VDM Metals

A company of ACERINOX

VDM® NeutroShield
Cronifer 4696 KS

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VDM® NeutroShield is an austenitic stainless steel which is alloyed with boron. Its chemical composition is based on materials standard AISI 304 (material number 1.4301). The finely dispersed boride precipitates enable the absorption of thermal neutrons. VDM® NeutroShield can be supplied with varying boron contents of up to 2.25 % whereby the boron content determines the neutron absorption rate.

- As a stainless steel with a Cr content of over 18 %, VDM® NeutroShield has good general corrosion resistance.
- The mechanical properties are dependent on the boron content. The strength increases with increasing boron content, and the ductility decreases.

VDM® NeutroShield is a metallurgically smelted wrought alloy which complies with "Class B“ in ASTM A887.

Designations and standards

Standard	Material designation
UNS	S30460 to S30467

Product form	ASTM A
Sheet, plate	887
Strip	887

Table 1 – Designations and standards

Chemical composition

	Ni	Cr	Fe	C	Mn	Si	Co	N	P	S	B
Min.	12	18	bal.								0.2
Max.	15	20		0.08	2	0.75	0.2	0.1	0.045	0.03	2.25

Table 2 – Chemical composition (%) according to ASTM A 887

Physical properties

Density
7,8 g/cm³

Temperature		Specific heat		Thermal conductivity		Modulus of elasticity		Coefficient of thermal expansion	
°C	°F	J / kg · K	Btu / lb · °F	W / m · K	Btu · in / sq. ft · h · °F	GPa	10³ ksi	10^{-6} / K	10^{-6} / °F
20	68	499	0.119	12.5	86.7	210	30.5		
100	212	513	0.123	13.8	95.7			16.2	9
200	392	536	0.128	15.6	108.2			17	9.4
300	572	567	0.135	17.6	122.1			17.4	9.7
400	752	585	0.140	19.1	132.5			17.7	9.8
500	932	595	0.142	20.5	142.2			18	10
600	1,112	622	0.149	22.9	158.9			18.2	10.1
700	1,292	631	0.151	25.3	175.5			18.4	10.2
800	1,472	643	0.154	26	180.4			18.6	10.3

Table 3 – Typical physical properties

Metallurgical structure

VDM® NeutroShield has a face-centred cubic lattice. Boride precipitates form due to the high boron content.

Mechanical properties

The following mechanical properties apply to VDM® NeutroShield in the solution-annealed condition and in the stated semi-fabricated forms and dimensions.

Temperature		Yield strength $R_{p\,0.2}$		Tensile strength R_m		Elongation A
°C	°F	MPa	ksi	MPa	ksi	%
20	68	210	30.5	520	75.4	15
350	662	190	27.6	435	63.1	10

Table 4 – Typical short-term properties of solution-annealed VDM® NeutroShield B4 at different temperatures

Material	UNS	Type	Boron content	Yield strength $R_{p\,0,2}$ MPa	Tensile strength R_m MPa	Elongation A %	Hardness, max	
							Brinell	Rockwell B
VDM® NeutroShield B	S30460	304B	0,20-0,29	205	515	40	201	92
VDM® NeutroShield B1	S30461	304B1	0,30-0,49	205	515	35	201	92
VDM® NeutroShield B2	S30462	304B2	0,50-0,74	205	515	27	201	92
VDM® NeutroShield B3	S30463	304B3	0,75-0,99	205	515	19	201	92
VDM® NeutroShield B4	S30464	304B4	1,00-1,24	205	515	16	217	95
VDM® NeutroShield B5	S30465	304B5	1,25-1,49	205	515	13	217	95
VDM® NeutroShield B6	S30466	304B6	1,5-1,74	205	515	9	241	100
VDM® NeutroShield B7	S30467	304B7	1,75-2,25	205	515	6	241	100

Table 5 – Mechanical properties of the different material variations in acc. w. ASTM A 887

Corrosion resistance

VDM® NeutroShield has approximately the same corrosion resistance of stainless steel type 304 (1.4301).

Applications

VDM® NeutroShield is used in the nuclear industry for

- containers for the transport and storage of fuel elements,
- Use in storage ponds for fuel elements,
- control rods and
- other applications in which the absorption of thermal neutrons plays an important role.

Fabrication and heat treatment

VDM® NeutroShield can be hot or cold-formed and can be machined.

Heating
Workpieces must be clean and free of any contaminants before and during heat treatment. Sulphur, phosphor, lead and other low-melting-point metals can lead to damage when heat-treating VDM® NeutroShield. This type of contamination is also contained in marking and temperature display paints or crayons, and also in lubricating grease, oils, fuels and similar materials.

Heat treatment can basically be carried out with gas, oil or electrically heated equipment and in atmospheres of air, protective gas or vacuum. Fuels should contain as little sulphur as possible. Natural gas with less than 0.1 % and heating oil with maximum 0.5 % sulphur are suitable if a slightly oxidising furnace atmosphere is set. Reducing or changing conditions should be avoided. Direct flame impingement needs to be avoided. Please ensure that temperature control is precise.

Hot working
VDM® NeutroShield can be hot-worked in a temperature range of between 1,150 and 950 °C (2,102 and 1,742 °F) with subsequent rapid cooling down in water or by using air nozzles. In order to heat up, the workpieces should be placed in the furnace heated up to hot working temperature. Once the temperature has equalised, the workpieces can be removed and worked within 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.

Cold working
Cold working should take place in a solution-annealed condition. VDM® NeutroShield has a lower ductility than austenitic stainless steels depending on its boron content. For this reason, surfaces should be sufficiently smooth in order to prevent surface cracking. Intermediate annealing is necessary for major cold working treatment. Heat treatment is recommended before use of the workpiece after cold working.

Heat treatment
The material must be placed in a furnace which has been heated up to the annealing temperature before any heat treatment. The cleanliness requirements listed under "Heating" must be observed. VDM® NeutroShield is solution-annealed in a temperature range of between 1,040 and 1,100 °C (1,904 and 2,012 °F) with subsequent rapid cooling.

The retention time during annealing depends on the semi-finished product/workpiece thickness and can be calculated as follows:

- For thicknesses d <= 10 mm the retention time is $t = d \cdot 3$ min/mm
- For thicknesses d = 10 to 20 mm the retention time is $t = 30 \text{ min} + (d - 10 \text{ mm}) \cdot 2$ min/mm

Descaling and pickling
Pickling of VDM® NeutroShield can take place with the same pastes or baths as for other stainless steels of type 304. Ten percent nitric acid with 2 % hydrofluoric acid are suitable for pickling, as is diluted nitric acid for passivating. Due to the boride precipitates in this material, VDM® NeutroShield tends to over-pickle quicker than boron-free stainless steel.

Availability

VDM® NeutroShield is available in the following standard semi-finished product forms:

Sheet and plate
Delivery condition:

Condition	Thickness mm (in)	Width mm (in)	Length mm (in)	Piece weight Kg (lb)
Hot-rolled	2-20 (0.08-0.8)	17-1,000 (0.7-39.4)	1.000-5.000 (39.4-196.9)	< 500 (< 227)

Legal notice

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