software, where analysis can be performed or the data exported.

The most typical use of the iNano is in performing indentation tests. There are many resources for understanding indentation. Please contact Nanomechanics if you would like recommendations for indentation tutorials or training.
3.0 Getting Started

3.1 Getting Started
This section of the manual guides the user through performing indentations on two different specimens, using a MultiSample test setup, and subsequent data review. Completion of these procedures should provide the user with a basic familiarity with the iNano and its operation. Some of the steps covered in this procedure are somewhat arbitrary, having been chosen to introduce aspects of instrument operation and data analysis, rather than being steps that the user will perform during routine operation.

Training in advanced operation of the iNano is available from Nanomechanics.

3.2 Before Running Tests
Before running any tests, make sure that the Unpacking & Setup instructions have been completely followed, including performing the Operational Check (see Section 4.1). Refer to the Unpacking Instruction document that was provided with the system (contact Nanomechanics if a new copy of this document is required). It is important that the instrument be properly set-up before running the following procedure. This procedure presupposes, among other criteria, that the “shipping rails” have been removed, the Tip Change Pins are not in the Actuator (see Section 4.4), the motion system is initialized, etc.

Finally, it is a good idea to read the Hardware Reference and Software Reference sections of this manual, as well as the Commonly Used Procedures. The following procedure directs the user to the appropriate sections of the manual, but a good overview of the system is helpful to improve understanding of the various operations performed.
3.3 Running Tests
Open the InView Test software on the Computer (see Section 6.3.1).

The InView Test software will open, and will ask for a method to be loaded. Select the method “Dyn.Indentation-Const.Strain Rate” in the Master Methods folder.

![Select Method](image1)

**Figure 1 – Select Method**

Select the desired Profile. In this example, it is “Example Profile.”

![Example Profile](image2)

**Figure 2 – Example Profile**
Verify the tip by selecting Main Menu > Tip and Settings. Use either the Default tip or select another tip from the drop-down menu if so desired. (see Section 6.3.2.1). In this example “Berkovich” is used.

Figure 3 – Tip and Instrument Configuration
Click on “Save & Close.” Then click on “Go To Load Sample” in the Motion Control Pane.

![Motion Control Pane](image)

**Figure 4 – Motion Control Pane**

Mount the aluminum specimen in Puck 1 location on the sample tray (see Section 4.2), and the fused silica specimen in the Puck 4 location.

![Mounting the aluminum specimen](image)

**Figure 5 – Mounting the aluminum specimen in Puck 1 location**

Open the iNano cabinet and load the sample tray into the iNano, so that the magnetic inserts in the Sample Tray lock in place and the Sample Tray rests against the sample tray Rails. Click on “Go To Puck 1” in the Motion Control Pane.
Use the microscope to focus on the surface of the aluminum specimen (see Section 6.3.5). Right-click on the video image and turn on Annotations > Test Locations, Sample Name, and Scale. Locate an area of the specimen where the indents should be placed (try to find a clear area of the sample with minimal scratches or debris). Note that you can move the specimen relative to the microscope by dragging the cursor across the video screen, or by clicking on a desired location on the video screen.

![Figure 6 - Annotations](image_url)
Go to the MultiSample Test Definition pane and use the Wrench Icon (displayed in the following image) to set the system in MultiSample Mode. Use the “Clear” button to clear the existing project and sample information.

![MultiSample Test Definition pane](image)

**Figure 7 – MultiSample Test Definition pane**

Select the Project Name. In this example, “Example Project” is used.
Click on the (+) button to add a Sample. Enter the Sample Name. For this first (aluminum) specimen, the Sample Name “Aluminum” is used. It is also a good practice to review the Method and ensure that it is the desired Method.

![MultiSample Add Sample pane]

Figure 8 – MultiSample Add Sample pane

Click on the Next Step button (>). Do not change any of the defaults on the Sample Level Inputs or Test Level Inputs. Click on the Next Step button (>).
Click on the “Add Array” button. The array of indents will be placed with the first indent at the current location of the crosshair on the video screen.

![Add Array Button, Define Test Locations](image)

*Figure 9 – Add Array Button, Define Test Locations*

When the dialog window appears, select a 2 x 2 array with 50µm spacing and a rotation of 0°. Click on “OK.”

![Generate Indent Array pane](image)

*Figure 10 – Generate Indent Array pane*
Click on the “Next Step” button (>). Add another Sample by clicking on the (+) button. Enter the Sample Name. For this second (fused silica) specimen, the Sample Name “Fused Silica” is used.

Click on the Next Step button (>). Do not change any of the defaults on the Sample Level Inputs or Test Level Inputs. Click on the Next Step button (>

Click on the “Go to Puck 4” button in the Motion Control Pane. When the move is completed, use the Microscope to focus on the surface of the fused silica specimen (see Section 6.3.5). Locate an area of the specimen where the indents should be placed (try to find a clear area of the sample with minimal scratches or debris).

Click on the “Add Array” button. The array of indents will be placed with the first indent at the current location of the crosshair on the video screen.

When the dialog window appears, select a 3 x 3 array with 20µm spacing and a rotation of 0°. Click on “OK.”

Click on the “Next Step” button (>). Add another Sample by clicking on the (+) button. Enter a new Sample Name. In this case, a third Sample will be added, but on the same specimen (fused silica) and using a different method. In this example, the Sample Name “Fused Silica Cycles” is used. Click on the Method and select “Cyclic Indentation To A Load” from the Master Methods folder.

Click on the Next Step button (>). Do not change any of the defaults on the Sample Level Inputs or Test Level Inputs. Click on the Next Step button (>

![MultiSample Add Sample pane]

Figure 11 – MultiSample Add Sample pane

Click on the Next Step button (>). Do not change any of the defaults on the Sample Level Inputs or Test Level Inputs. Click on the Next Step button (>

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Move to an area of the specimen where the indents should be placed (try to find a clear area of the sample with minimal scratches or debris). Drag the mouse across the video screen to move to an location near the first set of indents on this specimen (note that the Test Locations annotation is particularly useful in this case).

![Figure 12 – Example of specimen indents placement](image)

Click on the “Add Array” button. The array of indents will be placed with the first indent at the current location of the crosshair on the video screen.

When the dialog window appears, select a 1 x 3 array with 20µm spacing and a rotation of -35°. Click on “OK.”

Click on the Next Step button (>).

![Figure 13 – MultiSample Test Definition](image)
Close the iNano cabinet. Click on the green “Run” button to start the test.

The tests will take approximately one hour to complete (depending on how quickly the instrument meets the thermal drift criterion). While the test is running, note the initial hold for thermal drift before the indents begin. Once the first test starts, note the log window (see Section 6.3.2.5) and the Real Time Graph. Also observe the Method, Sample, and Test Information on the top bar, which shows the current sample and test. After the first indentation is complete, the Sample will change from (Not Saved) to “Aluminum,” which is the first sample on the MultiSample test run.

3.4 Reviewing Data
As each Test is completed, the data becomes available in the InView Review program. For this procedure, however, it is desirable to wait until all Samples are complete before reviewing data. Once the tests are all complete, open InView Review program by selecting the InView Review icon from the bottom tool bar.

![InView Review icon, bottom tool bar](image)

Click on the “New Data Available” notification at the top of the Review page. It may take a moment for the software to load the data and display it.

![New Data Available notification, Review page](image)

By default, the Sample that is loaded is the last Sample in the MultiSample test run, in this case “Fused Silica Cycles.”

Ensure that the Profile is set to “Example Profile”

![Active Profile set to Example Profile](image)
Select all tests by clicking on the first test in the Test Selection Pane, holding down the shift key, and then clicking on the last test. This will cause all three tests to be displayed in the graphs in the Plot Pane. Alternatively, “Control-a” can be keyed, which will select all Tests.

Figure 17 – Test Selection pane
Note the “Cycles” tab in the Plot Pane. Various results are displayed here. Notably the Stiffness (Su), Modulus (Eu), and Hardness (Hu). Scroll down to show the Cycle statistics. Note the Average and Standard Deviation.

<table>
<thead>
<tr>
<th>Cycles</th>
<th>Cycle Phase</th>
<th>Cycle Phase</th>
<th>Cycle Su</th>
<th>Cycle Acu</th>
<th>Cycle Eu</th>
<th>Cycle Mu</th>
<th>Cycle Hu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cycle 1</td>
<td>44.97</td>
<td>607</td>
<td>1.71e+05</td>
<td>4.671566</td>
<td>60.78</td>
<td>9.02</td>
<td>60.94</td>
</tr>
<tr>
<td>Cycle 2</td>
<td>44.96</td>
<td>607</td>
<td>1.71e+05</td>
<td>4.671566</td>
<td>60.78</td>
<td>9.02</td>
<td>60.94</td>
</tr>
<tr>
<td>Cycle 3</td>
<td>44.96</td>
<td>607</td>
<td>1.71e+05</td>
<td>4.671566</td>
<td>60.78</td>
<td>9.02</td>
<td>60.94</td>
</tr>
</tbody>
</table>

Cycle Statistics:

<table>
<thead>
<tr>
<th>Cycle</th>
<th>Avg</th>
<th>StdDev</th>
<th>Mean</th>
<th>StdDev</th>
<th>Mean</th>
<th>StdDev</th>
<th>Mean</th>
<th>StdDev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cycle 1</td>
<td>1.454</td>
<td>0.208</td>
<td>1.54e+02</td>
<td>3.746</td>
<td>6.2e+02</td>
<td>2.167</td>
<td>0.777</td>
<td>3.933</td>
</tr>
<tr>
<td>Cycle 2</td>
<td>2.008</td>
<td>123.5</td>
<td>4.15e+03</td>
<td>2.074</td>
<td>2.074</td>
<td>2.074</td>
<td>2.074</td>
<td>2.074</td>
</tr>
<tr>
<td>Cycle 3</td>
<td>5.617</td>
<td>188.3</td>
<td>5.52e+04</td>
<td>5.617</td>
<td>5.617</td>
<td>5.617</td>
<td>5.617</td>
<td>5.617</td>
</tr>
</tbody>
</table>

Figure 18 – Cycle tab in Plot Pane

Observe the Modulus vs Depth graph. Right-click on the graph and uncheck “Show Lines.” Then right-click on the Modulus axis and change the Maximum to 100 GPa and the Minimum to 0 GPa.

Figure 19 – Modulus vs Depth graph
Observe the Load vs Depth graph. Right-click on the graph and Show Legend > Tests AND Markers. Zoom in on the data from the Surface Marker to the end of the test. Right-click on the graph and change the legend position to Left.

![Figure 20 – Load vs Depth graph](image)

Go to Main Menu > Sample Data > Save.

Go to Main Menu > Sample Data > Open and locate the Sample file for the Fused Silica tests. In this example it is located in the Example Project. Open the “Fused Silica” Sample.

Select all tests by clicking on the first test in the Test Selection Pane, holding down the shift key, and then clicking on the last test. This will cause all nine tests to be displayed in the graphs in the Plot Pane.

Scroll down in the Results window to show the Summary & Statistics. Note the average modulus and hardness.

![Figure 21 – Results tab showing Summary & Statistics](image)
Click on Main Menu > Layout > New Data Graph.

![Test Data tab showing New Data graph](image)

**Figure 22 – Test Data tab showing New Data graph**


![Dyn. Load / Dyn. Disp. Vs DEPTH graph](image)

**Figure 23 – Dyn. Load / Dyn. Disp. Vs DEPTH graph**

Use the cursor (Tracker) to hover over the curve and observe the Index data at the bottom of the graph.
Go to the Test Parameters and change the Poisson’s Ratio to 0.25.

![Figure 24 – Test Parameters tab](image)

Then click on Main Menu > Sample Data > Recalculate. Observe the change to the average Hardness and Modulus in the Summary & Statistics of the Results window.

![Figure 25 – Results window showing Summary & Statistics](image)

Click on Main Menu > Sample Data > Open and locate the Sample file for the Aluminum tests. Note that the Fused Silica Sample was not saved, so the next time it is opened the changes made to Poisson’s Ratio will not have been saved.
Right-click on the Y axis of the Dyn.Stiff.^2/Load vs DEPTH graph and set the axis maximum to Autoscale.

![Diagram of Dyn. Stiff.^2/Load vs DEPTH graph]

**Figure 26 – Dyn. Stiff.^2 / Load vs DEPTH**

Hover the cursor over one of the curves in the graph and observe the Index data at the bottom of the graph. In this example, the Tracker is on Test 4, which is indicated in the Index data.

![Diagram with Tracker on Test 4]

**Figure 27 – Example of Test Tracker showing Index data**
Select Test 4 in the Test Selection Pane.

![Test Selection Pane](image1)

**Figure 28 – Test Selection Pane**

Click on Main Menu > Tests > Delete Test, and click on OK in the Confirmation dialog window.

![Confirm dialog window](image2)

**Figure 29 – Confirm dialog window**

Click on Main Menu > Export Data > Excel. Leave both the Start Export Marker and End Export Marker menus blank (this will cause all of the data to be exported). (See Section 6.4.2.1.)

