

Nicrofer® 4823 hMo – alloy G-3

Material Data Sheet No. 4013

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High-temperature alloy

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Nicrofer® 4823 hMo – alloy G-3

Nicrofer 4823 hMo is a stabilized austenitic nickel-chromium-iron alloy of high molybdenum content and with an addition of copper.

Nicrofer 4823 hMo is characterized by:

- very good resistance to a wide range of corrosive media under both oxidising and reducing conditions
- excellent resistance to crevice and pitting corrosion and to stress corrosion cracking

Designations and standards

Country	Material designation	Specification							
		Chemical composition	Tube and pipe		Sheet and plate	Rod and bar	Strip	Wire	Forgings
seamless	welded								
D DIN VdTÜV	W.-Nr. 2.4619 NiCr22Mo7Cu	17744	17751		17750	17752	17750		
F AFNOR									
UK BS									
USA ASTM ASME ASME Code Case AMS	UNS N06985		B 622 SB 622	B 619/626 SB 619/626	B 582 SB 582	B 581 SB 581	B 582 SB 582		
ISO	NiCr22Fe20Mo7Cu2	9722	6207		6208	9723	6208	9724	9725

Table 1 – Designations and standards.

Chemical composition

	Ni	Cr	Fe	C	Mn	Si	Cu	Mo	Co	Nb	W
min.	bal.	21.5	18.0				1.5	6.0		0.2	
max.		23.5	21.0	0.015	1.0	1.0	2.5	8.0	5.0	0.5	1.5

Table 2 – Chemical composition (wt.-%).

Physical properties

Density	8.3 g/cm ³	0.30 lb/in. ³
Melting range	1260 – 1340 °C	2300 – 2450 °F
Permeability at 20 °C / 68 °F (RT)	< 1.01	

Temperature (T)		Specific heat		Thermal conductivity		Electrical resistivity		Modulus of elasticity		Coefficient of thermal expansion between room temperature and T	
°C	°F	$\frac{\text{J}}{\text{kg K}}$	$\frac{\text{Btu}}{\text{lb } ^\circ\text{F}}$	$\frac{\text{W}}{\text{m K}}$	$\frac{\text{Btu in.}}{\text{ft}^2 \text{ h } ^\circ\text{F}}$	$\mu \Omega \text{ cm}$	$\frac{\Omega \text{ circ mil}}{\text{ft}}$	$\frac{\text{kN}}{\text{mm}^2}$	10 ³ ksi	$\frac{10^{-6}}{\text{K}}$	$\frac{10^{-6}}{^\circ\text{F}}$
0	32										
20	68	441	0.105	11.1	77	115	692	211	30.6		
93	200		0.108		86		700		29.9		7.9
100	212	452		12.6		117		205		14.3	
200	392	462		14.3		119		199		14.7	
204	400		0.110		99		716		28.9		8.2
300	572	471		16.0		121		192		15.0	
316	600		0.113		113		730		27.7		8.4
400	752	479		17.7		123		186		15.3	
427	800		0.115		126		744		26.7		8.6
500	932	487		19.3		125		180		15.7	
538	1000		0.117		137		754		25.7		8.8
600	1112	495		21.0		126		173		16.1	
649	1200		0.119		151		758		24.7		9.0
700	1292	503		22.6		127		167		16.5	

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

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Mechanical properties

The following properties are applicable to Nicrofer 4823 hMo in the solution treated condition and indicated size ranges. Specified properties of material outside these size ranges are subject to special enquiry.

Form	Dimensions		Tensile strength		0.2 % Yield strength		1.0 % Yield strength		Elongation A ₅ %	Brinell hardness HB
	mm	inches	N/mm ²	ksi	N/mm ²	ksi	N/mm ²	ksi		
Sheet, strip	0.5 - 20.0	0.02 - 3/4	620	90	240	35	260	38	45	240
Plate	> 20.0 - 65	3/4 - 2 1/4	590	85	210	30	230	33	35	
Tube, pipe	0.6 - 5	0.025 - 3/16	620	90	240	35	260	38	35	
Rod, bar	≤ 20	≤ 3/4	620	90	240	35	260	38	45	
	> 20 - 90	> 3/4 - 3 1/2	585	85	205	30	225	33	35	

Table 4 – Minimum mechanical properties at room temperature.

