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9631-130
VICKERS HARDNESS MEASURING SYSTEM
OPERATION MANUAL

V0

General Introduction

This system comes with a USB camera and the measurement software, it applies to almost all Vickers hardness testers with a camera port.

1 System Requirements

- **System:** IBM compatible PC (desktop or notebook) with Windows XP, Windows Vista, Windows 7, or Windows 8, 32 or 64 bit operating system. At least two USB2.0 ports are required with one for the USB license key and another for the USB camera. An additional USB port is needed for the version With Turret Control and above. If the total number of USB ports is limited on the PC, a high speed USB hub may be used.
  Supporting Software: MS Office (2003 or higher) with Excel and Word installed for reporting.

2 Main Features

- **Automatic measurement:** With a mouse click on a button, system automatically measures the indentation.
- **Hardness curve:** System automatically plots the hardness value vs. test point depth and calculates the hardness depth.
- **Hardness conversion, correction, and validation:** The measured HV value can be converted to other hardness scales such as HB,HR etc. HV can be corrected for non-planar surfaces. System calculates the minimum sample thickness, minimum test point to sample edge distance etc for validation.
- **Statistics:** Statistical values such as average, standard deviation, Cp, Cpk etc are automatically generated, and off the limit values are marked.
- **Data saving and retrieval:** System can save and retrieve the hardness measurement data and images in data files.
- **Reporting:** With a mouse click, the system automatically generates a Microsoft Word or Excel document, with a standard or user provided template, to report the measurement data, statistical information, the measurement image, and the hardness curve.

3 Standard Features

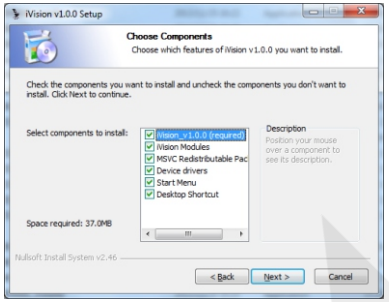
- **Image/Video capturing:** Capture and save images/videos on DirectShow compatible USB cameras.
- **Camera calibration:** For measurement applications, the camera can be calibrated with a microscope ruler or grid.
- **Calibration management:** System allows save/manage multiple calibrations, load a calibration, rename a calibration, or unload the current calibration.
- **Geometry measurement:** System provides the tools to draw and measure common geometric shapes such as lines, angles, rectangles, arcs/circles, ellipses, polygons, point-to-line, and point-to-arc etc.
- **Image processing:** System provides a rich set of image processing tools for advanced applications, which include adjusting Brightness, Contrast, Gamma, and Histogram Level, and the Sharpen, Smooth, Invert, and Convert to Grey functions. On grey scale images, system provides various advanced tools in filtering and finding edges, as well as some standard tools in morphological operations such as open, close, dilation, erosion, and flood fill, to name a few.
- **Document entry:** On an image, system provides a document editor to enter/edit documents with contents either in simple plain text format or in advanced HTML format with objects including tables, list, and images.
- **Album management:** System allows user manage multiple images in an album which can be saved to and opened from an album file. The images can have the standard geometric shapes and the documents as entered by user as described above.
- **Data saving and retrieval:** System can save and retrieve the geometry measurement data and images in data files.
- **Reporting:** With a mouse click, system generates a Word document for the geometry measurements.
- **Printing with magnification:** System can print the image with user specified magnification.

Software Installation

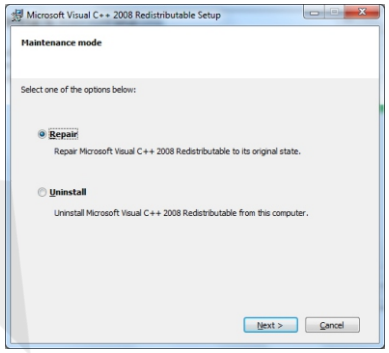
1 Installation Overview

The installation of the system is simple in that the software and its relevant device drivers all come in one installer file. The software is modular in architecture. It consists of the application platform and upon which the application modules. The following components are installed in the system: 1) Microsoft VC++ redistributable package since the software is developed with MSVC; 2) software platform, a general scriptable graphical user interface with built-in image processing functions; 3) Device drivers including USB camera driver and its DirectShow driver, and the motion control card driver if supplied; 4) HV Measurement application modules.

