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**PRODUCT
DATA SHEET**

**Stainless Steel for
Springs**

Stainless Steels

STAINLESS STEEL STRIP – SPRING QUALITY

Stainless steel strip for spring manufacture is a low carbon steel containing at least 11.0% chromium. The austenitic grades 301, 302, 316 also contain at least 5.9% nickel. These steels have a higher corrosion resistance than the martensitic grades (420, S29 and S45) and do not undergo structural changes when heated to high temperatures.

Austenitic steels cannot be hardened except by cold working which produces a rapid increase in hardness, yield strength and ultimate tensile strength. Low temperature heat treatment can improve spring properties after cold working.

The martensitic grades 420 S29 and S45 can be heat treated to high hardness values as follows:

	420S29	420S45
Hardening temperature range	950-1000°C	950-1000°C
Method of cooling	Oil quench	Oil quench
Tempering temperature range	150° - 350°C	150° - 250°C
Hardness HV	400 min.	540 min.

All the martensitic grades are magnetic in the work hardened or heat treated condition. Only fully softened austenitic grades are non-magnetic.

Chemical Composition BS 5770/81 – Pt.4

Grade	301S21		302S28		316S16		420S29		420S45	
	Element		Element		Element		Element		Element	
	% min	% max	% min	% max	% min	% max	% min	% max	% min	% max
Carbon	-	0.15	-	0.12	-	0.07	0.14	0.20	0.28	0.36
Silicon	0.20	1.00	0.20	1.08	0.20	1.00	-	0.80	-	0.80
Manganese	0.50	2.00	0.50	2.00	0.50	2.00	-	1.00	-	1.00
Chromium	16.00	18.00	17.00	19.00	16.50	18.50	11.50	13.50	12.00	14.00
Nickel	6.00	8.00	8.00	11.00	10.00	13.00	-	1.00	-	1.00
Molybdenum	-	-	-	-	2.25	3.00	-	-	-	-
Phosphorus	-	0.045	-	0.045	-	0.045	-	0.040	-	0.040
Sulphur	-	0.030	-	0.030	-	0.030	-	0.030	-	0.030

Permitted variations from cast analysis

Element	Permitted variations from cast analysis		
	Range in which maximum of specified element falls	Over max%	Under min %
Carbon	Up to 0.5%	0.01	0.01
	Over 0.25 to 0.50%	0.02	0.02
Silicon	0.20 up to 1.00%	0.05	0.05
	Manganese	0.50 up to 1.00%	0.03
Chromium	Over 1.00% to 2.00%	0.04	0.04
	Over 10 up to 15.00	0.15	0.15
Nickel	Over 15 up to 19.00	0.20	0.20
	Up to 1.00	0.03	-
Molybdenum	Over 5.00 up to 10.00	0.10	0.10
	Over 10.00 up to 13.00	0.15	0.15
Phosphorus	Over 2.00 up to 3.00	0.08	0.08
	Up to and including 0.045	0.004	-
Sulphur	Up to and including 0.030	0.003	-

STAINLESS STEEL STRIP – SPRING QUALITY (Continued)

Hardness/Tensile Testing

Spring quality cold worked austenitic stainless steels do not have the same consistent relationship between hardness and tensile strength as do carbon steels. This varies with the chemical composition, in particular the percentage of nickel. Hardness should be used as a guide only; for inspection and design purposes tensile properties are more reliable (UTS, 0.2% proof stress, etc.)

Formability

Austenitic stainless steels have excellent formability in the annealed condition but this decreases with increasing hardness (temper) so that fully hard rolled strip can only be formed to a limited extent. Composition is very important. Grade 301 has considerably better formability than grade 302 due to the lower nickel content of 301.

Hardness Values HV			Bend Tests 180° t = thickness						Tensile Strength (typical)		Elongation	
Symbols for Hardness Condition	Grades 301/302/316	Temper Indication	301S21		302S16 - 316S16		420S29 - 420S45		301 MPa	316 MPa	301 %	302 %
			Under 1.00mm	1.00mm & over	Under 1.00mm	1.00mm & over	Under 2.00mm	2.00mm & over				
TR230	230 - 279	¼ hard	A 2t	B 2t	A 2t	B 2t	A 2t	B 2t	900 1000 1100 1250 1750 1900	850 950 1050 1200 n/a n/a	30	15
TR280	280 - 329	½ hard	2t	3t	4t	6t	4t	6t				
TR330	330 - 379	¾ hard	4t	6t	6t	9t	6t	9t				
TR380	380 min	Full Hard	6t	9t	8t	12t	8t	12t				
TR500	500 min	Extra Hd	10t	15t	8t	14t	12t	20t				
HY * **	550 min	Ultra Hd	20t									
A (420S29 & SP 420S46)	220 max	Annealed					2t	2t	3t	4t		
	260 max	Skin passed					2t	3t	3t	4t		

