Starrett®

The Fundamentals of Spring Testing

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Starrett SMS Series
A Better Solution for Testing and Measuring Compression and Extension Springs

INTRODUCTION

The design, manufacture and use of springs can be traced back in time to The Bronze Age. Spring design is a science based on complex arithmetic calculations combined with material science. Springs are used in everyday consumer devices including cellular phones and computers; they are used widely in industrial applications including automotive and aerospace; they are used in precision medical devices where a spring, having a diameter of 0.0036 inch (about equal to the size of a human hair), is used in catheters and endoscopic instruments. While the wheel is often considered one of the most important inventions ever, the spring is arguably as equally important and with spring design constantly evolving and requiring more advanced testing and tolerancing.

Springs are used in all types of products and industries. Testing springs for their design characteristics and performance has become more critical as advances in spring technology and manufacturing processes evolve.

Determining a spring's characteristics and validating a spring's performance is critical to ensuring that the spring will perform to its specification over its intended life-cycle for its intended application. This paper will introduce the latest measurement technology from the L.S. Starrett Company, designed to ensure accurate, precise, repeatable and reliable testing of helical compression and extension springs using its innovative SMS Series Spring Testing Systems.

HOOKE'S LAW

One of the basic principles of a spring is to withstand a force while having the ability to compress or extend and then return to its original position or shape. Robert Hooke, a 17th century British physicist, determined that that the extension of a spring is in direct proportion with the load applied to it. Hooke's Law, named after Robert Hooke, is often used in spring design. The most commonly encountered form of Hooke's law is probably the spring equation, which relates the force exerted by a spring to the distance it is stretched or compressed by a spring constant, *k*, measured in force per length.

Equation: $F = -kx$

where

x is the displacement of the spring's end from its equilibrium position (a distance, in SI units: meters); *F* is the restoring force exerted by the spring on that end (in SI units: N or kg m/s2); and k is a constant called the rate or spring constant (in SI units: N/m or kg/s2).

Hooke's law only holds for some materials under certain loading conditions. Helical springs are examples of a product/material that in most cases, correspond and perform according to Hooke's Law.

SPRING TESTING

Spring test methods, such as load and free length testing for a compression spring, are useful to analyze and improve the spring making processes. Selecting the appropriate test method is dependent largely on the spring's intended application, the test purpose, the ultimate spring design and the instrumentation used for testing. Spring performance testing commonly uses load/rate testing where the spring's load and length are measured at 20% and 80% of either the spring's rated load or length. It is

generally agreed that the measuring system used to determine the load/rate analysis be at least accurate to +/-0.5% of full scale. The precision should be less than 0.1 times the load tolerance for the spring being measured. If the system is used to determine the length at various load limits, the measurements should be compensated for deflection of the load application and the measurement system as well as the spring when under applied loads. The precision of the height measurement must be less than 0.1 times the deflection tolerance or the load tolerance divided by the spring rate, whichever is less.

Extensions springs also use a load/rate method similar to compression springs but in the extension direction. Another attribute for an extension spring is to measure a property called initial tension. Initial tension is the load required to cause coil separation between all active coils.

THE STARRETT SMS SERIES SPRING TESTING SYSTEMS

Starrett has recently introduced a new series of spring testing systems designed for high-volume testing environments, the quality laboratory and for spring engineering and design applications. These systems are optimized to ensure accurate, precise and repeatable measurements. These systems feature innovative measurement software that simplifies the testing process and that allows operators with little spring measurement experience to perform testing in seconds and obtain reliable results.

The Starrett SMS Series are single column load testers available in four load capacities: 112 lbf (500N, 50 kgf), 225 lbf (1kN, 100 kgf), 560 lbf (2.5kN, 250 kgf), and 1124 lbf (5kN, 500 kgf). Testers can be supplied with strokes up to 40 inches (1016mm) with adjustable speeds from 0.001 inch to 50 inch (0.02 to 1270mm). High accuracy digital encoders have an outstanding resolution of better than 0.0001 inch standard. Features including a granite base and casted aluminum columns combine with software-controlled deflection compensation and linear error correction ensure a rigid system ideal for accurate measurement when testing compression or extension springs.

SMS Series spring testers come in four models based on their individual load capacities. They all use common software and load cell sensors. And with features such as a granite base, cast aluminum column and deflection compensation and linear error correction, they'll deliver reliable, repeatable load and length measurements.

SMS systems use interchangeable, low-profile load sensors with a measurement accuracy of better than 0.05% full scale. These sensors are optimized to ensure correct axial alignment and to compensate for off-center loading due to buckling, non-parallel surface conditions, squareness conditions, etc. Starrett load sensors comply with IEEE 1451.4 so they are interchangeable and self-identifying with their measurement and calibration characteristics stored digitally within the sensor's architecture. All sensors have built-in mechanical overload protection up to 150% of their rated capacity. Display resolution for these sensors is 10,000:1.

