Springflex™ Spring Datasheet
Wire

Zapp is certified according to ISO 9001

Springflex™ is a duplex (austenitic-ferritic) stainless steel characterized by:

- Very good fatigue resistance
- High resistance to stress corrosion cracking (SCC) in chloride-bearing environments
- High resistance to stress corrosion cracking (SCC) in environments containing hydrogen sulphide
- High resistance to general corrosion, pitting, and crevice corrosion
- High resistance to erosion corrosion and corrosion fatigue
- Physical properties that offer design advantages

Service temperature: -100 to 300 °C (-150 to 570 °F)

Standards

- UNS: S32205/S31803
- EN Number: 1.4462
- EN Name: X2CrNiMoN 22-5-3

Product standard

- EN 10270-3 is valid, excluding chemical composition and mechanical properties.
- ASTM A313

Chemical composition (nominal) %

C	Si	Mn	P	S	Cr	Ni	Mo	N
≤ 0.030	0.5	0.9	≤ 0.030	≤ 0.015	22.0	5.0	3.2	0.18

Forms of supply

Surface conditions and dimensions

	Dimension	
Surface finish	mm	in.
Coated	0.4 - 8.50	0.016 - 0.33
Bright	0.15 - 0.80	0.006 – 0.031
Polished	0.5 – 4.0	0.20 – 0.16
Degreased	0.4 – 10.0	0.016 – 0.39
Nicoat P (nickel coated + bright drawn)	1.2 – 2.4	0.05 – 0.094
Nicoat A (nickel coated + dry drawn)	0.22 – 2.50	0.009 – 0.098

Surface conditions and dimensions

	Dimension	
Surface finish	mm	in.
Flat wire		
Width	0.50 – 7.00	0.020 – 0.28
Thickness	0.05 – 4.00	0.0020 – 0.16
W/t	< 25	< 25

Delivery forms

- Coils with weight up to 300 kg (600 lb)
- Spools of various types with wire weight up to 450 kg (990 lb)
- Compact coils of 500 or 1,000 kg (1,100 or 2,200 lb)
- Straightened lengths 0.45 to 4 m (1.5 to 13 ft)

Mechanical properties

Tensile strength R_m and proof strength $Rp_{0.2}$ [1), MPa (ksi) in the ‘as delivered’ condition

Wire diameter	Nominal R_m	Nominal $R_{p0.2}$			
mm	in.	± 100 MPa	± 15 ksi	MPa	ksi
0.15 – 0.20	0.0059 - 0.0079	2,250	326	1,915	278
> 0.20 – 0.30	> 0.0079 - 0.012	2,200	319	1,870	271
> 0.30 – 0.50	> 0.012 - 0.020	2,100	305	1,785	259
> 0.50 – 0.80	> 0.020 - 0.031	2,000	290	1,700	247
> 0.80 – 1.25	> 0.031 - 0.049	1,900	276	1,615	234
> 1.25 – 2.00	> 0.049 - 0.079	1,800	261	1,530	222
> 2.00 – 3.50	> 0.079 - 0.138	1,650	239	1,405	204
> 3.50 – 5.00	> 0.138 - 0.197	1,550	225	1,320	191
> 5.00 – 8.00	> 0.197 - 0.315	1,450	210	1,235	179
Flat wire		900 – 1,800	130 – 261	0.85 x R_m	0.85 x R_m
Annealed wire		800	116	450	65
Intermediate strength levels		On request			

1) $R_{p0.2}$ corresponds to 0.2 % offset yield strength.

Tensile strength can be increased by 200 MPa (29 ksi) up to 450 MPa (65 ksi) by tempering depending on tensile and tempering conditions. Please click on heat treatment for further information. The tensile strength variation between spools/coils within the same production lot is ±50 MPa (7 ksi) maximum. Yield strength in the tempered condition is approx. 90 % of the tempered tensile strength. Tensile strength values are guaranteed and are measured directly after production. During storage, both the tensile strength and yield strength will increase somewhat due to ageing. Depending on the storage conditions, the tensile strength can increase by 0 - 80 MPa (0 - 12 ksi).

The tensile strength and yield strength will decrease by 3 – 4% per 100°C (184 F) increase in service temperature.

Straightened lengths

Straightening will reduce the tensile strength by approx. 7 %.

