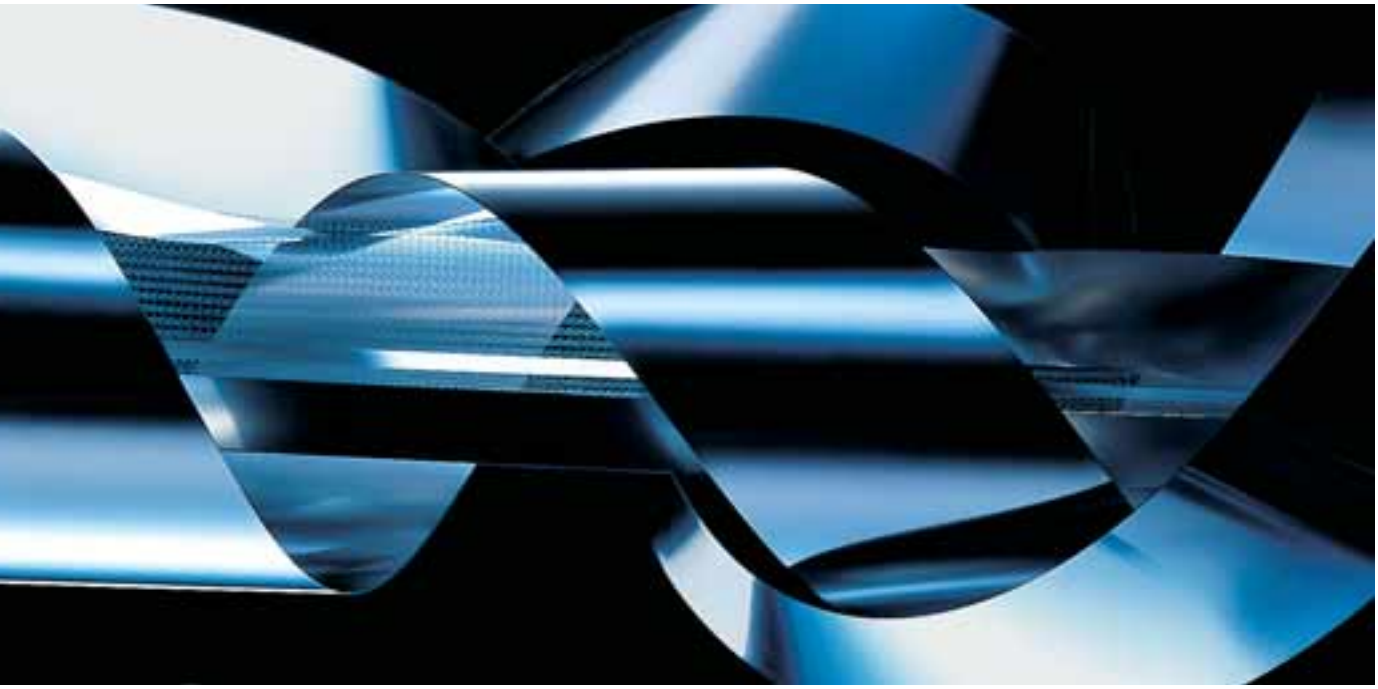
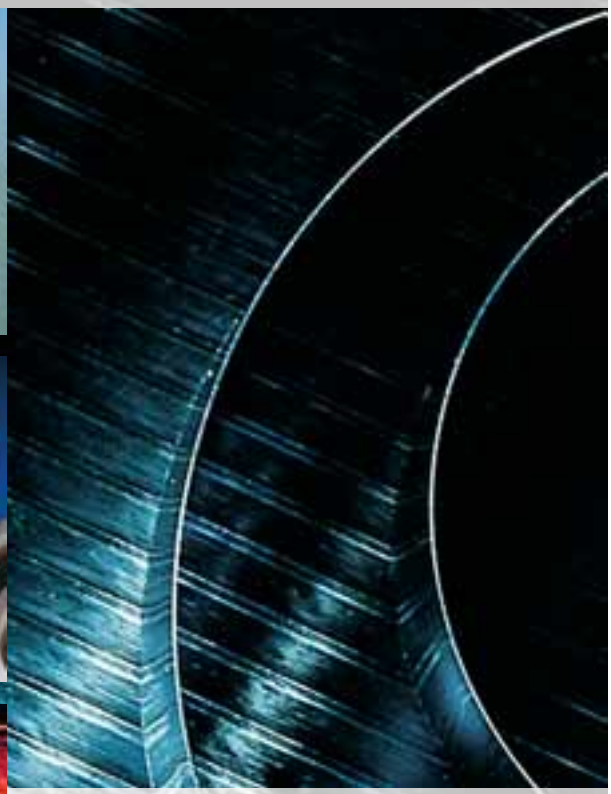
Strip from ThyssenKrupp VDM.
Quality by the meter.



A company of
ThyssenKrupp
Stainless

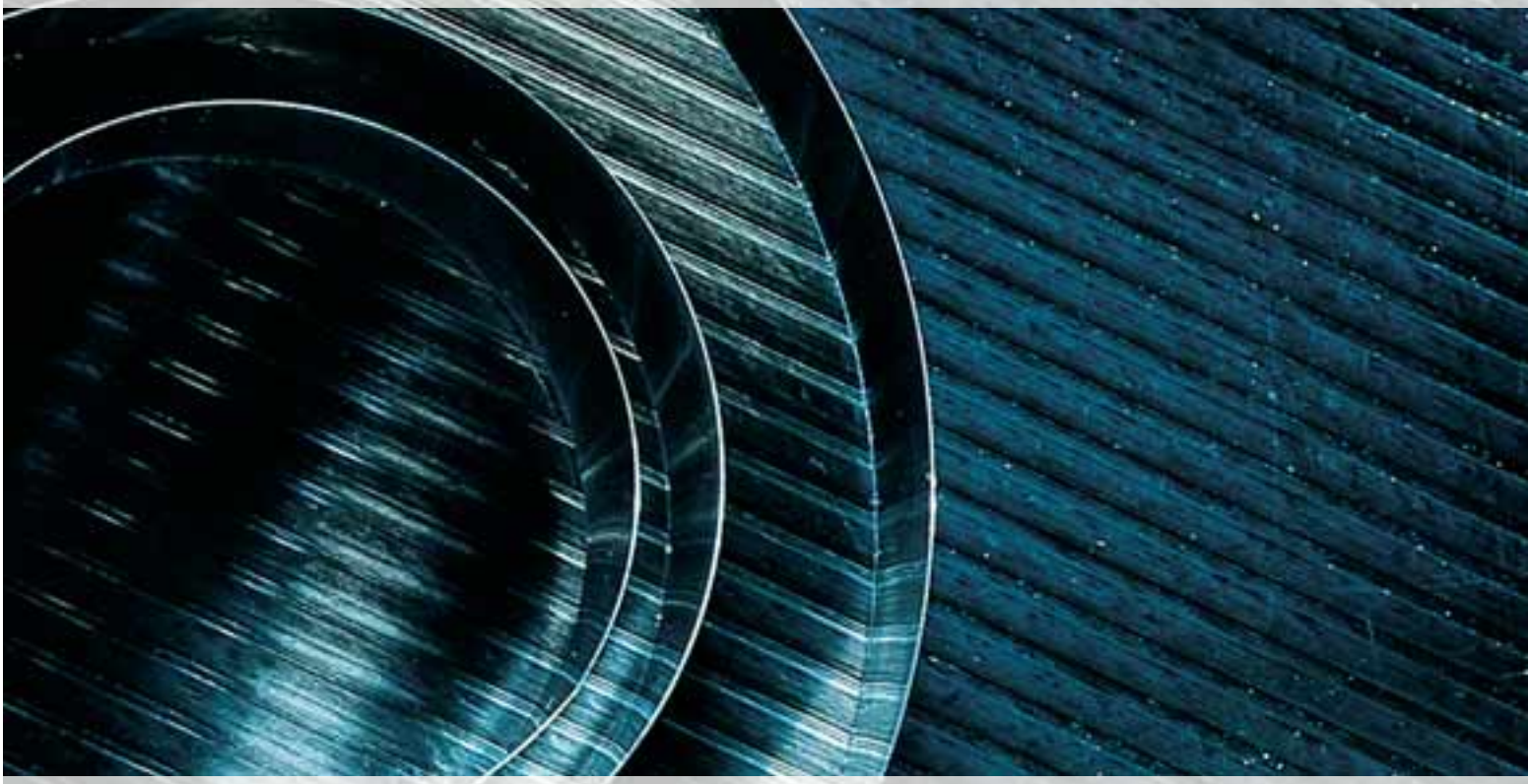
ThyssenKrupp VDM

ThyssenKrupp



Our target markets are electronics and electrical systems, transportation, industrial engineering and aerospace.

Contents.



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ThyssenKrupp VDM.
A high-performance enterprise.

Top:
One of the showpieces of the Werdohl works: the new 20-roll foil rolling stand.

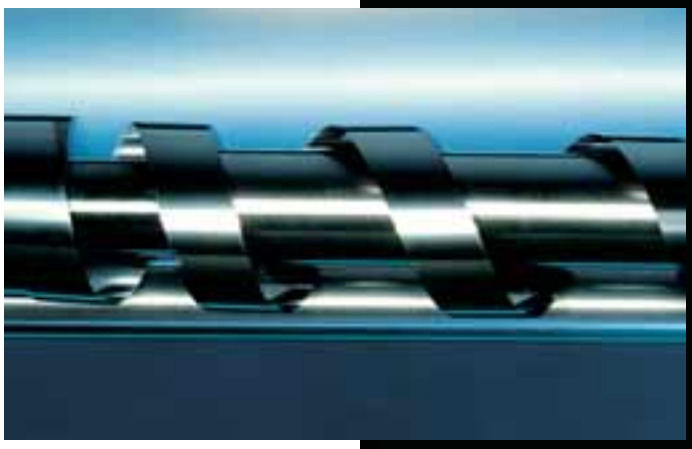
Bottom:
New precision slitting shears with modern CNC cutters and vacuum brake rolls.

ThyssenKrupp VDM GmbH, a company of ThyssenKrupp Stainless in Duisburg, has developed high-performance materials for especially demanding applications and processes for many decades. In this field, ThyssenKrupp VDM is now one of the leading producers of nickel-base alloys and high-alloy special materials. Its production programme includes strip, foil, sheet, plate, rod, bar, forgings, wire and material for tube and pipe production, as well as magnetic core technology products.

The company is based in Werdohl and has further production facilities in Altena, Siegen, Unna and Werdohl-Bärenstein. It has a division in the U.S.A. named Precision Rolled Products, Inc., which produces high-temperature, high-strength materials for the aerospace industry at plants in Reno and Florham Park. The six ThyssenKrupp VDM plants with their worldwide sales organization and the plants of Precision Rolled Products together employ over 1,900 people. To ensure optimum cooperation with its customers in the electrical and electronics industries, the automobile industry, the aerospace industry and the industrial engineering sector, ThyssenKrupp VDM has built up a worldwide network of advisory and sales offices, sales companies, representatives and authorized stockholders and distributors.

For intermediate annealing and for final heat treatment to establish defined material properties, the Werdohl works is equipped with continuous bright annealing furnaces with a 100% hydrogen atmosphere and a maximum annealing temperature of 1180 °C.

Precision grinding unit for processing pickled and roughed hot strip material; this is the last preliminary stage for the downstream cold rolling process.



ThyssenKrupp VDM has increased its production volume considerably in only a few years and has greatly improved its position in the nickel-base alloys market. The Strip Division in Werdohl is a major contributor to this growth.

ThyssenKrupp VDM.
The company at a glance.

ThyssenKrupp VDM GmbH,
Head office Werdohl

Our divisions
- Strip, Werdohl
- Wire, Werdohl-Bärenstein
- Plate and Sheet, Altena and Siegen
- Bar and Forgings, Altena
  Precision Rolled Products, Inc.,
  Florham Park, N.J. and Reno, Nevada/USA
- Melting and Casting, Unna
- Semis and Systems, Frankfurt

supply alloys and products
- High-performance materials
  Nickel- and cobalt-base materials
  Specialty alloys
- Magnetic core technology products

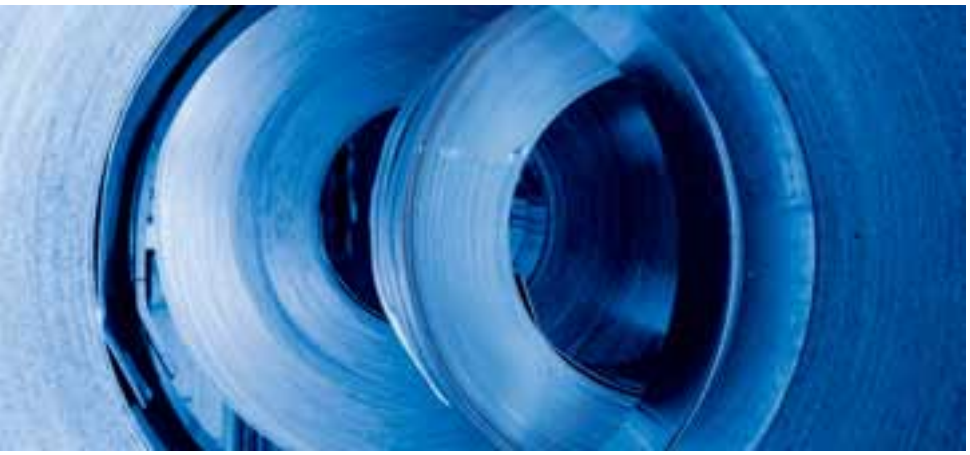
for the markets of tomorrow.

Our goals are
- Rigorous translation of customers' requirements into products and applications
- Improvement of our leadership on the European market
- A further improvement of our leading position worldwide among the producers of nickel-base alloys

The Strip Division.
Quality and innovation by the meter.

Up to 2,000 tonnes of materials, manufactured with high precision, leave ThyssenKrupp VDM's Strip Division in Werdohl every month. The keys to this success are a skilled workforce and the quality of our products – and not only these but also the company's willingness to innovate and customer relations which are geared to long-term cooperation. Last but not least, the growing demand for intelligent material concepts is an important factor.

The Werdohl works produces high-alloy materials with special magnetic, physical and electronic properties which are notable for their low rates of thermal expansion and high resistance to corrosion. The product range comprises wide and narrow strip, foils and coil sheets. Highly modern equipment guarantees surfaces of outstanding quality and a consistently high level of production.



Every month, 50 to 60 different alloys are processed in the Werdohl works and shipped to customers in the form of strip, coil sheets or foil.

Stopping points on the route from ingot to finished strip are Unna, Duisburg, Bochum and Werdohl. The ingots and slabs cast at the Unna melting works first pass through ThyssenKrupp Stahl's slab rolling mill in Duisburg. They are then dressed and hot-rolled on the ThyssenKrupp Nirosta hot wide strip mill in Bochum. The resulting hot strip is then transferred to Werdohl and is sand-blasted, pickled and, if necessary, also polished on the pickling line there, which has been radically modernised.

All the nickel-base and special alloys can be rolled to their final dimensions on various cold rolling lines. The strip thickness varies between 0.02 mm and 3.5 mm; the maximum strip width is 800 mm. The showpiece of the Werdohl works is the new 20-roll foil rolling mill, which is designed to produce strip widths of 350 - 750 mm and strip thicknesses of max. 1.00 mm down to 0.02 mm in coils weighing up to 9,000 kg. It is the most modern rolling stand anywhere in Europe for nickel-base and special alloys of this kind.

An ESR unit and a VAR facility are operating at the Unna works. In a further step, VIM technology was introduced in 2003. Whis this, ThyssenKrupp VDM has an integrated melting works for nickel-base alloys which is able to produce ultra-clean alloys with an extremely uniform matrix by removing non-metallic inclusions. Alloys of this kind are in demand in the aerospace and electronics industries.

A comprehensive in-production quality assurance system ensures that our customers' requirements are perfectly translated into production and products.

Left:
The 6-roll precision reversing mill is capable of producing narrow strip with extremely tight dimensional tolerances.

Above:
Soft-magnetic nickel-iron alloys are used in stepping motors of analogue quartz clocks and watches with yoke and armature.

The Strip Divison at a glance.

Our materials
- Corrosion-resistant, heat-resistant and high-temperature nickel- and cobalt-base alloys and high-alloy special stainless steels
- Catalytic converter support alloys
- Shadow mask and frame alloys
- Heating element and resistance alloys
- Controlled expansion and glass sealing alloys
- Soft magnetic alloys
- Shielding alloys
- Welding filler metals

and products
- Strip and foil thicknesses from 0.02 mm to 3.5 mm
- Coil sheets up to 4000 mm in length
- Slit strip
- Magnetic core technology components

are geared to the target markets:

Electrical industry
Heating element and resistance strip, starting and braking resistors, current lead-ins, contact plates, strip for tubular heaters

Electronics
Core plates for transformers and modems, toroidal tape-wound cores, magnetic core technology components, strip for glass sealing applications, lead frames, anode buttons, electromagnetic shielding devices, shadow mask and frame assemblies

Automotive industry
Catalytic converter support foils, exhaust manifolds, decouplers, diesel engine preheat plugs, airbags and fuel cells

Industrial engineering
Strip for longitudinally welded tubes and pipes, plate-type heat exchangers, overlay welding and flux-cored electrodes

Aerospace
Honeycombs, deflector shields and fasteners

In high-quality clocks employing magnet technology, soft magnetic Magnifer alloys are an essential material for the movement.

Our manufacturing know-how

- Production of the starting material in our own melting plant with electric arc, induction and vacuum induction furnaces, vacuum treatment; ESR unit (electro-slag remelting technology) and VAR (vacuum arc remelting) unit for production of ultra-clean alloys
- Bell-type and continuous annealing units with a protective gas atmosphere for establishing the mechanical and physical properties
- Pickling and grinding facilities for achieving defined surface conditions
- Four-high rolling mills, Sendzimir 20-roll mill, 20-roll foil mill and 6-roll precision reversing mill for very tight dimensional tolerances

in conjunction with our development laboratories

- Corrosion laboratory, high-temperature laboratory, welding laboratory, metallography laboratory with scanning electron microscopy, physics and metallurgy laboratory
- Technical laboratory with experimental facilities

With the new VIM, ESR and VAR units in Unna, ThyssenKrupp VDM has an integrated melting works for nickel-base alloys.

and our customer services

- Tailor-made individual materials solutions and delivery forms
- Process development and process optimization for specific quality requirements and approvals
- On-site application engineering advice
- Worldwide sales and marketing organization
- Participation in trade fairs, symposia and conventions
- Supply of technical literature, textbooks, data sheets, safety data sheets and our customer magazine

enable tailor-made solutions for processes and products.

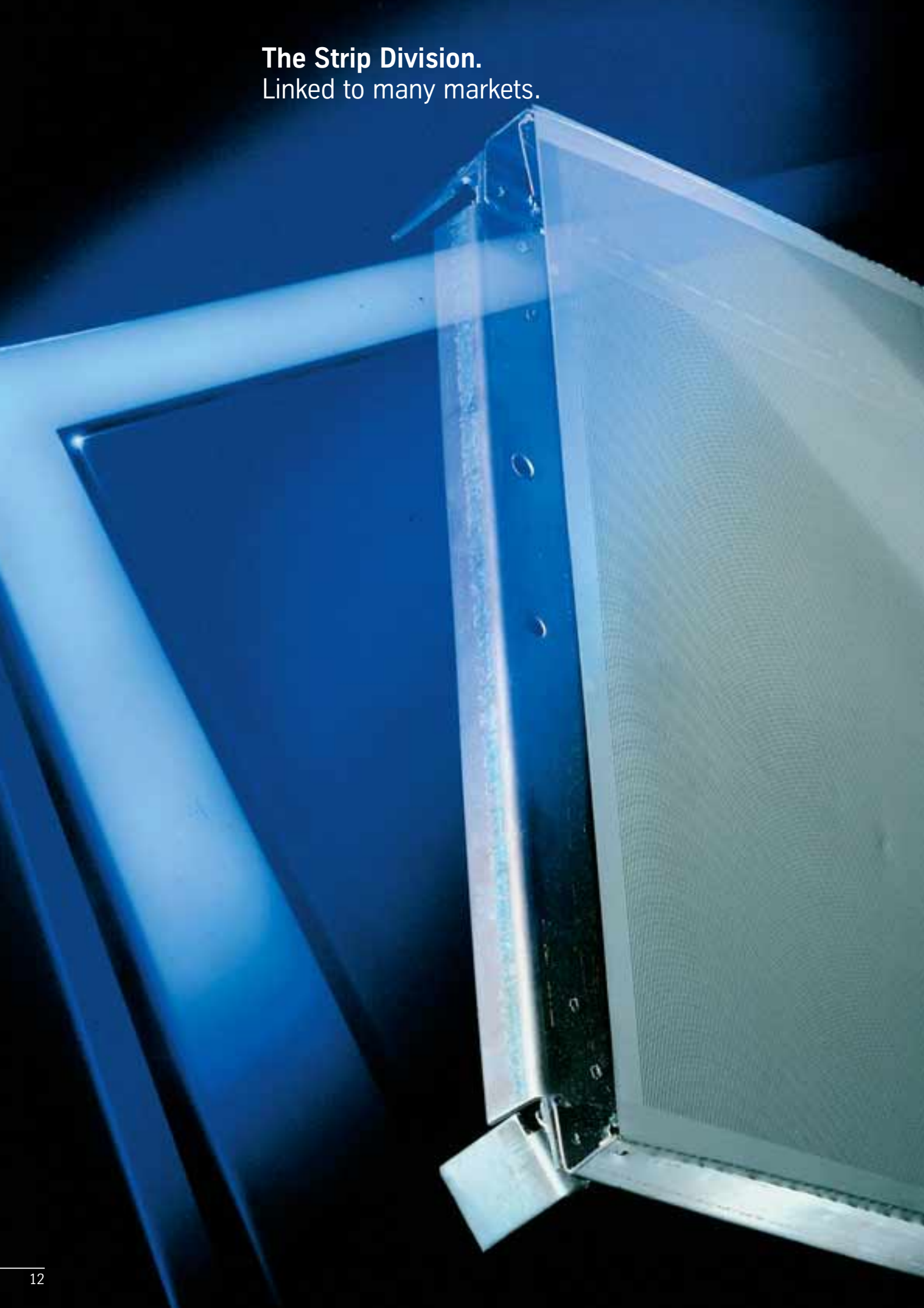
The Strip Division's considerable potential with regard to materials and development

- Development of new and improved materials and material concepts in close cooperation with the user
- Testing of the corrosion performance and heat resistance of alloy and structural components in its own high-temperature and corrosion laboratories
- Establishment of special physical properties
- Development of alloy variants within given standards for special applications
- Process development

strengthens its position as an expert partner for industry.

