Multitek BMS Essentials — Operator and Supervisor Manual

Document control	
Document title	Multitek BMS Essentials — Operator and Supervisor Manual
Document number	MT-BMS-OM-001
Manual revision	1.0
Software version	1.0.0.0
Issue date	03 August 2026
Product	Multitek BMS Essentials (Brinell Measurement System)
Prepared by	Multitek Technologies
Support	service@multitek.in
Approval	_____

Revision history

Revision	Date	Description
1.0	03 August 2026	Initial released operator edition for BMS Essentials 1.0.0.0

> **About the illustrations.** Application windows are real captures from this build. The indent, sample results, report content, folder listings and connection-state guides are demonstrations; they contain no customer or production data. Camera-driver pages, PLC alarm recovery and physical machine motion vary by installed hardware, so those procedures intentionally refer to the camera or machine manufacturer's instructions rather than showing invented hardware states.

Table of contents

1. What the system does

1.1 The measurement principle in plain language

A Brinell hardness test presses a hardened ball of a known diameter into the surface of a metal part with a known force, holds it there, and then lifts it off. The ball leaves a round dent — the **indentation**, or **indent**. A soft material lets the ball sink in further and leaves a wide indent; a hard material resists and leaves a narrow one. So the width of the dent is a direct measure of hardness, once you know how big the ball was and how hard you pushed.

Multitek BMS Essentials is the measuring half of that test. A camera looks down a microscope objective at the indent. You bring it into focus, the software finds the edge of the indent and measures its diameter, and then it converts that diameter — together with the ball diameter and the applied force — into a **Brinell hardness number (HBW)**.

The exact formula the software uses is:

$$HBW = \frac{2 \times F}{\pi \times D \times \left(D - \sqrt{D^2 - d^2} \right)}$$

where

- **F** is the applied force taken from the force table (see §10.3),
- **D** is the ball diameter in millimetres (10.0, 5.0 or 2.5 mm, chosen on the toolbar),
- **d** is the measured indent diameter in millimetres, taken as the **average of D1 and D2** — the horizontal and vertical measurements across the same indent.

The software refuses to produce a number (it shows `0.0`) unless the force is positive, the ball diameter is positive, the average diameter is positive, and the average diameter is not larger than the ball. That last guard exists because a dent cannot be wider than the ball that made it; if you see `0.0` it usually means the markers are in the wrong place or no force has been selected.

1.2 What the software is responsible for

The software does	The machine (PLC) does
Shows the live camera image	Moves the turret between objectives and the indenter
Focuses automatically by driving the Z axis and watching image sharpness	Actually drives the Z axis motor
Detects the indent and measures D1 and D2	Applies and releases the test load, holds the dwell
Converts diameter → HBW and to other hardness scales	Reports X/Y stage position and load-cell reading
Stores results in a table, plots them, exports Excel/PDF reports	Enforces limit switches and the emergency stop
Holds calibration factors per objective lens	—

The two halves talk over a serial **PLC link**. Everything in the bottom strip of the main window — turret, Z-axis jog, cycle start, emergency stop, micrometers, load cell — needs that link to be connected before it will do anything.

1.3 What the system is *not*

- It does not decide whether a part passes or fails on its own. It compares each reading against the tolerance minimum and maximum **you** type into the results table (or that come from a test pattern file) and marks the row Passed or Failed on that basis.
- It does not verify its own calibration. Calibration against a certified reference block is an operator/supervisor responsibility — see §7.

2. Safety and prerequisites

2.1 Safety

> **The application can command machine motion.** Clicking a turret position, a Z-axis jog button, Cycle Start or Auto Focus sends a command straight to the PLC and the machine will move. Nothing in the software asks "are you sure?" first.

1. Keep hands, tools and measuring instruments clear of the indenter and the objective turret whenever the PLC link is connected.
2. The red **STOP** button on the Machine Controls strip is the software emergency stop. It sets the emergency-stop flag, pulses the machine's stop bit, and aborts any auto focus sweep in progress. It is **not** a substitute for the machine's hardware emergency stop — use the hardware button for anything that involves reaching into the machine.
3. Zeroing the load cell (double-clicking the kgf readout) pops up the warning "*Continue only if Indenter free and away from sample*". Read it. Taring the cell while the indenter is loaded will make every subsequent force reading wrong.
4. Objectives sit very close to the specimen at focus. Use the **slow** Z jog (single arrow) near focus and keep the fast jog (double arrow) for gross travel.
5. Do not unplug the camera during an auto focus sweep. The sweep tells the camera library to ignore its "no frames arriving" watchdog, so a genuine disconnection is noticed later than usual.

2.2 Prerequisites before you can measure

Prerequisite	Why	Where to check
Valid licence file for this PC	The application will not start without one	§3.3
Camera connected and selected	No image, no measurement	§6
`best_circle.onnx` present next to the executable	The automatic indent detector needs it	§8.4
PLC connected on the right COM port	All machine motion, force write-back, load cell	§11.1
Objective lenses calibrated	Otherwise D1/D2 in millimetres are meaningless	§7
A force selected in the Machine Controls strip	HBW is `0.0` without it	§11.3
A ball diameter selected on the toolbar	Same	§9

2.3 System requirements

- 64-bit Windows. The application is built for `net10.0-windows10.0.19041.0` and targets x64 only.
- A DirectShow-compatible camera (industrial camera or USB microscope camera).
- A free serial port (or USB-to-serial adapter) for the Delta PLC.

- Microsoft Excel **only if you want PDF reports** — PDF export drives an installed copy of Excel. Excel workbooks (`.xlsx`) are produced without Excel installed.
- Only one copy of the application can run at a time; launching it again brings the running copy to the front.

3. Installation, first run and licensing

3.1 Installing

The application is deployed as a folder of files, not as a Windows installer. Copy the whole program folder to the machine PC — typically to a local drive, not a network share, because the application writes its data folder next to its own executable.

The folder must contain at least:

File	Purpose
`Multitek BMS Essentials.exe`	The application
`Multitek.LiveCam.dll`	Camera capture library (V7)
`Multitek.PLCBridge.dll`, `HslCommunication.dll`	PLC communication
`best_circle.onnx`	The trained model used by **Autoread** to find the indent
`runtimes\`	Native OpenCV binaries
`MT.Service.Packs\`	Your data — licence, database, patterns, report artwork

If `best_circle.onnx` is missing, the application still starts but shows "*Model file 'best_circle.onnx' not found next to the application.*" and Autoread will not work.

3.2 First run, step by step

1. Double-click `Multitek BMS Essentials.exe`.
2. The application creates or repairs the `MT.Service.Packs` folder structure and migrates any data left behind by an older installation (see §4.3).
3. It checks the Windows user settings file. If that file is unreadable or incomplete you are asked "*The settings was corrupted. Would you restore it from any backup?*" — see §13.3.
4. It checks the licence. If no valid licence is found, the licence dialog appears. Cancelling it closes the application.
5. The splash screen appears for a **minimum of five seconds** while the database is created or opened.
6. The main window opens with the Live Measure screen already inside it.
7. Choose your camera — **Settings ▸ Camera Setup...** — see §6.
8. Choose the PLC serial port in the top bar and press **Connect PLC** — see §11.1.
9. Check the lens calibration — see §7.

> A plain-text startup log is written to `%USERPROFILE%\bms_startup_log.txt` on every launch (for example `C:\Users\yourname\bms_startup_log.txt`). If the application fails to start, that file is the first thing to send to Multitek support.

3.3 Licensing

Licences are locked to the individual PC. The application derives a **Machine ID** from the CPU identifier, hashes it, and formats it as four groups of four hexadecimal characters (`XXXX-XXXX-XXXX-XXXX`).

To license a machine:

1. Start the application. The **Multitek Technologies, BMS** licence window appears if no valid licence is present.
2. Read the **Machine ID** shown on the right. It is read-only; select it and copy it.
3. Send the Machine ID and your **Customer ID** (the e-mail address in the left-hand box, which defaults to `service@multitek.in`) to Multitek.
4. Save the `.lic` file Multitek returns anywhere on the PC.
5. Click **Select License File**, choose the `.lic` file, then click **Check License**.
6. On success you see "*Valid license!*". The file is copied into `MT.Service.Packs\Binding\` and its file name is remembered. The application continues starting.
7. **Cancel** (or the Esc key) closes the dialog and, at startup, closes the application.

What is checked. The licence must carry a valid vendor signature, the product ID `Multitek BMS Essentials`, the Machine ID of this PC, a serial number derived from that Machine ID, and schema version 2. Licences are issued with a 25-year expiry. Any failure is reported as a specific message — see the troubleshooting table in §14.

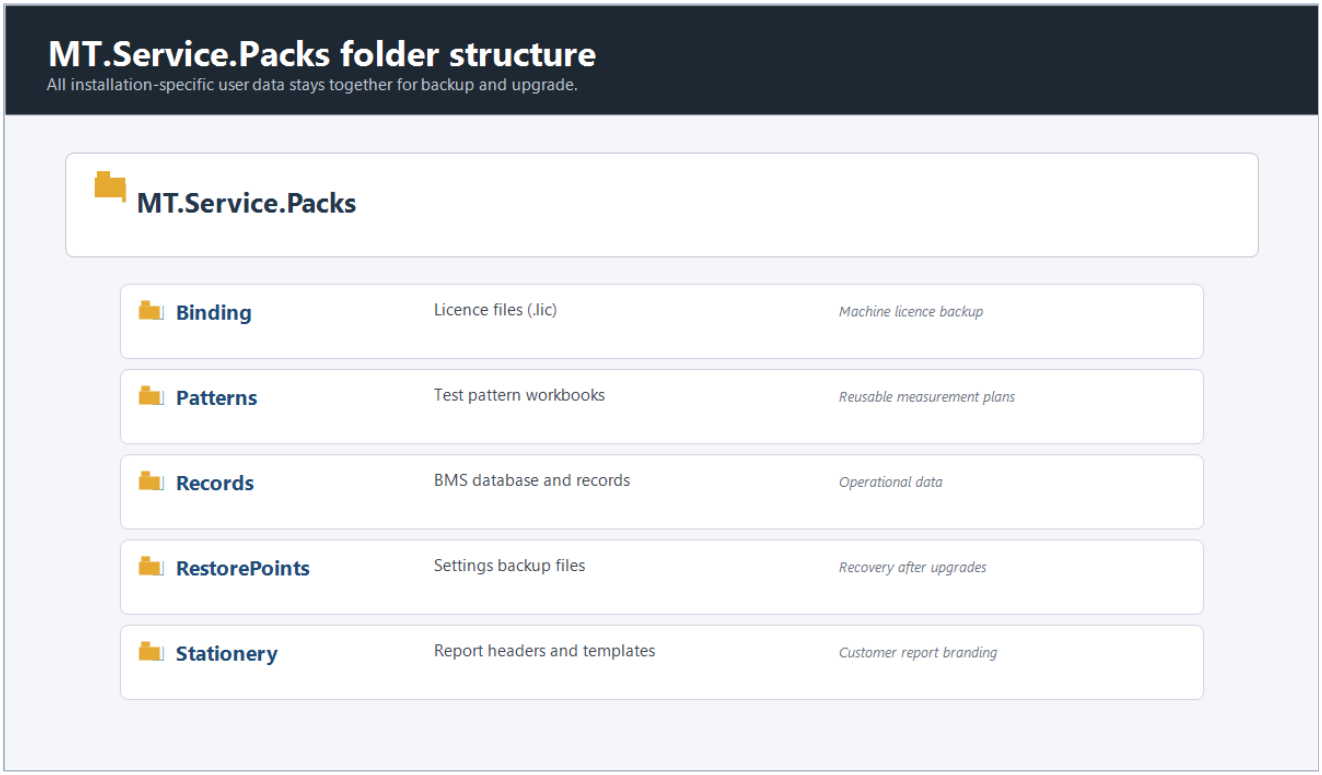
Where the licence lives. `MT.Service.Packs\Binding\`. On startup the application looks for (in order) the remembered file name inside `Binding`, then a legacy absolute path stored by an older build, and finally — only if nothing is remembered — a **single** `.lic` file in `Binding`.

> **Keep exactly one `.lic` file in `Binding`.** If the remembered file name is missing and there is more than one `.lic` file in the folder, the application cannot decide which one to use and will behave as if there were no licence at all. Move retired licence files out of the folder.

4. Where your data lives: the MT.Service.Packs folder

This section matters more than any other when you upgrade the software. **Everything that belongs to your machine, rather than to the program, lives in one folder.**

```
<folder containing Multitek BMS Essentials.exe>
└── MT.Service.Packs
    ├── Binding        ← the licence (.lic) for this PC
    ├── Patterns       ← test pattern workbooks (.xlsx)
    ├── Records        ← BMSDB, the calibration + turret database
    ├── RestorePoints  ← dated backups of your application settings
    └── Stationery     ← report letterhead image and custom report templates
```



4.1 What each subfolder holds

Subfolder	Contents	Created / written by
`Binding`	The active `.lic` licence file. Identifies this station.	Licence dialog, on **Check License**
`Patterns`	Test pattern workbooks — the list of measurement points, descriptions and tolerances that pre-fills the results grid. **Set Test Pattern** opens here by default.	You, via Excel
`Records`	`BMSDB` — a SQLite database holding `TURRET_SETTINGS` (lens names and calibration factors) and `FORCE_SETTINGS` (force names and values). This is your calibration.	Calibration screen

Subfolder	Contents	Created / written by
`RestorePoints`	Dated copies of the Windows user settings file, made by **Settings ▸ Backup**.	You, via Backup
`Stationery`	`BMSReportHeader.png` (the default report letterhead) and any custom Excel report templates. Header and template pickers open here by default.	You

4.2 Backing up and restoring across a software upgrade

This is the whole commissioning story: **copy one folder**.

Before upgrading:

1. Close Multitek BMS Essentials completely.
2. Open the program folder in Windows Explorer.
3. Right-click `MT.Service.Packs` ▸ **Copy**.
4. Paste it somewhere safe — a USB stick, a server share, or a dated folder such as `D:\BMS Backups\2026-08-03\`.
5. Optionally also take a settings backup first (**Settings ▸ Backup**, see §13) so it is included in the copy.

After installing the new version:

1. Do **not** start the new version yet.
2. Open the new program folder. If it already contains an `MT.Service.Packs` folder, rename it to `MT.Service.Packs.new`.
3. Paste your saved `MT.Service.Packs` folder in.
4. Start the application. Your licence, calibration, patterns and report artwork are all back.

If you only want to move part of it, the individual files are ordinary files:

To carry over…	Copy
Licence	`Binding\*.lic`
Lens and force calibration	`Records\BMSDB`
Test patterns	the whole `Patterns` folder
Report letterhead and templates	the whole `Stationery` folder
Application settings	the file you produced with **Settings ▸ Backup**, then use **Settings ▸ Restore**

> **A licence is tied to the PC, not to the folder.** Copying `MT.Service.Packs` to a *different* computer will carry the calibration across but the licence will be rejected. Request a new licence for the new Machine ID.

4.3 What happens to an older installation

On every startup the application quietly tidies an older layout into the new one. Nothing is overwritten — if the destination already holds an item, the old copy is left alone.

Old location (next to the exe)	Moves to
`Backup\*.lic`, `Backup\*.json`	`MT.Service.Packs\Binding\`
Everything else in `Backup\`	`MT.Service.Packs\RestorePoints\`
`Preset Hardness Patterns\`, `Preset Patterns\`	`MT.Service.Packs\Patterns\`
`Preset Report Formats\`, `Report Templates\`	`MT.Service.Packs\Stationery\`
`BMSDB` in the program folder	`MT.Service.Packs\Records\BMSDB`
`res\test_info_header.png`, `res\BMSReportHeader.png`	`MT.Service.Packs\Stationery\BMSReportHeader.png`

Emptied old folders are then deleted.

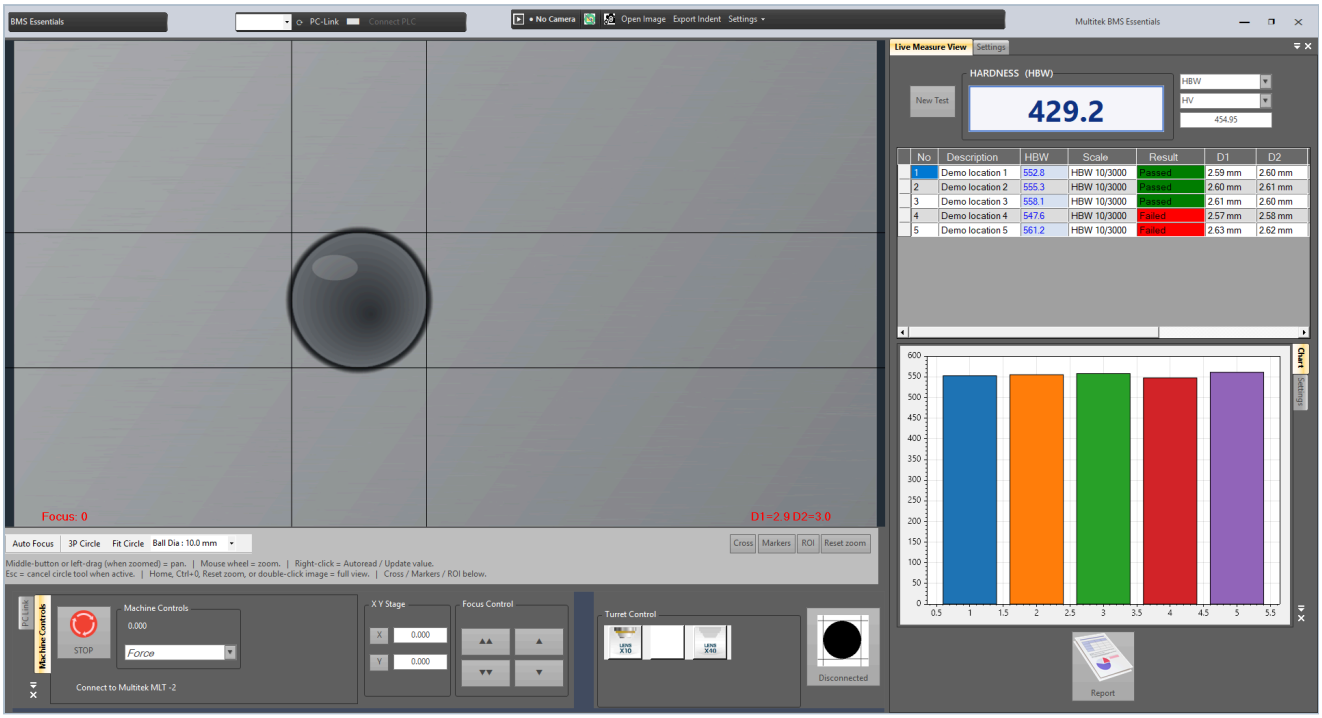
4.4 Other folders the application creates (not part of the backup)

These are working files. They are **not** in `MT.Service.Packs` and do not need backing up.

Folder / file (next to the exe)	Purpose
`Shots\`	The per-reading indent snapshots referenced by the results grid. **Emptied when the application closes**, so generate your report before you exit.
`ReportArtifacts\`	Temporary chart image and annotated indent images used while building a report.
`Final Reports\`	Output of the **Custom Report** button.
`BMS Report.xlsx` / `BMS Report.pdf`	Output of the default Excel / PDF report. Overwritten each time.