* only in Grade 201

** under 0.5mm thick

A=axis of bend 90° to rolling direction

B=axis of bend parallel to rolling direction

Dimensional Tolerances

THICKNESS TOLERANCE						WIDTH TOLERANCE				
Thickness		Width up to 300 mm		Width 300-640 mm		Specified Thickness		Tolerance on Width		
Over mm	Up to mm	Normal tolerance T1 mm	Precision tolerance T2 mm	Normal tolerance T1 mm	Precision tolerance T2 mm	Over mm	Up to mm	Width up to 152 mm	Width over 152-450 mm	Width over 450-610mm
0.025	0.10	± 8%	± 8%	± 8%	± 8%	0.025	0.10	± 0.08	± 0.10	± 0.25
0.10	0.18	± 0.012	± 5%	± 0.016	± 5%	0.10	0.40	± 0.10	± 0.13	± 0.20
0.18	0.265	± 0.016	± 0.008	± 0.020	± 0.013	0.40	0.63	± 0.10	± 0.13	± 0.20
0.265	0.375	± 0.020	± 0.010	± 0.025	± 0.013	0.63	1.25	± 0.10	± 0.13	± 0.40
0.375	0.56	± 0.025	± 0.015	± 0.032	± 0.020	1.25	3.00	± 0.20	± 0.20	± 0.40
0.56	0.80	± 0.030	± 0.015	± 0.040	± 0.025	NOTE: Widths under 152 mm as above are closer than British Standards 1448/55. B.S.S. 5770/81 only specified requirements for spring material from 0.10 mm to 3.55 mm thick (in 5 grades) in widths from 3.15 mm to 450 mm.				
0.80	1.06	± 0.035	± 0.020	± 0.045	± 0.030					
1.06	1.40	± 0.040	± 0.020	± 0.050	± 0.035					
1.40	1.70	± 0.045	± 0.025	± 0.070	± 0.040					
1.70	2.12	± 0.050	± 0.025	± 0.080	± 0.045					
2.12	2.50	± 0.055	± 0.040	± 0.080	± 0.060					

STAINLESS STEEL STRIP – SPRING QUALITY (Continued)

EDGE FINISH

- E3 (SH) Sheared from wider coil without further treatment – should be smooth and sharp – slight burr.
- E5 (DD) Slitting burr on turn-down removed after shearing, edges slightly rounded.
- E1 (DE) Edges rounded to remove burrs to give smooth polished edges.

QUALITY CONTROL

Most stainless steel – Spring Quality – can be fully released to BSI conditions. Test certificates and Release Notes with full range of chemical and mechanical properties can be supplied on request.

CUT FLATTENED LENGTHS

Specified length		TOLERANCE				RANGE OF WIDTHS				IN THICKNESSES					
OVER		TO		Normal		Precision		FROM		TO		FROM		TO	
mm	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch
0.25	10	1.0	39	-0 +3	-0 +0.12	-0 +1	-0 +0.040	12	½	305	12	0.30	.012	2.00	.080
1.0	39	3.0	118	-0 +6	-0 +0.24	-0 +1.6	-0 +0.063	12	½	230	9	0.40	.016	2.50	.087
3.0	118	8.0	236	-0 +12	-0 +0.48	-0 +5	-0 +0.200	25	1	230	9	0.50	.020	3.00	.118

STOCK RANGE

STOCK RANGE										PRODUCT RANGE		
SPECIFICATION		Standard Range of Widths				In a Range of Thickness				Popular Stock Widths	All specifications stated in tables in range of tempers. Available in thicknesses from 0.012mm(.0005") to 3.00mm (.118") in a range of widths Up to 1000mm (39.4")	
BS	AISI	From		To		From		To		300mm, 6",12",24" 300mm, 12",24" 620/640mm 6",12",24" 620/640mm 6",12",24"		
		mm	inch	mm	inch	mm	inch	mm	inch			
301S21 TR280 - 330	301	21.33	0.084	305	12	0.025	.001	0.050	.020			
301S21 TR380	301	38.1	1.5	640	25.2	0.12	.005	2.00	.079			
302S25 TR380	302	12.7	.5	635	25	0.012	.0005	1.63	.064			
316S16 TR380	316	50	198	368	14.5	0.05	.002	1.22	.048			
420S29 420S45	410 420 430	Stock range limited to certain sizes for special applications				From .12mm (.005") to 1.00mm (.040") up to 305mm (12") wide						