Top:
In the Chemical Laboratory, extremely low trace element contents of alloys can be measured by means of the atomic absorption spectrometer.

Bottom:
Extensive modernization work was undertaken to bring the Achenbach I roughing stand right up-to-date.



The Strip Division.
Linked to many markets.

Electrical systems and electronics
One of the most important markets for strip is the electrical and electronics industry. Demand for larger television screens, for instance, has increased significantly in recent years in both the private and the commercial sphere, mainly because of the high level of exclusivity and luxury that they convey.

With Pernifer 36 nMn, we have developed a material whose low coefficient of expansion permits brilliant picture quality even in very large CRTs. To maintain the geometry of the screen even under exposure to high levels of heat, Pernifer 42 TVR is used for the frame.

Lead frames made of Pernifer 40 and 41 LC are a favourite base material for microchips. In the suppression of electromagnetic fields and in analogue to digital signal conversion, it is chiefly our Magnifer alloys which provide efficient protective screening and transmission in computer disk drives, modems, telephone answering machines, monitor screen housings and measuring instruments.

For ceran hotplates, narrow strip made of ferritic Aluchrom alloys is the favoured choice.

Left:
Frame for shadow masks under tension in flat widescreen colour TV sets, made of the iron-nickel alloy Pernifer 42 TVR.

Far right:
Stamped parts and shielding housings for magnetic heads are primarily made of Magnifer 8105.

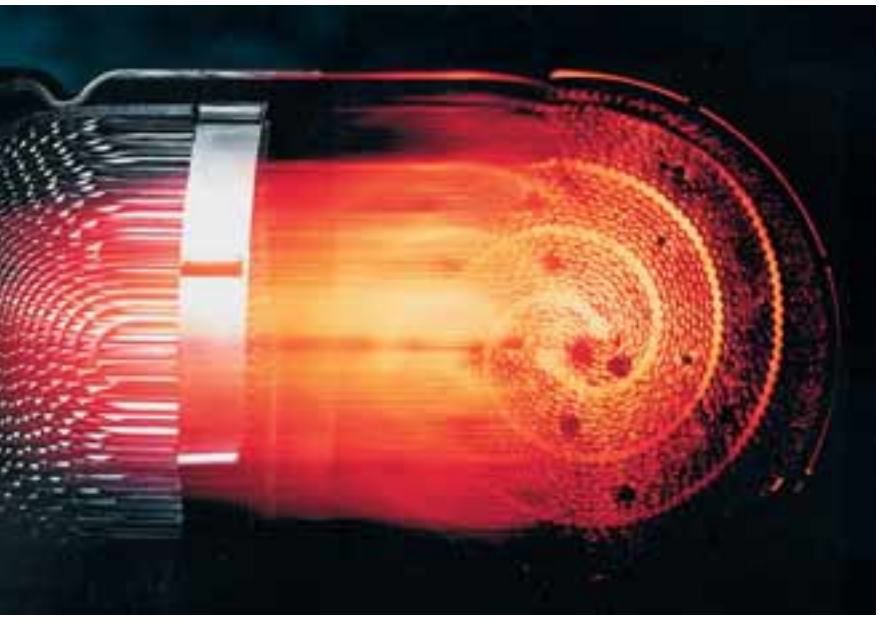
Right:
Perforated shadow masks made of Pernifer 36 nMn ensure a consistently good TV picture quality.

Transportation
If it's a question of movement, ThyssenKrupp VDM strip plays a very wide range of roles. In the automotive industry, for instance: here, ThyssenKrupp VDM material developments create the preconditions for environmentally safer vehicles.

New concepts in the field of catalytic converters will be necessary to meet future exhaust emission standards. For instance, the newly developed alloy Aluchrom YHf enables the catalyst to heat up ("trigger") more quickly thanks to the low foil thickness of only 30 µm, with no loss of converter service life. Using it, the SULEV and EURO LEVEL IV standards scheduled for introduction in 2003 and 2005 can, in fact, be met today.

Our strip products are used in other branches of automotive engineering, too. In decouplers, for instance, strip made of Nicrofer 6020 hMo – alloy 625 and Nicrofer 3220 H – alloy 800 H effectively protect the exhaust system from engine vibrations. And in diesel engine preheat plugs and exhaust manifolds, Nicrofer 6023 H – alloy 601 H and Nicrofer 6025 HT – alloy 602 CA provide resistance to hot combustion gases. Fuel cells, too, present no difficulties for our special alloys.

The specific electrical and physical properties of our resistance alloys and their excellent oxidation resistance make them the first choice for the start-up and brake resistance systems of electrically powered rail vehicles.



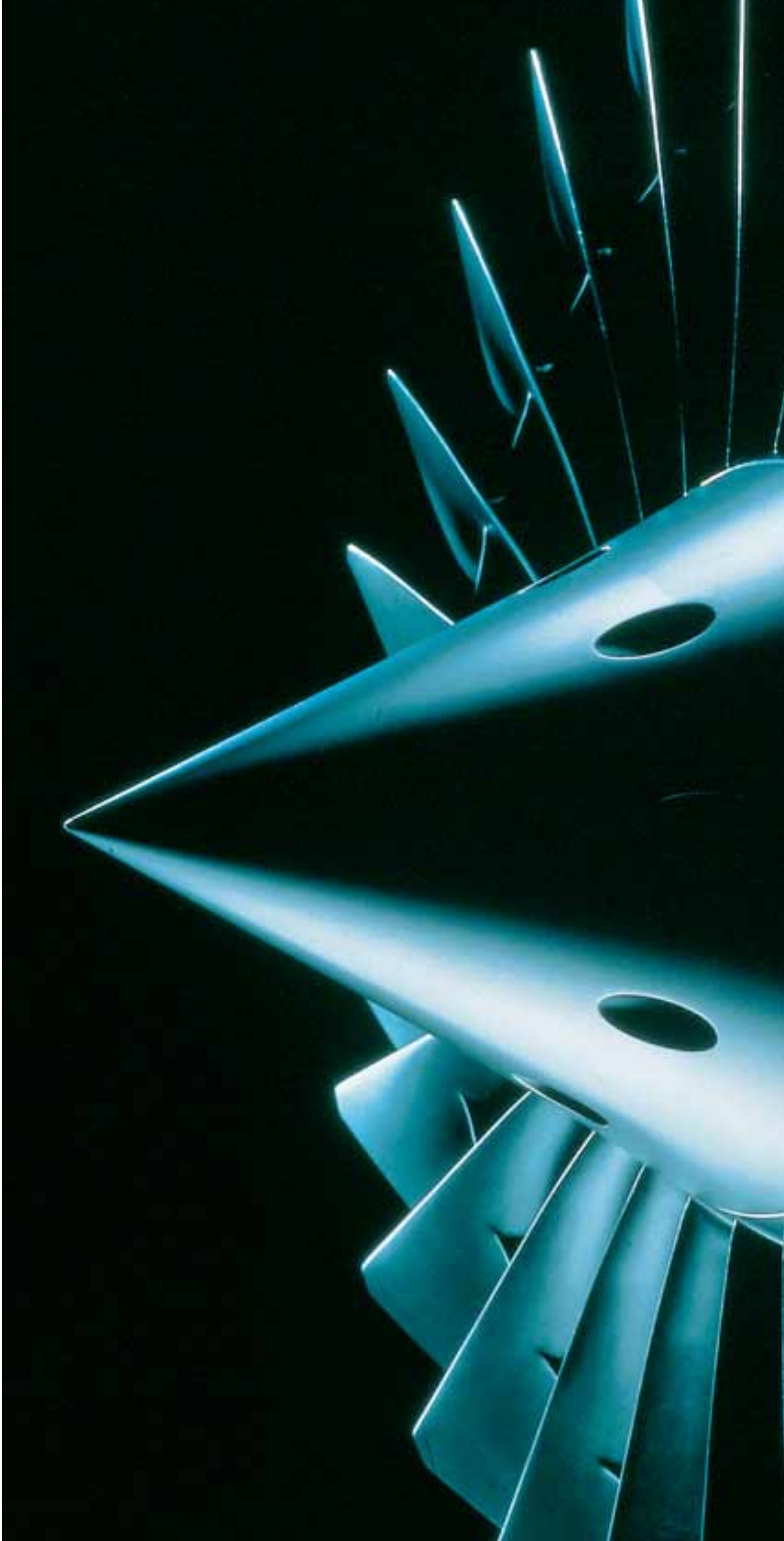
A feature of extremely low-emission motor vehicles is their use of metallic catalytic converters. These are made from ultra-thin Aluchrom foil which was specially developed for this application.

Nickel-base alloys with good high-temperature strength and creep strength are optimum materials for decouplers in high-performance engines.

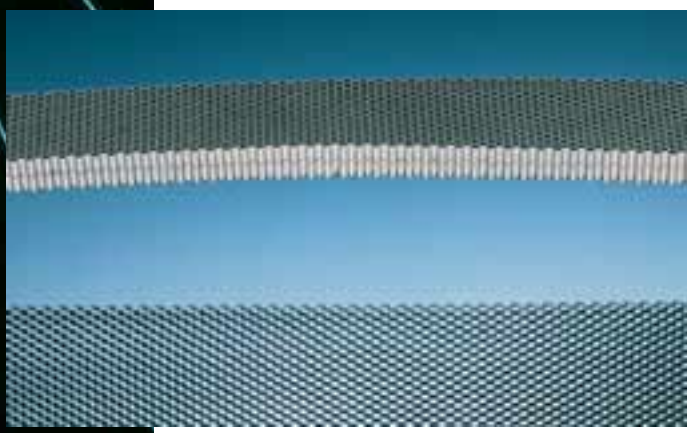
Industrial engineering
In the industrial engineering field, our Strip Division produces the input material needed to make welded pipes and tubes. Our high-temperature nickel/chromium alloys and our corrosion-resistant nickel/chromium/molybdenum alloys are used wherever plant and system components are exposed to aggressive fluids and corrosive processes: in the chemical, pharmaceutical, oil and gas industries and in the offshore sector. In these fields they are a vital component of production piping systems, and of underwater lines, terminal distribution systems, pipelines and plate-type heat exchangers. Here again, therefore, our products play leading roles.

Top:
Longitudinally welded tubes used as heat exchangers in the lignite-fired power station at Schkopau in eastern Germany were fabricated from strip made of the corrosion-resistant nickel-base alloy Nicrofer 5923 hMo – alloy 59.

Bottom:
Development of new alloys and optimization of existing material concepts is undertaken in laboratories, but always in close cooperation with Marketing, Sales, Production and the customer.



Aerospace
Whether it's a question of getting business travellers and tourists to their destination safely or exploring the outer reaches of space: in aerospace, safety is always the first consideration. The same naturally applies to the quality of the materials used, as flaws in safety-critical components are unpardonable. Our alloys' high level of oxide cleanness, extremely uniform surfaces and tight tolerances make them ideally suitable for use in aerospace applications, such as engines and fuel tanks. You could say that we quite simply take the principle of high-level performance quite literally.



For non-rotating components of aircraft turbines – sealing elements or so-called "honeycombs", for instance – ThyssenKrupp VDM supplies strip made of high-temperature, high-strength superalloys.

Availability.

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

Thickness	Width[3]	Coil i. d.
mm	mm	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	5 - 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.

Notes for use.

The material tables on the following pages are intended to be an aid to decision-making when selecting materials for specific applications in electronics, electrical engineering, transportation engineering, industrial engineering and in the aerospace industry. When an order is placed, the specifications and standards used as a basis become an integral part of the contract.

Standards comparisons by DIN “Werkstoff-Nummern” (material numbers) and UNS designations are shown on pages 76-77.

Specifications and designations
The materials are available in conformity with the standards indicated. Where a standard is shown in brackets, this indicates that the VDM data do not conform to the data in the standard in all respects.

Chemical composition
If the word “balance” is shown against an element in an analysis, it means that this element is the predominant element in the alloy. As well as the principal constituents, small quantities of other elements may be present.

Mechanical properties
The stated mechanical properties are typical data for the alloy in question, except in cases where they are labelled as minima or maxima. Figures in brackets apply to other mill products and only serve as a guide in the case of strip.
Comprehensive information is given in the individual Material Data Sheets, which will be sent to you on request.

Creep properties
The stated creep performance data are mean values of the scatter band recorded to date. The minima lie approximately 20% below these values.

The materials summarized.

ThyssenKrupp VDM alloy	Material No.	UNS designation	Page
Corrosion-resistant materials			
LC-Nickel 99.2 – alloy 201/205	2.4068	N02201	24
		(N02205)	24
Nickel 99.6 K – alloy 233	(2.4060)	N02233	24
Nickel 99.6 Rö C2	(2.4060)	N02200	25
Nickel 99.2 – alloy 200	2.4066	N02200	25
Nicorros – alloy 400	2.4360	N04400	26
NiCr 8020	(2.4891)	–	27
	(2.4639)		
NiCr 9010	(2.4999)	–	27
Nicrofer 3033 – alloy 33	1.4591	R20033	28
Nicrofer 3127 LC – alloy 28	1.4563	N08028	29
Nicrofer 3127 hMo	1.4562	N08031	29
Nicrofer 3620 Nb – alloy 20	2.4660	N08020	30
Nicrofer 4221 – alloy 825	2.4858	N 08825	30
Nicrofer 4823 hMo – alloy G-3	2.4619	N06985	31
Nicrofer 5219 Nb – alloy 718	2.4668	N07718	31
Nicrofer 5621 hMoW – alloy 22	2.4602	N06022	32
Nicrofer 5716 hMoW – alloy C-276	2.4819	N10276	32
Nicrofer 5923 hMo – alloy 59	2.4605	N06059	33
Nicrofer 6020 hMo – alloy 625	2.4856	N06625	33
Nicrofer 6616 hMo – alloy C-4	2.4610	N06455	34
Nicrofer 7216 LC – alloy 600 L	2.4817	N06600	34
Nimofer 6928 – alloy B-2	2.4617	N10665	35
Cronifer 1809 Ti – alloy 321	1.4541	S32100	36
Cronifer 1810 Ti – alloy 316 Ti	1.4571	S31635	36
Cronifer 1811 LC – alloy 305	1.4303	S30500	37
Cronifer 1925 LC – alloy 904 L	1.4539	N08904	38
Cronifer 1925 hMo – alloy 926	1.4529	N08926	38

ThyssenKrupp VDM alloy	Material No.	UNS designation	Page
Heat-resistant materials			
Crofer 22 APU	(1.4770)	–	40
Cronifer 1525 Ti – alloy 286	1.4980	S66286	40
Nicrofer 2020 – alloy 840	1.4847	–	41
Nicrofer 3220 – alloy 800	1.4876	N08800	41
Nicrofer 3718 So – alloy DS	1.4862	–	42
Nicrofer 6023 – alloy 601	2.4851	N06601	42
Nicrofer 7216 – alloy 600	2.4816	N06600	43
Nicrofer 7520 – alloy 75	2.4951	N06075	43
High-temperature materials			
Nicrofer 3220 H – alloy 800 H	1.4958	N08810	44
Nicrofer 6023 H – alloy 601 H	2.4851	N06601	44
Nicrofer 6025 HT – alloy 602 CA	2.4633	N06025	45
Nicrofer 7216 H – alloy 600 H	2.4816	N06600	45
Superalloys			
Nicrofer 4722 Co – alloy X	2.4665	N06002	46
Nicrofer 5120 CoTi – alloy C-263	2.4650	N07263	46
Nicrofer 5219 Nb – alloy 718	2.4668	N07718	47
Nicrofer 5520 Co – alloy 617	2.4663	N06617	47
Nicrofer 7016 TiNb – alloy X-750	2.4669	N07750	48
Nicrofer 7520 Ti – alloy 80 A	2.4952	N07080	48
Conicro 4023 W – alloy 188	2.4683	R30188	49

ThyssenKrupp VDM alloy	Material No.	UNS designation	Page
Heating element and resistance alloys			
Cronix 80	2.4869	N06003	50
Cronix 70	2.4658	N06008	50
Cronifer II	2.4867	N06004	51
Cronifer 45	2.4890	–	51
Cronifer III	1.4860	–	52
Aluchrom Y	1.4767	–	52
Aluchrom YHf	1.4767	–	53
Aluchrom W	1.4725	K91670	53
Konstantan	2.0842	C72150	54
Controlled expansion and glass sealing alloys			
Pernifer 1407	1.3930	–	56
Pernifer 2002	1.3933	–	56
Pernifer 2006	1.3932	–	57
Pernifer 2203	1.3942	–	57
Pernifer 2508	1.3902	–	58
Pernifer 2918	1.3981	K94610	58
Pernifer 36 – alloy 36	1.3912	K93600	59
Pernifer 39	1.3913	–	59
Pernifer 40 – alloy 42	1.3917	K94000	60
Pernifer 42	1.3917	K94100	60
Pernifer 42 Ti	(1.3917)	–	61
Pernifer 42 TVR	(1.3917)	–	61
Pernifer 42 TiNb	–	–	62
Pernifer 4205 Ti	–	N09902	62
Pernifer 4206	1.3946	K94750	63
Pernifer 46 – alloy 46	1.3920	–	63
Pernifer 4706	2.4486	–	64
Pernifer 48 – alloy 48	1.3922	K94800	64

ThyssenKrupp VDM alloy	Material No.	UNS designation	Page
Controlled expansion and glass sealing alloys			
Pernifer 50 – alloy 52	2.4478	N14052	65
Pernifer 51 – alloy 51	2.4475	–	65
Pernifer 5101	2.4480	–	66
Pernima 72	(2.6305) (1.3999)	M27200	66
Soft magnetic alloys			
Magnifer 36	1.3910	–	68
Magnifer 50	1.3922	K94840	68
Magnifer 53	2.4420	–	69
Magnifer 75	2.4501	N14076	69
Magnifer 77 TiNb	–	–	70
Magnifer 7904	2.4545	N14080	70
Magnifer 8105	–	–	71
Welding filler metals			
Nicorros B 6530 – WS 60	2.4377	(N04060)	72
Nicrofer B 7020 – WS 82	2.4806	(N06082)	73
Nicrofer B 6616 – WS C-4	2.4611	(N06455)	73
Nicrofer B 6020 – WS 625	2.4831	(N06625)	74
Nicrofer B 5923 – WS 59	2.4607	(N06059)	74
Nicrofer B 5716 – WS C-276	2.4886	(N10276)	75
Nicrofer B 6928 – WS B-2	2.4615	(N10665)	75

Corrosion-resistant materials

Nickel

ThyssenKrupp VDM alloy		LC-Nickel 99.2 – alloy 201/205		Nickel 99.6 K – alloy 233	
Specification					
D	Material No.	2.4068		(2.4060)	
	Designation	LC-Ni 99		–	
	DIN	17740/17750		(17740/17750)	
	VdTÜV Material Data Sheet	345		–	
F	AFNOR	–		–	
GB	BS	3073		3073	
	Type	NA 12		NA 12	
USA	UNS	N02201	(N02205)	N02233	
	ASTM	B 162	(F3)	B 162 + F 3	
	ASME	–		–	
	AMS	5553		–	

Chemical composition (% by weight)		
Nickel (+Cobalt)	min. 99.0	min. 99.6
Copper	max. 0.2	max. 0.2
Iron	max. 0.4	max. 0.4
Carbon	max. 0.,02	max. 0.01
Manganese	max. 0.3	max. 0.3
Silicon	max. 0.1	max. 0.1
Magnesium	max. 0.05	max. 0.05

Mechanical data (N/mm², %)

Temperature (°C)	Rp 0.2	Rp 1.0	Rm	A_5	A_{50}	Rp 0.2	Rp 1.0	Rm	A_5	A_{50}
20 (stress-relieved)	–	–	–	–	–	–	–	–	–	–
20 (annealed)	≥ 80	≥ 105	≥ 345	≥ 40	≥ 30	≥ 100	≥ 105	≥ 380	≥ 40	≥ 30
100	≥ 70	≥ 95	290	40	–	70	95	–	–	–
200	≥ 65	≥ 90	275	40	–	65	90	–	–	–
300	≥ 60	≥ 85	260	45	–	60	85	–	–	–
400	≥ 55	≥ 80	240	55	–	55	80	–	–	–
500	≥ 50	≥ 75	210	60	–	–	–	–	–	–
600	≥ 40	≥ 65	150	75	–	–	–	–	–	–
700	–	–	–	–	–	–	–	–	–	–
800	–	–	–	–	–	–	–	–	–	–
900	–	–	–	–	–	–	–	–	–	–
1000	–	–	–	–	–	–	–	–	–	–

Creep properties (N/mm²)

Temperature (°C)	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5
300	110	260	95	238	–	–	–	–
400	75	159	60	148	–	–	–	–
500	35	85	23	55	–	–	–	–
600	10	45	6	25	–	–	–	–
650	7	33	3	19	–	–	–	–

Physical properties at room temperature

Density	(g/cm³)	8.9					8.9			
Specific heat	(J/kgK)	456					456			
Thermal conductivity	(W/mK)	79					79			
Resistivity	(µΩ cm)	8.5					9.5			
Modulus of elasticity	(kN/mm²)	207					208			
Coefficient of thermal expansion from 20 °C to		100	200	300	400	500	100	200	300	400	500
	(10^{-6}/K)	13.3	13.9	14.3	14.8	15.2	13.4	14.0	14.5	14.8	15.2

Working		
Melting temperature (°C)	1445	1445
Max. working temperature (°C)	~ 600	–
Workability	very good	very good
Weldability	good	good

Material properties		
	Good mechanical properties, thermal conductivity and corrosion resistance. Good magnetic properties and electrical conductivity.	"Cathode nickel" owing to tightly restricted element contents.

Typical applications		
	Electrolysis plants, electrical and electronic components, incandescent lamp bases. Caustic soda evaporators at temperatures > 300 °C; production of man-made fibres.	Electron tubes, metal mesh for batteries, gas turbines, heat exchangers; production, processing and storage of caustic soda, vinyl chloride monomer (VDM). Processing of foodstuffs.

