VDM® Nickel 200
VDM® Nickel 201
Nickel 99.2
LC-Nickel 99.2

Material Data Sheet No. 1101
August 2017

VDM® Nickel 200 and 201

Nickel 99.2 and LC-Nickel 99.2

VDM® Nickel 200 and VDM® Nickel 201 are unalloyed nickel with a nickel concentration of at least 99.2%.
VDM® Nickel 201 is the low carbon version of VDM® Nickel 200.
They are characterized by:

- excellent resistance in alkaline media,
- high ductility in a wide temperature range,
- ferromagnetism,
- high electrical and thermal conductivity.

The materials are offered under the name VDM® Nickel 205 with a higher guaranteed nickel concentration of 99.6%.

Designations

Standard	Material designation	
	VDM Nickel 200	VDM Nickel 201
EN	2.4066	2.4068 LC-Ni 99.2
UNS	N02200	N02201

Standards

Product form	DIN	VdTÜV	ISO	ASTM	ASME	Others
Bar	17752[2] 17740[2]	345[2]		B 160 B 564[2]	SB 160 SB 564[2]	
Sheet	17740 17750	345[2]		B 162	SB 162 SA 578[1]	EN 10029[1] SAE AMS 5553[2]
Strip	17740	345[2]	6208	B 162 B 730[2]	SB 162[2]	SAE AMS 5553[2] SAE AMS 5555[2]
Wire	17740					

[1] only valid for VDM® Nickel 200

[2] only valid for VDM® Nickel 201

Table 1 – Designations and standards

Chemical composition

VDM® Nickel 200

	C	S	Ni	Mn	Si	Ti	Cu	Fe	Mg
Min.			99.2						
Max.	0.1	0.005		0.35	0.15	0.1	0.25	0.4	0.15
Due to technical reasons the alloy may contain more elements than listed									

Table 2a – Chemical composition (%)

VDM® Nickel 201

	C	S	Ni	Mn	Si	Ti	Cu	Fe	Mg
Min.			99.2						
Max.	0.02	0.005		0.35	0.15	0.1	0.25	0.4	0.15
Due to technical reasons the alloy may contain more elements than listed									

Table 2b – Chemical composition (%)

Physical properties

Density	Melting range	Curie temperature	Saturation flux density
8.9 g/cm³ bei 20°C 556 lb/ft³ at 68°F	1,435 – 1,445°C (2,610 – 2,630°F)	360°C (68 °F)	0,61 T

Temperature		Specific heat capacity[1)]		Electrical resistivity	Modulus of elasticity		Coefficient of thermal expansion	
°C	°F	J / Kg · K	Btu / lb · °F	µΩ · cm	GPa	10^6 psi	10^{-6} / K	10^{-6} / °F
-200	-328	150	0.0358	2	227	32.9	10.1	5.61
-100	-148	355	0.0848	4.5	218	31.6	11.3	6.28
0	32	426	0.102	8.5	207	30.0	-	-
20	68	456	0.109	9	205	29.7	-	-
100	212	475	0.113	13	200	29.0	13.3	7.39
200	392	500	0.119	19	196	28.4	13.9	7.72
300	572	570	0.136	26	190	27.6	14.3	7.94
400	752	530	0.172	33	182	26.4	14.8	8.22
500	932	525	0.125	37	175	25.4	15.2	8.44
600	1,112	535	0.128	40	165	23.9	15.6	8.67
700	1,292	550	0.131	43	153	22.2	15.8	8.78
800	1,472	565	0.135	45	140	20.3	16.2	9.0
900	1,652	580	0.139	48	134	19.4	16.5	9.17
1,000	1,832	590	0.141	51			16.7	9.28

1) The specific heat capacity has a distinct maximum at 358°C (676.4°F).

