Alleima

Springflex™

Strip steel

Datasheet

Springflex™ is a duplex (austenitic-ferritic) stainless spring steel with very good spring properties and excellent corrosion resistance. Springflex™ is characterized by:

- Very good spring properties and fatigue resistance
- High resistance to stress corrosion cracking (SCC) in chloride-containing environments
- High resistance to general corrosion, pitting and crevice corrosion
- High tensile strength
- High modulus of elasticity

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

Standards

- UNS: S32205, S31803
- EN Number: 1.4462
- EN Name: X 2 CrNiMo 22-5-3

Chemical composition (nominal)

Chemical composition (nominal) %

C	Si	Mn	P	S	Cr	Ni	Mo	N
0.030	0.5	0.9	≤0.030	≤0.015	22	5	3.2	0.18

Applications

Due to the unique combination of excellent spring properties and high resistance to corrosion, Springflex™ can advantageously replace ASTM 301, 17-7PH or coated carbon steel in the form of springs, coil springs, spring washers, hose clamps, etc. where heavy demands are made on the resistance to corrosion attack in many industrial applications, such as:

- Automotive
- Food
- Oil & Gas

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- Chemical
- Pulp & Paper
- Marine & Shipping

Corrosion resistance

In most media, Springflex™ possesses better resistance to general corrosion than steel of type ASTM 316L. For details please refer to Alleima Corrosion Handbook.

Pitting

The pitting resistance of stainless steel is determined primarily by its chromium and molybdenum contents, but also by its nitrogen content. A parameter for comparing the resistance of different steels to pitting is the PRE number (**P**itting **R**esistance **E**quivalent).

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 316L	17	2.2	-	Approx. 24
ASTM 301/304	18	-	-	Approx. 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 figure 3. 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 301/304 and ASTM 316 without pitting. It is, therefore, far more serviceable in chloride-bearing environments than standard austenitic steels.

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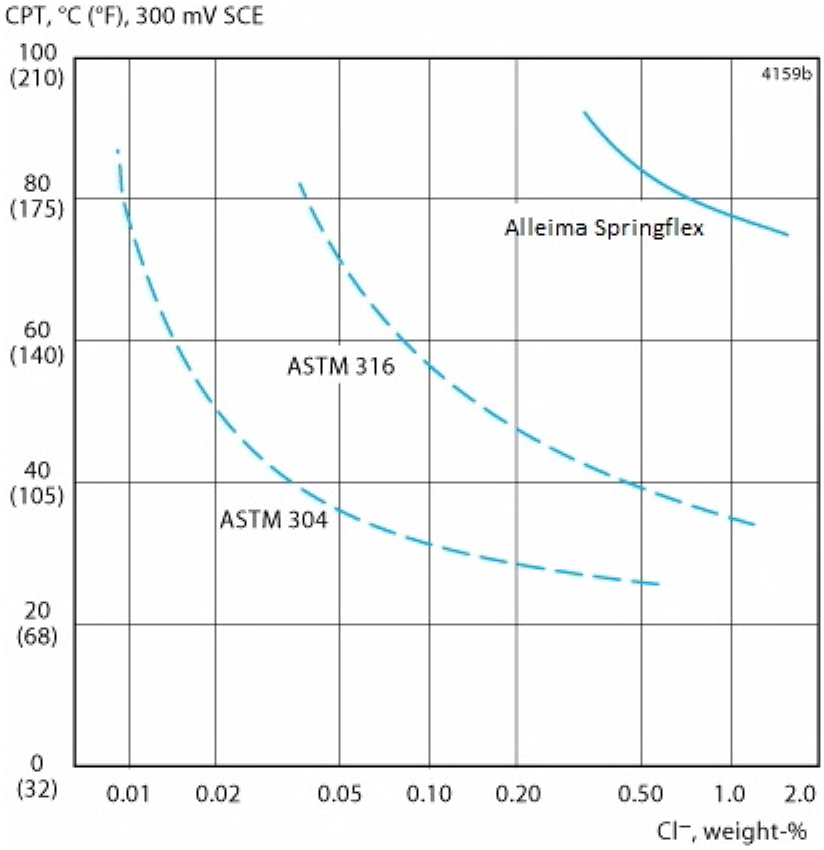

Figure 3. CPT at varying concentrations of sodium chloride (potentiostatic determination at +300mV SCE), pH approx. 6.0

