



Precision, Quality, Innovation

MEASUREMENT SYSTEMS FOR THE TIRE INDUSTRY

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

IN-LINE INSPECTION... BOTTOM LINE IMPROVEMENT.

Starrett-Bytewise Measurement Systems is a Division of The L.S. Starrett Company of Athol, Massachusetts, USA – a leader in metrology since 1880. Starrett is a manufacturing company with businesses in precision metrology tools, instruments, gages, optical comparators, vision systems, laser measurement systems, saw blades, granite plates, and lubricants. Starrett has five domestic manufacturing locations and three international manufacturing facilities located in the UK, China, and Brazil. The L.S. Starrett Company is listed on The New York Stock Exchange under the symbol SCX.

Component Preparation		
Tread and Sidewall Extrusion	Calendar	Apex Extrusion
On-Line Profilometer	Overlapping Ply Splice Monitor	
Off-Line Profilometer SL	CrossCheck Width	
Tire Building		
Carcass Drum	Belt/Tread Drum	Shaping Drum
Overlapping Inner Liner and Body Ply Splice Monitor	CrossCheck Belt Edge and Dog-Ear Monitor	GTU Radial Runout and Lateral Runout Monitor
GTU Diagnostic System	GTU Diagnostic System	GTU Diagnostic System
Tire Development and Testing		
Tread Wear	Tire Profile	Sidewall Profile
CTWIST - Circumferential Tread Wear Imaging System	Bead-to-Bead Tire Profile Measurement System	CrossCheck Laser Line Sensor

TIRE INDUSTRY PRODUCT LINES

PRODUCTS FOR COMPONENT PREPARATION

- Off-Line Profilometer
- Off-Line Profilometer SL (PSL)
- On-Line Profilometer (OLP)
- Ply Splice Monitor
- Ply, Belt and Extrusion

PRODUCTS FOR TIRE BUILDING

- Green Tire Uniformity (GTU)

PRODUCTS FOR TIRE DEVELOPMENT

- Circumferential Treadwear Imaging System (CTWIST)
- Bead-to-Bead Profile Measurement System (B2B)

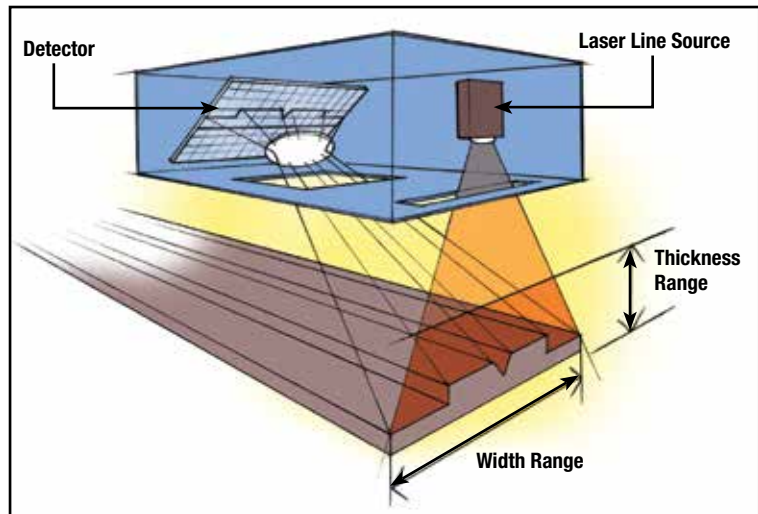
Products for Logistical Management

- Tire Identification System

GUIDE TO TECHNOLOGY

At Starrett-Bytewise, we employ three types of sensor technologies: fixed point laser, displacement sensors, CrossCheck low-speed laser line sensors, and CrossCheckHD high-speed laser line sensors. All laser line sensors are designed and built by Starrett-Bytewise.

CrossCheck Sensors project a laser line across a profile, digitize the image, and transform the image into a geometric coordinate system. Multi-sensor systems acquire thousands of data points around the profile and match them to a CAD template, where key measurement parameters are extracted.

