Nicrofer® 6023 H – alloy 601 H

Material Data Sheet No. 4003
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High-temperature alloy

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Nicrofer® 6023 H – alloy 601 H

Nicrofer 6023 H is a solid solution strengthened nickel-chromium-iron alloy with additions of aluminium and titanium.

It is characterized by:

- outstanding resistance to oxidation at high temperatures
- good resistance to carburizing conditions
- good mechanical properties at both room and elevated temperatures
- good resistance to stress-corrosion cracking

Nicrofer 6023 H is specifically recommended for service above 550 °C (1022 °F) because of higher creep-rupture properties, resulting from controlled carbon content and coarse grain size.

Designations and standards

Country / National standards	Material designation	Specification: Chemical composition	Tube and pipe: seamless	Tube and pipe: welded	Sheet and plate	Rod and bar	Strip	Wire	Forgings
D	**W.-Nr. 2.4851** NiCr23Fe								
DIN EN		10095			10095	10095	10095	10095	
DIN		17742	17751		17750	17752	17750	17753	
F AFNOR	NiC23FeA								
UK BS									
USA	UNS N06601								
ASTM			B 163,B 167, B 829		B 168	B 166	B 168	B 166	
ASME			SB-163,SB-167 SB-829		SB-168	SB-166	SB-168	SB-166	
ASME Code Case			1500	1500	1500	1500	1500		1500
AMS					5870	5715*	5870		5715
ISO	NiCr23Fe15Al	9722	6207		6208	9723	6208	9724	9725

* Bars only

Table 1 – Designations and standards.

Chemical composition

		Ni	Cr	Fe	C	Mn	Si	Cu	Al	Ti*	P*	S
	min.	58.0	21.0	bal.					1.0	0.3		
	max.	63.0	25.0		0.10	1.5	0.5	1.0	1.7	0.5	0.020	0.015

Some compositional limits of other specifications may vary slightly.

*Table 2 – Chemical composition (wt.-%) according to ASTM (*not specified in ASTM).*

Physical properties

Density	8.1 g/cm³	0.293 lb/in.³
Melting range	1320 – 1370 °C	2410 – 2500 °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	J/(kg K)	Btu/(lb °F)	W/(m K)	Btu in./(ft² h °F)	μ Ω cm	Ω circ mil/ft	kN/mm²	10³ ksi	10⁻⁶/K	10⁻⁶/°F
20	**68**	450	0.107	11.3	78	119	716	207	30.0		
93	**200**		0.112		87		722		29.3		7.6
100	212	470		12.7		120		201		13.8	
200	392	500		14.4		122		196		14.4	
204	**400**		0.119		100		737		28.4		8.0
300	572	525		16.0		124		191		14.6	
316	**600**		0.126		112		749		27.6		8.1
400	752	550		17.6		125		186		14.8	
427	**800**		0.133		126		752		26.7		8.3
500	932	580		19.2		125		180		15.3	
538	**1000**		0.141		139		755		25.4		8.5
600	1112	600		20.6		126		171		15.7	
649	**1200**		0.148		148		758		24.1		8.9
700	1292	630		22.2		126		161		16.3	
760	**1400**		0.155		165		761		22.5		9.1
800	1472	660		24.5		127		150		16.7	
871	**1600**		0.162		178		767		20.6		9.5
900	1652	690		26.1		128		138		17.2	
982	**1800**		0.169		190		775		18.4		9.8
1000	1832	710		27.7		129		124		17.7	
1093	**2000**		0.176		203		782		16.1		10.1
1100	2012	740		29.3		130		110		18.3	

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

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Mechanical properties
The following properties are applicable to Nicrofer 6023 H in the indicated product forms in the solution-annealed condition.