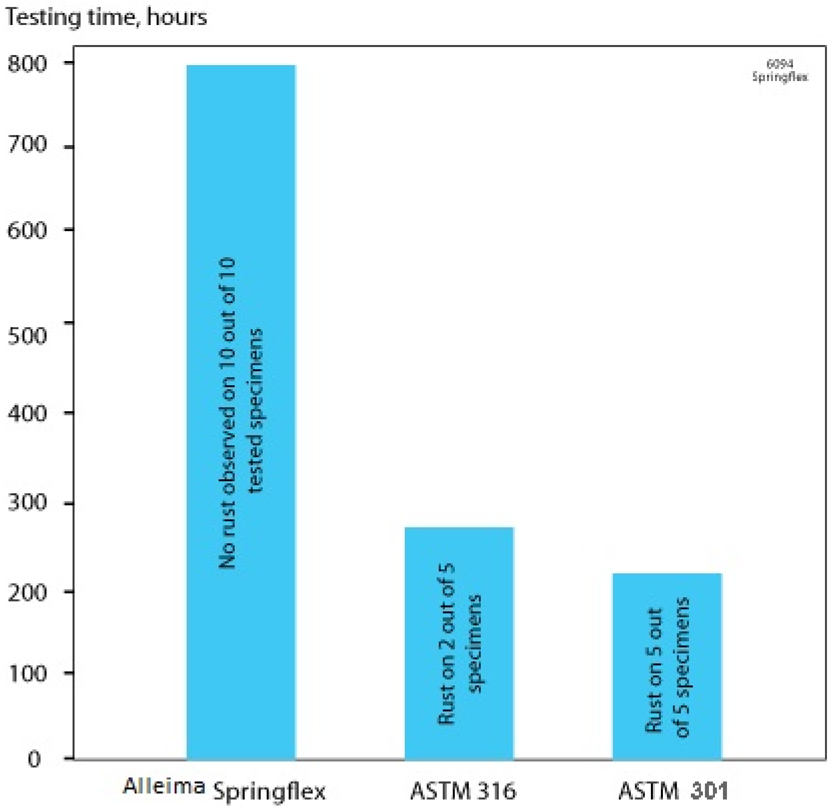

Figure 4. Neutral salt spray test according to ASTM B 117. Springs in the tempered condition were sprayed with neutral, 5% by volume, salt solution at *35°C (95°F), pH 6.5 - 7.2. Inspections were carried out every 24 hours.*

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Crevice corrosion

Crevice corrosion is a similar phenomenon as pitting corrosion, but occurs in crevices and cracks, e.g. between assembled parts or under deposits on the metal. 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. Springflex™ offers considerable better resistance to crevice corrosion compared to standard austenitic steels like ASTM 301 (EN 1.4310) and ASTM 316L (EN 1.4404).

Stress corrosion cracking

Standard austenitic steels of the ASTM 301/304 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™. Results from these tests are presented in Figure 5. The diagram indicates the temperature-chloride range within which Springflex™ shows superior resistance to SSCS compared with standard steels ASTM 301/304 and ASTM 316L.