ThyssenKrupp VDM alloy		Nickel 99.6 Rö C2	Nickel 99.2 – alloy 200
Specification			
D	Material No.	(2.4060)	2.4066
	Designation	–	Ni 99.2
	DIN	17740/17750	17740/17750
	VdTÜV Material Data Sheet	–	–
F	AFNOR	–	–
GB	BS	3073	3073
	Type	NA 11	NA 11
USA	UNS	N02200	N02200
	ASTM	B 162	B 162
	ASME	–	–
	AMS	–	–

Chemical composition (% by weight)		
Nickel (+Cobalt)	min. 99.6	min. 99.2
Copper	max. 0.1	max. 0.25
Iron	max. 0.2	max. 0.4
Carbon	max. 0.03	max. 0.1
Manganese	max. 0.3	max. 0.3
Silicon	max. 0.1	max. 0.1
Magnesium	max. 0.05	max. 0.05

Mechanical data (N/mm², %)

Temperaturee (°C)	Rp 0.2	Rp 1.0	Rm	A_5	Rp 0.2	Rp 1.0	Rm	A_5
20 (stress-relieved)	–	–	–	–	270	–	450	15
20 (annealed)	≥ 80	≥ 105	≥ 340	≥ 40	≥ 100	≥ 125	≥ 370	≥ 40
100	70	95	–	–	150	180	390	40
200	65	90	–	–	130	160	360	40
300	60	85	–	–	140	170	370	45
400	55	80	–	–	130	160	330	40
500	–	–	–	–	100	130	255	35
600	–	–	–	–	80	105	200	30
700	–	–	–	–	55	80	150	30
800	–	–	–	–	40	60	110	35
900	–	–	–	–	30	40	80	40
1000	–	–	–	–	20	30	60	40

Creep properties (N/mm²)

Temperature (°C)	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5
300	–	–	–	–	–	–	–	–
400	–	–	–	–	–	–	–	–
500	–	–	–	–	–	–	–	–
600	–	–	–	–	–	–	–	–
650	–	–	–	–	–	–	–	–

Physical properties at room temperature

Density	(g/cm³)	8.9					8.9				
Specific heat	(J/kgK)	456					456				
Thermal conductivity	(W/mK)	79					71				
Resistivity	(μΩ cm)	9.5					9				
Modulus of elasticity	(kN/mm²)	208					205				
Coefficient of thermal expansion from 20 °C to		100	200	300	400	500	100	200	300	400	500
	(10^{-6}/K)	13.4	14.0	14.5	14.8	15.2	13.3	13.9	14.3	14.8	15.2

Working		
Melting temperature (°C)	~ 1440	1445
Max. working temperature (°C)	–	~ 600
Workability	very good	very good
Weldability	good	good

Material properties		
	Free from readily volatilizable elements.	Good mechanical properties, thermal conductivity and corrosion resistance. Good magnetic properties and electrical conductivity.

Typical applications		
	Inner parts for incandescent lamps and electron tubes, transistor caps.	Electrolysis plants, electrical and electronic components, incandescent lamp bases.

Corrosion-resistant materials

Nickel-copper

ThyssenKrupp VDM alloy		Nicorros – alloy 400
Specification		
D	Material No.	2.4360
	Designation	NiCu 30 Fe
	DIN	17743/17750
	VdTÜV Material Data Sheet	263
F	AFNOR	NU 30
GB	BS	3073
	Type	NA 13
USA	UNS	N04400
	ASTM	B 127
	ASME	SB 127
	AMS	4544

Chemical composition (% by weight)	
Nickel (+Cobalt)	min. 63
Copper	28.0 – 34.0
Iron	1.0 – 2.5
Carbon	max. 0.15
Manganese	max. 1.25
Silicon	max. 0.5
Aluminium	max. 0.5
Titanium	max. 0.2

Mechanical data (N/mm², %)

Temperature (°C)	Rp 0.2	Rp 1.0	Rm	A_5	A_{50}
20 (stress-relieved)	≥ 400	–	≥ 580	≥ 18	–
20 (annealed)	≥ 195	≥ 210	≥ 485	≥ 35	≥ 35
100	≥ 150	220	420	30	–
200	≥ 135	210	390	30	–
300	≥ 130	190	380	30	–
400	≥ 130	180	370	30	–
425	≥ 130	–	360	30	–

Creep properties (N/mm²)

Temperature (°C)	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5
400	150	280	130	240
500	75	125	62	75
600	17	42	8	20
650	7	23	3	13

Physical properties at room temperature

Density	(g/cm³)	8.8				
Specific heat	(J/kgK)	430				
Thermal conductivity	(W/mK)	26				
Resistivity	(µΩ cm)	51.3				
Modulus of elasticity	(kN/mm²)	182				
Coefficient of thermal expansion from 20 °C to		100	200	300	400	500
	(10^{-6}/K)	13.9	15.5	15.8	16.0	16.8

Working	
Melting temperature (°C)	1350
Max. working temperature (°C)	~ 450
Workability	excellent
Weldability	good

Material properties

Resistant to seawater and steam at high temperatures as well as in salt and alkali hydroxide solutions.

Typical applications

Tubes and pipes for the chemical industry, fasteners for the aerospace industry, atmospheric crude oil distillation, high-pressure feedwater heaters in conventional power stations, salt extraction, offshore industry.

Corrosion-resistant materials

Nickel-chromium

ThyssenKrupp VDM alloy		NiCr 8020	NiCr 9010
Specification			
D	Material No.	(2.4891) (2.4639)	(2.4999)
	Designation	–	–
	DIN	– (1736-1)	–
	VdTÜV Material Data Sheet	–	–
F	AFNOR	–	–
GB	BS	–	–
	Type	–	–
USA	UNS	–	–
	ASTM	–	–
	ASME	–	–
	AMS	–	–
Chemical composition (% by weight)			
Nickel		balance	balance
Chromium		19.0 – 20.0	9.0 – 10.0
Iron		max. 0.20	max. 0.15
Carbon		max. 0.08	max. 0.05
Manganese		max. 0.05	0.03 – 0.06
Silicon		0.1 – 0.2	0.08 – 0.2
Aluminium		–	max. 0.03
Magnesium		0.01 – 0.02	max. 0.02
Other elements		Ca 0.002 – 0.008	–

Mechanical data (N/mm², %)

Temperature (°C)	NiCr 8020 Rp 0.2	Rp 1.0	Rm	A_5	A_{50}	NiCr 9010 Rp 0.2	Rp 1.0	Rm	A_5	A_{50}
20 (annealed)	≥ 200	≥ 270	≥ 600	–	≥ 30	≥ 170	≥ 200	≥ 500	–	≥ 35
100	–	–	–	–	–	–	–	–	–	–
200	–	–	–	–	–	–	–	–	–	–
300	–	–	–	–	–	–	–	–	–	–
400	–	–	–	–	–	–	–	–	–	–
500	–	–	–	–	–	–	–	–	–	–
600	–	–	–	–	–	–	–	–	–	–
700	–	–	–	–	–	–	–	–	–	–
800	–	–	–	–	–	–	–	–	–	–

Creep properties (N/mm²)

Temperature (°C)	NiCr 8020 Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5	NiCr 9010 Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5
300	–	–	–	–	–	–	–	–
400	–	–	–	–	–	–	–	–
500	–	–	–	–	–	–	–	–
600	–	–	–	–	–	–	–	–
650	–	–	–	–	–	–	–	–
700	–	–	–	–	–	–	–	–
800	–	–	–	–	–	–	–	–

Physical properties at room temperature

		NiCr 8020	NiCr 9010
Density	(g/cm^3)	–	–
Specific heat	(J/kgK)	–	–
Thermal conductivity	(W/mK)	–	–
Resistivity	(μΩ cm)	–	–
Modulus of elasticity	(kN/mm^2)	–	–

Coefficient of thermal expansion from 20 °C to	NiCr 8020 100	200	300	400	500	NiCr 9010 100	200	300	400	500
(10^{-6}/K)	–	–	–	–	–	–	–	–	–	–

Working

	NiCr 8020	NiCr 9010
Melting temperature (°C)	1425	1430
Max. working temperature (°C)	–	–
Workability	–	–
Weldability	–	–

Material properties

Typical applications

	NiCr 8020	NiCr 9010
	Production of synthetic industrial diamonds.	Welded tubes for the electronics industry.

Corrosion-resistant materials

Nickel-chromium-iron

ThyssenKrupp VDM alloy		Nicrofer 3033 – alloy 33
Specification		
D	Material No.	1.4591
	Designation	X 1 CrNiMoCuN 33-32-1
	DIN	–
	SEW	400
	VdTÜV Material Data Sheet	516
F	AFNOR	–
GB	BS	–
	Type	–
USA	UNS	R20033
	ASTM	B 625
	ASME	SB 625/Code Case 2227

Chemical composition (% by weight)	
Nickel	30.0 – 33.0
Chromium	31.0 – 35.0
Iron	balance
Carbon	max. 0.015
Manganese	max. 2.0
Silicon	max. 0.5
Copper	0.3 – 1.2
Molybdenum	0.5 – 2.0
Aluminium	–
Titanium	–
Other elements	N 0.35 – 0.6, P max. 0.02, S max. 0.01

Mechanical data (N/mm², %)

Temperature (°C)	Rp 0.2	Rp 1.0	Rm	A_5
20 (annealed)	≥ 380	≥ 420	–	–
100	≥ 320	≥ 350	≥ 720	≥ 40
200	≥ 270	≥ 300	–	–
300	≥ 240	≥ 270	–	–
400	≥ 220	≥ 250	–	–
500	≥ 210	≥ 240	–	–
550	–	–	–	–
600	–	–	–	–
700	–	–	–	–

Creep properties (N/mm²)

Temperature (°C)	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5
500	–	–	–	–
600	–	–	–	–
650	–	–	–	–
700	–	–	–	–

Physical properties at room temperature

Density	(g/cm³)	7.9				
Specific heat	(J/kgK)	~ 500				
Thermal conductivity	(W/mK)	13.4				
Resistivity	(µΩ cm)	104				
Modulus of elasticity	(kN/mm²)	195				
Coefficient of thermal expansion from 20 °C to		100	200	300	400	500
	(10^{-6}/K)	14.5	15.3	15.3	15.7	16.4

Working	
Melting temperature (°C)	1330 – 1370
Max. working temperature (°C)	–
Workability	good
Weldability	good

Material properties	
	Excellent corrosion resistance in oxidizing media (e. g. concentrated sulphuric acid), also in nitric/hydrofluoric acid mixtures and alkaline media.

Typical applications	
	Chemical and petrochemical industry plants, marine engineering.

Corrosion-resistant materials

Nickel-chromium-iron-molybdenum

ThyssenKrupp VDM alloy		Nicrofer 3127 LC – alloy 28	Nicrofer 3127 hMo – alloy 31
Specification			
D	Material No.	1.4563	1.4562
	Designation	X 1 NiCrMoCuN 31-27-4	X 1 NiCrMoCu 32-28-7
	DIN	EN 10088	–
	SEW	400	400
	VdTÜV Material Data Sheet	483	509
F	AFNOR	Z 1 NCDU 31.27	–
GB	BS	–	–
	Type	–	–
USA	UNS	N08028	N08031
	ASTM	B 709	B 625
	ASME	SB 709	–

Chemical composition (% by weight)

Nickel	30.0 – 32.0	30.0 – 32.0
Chromium	26.0 – 28.0	26.0 – 28.0
Iron	balance	balance
Carbon	max. 0.015	max. 0.015
Manganese	max. 2.0	max. 2.0
Silicon	max. 0.7	max. 0.3
Copper	1.0 – 1.4	1.0 – 1.4
Molybdenum	3.0 – 4.0	6.0 – 7.0
Aluminium	–	–
Titanium	–	–
Other elements	N 0.04 – 0.07	N 0.15 – 0.25

Mechanical data (N/mm², %)

Temperature (°C)	Rp 0.2	Rp 1.0	Rm	A_5	A_{50}	Rp 0.2	Rp 1.0	Rm	A_5	A_{50}
20 (annealed)	≥ 214	≥ 250	≥ 500	–	≥ 40	≥ 270	–	650	45	–
100	≥ 190	≥ 220	500	40	–	≥ 210	≥ 240	630	50	–
200	≥ 165	≥ 195	490	40	–	≥ 180	≥ 210	580	50	–
300	≥ 150	≥ 180	480	40	–	≥ 165	≥ 195	530	50	–
400	≥ 135	≥ 165	465	40	–	≥ 150	≥ 180	500	50	–
500	≥ 120	≥ 150	–	–	–	≥ 135	≥ 165	470	–	–
550	≥ 115	≥ 145	–	–	–	≥ 125	≥ 155	–	–	–
600	–	–	–	–	–	–	–	–	–	–

Creep properties (N/mm²)

Temperature (°C)	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5
500	–	–	–	–	–	–	–	–
600	–	–	–	–	–	–	–	–
650	–	–	–	–	–	–	–	–
700	–	–	–	–	–	–	–	–

Physical properties at room temperature

Density	(g/cm³)	8.0					8.1				
Specific heat	(J/kgK)	442					440				
Thermal conductivity	(W/mK)	10.8					12				
Resistivity	(μΩ cm)	99					100				
Modulus of elasticity	(kN/mm²)	195					195				
Coefficient of thermal expansion from 20 °C to		100	200	300	400	500	100	200	300	400	500
	(10^{-6}/K)	15.0	15.4	15.8	16.2	16.5	14.3	14.7	15.1	15.5	15.7

Working

Melting temperature (°C)	~ 1370	1350 – 1370
Max. working temperature (°C)	~ 500	~ 500
Workability	good	good
Weldability	good	good

Material properties

	High resistance to pitting, crevice corrosion and stress-corosion cracking.	Excellent resistance in many corrosive fluids including contaminated mineral and organic acids.

Typical applications

	Welded tubes for phosphoric acid plants, seawater condensers and coolers.	Welded tubes for the fertilizer industry. Pulp and paper production. Production of sulphuric and phosphoric acid. Flue gas scrubbers in fossil-fired power stations. Oil and gas extraction. Decouplers for the automotive industry.

Corrosion-resistant materials

Nickel-chromium-iron-molybdenum

ThyssenKrupp VDM alloy		Nicrofer 3620 Nb – alloy 20	Nicrofer 4221 – alloy 825
Specification			
D	Material No.	2.4660	2.4858
	Designation	NiCr 20 CuMo	NiCr 21 Mo
	DIN	17744/17750	17744/17750
	VdTÜV Material Data Sheet	–	432/1
F	AFNOR	–	NiFe 32 C 20 DU
GB	BS	–	3073
	Type	–	NA 16
USA	UNS	N08020	N08825
	ASTM	B 463	B 424
	ASME	SB 463	SB 424

Chemical composition (% by weight)

	Nicrofer 3620 Nb – alloy 20	Nicrofer 4221 – alloy 825
Nickel	36.5 – 38.0	38.0 – 46.0
Chromium	19.0 – 21.0	19.5 – 23.5
Iron	balance	balance
Carbon	max. 0.02	max. 0.025*
Manganese	1.0 – 2.0	max. 1.0
Silicon	max. 0.7	max. 0.5
Copper	3.0 – 4.0	1.5 – 3.0
Molybdenum	2.0 – 3.0	2.5 – 3.5
Cobalt	–	–
Aluminium	–	max. 0.2
Titanium	–	0.6 – 1.2
Niobium	0.1 – 0.3	–
Other elements	–	–
		*With C = 0.04 – 0.05% on request

Mechanical data (N/mm², %)

Temperature (°C)	Nicrofer 3620 Nb – alloy 20					Nicrofer 4221 – alloy 825				
	Rp 0.2	Rp 1.0	Rm	A_5	A_{50}	Rp 0.2	Rp 1.0	Rm	A_5	A_{50}
20 (annealed)	≥ 240	≥ 280	≥ 550	–	≥ 30	≥ 240	≥ 265	≥ 585	≥ 30	–
100	≥ 210	≥ 250	≥ 520	–	≥ 30	≥ 205	≥ 235	–	–	–
200	≥ 180	≥ 220	≥ 495	–	≥ 30	≥ 180	≥ 205	–	–	–
300	≥ 160	≥ 200	≥ 470	–	≥ 30	≥ 170	≥ 195	–	–	–
400	–	–	–	–	–	≥ 160	≥ 185	–	–	–
450	–	–	–	–	–	≥ 155	≥ 180	–	–	–
500	–	–	–	–	–	–	–	–	–	–
600	–	–	–	–	–	–	–	–	–	–
700	–	–	–	–	–	–	–	–	–	–
800	–	–	–	–	–	–	–	–	–	–

Creep properties (N/mm²)

Temperature (°C)	Nicrofer 3620 Nb – alloy 20				Nicrofer 4221 – alloy 825			
	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5
600	–	–	–	–	–	–	–	–
650	–	–	–	–	–	–	–	–

Physical properties at room temperature

		Nicrofer 3620 Nb – alloy 20	Nicrofer 4221 – alloy 825
Density	(g/cm³)	8.1	8.1
Specific heat	(J/kgK)	500	440
Thermal conductivity	(W/mK)	11.6	10.8
Resistivity	(μΩ cm)	103	112
Modulus of elasticity	(kN/mm²)	195	195
Coefficient of thermal expansion from 20 °C to		100 / 200 / 300 / 400 / 500	100 / 200 / 300 / 400 / 500
	(10^{-6}/K)	15.0 / 15.8 / 16.3 / 16.8 / 17.2	14.1 / 14.9 / 15.2 / 15.6 / 15.7

Working

	Nicrofer 3620 Nb – alloy 20	Nicrofer 4221 – alloy 825
Melting temperature (°C)	1380 – 1420	~ 1380
Max. working temperature (°C)	~ 500	~ 550
Workability	good	good
Weldability	satisfactory	good

Material properties

Nicrofer 3620 Nb – alloy 20	Nicrofer 4221 – alloy 825
Excellent resistance in sulphuric acid and other strongly reducing acids, also at elevated temperatures.	Resistant in sulphuric and phosphoric acid solutions. Excellent resistance to stress-corrosion cracking, good resistance to pitting and crevice corrosion.

Typical applications

Nicrofer 3620 Nb – alloy 20	Nicrofer 4221 – alloy 825
Welded tubes and pipes for the chemical industry. Crude oil distillation. Concertina elements for the aircraft industry.	Welded tubes and pipes for the chemical industry. Oil and gas extraction. Offshore industry.

Corrosion-resistant materials

Nickel-chromium-iron-molybdenum/niobium

ThyssenKrupp VDM alloy		Nicrofer 4823 hMo – alloy G-3	Nicrofer 5219 Nb – alloy 718
Specification			
D	Material No.	2.4619	2.4668
	Designation	NiCr 22 Mo 7 Cu	NiCr19Fe19Nb5Mo3
	DIN	17744/17750	17744/17750
	VdTÜV Material Data Sheet	–	–
F	AFNOR	–	NC 19 FeNb
GB	BS	–	–
	Type	–	–
USA	UNS	N06985	N07718
	ASTM	B 582	B 670
	ASME	SB 582	–
	AMS	–	5596/5597

Chemical composition (% by weight)

Nickel	balance	50.0 – 55.0
Chromium	21.5 – 23.5	17.0 – 21.0
Iron	18.0 – 21.0	balance
Carbon	max. 0.015	max. 0.045
Manganese	max. 1.0	max. 0.35
Silicon	max. 1.0	max. 0.35
Copper	1.5 – 2.5	max. 0.23
Molybdenum	6.0 – 8.0	2.80 – 3.30
Cobalt	max. 5.0	max. 1.0
Aluminium	–	0.40 – 0.60
Titanium	–	0.80 – 1.15
Niobium	0.2 – 0.5	4.87 – 5.20
Other elements	W max. 1.5	B max. 0.006

Mechanical data (N/mm², %)

Temperature (°C)	Rp 0.2	Rp 1.0	Rm	A_5	Rp 0.2	Rp 1.0	Rm	A_5
20 (annealed)	≥ 240	≥ 260	≥ 620	≥ 45	(≥ 550)	soft	(≥ 965)	(≥ 30)
20 (age-hardened)	–	–	–	–	≥ 1035		≥ 1240	≥ 12
100	270	–	640	60	1060		–	–
200	230	–	590	62	1040		–	–
300	210	–	570	66	1020		–	–
400	190	–	550	68	1000		–	–
500	180	–	530	68	980		–	–
600	170	–	500	64	950		–	–
700	170	–	450	68	870		–	–
800	160	–	350	68	640		–	–

age-hardened

Creep properties (N/mm²)

Temperature (°C)	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5
600	–	–	–	–	620	650	–	–
650	–	–	–	–	400	440	–	–
700	–	–	–	–	180	220	–	–

Physical properties at room temperature

Density	(g/cm³)	8.3					8.2				
Specific heat	(J/kgK)	450					432				
Thermal conductivity	(W/mK)	10.0					11.1				
Resistivity	(μΩ cm)	–					123				
Modulus of elasticity	(kN/mm²)	192					205				
Coefficient of thermal expansion from 20 °C to		100	200	300	400	500	100	300	500	700	900
	(10^{-6}/K)	13.5	13.9	14.6	14.9	15.5	12.6	13.8	14.4	15.4	16.8

Working

Melting temperature (°C)	~ 1340	~ 1290
Max. working temperature (°C)	–	–
Workability	good	solution treated: good
Weldability	good	solution treated: satisfactory

Material properties

Good resistance to pitting, crevice corrosion and stress-corrosion cracking, also in the heat-affected zones adjacent to welds.	Excellent corrosion resistance and outstanding mechanical properties because of age-hardenability. Good resistance to stress-corrosion cracking.

Typical applications

Welded tubes and pipes for the chemical industry.	Aerospace industry, nuclear technology.

Corrosion-resistant materials

Nickel-chromium-molybdenum

ThyssenKrupp VDM alloy		Nicrofer 5621 hMoW – alloy 22	Nicrofer 5716 hMoW – alloy C-276
Specification			
D	Material No.	2.4602	2.4819
	Designation	NiCr21Mo14W	NiMo16Cr15W
	DIN	17744	17744/17750
	VdTÜV Material Data Sheet	–	–
F	AFNOR	–	NC17D
GB	BS	–	–
	Type	–	–
USA	UNS	N06022	N10276
	ASTM	B 575	B 575
	ASME	SB 575/Code Cases 2226 N-621	SB 575/Code Case 1924
	AMS	–	–

Chemical composition (% by weight)

Nickel	balance	balance
Chromium	20.0 – 22.5	15.0 – 16.5
Iron	2.0 – 6.0	4.0 – 7.0
Carbon	max. 0.010	max. 0.010
Manganese	–	–
Silicon	max. 0.08	max. 0.08
Copper	–	–
Molybdenum	12.50 – 14.5	15.0 – 17.0
Cobalt	max. 2.5	max. 2.5
Aluminium	–	–
Titanium	–	–
Niobium	–	–
Other elements	W 2.5 – 3.5, V max. 0.35	W 3.0 – 4.5
		V 0.1 – 0.3

Mechanical data (N/mm^2, %)

Temperature (°C)	Rp 0.2	Rp 1.0	Rm	A_5	Rp 0.2	Rp 1.0	Rm	A_5
20 (annealed)	(≥ 310)	(≥ 335)	(≥ 690)	(≥ 45)	≥ 280	≥ 305	≥ 190	≥ 40
100	(≥ 270)	(≥ 290)	–	–	(≥ 240)	(≥ 275)	–	–
200	(≥ 225)	(≥ 245)	–	–	(≥ 220)	(≥ 245)	–	–
300	(≥ 195)	(≥ 215)	–	–	(≥ 195)	(≥ 230)	–	–
400	(≥ 175)	(≥ 195)	–	–	–	–	–	–
500	–	–	–	–	–	–	–	–
600	–	–	–	–	–	–	–	–

Creep properties (N/mm^2)

Temperature (°C)	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5
600	–	–	–	–	–	–	–	–
650	–	–	–	–	–	–	–	–
700	–	–	–	–	–	–	–	–

Physical properties at room temperature

Density	(g/cm^3)	8.7					8.9				
Specific heat	(J/kgK)	406					407				
Thermal conductivity	(W/mK)	9.4					10.6				
Resistivity	(μΩ cm)	114					125				
Modulus of elasticity	(kN/mm^2)	206					208				
Coefficient of thermal expansion from 20 °C to		100	300	500	700	900	100	300	500	700	900
	(10^{-6}/K)	12.4	12.5	13.7	14.9	15.8	11.7	12.8	13.5	14.7	16.0

Working

Melting temperature (°C)	~ 1370	~ 1340
Max. working temperature (°C)	–	–
Workability	good	good
Weldability	good	good

Material properties

	Excellent corrosion resistance in oxidizing fluids, acetic acid and acetic anhydride.	Excellent resistance in sulphuric acid at high chloride concentrations.