STAINLESS STEEL STRIP – SOFTENED (Fully Annealed)

Stainless Steel in the soft condition is the most popular for many applications, especially the austenitic grades (300 series) commonly known as 18/8 (approximately 18% chromium and 8% nickel). Austenitic grades cannot be hardened except by cold working (see section on spring quality stainless) but have very good corrosion resistance, especially those with higher nickel.

At elevated temperatures in excess of 400°C it is advisable to use steels with a carbon content of 0.03% or less, alternatively the addition of small quantities of titanium or niobium will prevent the precipitation of chromium carbide at the grain boundaries causing inter-crystalline corrosion. These grades are usually called stabilized. Austenitic steels are non-magnetic in the fully softened condition.

Chemical Composition BS1449 Part 2:1983

BS Grade	304S11		304S15		304S16		304S31		316S11		316S13		316S31	
Element	min % max		min % max		min % max		min % max		min % max		min % max		min % max	
Carbon	-	0.03	-	0.06	-	0.06	-	0.07	-	0.030	-	0.030	-	0.07
Silicon	-	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-	1.0	-	1.00
Manganese	-	2.00	-	2.00	-	2.00	-	2.00	-	2.00	-	2.00	-	2.00
Nickel	9.0	12.00	8.0	11.00	9.0	11.00	8.0	11.00	11.0	14.00	11.5	14.50	10.5	13.50
Chromium	17.0	19.00	17.5	19.00	17.5	19.00	17.0	19.00	16.5	18.50	16.5	18.50	16.5	18.50
Molybdenum	-	-	-	-	-	-	-	-	2.0	2.50	2.5	3.0	2.0	2.50
Phosphorus	-	0.045	-	0.045	-	0.045	-	0.045	-	0.045	-	0.045	-	0.045
Sulphur	-	0.030	-	0.030	-	0.030	-	0.030	-	0.030	-	0.030	-	0.030

THICKNESS TOLERANCE

Thickness		Width up to 450mm	Width 450-800mm	Width over 600mm
Over mm	Up to mm			
0.05	0.20	±5%	±5%	±5%
0.20	0.40	±.025	±.030	±.030
0.40	0.80	±.030	±.050	±.050
0.80	1.00	±.040	±.070	±.070
1.00	1.60	±.050	±.080	±.080
1.60	2.00	±.065	±.090	±.090
2.00	2.50	±.075	±.110	±.110
2.50	3.00	±.075	±.120	±.120

Note: For material greater than 0.050mm but less than or equal to 0.20mm in thickness, the tolerance to be applied is to be agreed when the material is ordered.

WIDTH TOLERANCE

Specified Thickness		Width up to 400mm	Width 400-600mm	Width over 600mm
Over mm	Up to mm			
0.025	0.10	±.10	±.13	-nil+1.6
0.10	0.56	±.13	±.20	-nil+1.6
0.56	0.91	±.13	±.40	-nil+1.6
0.91	1.63	±.13	±.40	-nil+1.6
1.63	2.12	±.20	±.40	-nil
2.12	2.50	±.25	±.50	+thickness of strip -nil + thickness of strip

Note: Widths under 150mm can usually be supplied to a much closer tolerance, i.e. ±.05mm and finer for very narrow sizes.

Surface Finish

Symbol	Description
2A	Cold rolled bright annealed
2B	Cold rolled softened and descaled with light pass to improve brightness
2D	Cold rolled softened and descaled (dull grey matt)
EBR	Extra bright produced by further polishing

Edges – Sheared, sheared and de-burred, dressed polished edges – available in narrow sizes only (see details on Spring Quality)

STAINLESS STEEL STRIP – SOFTENED (Fully Annealed) (Continued)

Flattened Cut lengths (see details of sizes available in Section on Stainless Spring Quality).
 Note: Flattening may affect surface condition and introduce slight marks or uneven stressing unless tension leveling has been used.

Quality Control

Stainless steel can be fully released to BSI conditions. Test certificates and Release Notes with full range of chemical and mechanical properties can be supplied on request.