Table 3 a– Typical physical properties at low, room and elevated temperatures of VDM® Nickel 200 and VDM® Nickel 201

Temperature		Thermal conductivity of Nickel 200		Thermal conductivity of Nickel 201[1)]	
°C	°F	W / m · K	Btu · in / sq. ft · h · °F	W / m · K	Btu · in / sq. ft · h · °F
-200	-328	79	45.6	93	53.7
-100	-148	75	43.3	87	50.3
0	32	72	41.6	81	46.8
20	68	71	41.0	79	45.6
100	212	67	38.7	73	42.2
200	392	62	35.8	67	38.7
300	572	57	32.9	60	34.7
400	752	56	32.4	57	32.9
500	932	58	33.5	59	34.1
600	1,112	60	34.7	61	35.2
700	1,292	62	35.8	63	36.4
800	1,472	64	37.0	66	38.1
900	1,652	67	38.7	68	39.3
1,000	1,832	69	39.9	71	41.0

1) Thermal conductivity is lower in contaminated material. This effect is extremely strong in the very deep temperature range. Above the Curie point, the thermal conductivity indicates a change of direction.

Table 3b – Typical thermal conductivity at low, room and elevated temperatures of VDM® Nickel 200 and VDM® Nickel 201

Microstructural properties

VDM® Nickel 200 and VDM® Nickel 201 are austenitic from the absolute zero point up to melting temperature.

Mechanical properties

The following mechanical properties apply to VDM® Nickel 200 and VDM® Nickel 201 in annealed condition and in the specified semi-finished forms and dimensions. The properties for larger dimensions must be agreed separately.

Mechanical properties of Nickel 200

Temperature		Yield strength $R_{p\,0.2}$		Yield strength $R_{p\,1,0}$		Tensile strength R_m		Elongation A
°C	°F	MPa	ksi	MPa	ksi	MPa	ksi	%
20	68	100	14.5	125	15.1	370	53.7	40

Table 4a – Mechanical short-term properties of soft-annealed VDM® Nickel 200 at room temperature according to DIN 17750

Mechanical properties of Nickel 201

Temperature		Yield strength $R_{p\,0.2}$		Yield strength $R_{p\,1,0}$		Tensile strength R_m		Elongation A
°C	°F	MPa	ksi	MPa	ksi	MPa	ksi	%
20	68	80	11.6	105	15.2	340	49.3	40
100	212	70	10.2	95	13.8	290	42.1	
200	392	65	9.43	90	13.1	275	39.9	
300	572	60	8.7	85	12.3	260	37.7	
400	752	55	7.98	80[2)]	11.6	240	34.8	
500	932	50	7.25	75[2)]	10.9	210	30.5	
600	1,112	40	5.8	65[2)]	9.43	150	21.8	

2) These values are above the point of intersection with the long term creep limit

Table 4b – Mechanical short-term properties of soft-annealed VDM® Nickel 201 at room and elevated temperatures according to VdTÜV material data sheet 345

Product form	Dimensions		Yield stress $R_{p\,0,2}$		Yield stress $R_{p\,1,0}$		Tensile strength R_m		Elongation A
	mm	in	MPa	ksi	MPa	ksi	MPa	ksi	%
Sheet	50	1.96	80		105		340		50

Table 4c – Mechanical properties at room temperature of VDM® Nickel 201 in annealed condition according to DIN 17750 - 17753

Temperature		Creep limit $R_m/10^4$ h		Creep limit $R_{p1.0}/10^4$ h	
°C	°F	MPa	ksi	MPa	ksi
380	716	85	12.3	70	10.2
400	752	75	10.9	60	8.7
420	788	67	9.72	52	7.54
440	824	59	8.56	44	6.38
460	860	51	7.4	36	5.22
480	896	43	6.24	29	4.21
500	932	35	5.08	23	3.34
520	968	28	4.06	17	2.47
540	1,004	22	3.19	13	1.89
560	1,040	17	2.47	9	1.31
580	1,094	13	1.89	7	1.02
600	1,112	10	1.45	6	0.87

Table 5 – Calculated characteristic values of VDM® Nickel 201 at elevated temperature according to VdTÜV data sheet 345. Notes of the VdTÜV sheets should be considered for interpretation.

Corrosion resistance

VDM® Nickel 200 and VDM® Nickel 201 have excellent resistance against many corrosive media, in particular hydrofluoric acid and alkalis. The corrosion resistance is particularly good under reduced conditions; but as soon as a passivating oxide layer forms, this is also true in oxidizing media. An extraordinary characteristic is the resistance in alkali solutions up to salt baths.

