VDM Metals

A company of ACERINOX

VDM® Alloy 825 CTP
Nicrofer 4022

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VDM® Alloy 825 CTP
Nicrofer 4022

VDM® Alloy 825 CTP is a fully austenitic nickel-iron-chromium alloy with additions of copper and molybdenum. VDM® Alloy 825 CTP is characterized by:

- High resistance to chloride-induced stress corrosion
- Good resistance to chloride-induced pitting and crevice corrosion
- Good resistance to oxidizing and non-oxidizing hot acids
- Good toughness, even under continuous operation, at both room and elevated temperatures, up to approximately 550 °C (1.020 °F)
- Ongoing approval for pressure vessels with wall temperatures up to 450 °C (842 °F) acc. to VdTÜV and 538 °C (1,000 °F) for Section VIII Division 1 vessels acc. to ASME.

Designations and standards

Standardisation	Material designation
EN	2.4861 - NiCr22Mo6
UNS	N08827

Table 1a – Designations and standards

Designations and standards

Product form	DIN	DIN EN	ISO	ASTM	ASME	VdTüV	NACE	API
Rod, bar				B 425 B 564	SB 425 SB 564		MR 0103* MR 0175	
Sheet, plate				B 424	SB 424		MR 0103* MR 0175	
Strip				B 424	SB 424		MR 0175	
Wire				B 425				

* In the solution-annealed condition

Table 1b – Designations and standards

Chemical composition

	Ni	Cr	Fe	C	Mn	Si	Co	Cu	Al	N	Nb	B	Mg	P	S	Mo
Min.	39.0	21.0	Ba-lance		0.5	0.2		1.6	0.06			0.002	0.006			4.5
Max.	43.0	23.0		0.015	0.9	0.5	0.5	2.3	0.25	0.03	0.15	0.004	0.015	0.02	0.005	6.5

Table 2 – Chemical composition (wt.-%) according to UNS N08827

Physical properties

Density	Melting range	Relative magnetic permeability at 20 °C (68 °F)
8.17 g/cm^3 (0.295 lb/in^3)	1,370-1,400 °C (2,500-2,550 °F)	1.005 (Maximum)

Temperature		Specific heat		Thermal conductivity		Electrical resistivity	Modulus of elasticity		Coefficient of thermal expansion	
°C	°F	$\frac{J}{Kg \cdot K}$	$\frac{Btu}{lb \cdot °F}$	$\frac{W}{m \cdot K}$	$\frac{Btu \cdot in}{sq.\ ft \cdot h \cdot °F}$	μΩ · cm	GPa	10^3 ksi	$\frac{10^{-6}}{K}$	$\frac{10^{-6}}{°F}$
20	68	422	0.101	10.7	74.2	108	194	28.1	–	
100	212	469	0.112	12.7	88.1	112	188	27.3	14.7	8.17
200	392	488	0.117	14.2	98.5	115	181	26.2	14.9	8.28
300	572	493	0.118	15.5	107.6	119	176	25.5	15.1	8.39
400	762	503	0.120	16.9	117.3	121	170	24.6	15.3	8.5
500	932	528	0.126	18.7	129.8	124	163	23.6	15.8	8.78
600	1,112	568	0.136	21.2	147.1	126	156	22.6	16.3	9.06

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

Microstructural properties

VDM® Alloy 825 CTP has a face-centered-cubic crystal structure.

Mechanical properties

The following properties are applicable to VDM® Alloy 825 CTP at room and elevated temperatures in the solution-annealed condition. Manufacturing size ranges are given below and the properties of material outside these size ranges are subject to special enquiry.

Temperature		Yield strength $R_{p\,0.2}$		Tensile strength R_m		Elongation A
°C	°F	MPa	ksi	MPa	ksi	%
20	68	240	34.8	585	84.8	30
100	212	205	29.7	530	76.9	
150	302	190	27.6	525	76.1	
200	392	180	26.1	515	74.7	
250	482	175	25.4	510	74	
300	572	170	24.7	500	72.5	
350	662	165	23.9	495	71.8	
400	752	160	23.2	490	71.1	
450	842	155	22.5	485	70.3	

Table 4 – Minimum mechanical properties at room temperature according to ASTM B 424. Expected minimum mechanical properties at elevated temperatures.