Fatigue strength

The diagrams below are based on tempered and pre-stressed cylindrical helical springs with a wire surface free from tooling damage.

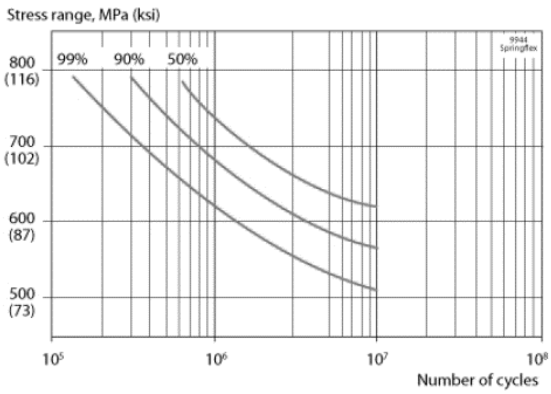

Figure 1.Wöhler diagram, mean stress 450 MPa (65 ksi). The curves are valid for springs coiled from wire 1.00 mm (0.039 in.) in diameter and represents 50 %, 90 % and 99 % certainty against failure.
Stress range = double the stress amplitude.

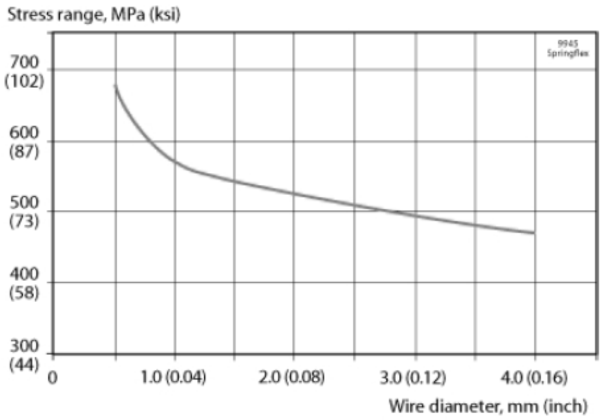

Figure 2. Stress range for different wire diameters, mean stress 450 MPa (65 ksi). Stress range at 10 load cycles as a function of the wire diameter and 90% certainty against failure.

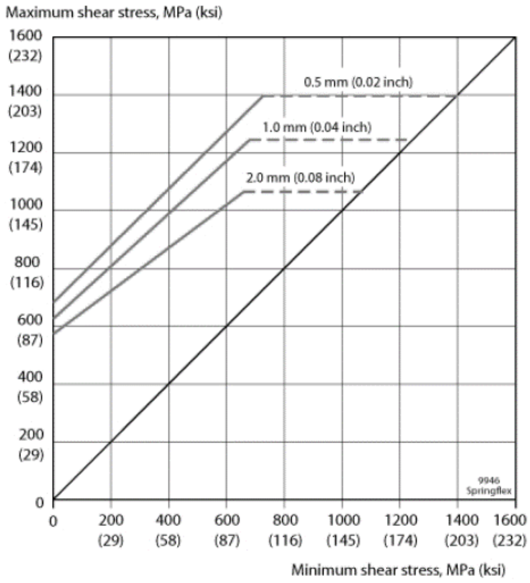

Figure 3. Modified Goodman diagram for different wire diameters. The curves are valid for 10 load cycles and represent 90 % certainty against failure. They are limited by the setting limit.

Relaxation and setting limit

Diagrams are based on tests with tempered springs.

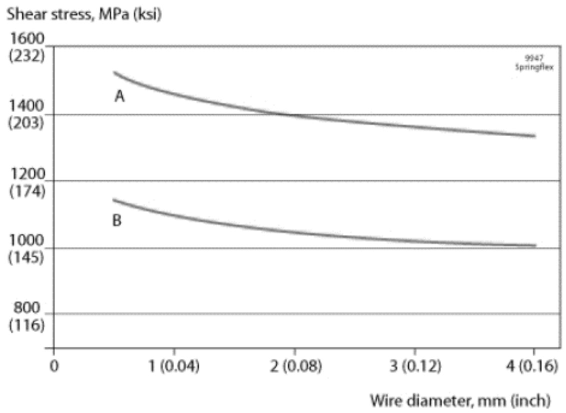

Figure 4. Setting limit and maximum permissible shear stress. Setting limit curve A, and maximum permissible shear stress, curve B, as a function of the wire diameter. The setting limit is defined as the shear stress at which the relaxation is 2 % after a load time of 24 hours. Curve B lies 25 % below curve A