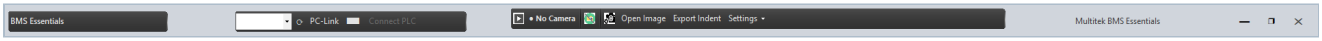
> **Important:** because `Shots\` is cleared on exit, the images embedded in a report must be generated in the same session as the readings. Closing the application discards them.

5. A tour of the main screen



The window has no standard Windows title bar. Multitek draws its own, so the top strip carries both the window controls and the most-used tools.

5.1 The top bar

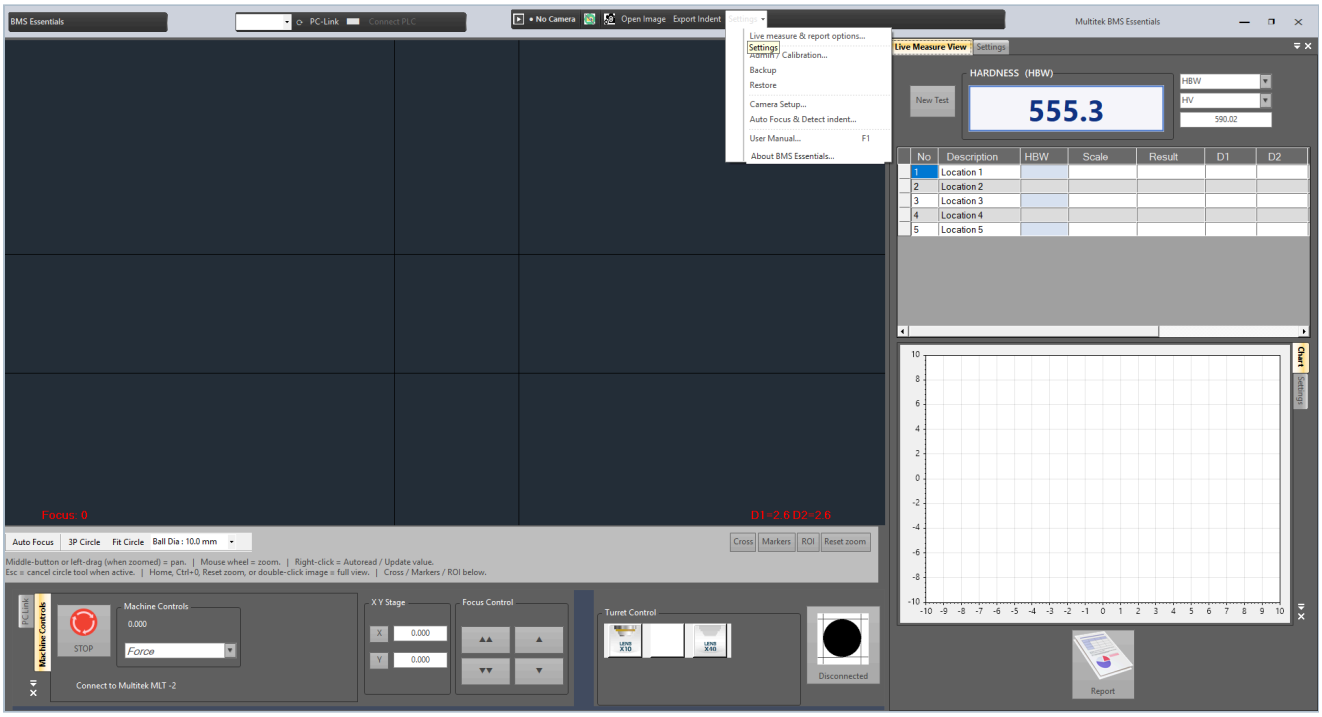


From left to right:

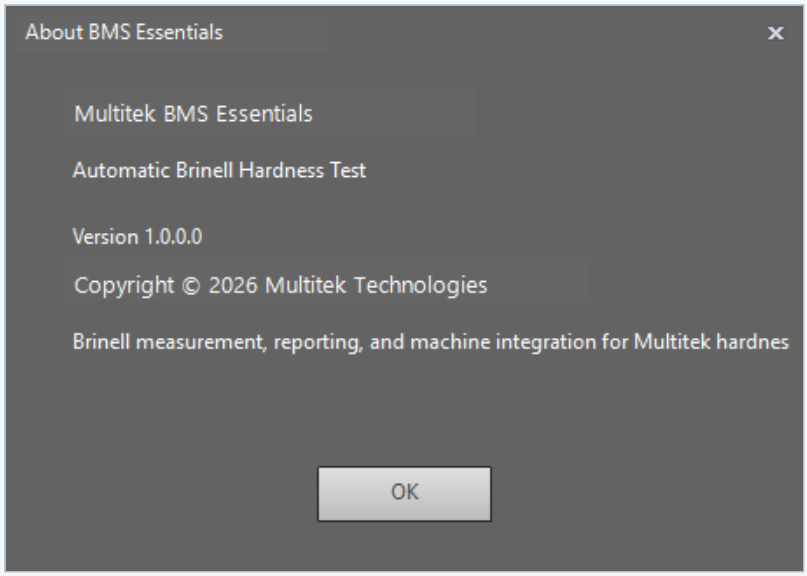
Element	Name in the software	What it does
Brand text	`BMS Essentials`	Label only. Drag it to move the window.
COM port list	`cmbComPorts`	Serial port for the PLC. Tooltip: *Serial port for the PLC*. Your choice is remembered.
⟳	`TsBtnComRefresh`	Re-scans the PC for serial ports.
`PC-Link`	`LblPcLink`	Label for the PLC group.
Coloured block ■	`tsConnectionIndicator`	PLC state: red = disconnected or faulted, orange = connecting/reconnecting, green = connected.
Connect PLC	`btnConnectCom`	Connects; becomes **Disconnect** when connected, **Retry PLC** after a fault, and pulses amber when the software wants your attention.
▶ / ⏸	`TopBarTsbPlayOrPauseCamera`	Starts the camera; once running, pauses and resumes the live image.
`● Live`	`LblCameraStatus`	Camera state. See §6.6.

Element	Name in the software	What it does
■	`TopBarTsbStopCamera`	Stops the camera and releases the device.
Camera icon	`TopBarTsbCameraSettings`	Opens the **camera driver's own property page** (brightness, exposure, gain…).
Open Image	`TopBarTsOpenImage`	Stops the camera and loads a still image from disk for measurement.
Export Indent	`TopBarTsbExportIndent`	Saves the current view — image plus overlays plus a D1/D2/force/HBW footer — as a JPEG.
Settings ▾	`TopBarTsbSettings`	The settings menu, below.
Window title	`LblAppInfo`	*Multitek BMS Essentials*. Drag to move; double-click to maximise/restore.
— □ ✕	chrome buttons	Minimise, maximise/restore, close.

The top-bar Settings menu:

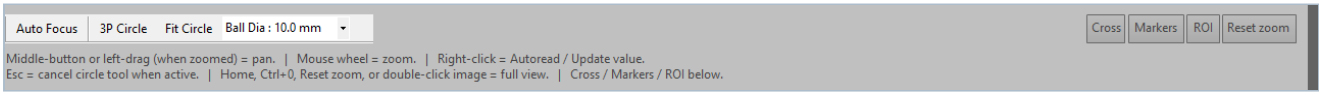


Item	Goes to
Live measure & report options… *(top bar only)*	Jumps to the **Settings** tab of the Live Measure screen
Admin / Calibration…	§7
Backup	§13.1
Restore	§13.2

Item	Goes to
Camera Setup…	§6
Auto Focus & Detect indent…	§8
User Manual… (`F1`)	Opens this released PDF in the default Windows PDF viewer
About BMS Essentials…	Version and copyright 

5.2 The Live Measure screen

This fills the rest of the window. It has four regions: the camera toolbar and the measurement toolbar above the image, the live image itself, the right-hand tab panel, and the machine strip across the bottom.



Camera toolbar (`TSCameraTools`), left to right:

Button	Effect
Camera ON	Start the camera; afterwards toggles pause/resume
Stop Camera	Stop capture and release the device
Camera Settings	Open the camera driver's property page
Open	Load a still image from disk (stops the camera first)
Save	Export the current view as an annotated JPEG
Settings ▾	Admin / Calibration…, Backup, Restore, Camera Setup…, Auto Focus & Detect indent…, About BMS Essentials…

Measurement toolbar (`TsMainTools`), left to right:

Control	Effect
Auto Focus	Starts / stops the automatic focus sweep (§8). The caption changes to *AutoFocus Step1/2/3*, then *AutoFocus Finished*, *AutoFocus Failed* or *Emergency Stop*.
3P Circle	Three-point circle tool (§9.4)
Fit Circle	Best-fit circle tool over three or more points
Ball Dia :	Ball diameter: `10.0 mm` , `5.0 mm` or `2.5 mm` . Changing it immediately recalculates HBW.

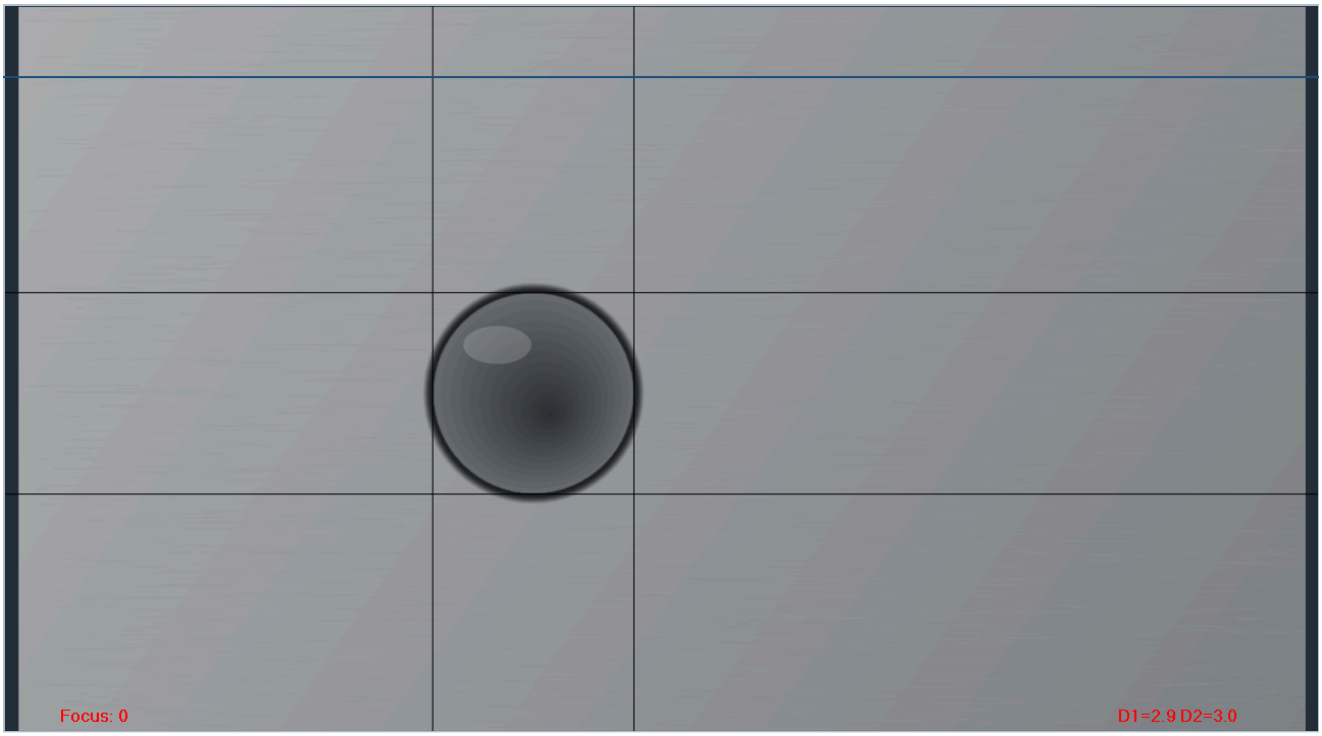
Below the image:

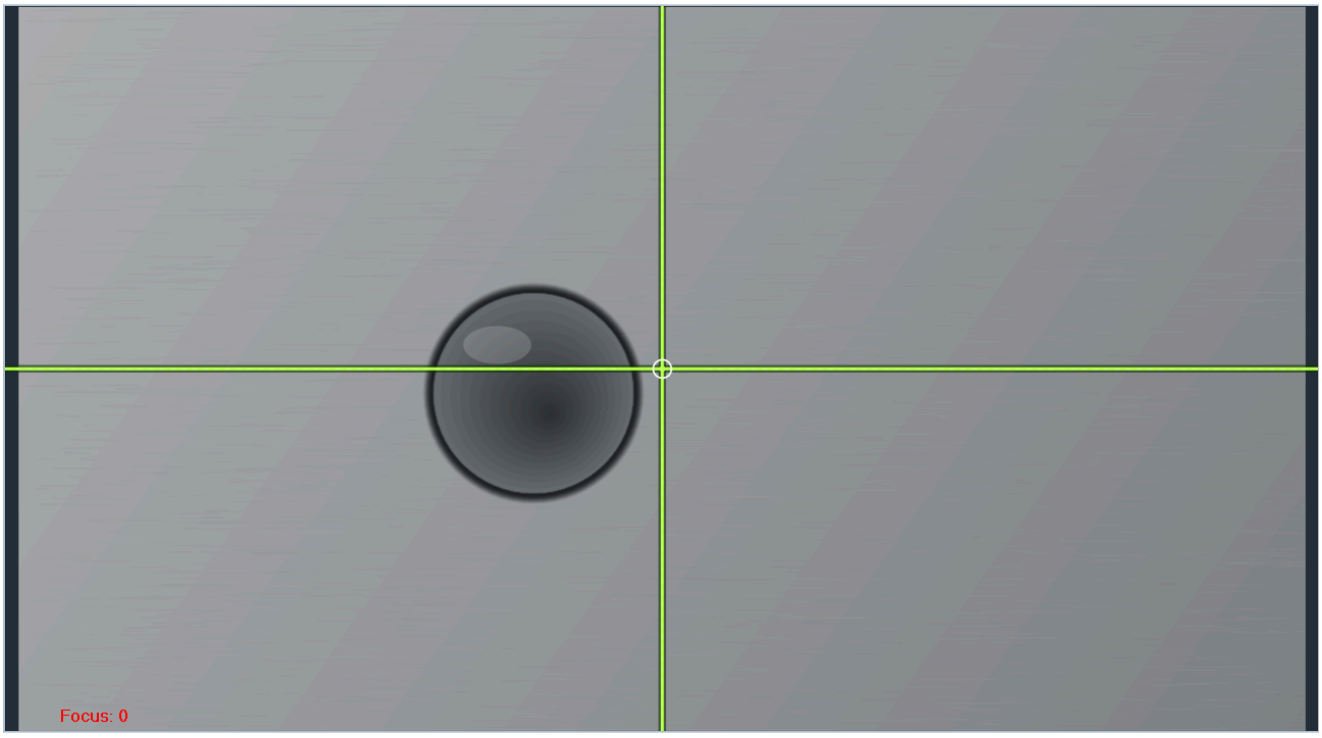
Control	Effect
Hint line	Context help that changes with the active tool
Cross	Show a centred crosshair overlay instead of the measuring markers
Markers	Show the four draggable marker lines and the `D1= D2=` readout (the normal working mode)
ROI	Show and edit the region of interest used by Autoread
Reset zoom	Return to a full, unzoomed, uncentred view

Whichever of Cross / Markers / ROI is active is highlighted in blue.

Overlays drawn on the image:

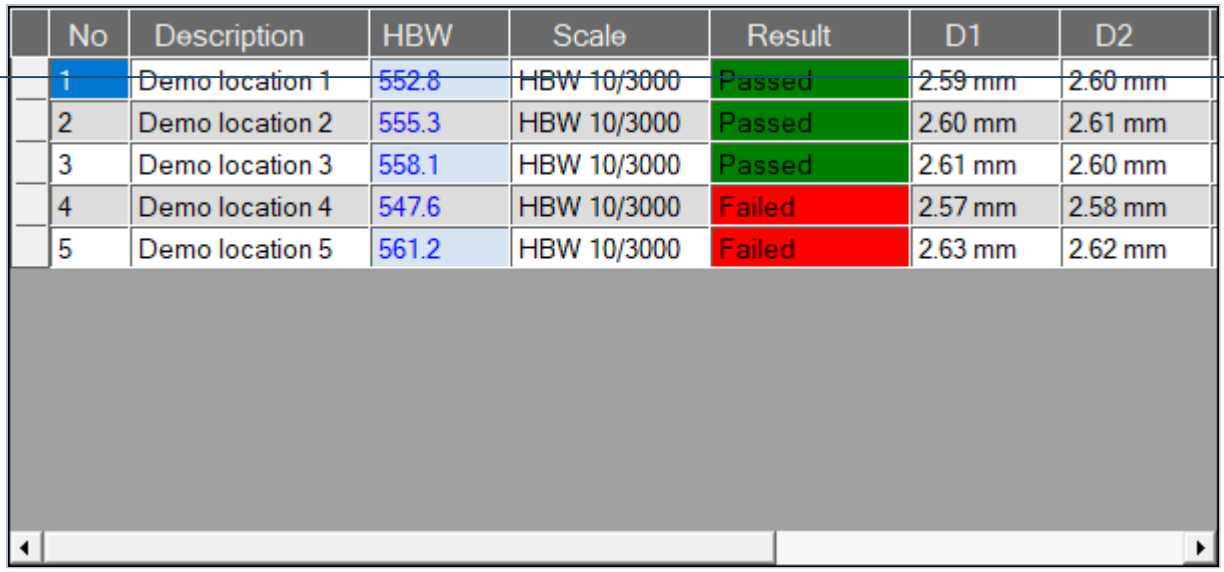
- Four black marker lines — two vertical, two horizontal. The one under the mouse turns red.
- `D1=… D2=…` in red at the bottom right (the two diameters in millimetres, one decimal place).
- `Focus: …` in red at the bottom left — the current sharpness score, which only updates during an auto focus sweep.
- A gold circle with an orange centre cross when a circle tool has produced a fit.
- A dashed lime rectangle when ROI mode is active.



