

Application note

Spring Test
Using CS2 UTM from Chatillon
(overview)

Aims and goals

Aims:
Spring test is an often needed test during the quality check of incoming goods or during maintenance tasks

Goals:
The test must deliver height of unloaded spring, load within limits at specified heights (work load test) and height within limits at specified load (block length test) for different specimen (varying materials, varying dimensions, varying design). Before performing the measurements often the springs have to get conditioned according to specified rules.
The testing procedure shall run as much as possible automatically. Results should get exported continuously and a report shall get generated after end every test batch.

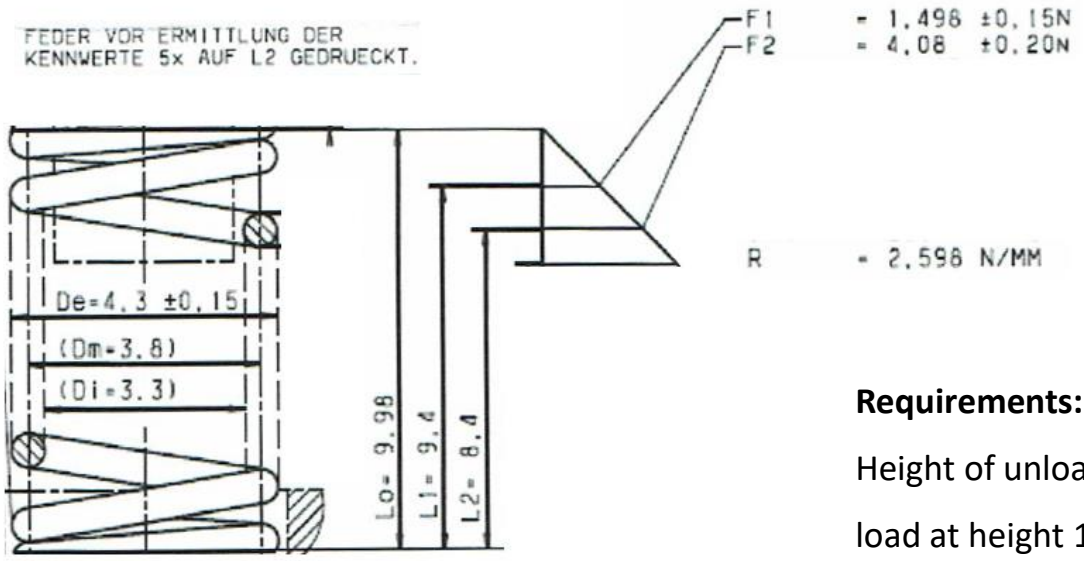
The Chatillon UTM **CS2** is a perfect solution for easy to use and accurate spring test.

Spring N° 1

The following example shows how to perform this test as a very small spring, which is used in automotive injection systems.

But this procedure is the same like e.g. testing very large springs from airplane brakes.

Specification of spring N° 1



Requirements:

Height of unloaded spring:	9,98 mm
load at height 1 (9.4mm):	1.498 ± 0.15N (1.348 to 1.648 N)
load at height 2 (8.4 mm):	4.08 ± 0.20N (3.88 to 4.28 N)
Spring rate:	2,598 N/mm

Defining the testing procedure

Prüfsetup Rev. Datum: 20.02.2018

Name der Prüfung: [redacted] Feder 2 mit Konditionierung Status: Setup rev.V1

Bemerkungen:

TESTEINSTELLUNGEN	Koordinatensystem	Height						
	Steife-Kompensation?	C10N						
	Test Name:	Feder [redacted] Typ2_Kond_SC						
	Bild Dateiname:	Feder2						
	Vorlast-Kraft in N	0,05N						
	Vorlast-Geschw. mm/min:	10 mm/min						
	Minimale Datenkomprimierg.?	nein						
	Datenübertragungsrate:	100Hz						
	Nullung Kraft am Vorlastpunkt?	nein						
	Nullung Weg am Vorlastpunkt?	nein						
	Auto-Return zum Nullpunkt?	ja						
	Absolutkoordinaten?	nein						
GRENZEN	Stufe Nr.	1	2	3	4	5	6	7
	Typ (Z, D, C, H, F, N)	D	D	C	D	D		
	Prüf-Geschw. in mm/min:	50	50		5	5		
	Grenzwert Kraft? in N							
	Grenzwert Weg? in mm							
	Grenzwert Höhe? in mm	8,4	9,9		9,4	8,4		
	Rampe?				ja	ja		
	Ohne Grenzen							
	Grenzwert Bruch scharf?							
	Grenzwert Bruch weich? in%							
	Start Brucherkennung in N:							
	Zyklus ab Stufe			1				
	Zyklusdauer Anzahl			5				
	Zyklusdauer Zeit:							
	Halten Dauer in s:							
	Halten Kraft:							
	Halten weg							
	Nullung Weg							
	Nullung Kraft							
	Frage Titel:							
	Frage Text:							

ERGEBNISSE		E1	E2	E3	E4	E5
	Stufe:	1	5	6	6	
	Größe:	HPL	L	L	SR	
	Titel	H0	F1	F2	C	
	anzeigen?	x	x	x	x	
	Nominal					
	Pass max:		1,648N	4,28N		
	Pass min:		1,348N	3,88N		
	Mittel oder SR start:				8,45mm	
	Mittel oder SR ende:				9.34mm	

EXPORTIEREN / ARCHIVIEREN		
	Export-Pfad:	\\ Netzwerk \ DatenexportCS2\ [redacted] Feder2
	Autoexp. nach jedem Run?	JA
	- Export CSV?	JA
	- Export PDF?	JA
	- Export RS232?	NEIN
	Exportspezifikation	Inkl. Statistik
	Archivierung nach n Tests?	NEIN > das wird manuell gemacht
	Bericht beim Archivieren?	JA

Readings and results are strongly depending from the test setup. For quality assurance systems and traceability it is important as to have a clear and understandable test setup documentation, in particular for ISO 9001 systems.

Therefor we have created two easy to use and easy to understand forms, a setup data table (lefthand figure) and a flow diagram (next slide).

The table includes 4 sections (basic settings, limits, results and export/archiving) added by the related setup page screen shots.

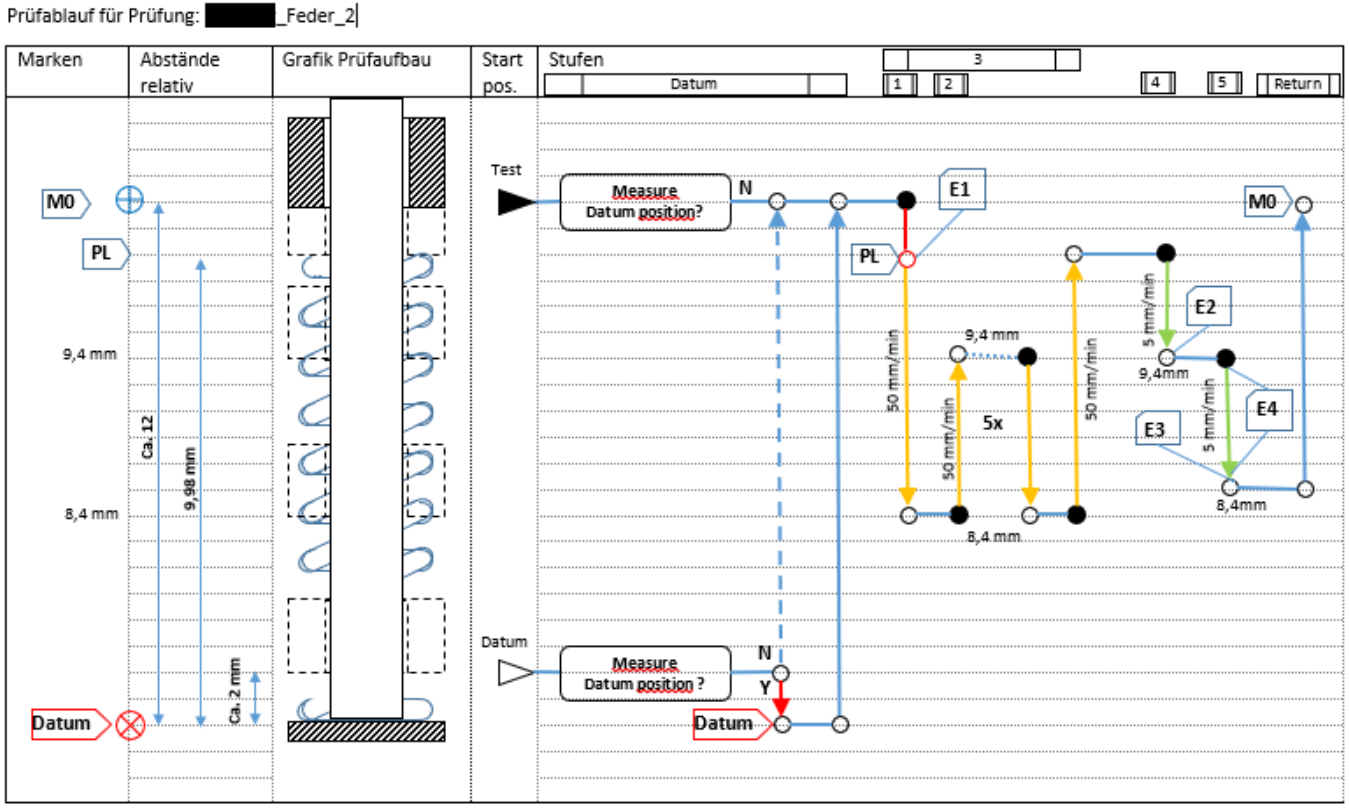
The limits section includes the stages and each stage is defined by direction or cycling and the special stage limit.

The result section includes at maximum 5 results. Each result is defined by the related stage, the internal name and the visible name and if given, by the limits.

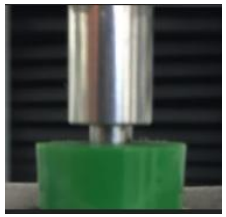
These table found a very high acceptance by users, because it shows very clear and easy all setup data from the test.

Defining the testing procedure

The flow diagram includes 5 sections from left to right: main test points, important distances, picture, start positions (test run or datum measurement) and the test stages. The test stages show the crosshead travel (arrows), the test parameters (speed, limit, repetition) and the results generated in each stage.



Creating a testing fixture



Testing springs requires a perfect deformation of the spring (no break away, no friction), particularly when testing very flexible springs.

The pictures left-hand show a simple but useful improvisation of a guidance for a very small and flexible spring, a rod-bush-system.