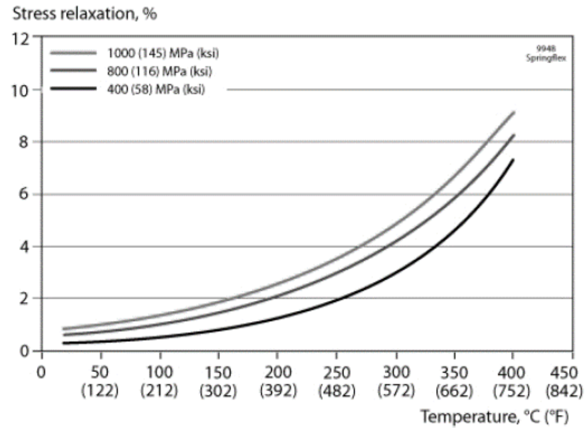

Figure 5. Relaxation 24 hours. Relaxation (load loss) at various shear stresses as a function of service temperature. This diagram refers to a wire diameter of 1.0 mm (0.04 in.).

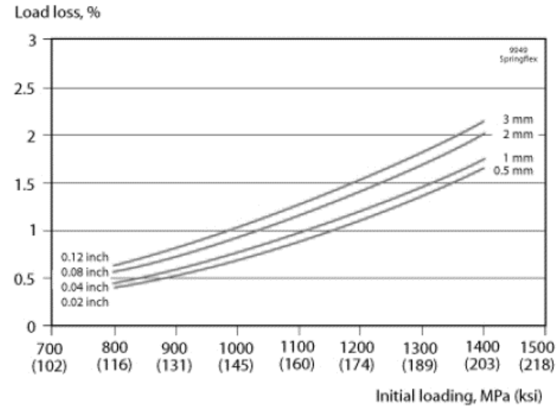

Fig 6. Relaxation, 24 hours. Relaxation (load loss) at various shear stresses as a function of wire diameter.

At elevated temperatures, the fatigue strength decreases at
100 °C (210 °F): by about 5 %
200 °C (390 °F): by about 10 %

Physical properties

Density: 7.8 g/cm³, 0.28 lb/in³

Specific heat capacity

500 J/kg °C	in the temperature range 50 – 100 °C
0.12 Btu/lb °F	in the temperature range 120 – 212 °F

Thermal conductivity

Temperature °C	W/m °C	Temperature °F	Btu/ft h °F
20	14	68	9
100	16	212	9
200	17	390	10
300	19	570	11

Resistivity

Temperature °C	μΩm	Temperature °F	μΩin.
20 - 100	0.84	120 - 212	33

Thermal expansion, mean values in temperature ranges ($x10^{6}$)

Cold worked

Metric units

Temperature °C, per °C	30 – 100	30 – 200	30 – 300	30 – 400
	12.5	11.5	11.5	12.0

Imperial units

Temperature °F, per °F	86 – 200	86 – 400	86 – 600	86 – 800
	7.0	6.5	6.5	6.5

Aged

Metric units

Temperature °C, per °C	30 – 100	30 – 200	30 – 300	30 – 400
	13.0	13.5	13.5	14.0

Imperial units

Temperature °F, per °F	86 - 200	86 - 400	86 - 600	86 – 800
	7.0	7.5	7.5	8.0

Magnetic permeability, μmax	
Annealed	60
Cold drawn	120

Shear modulus MPa (ksi)

as delivered: approx 77,000 (11,200)
tempered: approx 79,000 (11,500)

Modulus of elasticity MPa (ksi)

as delivered: approx 200,000 (29,000)
tempered: approx 205,000 (29,700)

Corrosion Resistance

General corrosion

The most common environments, where general corrosion occurs in stainless steels, are strongly acidic or alkaline solutions. The specific composition of the environment is crucial for corrosiveness and may change drastically if oxidizing or reducing compounds are added. The performance of stainless steel grades can vary considerably in the same environment and to different additives. It is, therefore, extremely important that the environment, where a product is to be used, is characterized thoroughly. When this is done, a suitable material can usually be selected. The economic advantages of choosing a grade with high corrosion resistance, sometimes acquired at a higher price per kilo, can be illustrated by estimating life cycle cost. In most media, Springflex possesses better resistance to general corrosion than steel of type ASTM 316L.