SMS systems make use of Starrett's S2 Series software engineered specifically for spring testing and measurement. S2 Series software operates on a Windows-based tablet computer with USB and Bluetooth capability. This allows the system to interconnect with network servers (for archiving and data management) or other devices including printers, mass memory storage devices, wireless keyboards, etc.

Starrett MLC Series load cell sensors are designed for spring testing applications. Accurate to 0.05% FS, they comply with IEEE 1451.4.

The S2 Series software includes two measurement templates. One template is used to perform testing and measurement on compression springs while the other is used for extension springs. Each template allows the operator to perform sophisticated spring measurements using fill-in-the-blank forms complete with radio buttons that help the operator select the measurement functions necessary for their intended application. Test setup can be performed in seconds.

Each template consists of four sections that the operator can use to setup their individual test: Pre Test, Test, Data and Post Test sections.

Pre Test Section

Each template's Pre Test section provides the operator with options that occur prior to the testing operation. Pre Test options include:

All SMS Series spring testing systems use the Starrett S2 software for spring measurement and testing. Easy-to-use and intuitive templates are supplied for compression and expression spring testing. Create a test and obtain your results in seconds.

- **Global Settings:** options are available for setting the units of measure for load and distance/length measurements. You may also specify the data sampling rate from 5 to 1000Hz; specify the load cell sensor model that is to be used for this test setup; you can secure the test setup by choosing the Lock Test option, which effectively prohibits this test setup from being modified except by the user who created it.

- **Prompting:** two prompts are available that when used, require the operator performing the test to enter the Operator Name (for identification) and/or the Batch Name- to identify the sample under test based on the operator's knowledge of the sample.

- **Preconditioning:** two types of spring preconditioning are available- scragging and load set. Scragging allows the operator to scrag or exercise the spring between two user-specified limits based on load or length, for a duration. The duration may be either a cycle count or a time duration. Load set lets you compress the spring to a load limit for a time duration, for example compress to a permanent set position and hold for 10 minutes.

The Pre Test section is used to setup global settings including units of measurement, data sampling rate and whether a specific model MLC load sensor is to be used for this setup.

- **Exceptions:** the operator has the option to include a test exception. An exception is an event that if it occurs, causes the test to abort (stops the test from being completed).

Test Section

Each template is unique to the spring type. The Compression template's Test Section lets the user measure the spring's height and perform either a single or two-point limit test. When the single point test is used, the default result is the Spring Constant. When a two point test is used, the default result is the Spring Rate.

During setup, the user can specify the single point based on a load limit or length limit. When the two-point method is used, the user can specify two limits which may be either a load or a length. The test speed is also specified.

The Extension template is similar to the compression template, however, instead of the option to measure height, the extension template has the option to measure initial tension.

Data Section

The Data Section is where you select and format your results. Additionally, the Data Section is used to apply a tolerance specification for your spring so that "pass" and "fail" status can be measured and reported.

- **Data Types:** Spring Rate and Spring Constant are default data types measured and reported using the system's displays and reports. Additional data types may be selected from a List and be measured and displayed.

- **Appearance:** All data types are displayed using an abbreviated term. For example, Spring Rate is displayed as KSR. Users have the option to rename any data and to resize the data as they prefer the data to be displayed on one of the system's display views. Data may be displayed in a large format (single line); medium format (dual column size); or small format (three column size). Multiple display languages are supported in the S2 software.

- **Tolerance:** setup limit targets for your spring's tolerance. Results that are reported that equal or fall within the tolerance range specified, are reported as "passed" results and displayed in black text. Results that occur outside the tolerance range, display in red and represent a "failed" result.

The Data section is used to specify which results are reported at the completion of a test. This section is used to format how results will be displayed. Additionally, this section is used to establish tolerance limits for each result.

Post Test Section

The Post Test section provides the operator with options that occur once the test is completed. Post Test options include:

- **Return Home:** when set to "yes", this option causes the SMS tester's crosshead to automatically return to its Home position once the test is completed.

- **Export Raw:** Raw data points correspond to the Sampling Rate specified in the Pre Test function. When the Sampling Rate is 100Hz, during the test, the system will acquire 100 data points per second. All data points for the test can then be exported via the USB port to an external device or network location. Options for exporting data include Overwrite and Auto Number. When Overwrite is used, a new .csv file is created for each Run and the previous file for that batch is over written by the newest data. When Auto Number is selected, a new .csv file is created for each Run. All Runs for the batch will have its own data file.

- **Export Results:** reported results (data) for your Run may be exported via the USB output as a .csv file. Options for exporting results include Overwrite and Auto Number- the same options as the Export Raw Data option.

- **Runs Limit:** each test performed is called a Run. Each Run is identified with a Run Number. Runs are listed in sequential order for later recall. Users can specify the Runs Limit so that tests may be performed in "sets". For example, if the Runs Limit is set to 10, when the Run #11 is performed, the Runs List will only show 10 Runs. When the Run #11 is performed, the first displayed Run Number is Run #2 and the last displayed Run Number is Run #11. Run #1 is deleted permanently.