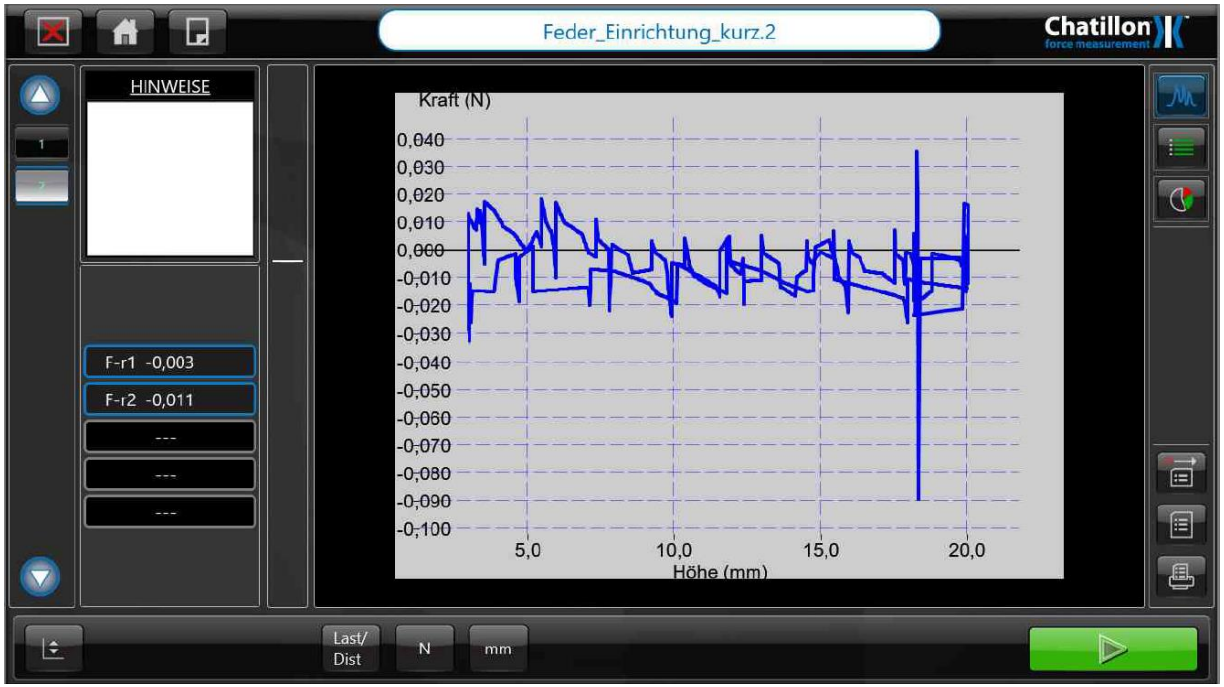
The challenge of this systems is to have on the one hand a very safe system, means no axial crash between rod and bush and on the other hand a minimum of friction. So the guiding system must have a self adjusting.

The fixture will be used for three tests, first a friction test a s to validate the impact of friction to the test results (middle top), second a datum test as to get the datum position and third the reals spring test (middle below).

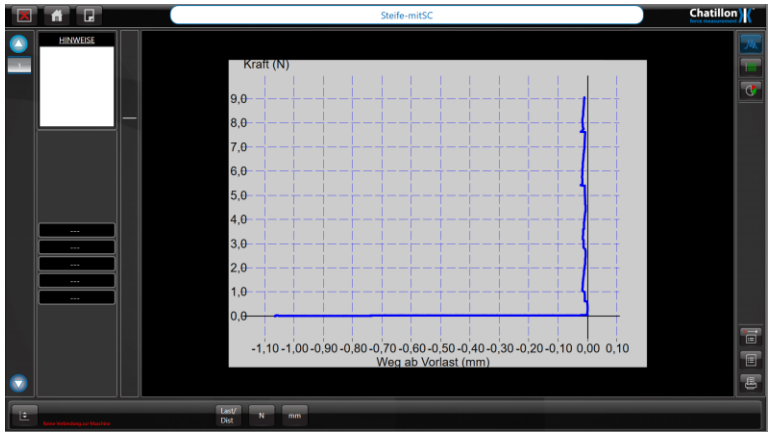
Please note, this improvisation is ok for pre-test, for practice there will be used a final developed industrial fixture.

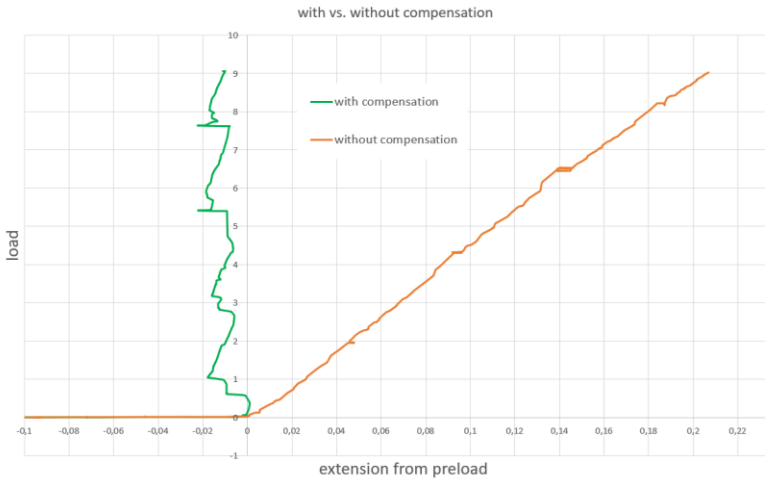
Validation of testing fixture – guidance friction test

The friction test shows that the impact of friction to the load readings is within the range of 0,01N and less.
This friction test must be performed when the fixture was touched in any way, e.g. dismounted from the test machine or adjusted in any way. It is recommended to report this test as to allow traceability of the spring test results. This is easy to solve by a special friction test setup and automatically export the test screen as PDF like shown below. The stored PDF file includes a time stamp as to allow traceability.



Validation of testing system – stiffness compensation



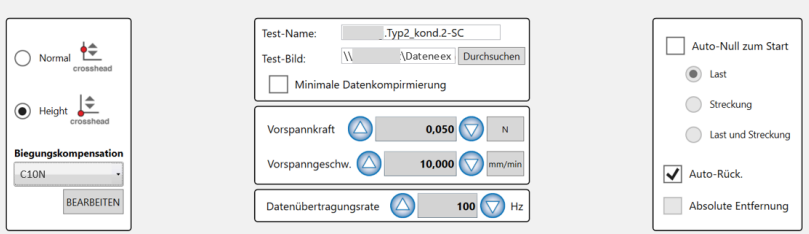


Often test results do not meet the spring specification. But this is not true if a test machine was used without a good stiffness compensation.

The Chatillon CS2 machine itself is very stiff. But there a two other impacts, the functional deformation of the load cell and the deformation of the fixture.
It is necessary to note that also very small loads cause significant deformation at low load cells!

The CS2 testing machine supply a very good and easy to perform stiffness compensation function. For adjusting the stiffness compensation the spring guidance fixture will be used without an inserted spring and a special compensation test has to be used. To the left you see a diagram showing the measurement using a 10N load cell both with and without stiffness compensation. Without stiffness compensation the deformation mistake will be at a range of some tenth millimeters, what is often more than the pass-fail range of the spring! When using the CS2 stiffness compensation the mistake is less than 20 microns!

Test setup (screen 1 and 2)

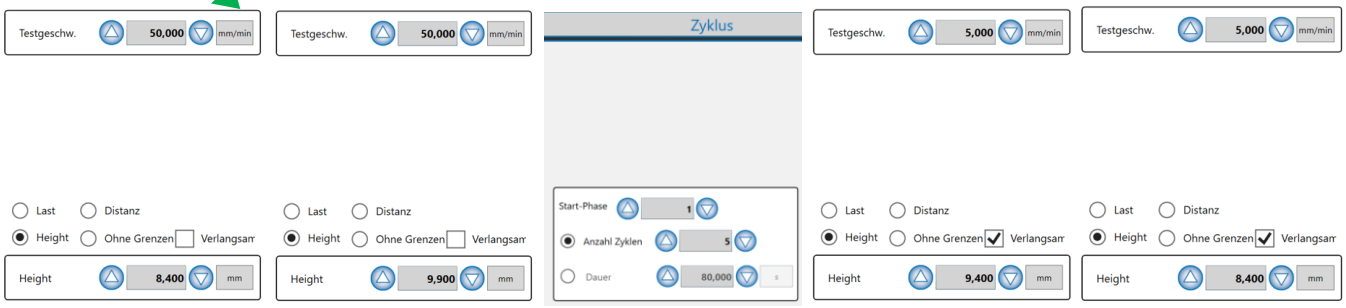


Screen 1: Basic settings

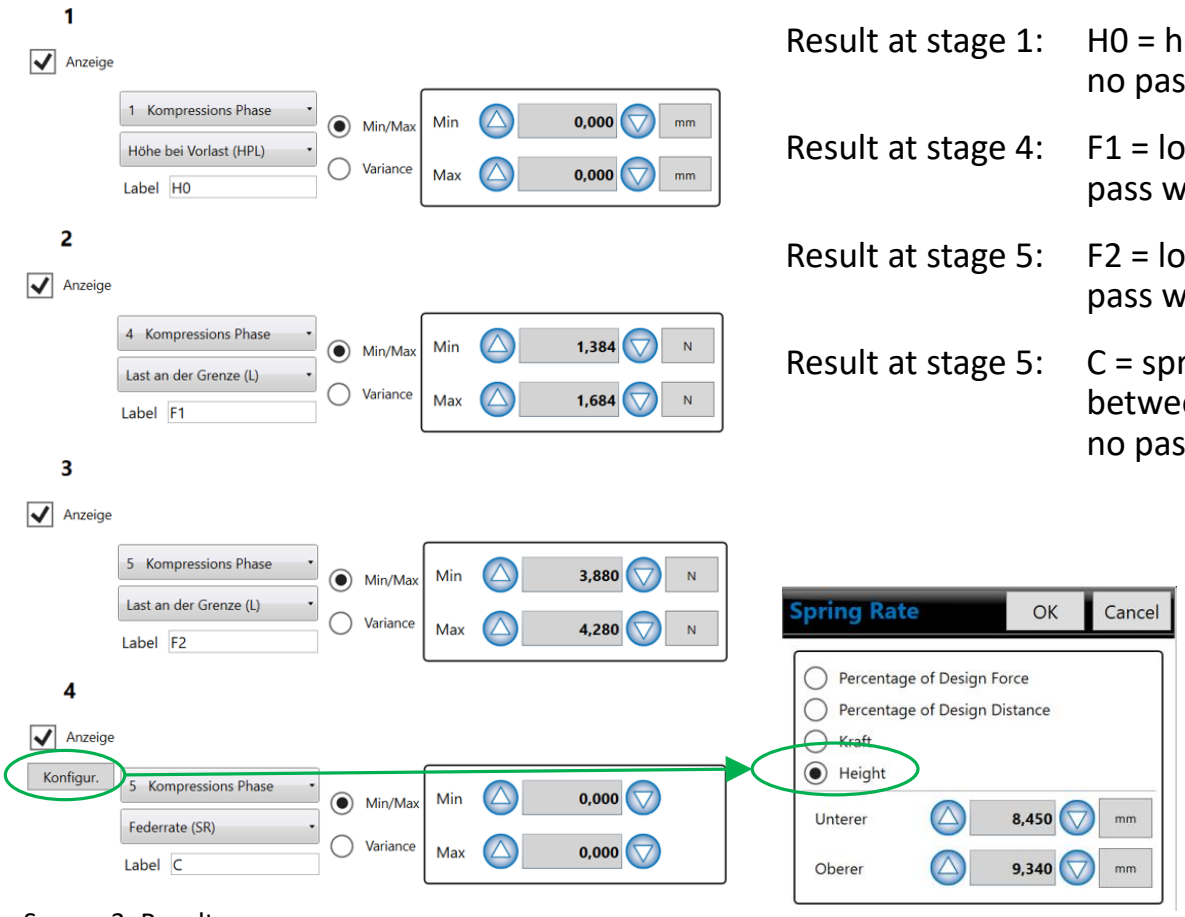
Screen 2: Test stages

Basic settings: height modus, C1kN stiffness compensation, test name, Link to test picture, pre-load (load and speed), data rate, no zero due to height modus, auto return after test finish