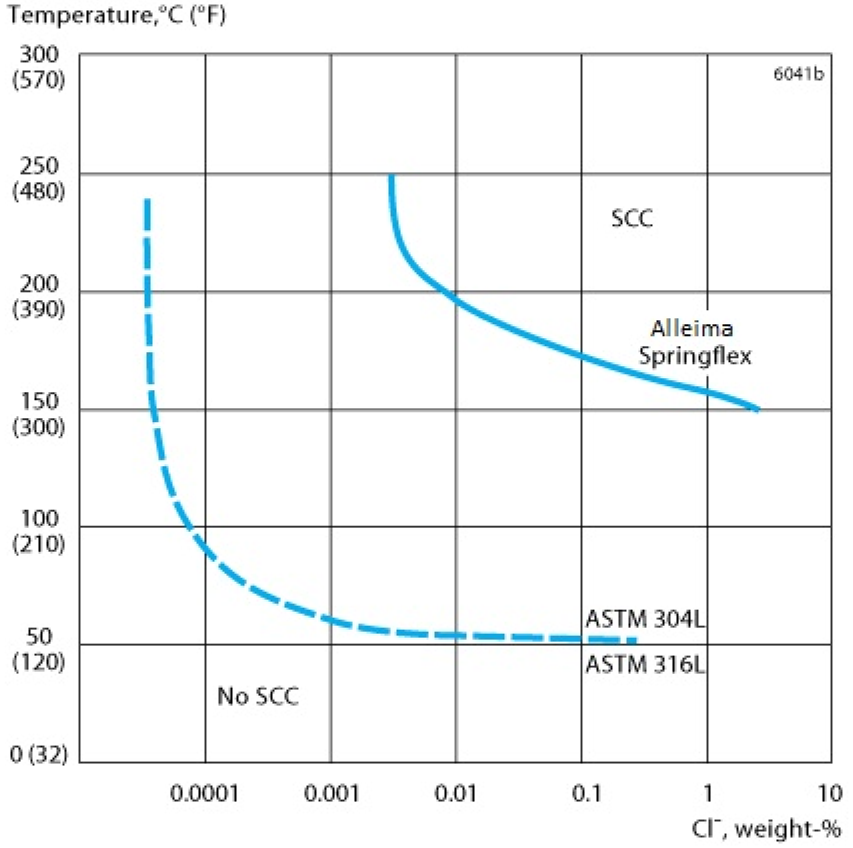

Figure 5. Resistance to stress *corrosion cracking, laboratory results for Springflex of constant load specimens loaded to 85% of the proof strength at the test temperature.*

Bending

The values given below have been obtained by bending according to Swedish standard SS 11 26 26 method 3 (in a 90° V-block with a 25 mm die opening, a sample of 35 mm width, turned so that the burrs of the blanked edges face into the bend). They can be used as guidance for the smallest recommended bending radius.

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Nominal tensile strength, Rm	Thickness, t	Min. bending radius as function of thickness *)	
MPa	mm	⊥	//
1300	0.25	<0.5 t	3 t
1300	0.50	t	4 t
1500	0.25	t	4 t
1500	0.50	2 t	10 t
1700	0.25	1.5 t	6.5 t
1700	0.50	3 t	10 t
1900	0.25	2.5 t	10 t

*) ⊥ Bend transverse to the rolling direction
// Bend parallel to the rolling direction

Forms of supply

Springflex™ is supplied, as standard, in the cold rolled condition. Strip steel can be supplied in coils, bundles, on plastic spools or in lengths. The edges can be slit, deburred or smoothly rounded. Contact us for more information.

The following range of thicknesses and widths can be supplied as standard.

Dimensions

Thickness, mm	Width, mm	Thickness, in	Width, in
0.03 - 3.5*	2 - 300	0.0012 - 0.14	0.079 - 12

*Depending on requested tensile strength.

Tolerances

The thickness and width tolerances are +/- tolerances to the nominal size. The normal tolerance classes for most of our strip products are T2 and B1. Tighter tolerances as well as other tolerance limits can be offered upon request.

Heat treatment

The strength of cold rolled Springflex™ can be increased by a tempering operation at 450°C (840°F) for 1 hour. An increase in tensile strength of approx. 200 to 350 MPa can be expected, depending on the initial cold rolled tensile strength. Further information on the nominal tempering effect can be seen under the "Mechanical properties" section. This heat treatment is also beneficial for relaxation and fatigue resistance.

Tempering is normally carried out after forming of the parts.

Tempering in open air furnaces gives a brownish oxide on the surface and can have a negative impact on the corrosion resistance. For applications where the corrosion resistance is critical, it is recommended to perform the tempering in protective gas, or to use parts in the untempered condition. Alternatively post-tempering treatment by pickling and/or tumbling can be performed. Contact Alleima for further recommendations.

Mechanical properties

Static strength, nominal values

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Condition[1)]	Tensile strength, R_m		Proof strength, $R_{p0.2}$[a)]		Elongation, $A_{11.3}$
	MPa	ksi	MPa	ksi	%
C	1100	160	1000	145	18
CT	1200	174	1150	167	10
C	1300	188	1200	174	5
CT	1500	217	1450	210	4
C	1500	218	1375	199	4
CT	1700	247	1650	239	3
C	1700	247	1600	232	3
CT	2000	290	1950	283	2
C	1900	276	1700	247	2
CT	2200	319	2000	290	2

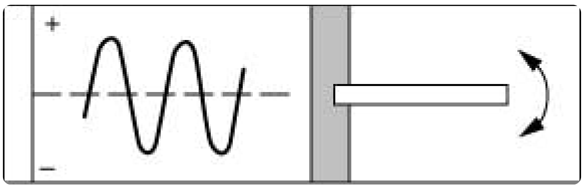
1) C = Cold rolled, CT = Cold rolled and tempered, 450 °C (840 °F)/1h. Refer to section 'Heat treatment'.
a) $R_{p0.2}$ corresponds to 0.2% offset yield strength.
1 MPa = 1 N/mm^2

Fatigue strength

Nominal values at 20 °C (68 °F) in a normal dry atmosphere. The fatigue limit is defined as the stress at which 50% of the specimens withstand a minimum of 2 million load cycles.