2 Double-click the installer file iVision_v1.0.0_TZXXXXXX_installer.exe to start the installation process, and answer at all the prompts in the driver installation, where TZXXXXXX is the USB license key ID. Note to change the drive in installation directory if other than the default D: drive.



If re-installation is necessary, the MSVC Redistributable Package does not need to be re-installed since it was not uninstalled during un-installation. If in any case the installation process prompts for Repair or Uninstall, select Repair.



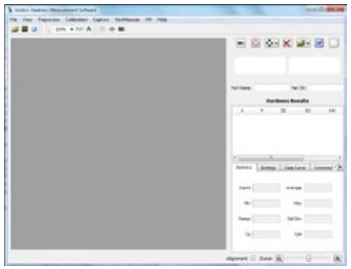
Usage

1 Driver installation

When the USB camera is plugged in at the first time, PC will take a minute to install its driver. If the operating system is Windows XP, when the computer asks to install the device driver either manually or automatically, answer "automatic installation".

2 Starting the application

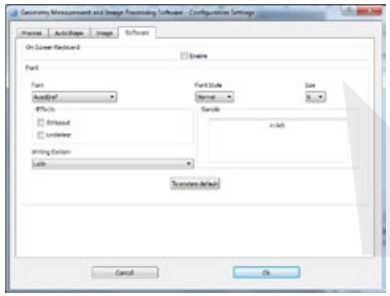
2.1 Graphical User Interface (GUI) setup
GUI Layouts: At first startup, the GUI will show the HV measurement interface. If user runs other application modules such as geometry measurement and wants to go back to HV measurement module, just select this menu (HV->HV measurement).



User may adjust the splitter dimensions and the table column widths to his/her preference, and the system will keep the GUI settings at exit. To do so, move the mouse cursor near the invisible separator in between the two panels of the splitter, when the cursor hits the separator, its shape will become ⇳ or ⇹ depending on the orientation of the splitter, just drag move the cursor to adjust the splitter sizes. It is the style of this software that the left panel displays the video or image while the right panel displays the user interfaces. The image album may show up automatically on the right at first time, but it can be docked at either of the up/down/left/right side of the main window or it can be dragged out floating.

If the option "Add simple interface" is checked at HV Measurement Settings, then a simple user interface with common used buttons will be added (convenient for touch screen or small screen version).

GUI configurations: Many other general GUI settings such as menu orders, font, pen drawing size, shape selection color, application on-screen keyboard enable, and image grid etc can be configured in the Configuration Settings dialog through menu File -> View/Edit configurations…If the on-screen keyboard is enabled in the application (by menu File->View/Edit configurations… , under Software tab), the application will use the system on-screen keyboard (suitable for international characters input) ,or the application on-screen keyboard (alphanumeric characters only), depending on whether "Use System On Screen Keyboard" is checked or not.



(a) System on-screen keyboard (b) Application on-screen keyboard

Language: To choose a different GUI language, go to menu Help->Language… Choose the new language and the application will exit. After restarting the application the new language will take effect.

2.2 Camera setup

Normally it is necessary to set up the camera for video quality at first use after driver installation.

- **Start Video:** Plug in the USB camera provided, and wait until its driver is installed if it is the first time plugged in a particular USB port. Clicking on the Video preview button at the right upper of the user interface should start the video of the camera. If in any case the non system camera on the PC is started, user will need to manually select the camera, to do so go to menu Capture->Open image capture window, and in the new window click on menu Devices, select the desired camera from there and close the window, and then click on the Video preview button to start the video. Clicking the Video preview button will set the video at predefined resolution for HV measurement besides starting the video. The video resolution is normally set at 1.3M pixels (1280X1024) resolution which is good enough for HV measurement. The image size (video resolution) normally is displayed on the message bar at the lower left bottom of the application at a mouse entering image event. To fit the image in window, user may need to adjust the Zoom at the lower right bottom of the application. Note that zooming does not affect measurement results.