Test stages can be added to the test sequence:
1 and 2 = compression (pre-conditioning),
3 = cycle (preconditioning)
4 and 5 = compression (test results)
Each stage has a separate window for test parameters like test speed, test limit and ramp at stage 1, 2, 4 and 5. Stage 3 parameters are stage at start of cycle and numbers of cycle.



Test setup (screen 3)



Screen 3: Results

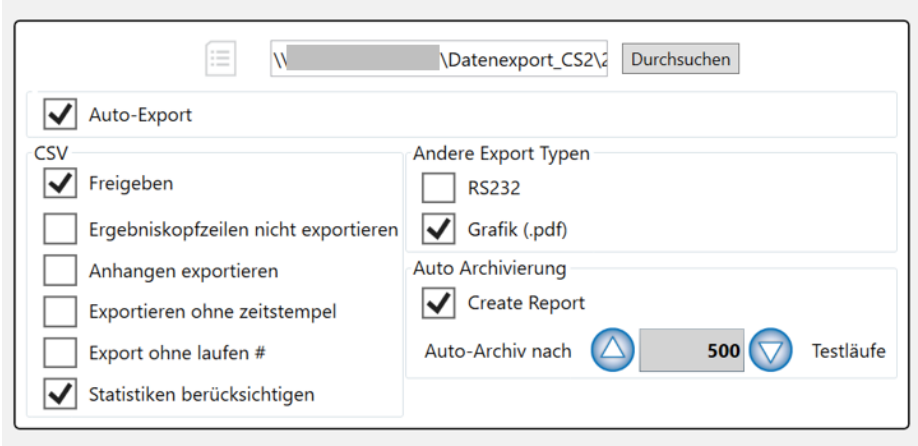
Result at stage 1: H0 = height of unloaded spring
no pass/fail criteria

Result at stage 4: F1 = load at end of stage
pass within 1,384 to 1,684 N

Result at stage 5: F2 = load at end of stage
pass within 3,880 to 4,280 N

Result at stage 5: C = spring rate
between 9,34 and 8,45 N
no pass/fail criteria

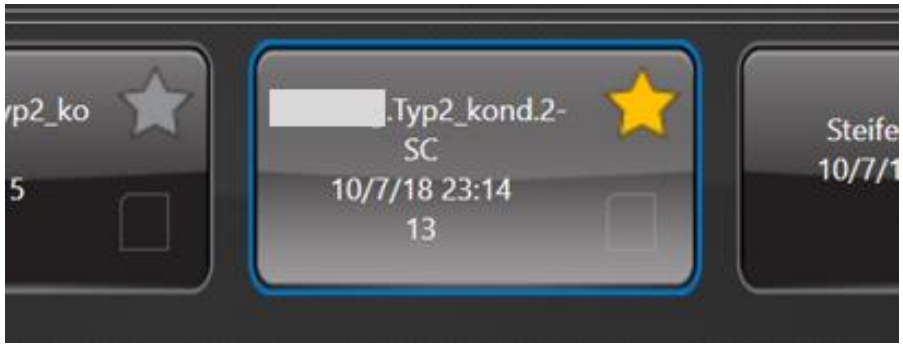
Test setup (screen 4)



Screen 3: Export and Print

Auto-Export after each run
This deliver automatically two reports after the run has finished:
> screen shot of graph and results as PDF
> load-extension readings table as CSV.

Auto Archiving after 500 runs (this is the preset number and also the maximum …)
But print a report and archiving can be done also manually by soft-button. In this case two reports will get generated:
> PDF report incl. statistics (report layout)
> CSV report incl. statistics



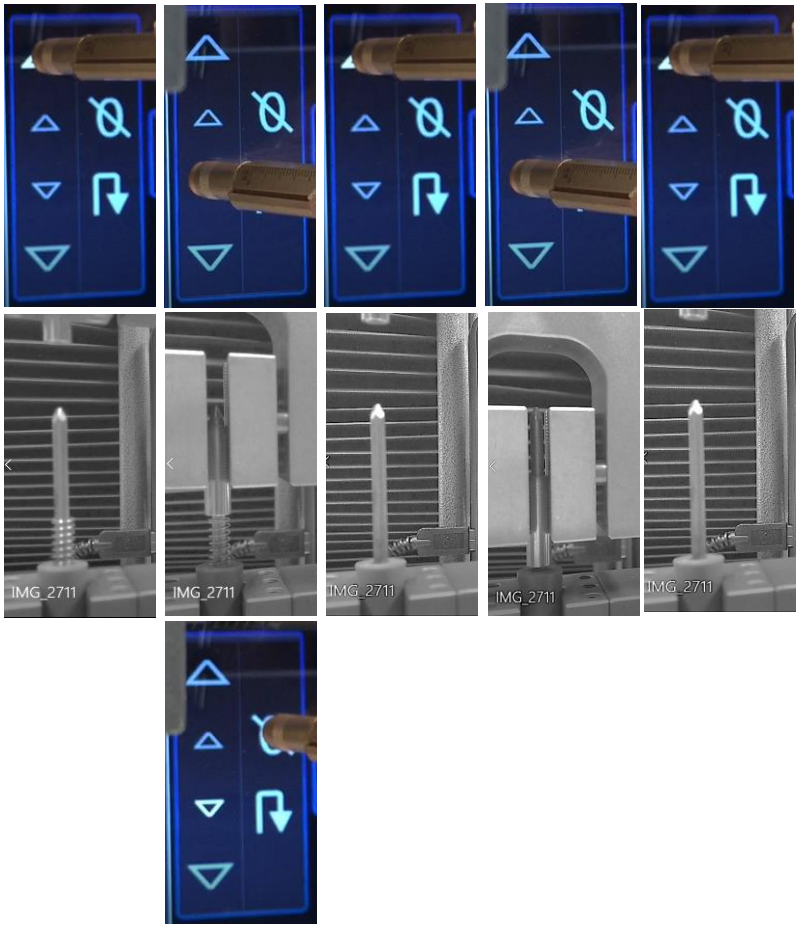
These only 4 speedy-to-fil-out setup-screens will supply a complete spring test inclusive stiffness compensation, height modus and conditioning as to get precise results. The test can be set in the test library as a favorite (golden star), what will offer this test directly at the start screen. Not necessary to pick up the test from the test library. Very easy and fast!

Test performance

Now the test can get started at the CS2 start screen from the favorite menu.

Test performance (Preparation)

P1 P2 P3 P4 P5



P1: Open the fixture, insert the spring.

P2: Position the bush appr. 2mm above the spring, then zero the system.

P3: Open the fixture, then remove the spring.

P4: Position the bush appr. 1-2 mm above the Datum position, then start the test.

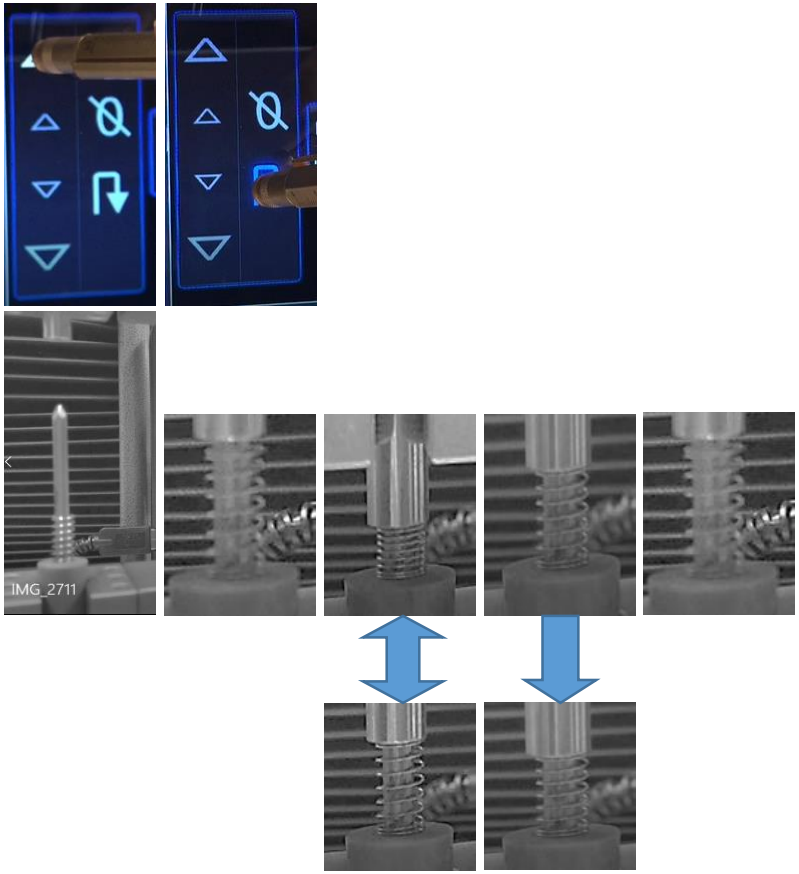
Confirm Datum position measurement:

Wait up to the bush is in zero position again:

P5: Stop the test and open the fixture.

Test performance (Running)

R1 R2 R3 R4 R5



R1: Open the fixture and insert the spring.

R2: Return to zero position, then start the test.

Refuse measuring the datum position again.

R3: The crosshead will cycle, so the bush will compress and decompress the spring five times.