Product form	Dimensions mm	Yield strength $R_{p\,0.2}$ MPa	Tensile strength R_m MPa	Elongation A %
Strip	0.5-6.4	≥ 240	≥ 585	≥ 30
Sheet, plate	5-100	≥ 240	≥ 585	≥ 30
Rod, bar	≤ 240	≥ 240	≥ 585	≥ 30

Table 5 – Mechanical properties at room temperature according to ASTM B424 (Plate, Sheet and Strip) and ASTM B425 (Rod and Bar)

ISO V-notch impact

Sheet, room temperature, transverse: >80 J
Sheet, room temperature, longitudinal: >130 J

Corrosion resistance

VDM® Alloy 825 CTP is a versatile engineering alloy with resistance to corrosion in acids and alkalis under both oxidizing and reducing conditions.

The high nickel content gives the alloy virtual immunity to stress corrosion cracking.

The corrosion resistance in various media like sulfuric, phosphoric, nitric and organic acids is good, as well as the corrosion resistance in alkalis or ammoniac, seawater and caustic chloride.

Applications

VDM® Alloy 825 CTP can be used in the oil and gas industry and in a wide variety of chemical processes. Typical application fields include:

- Pipes, tubes and fittings in the oil and gas extraction, e. g. in heat exchangers, evaporators, washers, immersion pipes in sea water cooled heat exchangers, offshore piping
- Components in sulfuric acid pickling plants like heating coils, vessels, boilers, baskets and chains
- Heat exchangers, evaporators, washers, immersion pipes in phosphoric acid production
- Food industry

Fabrication and heat treatment

VDM® Alloy 825 CTP can readily be hot- and cold-worked and machined.

Heating

Workpieces must be clean and free of any contaminants before and during heat treatment. Sulfur, phosphorus, lead and other low-melting-point metals can lead to damages when heat treating VDM® Alloy 825 CTP. Sources of such contaminants include marking and temperature-indicating paints and crayons, lubricating grease and fluids, and fuels. Fuels should contain as little sulfur as possible. Natural gas should contain less than 0.1 wt.-% of sulfur. Heating oil with a sulfur content of maximum 0.5 wt.-% is also suitable. Electric furnaces are to be preferred due to precise temperature control and freedom from contamination due to fuel. The furnace atmosphere should be set between neutral and slightly oxidising, and should not change between oxidising and reducing. Direct flame impingement needs to be avoided.

Hot working

VDM® Alloy 825 CTP may be hot-worked in the temperature range 1,150 to 900 °C (2,100 to 1,650 °F) with subsequent rapid cooling down in water or by using air. The workpieces should be placed in the furnace heated to hot working temperature in order to heat up. Once the temperature has equalised, a retention time of 60 minutes for each 100 mm (4 in) of workpiece thickness is recommended. After this, the workpieces should be removed immediately and formed during the stated temperature window. If the material temperature falls below the minimum hot working temperature, the workpiece must be reheated.

Heat treatment after hot working is recommended in order to achieve optimum properties and corrosion resistance.

Cold working

Cold working should be carried out on annealed material. VDM® Alloy 825 CTP has a higher work hardening rate than austenitic stainless steels. This must be taken into account during design and selection of forming tools and equipment and during the planning of the forming processes. Intermediate annealing may be necessary at high degrees of cold working deformation. After cold working with more than 15 % of deformation the material should be soft annealed.

Heat treatment

Solution annealing should be carried out at temperatures above 1,010 °C (1,850 °F). Water quenching or rapid cooling should be carried out to achieve optimum corrosion characteristics. Workpieces of less than 3 mm (0.12 in) thickness can be cooled down using air nozzles.

For strip and wire products, the heat treatment can be performed in a continuous furnace at a speed and temperature that is adapted to the material thickness.

