



PLX-AutoStage User Manual



PLASTOMETREX

Contents

1	PLX-AutoStage Introduction	3
2	PLX-AutoStage Overview	4
3	PLX-AutoStage Setup and CORSICA	9
4	Sample Requirements	20
5	Contact Details	21

1 PLX-AutoStage Introduction

1.1 Introduction

The PLX-AutoStage module from Plastometrex is designed to be used with the PLX-Benchtop to automate indentation testing and imaging, enabling efficient acquisition of indent data for the extraction of metal stress-strain curves using Profilometry-based Indentation Plastometry (PIP).

The PLX-AutoStage system comprises two main elements:

1. **CORSICA:** a desktop software application used to control the PLX-Benchtop and PLX-AutoStage hardware, guide users through the testing workflow, and analyse the acquired data. The data analysis implemented in CORSICA enables calculation of tensile stress-strain curves from indentation data through a numerical approach. This technique is known as Profilometry-based Indentation Plastometry (PIP).
2. **PLX-AutoStage Module:** the hardware used to automate sample positioning, indentation location, and image acquisition, shown in Figure 1.1. The PLX-AutoStage captures high-resolution images of the sample surface and automatically positions samples accurately beneath the indenter at predefined indentation locations. Together with the PLX-Benchtop and CORSICA software, it provides an integrated solution for automated indentation testing and analysis.



Figure 1.1 Key components of the PLX-AutoStage.

2 PLX-AutoStage Overview

2.1 Technical Specification

Feature	Requirements			
Electrical Supply	Powered from PLX-Benchtop Class 1 equipment must be connected to an earthed supply. Mains plug acts as disconnect device and should be readily accessible.			
Support Surface	Stable, level laboratory bench. A granite surface plate or similarly rigid support is recommended.			
PC Specification	Windows 10 or Windows 11 operating system CPU with a clock speed of 3.5 GHz or higher At least 16 GB of RAM Standard Ethernet port required 2 x USB-A ports (<u>at least one 3.0 USB-A port</u>)			
Force Capacity	8 kN			
Overload Characteristics	200%			
Load Resolution	0.1 N			
LVDT Resolution	0.3 μm			
Profilometer Resolution	0.1 - 0.4 μm			
Position Control Resolution	1 μm			
Indenter Material	Si_3N_4			
Indenter Radius	1 mm (standard)			
Vertical Test Space	40 mm			
Horizontal Test Space	80 x 125 mm			
Maximum Sample Weight	1.5 kg			
Maximum sample height variation	1 mm			
Dimensions & Weight	Height	Width	Depth	Weight
PLX-Benchtop	550 mm	400 mm	200 mm	40 kg
PLX-AutoStage	235 mm	400 mm	400 mm	21 kg
Room Operating Temperature	5 to 35°C			
Humidity	10 to 80% non-condensing			
Test Materials	Ductile Metallics (Yield Stresses < 3 GPa)			
Noise Levels	<70 dBA			

Force measurement accuracy

0.5% down to 1/100 of the load cell capacity, 1% from 1/100 to 1/500 of the load cell capacity. Linearity class 0.05% FRO.

Displacement measurement accuracy

±2 µm for a 200 µm indent.

Atmosphere

Designed for use under normal laboratory conditions. Indoor use and maximum altitude 2000 m.

Foreseeable Misuse

The PLX-AutoStage is intended for use in a laboratory environment. The user must not place their hands or any other body part within the test space while the AutoStage is moving or while an automated test is in progress. The user must not manually force the AutoStage platen or stages to move. The user must not exceed the maximum specified sample size and weight or use accessories or spare parts that are not approved by the manufacturer.

If the equipment is used in a manner not specified by the manufacturer, the protection provided by the unit may be impaired.

2.2 CE Marking

All systems conform to all relevant European standards and carry CE marking. The CE Marking on the product label indicates that Plastometrex has checked that products meet all applicable EU Essential Requirements, Standards and Directives as declared on the “Declaration of Conformity” included with the product. These specifications were developed in accordance with Plastometrex standard procedures and are subject to change without notice.

