Precision, Quality, Innovation

SPRING TESTING SOLUTIONS

Material Analysis

Force Analysis

High Volume Testing

Economical Testing

MTH Manual Tester

Digital Force Gages

Digital Force Testers

Accessories

Bulletin 1830

Precision. Accuracy. Repeatability. Flexibility.

Spring measurement, testing and analysis is complex. While a spring may appear to be a simple device, its operation and performance can be difficult to determine precisely. Until now.

Starrett, a global leader in measurement technology, has engineered spring analysis, spring testing and spring measurement solutions that precisely characterize a spring's operation and performance. Our solutions can verify and validate your spring's performance and characteristics including: working loads, height and solid height variations, spring index, slenderness ratio, initial tension and more.

Starrett solutions ensure measurement accuracy and repeatability. And we offer a level of testing and measurement solutions that are sophisticated enough for spring design engineers yet easy enough to use for the novice user.

Starrett knows spring measurement, testing and analysis.

Let Starrett show you how.

Engineered Measurement Solutions. Design. Production. Application.

Starrett offers a complete line of measurement, analysis and testing solutions for the design engineer, production manager and quality professional.

Spring performance begins with the materials used in its design; next to the manufacturing processes employed; and finally through to the quality evaluation.

Material Characterization

A spring's overall performance begins with choosing the appropriate materials for its application, service and life cycle.

Starrett L3 systems are used to characterize materials and to determine their performance capabilities. Material stress and strain measurements, using a Starrett L3 system, ensures that the material selected for your spring meets the design and performance requirements you require. Requirements such as material stiffness, elasticity, strength, and resilience are easily measured using a Starrett L3 system. Confidence in your spring performance begins with the material used in the spring design.

Performance Analysis

Verifying your spring design can consist of determining spring rate, spring constant, free length and initial tension.

Having the ability and methods to precisely determine the spring's performance and operation can be accomplished using the Starrett L2Plus system. With its graphical measurement capability, you see your spring's performance--- graphically. With data sampling at up to 2000Hz, you can use a variety of measurement tools to find precise points, slopes for spring rates, hysteresis traits, elasticity, linearity and nonlinearity performance.

Quality Control & Assurance

Once in to full production, Starrett S2 and S1 systems can be used to verify spring performance, repeatability and quality. Quality testing can be performed quickly and easily without compromising measurement accuracies or testing methods.

Starrett systems can be used to evaluate and determine spring tolerances and basic performance characteristics including free length, spring rate, spring constant and initial tension. Conditioning can be employed including scragging and solid height. Testing may be either a single or two-point method. Certification and compliance reports can be created and issued with your products for your customers.

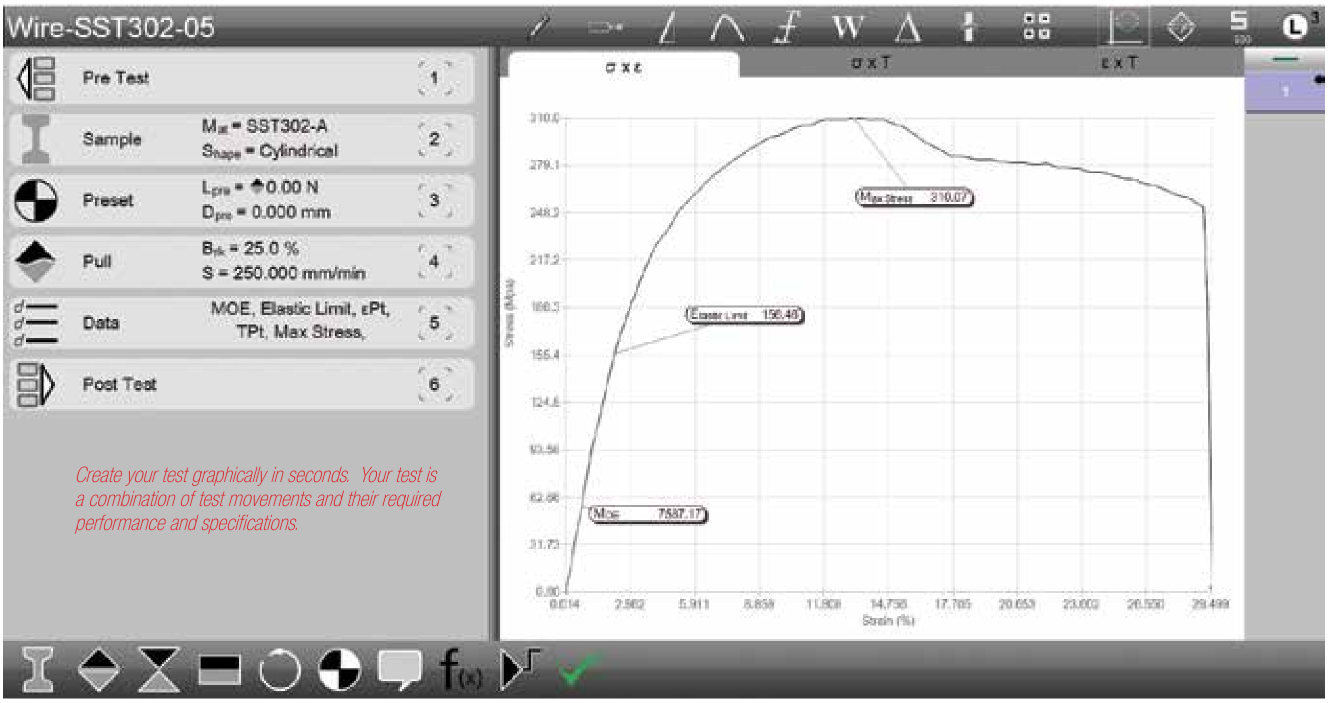
Material Analysis with the Starrett L3 System

Starrett L3 systems are ideal for analyzing, verifying and validating the application suitability and performance of material used in your spring design. The L3 system lets you perform tensile testing of your raw material to determine such performance factors as:

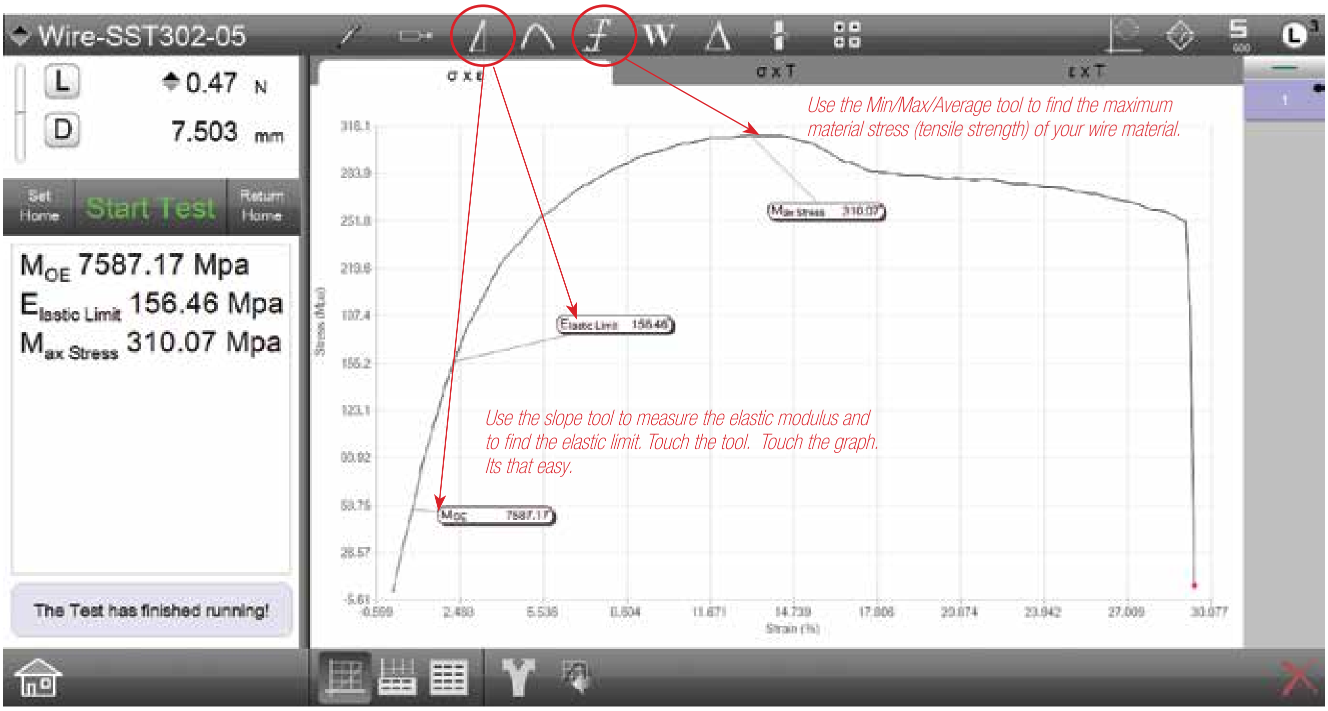
- Tensile strength
- Maximum shear stress
- Elastic modulus
- Elastic limit
- Endurance limit
- Proportional limit and offset yield
- Stress and strain limits
- Stiffness and brittleness

With L3 software, you can create tests based on international testing standards from ASTM, ISO, DIN and others. Test creation is graphical and intuitive. Once your test is created, you perform the test and determine material characteristics using powerful, yet easy-to-use measurement tools. Find results with a simple click on the graph.

Starrett delivers confidence in your materials' Performance.



Create your test method to internationally-accepted standards, measure results graphically, analyze your data and export to your SPC application. L3 systems are easy-to-use and let you test your materials without compromise up to 50kN. Ideal for all types of wire materials.