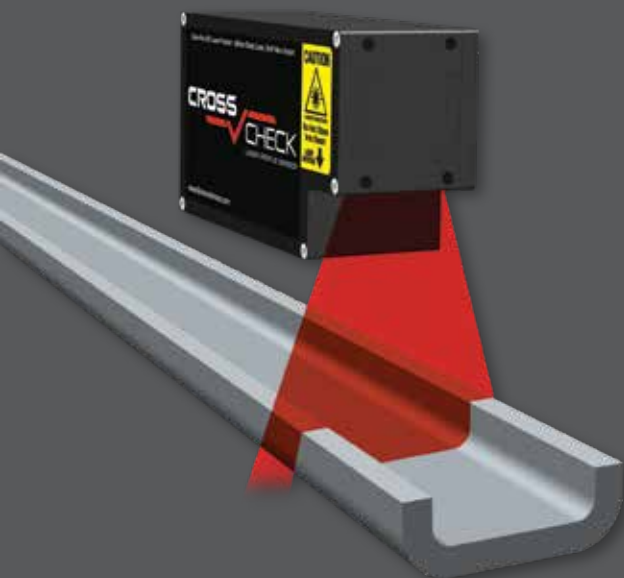


CROSSCHECK SPECIAL APPLICATIONS

Easy to use CrossCheck "shape tools" measure radius/diameter, height, width, angle, and location. Master Profile Comparison provides Pass/Fail testing for contours, and makes small variations easily visible. All for less than the price of a single point laser sensor. CrossCheck is ideal for OEMs who need a fully designed, calibrated, and environmentally sealed 3D laser machine vision solution.

CROSSCHECK'S AFFORDABILITY AND SIMPLICITY BRING PROFILE MEASUREMENT TO THE ENTIRE ORGANIZATION

- R&D - Reverse Engineering
- Engineering - Design Validation
- Production - Monitor and control
- Quality - Process Studies
- Maintenance - Set Up and Adjustment



REAL TIME SHAPE MEASUREMENTS FOR PROCESS CONTROL

- Pultrusion
- Extrusion
- Calendering
- Roll Forming

ROBOTIC GUIDANCE

- Weld Steam
- Glue Bead
- Pick and Place
- Chassis Location

PART INSPECTION

- Forging
- Casting
- Machining
- Injection Molding

SHAPE CHECK

- Crimp Validation
- Flush and Gap
- Embossing Depth
- Blade and Vane Rework

ON-LINE PROFILOMETER

Tread profile geometry has a strong influence on the cured tire uniformity. Treads that are non-symmetrical produce cured tires with uniformity and balance problems. Over-sized treads are a waste of materials. In order to assure the most precise tread and sidewall extrusion quality, tire makers worldwide have adopted the Starrett-Bytewise On-Line Profilometer (OLP) as their standard for extrusion monitoring. The Starrett-Bytewise On-Line Profilometer (OLP) provides automatic, high speed, non-contact measurement of tread and sidewall extrusions. OLP outperforms scanning systems by collecting an instantaneous cross-section profile rather than measuring in a zigzag pattern.

OLP can be installed after the die exit to monitor and alarm when key dimensions exceed the allowable tolerances. Dimension changes at the die often indicate changes in rubber visco-elastic properties or changes in the equipment set-up. When dimensions change, the operator is alerted to intervene. Early intervention can lead to faster startup, reduced rework, better production rates, and better tread uniformity.

OLP can also be installed after cooling to make 100% quality inspection of all treads before they are released to the tire building operation. This enables the QC organization to compare the current run to the historical standards, to pass or fail each run, and to maintain an audit trail for each lot.

USES

- Use OLP at the die during the startup of any run to assist in reducing the time required to reach stability.
- Use OLP at the die to continuously monitor the dimensional quality of any profile, and alarm the operator when any problem occurs.
- Use OLP at the die to immediately recognize changes in die swell associated with batch change so that the operator can adjust the extruder settings.
- Use OLP after cooling to produce data histories to compare any run with its historical performance and verify the effect of quality improvement initiatives.
- Use OLP after cooling to check for die wear.
- Use OLP data alongside other process data such as material theology, extruder die head pressure, screw RPM, screw power, and various temperatures to develop better knowledge as to the complex interactions between materials, process set-points, and profile geometry.

SPECIFICATIONS

	Measurement Range (in)				Measurement Range (mm)			
	Thickness	Width			Thickness	Width		
	2.36"	11.81"	17.72"	23.62"	60mm	300mm	450mm	600mm
Absolute Accuracy¹	.003"		.012"		±0.075mm		0.30mm	
Relative Accuracy²	.001"		.004"		0.0225mm		0.09mm	
Gage Repeatability³	.001" (0.025mm)							
Resolution⁴	.00004" (0.001mm)							
Measurement Rate	Selectable up to 7.5 profiles/second							
Outputs	Analog and digital I/O; Ethernet							
Laser Classification	IIIa CDRH, 3R IEC							

1. **ABSOLUTE ACCURACY:** The average error of all dimensions of a certified gage block using the mean of 75 consecutive measurements. Error is defined as the difference between the OLP measured value and the certified target value.
2. **RELATIVE ACCURACY:** The maximum amount of error present when comparing successive measurements of a target with changing dimensions and located at a fixed position within the field of view. (This also can be considered as "accuracy in measuring product variation.")
3. **GAGE REPEATABILITY:** An offline assessment calculating the standard deviation of the thickness of a certified gage block over 75 measurements.
4. **RESOLUTION:** The smallest meaningful unit of measurement that is reported by the system.



