

Pernifer® 2918

Material Data Sheet No. 7002
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Low-expansion special alloy

2918

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Pern

Ein Unternehmen
von ThyssenKrupp
Stainless

ThyssenKrupp VDM



ThyssenKrupp

Pernifer 2918 is a special low-expansion iron-nickel-cobalt alloy of closely controlled chemical composition. It is characterized by an almost linear variation of coefficient of thermal expansion between room temperature and the Curie temperature (430°C/806°F).

Its expansion characteristics are very similar to those of many medium-hard borosilicate glasses and ceramics.

It can therefore ensure good sealing and vacuum tightness in glass or ceramic-to-metal seals. A special heat treatment can be applied to ensure a decarburized surface.

Pre-oxidation of contact surfaces is recommended before sealing.

Pernifer 2918 is characterized by:

- very low expansion coefficient between -100 and +450°C (-150 and 840°F)
- good ductility and formability

Designations and standards

Country National standards	Material designation	Chemical composition	Specification						
			Tube and pipe seamless	Tube and pipe welded	Sheet and plate	Rod and bar	Strip	Wire	Forgings
D DIN SEW	W.-Nr. 1.3981 NiCo 29 18	17745			385		385	385	
F AFNOR	Fe-Ni29Co17	A 54-301							
UK BS									
USA ASTM SAE AMS	UNS K94610 I-23011 Class 1	F 15 I-23011	F 15 I-23011	F 15 I-23011	F 15 7728	F 15 I-23011 7727*	F 15 I-23011 7728	F 15 I-23011 7726	7727

*Bars only.

Table 1 – Designations and standards.

Chemical composition

Alloy		Ni	Co	Fe	C	Mn	Si	(Al+Ti+Zr+Mg)
Pernifer 2918	min.	28.0	16.0	bal.	0.05	0.50	0.30	
	max.	30.0	18.0					
Pernifer 2918 MS	nominal	29	17.0	bal.	0.06	0.50	0.20	0.20 (with 0.10 max. for each element)
	max.							

Various other Pernifer 2918 grades with slightly modified chemical compositions are available on request for specialized applications especially at very low temperatures.

Table 2 – Chemical composition (wt.-%) of Pernifer 2918 according to DIN 17745 and Pernifer 2918 MS similar to AMS-I-23011, Class 1.

Physical properties

Density	8.3 g/cm ³	0.30 lb/in. ³
Melting point	1450°C	2640°F
Curie temperature	430°C	810°F
Specific heat	500 J/kg·K	0.12 Btu/lb·°F
Thermal conductivity	17.5 W/m·K	121 Btu in./ft ² h°F
Modulus of elasticity	160 kN/mm ²	23200 ksi

Temperature (T)		Electrical resistivity		Coefficient of thermal expansion*			
				according to SEW 385		according to ASTM F-15	
°C	°F	μΩ · cm	Ω circ mil ft	between 20°C and T 10 ⁻⁶ /K	between 68°F and T 10 ⁻⁶ /°F	between 30°C and T 10 ⁻⁶ /K	between 86°F and T 10 ⁻⁶ /°F
20	68	49	295				
93	200		325		3.5		
100	212	55		6.3			
200	392	72		5.8		5.5	
204	400		440		3.2		3.1
300	572	88		5.4		5.1	
316	600		550		3.0		2.8
400	752	100		5.1		4.9	
427	800		620		2.8		2.7
450	842	104				5.3	3.0
500	932	109		6.4		6.2	
538	1000		670		3.9		3.8
600	1112	114		8.0		7.9	
649	1200		700		4.8		4.8
700	1292	118				9.3	

*The linear coefficient of thermal expansion is determined after heat treatment in a hydrogen atmosphere:
 1 h at 900°C (1652°F), followed by 15 min. at 1100°C (2012°F), cooling rate <5°C (10°F) per minute down to ≤175°C (347°F).
 The samples are reheated in the dilatometer to 630°C (1166°F) and the values determined on the cooling curve.

Table 3 – Typical physical properties at room and elevated temperatures.