OPTIONAL TEST BUILDER SOFTWARE

The optional Test Builder is an advanced application available for use with SMS Series systems. The Test Builder is a separate application that compliments your Compression Spring and Extension Spring test templates.

The Test Builder application lets you create a test setup without the use of a template. You create a test using stage movements and other stage types including holds, cycles, etc. The Test Builder gives the user ultimate freedom and flexibility to construct multiple stage test setups with the ability to report a significant number of more advanced test results.

You can create a spring test using either the compression or extension template and then convert the test setup to the Test Builder application allowing more flexibility and advanced testing features to be used.

When the optional Test Builder software is installed, the user may convert a spring template and include more sophisticated test methods and advanced test results and reporting.

TEST FIXTURES FOR SPRING TESTING

Compression springs can be tested using platens. Springs that may have nonparallel surfaces may benefit from self-adjusting platens. Specialized test fixtures can be used that secure the spring during testing. These fixtures are generally customized based on the spring's inside diameter. Hooks are used for extension springs. Starrett can supply specialized test fixtures for spring testing.

DISPLAY VIEWS

The SMS Series systems display measurement and test results in tabular and graphical formats. There are four types of display views:

- **Data View:** displays numerical and textual results for a specific Run.
- **Batch/Summary View:** displays the results for all Runs within a batch in a tabular/spreadsheet-style.
- **Graph View:** displays graph lines based on the sampling rate. Display load v. extension and load v. time. Users may also overlay graph lines for individual Runs so that Runs can be compared to one another graphically, e.g. view spring hysteresis curves.
- **Statistics View:** calculates statistical results for user-selected results. View mean, standard deviations, min/max, pass/fail and six sigma calculations.

CONCLUSION

The Starrett SMS Series spring testers are highly accurate instruments for determining quality and performance characteristics for compression and extension springs. These systems are easy to use and can be applied on the production floor or in the laboratory. For a risk-free demonstration on the Starrett SMS Series spring testers, please contact Starrett and let us show you how the SMS Series can improve your spring testing and measurement.

HOW TO ORDER

866-945-5742
sales@willrich.com

Data View

Graph View

Batch/Summary View

Statistics View

Follow Us

SPECIFICATIONS

Specification	FMS500	FMS1000	FMS2500	FMS5000
Load Capacity	500N 112lbf 50kgf	1000N 225lbf 100kgf	2500N 562lbf 250kgf	5000N 1124lbf 500kgf
Maximum Crosshead Speed	50 in/min 1270 mm/min	50 in/min 1270 mm/min	50 in/min 1270 mm/min	50 in/min 1270 mm/min
Minimum Crosshead Speed	0.001 in/min 0.02 mm/min	0.001 in/min 0.02 mm/min	0.001 in/min 0.02 mm/min	0.001 in/min 0.02 mm/min
Speed Accuracy	+/-0.2% of set speed	+/-0.2% of set speed	+/-0.2% of set speed	+/-0.2% of set speed
Distance Accuracy (no load)	Better than 0.02%	Better than 0.02%	Better than 0.02%	Better than 0.02%
Crosshead Travel	15 in 381 mm	30 in 762 mm	40 in 1016 mm	40 in 1016 mm
Throat Depth	4.25 in 108 mm	4.25 in 108 mm	4.25 in 108 mm	4.25 in 108 mm
Height	32 in 813 mm	50 in 1270 mm	62 in 1575 mm	62 in 1575 mm
Width	15 in 381 mm	15 in 381 mm	15 in 381 mm	15 in 381 mm
Depth	20.25 in 514 mm	20.25 in 514 mm	20.25 in 514 mm	20.25 in 514 mm
Weight	135 lbs 61 kg	170 lbs 77 kg	195 lbs 88 kg	195 lbs 88 kg
Input Voltage	85 - 264Vac	85 - 264Vac	85 - 264Vac	85 - 264Vac
Fuse	250V 3.15A Slo-Blo 5 x 20mm (2ea.)	250V 3.15A Slo-Blo 5 x 20mm (2ea.)	250V 3.15A Slo-Blo 5 x 20mm (2ea.)	250V 3.15A Slo-Blo 5 x 20mm (2ea.)
Input Frequency	47 - 63Hz	47 - 63Hz	47 - 63Hz	47 - 63Hz
Operating Temp	+50° to +100°F +10° to +38°C	+50° to +100°F +10° to +38°C	+50° to +100°F +10° to +38°C	+50° to +100°F +10° to +38°C
Storage Temp	-40° to +150°F -40° to +66°C	-40° to +150°F -40° to +66°C	-40° to +150°F -40° to +66°C	-40° to +150°F -40° to +66°C
Humidity Range	+10% to +90%, non-condensing	+10% to +90%, non-condensing	+10% to +90%, non-condensing	+10% to +90%, non-condensing
CE Compliant	Yes	Yes	Yes	Yes