Pitting

The pitting resistance of a steel is determined primarily by its chromium and molybdenum contents, but also by its nitrogen content, as well as its slag composition and slag content. A parameter for comparing the resistance of different steels to pitting is the PRE number (Pitting Resistance Equivalent).

The PRE is defined as, in weight-%:
PRE = % Cr + 3.3 x % Mo + 16 x % N
The PRE numbers for Springflex™ and two standard materials are given in the following table.

Grade	% Cr	% Mo	% N	PRE
Springflex	22	3.2	0.18	> 35
ASTM 316 L	17	2.2	-	24
ASTM 302/304	18	-	-	18

The ranking given by the PRE number has been confirmed in laboratory tests. This ranking can generally be used to predict the performance of an alloy in chloride containing environments.

Laboratory determinations of critical temperatures for the initiation of pitting (CPT) at different chloride contents are shown in the figure below. The chosen testing conditions have yielded results that agree closely with practical experience.

Springflex™ can be used at considerably higher temperatures and chloride contents than ASTM 302/304 and ASTM 316 without pitting. It is, therefore, far more serviceable in chloride-bearing environments than standard austenitic steels.

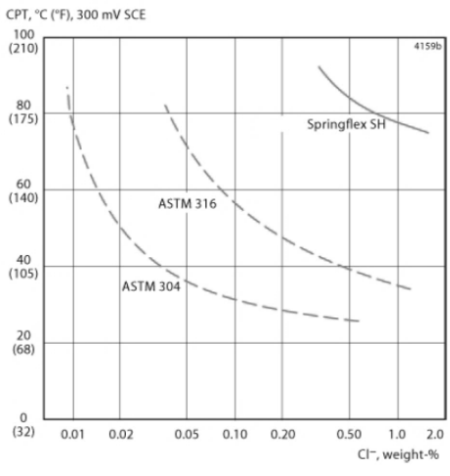

Figure 6. CPT at varying concentrations of sodium chloride (potentiostatic determination at +300mV SCE), pH appr 6.0.

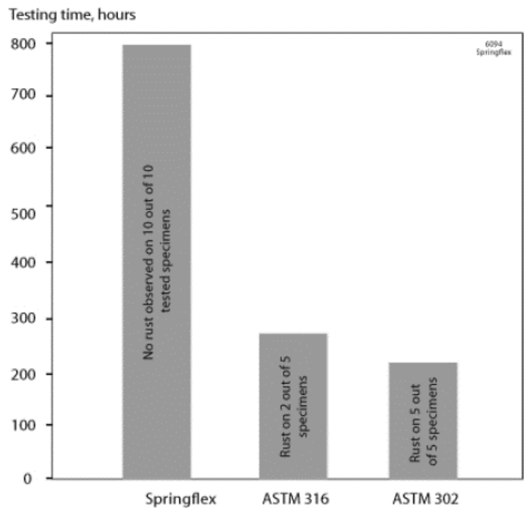

Figure 7. Neutral salt spray test according to ASTM B117. Springs in the tempered and unpassivated condition were sprayed with neutral, 5 % by volume, salt solution at 35°C (95°F), pH 6.5 - 7.2. Inspections were carried out every 24 hours.

Crevice corrosion

Crevice corrosion is in principle the same as pitting corrosion, but occurs in crevices and cracks, e.g. between flange joints, under deposits on the metal surface or in welds with incomplete penetration. Crevice corrosion often occurs at lower temperatures and at lower chloride contents than those necessary for pitting to occur. Resistance is influenced by the content of Cr, Mo and N, in the same way as pitting resistance.

Stress corrosion cracking

The standard austenitic steels of the ASTM 302/304 and ASTM 316L types are prone to stress corrosion cracking (SCC) in chloride-bearing solutions at temperatures above 60°C (140°F).

Duplex stainless steels are far less prone to this type of corrosion. Laboratory tests have shown the good resistance to stress corrosion cracking of Springflex™ SH. Results from these tests are presented in the diagrams below. The first diagram indicates the temperature-chloride range within which Springflex™ SH and the standard steels ASTM302/304 and ASTM 316L can be used without risk of stress corrosion cracking.