Product	Tensile strength R_m N/mm²	ksi	0.2% Yield strength $R_{p\,0.2}$ N/mm²	ksi	Elongation A_{50} %	Brinell hardness HB
Sheet & plate Strip Rod & Bar	550	80	205	30	30	≤ 220

Table 4 – Minimum mechanical properties at room temperature according to ASTM B 166 and B 168.

Short-time mechanical properties of solution annealed Nicrofer 6023 H at elevated temperatures are represented graphically in Fig. 1 and listed in Table 5.

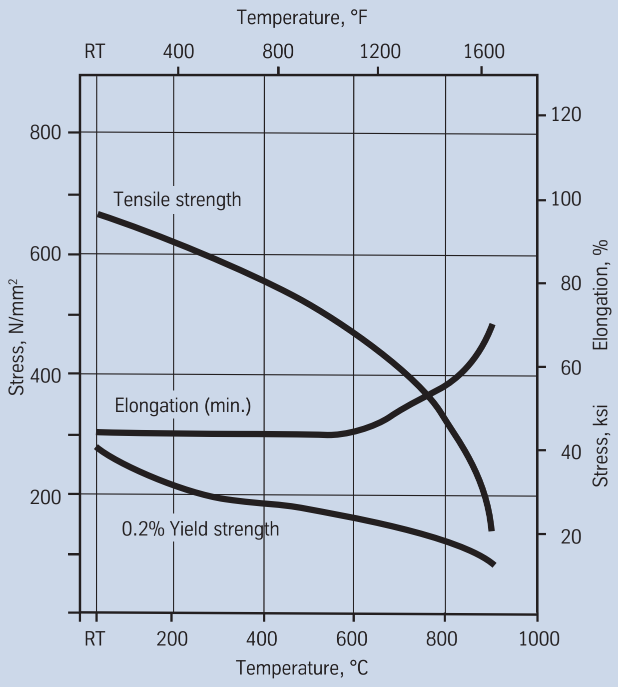

Fig. 1 – Typical short-time properties of solution annealed Nicrofer 6023 H at elevated temperatures.

Temperature °C	°F	Tensile strength R_m N/mm²	ksi	0.2 % Yield strength $R_{p\,0.2}$ N/mm²	ksi	Elongation* A_{50} %
20	68	min. 600	87.0	min. 240	34.8	min. 30
38	**100**		(95.0)		(38.0)	
100	212	650	94.3	260	37.7	45
149	**300**		(92.0)		(35.5)	
200	392	620	89.9	230	33.3	45
260	**500**		(87.2)		(30.7)	
300	572	590	85.6	200	29.0	45
400	752	560	81.2	180	26.1	45
482	**900**		(76.1)		(25.5)	
500	932	520	75.4	175	25.4	45
600	1112	480	69.6	170	24.7	45
649	**1200**		(64.9)		(23.2)	
700	1292	410	59.5	150	21.7	50
760	**1400**		(51.4)		(18.6)	
800	1472	320	46.4	120	17.4	55
900	1652	140	20.3	95	13.8	65

(...) = interpolated values * Elongation values are minimum

Table 5 – Typical short-time properties of solution annealed Nicrofer 6023 H at elevated temperatures.

Long-term mechanical properties of solution annealed Nicrofer 6023 H are listed in Tables 6a and 6b respectively.

Temper-ature °C	°F	Stress to produce 1% creep $R_{p\ 1.0/10^4\ h}$ N/mm²	ksi	$R_{p\ 1.0/10^5\ h}$ N/mm²	ksi
600	1112	151		116	
649	**1200**	111	16.0	70	10.1
700	1292	69		39	
760	**1400**		5.1		2.9
800	1472	22		11.8	
871	**1600**		1.45		0.61
900	1652	6.9		2.2	

Table 6a – Stress to produce 1% creep in solution annealed Nicrofer 6023 H.