Reversed bending stress

Average stress = 0
Bending transversal to rolling direction.



Tensile strength, Rm	Fatigue limit	Tensile strength, Rm	Fatigue limit
MPa	MPa	ksi	ksi
1600	±615	232	±89

*Measured on strip in thickness 0.50 mm (0.020 in).

Relaxation

Relaxation testing of Springflex™ shows better relaxation properties than for austenitic grades at comparable tensile strength levels. The figure shows the relaxation (load loss) at room temperature as a function of time for Springflex in the tempered condition compared to standard spring grades 17-7PH (EN 1.4568) and ASTM 301 (EN 1.4310). See figure 1.

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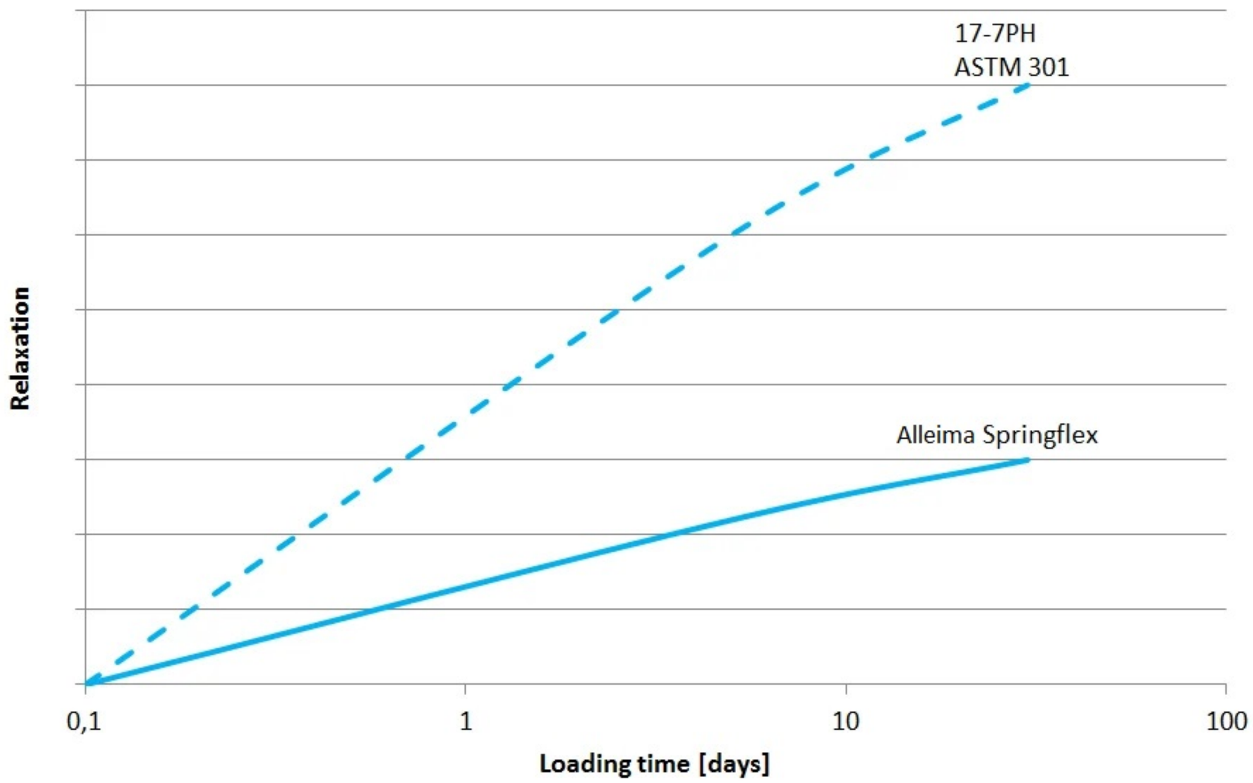

1. Relaxation (load loss) at room temperature as a function of time. Springflex compared to 17-7PH and ASTM 301

Physical properties

The values refer to cold rolled material, at a temperature of 20°C (68°F) unless otherwise stated.

