



Tech-Spring Report 17A High Tensile SiCr Wire

This report is an update of the original report 17, and now includes a tensile range for the wire itself and a Goodman diagram for the new material type itself. This material will be added into the Tech-Spring toolkit as a specific material type (High strength Si Cr (Tech-Spring))

Introduction

Pengg made some superclean SiCrV wire that had a higher strength than regular SiCr. Project partners wanted to know the scope that higher strength wire gave them for designing higher stressed springs.

Tensile Strength of the Wire

Tensile testing of the wire indicated that it had a tensile strength of 2236 – 2238 N/mm² at a diameter of 3.491 to 3.496 mm.

Spring design

A quantity of 50 compression springs were manufactured from the supplied material. Approximately 30 of the springs were shot-peened (0.6mm conditioned cut steel wire shot, almen arc rise 0.25 – 0.33mm A2, followed by a 225°C / 30 minute low temperature heat treatment). By dimensional measurement and load test, the manufactured spring design was found to be as detailed in figure 1 below.



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Date: 21/07/2008 15:40:39

Identifier: 810 - Pengg

Spring Type Round Wire Compression
 Designed To: BS 1726-1: 1987
 Tolerance Standard: BS 1726-1: 2002

Calculated Data
 Solid Length: 19.72 mm
 Solid Load: 754.08 N
 Solid Stress: 1428.4 N/mm²
 Stress Factor: 1.19
 Active Coils: 3.65
 Spring Index: 7.21
 Helix Angle: 8.68 Deg
 Buckling Possible: Not Applicable
 Buckling Definite: Not Applicable
 Spring Pitch: 11.75 mm
 Inside Diameter: 21.10 mm
 Mean Coil Dia.: 24.50 mm
 Wire Length: 465.25 mm
 Weight / 100: 3.32 Kg
 Natural Freq: 33347 RPM

Material
 EN 10270 Pt2 Silicon -Cr
 Youngs Mod (E): 206000 N/mm²
 Rigidity Mod (G): 79500 N/mm²
 Density: .00000785 Kg/mm³
 Unprestress: 0-53 %
 Prestress: 53-70 %

End Type: Closed and Ground
 Dead Coils: 2.35
 Tip Thickness: 40.00 %
 End Fixation: Fixation not known

Design Parameters
 Wire Diameter: 3.40 mm
 Outside Diameter: 27.90 mm
 Total Coils: 6.00
 Spring Rate: 24.74 N/mm (Calculated)
 Free Length: 50.20 mm

Stress Data

	Upper Tensile	Solid	Operating Positions		
			% Tensile	1	2
FDSiCr	2060	69 P	5 U	51 U	63 P
TDSiCr	2010	71 O	5 U	52 U	65 P
VDSiCr	2010	71 O	5 U	52 U	65 P
Specified					

Operating Data

	Operating Positions		
	1	2	3
Length (mm)	48.06	27.80	22.45
Load (N)	52.94	554.18	686.54
Deflection (mm)	2.14	22.40	27.75
Stress (N/mm ²)	100	1050	1300
Stress % Solid	7	73	91
Load Tol. Grade 1 (N)	25.04	35.07	37.71
Load Tol. Grade 2 (N)	37.56	52.60	56.57
O.D. Expansion (N)	0.0297	0.311	0.386

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Figure 1 – Manufactured spring design (after prestress)

Fatigue Testing

Sets of four springs were fatigue tested from an initial stress value of 100N/mm² to a range of maximum stress values to enable an S-N curve to be produced. To minimise the effects of manufacturing variation on the results obtained, each spring was individually load tested to determine the test lengths corresponding to the required stress level.



The fatigue test results are given in Table 1.

Table 1

Stress (N/mm ²)		Cycles completed	Broken	Unbroken
Initial	Final			
100	1050	10,000,000		X
100	1050	10,000,000		X
100	1050	10,000,000		X
100	1050	10,000,000		X
100	1100	9,537,690	X	
100	1100	9,180,300	X	
100	1100	10,000,000		X
100	1100	10,000,000		X
100	1150	<10,000,000	X	
100	1150	6,671,920	X	
100	1150	9,009,470	X	
100	1150	8,918,780	X	
100	1200	7,946,100	X	
100	1200	10,000,000		X
100	1200	4,479,360	X	
100	1200	7,417,790	X	
100	1250	4,485,120	X	
100	1250	5,638,210	X	
100	1250	4,690,380	X	
100	1250	7,708,850	X	
100	1300	1,864,390	X	
100	1300	2,558,670	X	
100	1300	2,203,590	X	
100	1300	2,275,570	X	

The S-N curve generated from these results is included below as figure 4.