UK/EC Declaration of Conformity

ORIGINAL



We

Plastometrex Ltd

Unit 7, Cambridge Technopark, Newmarket Rd, Cambridge CB5 8PB

declare under our sole responsibility that the product:

Description	Model	Serial No.
PLX-AutoStage	PLX-AS	PLX-AS-5XXX

to which this declaration relates are in conformity with all the essential requirements of Machinery Directive 2006/42/EC, EMC Directive 2014/30/EU, RoHS Directive 2011/65/EU and The Supply of Machinery (Safety) Regulations 2008 as amended, The Electromagnetic Compatibility Regulations 2016 as amended and The Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012, as amended:

The following harmonised standards have been applied with respect to this product:

BS EN ISO 12100:2010

BS EN 61010-1:2010

BS EN ISO 13849-2:2012

BS EN 61326-1:2013

BS EN ISO 13850:2015

BS EN IEC 63000:2018

Person Authorised to Compile Technical File & EU Authorised Representative

Hold Tech Files Ltd,

Dun Iseal, Newtown, Gaulsmills, Ferrybank, Waterford X91F638

Person Empowered to draw up Declaration

Dr. Jimmy Campbell

Chief Technology Officer



Signed at: Cambridge, UK

July 2027

Figure 2.1 UK/EC Declaration of Conformity

2.3 PLX-AutoStage Safety

The use of the PLX-AutoStage carries risks associated with moving mechanical components. Carefully read all the relevant manuals and observe all warnings. Ensure that the system is correctly installed and calibrated and that the tests you will be performing pose no hazard to yourself or others. The following section details general warnings that must be observed at all times.

If the equipment is used in a manner not specified by the manufacturer, the protection provided by the unit may be impaired.

2.3.1 Moving Parts and Crushing Hazard

The PLX-AutoStage contains motorised X-Y stages that automatically position the sample during calibration and testing. The platen will move without further user intervention once a test or calibration has been started. Do not place hands or any other part of the body within the test space of the PLX-Benchtop while the AutoStage is moving. Do not attempt to load, reposition or remove samples during automated movement. Wait until the software indicates that the operation has completed before accessing the test space.

There is also a potential crushing hazard when using the PLX-Benchtop and PLX-AutoStage, particularly to the user's fingers. The PLX-Benchtop is marked with four crushing hazard stickers as shown in Figure 2.2. Please ensure that fingers are always removed from the test space when the crosshead is moving. Do not place fingers on top of the crosshead cover for any reason.



Figure 2.2 Crushing hazard symbol.

2.3.2 Sample Suitability

Sample requirements are given in §4 of the PLX-AutoStage Manual. Samples that do not meet the requirements and/or present a danger in loading/testing should not be tested. In particular, the sample must be well supported underneath the indenter and not be at risk of toppling under the indentation load.

2.3.3 Personal Protective Equipment (PPE)

Safety goggles should be worn when using the machine.

2.3.4 Emergency Stop

The emergency stop is located on the right-hand side of the PLX-Benchtop. If the emergency stop is pressed, all automated machine movement will stop. Rotate the emergency stop button to release.



Figure 2.3 PLX-Benchtop emergency stop.

If the emergency stop has been activated due to suspected damage or abnormal machine behaviour, discontinue use and contact Plastometrex at support@plastometrex.com before resuming operation.

2.3.5 Transportation

The PLX-AutoStage module weighs approximately 21 kg. The combined weight of the PLX-Benchtop with the PLX-AutoStage installed is approximately 62 kg. The PLX-AutoStage must be removed from the PLX-Benchtop for transportation. For transportation, use the packaging or transport case supplied with the equipment.

2.3.6 Maintenance and Cleaning

The following procedures are recommended:

- Carry out the calibration procedures when prompted by the software, including the Machine Setup, Mapping Calibration, and Profilometer Calibration.
- Regularly clean the PLX-AutoStage and PLX-Benchtop, depending on usage and operating environment. Ensure the platen is free from debris before loading samples. Use 70% alcohol wipes or a damp lint-free cloth for cleaning. Do not use bleach-based cleaning products or allow liquids to enter the equipment.
- Regularly clean the mirror and lens by gently blowing away loose dust with clean, dry, oil-free compressed air, avoiding direct contact with the optical surfaces.

3 PLX-AutoStage Setup and CORSICA

3.1 PLX-AutoStage Setup

The following procedure should be followed to set up the PLX-AutoStage Module.