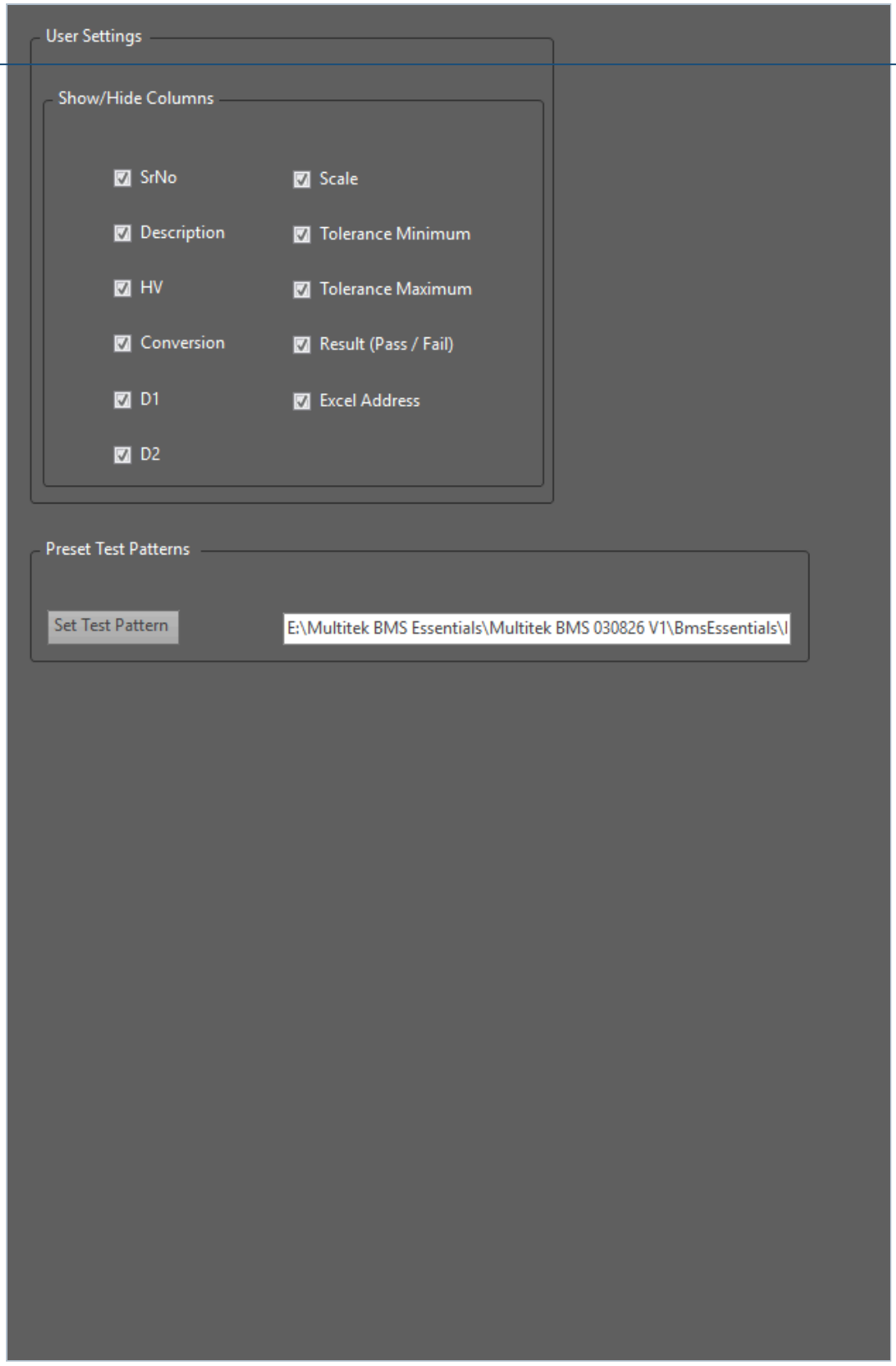


Right-hand tab panel (`TabMain`) has two pages:

- **Live Measure View** — the big HBW readout, the conversion boxes, the **New Test** and **Report** buttons, the results grid, and a nested Chart / Settings tab pair.
- **Settings** — the test-pattern picker and the results-grid column checkboxes.



No	Description	HBW	Scale	Result	D1	D2
1	Demo location 1	552.8	HBW 10/3000	Passed	2.59 mm	2.60 mm
2	Demo location 2	555.3	HBW 10/3000	Passed	2.60 mm	2.61 mm
3	Demo location 3	558.1	HBW 10/3000	Passed	2.61 mm	2.60 mm
4	Demo location 4	547.6	HBW 10/3000	Failed	2.57 mm	2.58 mm
5	Demo location 5	561.2	HBW 10/3000	Failed	2.63 mm	2.62 mm



The machine strip across the bottom hosts two panels side by side: **Machine Operation** on the left and the **Turret** on the right. Both are covered in §11.

5.3 Mouse and keyboard

Action	Result
Mouse wheel over a marker line	Nudges that line one pixel per notch
Mouse wheel elsewhere, or with Ctrl held	Zooms in/out about the pointer (1× to 10×)
Left-drag a marker line	Moves it; D1/D2 and HBW update continuously
Left-drag or middle-drag elsewhere while zoomed	Pans
Left-drag in ROI mode	Draws the region of interest (must move at least ~11 pixels)
Double-click the image	Resets zoom and pan
Right-click the image	Context menu: **Autoread**, **Update Value**
`Home` or `Ctrl` + `0`	Resets zoom and pan
`Esc`	Cancels the active circle tool
`Enter`	Finishes a best-fit circle

> The window "close" button on the Live Measure screen is deliberately inert — closing the child would leave you with no way to get it back. Close the application from the top bar instead.

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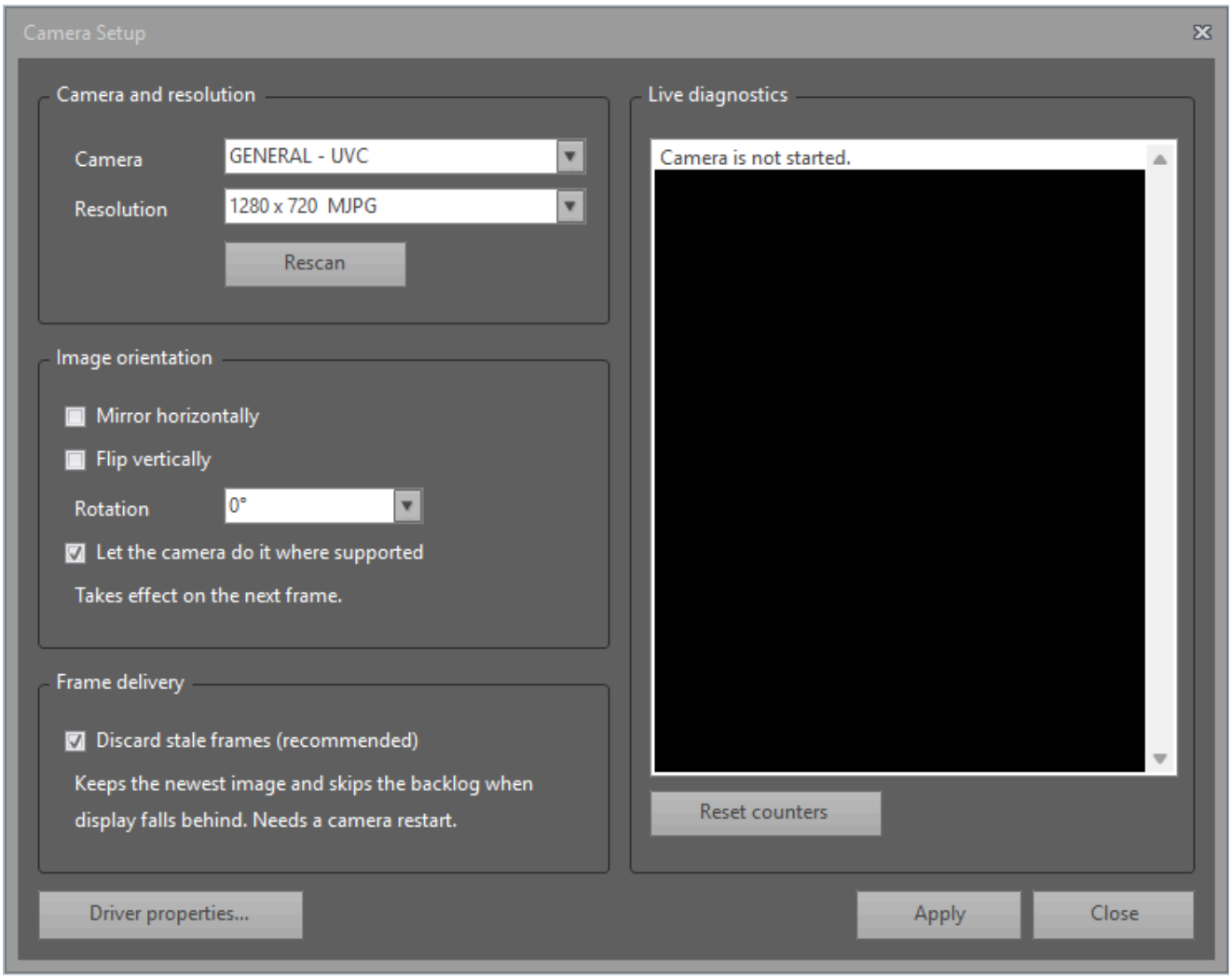
6. Camera Setup

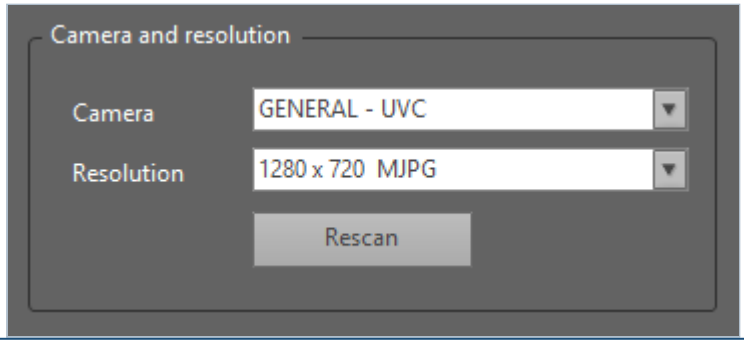
Settings ▸ Camera Setup...

This window is the operator's single entry point for anything camera related. It opens *non-modally*, so you can leave it on screen and watch the live image change as you adjust it.



The window has four groups plus three buttons.

6.1 Camera and resolution



Control	What it does
Camera	Every DirectShow capture device the PC can see, by name. If none are found the list shows the single entry *No camera found*.
Resolution	The capture modes the selected camera actually reports, listed as `width x height PixelFormat` — for example `1920 x 1080 RGB24`. This list is read from the camera, not guessed.
Rescan	Re-enumerates devices. Use it after plugging a camera in.

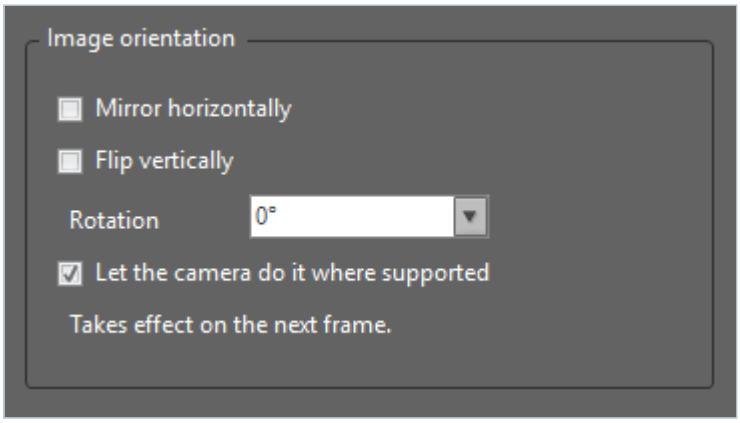
To change camera or resolution:

1. Pick the camera in **Camera**. The **Resolution** list refills automatically for that device.
2. Pick the resolution.
3. Click **Apply**.
4. The camera stops and restarts. If it was running before, it comes back running; if it was stopped, it stays stopped.

The chosen camera is remembered by its device *moniker*, a stable identifier that survives unplugging and re-plugging the camera, with the friendly name and the list position kept as fallbacks. That is why the right camera is usually re-selected even after a USB re-plug.

> Choosing a resolution is a real trade-off. A higher resolution gives you more pixels across the indent — a finer measurement — but a lower frame rate and a heavier CPU load. **Re-calibrate after changing the resolution** (§7.5): the calibration factors convert pixels to millimetres, and the number of pixels per millimetre changes with the sensor mode.

6.2 Image orientation



These four controls take effect **on the next frame** — there is no Apply and no restart. Watch the live image and set them by eye.

Control	Setting	Default	What it does
Mirror horizontally	`CamMirrorHorizontal`	off	Flips the image left-to-right. Use it when the optical path has an odd number of mirrors or prisms, or when a webcam driver applies its own selfie-view mirroring.

Control	Setting	Default	What it does
Flip vertically	`CamFlipVertical`	off	Flips the image top-to-bottom, on top of the automatic correction the library already applies for bottom-up source frames.
Rotation	`CamRotationDegrees`	0°	Clockwise rotation applied *after* mirror and flip. Choices are 0°, 90°, 180°, 270°. 90° and 270° swap the image width and height.
Let the camera do it where supported	`CamUseHardwareFlip`	on	When on, mirror and flip are handed to the camera itself wherever the driver supports it, which costs no CPU time. Turn it **off** if a driver misreports or transposes the flip flags — the software will then do the work instead.

How to correct an upside-down or mirrored image:

1. Put a specimen with an obvious asymmetric feature under the objective — a scratch, an engraved character, or the edge of the sample.
2. Move the stage slightly to the right. If the image moves left, you need **Mirror horizontally**.
3. Move the stage away from you. If the image moves the wrong way, you need **Flip vertically**.
4. If the image is on its side, set **Rotation** to 90° or 270° until it is upright.
5. If nothing changes when you tick the boxes, clear **Let the camera do it where supported** and try again — the driver may be accepting the request and ignoring it.
6. Confirm what actually happened in the diagnostics panel: the **Mirror** and **Flip** lines say `on (camera)`, `on (software)` or `off`, and the two lines at the bottom report whether the camera claims hardware support at all.

> Orientation changes are saved when you close the Camera Setup window even if you never press **Apply**.

6.3 Frame delivery

Control	Setting	Default	What it does
Discard stale frames (recommended)	`CamDiscardStaleFrames`	on	On: frames are handed to the display on a dedicated background thread through a two-slot buffer that keeps the newest frame and drops the backlog whenever the display falls behind. Off: frames are delivered synchronously on the capture thread, so a slow display stalls capture.

The on-screen hint says it plainly: "*Keeps the newest image and skips the backlog when display falls behind. Needs a camera restart.*" Changing this checkbox is one of the three things that require **Apply** (and therefore a stop/start of the camera).

Leave it on unless Multitek support asks you to turn it off. With it off you will see the live image lag behind the stage when the PC is busy.

6.4 Driver properties

Driver properties... opens the camera manufacturer's own property page — the dialog with brightness, contrast, exposure, gain, white balance and so on. Multitek does not draw this window and does not store anything from it; the camera driver owns those values.

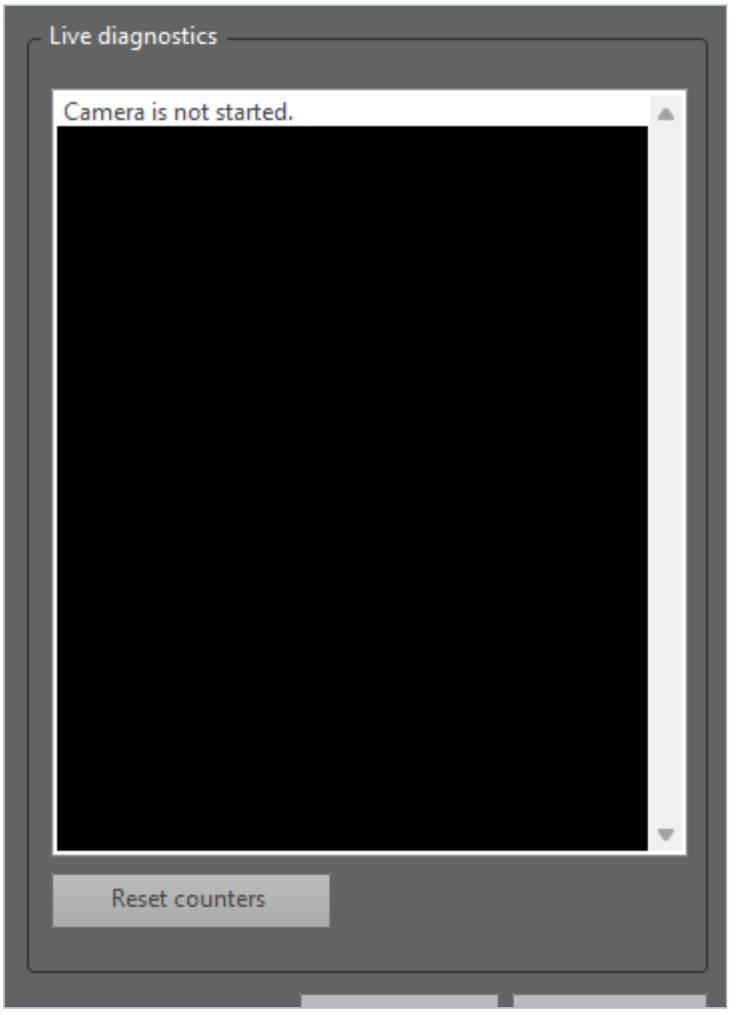
The page is intentionally not illustrated here because its controls and wording come from the installed camera driver and differ between camera models.

The camera must be running. If it is not, you get "*Please start the camera first, then open driver settings.*"

For Brinell measurement, aim for:

- **Exposure / gain** set so the indent floor is clearly darker than the surrounding surface without the highlights burning out.
- **Auto exposure off** once you are happy, so the image does not shift while you measure.
- **Sharpening low or off.** Driver sharpening creates halos on the indent edge, which pushes the detected diameter out and inflates the measurement.

6.5 Live diagnostics



The panel refreshes roughly every three-quarters of a second. **Reset counters** zeroes the totals and the rate averages so you can measure a fresh interval.