![Select Export Range window](image3)

**Figure 30 – Select Export Range window**
After completing all of these steps, the user should have a good familiarity with commonly performed operations. As mentioned previously, it is a good idea to read through the Commonly Used Procedures, Hardware Reference, and Software Reference sections of this manual.
4.0 Commonly Used Procedures

4.1 Operational Check

The Operational Check method is provided as a convenient way to ensure that the iNano is functioning properly. The method moves the iNano actuator through its range of motion, and then analyzes that motion for inconsistencies in the linearity and support spring stiffness of the actuator. If the Operational Check is successful, there is a high degree of confidence that the iNano is performing to its required specifications.

It is a good idea to run the Operational Check frequently, and to save the resultant sample files. If there is a problem with the iNano, an Operational Check history can help diagnose the problem.

Close the iNano cabinet if it is not already closed.

From the main menu, select Test Method > Open

![Figure 31 – Open a Test Method](image)
Select the MasterMethods folder and Open. By default the software should navigate to the Methods folder. In this example, there is a Profile called “NMI” and the MasterMethods folder is located under the Methods folder in this Profile. If you have switched to a new profile, you should be able to locate MasterMethods in the Methods folder under the new profile. The file path in this example is:

Users/Public/Public Documents/Nanomechanics/Profiles/NMI/Methods

Figure 32 – Select MasterMethods folder
When the MasterMethods folder is opened, select the Operational Check method and click on Open. This will load the Operational Check method.

![Figure 33 – Example of selecting the Operational Check method](image)

Switch the system into “Single Test Mode” by clicking on the wrench icon at the top of the MultiSample Test Definition pane.

![Figure 34 – Single Test Mode option](image)
Click on the green Run button at the top of the screen.

![Green Run Button](image)

**Figure 35 – Green Run Button**

A prompt will appear for a file name to store the data you are about to record. In this example, opcheck01122015 is used. It is recommended to use a filename that includes the date of the test.

![Prompt to store data under file name](image)

**Figure 36 – Prompt to store data under file name**
When the filename is selected, click on “Save.” The system will then begin the Operational Check. The default plot shows the Displacement vs time.

Figure 37 – Example of Operational Check process
Once the test is complete, an audible tone will sound (if the volume on the Computer speaker is not muted) and the Run button will change from the red “Stop” button back to the green “Run” button.

![Figure 38 – Example of Run Button status color change](image)

Click on the Review Program from the bottom toolbar.

![Figure 39 – Review Program on bottom tool bar](image)
The Review page will open. At the top of the page, a message “New Data Available” will most often appear\(^1\). Click on this message to load the results of the Operational Check.

Figure 40 – Review page, New Data Available notification message

The two parameters at the top of the Results screen should have a value of one (1), indicating that the system has passed the Operational Check. If either or both of these values are zero (0), re-run the Operational Check. If the Check fails a second time, contact Nanomechanics support (see Section 1.2).

Figure 41 – Results screen showing two parameter window

\(^1\) The New Data Available message will only appear if a different Sample File or a previous Test is already open in the InView Review program.
This completes the Operational Check of the instrument.

The New Data Available message will only appear if a different Sample File or a previous Test is already open in the InView Review program.
4.2 Loading Specimens

4.2.1 Loading Specimens

The iNano utilizes a standard “sample tray” which can mount up to four metallurgical pucks (1.25” diameter x 1” high). Specimens are typically attached to the surface of the pucks utilizing a thermosetting polymer such as “crystalbond” or a fast-setting adhesive such as cyanoacrylate (CA, or “superglue”). Alternatively, samples may be embedded in an epoxy or resin puck and polished, or entire pucks of material may be polished for use as specimens.

Figure 43 – iNano standard sample tray

The sample tray is designed with four posts, which can be used to either visually or mechanically determine the plane of indentation for the samples. It is important when mounting the pucks in the sample tray that the highest point of the specimen be located no higher than the posts at each corner of the sample tray. This ensures that there are no surfaces projecting up over the plane of indentation that could potentially strike the indenter as the motion system is moving the sample tray.

Each puck is held in place by a thumbscrew.
4.2.2 The Visual Method

Place the sample tray on a hard surface and drop the pucks into the sample tray. Tighten the thumbscrews lightly – just enough to hold the puck in place. Lift up the sample tray so that the underside of the puck can be accessed. One at a time, loosen the thumbscrew of each puck and raise or lower it until the top surface is even with the posts at the edges of the sample tray. You can use two posts to sight along the surface of the puck. When each puck is at the right height, tighten the thumbscrew. Be careful when handling the Sample Tray and Pucks that the Puck doesn’t “drop out” of the Sample Tray hole unexpectedly. It is a good practice to keep one finger beneath the Puck anytime that the thumbscrew is loosened.

Figure 44 – Example of Puck placement and handling of Sample Tray
4.2.3 The Mechanical Method

If the surfaces of the specimens are not extremely delicate, the Mechanical method is an easy way to ensure all specimen surfaces are at the same height. First obtain a clean sheet of lint-free paper and place it on a hard surface. Place the sample tray on the hard surface and drop the pucks into the sample tray, then lightly tighten each thumbscrew. Lift up the sample tray so that the underside of the puck can be accessed. Set the height of each puck so that it is roughly at the same height as the posts on the corners of the sample tray. Next, turn the sample tray over and place it upside down on the paper.

Loosen all four thumbscrews. The specimen surfaces should now all be on the same plane as the four posts on the corners of the sample tray. Tighten all four thumbscrews. Use “canned air” or a similar aerosol to spray off the surfaces of the specimens to remove any lint or dust that may have become attached to the specimen surface.
Once the specimens are mounted in the sample tray, the sample tray can be loaded into the iNano. Press the “Go to Load Sample” button in the Motion Control pane.

![Motion Control pane, Puck tab displayed](image)

**Figure 46 – Motion Control pane, Puck tab displayed**
The motion system will move to the front left corner of its travel. When the motion system stops moving, lift the sample tray by the knob on the front of the tray, and place it on the motion system – the left and back sides of the sample tray should rest against the rails on the motion system, and the magnetic lock should engage with the bottom of the sample tray and hold it in place.

The specimens are now loaded into the iNano. Click on the “Go to Puck” button to move the desired specimen under the microscope.
4.3 Video Source Calibration

Video Source Calibration

When indentation tests are performed, the user selects target locations using the microscope and defines the tests to be performed at those locations. When the Run button is pressed, the system will translate the samples from under the microscope to under the indenter. The distance that the system will move in this translation is calibrated by the Video Source Calibration.

The principle of this calibration is that the user selects a target location on a sample in which large indentations can be made. The iNano is provided with an aluminum calibration standard for this purpose. Once the target location is selected, the system performs a set of five indentations, with the center indentation located at the user’s target location.

When the sample is translated back under the microscope, the indentations should appear in the field of view of the video screen, with the center indentation located under the red crosshairs. If the center indentation is not located at the crosshair, the user manually moves the iNano stages so that the center indent is under the crosshair. This correction is recorded by the software.

If the Video Source is very far out of calibration (as may occur after a tip change or when the actuator has been removed from the system), the indentation might not be located in the field of view, in which case the user must find the indentations. It is a good practice to select an area of the aluminum calibration standard that is free of previous tests so that the wrong indentations are not selected. It is also a good practice to place the indentations near a surface scratch or dust particle, which will serve as a visual “home” point as the user searches for the indentations. Finally, the user can also note the X and Y position of the target location on the meters pane so that the target position is not “lost” during a search of the sample surface.

As a precursor to performing the video source calibration, the user must ensure that the Field of View is properly calibrated. The Field of View calibration ensures that the distances displayed in the video pane are accurate (that is, that the cursor position measures the distances displayed in the video pane accurately). This calibration is performed by selecting a “feature” in the video image, using the motion system to move that feature a known distance within the video image, and then reselecting the feature.
4.3.1 Preparing for the calibrations

Load the aluminum calibration standard into the sample tray, and load the sample tray into the iNano (see Section 4.2).

Click on the appropriate puck button on the motion control pane to move the aluminum standard under the microscope.

![Motion Control pane](image)

Figure 48 – Motion Control pane

Use the microscope to focus on the surface of the aluminum (see Section 6.3.5). Locate a feature on the surface of the specimen to serve as a reference point.

![Crosshair symbol](image)

Figure 49 – Example of Crosshair symbol used for focusing on surface of samples
As mentioned above, it can sometimes be helpful to use the X and Y position meters when searching for indentations that do not show up in the video screen. To add these meters to the meters pane, select the wrench icon from the meters pane.

The Meters Selection Window will be displayed. Click on the X Axis Position meter in the “Available” pane and then click on the > button to move the meter to the “Selected” pane. Repeat for the Y Axis Position meter.
Click Done. The X and Y axis meters will now appear in the Meters Pane. Write down the numbers for reference purposes.

![Figure 52 – Meters pane, X and Y Axis Positions](image)
4.3.2 Field of View Calibration

Select the wrench icon in the video pane and select Calibrate Video Source

![Calibrate Video Source option in Video pane](image1)

Figure 53 – Calibrate Video Source option in Video pane

The Video Calibration Assistant window will open. The red crosshair will be the target location for the indentations.

![Video Calibration Assistant window, Red Crosshair indicating target location](image2)

Figure 54 – Video Calibration Assistant window, Red Crosshair indicating target location
Right-click on the Video Screen and select “Remove Backlash.”

Click on the “Perform Field of View Calibration” button. A dialog window will appear.

![Perform Field of View Calibration dialog window](image)

**Figure 55 – Perform Field of View Calibration dialog window**

Click on “Yes” to continue. A field will appear in the video calibration assistant screen for Step 1 of this process, which requires that the user enter a distance for the calibration move. The default of 100µm should be sufficient at the standard video zoom.

![Video Calibration Assistant window, Red Crosshair positioned over Feature](image)

**Figure 56 – Video Calibration Assistant window, Red Crosshair positioned over Feature**
Click on Next Step. Then locate an identifiable feature that can be used in the calibration. In this example, a circular mark on the surface of the sample, near a set of previously performed indentations, will be used.

![Video Calibration Assistant window, Next Step button displayed](image)

Figure 57 – Video Calibration Assistant window, Next Step button displayed
Clicking on the desired feature will display a circle/crosshair pattern. Click on Next Step, and be prepared to watch the “move” of the feature.

Figure 58 – Example of steps to choose desired Feature, and observe the “move” of the feature
The motion system will then move in the X axis direction by the specified amount (default 100µm).

Figure 59 – Feature moved by specified amount
Clicking on the desired feature will display a circle/crosshair pattern. Click on Next Step, and be prepared to watch the “move” of the feature.

Figure 60 – Example of Circle / Crosshair Pattern annotation
The motion system will then move in the Y axis direction by the specified amount (default 100µm).

Figure 61 – Example of Motion System movement in Y Axis direction
Clicking on the desired feature will display a circle/crosshair pattern. Click on Next Step.

Press Next Step to complete the calibration.
Note that it is necessary to target the desired feature very precisely. In practice, it is better to select a smaller feature than the one used in this example. If the target is not precisely selected in both the X and Y axis moves, the following message may be displayed:

![Figure 63 – Example of Step 999 warning message](image)

If this message is displayed, click on “Cancel” and repeat the process, choosing a smaller feature and taking care to click exactly on the feature. If repeated attempts to perform this calibration are not successful, contact Nanomechanics technical support.

When the Field of View calibration is complete, the software will continue directly to the Video Source Calibration. Refer to the next few steps for details on completing the Video Source Calibration.
4.3.3 Video Source Calibration

Select the wrench icon in the video pane and select Calibrate Video Source

![Wrench icon and Calibrate Video Source options](image)

Figure 64 – Calibrate Video Source and Wrench icon options

The Video Calibration Assistant window will open. The red crosshair will be the target location for the indentations.

![Video Calibration Assistant window with Red Crosshair](image)

Figure 65 – Video Calibration Assistant window with Red Crosshair displayed

Right-click on the Video Screen and select “Remove Backlash.”
When you are ready to perform the test, click on Next Step. The motion system will translate the specimen under the microscope and automatically perform five indentations at the desired location.

![Sample Positioning Control dialog box](image)

*Figure 66 – Sample Positioning Control dialog box*

Once the indentations are complete, the sample tray will be moved back under the microscope. If the calibration is close to accurate, the five indentations will be visible on the video screen. In this example, there is a slight offset from the crosshair to the center indentation.

![Video Calibration Assistant window](image)

*Figure 67 – Video Calibration Assistant window, Center Indent indicated*
Using the video screen motion control (see Section 6.3.5), move the crosshair to the center of the center indentation.

Figure 68 – Video Calibration Assistant window, Crosshair positioned to center of the center indentation
You can also use the Zoom function to further magnify the indentations.

![Video Calibration Assistant window, Zoom function indicated](image)

Figure 69 – Video Calibration Assistant window, Zoom function indicated

When you have centered the center indent under the crosshair, remove backlash again, and then click on the Next Step button. A final “congratulations” window will appear, indicating that the calibration is complete.