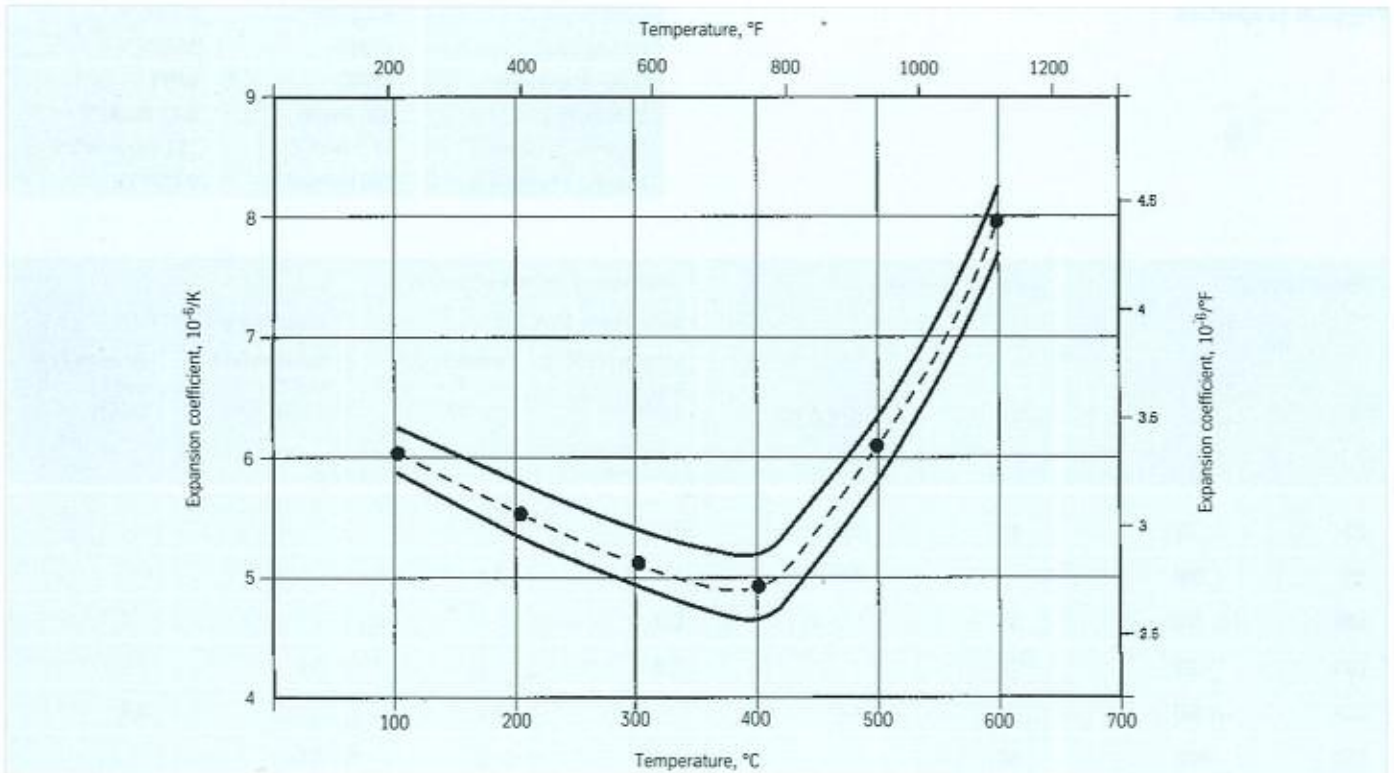


Fig. 1— Typical - - - • - - - and limiting ——— ThyssenKrupp VDM values of thermal expansion coefficient of Pernifer 2918 between RT and T.

Mechanical properties

Temperature		Tensile strength R_m		0.1 % Yield strength $R_p 0.1$		Elongation A_5
°C	°F	N/mm ²	ksi	N/mm ²	ksi	%
93	200		63		38	
100	212	430		260		42
200	392	405		200		
204	400		59		29	
300	572	395		140		45
316	600		57		20	
400	752	350		110		50
427	800		47		16	
500	932	280		100		55
538	1000		35		14	57
600	1112	200		90		60

Table 4 – Typical mechanical properties of Pernifer 2918 at elevated temperatures in the soft-annealed condition.

Alloy and condition	Tensile strength R_m		0.2 % Yield strength $R_{p0.2}$		Elongation A_{50}	Brinell hardness
	N/mm ²	ksi	N/mm ²	ksi	%	HB
Pernifer 2918						
soft annealed	530	77	370	54	30	160
1/4 hard	640	93	590	86	10	200
hard	850	123	840	122	2	60
Pernifer 2918 MS						
soft annealed	520	75	350	51	30	150
1/4 hard	620	90	540	78	10	200

Table 5 – Typical mechanical properties of Pernifer 2918 and 2918 MS at room temperature in various conditions.