Temper-ature °C	°F	Creep-rupture strength $R_{m\ /10^4\ h}$ N/mm²	ksi	$R_{m/10^5\ h}$ N/mm²	ksi
600	1112	205	29.7	156	22.6
649	**1200**	150	21.8	102	14.5
700	1292	101	14.7	55	8.0
760	**1400**		7.5		3.9
800	1472	31	4.5	17	2.5
871	**1600**		2.1		1.1
900	1652	10	1.45	3.7	0.54
1000	1832	5	0.73	2	0.29

Table 6b – Creep-rupture strength of solution annealed Nicrofer 6023 H according to DIN EN 10095.

For metal temperature not exceeding °C	°F	Maximum allowable stress values ksi
38	100	20.0 (20.0) (Note 1)
93	200	17.8 (20.0) (Note 1)
149	300	16.6 (20.0) (Note 1)
294	400	15.5 (20.0) (Note 1)
260	500	14.7 (19.9) (Note 1)
316	600	14.2 (19.2) (Note 1)
343	650	14.0 (19.0) (Note 1)
371	700	13.9 (18.8) (Note 1)
399	750	13.8 (18.7) (Note 1)
427	800	13.8 (18.6) (Note 1)
454	850	13.8 (18.6) (Note 1)
482	900	13.8 (18.6) (Note 1)
510	950	13.7 (18.6) (Note 1)
538	1000	13.7 (17.6*) (Note 1)
566	1050	13.6*
593	1100	10.4* (Note 2)
621	1150	8.0* (Note 2)
649	1200	6.1* (Note 2)
677	1250	4.6* (Note 2)
704	1300	3.6* (Note 2)
732	1350	2.8* (Note 2)
760	1400	2.1* (Note 2)
788	1450	1.7* (Note 2)
816	1500	1.3* (Note 2)
843	1550	1.1* (Notes 2,3)
871	1600	0.87* (Notes 2,3)
899	1650	0.71* (Notes 2,3)

*Values from time-dependent variables
Notes:
(1) Due to the relatively low yield strength of this material, the higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of this alloy where slightly greater deformation is acceptable. The higher stress values exceed 66 2/3 %, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. The higher stress values are not recommended for flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
(2) For a design temperature above 1100 ° F (593 °C). filler metals shall be limited to Nicrofer S 5520-FM 617, UNS N06617 (AWS A5.14, ERNiCrCoMo-1) or UNS W86117 (AWS A5.11, ENiCrCoMo-1).
(3) Creep fatigue, thermal ratcheting, and environmental effects are increasingly significant failure modes at temperatures in excess of 1500 °F (816 °C) and shall be considered in the design.

Table 7 – Maximum allowable stress values of Nicrofer 6023 H in the solution-annealed condition according to ASME Code Case 1500 for use in welded construction under ASME Section I for superheater service only and under section VIII, Division I.

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For alloys which are predominantly solid solution hardened, there is a clear correlation between the weighted sum of solid solution hardening elements and the creep-rupture strength. Higher contents of the elements Cr, Co, Mo and W produce an increase in the creep-rupture strength, whereas silicon has a markedly detrimental effect on creep-rupture strength. The usefullness of solid solution hardened alloys strictly only with respect to creep-rupture strength (i.e., disregarding environmental factors) can thus be classified as shown in Table 8 using their 10,000 h creep-rupture strength at 800 °C (1472 °F) as a criterion.

ThyssenKrupp VDM trademark	Alloy designation	UNS No.	Weighted content of solid solution hardenlng elements 1x (Cr + Co) + 2x (Mo + W)- 5x (Si)	$R_{m/10,000h/800\,°C}$ N/mm[2]
Nicrofer 45 TM	45 TM	N06045	14.5	19
Nicrofer 7216 H	600 H	N06600	16	29
Nicrofer 6023 H	601 H	N06601	23	31
Nicrofer 4626 MoW	333	N06333	32	42
Nicrofer 4722 Co	X	N06002	41	59
Nicrofer 5520 Co	617	N06617	51	65

Table 8 – Influence of solid solution hardening elements on the creep-rupture strength $R_{m/10,000\,h}$ at 800 °C (1472 °F) of nickel alloys.