Density 7.8 g/cm^3 (0.28 lb/in^3)

Thermal conductivity

Temperature, °C	W/m °C	Temperature, °F	Btu/ft h °F
20	14	68	8
100	16	200	9
300	19	600	11

Specific heat capacity

500 J/kg °C (in the temperature range 50 – 100°C)

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

Temperature, °C	per °C	Temperature, °F	per °F
20 - 100	13	68 - 200	7
20 - 200	13.5	68 - 400	7.5
20 - 300	14	68 - 550	8

Resistivity

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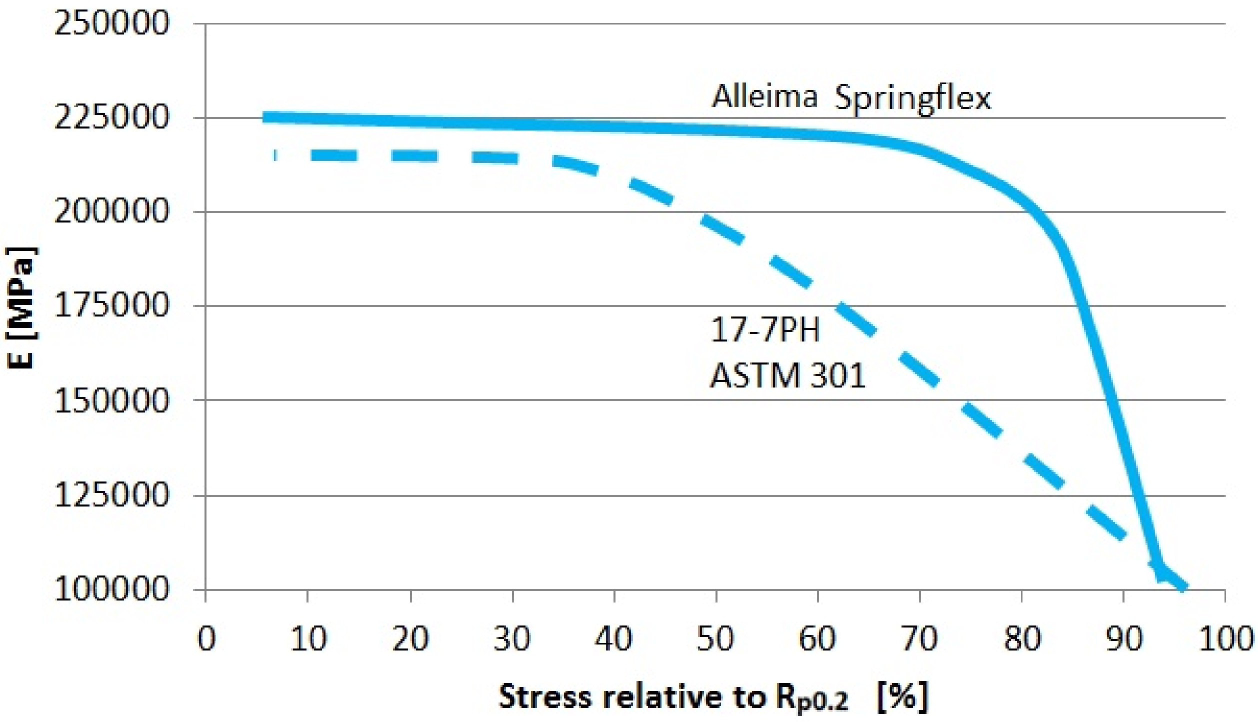
Temperature, °C	µΩm	Temperature, °F	µΩinch
20	0.74	68	29
100	0.85	200	33
200	0.96	400	38
300	1.0	600	40

Modulus of elasticity

Cold rolled, C: approx. 200 000 MPa (29 000 ksi)
Cold rolled and tempered, CT: approx. 210 000 MPa (30 400 ksi)

For cold rolled and tempered condition, the modulus of elasticity shows a high and almost constant value up to loads of about 70% of the yield strength, as shown in figure 2. For comparison, similar values for grades 17-7PH (EN 1.4568) and ASTM 301 (EN 1.4310) spring steels are added.



2. Modulus of Elasticity, E, as a function of applied stress. Springflex compared with 17-7PH and ASTM 301.

Disclaimer: Recommendations are for guidance only, and the suitability of a material for a specific application can be confirmed only when we know the actual service conditions. Continuous development may necessitate changes in technical data without notice. This datasheet is only valid for Alleima materials.

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