Metallurgical structure

Pernifer 2918 has a face-centered cubic structure. Balancing the nickel to cobalt content prevents transformation of gamma phase to alpha phase during cold-working processes or in service at sub-zero temperature down to -80°C (-110°F).

Corrosion resistance

Pernifer 2918 is corrosion resistant in dry atmospheres at room temperature. Under unfavourable conditions, i.e., in humid or moist atmospheres, corrosion can occur in the form of rust.

Applications

Pernifer 2918 was developed for applications requiring low thermal expansion coefficients and good sealing characteristics up to 450°C (840°F).

Typical applications are:

- electronic elements and components to be sealed to hard glasses and ceramics, actuators
- lead wires, lead frames and transistor caps
- X-ray tubes and other hermetic sealing applications

Fabrication and heat treatment

Pernifer 2918 can readily be hot and cold worked, fabricated and machined. Working characteristics are similar to those of austenitic stainless steel.

Heating

Workpieces must be clean and free from all kinds of contaminants before and during any heat treatment.

Pernifer 2918 may become embrittled if heated in the presence of contaminants such as sulfur, phosphorus, lead and other low-

melting-point metals. Sources of such contaminants include marking and temperature-indicating paints and crayons, lubricating grease and fluids, and fuels.

Fuels must be as low in sulfur as possible. Natural gas should contain less than 0.1 wt.-% sulfur. Fuel oils with a sulfur content not exceeding 0.5 wt.-% are suitable.

Due to their close control of temperature and freedom from contamination, thermal treatments in electric furnaces under vacuum or an inert gas atmosphere are to be preferred.

Treatments in an air atmosphere and alternatively in gas-fired furnaces are acceptable though, if contaminants are at low levels so that a neutral or slightly oxidizing furnace atmosphere is attained. A furnace atmosphere fluctuating between oxidizing and reducing must be avoided as well as direct flame impingement on the metal.

Hot working

Pernifer 2918 may be hot worked in the temperature range 1050 to 750°C (1920 to 1380°F), followed by water quenching or rapid air cooling.

For heating up, workpieces may be charged into the furnace at maximum working temperature. When the furnace has returned to temperature, the workpieces should be soaked for 60 minutes per 100 mm (4 in.) of thickness. At the end of this period it should be withdrawn immediately and worked within the above temperature range.

Soft annealing is recommended after hot working to ensure optimum mechanical properties.

Cold working

For cold working the material should be in the soft-annealed condition. Pernifer 2918 has a work-hardening rate similar to austenitic stainless steels. This should be taken into account when selecting forming equipment.

Interstage annealing may be necessary with high degrees of cold forming.

Heat treatment

Soft annealing is carried out in the temperature range 800 to 900°C (1470 to 1650°F) and generally followed by air cooling. Stress-relief annealing may be performed at temperatures up to 360°C (680°F).

Before sealing parts must be annealed at about 900 to 1000°C (1650 to 1830°F) for 10 min. in a wet hydrogen atmosphere. For any thermal treatment the material should be charged into the furnace at maximum annealing temperature observing the precautions concerning cleanliness mentioned earlier under 'Heating'.

Descaling and pickling

Oxides of Pernifer 2918 and discoloration (heat tint) adjacent to welds are more adherent than on stainless steels. Grinding with very fine abrasive belts or discs is recommended. Care should be taken to prevent tarnishing.

Before pickling, which may be performed in a 20% nitric acid solution with proper control of pickling time and temperature, the surface oxide layer should be broken up by abrasive blasting or by carefully performed grinding or by pretreatment in a fused salt bath.

To avoid over-etching of the material it is recommended to first carry out pickling trials using samples.

Machining

Pernifer 2918 should be machined in the soft-annealed condition. As the alloy exhibits a high work-hardening rate, only low cutting speeds should be used compared with low-alloyed standard austenitic stainless steels. Tools should be engaged at all times. An adequate depth of cut is important in order to cut below the previously formed work-hardened zone.

Welding

If Pernifer 2918 has to be welded, consultation with ThyssenKrupp VDM's Welding Laboratory is recommended.