OFF-LINE PROFILOMETER

Tread and sidewall extrusions can be no more precise than the dies used to make them. When a new die is cut it should be well-centered, so the Operator has the flexibility to optimize the extruder set-up. After some time in service, die wear can be uneven so that certain areas along the profile get excessive rubber flow. This is a very costly waste of raw materials. Unbalanced flow can also disrupt the symmetry of the tread - a factor that influences cured tire uniformity and balance.

The Starrett-Bytewise Profilometer was developed as an automated, non-contact measurement system to displace checking with hand tools. The Profilometer is used to verify the accuracy of newly-cut dies. Its accuracy and speed helps reduce the number of die trials needed to approve a new die for production. Once in production, the Profilometer is used to check each run for overall quality, and to monitor for die wear.

FEATURES AND SPECIFICATIONS

- The visual display overlays the measurement onto the specified design.
- The point and gage analysis measures the thickness and width of each breakpoint.
- The conicity analysis compares the right and left extrusion halves.
- The regional analysis reports the area and center of gravity for each region.
- The statistical analysis allows export of data for analysis in spreadsheet applications.
- Experienced users report that fewer die trials are needed, conserving time and raw materials.
- Dies can be designed to increasingly tighter tolerances for materials that are more difficult to extrude uniformly.

SPECIFICATIONS

Measurement Parameter	Car Tire Model	Truck Tire Model
Thickness Measurement Range	30mm	60mm
Width Measurement Range	600mm	900mm
Gage Repeatability on Flat Surfaces	<0.0125mm	<0.025mm
Gage Accuracy on Flat Surface	<0.060mm	0.060mm
Area Calculation Repeatability	<.25%	<.25%
Area Calculation Accuracy	<.25%	<.25%
Sample Interval (with resolution)	0.1mm	0.1mm
Measurement Spot Size	0.3mm	0.3mm
Dimensions (W x D x H)	1225 x 775 x 1400mm	1524 x 775 x 1400mm



OFF-LINE PROFILOMETER SL

The Starrett-Bytewise Profilometer SL (PSL) combines the CrossCheckLine Laser Sensor technology with our proven Profilometer software platform to produce a low cost, reliable, and accurate tread and sidewall extrusion measurement system. PSL is an all-in-one package, with C-Frame, PC, and electronics combined into a mobile cart. PSL is non-contacting and has no moving parts, so reliability is uncommonly high. The measurement is instantaneous, so there is no waiting for results. With this new instant-scan capability and portability, geometry checks on tire components can be performed quickly at any location in the factory.

FEATURES AND SPECIFICATIONS

- No moving parts.
- Instantaneous cycle time.
- Portable.
- The visual display overlays the measurement onto the specified design.
- The point and gauge analysis measures the thickness and width of each breakpoint.
- The conicity analysis compares the right and left extrusion halves.
- The regional analysis reports the area and center of gravity for each region.
- The statistical analysis allows export of data for analysis in spreadsheet applications.
- Experienced users report that fewer die trials are needed, conserving time and raw materials.
- Dies can be designed to increasingly tighter tolerances for materials that are more difficult to extrude uniformly.

SPECIFICATIONS

Measurement Parameter	
Thickness Measurement Range	60mm
Width Measurement Range	300mm (4 sensors) 450mm (6 sensors)
Gage Repeatability of Flat Surfaces	<0.025mm
Gage Accuracy on Flat Surfaces	0.075mm
Area Calculation Repeatability	<0.25%
Area Calculation Accuracy	<0.25%
Sample Interval (width resolution)	0.1mm
Scan Speed	Instantaneous
Dimensions (W x L x H)	77 x 110 x 104cm (excluding LCD monitor)
Laser Classification	IIIa CDRH, 3R IEC