![Congratulations window indicating calibration is complete](image)

Figure 70 – Congratulations window indicating calibration is complete

Click on the Finish button to complete the calibration and return to the Test Window.
4.4 Tip Change

Tip Change

Changing the indentation tip is a common procedure that is used when replacing a worn tip, or changing to a different tip geometry. Care should be taken during this procedure, as it is possible to damage either the tip, or the actuator.

Note that in this procedure, it is assumed that the tip is removed or installed without the use of an optical magnifier or microscope. However, if a magnifier or high-depth-of-field microscope is available, then the user of these tools can make it easier to remove or install the tip.

4.4.1 Removing the Tip

The first step is to perform an Operational Check so that a baseline dataset is available for comparison with the post-tip-change Operational Check (see Section 4.1).

Use the Motion Control pane to “Go to Load Sample.” Open the iNano cabinet and remove the sample tray. In the inView test screen, go to the Main Menu and select System>Shutdown Controllers

![Figure 71 – InView test screen -> Main Menu -> select System -> Shutdown Controllers](image)
Physically turn the controller off by reaching through the access hole on the right rear corner of the iNano cabinet and turning the power switch off.

![Access Hole on Controller Cabinet](image)

*Figure 72 – Access Hole on Controller Cabinet to turn the Power Switch off*
Locate the Tip Change Pins and the Tip Change Tool. Both the pins and the tool should be located in the Tip Folder that is provided with the instrument. It is important to store the Pins and Tool in a safe location.

![Image of Tip Change Tool and Tip Change Pins](image1)

**Figure 73 – Example of Tip Change Tool and Tip Change Pins**

Clean both pins with a lint-free cloth to ensure that there is no lint or other debris on the pin. Insert the Tip Change Pins into the actuator. This will lock the actuator shaft so that it will not rotate as the tip is screwed in or out of the threads on the end of the shaft. **Be very careful while working around the actuator that you don’t accidentally touch the tip or the bottom of the microscope objective lens.**

![Image of inserting Tip Change Pins into the Actuator](image2)

**Figure 74 – Example of inserting Tip Change Pins into the Actuator**
Next, unplug the cable from the actuator.
Once the actuator cable is unplugged, with one hand, carefully reach in and hold the actuator body above the pins, being very careful not to touch the pins or the tip. With the other hand, reach in and loosen the thumbscrew that holds the actuator in place. **Be very careful not to drop the actuator when it comes loose from its mount.**

![Figure 77 – Example of loosening Thumbscrew holding Actuator in place](image1)

Once the actuator is removed, set it on a safe, flat surface with the tip facing upward, as displayed in the following image.

![Figure 78 – Actuator removed from Mount, locking pins in place](image2)
Locate the tip storage box. This is typically stored in the tip folder. Use a pair of tweezers to peel back one half of the circle of tape in the tip storage box. There should be a small plastic tube in the tip storage box. This tube will be used to help remove the tip.

![Figure 79 – Example of Tip Storage Box, Plastic Tube and Tape displayed](image)

Ensure that the Tip Change Tool is clean (that there is no oil or other debris in the recess on the end of the Tip Change Tool).
Now that the tip storage box is prepared, use the tip change tool to carefully remove the tip from the actuator. The tip uses standard threads, so it will be removed using a standard “left to loosen” motion. Avoid placing lateral force on the indenter shaft while removing the tip. It is a good idea to perform this operation over a sheet of white paper; in the event the tip is dropped it will be much easier to find it.

![Figure 80 – Example of Tip Change Tool being used to remove the Tip from the Actuator](image-url)
When you have removed the tip, set the actuator to the side in a safe location, and, gently place the tip in the tip storage box. You can use the small plastic tube to nudge the tip out of the tip change tool, if it does not easily fall out into the tip storage box. Once the tip is in the box, cover it with the circular plastic tape, close the box, and store it with the tip folder so that it does not become disassociated with its documentation.
4.4.2 Installing a Tip

Locate the tip storage box for the tip to be installed. Carefully peel back the circular plastic tape to expose the tip. It’s a good idea to perform this procedure over a piece of white paper. Have the actuator and the tip change tool readily at hand.

First, use fine-pointed tweezers to pick up the tip, gripping the tip on the threaded post. Be very careful not to touch the exposed diamond of the tip, as it is possible to damage the tip with mishandling.

![Image of retrieving a Tip with Tweezers from the Tip Storage Box for installation](image1)

Figure 83 – Example of retrieving a Tip with Tweezers from the Tip Storage Box for installation

Carefully insert the tip, diamond first, into the tip change tool so that the threaded post is exposed.

![Image of Tip properly inserted into the Tip Change Tool](image2)

Figure 84 – Example of Tip properly inserted into the Tip Change Tool
Ensure that the pins are inserted into the Actuator to lock the Indenter Shaft in place. Use the tip change tool to carefully screw the tip into the actuator shaft. The tip uses standard threads, so it will be removed using a standard “right to tighten” motion. Avoid placing lateral force on the indenter shaft while attaching the tip. It is a good idea to perform this operation over a sheet of white paper; in case the tip is dropped it will be much easier to find it.

It is a good practice to tighten the tip into the actuator shaft until it is “snug,” then to loosen it a small amount, retighten to “snug,” loosen again, and then finally retighten a last time. This will ensure a good contact between the tip and the actuator shaft, which is very important for proper measurement. Do not over tighten or use excessive force. When done, place the tip change tool in a safe location (the tip folder is a good place to store the tip change tool).

Set the actuator on a safe, flat surface until you are ready to install it into the iNano.

Hold the actuator with one hand with the tip pointed downward, being careful not to touch the tip or the tip change pins. With the other hand, hold the actuator cable. Identify the correct orientation of the cable. The numbers on the Plug should be facing upward, as displayed in the second image below.

![Example of proper handling of the Actuator and Actuator Cable](image)

Figure 85 – Example of proper handling of the Actuator and Actuator Cable
While the plug on the end of the cable is designed to only be installed in one orientation, it is possible to “force” the plug onto the pins in an incorrect manner, so be certain to align the pins on the actuator with the pin holes on the plug. When you are certain of the alignment, attach the plug to the actuator pins.

Figure 86 – Example of Cable Plug End and Matching Actuator Pins for proper alignment
Once the actuator cable is plugged in, with one hand, carefully hold the actuator above the pins, being very careful not to touch the pins or the tip. With the other hand, reach in and loosen the thumbscrew. Carefully insert the actuator back into its mount, ensuring that it is fully seated against the mount, and then tighten the thumbscrew. Be very careful to ensure that the actuator is fully tightened into its mount before letting go, so as not to drop the actuator.

Figure 87 – Example of Actuator Cable successfully plugged into Actuator

Figure 88 – Example of Actuator properly reinstalled
When the actuator is installed, remove the tip change pins and place them in a safe location (the tip folder is an ideal place to store the tip change pins).

Physically turn the controller on by reaching through the access hole on the right rear corner of the iNano cabinet and turning the power switch on.

In the inView test screen, go to the Main Menu and select System>Start Controllers

Figure 89 – InView test screen -> Main Menu -> select System -> Start Controllers

Close the iNano cabinet. The last step is to perform an Operational Check so that a dataset is available for comparison with the baseline (pre-tip-change) Operational Check (see Section 4.1).

Once the Operational Check is complete, open the iNano cabinet and install the sample tray, being sure that the aluminum calibration specimen is installed (see Section 4.2).

Perform a Video Source Calibration to re-establish the relationship between the microscope target location and the indentation location (see Section 4.3).

Once the Video Source Calibration is complete, the iNano is ready to run with the new tip. It is a good idea to run a Tip Calibration prior to running any tests (see Section 4.5).
4.5 Advanced Tip Calibration

Advanced Tip Calibration

The conversion of the acquired data of load and displacement to the desired engineering properties of modulus and hardness depends upon the “contact area” of the indentation. If the diamond tip was perfect (and neglecting other factors such as sink-in and pile-up), the contact area could be determined from just the geometry of the diamond tip and the contact depth. For all real diamond tips, however, there is some degree of imperfection – whether in the face angles of the diamond or in rounding at the tip. The smaller the indentation, the more this imperfection comes into play.

In order to compensate for these imperfections, the Advanced Tip Calibration procedure is used. In this procedure, indentations are performed on a well-known material (fused silica). The results of these indentations are used to calculate the relationship between the contact depth and the area.

A related problem is the load frame stiffness of the indentation system. The spring model for the indentation system includes not only the stiffness of the specimen (measured), but the stiffness of the load frame as well. This means that in a measured displacement, the largest component is the penetration into the specimen surface, but a small component will come from the deflection of the load frame. The larger the indentation load, the more the load frame stiffness comes into play.

The load frame stiffness is calibrated for the indentation system, but the same data that is used to calculate the tip geometry correction can also be used to calculate the load frame stiffness correction. Reference will be made to load frame stiffness in this procedure, although it is generally unnecessary to recalculate the load frame stiffness correction.

The Advanced Tip Calibration procedure will be need to be performed when a new tip is to be used, or when a tip has been worn by repeated use.

There are many potential parameters that can be changed in the Advanced Tip Calibration. This procedure focuses on the most commonly used, and most effective technique. If further understanding of the Advanced Tip Calibration or its parameters is desired, please contact Nanomechanics for resources.

Finally, the Advanced Tip Calibration can be used for a variety of tip geometries, although the most common is the Berkovich geometry. This procedure only addresses the Berkovich geometry. In this procedure, a new tip is defined, as opposed to the recalibration of an existing tip.

The first step in performing the Advanced Tip Calibration is to run the experiments and generate the data. Begin by opening the InView Test window.
From the Main Menu, select Tip and Settings.

![Main Menu, Tip and Settings option displayed](image)

**Figure 90 – Main Menu, Tip and Settings option displayed**

The Tip and Instrument Configuration window will be displayed.

![Tip and Configuration Window](image)

**Figure 91 – Tip and Configuration Window**

Click on the (+) button to add a new tip.
Enter the tip name. A good tip name will include the geometry information.

The tip is now defined in the system with default parameters. Note that the tip name is automatically time & date stamped. This is particularly useful when recalibrating tips. Click on the “Save & Close” button.

From the main menu, select Test Method > Open
Select the MasterMethods folder and Open. By default the software should navigate to the Methods folder. In this example, there is a Profile called “NMI” and the MasterMethods folder is located under the Methods folder in this Profile. If you have switched to a new profile, you should be able to locate MasterMethods in the Methods folder under the new profile. The file path in this example is:

Users/Public/Public Documents/Nanomechanics/Profiles/NMI/Methods
When the MasterMethods folder is opened, select the Dyn. Indentation-Const Strain Rate method and click on Open. This will load the desired method.

![Figure 96 – Example of selecting and opening preferred Method in the MasterMethods folder](image)

Switch the system into “Multisample Mode” by clicking on the wrench icon at the top of the MultiSample Test Definition pane.

![Figure 97 – Example of switching system into MultiSample Mode using Wrench icon in top left corner of pane](image)
Enter the Project Name in the Multisample Test Definition pane. Note that you can also select an existing project name if desired. In this example “Tip Calibration” is used as the project name.

Load the fused silica standard into the sample tray and then load the sample tray into the iNano (see Section 4.2).

Close the iNano cabinet, and then move to the desired puck location by clicking on the appropriate button in the Motion Control Pane.
Focus on the surface of the fused silica standard (see Section 6.3.5) and locate a clear area of the surface to place the indentation array.

![Image](image1.png)

*Figure 100 – Example of locating a clear area of the surface for indentation array placement*

In the Multisample Test Definition Pane above, click on the (+) button to add a new Sample. Enter the sample name. In this example, “Fused Silica” is used.

![Image](image2.png)

*Figure 101 – Example of new Sample Name entered into MultiSample Add Sample pane*
Click on the Next button (>). Using all of the default parameters for the Sample Level Inputs, click on the Next button on the ensuing screen.

![Sample Level Inputs]

<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poisson's Ratio of Sample [None]</td>
<td>0.188</td>
</tr>
</tbody>
</table>

![Test Level Inputs]

<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target Load [mN]</td>
<td>45.00</td>
</tr>
<tr>
<td>Target Depth [nm]</td>
<td>5000.0</td>
</tr>
<tr>
<td>Target Ind. Strain Rate [WS]</td>
<td>0.200</td>
</tr>
</tbody>
</table>

*Figure 102 – Example of Sample Level and Test Level Inputs*
Define an array of indentations by clicking on the Add Array button.

![Add Array button](image)

**Figure 103 – Define Test Locations pane, Add Array button indicated**

Select a 5 x 4 array with 20 µm spacing in the X and Y dimensions. Click on “OK”

![Array selection and the X and Y dimensions](image)

**Figure 104 – Example of Array selection and the X and Y dimensions**
Click on the Next button (>) in the Define Test Locations screen.

![Define Test Locations pane](image1)

**Figure 105 – Define Test Locations pane**

The test is now ready to run. Click on the green Run button to start the test.

![Green Run Button](image2)

**Figure 106 – Green Run Button**

Once the tests are complete, go to the Review program by selecting the InView Review icon from the bottom tool bar.