Results of laboratory tests carried out in calcium chloride are shown in the next diagram. The tests have been continued to failure or a max. test time of 500 h. The diagram shows that Springflex™ SH has a much higher resistance to SCC than the standard austenitic steels ASTM 302/304 and ASTM 316. In aqueous solutions containing hydrogen sulphide and chlorides, stress corrosion cracking can also occur in stainless steels at temperatures below 60 °C (140 °F). The corrosivity of such solutions is affected by acidity and chloride content.

Laboratory tests of Springflex™ SH have confirmed the good resistance to stress corrosion cracking in environments containing hydrogen sulphide. This has also been verified by available operating experience.

In accordance with NACE MR 0175, solution annealed and cold worked UNS S31803 (Springflex™ SH) is acceptable for use at any temperature up to 232 °C (45 °F) in sour environments. This is provided that the partial pressure of hydrogen sulphide does not exceed 0.02 bar (0.3 psi), the proof strength ($R_{p0.2}$) of the material is not greater than 1,100 MPa, and its hardness is not greater than HRC 36.

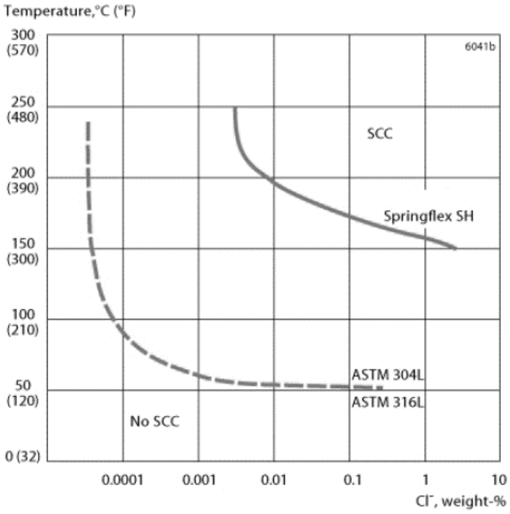

Figure 8. Resistance to stress corrosion cracking, laboratory results for Springflex™ SH of constant load specimens loaded to 85 % of the proof strength at the test temperature.

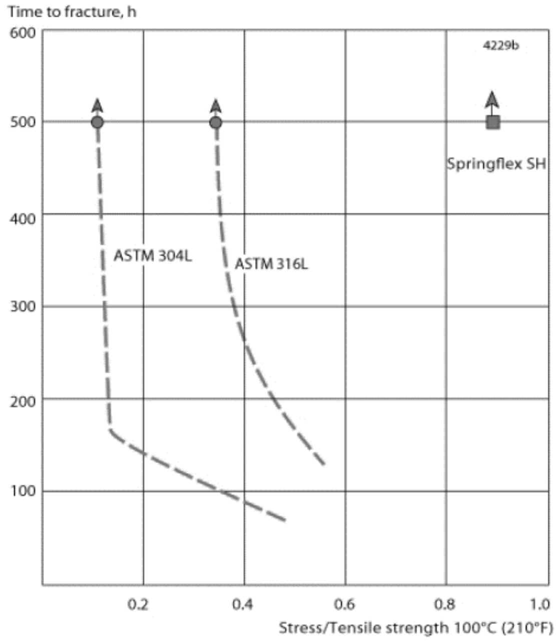

Figure 9. Results of stress corrosion cracking tests on Springflex™ SH, ASTM 302/304 and ASTM 316L in 40 % CaCl2 at 100 °C (210 °F) with an aerated test solution.

Heat treatment

Spring tempering will increase the tensile strength with up to to 450 MPa (65 ksi) depending on initial tensile strength. We recommend 450 °C (840 °F)/1 – 3 h for batch tempering. To obtain best results, when tempering in a continuous conveyor furnace, where holding times at full temperature are very short, the temperature should be increased preferably to about 500 °C (930 °F). The holding time should be 3 - 10 minutes. Shorter times may result in uneven tempering.

Bending

The minimum bending radius should not be less than half the wire diameter. The wire surface should be free from any tooling damage because slight imperfections in the surface can lead to fracture, even at large bending radii.

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