1. Ensure that the latest version of CORSICA is installed on the computer and that an active license file with PLX-AutoStage capability enabled has been installed.
2. Switch off the PLX-Benchtop and disconnect it from the mains supply. Do not reconnect or switch on the system until instructed. Ensure the PLX-Benchtop and PLX-AutoStage are on a flat, stable, and rigid work surface.
3. Open CORSICA and select PLX-AutoStage from the landing page. CORSICA will guide you through the required steps to install and configure the PLX-AutoStage module.



Figure 3.1 CORSICA landing page.

4. Screw the two knurled shoulder bolts into the rear of the PLX-Benchtop base plate by hand. Leave approximately 1 mm of thread exposed. Do not fully tighten the bolts at this stage. Take care not to touch the profilometer when reaching into the PLX-Benchtop.



Figure 3.2 Knurled shoulder bolts installation.

5. Position the PLX-AutoStage centrally behind the PLX-Benchtop. Align the two knurled shoulder bolts with the V-shaped slots. Slide the PLX-AutoStage forwards until it is flush with the PLX-Benchtop. Check that there is no gap between the two units and that their outer edges are parallel.



Figure 3.3 PLX-AutoStage positioning.

6. Tighten the two knurled shoulder bolts using the Allen key provided in the screwdriver kit. Do not overtighten the bolts.



Figure 3.4 PLX-AutoStage attachment.

7. The two large through-holes identify the rear of the load cell adaptor plate:
 - Loosen the two rear countersunk Torx bolts by approximately four full turns. Do not remove them.
 - Completely remove the single front countersunk Torx bolt and remove the front load cell gripper. Keep the gripper and bolt together for reinstallation.

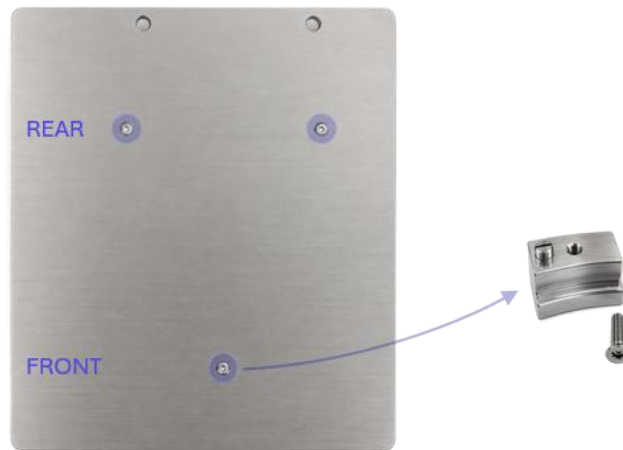


Figure 3.5 Load cell adaptor plate preparation.

8. Slide the load cell adaptor plate over the load cell and push it fully towards the rear until it sits flush on the load cell. Gently pull the adaptor plate as far forwards as possible, keeping its front edge parallel with the front edge of the PLX-Benchtop. Refit the front load cell gripper and tighten the countersunk Torx bolt. Then tighten the two rear bolts.



Figure 3.6 Load cell adaptor plate installation.

9. Ensure the PLX-Benchtop mains power, ethernet, and USB cables are connected.
10. Connect the PLX-AutoStage mains power cable between the PLX-AutoStage and the PLX-Benchtop. Rotate the connectors clockwise until they click and lock into place. Connect the PLX-AutoStage USB cable to a **USB 3.0 port** on the PC.



Figure 3.7 PLX-AutoStage connections.

11. Switch on the PLX-Benchtop.
12. **Keep clear of the test space while the following automatic movement takes place.** CORSICA will raise the crosshead to its upper limit and home the PLX-AutoStage linear stages. The sample platen linkage will move out of the PLX-AutoStage housing. **This step can take up to 5 minutes.** Wait until all stage movement has stopped before continuing.

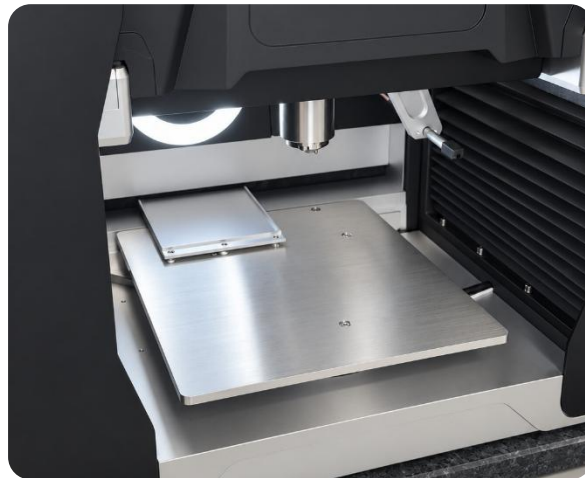


Figure 3.8 PLX-AutoStage stages homing.

