Tech-Spring Report 19
Speed of Testing

At the Tech-Spring mid-term meeting it was agreed that speed of testing did not affect spring life when the testing speed was low. Equally, when the speed of testing was high and resonant affects effect the dynamic stress, fatigue life will be reduced.

However, with test speeds in the range 10 to 50Hz Innotec have observed that the fatigue life is longer at 50Hz than 10Hz, providing that 50Hz was less than $^{1}/_{13}$ of the natural frequency. The purpose of the following tests was to validate this observation.

Compression springs with closed and ground ends were made from 3.0mm diameter DIN 17223-1 B material that had partial decarburisation to 40 microns maximum. The spring design was as follows:

INSTITUTE OF SPRING TECHNOLOGY Date: 23/07/2008 15:11:09

Identifier: Speed of Testing
Details: 810h

Spring Type Round Wire Compression

Designed To:	BS 1726-1: 1987	
Tolerance Standard:	BS 1726-1: 2002	
Material		
DIN 17223 Patented Carbon		
Youngs Mod (E):	206000	N/mm^2
Rigidity Mod (G):	81500	N/mm^2
Density:	.00000785	Kg/mm^3
Unprestress:	0-49	%
Prestress:	49-70	%
End Type:	Closed and Ground	
Dead Coils:	1.72	
Tip Thickness:	43.00	%
End Fixation:	Both Ends Fixed and Guided	

Calculated Data

Solid Length:	17.58	mm
Solid Load:	421.72	N
Solid Stress:	962.79	N/mm^2
Stress Factor:	1.21	
Active Coils:	4.28	
Spring Index:	6.66	
Helix Angle:	6.43	Deg
Buckling Possible:	STABLE	
Buckling Definite:	STABLE	
Spring Pitch:	7.07	mm
Inside Diameter:	16.97	mm
Mean Coil Dia.:	19.97	mm
Wire Length:	378.25	mm
Weight / 100:	2.10	Kg
Natural Freq:	38240	RPM
As-Coiled Length:		mm
Max Test Speed:	2942	RPM

Design Parameters

Wire Diameter:	3.00	mm	
Outside Diameter:	22.97	mm	
Total Coils:	6.00		
Spring Rate:	24.21	N/mm	(Calculated)
Free Length:	35.00	mm	