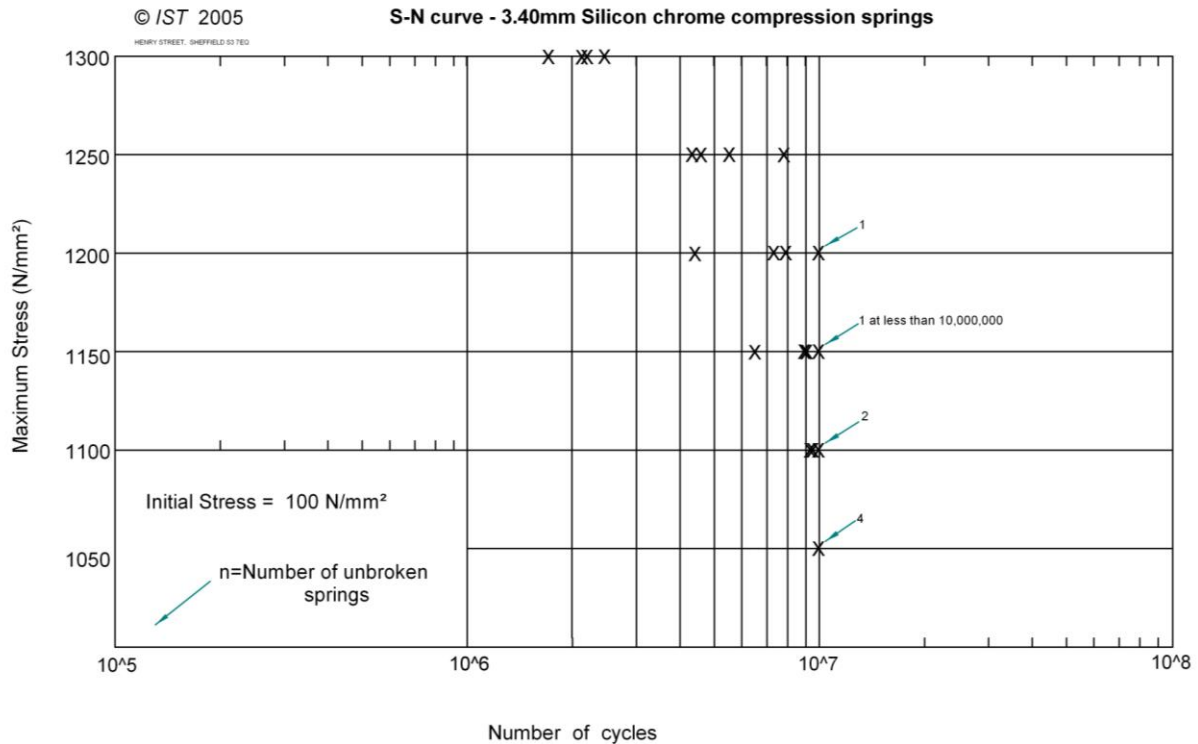


Figure 4 – S-N curve

Discussion

Goodman diagrams are included below (figures 2 and 3) showing the performance of silicon chrome material compression springs which would be predicted, using currently available IST data, for the lowest and highest stress values used in this investigation.



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Date: 22/07/2008 10:33:21

Identifier: 810 - Pengg

Goodman Diagram

Material: EN 10270 Pt2 Silicon -Cr
 Grade: VDSiCr
 Shot Peened: Yes
 Pre-Stressed: Yes