Line	Meaning	What good looks like
`State`	The library's own connection state	`Connected`
`Source rate`	Frames per second arriving from the camera	Close to the camera's rated frame rate for the chosen resolution
`Delivered rate`	Frames per second actually handed to the application	Equal to, or a little below, the source rate
`Frames received` / `delivered` / `dropped`	Running totals since start or since Reset counters	Dropped should stay near zero; a slow, steady climb under **Discard stale frames** is normal and harmless
`Callback avg / max`	How long the application takes to process one frame, in milliseconds	Average comfortably under the frame interval (under ~33 ms at 30 fps)
`Negotiated format`	The resolution and pixel format the camera actually agreed to	Should match what you picked in **Resolution**
`Delivered format`, `stride`	Pixel format handed to the application and its row length in bytes	Informational
`Dispatch`	`LatestFrame (buffer 2)` when Discard stale frames is on, `Synchronous` when off	Matches the checkbox
`Source layout`	`top-down` or `bottom-up (corrected)`	Either is fine; the library normalises it
`Mirror`, `Flip`	`off`, `on (camera)` or `on (software)`	Matches what you asked for
`Rotation`	The rotation in force	Matches the combo
`Reconnects`	`N ok / M failed of K` attempts	All zeros on a healthy cable
`Hardware mirror` / `Hardware flip`	Whether the camera claims driver-level support	Informational
`Last error`	Stage, message, local timestamp, and whether it is recoverable	Absent

If the camera has not been started, the panel simply reads "*Camera is not started.*"

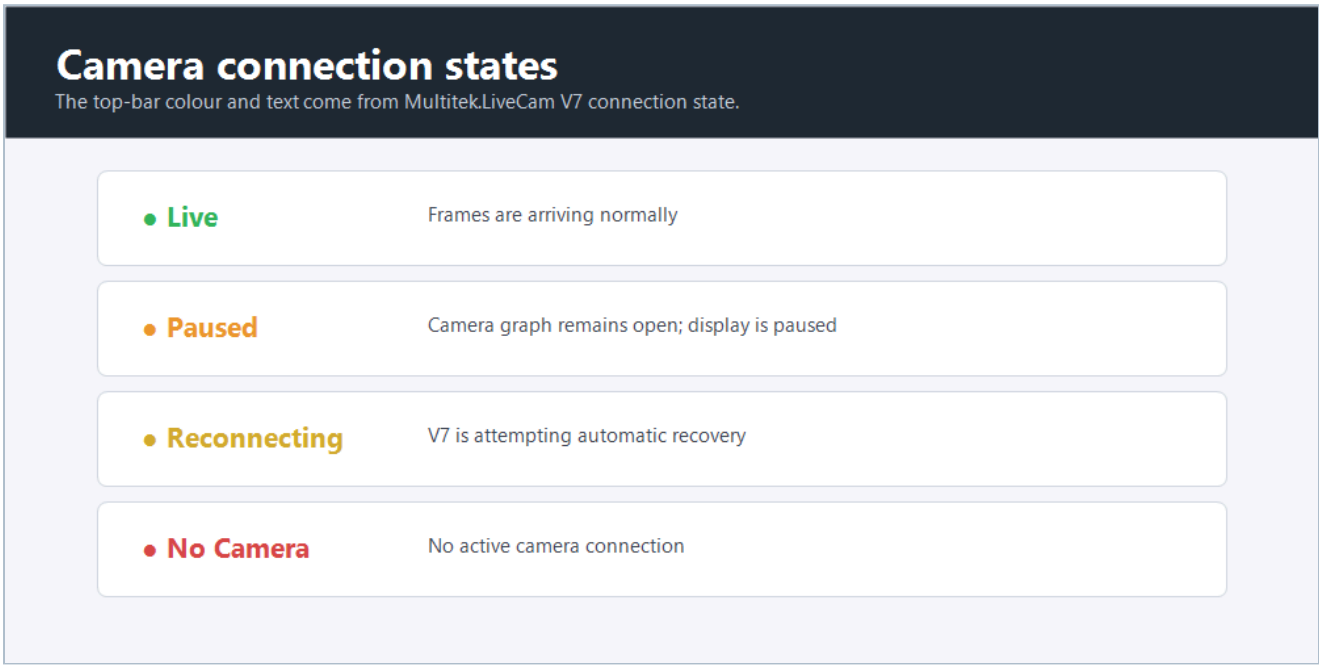
Reading it in practice:

- **Delivered rate much lower than source rate, dropped climbing fast** — the PC cannot keep up. Reduce the resolution, close other applications, or check the `Callback avg / max` line.
- **Reconnect counts climbing** — a marginal USB cable, a hub without enough power, or a camera that is browning out. Try a different port, a shorter cable, or a powered hub.
- **Negotiated format different from the one you chose** — the driver substituted a mode. Pick a different resolution.

- `Last error` **present and *needs attention*** — the capture cannot recover on its own. Stop the camera, fix the cause, start it again.

6.6 Reading the camera status indicator

The coloured dot and text in the top bar are driven by the capture library's real connection state, not by whether a picture happens to be on screen.



Text	Colour	Meaning
`● Live`	Green	Capturing and displaying
`● Paused`	Orange	Session is open, display paused by you
`● Connecting`	Gold (session open) / Orange (not yet open)	Building the capture graph
`● Reconnecting`	Gold	The camera stopped delivering; the library is rebuilding the graph automatically
`● Camera Lost`	Red	Automatic reconnection gave up. Any auto focus sweep is stopped.
`● No Camera`	Red	Not started, or stopped

Automatic reconnection means an unplugged and re-plugged camera normally comes back on its own, without you touching anything.

6.7 The three buttons at the bottom

Button	Effect
Driver properties…	Opens the camera driver's own dialog (camera must be running)
Apply	Saves camera, resolution, discard-stale and orientation; restarts the camera **only** if the camera, the resolution or the discard-stale setting changed
Close	Closes the window. Orientation is saved regardless.

If you press **Apply** with no camera selected you get "*Select a camera first.*"

7. Calibration

7.1 What calibration is

The camera measures in pixels. Hardness is calculated from millimetres. Calibration is the number that converts one into the other — for each objective lens, and separately for the horizontal (X) and vertical (Y) directions:

```
D1 (mm) = horizontal pixel distance × CF_X
D2 (mm) = vertical   pixel distance × CF_Y
```

`CF_X` and `CF_Y` are the **hardness calibration factors**, stored per lens in the `TURRET_SETTINGS` table of `MT.Service.Packs\Records\BMSDB`. Selecting a lens on the turret strip loads that lens's factors and every subsequent measurement uses them.

Separate X and Y factors let you compensate for non-square pixels and for slight anisotropy in the optical path.

7.2 Opening the calibration screen

Settings ▸ Admin / Calibration…

The window opens non-modally, so you can still drive the turret, choose a force and move the markers while it is open — which you need to do, because calibration reads the live measurement.

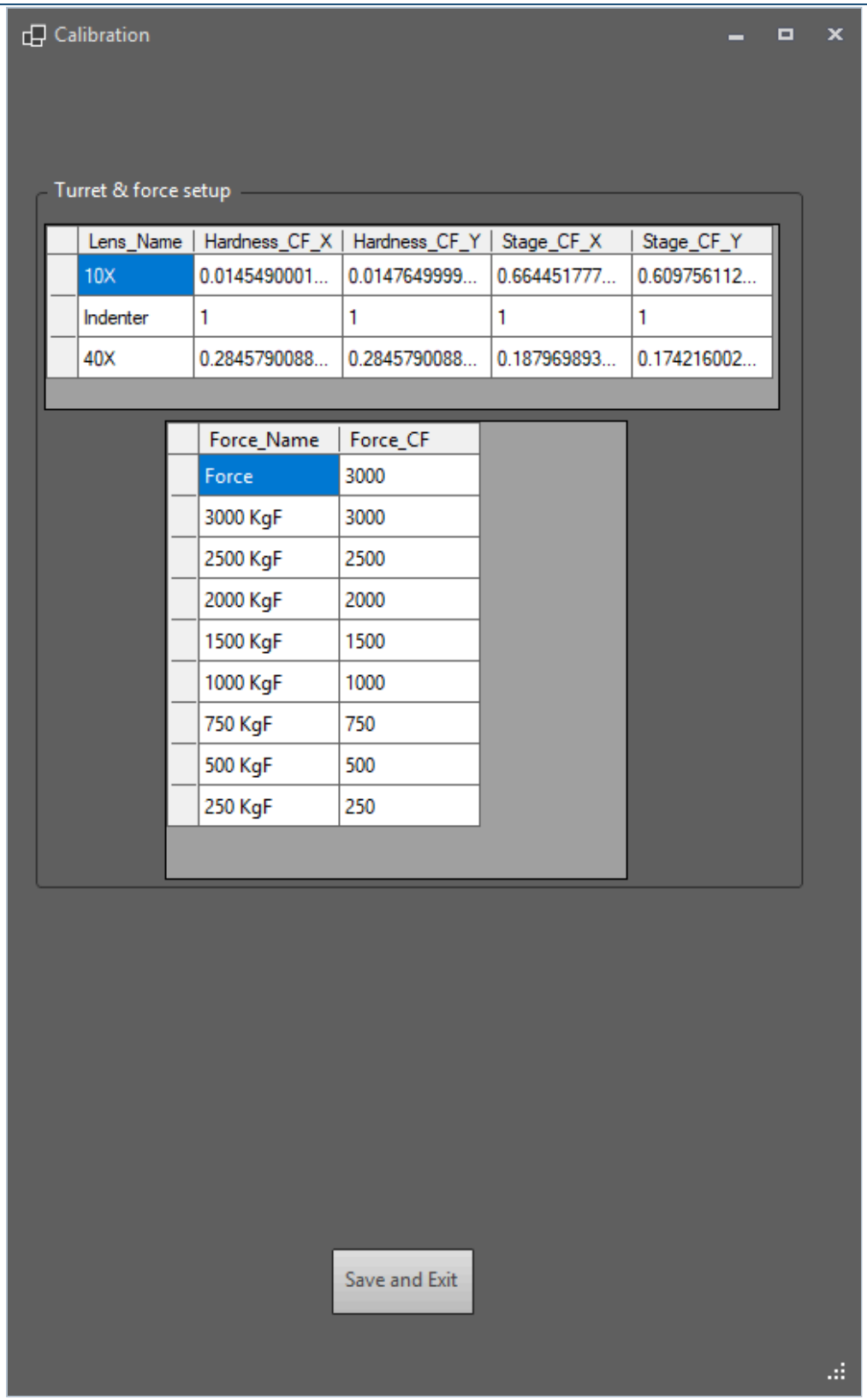
There are two passwords, and they unlock two different things:

Password	Unlocks
`123456`	**Turret & force setup** — the two editable tables and **Save and Exit**
`123.456`	**Hardness Calibration** — the target-value box and the **Calibrate** button

Any other entry shows "*Password Incorrect*" and closes the window.

> These passwords are supervisor-level, not operator-level. Editing the tables can invalidate every measurement the machine produces.

7.3 Turret and force setup (password `123456`)



Two grids appear.

Lens table (`TURRET_SETTINGS`):

Column	Meaning
`Lens_Name`	The name shown on the turret strip and used to look up the button image. It must match the name you calibrate against.
`Hardness_CF_X`	Millimetres per pixel, horizontal, for this lens
`Hardness_CF_Y`	Millimetres per pixel, vertical, for this lens
`Stage_CF_X`	Reserved stage-related X factor. It is retained for database compatibility but is not used by this application's measurement path.
`Stage_CF_Y`	Reserved stage-related Y factor; likewise not used by the current measurement path.

A freshly created database is seeded with three rows, in turret order:

Position	Lens_Name	Hardness_CF_X	Hardness_CF_Y	Stage_CF_X	Stage_CF_Y
1	`10X`	0.228868	0.222510	0.6644518	0.6097561
2	`Indenter`	1	1	1	1
3	`40X`	0.284579	0.284579	0.1879699	0.1742160

These are placeholder values from a factory template. They are not your machine's calibration. Calibrate every objective before you report a single result.

> Position 2 is assumed to be the indenter. Auto focus refuses to run when position 2 is selected. Keep the indenter in the middle turret position, and keep its row in the middle of this table.

Force table (`FORCE_SETTINGS`):

Column	Meaning
`Force_Name`	The text shown in the **Force Selection** list on the Machine Controls strip
`Force_CF`	The numeric force fed into the HBW formula

A freshly created database is seeded with the standard Brinell **kgf** series: `3000`, `1500`, `1000`, `750`, `500`, `250`, `187.5`, `125`, `100`, `62.5` and `31.25 kgf`. `Force_CF` is always interpreted as kilograms-force by the HBW formula.

> The seed list does not prove that the physical machine can generate every listed load. During commissioning, retain only the loads supported and calibrated on that machine. Existing databases are not overwritten by a software upgrade, so previously commissioned force tables remain intact.

To edit either table:

1. **Settings** ▸ **Admin / Calibration...**, type `123456`, click **Login**.

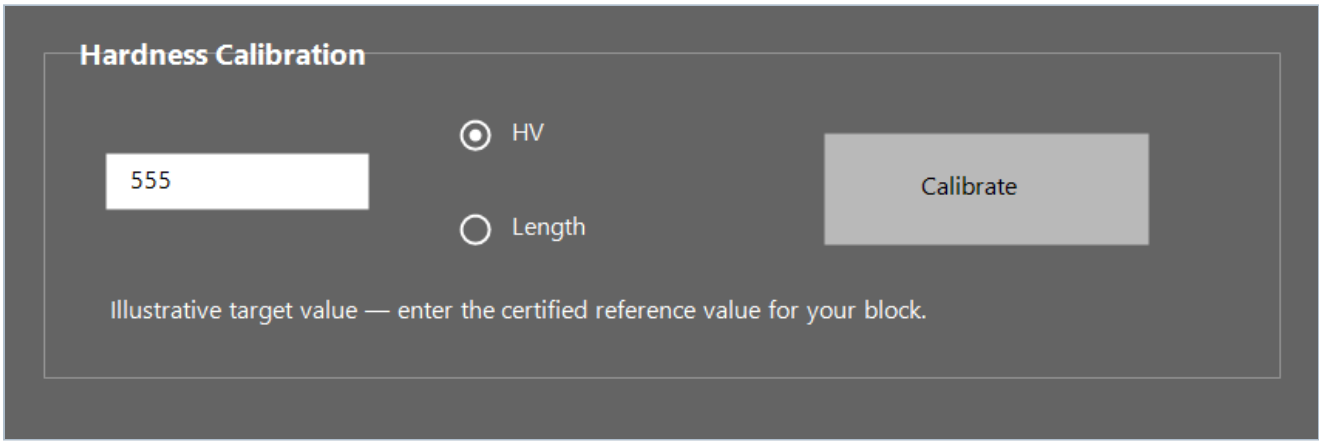
2. Edit cells directly. Use the blank row at the bottom to add an entry; select a row and press `Delete` to remove one.
3. Click **Save and Exit**.

What Save and Exit does: it replaces the *entire* contents of both tables with what is in the grids — every existing row is deleted first. It then reloads the force list, rebuilds the turret buttons, re-applies your saved force selection and refreshes the live HBW reading. If the database write fails you get a "*Database save failed*" message and nothing is lost.

Because the tables are rewritten wholesale, **do not delete a lens row you still have calibration for unless you mean it.**

The turret strip shows one button per lens row, in table order. The button picture comes from an image resource named after the lens (`lens_10x`, `lens_10x_on`, and so on, with dots replaced by underscores). A lens name with no matching image simply keeps a blank button — harmless, but position 1, 2, 3 then have to be counted rather than recognised.

7.4 Calibrating a lens against a reference block (password `123.456`)



You can calibrate in either of two ways:

- **Length** — you measure a feature of known physical size (a stage micrometer graticule, or a certified indent whose diameter you know) and type that size in millimetres.
- **HV** — you measure an indent on a certified reference block and type the block's certified hardness value. The software works backwards through the hardness formula to find what the indent diameter *should* be, and calibrates to that.

Procedure:

1. Mount the certified reference block or stage micrometer on the stage.
2. Connect the PLC and select the correct **force** on the Machine Controls strip.
3. Select the correct **ball diameter** on the toolbar.
4. Rotate the turret to the objective you want to calibrate — click its button on the turret strip so that it highlights. **The highlighted lens is the one that gets written.**
5. Focus. Auto focus or the Z jog buttons both work.
6. Measure the feature or the indent using **Fit Circle**, **3P Circle**, or by dragging the four marker lines. Check that `D1=` and `D2=` at the bottom right of the image are both positive.
7. **Settings** ▸ **Admin / Calibration...**, type `123.456`, click **Login**.

8. Choose **Length** or **HV**.
9. Type the certified value in the input box.
10. Click **Calibrate**.
11. Read the confirmation: it names the lens and shows the new `CF_X` and `CF_Y`.
12. **Re-measure the same indent** and confirm the reading now matches the certificate.
13. Repeat for every objective.

Before it will calibrate, the software checks the following and lists everything that is missing in a single message:

- a force is selected (greater than zero);
- a ball diameter is selected (greater than zero);
- a lens is active on the turret strip;
- that lens already has positive, non-NaN `CF_X` and `CF_Y` — if it does not, open the turret table with password `123456` and seed it with a sensible starting value such as `1.0`;
- D1 and D2 are both positive, i.e. you have actually measured something;
- the target value you typed is positive.

In **HV** mode there is one more check: if the target hardness is not physically achievable with the selected ball and force, you get "*Target HV … is not physically achievable with ball Ø … mm at … kgf*" and nothing is written. Choose a larger ball or a different force and measure again.

If the highlighted lens has no matching row in the turret table, the calibration is refused rather than written to the wrong lens.

7.5 When to recalibrate

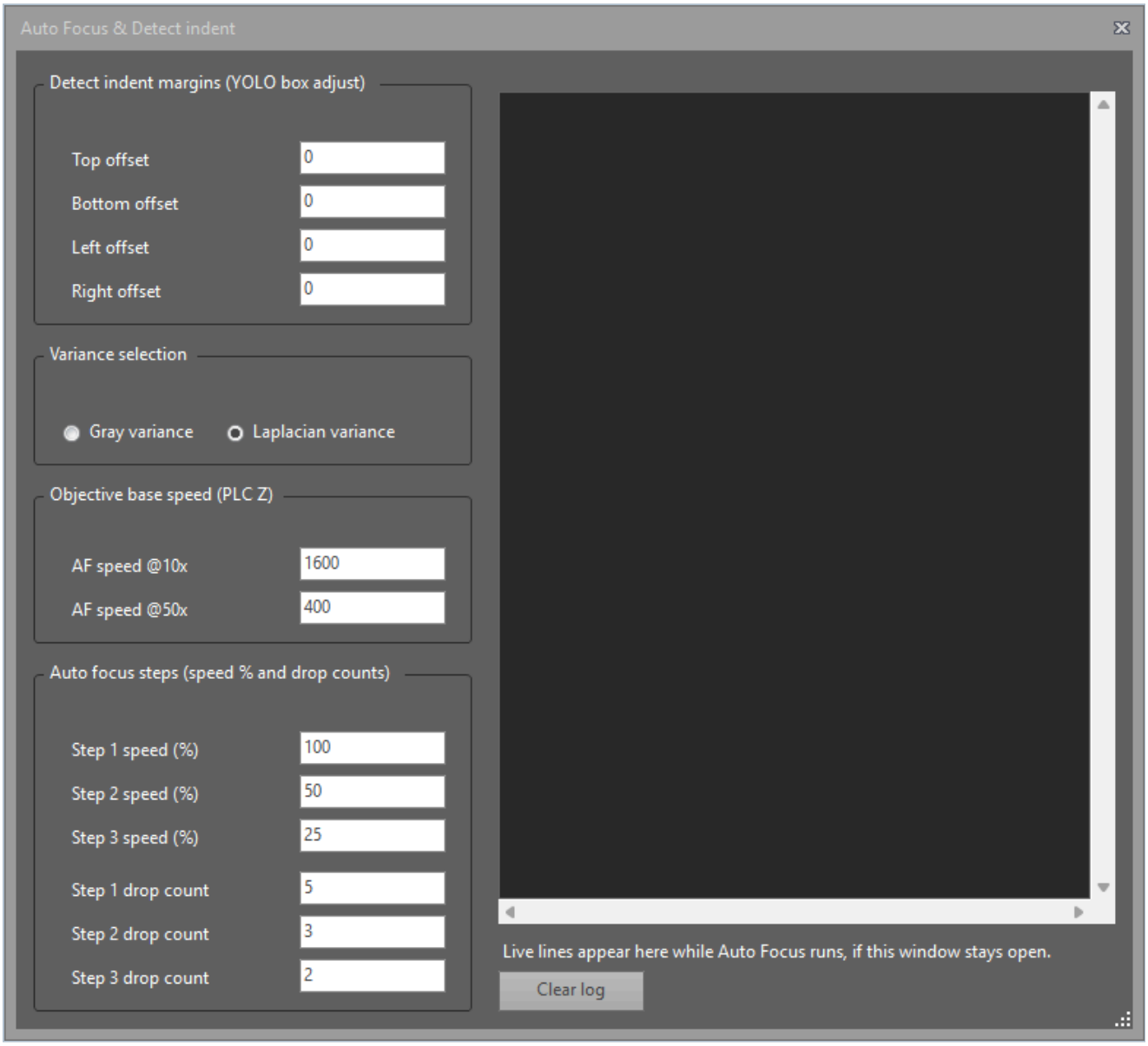
Recalibrate the affected objective whenever any of these happens:

Event	Why
The camera is changed or replaced	Different sensor, different pixel size
The camera **resolution** is changed in Camera Setup	Pixels per millimetre changes
An objective is changed, cleaned out of its mount, or refocused mechanically	Optical magnification changes
The camera adapter, tube lens or C-mount spacer is disturbed	Magnification changes
A periodic verification against a reference block falls outside tolerance	The standard requires it
The `BMSDB` database is replaced or restored from another machine	The factors may not be this machine's
Software is upgraded **and** `MT.Service.Packs` was *not* carried over	The seeded placeholder values are in force

Verification against a certified block on a documented interval — typically daily or per shift for production work — is a quality-system requirement, not a software one. Follow your own procedure.