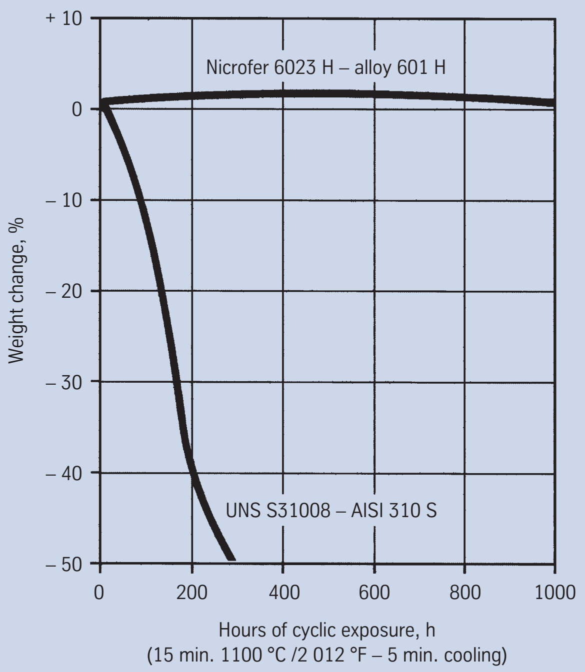

Fig. 2 – Scaling resistance of Nicrofer 6023 H compared to AISI 310 S.

Relaxation cracking susceptibility
Nicrofer 6023 H may be susceptible to relaxation cracking if new solution-annealed material welded with ERNiCr-3 (UNS N06082), a practice which should be avoided, is exposed to service temperatures within the range of 575 – 625 °C (1067 – 1157 °F). Susceptibility to relaxation cracking during subsequent service within that temperature range may also be encountered with material which had already been exposed to that critical temperature range. A stabilizing heat treatment at 980 °C (1800 °F) for 3 hrs alleviates susceptibility to relaxation cracking.

Metallurgical structure
Nicrofer 6023 H has a face-centered cubic structure.

Corrosion resistance
According to DIN EN 10095 Nicrofer 6023 H is termed a heat-resistant alloy on account of its excellent resistance above 550 °C (1022 °F) against hot gases and combustion products, as well as against molten salt and molten metal corrosion, while at the same time exhibiting good mechanical short-time and long-term properties. Even under severe conditions, such as under cyclic heating and cooling, Nicrofer 6023 H retains a tightly adherent oxide layer which is very resistant to spalling.

Resistance to carburization is good. Nicrofer 6023 H has also shown good resistance in carbonitriding conditions, if a sufficiently high oxygen partial pressure is present.

Applications
Nicrofer 6023 H has found a wide variety of applications in industries as diverse as thermal and chemical processing, pollution control and power generation.

Typical applications are:

- trays, baskets and fixtures for heat treatment plant
- refractory anchors, strand-annealing and radiant heater tubes, high-velocity gas burners, wire mesh belts in industrial furnaces
- insulating cans in ammonia reformers and catalyst support grids in nitric acid production
- components in exhaust gas systems
- combustion chambers in solid waste incinerators
- tube supports and ash-handling components
- components of waste-gas detoxification systems
- oxygen preheaters

Fabrication and heat treatment
Nicrofer 6023 H can readily be hot- and cold worked and machined.

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

The quality of Nicrofer 6023 H may be impaired if heated in the presence of contaminants such as sulfur, phosphorus, lead and other low-melting-point metals. Sources of such contaminants also include marking and temperature-indicating paints and crayons, lubricating grease, 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
Nicrofer 6023 H may be hot worked in the temperature range 1200 to 900 °C (2190 to 1650 °F), followed by water quenching or rapid air cooling.