Typical applications

	Energy and environmental engineering plants and the chemical process industries.	Chemical and petrochemical engineering plants. Pulp and paper industry. Environmental engineering. Heat exchangers for sulphuric acid plants.

ThyssenKrupp VDM alloy		Nicrofer 5923 hMo – alloy 59	Nicrofer 6020 hMo – alloy 625
Specification			
D	Material No.	2.4605	2.4856
	Designation	NiCr23Mo16Al	NiCr22Mo9Nb
	DIN	17744/17750	17744/17750
	VdTÜV Material Data Sheet	505	499
F	AFNOR	–	NC22DNb
GB	BS	–	–
	Type	–	NA 21
USA	UNS	N06059	N06625 (grade 1)
	ASTM	B 575	B 443
	ASME	SB 575/Code Case 2134	SB 443/Code Case 1935
	AMS	–	5599

Chemical composition (% by weight)		
Nickel	balance	balance
Chromium	22.0 – 24.0	21.0 – 23.0
Iron	max. 1.5	max. 5.0
Carbon	max. 0.010	max. 0.03
Manganese	max. 0.5	max. 0.40
Silicon	max. 0.10	max. 0.40
Copper	–	–
Molybdenum	15.0 – 16.5	8.0 – 10.0
Cobalt	max. 0.3	max. 1.0
Aluminium	0.1 – 0.4	max. 0.40
Titanium	–	max. 0.40
Niobium	–	3.2 – 3.8
Other elements	–	–

Mechanical data (N/mm², %)

Temperature (°C)	Rp 0.2	Rp 1.0	Rm	A_{50}	Rp 0.2	Rp 1.0	Rm	A_{50}
20 (grade 2 ASTM B443)	–	–	–	–	≥ 276	–	≥ 690	≥ 30
20 (grade 1 ASTM B443)	≥ 310	≥ 380	≥ 690	≥ 45	≥ 415	≥ 445	≥ 827	≥ 30
100	≥ 290	≥ 330	650	–	≥ 350	–	740	–
200	≥ 250	≥ 290	615	–	≥ 320	–	700	–
300	≥ 220	≥ 260	580	–	≥ 300	–	685	–
400	≥ 190	≥ 230	545	–	≥ 280	–	670	–
500	≥ 175	≥ 215	525	–	–	–	–	–
600	–	–	–	–	–	–	–	–
700					–	–	–	–

Creep properties (N/mm²)

Temperature (°C)	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5
600	–	–	–	–	–	–	–	–
650	–	–	–	–	–	–	–	–
700	–	–	–	–	–	–	–	–

Physical properties at room temperature

Density	(g/cm³)	8.8					8.5				
Specific heat	(J/kgK)	410					415				
Thermal conductivity	(W/mK)	9.4					9.8				
Resistivity	(μΩ cm)	120					128				
Modulus of elasticity	(kN/mm²)	205					209				
Coefficient of thermal expansion from 20 °C to		100	200	300	400	500	100	200	300	400	500
	(10^{-6}/K)	11.9	12.2	12.5	12.7	12.9	12.8	13.1	13.4	13.7	14.1

Working		
Melting temperature (°C)	1360	~ 1310
Max. working temperature (°C)	–	550
Workability	good	good
Weldability	good	good

Material properties		
	Best material in many oxidizing and reducing fluids and for combating pitting, crevice corrosion and stress-corrosion cracking.	Excellent resistance to pitting, crevice corrosion and stress-corrosion cracking and outstanding mechanical properties up to 550 °C.
Typical applications		
	Chemical and petrochemical engineering plants. Pulp and paper industry. Environmental engineering. Marine applications.	Welded tubes and pipes for the chemical industry. Aerospace industry. Oil and gas extraction. Offshore industry.

Corrosion-resistant materials

Nickel-chromium-molybdenum/Nickel-chromium-iron

ThyssenKrupp VDM alloy		Nicrofer 6616 hMo – alloy C-4	Nicrofer 7216 LC – alloy 600 L
Specification			
D	Material No.	2.4610	2.4817
	Designation	NiMo16Cr16Ti	LC-NiCr15Fe
	DIN	17744/17750	17742/17750
	VdTÜV Material Data Sheet	(424)	–
F	AFNOR	–	–
GB	BS	–	3073
	Type	–	NA 14*
USA	UNS	N06455	N06600*
	ASTM	B 575	B 168
	ASME	SB 575	SB 168
	AMS	–	–
Chemical composition (% by weight)			
Nickel		balance	min. 72.0
Chromium		14.5 – 17.5	14.0 – 17.0
Iron		max. 3.0	6.0 – 10.0
Carbon		max. 0.009	max. 0.025*
Manganese		max. 1.0	max. 1.0
Silicon		max. 0.05	max. 0.5
Copper		–	max. 0.5
Molybdenum		14.0 – 17.0	–
Cobalt		max. 2.0	–
Aluminium		–	max. 0.3
Titanium		max. 0.7	max. 0.3
Niobium		–	–
Other elements		–	B max. 0.006
		–	* Specify C content

Mechanical data (N/mm², %)

Temperature (°C)	Rp 0.2	Rp 1.0	Rm	A_5	Rp 0.2	Rp 1.0	Rm	A_5
20 (annealed)	≥ 290	≥ 320	≥ 690	≥ 40	≥ 170	≥ 210	≥ 550	≥ 30
100	≥ 285	≥ 315	–	–	160	190	530	–
200	≥ 255	≥ 285	–	–	150	180	500	–
300	≥ 245	≥ 270	–	–	145	175	485	–
400	≥ 225	≥ 260	–	–	140	170	480	–
500	–	–	–	–	120	150	470	–
600	–	–	–	–	100	130	460	–

Creep properties (N/mm²)

Temperature (°C)	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5
600	–	–	–	–	–	–	–	–
650	–	–	–	–	–	–	–	–
700	–	–	–	–	–	–	–	–

Physical properties at room temperature

		Nicrofer 6616 hMo – alloy C-4					Nicrofer 7216 LC – alloy 600 L				
Density	(g/cm³)	8.6					8.4				
Specific heat	(J/kgK)	408					455				
Thermal conductivity	(W/mK)	10.1					14.8				
Resistivity	(µΩ cm)	124					103				
Modulus of elasticity	(kN/mm²)	211					214				
Coefficient of thermal expansion from 20 °C to		100	200	400	600	800	100	200	400	600	800
	(10^{-6}/K)	10.9	11.9	12.9	13.6	14.5	13.7	14.1	14.8	15.4	16.1

Working

	Nicrofer 6616 hMo – alloy C-4	Nicrofer 7216 LC – alloy 600 L
Melting temperature (°C)	~ 1350	~ 1390
Max. working temperature (°C)	–	~ 450
Workability	good	good
Weldability	good	good

Material properties

Nicrofer 6616 hMo – alloy C-4	Nicrofer 7216 LC – alloy 600 L
Exceptionally resistant to corrosion in oxidizing and reducing fluids, also in the welded state.	Low-carbon variant of Nicrofer 7216 with excellent resistance to stress-corrosion cracking.

Typical applications

Nicrofer 6616 hMo – alloy C-4	Nicrofer 7216 LC – alloy 600 L
Chemical engineering plants. Welded tubes for acetic acid, fertilizers and plant protection products. Environmental engineering.	Inner parts for electron and television tubes. Flight recorders for the aircraft industry. Chemical engineering plants. Production and processing of vinyl chloride monomer (VCM). Pulp and paper production. Rubber.

Corrosion-resistant materials

Nickel-molybdenum

ThyssenKrupp VDM alloy		Nimofer 6928 – alloy B-2
Specification		
D	Material No.	2.4617
	Designation	NiMo28
	DIN	17744/17750
	VdTÜV Material Data Sheet	(436)
F	AFNOR	NiMo28
GB	BS	–
	Type	–
USA	UNS	N10665
	ASTM	B 333
	ASME	SB 333
	AMS	–

Chemical composition (% by weight)	
Nickel	balance
Chromium	max. 1.0
Iron	max. 2.0
Carbon	max. 0.01
Manganese	max. 1.0
Silicon	max. 0.08
Copper	max. 0.5
Molybdenum	26.0 – 30.0
Cobalt	max. 1.0
Aluminium	–
Other elements	–

Mechanical data (N/mm^2, %)				
Temperature (°C)	Rp 0.2	Rp 1.0	Rm	A_5
20 (annealed)	≥ 350	≥ 380	≥ 760	≥ 40
100	(≥ 315)	(≥ 355)	–	–
200	(≥ 285)	(≥ 325)	–	–
300	(≥ 270)	(≥ 310)	–	–
400	(≥ 255)	(≥ 295)	–	–
500	–	–	–	–
600	–	–	–	–
700	–	–	–	–

Creep properties (N/mm^2)				
Temperature (°C)	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5
600	–	–	–	–
650	–	–	–	–
700	–	–	–	–

Physical properties at room temperature						
Density	(g/cm^3)	9.2				
Specific heat	(J/kgK)	377				
Thermal conductivity	(W/mK)	11.4				
Resistivity	(μΩ cm)	137				
Modulus of elasticity	(kN/mm^2)	217				
Coefficient of thermal expansion from 20 °C to		100	200	300	400	500
	(10^{-6}/K)	10.3	10.8	11.1	11.4	11.6

Working	
Melting temperature (°C)	~ 1350
Max. working temperature (°C)	–
Workability	satisfactory
Weldability	good

Material properties
Outstandingly resistant in reducing fluids.

Typical applications
Welded tubes and pipes for the chemical industry. Sulphuric acid of reducing composition, acetic acid, ethylbenzene, melamine.

Corrosion-resistant materials

Special stainless steels

ThyssenKrupp VDM alloy		Cronifer 1809 Ti – alloy 321	Cronifer 1810 Ti – alloy 316 Ti
Specification			
D	Material No.	1.4541	1.4571
	Designation	X 6 CrNiTi 18-10	X 6 CrNiMoTi 17-12-2
	DIN	17441/EN 10028-7/EN 10088	17441/EN 10028-7/EN 10088
	SEW	–	–
	VdTÜV Material Data Sheet	–	–
F	AFNOR	Z 6 CNT 18.10	Z 6 CNDT 17.12
GB	BS	1449	1449
	Type	321 S 31	320 S 31/33
USA	UNS	S32100	S31635
	ASTM	A 167/240	A 167/240
	ASME	SA 240	–
	AMS	5510	–
Chemical composition (% by weight)			
Nickel		9.0 – 12.0	10.5 – 13.5
Chromium		17.0 – 19.0	16.5 – 18.5
Iron		balance	balance
Carbon		max. 0.08	max. 0.08
Manganese		max. 2.0	max. 2.0
Silicon		max. 1.0	max. 1.0
Copper		–	max. 1.0
Molybdenum		–	2.0 – 2.5
Cobalt		–	–
Aluminium		–	–
Titanium		max. 0.80	max. 0.8
Other elements		–	–

Mechanical data (N/mm², %)

Temperature (°C)	Cronifer 1809 Ti – alloy 321				Cronifer 1810 Ti – alloy 316 Ti			
	Rp 0.2	Rp 1.0	Rm	A_5	Rp 0.2	Rp 1.0	Rm	A_5
20 (annealed)	≥ 205	≥ 260	≥ 515	≥ 40	≥ 205	≥ 270	≥ 515	≥ 40
100	≥ 196	≥ 226	–	–	≥ 205	≥ 235	–	–
200	≥ 177	≥ 207	–	–	≥ 187	≥ 217	–	–
300	≥ 156	≥ 186	–	–	≥ 165	≥ 195	–	–
400	≥ 145	≥ 175	–	–	≥ 155	≥ 185	–	–
500	≥ 139	≥ 169	–	–	≥ 149	≥ 179	–	–

Creep properties (N/mm²)

Temperature (°C)	Cronifer 1809 Ti – alloy 321				Cronifer 1810 Ti – alloy 316 Ti			
	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5
400	–	–	–	–	–	–	–	–
500	–	–	–	–	–	–	–	–
600	–	–	–	–	–	–	–	–
650	–	–	–	–	–	–	–	–

Physical properties at room temperature

		Cronifer 1809 Ti – alloy 321					Cronifer 1810 Ti – alloy 316 Ti				
Density	(g/cm³)	7.9					8.0				
Specific heat	(J/kgK)	500					500				
Thermal conductivity	(W/mK)	15					15				
Resistivity	(μΩ cm)	71					75				
Modulus of elasticity	(kN/mm²)	200					200				
Coefficient of thermal expansion from 20 °C to		100	200	300			100	200	300		
	(10^{-6}/K)	16	17	17.4			16.5	17.5	18.5		

		Cronifer 1809 Ti – alloy 321	Cronifer 1810 Ti – alloy 316 Ti
Working			
Melting temperature (°C)		~ 1410	~ 1410
Max. working temperature (°C)		–	–
Workability		good	good
Weldability		good	good
Material properties			
		Stainless, austenitic special steel with good welding properties.	Stainless, austenitic special steel. Stabilized with Ti to prevent precipitation of carbides during welding.
Typical applications			
		Welded tubes and pipes for the chemical industry. Food processing industry, medical engineering and domestic appliances. Corrugated hoses. Expansion joints. Tubular heaters.	Welded tubes and pipes for the chemical industry. Pulp, dyestuffs and textile industries. Corrugated hoses. Expansion joints. Tubular heaters.

ThyssenKrupp VDM alloy		Cronifer 1811 LC – alloy 305
Specification		
D	Material No.	1.4303
	Designation	X 5 CrNi 18-12
	DIN	EN 10088
	SEW	–
	VdTÜV Material Data Sheet	–
F	AFNOR	Z 8 CN 18.12
GB	BS	1449
	Type	305 S 19
USA	UNS	S30500
	ASTM	A 167/240
	ASME	SA 240
	AMS	5514

Chemical composition (% by weight)	
Nickel	11.0 – 13.0
Chromium	17.0 – 18.5
Iron	balance
Carbon	max. 0.06
Manganese	1.0 – 1.5
Silicon	max. 0.6
Copper	max. 1.0
Molybdenum	max. 0.5
Cobalt	–
Aluminium	–
Titanium	–
Other elements	

Mechanical data (N/mm^2, %)				
Temperature (°C)	Rp 0.2	Rp 1.0	Rm	A_5
20 (annealed)	≥ 200	≥ 230	≥ 500	≥ 43
100	≥ 162	≥ 192	–	–
200	≥ 134	≥ 164	–	–
300	≥ 117	≥ 147	–	–
400	≥ 105	≥ 135	–	–
500	≥ 99	≥ 129	–	–
550	–	–	–	–

Creep properties (N/mm^2)				
Temperature (°C)	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5
400	–	–	–	–
500	–	–	–	–
600	–	–	–	–
650	–	–	–	–

Physical properties at room temperature							
Density	(g/cm^3)	7.9					
Specific heat	(J/kgK)	500					
Thermal conductivity	(W/mK)	15					
Resistivity	(μΩ cm)	73					
Modulus of elasticity	(kN/mm^2)	200					
Coefficient of thermal expansion from 20 °C to		100	200	300			
	(10^{-6}/K)	16	17	17.7			

Working	
Melting temperature (°C)	~ 1420
Max. working temperature (°C)	–
Workability	good
Weldability	good

Material properties
Non-magnetizable special stainless steel.

Typical applications
Inner parts for electron and television tubes.

Corrosion-resistant materials

Special stainless steels

ThyssenKrupp VDM alloy		Cronifer 1925 LC – alloy 904 L	Cronifer 1925 hMo – alloy 926
Specification			
D	Material No.	1.4539	1.4529
	Designation	X 1 NiCrMoCuN 25-20-5	X 1 NiCrMoCuN 25 20 7
	DIN	EN 10028-7/EN 10088	EN 10028-7/EN 10088
	SEW	–	–
	VdTÜV Material Data Sheet	421	502
F	AFNOR	Z 1 NCDU 25.20	–
GB	BS	–	–
	Type	–	–
USA	UNS	N08904	N08926
	ASTM	B 625	B 625
	ASME	SB 625	SB 625
	AMS	–	–

Chemical composition (% by weight)		
Nickel	24.0 – 26.0	24.0 – 26.0
Chromium	19.0 – 21.0	20.0 – 21.0
Iron	balance	balance
Carbon	max. 0.020	max. 0.020
Manganese	max. 2.0	max. 1.0
Silicon	max. 0.7	max. 0.5
Copper	1.2 – 2.0	0.5 – 1.5
Molybdenum	4.0 – 5.0	6.0 – 7.0
Cobalt	–	–
Aluminium	–	–
Titanium	–	–
Other elements	N 0.05 – 0.10, on request 0.16 – 0.20	N 0.15 – 0.25

Mechanical data (N/mm², %)

Temperature (°C)	Rp 0.2	Rp 1.0	Rm	A_5	Rp 0.2	Rp 1.0	Rm	A_5
20 (annealed)	≥ 215	≥ 250	≥ 490	≥ 35	≥ 295	≥ 340	≥ 650	≥ 35
100	≥ 175	≥ 205	440	–	≥ 230	≥ 270	610	–
200	≥ 155	≥ 185	400	–	≥ 190	≥ 225	550	–
300	≥ 135	≥ 165	380	–	≥ 170	≥ 205	510	–
400	≥ 125	≥ 155	360	–	≥ 160	≥ 190	500	–
500	≥ 110	≥ 140	–	–	≥ 120	≥ 150	–	–
550	≥ 105	≥ 135	–	–	–	–	–	–
600	–	–	–	–	≥ 105	≥ 135	–	–

Creep properties (N/mm²)

Temperature (°C)	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5
400	–	–	–	–	–	–	–	–
500	–	–	–	–	–	–	–	–
600	–	–	–	–	–	–	–	–
650	–	–	–	–	–	–	–	–

Physical properties at room temperature

Density	(g/cm³)	8.1					8.1			
Specific heat	(J/kgK)	450					415			
Thermal conductivity	(W/mK)	11.6					12.0			
Resistivity	(µΩ cm)	95					96			
Modulus of elasticity	(kN/mm²)	197					193			
Coefficient of thermal expansion from 20 °C to		100	200	300	400	500	100	200	300	400	500
	(10^{-6}/K)	15.1	15.5	15.8	16.1	16.5	16.6	16.6	16.6	16.6	16.9

Working		
Melting temperature (°C)	~ 1380	~ 1340
Max. working temperature (°C)	–	–
Workability	good	good
Weldability	good	good

Material properties		
	Good resistance in phosphoric and sulphuric acids, even when contaminated with chlorides and fluorides.	As Cronifer 1925 LC, but improved resistance to pitting and crevice corrosion.

Typical applications		
	Welded tubes and pipes for the chemical industry, seawater desalination, FGD plants, chimney flue pipes.	Welded tubes and pipes for the chemical industry. Production and processing of sulphuric and phosphoric acid. Oil and gas extraction. Offshore industry and seawater desalination. Environmental technology.

Heat-resistant materials

Iron-chromium/Nickel-chromium-iron

ThyssenKrupp VDM alloy		Crofer 22 APU	Cronifer 1525 Ti – alloy 286
Specification			
D	Material No.	(1.4770)	1.4980
	Designation	–	X 5 NiCrTi 26-15
	DIN	–	–
	SEW	–	–
	VdTÜV Material Data Sheet	–	–
F	AFNOR	–	Z 6 NCTDV 25.15 B
GB	BS	–	–
	Type	–	HR 251
USA	UNS	–	S66286
	ASTM	–	–
	ASME	–	–
	AMS	–	5525/5858

Chemical composition (% by weight)		
Nickel	–	min. 24.0 – 27.0
Chromium	21.0 – 24.0	14.0 – 16.0
Iron	balance	balance
Carbon	max. 0.03	max. 0.08
Manganese	max. 0.8	max. 2.0
Silicon	max. 0.5	max. 0.5
Copper	max. 0.5	–
Aluminium	–	max. 0.35
Titanium	max. 0.2	1.9 – 2.3
Other elements	P max. 0.05, La max. 0.2	V 0.1 – 0.5, B 0.003 – 0.010

Mechanical data (N/mm², %)

Temperature (°C)	Crofer 22 APU Rp 0.2	Rp 1.0	Rm	A_5	Cronifer 1525 Ti – alloy 286 Rp 0.2	Rp 1.0	Rm	A_5
20 (annealed)	330	335	465	35	360	380	660	30
20 (age-hardened)	–	–	–	–	770	800	1050	20
100	–	–	–	–	770	800	1010	23
200	–	–	–	–	760	790	980	22
300	–	–	–	–	750	780	960	20
400	235	240	370	30	730	770	950	18
500	–	–	–	–	720	760	920	19
600	140	155	205	37	710	750	850	14
700	55	58	59	52	510	–	600	12
800	29	–	30	60	290	–	370	47

Creep properties (N/mm²)

Temperature (°C)	Crofer 22 APU Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5	Cronifer 1525 Ti – alloy 286 Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5
500	–	–	–	–	–	610	540	–
600	–	–	–	–	–	370	250	–
700	–	–	–	–	–	100	–	–
800	–	–	–	–	–	–	–	–
900	–	–	–	–	–	–	–	–

Physical properties at room temperature

		Crofer 22 APU	Cronifer 1525 Ti – alloy 286
Density	(g/cm³)	7.7	7.9
Specific heat	(J/kgK)	–	419
Thermal conductivity	(W/mK)	19.4	12.7
Resistivity	(µΩ cm)	0.5	91
Modulus of elasticity	(kN/mm²)	140	200

Coefficient of thermal expansion from 20 °C to	Crofer 22 APU 100	300	500	700	900	Cronifer 1525 Ti – alloy 286 100	200	400	600	800
(10^{-6}/K)	7.1	7.9	9.0	10.0	11.2	16.6	16.8	17.0	17.5	–

Working		
Melting temperature (°C)	≥ 1300	~ 1350
Max. working temperature (°C)	≤ 900	~ 1000
Workability	good	good
Weldability	–	good

Material properties		
	Material with a readily conductive oxide film and low chromium volatilization.	Age-hardenable alloy for temperatures up to 750 °C.

