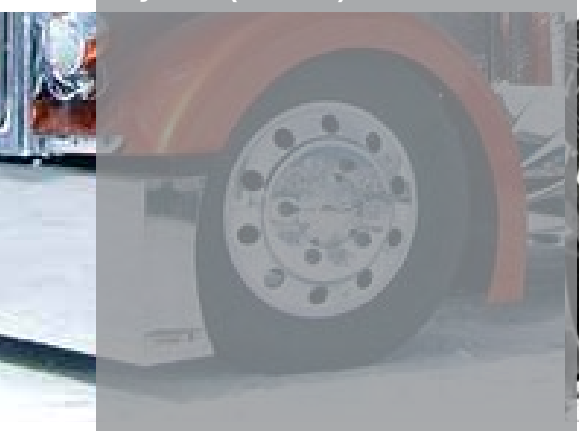
Precision, Quality, Innovation

Starrett BYTEWISE

Measurement Systems for the Tire Industry

OFF-LINE PROFILOMETER 3D (3DP)

- Off-Line Profilometer (OFLP)
- Off-Line Profilometer SL (PSL)
- Off-Line Profilometer 3D (3DP)
- On-Line Profilometer (OLP)
- Ply, Belt, and Extrusion Feature Tracker (FT)
- Profile360 for Apex and Bead Measurement (P360)
- Green Tire Uniformity Diagnostic System (GTU)
- Green Tire Uniformity Integrated System (GTUint)
- Bead-to-Bead Profile Measurement System (B2B)
- Bead-to-Bead Tire Scanner (Tire360)
- Circumferential Tread Wear System (CTWIST)



LASER MEASUREMENT SOLUTIONS

Off-Line Profilometer 3D (3DP)

The Profilometer3D is the third-generation offline Profilometer from Starrett-Bytewise, and comes after 20 years of product experience. Profilometer3D is used to verify the accuracy of newly-cut dies by checking the extrusion dimensions. Its accuracy and speed helps reduce the number of die trials needed to approve a new die for production. Once the die is in production, Profilometer3D is used to check each run for overall quality, and to monitor for die wear. Under ideal conditions it is favorable to run tread extrusions so that the three main parameters – thickness, width and weight, are as near as possible to the lower control limits. This reduces the cost of the compound consumed. In practice extrusion lines normally operate with some if not all parameters above the limits. Since the tread measurements are used to tune the die dimensions, reductions to measurement uncertainty directly relate to improved die accuracy, which translates into less "running heavy".

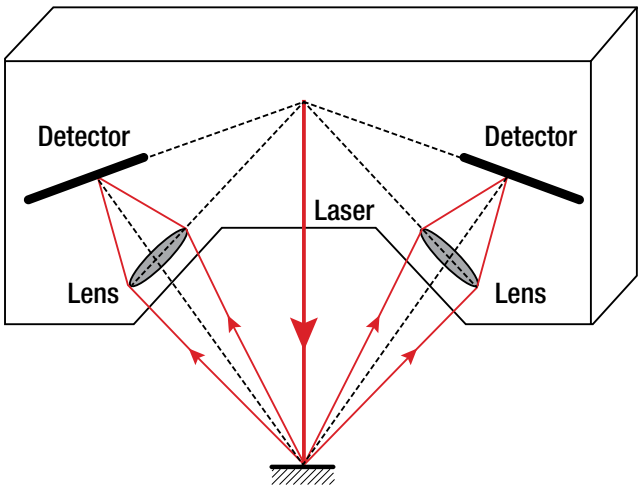
Profilometer3D is built on a monolithic granite super-structure in the “Academy Black” granite fabricated by Starrett Tru-Stone™ Technologies. This granite was selected due to its excellent properties for machinability, flatness, and coefficient of thermal expansion. Sensors are mounted to servo-motor controlled traversing slides mounted top and bottom. Linear travel is encoded to 5um intervals. Profilometer3D is positioned on a wheel cart with locking casters.

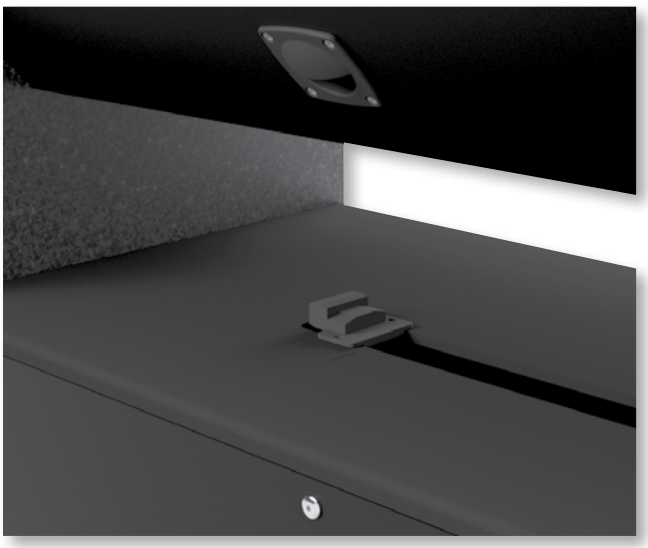
Sensor Technology

Profilometer3D utilizes CrossCheck2T line laser sensors. These sensors project a laser line across the tread, and view the laser line with two CMOS cameras, one each side of the laser line. The resulting images are transformed into dimensional coordinates using triangulation methods. The two images are combined so that any data lost due to triangulation blockage of one camera can be augmented by data from the other camera. CrossCheck2T sensors employ high-speed CMOS detectors that run at frequencies 1,000 Hz and higher. The Starrett-Bytewise CMOS-based sensors were introduced in 2002 and there are over 3,000 sensors in use.