Form	0.2 % Yield strength N/mm ² at... °C						1.0 % Yield strength N/mm ² at...°C					
	100	200	300	400	500	600	100	200	300	400	500	600
	270	230	210	190	180	170	290	260	240	220	210	200
Form	ksi at... °F					ksi at... °F						
	200	400	600	800	1000	200	400	600	800	1000		
	39	33	30	27	25	42	38	34	31	30		

Table 5 – Typical mechanical properties at elevated temperatures.

Metallurgical structure

Nicrofer 4823 hMo has a face-centred cubic structure.

Corrosion resistance

Nicrofer 4823 hMo is highly resistant to corrosion in acids and alkalis under both oxidising and reducing conditions. It exhibits very good resistance to mixed inorganic and organic acids, fluosilicic acid, contaminated nitric, sulphuric and phosphoric acid, hydrofluoric acid and flue gases below dew point.

The high molybdenum content ensures excellent resistance to crevice and pitting corrosion.

Nicrofer 4823 hMo is virtually immune to chloride-induced stress corrosion cracking.

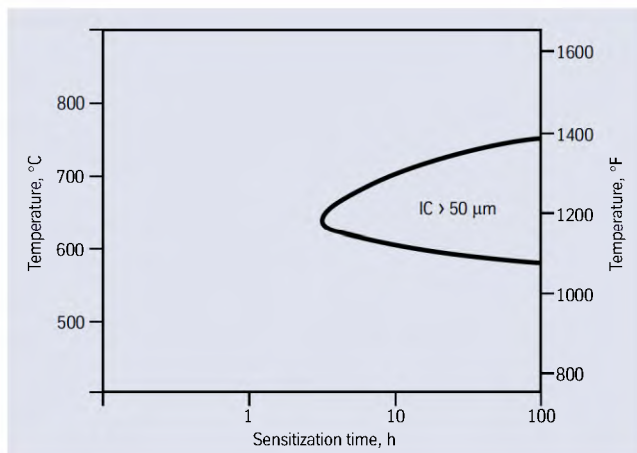


Fig. 1 – Time-temperature-sensitization (TTS) diagram for Nicrofer 4823 hMo, according to ASTM G-28 A (24 h).

Applications

Nicrofer 4823 hMo finds wide application in the chemical and petrochemical industry for components handling sulphuric and phosphoric acids at ambient and higher temperatures.

Typical applications are:

- Vessels and equipment for the dissolution of waste nuclear fuel elements
- components for flue gas desulphurization systems
- equipment and components in sour gas service
- equipment for acetic acid manufacture

Fabrication and heat treatment

Nicrofer 4823 hMo is readily fabricated by usual industrial procedures. Hot and cold working, however, require high-power machines, owing to the high strength of the material.

The weldability of Nicrofer 4823 hMo is excellent. Joining can be performed by all conventional welding processes.

Heating

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

Nicrofer 4823 hMo 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 as low in sulphur; e.g. natural and liquefied petroleum gases should contain less than 0.1 % by mass, and town gas 0.25 g/m³ 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.

Hot working

Nicrofer 4823 hMo may be hot-worked in the range 1150 to 900 °C (2100 to 1650 °F). Cooling should be by water quenching or as fast as possible.

Solution treatment is required after hot working to ensure maximum corrosion resistance and optimum properties.

The material may be charged into the furnace at maximum working temperature. 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.

Cold working

Cold working should be carried out on solution-treated material. Nicrofer 4823 hMo has a much higher work-hardening rate than austenitic stainless steel and the forming equipment must be adapted accordingly.

When heavy cold working is performed, interstage annealing may become necessary.

After cold reductions of more than 15 %, final annealing is required before use.

Heat treatment

Solution treatment should be carried out in the temperature range 1100 to 1150 °C (2010 to 2100 °F).

Water quenching after heating is essential for maximum corrosion resistance.

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

Descaling

Oxides of Nicrofer 4823 hMo are more adherent than those of stainless steel. Both mechanical and chemical methods of descaling may be applied. Mechanical methods should be avoided which produce either contamination of the metal, or a highly-deformed surface layer.