Typical applications		
	Fuel cell, interconnector plates.	Fasteners in the aerospace industry.

Heat-resistant materials

Nickel-chromium-iron

ThyssenKrupp VDM alloy		Nicrofer 2020 – alloy 840	Nicrofer 3220 – alloy 800
Specification			
D	Material No.	1.4847	1.4876
	Designation	X 8 CrNiAlTi 20-20	X 10 NiCrAlTi 32-20
	DIN	–	10095
	SEW	–	470
	VdTÜV Material Data Sheet	–	–
F	AFNOR	–	Z 8 NC 32.21
GB	BS	–	3073
	Type	–	NA 15
USA	UNS	–	N08800
	ASTM	–	B 409
	ASME	–	SB 409
	AMS	–	5871

Chemical composition (% by weight)		
Nickel	19.0 – 22.0	30.0 – 32.0
Chromium	19.0 – 22.0	19.0 – 21.0
Iron	balance	balance
Carbon	max. 0.05	max. 0.05
Manganese	max. 1.0	0.5 – 1.0
Silicon	max. 1.0	0.1 – 0.6
Aluminium	max. 0.60	0.20 – 0.60
Titanium	max. 0.60	0.20 – 0.50
Other elements	–	Al+Ti max. 0.8

Mechanical data (N/mm², %)									
Temperature (°C)	Rp 0.2	Rp 1.0	Rm	A_5	Rp 0.2	Rp 1.0	Rm	A_5
20 (annealed)	200	230	≥ 500	≥ 35	≥ 260	≥ 300	≥ 620	≥ 30
100	–	–	–	–	≥ 240	≥ 280	≥ 610	–
200	–	–	–	–	≥ 220	≥ 260	≥ 580	–
300	–	–	–	–	≥ 200	≥ 240	≥ 550	–
400	–	–	–	–	≥ 190	≥ 220	≥ 530	–
500	–	–	–	–	≥ 180	≥ 210	≥ 500	–
600	–	–	–	–	≥ 170	≥ 200	≥ 470	–
700	125	–	280	55	≥ 160	≥ 170	≥ 360	–
1000	55	–	55	110	–	–	–	–

Creep properties (N/mm²)								
Temperature (°C)	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5
500	–	–	–	–	–	–	–	–
600	–	–	–	–	–	–	–	–
700	–	–	–	–	–	–	–	–
800	–	–	–	–	–	–	–	–
900	–	–	–	–	–	–	–	–

Physical properties at room temperature										
Density	(g/cm³)	7.9					8.0				
Specific heat	(J/kgK)	456					455				
Thermal conductivity	(W/mK)	14.0					11.6				
Resistivity	(μΩ cm)	–					98				
Modulus of elasticity	(kN/mm²)	–					198				
Coefficient of thermal expansion from 20 °C to		100					100	200	300	400	500
	(10^{-6}/K)	12.5					14.4	15.2	15.8	16.2	16.6

Working		
Melting temperature (°C)	~ 1380	~ 1370
Max. working temperature (°C)	~ 1050	~ 600
Workability	good	good
Weldability	good	satisfactory

Material properties		
	Good resistance to oxidation in contact with air and in carburizing atmospheres.	Good resistance to oxidation in contact with air and in carburizing atmospheres. Good ductility, resistant to combustion gases.

Typical applications		
	Heating element tubes for domestic and industrial uses.	Tubular heaters for domestic appliances and industrial uses. Heat sink in washing machines.

Heat-resistant materials

Nickel-chromium-iron

ThyssenKrupp VDM alloy		Nicrofer 3718 So – alloy DS	Nicrofer 6023 – alloy 601
Specification			
D	Material No.	1.4862	2.4851
	Designation	X 8 NiCrSi 38-18	NiCr23Fe
	DIN	–	17742/17750
	VdTÜV Material Data Sheet	–	–
F	AFNOR	Z 12 NCS 37.18	NC23FeA
GB	BS	3073	–
	Type	NA 17	–
USA	UNS	–	N06601
	ASTM	–	B 168
	ASME	–	–
	AMS	–	5870
Chemical composition (% by weight)			
Nickel		35.0 – 39.0	min. 58.0 – 63.0
Chromium		17.0 – 19.0	22.0 – 24.0
Iron		balance	balance
Carbon		max. 0.10	0.03 – 0.08
Manganese		0.8 – 1.5	max. 0.8
Silicon		1.9 – 2.5	max. 0.5
Copper		max. 0.50	–
Aluminium		–	1.1 – 1.6
Titanium		max. 0.20	0.1 – 0.4
Other elements		–	–

Mechanical data (N/mm^2, %)

Temperature (°C)	Rp 0.2	Rp 1.0	Rm	A_5	Rp 0.2	Rp 1.0	Rm	A_5
20 (annealed)	≥ 230	–	≥ 550	≥ 30	≥ 205	≥ 330	≥ 550	≥ 30
100	330	–	640	35	440	–	750	40
200	300	–	620	35	430	–	740	40
300	290	–	610	35	400	–	730	35
400	280	–	600	35	370	–	700	35
450	–	–	–	–	360	–	685	–
500	265	–	560	35	350	–	670	40
600	250	–	490	40	320	–	580	35
700	–	–	–	–	–	–	–	–
800	–	–	–	–	–	–	–	–
900	–	–	–	–	–	–	–	–

Creep properties (N/mm^2)

Temperature (°C)	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5
500	–	–	–	–	–	–	–	–
600	–	–	–	–	–	–	–	–
700	–	–	–	–	–	–	–	–
800	–	–	–	–	–	–	–	–
900	–	–	–	–	–	–	–	–

Physical properties at room temperature

Density	(g/cm^3)	8.0					8.1				
Specific heat	(J/kgK)	452					450				
Thermal conductivity	(W/mK)	13.0					11.3				
Resistivity	(µΩ cm)	108					119				
Modulus of elasticity	(kN/mm^2)	195					207				
Coefficient of thermal expansion from 20 °C to		100	300	500	700	900	100	300	500	700	900
	(10^{-6}/K)	15.0	15.9	16.5	17.5	18.5	13.8	14.6	15.1	16.3	17.2

Working		
Melting temperature (°C)	~ 1350	~ 1370
Max. working temperature (°C)	~ 1000	~ 550
Workability	good	good
Weldability	good	satisfactory
Material properties		
	Good resistance to scaling in air and combustion gases and resistant to carburization.	Good oxidation resistance up to 1050 °C and resistant to carburization. Good mechanical properties.
Typical applications		
	Radiant tubes, protective tubes for thermocouples, industrial furnace construction.	Welded tubes and pipes. Components in exhaust gas systems and exhaust gas clean-up plants. Gas burner jets. Radiant tubes.

ThyssenKrupp VDM alloy		Nicrofer 7216 – alloy 600	Nicrofer 7520 – alloy 75
Specification			
D	Material No.	2.4816	2.4951
	Designation	NiCr15Fe	NiCr20Ti
	DIN	17742/17750	17742/17750
	VdTÜV Material Data Sheet	(305)	–
F	AFNOR	NC15Fe	NC20T
GB	BS	3073	–
	Type	NA 14	HR 203
USA	UNS	N06600	N06075
	ASTM	B 168	–
	ASME	SB 168	–
	AMS	5540	–

Chemical composition (% by weight)		
Nickel	min. 72.0	balance
Chromium	14.0 – 17.0	19.0 – 21.0
Iron	6.0 – 10.0	max. 5.0
Carbon	0.03 – 0.08	0.08 – 0.13
Manganese	max. 1.0	max. 1.0
Silicon	max. 0.5	0.3 – 0.7
Copper	max. 0.5	max. 0.5
Aluminium	max. 0.3	max. 0.3
Titanium	max. 0.3	0.2 – 0.6
Other elements	B max. 0.006	–

Mechanical data (N/mm², %)

Temperature (°C)	Rp 0.2	Rp 1.0	Rm	A_5	Rp 0.2	Rp 1.0	Rm	A_5
20 (annealed)	≥ 240	≥ 265	≥ 550	≥ 30	≥ 260	≥ 270	≥ 650	≥ 25
100	(≥ 180)	–	520	–	450	–	800	30
200	(≥ 165)	–	500	–	445	–	790	30
300	(≥ 155)	–	485	–	435	–	780	30
400	(≥ 150)	–	480	–	425	–	750	30
450	(≥ 145)	–	475	–	–	–	–	–
500	–	–	–	–	400	–	680	30
600	–	–	–	–	350	–	580	30
700	–	–	–	–	250	–	400	40
800	–	–	–	–	130	–	200	85
900	–	–	–	–	70	–	110	–

Creep properties (N/mm²)

Temperature (°C)	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5
500	–	–	–	–	–	295	–	190
600	–	–	–	–	–	85	–	63
700	–	–	–	–	–	32	–	22
800	–	–	–	–	–	16	–	12
900	–	–	–	–	–	10	–	7

Physical properties at room temperature

Density	(g/cm³)	8.4					8.4			
Specific heat	(J/kgK)	455					460			
Thermal conductivity	(W/mK)	14.8					11.7			
Resistivity	(μΩ cm)	103					110			
Modulus of elasticity	(kN/mm²)	214					215			
Coefficient of thermal expansion from 20 °C to		100	300	500	700	900	100	300	500	700	900
	(10^{-6}/K)	13.7	14.4	15.1	15.8	16.4	10.8	13.3	14.3	15.4	17.1

Working		
Melting temperature (°C)	~ 1390	~ 1360
Max. working temperature (°C)	~ 500	~ 1100
Workability	good	good
Weldability	good	good

Material properties		
	Good oxidation resistance at high temperatures.	Good resistance to scaling and excellent mechanical properties at high temperatures.

Typical applications		
	Welded tubes and pipes for the chemical industry, heat exchangers.	Aerospace industry. Honeycombs. Flame tubes. Components for heat treatment furnaces.

High-temperature materials

Nickel-chromium-iron

ThyssenKrupp VDM alloy		Nicrofer 3220 H – alloy 800 H	Nicrofer 6023 H – alloy 601 H
Specification			
D	Material No.	1.4958/1.4876 H	2.4851
	Designation	X 5 NiCrAlTi 31-20	NiCr 23 Fe
	DIN	17460 (E DIN EN 10302)	17742/17750
	VdTÜV Material Data Sheet	412/434	–
F	AFNOR	–	NC23FeA
GB	BS	3073	–
	Type	NA 15 H	–
USA	UNS	N08810	N06601
	ASTM	B 409	B 168
	ASME	SB 409	–
	AMS	–	–
Chemical composition (% by weight)			
Nickel		30.0 – 32.0	58.0 – 63.0
Chromium		19.0 – 22.0	22.0 – 24.0
Iron		balance	balance
Carbon		0.06 – 0.08	max. 0.10
Manganese		0.5 – 1.0	max. 0.6
Silicon		0.2 – 0.6	max. 0.5
Copper		–	–
Aluminium		0.20 – 0.40	1.1 – 1.6
Titanium		0.20 – 0.50	0.3 – 0.5
Niobium		–	–
Other elements		Al+Ti max. 0.7	Zr max. 0.03

Mechanical data (N/mm², %)

Temperature (°C)	Rp 0.2	Rp 1.0	Rm	A_5	Rp 0.2	Rp 1.0	Rm	A_5
20 (annealed)	267	303	537	50	280	270	662	30
100	251	286	425	–	260	–	656	45
200	230	265	400	–	225	–	631	45
400	196	229	380	–	175	–	562	45
500	181	211	360	–	163	–	534	45
600	175	203	300	–	157	–	489	45
700	161	179	298	43	153	–	433	45
800	211	124	234	55	150	–	348	45
900	60	82	142	85	106	–	208	45

Creep properties (N/mm²)

Temperature (°C)	$Rp\ 1.0/10^4$	$Rm/10^4$	$Rp\ 1.0/10^5$	$Rm/10^5$	$Rp\ 1.0/10^4$	$Rm/10^4$	$Rp\ 1.0/10^5$	$Rm/10^5$
500	–	290	–	215	–	–	–	–
600	–	152	–	114	151	205	124	163
700	–	75	–	53	69	101	43	61
800	–	37	–	24	22	31	13	18
900	–	17	–	10.5	6.9	10.1	3	4
950	–	11.5	–	7	–	–	–	–

Physical properties at room temperature

Density	(g/cm^3)	8.0					8.1			
Specific heat	(J/kgK)	455					480			
Thermal conductivity	(W/mK)	11.6					11.3			
Resistivity	(µΩ cm)	98					119			
Modulus of elasticity	(kN/mm^2)	198					207			
Coefficient of thermal expansion from 20 °C to		100	300	500	700	900	100	300	500	700	900
	(10^{-6}/K)	14.4	15.8	16.6	17.4	18.2	13.8	14.6	15.1	16.3	17.2

Working

Melting temperature (°C)	~ 1370	1320 – 1370
Max. working temperature (°C)	~ 950	~ 1050
Workability	good	good
Weldability	satisfactory	satisfactory

Material properties

	Excellent mechanical properties and oxidation resistance at high temperatures up to 950 °C. Resistant to combustion gases.	Good scaling resistance up to 1150 °C and resistant to carburization. Good mechanical properties and creep resistance.

Typical applications

	Pyrolysis tubes, tubular heaters for industry.	Components for thermal and chemical/petro-chemical plants, exhaust gas systems and exhaust gas clean-up plants.

ThyssenKrupp VDM alloy		Nicrofer 6025 HT – alloy 602 CA	Nicrofer 7216 H – alloy 600 H
Specification			
D	Material No.	2.4633	2.4816
	Designation	NiCr25FeAlY	NiCr 15 Fe
	DIN	–	17742/17750
	VdTÜV Material Data Sheet	–	–
F	AFNOR	–	–
GB	BS	–	3073
	Type	–	NA 14 (H)
USA	UNS	N06025	N06600
	ASTM	B 168	–
	ASME	SB 168, Code case Nr. 2359	–
	AMS	–	–

Chemical composition (% by weight)		
Nickel	balance	min. 72.0
Chromium	24.0 – 26.0	14.0 – 17.0
Iron	8.0 – 10.0	6.0 – 10.0
Carbon	0.15 – 0.25	0.03 – 0.08
Manganese	max. 0.1	max. 1.0
Silicon	max. 0.5	max. 0.5
Copper	max. 0.1	max. 0.5
Aluminium	1.8 – 2.4	max. 0.3
Titanium	0.1 – 0.2	max. 0.3
Niobium	–	–
Other elements	Y 0.05 – 0.12, Zr 0.01 – 0.10	B max. 0.006

Mechanical data (N/mm², %)									
Temperature (°C)	Rp 0.2	Rp 1.0	Rm	A_5	Rp 0.2	Rp 1.0	Rm	A_{50}
20 (annealed)	300	340	700	35	≥ 240	–	≥ 550	≥ 30
100	270	310	670	35	(≥ 170)	–	480	–
200	250	290	650	35	(≥ 160)	–	460	–
400	220	260	620	35	(≥ 150)	–	440	–
600	200	240	580	40	–	–	–	–
800	160	180	310	60	–	–	–	–
1000	90	95	100	75	–	–	–	–
1100	65	70	75	80	–	–	–	–
1200	35	38	40	85	–	–	–	–

Creep properties (N/mm²)								
Temperature (°C)	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5
600	205	240	180	209	91	138	66	97
700	118	136	95	113.5	43	63	28	42
800	27	38	18	29	18	29	12	17.1
900	10.5	15.4	8.2	13	8	13	4	7
1000	5.0	8.0	3.9	7.1	–	–	–	–
1100	1.9	4.3	1.5	3.6	–	–	–	–

Physical properties at room temperature			
Density	(g/cm^3)	7.9	8.4
Specific heat	(J/kgK)	450	455
Thermal conductivity	(W/mK)	11.3	14.8
Resistivity	(μΩ cm)	118	103
Modulus of elasticity	(kN/mm^2)	215	214

Coefficient of thermal expansion from 20 °C to		100	300	500	700	900	1100	100	300	500	700	900
	(10^{-6}/K)	11.9	14.0	14.7	15.7	17.1	17.6	13.7	14.4	15.1	15.8	16.4

Working		
Melting temperature (°C)	1370 – 1400	~ 1390
Max. working temperature (°C)	~ 1200	~ 900
Workability	good	good
Weldability	satisfactory	good

Material properties		
	Excellent resistance to scaling, even under cyclic conditions, up to 1200 °C. Resistant to carburization and under metal dusting conditions.	Solution treated variant of Nicrofer 7216 for service at over 700 °C owing to its high creep strength.

Typical applications		
	Furnace components, components of exhaust gas systems, synthesis of methanol and ammonia.	Welded tubes and pipes for the chemical and petrochemical industry. Components for thermal plants, radiant tubes.

Superalloys

Nickel-chromium-iron-molybdenum/Nickel-chromium-molybdenum-cobalt

ThyssenKrupp VDM alloy		Nicrofer 4722 Co – alloy X	Nicrofer 5120 CoTi – alloy C-263
Specification			
D	Material No.	2.4665	2.4650
	Designation	NiCr 22 Fe 18 Mo	NiCo20Cr20 MoTi
	Luftfahrt	WL, Teil 1	WL, Teil 1
	VdTÜV Material Data Sheet	–	–
F	AFNOR	NC 22 FeD	NCK 20 D
GB	BS	HR 204	HR 206
USA	UNS	N06002	N07263
	ASTM	B 435	–
	ASME	SB 435	–
	AMS	5536	5872
Chemical composition (% by weight)			
Nickel		balance	balance
Chromium		20.5 – 23.5	19.0 – 21.0
Iron		17.0 – 20.0	max. 0.7
Carbon		0.05 – 0.15	0.04 – 0.08
Manganese		max. 1.0	max. 0.6
Silicon		max. 1.0	max. 0.4
Copper		–	max. 0.2
Molybdenum		8.0 – 10.0	5.6 – 6.1
Cobalt		0.5 – 2.5	19.0 – 21.0
Aluminium		max. 0.10	0.30 – 0.60
Titanium		–	1.90 – 2.40
Other elements		W 0.2 – 1.0, B max. 0.005	Al+Ti 2.40 – 2.80, B max. 0.005

Mechanical data (N/mm², %)

Temperature (°C)	Rp 0.2	Rp 1.0	Rm	A_5	Rp 0.2	Rp 1.0	Rm	A_5
20 (annealed)	≥ 310	–	≥ 725	≥ 30	≥ 590	age-hardened	≥ 1000	≥ 35
100	310	–	720	40	520		–	–
200	290	–	710	40	490		–	–
300	270	–	700	40	480		–	–
400	250	–	680	45	480		–	–
500	230	–	640	45	480		–	–
600	220	–	600	40	470		–	–
700	210	–	510	40	460		–	–
800	200	–	400	40	410		–	–
900	160	–	300	50	190		–	–

Creep properties (N/mm²)

Temperature (°C)	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5
600	123	231	100	186	–	~ 490	–	–
700	74	122	60	97	–	~ 220	–	–
800	42	59	29	38	–	~ 90	–	–
900	18.5	31	9.6	14	–	~ 22	–	–
1000	4.9	7.4	2.3	3.2	–	–	–	–

Physical properties at room temperature

Density	(g/cm³)	8.3	8.4
Specific heat	(J/kgK)	435	426
Thermal conductivity	(W/mK)	11.3	11.7
Resistivity	(µΩ cm)	115	115
Modulus of elasticity	(kN/mm²)	205	222
Coefficient of thermal expansion from 20 °C to		100 / 300 / 500 / 700 / 900	100 / 300 / 500 / 700 / 900
	(10^{-6}/K)	13.6 / 14.3 / 14.9 / 15.6 / 16.3	10.7 / 12.5 / 13.5 / 14.9 / 17.2

Working

Melting temperature (°C)	~ 1280	~ 1320
Max. working temperature (°C)	~ 1100	~ 850
Workability	good	good
Weldability	good	good

Material properties

	High-temperature alloy with excellent resistance in oxidizing, carburizing and nitriding gases, accompanied by outstanding mechanical properties.	Precipitation-hardenable alloy for temperatures up to 850 °C.

Typical applications

	Combustion chambers, exhaust systems, aviation, honeycombs.	Gas turbines, thrust reversal and silencers.

Superalloys

Nickel-chromium-iron-niobium/Nickel-chromium-molybdenum-cobalt

ThyssenKrupp VDM alloy		Nicrofer 5219 Nb – alloy 718	Nicrofer 5520 Co – alloy 617
Specification			
D	Material No.	2.4668	2.4663
	Designation	NiCr19Fe19Nb5Mo3	NiCr23Co12 Mo
	DIN	17744/17750	–
	Luftfahrt	WL, Teil 1	–
	VdTÜV Material Data Sheet	–	485
F	AFNOR	NC 19 FeNb	–
USA	UNS	N07718	N06617
	ASTM	B 670	–
	AMS	5596/5597	–
Chemical composition (% by weight)			
Nickel		50.0 – 55.0	balance
Chromium		17.0 – 21.0	20.0 – 23.0
Iron		balance	max. 2.0
Carbon		max. 0.08	0.05 – 0.10
Manganese		max. 0.35	max. 0.70
Silicon		max. 0.35	–
Copper		max. 0.30	–
Molybdenum		2.8 – 3.3	8.0 – 10.0
Cobalt		max. 1.0	10.0 – 13.0
Aluminium		0.20 – 0.80	0.80 – 1.50
Titanium		0.65 – 1.15	0.20 – 0.60
Niobium		4.75 – 5.50	–
Other elements		B max. 0.006	–

Mechanical data (N/mm², %)

Temperature (°C)	Rp 0.2	Rp 1.0	Rm	A_5	Rp 0.2	Rp 1.0	Rm	A_5
20 (annealed)	(≥ 550)	soft	(≥ 965)	(≥ 30)	≥ 370	≥ 440	≥ 750	≥ 35
20 (age-hardened)	≥ 1035	age-hardened	≥ 1240	≥ 12	–	–	–	–
100	1060		–	–	≥ 330	≥ 360	≥ 720	–
200	1040		–	–	≥ 248	≥ 290	≥ 680	–
300	1020		–	–	≥ 230	≥ 270	≥ 650	–
400	1000		–	–	≥ 229	≥ 250	≥ 630	–
500	980		–	–	≥ 223	≥ 250	≥ 610	–
600	950		–	–	≥ 200	≥ 230	≥ 580	–
700	870		–	–	≥ 210	≥ 250	≥ 560	–
800	640		–	–	≥ 220	≥ 260	≥ 510	–
900	–		–	–	≥ 194	≥ 199	≥ 340	–

Creep properties (N/mm²)

Temperature (°C)	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5
600	620	650	–	–	220	260	140	190
700	180	220	–	–	187	200	66	152
800	–	–	–	–	74	87	53	62
900	–	–	–	–	29	33	20	23
1000	–	–	–	–	6.1	10	2.5	5.3

Physical properties at room temperature

Density	(g/cm³)	8.2					8.4			
Specific heat	(J/kgK)	432					420			
Thermal conductivity	(W/mK)	11.1					13.4			
Resistivity	(μΩ cm)	123					122			
Modulus of elasticity	(kN/mm²)	205					212			
Coefficient of thermal expansion from 20 °C to		100	300	500	700	900	100	300	500	700	900
	(10^{-6}/K)	12.6	13.8	14.4	15.4	16.8	11.6	13.1	13.9	14.8	15.8

Working

Melting temperature (°C)	~ 1290	~ 1350
Max. working temperature (°C)	–	~ 1100
Workability	solution treated: good	satisfactory
Weldability	solution treated: satisfactory	good

Material properties

	Precipitation-hardenable alloy with good high-temperature corrosion resistance, outstanding mechanical properties and good ductility.	High creep strength with good corrosion resistance in oxidizing and carburizing gases up to 1100 °C and good ductility.