13. Position the sample platen under the linkage and align it with the three holes. Using the supplied screwdriver, tighten the three custom screws until the platen is securely fixed to the linkage.

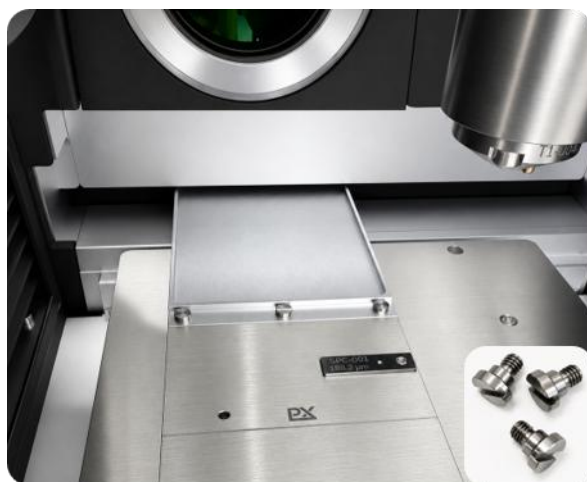


Figure 3.9 Sample platen installation.

14. Slide the mirror holder over the indenter head and move it upwards until it sits against the PLX-Benchtop crosshead. Apply firm pressure to the lower-left corner of the mirror holder, pushing it towards the PLX-AutoStage. While maintaining this pressure, tighten the Torx bolt until you start to feel resistance. Do not overtighten.



Figure 3.10 Mirror installation.

15. CORSICA will now begin its start-up sequence. During this process, the LED status indicator on the PLX-Benchtop displays a flashing blue (“building”) pattern. When start-up is complete, the LED changes to steady blue and the **Devices Ready** indicator appears in the lower-left corner of the CORSICA windows. Table 3.1 details the meaning of the LED status lights.

Table 3.1 Meaning of LED status lights colour display.

Colour	Form	Meaning
Blue	Building/Flashing	Booting
Blue	Steady	Standby
Green	Building	Indentation Progress
Yellow	Building	Profilometry Progress
Purple	Building	Calibration Progress
Red	Flashing	Error

3.2 PLX-AutoStage Calibrations

After installing the PLX-AutoStage, complete the following before the first test:

- Machine Setup
- Profilometer Calibration
- Mapping Calibration

3.2.1 Machine Setup

The Machine Setup operation can be accessed through **Tools > Machine Setup**. This operation automatically carries out the Crosshead Mirror Calibration, LVDT Calibration, Working Distances Calibration, and Indent Centre Search Calibration.

3.2.2 Profilometer Calibration

The Profilometer Calibration operation can be accessed through **Tools > Calibrate > Profilometer (PLX-AutoStage)**. This operation involves calibrating the profilometer signal using an indent with known dimensions, located at the back of the sample platen. CORSICA will prompt the profilometer calibration based on both time (3 hours) and temperature fluctuations ($\pm 2.5^{\circ}\text{C}$).

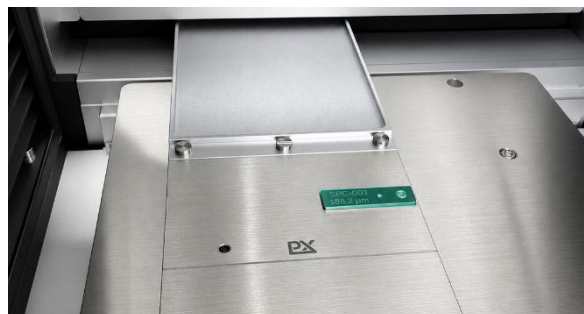


Figure 3.11 PLX-AutoStage profilometer calibration sample.

3.2.3 Mapping Calibration

The mapping calibration operation can be accessed through **Tools > Calibrate > Mapping Calibration**. This operation establishes the relationship between positions in the camera image (measured in pixels) and the physical coordinates of the positioning stages. This enables the system to accurately convert locations selected within an image into precise stage movements for automated indentation.

