

# Nicrofer<sup>®</sup> 4626 MoW – alloy 333

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Nicrofer 4626 MoW, a solid-solution nickel-chromium-iron-alloy with equal additions of molybdenum, cobalt and tungsten, is normally used at temperatures above 800 °C (1470 °F).

Nicrofer 4626 MoW is characterised by:

- very good mechanical properties and creep resistance up to 1200 °C (2200 °F)
- excellent resistance to carburisation, oxidation and sulphidation
- good resistance to stress-corrosion cracking
- good formability and weldability

## Designation and standards

Country	Material designation	Chemical composition	Specification								
			Tube and pipe seamless	Tube and pipe welded	Sheet and plate	Rod and bar	Strip	Wire	Forgings		
<b>National standards</b>											
<b>France</b> AFNOR	NC 26 DW										
<b>Germany</b>  DIN VdTÜV	<b>W.-Nr. 2.4608</b> NiCr26MoW										
<b>United Kingdom</b> BS											
<b>USA</b> ASTM	UNS N06333		B 722	B 723, B 726	B 718	B 719	B 718				
ASME ASME Code Case AMS							5593	5717	5593		5717
ISO	NiCr26Fe20Co3Mo3W3										

## Chemical composition (%)

	Ni	Cr	Fe	C	Mn	Si	Cu	Mo	Co	W	Ti
min	44.0	24.0	bal.	0.03	1.2	0.8		2.5	2.5	2.5	0.1
max	47.0	26.0		0.06	2.0	1.2	0.5	3.5	3.5	3.5	0.2

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## Physical properties

Typical physical properties at room and elevated temperatures.

Density	8.2 g/cm <sup>3</sup>	0,295 lb/in <sup>3</sup>
Melting range	1300–1345 °C	2375–2450 °F
Permeability at 20 °C/68 °F (RT)	1.004	

Temperature T		Specific heat		Thermal conductivity		Electrical resistivity		Modulus of elasticity		Coefficient of thermal expansion between room temperature and T	
°C	°F	J/kg K	Btu/lb °F	W/m K	Btu in/ft <sup>2</sup> h °F	μ Ω cm	Ω circ mil/ft	kN/mm <sup>2</sup>	10 <sup>3</sup> ksi	10 <sup>-6</sup> /K	10 <sup>-6</sup> /°F
0	32										
<b>20</b>	<b>68</b>	441	0.105	11.1	77	114	688	201	29.1		
93	<b>200</b>		0.109		84		699		28.9		7.0
<b>100</b>	212	455		12.2		116		198		12.7	
<b>200</b>	392	469		14.0		119		194		13.9	
204	<b>400</b>		0.112		97		716		28.1		7.8
<b>300</b>	572	480		15.6		121		187		14.7	
316	<b>600</b>		0.115		110		729		27.0		8.2
<b>400</b>	752	487		17.1		123		179		15.0	
427	<b>800</b>		0.117		122		740		25.8		8.4
<b>500</b>	932	494		18.8		124		172		15.4	
538	<b>1000</b>		0.119		135		749		24.6		8.7
<b>600</b>	1112	503		20.6		125		165		16.0	
649	<b>1200</b>		0.122		149		755		23.4		9.1
<b>700</b>	1292	515		22.4		126		157		16.7	
760	<b>1400</b>		0.124		162		760		22.1		9.3
<b>800</b>	1472	524		24.0		126.5		148		16.8	
871	<b>1600</b>		0.127		173		765		20.2		9.5
<b>900</b>	1652	533		25.6		127		135		17.1	
982	<b>1800</b>		0.129		187		769		18.2		9.8
<b>1000</b>	1832	541		27.4		128		123		17.8	
1093	<b>2000</b>		0.131		200		770		16.1		10.3
<b>1100</b>	2012	550		29.0		128.5		110		18.7	

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## Mechanical properties

The following properties are applicable to Nicrofer 4626 MoW in the solution annealed condition and the

indicated size ranges. Specified properties of material outside these size ranges are subject to special enquiry.