![InView Review program icon indicated](image3)

**Figure 107 – InView Review program icon indicated in bottom tool bar**
Click on the “New Data Available” notification at the top of the Review page. It may take a moment for the software to load the data and display it.

![New Data Available notification](image1)

*Figure 108 – New Data Available notification at top of the Review page*

Select all tests by clicking on the first test in the Test Selection Pane, holding down the shift key, and then clicking on the last test, or by clicking in the Test Selection Pane and using Control-a to select all tests.

![Test Selection tab](image2)

*Figure 109 – Test Selection tab, all Tests selected*
All of the tests will be displayed in the various plot Panes. Look for any aberrant tests – tests that are clearly outliers from the main grouping of data.

![Figure 110 – Tests displayed in various Plot Panes](image)

If one or more aberrant tests are identified, it will be necessary to delete them before processing the data. Determine which test number is associated with the plot data by holding the crosshair over the data. The test number will be displayed at the bottom of the plot pane.

![Figure 111 – Example of Crosshair being used to display corresponding test number at bottom of Plot Pane](image)
Once the aberrant tests are identified, they can be deleted. Click on the test name in the Test Selection window, then go to Main Menu> Tests >Delete Selected. Note that Deleting Tests cannot be undone, so be careful in selecting the tests for deletion.

![Example of Test Deletion process/pathway](image)

Figure 112 – Example of Test Deletion process/pathway

Once all aberrant tests have been deleted, click on Main Menu> Tip & Settings > Advanced Tip Calibration

![process displayed to implement after aberrant tests have been deleted](image)

Figure 113 – process displayed to implement after aberrant tests have been deleted:

Main Menu -> Tip & Settings -> Advanced Tip Calibration
In the resultant screen, uncheck “Fixed Lead Term”, but leave all of the other inputs as defaults.

Figure 114 – Example of how to uncheck “Fixed Lead Term”

Click on the Calibrate button. The Advanced Tip Calibration may take a few seconds to complete. When it is done, the results will be displayed.
Figure 115 – Calculate Tip Area Function & Frame Stiffness window

Review the curve fit and the percentage deviation displayed on the plots. Click on “Accept.” Then, click on Main Menu > Sample Data > Recalculate. The software will use the new Tip Calibration and Load Frame Stiffness parameters to recalculate the data. When this process is complete, select all tests and examine the data.
There are a number of ways to determine if the data is correct:

- The Average Modulus should be in the range of 71.6 – 72.4 GPa
- The Average Hardness should be in the range of 9.3 – 9.7 GPa
- The standard deviation of both the Average Modulus and Average Hardness should be small.
- The Modulus vs. Depth curves should be flat and constant from about 10nm to maximum depth.
- The Hardness vs. Depth curve should be flat and constant from about 200nm to maximum depth.
- The Dyn.Stiff.^2/Load vs. Depth data should be flat, and with a value between 640 and 660 GPa at depths above 200nm.

If the Modulus, Hardness, or Dyn.Stiff.^2/Load values deviate from the nominal values listed above, or if the curves are not flat, then re-run the data on fused silica and repeat this procedure.

If the Dyn.Stiff.^2/Load value is not flat by 200nm, then the tip is most likely worn, and needs to be replaced. This can be further confirmed by examining the Hardness vs. Depth plot. The Hardness value should stabilize and become flat by 200nm. If it does not, then there is likely excessive tip wear.

If there is still uncertainty about the quality of the data after performing the Advanced Tip Calibration, contact Nanomechanics for support.
5.0 Hardware Reference

5.1 Overview of the System
The iNano consists of a number of subsystems:

- CPU: The computer that operates the iNano, including the keyboard and mouse.
- Isolation Cabinet: The enclosure that contains the iNano gantry. This cabinet serves the purpose of isolating the system from acoustic vibrations and thermal changes in the environment.
- Microscope: The microscope is used to target locations for indentations and for imaging of the specimen.
- Gantry: The gantry is the structure that supports the motion system, actuator, and other physical components. It is sometimes referred to as the “load frame.”
- Motion System: The motion system consists of the X and Y axis. The motion system moves the sample tray between the microscope and the actuator, and is used for targeting and positioning indentations. A third “Z” axis used to move the Actuator and Microscope relative to the specimen surface.
- Sample Tray: The sample tray is used to mount specimens.
- InQuest Controller: The InQuest Controller is the electronic interface between the iNano hardware and the CPU. The Controller handles the dual tasks of control of the system and data acquisition.
- InForce 50 Head: The InForce 50 Head, referred to as the “Actuator” in most of this document, is the core component of the iNano that actually performs the tests.
- InView Software: The InView Software consists of two main components – the Test Page which is used to setup experiments, and the Review Page which is used to analyze and export data.
The following image indicates the key components of the iNano.

![iNano key components callouts](image)

**Figure 117 – iNano key components callouts**
5.2 Description of Components

5.2.1 Actuator

The Actuator or InForce 50 Head, is the core component of the iNano. This device utilizes an electromagnetic “voice-coil” to generate force, and a capacitive displacement gauge to measure displacements. The force is transmitted through the Indenter Shaft. A probe of some type is attached to the end of the Indenter Shaft; this is typically a diamond Tip that is used to indent a material. The Indenter Shaft is supported by flexible leaf springs.

The Actuator is mounted to the Extension axis (see Section 5.2.5), which is used to retract the Actuator away from the specimen surface or to engage the surface during an experiment. The Actuator itself performs the experiment.

The Tip is removable from the Indenter Shaft (see Section 4.4). During this operation, the Indenter Shaft is locked in place using Tip Change Pins, and the Actuator is removed from the Extension Axis.

![Example of Actuator device with callouts for Tip, Indenter Shaft, Plug, Actuator Body and Tip Change Pin](image)

Figure 118 – Example of Actuator device with callouts for Tip, Indenter Shaft, Plug, Actuator Body and Tip Change Pin
5.2.2 Aluminum Specimen

The iNano is provided with an Aluminum Specimen, which is intended for use in the Video Source Calibration.

![Figure 119 – iNano Aluminum Specimen](image)

5.2.3 Cabinet

The Isolation Cabinet of the iNano is designed to reduce the effects of acoustic noise and thermal changes in the environment. It is a good idea to keep the iNano cabinet closed as much as possible so that the iNano stays at a constant temperature.

The cabinet hood is opened by lifting under the front panel (below the Nanomechanics logo).
5.2.4 Controller

The InQuest Controller is the electronic interface between the iNano hardware and the CPU. The Controller handles the dual tasks of control of the system and data acquisition.

It is sometimes necessary to turn the Controller on or off using the power switch. This can be accessed through the access hole on the right rear side of the iNano cabinet.

![Figure 120 – side view of iNano cabinet with Controller Power Switch Access Hole indicated](image)

5.2.5 Extension Axis (Z Axis)

The Extension Axis is used to drive both the Actuator and Microscope up or down relative to the surface of the specimen. The home position for the Extension Axis is at the top of its travel.
5.2.6 Fused Silica Specimen

The iNano is provided with a Fused Silica Specimen, which is intended for use in the Advanced Tip Calibration. Replacement Specimens can be obtained from Nanomechanics, Inc. or a local representative.

![Figure 121 – iNano Fused Silica Specimen](image)

5.2.7 Gantry

The gantry is the structure that supports the motion system, actuator, and other physical components. It is sometimes referred to as the “load frame.”

5.2.8 Microscope

The microscope is used to target locations for indentations. It consists of a microscope body, camera, light source, and objective lens. The microscope is controlled through the Video Screen in the InView software. (See Section 6.3.5.)

5.2.9 Motion System (X & Y Axes)

The motion system consists of two axes with screw-drives, recirculating ball bearing support, and stepper motors. The motion system is controlled through the Motion Control Pane in the InView Software, or through the Video Screen, or automatically when tests are performed.
5.2.10 Puck

The Pucks used in the Sample Tray are 1.25” diameter by 1” tall metallurgical mounts.

5.2.11 Sample Tray

The Sample Tray consists of an aluminum block with magnetic inserts in the base that “snaps” into place onto the motion system (see Section 4.2). The Sample Tray can hold up to four Pucks, which are held in place with thumbscrews.

![Figure 122 – iNano Sample Tray](image)

5.2.12 Tip

The standard Tip for the iNano is a Berkovich geometry diamond tip. The tip is screwed into the Indenter Shaft of the Actuator (see Section 4.4). Alternative geometries and materials of the tip are available. Geometries include Cube Corner, Vickers, Conical with rounded tips, Conical with Punch tips, and Spherical. Materials include diamond, sapphire, ruby, and others.

5.2.13 Tip Change Pins

The Tip Change Pins are used to lock the Indenter Shaft in place during a Tip Change operation (see Section 4.4).
5.2.14 Vibration Isolation

Vibration Isolation is accomplished through four dampers that are mounted to the base of the gantry.
6.0 Software Reference

The InView Software that is bundled with the iNano includes two major applications: the Test program and the Review program. These are separate applications that work together for the primary tasks of operating the instruments to generate data, and reviewing and analyzing that data.

6.1 The CPU & Operating Software

The iNano is provided with an All-in-one computer utilizing a Windows Operating System. The details of the computer (CPU) and Operating System (OS) may change from time to time.

When the CPU is powered-on, the user will have to enter a password to access the system. The default password is “iNano.” This can, of course, be changed by the user. Once the password is entered, the desktop is displayed. The InView (Test) icon is displayed in the lower left corner of the screen.

Figure 123 – desktop screen example showing InView Review Data software icon and InView software icon
6.2 Key terminology
Test: A test is a single experiment – typically a single indentation.

Method: A Method is an experimental recipe that defines how the instrument operates during a test. The standard methods are:

- Cyclic Indentation To A Load: This method utilizes the “Oliver-Pharr” technique to perform a quasi-static indentation, cycling the load/unload technique to increasing loads until the maximum load is reached.
- Dyn. Compression-Const. Disp. Rate: This method utilizes the iNano Dynamics feature and a constant displacement rate to perform an indentation to a desired load or depth.
- Dyn. Compression-Const. Load Rate: This method utilizes the iNano Dynamics option and a constant loading rate to perform an indentation to a desired load or depth.
- Dyn. Indentation-Const. Strain Rate: This method utilizes the iNano Dynamics option and a constant strain rate to perform an indentation to a desired load or depth.
- Low K Dyn. Indentation: This method is similar to the constant strain rate method, but utilizes a model that takes into account the substrate effects.
- Operational Check: This method provides a convenient way to ensure that the iNano is functioning properly. The method moves the iNano actuator through its range of motion, and then analyzes that motion for inconsistencies in the linearity and support spring stiffness of the actuator.

User: The User is the Windows OS defined user. The iNano comes with a default user (iNano).

Profile: Since most customers will only utilize a single Windows OS User for accessing the system, InView defines a “Profile” so that data, methods, and settings can be segregated by different physical users without resorting to the Windows OS User. That is, there can be multiple Profiles for a single User.

Project: A Project is a way to segregate data under a Profile. This is a good way to group data either by a project name, or customer name, etc.

Sample: A Sample is a set of tests – most commonly an array of indentations. This can be a single collection of tests on one specimen, or a series of tests spanning multiple specimens. In MultiSample mode, the user can define multiple samples as is most convenient. For example, each specimen could be called a sample, or all of the specimens can be tested in a single sample. The term Sample refers to a group of tests.
Specimen: A specimen is a physical material – the material that is tested by the iNano.

Settings: Settings contains information about the iNano that may be specific to a Profile. Examples of such information include the tip parameters, video source calibration, and load frame stiffness.

Channel: Channels are streams of data, such as Displacement, Load, Time, etc.
6.3 InView Test Program

6.3.1 Opening InView Test Program

To open the Test page of InView, double-click on the Inview icon on the desktop.

![InView desktop icon](image)

Figure 124 – InView desktop icon

The InView software will open, and will ask for a method to be loaded. By default, the software looks for the method in the most recently used profile (in this example, the profile is “NMI,” and the method selected is “Dyn. Indentation Const Strain Rate” located in the Master Methods folder).

![InView software open - select preferred Method](image)

Figure 125 – InView software open – select preferred Method
The Test page screen will then be displayed.

![Test page screen](image)

**Figure 126 – InView software Test Page screen**

Features of the Test Page: The Test Page consists of the Top Bar, the Meters Pane, the Motion Control Pane, the Video Pane, the Real Time Graph, and the MultiSample Test Definition Pane. Note that you can resize various elements of the Test Page by positioning the cursor at the border of a particular element.
6.3.2 Top Bar

![Top Bar icon](image)

Figure 127 – Top Bar icon

6.3.2.1 Main Menu

The Main Menu icon is the Nanomechanics logo. Basic functions such as loading methods, samples, or exiting the software are located here.