8. Auto focus and indent detection

Settings ▸ Auto Focus & Detect indent…



One window configures two separate things: how the software finds focus, and how it interprets the box the detector draws around the indent. Settings are saved when you close the window.

8.1 How auto focus works

The software drives the Z axis at a commanded speed and continuously scores how sharp the image is. A well-focused image has high contrast; a blurred one does not. The score is called the **variance** and it is shown live on the image as `Focus: …`.

The sweep runs in three steps:

1. **Step 1** runs at the fastest speed, moving **up**, until the sharpness has fallen for more consecutive samples than the step's drop count allows.
2. **Step 2** reverses direction and runs slower, again until the drop count is exceeded.

3. **Step 3** reverses again and runs slower still.

After step 3 the sweep declares *AutoFocus Finished* and leaves the axis where it stopped. The approach converges on the peak by overshooting it three times, each time less far.

Samples are taken ten times a second. The base speed is chosen by turret position: position 1 uses **AF speed @10x**, and any other position uses **AF speed @50x**.

8.2 Auto focus settings

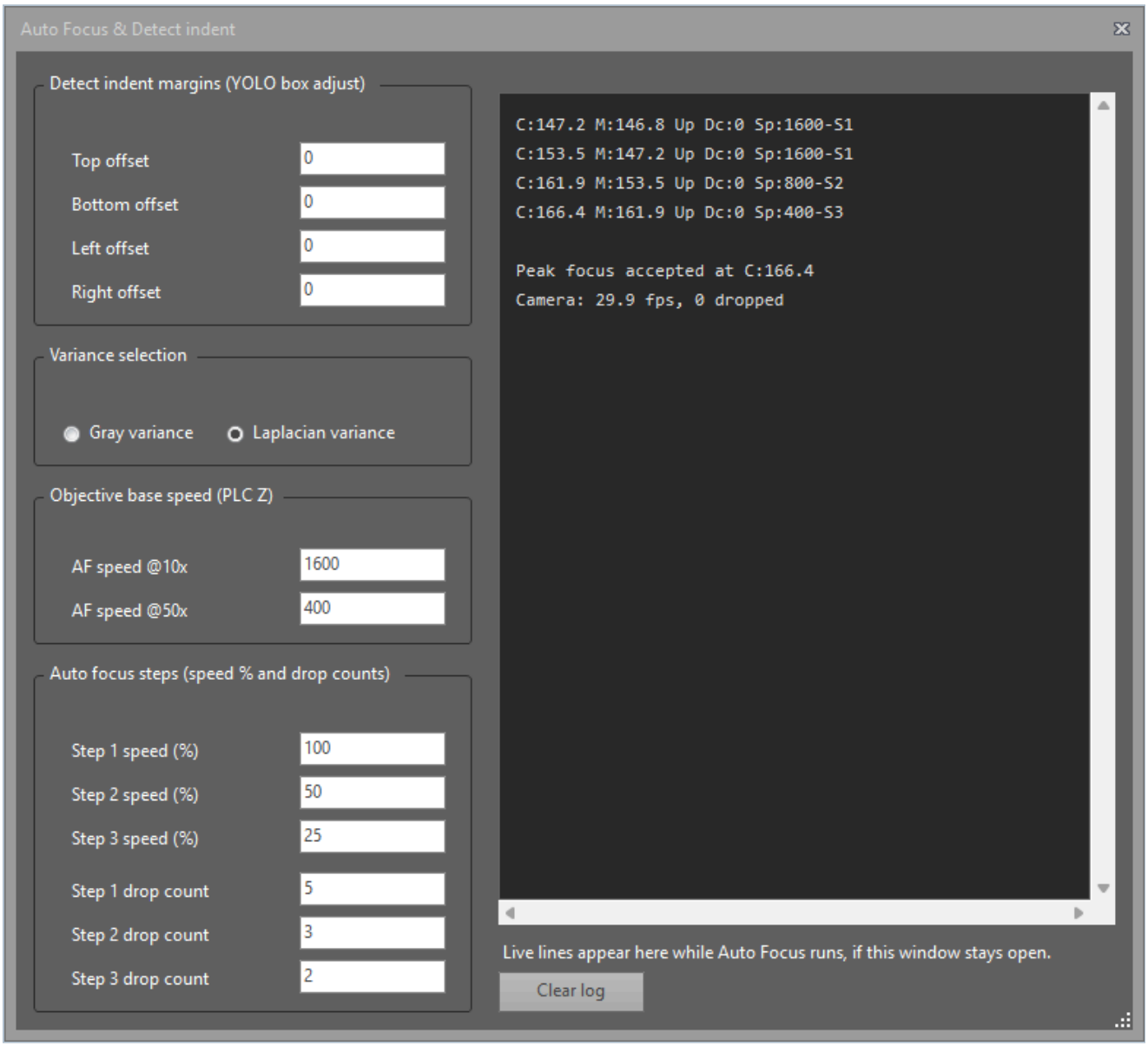
Group	Setting	Default	Meaning and how to tune it
Variance selection	**Gray variance**	selected	Sharpness scored from the spread of grey levels across the whole image. Robust, cheap, works well on a clean field.
	Laplacian variance	—	Sharpness scored from edge energy. More sensitive to fine detail, and therefore better on a low-contrast or finely-textured surface, but noisier and more easily fooled by image noise at high gain. Try it if Gray variance keeps stopping short of focus.
Objective base speed (PLC Z)	**AF speed @10x**	1600	Base Z speed used when turret position 1 is selected. Units are machine-specific PLC speed counts. Larger is faster and coarser; change only during commissioning.
	AF speed @50x	400	Base Z speed used for every other turret position. Higher magnification needs a slower approach because the depth of field is far shallower.
Auto focus steps	**Step 1 speed (%)**	100	Percentage of the base speed used in step 1
	Step 2 speed (%)	50	Percentage used in step 2, after the first reversal
	Step 3 speed (%)	25	Percentage used in step 3
	Step 1 drop count	5	How many consecutive falling samples are tolerated before step 1 gives up and reverses. Higher = travels further past the peak.
	Step 2 drop count	3	Same, for step 2
	Step 3 drop count	2	Same, for step 3

Tuning guidance:

- **Auto focus stops before it is sharp** — the drop counts are too small; the sweep is reversing on image noise. Raise **Step 1 drop count** first.
- **Auto focus overshoots badly and takes a long time to come back** — the drop counts are too large, or the base speed is too high. Lower the base speed for that objective.
- **Auto focus hunts around focus and never settles** — lower **Step 3 speed (%)** so the final approach is finer.

- **Auto focus works on 10x but not on the high-power objective** — the high-power base speed is almost always the culprit. Halve **AF speed @50x**.
- **The `Focus:` number barely changes as you jog through focus** — the image has too little contrast for Gray variance. Improve the illumination, or switch to Laplacian variance.

8.3 The diagnostics log



Leave this window open while a sweep runs and you get a line for every sample:

```
C:1843, M:2310, Up, Dc:0, Sp:1600-S1
```

Field	Meaning
`C:`	Current sharpness score
`M:`	Highest score seen so far this sweep

Field	Meaning
`Up` / `Dn`	Current direction of travel
`Dc:`	Consecutive falling samples so far
`Sp:`	Commanded speed, and `-S1` / `-S2` / `-S3` for the step

The log is cleared at the start of each sweep and keeps the last 1000 lines. When the sweep ends, one camera summary line is appended — source fps, delivered fps, dropped frames and average callback time — which is exactly what Multitek support needs if focus is misbehaving. Camera errors are also logged here as they occur. **Clear log** empties the box by hand.

8.4 Indent detection (Autoread)

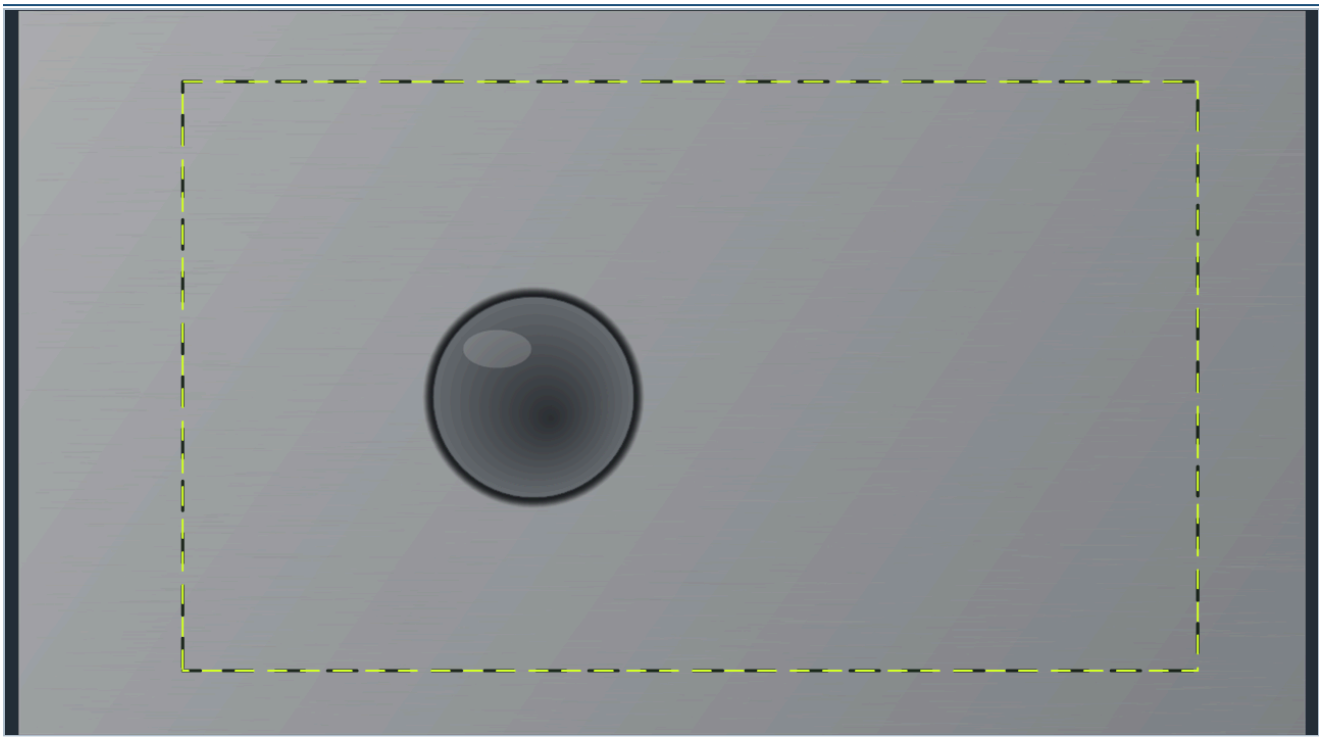
Autoread (right-click the image ▸ **Autoread**) runs a trained neural-network detector over the current frame, finds the indent, and snaps the four marker lines to its edges.

How it works, in order:

1. The current frame is converted to grey, then back to a three-channel image, and letterboxed into a square.
2. The square is scaled to 640 × 640 and passed to the model in `best_circle.onnx`.
3. Candidate boxes scoring at least 0.25 are kept, and overlapping candidates are merged.
4. Candidates are scaled back to full image coordinates.
5. **Only candidates that lie entirely inside the ROI rectangle survive.** The largest survivor wins.
6. The four **Detect indent margins** offsets are added to that box.
7. The marker lines are placed one pixel outside the adjusted box, D1/D2 are recomputed, and HBW is updated. The frozen, annotated frame is shown briefly before the live view resumes.

> **If no candidate lies entirely inside the ROI, the markers stay where they are.** The current build creates a centred 400 × 300 pixel ROI after the first frame establishes the source-image size. If Autoread does not move the markers, switch to **ROI**, draw a rectangle that fully contains the indent, return to **Markers**, then try again.

8.5 Detect indent margins (YOLO box adjust)



Setting	Default	Effect
Top offset	0	Moves the top edge of the detected box down by this many pixels (negative moves it up)
Bottom offset	0	Moves the bottom edge down by this many pixels
Left offset	0	Moves the left edge right by this many pixels
Right offset	0	Moves the right edge right by this many pixels

In effect, the box's **width** changes by `Right offset − Left offset`, and its **height** by `Bottom offset − Top offset`.

How to tune them:

1. Measure a certified indent by hand using **Fit Circle** and note D1 and D2.
2. Run **Autoread** on the same indent and note D1 and D2 again.
3. If Autoread reads consistently **small**, make the box wider: increase **Right offset** and decrease **Left offset** by the same amount, and likewise **Bottom** / **Top**.
4. If it reads consistently **large**, do the opposite.
5. Work in single pixels. The millimetres represented by one pixel come from the active lens's `Hardness_CF_X` and `Hardness_CF_Y`; use the calibrated values for that machine rather than a generic pixel-to-millimetre estimate.

These offsets correct a *systematic* bias in where the detector puts the edge. They cannot fix a detector that is finding the wrong thing entirely.

9. Making a measurement

The complete procedure, assuming the machine is licensed, calibrated and connected.

9.1 Prepare

1. Start Multitek BMS Essentials.
2. In the top bar, select the PLC's serial port and click **Connect PLC**. Wait for the indicator to turn green and the button to read **Disconnect**.
3. Click **Camera ON**. The status should read `● Live`.
4. Choose the **ball diameter** on the measurement toolbar to match the ball fitted to the indenter: `Ball Dia : 10.0 mm`, `5.0 mm` or `2.5 mm`.
5. Choose the **force** in the **Force Selection** list on the Machine Controls strip, to match the load the machine is set to apply.
6. If you are working to a test plan, load it: **Settings** tab ▸ **Set Test Pattern**, then pick the workbook. The results grid fills with the planned points, descriptions and tolerances. **New Test** reloads it and clears any readings.

9.2 Make the indentation

1. Place the specimen on the stage. Make sure it is supported, flat and clean.
2. Rotate the turret to the **indenter** position (turret button 2) and position the point of interest under it, using the X/Y stage.
3. Press **START** on the turret strip, or **Cycle Start**, to run the machine's indentation cycle. Watch the status line: *Detecting Surface – Fast Approach*, *Apply Load Fast*, *Apply Load Slow*, *Impression Stabilizing – Dwell Time*, *Release Load Slow*, *Move Back to Focus Point*. The button reads **RUNNING...** and flashes while the cycle is active.
4. Wait for the cycle to complete and the status to return to *Ready to Test*.

> The load profile and dwell time are set in the machine's PLC program, not in BMS. Use only the commissioned cycle for the selected ball and force; changes require the machine's authorised service procedure.

9.3 Focus and find the indent

1. Rotate the turret to the measuring objective — for a Brinell indent this is usually the low-power objective in position 1.
2. Click **Auto Focus**. Watch the button caption walk through *AutoFocus Step1*, *Step2*, *Step3* and finish at *AutoFocus Finished*. *Alternatively*, focus by hand with the ▲ / ▼ (slow) and ▲▲ / ▼▼ (fast) Z buttons on the Machine Operation panel.
3. If the indent is not centred, move it into view with the X/Y stage.
4. Optional but recommended: click **ROI** and drag a rectangle that comfortably contains the indent and nothing else. Then click **Markers** to go back to the working view.

9.4 Measuring with the circle tools

A Brinell indent is round, so the circle tools give a better answer than dragging straight lines.

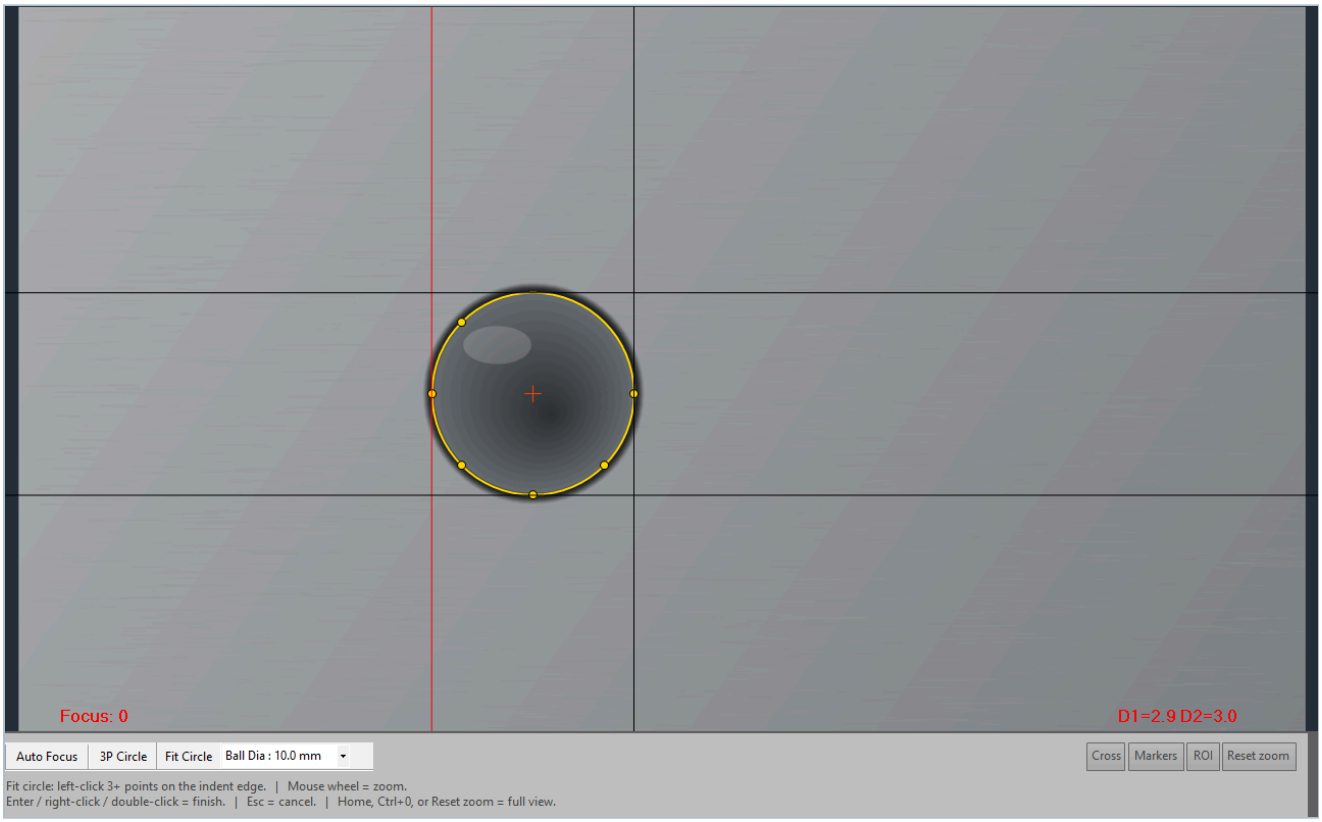
Best fit (recommended):

1. Click **Fit Circle**.
2. Left-click points all the way around the edge of the indent — the more, the better, and spread evenly. A running gold circle appears once you have three.
3. Zoom in with the mouse wheel for accuracy; the picked points stay put.
4. Press `Enter`, right-click, or double-click to finish. (`Esc` cancels.)

