HÄUSSERMANN

The HAUSSERMANN inter-laboratory test

Purpose of test

Participants learn about:

1. the deviation of their load test result from the true value which equals the systematic error of their load tester, and are thus able to calibrate their tester accordingly;

2. the random error of their load tester represented by repeatability, the magnitude of which indicates if the load tester is appropriate to the job.

Test conditions

- All springs have been tested between hardened (60 HRC) and ground loading platens. Only lab. no. 3 used soft and partly worn plates.
- Spring no. 2.0045.0003 (7T5020) was deflected between hardened pivot rings.
- All springs were tested under wet conditions, i.e. a normal engine oil was applied so that sufficient oil was available between the mating surfaces at all times, unless noted otherwise. Lab no. 3 only applied a thin oil film over the plates at the beginning of the test, thus resembling more or less dry conditions for the whole test. Machine no. 10 used Molycote as lubricant, so the hysteresis of this test is not comparable with other tests.
- Each spring was measured 10 times in order to determine repeatability and to calculate average and standard deviation. Between each measurement the springs were moved and turned in order to create true repeatability conditions.
- The springs were measured at the indicated test heights during both the loading and unloading cycles.
- During dynamic (pass-through) testing, the test speed was less than 2 mm/s.

Laboratories included in the test

A total of 10 labs and 12 different test machines have now been involved in the test.
The labs can be grouped as follows:

4 disc spring manufacturers
2 HAUSSERMANN customers
2 public test labs
2 load testing machine manufacturers

The list below provides a coded overview of the different labs and the principal characteristics of their test machines.
The following load testers use the pass-through technique:
1, 6, 7, 9, 11 ,12.

Test specimen

HL no. customer PN	Test height L/mm		Return height	Spring rate (kn/mm)	Load range of spring (N)	Dimensions OD*ID*T (mm)
2.0016.0085	5,830		4,17	7,400	10000	149/101,5/3,42
2.0026.0024	7,250		5,4	8,200	15000	254/213/4,57
2.0040.0032	8,800	0,900	6,5	1,3/0,2	40000	399,9/314,5/6,4
2.0040.0033	7,940		7,82	6,200	13000	399,9/298/7,32
2.0045.0003	6,490	4,030	0,98	0,400	25000	399,9/309,9/5,65
Load Ring	185,5	185,4				---
	185,0	184,6	184,4	45	72000	

Mach no.	Type of lab.	load range (kN)	Type of display Load	Deflect.	Testing technique	No. of load cells	Division Load	Defl.	Height meas. system
1	Spring mfr.	20/5/1	digital	digital	Pass-thru	3	1	0.010	El. transducer
2	Spring mfr.	400/200/80/40	analog	analog	Static	Lever-sys.	10	0.020	
3	Customer	1800/350/35	analog	analog	Static	Hydr. pres.	450/45	0.010	Dial indicator
4	Customer	?	digital	digital	Static	1	4	0.025	Dial indicator 5
5	Spring mfr.	20/0,4	analog	digital	Static	Lever-sys.	20	0.010	El. dial indicator
6	Spring mfr.	60/3	digital	digital	Pass-thru	3	1	0.005	El. transducer
7	Spring mfr.	100	digital	digital	Pass-thru	3	10	0.010	El. transducer
8	Public lab.	200	digital	analog	Static	1	10	0.010	El. dial indicator
9	Mach. mfr.	20	digital	digital	Pass-thru	3	1	0.001	El. transducer
10	Public lab.	1000/500/200/100	analog	analog	Static	1	200	0.020	Dial indicator
11	Mach. mfr.	50	digital	digital	Pass-thru	3	1	0.001	El. transducer
12	Spring mfr.	100/50/20/10/5/2/1	digital	digital	Pass-thru	3	1	0.001	El. transducer

Test results

Definitions:

U = Uncertainty of measurement

R = random errors

S = systematic errors

Systematic error

The systematic error consists mainly of:

- output value error
- resolution of reading
- hysteresis error

The systematic error is difficult to find as there is no official or standardized reference that describes the measurement of the load together with the spring height under load. As a substitute we use a loading ring which has been calibrated at MPA official laboratory. The advantage of a loading ring over a disc spring is the almost complete absence of friction between the sample and the testing machine; otherwise this could result in inconsistent readings.

The internal friction of the ring is considered to be highly consistent.

As another standard for judging the individual systematic error we can use the "true" value which can be calculated as the mean of all results from all machines, excluding the outliers.

One of the main purposes of this inter-laboratory test is that the results shown in the charts should act as a substitute for the absence of a reference standard. This allows all parties to see their position in relation to others, thus enabling them to reach appropriate conclusions about possible systematic error in their test machines.

Random error

The random error of the test results is shown as the repeatability standard deviation s of the arithmetic mean of the individual measurements.

A large deviation s indicates that the individual test procedure is not appropriate for the job.