The calibration is performed using a dedicated calibration block containing a predefined pattern of indents. This block should be placed onto the dowel pin locating holes as shown in Figure 3.12. During the procedure, the PLX-AutoStage automatically captures images of the calibration block, identifies the reference indents, and calculates the transformation between image coordinates and stage coordinates. This calibration is then used for all subsequent automated positioning operations. The Mapping Calibration should be performed whenever instructed by the software, or **after any changes that could affect the relative position of the camera, optics, or sample platen** (uninstallation and reinstallation of the mirror or sample platen or movement of the AutoStage relative to Benchtop).

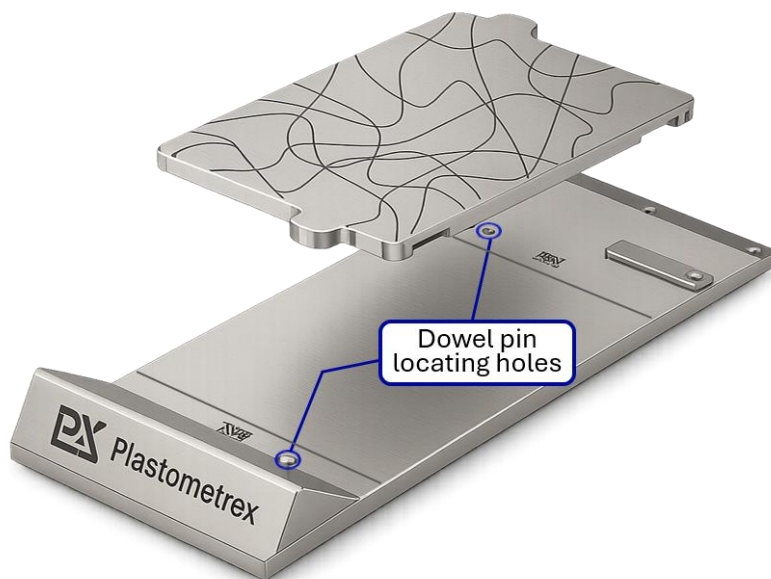


Figure 3.12 Mapping calibration sample positioning.

3.3 Data Capture

With the PLX-AutoStage installed, and all required calibrations completed, the system is ready for testing.

1. Open the **PLX-AutoStage Test Control** panel and click **Start**. Enter a test file name and select the directory in which the test will be saved.

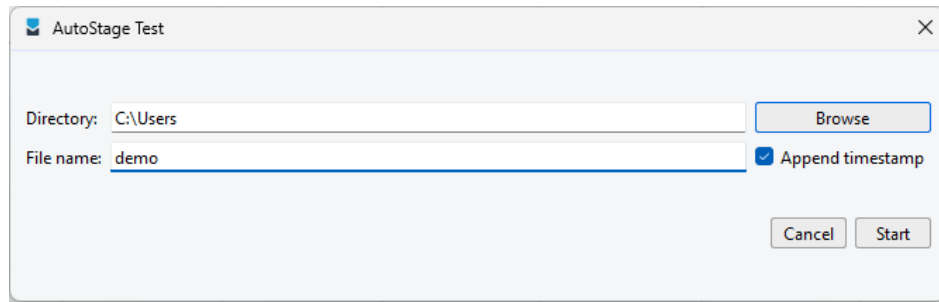


Figure 3.13 PLX-AutoStage file name and directory

2. The Sample Platen moves to the loading position. Place the sample(s) on the designated sample area and click **Next**. Ensure that:
 - The maximum difference in height between samples is less than 1 mm.
 - Each sample is less than 40 mm tall.
 - All samples fit within the designated sample area.
 - All samples sit flat and are stable on the platen.