The very much reduced carbon content of VDM® Nickel 201 ensures practically a complete absence of grain boundary attacks even above 315°C (599°F). In alkali solutions, the chlorate concentration must be kept low however, as it promotes corrosion attacks through chloride formation.

The resistance of VDM® Nickel 200 and VDM® Nickel 201 against mineral acids varies depending on temperature and concentration and on whether the solution is ventilated or not. The corrosion resistance in unventilated acids is better. In acids, alkalis and solutions of neutral salts, VDM® Nickel 200 and VDM® Nickel 201 prove good resistance, but in oxidizing salt solutions, strong corrosion can occur. Both materials are resistant to dry gases in room temperature.

VDM® Nickel 201 can be used in dry chlorine gas and hydrogen chloride in temperatures of up to 550°C (1,022°F).

The material is offered under the name VDM® Nickel 205 with a higher guaranteed nickel concentration of 99.6%.

Applications

Unalloyed nickel combines good mechanical properties with good corrosion resistance. In application temperatures above 300°C (572°F), VDM® Nickel 201, which stands out for a low C-concentration, is preferable over VDM® Nickel 200. The lowered C-concentration reduces strength and the work hardening rate, and it raises ductility.

Typical applications are:

- Food manufacturing such as handling of cooling brine, fatty acids and fruit juices due to the material's resistance against acids,
- alkalis and neutral salt solutions and against organic acids
- Tanks in which fluorine is produced and where it reacts with hydrocarbon (CFC) due to the material's resistance against fluorine
- Storage and transport of phenol
- Production and treatment of caustic soda
- Production of synthetic fibers and soaps
- Production of hydrogen chloride and chlorination of hydrocarbons such as benzene, methane and ethane
- Production of vinyl chloride monomer due to the material's resistance against dry chlorine gas and hydrogen chloride in increased temperatures
- Electrical and electronic components
- Electrode contacts and current conductors in batteries
- Current conductors in alkali fuels

Fabrication and heat treatment

VDM® Nickel 200 and VDM® Nickel 201 are ideally suited for processing by means of common processing techniques customary in metalworking.

Heating

It is important that the workpieces are clean and free of any contaminations before and during heat treatment. Sulfur, phosphorus, lead and other low-melting point metals can result in material damage during the heat treatment. This type of contamination is also contained in marking and temperature-indicating paints or pens, and also in lubricating grease, oils, fuels and similar materials. The sulfur content of fuels must be as low as possible. Natural gas should contain less than 0.1 wt.-% of sulfur. Heating oil with a maximum sulfur content of 0.5 wt.-% is also suitable. Electric furnaces are preferable for their precise temperature control and a lack of contaminations from fuels. The furnace temperature should be set between neutral and slightly oxidizing and it should not change between oxidizing and reducing. The workpieces must not come in direct contact with flames.

Hot forming

VDM® Nickel 200 and VDM® Nickel 201 are well suited for hot forming in the temperature range between 1,200 and 800 °C (2,192 and 1,472 °F). For heating up, workpieces should be placed in a furnace that is already heated up. Rapid cooling down after the hot forming is not required. A heat treatment after the hot forming is recommended for achieving the optimal corrosion characteristics and controlled mechanical properties.

Cold forming

Cold forming should be conducted on the soft annealed material. The forming characteristics of VDM® Nickel 200 and 201 are comparable to those of carbon steels. In strong cold forming, intermediate annealing may be necessary to reinstate the formable soft condition.

Heat treatment

VDM® Nickel 200 and 201 are soft annealed in the temperature range between 700 and 850 °C (1,292 and 1,562 °F). To achieve a fine-grained microstructure, it is recommended to determine the parameters of the annealing temperature and retention time carefully prior to the heat treatment. Work-hardened VDM® Nickel is advantageous for some applications. Work-hardened material can be heat treated in temperatures between 550 and 650 °C (1,022 and 1,202 °F) to compensate forming tensions. In this temperature range, the material does not recrystallize and therefore largely retains the strength that was obtained through the forming process. The cooling down speed after heat treatment of VDM® Nickel 200 or 201 is generally unproblematic. For strips as the product form, the heat treatment can be performed in a continuous furnace at a speed and temperature that is adapted to the strip thickness. In each heat treatment, the aforementioned cleanliness requirements must be observed.