Note: If user wants to start the video manually at different camera resolution for purposes other than HV measurement, go to menu Capture->Video format settings to set the resolution, and start the video by menu Capture->Video preview.

- **Camera setup:** On the Result interface page, under the Settings tab, click on the Camera Settings tool button , the camera control dialog will appear.

  Different cameras have their own sets of control parameters and interfaces. For example, on the right is the control from one camera brand. It is necessary to adjust the Exposure time and Global Gain to get the proper video signals at first use after driver installation.

- **Grid display:** Sometimes need to display the grid in the image as a reference, switch button to show/hide toolbar by clicking on the grid. User may drag move the grid center, and reset the center by clicking on the Reset grid offset tool button on the tool bar.

- **Snap image:** To snap an image, click on the Snap image tool button on the tool bar.

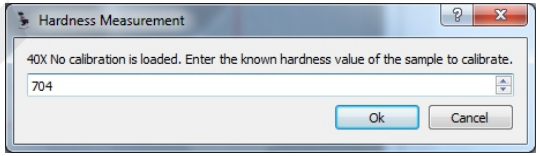
2.3 Camera calibration

In order to get quantitative geometry measurement (e.g., indentation diagonals) from the camera image it is necessary to calibrate the camera to obtain the conversion from pixel distances to their physical distances. There are two ways to calibrate the camera in the HV hardness measurement: 1) Calibration with a standard test block; 2) Calibration on a standard calibration ruler or grid .

- **1) Calibration with a standard test block**

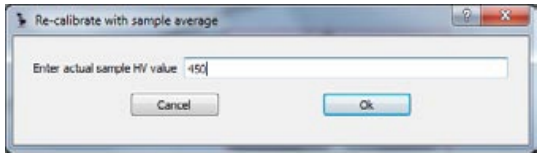
  Unload existing calibration: If no calibration is loaded in the system, after a HV measurement, the system will prompt user to enter its HV value for calibration. To recalibrate after a calibration, unload the calibration first, simply go to menu Calibration->Calibration viewer, enter the password if it was set or simply click OK to pass if no password was set, click button Unload at the calibration viewer dialog. Ensure that the test force is set before the measurement calculation.

Measure and calibrate: System provides two ways to measure HV on an indentation image: automatic or manual. To automatically measure, click the Auto measure tool button , the system should find the indentation and mark it with a rectangular box or whatever marking method configured in Settings. To make a manual measurement, click on the Manual measure tool button to toggle the mouse in manual measure mode with the cursor in cross hair, click on the 4 vertices of the indentation (in any order). After the measurement, system will prompt user to enter the HV value of the test sample. After user enters the HV value and click OK, the system will automatically load and save the calibration with a default name "HVSampleCalibration" or "HVSampleCalibration_1000g". User may opt to click Cancel at the prompt, and mouse drag move the marking lines to fine adjust to match with the indentation vertices, and enter the HV finally.



Rename calibration: To rename a calibration, for example, to distinguish between different lens and different test load, go to menu Calibration->Calibration viewer, select the calibration and click button rename to change the calibration name.

Re-calibrate with sample average: For better calibration accuracy, the system allows user to re-calibrate with the average of the HV values from the calibration sample. To do so, measure HV values on multiple indentations on the same sample to get the average, click on the Re-calibrate with sample average button in the Settings tab and enter the sample HV value at the prompt. The calibration loaded is re-calibrated and saved automatically.

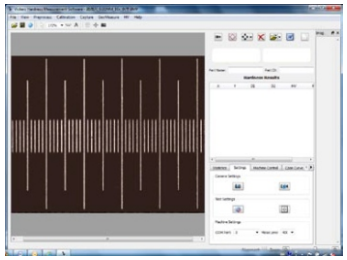


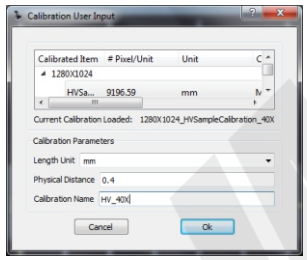
◆ **2) Calibration on a ruler or grid**

User may prefer to calibrate the camera directly with a standard ruler instead of a standard hardness block, especially when the calibration is used in geometry measurement instead of hardness measurement. The system provides two ways to do calibration with a ruler or grid:
a) Manual calibration; b) Automatic calibration.