R4: The crosshead will travel in a first step to a spring height of 9,4 mm an measure the load. Then in a second stage to 8,4 mm an measure the load.

R5: The test will finish in the zero position.

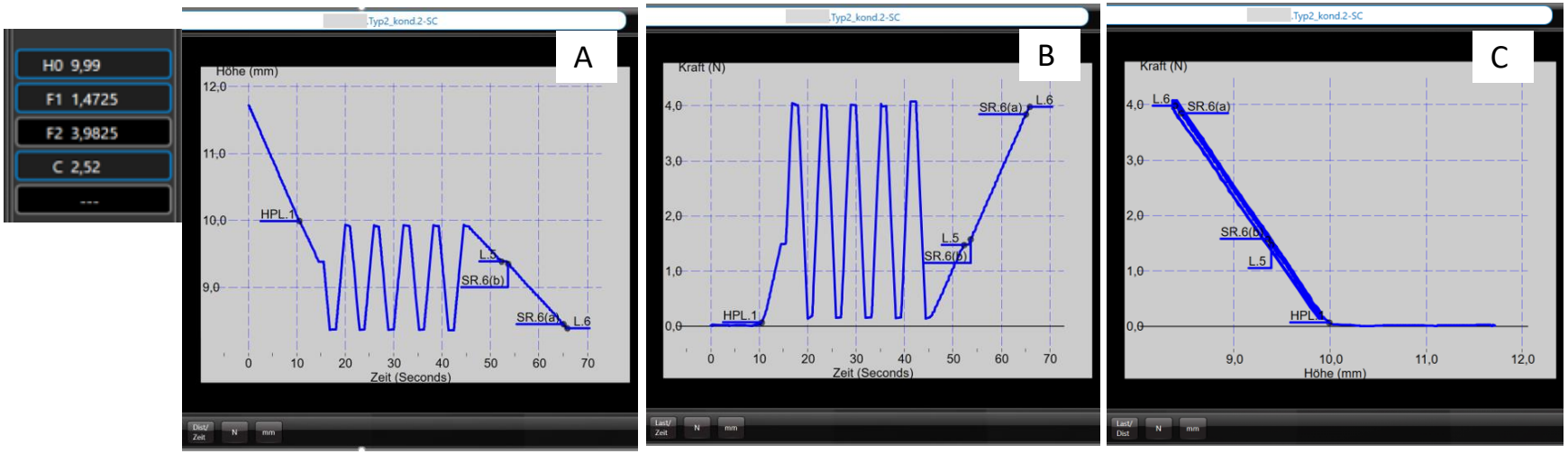
Test graphs

Each run can be present by three diagrams: A = height vs. time, B = load vs. time, C = Load vs. height.

A: Crosshead started at height appr. 11,7mm. In stage 1 it traveled to 8,4 mm. At the pre-load-point the height of the unloaded spring was measured (HPL.1) and show as H0 result. Then the crosshead has cycled between 8,4 and 9,9 mm. In stage 4 and 5 the load was measured at height 9,4mm (L5) and height 8,4mm (L6) and shown as result F1 and F2. Last the spring rate between L5 and L6 was calculated and shown as C.

B: HPL.1 mark the pre-load point at 0,05N. The load results (L6, L7) are within the pre-conditioning load span.

C: The load-height graph show the hysteresis of the load during the cycling of appr. 0,25N. This is not the friction of the fixture (0,01N). The readings during the measuring stage are in the middle of the hysteresis, what may be due a good conditioning and an enough slow compression speed.



Test results

Starten	H0 (mm)	F1 (N)	F2 (N)	C (N/mm)
1				
2	9,65	0,6280	3,1075	2,50
3	9,67	0,7410	3,2195	2,49
4	10,01	1,5610	4,0430	2,48
5				
6	9,91	1,3110	3,8040	2,50
7	9,95	1,4755	3,9700	2,52
8	9,94	1,4010	3,9625	2,57
9	9,68	0,6655	3,2140	2,49
10	9,95	1,4595	3,9785	2,54
11	9,68	0,6485	3,1925	2,48
12	9,99	1,4725	3,9825	2,52

Show single test run (graph and result).

Show batch result table.

Show statistics.

Exclude a run.

After the test of 10 springs was finished, the results was shown in the result table. What happened?

Two tests (1, 5) have been excluded due to any fail in operation. These lines are yellow backlighted.

Five springs (test run 4, 7, 8, 10, 12) have passed. This is green written.

Five springs (test run 2, 3, 6, 9, 11) have failed. This is red written.

The length of the unloaded springs (H0), what was measured using the pre-load at the first test stage, are at length of 9,65 to 9,91 mm. Note, the nominal length of the spring is 9,98mm. These 5 too shorten springs have failed.
The other 5 springs are at unloaded length of 9,94 to 10,01, what is more close to the nominal length of 9,98 mm. These good 5 springs have passed.

Test Report

1 [redacted]Typ2_kond.2-SC

2

Seriennummer:	CS225 S/No.681	Bediener	axel
Gestell-Kapazität:	1000 N	Datum	2018-02-22 16:12:03
Zelle Seriennummer laden:	2LB0042		
Wägezellenkapazität	10,0 N		

3 **Statistik-Testergebnisse**

Testläufe:	12
Bestanden:	5
Nicht bestanden:	5
Ausgeschlossen:	2

4

Ergebnis	Max	Min	Ber.	Durchschn.	Stdabw.	KOV
H0 (mm)	10,01	9,65	0,36	9,84	0,14	1,46
F1 (N)	1,561	0,628	0,933	1,136	0,386	33,936
F2 (N)	4,043	3,108	0,935	3,647	0,384	10,530
C (N/mm)	2,57	2,48	0,10	2,51	0,03	1,11

5 **TESTERGEBNISSE**

Starten	H0 (mm)	F1 (N)	F2 (N)	C (N/mm)
(1)				
2	9,65	0,628	3,108	2,50
3	9,67	0,741	3,219	2,49
4	10,01	1,561	4,043	2,48
(5)				
6	9,91	1,311	3,804	2,50
7	9,95	1,475	3,970	2,52
8	9,94	1,401	3,963	2,57
9	9,68	0,666	3,214	2,49
10	9,95	1,459	3,978	2,54
11	9,68	0,649	3,193	2,48
12	9,99	1,472	3,982	2,52

The CS2 software deliver an easy and fast to finished report, showing:

1 test name

2 equipment and processing specification
> machine typ, SN° and frame capacity
> load cell SN° and load capacity
> operator and operation date

3 overview
> number of runs total
> number of passed and failed runs
> number of excluded runs

4 statistics
> Mean, Max, Min, and Range
> standard deviation and COV

5 results of each run

The layout is fixed, but can include a customized logo. In the lefthand figure the backlight colors mark passed (green) and failed (red)springs.

What advantage can you get from the CS2 machine?

- ✓ Various possibilities for fixture adaption
- ✓ Wide range of load cells with optimum load capacity, plug & play
- ✓ Very easy and fast test setup
- ✓ Library of different types of test stages, a.o. useful for pre-conditioning of springs.
- ✓ Very easy operation.
- ✓ Precise stiffness compensation, a.o. for testing springs within narrow pass/fail confines.
- ✓ Automatical measurement of datum position, e.g. for precise spring height axis.
- ✓ Accurate crosshead positioning at the target positions, using ramps.
- ✓ Very easy and fast report generation.

Somebody may say, also a test setup without height measurement, pre-conditioning and stiffness compensation may work. But this will fail.
If a spring is a little bit too short, like shown above, a distance measurement from a zero point or from a pre-load point could deliver right results, but when assembled in the final product the spring could fail.

Regarding precise stiffness compensation and pre-conditioning, see next slides, what will happen if the test system will not have or not use theses features, supported by the CS2 machine.

The right method: pre-conditioning + stiffness compensation

[redacted]Typ2_kond.2-SC

Seriennummer:	CS225 S/No.681	Bediener	axel
Gestell-Kapazität:	1000 N	Datum	2018-02-22 16:12:03
Zelle Seriennummer laden:	2LB0042		
Wägezellenkapazität	10,0 N		

Statistik-Testergebnisse

Testläufe:	12
Bestanden:	5
Nicht bestanden:	5
Ausgeschlossen:	2

Ergebnis	Max	Min	Ber.	Durchschn.	Stdabw.	KOV
H0 (mm)	10,01	9,65	0,36	9,84	0,14	1,46
F1 (N)	1,561	0,628	0,933	1,136	0,386	33,936
F2 (N)	4,043	3,108	0,935	3,647	0,384	10,530
C (N/mm)	2,57	2,48	0,10	2,51	0,03	1,11

TESTERGEBNISSE

Starten	H0 (mm)	F1 (N)	F2 (N)	C (N/mm)
(1)				
2	9,65	0,628	3,108	2,50
3	9,67	0,741	3,219	2,49
4	10,01	1,561	4,043	2,48
(5)				
6	9,91	1,311	3,804	2,50
7	9,95	1,475	3,970	2,52
8	9,94	1,401	3,963	2,57
9	9,68	0,666	3,214	2,49
10	9,95	1,459	3,978	2,54
11	9,68	0,649	3,193	2,48
12	9,99	1,472	3,982	2,52

The report lefthand once more show the right detection of bad springs using pre-conditioning and stiffness compensation.

Remember: We found 5 good and 5 wrong springs, what was conform to the measured length (height) of the unloaded springs. The nominal length of the springs is 9,98 mm.

5 springs passed right due to its right length
(green marked, green arrows)

5 springs failed right due to its too short length.
(red marked, green arrows)

Each line is either completely green or completely red marked, what is a perfect detection of good and bad springs.