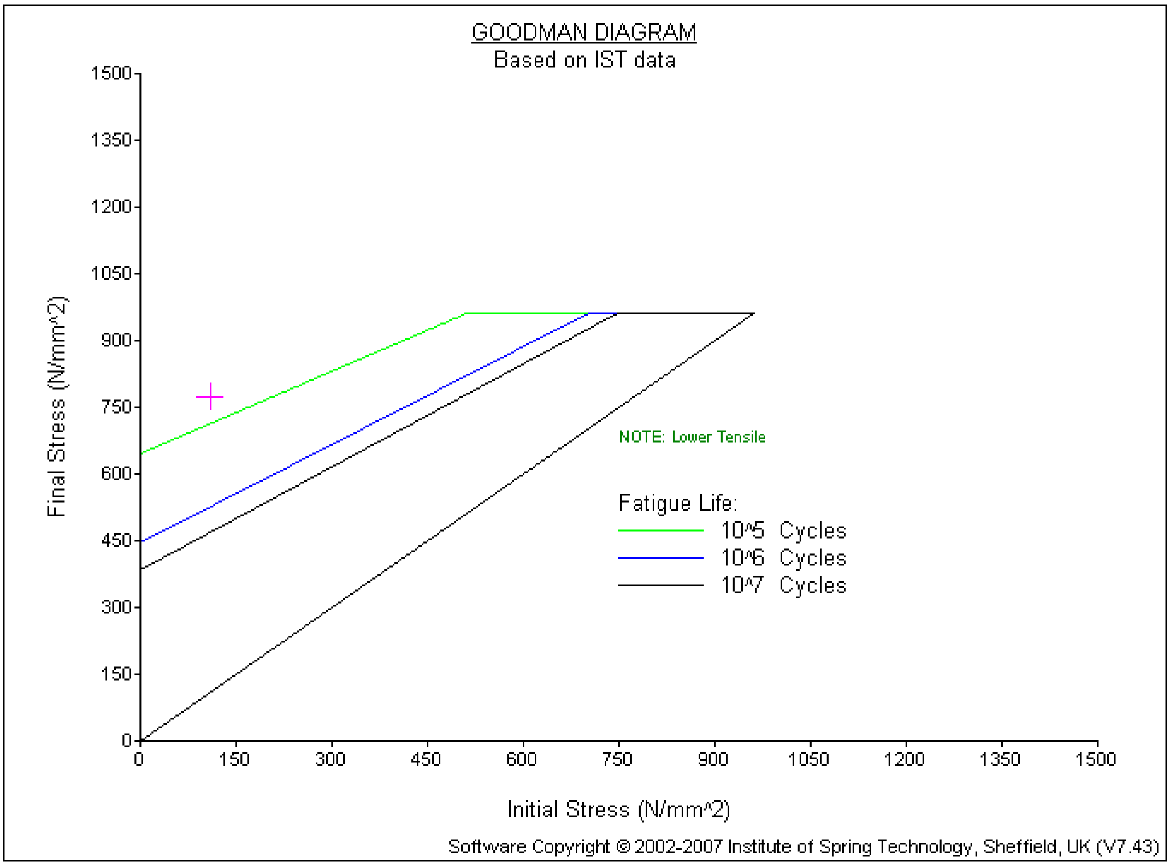
Stress Data

	Lower Tensile	Solid	Operating Positions % Tensile 1	2
KLASSE A	1410	68 P	8 U	55 P
KLASSE B	1630	59 P	7 U	47 U
KLASSE C	1840	52 P	6 U	42 U
KLASSE D	1840	52 P	6 U	42 U
Specified				

Operating Data

	Operating Positions 1	2
Length (mm)	33.00	21.00
Load (N)	48.42	338.92
Deflection (mm)	2.00	14.00
Stress (N/mm^2)	111	774
Stress % Solid	11	80
Load Tol. Grade 1 (N)	18.21	24.02
Load Tol. Grade 2 (N)	27.32	36.03
O.D. Expansion (N)	0.0179	0.126

The springs were prestressed to solid and fatigue tested at lengths of 33 and 21mm i.e.. with a stroke of 12mm. The predicted fatigue performance was that there would be a risk of fatigue failure before 100,000 cycles, but all springs tested exceeded 200,000 cycles:



The springs were tested by IST at 50Hz and 10Hz and by Innotec at 20Hz and 10Hz. The fatigue test results were as follows:

Table 1 at IST

Lives

50Hz	304,660	1,583,770	740,160	1,638,980
	605,470	1,481,780	764,830	1,009,240
	901,000	2,036,930	989,400	2,397,750

10Hz	245,860	754,470	1,020,610	575,260
	433,380	445,220	455,730	513,020
	268,090	603,750	340,710	316,090