a) Manual calibration

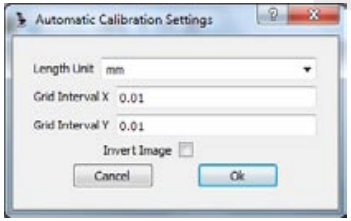
Manual calibration simply calculates the linear scale between the pixel distance and the physical distance of two points on image. Place the calibration ruler or grid under the microscope lens, start video preview, move the ruler to make sure the lines are approximately aligned in the XY directions, and snap an image by pressing the Snap image button on the tool bar. Select menu Calibration -> Manual calibration, hold down the mouse and drag from one the center of one line to another line with adequate separation distance and then release mouse. Enter the physical distance between the two lines and a name for the calibration. This calibration will be saved and be loaded later or immediately.



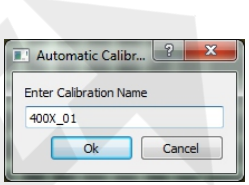


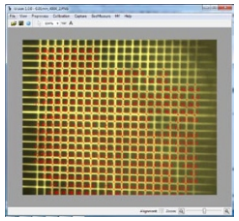
b) Automatic calibration

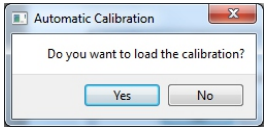
Automatic calibration is much more complex in the algorithms but ironically it is more convenient in usage. It automatically finds the cross points on the grid image, map them to their physically locations and obtain the true 2-D mapping between a physical location and its pixel location via interpolation.



Instead of a calibration ruler, a calibration grid is needed to do the automatic calibration. First select menu Calibration->Auto calibration settings to set up the X&Y line distance, unit etc. If the lines in image will be darker than the background then Invert Image needs to be checked. Select menu Calibration->Automatic calibration, the system will locate and mark most of the cross points of the grid image.

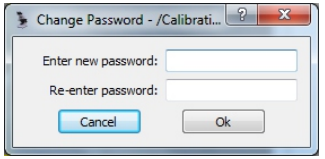




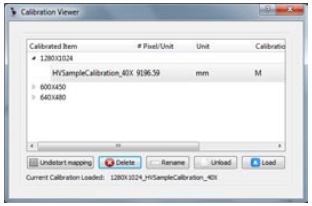


2.4 Calibration management

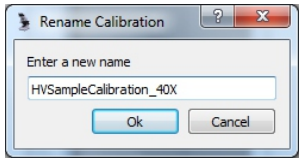
◆ **Set/Change password:** User may set the password to protect the calibration for privileged access only. If no password was set after the installation, user can simply bypass by clicking OK at the password prompt. To set or change the password, go to menu Calibration->Change password, enter current password or click OK to bypass if no password was set, and enter and re-enter the new password at the prompt.



◆ **Load/Unload calibration:** Select menu Calibration->Calibration viewer to bring out the Calibration Viewer dialog, click button Load to load a selected calibration or click button Unload to unload the current calibration. Current loaded calibration is normally displayed on the message bar at the lower left bottom of the application at a mouse entering image event.