Wrong spring testing due to missed stiffness compensation

Feder[redacted]Typ2_kond

Seriennummer:	CS225 S/No.681	**Bediener**	axel
Gestell-Kapazität:	1000 N	**Datum**	2018-02-15 18:15:39
Zelle Seriennummer laden:	2LB0042		
Wägezellenkapazität	10,0 N		

Statistik-Testergebnisse

Testläufe:	12
Bestanden:	2
Nicht bestanden:	9
Ausgeschlossen:	1

Ergebnis	Max	Min	Ber.	Durchschn.	Stdabw.	KOV
H0 (mm)	10,05	9,67	0,38	9,87	0,15	1,51
H0b (mm)	10,74	9,67	1,06	9,96	0,29	2,88
F1 (N)	1,474	0,608	0,866	1,085	0,377	34,754
F2 (N)	3,922	2,959	0,963	3,485	0,406	11,642
C (N/mm)	2,51	2,34	0,17	2,39	0,05	2,15

TESTERGEBNISSE

Starten	H0 (mm)	H0b (mm)	F1 (N)	F2 (N)	C (N/mm)
(1)					
2	9,97	9,97	1,416	3,820	2,42
3	10,03	9,98	1,408	3,903	2,51
4	9,68	9,68	0,612	2,959	2,36
5	9,67	9,67	0,608	2,963	2,34
6	9,99	10,10	1,456	3,922	2,46
7	9,70	9,73	0,696	3,059	2,34
8	9,73	9,92	0,768	3,203	2,39
9	9,99	9,99	1,406	3,800	2,39
10	9,97	10,74	1,399	3,789	2,39
11	9,76	9,73	0,691	3,055	2,34
12	10,05	10,04	1,474	3,868	2,38

The report lefthand shows the results from the test of the same spring batch like shown some slides above plus one more spring.
Now, without stiffness compensation, we see:

2 right passed springs (3, 6), instead of 5!
apparent unloaded length 9,99 to 10,03 mm (green marked + green arrow)

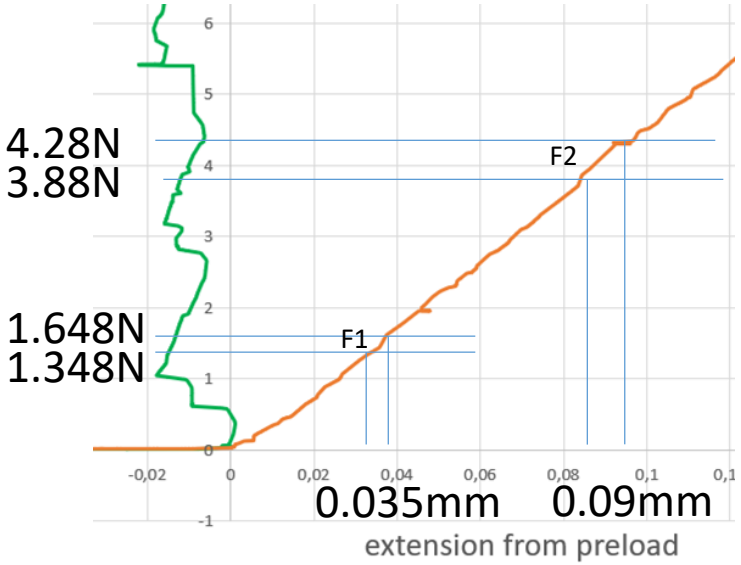
5 right failed springs (4, 5, 7, 8, 11)
apparent unloaded length less 9,8 mm (red marked + green arrow)

4 wrong failed springs (2, 9, 10, 12)
apparent unloaded length 9,97 to 10,05 mm red arrow!

4 of 6 good springs with unloaded length H0 close to the nominal length failed at F2!

Note H0b was a 2nd dynamic measurement of H0 after pre-conditioning was finished. At nearly all runs this has confirmed the H0 measurement at the pre-load point.

What is stiffness correction doing?



How to explain the wrong results when testing springs without stiffness correction?

Due to the deformation of both load cell and fixture, the crosshead travel is less then the target value for the spring compression. So the load is too low.
If we correct the achieved load from the previous slide manually by the load correction, we will get consistency between the expected pass/fail of each line due to the good/wrong spring length with the pass/fail of the corresponding load.

Load correction:
0.09mm * 2,598 N/mm = 0,234 N
0.035mm * 2,598 N/mm = 0,091 N

Right pass/ fail			F1			F2	
	1,35	min	1,35	3,88	min	3,88	
	1,65	max	1,65	4,28	max	4,28	
	reading		corr	reading		corr	
2	1,416	0,091	1,507	3,820	0,234	4,054	F2 well corrected.
3	1,408	0,091	1,499	3,930	0,234	4,164	No change
4	0,612	0,091	0,703	2,959	0,234	3,193	No change
5	0,604	0,091	0,695	2,963	0,234	3,197	No change
6	1,456	0,091	1,547	3,922	0,234	4,156	No change
7	0,696	0,091	0,787	3,059	0,234	3,293	No change
8	0,768	0,091	0,859	3,203	0,234	3,437	No change
9	1,406	0,091	1,497	3,800	0,234	4,034	F2 well corrected
10	1,399	0,091	1,49	3,789	0,234	4,023	F2 well corrected
11	0,691	0,091	0,782	3,055	0,234	3,289	No change
12	1,474	0,091	1,565	3,868	0,234	4,102	F2 well corrected

Absolutely wrong - no stiffness compensation + no pre-conditioning

Feder_[redacted]Typ2

Seriennummer:	CS225 S/No.681	**Bediener**	axel
Gestell-Kapazität:	1000 N	**Datum**	2018-02-15 14:43:40
Zelle Seriennummer laden:	2LB0042		
Wägezellenkapazität	10,0 N		

Statistik-Testergebnisse

Testläufe:	10
Bestanden:	0
Nicht bestanden:	9
Ausgeschlossen:	1

Ergebnis	Max	Min	Ber.	Durchschn.	Stdabw.	KOV
H0 (mm)	10,02	9,71	0,31	9,96	0,09	0,90
F1 (N)	1,427	0,640	0,788	1,301	0,235	18,088
F2 (N)	3,878	3,010	0,868	3,716	0,254	6,823
C (N/mm)	2,50	2,35	0,14	2,41	0,04	1,78

TESTERGEBNISSE

Starten	H0 (mm)	F1 (N)	F2 (N)	C (N/mm)
1	10,00	1,384	3,779	2,37
2	9,97	1,343	3,760	2,43
3	9,98	1,395	3,843	2,50
(4)	9,68	0,560	2,922	2,34
5	10,02	1,427	3,878	2,46
6	9,71	0,640	3,010	2,35
7	10,00	1,412	3,822	2,40
8	9,97	1,381	3,786	2,40
9	9,99	1,338	3,728	2,38
10	10,00	1,387	3,839	2,43

Lefthand we see the results in case of testing the same 10 springs without stiffness compensation and without pre-conditioning.

Due to the too short length 5 of these 10 springs should pass. Without Stiffness compensation we had seen still 2 passing.

Now without both, ALL springs fail !!!

Additionally we see only 2 too short measured springs, all other springs seems to have a right length, but this should be a wrong good result due to the missed pre-conditioning.

Even if nearly all length are “ok”, all springs are “bad”.
Due to this confusion, it’s not possible to check the quality of springs by only measuring the spring length.
A pre-conditioning must be performed before testing length and load.

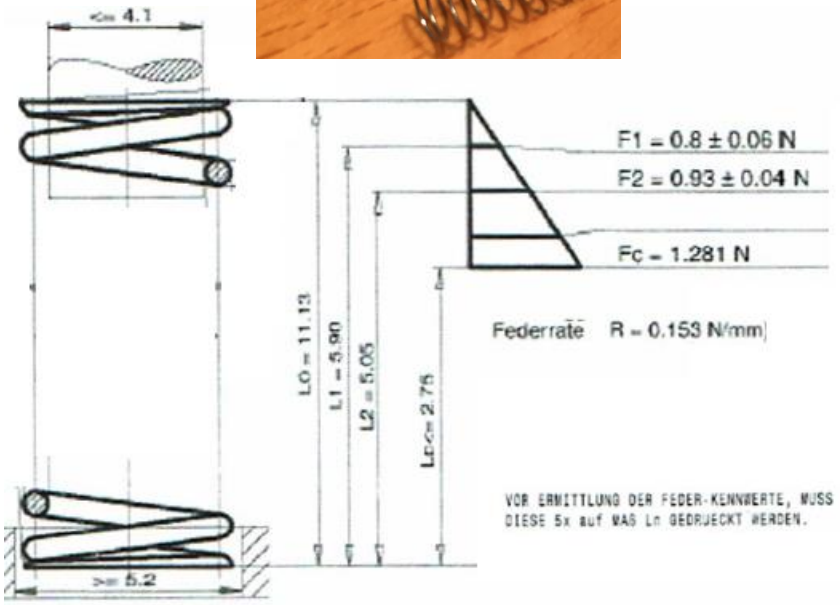
Spring N° 2

The following example shows the nearly same test, like done with spring N°1.
This is again a very small spring, also used in automotive injection systems.

In this test we have the challenge due the very low load range (F1 and F2 less 1N) combined with a very low pass/fail window.
Additionally the test includes measuring the height at a maximum load close to the block length.

So the test is similar to spring N° 1 added by one more stage.

Specification of spring N° 2



An other ….

Requirements:

Height of unloaded spring:	11.13 mm
load at height 1 (5.90 mm):	0.8 ± 0.06N (0.74 to 0.86 N)
load at height 2 (5.05 mm):	0.93 ± 0.04N (0.89 to 0.97 N)
Height at load max (1.281 N): = before block length	>= 2.75 mm
Spring rate:	0.153 N/mm

Report

Feder_[redacted]Typ1_kond.2SC

Seriennummer:	CS225 S/No.681	Bediener	axel
Gestell-Kapazität:	1000 N	Datum	2018-02-22 15:19:37
Zelle Seriennummer laden:	2LB0042		
Wägezellenkapazität	10,0 N		

Statistik-Testergebnisse

Testläufe:	11
Bestanden:	7
Nicht bestanden:	3
Ausgeschlossen:	1

Ergebnis	Max	Min	Ber.	Durchschn.	Stdabw.	KOV
H0 (mm)	11,29	11,05	0,25	11,20	0,09	0,76
Hend (mm)	3,51	3,11	0,40	3,23	0,13	4,13
F1 (N)	0,855	0,804	0,051	0,825	0,014	1,696
F2 (N)	1,003	0,947	0,056	0,967	0,017	1,725
C (N/mm)	0,18	0,15	0,03	0,16	0,01	5,17

TESTERGEBNISSE

Starten	H0 (mm)	Hend (mm)	F1 (N)	F2 (N)	C (N/mm)
(1)					
2	11,14	3,23	0,824	0,956	0,16
3	11,20	3,11	0,810	0,956	0,16
4	11,05	3,15	0,814	0,955	0,16
5	11,05	3,14	0,820	0,947	0,15
6	11,26	3,19	0,825	0,966	0,17
7	11,29	3,51	0,855	1,003	0,15
8	11,19	3,11	0,804	0,953	0,17
9	11,26	3,17	0,836	0,973	0,16
10	11,29	3,19	0,822	0,969	0,18
11	11,24	3,45	0,835	0,989	0,17

The report shows the results from the test of 10 springs. Run 1 was excluded.

Pass criteria
F1: 0.74 to 0.86 N
F2: 0.89 to 0.97 N
Hend: >= 2.75 mm

7 of 10 springs passed.

3 of 10 springs failed.
From this 2 springs very clos to pass.
All 3 springs are at upper H0 values.

The H0 average value (11,20mm) is very clos to the nominal length of 11,13 mm.
The spring rate (0,16 N/mm) is very close to the nominal value of 0,15 N/mm.

The COV's of the direct measurements are less 5%.