STOCK RANGE

Specification BS	AISI	Standard range of Widths				In a range of thicknesses				Popular Stock Widths	Product Range	
		From		To		From		To				
		mm	inch	mm	inch	mm	inch	mm	inch			
302S25	302	25.4	1	305	12	0.25	0.010	1.63	0.064	6",12",24"	All specifications stated in tables. Available in thicknesses from 0.025mm (0.0005") to 3.00mm (0.118") in a range of widths up to 1250mm (49")	
304S16	304	78	3	1000	39.4	0.076	0.003	1.63	0.064	620/640, 1000mm, 6",12",24",		
316S31	316	50.8	2	1250	49	0.038	0.0015	2.00	0.079	620/640, 1000mm, 12",24"		
321S31	321	6.3	0.25	914	36	0.025	0.0010	1.63	0.064	620/640, 1000mm, 6",12",24"		
304S11/13	304L	Stock range limited to certain sizes but similar to the above.				Usually within range of 0.5mm (.002") to .50mm (.020")				Notes: Narrow widths ½" (12.7mm) and under usually made as flat wire with rounded edges		
316S11/13	316L											
347S31	347											
S526	S526 is available ex stock in a limited range of thickness but most stock of 321S31 is a suitable alternative (subject to Assurance Testing under the terms of our approval).									Both specifications are aerospace standards approximating to 321S31 and 347S31 respectively		
S527	347S17 is a suitable subject to above											
302S25 for chemical composition see section Stainless Steel (Spring Quality)												

BS Grade	316S33		320S31		320S33		321S31		347S31		410S21		420S45		430S17	
Element	min % max		min % max		min % max		min % max		min % max		min % max		min % max		min % max	
Carbon	-	0.07	-	0.08	-	0.08	-	0.08	-	0.08	0.09	0.15	0.28	0.36	-	0.08
Silicon	-	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-	1.00
Manganese	-	2.00	-	2.00	-	2.00	-	2.00	-	2.00	-	1.00	-	1.00	-	1.00
Nickel	11.0	14.00	11.0	14.00	11.5	14.50	9.0	12.00	9.0	12.00	-	1.00	-	1.00	-	1.00
Chromium	16.5	18.50	16.5	18.50	16.5	18.50	17.0	19.00	17.0	19.00	11.5	13.50	12.0	14.00	16.0	18.00
Molybdenum	2.5	3.00	2.0	2.50	2.5	3.00	-	-	-	-	-	-	-	-	-	-
Phosphorus	-	0.045	-	0.045	-	0.045	-	0.045	-	0.045	-	0.040	-	0.040	-	0.040
Sulphur	-	0.030	-	0.030	-	0.030	-	0.030	-	0.030	-	0.030	-	0.030	-	0.030
Others	-	-	Ti5C	0.80	Ti5C	0.80	Ti5C	0.80	Nb10C	1.00	-	-	-	-	-	-

S526 Analysis same as 321S12

S527 Analysis same as 347S17 except nickel 11% max., phosphorus 0.035% max., sulphur 0.025% max.

STAINLESS STEEL STRIP – SOFTENED (Fully Annealed) (Continued)

MECHANICAL PROPERTIES OF ANNEALED FERRITIC & MARTENSITIC STEELS

Steel Grade	0.2% Proof Stress min MPa	Tensile Strength min MPa	Elongation min %	Hardness max. HV	Temperature Range °C					
					Softening		Hardening		Temperature	
					Min	Max	Min	Max	Min	Max
Ferritic 430S17	245	430	20	175	750	820	-	-	-	-
Martensitic 410S21	205	425	20	185	700	780	950	1020	650	750
420S45	350	690	15	220	700	780	950	1050	150	250

MECHANICAL PROPERTIES OF ANNEALED AUSTENITIC STAINLESS STEELS

Steel Grade	Proof Stress 0.2% min MPa	Tensile Strength min MPa	Elongation min %	Hardness max HV	Softening Temp range	
					min °C	max °C
304S11	180	480	40	185	1000	1120
304S15	195	500	40	190	1000	1120
304S16	195	500	40	190	1000	1120
304S31	195	500	40	190	1000	1120
306S19	185	490	40	185	1000	1120
316S11	190	490	40	195	1000	1120
316S13	190	490	40	195	1000	1120
316S31	205	510	40	205	1000	1120
316S33	205	510	40	205	1000	1120
320S31	210	510	40	205	1000	1120
320S33	210	510	40	205	1000	1120
321S31	200	500	35	200	1000	1120
347S31	205	510	35	200	1000	1120

PRECIPITATION HARDENING STAINLESS STEEL**General Description**

17-7 PH, PH 15-7 Mo are semi austenitic grades of stainless steel with design and production advantages possessed by none of the standard types of stainless steel. The ductile austenitic structure permits forming by conventional techniques used for 18-8 types and by simple heat treatments can be hardened to high strength levels.