Three-point circle:

1. Click **3P Circle**.
2. Left-click exactly three points on the edge of the indent, well spread around it.
3. The circle is fitted immediately. (Right-click or `Esc` cancels.)

Both tools set D1 and D2 to the fitted circle's diameter converted to millimetres, so D1 and D2 will be very close to each other — which is what you want for a round indent.



Automatic detection: right-click the image and choose **Autoread**. The markers snap to the detected indent. See §8.4.

Manual markers: click **Markers**, then drag the two vertical lines to the left and right edges of the indent and the two horizontal lines to the top and bottom edges. Hover a line and roll the wheel to nudge it one pixel at a time. D1, D2 and HBW update continuously.

> Manual markers measure a *rectangle*, so D1 and D2 can legitimately differ if the indent is not perfectly round. The standard asks you to average two diameters at right angles — which is exactly what the HBW calculation does.

9.5 Record the reading

1. Check the big **HBW** number at the top of the Live Measure View panel.
2. Click the row you want in the results grid — or leave the current row selected.
3. Right-click the image ▸ **Update Value**.

That writes the hardness, the scale string, D1, D2 and the converted value into the row; captures the image with all overlays into `Shots\`; marks the row **Passed** or **Failed** against its tolerances; adds a new row if you were on the last one; and moves the selection down. If you are about to overwrite a row that already holds a reading, you are asked to confirm first.

4. Repeat from §9.2 for every point on the part.
5. When the set is complete, generate the report — §12 — **before** closing the application, because the indent images are deleted on exit.

---

10. Understanding the result

10.1 The numbers on screen

Where	What it is
`D1=` at the bottom right of the image	Horizontal indent diameter in millimetres, one decimal
`D2=` at the bottom right of the image	Vertical indent diameter in millimetres, one decimal
`Focus:` at the bottom left	Sharpness score, updated during an auto focus sweep only
The large box on the Live Measure View panel	The calculated hardness, one decimal
The box next to it	The same hardness converted to the scale chosen in **Conversion To**

10.2 Diameter and ball diameter

d, the value that goes into the formula, is `(D1 + D2) ÷ 2`.

D, the ball diameter, is whatever the **Ball Dia :** toolbar list is showing — 10.0, 5.0 or 2.5 mm. It is parsed straight out of the list text, so it changes the instant you pick a different entry, and HBW is recalculated immediately.

> Setting the ball diameter to match the ball actually fitted is the operator's responsibility. Nothing in the software checks it against the machine.

10.3 The force value and its units

F is the `Force_CF` value of the force you selected in the **Force Selection** list, straight from the `FORCE_SETTINGS` table. The software's own messages describe it as **kgf** — the calibration warning says "*at … kgf*", and the footer stamped on exported indent images says "*Force: … kgf*".

> **Check the force table against the machine's calibration certificate.** New databases use the standard Brinell kgf series, but an upgraded installation deliberately keeps its existing commissioning database.

10.4 The Scale column

When you record a reading, the **Scale** column is filled with a string built from three things:

```
<Conversion From text>  <ball diameter>/<force>
```

for example `HBW 10/3000`. This is the conventional Brinell designation: scale, ball diameter in millimetres, and load. If the force list entry does not begin with a number — the seeded row named simply `Force`, for instance — the load part comes out as `0`.

10.5 Scale conversions

Two lists sit under the hardness readout.

Control	Choices
Conversion From	`HBS`, `HBW` — the scale the measured value is treated as
Conversion To	`HV`, `HRA`, `HRB`, `HRC`, `HRD`, `HBW`, `HR15-N`, `HR30-N`, `HR45-N`, `SSCOPE`, `HK`, `HBS`, `ROCKWELL`, `HR15-T`, `HR30-T`, `HR45-T`

The conversion is a straight-line interpolation between the two nearest rows of a built-in hardness-equivalence table. The **Conversion To** choice also becomes the header of the **Conversion** column in the results grid, and the converted value is stored alongside each reading.

> **Two cautions.**
>
> 1. Hardness scale conversions are approximate by nature. They are valid only for the material families the reference tables were built from — broadly, unalloyed and low-alloy steels and cast iron. Never report a converted value as a measured value, and never convert for aluminium, copper alloys or hardened tool steels outside the table's range without checking the applicable standard.
> 2. A conversion is returned only where both scales contain defined reference-table values. Outside their common range the software displays **out of range** instead of extrapolating. For example, HBS ends at 500 in the built-in table while HBW continues to 739.

10.6 Pass and fail

If a row has a **TolMin**, a **TolMax**, or both, the hardness is compared against them and the **Result** cell is filled with **Passed** (green) or **Failed** (red). A row with neither tolerance filled in is left blank — it is a reading, not a judgement.

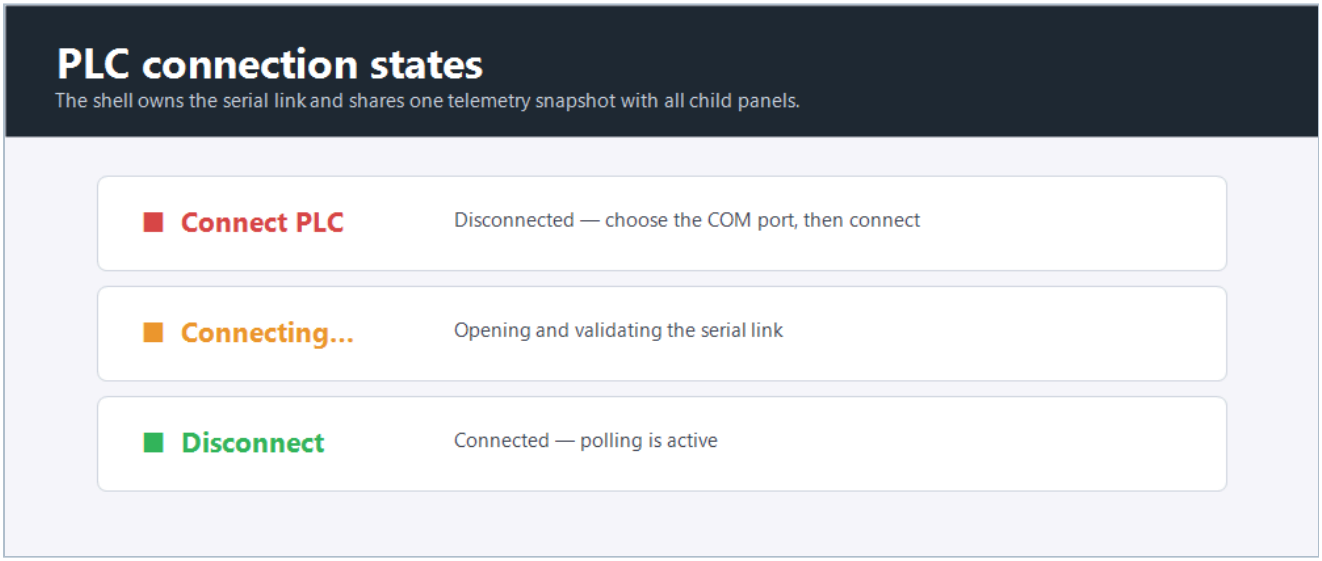
Editing the hardness, the conversion or either tolerance re-evaluates the row immediately.

11. Machine operation and the turret

11.1 Connecting the PLC

1. Switch the machine on and wait for its own start-up to complete.
2. In the top bar, pick the serial port from the list. Press ⟳ first if the port is not listed (for example after plugging in a USB-to-serial adapter). Your choice is remembered.
3. Click **Connect PLC**.
4. The button reads **Connecting…** while the link is established and the machine identity is verified. On success the indicator turns green and the button becomes **Disconnect**.

The link is a Delta serial connection at **9600 baud, 7 data bits, even parity, 1 stop bit**. Once connected, the application polls machine telemetry about three times a second and every panel updates from that single stream.



Indicator	Button	Meaning
Red ■	**Connect PLC**	Not connected
Orange ■	**Connecting…**	Opening the port and validating the machine
Orange ■	**Reconnecting…**	The link dropped; the driver is retrying (up to three attempts)
Green ■	**Disconnect**	Connected and validated
Red ■	**Retry PLC**	Communication fault; click to try again

If you press a machine control while the PLC is disconnected, the whole PLC group in the top bar pulses amber for a few seconds with the caption **Connect PLC !** — that is the software telling you the command went nowhere.

> **Machine identity check.** BMS validates the connected machine before enabling control. If the identity does not match the BMS profile, the software shows "*Incorrect machine connected*" and closes immediately so it cannot drive a different Multitek machine. If you see it, you are on the wrong PC, the wrong port, or the wrong PLC program.

If the poller loses the connection after a successful start, you get "*PLC Connection Lost*" and the software disconnects cleanly.

11.2 The Machine Controls tab

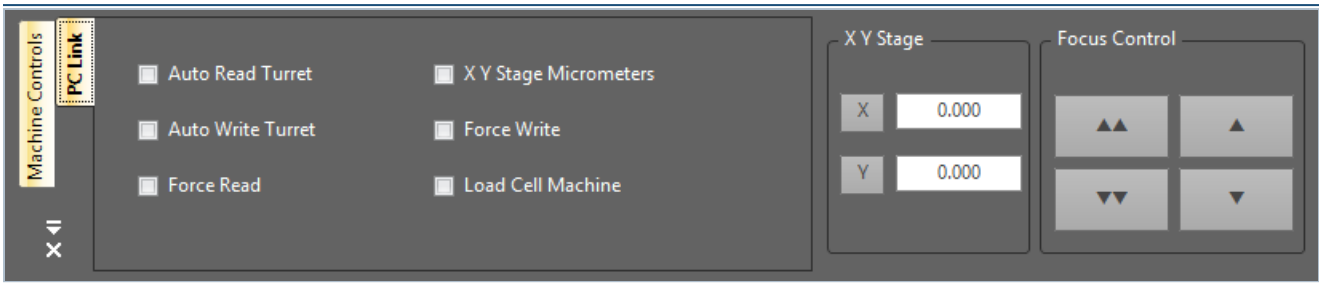
Control	What it does
Status line	Plain-language machine state — see the table in §11.6
STOP (red)	Emergency stop: raises the stop flag, pulses the machine's stop bit, and aborts any auto focus sweep
Force Selection	The force list from `FORCE_SETTINGS`. Choosing a force loads its value for the HBW calculation and, if **Force Write** is ticked, tells the machine to use it.
Load readout (kgf)	The live load-cell reading, shown only when **Load Cell Machine** is ticked. **Double-click it to zero the cell** — you are warned to make sure the indenter is free and clear first.
X Y Micrometers group	Live X and Y stage position in millimetres to three decimals, with **X** and **Y** buttons that zero the respective axis. Shown only when **X Y Stage Micrometers** is ticked.
Z Axis group	▲ slow up, ▲▲ fast up, ▼ slow down, ▼▼ fast down. The motion runs while the button is held and stops when you release it or move the pointer off it. The whole group is hidden while a machine cycle is running.

11.3 Selecting the test force

1. Tick **Force Read** on the PC Link tab if you want the software to follow the machine's own force selection, or **Force Write** if you want the software to command it.
2. Pick the force in **Force Selection**.
3. With **Force Write** on, the software writes the list position to the machine and pulses the force-set bit.
4. The HBW calculation switches to the new force immediately.

Your force choice is remembered across restarts, clamped to the list if the table has changed.

11.4 The PC Link tab



Checkbox	Effect
Auto Read Turret	The software follows the machine's reported turret position and highlights the matching lens button automatically
Auto Write Turret	Clicking a lens button actually commands the machine to rotate the turret. With this **off**, clicking a lens button only changes which calibration factors are used — the turret does not move, and the status line says *Move to Turret Pos* rather than *Moving to Turret Pos*.
X Y Stage Micrometers	Show and update the X/Y position display
Load Cell Machine	Show and update the load-cell readout
Force Read	Follow the machine's force selection
Force Write	Command the machine's force selection

All six are remembered between sessions.

11.5 The turret strip

One button per row of the lens table, in table order. The active lens is drawn with its "on" picture.

Element	Behaviour
Lens buttons	Click to select. The selection is saved, the lens's calibration factors are loaded immediately, and — if **Auto Write Turret** is on — the machine is commanded to that position.

Element	Behaviour
Status label	Shows *Moving to Turret Pos (name: n)* while a move is in progress; the strip is disabled until it completes.
START	Starts the machine's measuring/indentation cycle. Reads **RUNNING...** and flashes red while a cycle is active, and **START** on a cream background otherwise. Before the PLC connects it reads **Disconnected**.

A commanded move waits up to 10 seconds for the machine to report the new position (5 seconds when **Auto Write Turret** is off, since the software is only waiting for you to turn the turret by hand). If the position never arrives after a commanded move you get "*Turret Error.*"

The lens selection is remembered across restarts and restored on startup, defaulting to position 1.

11.6 Machine status messages

Message	Meaning
Ready to Test	Idle, ready
Turret Move: Left Lens to Indenter	Turret rotating
Turret Move: Indenter to Right Lens	Turret rotating
Turret Move: Right Lens to Indenter	Turret rotating
Turret Move: Indenter to Left Lens	Turret rotating
Turret Move: Right Lens to Left Lens	Turret rotating
Turret Move: Left Lens to Right Lens	Turret rotating
Z Axis UP Movement	Z axis rising
Z Axis Down Movement	Z axis descending
Detecting Surface - Fast Approach	Finding the specimen surface
Apply Load Fast	Loading
Apply Load Slow	Loading, final approach to full load
Impression Stabilizing - Dwell Time	Holding the load
Release Load Slow	Unloading
Move Back to Focus Point	Returning to the measuring height
Turret Position Error	The turret did not reach the commanded position
Sample Too Far - Focus Error	The surface was not found within travel — raise the specimen
Sample Too Near - Focus Error	The surface is too close — lower the specimen
Load System Homing	Load mechanism homing

Message	Meaning
Load System Homing Error	Homing failed
MHT Load Cell Overload Alarm	Load cell overloaded
VHT Load Cell Overload Alarm	Load cell overloaded
Left / Right / Back / Front / Top / Bottom Limit	A travel limit has been reached

The exact recovery action for homing, limit and overload alarms is machine-specific. Follow the machine manual and the site's lock-out procedure; do not clear an overload merely by restarting BMS.

12. Recording results and generating reports

12.1 The results grid

Column	Header	Filled by
Serial number	`No`	Pattern file, or automatically as rows are added
Description	`Description`	Pattern file, or typed by you
Hardness	`HBW`	**Update Value**, or typed by you
Scale designation	`Scale`	**Update Value**
Pass/fail	`Result`	Calculated from the tolerances
Horizontal diameter	`D1`	**Update Value**
Vertical diameter	`D2`	**Update Value**
Converted value	*(named after the Conversion To scale)*	**Update Value**
Lower tolerance	`TolMin`	Pattern file, or typed by you
Upper tolerance	`TolMax`	Pattern file, or typed by you
Target cell in a custom template	`Excel Cell`	Pattern file, or typed by you
Snapshot path	`Image Path`	**Update Value** (hidden in normal use)

Which columns are visible is controlled by the checkboxes on the **Settings** tab of the right-hand panel: `SrNo`, `Description`, `HV`, `Scale`, `Conversion`, `D1`, `D2`, `Tolerance Minimum`, `Tolerance Maximum`, `Result (Pass / Fail)` and `Excel Address`.

> Known quirk: the checkboxes are not synchronised with the restored column visibility at startup, so a tick box can disagree with what the grid is actually showing until you click it. Visibility of `SrNo`, `HV` and `Excel Address` is not remembered between sessions at all.

Typing directly into the hardness, conversion or tolerance cells is allowed and re-evaluates the row. Editing the hardness cell also updates the big readout and redraws the chart.

12.2 Test pattern files

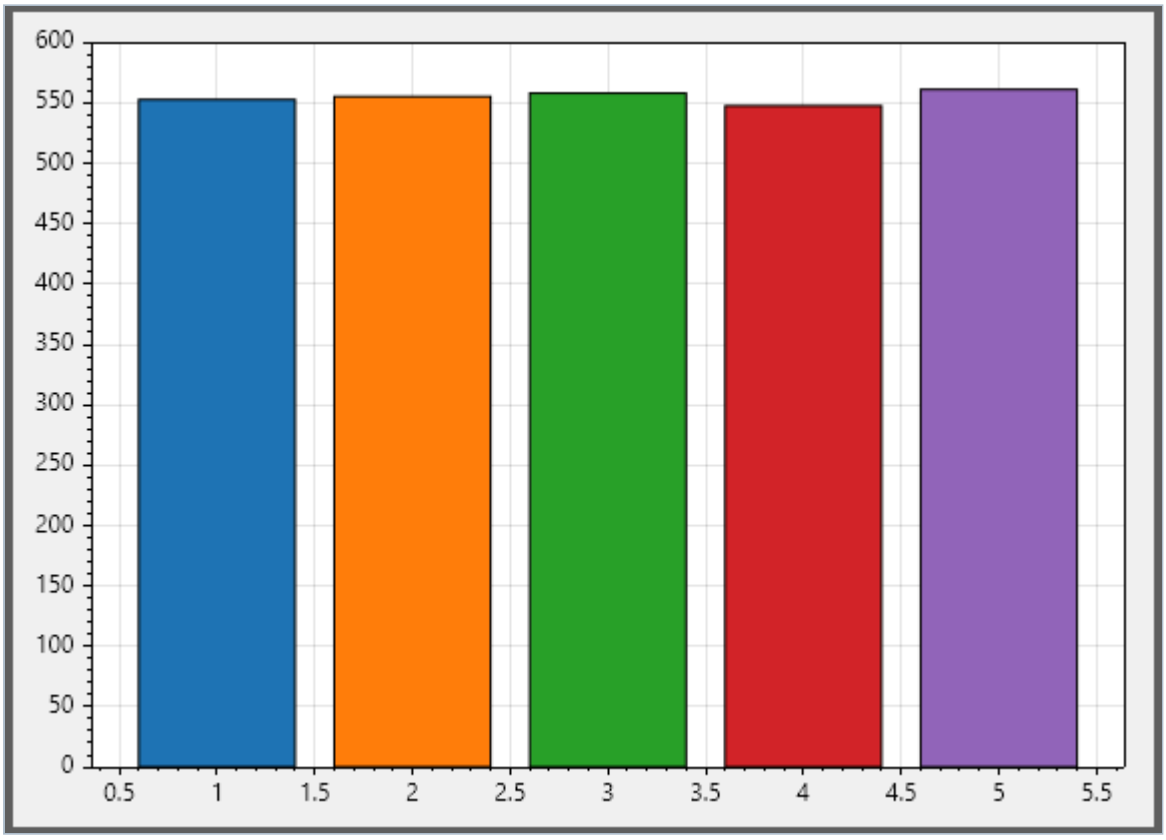
A test pattern is an ordinary Excel workbook that pre-loads the grid with the points you have to measure. Load one from the **Settings** tab ▸ **Set Test Pattern**; the picker opens in `MT.Service.Packs\Patterns`. The chosen file is remembered and reloaded at every startup, and **New Test** reloads it to start a fresh part.