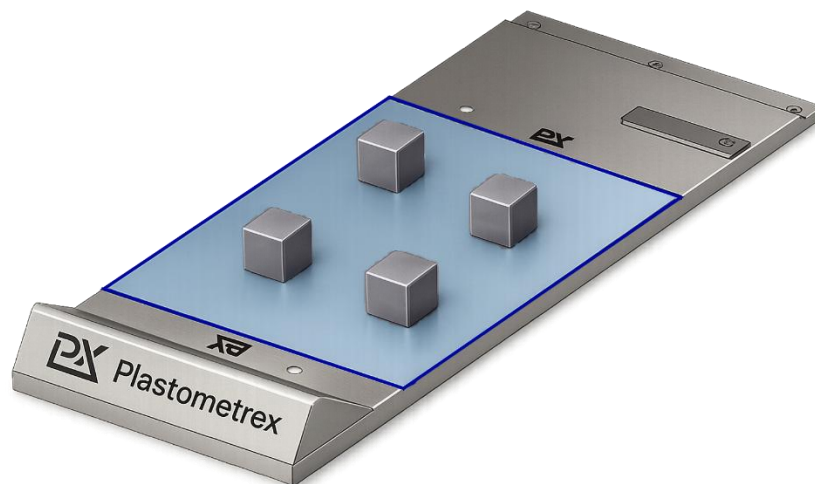
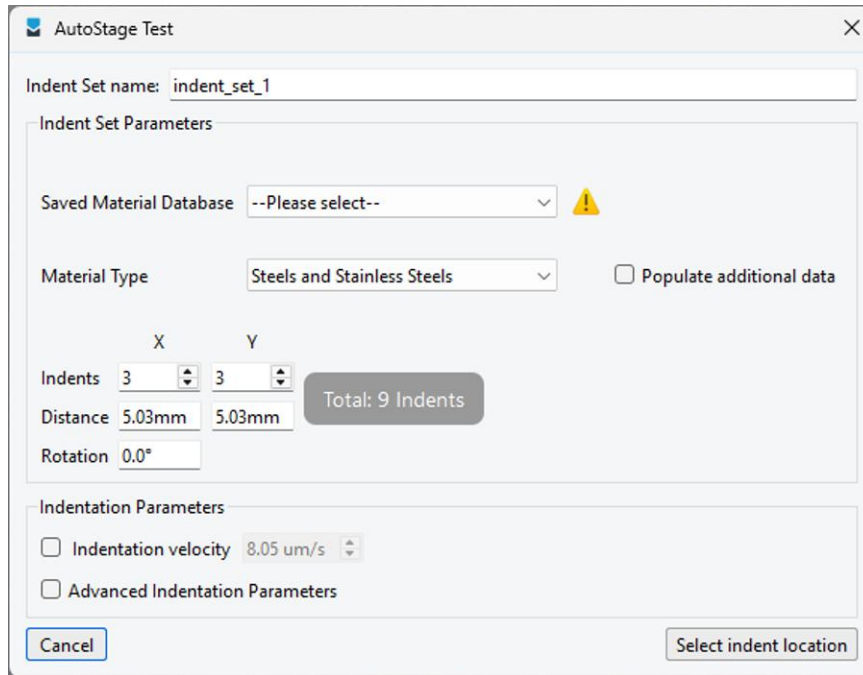


Figure 3.14 PLX-AutoStage sample area

3. The system automatically acquires a series of images of the platen. These images are stitched together to produce an overview of the test area, which is displayed in the **Platen Image** tab.
4. Click **Create Indent Set**. The dialog shown in Figure 3.15 appears. Enter the required parameters for the Indent Set:
 - Indent set name
 - Material type
 - Number of indents (X, Y)
 - Distance between indents (X, Y)
 - Rotation angle
 - Optional advanced parameters

- Optional additional material information



The screenshot shows the 'AutoStage Test' dialog box. At the top, the 'Indent Set name' is 'indent_set_1'. Below this is the 'Indent Set Parameters' section, which includes a 'Saved Material Database' dropdown set to '--Please select--' with a warning icon, a 'Material Type' dropdown set to 'Steels and Stainless Steels', and a checkbox for 'Populate additional data'. Underneath, there are input fields for 'X' and 'Y' (both set to 3), 'Distance' (both set to 5.03mm), and 'Rotation' (set to 0.0°). A button labeled 'Total: 9 Indents' is positioned to the right of these fields. The 'Indentation Parameters' section at the bottom has checkboxes for 'Indentation velocity' (set to 8.05 um/s) and 'Advanced Indentation Parameters'. At the bottom of the dialog are 'Cancel' and 'Select indent location' buttons.

Figure 3.15 Indent set test parameters in PLX-AutoStage

5. Click **Select Indent Location**.
6. Click on the platen image to position the Indent Set. Ensure that the shaded green boundary representing the Indent Set lies entirely within the sample, as shown in Figure 3.16. Confirm the location of the indent set or reconfigure it if needed.