Operating Positions

	1	2
Length (mm):	48.06	27.80
Load (N):	52.94	554.18
Stress (N/mm ²):	100	1050

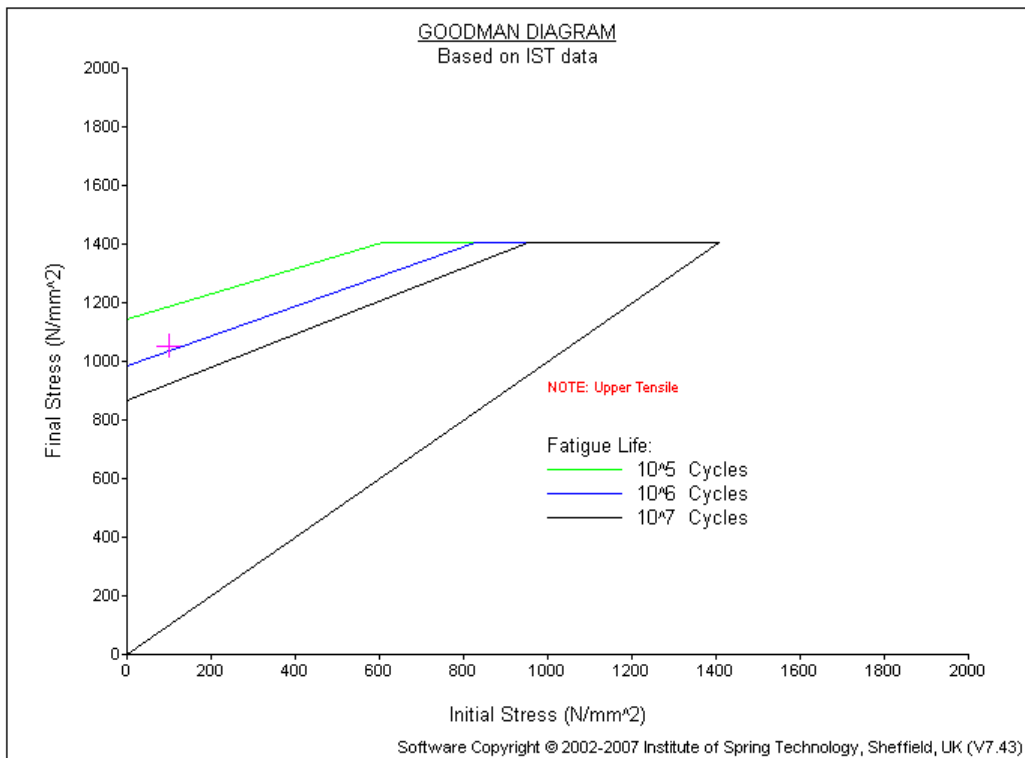


Figure 2 – Fatigue prediction, 100 – 1050N/mm²



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Date: 22/07/2008 10:34:20

Identifier: 810 - Pengg

Goodman Diagram

Material: EN 10270 Pt2 Silicon -Cr
 Grade: VDSiCr
 Shot Peened: Yes
 Pre-Stressed: Yes