The workpiece has to be put into the pre-heated furnace. The furnace should be heated up to the maximum annealing temperature. The retention time during annealing depends on the workpiece thickness and can be calculated as follows:

- For thicknesses d ≤ 10 mm (0.4 in) the retention time is t = d • 3 min/mm
- For thicknesses d = 10 to 20 mm (0.4 to 0.8 in) the retention time is t = 30 min + (d - 10 mm) • 2 min/mm
- For thicknesses d > 20 mm (0.8 in) the retention time is t = 50 min + (d - 20 mm) • 1 min/mm

The cleanliness requirements listed under ‘Heating’ must be complied with.

Descaling and pickling
Oxides of VDM® Alloy 825 CTP 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.

Machining
VDM® Alloy 825 CTP should be machined in the annealed condition. As the alloy is prone to work-hardening, low cutting speeds and appropriate feed rates should be used and the tool should be engaged at all times. Sufficient chip depths are important to get below the work-hardened surface layer. The optimum dissipation of heat through the use of large amounts of appropriate, preferably water containing cooling lubricants is crucial for a stable machining process.

Welding

When welding nickel-base alloys and special stainless steels, the following instructions should be adhered to:

Workplace
A separately-located workplace, which is specifically separated from areas in which carbon steels are being processed, should be used. Maximum cleanliness is required, and draughts should be avoided during inert gas welding.

Auxiliary equipment and clothing
Clean fine leather gloves and clean working clothes should be used.

Tools and machines
Tools used for other materials must not be used for nickel-base alloys and stainless steels. Brushes should be made of stainless materials. Processing and machining equipment such as shears, punches or rollers must be fitted with means (felt, cardboard, films) in order to avoid material contamination with ferrous particles, which can be pressed into the surface of the material and thus lead to corrosion.

Welding edge preparation
Welding edge preparation should preferably be carried out using mechanical methods such as lathing, milling or planing. Abrasive waterjet cutting or plasma cutting is also suitable. In the latter case, however, the cut edge (seam flank) must be cleanly re-worked. Careful grinding without overheating is acceptable.

Ignition
The arc may only be struck in the weld area, e.g. along the seam flanks or outlets, and should not be carried out on the workpiece surface. Arc striking areas are prone to corrosion.

Included angle

The different physical characteristics of nickel alloys and special stainless steels are generally expressed through lower thermal conductivity and higher thermal expansion in comparison with carbon steel. This should be allowed for by means of, among other things, wider root gaps or openings (1-3 mm; 0.04-1.2 in), while larger included angles (60-70°), as shown in Fig. 1, should be used for butt joints owing to the viscous nature of the molten weld metal and to counteract the pronounced shrinkage tendency.