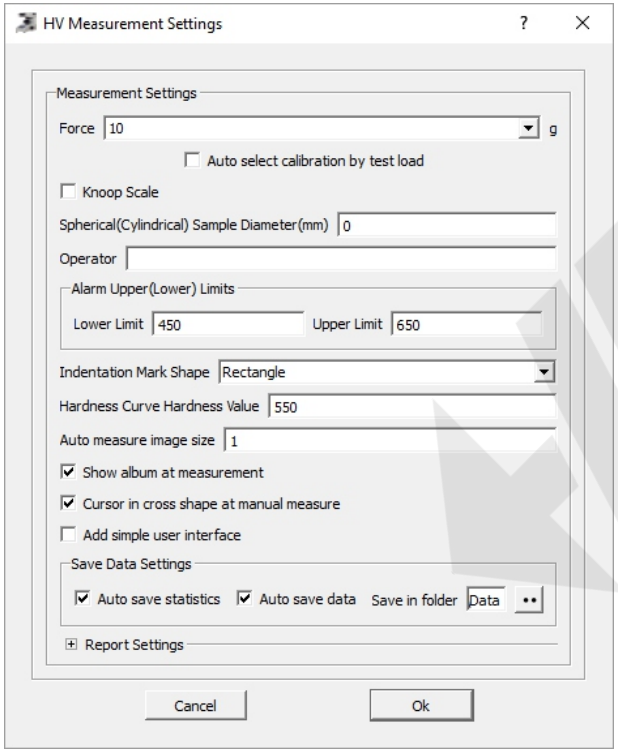


- **Rename calibration:** On the Calibration viewer dialog, select the calibration to be renamed, click on button Rename and enter the new name at the prompt and click OK.



2.5 Settings

Click on the Test Settings tool button  under Settings tab to invoke the HV Measurement Settings dialog.



- **Force:** The test force needs to be selected manually in this dialog or directly at the Often Used Setting under the Settings tab. The default value is 0. For user's reference, the HV calculation formula is: HV = 1.8544 * Force / pow((D1 + D2)/2.0, 2.0) / 1000.0, where D1 and D2 are the diagonals of the indentation in mm and Force is the test load in gram.

- **Auto select calibration by test load:** For better accuracy, if checked, this setting allows the system load different calibration under different test load force automatically at test load change. The default is unchecked. If checked, a selection box with all available calibrations will appear at the right to allow user select the calibration for the test load force as set above.

- **Knoop Scale:** If checked, the measurement in the application will be on Knoop indentation instead of Vicker's indentation, where two vertices (on the elongated side) instead of four vertices of the indentation are measured. Default is unchecked. For user's reference, the HK calculation formula is: HK = 14.229 * Force / pow(D1,2.0)/1000.0, where D1 is the elongated diagonal in mm and Force is in gram.

- **Fracture toughness:** If checked, system allows user continue measure the fracture dimensions (by mouse clicking the left, right, top and bottom most points on the fractures), and the software automatically calculates the fracture toughness value. The software will display 3 additional columns C1,C2 and Kic, where C1 is the distance from the left most to the right most (unit mm) and C2 is that from the top most to the bottom most fracture points. The total length of fracture L = C1 + C2 – D1 – D2, D1 and D2 are the indentation diagonals obtained in HV measurement. The fracture toughness Kic is calculated according to Kic = 0.0028 * sqrt(Hv * F/L), where Hv is the hardness value obtained in the table, F is the test load (unit in N), and unit of L is m, the unit of Kic is MPa m^1/2. Different calculation formulas will be provided in later versions. Just like for the indentation, the software will label the fracture with a rectangle on the image. User may mouse drag move any side to correct and the system will automatically update the measurement results. Under the Statistics tab, a "Fracture toughness" checkbox allows display of statistics results on either Kic or HV. In the WORD and EXCEL report, the three columns C1,C2 and Kic are automatically added in.
  Note: do not check Knoop Scale while choosing Fracture toughness measurement.

- **Spherical (Cylindrical) Sample Diameter (mm):** Used for HV correction for non-planar sample surface.

- **Operator:** Test operator, for reporting purpose only.

- **Alarm Upper (Lower) Limits:** The UL and LL are used for automatically marking out of spec HV values, and for calculating statistical Cp and Cpk.

- **Indentation Mark Shape:** After an indentation is measured, a Rectangle, or Quadrilateral, or Diagonal shape to mark the indentation with the measured 4 vertices. Default is Rectangle.

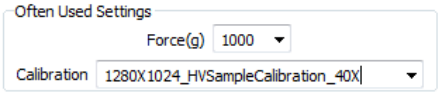
- **Hardness Curve Hardness Value:** The hardness value in calculating the hardness Case depth. The default value is 550.

- **Auto measure image fraction (center by grid):** Automatic measurement will be limited in the specified image area only instead of the whole image, with value 1 for the whole image. The center is specified by the image grid center (note: the image grid toggle display tool icon is on the tool bar, and the center of the grid can be mouse dragged). This feature is useful for speeding up the calculation and to specify which indentation to measure if there are multiple indentations in the field of view.