![Main Menu icon](image)

Figure 128 – InView Main Menu icon (Nanomechanics logo)

Main Menu: Sample Data

![Sample Data](image)

Figure 129 – Main Menu -> Sample Data option

- Open: Open allows the user to open a previously saved sample. The sample will be loaded into both the Test Page and the Review Page.
- Save: Saves a sample, including all changes that have been made since the sample was run or opened.
- Save As: Allows the user to save the sample with a different name.
- New: Creates a new Sample
Main Menu: Test Method

![Main Menu - Test Method option](image)

**Figure 130 – Main Menu -> Test Method option**

- **Open:** Allows the user to open a method.
- **Save:** Saves a method
- **Save As:** Allows the user to save the method with a different name.
- **Edit:** If the user has purchased the User Method Development for InView Option, this menu item will open the Test Design window. Refer to the documentation for the User Method Development option for more information about this powerful tool.
- **Info:** Opens a window that describes the method.
Main Menu – Tips and Settings

Tip and Settings:

Opens the Tip and Instrument Configuration window.

![Tip and Instrument Configuration window](image)

Figure 131 – Main Menu -> choosing Tips & Settings window opens Tip and Instrument Configuration window

- Tip Selection Drop Down Menu: All of the available tips defined by the User (note that all tips will be displayed, regardless of which Profile was in place when they were created).
- Tip Info: Displays the file path to the sample that was used to determine the Advanced Tip Calibration for a given tip.
- Tip Info/Serial Number: Allows the user to enter a serial number for the tip.
- Comment: Allows the user to enter comments associated with a tip.
- Frame Stiffness: Displays the Load Frame Stiffness associated with the instrument. By default, this will be the most recently determined Load Frame Stiffness from the Advanced Tip Calibration. This value can be manually changed, but it is not recommended to do so.
• Tip Poisson’s Ratio: Displays the Poisson’s ratio for the tip. The default value is for diamond, although the user can enter values for other materials (sapphire, etc.) if desired.
• Tip Modulus: Displays the Modulus of the tip material. The default value is for diamond, although the user can enter values for other materials (sapphire, etc.) if desired.
• Area Calculations: Displays the coefficients determined by the Advanced Tip Calibration. The user can manually change these values, although it is not recommended to do so.

Main Menu – System:

![Main Menu System Option](image)

**Figure 132 – Main Menu -> System option**

• Shutdown Controllers: Shuts down the communication with the iNano controller (the device that communicates between the software and the iNano physical systems).
• Start Controllers: Starts communication with the controller.
• About InView: Displays a window containing information about the software.

Main Menu – Exit:

Shuts down the InView software
6.3.2.2 Method, Sample and Test Information

Located next to the Main Menu, information is displayed about the currently selected Method, Sample, Test, and Tip. While the instrument is performing tests, the “Test” information will be updated here with the currently running test.

![Example of window showing updated Test information for currently running test](image)

6.3.2.3 Profile

The Active Profile is displayed in a drop-down menu. Selecting the drop-down menu allows the user to switch to an existing profile,

- Add New: Opens a field in which the user can type in the name of the new profile.
- Browse: Opens an explorer window in which the user can browse the existing profiles.

6.3.2.4 Run Button

The green run button in the center of the top bar is used to start tests.

![Green Run button](image)
While the test is running, the button changes to a red Stop button, which will immediately discontinue a test.

![Red Stop button](image)

**Figure 136 – Red Stop button**

When the Stop button is pressed, a dialog window will open which asks if the user wants to stop all tests.

![Stop Button Pressed dialog window](image)

**Figure 137 – Stop Button Pressed dialog window**

If “No” is selected, the system will abort the current test and proceed to the next test location, continuing on with the sample. If “Yes” is selected, the system will abort the entire sample and return to the microscope position.

### 6.3.2.5 Log Pane

On the right side of the top bar, the log pane is displayed. This pane displays system messages describing actions by the user or the system during a test or test setup.

![Log Pane displaying system messages](image)

**Figure 138 – Log Pane displaying system messages**
6.3.2.6 Window Control icons

The final item on the top bar is the standard minimize, maximize, and exit icons. Clicking the minimize icon will reduce the InView Test page to the Windows bottom bar. Clicking the maximize icon will increase the InView Test page to use the full screen. Finally, clicking on the Exit icon will close InView Test.

![Figure 139 – Standard Minimize, Maximize and Exit icons](image)

6.3.3 Meters Pane

The Meters Pane displays real-time data from the system.

![Figure 140 – Meters Pane displaying example of real-time data from the system](image)

Meters can be added or removed to customize the view. Clicking on the wrench icon in the upper left corner of the Meters Pane will open the Meter Selection Window, in which meters can be added or removed from the Meters Pane:
To add a meter, select the desired meter from the “Available” list, and click on the “>” button, or double-click on the desired meter. To add all meters, click on the “>>” button. The meter(s) will then appear in the “Selected” list on the right side of the window.

To remove a meter, select the desired meter from the “Selected” list, and click on the “<” button, or double-click on the desired meter. To remove all meters, click on the “<<” button. The meter(s) will then disappear from the “Selected” list on the right side of the window.

When done adding or removing meters, click on the “Done” button.

The meters can also be changed by right-clicking on a specific meter. A pop-up window will be displayed.
Selecting Units displays a list of the available units for a particular meter. In this first example, the meter is the Extension meter, so the units will be appropriate for linear distance:

![Figure 143 – Units options](image)

If a different meter is selected, a different set of units may be displayed. In the second example, the Force meter is chosen, so the units displayed are appropriate for force measurement.

![Figure 144 – Units, Force Meter option](image)

Selecting Decimals will display a window in which the decimal places for the meter can be selected.

![Figure 145 – Units, Decimal Places option](image)
Selecting Notation will allow the user to choose between Standard and Scientific notations.

![Notation options](image)

**Figure 146 – Notation options**

Finally, note that meters will only display values when there is available data. Some meters (such as Force, Displacement, etc.) will always show values, while others (such as Depth, Stiffness, Hardness, etc.) will show “NaN” indicating that there is no data to display. Depth, for example, is only meaningful during an indentation, in which Depth indicates the displacement into the surface of the specimen.
6.3.4 Motion Control Pane

6.3.4.1 Pucks Tab

The motion control pane is used to position specimen under the microscope, to move the motion control system to a position for loading the sample tray, or to manually control the position of the motion system, actuator, or extension axis. The default for the Motion Control Pane is to display the “Go To Pucks” buttons.

Clicking on any of the four Go To Puck buttons will cause the system to move that puck location under the microscope. Clicking on the “Go to Load Sample” button will cause the system to move to the Sample Tray load position, at the front-right corner of the motion system’s range of travel.

At the bottom of the Motion Control Pane is the Info tab. Clicking on the Info tab will display a log window. This window displays system messages describing actions by the user or the system during a test or test setup.
By clicking on the wrench icon in the upper left corner of the Motion Control pane, the user can choose to show (or hide) more control panels. When Show Control Panels is selected, the Z Control, X&Y, and Dynamics tabs will appear at the bottom of the Motion Control pane.

![Motion Control pane with wrench icon and puck controls](image)

**Figure 148 – Motion Control pane; Wrench icon in top left corner is used to show or hide more control panels**
6.3.4.2 Z Control Tab

The Z Control tab will cause the pane to display buttons that allow for the manual control of the Extension axis or the Actuator (Displacement Control). Note that Z Control is used primarily for the InSEM product line from Nanomechanics. The user should have little or no need to use this tab for the iNano.

USE EXTREME CAUTION WHEN MANUALLY CONTROLLING EITHER THE EXTENSION OR THE ACTUATOR.

The Extension buttons control the motion of the microscope axis – the buttons move the microscope either upward or downward relative to the surface of the specimen. There are two rows of buttons; an upper row of five buttons and a lower row of three buttons along with a field for value entry.
Figure 150 – Extension Control pane, all Extension buttons displayed

On the upper row of buttons, there are two directional fast buttons (<< and >>) and two directional slow buttons (-/+), along with a “Stop” button. Clicking on the (+) button will move the microscope slowly toward the surface of the specimen. Clicking on the (-) will move the microscope slowly away from the surface of the specimen. Clicking on either the (<<) or (>>) button will move the microscope fast either up or down. Note that all of these buttons are “click & hold” in that motion will only occur while the cursor is held on the button. Once the mouse click is released, the motion stops.

The Stop button can be used when the Extension axis is moving to cause it to stop immediately.

IT IS IMPORTANT TO NOTE THAT BOTH THE MICROSCOPE AND THE ACTUATOR ARE MOUNTED TO THE EXTENSION AXIS. This means that when the Extension axis control is used, the actuator is being moved relative to the specimen surface. Be very certain not to drive the actuator into a hard object, as extensive damage to the instrument can result.

The lower row of buttons allow for automated control of the Extension axis. The Init button will move the Extension axis all the way to the top of its travel to find its “home” position and set the Extension position to zero.

The Set button allows the user to enter an absolute position in the value entry field (in mm). The Extension axis will then be moved to this location. Refer to the Extension meter to see the current location of the Extension axis.

Finally, the Engage button will move the Extension axis downward (toward the specimen) while the software monitors the Actuator displacement. The purpose of this button is to place the indenter in contact with a specimen surface. This function is used in the InSEM line of products from Nanomechanics, and will rarely, if ever, have use on the iNano. It is critical that this button not be used while the microscope is focused on the specimen.

On the lower part of the Z Control screen are the Displacement Control buttons. There are two rows of buttons; an upper row of five buttons and a lower row of four buttons along with a field for value entry. In addition, there are two checkboxes for Force and Enable Alarm.
Similar to the Extension axis controls, the Displacement controls allow the user to manually control the position of the indenter column within the Actuator.

On the upper row of buttons, there are two directional fast buttons (<< and >>) and two directional slow buttons (-/+), along with a “Stop” button. Clicking on the (+) button will move the indenter shaft slowly toward the surface of the specimen. Click on the (-) will move the indenter shaft slowly away from the surface of the specimen. Clicking on either the (<<) or (>>) button will move the indenter shaft fast either up or down. Note that all of these buttons are “click & hold” in that motion will only occur while the cursor is held on the button. Once the mouse click is released, the motion stops.

The Stop button can be used when the indenter shaft is moving to cause it to stop immediately.

The lower row of buttons allow for automated control of the indenter shaft. The (|<) button will cause the indenter shaft to move to the top of its travel (away from the specimen surface). The (>|) button will cause the indenter shaft to move to the bottom of its travel (toward the specimen surface). The (0.0) button will cause the indenter shaft to move to the center of its travel.

The Set button allows the user to enter an absolute position in the value entry field (in µm). The indenter shaft will then be moved to this location. Refer to the Displacement meter to see the current location of the indenter shaft.

Clicking on the “Force” checkbox will change from displacement control to force (load) control of the indenter shaft. Most of the buttons function in the same way in this mode; the (<<) button will move the indenter shaft fast upward, the (>|) button will move the indenter to the bottom of its travel, etc.

The “Set” button, however, changes to setting the force (load) at a specific absolute value. Note that the units next to the value entry field change to mN rather than µm when the Force checkbox is selected. The (0.0) button will cause the indenter to move to the zero-load position.

The “Enable Alarm” button turns on an audible alarm tone when the indenter shaft is at a displacement less than 10,000nm. For example, if the indenter shaft was set at a displacement of 20,000nm, and the extension axis was being used to move the actuator toward the surface of the specimen, when contact
was made with the specimen, the indenter shaft would be pushed upward, causing the displacement signal to decrease from 20,000nm. When 10,000nm is reached, the alarm will sound.

NOTE THAT EXTREME CAUTION SHOULD BE USED IN SUCH A MANUAL OPERATION.

Further, note that the Z axis will not move toward the sample if the displacement is less than 12,000 nm. This is a safety feature to prevent damage to the instrument.

6.3.4.3 X&Y Tab

The X&Y Control tab will cause the pane to display buttons that allow for the manual control of the X and Y axes of the motion system.

![X & Y Control tab, displaying X Axis and Y Axis function buttons](image)

The X&Y Axis Position buttons control the motion of the X and Y axes of the motion control system – the buttons move the motion control system laterally within the iNano gantry. There are two rows of buttons; an upper row of five buttons and a lower row of two buttons along with a field for value entry. Operation is identical for the X and Y axes.

On the upper row of buttons, there are two directional fast buttons (<< and >>) and two directional slow buttons (-/+), along with a “Stop” button. Clicking on the (+) button will move the motion axis slowly toward the front of the iNano gantry. Click on the (-) will move the motion axis slowly away from the
front of the iNano gantry. Clicking on either the (<<) or (>>) button will move the motion axis fast either toward the front or back.

The Stop button can be used when the motion system axis is moving to cause it to stop immediately.

The lower row of buttons allow for automated control of the motion axis. The Init button will move the motion axis all the way to the end of its travel (to the left) to find its “home” position and set the motion axis encoder position to zero. Note that the X Axis Position meter should read zero (0.0). The Y axis functions in the same manner, except that its home position is at the rear of the iNano gantry.

The Set button allows the user to enter an absolute position in the value entry field (in mm). The motion axis will then be moved to this location. Refer to the X or Y Axis Position meter to see the current location of the motion axis.

Note that if the Extension axis is not at the top of its travel, the X and Y axes cannot be initialized. A dialog window will appear with a warning if there is an attempt to initialize the X or Y axis while the Extension axis is located near the specimen surface.