These materials all possess higher work hardening rates than type 301 (17-7) but will have higher ductility at a given strength level and less reduction in strength with increasing temperature.

Type 17-7 PH is a chromium nickel stainless with good working, easy hardening, high strength, good corrosion resistance and excellent mechanical properties at elevated temperatures. It can also be heat treated at sub-zero temperatures.

Type PH 15-7 Mo is a chromium nickel stainless with similar characteristics to 17-7 PH. The addition of molybdenum develops much higher strength in this alloy with the same heat treatment.

Specification and Analysis		
Element	17-7 PH AMS 5528 %	PH 16-7MO AMS 5520 %
Carbon	0.09 max	0.09 max
Manganese	1.0 max	1.0 max
Phosphorus	0.04 max	0.04 max
Sulphur	0.04 max	0.04 max
Silicon	1.0 max	1.0 max
Chromium	16.00-18.00	14.00-16.00
Nickel	6.50-7.75	6.50-7.75
Aluminium	0.75-1.50	0.75-1.50
Molybdenum	residual	2.00-3.00
Iron	balance	balance

Mechanical and Physical Properties before heat treatment			
Temper	17-7PH Annealed	PH15-7Mo Annealed	17-7PH Hard
Ultimate tensile strength MPa max	101.9	101.9	154.7
2% offset yield strength MPa max	31.6	38.7	140.6
Elongation in 2" % (50mm)	25	30	4
Hardness Rockwell	881	890	C45
Modulus of Elasticity, GPa	20.4	-	20.4
Magnetic Permeability at 200H	2.3	4.7	-
Electrical resistivity ohm-m x 10 ⁴	80	80	-
Density kg/mm ³ x 10 ³	7.81	7.81	-
Coefficient of Thermal Expansion x 10 ⁶ /°C			
20 - 90°C	15.3	14.4	15.3
20 - 200°C	18.2	14.4	16.2
20 - 425°C	17.3	16.0	17.3
20 - 540°C	-	16.9	-
Structure	Semi-austenitic	Semi-austenitic	

Corrosion Resistance

In the heat treated condition the corrosion resistance of these alloys is superior to ordinary chromium grades and in certain environments similar to austenitic types of stainless steel. It is difficult to indicate precisely the corrosion resistance in any specific application without service experience and therefore if this is a critical factor actual service tests should be carried out wherever possible.

Heat Treatment

Parts made from material in the hard rolled condition (condition C) require a single precipitation hardening treatment to achieve full mechanical properties. They should be heated to 482°C±6°(900°F±10°), held for 1 hour then air cooled – this results in Condition CH900.

For parts manufactured from annealed precipitation hardening stainless steel several stages of heat treatment are required depending on the final mechanical properties specified.

Full details of these heat treatments are available on request.

PRECIPITATION HARDENING STAINLESS STEEL (Continued)

Weldability

Welding procedures are similar to those used on most types of austenitic stainless steel and excellent mechanical properties are developed without pre-heating or post-annealing as is often necessary in standard hardenable stainless steel.

Brazing is easily accomplished although temperatures higher than 1100°C may affect the final properties.

Formability

These grades in the annealed condition are ductile and can be readily formed in a similar way to type 301 stainless steel. As they are essentially austenitic and work harden rapidly an intermediate annealing may be required for deep drawing and intricate formed parts. Generally, springback is similar to that of type 301. Fully cold worked hard temper is similar to type 301.

STOCK RANGE

Specification and Temper	Standard Range of Widths				In a Range of Thicknesses				Popular Stock Width
	From		To		From		To		
	mm	inch	mm	inch	mm	inch	mm	inch	
17-7 PH Hard (Condition C)	305	12	390	15.35	0.05	0.002	0.05	0.020	12"
17-7 PH Annealed	152.4	6	390	15.35	0.025	0.001	0.075	0.030	12"
PH 15-7 Mo Annealed	152.4	6	305	12.0	0.05	0.002	0.30	0.012	12"
PRODUCT RANGE									
17-7 PH Hard and Annealed PH 15-7 Annealed	In a range of widths from 0.75mm (.030") up to 640mm (25") in thickness from 0.025mm (.001") up to 1.63mm (.064").								