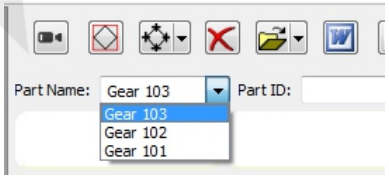
- **Show album at measurement:** If checked (default), the album with measurement image with the result indentation mark will be displayed.

- **Add simple user interface:** If checked, the software will add a long button with the interface, which applies to the touch screen display.
  Click Report Settings to expand/collapse its setting group.

- **Report document format:** Selection of WORD or EXCEL format for the report. Data, Indentation Images, and the Case H Curve and be checked or unchecked for reporting. Indentation image width and the Case curve width and height in pixels can be specified. If Save in folder is specified, then the generated report files (word or excel) with file names given by time stamp will be automatically saved in this folder. If Delete last saved data file is checked, then the last saved data file will be deleted when a new file is generated, to clean up space.
  For convenience, the common settings are added to the settings bar, where the user can select the corresponding test force and calibration for the test.



For reporting and display purpose, the sample part name and part ID can be entered on the main GUI. Part names can be entered in the dropdown list. To enter one new part name, type a name in the line editor and hit return key, the software will keep the entry. To delete one entry, select the one to be deleted, type in a '?' character and hit return to delete.



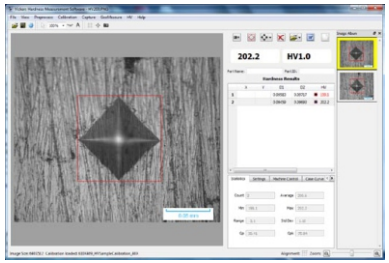
- **Save Data Settings:**

Auto save statistics: If checked, the statistics data for each part name and part ID will be saved in an excel file (named stat_summary_hv.xls) under the directory specified in “Save in folder”. And an icon tool button with icon will show under the Statistics tab to open this file.

Auto save data: If checked, the measurement data including the test images will be saved in a file (.ivd suffix) named with part name and part ID under the directory specified in “Save in folder”. This file can be opened later by clicking the “Open data file” button .

2.6 Measurement

- **Automatic measurement:** With an indentation image, click on the Auto measure tool button, the system will automatically finds the 4 vertices, calculates HV, and updates the statistics and the indentation image in the album. If the indentation in the image appears too fuzzy or the image background is too noisy, the system may not be able to find the indentation or incorrectly locates the four vertices. If the system can't find the indentation, user may try to narrow the search area manually by mouse dragging to select the area that encloses the indentation, and do the auto measurement. If the system still can't find the indentation, then manual measurement is necessary. Note that for the mouse to select an area, it can't be in the manual measurement mode. To put the mouse in selection mode, simply click on the Selection tool button on the tool bar, or toggle the Manual measurement tool button.



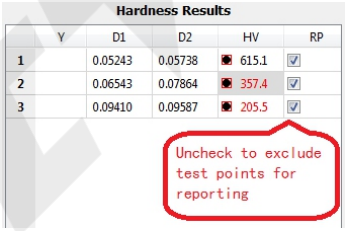
- **Manual measurement:** The system provides two methods to manually measure HV hardness from an indentation image, Measure by 4 points and Measure by diagonals. Click on the dropdown arrow button on the Manual measure tool button to select the method, the icon of the Manual measure tool button will disply accordingly. Click on the Manual measure tool button will toggle the mouse in either manual measure mode (with cursor being crosshair) or in selection mode (cursor restored). Measure by 4 points is done by clicking on the 4 vertices on the indentation in any order, while Measure by diagonals is done by mouse dragging from one end of the diagonal to the other end for the two diagonals. It is up to user's preference to choose the method. Note that the cursor crosshair will become restored after a manual measurement while the mouse is still in manual measurement mode.

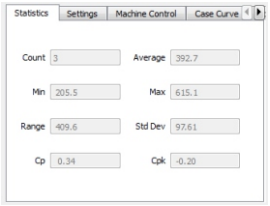
- **Measurement correction:** To fine tune the measurement if necessary, mouse move the lines of the marking rectangle to align with the indentation vertices, after the mouse release measurement results (HV, statistics, indentation measurement image etc.) will update automatically.