Form	Dimensions		Tensile strength		0.2% Yield strength		Elongation A <sub>5</sub>	Brinell hardness (inform.)
	mm	inches	N/mm <sup>2</sup>	ksi	N/mm <sup>2</sup>	ksi		
Sheet, strip	≤ 4.75	≤ 3/16						
Plate	> 4.75 – 50	> 3/16 – 2	550	80	240	35	30	140–210
Rod, bar	up to 50	up to 2						
Tube, pipe	3.2 – 200	1/8 – 8						

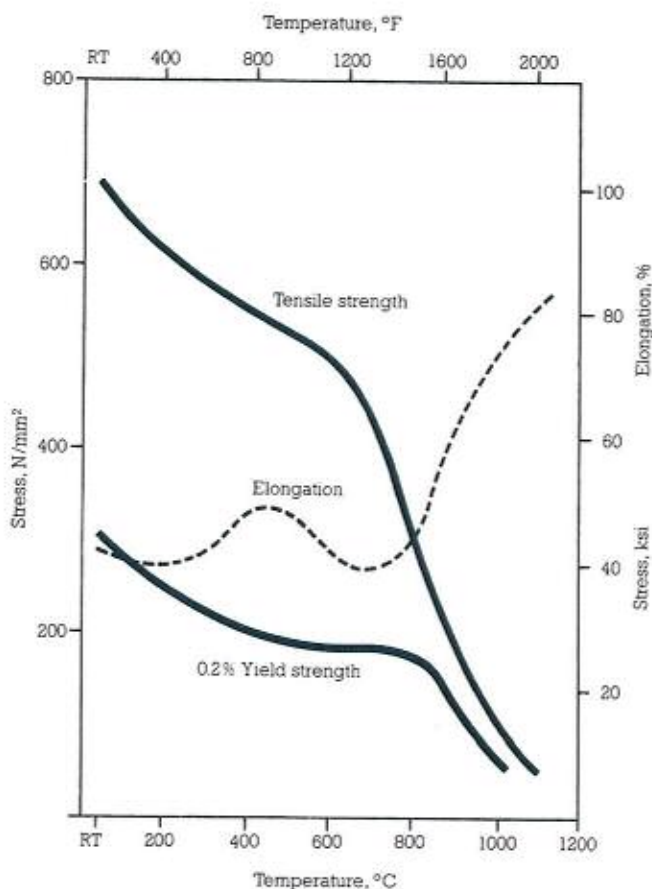
**Table 4** – Minimum mechanical properties at room temperature, according to ASTM.

Temperature		Rupture strength, R <sub>m</sub>				Creep strength, R <sub>p 1.0</sub>			
°C	°F	10 <sup>4</sup> hrs		10 <sup>5</sup> hrs		10 <sup>4</sup> hrs		10 <sup>5</sup> hrs	
		N/mm <sup>2</sup>	ksi	N/mm <sup>2</sup>	ksi	N/mm <sup>2</sup>	ksi	N/mm <sup>2</sup>	ksi
538	<b>1000</b>						15.2		
<b>600</b>	1112	150		110		72		60	
649	<b>1200</b>		15.7		11.9		7.5		5.5
<b>700</b>	1292	80		60		38		25	
760	<b>1400</b>		8.0		6.1		3.6		2.5
<b>800</b>	1472	42		32		19		13	
871	<b>1600</b>		3.3		2.4		1.6		1.1
<b>900</b>	1652	17.5		12		9		6.1	
982	<b>1800</b>		1.16		0.87		0.65		0.44
<b>1000</b>	1832	6.9		4		4.2		2.5	

**Table 5** – Typical creep values of Nicrofer 4626 MoW, solution treated.



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**Fig. 1** – Typical short time mechanical properties at room and elevated temperatures.

## Metallurgical structure

Nicrofer 4626 MoW has a face-centred cubic structure.

## Corrosion resistance

The chromium and silicon contents confer high resistance to oxidation and carburisation. Additions of molybdenum, cobalt and tungsten provide solid-solution strengthening and are responsible for the excellent high-temperature strength and creep resistance.

## Applications

Due to the trends in industry towards higher temperatures and more aggressive environments, Nicrofer 4626 MoW finds wide application.

Typical applications are:

- furnace parts i.e. muffles, fans, support rolls and radiant tubes
- equipment in the chemical and petrochemical industry
- high-temperature components in gas turbines

## Fabrication and heat treatment

Nicrofer 4626 MoW is readily hot or cold formed and machined by common industrial processes. Hot and cold working, however, require high-power machines, owing to the strength of the material.

Weldability of Nicrofer 4626 MoW is excellent. Joining can be performed by conventional welding processes.

## Heating

It is very important that the workpiece be clean and free from any contaminant before and during heating.