Typical applications

	Springs and spacers in nuclear engineering, aviation and automotive engineering.	Gas turbines, radiant tubes, air heaters.

Superalloys

Nickel-chromium-iron/Nickel-chromium

ThyssenKrupp VDM alloy		Nicrofer 7016 TiNb – alloy X-750	Nicrofer 7520 Ti – alloy 80 A
Specification			
D	Material No.	2.4669	2.4952
	Designation	NiCr15Fe7TiAl	NiCr20TiAl
	DIN	–	17750
F	AFNOR	NC 15 TNbA	NC 20 TA
GB	BS	–	3073
	Type	–	NA 20/2 HR 201
USA	UNS	N07750	N07080
	AMS	5548/5598	–
Chemical composition (% by weight)			
Nickel		min. 70.0	balance
Chromium		14.0 – 17.0	19.0 – 21.0
Iron		5.0 – 9.0	max. 1.0
Carbon		max. 0.08	0.04 – 0.09
Manganese		max. 1.0	max. 1.0
Silicon		max. 0.5	–
Copper		max. 0.5	–
Molybdenum		–	–
Cobalt		–	max. 2.0
Aluminium		0.40 – 1.00	1.1 – 1.7
Titanium		2.25 – 2.75	2.0 – 2.6
Niobium		0.70 – 1.20	–
Other elements		–	B: max. 0.008

Mechanical data (N/mm², %)

Temperature (°C)	Rp 0.2	Rp 1.0	Rm	A_5	Rp 0.2	Rp 1.0	Rm	A_5
20 (annealed)	≥ 515	age-hardened	≥ 930	≥ 35	370	age-hardened	800	50
20 (age-hardened)	800		1190	30	≥ 650		≥ 1030	≥ 20
100	790		1170	30	750		1070	30
200	780		1150	35	740		1050	30
300	770		1120	40	720		1020	30
400	750		1080	40	710		1000	30
500	740		1020	40	710		990	30
600	720		880	30	700		930	20
700	650		700	45	690		800	15
800	450		450	65	500		590	15
900	–		–	–	250		310	30
1000	–		–	–	60		80	80

Creep properties (N/mm²)

Temperature (°C)	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5
550	620	630	–	–	–	620	–	–
600	490	500	–	–	420	460	390	425
650	390	400	–	–	–	320	–	–
700	250	270	–	–	170	220	120	140
750	110	120	–	–	–	140	–	–
800	45	60	–	–	40	70	31	40

Physical properties at room temperature

		Nicrofer 7016 TiNb – alloy X-750					Nicrofer 7520 Ti – alloy 80 A				
Density	(g/cm³)	8.3					8.2				
Specific heat	(J/kgK)	430					450				
Thermal conductivity	(W/mK)	12.0					11.2				
Resistivity	(μΩ cm)	121					124				
Modulus of elasticity	(kN/mm²)	214					183				
Coefficient of thermal expansion from 20 °C to		100	300	500	700	900	100	300	500	700	900
	(10^{-6}/K)	12.9	14.0	14.8	16.3	17.8	12.7	13.7	14.4	15.5	17.1

Working

	Nicrofer 7016 TiNb – alloy X-750	Nicrofer 7520 Ti – alloy 80 A
Melting temperature (°C)	~ 1410	~ 1340
Max. working temperature (°C)	–	–
Workability	good	good
Weldability	satisfactory	possible

Material properties

Nicrofer 7016 TiNb – alloy X-750	Nicrofer 7520 Ti – alloy 80 A
Precipitation-hardenable material with high strength up to approximately 815 °C and good resistance to combustion gases.	Precipitation-hardenable alloy with good creep resistance up to approx. 815 °C.

Typical applications

Nicrofer 7016 TiNb – alloy X-750	Nicrofer 7520 Ti – alloy 80 A
Fasteners and gas turbine components.	Aviation and components of gas turbines.

Superalloys

Cobalt-nickel-chromium-tungsten

ThyssenKrupp VDM alloy		Conicro 4023 W – alloy 188
Specification		
D	Material No.	2.4683
	Designation	CoCr20NiW
	DIN	–
F	AFNOR	KCN 22 W
GB	BS	–
	Type	–
USA	UNS	R30188
	AMS	5608

Chemical composition (% by weight)	
Nickel	20.0 – 24.0
Chromium	20.0 – 24.0
Iron	max. 3.0
Carbon	0.05 – 0.15
Manganese	max. 1.25
Silicon	0.2 – 0.4
Copper	–
Molybdenum	–
Cobalt	balance
Aluminium	max. 0.20
Titanium	–
Niobium	–
Other elements	W 13.0 – 16.0, La 0.02 – 0.12

Mechanical data (N/mm², %)

Temperature (°C)	Rp 0.2	Rp 1.0	Rm	A_5
20 (annealed)	380	–	860	40
100	360	–	820	40
200	330	–	780	40
300	310	–	740	40
400	280	–	700	40
500	250	–	660	40
600	250	–	620	40
700	260	–	550	60
800	270	–	410	60
900	200	–	340	65
1000	110	–	280	70

Creep properties (N/mm²)

Temperature (°C)	Rp 1.0/10^4	Rm/10^4	Rp 1.0/10^5	Rm/10^5
550	–	–	–	–
600	–	–	–	–
650	–	–	–	–
700	–	–	–	–
750	–	–	–	–
800	–	160	120	80

Physical properties at room temperature

Density	(g/cm³)	9.1				
Specific heat	(J/kgK)	405				
Thermal conductivity	(W/mK)	10.2				
Resistivity	(μΩ cm)	95				
Modulus of elasticity	(kN/mm²)	222				
Coefficient of thermal expansion from 20 °C to		100	300	500	700	900
	(10^{-6}/K)	11.9	13.2	14.5	15.8	17.2

Working	
Melting temperature (°C)	1300 – 1330
Max. working temperature (°C)	1150
Workability	good
Weldability	good

Material properties
High-temperature alloy with good resistance to oxidation and good mechanical properties.

Typical applications
Components of gas turbines, heat exchangers and fastenings.

Heating element and resistance alloys

Nickel-chromium

ThyssenKrupp VDM alloy		Cronix 80	Cronix 70
Specification			
D	Material No.	2.4869	2.4658
	Designation	NiCr 8020	NiCr 7030
	DIN	17470/17471/17742	17470/17742
	VdTÜV Material Data Sheet	–	–
F	AFNOR	–	–
GB	BS	–	–
	Type	–	–
USA	UNS	N06003	N06008
	ASTM	–	–
	AMS	5676	–
Chemical composition (% by weight)			
Nickel		balance	balance
Chromium		19.0 – 21.0	29.0 – 31.0
Iron		max. 1.0	max. 1.0
Carbon		max. 0.08	max. 0.07
Manganese		max. 1.0	max. 1.0
Silicon		1.0 – 1.5	1.0 – 1.5
Copper		–	–
Aluminium		max. 0.20	max. 0.20
Other elements		R.E. 0.01 – 0.04	R.E. 0.01 – 0.04

Mechanical data (N/mm², %)

Temperature (°C)	Rp 0.2	Rm	A_5		Rp 0.2	Rm	A_{50}	
20	≥ 240	≥ 650	≥ 30		≥ 300	≥ 680	≥ 30	
Typical values	–	–	–		–	–	–	

Specific electrical resistivity (μΩ cm)

Temperature (°C)	Cronix 80	Cronix 70
20	112	119
200	113	122
400	115	124
600	115	124
800	114	124
1000	115	124
1200	117	125

Creep properties (N/mm²)

Temperature (°C)	Cronix 80 Rp 1.0/10^3	Cronix 70 Rp 1.0/10^3
600	80	80
700	40	40
800	15	15
900	9	9
1000	4	4
1100	1.5	1.5
1200	0.5	0.5

Physical properties at room temperature

		Cronix 80					Cronix 70				
Density	(g/cm^3)	8.3					8.1				
Specific heat	(J/kgK)	420					420				
Thermal conductivity	(W/mK)	15					13.8				
Modulus of elasticity	(kN/mm^2)	200					200				
Coefficient of thermal expansion from 20 °C to		100	200	400	600	800	100	200	400	600	800
	(10^{-6}/K)	13.5	14.0	15.0	15.5	16.0	13.0	13.5	14.5	15.0	16.0

Working

	Cronix 80	Cronix 70
Melting temperature (°C)	1400	1380
Max. working temperature (°C)	Heating element m. ~ 1250, resistance m. ~ 600	Heating element m. ~ 1250, resistance m. ~ 600
Workability	good	good
Weldability	satisfactory	satisfactory

Material properties

Cronix 80	Cronix 70
High heat resistance, strong at high temperatures.	High heat resistance, very strong at high temperatures.

Typical applications

Cronix 80	Cronix 70
Precision resistors, electric furnaces, enamelling furnaces, electronics.	Electric furnaces, furnaces with a changing atmosphere.

Heating element and resistance alloys

Nickel-chromium-iron

ThyssenKrupp VDM alloy		Cronifer II					Cronifer 45				
Specification											
D	Material No.	2.4867					(2.4890)				
	Designation	NiCr 6015					(NiCr 45 23)				
	DIN	17470/17741/17742					–				
	VdTÜV Material Data Sheet	–					–				
F	AFNOR	–					–				
GB	BS	–					–				
	Type	–					–				
USA	UNS	N06004					–				
	ASTM	–					–				
	AMS	–					–				
Chemical composition (% by weight)											
Nickel		min. 57.0					45.0 – 48.0				
Chromium		14.0 – 17.0					22.0 – 24.0				
Iron		balance					balance				
Carbon		max. 0.10					max. 0.08				
Manganese		max. 1.0					max. 1.0				
Silicon		1.0 – 1.75					1.5 – 2.2				
Copper		–					–				
Aluminium		max. 0.3					max. 0.3				
Other elements		R.E. max.0.04					R.E. max.0.04				
Mechanical data (N/mm^2, %)											
Temperature (°C)		Rp 0.2	Rm	A_5			Rp 0.2	Rm	A_5		
20		≥ 210	≥ 600	≥ 30			≥ 250	≥ 600	≥ 30		
Typical values		–	–	–			–	–	–		
Specific electrical resistivity (µΩ cm)											
Temperature (°C)											
20		113					113				
200		116					118				
400		120					124				
600		121					126				
800		122					128				
1000		124					131				
1200		128					131				
Creep properties (N/mm^2)											
Temperature (°C)		Rp 1.0/10^3					Rp 1.0/10^3				
600		80					90				
700		40					45				
800		15					20				
900		9					9				
1000		4					4				
1100		1.5					1.5				
1200		0.5					0.5				
Physical properties at room temperature											
Density	(g/cm^3)	8.2					8.0				
Specific heat	(J/kgK)	460					500				
Thermal conductivity	(W/mK)	13.4					13.0				
Modulus of elasticity	(kN/mm^2)	200					200				
Coefficient of thermal expansion from 20 °C to		100	200	400	600	800	100	200	400	600	800
	(10^{-6}/K)	13.5	14.0	15.0	15.5	16.0	–	15.0	16.0	17.0	18.0
Working											
Melting temperature (°C)		1390					1390				
Max. working temperature (°C)		Heating element m. ~ 1200, resistance m. ~ 600					~ 1170				
Workability		good					good				
Weldability		satisfactory					satisfactory				
Material properties											
		Heat resistant, strong at high temperatures.					Heat resistant, strong at high temperatures.				
Typical applications											
		Heavy duty resistors, electric heating appliances.					Furnaces with a changing atmosphere, braking and starting resistors.				

Heating element and resistance alloys

Nickel-chromium-iron/Iron-chromium-aluminium

ThyssenKrupp VDM alloy		Cronifer III	Aluchrom Y
Specification			
D	Material No.	1.4860	1.4767
	Designation	X 16 NiCr 30-20	X 8 CrAl 20-5
	DIN	17470	–
	VdTÜV Material Data Sheet	–	–
F	AFNOR	–	–
GB	BS	–	–
	Type	–	–
USA	UNS	–	–
	ASTM	–	–
	AMS	–	–

Chemical composition (% by weight)		
Nickel	30.0 – 32.0	max. 0.30
Chromium	19.5 – 21.5	20.0 – 22.0
Iron	balance	balance
Carbon	max. 0.10	0.01 – 0.1
Manganese	max. 1.0	max. 0.3
Silicon	1.8 – 3.0	max. 0.5
Copper	–	–
Aluminium	max. 0.3	5.0 – 6.0
Other elements	R.E. max.0.10	Zr max. 0.01 – 0.10, Y 0.05 – 0.15

Mechanical data (N/mm², %)

Temperature (°C)	Cronifer III Rp 0.2	Rm	A_5		Aluchrom Y Rp 0.2	Rm	A_5	
20	≥ 210	≥ 600	≥ 30		≥ 400	≥ 650	≥ 10	
Typical values	–	–	–		–	≥ 750	–	

Specific electrical resistivity (μΩ cm)

Temperature (°C)	Cronifer III	Aluchrom Y
20	104	139
200	111	140
400	117	141
600	122	143
800	126	146
1000	130	147
1200	–	147

Creep properties (N/mm²)

Temperature (°C)	Cronifer III Rp 1.0/10^3				Aluchrom Y Rp 1.0/10^3			
600	100				40			
700	45				15			
800	20				6			
900	9				2.5			
1000	4				1.0			
1100	1.5				0.3			
1200	0.5				0.1			

Physical properties at room temperature

		Cronifer III	Aluchrom Y
Density	(g/cm³)	7.9	7.2
Specific heat	(J/kgK)	500	460
Thermal conductivity	(W/mK)	13.0	13.0
Resistivity	(μΩ cm)	–	139
Modulus of elasticity	(kN/mm²)	200	210
Coefficient of thermal expansion from 20 °C to		100 / 200 / 400 / 600 / 800	100 / 200 / 400 / 600 / 800
	(10^{-6}/K)	14.5 / 15.0 / 16.0 / 17.0 / 18.0	10.6 / 11.3 / 12.3 / 13.0 / 13.8

Working		
Melting temperature (°C)	1380	1500
Max. working temperature (°C)	~ 1100	~ 1330
Workability	good	good
Weldability	satisfactory	satisfactory

Material properties		
	Heat resistant, very strong at high temperatures.	Excellent oxidation behaviour.

Typical applications		
	Electric furnaces up to 1150 °C, resistors. Domestic appliances.	High-temperature industrial furnaces. Ceran hobs. Foil supports for exhaust gas catalytic converters in the automotive industry.

Heating element and resistance alloys

Iron-chromium-aluminium

ThyssenKrupp VDM alloy		Aluchrom YHf				Aluchrom W			
Specification									
D	Material No.	1.4767				1.4725			
	Designation	X 8 CrAl 20-5				X 8 CrAl 14-4			
	DIN	–				17470			
	VdTÜV Material Data Sheet	–				–			
F	AFNOR	–				–			
GB	BS	–				–			
	Type	–				–			
USA	UNS	–				K91670			
	ASTM	–				B 603 (III)			
	AMS	–				–			
Chemical composition (% by weight)									
Nickel		max. 0.30				–			
Chromium		19.0 – 22.0				14.0 – 16.0			
Iron		balance				balance			
Carbon		max. 0.05				max. 0.08			
Manganese		max. 0.50				max. 0.6			
Silicon		max. 0.50				max. 0.5			
Copper		–				–			
Aluminium		5.5 – 6.5				3.5 – 5.0			
Other elements		Zr max. 0.07, Y max. 0.1, Hf max. 0.1				Zr max. 0.30			
Mechanical data (N/mm², %)									
Temperature (°C)		Rp 0.2	Rm	A_5		Rp 0.2	Rm	A_5	
20		≥ 510	≥ 650	15		≥ 400	≥ 550	≥ 15	
Typical values		–	–	–		–	–	–	
Specific electrical resistivity (µΩ cm)									
Temperature (°C)									
20		140				125			
200		141				127			
400		141				131			
600		144				135			
800		145				139			
1000		–				142			
1200		–				–			
Creep properties (N/mm²)									
Temperature (°C)		Rp 1.0/10^3				Rp 1.0/10^3			
600		–				16			
700		–				8			
800		–				4			
900		–				2			
1000		–				0.8			
1100		–				–			
1200		–				–			
Physical properties at room temperature									
Density	(g/cm^3)	7.16				7.3			
Specific heat	(J/kgK)	490				480			
Thermal conductivity	(W/mK)	9.8				14.5			
Resistivity	(µΩ cm)	140				125			
Modulus of elasticity	(kN/mm^2)	–				210			
Coefficient of thermal expansion from 20 °C to		100	200	400	600	800	100	200	400	600	800
	(10^{-6}/K)	12.2	12.4	12.9	13.6	14.3	10.5	11.0	12.0	13.0	14.0
Working									
Melting temperature (°C)		~ 1500				1500			
Max. working temperature (°C)		1330				~ 1050			
Workability		good				good			
Weldability		–				satisfactory			
Material properties									
		Excellent oxidation behaviour.				Ferritic heating element material with high scale bonding strength.			
Typical applications									
		Foil supports for exhaust gas catalytic converters in the automotive industry. Ceran hobs.				High-temperature load resistors.			

Heating element and resistance alloys

Copper-nickel

ThyssenKrupp VDM alloy		Konstantan					
Specification							
D	Material No.	2.0842					
	Designation	CuNi 44					
	DIN	17664/17471/17670					
	VdTÜV Material Data Sheet	–					
F	AFNOR	CuNi 44					
GB	BS	–					
	Type	–					
USA	UNS	C72150					
	ASTM	–					
	AMS	–					
Chemical composition (% by weight)							
Nickel (+Cobalt)		43.0 – 45.0					
Copper		balance					
Iron		max. 0.5					
Carbon		max. 0.05					
Manganese		0.5 – 1.2					
Silicon		–					
Magnesium		0.02 – 0.05					
Blei		max. 0.002					
Mechanical data (N/mm², %)							
Temperature (°C)		Rp 0.2	Rm	A_5			
20		≥ 150	≥ 460	≥ 30			
Typical values		–	–	–			
Specific electrical resistivity (µΩ cm)							
Temperature (°C)							
20		49					
200		49					
400		49					
600		51					
Creep properties (N/mm²)							
Temperature (°C)		Rp 1.0/10^3					
600		–					
700		–					
800		–					
900		–					
Physical properties at room temperature		–					
Density	(g/cm³)	8.9					
Specific heat	(J/kgK)	410					
Thermal conductivity	(W/mK)	23					
Resistivity	(µΩ cm)	49					
Modulus of elasticity	(kN/mm²)	180					
Coefficient of thermal expansion from 20 °C to		100	200	300	400	600	
	(10^{-6}/K)	13.5	14.0	14.5	15.0	16.0	
Working							
Melting temperature (°C)		1280					
Max. working temperature (°C)		800					
Workability		good					
Weldability		satisfactory					
Material properties							
		Very low temperature coefficient of electrical resistivity.					
Typical applications							
		Power and precision resistors.					

ThyssenKrupp VDM alloy		Pernifer 1407				Pernifer 2002			
Specification									
D	Material No.	1.3930				1.3933			
	Designation	X 60 NiMn 14-7				–			
	DIN	–				–			
	SEW	–				–			
	VdTÜV Material Data Sheet	–				–			
F	AFNOR	–				–			
UK	BS	–				–			
	Type	–				–			
USA	UNS	–				–			
	ASTM	–				B 753 (T-19)			
	ASME	–				–			
	AMS	–				–			
Chemical composition (% by weight)									
Nickel		12.5 – 14.5				19.5 – 21.0			
Chromium		–				2.0 – 3.0			
Iron		balance				balance			
Carbon		0.55 – 0.65				0.50 – 0.65			
Manganese		6.0 – 7.0				max. 1.50			
Silicon		max. 1.0				max. 0.30			
Copper		–				–			
Cobalt		–				–			
Aluminium		–				max. 0.10			
Titanium		–				–			
Mechanical data (N/mm², %)									
		Rp 0.2	Rm	A_{50}	HV	Rp 0.2	Rm	A_{50}	HV
50% cold-worked		1150	1200	5	300	–	–	–	–
deep-drawable		230	590	30	130	–	–	–	–
Mean rate of thermal expansion (10^{-6}/K)									
T on cooling (°C)		20 °C up to T				20 °C up to T			
100		19.4				20.5			
200		20.3				20.7			
300		20.8				20.8			
350		–				–			
400		21.1				20.8			
425		–				–			
450		–				–			
500		–				–			
550		–				–			
600		–				–			
Salient point T_G		–				–			
Physical properties at room temperature									
Density	(g/cm^3)	8.0				8.0			
Specific heat	(J/kgK)	–				–			
Thermal conductivity	(W/mK)	13				–			
Resistivity	(µΩ cm)	73				78			
Modulus of elasticity	(kN/mm^2)	196				–			
Working									
Melting temperature (°C)		1420				–			
Max. working temperature (°C)		–				–			
Workability		–				–			
Weldability		–				–			
Material properties									
		High thermal expansion.				High thermal expansion.			
Typical applications									
		Thermostatic bimetals, active component.				Thermostatic bimetals, active component.			