This may show, a CS2 is also perfect for precise measurement of very low load and height gates.

Spring N° 3

The following example shows the test of a larger and more stiff spiral spring, using a CS2 testing machine, particularly:
> repeatability of results
> CSV graph data export

test Frame capacity 1000N
load cell capacity 1000N

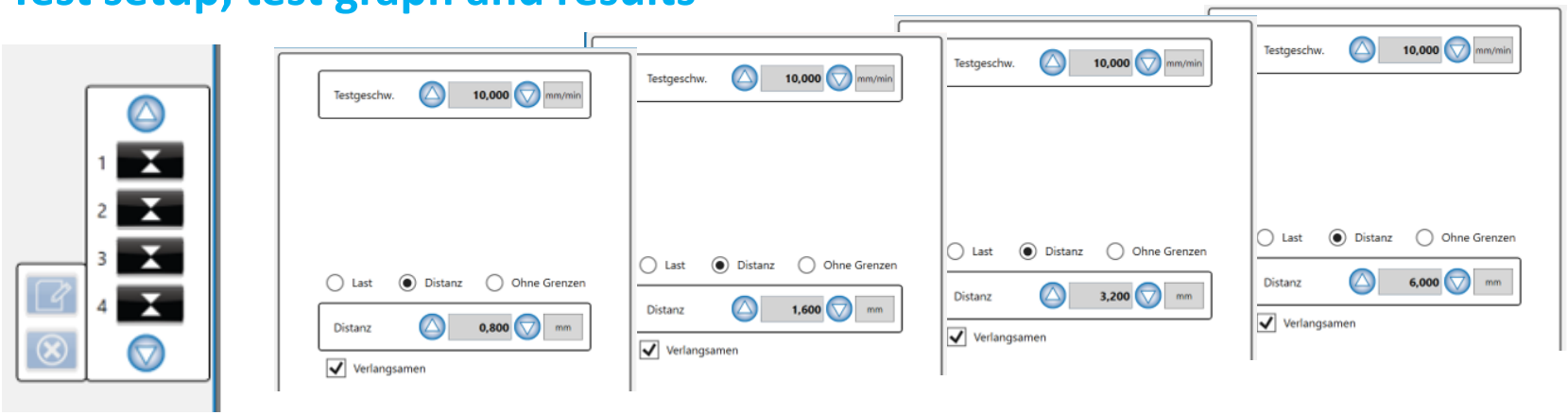
Test between plates

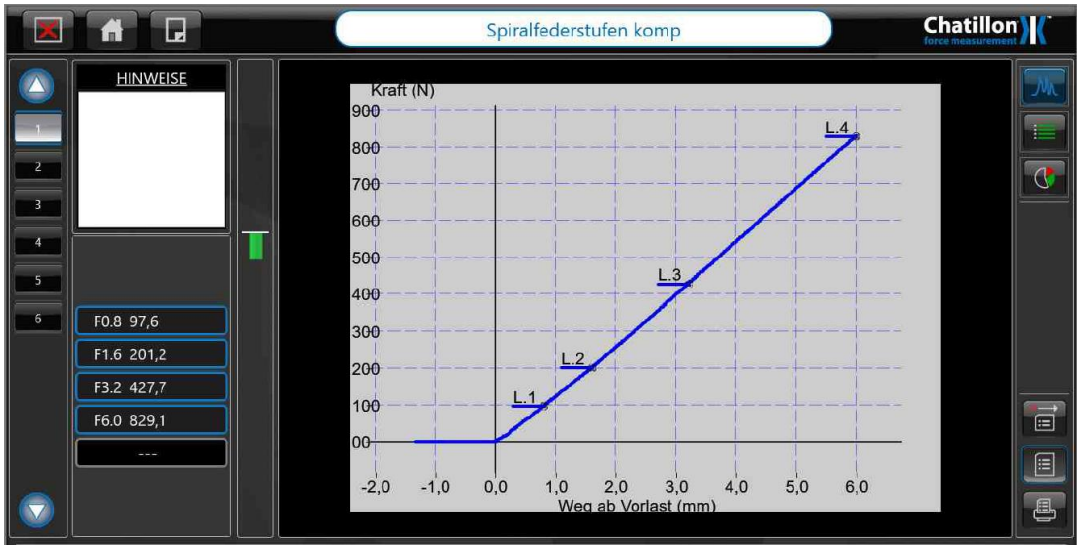
Pre-load 1N
Pre-load speed 10mm/min

extension coordinates

Four test points
> extension 0.8 mm
> extension 1.6 mm
> extension 3.2 mm
> extension 6.0 mm

Test setup, test graph and results

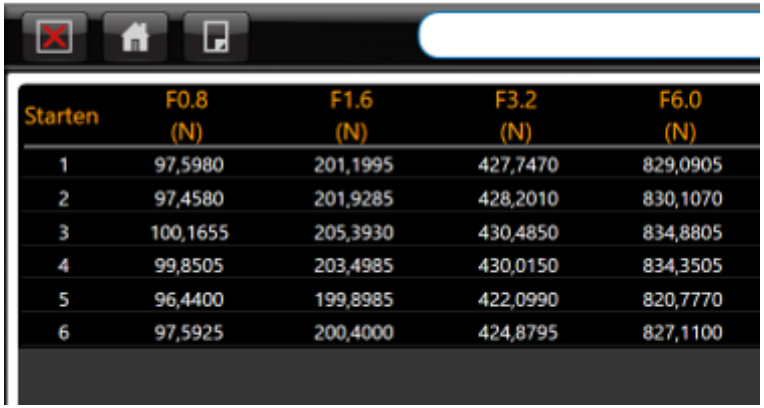




The sequence of this test includes 4 compression stages with distance limits, each stage with ramping as to get a precise positioning at the requested distance.

F0.8 = load at distance 0.8mm
F1.6 = load at distance 1.6mm
F3.2 = load at distance 3.2mm
F6.0 = load at distance 6.0mm

Results and Statistics - repeatability



Starten	F0.8 (N)	F1.6 (N)	F3.2 (N)	F6.0 (N)
1	97,5980	201,1995	427,7470	829,0905
2	97,4580	201,9285	428,2010	830,1070
3	100,1655	205,3930	430,4850	834,8805
4	99,8505	203,4985	430,0150	834,3505
5	96,4400	199,8985	422,0990	820,7770
6	97,5925	200,4000	424,8795	827,1100

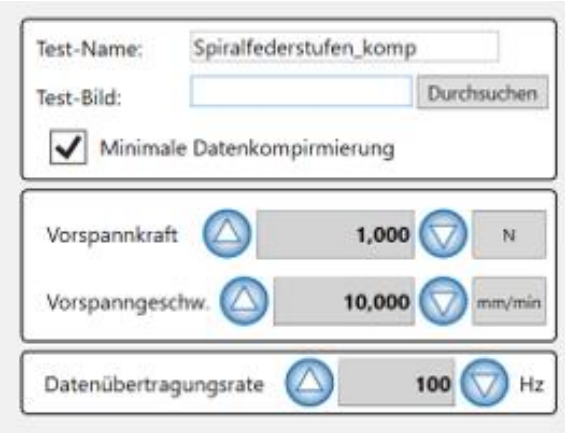
The result table (figure left-hand) shows all results for each test. A good repeatability is already visible.

The Statistics table (figure below) give precise data for the statistics. Like Maximum, Minimum, range, Standard deviation and Coefficient of variance.
Even if the spring was turned and the stiffness compensation was used, the achieved COV's for all 4 results (0,5% to 1,4%) are very good.

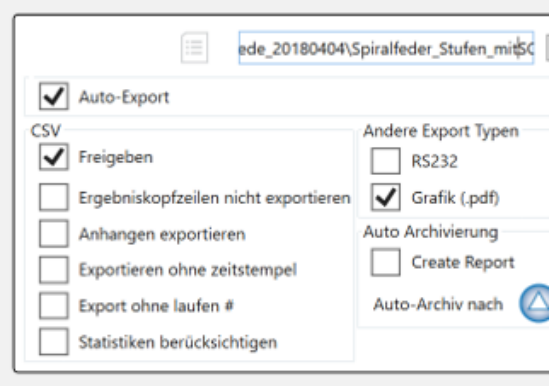
The CS2 machine can deliver very good repeatable results.

Ergebnis	Max	Min	Ber.	Durchschn.	Stdabw.	KOV
F0.8 (N)	100,1655	96,4400	3,7255	98,1840	1,3520	1.38
F1.6 (N)	205,3930	199,8985	5,4950	202,0530	1,8870	0.93
F3.2 (N)	430,4850	422,0990	8,3860	427,2375	2,9270	0.69
F6.0 (N)	834,8805	820,7770	14,1030	829,3860	4,7385	0.57