![Figure 153 – Extension retraction dialog notification window](image)

In this circumstance, change back to the Z Control tab, press the init button to move the Extension axis to the top of its travel. Then return to the X&Y tab to initialize the desired axis.
### 6.3.4.4 Dynamics Tab

The Dynamics Tab displays control parameters for the Dynamics feature of the iNano. Normal operation of the instrument does not require the use of the manual control of the dynamics parameters. Further, changing these parameters has no effect on the performance of the Dynamics feature when tests are run. Manual control of Dynamics is primarily used for diagnostics and for the InSEM product line. iNano users can safely ignore the features provided by the Dynamics control pane.

The Dynamics tab provides four parameters that can be modified. When the “Set” button is pressed, the phase lock amplifier used in the Dynamics feature will be controlled using the new parameter settings.

**Figure 154 – Dynamics tab displayed**

**Frequency:**

The frequency of oscillation for the superimposed dynamic load signal.

**Time Constant:** The time constant for averaging the dynamic data. The longer the time constant, the more data is included in the average and the less sensitivity is present in the data.

**Max Dynamic Displacement:**

This is used to set the gain of the dynamic displacement signal by limiting its range to the maximum displacement specified here.
6.3.4.5 Dynamic Force
The amplitude of the superimposed dynamic force oscillation.

6.3.4.6 Info Tab
When the Info tab is selected, the log pane is displayed. This pane displays system messages describing actions by the user or the system during a test or test setup.
6.3.5 Video Pane

The Video Pane displays an image from the microscope (or other selected video source, such as the CPU’s integrated webcam). This pane is used for observing and targeting positions on the specimens.

Figure 155 – Video Pane with callouts for Wrench Icon, Cursor Position Meter, Video Zoom Slider, Focus Control Buttons, Brightness Slider and Crosshair

Crosshair:

The Crosshair indicates the center of the screen, or the target position (the position for an indentation, or the beginning of an array of indentations).

Focus Control Buttons:

The Focus Control buttons move the microscope either toward the surface of the specimen (+) or away (-). Using these buttons moves the Extension Axis and hence caution needs to be exercised.
Video Zoom Slider:

The Video Zoom Slider will increase the magnification of the image in the video pane.

Brightness Slider:

The Brightness Slider will increase or decrease the brightness of the image by increasing or decreasing the intensity of the light. However, as the camera auto-gains, there is limited effect for most materials. It is preferable to leave this slider at its maximum position.

Cursor Position Meter:

The Cursor Position Meter displays the X and Y coordinates of the cursor relative to the crosshair.

Several functions can be accessed from the Wrench Icon in the upper left corner of the video screen.

Figure 156 – Drop-down menu options of Cursor Position Meter

Select Video Source allows the user to select the video device that will be used to generate the image in the video pane. There should be no need to change this, although if the camera USB is disconnected and moved to another USB port, it may be necessary to re-select the video device from the drop down menu.

Figure 157 – Video Capture Device Settings window options
Camera Configuration:

Selecting this option will display the camera properties window. There are two tabs in this window. The first, Video Proc Amp allows the user to modify the brightness, contrast, saturation, and other aspects of the video display. There is normally no need to modify these settings.

Figure 158 – SCMOS1300KPA Properties window with Video Proc Amp tab selected

The second tab, Camera Control, allows the user to modify the zoom, exposure, and other aspects of the video camera. There is normally no need to modify these settings.

Figure 159 – SCMOS1300KPA Properties window with Camera Control tab selected
Save Image To File:

This function allows the user to save the image currently displayed on the video pane. A dialog window will appear to select the folder to store the image file. The location will default to the current Profile. The default image format is JPEG, although PNG and BMP are also available.

![Image of Save As dialog window](figure160.png)

**Figure 160 – Save As dialog window; **be aware that the location will default to the current Profile**

Calibrate Video Source:

This function allows for determination of the distance between the microscope and the indenter, which is necessary for correct targeting of indentation locations, and calibration of the video screen. Refer to **Section 4.3** for details on performing these calibrations.

Several functions can be accessed by right-clicking on the video screen:

![Calibrate Video Source functions](figure161.png)

**Figure 161 – Calibrate Video Source functions displayed**
Remove Backlash:

This function moves the motion system in a pattern so that backlash in the X and Y axes of the motion system is removed. Backlash refers to the error that occurs in motion systems caused by the reversal of direction, and due to “slack” or “clearances” in the motion system.

Move Relative:

This function allows the user to move the motion system relative to the current position of the crosshairs. The following image shows a 50 µm relative move that was made by entering 50.0 in the value entry field, and clicking on the right hand side arrow button (>

![Figure 162 – Example of a 50 µm relative move being initiated by entering 50.0 in the value entry field](image)

![Figure 163 – Example of a 50 µm relative move implemented, movement to center of field displayed](image)
Move Absolute:

This function allows the user to move the motion to an absolute position. Note the coordinates displayed on the X and Y Axis Position meters. The images displayed below demonstrate an absolute move from 70.888 mm in the X axis to 70.988 mm in the X axis (100µm move). This move was made by entering 70.988 in the value entry field and clicking on the green “go” button in the Absolute Move window.

![Figure 164 – Absolute Move options initiated](image1)

![Figure 165 – Absolute Move implemented and displayed](image2)
Annotations:

There are three types of Annotations available for the video screen:

![Annotations options](image)

**Figure 166 – Annotations options**

Show Test Locations will visually display the locations for individually selected indentations or an array of indentations, when those locations have been defined for a sample. This is particularly useful for determining whether an array will fit into a “clear space” on a specimen (that is, that an array will be free of interference with visual features on a specimen).

![Show Test Locations visual example](image)

**Figure 167 – Show Test Locations visual example for individually selected indentations**
Show Sample Name will display the sample name at the locations for selected indentations. This can be very useful when multiple samples are used on a single specimen. In the example below, two samples are visible in the same field of view. The first, Fused Silica, is a 5 x 5 array with 20 µm spacing between indents using the Dyn. Indentation – Const. Strain Rate method. The second, Fused Silica Cycle Method is a 3 x 3 array with 20 µm spacing, using the Cyclic Indentation to a Load method. The user has defined the sample name for the second sample so that the different method is clearly visible in the annotation.

![Image of the examples](image)

**Figure 168 – Example of Show Sample Name option, with Fused Silica and Fused Silica Cycle Method displayed**

Show Scale:

As is visible in the images above, the Show Scale annotation will display a scale marker in the lower left corner of the screen.
Saved Locations:

The Saved Locations function allows the user to save specific absolute locations. This function can be useful when test locations on specimens are used repeatedly (such as on a patterned specimen or an ASIC specimen). Until locations are saved, the only option under Saved Locations will be “Save Current.”

![Figure 169 – Saved Locations options](image)

Save Current:

Selecting this option will display a dialog window in which a name for a location can be entered (in this example “Video Source Indents”).

![Figure 170 – Save Location dialog window](image)

The location is saved in the Settings folder under the current Profile (note that this is for reference purposes – it is not necessary for the user to access the saved locations through the Windows).
Once a location has been saved, then that location will be available in the Saved Locations menu. In the example below, “Video Source Indents” is available for use. There are three options when locations have been saved.

![Saved Locations options](image)

**Figure 171 – Saved Locations options**

Go To:

This function will move the motion system to the saved location.

Update:

This function allows the user to update the saved location to the current location (of the crosshair).

Remove:

This function removes a saved location. This action is permanent and cannot be undone.
6.3.6 Real Time Graph

The Real Time Graph (RTG) displays data when a test is being performed. The default axes are Displacement and Time, but there are a number of options for configuring the Real Time Graph.

While the sample is being moved into position, the RTG cannot be modified. However, the RTG axes can be changed either before, or during the test. The RTG will default back to the Displacement vs. Time axes at the start of a Sample run.

The scale of the RTG can also be changed “on-the-fly” by right-clicking on the RTG and sliding the mouse up or down. Note that if the axes are set to scale automatically, and data is displayed on the RTG, the RTG may “snap back” to its original scale after the right-click button is released. This will also occur if the scale is set to absolute values.

To change an axis of the RTG, right-click on the axis title (in this example, right-click on “Displacement.”) A window will be displayed with a number of options.

![Figure 172 – Editing the axes](image)

**Axis Channel:**

Selecting this function will display a list of all available Channels that can be selected for the desired axis.

**Axis Units:**

Selecting this function will display the units available for the selected Channel.
Auto Scale Max and Min:

When the checkbox by the Auto Scale is selected, the RTG will automatically be rescaled as necessary to display the available data. When the checkbox is unchecked, the maximum or minimum scale of the axis will be set to the value entered in the value entry field. Note that the units are contextual (i.e., Displacement will be displayed as the selected Axis Unit, such as nm or mm, etc.).

Font:

The Font size can be increased or decreased as desired.
Grid:

The user can choose whether or not to show the Major and Minor gridlines on the RTG.

Both the X and Y axes of the graph are modified in the same manner. If the axes are modified at the start of a Sample run, they will remain modified throughout the Sample run, or until changed.

The following images show examples of the Load vs. DEPTH and MODULUS vs. DEPTH plots displayed on the RTG during a test. Note that the Load vs. DEPTH was allowed to Auto Scale, while the MODULUS vs. DEPTH was fixed with 0 to 100 GPa on the Y axis.

![Load vs DEPTH and MODULUS vs DEPTH plots](image)

Figure 173 – Example of the Load vs DEPTH and MODULUS vs DEPTH plots displayed on the RTG during a test

![Load vs DEPTH and MODULUS vs DEPTH plots](image)

Figure 174 – Example of the Load vs DEPTH and MODULUS vs DEPTH plots displayed on the RTG during a test
6.3.7 MultiSample Test Definition

The MultiSample Test Definition pane is used to define the tests that will be performed during a Sample run. This pane is organized into a “flow” that guides the user through setting up a test.

Wrench Icon:

The Wrench Icon in the upper left corner of the MultiSample Test Definition pane displays a number of options for working with Samples or Projects.

![MultiSample Test Definition pane with drop-down menu options](image)

Figure 175 – MultiSample Test Definition pane with drop-down menu options (access by clicking the Wrench icon in top left corner)

Select Inputs:

Select Inputs allows the user to display various test inputs. This option is enabled only after selecting the Single Test Mode, and consequently has minimal use for the iNano.

Single Test Mode:

The Single Test Mode is used to run the Operational Check Method (see Section 4.1). This mode is also used in the InSEM product line from Nanomechanics, but does not have many applications for the iNano.
MultiSample Mode:

The Multisample Mode is the primary means of setting up tests on the iNano. A Sample is a set of tests – most commonly an array of indentations. This can be a single collection of tests on one specimen, or a series of tests spanning multiple specimens. In MultiSample mode, the user can define multiple samples as is most convenient. For example, each specimen could be called a sample, or all of the specimens can be tested in a single sample. When the instrument is set to operate in Multisample mode, the MultiSample Test Definition pane displays a series of windows, described hereafter, that are used to set up the test.

Save Multisample Project:

The user can save a Multisample Project. This allows for the re-use of standard test setup or the use of a Project as the starting point for a new Project. When this function is selected, a dialog window will open directing the user to enter a filename under which to save the Project.
Load Multisample Project:

This function allows the user to open a previously saved Project for the purposes described above. When this function is selected, a dialog window will open directing the user to locate the Project to be opened.

It should be noted that when a Multisample Project is loaded, all of the parameters, including the test locations, are loaded along with it. Consequently, if the user were to run the Multisample Project immediately without any editing, the indentations would be performed at the same coordinates that were in place when the Multisample Project was saved. For users performing tests on bulk materials, this may be acceptable. However, it is better practice to select the locations for the indentations by editing the Multisample Project (see below).

Engage Options:

The Engage Options function allows the user to change the parameters that are utilized when the instrument automatically contacts the surface of the specimen at the beginning of a Sample. There is rarely a need for these parameters to be modified.

The X and Y Offsets refer to the distance in µm by which the initial surface contact will be made, relative to the position of the first indentation in a Sample. That is, if the first indent in an array is defined as (0,0), then the surface contact will be made at a location (-50,-50). After making this initial surface contact, the last move will be made to the location for the first indentation and the test will proceed.

The Drift parameter sets the limit for drift before the Sample run begins. Drift is typically caused by thermal expansion or contraction of the specimen or other mechanical components. Allowing the system to stabilize to a low drift level before beginning the Sample run is a good way to minimize the effect of drift on the data.
Test Setup in Multisample Mode:

When the instrument is set to operate in Multisample mode, the MultiSample Test Definition pane displays a series of windows that are used to set up the test.

MultiSample Test Definition Window:

The first window displayed is the MultiSample Test Definition Window. A new Project Name can be entered here, or a previously defined Project can be selected from the drop down menu.

![MultiSample Test Definition Window](image)

Figure 178 – MultiSample Test Definition window; new Project Name can be entered or selected from drop-down menu
Multisample Mode Add Sample Window:

This window allows the user to enter information about the sample. The sample name should be descriptive of the specimen and any other relevant information. The currently selected method will be displayed under “Method.” This can be changed by selecting a method from the drop-down menu. Finally, comments can be entered as desired.