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 4823 hMo 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 steels. Tools should be engaged at all times. Heavy feeds are important in getting below the workhardened 'skin'.

Joining

Nicrofer 4823 hMo can be welded by all conventional processes, including gas tungsten-arc (GTAW/TIG), gas metal-arc (GMAW/MIG) and shielded metal-arc welding (SMAW/MMA). 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 150 °C (300 °F).

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

The following welding products are recommended :

GTAW/GMAW	Nicrofer S 6020	W.-Nr. 2.4831 SG-NiCr21Mo9Nb AWS A 5.14 ERNiCrMo-3
		or
	Nicrofer S 5923	W.-Nr. 2.4607 SG-NiCr23Mo16 AWS A 5.14 ERNiCrMo-12
SMAW		W.-Nr. 2.4621 EL-NiCr20Mo9Nb AWS A 5.11 ENiCrMo-3
		or
		W.-Nr. 2.4609 EL-NiCr22Mo16

For optimum properties of the weld GTAW is preferred.

Technical publications

The following publication concerning Nicrofer 4823 hMo may be obtained from ThyssenKrupp VDM GmbH:

„Das Zeit-Temperatur-Ausscheidungs- und das Zeit-Temperatur-Sensibilisierungs-Verhalten von hochkorrosionsbeständigen Nickel-Chrom-Molybdän-Legierungen“
U. Heubner, M. Köhler, WuK. 43, S.181-190 (1992)

Availability

Nicrofer 4823 hMo is available in all 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	hr / cr	Width ¹⁾ mm	Length ¹⁾ mm
1.10 < 1.5	cr	2000	6000
≥ 1.50 < 6.0	cr	2500	8000
≥ 6.0 < 10.0	cr	2500	8000
≥ 6.0 < 10.0	hr	2500	8000
≥ 10.0 < 20.0	hr	3000	8000
≥ 20 ¹⁾	hr		

inches		inches	inches
0.043 < 0.060	cr	80	240
≥ 0.060 < 1/4	cr	100	320
≥ 1/4 < 3/8	cr	100	320
≥ 1/4 < 3/8	hr	100	320
≥ 3/8 < 3/4	hr	120	320
≥ 3/4 ¹⁾	hr		

¹⁾ other sizes subject to special enquiry

Discs and rings

Conditions:

hot rolled or forged,
solution treated,
pickled or machined

Product	Weight kg	Thickness mm	o. d. ¹⁾ mm	i. d. mm
Disc	≤ 10000	≤ 300	≤ 3000	
Ring	≤ 3000	≤ 200	≤ 2500	on request

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

¹⁾ other sizes subject to special enquiry

Rod and bar

Conditions:

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

Product		forged ¹⁾ mm	rolled ¹⁾ mm	drawn ¹⁾ mm
round	d	≤ 300	8 – 75	12 – 76
square	a	40 – 300	15 – 100	12 – 65
flat		40 – 80	5 – 20	10 – 20
	x		x	x
a x b		200 – 600	120 – 600	30 – 80
hexagon	s	25 – 80	13 – 50	12 – 60

		inches	inches	inches
round	d	≤ 12	0.32 – 3	1/2 – 3
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
	x		x	x
a x b		8 – 24	5 – 24	1 1/4 – 3 1/8
hexagon	s	1 – 3 1/8	1/2 – 2	1/2 – 2 3/8

¹⁾ other sizes subject to special enquiry**Forgings**

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

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

Strip¹⁾

Conditions:

cold rolled, solution treated
and pickled
or bright annealed²⁾

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

¹⁾ Cut-to-length available in lengths from 500 to 3000 mm (20 to 120 in.)²⁾ Maximum thickness 3.0 mm (1/8 in.)**Seamless tube and pipe**

Using ThyssenKrupp VDM cast materials seamless tubes and pipes are produced and available from DMV STAINLESS SAS, Tour Neptune, F-92086 Paris, La Défense Cedex (Fax: +33-1-4796 8141; Tel.: +33-1-4796 8140; E-mail: dmv-hq@dmv-stainless.com).

Welded tube and pipe

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

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