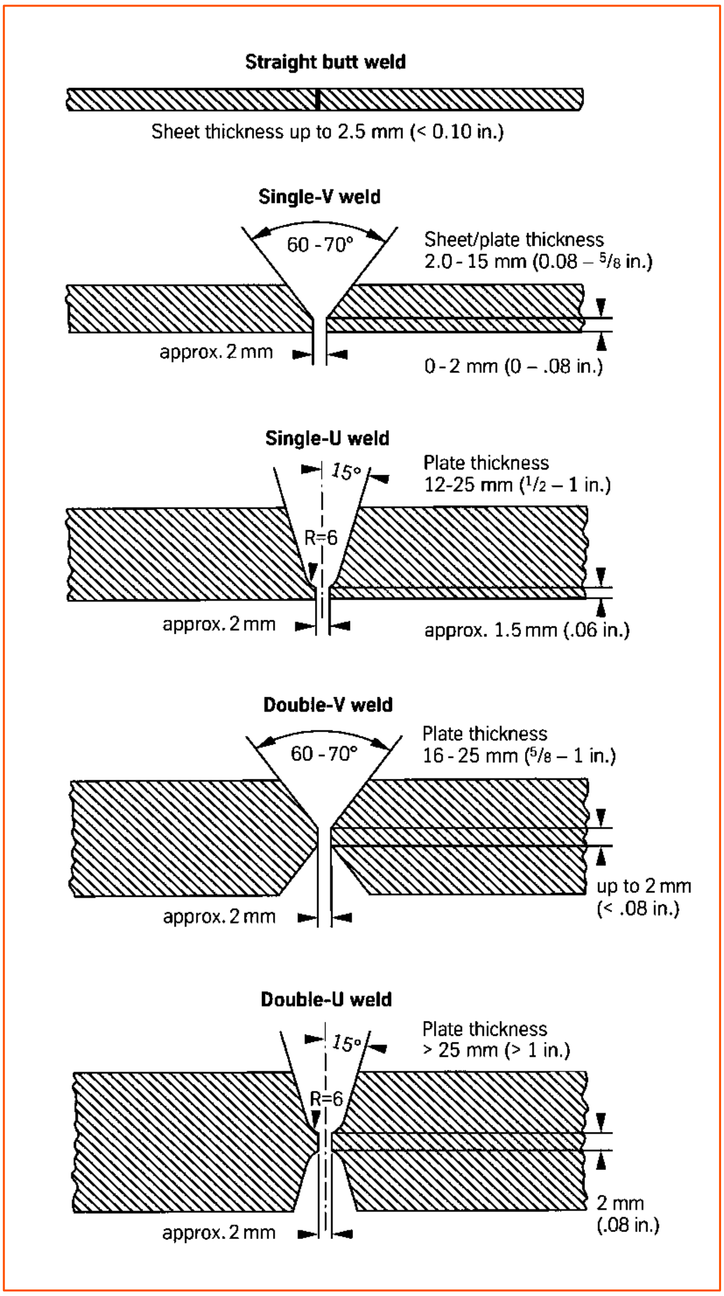

Figure 1 – Edge preparation for welding nickel alloys and special stainless steels

Cleaning

Cleaning of the base material in the seam area (both sides) and the filler material (e.g. welding rod) should be carried out using Acetone.

Welding process

VDM® Alloy 825 CTP can be joined to itself and to many other metals by conventional welding processes. These include GTAW (TIG), plasma arc and GMAW (MIG/MAG). Pulsed arc welding is the preferred technique for GMAW. For the MAG process, the use of a multi-component shielding gas (Ar + He + H2 + CO2) is recommended. For welding, VDM® Alloy 825 CTP should be in the annealed condition and be free from scale, grease and markings.

When welding roots, sufficient protection of the root needs to be ensured with pure argon (Ar 4.6) so that the welding seam is free of oxides after welding. Root backing is also recommended for the first intermediate pass following the initial root pass and in some cases even for the second pass, depending on the weld set-up.

Any discoloration/heat tint should be removed preferably by brushing with a stainless steel wire brush while the weld metal is still hot.

Filler metal

The following filler materials are recommended:

Solid wire electrodes, solid wires and solid rods.

VDM® FM 625 (W.-Nr. 2.4831)
DIN EN ISO 18274: S Ni 6602 (SG-NiCr 21 Mo 9 Nb)
AWS A 5.14: ERNiCrMo-3

VDM® FM 825 CTP (W.-Nr. 2.4861)
DIN EN ISO 18274: S Ni 8827 (NiFe30Cr22Mo6)

Welding parameters and influences

Care should be taken that the work is performed with a deliberately chosen, low heat input as indicated in Table 6 by way of example. The stringer bead technique is recommended. The interpass temperature should not exceed 150 °C (302 °F). The welding parameters should be monitored as a matter of principle.

The heat input Q can be calculated as follows:

$$Q=\frac{U \cdot I \cdot 60}{v \cdot 1{,}000}\left(\frac{kJ}{cm}\right)$$

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

Post-weld treatment

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. Please also refer to the information on ‘Descaling and pickling’. Neither pre- nor postweld heat treatments are required. Preheating before welding is generally not necessary.