The Starrett L3 system for material testing will verify and validate your spring design materials. Perform tensile strength analysis and characterize your materials with our comprehensive testing software that is easy-to-use, intuitive, and precise.

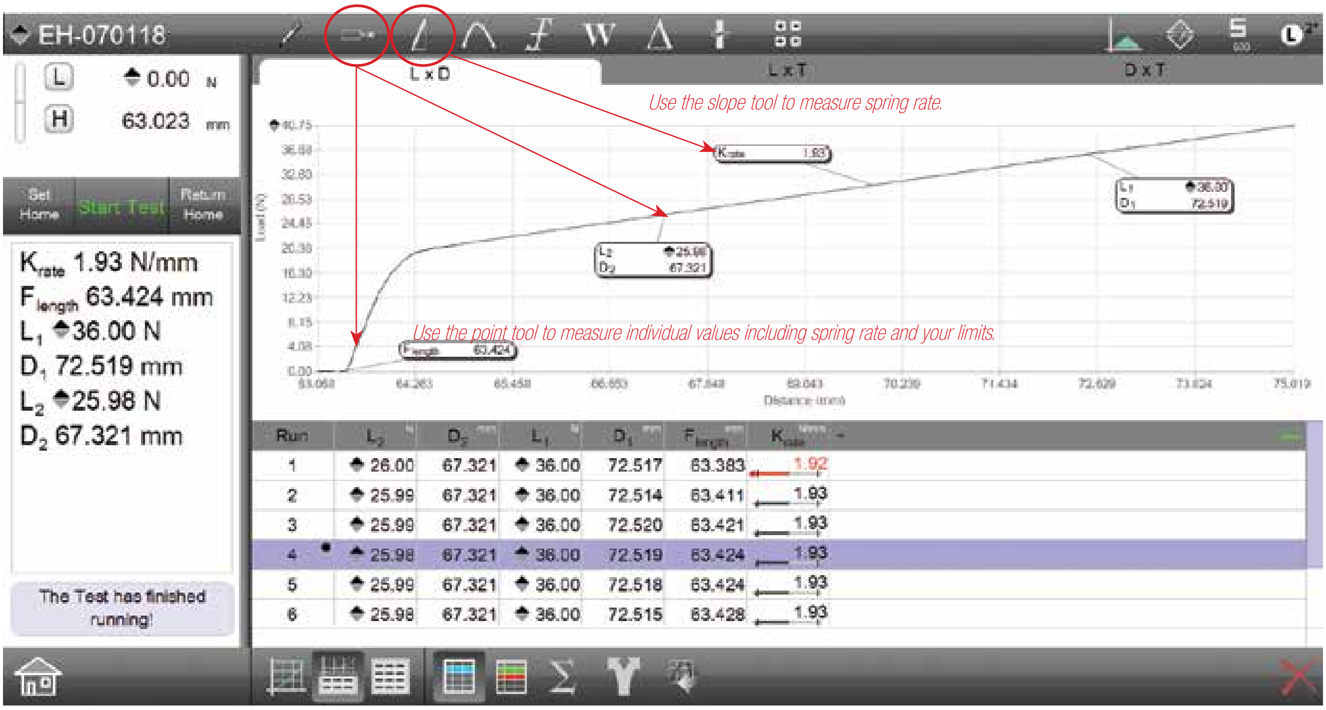
Force Analysis with the Starrett L2 Plus System

Starrett L2 Plus systems are ideal for determining your spring design performance. Create simple or complex testing routines and perform complex measurements with a simple "click on the graph".

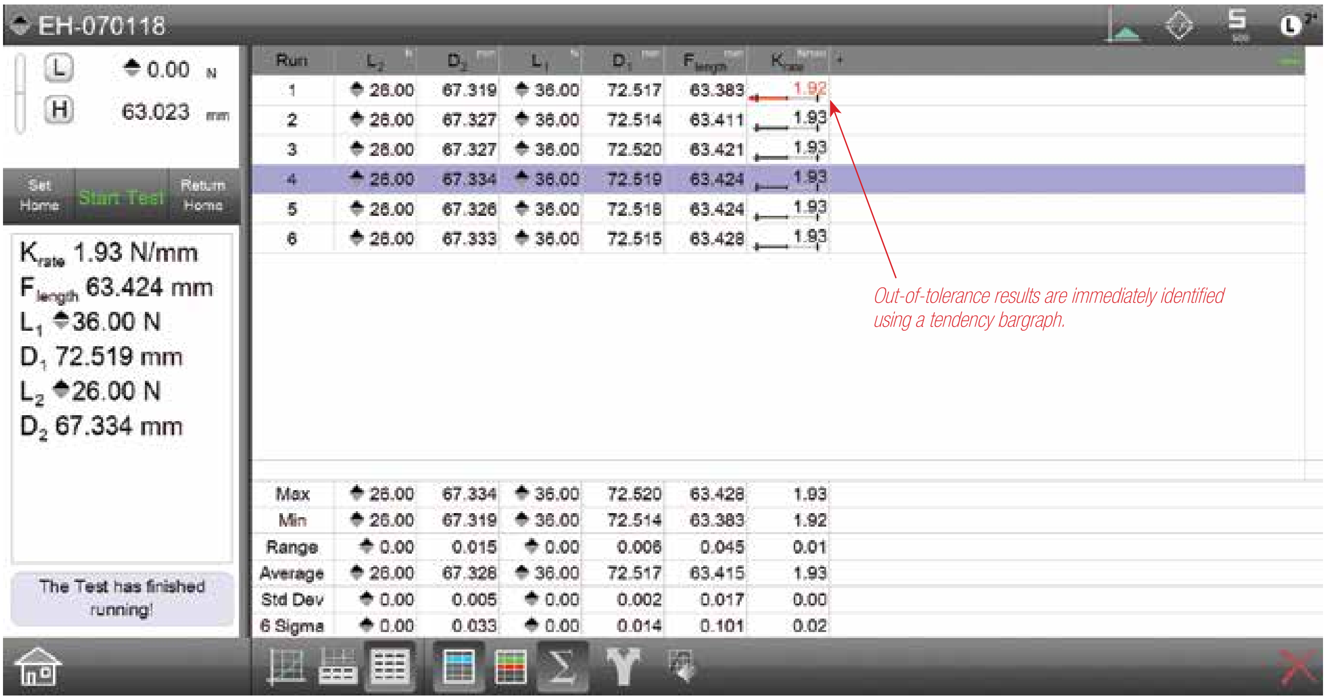
With L2 Plus software, you find your results using the graph created from your test method. Measurement tools let you find key spring characteristics including:

- Spring rate
- Spring constant
- Free length
- Initial tension
- Solid height
- Resilience

With L2 Plus software, you not only find the measurements for your springs, but you have comprehensive data and information on your sample that shows precisely the "why, where and when" the measurement occurred. Plus, with advanced tolerancing, including the ability to have tolerance banding for your sample, you can view any single point that may be outside your tolerance limits.



Display individual results using the graph while displaying the results in a tabular format for all individual tests for that batch. Krate is measured using the slope tool between the L1 and L2 points. Height information is also displayed, including the free length. Just touch the graph to measure your results.



The L2 Plus software data view displays results in a tabular format. You can view statistics for your batch and compare individual test results quickly and easily. Out-of-tolerance results are displayed in red with a tendency bargraph.

High-volume Production Testing with the Starrett S2 System

Starrett S2 software is ideal for compression and extension. Springs are available withan outside diameter of 8 inches (200 mm), load rates of 1100lbf (5 kN) and travel lengths of 40 inches (1016 mm). The software lets you determine the following:

- Load at Height/Length Limits (One or Two Points)
- Load at Height/Length Limits (Multiple Points with optional Test Builder)
- Height/Length at Load Limits (One or Two Points)
- Height/Length at Load Limits (Multiple Points with optional Test Builder)
- Free Length/Height
- Spring Rate, Spring Constant, Initial Tension

S2 software can operate on any Windows computer, including tablet computers, laptop computers or all-in-one workstations.

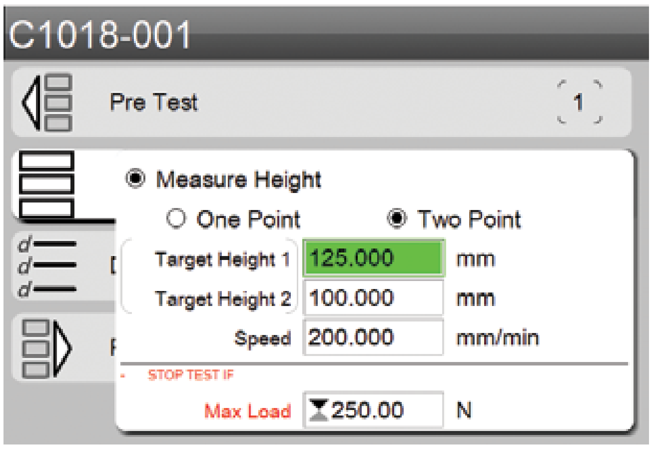
Fast. Efficient, Production Testing.