Nicrofer 4626 MoW may become embrittled if heated in the presence of contaminants such as sulphur, phosphorus, lead and other low-melting-point metals. Sources of contamination include marking and temperature-indicating paints and crayons, lubricating grease and fluids, and fuels. Fuels must be low in sulphur; e.g. natural and liquefied petroleum gases should contain less than 0.1% by mass and town gas 0.25 g/m<sup>3</sup> maximum of sulphur. Fuel oils containing no more than 0.5% by mass of sulphur are satisfactory.

Electric furnaces are desirable due to their close control of temperature and freedom from contamination. Gas-fired furnaces are acceptable if impurities are at low levels.

The furnace atmosphere should be neutral to slightly oxidising and must not fluctuate between oxidising and reducing. Flame impingement on the metal must be avoided.

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## Hot working

Nicrofer 4626 MoW may be hot-worked in the range 1180 to 950 °C (2160 to 1740 °F). Cooling after working should be by water quenching or as fast as possible.

For hot working, the material may be charged into the furnace at maximum working temperature.

When the furnace has returned to temperature, the material should be soaked for 60 minutes per 100 mm (4 in) of thickness. After soaking for the required time the metal should be withdrawn immediately and worked within the specified range. If the metal temperature falls below the minimum working temperature, it must be reheated.

Solution treatment is recommended after hot working to ensure optimum properties.

## Cold working

Cold working should be carried out on solution-treated material. Nicrofer 4626 MoW has a much higher work-hardening rate than austenitic stainless steel and the forming equipment must be adapted accordingly.

When cold working is performed, interstage annealing may be necessary.

After cold reduction of more than 15%, final solution treatment is required.

## Heat treatment

Solution treatment should be carried out in the temperature range 1150 to 1180 °C (2100 to 2160 °F), preferably at about 1165 °C (2130 °F). Water quenching or rapid air cooling is recommended for thicknesses above about 1.5 mm (0.06 in) and is essential for maximum creep resistance. For resistance to wet corrosion, a stabilising anneal may be performed at 950 °C (1740 °F).

During any heating operation the precautions outlined earlier regarding cleanliness must be observed.

## Descaling

Oxides of Nicrofer 4626 MoW and discoloration adjacent to welds, are more adherent than on stainless steels. Grinding with very fine abrasive belts or discs is recommended.

Before pickling in a nitric/hydrofluoric acid mixture, oxides must be broken up by grit-blasting or by pretreatment in a fused salt bath.

## Machining

Nicrofer 4626 MoW should be machined in the solution-treated condition. The alloy's high work-hardening rate should be considered; i.e. only low surface cutting speeds are possible compared with low-alloy standard austenitic stainless steel. Tools should be engaged at all times. Heavy feeds are important in getting below the work-hardened 'skin'.

## Joining

Nicrofer 4626 MoW can be welded by conventional processes, including gas tungsten-arc (GTAW/TIG) and gas metal-arc (GMAW/MIG). Pulsed arc welding is the preferred technique.

Prior to welding, material should be in the solution-treated condition, clean and free from scale, grease, marking paints etc. A zone approximately 25 mm (1 in) wide on each side of the joint should be ground to bright metal.

Low heat input is necessary. Interpass temperature should not exceed 120 °C (250 °F).

Neither pre- nor post-weld heat treatment is required.

The following welding products are recommended:

GTAW/GMAW	Nicrofer S 4626	W.-Nr. 2.4608 NiCr26MoW
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## Availability

Nicrofer 4626 MoW is available in the following standard mill product forms.

### Sheet and plate

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

Conditions:

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

Thickness mm			Width* mm	Length* mm
1.10	< 1.50	cr	2000	6000
≥ 1.50	< 6.0	cr	2400	8000
≥ 6.0	< 10.0	cr	2400	8000
≥ 6.0	< 10.0	hr	2400	8000
≥ 10.0	< 20.0	hr	2400	5000**
≥ 20*		hr		

inches			inches	inches
0.047	< 0.060	cr	80	240
≥ 0.060	< 1/4	cr	96	320
≥ 1/4	< 3/8	cr	96	320
≥ 1/4	< 3/8	hr	96	320
≥ 3/8	< 3/4	hr	96	200**
≥ 3/4*		hr		