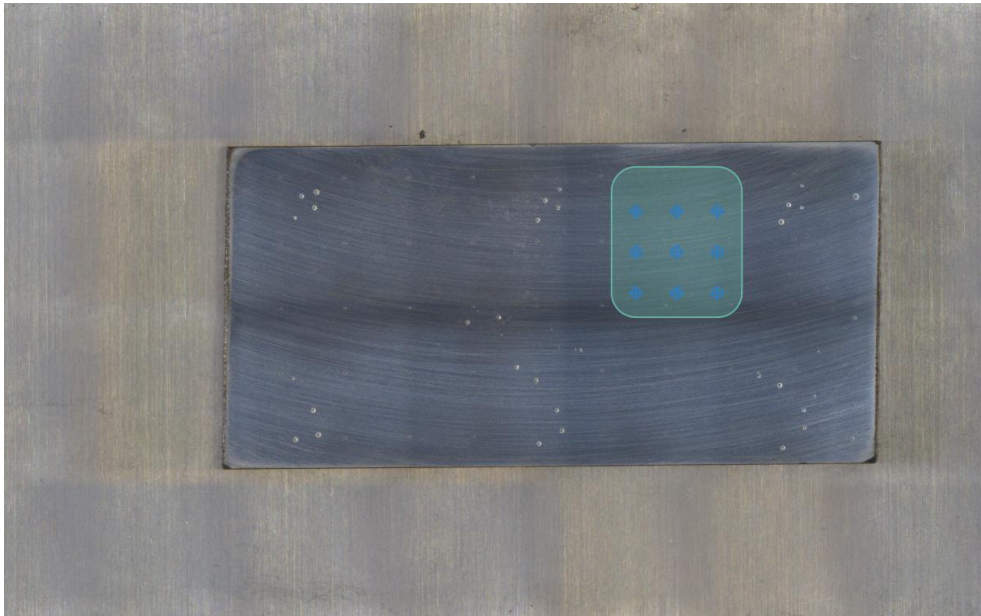


Figure 3.16 Indent set placement

7. Repeat Steps 4-6 for each additional Indent Set required.
8. When all Indent Sets have been defined, click **Start** to begin the test.

9. A safety confirmation dialog is displayed. Verify that the testing area is clear and confirm to continue.
10. The system automatically performs each indentation in turn. For every indent, the PLX-AutoStage positions the sample under the indenter, performs the indentation, retracts the indenter, positions the profilometer over the indent, and measures the residual indent profile
11. Step 10 is repeated until every indent in every Indent Set has been completed.
12. After all indents have been performed, the system automatically acquires a second set of platen images. These are stitched together and displayed in the **Platen Image – Post Indentation** tab, providing a record of the completed test.
13. When the test is complete, the **Transfer to Data Analysis** button becomes available. Click this button to open the completed test in the **Data Analysis** module.

3.4 Data Analysis

A completed AutoStage test file may be transferred from Data Capture by selecting **Transfer to Data Analysis**, or an existing AutoStage test file (.CX5) may be opened using the **Open** button. Once the file has been loaded, the analysis is performed automatically, and the results are displayed as shown in Figure 3.17.