Heat treatment after hot working is recommended in order to achieve optimum properties. For heating up, workpieces should be charged into the furnace at maximum working temperature.

Cold working
For cold working the material should be in the solution-annealed condition. Nicrofer 6023 H has a higher work-hardening rate than austenitic stainless steels. This should be taken into account when selecting forming equipment.

Interstage annealing may be necessary with high degrees of cold forming. After cold working with more than 10% deformation solution annealing is required before use.

Oxidized sheet and plate can also be bent and cold worked. The inside bending diameter should be at least three times the sheet/plate thickness.

Heat treatment
Solution heat treatment should be carried out in the temperature range 1100 to 1200 °C (2010 to 2190 °F).

Water quenching is essential for maximum creep resistance and for minimizing carbide precipitation in the temperature range 500 to 800 °C (930 to 1470 °F). Below about 3 mm (0.120 in.) thickness, rapid air cooling is practicable.

As with some other high-temperature, high-strength nickel alloys, Nicrofer 6023 H already exposed to service temperatures within the range 575 – 625 °C (1067 – 1157 °F) or new material exposed within that temperature range, if welded with ERNiCr-3 (UNS N06082), a practice which should be avoided, may suffer stress relaxation cracking. In such cases, stabilization annealing at 980 °C (1800 °F) for 3 hrs is recommended to relieve stresses and deliberately influence precipitation processes prior to placing or returning material into service under such temperature conditions.

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
High-temperature alloys develop a protective oxide layer in service. Pre-oxidation in air can produce increased corrosion resistance. Therefore on the basis of the end use the necessity of descaling should be checked.

Oxides of Nicrofer 6023 H and discoloration 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 in a nitric/hydrofluoric acid mixture, the surface oxide layer must be broken up by abrasive blasting or grinding or by pretreatment in a fused salt bath. Particular attention should be paid to the pickling time and temperature.

Machining
Nicrofer 6023 H should preferably be machined in the heat-treated condition. As the alloy is prone to work-hardening, a low cutting speed should be used and the tool 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
When welding nickel alloys, the following instructions should be adhered to:

Workplace
The workplace should be in a separate location, well away from areas where carbon steel fabrication takes place. Maximum cleanliness and avoidance of draughts are paramount.

Auxiliaries, clothing
Clean fine leather gloves and clean working clothes should be used.

Tools and machines
Tools used for nickel alloys and stainless steels must not be used for other materials. Brushes should be made of stainless materials.

Fabricating and working machinery such as shears, presses or rollers should be fitted with means (felt, cardboard, plastic sheeting) of avoiding contamination of the metal with ferrous particles, which can be pressed into the surface and thus lead to corrosion.

Cleaning
Cleaning of the base metal in the weld area (both sides) and of the filler metal (e.g. welding rod) should be carried out with ACETONE.

Trichlorethylene (TRI), perchlorethylene (PER) and carbon tetrachloride (TETRA) must not be used.

Edge preparation
This should preferably be done by mechanical means by turning, milling or planing; abrasive water jet or plasma cutting is also possible. However, in the latter case the cut edge (the face to be welded) must be finished off cleanly. Careful grinding without overheating is permissible.

Included angle
The different physical characteristics of nickel alloys and special stainless steels compared with carbon steel generally manifest themselves in a lower thermal conductivity and a higher rate of thermal expansion. This should be allowed for by means of, among other things, wider root gaps or openings (1-3 mm), while larger included angles (60-70 °), as shown in Fig. 3, should be used for individual butt joints owing to the viscous nature of the molten weld metal and to counteract the pronounced shrinkage tendency.

Striking of the arc
The arc should only be struck in the weld area, i.e., on the faces to be welded or on a run-out piece. Striking marks lead to corrosion.