Self-Calibration

A multi-step certified gauge block is mounted at the start position. At the beginning of each scan the gauge block is measured. If the gauge block measurements are inside the allowable range the measurement cycle is executed using the current calibration values. If the gauge block measurement is outside the allowable tolerance the calibration offset is automatically adjusted. This means that the system is self-calibrating. This self-calibration compensates for error due primarily to temperature change in the environment. The gauge block spans the entire width of the laser line. The calibration adjustments can be set to update automatically or to prompt the user to accept the changes. We log all calibration changes along with the temperature in the top and bottom chambers.



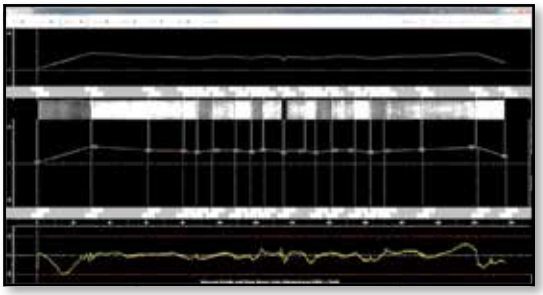


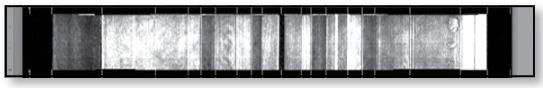
Software

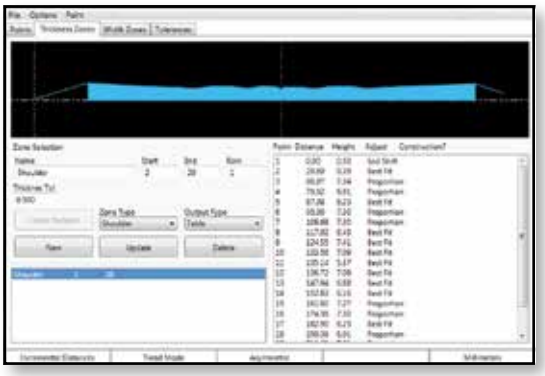
Profilometer3D software overlays the measured profile to a specified profile and compares the X and Y coordinates for all breakpoints. In the screen at right the top window displays the entire tread. The center window displays the thickness and width values for each breakpoint, with the actual measurement values displayed above, and specification values below the profile image. The bottom window displays the subtraction of the specification from actual, with upper and lower control limits indicated by the red lines.

The zoom view at right shows the visual image, or light intensity, of the 25mm wide tread profile aligned to the point data waveform. This clearly shows the small die lines. This enables the operator to check the positions of any breakpoints relative to any die line. This has proven difficult for many systems due to the small size of the die lines.

The design editor is tab driven, with tabs for Points, Thickness Zones, Width Zones, and Tolerances. Die break points are entered in the window shown at right, and can be imported as ASCII text characters. Note that all profile points must be entered first, and then the Zones are constructed from these points.







Measurement Capability

No measurement system is exact, and all measurement systems have some degree of uncertainty, or error. We characterize measurement uncertainty by the Error of Measure method (EoM). EoM characterizes the inherent variation or capability of the equipment itself without regard to contributions from external sources. EoM is a means to express the capability of the measurement system that includes both the bias and repeatability components of variation. EoM encompasses the 99% confidence interval.

Parameter	µm
Thickness Error of Measure (bias + 3σ)	25
Thickness Bias (typical)	15
Thickness Repeatability (typical) 1σ	3.3
Width Error of Measure (bias + 3σ)	250
Width Bias (typical)	100
Width Repeatability (typical) 1σ	50

Error of Measure (EoM) is representative of the system's error in measuring a known value. It is calculated as the absolute value of the Bias plus 3σ for the measurement series. EoM is reported as two values - one for thickness and one for width.

Bias is the average error from the known value. It is calculated as the absolute value of the average measurement minus the known value.

Repeatability is representative of the system's ability to monitor process variation. It is calculated as the range (maximum minus minimum) divided by 6, and expressed as the 1-sigma standard deviation of the measurement series.

Even if the measurement uncertainty is zero, there is measurand uncertainty – the uncertainty in how well the sample measured represents the overall tread. As measurement uncertainty approaches zero, the measurand uncertainty can become the main source of variation. Profilometer3D acquires 512 tracks across 25mm width. This permits one to assess an area wide enough to average out variations and edge artifacts, something that can't be done with a single track area of interest.

Standards Compliance

- Low Voltage Directive 2006/95/EC
- EMC Directive 2004/108/EC
- Machinery Directive 2006/42/EC

Laser Safety Class

- CDRH Class 3A
- IEC 60825-1 Class 3R

Measurement Systems for the Tire Industry

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