Graph data export to CSV



Setup screen 1: Basic settings



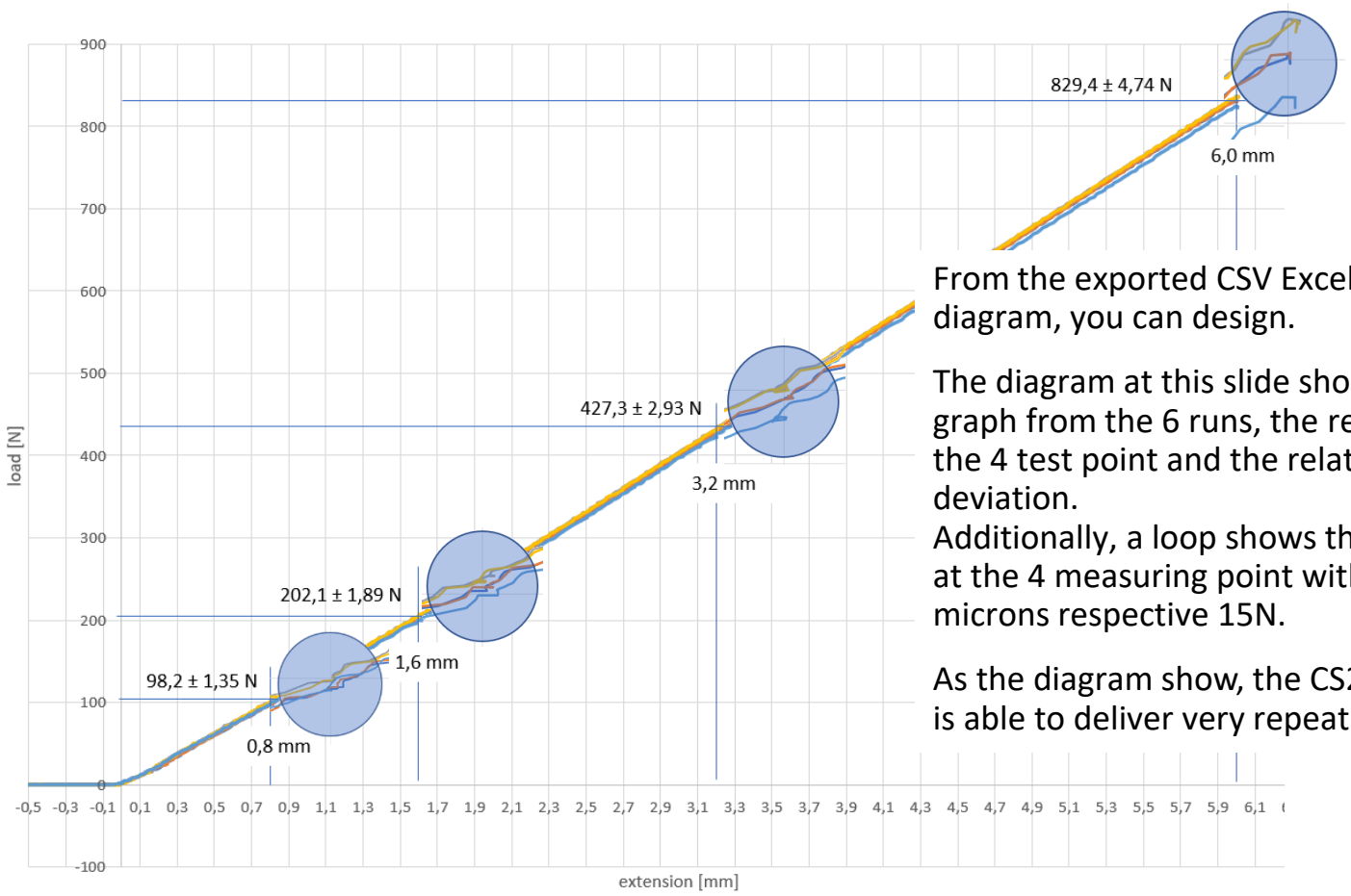
Setup screen 4: Export settings

	A	B	C	D
1	Zeit (s)	Kraft (N)	Machinenweg (mm)	Weg ab Vorlast (mm)
1176	11,69	97,61	1,628 €	0,797 €
1177	11,70	97,61	1,629 €	0,797 €
1178	11,71	97,61	1,629 €	0,798 €
1179	11,72	97,61	1,629 €	0,798 €
1180	11,73	97,61	1,630 €	0,798 €
1181	11,74	97,61	1,630 €	0,799 €
1182	11,75	97,61	1,631 €	0,799 €
1183	11,76	97,61	1,631 €	0,800 €
1184	11,77	97,61	1,632 €	0,800 €
1185	11,78	97,61	1,632 €	0,801 €
1186	11,79	97,61	1,632 €	0,801 €
1187	11,80	97,61	1,633 €	0,801 €
1188	11,81	97,61	1,633 €	0,802 €
1189	11,82	97,61	1,634 €	0,802 €
1190	11,83	97,61	1,634 €	0,803 €
1191				
1192				
1193				
1194				
1195				

For some reasons, e.g. graph overlay print, a graph data export is needed. Enabling Auto-Export + CSV will send the graph data automatically to the destination folder, specified at setup screen 4.
The CS2 software automatically add a timestamp to this file, if not other avoided in setup screen 4.

This export file contain a table for time, load, machine extension and extension.
The number of lines is according to the data rate in basic settings, e.g 100 Hz, specified in setup screen 1, gives a time resolution of 0,01s.

Overlay graph from exported graph data



From the exported CSV Excel can make any diagram, you can design.

The diagram at this slide show the overlay graph from the 6 runs, the results at each of the 4 test point and the related standard deviation.
Additionally, a loop shows the graph overlay at the 4 measuring point with a range of 100 microns respective 15N.

As the diagram show, the CS2 testing machine is able to deliver very repeatable results.

Spring N° 4

The following example shows the test of a batch of wave springs, using a CS2 testing machine, particularly:
> CSV result data export

frame capacity 1000N
load cell capacity 250N

Test between plates

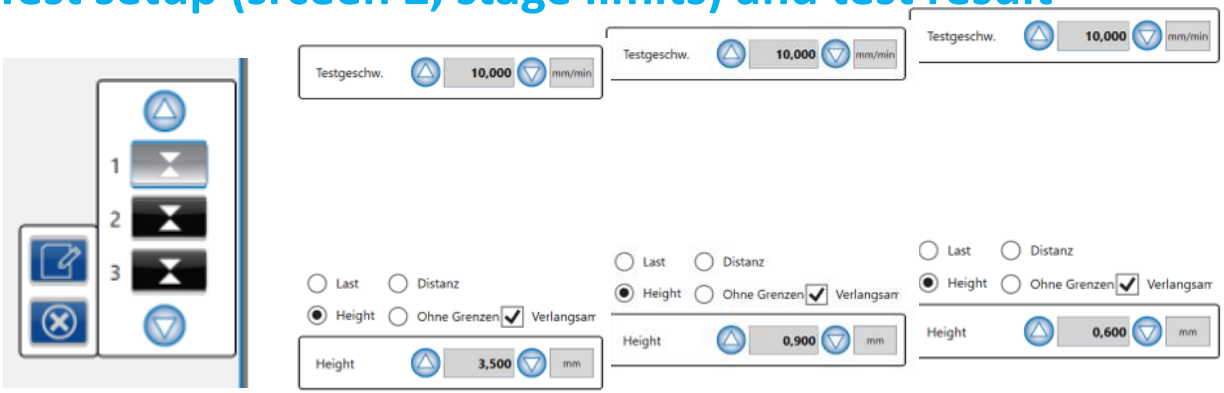
Pre-load 1N
Pre-load speed 10mm/min

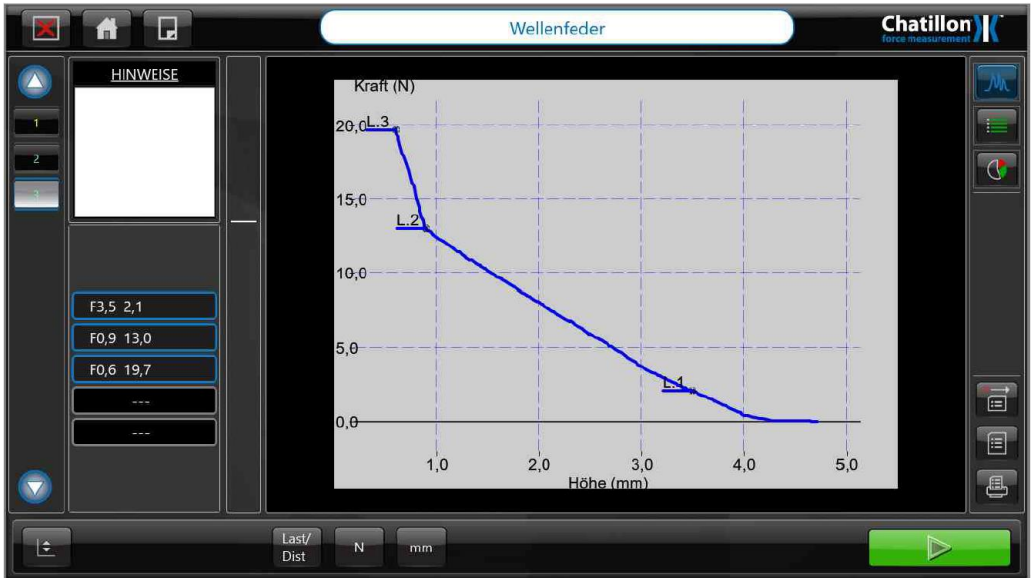
height coordinates

Three test points
> height 3.5 mm
> height 0.9 mm
> height 0.6 mm

The challenge is the very small height close to the datum position at two measuring points.

Test setup (srceen 2, stage limits) and test result





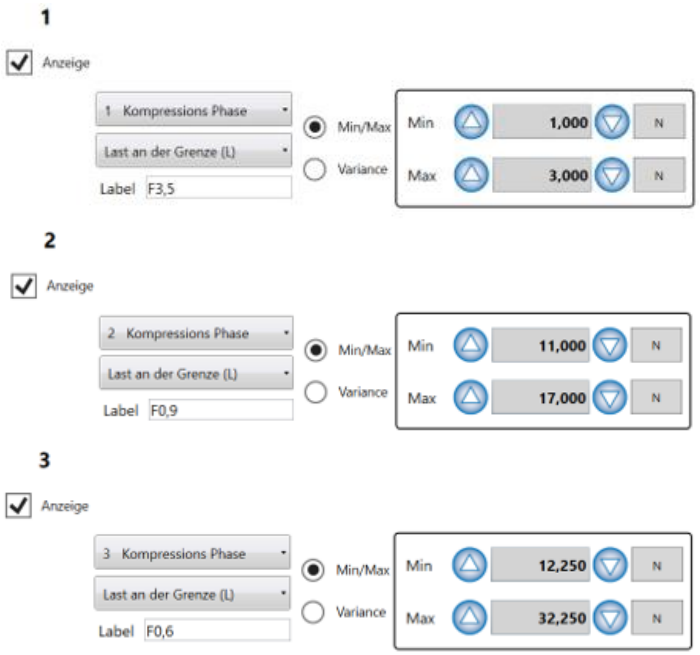
The test procedure includes 3 compression stages with height limit and ramping.

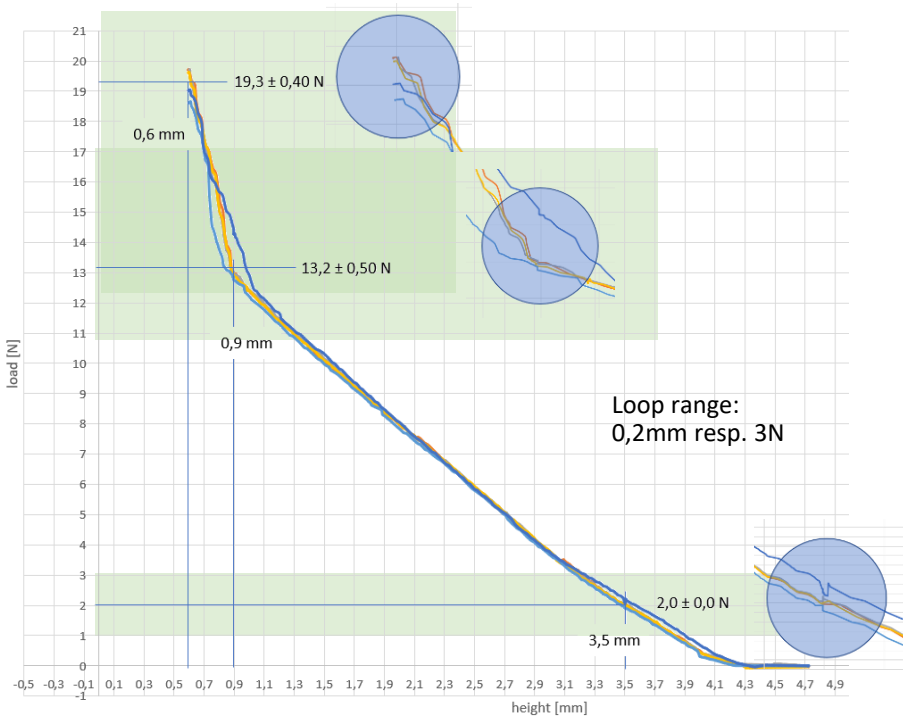
Stage 1 (result L1) mark the point at which the spring will assembled.