- **Delete measurement:** Select one or multiple measurements to delete on the Hardness Results table by click or control-click on the vertical headers, click on the Remove measurement tool button to delete. To delete all measurements and start new measurements from scratch, click on the New sample tool button.

2.7 Utilities

- **Statistics:** After each measurement, the statistical values displayed under Statistics tab are automatically updated.

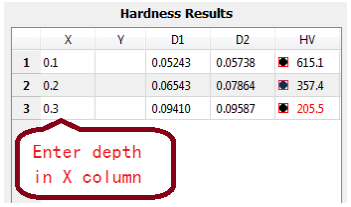


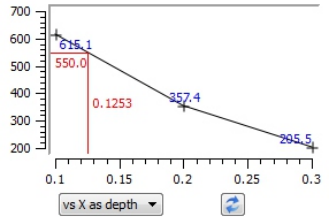


User may uncheck RP column to exclude particular test points for statistics and reporting.

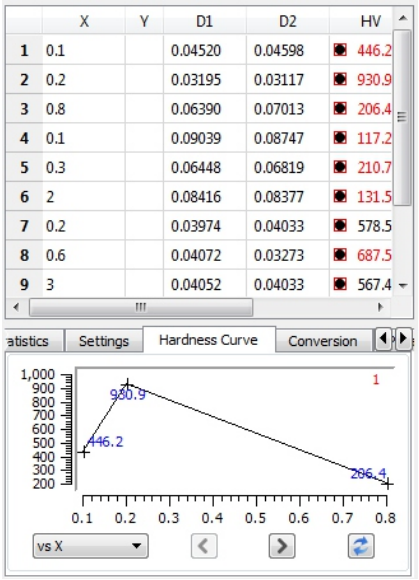
For user's reference: Cp = abs(UL - LL) / 6 / StdDev; Cpk = Cp * (1 - abs(Average - (UL + LL)/2) / abs(UL - LL) * 2). UL and LL are the upper limit and lower limit set in the Settings.

- **Hardness Curve:** Case hardness curve is displayed under tab Case Curve. To plot the hardness Case curve, it is necessary for user to manually enter the depth values for the test points in the X column in the Hardness Results table (Note: Y column is ignored). At each point entry, the curve display is automatically updated. The dropdown list at the bottom provides the options to plot the HV vs 1) Seq #; 2) X; 3) X as depth; 4) Y; 5) Y as depth; 6) XY 3D. To obtain the hardness depth, one needs to choose vs X as depth and enter the depth in the X column.



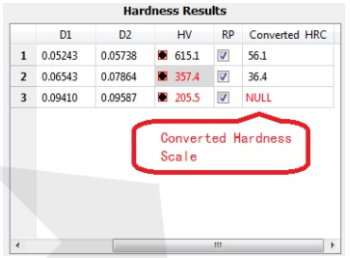


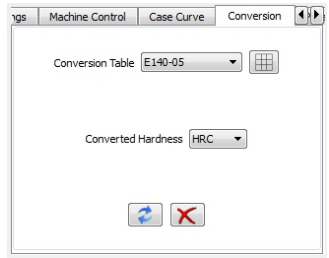
With the option "vs X" or "vs Y", system may plot multiple hard ness curves. When X or Y starts with a lower value in the table which indicates a new test line, the system will start plotting a new curve. User may click the Previous ❮ or Nex ❯ button to view all the curves.



For convenience, if the depth X becomes a pattern, user may prepare a template file with just the X values and load the file for each test so the tedious entry of X at each test can be saved. This feature will be described next in Pre-defined depth table section.

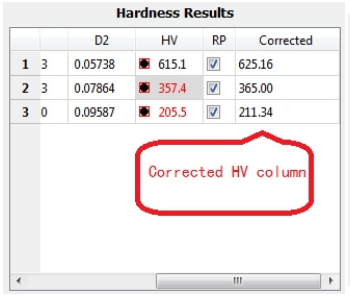
◆ **Conversion:** Converts HV to other hardness scale. Select the Conversion Table (currently E 140-05 for ASTM, and GB T 1172-1999 for the Chinese standard are entered in the application, others can be easily added in) and the Converted Hardness, system automatically adds a column or updates the column Converted XXX in the Hardness Results table., where XXX is the converted hardness scale. This column is kept until new converted hardness is selected or it is deleted. To delete the converted hardness column, click the Delete Converted Hardness Column tool button ✕ under the Conversion tab. To restore the column, simply click on the Update ⟳ utton or select the Converted Hardness.