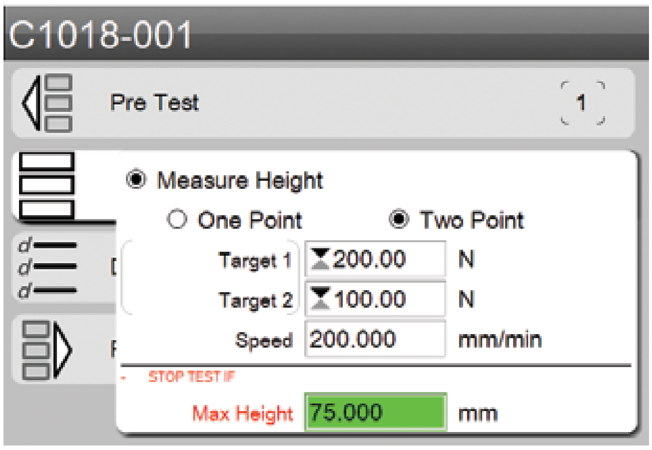
Software Features

- Use preconditioning options to exercise your spring prior to testing. You can scrag for a number of cycles or duration. You can also compress to a load set and hold for a duration.
- Single or dual limit tests may be used. You may specify a target load or target height/length to determine spring rate, spring constant, load and length at target limits, initial tension and measured free length.
- The Data View displays the measured results. The spring constant is displayed for a single point test while the spring rate is displayed when using a dual point test method.
- You may graph the test including the ability to witness the load at length/height or load at time profiles. Using the “overlay” function, you can map individual test graphs and overlay them onto one another to get a visual of individual test relationships.
- The Summary View lets you compare all tests within a batch. You can establish tolerances for your springs and display “pass/fail” and tolerance relationships.
- The Statistics View displays key statistical information for your batch including mean, range, standard deviations and tolerance results.
- Perform more sophisticated, multi-stage testing when you use the optional Test Builder software. You can convert from a Spring Test template to the Test Builder quickly and easily.

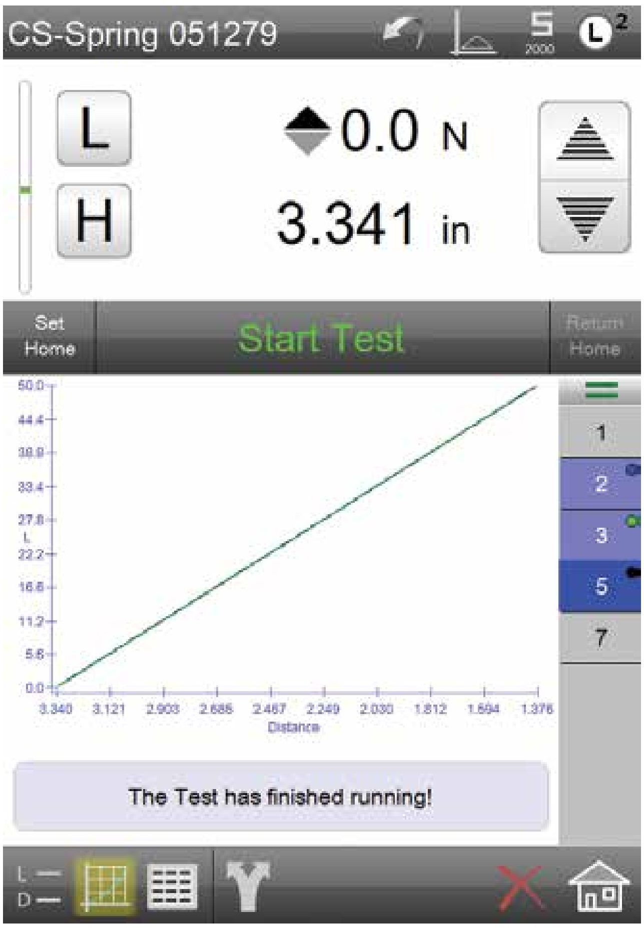
Test Setup Options

- Pre-Test Options
  - Units of Measurement
  - User Prompts to assist operator during testing
  - Spring preconditioning (Scrag & Load Set Hold for duration)
- Test Options
  - Measure Free Length
  - One Point Limit Test (Load or Height)
  - Two Point Limit Test (Load and/or Height)
  - Exceptions (Abort test if an exception is met)
- Data Options
  - Spring Constant (One Point)
  - Spring Rate (Two Point)
  - Date, User, Limit Setpoints
- Post-Test Options
  - Export Raw Data to a file location (up to 1000 pts/second)
  - Export Results (Overwrite or Append data file)





Your two-point test setups may be based on a load or height target. (Top) Height targets are used as setpoints where the KSR is determined based on the spring length. (Bottom) Load targets are used as setpoints to determine KSR. The "Stop Test If" conditions will stop a test should either the Max Load or Max Height be encountered. SI units of measure are being used.



With the S2 software you can overlay the graphs of multiple test results to verify each spring against a benchmark curve. Imperial units are used.

Economical Spring Testing with the Starrett S1 System

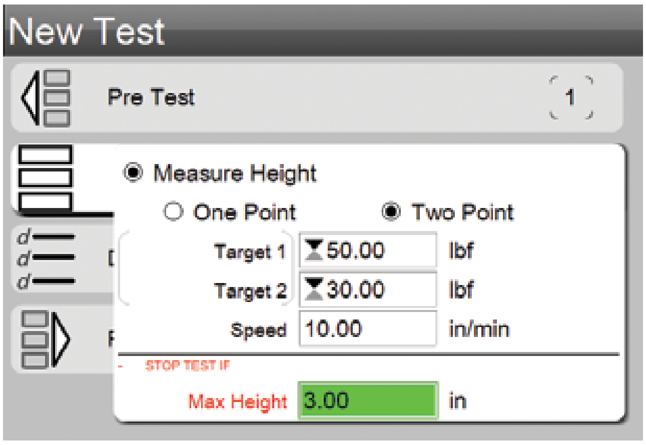
Starrett S1 systems represent our most basic digital testing solution for compression and extension springs. S1 systems are ideal for high-volume production testing and individuals looking for more consistent testing results over manual testing methods.

Two types of test methods are supplied for compression and extension springs. Easy-to-use test templates let you create your test setup in seconds. The small footprint make S1 systems ideal for lean manufacturing environments or in-situ production locations.

With the S1 system, you can measure:

- Spring rate
- Spring constant
- Free length
- Solid Height
- Initial tension

Make use of tolerances to determine immediate "Pass/fail" results. View results graphically or in tabular formats. You can also print out custom reports and export data to Microsoft Excel or SPC software such as ProLink's QC CALC application.