Descaling and pickling

Oxides on VDM® Nickel 200 and 201 and discolorations in the area of weld seams must be removed before use. Before the pickling in hot sulfuric acid, blasting of the surfaces is helpful to shorten the pickling times. Pickling in saltpeter hydrofluoric acid mixtures leads to the formation of nitric gases damaging to health and the environment it is therefore recommendable only with limitations.

Machining

VDM® Nickel 200 and 201 is preferably processed in annealed condition. Since the material has a propensity for work hardening, a low cutting speed should be selected and the cutting tool should stay engaged at all times. An adequate chip depth is important in order to cut below the previously formed work-hardened zone. An optimal heat dissipation by using large quantities of suitable, preferably aqueous, cold forming lubricants has considerable influence on a stable machining process.

Welding information

When welding nickel alloys and special stainless steels, the following information should be taken into account:

Safety
The generally applicable safety recommendations, especially for avoiding dust and smoke exposure must be observed.

Workplace
A separately located workplace, which is specifically separated from areas in which C steel is being processed, must be provided. Maximum cleanliness is required, and drafts should be avoided during gas-shielded welding.

Auxiliary equipment and clothing
Clean fine leather gloves and clean working clothes must be used.
Since nickel compared to nickel alloys has a greater propensity for forming pores, a particularly good shielding gas cover must be ensured during the welding.

Tools and machines
Tools that have been used for other materials may not be used for nickel alloys and stainless steels. Only stainless steel brushes may be used. Machines such as shears, punches or rollers must be fitted (e.g. with felt, cardboard, films) so that the workpiece surfaces cannot be damaged by such equipment due to pressed-in iron particles as this can lead to corrosion.

Edge preparation
Edge preparation should preferably be carried out using mechanical methods such as lathing, milling or planning. Abrasive waterjet cutting or plasma cutting is also possible. In case of the latter, however, the cut edge (seam flank) must be reworked cleanly. Careful grinding without overheating is also permissible.

Striking the arc
Striking the arc may only take place in the seam area, e.g. on the seam flanks or on an outlet piece, and not on the component surface. Scaling areas are places that may be more susceptible to corrosion.

Included angle
Compared to C-steels, nickel alloys and special stainless steels exhibit lower thermal conductivity and greater heat expansion. Larger root openings and web spacings (1 to 3 mm) are required to live up to these properties. Due to the viscosity of the welding material (compared to standard austenites) and the tendency to shrink, included angles of 60 to 70° – as shown in Figure 1 – have to be provided for butt welds.