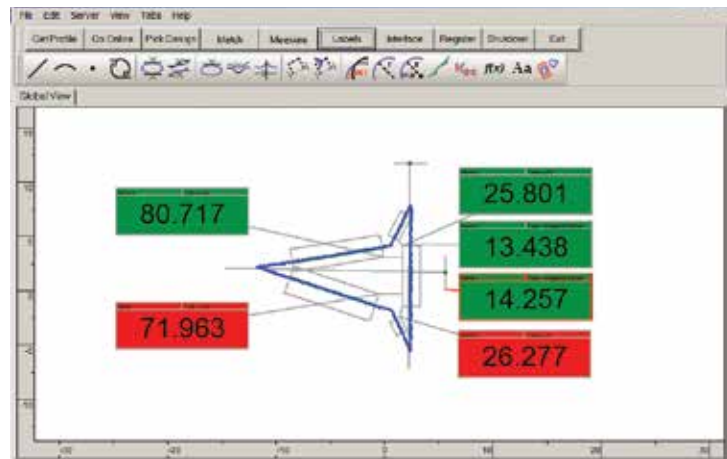


PROFILE360™ FOR APEX EXTRUSION

Profile360™ is an in-line, real-time measurement system for continuously monitoring key profile dimensions in complex profile extrusions. Profile360™ employs CrossCheck Line Laser Sensors manufactured by Starrett-Bytewise. These multi-sensor systems acquire thousands of data points around the profile and match them to a CAD template, where key measurement parameters such as width, thickness, radius, and angle are extracted. Measurement parameters are compared to allowable control limits and displayed on the operator's terminal with a green/yellow/red (pass/caution/fail) status indicator. Profile360™ runs at rates up to 14 profiles per second.

Specifications	
Measurement Rate	Selectable up to 14 profiles/second
Communication Interface	Analog and digital outputs; Ethernet
Run Modes	Clock frequency or encoder
Data Output	Modbus TCP or OPC server native; Conversion to other platforms available
Operating Temperature	32 to 113°F (0 to 45°C); Cooling systems are available

Profile360™ conforms to the Machinery Safety, Electromagnetic Compatibility and Low Voltage directives of the EC. Laser safety class by the CDRH standard is Class 3A and the IEC 60825-1 classification is Class 3R.



PLY SPlice MONITOR

The Starrett-Bytewise In-Line Splice Width Monitor enables continuous, real-time product and process quality feedback for both automatic and manual fabric ply splicing operations. This effectively minimizes finished tire sidewall bulges and depressions caused by out-of-tolerance splice widths created during material preparation.

Specifications

Encoder Resolution	0.10mm
Splice Width Accuracy	±0.15mm (0.006")
Splice Width Repeatability (1 sigma)	0.15mm (0.006")

The above measurement specifications are based on material line speed of 1 meter/second (3 feet/second).
A faster laser (33kHz sampling frequency) may be required if line speeds are much greater than 1m/second.

FEATURES AND SPECIFICATIONS

- High-speed, non-contact laser sensors.
- In-line configuration.
- Splice width trend and variation analysis software.
- Multi-channel systems measure at several locations across the product width.
- Enables repeatable detection of leading and trailing splice edges resulting in a more accurate splice width measurement.
- Enables splice width to be measured without affecting cycle time.
- Provides immediate product and process feedback.
- Provides real-time data output to a PLC for automatic process control in automatic splicing operations.
- Provides instant feedback to the operator of a manual splicing operation, thereby enabling immediate corrective actions to be made.
- Enables width tolerances to be confidently reduced, thereby eliminating heavy splices and saving material.
- Improves splice width consistency across the entire product, thereby minimizing open splices and improving tire radial uniformity.



GREEN TIRE UNIFORMITY SYSTEM

Tire Building is the most complex operation in the tire factory. Multiple components are centered, applied, spliced, turned-up, inflated, and stitched. Component stock variations combine with machine variations to produce green tires with variations in radial runout, tread snaking, lateral runout, and splice quality. Green tires with the largest variations invariably produce tires with the worst cured tire uniformity and balance performance.

The Green Tire Uniformity System utilizes the CrossCheckHD™ Line Laser Sensor to scan green tires at any stage of production. The GTU Software has a suite of viewing and analysis tools for assessing all aspects of the green tire uniformity. The system is available in two configurations - portable and fixed.

The portable tripod-mounted version can be moved from drum-to-drum, and from machine-to-machine. This provides a way to thoroughly study the carcass, belt/tread package, and final shaped green tire for radial and lateral runout, tread snaking, and splice quality. This can be used by the Set-Up Technician to verify the TBM set-up, and can be used by the Uniformity Engineer to troubleshoot tires with uniformity problems.

The fix-mounted version provides a means to perform 100% inspection at any drum for any parameter. This is useful for understanding the population characteristics of green tire runouts and to alarm when limits are exceeded.