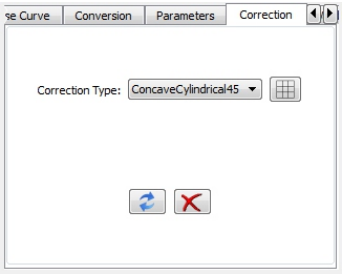




To view the data in the conversion table, click on the Show table tool button ▦ .

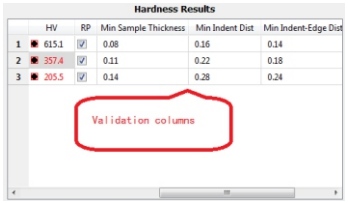
◆ **Correction:** For non-planar sample surface, the system can provide the corrected HV according to standard predefined tables for spherical and cylindrical sample surfaces and the relative orientation of the indentation. To obtain the corrected HV, enter the sample diameter in the Settings, select the Correction Type under the Correction tab, the system will add or update the Corrected column. To remove or restore the Corrected column, click on the Delete Corrected Hardness Column tool button ✕ or the Update tool button ⟳ under the Correction tab.

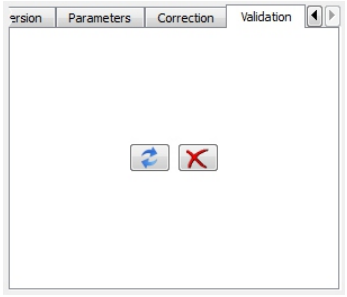




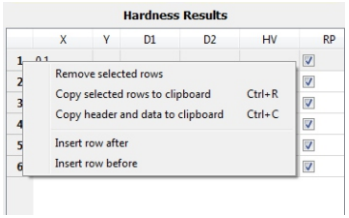
To view the data in the correction table, click on the Show table tool button ▦ .

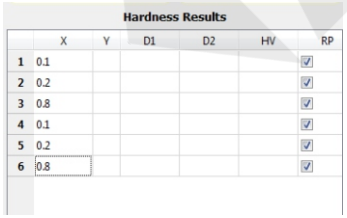
- **Validation:** V alidation simply calculates the minimum sample thickness, minimum indentation distance, and minimum indentation to sample edge distance for each test points and displays these in 3 columns on the Hardness Results table. Min Sample Thickness (minimum sample thickness) is 1.5 times, Min Indent Dist (minimum indentation distance) is 3 times, and Min Indent-Edge Dist (minimum indentation to sample edge distance) is 2.5 times of the average diagonal length of the indentation. To remove or restore the validation columns, simply click on the Delete Validation Columns tool button and the Update tool button .





- **Pre-defined depth table:** Often user needs to test at the same pre-defined depths to measure hardness curve. It is convenient to generate a pre-defined depth table as a template. To do so, click the New Sample button to clear the result display if needed, click the same button to generate a blank row in the Hardness Results table. Enter the first depth in the "X" column. To generate more rows, right click on the vertical table row header, and select menu "Insert row before" or "Insert row after" to generate more rows and enter their depths in X column if needed. Finally click the Save data file button to save the depth table in a file which serves as a template. To test with this template, click the Open data file button to load, click on the header on the row with the depth to test, the hardness result will be entered in this row automatically after measurement.





Specification

Sensor	1/2" CMOS
Pixel	1.3M(resolution 1280×1024)
Hardness measurement resolution	0.1HV
Length measurement resolution	0.1μm
Hardness measurement accuracy	±3%
Test force	0.01, 0.025, 0.05, 0.1, 0.2, 0.3, 0.5, 1, 2, 2.5, 3, 5, 10, 20, 30, 50, 100kgf
Dimension	36×33×32mm
Weight	500g

Standard Delivery

Name	Quantity
Main unit	1Pc
USB dongle	1Pc
USB cable and software	1Pc