Welding processes
For welding, Nicrofer 6023 H must be in the solution-annealed condition and be free from scale, grease and markings. Nicrofer 6023 H can be welded by the following welding processes: GTAW (TIG), plasma arc, GMAW (MAG = metal active gas) and SMAW (MMA = manual metal arc). For the MAG process the use of the shielding gas Cronigon HT is recommended, only if FM 602 bare electrodes are used. With FM 617 bare electrodes only pure argon must be used. If the submerged-arc process is used, the high aluminium burn-off makes it necessary to cover the weld metal with two weld layers using the GTAW process.

When welding the root, care should be taken to achieve best-quality root backing (argon 99.99), so that the weld is free from oxides after welding the root. Any heat tint should be removed preferably by brushing with a stainless steel wire brush while the weld metal is still hot. The shielding gas used for the GTAW and plasma-arc processes should be an argon/nitrogen mixture (argon + 1 to 3 % N_2), if FM 602 bare electrodes are used. In this case the gas should be used for all welding passes, i.e., for depositing root, intermediate and cover layers. If FM 617 bare electrodes are used, however, only pure argon must be used as shielding gas.

Filler metal
For the gas-shielded welding processes, filler metal with an overalloyed composition compared to the base metal is recommended:

Bare electrodes:

Nicrofer S 6025 - FM 602
UNS N06025
AWS A5.14: ERNiCrFe-12
DIN 1736: SG-NiCr25 FeAlY (W.-Nr. 2.4649)
DIN EN ISO 18274: G Ni 6602 (NiCr25Fe10AlY)

Note: According to VdTÜV approval, Nicrofer S 6025 filler wire is suitable for GTAW, GTAW-plasma and MAG welding of Nicrofer 6023 H and Nicrofer 6025 HT (UNS N06025).

or Nicrofer S 5520 - FM 617
UNS N06617
AWS A5.14: ERNiCrCoMo-1
DIN 1736: SG-NiCr22 Co12Mo (W.-Nr. 2.4627)
DIN EN ISO 18274: G Ni 6617 (NiCr22Co12Mo)

Note: With FM 617 bare electrodes only pure argon must be used as shielding gas.

Covered electrodes:

UNS W86025
AWS A5.11: ENiCrFe-12
DIN 1736: ≈ EL-NiCr25Fe10Al
DIN EN ISO 14172: E Ni 6704 (NiCr25Fe10Al3YC)

or UNS W86117
AWS A5.11: ENiCrCoMo-1
DIN 1736: EL-NiCr21Co12Mo (W.-Nr. 2.4628)
DIN EN ISO 14172: E Ni 6617 (NiCr22Co12Mo)

Welding parameters and influences
(heat input)

Care should be taken that the work is performed with a deliberately chosen, low heat input as indicated in Table 9 by way of example. Use of the stringer bead technique should be aimed at. Interpass temperature should be kept below 120 °C (250 °F).

The welding parameters should be monitored as a matter of principle.

The heat input Q may be calculated as follows:

$$Q = \frac{U \times I \times 60}{v \times 1000} \text{ (kJ/cm)}$$

U = arc voltage, volts
I = welding current, amps
v = welding speed, cm/min.

Consultation with ThyssenKrupp VDM's Welding Laboratory is recommended.