FEATURES AND SPECIFICATIONS

- Start scan from keyboard.
- Start scan from relay contact.
- Scan with encoder count.
- Scan number of profiles.
- Scan from encoder start/stop.
- View runout color map.
- View 3D image.
- View circumferential waveform.
- View lateral waveform.
- View harmonics.
- Filter data.
- Rotate data.
- Crop data.
- Radial runout caliper.
- Lateral runout caliper.
- Tread splice caliper.
- Width caliper.
- Set pass/fail limits.
- Subtract layers.
- Export caliper waveform as .csv.
- Export point cloud as .csv.
- Portable system includes sensor, notebook PC, and carry case.
- Fix-Mounted System includes sensor, PC, and PLC interface module.

Specifications	
Input Voltage	110-240 VAC
Power Usage	50 W
Operating Temperature	32-104°F (0-40°C)
Sensor Sample Rate	700 Hz
Laser Classification	660nm Wavelength; IIIa (CDRH); 3R (IEC)
Interfaces	Telnet PLC Input for Triggering Incremental Encoder Input



Radial Runout 0.23mm
Lateral Runout 0.42mm
Splice Bump 0.33mm

TREAD WEAR MEASUREMENT SYSTEM

Tire designers are challenged to develop new tread patterns and compounds that deliver longer tread life and more uniform tread wear. Starrett-Bytewise partnered with Ford Motor Company and several leading OEM tire makers to develop CTWIST as a way to measure and characterize tread wear so the designers could better understand wear behavior. With the CTWIST process, new tires are scanned after break-in, then periodically scanned during the wear cycles. CTWIST predicts the tread life for each rib, and produces several tread wear reports to help the designer understand where improvements are needed.

CTWIST utilizes a non-contacting high-speed laser sensor to collect about 1,000,000 measuring points in less than 5 minutes.

Specifications	
Typical Measurement Time	5 minutes
Measurement Technology	Scanned laser triangulation
Measurement Range	32mm
Laser Standoff	180mm
Measurement Spot Diameter	0.1mm
Laser Classification	Class IIb Gallium Arsenide
Laser Resolution	<0.008mm
Data Signal	Digital with invalid data signal
Data Points per Scan Line	4096
Senor Frequency	16kHz
Encoder	= 16,000 PPR
Typical Data File Size	1Mb
Compatible Tire Radius Range	200 to 625mm
Compatible Tire Widths	Up to 400mm
Maximum Tire and Wheel Assembly Weight	100kg
Maximum Tire Rotation Speed	120RPM
Machine Dimensions (W x D x H)	1000 x 1150 x 900mm

FEATURES AND SPECIFICATIONS

- Tread Depth Profile Report - shows the tread depth profile for each wear cycle.
- Heel/Toe Wear Report - shows the heel-toe wear profile across the tread.
- Irregular Wear Report - shows a 3D color map of the tread loss.
- Tread Loss Report - shows the tread loss profile across the tread.
- Tread Life Mileage Projection - shows the predicted tread life of each rib.



BEAD-TO-BEAD PROFILE MEASUREMENT SYSTEM

Tire and mold designers are tasked with creating new tire designs that meet strict dimensional requirements when the tire is inflated. The inflated growth is predicted using powerful CAD modeling software. The inflated tire is traditionally measured with hand tools to check compliance to the design target. Checking with hand tools is time consuming, imprecise, and operator dependant.

The Starrett-Bytewise Bead-to-Bead Measurement System (B2B) is a non-contact scanning system that provides instantaneous acquisition for tire profiles from one bead to the other, across both sidewalls and the tread. Data is rendered in a visual display. Drag and drop caliper tools enable easy measurement. The CAD model can be imported into the Bead-to-Bead software so that the actual profile can be overlaid to the design. Data can be exported back to the CAD system for further analysis.

Bead-to-Bead can scan tires rotating at high speed to measure centrifugal growth and deformation.

FEATURES AND SPECIFICATIONS

- B2B acquires 4,000 or more data points per profile.
- B2B acquires complete profiles in less than one second.
- Profiles are rendered the profile in a visual display, and matched to a CAD template.
- Profiles are analyzed with easy-to-use tools for section width, crown radius, and other parameters.
- Data points are output in DXF and TXT formats.

Specifications

Tire Size Capability	Various configurations to accommodate tire sizes ranging from passenger to truck and bus
Sensor Accuracy	0.15mm (based on standard sensors)
Measurement Accuracy	0.15mm or 0.3mm (*)
Triggering	Keyboard
Point Data Output Formats	DXF, TXT
Communication Interface	Digital and Analog I/O, Ethernet (Modbus TCP)
Laser Classification	IIIa

* Measurement accuracy will depend on whether the data required to complete the desired measurement comes from one or two sensors.





MEASUREMENT SYSTEMS FOR THE TIRE INDUSTRY



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