ThyssenKrupp VDM alloy		Pernifer 2006				Pernifer 2203			
Specification									
D	Material No.	1.3932				1.3942			
	Designation	NiMn 20 6				X 15 NiCr 22-3			
	DIN	1715-1				–			
	SEW	–				385			
	VdTÜV Material Data Sheet	–				–			
F	AFNOR	–				–			
UK	BS	–				–			
	Type	–				–			
USA	UNS	–				–			
	ASTM	–				B 753 (T-22)			
	ASME	–				–			
	AMS	–				–			
Chemical composition (% by weight)									
Nickel		20.0 – 21.0				21.0 – 23.0			
Chromium		max. 0.5				2.5 – 3.5			
Iron		balance				balance			
Carbon		max. 0.10				max. 0.20			
Manganese		5.5 – 7.0				max. 0.50			
Silicon		max. 0.30				max. 0.5			
Copper		–				max. 0.5			
Cobalt		max. 0.30				–			
Aluminium		max. 0.05				–			
Titanium		–				–			
Mechanical data (N/mm², %)									
		Rp 0.2	Rm	A_{50}	HV	Rp 0.2	Rm	A_{50}	HV
50% cold-worked		–	–	–	–	≥ 800	≥ 850	≥ 5	≥ 250
deep-drawable		≥ 170	≥ 500	≥ 30	≥ 130	≥ 200	≥ 500	≥ 35	≥ 120
Mean rate of thermal expansion (10^{-6}/K)									
T on cooling (°C)		20 °C up to T				20 °C up to T			
100		20.1				19.3			
200		20.6				19.8			
300		20.9				19.9			
350		–				–			
400		21.0				19.9			
425		–				–			
450		–				19.9			
500		21.1				19.9			
550		–				–			
600		21.2				19.9			
Salient point T_G		–				–			
Physical properties at room temperature									
Density	(g/cm^3)	8.1				8.1			
Specific heat	(J/kgK)	–				–			
Thermal conductivity	(W/mK)	13				17			
Resistivity	(µΩ cm)	78				77			
Modulus of elasticity	(kN/mm^2)	196				186			
Working									
Melting temperature (°C)		1440				1460			
Max. working temperature (°C)		–				–			
Workability		–				–			
Weldability		–				–			
Material properties									
		High thermal expansion.				High thermal expansion.			
Typical applications									
		Thermostatic bimetals, active component.				Thermostatic bimetals, active component.			

Controlled expansion and glass sealing alloys

ThyssenKrupp VDM alloy		Pernifer 2508				Pernifer 2918			
Specification									
D	Material No.	1.3902				1.3981			
	Designation	–				NiCo 29 18			
	DIN	–				17745			
	SEW	–				385			
	VdTÜV Material Data Sheet	–				–			
F	AFNOR	–				Fe-Ni 29 Co 17			
UK	BS	–				–			
	Type	–				–			
USA	UNS	–				K94610			
	ASTM	B 753 (T-25)				F 15			
	ASME	–				–			
	AMS	–				7728 I-23011			
Chemical composition (% by weight)									
Nickel		24.5 – 25.5				28.0 – 30.0			
Chromium		8.2 – 8.8				max. 0.10			
Iron		balance				balance			
Carbon		max. 0.03				max. 0.05			
Manganese		max. 0.9				max. 0.5			
Silicon		max. 0.9				max. 0.3			
Copper		–				–			
Cobalt		–				16.0 – 18.0			
Aluminium		max. 0.10				max. 0.05			
Titanium		–				max. 0.10			
Mechanical data (N/mm², %)									
		Rp 0.2	Rm	A_{50}	HV	Rp 0.2	Rm	A_{50}	HV
50% cold-worked		–	–	–	–	660	720	5	220
deep-drawable		–	–	–	–	380	≥ 440	25	150
Mean rate of thermal expansion (10^{-6}/K)									
T on cooling (°C)		20 °C up to T				20 °C up to T		30 °C up to T	
100		18.9				6.5		–	
200		18.9				5.8		5.5	
300		19.0				5.3		5.1	
350		–				–		–	
400		19.1				4.9 ± 0.3		4.9 ± 0.3	
425		–				–		–	
450		–				–		5.3 ± 0.2	
500		–				6.1		6.2	
550		–				–		–	
600		–				7.8		7.9	
Salient point T_G		–				430			
Physical properties at room temperature									
Density	(g/cm³)	–				8.2			
Specific heat	(J/kgK)	–				500			
Thermal conductivity	(W/mK)	–				17.5			
Resistivity	(µΩ cm)	86				49			
Modulus of elasticity	(kN/mm²)	–				160			
Working									
Melting temperature (°C)		–				~ 1450			
Max. working temperature (°C)		–				–			
Workability		–				good			
Weldability		–				good			
Material properties									
		High thermal expansion.				Low thermal expansion up to 400 °C. Freedom from martensite down to -196 °C demonstrable.			
Typical applications									
		Thermostatic bimetals, active component.				Toughened glass bonds TO-housing bases, shaped etched parts, X-ray tubes, leadframes.			

ThyssenKrupp VDM alloy		Pernifer 36 – alloy 36			Pernifer 39
Specification					
D	Material No.	1.3912			1.3913
	Designation	Ni 36			Ni 38
	DIN	17745			17745
	SEW	385			–
	VdTÜV Material Data Sheet	–			–
F	AFNOR	Fe-Ni 36			–
UK	BS	–			–
	Type	–			–
USA	UNS	K93600	K93601	K93603	–
	ASTM	B 388 (Bi-Met.)	B 753 (T-36)	ASTM F1684	B 753 (T-39)
	ASME	–			–
	AMS	I-23011			–

Chemical composition (% by weight)		
Nickel	35.0 – 37.0	37.5 – 40.0
Chromium	max. 0.2	–
Iron	balance	balance
Carbon	max. 0.05	max. 0.10
Manganese	max. 0.5	max. 1.0
Silicon	max. 0.3	–
Copper	–	–
Cobalt	max. 0.5	–
Aluminium	–	–
Titanium	–	–

Mechanical data (N/mm^2, %)									
	Rp 0.2	Rm	A_{50}	HV	Rp 0.2	Rm	A_{50}	HV
50% cold-worked	600	630	5	200	720	740	5	230
deep-drawable	270	≥ 440	30	130	240	490	30	130

Mean rate of thermal expansion (10^{-6}/K)				
T on cooling (°C)	20 °C up to T		20 °C up to T	
100	1.2		3.6	
200	2.2		3.5	
300	5.5		4.7	
350	–		–	
400	8.2		7.4	
425	–		–	
450	–		–	
500	10		9.3	
550	–		–	
600	11.3		10.6	
Salient point T_G	230		–	

Physical properties at room temperature			
Density	(g/cm^3)	8.1	–
Specific heat	(J/kgK)	515	–
Thermal conductivity	(W/mK)	12.5	–
Resistivity	(μΩ cm)	75	71
Modulus of elasticity	(kN/mm^2)	143	–

Working		
Melting temperature (°C)	~ 1430	–
Max. working temperature (°C)	–	–
Workability	good	good
Weldability	good	good

Material properties		
	Extremely low thermal expansion up to 200 °C. Special versions with even lower thermal expansion are available.	Low thermal expansion up to 250 °C.

Typical applications		
	Thermostatic bimetals, active component.	Thermostatic bimetals.

Controlled expansion and glass sealing alloys

ThyssenKrupp VDM alloy		Pernifer 40 – alloy 42				Pernifer 42			
Specification									
D	Material No.	1.3917				1.3917			
	Designation	Ni 42				Ni 42			
	DIN	17745				17745			
	SEW	–				385			
	VdTÜV Material Data Sheet	–				–			
F	AFNOR	–				Fe-Ni 42			
UK	BS	–				–			
	Type	–				–			
USA	UNS	K94000				K94100			
	ASTM	F 30 (Alloy 42)		B 753 (T-40)		B 753 (T-42)			
	ASME	–				–			
	AMS	I-23011				I-23011			
Chemical composition (% by weight)									
Nickel		40.0 – 41.0				41.0 – 43.0			
Chromium		max. 0.25				–			
Iron		balance				balance			
Carbon		max. 0.02				max. 0.02			
Manganese		max. 0.7				max. 0.7			
Silicon		max. 0.15				max. 0.2			
Copper		max. 0.5				max. 0.5			
Cobalt		–				–			
Aluminium		–				–			
Titanium		–				–			
Mechanical data (N/mm^2, %)									
		Rp 0.2	Rm	A_{50}	HV	Rp 0.2	Rm	A_{50}	HV
50% cold-worked		620	700	5	210	650	710	5	210
deep-drawable		240	490	30	130	240	490	30	130
Mean rate of thermal expansion (10^{-6}/K)									
T on cooling (°C)		20 °C up to T		30 °C up to T		20 °C up to T			
100		4.5		4.4		6.0			
200		4.2		4.3		5.5			
300		4.5		4.0 – 4.7		5.3 ± 0.3			
350		–		–		–			
400		6.2		6.0		6.6			
425		–		–		–			
450		–		6.7 – 7.4		–			
500		8.1		7.9		8.3			
550		–		–		–			
600		9.6		9.6		9.7			
Salient point T_G		345				355			
Physical properties at room temperature									
Density	(g/cm^3)	8.2				8.2			
Specific heat	(J/kgK)	500				500			
Thermal conductivity	(W/mK)	15				15			
Resistivity	(µΩ cm)	66				66			
Modulus of elasticity	(kN/mm^2)	148				148			
Working									
Melting temperature (°C)		~ 1440				~ 1440			
Max. working temperature (°C)		–				–			
Workability		good				good			
Weldability		good				good			
Material properties									
		Low thermal expansion up to 300 °C.				Low thermal expansion up to 300 °C.			
Typical applications									
		Thermostatic bimetals, IC flat packs, bonds with moulded glass, X-ray tubes.				Thermostatic bimetals. IC flat packs, etched shaped parts, alumina/ceramic bonds, transistor caps.			

ThyssenKrupp VDM alloy		Pernifer 42 Ti				Pernifer 42 TVR			
Specification									
D	Material No.	(1.3917)				(1.3917)			
	Designation	–				–			
	DIN	–				–			
	SEW	–				–			
	VdTÜV Material Data Sheet	–				–			
F	AFNOR	–				–			
UK	BS	–				–			
	Type	–				–			
USA	UNS	–				–			
	ASTM	–				–			
	ASME	–				–			
	AMS	–				–			
Chemical composition (% by weight)									
Nickel		40.0 – 41.5				41.0 – 43.0			
Chromium		–				–			
Iron		balance				balance			
Carbon		max. 0.025				max. 0.02			
Manganese		max. 1.0				max. 0.1			
Silicon		max. 0.2				max. 0.1			
Copper		max. 0.5				–			
Cobalt		–				–			
Aluminium		–				max. 0.3			
Titanium		0.10 – 0.30				max. 2.4			
Other elements						Nb max. 0.4			
Mechanical data (N/mm^2, %)									
Pernifer 42 Ti	Pernifer 42 TVR	Rp 0.2	Rm	A_{50}	HV	Rp 0.2	Rm	A_{50}	HV
50% cold-worked	age-hardened	–	–	–	–	830	1150	14	340
deep-drawable	flexible	250	490	40	150	340	660	34	160
Mean rate of thermal expansion (10^{-6}/K)									
T on cooling (°C)		20 °C up to T				20 °C up to T			
100		4.6				3.7			
200		4.4				4.1			
300		4.5				5.3			
350		–				–			
400		6.3				7.6			
425		–				–			
450		–				–			
500		8.0				9.2			
550		–				–			
600		9.6				10.4			
Salient point T_G		330				270			
Physical properties at room temperature									
Density	(g/cm^3)	8.2				8.1			
Specific heat	(J/kgK)	500				–			
Thermal conductivity	(W/mK)	15				–			
Resistivity	(µΩ cm)	66				–			
Modulus of elasticity	(kN/mm^2)	150				–			
Working									
Melting temperature (°C)		~ 1450				–			
Max. working temperature (°C)		–				–			
Workability		good				good			
Weldability		good				good			
Material properties									
		Low thermal expansion up to 300 °C.				High mechanical strength with low thermal expansion.			
Typical applications									
		Deep-drawn transistor caps.				TV frames.			

Controlled expansion and glass sealing alloys

ThyssenKrupp VDM alloy		Pernifer 42 TiNb				Pernifer 4205 Ti			
Specification									
D	Material No.	–				–			
	Designation	–				(NiCr 42 5 2)			
	DIN	–				–			
	SEW	–				–			
	VdTÜV Material Data Sheet	–				–			
F	AFNOR	–				–			
UK	BS	–				–			
	Type	–				–			
USA	UNS	–				N09902			
	ASTM	–				–			
	ASME	–				–			
	AMS	–				5221/5223/5225			
Chemical composition (% by weight)									
Nickel		42.0 – 43.5				42.0 – 43.5			
Chromium		–				5.0 – 5.8			
Iron		balance				balance			
Carbon		max. 0.02				max. 0.05			
Manganese		max. 0.2				max. 0.6			
Silicon		max. 0.15				max. 1.0			
Copper		–				max. 0.5			
Cobalt		max. 2.3				–			
Aluminium		–				max. 0.8			
Titanium		max. 2.0				2.0 – 3.0			
Other elements		Nb max. 0.6				–			
Mechanical data (N/mm², %)									
		Rp 0.2	Rm	A_{50}	HV	Rp 0,2	Rm	A_{50}	HV
50% cold-worked		–	–	–	–	≥ 900	≥ 1000	≥ 5	≥ 240
deep-drawable		–	–	–	–	≥ 340	≥ 440	≥ 25	≥ 170
Mean rate of thermal expansion (10^{-6}/K)									
T on cooling (°C)		20 °C up to T				20 °C up to T		30 °C up to T	
100		4.8				8.4		8.2	
200		4.8				10.1		10.1	
300		5.0				12.2		12.2	
350		–				–		–	
400		6.7				13.6		13.6	
425		–				–		–	
450		–				14.4		14.4	
500		8.4				–		–	
550		–				–		–	
600		9.7				15.0		15.1	
Salient point T_G		310				–			
Physical properties at room temperature									
Density	(g/cm³)	–				8.2			
Specific heat	(J/kgK)	–				–			
Thermal conductivity	(W/mK)	–				11.8			
Resistivity	(µΩ cm)	–				100			
Modulus of elasticity	(kN/mm²)	–				–			
Working									
Melting temperature (°C)		–				1440			
Max. working temperature (°C)		–				–			
Workability		good				good			
Weldability		good				good			
Material properties									
		High mechanical strength with low thermal expansion.				Constant spring qualities with temperature. Modulus of elasticity alloy.			
Typical applications									
		Components required to function at high temperatures with low thermal expansion.				Weighing equipment, mechanical filters.			

ThyssenKrupp VDM alloy		Pernifer 4206				Pernifer 46 – alloy 46			
Specification									
D	Material No.	1.3946				1.3920			
	Designation	NiCr 42 6				Ni 46			
	DIN	17745				17745			
	SEW	385				385			
	VdTÜV Material Data Sheet	–				–			
F	AFNOR	Fe-Ni 42 Cr 6				–			
UK	BS	–				–			
	Type	–				–			
USA	UNS	K94750				–			
	ASTM	F 31				F 30			
	ASME	–				–			
	AMS	–				I-23011			
Chemical composition (% by weight)									
Nickel		41.0 – 43.0				45.0 – 46.5			
Chromium		5.0 – 6.0				–			
Iron		balance				balance			
Carbon		max. 0.07				max. 0.10			
Manganese		max. 0.5				max. 0.80			
Silicon		max. 0.30				max. 0.50			
Copper		max. 0.20				–			
Cobalt		–				–			
Aluminium		max. 0.20				–			
Titanium		–				–			
Mechanical data (N/mm^2, %)									
		Rp 0.2	Rm	A_{50}	HV	Rp 0.2	Rm	A_{50}	HV
50% cold-worked		≥ 720	≥ 750	≥ 3	≥ 280	770	780	3	240
deep-drawable		≥ 240	≥ 440	≥ 30	≥ 140	250	510	30	135
Mean rate of thermal expansion (10^{-6}/K)									
T on cooling (°C)		20 °C up to T		30 °C up to T		20 °C up to T		30 °C up to T	
100		7.4		6.9		8.4		8.2	
200		7.3		7.2		8.0		–	
300		8.3		8.2		7.5		7.4	
350		–		8.5 – 9.2		–		7.3	
400		10.0		10.1		7.4		7.3	
425		–		9.7 – 10.4		–		–	
450		–		–		–		–	
500		11.3		11.2		8.4		8.4	
550		–		–		–		–	
600		12.4		12.1		9.6		–	
Salient point T_G		295				460			
Physical properties at room temperature									
Density	(g/cm^3)	8.2				8.2			
Specific heat	(J/kgK)	500				500			
Thermal conductivity	(W/mK)	12.5				15			
Resistivity	(µΩ cm)	95				60			
Modulus of elasticity	(kN/mm^2)	159				152			
Working									
Melting temperature (°C)		1440				1440			
Max. working temperature (°C)		–				–			
Workability		good				–			
Weldability		good				–			
Material properties									
		Thermal expansion matched to type of glass.				Low thermal expansion up to 450 °C.			
Typical applications									
		Bonds with TV tube glass, flashbulbs.				Glass seals.			

Controlled expansion and glass sealing alloys

ThyssenKrupp VDM alloy		Pernifer 4706	Pernifer 48 – alloy 48
Specification			
D	Material No.	2.4486	1.3922
	Designation	NiFe 47 Cr	Ni 48
	DIN	17745	17745
	SEW	385	385
	VdTÜV Material Data Sheet	–	–
F	AFNOR	Fe-Ni 47 Cr 5	Fe-Ni 48
UK	BS	–	–
	Type	–	–
USA	UNS	–	K94800
	ASTM	–	F 30
	ASME	–	–
	AMS	–	I-23011
Chemical composition (% by weight)			
Nickel		47.0	47.0 – 49.0
Chromium		max. 5.5 – 6.5	–
Iron		balance	balance
Carbon		max. 0.02	max. 0.05
Manganese		max. 0.3	max. 0.5
Silicon		max. 0.30	max. 0.3
Copper		–	–
Cobalt		–	–
Aluminium		max. 0.4	max. 0.10
Titanium		–	–

Mechanical data (N/mm², %)

	Rp 0.2	Rm	A_{50}	HV	Rp 0.2	Rm	A_{50}	HV
50% cold-worked	930	950	3	280	700	750	4	220
deep-drawable	200	≥ 500	35	120	280	530	30	125

Mean rate of thermal expansion (10^{-6}/K)

T on cooling (°C)	20 °C up to T		20 °C up to T	30 °C up to T
100	9.7		9.8	9.2
200	9.3		9.2	9.0
300	9.2		8.8	8.8
350	9.5		–	–
400	10.3		8.6 ± 0.3	8.7 ± 0.5
425	–		–	–
450	11.0		–	–
500	11.6		9.1	9.4
550	–		–	9.6 – 10.3
600	12.5		10.2	10.4
Salient point T_G	320		465	

Physical properties at room temperature			
Density	(g/cm³)	8.2	8.2
Specific heat	(J/kgK)	500	500
Thermal conductivity	(W/mK)	14.0	15.9
Resistivity	(µΩ cm)	92	50
Modulus of elasticity	(kN/mm²)	170	164
Working			
Melting temperature (°C)		1450	~ 1440
Max. working temperature (°C)		–	–
Workability		good	good
Weldability		good	good
Material properties			
		Thermal expansion matched to type of glass.	Low thermal expansion up to 450 °C.
Typical applications			
		Bonds with soft glass, especially lead glass, welding filler metal.	Glass seals.

ThyssenKrupp VDM alloy		Pernifer 50 – alloy 52				Pernifer 51 – alloy 51			
Specification									
D	Material No.	2.4478				2.4475			
	Designation	NiFe 47				NiFe 46			
	DIN	17745				17745			
	SEW	385				385			
	VdTÜV Material Data Sheet	–				–			
F	AFNOR	Fe-Ni 50,5				Fe-Ni 51.5			
UK	BS	–				–			
	Type	–				–			
USA	UNS	N14052				–			
	ASTM	F 30				F 30			
	ASME	–				–			
	AMS	–				–			
Chemical composition (% by weight)									
Nickel		50.0 – 51.0				51.0 – 52.0			
Chromium		–				–			
Iron		balance				balance			
Carbon		max. 0.01				max. 0.01			
Manganese		max. 0.5				max. 0.1			
Silicon		max. 0.1				max. 0.1			
Copper		–				–			
Cobalt		–				–			
Aluminium		–				–			
Titanium		–				–			
Mechanical data (N/mm^2, %)									
		Rp 0.2	Rm	A_{50}	HV	Rp 0.2	Rm	A_{50}	HV
50% cold-worked		810	820	3	250	810	820	3	250
deep-drawable		240	540	30	135	240	540	30	135
Mean rate of thermal expansion (10^{-6}/K)									
T on cooling (°C)		20 °C up to T		30 °C up to T		20 °C up to T		30 °C up to T	
100		11.0		10.2		10.5			
200		10.6		10.1		10.4			
300		10.4		10.1		10.3		10.2	
350		–		–		–		–	
400		10.1		9.9		10.2		10.2	
425		–		–		–		–	
450		–		9.7 – 10.2		–		9.9 – 10.5	
500		10.0		9.9		10.0		10.1	
550		–		10.0 – 10.5		–		10.0 – 10.7	
600		10.9		10.8		10.7		11.0	
Salient point T_G		520				520			
Physical properties at room temperature									
Density	(g/cm^3)	8.3				8.3			
Specific heat	(J/kgK)	500				500			
Thermal conductivity	(W/mK)	16.8				16.8			
Resistivity	(µΩ cm)	44				44			
Modulus of elasticity	(kN/mm^2)	160				155			
Working									
Melting temperature (°C)		1445				1445			
Max. working temperature (°C)		–				–			
Workability		good				good			
Weldability		good				good			
Material properties									
		Constant rate of thermal expansion up to 500 °C.				Constant rate of thermal expansion up to 500 °C.			
Typical applications									
		Glass seals, reed relays.				Glass seals, reed relays.			