The first worksheet is read. The **first two used rows are treated as headings and skipped**; everything after that becomes a grid row, taking:

Workbook column	Goes to grid column
A	`No`
B	`Description`
C	`TolMin`
D	`TolMax`
E	`Excel Cell`

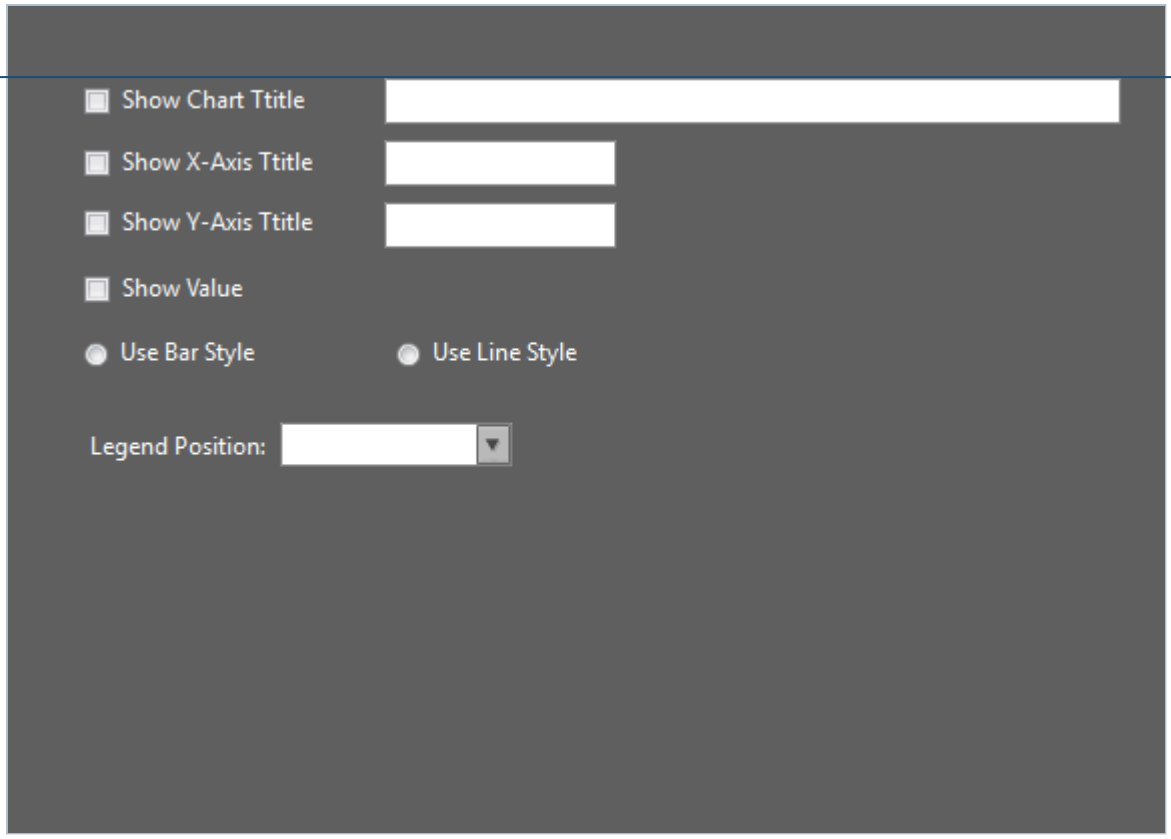
`MT.Service.Packs\Patterns\Ptn_Blank BMS.xlsx` is supplied as a starting point. Its first worksheet uses row 1 for the headings `SrNo`, `Description`, `Min`, `Max`, `Address`; sample data begins on row 2 and maps directly to columns A–E in the table above.

12.3 The chart



The **Chart** tab plots one bar per row of the results grid, using the hardness column. It refreshes whenever a hardness value changes or a row is removed, and the current chart image is embedded near the top of every default report.

The **Settings** sub-tab controls its appearance:

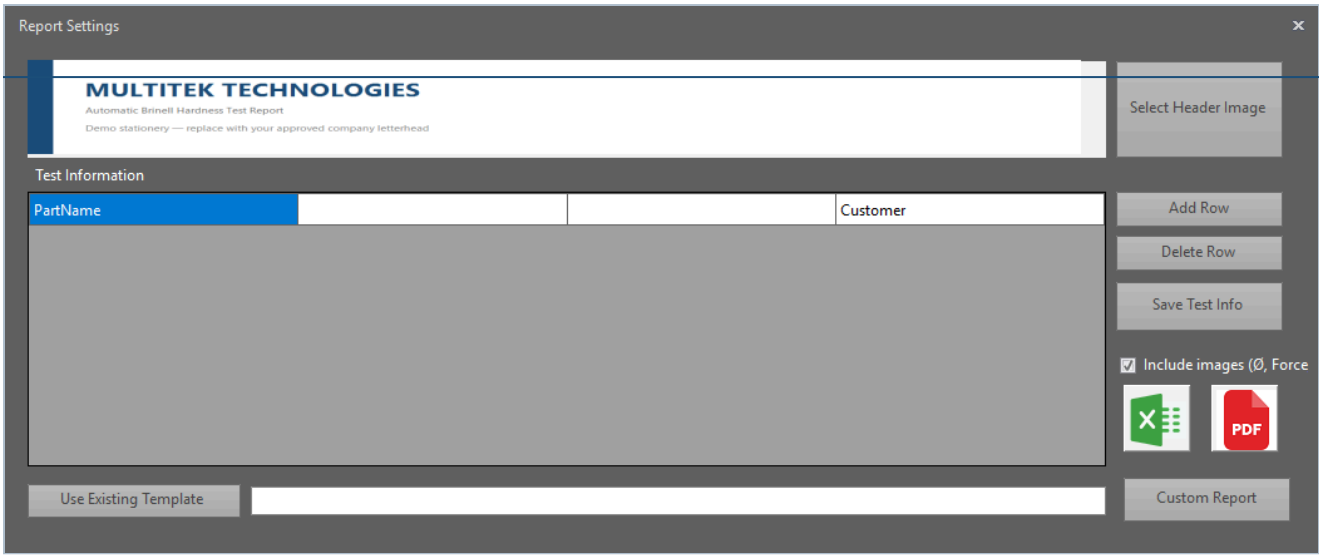


Control	Default	Effect
Show Chart Title / title text	on / `Harness`	Title above the plot
Show X-Axis Title / text	off / `Distance (mm)`	X-axis label
Show Y-Axis Title / text	off / `HV`	Y-axis label
Show Value	on	Prints each bar's value beside it
Use Bar Style / **Use Line Style**	Bar	The current build draws bars for both choices; **Use Line Style** is retained for compatibility but has no visible effect.
Legend Position	`Top Right`	`Top Left`, `Top Right`, `Bottom Left`, `Bottom Right`

Chart settings are applied when you switch to the **Chart** tab.

12.4 Report Settings

Report button on the Live Measure View panel.



Control	What it does
Test Information grid	Four columns of free text that become the header block of the report
Add Row / **Delete Row**	Add or remove a line of test information
Header image preview	The letterhead that goes at the very top of the report
Select Header Image	Choose a `.png`, `.jpg`, `.jpeg` or `.bmp`. The picker opens in `MT.Service.Packs\Stationery`.
Include images (Ø, Force, HBW footer + software tag)	Embeds each reading's indent snapshot in the report, with a black footer strip carrying D1 × D2, the average diameter, the force, the HBW value and a Multitek credit line
Save Test Info	Saves the test information grid and the include-images choice
Excel icon	Generates the default report as `.xlsx` and opens it
PDF icon	Generates the default report and converts it to `.pdf`
Use Existing Template	Choose a custom `.xlsx` template. The picker opens in `MT.Service.Packs\Stationery`.
Custom Report	Fills the chosen template and opens the result

Closing the window saves the template path and the test information automatically.

12.5 Customising the report header and test information

The letterhead:

1. Prepare an image — a logo strip, a company header, a form heading. A wide, short image works best; it is stretched across the width of the report.
2. **Report** ▸ **Select Header Image** ▸ pick the file.
3. It is best practice to keep the image in `MT.Service.Packs\Stationery` so that it travels with the rest of your data when the software is upgraded. The default location and name is

`MT.Service.Packs\Stationery\BMSReportHeader.png`, and if the remembered file is ever missing the software falls back to that path. If neither exists, the report is produced without a letterhead.

The test information block:

This is the grid of labels and values printed beneath the letterhead — part name, customer, date, batch code, heat code, shift, operator, machine ID and so on. It is four columns wide, and columns alternate between bold labels and plain values.

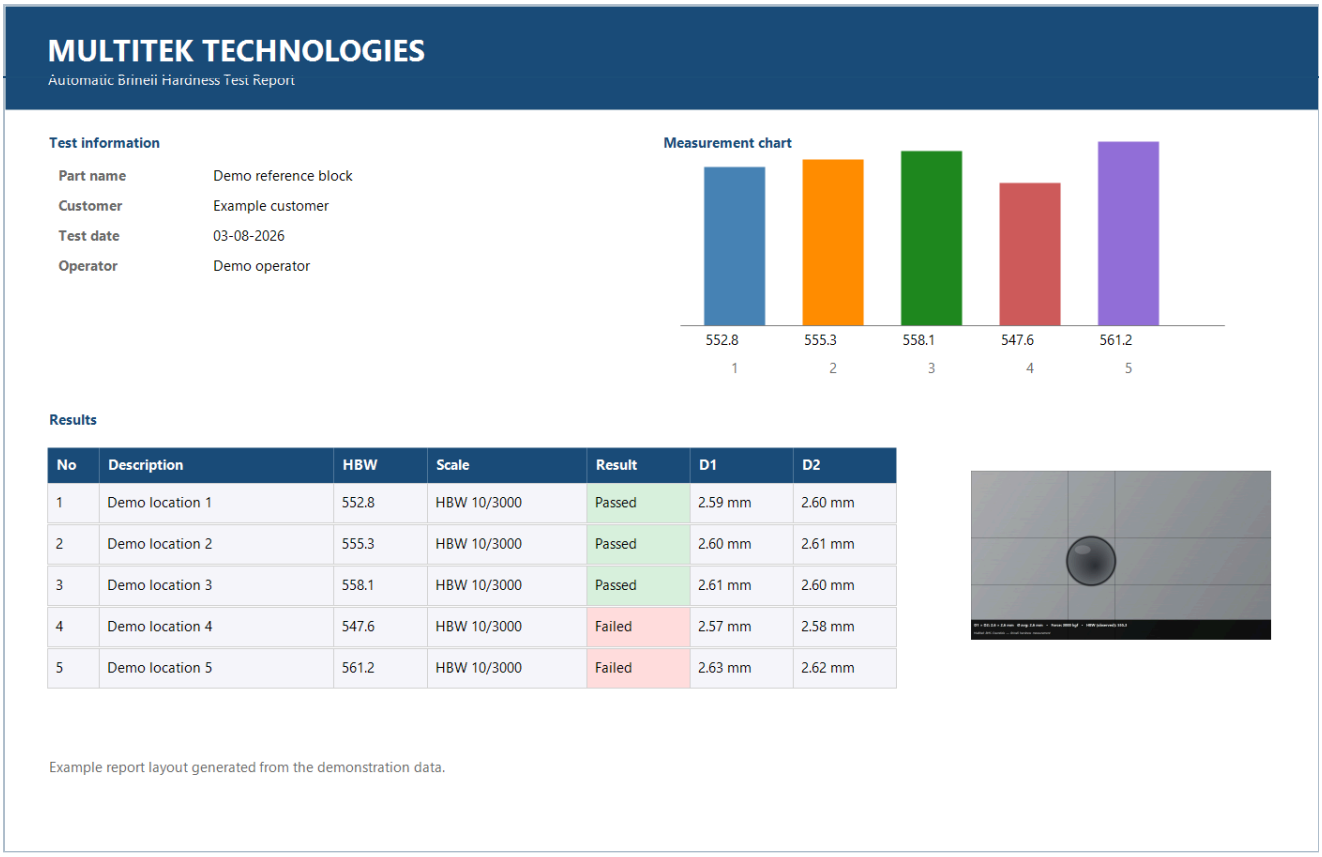
1. **Report** ▸ edit the **Test Information** grid.
2. Put the label in the first column and the value in the second; the third and fourth columns give you a second label/value pair on the same line.
3. Leave a row's cells empty to create a blank line.
4. **Add Row** / **Delete Row** to change the number of lines.
5. **Save Test Info**.

The supplied default is:

PartName			
Customer		Date	
Batch Code		Heat Code	
Shift		Operator	
Machine ID	Multitek MLT-2	Measurement System	BMS Essentials

12.6 Generating the default report

1. Complete your readings. Do not close the application — the indent images live in a folder that is emptied on exit.
2. Click **Report**.
3. Tick **Include images** if you want the indent snapshots embedded.
4. Click the **Excel** icon for a workbook, or the **PDF** icon for a PDF.
5. The file is written next to the application as `BMS Report.xlsx` (or `.pdf`) and opens automatically.



The default report is laid out as: letterhead across the top; the test information block; the chart; the results table with Passed cells filled green and Failed cells filled red, and each reading's indent image alongside if images are included; then **Disposition**, **Remarks**, and **Checked by** / **Approved by** signature boxes. It is set up to print on A4, fitted to one page wide.

> `BMS Report.xlsx` **is overwritten every time.** Save or rename it before you generate the next one.

PDF export needs Microsoft Excel installed on the PC. If Excel is not available you get "*PDF export requires Microsoft Excel to be installed on this computer. The Excel report was created instead.*" and you keep the workbook.

12.7 Using a custom Excel template

If your customer or quality system needs a specific form, you can fill one directly.

1. Build the form in Excel and save it as `.xlsx`, ideally in `MT.Service.Packs\Stationery`.
2. Decide which cell each measurement point should land in.
3. In the results grid, put the target cell address (for example `D14`) in the **Excel Cell** column of each row. Show the column with the **Excel Address** checkbox on the Settings tab, or supply the addresses from column E of your test pattern file.
4. **Report** ▸ **Use Existing Template** ▸ choose your file.
5. Click **Custom Report**.
6. The filled workbook is written to a `Final Reports` folder next to the application and opened.

Only the hardness value is written, into the named cell. The chart, the images and the test information block are not used in custom-template mode.

> Two things to watch. Every row that will be processed needs a valid cell address — an empty or malformed address aborts the whole report with a raw error message. And the generated file name is built from the current minute and hundredths of a second, not the date, so custom reports can collide with each other. Rename each one as soon as it is produced.

12.8 Exporting a single indent image

Export Indent on the top bar (or **Save** on the Live Measure toolbar) writes the current view — image, markers or fitted circle, everything you can see — to a JPEG of your choosing, with a footer strip carrying `D1 × D2`, the average diameter, the force in kgf, the HBW value and the line *Multitek BMS Essentials — Brinell hardness measurement*. The default file name is stamped with the date and time.

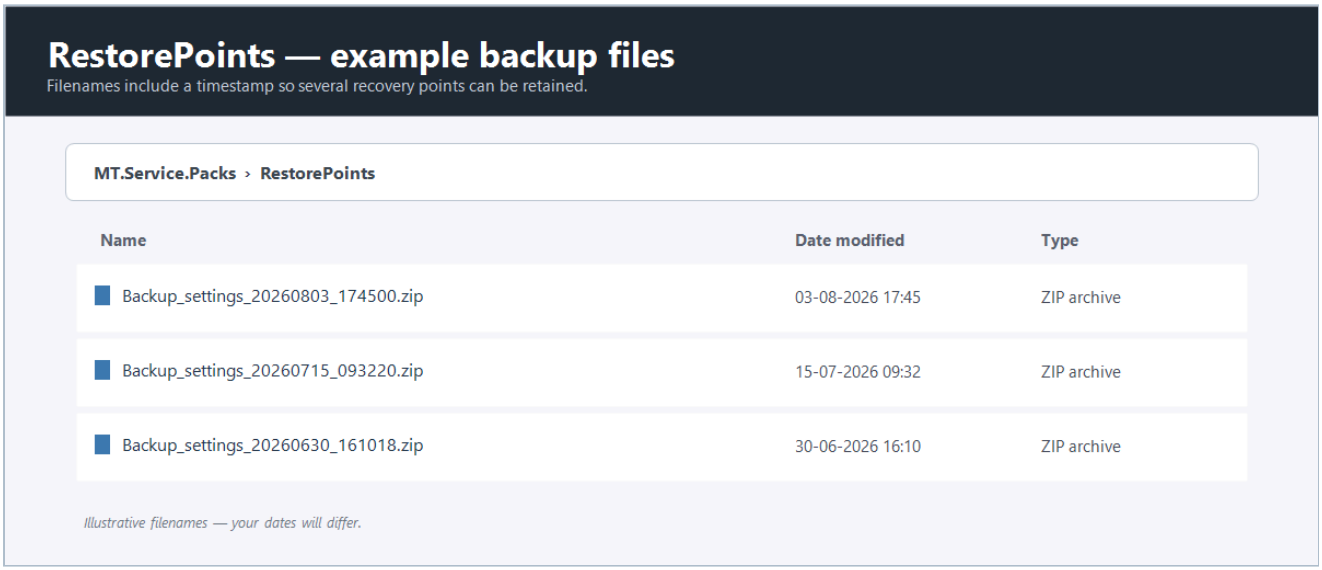
13. Settings backup and restore

Your **settings** are the application's own preferences — camera choice and orientation, auto focus tuning, ROI, report test information, grid column choices, chart options, PC-Link tick boxes, the remembered COM port and lens. They live in the Windows per-user settings file, **not** in `MT.Service.Packs`, which is why they need their own backup.

Settings are saved automatically when the application exits, and at various points during use (closing Camera Setup, closing Auto Focus setup, changing a PC-Link tick box, finishing an ROI drag, choosing a COM port, choosing a lens).

13.1 Backing up your settings

1. **Settings** ▸ **Backup**.
2. A save dialog opens in `MT.Service.Packs\RestorePoints` with a name already filled in, of the form `Backup_settings_03.08.2026.05.12.44`.
3. Accept the name or change it, and save.
4. You get "*Succeeded to backup Settings.*"



Take a backup:

- after commissioning, once the camera, focus and report settings are all correct;
- before any software upgrade;
- before letting anyone experiment with the auto focus or camera settings.

The file has no extension by default. Leave the suggested name alone and it will sort by date in Explorer.

13.2 Restoring your settings

1. **Settings** ▸ **Restore**.
2. Pick a backup file from `MT.Service.Packs\RestorePoints`.
3. You are told the restored values take effect after a restart, and asked whether to restart now.
4. Answer **Yes** to restart immediately, or **No** to keep working and restart later.

Restoring copies the backup over the live settings file. Nothing in `MT.Service.Packs` — licence, database, patterns, stationery — is touched.

> Because the application is single-instance, some Windows installations may focus the existing instance instead of completing the automatic restart. If BMS does not return within a few seconds, close it and start it again from the desktop; the restored settings file is already in place.

13.3 Recovering from a corrupted settings file

If Windows cannot read the settings file at startup, you are asked "*The settings was corrupted. Would you restore it from any backup?*"

- **Yes** — pick a backup from `RestorePoints`, as in §13.2.
- **No**, or if the restore fails — the settings file is deleted and you are told "*The settings was reset to default values.*" The application then continues with factory defaults. You will need to re-select the camera, re-check the report settings and re-tune auto focus. Your licence, calibration and patterns are unaffected because they are in `MT.Service.Packs`.