![MultiSample Add Sample window](image)

Figure 179 – MultiSample Add Sample window

When the sample has been defined, clicking on the Next Step button (>) will move to the Sample Level Inputs Window.
Sample Level Inputs Window:

This window displays the parameters that can be edited by the user for a given method. If the Poisson’s Ratio of the sample is known, enter it here (the default will work well for most engineering materials). Most commonly, the user will edit the Test Level Inputs: target load or depth. Depending on the method, the load rate, displacement rate, or strain rate may also be edited.

![Sample Level Inputs window with parameters displayed](image)

<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poisson’s Ratio of Sample</td>
<td>0.188</td>
</tr>
<tr>
<td>Test Level Inputs</td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td>Value</td>
</tr>
<tr>
<td>Target Load [mN]</td>
<td>45.00</td>
</tr>
<tr>
<td>Target Depth [um]</td>
<td>5000.0</td>
</tr>
<tr>
<td>Target Ind. Strain Rate [%]</td>
<td>0.200</td>
</tr>
</tbody>
</table>

Figure 180 – Sample Level Inputs window with parameters displayed

Once all of the inputs have been entered, or the defaults left in place, clicking on the Next Step button (>) will move to the Define Test Locations Window.
Define Test Locations Window:

This window is used to pick the target locations for indentations. When first entering this screen, there will be no target locations listed.

![Define Test Locations window with callouts for Add Array, Add Position, Remove Position, and Clear All Positions](image)

Figure 181 – Define Test Locations window with callouts for Add Array, Add Position, Remove Position, and Clear All Positions

After the Video Pane is used to find a desired target on the specimen surface, an array of indentations can be added by clicking on the “Add Array” button. When this is selected, a dialog window will appear requesting the number of indents in the X and Y directions, the spacing between indents, and the rotation of the array. Note that rotation is clockwise.

![Generate Indent Array window, displayed by clicking “Add Array” button](image)

Figure 182 – Generate Indent Array window, displayed by clicking “Add Array” button
When the array is defined, the locations will appear in the Define Test Locations window.

![Example of locations displayed after array is defined](image)

**Figure 183 – Example of locations displayed after array is defined; these locations will appear in the Define Test Locations window**

The (+) and (-) buttons can be used to add or remove single indentations. In the example displayed in the image above, three individually selected locations are displayed (the first three positions). A 3 x 3 array has been added, and two locations of that array have been removed.

If at any time there is a desire to move to a specific defined position, right-clicking on the position in the Define Test Locations list will provide the user with the option to “Move to Selected Position”

When all desired indentation positions have been added, clicking on the Next Step button (>) will move to the summary window.

![MultiSample Test Definition](image)

**Figure 184 - MultiSample Test Definition Summary window**
If more tests are desired, click on the (+) button to add another Sample. The process will be identical to that described above. The additional Sample can be on the same specimen, or a different specimen or puck location. A different method can be used if desired. In the following image, a second set of arrays has been added on the same specimen, using a different method.

![Image](image_url)

**Figure 1845 – Example of a second set of arrays added on the same specimen, using a different method**

Multiple samples can be defined. The following image shows the summary screen for a three-Sample test.

![Image](image_url)

**Figure 185 – Example of the Summary Screen for a three-Sample test**

When the user is prepared to perform the tests, clicking on the green “Run” button will cause the instrument to start the test.

![Image](image_url)

**Figure 187 – Click the Green Run button to initiate the test**
Note that the first dialog should be a message indicating that the specimen is being moved, followed by the “drift check” that begins all experiments:

Click on “Continue” to bypass the drift check, if desired (this is not recommended).
6.4 InView Review Program

6.4.1 InView Opening

To open the Review Page of InView, double-click on the InView Review icon on the desktop.

The Review Page will open, and will ask for a method or sample to be loaded.
By default, the software looks for the method in the most recently used profile (in this example, the profile is “NMI,” and the method selected will be in the Tip Calibration Sample folder).

Figure 189 – Folder selection process; InView software defaults to searching for the method in the most recently used profile
The Review page screen will then be displayed.

Figure 190 – Example of Review Page screen with callouts for Main Menu, Test Selection Pane, Info, Profile, New Data Message, Results Pane, Log Window, Window Control, Test Parameters Pane, and Plot Pane
6.4.2 Top Bar

![Top Bar icon]

Figure 191 – Top Bar icon

6.4.2.1 Main Menu

The Main Menu icon is the Nanomechanics logo. Basic functions such as loading methods, samples, or exiting the software are located here.

![Main Menu icon (Nanomechanics logo)]

Figure 192 – Main Menu icon (Nanomechanics logo)

Main Menu Sample Data:

- **Open**: Open allows the user to open a previously saved sample. The sample will be loaded into both the Test Page and the Review Page.
- **Save**: Saves a sample, including all changes that have been made since the sample was run or opened.
- **Save As**: Allows the user to save the sample with a different name.
- Recalculate: Recalculates the data with any changed inputs, or with a new Advanced Tip Calibration or tip profile (See Section 4.5).
- Info: Displays information about the method that was used to run the Sample.

Main Menu - Test Method:

- Open: Allows the user to open a method.
- Save: Saves a method
- Save As: Allows the user to save the method with a different name.
- Edit: If the user has purchased the User Method Development for InView Option, this menu item will open the Test Design window. Refer to the documentation for the User Method Development option for more information about this powerful tool.

Main Menu – Tests:

- Delete Selected: Deletes the currently selected test(s). Note that this cannot be undone. However, if the Sample has not been saved, the original Sample file can be opened again to restore the data.
Main Menu: Export Sample:

![Main Menu; Export Sample options](image)

Figure 196 – Main Menu; Export Sample options

The Export Sample feature has two format options: CSV or Excel. Selecting either of these formats will display a dialog window in which details of the export can be defined. Note that the channel data and results that will be exported are selected in the Results and Data Grid layout.

![Export Sample feature’s Select Export Range window with menu options displayed](image)

Figure 197 – Export Sample feature’s Select Export Range window with menu options displayed
Selecting the “Start Export Marker” drop-down menu will display the various “markers” that can be used for the beginning of the data export (data prior to the selected marker will not be exported). Note that the markers that are available are dependent upon the test method used. For example, the dynamics markers would not be applicable in a quasi-static (cycles) test. In this example, the markers associated with the “Dyn. Indentation-Const. Strain Rate” methods are used.

![Start Export Marker](image)

**Figure 198 – Start Export Marker drop-down menu options**

- **End Average Dynamics Index**: The end depth that was used to calculate the dynamics data, as displayed in the Results Pane. Note that this value is displayed in the Sample Level Test Parameters (see Test Parameters Pane). This value can be edited, and selecting the “Recalculate” option from Main Menu>Sample Data will cause the data to be recalculated using the current value of “Depth to End Ave. (nm)” in the Sample Level Inputs.
- **End of Hold at Load Index**: The point at which the “hold” at maximum load is completed.
- **End of Loading Index**: The point at which the peak load is reached, prior to the “hold.”
- **Start Average Dynamics Index**: The start depth that was used to calculate the dynamics data, as displayed in the Results Pane. Note that this value is displayed in the Sample Level Test Parameters (see Test Parameters Pane). This value can be edited, and selecting the “Recalculate” option from Main Menu>Sample Data will cause the data to be recalculated using the current value of “Depth to Start Ave. (nm)” in the Sample Level Inputs.
- **Surface Index**: The point at which the instrument recognized surface contact (the beginning of the indentation).

Selecting the “End Export Marker” drop-down menu will display the various “markers” that can be used for the end of the data export (data after the selected marker will not be exported). The markers available will be the same as for the “Start Export Marker.”

Note that leaving both the Start and Export Markers blank will result in all of the data being exported.

Note that entering the same marker in both the Start and Export Markers will result in none of the raw data being exported – only the Results will be exported.
Main Menu - Tip and Settings:

- Machine Settings: Opens the Tip and Instrument Configuration window, see Section 6.3.2.1.
- Advanced Tip Calibration: Performs a tip calibration using the current Sample data. (See Section 4.5).

Figure 199 – Main Menu; Tip and Settings options
Main Menu – Layout:

- New Data Graph: will display a new data graph in the Plots Pane. By default, the new data graph will be displayed as a new tab in the second Plots Pane graph window (the top left graph window). In this example, a new graph “Dyn. Force vs Time” is displayed.
• Show Data Grid: Displays the raw data for the test in the Plots Pane. By default, the new data graph will be displayed as a new tab in the second Plots Pane graph window. In this example, the Raw Data for Test 1 is displayed as a tab in the “Dyn. Stiff.^2/Load vs. DEPTH graph window.

![Select Test Window]

Figure 202 – Show Data Grid with raw data for the test displayed in the Plots Pane

The user can select which test will be displayed in the Data Grid by using the “Select Test” window as displayed in the image above. Either the up/down buttons can be used; or the user can type a number directly into the value entry field. The channels that are displayed can be altered by clicking on the wrench icon, and using the Select Columns function (see Section 6.3.3).

• Show Video: For the InSEM product line, SEM video is acquired and synchronized with the test data. The video can be displayed in a graph window in the Plot Pane. For the iNano, there is no applicable video to sync, so this can be ignored.

• Show Results: By default, the Results Pane will be displayed along the top of the Review Page screen. If the Results Pane has been closed, it can be displayed again by selecting Show Results.
- **Show Cycles**: For a method that utilizes Cycles (see Section 6.2), selecting this option will display data from each of the tests. In this example, four indentations were performed.

![Figure 203 – Show Cycles tab with data displayed from each of the four indentations performed for this example](image)
• Show Sample Summary Data: Show Sample Summary Data can be used to discretize and calculate the mean, median, and standard deviation of tests together. Selecting the Show Sample Summary Data will create a new window in the Test Selection Pane.

![Figure 204 – Show Sample Summary Data](image)

Drag this window onto the first graph in the Plots pane to increase the size of the graph.

![Figure 205 – Sample Summary tab](image)
Click on the Wrench Icon to display the menu.

![Sample Summary menu options](image)

**Figure 206 – Sample Summary menu options**

Click on Select Columns. A dialog window will be displayed with the available channels. In this example, DEPTH, HARDNESS, and MODULUS are selected.

![Item Selection List Form dialog window](image)

**Figure 207 – Item Selection List Form dialog window**
In the Sample Summary window, select “Recalculate Summary”

The data will be discretized and averaged. Standard deviations will be calculated for each discrete window.

![Recalculate Summary](image)

Figure 208 – Sample Summary tab with Recalculate Summary option indicated

![Data Discretized and Averaged](image)

Figure 209 – Sample Summary tab with data discretized and averaged
Note that the Start: Surface Index, and End: End of Loading Index can be defined by clicking on these options in the window. Selecting these options will display the choices of markers to be used for calculating the data. If these options are changed from the default, use the Recalculate Summary function to perform the recalculation.

![Sample Summary tab with Start Surface Index menu options displayed](image)

**Figure 210 – Sample Summary tab with Start Surface Index menu options displayed**

- New Sample Summary Graph. Once the Summary Data has been calculated, a graph of the data can be displayed by selecting Main Menu > Layout > New Sample Summary Graph. The default axes will be Time vs. Time. Right-click on the axes to change to the desired data (see Section 6.3.6). In this example, the MODULUS vs. DEPTH is displayed. Note the scatter bars showing one standard deviation for the data.

![New Sample Summary Graph with MODULUS vs DEPTH displayed](image)

**Figure 211 – New Sample Summary Graph with MODULUS vs DEPTH displayed**

Main Menu: About InView

Displays a window containing information about the software. The software version can be found here.
Main Menu – Exit:

Shuts down the InView Review software.

Method, Sample, and Test Information:

Located next to the Main Menu, information is displayed about the currently selected Method, Sample, Test, and Tip.

**Figure 212** – Method, Sample and Test Information window with data displayed from the currently selected Method, Sample, Test, and Tip

### 6.4.2.2 Profile

The Active Profile is displayed in a drop-down menu. Selecting the drop-down menu allows the user to switch to an existing profile, or to create a new profile.

**Figure 213** – Active Profile window with drop-down menu options displayed

- **Add New**: Opens a field in which the user can type in the name of the new profile.
- **Browse**: Opens an explorer window in which the user can browse the existing profiles.
6.4.2.3 New Data Available Notification
As each test is run, the data is made available for review. In the Review Page, a notice will appear at the top of the page.

![New Data Available](image)

Figure 214 – New Data Available notification

Clicking on this notice will result in the data being loaded. Note that if any changes have been made to the Sample in the Review page when this notice is clicked, they will be discarded and the raw data reloaded.

6.4.2.4 Log Pane
On the right side of the top bar, the log pane is displayed. This pane displays system messages describing actions by the user or the system during a test or test setup.

![Log Pane](image)

Figure 215 – Log Pane displays system messages

6.4.2.5 Window Control Icons
The final item on the top bar is the standard minimize, maximize, and exit icons. Clicking the minimize icon will reduce the InView Review page to the Windows task bar. Clicking the maximize icon will increase the InView Review page to use the full screen. Finally, clicking on the Exit icon will close InView Review.