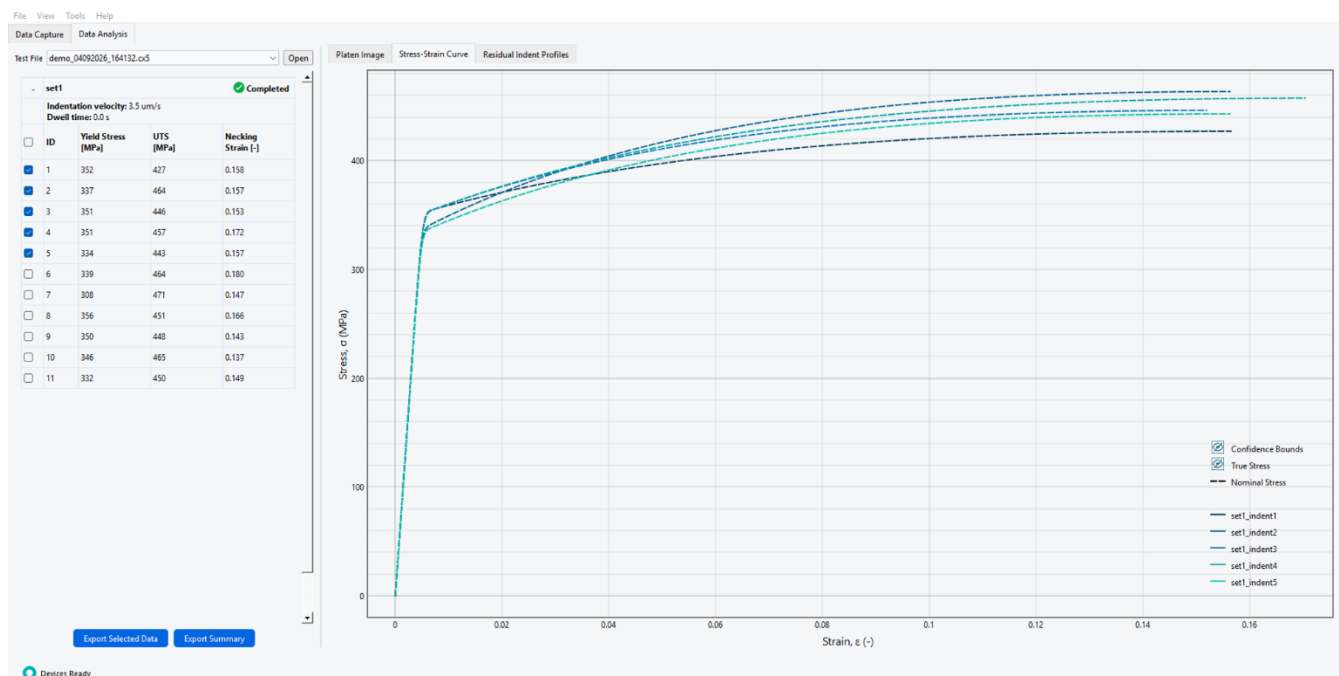


Figure 3.17 The Data Analysis window displayed after data analysis has been completed

The left-hand panel contains all Indent Sets created during the test. Each Indent Set displays the test conditions (indentation velocity and dwell time), completion status, and a summary table containing the key mechanical properties for every indent:

- Yield Stress (σ_Y) [MPa]
- Ultimate Tensile Strength (σ_{UTS}) [MPa]
- Necking Strain [-]

Each indent may be selected individually using the check box beside its ID. The selected indents determine which results are displayed in the plots and can also be used for exporting selected data.

The main viewing area contains four tabs:

- **Platen Image:** Displays the captured image of the sample platen together with the locations of the completed indents.
- **Stress-Strain Curve:** Displays the inferred tensile stress-strain curves for all selected indents, allowing direct comparison between locations on the sample.
- **Residual Indent Profiles:** Displays the measured residual indent profiles together with the corresponding best-fit modelled profile for the selected indents.

Two export options are available:

- **Export Selected Data:** Exports detailed analysis results for the currently selected indents. A separate CSV file is generated for each selected indent.
- **Export Summary:** Exports a single CSV file containing a summary of the mechanical properties and test parameters for every indent in the test.

These export functions allow the analysis results to be imported into external software for further processing or reporting.

4 Sample Requirements

The sample requirements for the PLX-AutoStage are detailed below:

Table 4.1 Sample requirements for the PLX-AutoStage.

Feature	Requirements
Material Type	Ductile Metallics (Yield Stresses < 3 GPa)
Porosity	< 1%
Dimensions	
1 mm radius indenter	Thickness: 3 to 40 mm Lateral: 6 to 80 mm (X) and 6 to 125 mm (Y)
0.5 mm radius indenter	Thickness: 1.5 to 40 mm Lateral: 3 to 80 mm (X) and 3 to 125 mm (Y)
0.25 mm radius indenter	Thickness: 0.75 to 40 mm Lateral: 1.5 to 80 mm (X) and 1.5 to 125 mm (Y)
Maximum sample height variation	1 mm
Tilt	< 2°
Surface finish	$R_z < 4\ \mu\text{m}$ and $R_a < 0.5\ \mu\text{m}$ Abrasive paper recommendations: • P1200 for 1 and 0.5 mm radius indenters • P2500 for 0.25 mm radius indenters P120 recommended for the backside of samples
Grain size	• < 500 μm for 1 mm radius indenters • < 250 μm for 0.5 mm radius indenters • < 125 μm for 0.25 mm radius indenters

5 Contact Details

Plastometrex UK (Global Headquarters)

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Information, diagrams and instructions for the repair of the machine are available upon request, by contacting support@plastometrex.com