Display of the test results

The following table and diagrams are an extract serving merely to explain the system using the results of one of the test specimens. The first column of the table shows the test machine number, the number of load measurements which lead to the mean and standard deviation in the next columns, for loading (lo) and unloading (un), for the difference of both which equals the hysteresis (hys.), and for the loading and unloading mean (m.).

HÄUSSERMANN

The "true" values represent the means of all the machines, excluding the outliers. Outliers ar outside a tolerance band of (mean +/- 2 s).
The column headed "SB" shows the +/- confidence interval of the measured load values. It is based on a confidence level of 95 %. In other words 95 % of all load values measured on this machine can be expected to be within a band of 2 times the "SB" value. It represents random error.

The first chart, "Load Readings", shows a vertical line for each machine, the ends of which are the loads during loading (xq-lo) and unloading (xq-un). So the length of the line represents the hysteresis (xq-hys.). The small dash in the middle of the line represents the mean load (xq-m).
The last vertical line is the "true value" determined as a result of all machines with the exception of the outliers. It is thus possible to display the position of each machine by referring to the "true value".
The second chart, "Dispersion SB", shows the repeatability of each machine for loading (SB-lo.) and unloading (SB-un.).
The last two columns again show the "true value". In the example given, machine # 10 is clearly an outlier and does not seem to be suitable for testing diaphragm springs.

Part No.: 2.0026.0024
Dimensions (De/Di/t): 254.0 / 213.0 / 4.57 mm
Test height: 7.25 mm
Spring rate: 8.2 kN/mm

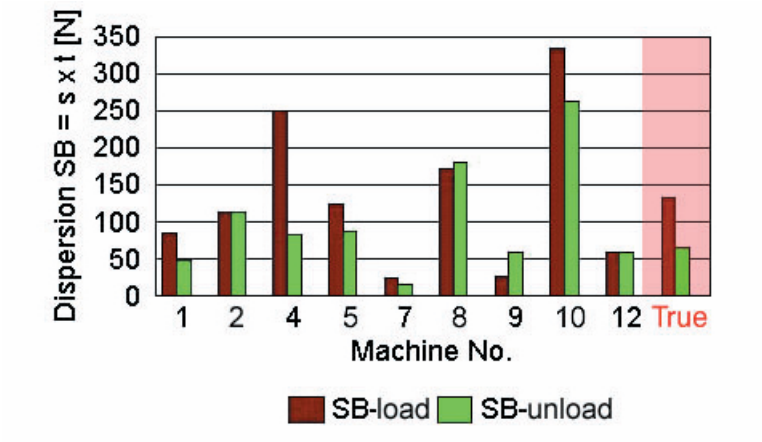
		Loading			Unloading			Hysteresis			Mean		
Mach. no.	**No. of meas.**	**Xq-lo.**	**S-lo.**	**SB-lo.**	**Xq-un.**	**S-un.**	**SB-un.**	**Xq-hys.**	**S-hys.**	**SB-hys**	**Xq-m.**	**S-m.**	**SB-m.**
1	10	15221	37	85	13525	21	48	1696	57	129	14373	10	24
2	10	15054	50	114	13711	49	112	1343	98	224	14383	7	16
4	10	15145	110	250	12437	36	82	2708	117	267	13791	57	131
5	10	15160	55	124	13548	39	88	1612	44	100	14354	42	95
7	5	**a** 13566	8	25	**a** 11746	5	15	1820	12	34	**a** 12656	4	12
8	10	15224	75	172	12826	**a** 79	**a** 181	2398	65	148	14025	70	160
9	10	14999	12	27	13037	26	59	1962	31	70	14018	13	29
10	10	**a** 14580	147	333	13630	**a** 116	**a** 262	950	127	287	14105	**a** 116	**a** 262
12	10	14902	26	59	13156	26	59	1746	45	102	14029	14	32
"True value"		**15101**	**57.78**	**132.1**	**13234**	**28.86**	**66.14**	**1804**	**66.22**	**151.2**	**14135**	**27.13**	**62.38**
S-Deviation		120.53	46.19	103.9	449.47	14.18	31.3	523.1	39.52	88.76	214.52	25.51	57.94
Maximum		15224	147	333	13711	49	112	2708	127	287	143823	70	160
Minimum		14902	8	25	12437	5	15	950	12	34	13791	4	12
Mean+2s		15342	150.2	339.9	14133	57.22	128.7	2850	145.3	328.7	14564	78.15	178.3
Mean-2s		14860	-34.6	-75.6	12335	0.492	3.539	757.7	-12.8	-26.3	13706	-23.9	-53.5

a=Outlier

Load readings P/N 2.0026.0024
Dispersion SB P/N 2.0026.0024

We invite you to take part in the HAUSSERMANN inter-laboratory test!

Dispersion SB
P/N 2.0026.0024



Load Readings
P/N 2.0026.0024