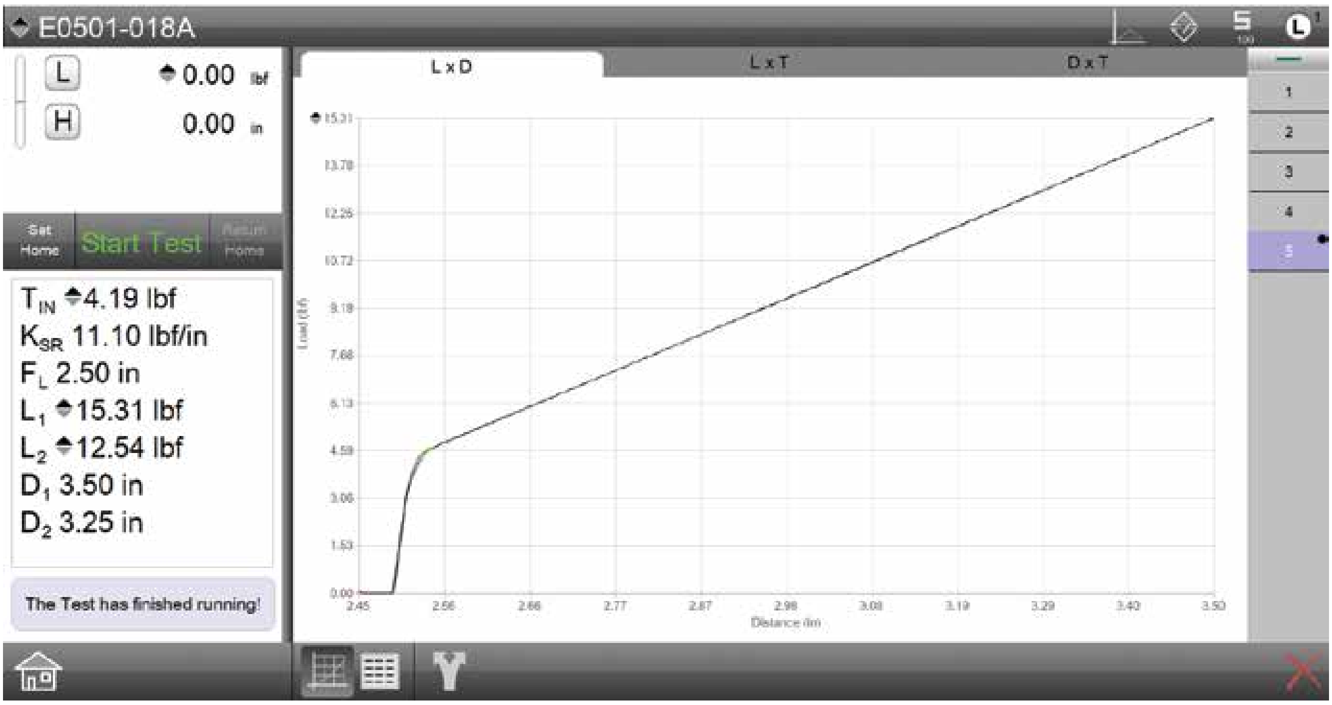


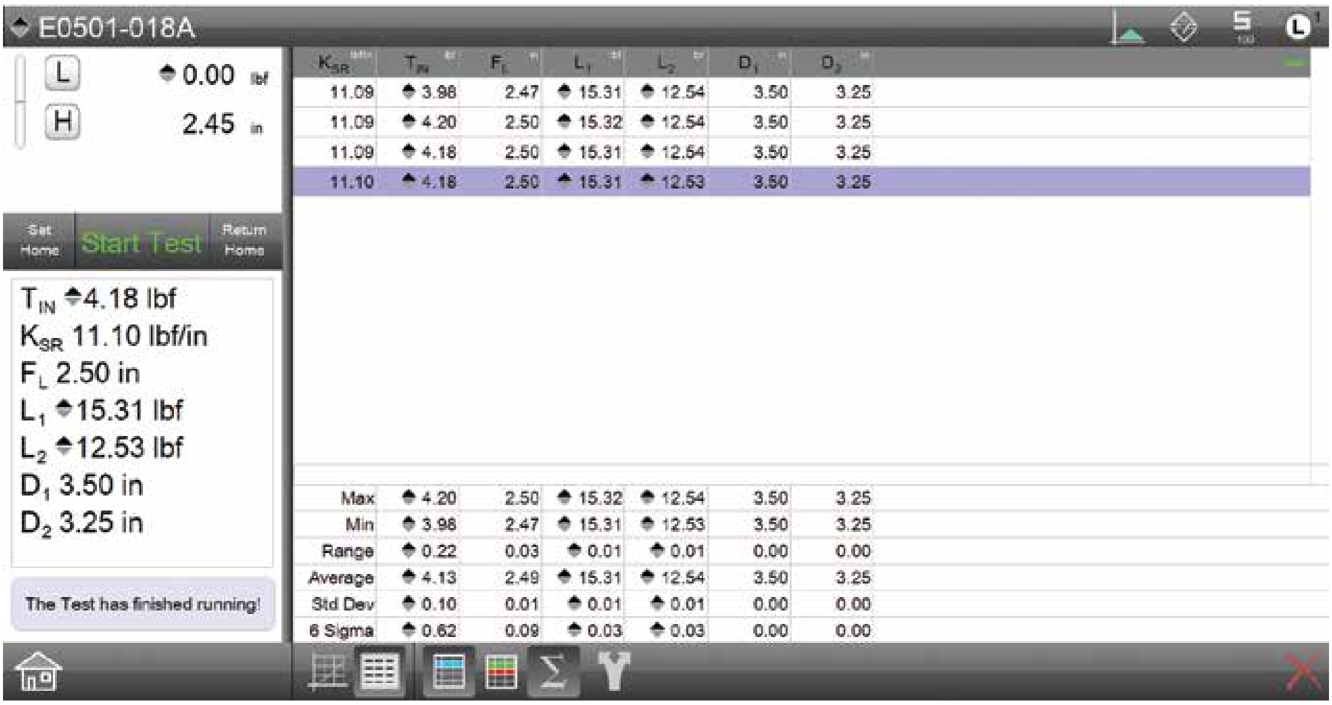
Test templates make test setup simple and fast. One- and two-point methods may be used. Measure free length by selecting the combo button. Test targets may be load- or height-based.

Economical Digital Spring Testing.

Software Features

- Use preconditioning options to exercise your spring prior to testing. You can scrag for a number of cycles or duration. You can also compress to a load set and hold for a duration.
- Single or dual limit tests may be used. You may specify a target load or target height/length to determine spring rate, spring constant, load and length at target limits, initial tension and measured free length.
- The Statistics View displays key statistical information for your batch including mean, range, standard deviations and tolerance results.





(Top) Display your results with a full graph for your test. You can display three graph types: Load x Height, Load x Time or Distance x Time. You can also overlay graphs to compare the graph profiles. You can also print out a report with your graph and the results for each test with a single key-press.

(Bottom) Display your results in a tabular format. Tabular results may be displayed with tolerance limits and "pass/fail" indication. You can also display statistical results for individual tests or for all the tests performed for a batch. Export result or your raw data with a single key-press.

MTH Manual Spring Tester

The MTH Manual Tester is a single column, manually-operated force tester. The MTH has a load measurement capacity of 550lbf (2500N, 250kgf) and can be used for compression or tensile testing. The mechanical advantage afforded by the MTH-550's precision, high-resolution worm gear design lets you test effortlessly. One rotation of the hand wheel positions the crosshead 0.03" (0.75mm). Total stroke for the MTH-550 is 4" (102mm). Force measurement is performed using a Starrett digital force gage.

The MTH-550 is an ideal, affordable solution for spring testing. Fit the MTH-550 with a digital force gage and optional digital scale to determine spring rates, initial tension and more.

The hand wheel may be positioned anywhere along the 30" (762mm) column, and with a 4" (102mm) throat, large samples can be accurately tested. The base may be permanently affixed to your workbench. Optional gage adapter kits are available for use with non-Starrett force gages. Quick-change clevis adapters let you mount a large selection of Starrett testing fixtures.

Features

- Tension or Compression Testing
- Excellent for Cost-Effective Spring Testing
- Effortless Crosshead Movement
- Precision Worm Gear Design
- Excellent Position Resolution: Single Rotation for 0.03" (0.75mm)
- 30" (762mm) Column Height, 15" (380mm) Working Area
- Adjustable Gage Mounting

Digital Force Gages

- Use as handheld instrument or mount to Starrett test frames: FMM, MTL and MTH
- Excellent display resolutions:
  - DFC 10,000:1
  - DFG 5,000:1
- Precise and accurate load measurements:
  - DFC 0.1% full scale
  - DFG 0.2% full scale
- Load sensors have safe overload rating of 200%
- High-resolution OLED color display with adjustable backlight and Auto Off feature
- Supplied with NIST-traceable Certificate of Calibration
- 3-year warranty
- A primary and secondary display window shows your results, out-of-tolerance results display in red
- Adjustable sampling rates help you capture peak loads, filters can be applied to peak and display values
- Multiple display languages
- Battery provides more than 30 hours of continuous operation, charge battery using USB cable
- Programmable sounds for alarms, such as an out-of-tolerance result

MMS and FMS Series Precision Digital Force Testers

Specifications

MMS & FMS Series - Digital Force Testers

Models		**Material Testers**				**Force Measurement Testers**			
		MMS-500	**MMS-1000**	**MMS-2500**	**MMS-5000**	**FMS-500**	**FMS-1000**	**FMS-2500**	**FMS-5000**
Load Capacity	N kgf lbf	500 50 112	1000 100 225	2500 250 652	5000 500 1124	500 50 112	1000 100 225	2500 250 652	5000 500 1124
Crosshead Speed - MINIMUM	mm/min in/min	0.001 0.00004				0.02 0.001			
Crosshead Speed - MAXIMUM	mm/min in/min	1525 60							
Position Control Resolution	µm µin	0.125 4.9				0.250 9.8			
Frame Axial Stiffness	kN/mm lbf/in	2.7 15,400	4.3 24,500	4.3 24,500	8.5 48,500	2.7 15,400	4.3 24,500	4.3 24,500	8.5 48,500
Vertical Test Space[1]	mm in	559 22	953 37.5	1257 49.5	1257 49.5	559 22	953 37.5	1257 49.5	1257 49.5
Total Crosshead Travel	mm in	381 15	762 30	1016 40	1016 40	381 15	762 30	1016 40	1016 40
Throat	mm in	100 4							
Total Height	mm in	813 32	1270 50	1575 62	1575 62	813 32	1270 50	1575 62	1575 62
Total Width	mm in	381 15							
Total Depth	mm in	514 20.25							
Test Frame Weight	kg lb	61 135	77 170	88 195	88 195	61 135	77 170	88 195	88 195
Load Measurement Accuracy	±0.5% of reading down to 1/1000 of load cell capacity. Starrett load cell sensors are supplied with a Certificate of Calibration traceable to NIST. Starrett recommends verification of load cell accuracy during installation per ASTM E4, ISO 7500-1 or EN 10002.					FMS frames cannot use extensometers			
Position Measurement Accuracy	±0.005mm or 0.1% displacement (whichever is greater)					±0.010mm or 0.1% displacement (whichever is greater)			
Strain Measurement Accuracy	±0.5% of reading down to 1/50 of full scale with ASTM E83 class B or ISO 9513 class 0.5 extensometer					FMS frames cannot use extensometers			
Crosshead Velocity Accuracy	±0.1% of set speed at zero or constant load hold								
Data Sampling	0.001 to 2000Hz								
Digital I/O	12 total channels Channel 1 & 2 for Power (5-24V) Channels 3 thru 10 for either digital inputs or outputs Channels 11 & 12 for Ground								
Analog Inputs	1 channel @ ±10V								
Analog Outputs	2 channels @ 0-10V								
Extensometer Ports	2 channels for independent connection to an extensometer(s)					FMS frames cannot use extensometers			
USB Interface	1 USB 2.0 connector								
Electrical Phase	Single Phase Voltage (Vac) ±10% 110, 120, 220, 230, 240								
Frequency	50/60Hz								
Operating Temperature	°C °F	+10 to +38 °C +50 to +100 °F							
Storage Temperature	°C °F	-40 to +66 °C -40 to +150 °F							
Humidity	10% to 90%, non-condensing								
CE Compliance	MMS and FMS Series Systems meet all relevant CE standards								

NOTES
Total vertical space is the distance from the top surface of the base plate to the bottom surface of the crosshead.
MMS and FMS Test Frames use MLC and FLC Series load cell sensors only.
MMS and FMS Test Frames may be used with L3, L2Plus and S2 software applications only.
Starrett MMD and FMD Test frames (not shown) are available in 10kN, 30kN and 50kN capacities.