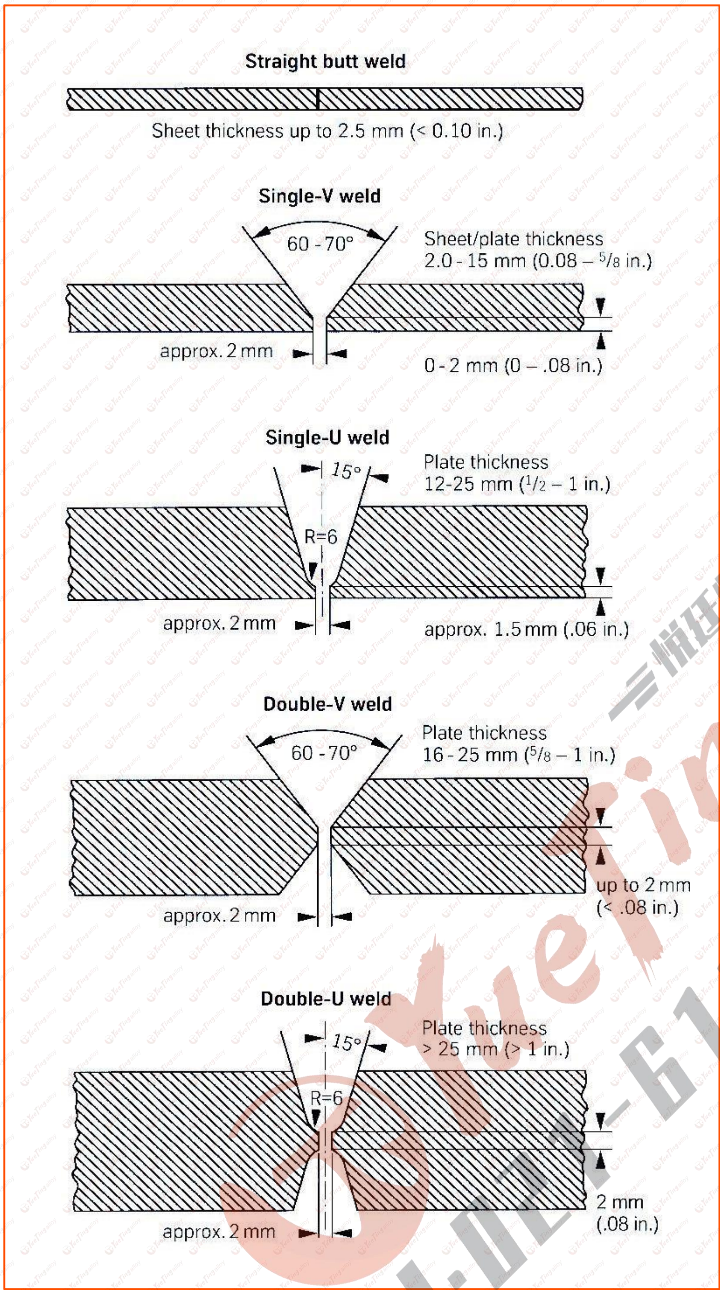

Figure 1 – Edge preparations for welding nickel alloys and special stainless steels

Cleaning

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

Welding filler

The use of the following fillers is recommended for gas-shielded welding methods:

Welding rods and wire electrodes: VDM® FM 61 (material no. 2.4155) AWS 5.14 - ERNi-1
DIN EN ISO 18274 - S Ni 2061 (NiTi3)

The use of bar electrodes in sleeves is possible.

Post-treatment

If the work is performed optimally, brushing immediately after welding, i.e. while still warm, and without additional pickling, will result in the desired surface condition. In other words, heat tint can be removed completely. Pickling, if required or specified, should generally be the last operation in the welding process. The information contained in the section entitled "Descaling and pickling" must be observed.

Heat treatments are normally not required either before or after welding. If necessary, however, a low-tension annealing can be conducted with VDM® Nickel 201 after the welding at temperatures between 550 and 650°C (1,022 and 1,202°F) with a retention time between 30 min and up to 3 hours.

Thickness	Welding process	Filler materia l		Rootpass[1]		Intermediate and final passes		Welding speed	Shielding glass	
mm (in)		Diameter mm (in)	Speed (m/min.)	I in (A)	U in (V)	I in (A)	mm (in)		Diameter mm (in)	Speed (m/min.)
3 (0.118)	Manual TIG	2.0 (0.079)		90	10	110-120	11	15	I1, R1 with max. 3% H_2	8-10
6 (0.236)	Manual TIG	2.0-2.4 (0.079-0.0945)		100-110	10	120-140	12	14-16	I1, R1 with max. 3% H_2	8-10
8 (0.315)	Manual TIG	2.4 (0.0945)		100-110	11	130-140	12	14-16	I1, R1 with max. 3% H2	8-10
10 (0.394)	Manual TIG	2.4-4.0 (0.0945-0.16)		100-110	11	130-140	12	14-16	I1, R1 with max. 3% H2	8-10
3 (0.118)	Autom.-TIG[1]	1.0 (0.039)	1.2			150	11	25	I1, R1 with max. 3% H2	12-14
5 (0.197)	Autom.-TIG[1]	1.2 (0.0472)	1.4			180	12	25	I1, R1 with max. 3% H2	12-14
2 (0.0787)	Autom. TIG HD	1.0 (0.039)				180	11	80	I1, R1 with max. 3% H2	12-14
10 (0.394)	Autom. TIG HD	1.2 (0.0472)				220	12	40	I1, R1 with max. 3% H2	12-14
4 (0.157)	Plasma[3]	1.2 (0.0472)	1	180	25			30	I1, R1 with max. 3% H2	30
6 (0.236)	Plasma[3]	1.2 (0.047)	1	200-220	26			26	I1, R1 with max. 3% H2	30
8 (0.315)	GMAW (MIG/MAG [4])	1.0 (0.039)	6-7			130-140	23-27	24-30	I1, I3—ArHe30, Z-ArHeHC30/2/0,05	18
10 (0.394)	GMAW (MIG/MAG [4])	1.2-1.6 (0.047-0.063)	6-7			130-150	23-27	25-30	I1, I3—ArHe30, Z-ArHeHC30/2/0,05	18