14. Troubleshooting

14.1 Camera

Symptom	Likely cause	What to do
Camera Setup lists only "No camera found"	Camera not plugged in; driver not installed; another application already has the camera open	Plug the camera in, close any other application using it (Skype, Teams, the vendor's viewer), install the driver, then press **Rescan**
"The camera could not be started"	Device in use, driver fault, or the saved resolution is not available	Close whatever else is using the camera; open **Camera Setup**, pick a different **Resolution**, press **Apply**
"No camera was found. Connect the camera and try again."	No DirectShow device present at all	Check the cable and the Device Manager entry, then press **Camera ON** again
Status shows `● Reconnecting` repeatedly	Marginal USB cable, unpowered hub, camera browning out	Try a different USB port (ideally a rear port on the PC), a shorter or better cable, or a powered hub. Check `Reconnects` in the diagnostics panel.
Status shows `● Camera Lost`	Automatic reconnection gave up after repeated attempts	Re-seat the cable, then click **Camera ON**. Read the `Last error` line in the diagnostics panel before you clear it.
`● Paused` and the image is frozen	The play/pause button was pressed	Click the play/pause button again
Image on screen but nothing in the diagnostics panel	Camera has not been started through the application (for example a still image is loaded)	Click **Camera ON**
Dropped frames climbing, delivered rate well below source rate	PC cannot keep up with the chosen resolution	Lower the resolution; close other applications; check `Callback avg / max`; make sure **Discard stale frames** is ticked
Live image lags behind the stage	**Discard stale frames** is off	Tick **Discard stale frames** and press **Apply**
Image is upside down	Optical path, or a driver default	**Camera Setup** ▸ **Image orientation** ▸ **Flip vertically**, or **Rotation 180°**
Image is mirrored left-to-right	Odd number of mirrors/prisms, or driver selfie-view mirroring	Tick **Mirror horizontally**
Image is on its side	Camera mounted rotated	Set **Rotation** to 90° or 270°
Ticking Mirror or Flip changes nothing	The camera claims hardware support and then ignores the request	Clear **Let the camera do it where supported**; confirm the diagnostics **Mirror**/**Flip** lines now say `on (software)`

Symptom	Likely cause	What to do
"Please start the camera first, then open driver settings."	Driver property page requested with no capture running	Click **Camera ON**, then **Driver properties...**
Resolution reverts, or the negotiated format differs from the choice	Driver substituted a mode it prefers	Pick a different resolution; check the `Negotiated format` diagnostics line
Measurements changed after touching the camera	Resolution or optics changed	**Recalibrate every objective** — §7

14.2 Focus and detection

Symptom	Likely cause	What to do
Auto Focus does nothing and the axis never moves	PLC not connected	Connect the PLC. The button will keep cycling for roughly eight minutes before reporting *AutoFocus Failed* — click **Auto Focus** again to stop it now.
Auto Focus refuses to start	Turret is on position 2, the indenter	Rotate to a measuring objective first
Auto Focus reports "AutoFocus Failed"	The sweep ran out of attempts without converging	Focus roughly by hand first, then run auto focus; reduce the base speed for that objective; try the other variance method
Auto Focus reports "Emergency Stop"	The STOP button was pressed during the sweep	Clear the machine, then run again
Auto Focus stops short of sharp focus	Drop counts too small — reversing on image noise	Increase **Step 1 drop count**, then Step 2
Auto Focus overshoots and takes a long time	Drop counts too large or base speed too high	Reduce the base speed for the objective; reduce the drop counts
`Focus:` **barely changes through focus**	Too little contrast	Improve illumination; switch **Variance selection** to **Laplacian variance**
Autoread does nothing at all — no message, no marker movement	No candidate detection lies entirely inside the ROI, or no ROI has ever been drawn	Click **ROI**, drag a rectangle around the indent, click **Markers**, then try **Autoread** again
"YOLO model not loaded. Place best_circle.onnx next to the application."	The model file is missing	Copy `best_circle.onnx` into the program folder and restart
"Model file 'best_circle.onnx' not found next to the application." at startup	Same	Same
"No image available for detection."	Camera not started and no image loaded	Click **Camera ON**, or **Open Image**

Symptom	Likely cause	What to do
Autoread finds something that is not the indent	Reflection, scratch or edge inside the ROI	Shrink the ROI so it contains only the indent; improve the lighting
Autoread is consistently a little large or a little small	Systematic edge bias	Tune the **Detect indent margins** offsets — §8.5

14.3 Measurement and calibration

Symptom	Likely cause	What to do
HBW shows `0.0`	No force selected, no ball diameter, D1/D2 zero, or the average diameter is larger than the ball	Select a force; select the ball diameter; re-measure; check you are on the right ball size
HBW is plainly wrong by a large factor	Lens not calibrated, or the wrong lens is highlighted	Highlight the correct lens on the turret strip; recalibrate — §7
"Calibration is missing the following: ..."	One or more preconditions unmet	Work through the bullet list in the message; each line names exactly what to do
"Target HV ... is not physically achievable with ball Ø ... at ... kgf"	The target hardness cannot be produced by that ball and load	Choose a larger ball or a different force and re-measure
"Lens '...' is not present in the turret table"	The highlighted lens has no matching row	Open the turret table with password `123456` and add the lens row
"Computed calibration factor is invalid (NaN/Infinity)"	Bad operands slipped through	Re-measure the indent; check the current lens has positive CF_X and CF_Y
"Database save failed"	`BMSDB` is read-only, missing or locked	Check that `MT.Service.Packs\Records\BMSDB` exists and that the program folder is writable; close any tool that has the file open
"Could not fit a circle from these points."	The picked points are collinear or too close together	Spread the points evenly right around the indent edge
"Please select at least 3 points for best-fit circle measurement."	Fewer than three points picked	Pick more points before pressing Enter
Conversion shows `out of range`	The measured hardness lies outside the range where both selected scales have defined table values	Report the measured HBW or select a target scale whose reference-table range overlaps the reading — §10.5
Force reads as `0` in the Scale column	The force list entry does not start with a number	Rename the force entry so it begins with the numeric load, e.g. `3000 kgf`

14.4 Machine and PLC

Symptom	Likely cause	What to do
The PLC toolbar pulses amber	You used a machine control while disconnected	Select the port and click **Connect PLC**
"Connection failed: ..."	Wrong port, port in use, machine off, cable fault	Check the machine is powered; press ⟳ and re-select the port; close any terminal program using it
"Timed out waiting for PLC telemetry and machine identity validation."	Link opened but no valid data arrived within 10 seconds	Check the cable and the PLC program; confirm the port settings match the machine (9600, 7 data bits, even parity, 1 stop bit)
"Incorrect machine connected" and the application closes	The connected machine identity does not match the BMS profile	You are connected to a different Multitek machine or the wrong PLC program is loaded. Contact Multitek.
"PLC Connection Lost"	The link dropped while running	Check the cable, then reconnect
"Turret Error."	The turret did not reach the commanded position in time	Check for a mechanical obstruction; check **Auto Read Turret** is ticked so the software can see the position
Clicking a lens button does not move the turret	**Auto Write Turret** is off	Tick **Auto Write Turret** on the PC Link tab, or rotate the turret by hand
The lens highlight jumps back on its own	**Auto Read Turret** is on and the machine reports a different position	Expected behaviour — the machine is the authority
Status says *Sample Too Far / Too Near - Focus Error*	The specimen is outside the machine's search range	Adjust the specimen height or the anvil and run the cycle again
X/Y or load cell readouts stay at zero	The corresponding PC Link checkbox is off	Tick **X Y Stage Micrometers** / **Load Cell Machine**
Load cell readings are offset	Cell needs zeroing	Move the indenter clear, double-click the kgf readout, confirm the warning
START stays lit as RUNNING after the cycle	The turret **START** button latches the machine's cycle bit on rather than pulsing it, so the machine can be left holding it	Report to Multitek; in the meantime confirm the cycle state on the machine's own indicators

14.5 Licence

Symptom	Likely cause	What to do
The licence dialog appears at every start	No valid licence found	Complete the licensing procedure — §3.3

Symptom	Likely cause	What to do
"License does not belong to this machine."	The licence was issued for a different Machine ID	Send the Machine ID shown in the dialog to Multitek and request a new licence
"License product mismatch. Expected Multitek BMS Essentials."	The licence is for a different Multitek product	Request the correct licence
"Invalid serial number." / "Unsupported license version."	Damaged or obsolete licence file	Request a fresh licence
"License file was not found." / "License file is empty."	The `.lic` file has been moved, deleted or truncated	Restore it into `MT.Service.Packs\Binding`, or request a new one
"Please connect Camera, and Restart"	The application could not read the CPU identifier. *Despite the wording, this has nothing to do with the camera.*	Run the application as a normal user on the physical machine; confirm Windows Management Instrumentation is working; contact Multitek
A valid licence still is not picked up at startup	More than one `.lic` file in `Binding` and no remembered file name	Leave exactly one `.lic` file in `MT.Service.Packs\Binding`, or re-run **Check License** to record the file name
The licence stopped working after a hardware change	The Machine ID is derived from the CPU	Request a new licence for the new Machine ID

14.6 Reports and data

Symptom	Likely cause	What to do
The report has no images	**Include images** unticked, or the application was restarted since the readings were taken	Tick **Include images**; take readings and generate the report in the same session — the snapshot folder is emptied on exit
The report has no letterhead	No header image selected and no `BMSReportHeader.png` in `Stationery`	**Report ▸ Select Header Image**
"PDF export requires Microsoft Excel to be installed..."	No Excel on the PC	Use the Excel report, or install Excel
The report will not save	`BMS Report.xlsx` is open in Excel, or the program folder is read-only	Close the workbook; install the application somewhere writable
"Excel file does not exist."	The custom template path is wrong	**Report ▸ Use Existing Template** and re-select it

Symptom	Likely cause	What to do
A custom report fails with a cell-reference error	A row has an empty or invalid **Excel Cell** address	Fill in a valid address for every row, or delete the empty rows
Custom reports overwrite each other	The generated name is built from minutes and hundredths of a second, not the date	Rename each report as soon as it is produced
A previous report was overwritten	The default report always writes `BMS Report.xlsx`	Save or rename each report before generating the next
Test pattern loads with the first rows missing	The first two used rows of the sheet are treated as headings	Put two heading rows at the top of the sheet
The pattern picker shows nothing	`MT.Service.Packs\Patterns` is empty	Put your pattern workbooks there

14.7 Application

Symptom	Likely cause	What to do
The application will not start at all	Missing runtime files, corrupt install	Read `%USERPROFILE%\bms_startup_log.txt` and send it to Multitek
"The settings was corrupted..."	The Windows settings file is unreadable	Restore from `RestorePoints`, or accept the reset — §13.3
Double-clicking the icon does nothing	An instance is already running	Look for it on the taskbar; only one copy can run
The Live Measure window will not close	Deliberate — closing it would remove the working screen	Close the application from the ✕ in the top bar
After a Restore, the application did not restart	Single-instance handover	Start it again from the desktop
Everything was lost after an upgrade	`MT.Service.Packs` was not carried across	Copy the old folder in and restart — §4.2

15. Glossary

Term	Meaning
Autoread	The automatic indent-detection command on the image right-click menu. Runs the trained model and snaps the markers to the detected indent.
Ball diameter (D)	The diameter of the hardened ball in the indenter, in millimetres. Selected on the measurement toolbar as 10.0, 5.0 or 2.5 mm.
Best fit circle	A circle fitted through three or more points you click around the edge of the indent, using a least-squares fit.
Binding	The `MT.Service.Packs` subfolder holding the licence file that binds the software to this PC.
BMSDB	The SQLite database in `MT.Service.Packs\Records` holding lens and force calibration.
Calibration factor (CF_X, CF_Y)	Millimetres per pixel, horizontally and vertically, for one objective lens.
Cycle	One complete machine indentation sequence: approach, load, dwell, unload, return.
D1 / D2	The horizontal and vertical measured diameters of the indent, in millimetres.
Dispatch mode	How captured frames reach the application. `LatestFrame` keeps the newest frame and drops the backlog; `Synchronous` delivers every frame on the capture thread.
Drop count	How many consecutive falling sharpness samples an auto focus step tolerates before it reverses.
Dwell time	How long the full test load is held on the specimen. Set in the PLC, not in this software.
HBW	Brinell hardness measured with a tungsten-carbide ball. The number this software calculates.
HBS	Brinell hardness measured with a hardened-steel ball.
HV / HRA / HRB / HRC / HK	Vickers, Rockwell A/B/C and Knoop hardness scales, available as conversion targets.
Indent / indentation	The round impression the ball leaves in the specimen.
Indenter	The tool holding the ball. Occupies turret position 2.
Laplacian variance	A sharpness measure based on edge energy. One of the two auto focus scoring methods.
Gray variance	A sharpness measure based on the spread of grey levels. The other auto focus scoring method.
Machine ID	The four-group hexadecimal identifier derived from this PC's CPU, used to issue a licence.
Marker lines	The four draggable lines — two vertical, two horizontal — that define D1 and D2 by hand.
Moniker	The stable identifier Windows gives a capture device. Used to re-find the right camera after a re-plug.

Term	Meaning
MT.Service.Packs	The single folder next to the executable that holds all of this installation's data.
Objective	A microscope lens on the turret, e.g. 10×.
Pattern file	An Excel workbook that pre-loads the results grid with planned measurement points and tolerances.
PLC	Programmable Logic Controller — the machine's own controller, which the software talks to over serial.
PC-Link	The label for the PLC connection controls in the top bar.
Restore point	A dated backup of the Windows user settings file, in `MT.Service.Packs\RestorePoints`.
ROI	Region of Interest. The rectangle that constrains where automatic indent detection is allowed to look.
Scale designation	The conventional Brinell notation `HBW <ball>/<load>`, e.g. `HBW 10/3000`.
Stale frame	A captured frame that has been superseded by a newer one before the display could show it.
Stationery	The `MT.Service.Packs` subfolder holding the report letterhead and custom report templates.
Turret	The rotating head carrying the objectives and the indenter.
Variance	The numeric sharpness score used by auto focus, shown on the image as `Focus:`.

Appendix A — Complete settings reference

Every setting below is stored in the Windows per-user settings file and is included in a **Settings ▸ Backup**.

A.1 Camera

Setting	Default	Set from	Notes
`CamDeviceId`	*(empty)*	Camera Setup ▸ Apply	Device moniker — the preferred identifier
`CamDeviceName`	*(empty)*	Camera Setup ▸ Apply	Friendly name, used as a fallback
`CamDeviceIndex`	0	Camera Setup ▸ Apply	Position in the device list, last-resort fallback
`CamModeIndex`	0	Camera Setup ▸ Apply	Capture mode index reported by the camera
`CamMirrorHorizontal`	False	Camera Setup, live	Mirror left-to-right
`CamFlipVertical`	False	Camera Setup, live	Flip top-to-bottom
`CamRotationDegrees`	0	Camera Setup, live	0, 90, 180 or 270, clockwise, applied after mirror and flip
`CamUseHardwareFlip`	True	Camera Setup, live	Let the camera perform mirror/flip where it can
`CamDiscardStaleFrames`	True	Camera Setup ▸ Apply	Latest-frame delivery with a two-slot buffer; needs a camera restart
`CamFps`	30	*(no UI)*	Internal cap on live-view redraw rate, in frames per second. It is intentionally not an operator setting.
`CamBrightness`, `CamContrast`, `CamHue`, `CamSaturation`, `CamSharpness`, `CamGamma`, `CamExposure`, `CamAutoExposure`, `CamWhiteBalanceBlueU`, `CamWhiteBalanceRedV`, `CamAutoWhiteBalance`, `CamAutoFocus`, `CamFocus`	various	*(none)*	**Legacy.** Retained in the settings file but no longer read or written by the application; image controls now live in the camera driver's property page.

A.2 Auto focus and detection

Setting	Default	Set from
`UseLaplacianVariance`	False	Auto Focus setup ▸ Variance selection
`AfSpeed10X`	1600	Auto Focus setup ▸ AF speed @10x
`AfSpeed50X`	400	Auto Focus setup ▸ AF speed @50x
`AfStep1SpeedPct` / `AfStep2SpeedPct` / `AfStep3SpeedPct`	100 / 50 / 25	Auto Focus setup ▸ Step n speed (%)
`AfStep1DropCount` / `AfStep2DropCount` / `AfStep3DropCount`	5 / 3 / 2	Auto Focus setup ▸ Step n drop count
`TopOffset`, `BottomOffset`, `LeftOffset`, `RightOffset`	0	Auto Focus setup ▸ Detect indent margins
`RoiPos`, `RoiWidth`, `RoiHeight`	0,0 / 0 / 0 (initialised to 400 × 300 centred on first run)	Drag on the image in ROI mode

A.3 Measurement

Setting	Default	Set from
`BallDiaIdx`	0	Ball Dia list on the measurement toolbar
`LensIdx`	1	Turret strip
`ForceIdx`	0	Force Selection list
`SourceConvUnit`	0	Conversion From list
`TargetConvUnit`	0	Conversion To list
`MarkPosX1`, `MarkPosX2`, `MarkPosY1`, `MarkPosY2`	0	Marker line positions, saved on exit
`CF_Mem`	0	**Legacy**, unused

A.4 Machine

Setting	Default	Set from
`MachineComPort`	`COM1`	Top bar COM port list
`McAutoReadTurret`	False	PC Link ▸ Auto Read Turret
`McAutoWriteTurret`	`False`	PC Link ▸ Auto Write Turret

Setting	Default	Set from
`McTypeCB4`	False	PC Link ▸ Force Read
`McTypeCB5`	False	PC Link ▸ Force Write
`McTypeCB8`	False	PC Link ▸ Load Cell Machine
`McTypeCB13`	False	PC Link ▸ X Y Stage Micrometers
`McTypeCB2` , `McTypeCB14` , `McTypeCB15`	True / True / True	**Legacy**, unused

A.5 Results grid, chart and reports

Setting	Default	Set from
`ChkDesc` , `ChkConv` , `ChkD1` , `ChkD2` , `ChkScale` , `ChkTolMin` , `ChkTolMax` , `ChkResult`	True	Settings tab column checkboxes
`ChkDisX` , `ChkDisY`	True	**Legacy**, unused
`CustomPatternFile`	*(empty)*	Settings tab ▸ Set Test Pattern
`CustomReportFile`	*(empty)*	Report Settings ▸ Use Existing Template
`TestInfoHeader`	`MT.Service.Packs\Stationery\BMSReportHeader.png`	Report Settings ▸ Select Header Image
`TestInfo`	Six-line default block	Report Settings ▸ Test Information grid
`IncludeImagesInReport`	True	Report Settings ▸ Include images
`ShowChartTitle` / `ChartTitle`	True / `Harness`	Chart Settings
`ShowXAxisTitle` / `XAxisTitle`	False / `Distance (mm)`	Chart Settings
`ShowYAxisTitle` / `YAxisTitle`	False / `HV`	Chart Settings
`ShowChartValue`	True	Chart Settings
`UseChartBarStyle`	True	Chart Settings
`ChartLegendPosition`	`Top Right`	Chart Settings

Setting	Default	Set from
`LicenseFilePath`	*(empty)*	Licence dialog ▸ Check License (stores the file name only)

End of manual — MT-BMS-OM-001, Revision 1.0, issued 03 August 2026.