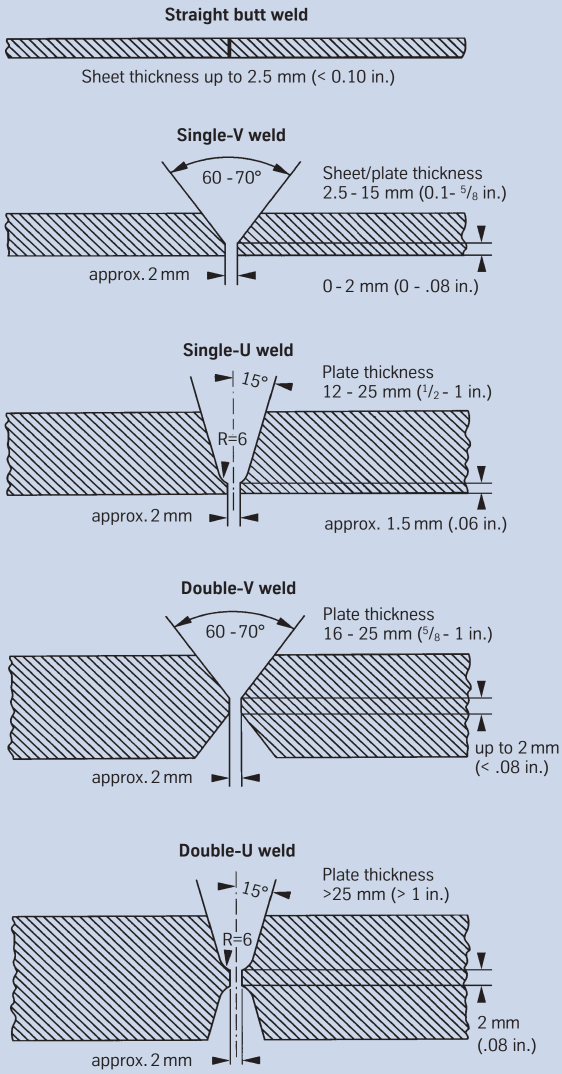

Fig. 3 – Edge preparation for welding of nickel alloys and special stainless steels.

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Sheet/ plate thick- ness mm	Welding process	Filler metal dia- meter mm	Welding parameters Root pass A	V	Intermediate and final passes A	V	Welding speed cm/min.	Heat input kJ/cm	Shielding gas* Type and rate l/min.
2.0	manual GTAW	2.0	90–100	11			10–15	max. 8	Argon + 1–3% N_2 8–10
6.0	manual GTAW	2.0–2.4	110	11	130–150	15	10–15	max. 8	Argon + 1–3% N_2 8–10
12.0	manual GTAW	2.4	110	11	130–150	15	10–15	max. 8	Argon + 1–3% N_2 8–10
3.0	autom. GTAW	0.8–1.2	manual GTAW		150–250	10–15	20–30	max. 8	Argon + 1–3% N_2 15–20
8.0	autom. GTAW	0.8–1.2	manual GTAW		150–250	10–15	20–30	max. 8	Argon + 1–3% N_2 15–20
5.0	Plasma-arc	1.0–1.2	180	25			Plasma 25–30	Plasma max. 10	Argon + 1–3% N_2 30
12.0	Plasma-arc	1.0–1.2	180	25	manual GTAW dia. 2.4 mm 130–150	15	Plasma 25–30 manual GTAW 12–15	Plasma max. 10 manual GTAW max. 8	Argon + 1–3% N_2 30
≥ 8.0	GMAW (MAG)	1.0–1.2	GTAW		160–180	23–27	25–35	max. 11	Cronigon HT: Argon + 5% N_2 + 5–10% He + 0.05% CO_2 16 – 20
8.0	SMAW (MMA)	2.5–3.2	40–70	approx. 21	70–100	approx. 22		max. 7	–
16.0	SMAW (MMA)	3.2–4.0	70–100	approx. 21	90–130	approx. 22		max. 7	–

In all gas-shielded welding operations, ensure adequate root shielding with argon 99.99 as backing gas so as to prevent contamination by atmospheric oxygen.
Figures are for guidance only and are intended to facilitate setting of welding machines.
* The listed shielding gases apply for welding with FM 602. For welding with FM 617 only pure argon is to be used.

Table 9 – Welding parameters (guide values).

Postweld treatment
(brushing, pickling and thermal treatments)

Brushing with a stainless steel wire brush immediately after welding, i.e., while the metal is still hot, generally results in removal of heat tint and produces the desired surface condition without additional pickling.

Pickling, if required or prescribed, however, would generally be the last operation performed on the weldment. Also refer to the information on **'Descaling and pickling'**.