Information

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

[2] Autom. TIG: the root pass should be welded manually (see manual TIG parameters)

[3] Plasma: recommended plasma gas Ar 4.6 / plasma quantity 3.0-3.5 l/min

[4] GMAW (MIG/MAG): the use of multi-component shielding gases is recommended for MAG welding.

Section energy kJ/cm: autom. TIG-HD max. 6; TIG, GMAW (MIG/MAG) manual, mechanized max. 8; plasma max. 10 The values are intended as guidance to simplify the setting of welding machines.

Table 6 – Welding parameters

Availability

VDM® Nickel 200 and VDM® Nickel 201 are available in the following semi-finished forms:

Sheet/Plate

Delivery condition: hot or cold rolled, heat treated, descaled or pickled

Condition	Thickness mm	Width mm	Length mm	Piece weight kg (lb)
Cold rolled	1-7 (0.039-0.275)	≤ 2,500 (98.42)	≤ 12,500 (492)	
Hot rolled	3-20 (0.11811-0.787402)	≤ 2,500 (98.42)	≤ 12,500 (492)	≤ 2,450 (5,400)

Strip

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

Thickness mm (in)	Width mm (in)	Coil inside diameter mm (in)			
0.02-0.2 (0.000787-0.00787)	4-230 (0.157-9.06)	300 (11.8)	400 (15.7)	500 (19.7)	–
0.2-0.25 (0.00787-0.00984)	4-720 (0.157-28.3)	300 (11.8)	400 (15.7)	500 (19.7)	–
0.25-0.6 (0.00984-0.0236)	6-750 (0.236-29.5)	–	400 (15.7)	500 (19.7)	600 (23.6)
0.6-1 (0.0236 -0.0394)	8-750 (0.315-29.5)	–	400 (15.7)	500 (19.7)	600 (23.6)
1-2 (0.0394-0.0787)	15-750 (0.591-29.5)	–	400 (15.7)	500 (19.7)	600 (23.6)
2-3.5 (0.0787-0.1378)	25-750 (0.984-29.5)	–	400 (15.7)	500 (19.7)	600 (23.6)

Rolled sheet – separated from the coil – are available in lengths from 250-4,000 mm (9.84 to 157.48 in).

Rod: available as VDM Nickel 201

Delivery condition: forged, rolled, drawn, heat treated, oxidized, descaled or pickled, turned, peeled, ground or polished

Dimensions	Outside diameter mm (inch)	Length mm (inch)
General dimensions	6-800 (0.236-31.5)	1,500-12,000 (59.1 – 472)
Material specific dimensions	13-340 (0.511811-13.3858)	1,500-12,000 (59.1 – 472)

VDM® Nickel 200 is not manufactured in the rod product form

Wire

Delivery condition: drawn bright, ¼ hard to hard, bright annealed in rings, containers, on spools and headstocks

Drawn mm (in)	Hot rolled mm (in)
0.16 – 10 (0.0063-0.393701)	5.5 – 19 (0.22-0.75)

Other shapes and dimensions such as discs, rings, seamless or longitudinally welded pipes and forgings can be requested.

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