\* other sizes subject to special enquiry

\*\* depending on piece weight

## Discs and rings

Conditions:

hot rolled or forged,  
solution treated,  
pickled or machined

Product	Weight kg	Thickness mm	OD* mm	ID mm
Disc	≤ 4000	≤ 200	≤ 2000	-
Ring	≤ 3000	≤ 200	≤ 2500	on request

	lb	inches	inches	inches
Disc	≤ 8800	≤ 8	≤ 80	-
Ring	≤ 6600	≤ 8	≤ 100	on request

\* other sizes subject to special enquiry

## Rod and bar

Conditions:

forged, rolled, drawn,  
solution treated,  
pickled, machined, peeled or ground

Product		forged* mm	rolled* mm	drawn* mm
round	d	≤ 300	15- 75	12- 65
square	a	40- 250	15- 100	12- 65
flat		40- 80	5- 20	10- 20
a x b		x 200- 600	x 120- 600	x 30- 80
hexagon	s	40- 80	13- 50	12- 60

		inches	inches	inches
round	d	≤ 12	5/8 - 3	1/2 - 2 1/2
square	a	1 5/8 - 12	5/8 - 4	1/2 - 2 1/2
flat		1 5/8 - 3 1/8	3/16 - 3/4	3/8 - 3/4
a x b		x 8 - 24	x 5 - 24	x 1 1/4 - 3 1/8
hexagon	s	1 5/8 - 3 1/8	1/2 - 2	1/2 - 2 3/8

\* other sizes subject to special enquiry

## Forgings

Shapes other than discs, rings, rod and bar are subject to special enquiry.

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## Strip\*

Conditions:  
cold rolled,  
solution treated and pickled or bright annealed\*\*

Thickness mm	Width mm	Coil I D mm		
0.04 ≤ 0.10	30–120	100	300	
> 0.10 ≤ 0.20	4–200		300	400
> 0.20 ≤ 0.25	4–400		300	400
> 0.25 ≤ 0.60	5–635		300	400
> 0.60 ≤ 1.0	8–635		400	500
> 1.0 ≤ 2.0	15–635		400	500 600
> 2.0 – 3.0	25–635		400	500 600

inches	inches	inches		
0.0016 ≤ 0.004	1.20– 5	4	12	
> 0.004 ≤ 0.008	0.16– 8		12	16
> 0.008 ≤ 0.010	0.16–16		12	16
> 0.010 ≤ 0.024	0.20–25		12	16
> 0.024 ≤ 0.04	0.32–25		16	20
> 0.04 ≤ 0.08	0.60–25		16	20 24
> 0.08 – 0.12	1.0 –25		16	20 24

\* cut-to-length available in lengths from 500 to 3000 mm (20 to 120 in)  
\*\* maximum thickness 3.0 mm (1/8 in)

## Wire

Conditions:  
bright drawn, 1/4 hard to hard  
bright annealed

Dimensions:  
0.01 – 12.7 mm (0.0004 – 1/2 in) diameter  
in coils, pay-off packs, on spools and spiders.

## Welding filler metals

Suitable welding rods and wire are available in standard sizes.

## Seamless tube and pipe

Conditions:  
cold rolled, cold drawn,  
bright annealed or solution treated and pickled

Outside diameter	12 – 133 mm	1/2 – 5 1/4 in.
Wall thickness	0.5– 20 mm	0.02 – 0.80 in.
Length	max 26 m*	85 ft*

\* depending on tube size

Conditions:  
hot extruded or  
solution treated and pickled

Outside diameter	114 – 219 mm	4 1/2 – 8 5/8 in.
Wall thickness	5 – 40 mm	0.20 – 1 5/8 in.
Length	max 17.5 m*	57 ft*

\* depending on tube size

## Seam-welded tube and pipe (from strip)

Conditions:  
as seam-welded or  
solution treated and pickled or bright annealed

Outside diameter	12 – 114 mm	1/2 – 4 1/2 in.
Wall thickness	0.5– 4.0 mm	0.02 – 0.16 in.
Length	max 26 m*	85 ft*

\* depending on condition

## Seam-welded tube and pipe (from sheet and plate)

Conditions:  
as seam-welded or  
solution treated and pickled

Outside diameter	114 – 1500 mm	4 1/2 – 60 in.
Wall thickness	3 – 15 mm	1/8 – 5/8 in.
Length	max 6 m	20 ft

We reserve the right to make alterations, especially where necessitated by technical developments or changes in availability.

The information contained in this data sheet, which in any case provides no guarantee of particular characteristics, has been compiled to the best of our knowledge but is given without any obligation on our part.

Our liability is determined solely by the individual contract terms, in particular by our general conditions of sale.

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Please ask for the latest edition of this data sheet.

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