Thickness	Welding technique	Filler material		Root pass[1]		Intermediate and final passes		Welding speed	Shielding gas	
(mm)		Diameter (mm)	Speed (m/min)	I in (A)	U in (V)	I in (A)	U in (V)	(cm/min)	Type	Rate (l/min)
3	manual TIG	2		90	10	110-120	11	10-15	I1	8-10
6	manual TIG	2-2.4		100-110	10	120-140	12	10-15	I1	8-10
8	manual TIG	2.4		10-110	11	130-140	12	10-15	I1	8-10
10	manual TIG	2.4		100-110	11	130-140	12	10-15	I1	8-10
3	autom. TIG[2]	1.2	0.5			150	11	25	I1	15-20
5	autom. TIG[2]	1.2	0.5			180	12	25	I1	15-20
4	Plasma[3]	1.2	1	165	25			25	I1	30
6	Plasma[3]	1.2	1	190-220	25			25	I1	30
8	MIG/MAG[4]	1	8			130-140	23-27	24-30	I1, Z-ArHeHC 30-2-0.05	18-20
10	MIG/MAG[4]	1.2	5			130-150	23-27	24-30	I1, Z-ArHeHC 30-2-0.05	18-20

[1] It must be ensured that there is sufficient root protection, for example using Ar 4.6, for all inert gas welding processes.

[2] Root pass should be welded manually (please see ‘manual TIG‘ for parameters).

[3] Recommended plasma gas I1, R1 at max. 3 % H2 / rate 3,0 bis 3,5 l/min

[4] For MAG welding the use of multicomponent inert gases is recommended.

Section energy kJ/cm:
manual TIG, autom. TIG, Plasma max. 10; TIG-HD max. 6; manual TIG, autom. TIG, MIG/MAG max. 11

Figures are for guidance only and are intended to facilitate setting of the welding machines.

Table 6 – Welding parameters

Availability

VDM® Alloy 825 CTP is available in the following standard semi-finished product forms:

Rod and bar

Delivery conditions: forged, rolled, drawn, heat treated, oxidized, descaled resp. pickled, machined, peeled, ground or polished

Dimensions*	Outside diameter mm (in)	Length mm (in)
General dimensions	6-800 (0.24-31.5)	1,500-12,000 (59.06-472.44)
Material specific dimensions	22-550 (0.87-21.65)	1,500-12,000 (59.06-472.44)

* Further dimensions on request

Sheet and plate

Delivery conditions: hot or cold rolled, heat treated, descaled resp. pickled

Condition	Thickness mm (in)	Width mm (in)	Length mm (in)	Piece weight kg
Cold rolled	1-7 (0.04-0.28)	≤ 2,500 (98.43)	≤ 12,500 (492.13)	
Hot rolled*	3-70 (0.12-2.76)	≤ 2,500 (98.43)	≤ 12,500 (492.13)	≤ 2,300

* 2 mm thickness on request

Strip

Delivery conditions: cold rolled, heat treated, pickled or bright annealed

Thickness mm (in)	Width mm (in)	Coil - inside diameter mm			
0.02-0.15 (0.0008-0.0059)	4-230 (0.16-9.06)	300	400	500	–
0.15-0.25 (0.0059-0.01)	4-720 (0.16-28.34)	300	400	500	–
0.25-0.6 (0.01-0.024)	6-750 (0.24-29.5)	–	400	500	600
0.6-1 (0.024-0.04)	8-750 (0.32-29.5)	–	400	500	600
1-2 (0.04-0.08)	15-750 (0.6-29.5)	–	400	500	600
2-3 (0.08-0.12)	25-750 (0.98-29.5)	–	400	500	600

Wire

Delivery conditions: bright drawn, ¼ hard to hard, bright annealed in rings, containers, on spools and spiders

Drawn mm (in)	Hot rolled mm (in)
0.16-10 (0.006-0.4)	5.5-19 (0.22-0.75)

Other shapes and dimensions such as circular blanks, rings, seamless or longitudinal-welded tubes and pipes or forgings are subject to special enquiry.

Legal information

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