Availability

Pernifer 2918 is available in the following standard product forms:

Sheet and plate

(for cut-to-length availability, refer to strip)

Conditions:

hot or cold rolled (hr, cr),
thermally treated and pickled

Thickness mm		Width ¹⁾ mm	Length ¹⁾ mm
1.10 - < 1.50	cr	2000	8000
1.50 - < 3.00	cr	2500	8000
3.00 - < 7.50	cr/hr	2500	8000
7.50 - ≤ 25.00	hr	2500	8000 ²⁾
>25.00 ¹⁾	hr	2500 ²⁾	8000 ²⁾

inches		inches	inches
0.043 - < 0.060	cr	80	320
0.060 - < 0.120	cr	100	320
0.120 - < 0.300	cr	100	320
0.300 - ≤ 1.000	hr	100	320 ²⁾
>1.000 ¹⁾	hr	100 ²⁾ 320 ²⁾	

¹⁾ other sizes subject to special enquiry.

²⁾ depending on piece weight.

Discs and rings

Conditions:

hot rolled or forged,
thermally treated,
descaled or pickled or machined

Product	Weight kg	Thickness mm	O.D. ¹⁾ mm	I.D. ¹⁾ mm
Disc	≤ 10000	≤ 300	≤ 3000	
Ring	≤ 3000	≤ 200	≤ 2500	on request

	lbs.	inches	inches	inches
Disc	≤ 22000	≤ 12	≤ 120	
Ring	≤ 6600	≤ 8	≤ 100	on request

¹⁾ other sizes subject to special enquiry.

Forgings

Shapes other than discs, rings, rod and bar are subject to special enquiry. Flanges and hollow shafts may be available up to a piece weight of 10 t.

Rod and bar

Conditions:

forged, rolled, drawn,
thermally treated,
descaled or pickled, machined, peeled or ground

Product	Forged ¹⁾ mm	Rolled ¹⁾ mm	Drawn ¹⁾ mm
Rod (o.d.)	≤ 200	8 - 100	12 - 65
Bar, square (a)	40 - 200	15 - 280	not standard
Bar, flat (a x b)	on request	on request	on request
Bar, hexagonal (s)	40 - 80	13 - 41	≤ 50

	inches	inches	inches
Rod (o.d.)	≤ 8	$\frac{3}{16}$ - 4	$\frac{1}{2}$ - 2 $\frac{1}{2}$
Bar, square (a)	1 $\frac{1}{2}$ - 8	$\frac{10}{16}$ - 11	not standard
Bar, flat (a x b)	on request	on request	on request
Bar, hexagonal (s)	1 $\frac{1}{2}$ - 3 $\frac{1}{2}$	$\frac{1}{2}$ - 1 $\frac{1}{4}$	≤ 2

¹⁾ other sizes subject to special enquiry.

Wire

Conditions:

dry or wet drawn, depending on dimension,
 $\frac{1}{2}$ hard to hard,
bright annealed

Dimensions:

0.01 - 12.0 mm (0.0004 - 0.47 in.) diameter,
in coils, pay-off packs, on spools and spiders

Welded tube and pipe

Welded tubes and pipes are obtainable from qualified manufacturers using ThyssenKrupp VDM semi-fabricated products.

Strip¹⁾

Conditions:

cold rolled,

thermally treated and pickled or bright annealed²⁾

Thickness mm	Width mm	Coil I.D. mm		
0.02 - ≤0.10	4 - 200	300	400	
> 0.10 - ≤0.20	4 - 350	300	400	500
> 0.20 - ≤0.25	4 - 750		400	500 600
> 0.25 - ≤0.60	6 - 750		400	500 600
> 0.60 - ≤1.0	8 - 750		400	500 600
> 1.0 - ≤2.0	15 - 750		400	500 600
> 2.0 - ≤3.0 ²⁾ ≤3.5 ²⁾	25 - 750		400	500 600

inches	inches	inches		
0.008 - ≤0.004	0.16 - 8 ³⁾	12	16	
> 0.004 - ≤0.008	0.16 - 14 ³⁾	12	16	20
> 0.008 - ≤0.010	0.16 - 30 ⁴⁾		16	20 24
> 0.010 - ≤0.024	0.20 - 30 ⁴⁾		16	20 24
> 0.024 - ≤0.040	0.32 - 30 ⁴⁾		16	20 24
> 0.040 - ≤0.080	0.60 - 30 ⁴⁾		16	20 24
> 0.080 - ≤0.120 ²⁾ ≤0.140 ²⁾	1.0 - 30 ⁴⁾		16	20 24

¹⁾ Cut-to-length available in lengths from 250 to 4000 mm (10 to 158 in.).

²⁾ Maximum thickness:
bright annealed - 3.0 mm (0.120 in.)
cold rolled only - 3.5 mm (0.140 in.)

³⁾ Wider widths up to 730 mm (29 in.) subject to special enquiry.

⁴⁾ Wider widths subject to special enquiry.

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