Neither pre- nor postweld thermal treatments are normally required.

However, to eliminate the risk of relaxation cracking of material already exposed to service temperatures within the range of 575 – 625 °C (1067 – 1157 °F) or of new material exposed to that temperature range following welding with ERNiCr-3 (UNS N06082), a practice which should be avoided, the stabilization annealing recommendations given under **'Relaxion cracking susceptibility'** should be adhered to.

Availability

Nicrofer 6023 H is available in the following standard product forms:

Sheet & plate

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

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

Thickness mm	hr/cr	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/hr	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,
oxidized, 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

Rod & bar

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

Product	Forged[1] mm	Rolled[1] mm	Drawn[1] mm
Rod (O. D.)	≤ 600	8 – 100	12 – 65
Bar, square (a)	40 – 600	15 – 280	not standard
Bar, flat (a x b)	(40 – 80) x (200 – 600)	(5 – 20) x (120 – 600)	(10 – 20) x (30 – 80)
Bar, hexagonal (s)	40 – 80	13 – 41	≤ 50

	inches	inches	inches
Rod (O. D.)	≤ 24	$^{5}/_{16}$ – 4	$^{1}/_{2}$ – 2 $^{1}/_{2}$
Bar, square (a)	$1^{5}/_{8}$ – 24	$^{10}/_{16}$ – 11	Not standard
Bar, flat (a x b)	($1^{5}/_{8}$ – $3^{1}/_{8}$) x (8 – 24)	($^{3}/_{16}$ – $^{3}/_{4}$) x ($4^{3}/_{4}$ – 24)	($^{3}/_{8}$ – $^{3}/_{4}$) x ($1^{1}/_{4}$ – $3^{1}/_{8}$)
Bar, hexagonal (s)	$1^{5}/_{8}$ – $3^{1}/_{8}$	$^{1}/_{2}$ – $1^{5}/_{8}$	≤ 2

[1] other sizes and conditions 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.

Strip[1]
Conditions:
cold rolled,
thermally treated and pickled or bright annealed[2].

Thickness mm	Width[3] mm	Coil I. D. mm			
0.02 – ≤ 0.10	4 – 200[4]	300	400		
> 0.10 – ≤ 0.20	4 – 350[4]	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 (3.5)[2]	25 – 750		400	500	600

inches	inches	inches			
0.0008 – ≤ 0.004	0.16 – 8[4]	12	16		
> 0.004 – ≤ 0.008	0.16 – 14[4]	12	16	20	
> 0.008 – ≤ 0.010	0.16 – 30		16	20	24
> 0.010 – ≤ 0.024	0.24 – 30		16	20	24
> 0.024 – ≤ 0.040	0.32 – 30		16	20	24
> 0.040 – ≤ 0.080	0.60 – 30		16	20	24
> 0.080 – ≤ 0.120[2] ≤ 0.140[2]	1.0 – 30		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 mm (0.120 in.),
cold rolled only - 3.5 mm (0.140 in.)
3) Wider widths subject to special enquiry
4) Wider widths up to 730 mm (29 in.) subject to special enquiry

Wire
Conditions:
bright drawn, 1/4 hard to hard,
bright annealed or oxidized

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

Welding filler metals
Suitable welding rods, wire, strip electrodes and electrode core wire are available in all standard sizes.

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.

Technical publications
The following publications, concerning Nicrofer 6023 H, may be obtained from ThyssenKrupp VDM GmbH:

U.Brill:
Korrosion von Nickel, Cobalt und Nickel- und Cobalt-Basislegierungen;
Reprint of Korrosion und Korrosionsschutz, 1992.

U.Brill, M. Rockel:
High-temperature alloys from Krupp VDM for industrial engineering; VDM-Report No. 25, 2000.

U. Heubner, J.Klöwer et al.:
Nickel alloys and high-alloy special stainless steels; expert Verlag, 3rd revised edition, 2003.

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