FMM Series Economy Digital Force Testers

Specifications

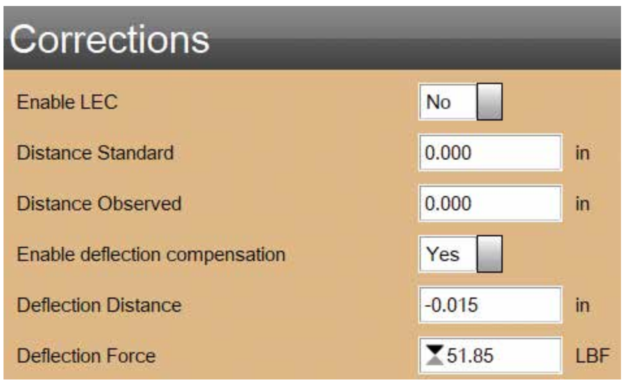
FMM Series - Motorized Force Testers

Models		Short Travel			Standard Travel			Extended Travel		
		FMM-110S	FMM-330S	FMM-550S	FMM-110	FMM-330	FMM-550	FMM-110X	FMM-330X	FMM-550X
Load Capacity, Full Scale	Lbf	110	330	550	110	330	550	110	330	550
	N	500	1500	2500	500	1500	2500	500	1500	2500
	Kgf	50	150	250	50	150	250	50	150	250
Crosshead Speed, Minimum	inch/min	0.002								
	mm/min	0.05								
Crosshead Speed, Maximum	inch/min	40								
	mm/min	1000								
Maximum Speed, Full Load	inch/min	40								
	mm/min	1000								
Accuracy- Speed		Better than 0.1% of test speed								
Accuracy- Crosshead Position		±0.001mm (±20 microns) or 0.1% displacement (whichever is greater)								
Travel Resolution	inch	0.001								
	mm	0.025								
Axial Frame Stiffness	kN/mm	2.5	2.6	2.7	2.5	3.1	3.1	2.2	2.5	2.5
	lbf/in	14,200	14,800	15,400	14,200	17,700	17,700	12,500	14,200	14,200
Cycling, Maximum	Counts	99,999								
	Duration	27 hours								
Constant Hold, Maximum	Duration	27 hours								
Vertical Test Space[1]	inch	15.6			22			32		
	mm	400			559			813		
Crosshead Travel	inch	12			20			30		
	mm	305			508			762		
Communication	USB 2.0, RS-232									
Input/Output Channels	0 - 24Vdc (independent, configurable)									
Power	Single Phase Voltage (Vac) +10% 110, 120, 220, 230, 240 50/60 Hz									
Using 117V Mains at Full Scale Load	Amps	0.09A Holding	0.11A Holding	0.18A Holding	0.09A Holding	0.11A Holding	0.18A Holding	0.09A Holding	0.11A Holding	0.18A Holding
	Watts	10.5 Watts	12.9 Watts	21.1 Watts	10.5 Watts	12.9 Watts	21.1 Watts	10.5 Watts	12.9 Watts	21.1 Watts
Operating Temperature	°F	+40 to +110								
	°C	+5 to +43								
Humidity	10 to 90%, non-condensing									
Throat	inch	3.9								
	mm	100								
Height	inch	28.9			37			47		
	mm	733			940			1194		
Width	inch	11.5								
	mm	292								
Depth	inch	16.5								
	mm	419								
Base Plate Threads	inch	#10-32, 5/16-18, 1/4-28, 1/2-20 (optional)								
	mm	M4, M6, M10, M12 (standard)								
Weight (approx.)	lbs	70			80			95		
	kgs	31.8			36.3			43		
CE Compliance	Meets all relevant CE standards for safety, immunity, noise									

NOTES
Total vertical space is the distance from the top surface of the base plate to the bottom surface of the crosshead.
FMM Test Frames use BLC Series load cell sensors only.
FMM Test Frames may be used with S1 or S2 software applications only.

Easy-to-use Deflection Compensation

Spring testing results may be adversely affected when total system deflection is not correctly compensated for. Starrett software includes deflection compensation so that your entire system's deflection can be compensated for so you achieve more accurate results. When deflection compensation is used, the deflection affects of the test frame, load cell and test fixture are entered into the software's Correction setting. When the specific load cell, test fixture and test frame are used for compression or extension spring measurement, the associated deflection compensation values are automatically applied. You have more accurate results.



Starrett®

Starrett Testing Fixtures and Accessories

Starrett offers a variety of testing fixtures and accessories optimized for spring analysis, testing and measurement. We also develop custom solutions for testing to your exact requirements.

Hook Adapters

Starrett can supply a variety of specialized hook adapters ideal for extension spring testing. Swivel-style hooks help ensure correct axial alignment. Fixed, clevis-style hooks are available for testing up to 50kN (11,000lbf).

Compression Platens

A variety of compression platens are available including swivel platens that help counter issues with non-parallelism. Starrett can supply platens made from aluminum, steel, stainless steel or specialized metals to your requirements.

Spring Rod Sets

Spring rod sets help maintain perpendicularity, especially on small dimension springs that may buckle when a load is applied. Starrett offers standard spring rod sets, or we can create spring rods to your spring's dimensions: inside diameter, wire diameter, outside diameter and free length.

Splinter Shields

Splinter shields are available for all Starrett test frames. We can provide simple manual shields made from clear acrylic to shields made of Lexan® aerospace acrylic with electronic interlocks.

Load Cell Sensors

Starrett has available a complete selection of load cell sensors with capacities from 1N to 50kN (100gf to 11,000lbf). We offer both s-beam style and our superior MLC sensors ideal for applications where axial alignment affects are present. All sensors have a ±0.1% measurement accuracy and come with a Certificate of Calibration.

Extensometers

Starrett L3 systems can be supplied with extensometers for precision stress and strain on the material used to construct your springs.

Load Cell Sensors

Starrett offers a full range of accessories including sensor technologies for precision load and strain measurements. These sensors interface seamlessly with our testing frames and are "self-recognizing". Starrett sensors are ideal for demanding material testing and force measurement applications. All load cell sensors are compliant with IEEE 1451.4 and meet or exceed ASTM E4, BS 1610, ISO 7500-1 and EN 10002-2. Sensors are supplied with a NIST-traceable Certificate of Calibration. Load accuracy on all sensors is 0.1% full scale.

MLC Series - Material Test Low-profile Sensors

Model	Load Capacity			Safe Overload	Full Scale Deflection		Height[1]		Width		Thread
Number	N	KGF	LBF	% Full Scale	in	mm	in	mm	in	mm	mm
MLC-125	125	12.5	28	150	0.003	0.08	1.5	38.1	2.75	69.8	M6 x 1-6H
MLC-250	250	25	56	150	0.003	0.08	1.5	38.1	2.75	69.8	M6 x 1-6H
MLC-500	500	50	112	150	0.003	0.08	1.5	38.1	2.75	69.8	M6 x 1-6H
MLC-1000	1000	100	225	150	0.003	0.08	1.5	38.1	2.75	69.8	M6 x 1-6H
MLC-1500	1500	150	337	150	0.001	0.03	2.51	104.8	4.13	104.8	M16 x 2-4H
MLC-2500	2500	250	562	150	0.001	0.03	2.51	104.8	4.13	104.8	M16 x 2-4H
MLC-5K	5000	500	1124	150	0.001	0.03	2.51	104.8	4.13	104.8	M16 x 2-4H
MLC-10K	10,000	1000	2248	150	0.001	0.03	2.51	104.8	4.13	104.8	M16 x 2-4H
MLC-25K	25,000	2500	5620	150	0.002	0.05	2.51	104.8	4.13	104.8	M16 x 2-4H
MLC-50K	50,000	5000	11,240	150	0.002	0.05	2.51	104.8	4.13	104.8	M16 x 2-4H

NOTES
MLC Sensors cannot be used with FMM Test Frames or with S1 systems.
Load measurement accuracy is ±0.05% of load cell capacity. Display resolution is 10,000:1.
Height includes the base adapter

FLC-P Series - Force Measurement Premium Sensors

	Load Capacity			Safe Overload	Full Scale Deflection		Height		Width		Thread
Model Number	N	KGF	LBF	% Full Scale	in	mm	in	mm	in	mm	mm
FLC-5P	5	0.5	1	1000	0.014	0.4	2.48	63.0	2.33	59.2	M6 x 1-6H
FLC-10P	10	1	2	1000	0.012	0.3	2.48	63.0	2.33	59.2	M6 x 1-6H
FLC-25P	25	2.5	5	1000	0.011	0.3	2.48	63.0	2.33	59.2	M6 x 1-6H
FLC-50P	50	5	11	1000	0.009	0.2	2.48	63.0	2.33	59.2	M6 x 1-6H
FLC-100P	100	10	22	1000	0.007	0.2	2.48	63.0	2.33	59.2	M6 x 1-6H
FLC-250P	250	25	56	1000	0.006	0.2	2.48	63.0	2.33	59.2	M6 x 1-6H

NOTES
FLC-P Sensors cannot be used with FMM Test Frames or with S1 systems.
Load measurement accuracy is ±0.1% of load cell capacity. Display resolution is 10,000:1.

FLC-E Series - Force Measurement Economy Sensors

	Load Capacity			Safe Overload	Full Scale Deflection		Height		Width		Thread
Model Number	N	KGF	LBF	% Full Scale	in	mm	in	mm	in	mm	mm
FLC-50E	50	5	11	150	0.003	0.08	2.5	63.5	2.0	50.8	M6 x 1-6H
FLC-100E	100	10	22	150	0.003	0.08	2.5	63.5	2.0	50.8	M6 x 1-6H
FLC-200E	200	20	45	150	0.003	0.08	2.5	63.5	2.0	50.8	M6 x 1-6H
FLC-500E	500	50	112	150	0.004	0.10	2.5	63.5	2.0	50.8	M6 x 1-6H
FLC-1000E	1000	100	225	150	0.006	0.15	2.5	63.5	2.0	50.8	M6 x 1-6H
FLC-2000E	2000	200	450	150	0.006	0.15	3.0	76.2	2.0	50.8	M6 x 1-6H
FLC-2500E	2500	250	562	150	0.005	0.13	3.0	76.2	2.0	50.8	M6 x 1-6H
FLC-5000E	5000	500	1124	150	0.005	0.13	3.0	76.2	2.0	50.8	M6 x 1-6H

NOTES
FLC-E Sensors cannot be used with FMM Test Frames or with S1 systems.
Load measurement accuracy is ±0.1% of load cell capacity. Display resolution is 10,000:1.