![Window Control Icons](image)

Figure 216 – Window Control icons, with the standard Minimize, Maximize and Exit icons displayed
6.4.3 Test Selection Pane

The Test Selection Pane displays the available Tests in a Sample. Normally there is only one Tab in this Pane. However, if the Show Summary Data feature is selected (as described above), then a second tab will be present. Move between the tabs by clicking on them, or by selecting the window selection icon in the upper right hand corner of the pane.

![Test Selection Pane with callouts indicating Test Selection tab and Window Selection Icon](image)

Figure 217 – Test Selection Pane with callouts indicating Test Selection tab and Window Selection Icon

Note that you can select individual tests by clicking on them. To select all tests, click in the pane and use Control-A. To select multiple tests, click on a Test, hold down the shift key, and click on the last test in a series. To click on multiple individual tests, click on a test, hold down the Control key, and click on the other desired tests.

As tests are selected the data is displayed in the graphs in the Plot Pane.
6.4.4 Test Parameters Pane
The Test Parameters Pane displays the Sample Level and Test Level editable post-test inputs for a given Sample. Note that these may change depending on the Method used. In the example below, it is possible for the user to change the Poisson’s Ratio, whether or not to apply the Drift Correction, and the Start and End Depths used for averaging the hardness, modulus, and other dynamic channels.

![Test Parameters Pane displaying Sample Level and Test Level fields](image)

Note that any changes made in this pane will not be applied until the Sample is recalculated (see Section 6.4.2.1).

6.4.5 Results Pane
The Results Pane shows data for each test. The channels available will depend on the Sample and Method used. Scrolling to the bottom of the Results Pane will display summaries for each column, including the average, standard deviation, and coefficient of variation.

![Results Pane showing data for each test](image)
The Wrench Icon in the upper left corner allows the user to select the columns to be displayed in the Results Pane, or to copy data to the Clipboard.

Choosing “Select Columns” will display a dialog window in which columns can be added or removed from the Results Pane.

To add a column, select the desired column from the “Available” list, and click on the “>” button. To add all columns, click on the “>>” button. The column(s) will then appear in the “Selected” list on the right side of the window.

To remove a column, select the desired column from the “Selected” list, and click on the “<” button. To remove all columns, click on the “<<” button. The column(s) will then disappear from the “Selected” list on the right side of the window.

When done adding or removing columns, click on the “Done” button.
6.4.6 Plot Pane

The Plot Pane displays graphs, video, and test data.

Figure 222 – Plot Pane displaying graphs, video and test data

In the image above, there are four graphs displayed. Note that the first graph (upper left) also includes the Video tab. Each graph includes a Window Selection icon which can be used to navigate among multiple tabs in the Plot Pane, as well as a Close icon that will close the graph.
Note that Index Data is displayed along the bottom of the graph, which shows the data point at the location of the cursor in the appropriate units for the graph. In the example below, the data for Test 1 is displayed in a MODULUS vs DEPTH graph. The Index Data shows the X and Y position on the graph in terms of Depth (X axis), Modulus (Y Axis), Index point and time.

Figure 223 – MODULUS vs DEPTH tab displayed with callouts for Tabs, Legend, Window Selection, Close, and Index Data
The axes can be modified by right-clicking on the axis title or the axis units.

![Dialog window with options to modify axes]

**Figure 224 – Right-clicking on the Axis Title will display the above dialog window with options to modify axes**

- **Y Axis Channel** will display a list of the available Channels.
- **Y Axis Units** will display the units that are available for a specific Channel.
- **Auto Scale Max and Min**: When the checkbox by the Auto Scale is selected, the graph will automatically be rescaled as necessary to display the available data. When the checkbox is unchecked, the maximum or minimum scale of the axis will be set to the value entered in the value entry field. Note that the units are contextual (i.e., Displacement will be displayed as the selected Axis Unit, such as nm or mm, etc.).
- **Font**: The Font size can be increased or decreased as desired.
- **Grid**: The user can choose whether or not to show the Major and Minor gridlines on the graph.

Right-clicking on the graph itself will display another menu that can be used to control how the graph is displayed.

![Menu with graph control display options]

**Figure 225 – Right-clicking on the graph will display another menu with graph control display options**
- **Show Legend**: Show Legend allows the user to control how (or if) the legend is displayed on the graph.

  ![Image of Show Legend menu options]

  **Figure 226 – Show Legend menu options**

  - Selecting Tests will display the test number
  - Selecting Markers will display the markers and marker title.
  - Selecting Tests AND Markers will display both
  - Selecting None will remove the legend.
  - Position Left places the legend at the left side of the graph.
  - Position Right places the legend at the right side of the graph.
  - Position Far Right places the legend outside the body of the graph

- **Show Title**: Displays the Sample Name at the top of the graph.
- **Show Lines**: Displays lines between each data point on the graph (displays a “curve”).
- **Show Data Points**: Displays the individual data points on the graph.
- **Show Tracker**: Displays crosshairs at the cursor location (and the corresponding Index data at the bottom of the graph).
- **Set Marker**: This function enables the user to manually place a marker at the current location of the crosshairs. For example, the Surface Marker can be moved by this functionality. Note that this is method-specific. If a Marker is moved, use Recalculate to apply changes. Note that Set Marker can only be used when a single test is selected.
- **Copy to Clipboard**: Creates a copy of the graph on the clipboard so that it can be pasted into another document.
- **Export**: Export allows the graph to be saved as either a SVG or PNG file. Selecting this option will cause a dialog window to be displayed in which the user can select the filename and location to save the image file.
- **Line Width**: This option allows the user to change line width on the line or “curve.” There are three options: Thin, Normal, or Thick.
As noted in previous descriptions, new graphs can be added to the Plot Pane. Main Menu > Layout > New Data Graph will display a new data graph in the Plots Pane. By default, the new data graph will be displayed as a new tab in the second Plots Pane graph window. In this example, a new graph “Dyn. Force vs Time” is displayed.

![Figure 227 – Example of new graphs added to the Plot Pane](image)

The graphs can be repositioned as desired. Clicking on the tab with the graph name (in this example, Dyn Force vs Time) and dragging the graph into a “free area” of the Plot Pane will cause the graph to become a free-floating window.

![Figure 228 – Example of free-floating window](image)
Note that while the graph is being dragged from one location to another, the graph placement function will appear over the “dominant” pane in the Plot Pane.

The dominant pane is the pane in which the actions of the graph placement function will take place. In the example below, the MODULUS vs. DEPTH graph is the “Active Graph” in that it is being dragged to a new location. The Shaded Area shows where the graph will be placed. The Graph Placement function appears over the Dyn.Stiff.^2/Load vs. DEPTH graph, as the cursor is located over this graph.
The shaded area shows where the graph will be placed – and in this example, it indicates that the floating Active Graph will remain floating. However, by dragging the graph onto the Graph Placement function, the graph can be added to the Plot Pane so that it displays in one of several ways.

![Diagram](image1)

**Figure 231 – Callouts – Home, Up, and Right - to identify directional function buttons**

Dragging the Active Graph to the “Up” position on the Graph Placement function will cause the graph to be displayed in a horizontal split pane with the Dominant Graph, with the Active Graph displayed “above” the Dominant Graph.

![Graph Example](image2)

**Figure 232 – Example of a graph displayed in a horizontal split pane orientation, with Active Graph displayed “above” the Dominant Graph**

Dragging the Active Graph to the “Down” position will cause the graph to be displayed in a horizontal split pane with the Dominant Graph, with the Active Graph displayed “below” the Dominant Graph.
Likewise, dragging the Active Graph to the “Left” or “Right” position will cause the graph to be displayed in a vertical split pane with the Dominant Graph, with the Active Graph displayed to the left or right of the Dominant Graph.

![Figure 233 – Example of the Active Graph displayed in a vertical split pane orientation](image)

Dragging the Active Graph to the “Home” position will cause the graph to be displayed as another tab along with the Dominant Graph.

![Figure 234 – Example of the Active Graph displayed as another tab along with the Dominant Graph](image)
6.5 References

6.5.1 Channels
There are a number of Channels defined in the InView software. The following list describes most of the channels:

- **Extension**: The position of the extension system relative to the last point at which it was zeroed.

- **Force**: The force being generated by the coil and magnet. It is calibrated as a function of current to the coil. It has a range of +/- 50mN. Zero is zero current through the coil and positive values try to extend the probe.

- **Displacement**: The displacement from the center of travel as measured by the capacitive sensor. It is calibrated as a function of “DisplacementVolts” from the sensor. It has a value of approximately +/- 25µm travel. Zero is in the center of motion and the positive direction is extending the probe.

- **LOAD**: The LOAD represents the load applied on the specimen for both dynamic and nondynamic portions of the experiment.

- **DEPTH**: The DEPTH represents the penetration into the sample for both dynamic and nondynamic portions of the experiment.

- **STIFFNESS**: The STIFFNESS represents the contact stiffness corrected for the load frame compliance for both dynamic and nondynamic portions of the experiment.

- **HARDNESS**: The HARDNESS final result for this experiment.

- **MODULUS**: The modulus calculated from dynamics and the Oliver and Pharr method.

- **Tip Temperature**: The temperature of the tip.

- **Dyn. Damping**: The measured contact damping during a dynamic experiment.

- **Dyn. Disp.**: The RMS value of the “Displacement” at the “Target Frequency.”

- **Dyn Force**: The RMS value of the “Force” at the “Target Frequency.”

- **Dyn. Frequency**: The frequency at which dynamic measurements are made.


- **Dyn. Stiffness**: The stiffness being measured by the dynamic system. It is calculated using the calibrated system spring constant, damping, and mass.
Spring Stiffness: The stiffness of the support springs. It is calibrated as a function of “Displacement.”

Time: Time is measured from the start of the test.

X Axis Position: The position of the X axis manipulator.

Y Axis Position: The position of the Y axis manipulator.

\( \frac{dP}{dt}/P \): The time derivative of the Load divided by the Load at each point in time. If Hardness and Modulus are constant and this parameter is constant, the indentation strain rate should be constant.

Auto Derivatives Tc: The time constant used to calculate the derivatives. It is set such that the “Delta Disp. In Der.” is satisfied.

Auto Points In Derivative: The number of data points in the buffers used to measure the derivatives. In this case the number is set such that there is at least “Delta Disp. In Der.” displacement change in the buffer. There is a maximum set by the system.

Cor. Dyn. Stiffness: The stiffness from dynamics corrected for the load frame stiffness.

d(Disp)/d(Time): The slope of the “Displacement” versus “Time” curve.

d(Force)/d(Disp): The slope of the “Force” versus “Displacement” curve.

d(Force)/d(Time): The slope of the “Force” versus “Time” curve.

Depth: The depth of the indentation. It is the zeroed value of the “Displacement” corrected for load frame stiffness and drift rate. It is zero prior to surface detection.

Dyn. H: The hardness calculated from the dynamics and the Oliver and Pharr method.

Dyn. Ac: The contact area calculated from the dynamics and the Oliver and Pharr method, as well as the current tip area calibration.

Dyn. E: The modulus calculated from the dynamics and the Oliver and Pharr method.

Dyn. Er: The reduced modulus calculated from the dynamics and the Oliver and Pharr method.

Dyn. hc: The contact depth calculated from the dynamics and the Oliver and Pharr method.

Dyn. Load / Dyn. Disp: This parameter should be equal to spring stiffness at low frequencies.
Dyn. Load Con.: This is the control loop that is modifying “Dyn.Force.” At small loads the result is a fraction of the applied “Load.” At larger loads the result tries to achieve a constant “Dyn.Disp.”

Dyn. Load Req.: This value is used to control “Dyn.Force” to obtain a constant value of “Dyn.Disp.”

Dyn. Stiff.^2/Load: The Stiffness^2/Load is a parameter that should be insensitive to the area function. It can be used to determine load frame stiffness.

Filtered Depth With Dyn.: The depth of the indentation when dynamics are in use. It is the zeroed value of the “Filtered Disp.” Corrected for load frame stiffness, drift rate, and the “Dyn.Disp.” It is zero prior to surface detection.

Filtered Disp.: The “Displacement” filtered to remove the “Dyn.Disp.” The “Displacement” is averaged over “Points In Depth” which represents an integer number of waves, “Waves to Filter Dynamics.”

Index: The index of a point in the data array.

Load: The “Load” applied to the sample. It is the zeroed value of the “Force” corrected for spring deflection. It is zero prior to surface detection. Dynamics are not considered.

Load With Dynamics: The load applied to the sample. It is the zeroed value of the “Force” corrected for spring deflection and the “Dyn.Load.” It is zero prior to surface detection.

Loading Rate Req.: The loading rate required to achieve a constant value of loading rate/“Load.” The “Approach Loading Rate” is assumed to be small and is added in to achieve a smooth transition.

Surface Trigger Counter: The surface is detected when “d(Force)/d(Disp)” exceeds the “Surface Stiffness Trigger” + Spring Constant. This must occur “Surface Trigger Required” number of times sequentially. “Surface Trigger Counter” tracks this number.

Time On Sample: The “Time” that has passed since the “Surface Index” was assigned.