Stage 2 (result L2) mark the normally expected maximum compression.

Stage 3 (result L3) mark the maximum allowed compression.

Test setup (screen 3, results and pass fail criteria)

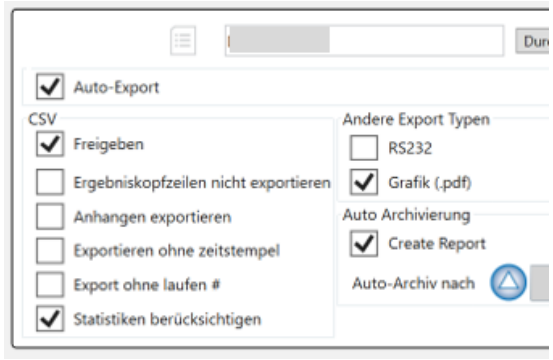




Result at stage 1: F3.5 = load at end of stage; pass within 1 to 3 N; measured 2 ± 0,0 N
Result at stage 2: F0.9 = load at end of stage; pass within 11 to 17 N; measured 13,2 ± 0,5 N
Result at stage 3: F0.6 = load at end of stage; pass within 12,25 to 32,25 N; measured 19,3 ± 0,4 N

Even tough the load pass window is quite wide, a wrong height measurement (e.g. deviation of 0.2mm) could push the results at L2 and L3 to fail. Due to this a very good stiffness compensation is mandatory.

CSV result data export



	A	B	C	D	E	F	G
1	Testläufe	6					
2	Bestanden	5					
3	Nicht bestanden	0					
4	Ausgeschlossen	1					
5							
6	Ergebniss	Max.	Min.	Ber.	Durchschn.	Stdabw.	KOV
7	F3,5 (N)	2,1	2,0	0,1	2,0	0,0	2,11
8	F0,9 (N)	14,3	12,8	1,4	13,2	0,5	4,14
9	F0,6 (N)	19,7	18,6	1,1	19,3	0,4	2,26
10							
11	Einzelmessung	Ausgeschlossen	F3,5 (N)	F0,9 (N)	F0,6 (N)	Hinweise	
12	1	x					
13	2		2,0	12,9	19,7		
14	3		2,1	13,0	19,7		
15	4		2,0	12,9	19,6		
16	5		2,0	12,8	18,6		
17	6		2,1	14,3	19,0		
18							

If the test setup has enabled “create report” + “CSV enabling” + “Statistics”, the operator can manually start the result data export to CSV.

The export file includes:

> Number of runs
(6 total, 5 passed, 0 failed, 1 excluded)
All results are according the pass criteria due to the good CS stiffness compensation.

> Statistics
(Max, Min, range, mean, standard deviation, COV)
The COV of all results is less 5%, a good result related to the batch of 5 wave springs.

> Results of each run
(3 Test points, comment)

From this CSV export file some further report can get generated.

Spring N° 5

The following example shows the test of batch of disc springs, using a CS2 testing machine, particularly:
> impact of stiffness compensation

frame capacity 1000N
load cell capacity 1000N

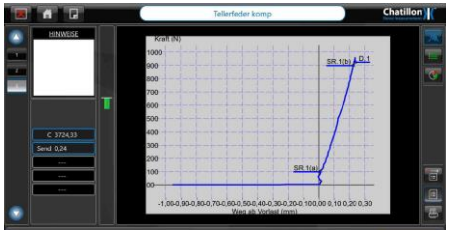
Test between plates

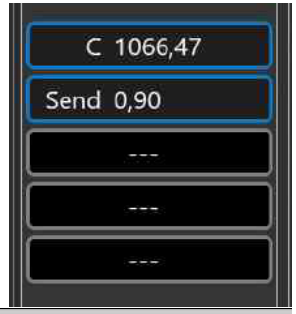
Pre-load 10N
Pre-load speed 10mm/min

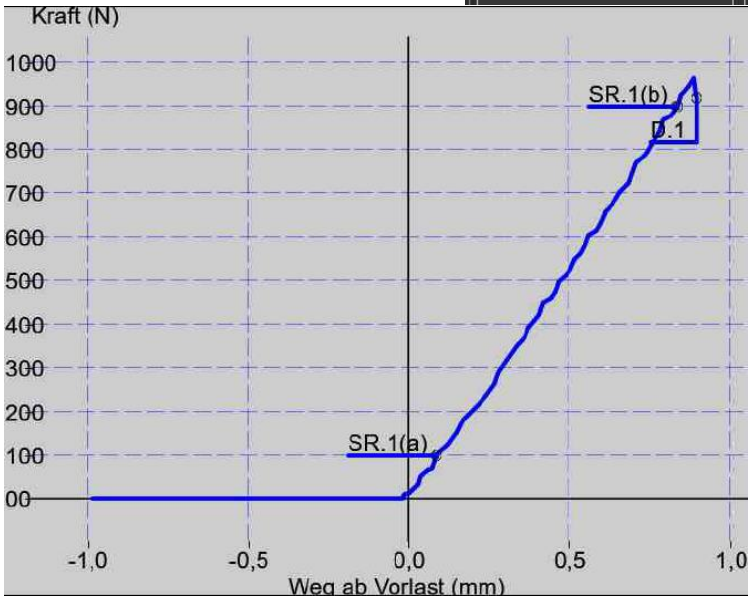
height coordinates

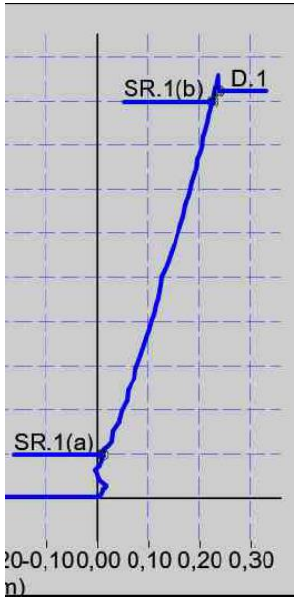
The challenge is the very small deformation of this spring, what is less than the stiffness compensation itself.

Disc spring test with/without stiffness compensation









The test procedure includes on compression stage up to 900 N.

Results:
> spring rate (C)
> deformation (Send) at 900mm

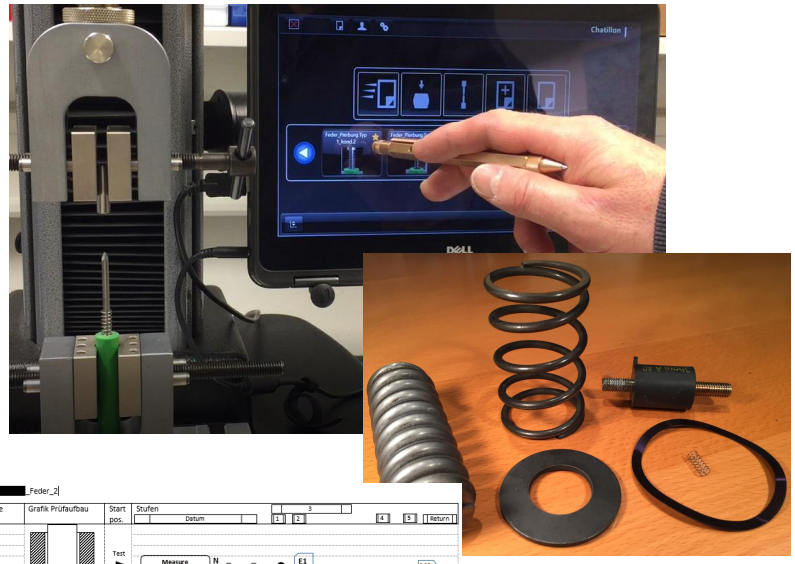
Spring rate
1066 N/mm without stiffness comp.
3724 N/mm with stiffness comp.

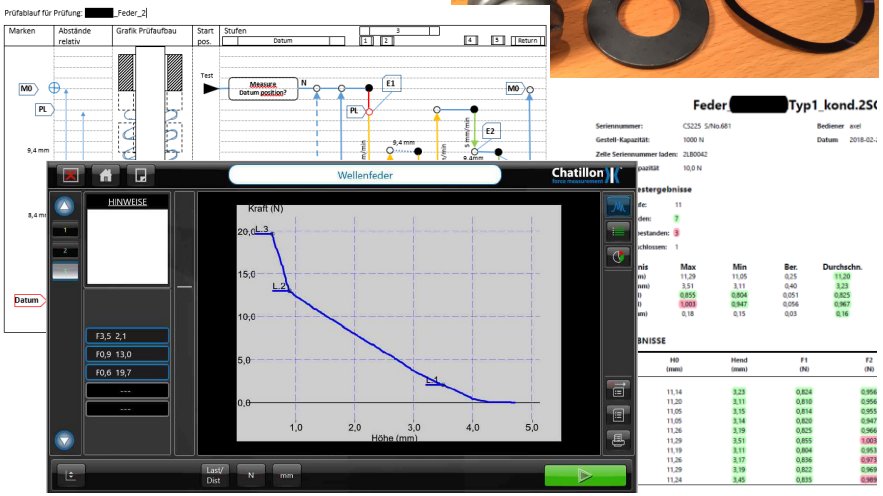
deformation
0,90 mm without stiffness comp.
0,24 mm with stiffness comp.

Stiffness compensation at 900N
0,64 mm

If the stiffness compensation was well performed, the CS2 machine can deliver also good results even at small deformations of 200 microns. This is very close to the field of extensometer use …

conclusions





The CS2 testing machine is a perfect solution for spring testing:

Compression plates or special fixtures can easily be assembled to the CS2 machine.

A perfect stiffness compensation up to less 20 microns remain deviation and a stage library also for pre-conditioning enable accurate results even at very low load or very low deformation.

The automatic datum position measurement enable results at defined height, what meet the requirements from spring assembling into technical systems.

Results at defined measuring point can get defined easily and fast and pass fail criteria can be added.

The test setup can be finished within some minutes. Operating the machine is fast and easy.

Results and graphs can get exported as CSV or print as PDF by one-click button.

Fast, easy, accurate!