BLC Series - Basic Force Measurement S-beam Sensors (Use with FMM Test Frames and S1 Software only)

	Load Capacity			Safe Overload	Full Scale Deflection		Height		Width		Thread
Model Number	N	KGF	LBF	% Full Scale	in	mm	in	mm	in	mm	mm
BLC-2	10	1	2	150	0.009	0.22	3.0	76.2	3.0	76.2	M6 x 1-6H
BLC-5	20	2	5	150	0.008	0.21	3.0	76.2	3.0	76.2	M6 x 1-6H
BLC-10	50	5	10	150	0.007	0.18	3.0	76.2	3.0	76.2	M6 x 1-6H
BLC-20	100	10	20	150	0.007	0.18	2.0	50.8	2.0	50.8	M6 x 1-6H
BLC-50	250	25	50	150	0.006	0.15	2.0	50.8	2.0	50.8	M6 x 1-6H
BLC-100	500	50	110	150	0.003	0.08	2.0	50.8	2.0	50.8	M6 x 1-6H
BLC-200	1000	100	225	150	0.003	0.08	2.0	50.8	2.0	50.8	M6 x 1-6H
BLC-500	2500	250	550	150	0.005	0.13	2.0	50.8	2.0	50.8	M12 x 1.75-5H

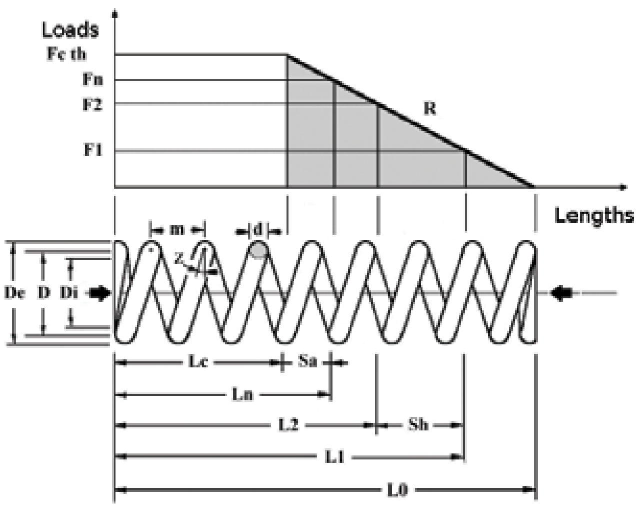
NOTES
BLC Sensors are to be used on FMM test frames and S1 systems. They may not be used with MMS, FMS, MMD or FMD test frames or with S2, L2Plus or L3 software.
Load measurement accuracy is ±0.1% of load cell capacity. Display resolution is 10,000:1.
Starrett recommends on-site verification of accuracy during installation. Sensor calibration should be performed at least annually.

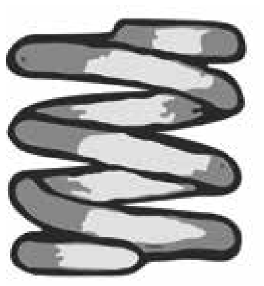
Glossary of Spring Terms

Terms	Description
Active Coils	The coils that are free to deflect when under load.
Allow for Set	Spring is supplied longer than specified to compensate for length loss when fully compressed.
Angular Relationship to Ends	The relative position of the plane of the hooks or loops of extension springs to each other.
Buckling	Bowing or lateral deflection of compression springs when compressed, related to the slenderness ratio (L/D).
Closed Ends	Ends of compression springs where pitch of the end coils is reduced so that the end coils touch.
Closed & Ground Ends	Same as with closed ends, except that the end is ground to provide a flat plane.
Closed Length	Also called Solid Height. Height of a compression spring when under sufficient load to bring all the coils into contact with adjacent coils.
Close-Wound	Coiled with adjacent coils in contact.
Coils per Inch	Also called Pitch. The distance from center to center of the wire in adjacent active coils (recommended practice is to specify number of active coils rather than pitch).
Deflection	Motion of spring ends or arms under the application or removal of an external load.
Elastic Limit	Maximum stress to which a material may be subjected without producing permanent set.
Endurance Limit	Maximum stress at which any given material will operate indefinitely without failure for a given minimum stress.
Free Length	The overall length of a spring in the unloaded position.
Gradient	Also called Rate. Change on load per unit deflection, generally given in pounds per inch or Newtons per millimeter.
Helix	The spiral form (open or closed) of compression, extension and torsion springs.
Hooks	Open loops or ends of extension springs.
Hysteresis	The mechanical energy loss that always occurs under cyclic loading and unloading of a spring, proportional to the area between the loading and unloading load-deflection curves within the elastic range to a spring.
Initial Tension	The force that keeps the coils of an extension spring closed and which must be overcome before the coils start to open.
Load	The force applied to a spring that causes a deflection.
Loops	Coil-like wire shapes at the end of extension springs that provide for attachment and force application.
Mean Coil Diameter	Outside spring diameter (O.D.) minus one wire diameter.
Modulus in Shear	Coefficient of stiffness for extension and compression springs.
Modulus in Tension	Coefficient of stiffness used for torsion and flat springs (Young's Modulus).
Moment	Also called Torque. A twisting action in torsion springs which tends to produce rotation, equal to the load multiplied by the distance (or moment arm) from the load to the axis of the spring body. Usually expressed in inch-oz., inch-pounds or foot-pounds.
Open Ends. Not Ground	End of a compression spring with a constant pitch for each coil.
Open and Ground End	"Open ends, not ground" followed by an end grinding operation.
Permanent Set	A material that is deflected so far that its elastic properties have been exceeded and it does not return to its original condition upon release of load is said to have taken a "permanent set".
Pitch	The distance from center to center of the wire in adjacent active coils (recommended practice is to specify number of active coils rather than pitch).
Preset	Full compression of a spring to solid state by manufacturer when needed to prevent length loss in operation.
Rate	Change on load per unit deflection, generally given in pounds per inch or Newtons per millimeter.
Remove Set	Full compression of a spring to solid state by manufacturer when needed to prevent length loss in operation.
Residual Stress	Stresses induced by set removal, shot peening, cold working, forming and other means. These stresses may or may not be beneficial, depending on the application.
Set	Length loss in operation due to the high stress condition of the spring.
Slenderness Ratio	Ratio of spring length (L) to mean coil diameter (D).
Solid Height	Height of a compression spring when under sufficient load to bring all the coils into contact with adjacent coils.
Spring Index	Ratio of the mean coil diameter (D) to wire diameter (d).
Stress Range	The difference in operating stress at minimum and maximum loads.
Stress Relieve	To subject springs to low-temperature heat treatment so as to relieve residual stresses.
Shot Peened	A cold working process in which the material surface is peened to induce compressive stresses and thereby improve fatigue life.
Squareness of Ends	Angular deviation between the axis of a compression spring and a normal to the plane of the ends.
Squareness Under Load	Same as Squareness of Ends, except with the spring under load.
Torque	A twisting action in torsion springs which tends to produce rotation, equal to the load multiplied by the distance (or moment arm) from the load to the axis of the spring body. Usually expressed in inch-oz., inch-pounds or foot-pounds.
Total Coils	Number of active coils (n) plus the coils forming the ends.
Wahl Factor	A factor to correct stress in helical springs effects of curvation and direct shear.

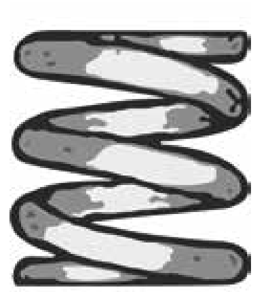
Common Compression Spring Terminology

Symbol	Units	Description	Formula
D	mm, in	Mean diameter	D = De - d
De	mm, in	External diameter	De = D + d
Di	mm, in	Internal diameter	Di = D - d
d	mm, in	Wire diameter	d = De - D
E,	Mpa, PSI	Modulus of elasticity	E = δ/ε
L1, L2	N, Lbf	Target loads (related to target heights/lengths)	
Fc Th	N, Lbf	Theoretical load/force at set solid	
Fn	N, Lbf	Load/force related to Ln (smalled length)	
fe	Hz	Natural frequency	
k	-	Stress correction factor	
L0, FL	mm, in	Free length/height	
D1, D2	mm, in	Target Length/distance (related to target loads)	
Lc	mm, in	Solid length	Lc = d(n+ni+nm)
Ld	mm, in	Length of wire	Ld = p D [2 + nm + n / Cos(z)]
LK	mm, in	Buckling length	
Ln	mm, in	Smallest allowed operating length (geometric)	Ln = d (n + ni +nm) + Sa
Lr	mm, in	Smalled allowed operating length (stress)	
M	g, lb	Mass	$M = Ld\ p\ \pi\ d^2\ 10^{-3} / 4$
m	mm, in	Spring pitch	m = [L0 - d (ni + nm)]/n
N		Number of cycles	
n		Number of active coils	$n = G\ d^4 / (8\ R\ D^3)$
ni		Coils related to the ends	
nm		Number of dead coils	
nt		Total number of coils	nt = n + nm + 2
R, KSR	N/mm, Lbf/in	Spring Rate	$R = G\ d^4 / (8\ n\ D^3)$ or (L1-L2) / (D1-D2)
Rm	Mpa, PSI	Ultimate tensile strength	
Sh	mm, in	Spring travel	Sh = D1 - D2
W	Nmm, Joule	Stored energy	W = 0.5(L1+L2)(D1-D2)
w	-	Spring index	w = D / d



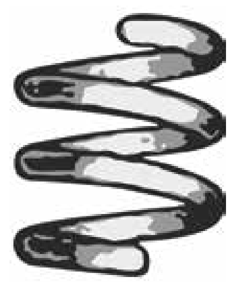


Closed and Squared
Closed and squared end compression springs are the most common. This end type allows the spring to stand vertically when placed on a flat surface. The last coil on either end is closed. This end type is suited for compression springs with a low slenderness ratio.