Operating Positions

	1	3
Length (mm):	48.06	22.45
Load (N):	52.94	686.54
Stress (N/mm ²):	100	1300

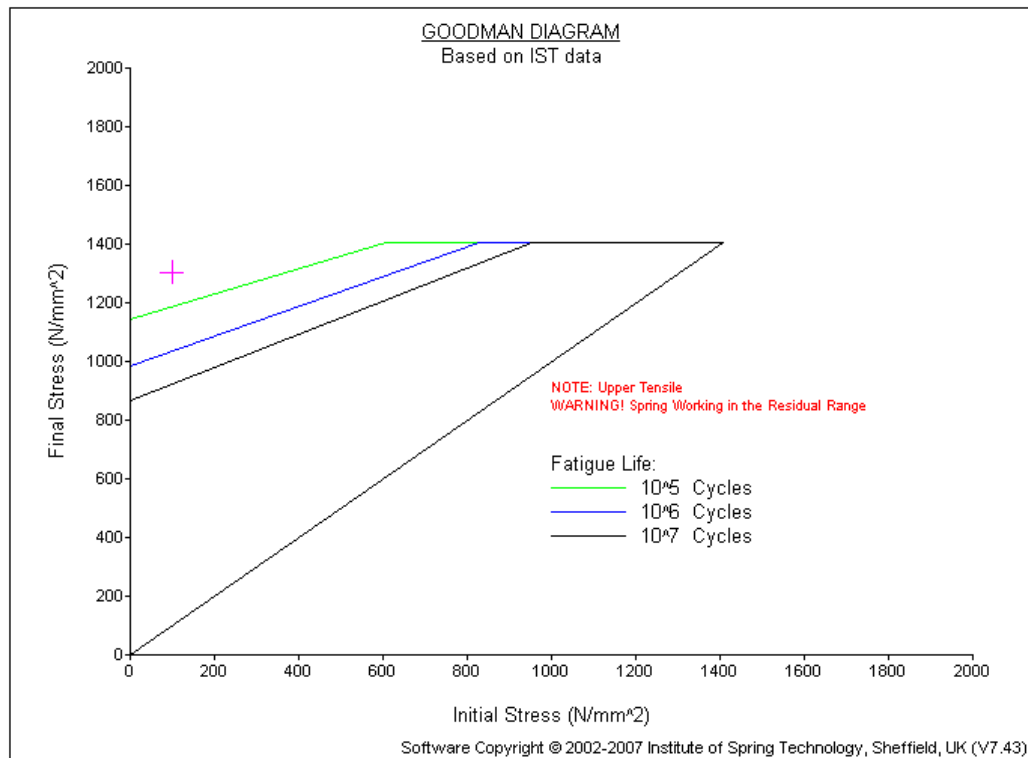


Figure 3 – Fatigue prediction, 100 – 1300N/mm²

It can be seen from figure 2 (100 – 1050N/mm²) that a fatigue life of just less than 1,000,000 cycles is predicted, whereas the Pengg wire springs have achieved a life in excess of 10,000,000 cycles. From figure 3 (100 – 1300N/mm²) a fatigue life of less than 100,000 cycles is predicted, whereas the earliest recorded Pengg wire spring failure was at 1,864,390 cycles.

Data Incorporated into the Tech-Spring Toolkit 3

As a result of the above testing the following data has been agreed and incorporated into the Tech-Spring toolkit 3:-

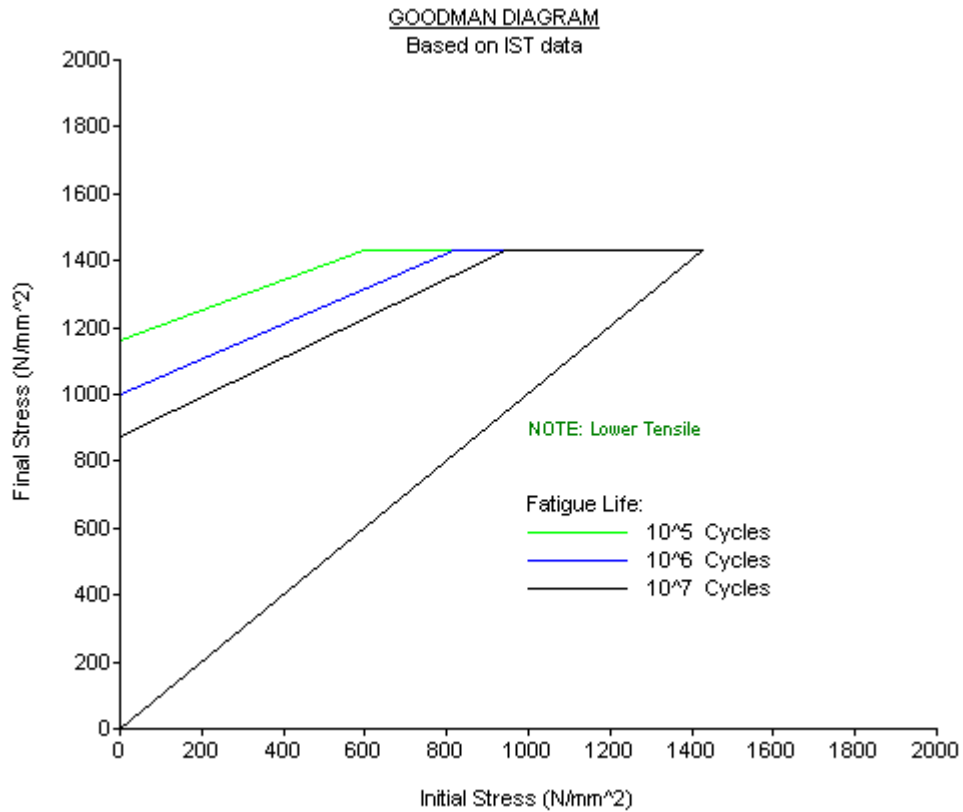
Material name: High strength Si Cr (Tech-Spring)

Size Range 2.5 – 5 mm diameter



Tensile Range: 2100 – 2300 N/mm²

Goodman Diagram:



Conclusions

- 1) The higher strength enables higher stressed spring designs, and yet the wire still has sufficient ductility for spring manufacturers.
- 2) The fatigue performance achieved by the Pengg silicon chrome wire compression springs exceeds that which would currently be predicted based on IST data.

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