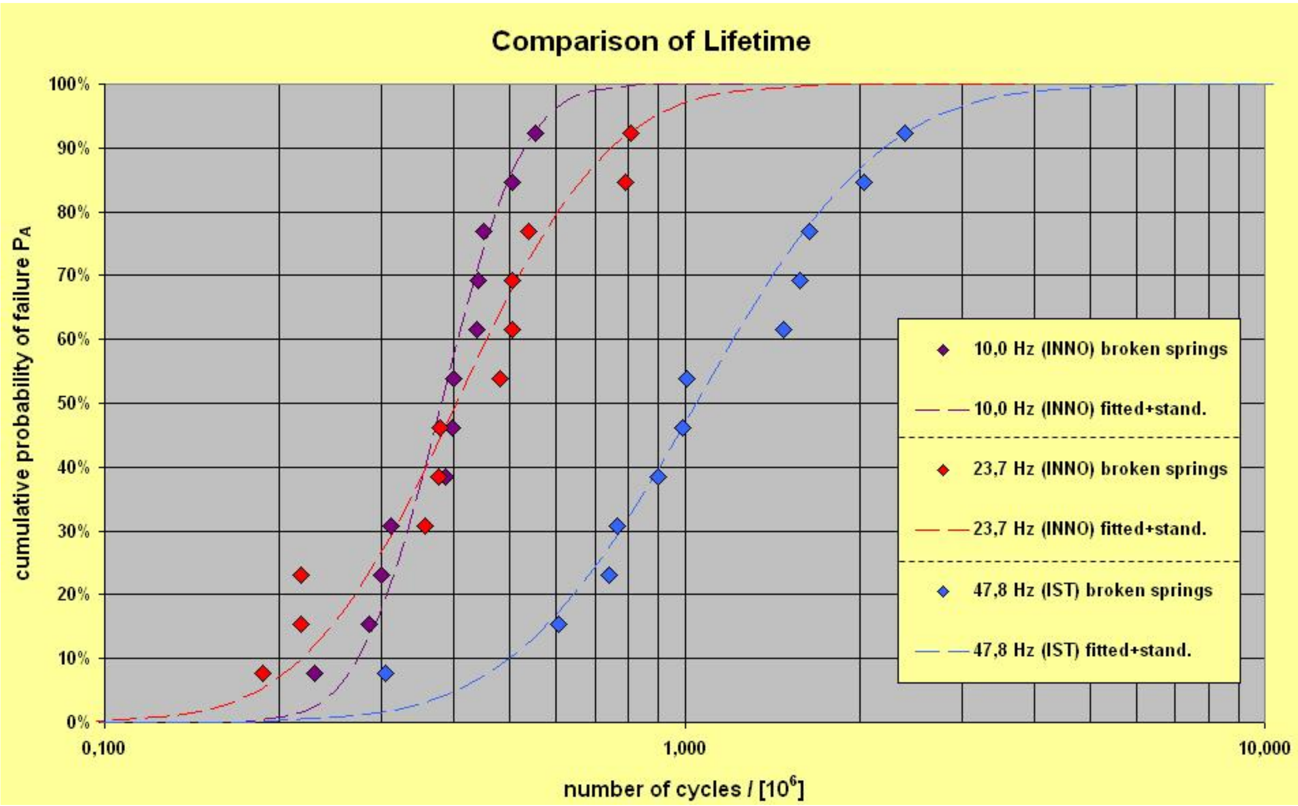
Table 2 at Innotec

Lives

20Hz	190,000	220,000	220,000	350,000
	380,000	380,000	480,000	500,000
	510,000	540,000	800,000	820,000

10Hz	230,000	290,000	300,000	310,000
	390,000	400,000	405,000	430,000
	430,000	450,000	510,000	560,000

This data is also presented graphically on a cumulative probability vs number of cycles as follows:



Discussion

The experience of Innotec has been borne out by these results. A recent set of results on MP35N compression springs at IST did not show this trend, as shown in Table 3.

Table 3

Test Speed Hz	Cycles to Failure ($x10^6$)
5	3.7 4.3
15	4.4 8.1
25	8.8 8.1
35	3.0 6.0
45	4.3 5.3

Conclusion

By testing at speeds in excess of 20Hz it is possible to gain a false impression of the fatigue life. The shortest life obtained with the 50Hz results is not radically different from the shortest life at slow speeds, but the dangers of testing too few springs and using a high test speed are plain to see. Innotec's explanation (if I have understood correctly) for the longer lives when testing at 50Hz is that there is insufficient time for fatigue crack propagation when testing at high speed. That is to say the time to initiation of the first crack does not depend upon the test speed, but the speed of fatigue crack propagation does. IST's further evidence suggests that this speed effect may be material dependent – i.e. some spring materials may show this effect and others may not.

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