Closed and Ground
Closed and ground ended compression springs are also common but they are more expensive. Closed and ground ends will help your compression spring stand vertically straight on a flat surface when the slenderness ratio is too large.

Double Closed
Double closed ends are very similar to closed and squared ended compression springs. Instead of the spring having one closed coil at the ends, it has two. They are used to provide stability when your spring has a high slenderness ratio. This end type helps prevent buckling.



Open Ended
Open ended compression springs are uncommon since the spring will not be able to stand unless supported by a shaft or mandrel. There is a pitch between each coil on an open ended compression spring.

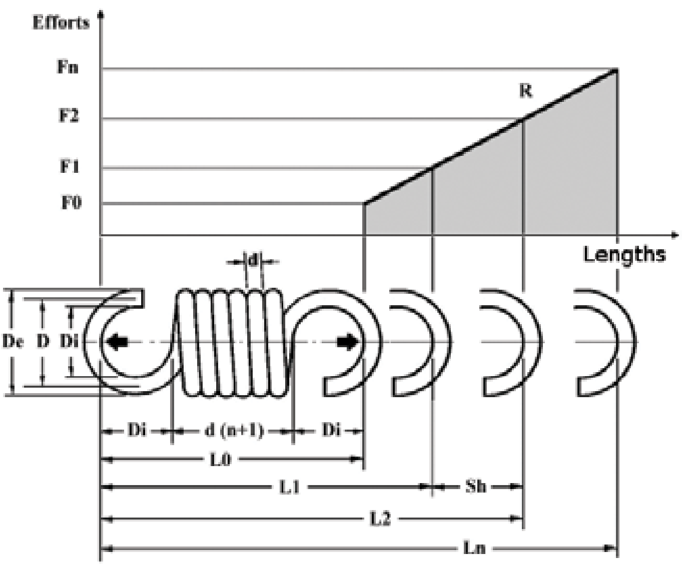
Common Spring Design Materials

Material	Stress	Corrosion Resistance	Application
Brass	Low	Yes	Water resistant
Phosphor Bronze	Low	Yes	Electrical connectivity
Stainless Steel (302/304)	Low	Yes	Corrosive environments
Oil Tempered	Medium	No	Large diameters
Hard Drawn MB	Medium	No	Low cost
Music Wire	High	No	High stress

Starrett®

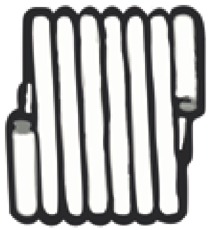
Common Extension Spring Terminology

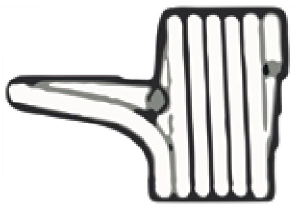
Symbol	Units	Description	Formula
A_{L0}	mm, in	Free length tolerance	
D	mm, in	Mean diameter	D = De - d
De	mm, in	External diameter	De = D + d
Di	mm, in	Internal diameter	Di = D - d
d	mm, in	Wire diameter	d = De - D
E,	Mpa, PSI	Modulus of elasticity	$E = \delta / \varepsilon$
F0	N, Lbf	Initial tension	Pi = 2P1 - P2
L1, L2	N, Lbf	Target loads (related to target heights/lengths)	
Fc Th	N, Lbf	Theoretical load/force at set solid	
Fn	N, Lbf	Load/force related to Ln (smalled length)	
fe	Hz	Natural frequency	
k	-	Stress correction factor	
L0, FL	mm, in	Free length/height	
D1, D2	mm, in	Target Length/distance (related to target loads)	
Lc	mm, in	Solid length	Lc = d(n+ni+nm)
Ld	mm, in	Length of wire	Ld = p D [2 + nm + n / Cos(z)]
LK	mm, in	Buckling length	
Ln	mm, in	Smallest allowed operating length (gemometric)	Ln = d (n + ni +nm) + Sa
Lr	mm, in	Smalled allowed operating length (stress)	
M	g, lb	Mass	$M = Ld\ p\ \pi\ d^2\ 10^{-3} / 4$
m	mm, in	Spring pitch	m = [L0 - d (ni + nm)]/n
N		Number of cycles	
n		Number of active coils	$n = G\ d^4 / (8\ R\ D^3)$
ni		Coils related to the ends	
nm		Number of dead coils	
nt		Total number of coils	nt = n + nm + 2
R, KSR	N/mm, Lbf/in	Spring Rate	$R = G\ d^4 / (8\ n\ D^3)$ or (L1-L2) / (D1-D2)
Rm	Mpa, PSI	Ultimate tensile strength	
Sh	mm, in	Spring travel	Sh = D1 - D2
W	Nmm, Joule	Stored energy	W = 0.5(L1+L2)(D1-D2)
w	-	Spring index	w = D / d



Hooks and Loops

Extension springs make use of hooks or loops. Loops are closed while hooks have an open side or section.



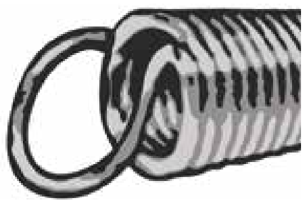


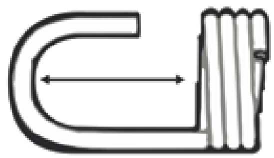
No Hooks

These types of ends have o stress or fatigue on the ends of the extension spring. The amount of pulling force and distance increases and the life cycles re longer. No hooks have the ability to use a bolt to thread into the inner diameter of the extension or tension spring thus securing the ends of the spring

Machine Hook and Loop

Machine hooks are a common type of extension spring hook. These hooks are stronger than cross over center hooks because the radius of the bend to make the hook is not as pronounced.



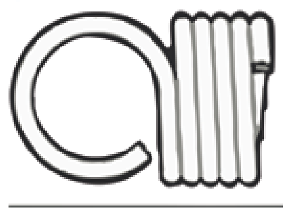


Crossover Center Hooks

Crossover center type extension springs are very common. This type of hooks is made by lifting the last coil and twisting the coil towards the middle therefore crossing the center.

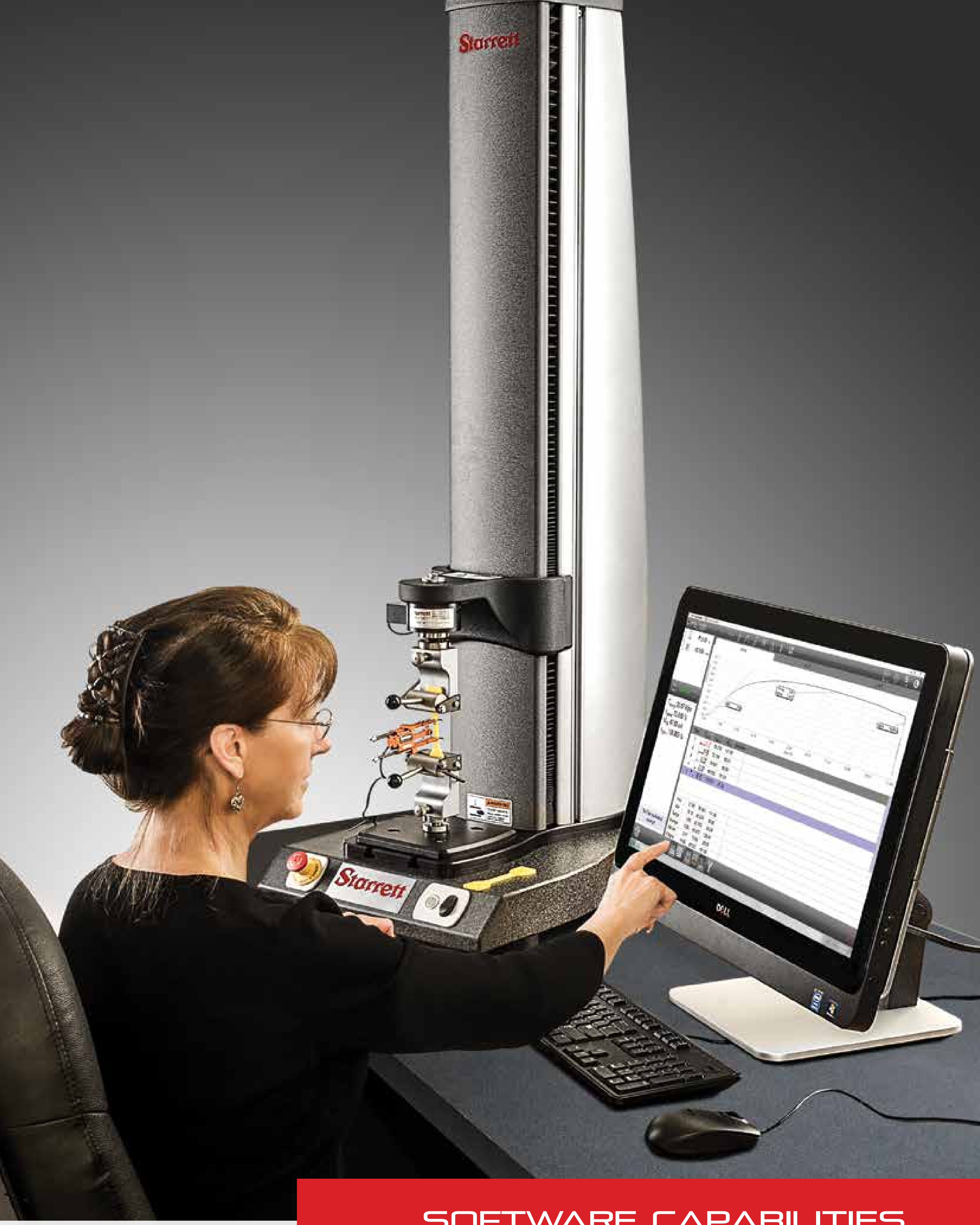
Extended Hooks

Extended hook extension springs are very useful when you need a long length inside hooks but a short body length to get more force out of the spring through less coils. It is the most expensive hook type.



Side Hooks

This hook type is used when the body of the spring must not interfere with the components of a mechanism. This is due to the fact that the hooks are on one side of your spring therefore the other side of the spring is offset. They are made by simply bending the last coil so they are more economical than cross over center hooks



SOFTWARE CAPABILITIES

Lx System Product Comparisons and Capabilities						
Target Applications	L3	L2 Plus	L2	L1	S2	S1
Use for Stress, Strain and Material Testing applications	❍					
Use for Advanced Load, Distance and Force Analysis applications	❍	❍				
Use for Basic Load, Distance and Force Measurement applications	❍	❍	❍	❍		
Use for Advanced Extension and Compression Spring applications	❍	❍				
Use for Basic Extension and Compression Spring applications					❍	❍
User Interface						
All-In-On Computer Workstation, Windows® OS	❍	❍				
Tablet Computer, Windows® OS			❍	❍	❍	❍
Software Applications						
Test Builder	❍	❍	❍		❍	
Force Quick Test Templates			❍	❍		
Spring Quick Test Templates					❍	❍
Formula Builder	❍	✪	✪		✪	
Automation Builder	✪	✪	✪		✪	
Measurement Methodology						
Measure results using the graph	❍	❍				
Measure results using a List of Value menu	❍	❍	❍		❍	
Create Test Setups using Graphical Test Methods (No programming)	❍	❍	❍		❑	
Create Test Setups using Quick-Test Templates			❍	❍	❍	❍
Test Methods						
Tensile Testing, Load, Distance, Break, Rate	❍	❍	❍	❍	❑	
Compression Testing, Load, Distance, Break, Rate	❍	❍	❍	❍	❑	
Hold Testing, Load, Distance for Duration or Event	❍	❍	❍	❍	❑	
Cyclic Testing for Duration, Count, Loop or Event	❍	❍	❍	❍	❑	
Shear Testing	❍	❍				
Flexural Testing	❍	❍				
Peel Testing	❍	❍				
Coefficient of Friction Testing	❍	❍				
Spring Testing	❍	❍			❍	❍
Measurement Capabilities						
Measure Stress, Strain, Elongation, Strengths	❍					
Measure Offset Yield	❍					
Measure Modulus (Elastic, Chord, Tangent)	❍					
Measure Strain and Elongation using Extensometer(s) (requires MMx test frames)	❍					
Measure Energy, Work, Resilience	❍	❍				
Create Mathematical Expressions using Algebraic, Trigonometric and Logarithmic functions	❍	▷				
Create Basic Expressions using Add, Subtract, Multiple and Divide	❍	▷	▷		▷	
Use Digital I/O	▷	▷	▷		▷	
Use Analog I/O (requires MMx test frames)	▷	▷				
Use Command and Conditional Logic	▷	▷	▷		▷	
Measure Load, Distance, Time	❍	❍	❍	❍	❍	
Measure Minimum, Maximum and Averages	❍	❍	❍	❍	❍	
Measure Slopes and Intersections	❍	❍				
Measure Peaks, Valleys, Counts, Averages	❍	❍				
Measure Break, Rupture	❍	❍	❍	❍	❒	
Measure Delta between results within a test	❍	❍	❍			
Measure results within multiple test runs simultaneously (multiview)	❍	❍				
Measure Spring Rate, Spring Constant, Free Length	❍	❍			❍	❍
Reporting and Exporting Data						
Print using standard reports, graph, batch, tolerance, statistics	❍	❍	❍	❍	❍	❍
Export results/data in .csv for custom reporting	❍	❍	❍	❍	❍	❍
Export results/data in .csv for integration with SPC software	❍	❍	❍	❍	❍	❍
Include tolerances on any result	❍	❍	❍	❍	❍	❍

Note: L1 and S1 require a FMM frame.
L3, L2 Plus, L2 and S2 software require a FMS, MMS, FMD or MMD frame

❍ = Standard
✪ = Optional
❑ = Requires Test Builder application
▷ = Requires Automation Builder application

FACTORIES AROUND THE WORLD

1-Athol, Massachusetts, USA

2-Laguna Hills, California, USA

3-Waite Park, Minnesota, USA

4-Cleveland, Ohio, USA

Factories and Distribution Centers

Starrett Distribution Centers and Offices

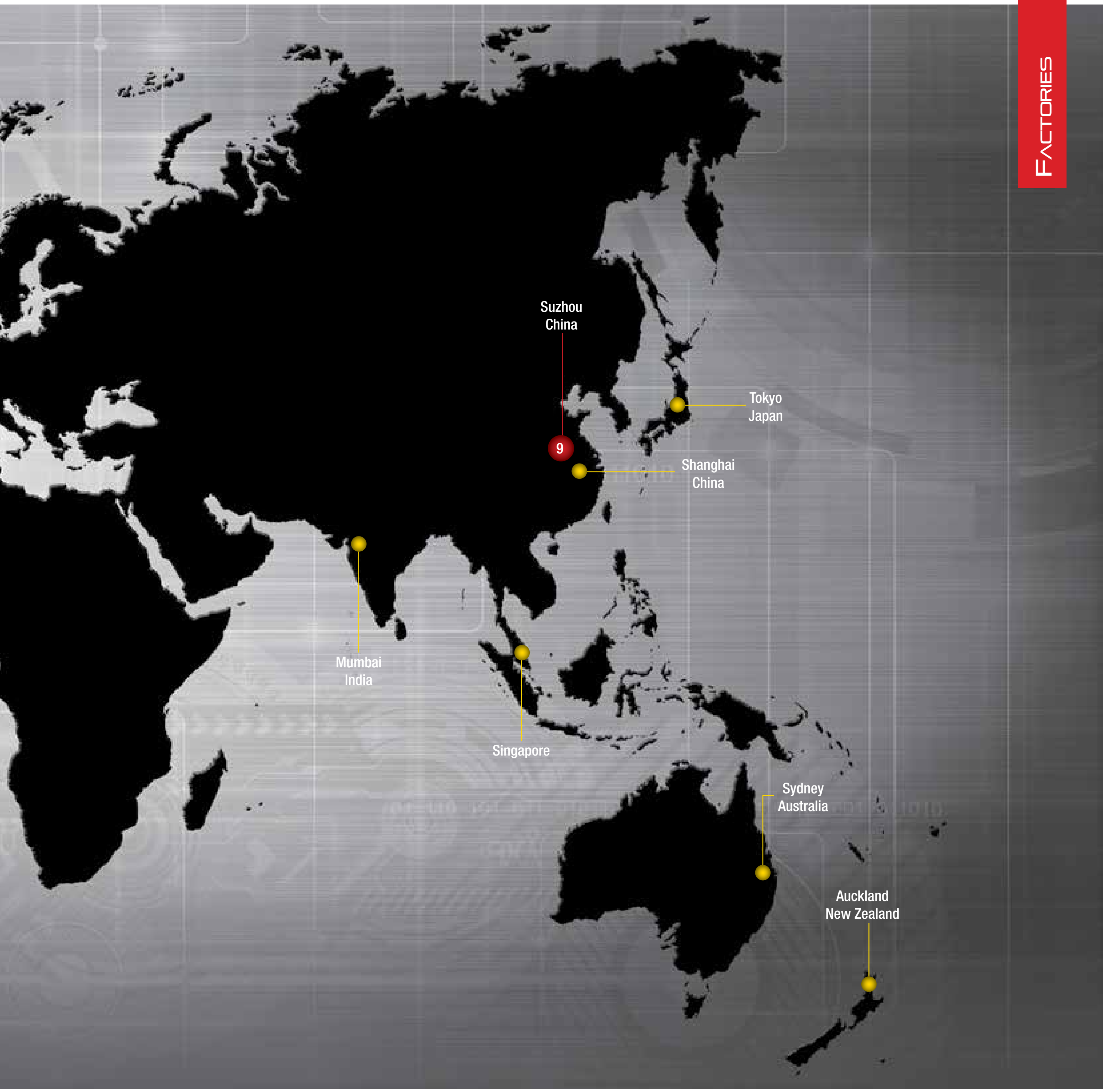

5-Mount Airy, North Carolina, USA

6-Columbus, Georgia, USA


7-Itu, São Paulo, Brazil


8-Jedburgh, Scotland


9-Suzhou, China



STARRETT PRODUCT LINES

- Band Saw Blades
- Force Measurement
- Material Test
- Jobsite & Workshop Tools
- Laser Measurement
- Metrology Equipment
- Precision Granite
- Precision Ground Solutions
- Precision Measuring Tools
- PTA & Hand Tools
- Service
- Webber Gage Blocks

SPRING TESTING SOLUTIONS

Follow us!

Starrett®

Phone: (978) 249-3551 | Fax: (978) 249-8495
121 Crescent Street-Athol, MA 01331-1915-USA

starrett.com

Bulletin 1830 Spring Testing Solutions 09/18