ThyssenKrupp VDM alloy		Pernifer 5101				Pernima 72			
Specification									
D	Material No.	2.4480				(2.6305) (1.3999)			
	Designation	NiFe 48 Cr				MnCuNi			
	DIN	17745				(1715-1)			
	SEW	385				–			
	VdTÜV Material Data Sheet	–				–			
F	AFNOR	Fe-Ni 50 Cr 1				–			
UK	BS	–				–			
	Type	–				–			
USA	UNS	–				M27200			
	ASTM	–				B 753 (T-10)			
	ASME	–				–			
	AMS	–				–			
Chemical composition (% by weight)									
Nickel		50.5 – 52.5				9.0 – 11.0			
Chromium		max. 1.0 – 1.3				–			
Iron		balance				–			
Carbon		max. 0.01				max. 0.10			
Manganese		max. 0.6				balance			
Silicon		max. 0.15				max. 0.2			
Copper		–				max. 17.0 – 19.0			
Cobalt		–				–			
Aluminium		–				–			
Titanium		–				–			
Mechanical data (N/mm^2, %)									
		Rp 0.2	Rm	A_{50}	HV	Rp 0.2	Rm	A_{50}	HV
50% cold-worked		790	800	3	250	–	–	–	–
deep-drawable		250	550	30	135	–	–	–	≥ 130
Mean rate of thermal expansion (10^{-6}/K)									
T on cooling (°C)		20 °C up to T				20 °C up to T			
100		11.1				26.8			
200		10.5				28.4			
300		10.3				29.5			
350		–				–			
400		10.1				30.1			
425		–				–			
450		–				–			
500		10.5				31.7			
550		–				–			
600		11.5				32.7			
Salient point T_G		490				–			
Physical properties at room temperature									
Density	(g/cm^3)	8.3				7.2			
Specific heat	(J/kgK)	500				–			
Thermal conductivity	(W/mK)	17				8.5			
Resistivity	(µΩ cm)	43				176			
Modulus of elasticity	(kN/mm^2)	157				–			
Working									
Melting temperature (°C)		1440				1120			
Max. working temperature (°C)		–				–			
Workability		good				–			
Weldability		good				–			
Material properties									
		Constant rate of thermal expansion up to 450 °C.				Very high rate of thermal expansion.			
Typical applications									
		Glass seals for overvoltage protection.				Thermostatic bimetals, active component.			

Soft magnetic materials

ThyssenKrupp VDM alloy		Magnifer 36[1]					Magnifer 50[1]				
Specification											
D	Material No.	1.3910	1.3911				1.3922	1.3926	1.3927		
	Designation	Ni 36	RNi 24				Ni 48	RNi 12	RNi 8	E 31	(F3)
	DIN	17745	17405/17745				17745	17405	17405	DIN IEC 740-2 (E DIN 40006)	(41301)
	VdTÜV Material Data Sheet	–					–				
F	AFNOR	–					–				
UK	BS	–					–				
	Type	–					–				
USA	UNS	–					K94840				
	ASTM	A 753					A 753				
	ASME	–					–				
Chemical composition (% by weight)											
Nickel		35.0 – 37.0					47.0 – 48.5				
Chromium		–					–				
Iron		balance					balance				
Carbon		max. 0.05					max. 0.05				
Manganese		max. 1.0					max. 0.3 – 0.5				
Silicon		max. 0.3					max. 0.3				
Copper		–					–				
Molybdenum		–					–				
Aluminium		max. 0.02					max. 0.02				
Other elements		Mg max. 0.01					Mg max. 0.01				
Mechanical data (N/mm², %)											
		Rp 0.2	Rm	A_{50}	HV		Rp 0.2	Rm	A_{50}	HV	
50% cold-worked		600	630	5	200		700	750	4	200	
deep-drawable		290	≥ 440	30	140		280	530	30	125	
Magnetic properties[2]											
		Quality Grade	Permeability (min.) μ_{16}	μ_{max}	Coercive field strength		Quality Grade	Permeability (min.) μ_4	μ_{max}	Coercive field strength	
		MD 1	2000±200	–	–		MF 6	6000	70000	≤ 8	
		MD 1a	2300±200	–	–		MF 8	8000	70000	≤ 8	
							MF 10	10000	80000	≤ 5	
		MD 3	2900	20000	≤ 16		MH 12			≤ 12	
							MH 8	–	–	≤ 8	
		MD 5	μ_4 5000	25000	≤ 12						
							MG 6	6000	70000	–	
							MG 10	10000	80000	–	
							Strip thickness ~ 0.2 mm				
		Strip thickness 0.3 mm					MT Strip thickness 0.1 mm with cubic texture				
Saturation induction	(T)	1.3					1.55				
Curie temperature	(°C)	250					470				
Saturation magnetostriction	(10^{-6})	+ 20					+ 25				
Physical properties at room temperature											
Density	(g/cm^3)	8.1					8.25				
Specific heat	(J/kgK)	515					500				
Thermal conductivity	(W/mK)	12.5					15				
Resistivity	(µΩ cm)	75					45				
Modulus of elasticity	(kN/mm^2)	140					164				
Coefficient of thermal expansion from 20°C to		100	200	300	400	500	100	200	300	400	500
	(10^{-6}/K)	1.2	2.2	5.5	8.2	10.0	9.8	9.2	8.8	8.7	9.1
Working											
Melting temperature (°C)		1450					1440				
Workability		good					good				
Weldability		good					good				
Material properties											
		High resistivity, good permeability with low losses at high frequencies.					Low coercive field strength, good permeability with low losses. High saturation induction.				
Typical applications											
[1] For further material nos. according to DIN, see specific Material Data Sheet [2] AC values after optimum heat treatment. DC values supplied on request.		Transformers, converters, earth-leakage trips, relay and shielding components.					Transformers, converters, earth-leakage trips, relay and shielding components, storage cores, pulse generators, magnetic switches, toroidal tape-wound cores, stepping motors.				

ThyssenKrupp VDM alloy		Magnifer 53[1]	Magnifer 75[1]
Specification			
D	Material No.	2.4420	2.4501 (2.4591) (2.4592) 2.4595 2.4596
	Designation	NiFe 44	NiFe16CuCr (E3) (E4) RNi 2 RNi 5 E 11
	DIN	17745	17745 (41301) (41301) 17405 17405 DINIEC740-2 (E DIN40006)
	VdTÜV Material Data Sheet	–	–
F	AFNOR	–	–
UK	BS	–	–
	Type	–	–
USA	UNS	–	N14076
	ASTM	–	A 753
	ASME	–	–

Chemical composition (% by weight)		
Nickel	54.0 – 56.0	balance
Chromium	–	1.5 – 2.5
Iron	balance	15.0 – 17.0
Carbon	max. 0.05	max. 0.05
Manganese	max. 0.5	max. 1.0
Silicon	max. 0.3	max. 0.3
Copper	–	4.0 – 6.0
Molybdenum	–	–
Aluminium	max. 0.005	–
Other elements	–	–

Mechanical data (N/mm², %)	Rp 0.2	Rm	A_{50}	HV	Rp 0.2	Rm	A_{50}	HV
50% cold-worked	–	–	–	–	800	860	5	270
deep-drawable	–	–	–	–	290	600	40	150

Magnetic properties[2]	Quality Grade	Permeability (min.) μ_4	Permeability (min.) μ_{max}	Coercive field strength	Quality Grade	Permeability (min.) μ_4	Permeability (min.) μ_{max}	Coercive field strength
	MG 40	40000	100000	2	ME 4	40000	115000	–
	MG 60	60000	130000	1.2	ME 6	60000	140000	–
					ME 8	80000	175000	–
					MH 2	–	–	≤ 2
	Strip thickness 0.1 mm				Strip thickness ~ 0.2 mm			
Saturation induction (T)	1.5				0.8			
Curie temperature (°C)	530				400			
Saturation magnetostriction (10^{-6})	+ 25				+ 1			

Physical properties at room temperature										
Density (g/cm^3)	8.3					8.6				
Specific heat (J/kgK)	500					460				
Thermal conductivity (W/mK)	16.5					17				
Resistivity (μΩ cm)	45					55				
Modulus of elasticity (kN/mm^2)	–					–				
Coefficient of thermal expansion from 20°C to	100	200	300	400	500	100				
(10^{-6}/K)	10.6	10.6	10.7	10.7	10.8	12.5				

Working		
Melting temperature (°C)	1445	~ 1450
Workability	good	good
Weldability		good

Material properties		
	High permeability with high saturation induction.	High permeability and low coercive field strength.

Typical applications		
[1] For further material nos. according to DIN, see specific Material Data Sheet [2] AC values after optimum heat treatment. DC values supplied on request.	Converters, transformers, earth-leakage trips, toroidal tape-wound cores for specific applications.	Converters, transformers, earth-leakage trips, relay and shielding components, toroidal tape-wound cores.

Soft magnetic materials

ThyssenKrupp VDM alloy		Magnifer 77 TiNb	Magnifer 7904[1]
Specification			
D	Material No.	–	2.4545
	Designation	–	NiFe 15 Mo
	DIN	–	17745
	VdTÜV Material Data Sheet	–	–
F	AFNOR	–	–
UK	BS	–	–
	Type	–	–
USA	UNS	–	N14080
	ASTM	–	A 753
	ASME	–	–
Chemical composition (% by weight)			
Nickel		77.0 – 78.5	79.5 – 81.0
Chromium		–	–
Iron		balance	balance
Carbon		max. 0.05	max. 0.05
Manganese		–	max. 0.8
Silicon		max. 0.5	max. 0.5
Copper		4.0 – 5.0	–
Molybdenum		max. 0.2	4.0 – 6.0
Aluminium		–	–
Other elements		Ti 0.5 – 1.0; Nb 1.0 – 2.0	–

Mechanical data (N/mm², %)

	Rp 0.2	Rm	A_{50}	HV	Rp 0.2	Rm	A_{50}	HV
50% cold-worked	1030	1050	3	300	900	1000	4	350
80% cold-worked	1210	1240	1	350				
deep-drawable	250	640	40	140	310	750	40	150

Magnetic properties[2]

	Quality Grade	Permeability (min.) μ_4	Permeability (min.) μ_{max}	Coercive field strength	Quality Grade	Permeability (min.) μ_4	Permeability (min.) μ_{max}	Coercive field strength
	–	65.000	250.000	1.5	MP 130	130000	275000	–
	–	–	–	–	MP 160	160000	300000	–
	–	–	–	–	MP 200	200000	350000	–
	–	–	–	–	MP 240	240000	400000	–
	–	–	–	–	MP 280	280000	420000	–
	–	–	–	–				
	–	–	–	–				
	Strip thickness 1.0 mm				Strip thickness 0.06 mm			
Saturation induction (T)	–				0.8			
Curie temperature (°C)	–				410			
Saturation magnetostriction (10^{-6})	–				+ 1			

Physical properties at room temperature

Density	(g/cm^3)	8.7					8.7				
Specific heat	(J/kgK)	–					460				
Thermal conductivity	(W/mK)	25					17				
Resistivity	(µΩ cm)	40					55				
Modulus of elasticity	(kN/mm^2)	–					–				
Coefficient of thermal expansion from 20°C to		100	200	300	400	500	100	200	300	400	500
	(10^{-6}/K)	12.7	–	–	–	–	12.0	12.8	13.0	13.6	14.3

Working

Melting temperature (°C)	–	~ 1440
Max. working temperature (°C)	–	–
Workability	–	good
Weldability	–	good

Material properties

	Precipitation-hardening alloy with good corrosion performance.	High initial permeability and maximum permeability with minimum hysteresis loss.

Typical applications

[1] For further material nos. according to DIN, see specific Material Data Sheet [2] AC values after optimum heat treatment. DC values supplied on request.	Stampings for relays, magnetic heads.	Converters, transformers, earth-leakage trips, relays, shields, magnetic boosters, storage cores, pulse transmitters, chokes, stepping motors.

ThyssenKrupp VDM alloy		Magnifer 8105
Specification		
D	Material No.	–
	Designation	–
	DIN	–
	VdTÜV Material Data Sheet	–
F	AFNOR	–
UK	BS	–
	Type	–
USA	UNS	–
	ASTM	–
	ASME	–

Chemical composition (% by weight)	
Nickel	80.0 – 82.0
Chromium	–
Iron	balance
Carbon	–
Manganese	max. 0.8
Silicon	–
Copper	–
Molybdenum	5.0 – 6.0
Aluminium	–
Other elements	–

Mechanical data (N/mm^2, %)	Rp 0.2	Rm	A_{50}	HV
50% cold-worked	1250	1250	3	350
deep-drawable	310	700	30	140 – 180

Magnetic properties[2]	Quality Grade	Permeability (min.) μ_4	Permeability (min.) μ_{max}	Coercive field strength
		100000	200000	1

	Strip thickness 0.55 mm
Saturation induction (T)	0.72
Curie temperature (°C)	420
Saturation magnetostriction (10^{-6})	- 1 x 10^{-6}

Physical properties at room temperature						
Density	(g/cm^3)	8.7				
Specific heat	(J/kgK)	–				
Thermal conductivity	(W/mK)	17				
Resistivity	(µΩ cm)	60				
Modulus of elasticity	(kN/mm^2)	–				
Coefficient of thermal expansion from 20°C to		100	200	300	400	500
	(10^{-6}/K)	12.0				

Working	
Melting temperature (°C)	~ 1450
Max. working temperature (°C)	–
Workability	good
Weldability	good

Material properties
Negative magnetostriction.

Typical applications
Stampings and shielding housings for magnetic heads.

[2] AC values after optimum heat treatment. DC values supplied on request.

Welding filler metals

Strip electrodes

ThyssenKrupp VDM alloy		Nicorros B 6530 – WS 60	
Specification			
D	Material No.	2.4377	
	Designation	UP-NiCu30MnTi	
	DIN	1736	
GB	BS	2901	
	Type	(NA 33)	
USA	UNS	(N04060)	
	ASME	(ERNiCu-7)	
Chemical composition (% by weight)			
Nickel (+ Cobalt)		min. 62.0	
Chromium		–	
Iron		max. 0.5	
Carbon		max. 0.10	
Manganese		3.0 – 4.0	
Silicon		max. 0.10	
Copper		28.0 – 34.0	
Aluminium		max. 1.0	
Titanium		1.5 – 3.0	
Niobium		–	
Other elements		max. 0.5	
Typical applications			
		Submerged arc overlay welding applied to unalloyed structural and boiler steels. Used in the chemical engineering sector and in offshore and marine engineering.	

ThyssenKrupp VDM alloy		Nicrofer B 7020 – WS 82	Nicrofer B 6616 – WS C-4
Specification			
D	Material No.	2.4806	2.4611
	Designation	UP-NiCr20Nb	UP-NiMo16Cr16Ti
	DIN	1736	1736
GB	BS	2901	2901
	Type	(NA 35)	(NA 45)
USA	UNS	(N06082)	(N06455)
	ASME	(ERNiCr-3)	(ERNiCrMo-7)
Chemical composition (% by weight)			
Nickel		min. 67.0	balance
Chromium		18.0 – 22.0	14.0 – 18.0
Iron		max. 3.0	max. 3.0
Carbon		max. 0.05	max. 0.01
Manganese		2.5 – 3.5	max. 0.5
Silicon		max. 0.5	max. 0.08
Copper		max. 0.5	–
Molybdenum		–	14.0 – 17.0
Cobalt		max. 0.1	max. 2.0
Aluminium		–	–
Titanium		max. 0.75	max. 0.7
Niobium		2.3 – 3.0	–
Other elements		max. 0.5	max. 0.5
Typical applications			
		Submerged arc and electroslag overlay welding applied to unalloyed structural and boiler steels. Used in the chemical engineering sector and in reactor technology.	Electroslag overlay welding on unalloyed structural and boiler steels. Used in the chemical and petrochemical engineering sector.

Welding filler metals

Strip electrodes

ThyssenKrupp VDM alloy		Nicrofer B 6020 – WS 625	Nicrofer B 5923 – WS 59
Specification			
D	Material No.	2.4831	2.4607
	Designation	UP-NiCr21Mo9Nb	UP-NiCr23Mo16
	DIN	1736	1736
GB	BS	2901	2901
	Type	(NA 43)	–
USA	UNS	(N06625)	(N06059)
	ASME	(ERNiCrMo-3)	(ERNiCrMo-13)
Chemical composition (% by weight)			
Nickel		min. 60.0	balance
Chromium		20.0 – 23.0	22.0 – 24.0
Iron		max. 2.0	max. 1.5
Carbon		max. 0.025	max. 0.010
Manganese		max. 0.5	max. 0.5
Silicon		max. 0.5	max. 0.10
Copper		max. 0.5	–
Molybdenum		8.0 – 10.0	15.0 – 16.5
Cobalt		–	max. 0.3
Aluminium		max. 0.3	0.1 – 0.4
Titanium		max. 0.4	–
Niobium		3.2 – 4.1	–
Other elements		max. 0.5	–
Typical applications			
		Submerged arc and electroslag overlay welding applied to unalloyed structural and boiler steels. Used in the chemical and petrochemical engineering sector, in marine engineering and in offshore engineering.	Submerged arc and electroslag overlay welding applied to unalloyed structural and boiler steels. Used in the chemical engineering sector and in flue gas desulphurization.

ThyssenKrupp VDM alloy		Nicrofer B 5716 – WS C-276	Nimofer B 6928 – WS B-2
Specification			
D	Material No.	2.4886	2.4615
	Designation	UP-NiMo16Cr16W	UP-NiMo27
	DIN	1736	1736
GB	BS	2901	2901
	Type	(NA 48)	(NA 44)
USA	UNS	(N10276)	(N10665)
	ASME	(ERNiCrMo-4)	(ERNiMo-4)
Chemical composition (% by weight)			
Nickel		balance	balance
Chromium		15.0 – 16.5	0.4 – 1.0
Iron		4.0 – 7.0	1.5 – 2.0
Carbon		max. 0.01	max. 0.01
Manganese		max. 1.0	max. 1.0
Silicon		max. 0.08	max. 0.08
Copper		–	–
Molybdenum		15.0 – 17.0	26.0 – 30.0
Cobalt		max. 2.5	–
Aluminium		–	–
Titanium		–	max. 1.0
Niobium		–	–
Other elements		W 3.0 – 4.5 V 0.1 – 0.3	max. 0.5
Typical applications			
		Submerged arc and electroslag overlay welding applied to unalloyed structural and boiler steels. Use in the chemical engineering sector and in flue gas desulphurization.	Submerged arc and electroslag overlay welding applied to unalloyed structural and boiler steels. Used mainly in the chemical and petrochemical engineering sector.

Comparison of standards by material numbers.

Material No.	UNS	ThyssenKrupp VDM alloy	Page
1.3902	–	Pernifer 2508	58
1.3910	–	Magnifer 36	68
1.3912	K93600	Pernifer 36 – alloy 36	59
1.3913	–	Pernifer 39	59
1.3917	K94000	Pernifer 40 – alloy 42	60
1.3917	K94100	Pernifer 42	60
(1.3917)	–	Pernifer 42 Ti	61
(1.3917)	–	Pernifer 42 TVR	61
1.3920	–	Pernifer 46 – alloy 46	63
1.3922	K94800	Pernifer 48 – alloy 48	64
1.3922	K94840	Magnifer 50	68
1.3930	–	Pernifer 1407	56
1.3932	–	Pernifer 2006	57
1.3933	–	Pernifer 2002	56
1.3942	–	Pernifer 2203	57
1.3946	K94750	Pernifer 4206	63
1.3981	K94610	Pernifer 2918	58
(1.3999)	M27200	Pernima 72	66
1.4303	S30500	Cronifer 1811 LC – alloy 305	37
1.4529	N08926	Cronifer 1925 hMo – alloy 926	38
1.4539	N08904	Cronifer 1925 LC – alloy 904 L	38
1.4541	S32100	Cronifer 1809 Ti – alloy 321	36
1.4562	N08031	Nicrofer 3127 hMo – alloy 31	29
1.4563	N08028	Nicrofer 3127 LC – alloy 28	29
1.4571	S31635	Cronifer 1810 Ti – alloy 316 Ti	36
1.4591	R20033	Nicrofer 3033 – alloy 33	28
1.4725	K91670	Aluchrom W	53
1.4767	–	Aluchrom Y	52
1.4767	–	Aluchrom YHf	52
(1.4770)	–	Crofer 22 APU	40
1.4847	–	Nicrofer 2020 – alloy 840	41
1.4860	–	Cronifer III	52
1.4862	–	Nicrofer 3718 So –alloy DS	42
1.4876	N08800	Nicrofer 3220 – alloy 800	41
1.4958	N08810	Nicrofer 3220 H – alloy 800 H	44
1.4980	S66286	Cronifer 1525 Ti – alloy 286	40
2.0842	C72150	Konstantan	54
(2.4060)	N02233	Nickel 99.6 K – alloy 233	24
(2.4060)	N02200	Nickel 99.6 Rö C2	25
2.4066	N02200	Nickel 99.2 – alloy 200	25
2.4068	N02201	LC-Nickel 99.2 – alloy 201	24
–	(N02205)	LC-Nickel 99.2 – alloy 205	24
2.4360	N04400	Nicorros – alloy 400	26
2.4377	(N04060)	Nicorros B 6530 – WS 60	72
2.4420	–	Magnifer 53	69
2.4475	–	Pernifer 51 – alloy 51	65
2.4478	N14052	Pernifer 50 – alloy 52	65
2.4480	–	Pernifer 5101	66
2.4486	–	Pernifer 4706	64

Material No.	UNS	ThyssenKrupp VDM alloy	Page
2.4501	N14076	Magnifer 75	69
2.4545	N14080	Magnifer 7904	70
2.4602	N06022	Nicrofer 5621 hMoW – alloy 22	32
2.4605	N06059	Nicrofer 5923 hMo – alloy 59	33
2.4607	(N06059)	Nicrofer B 5923 – WS 59	74
2.4610	N06455	Nicrofer 6616 hMo – alloy C-4	34
2.4611	N06455	Nicrofer B 6616 – WS C-4	73
2.4615	(N10665)	Nimofer B 6928 – WS B-2	75
2.4617	N10665	Nimofer 6928 – alloy B-2	35
2.4619	N06985	Nicrofer 4823 hMo – alloy G-3	31
2.4633	N06025	Nicrofer 6025 HT – alloy 602 CA	45
(2.4639)	–	NiCr 8020	27
2.4650	N07263	Nicrofer 5120 CoTi – alloy C-263	46
2.4658	N06008	Cronix 70	50
2.4660	N08020	Nicrofer 3620 Nb – alloy 20	30
2.4663	N06617	Nicrofer 5520 Co – alloy 617	47
2.4665	N06002	Nicrofer 4722 Co – alloy X	46
2.4668	N07718	Nicrofer 5219 Nb – alloy 718	31, 47
2.4669	N07750	Nicrofer 7016 TiNb – alloy X-750	48
2.4683	R30188	Conicro 4023 W – alloy 188	49
2.4806	N06082	Nicrofer B 7020 – WS 82	73
2.4816	N06600	Nicrofer 7216 – alloy 600	43
2.4816	N06600	Nicrofer 7216 H – alloy 600 H	45
2.4817	N06600	Nicrofer 7216 LC – alloy 600 L	34
2.4819	N10276	Nicrofer 5716 hMoW – alloy C-276	32
2.4831	(N06625)	Nicrofer B 6020 – WS 625	74
2.4851	N06601	Nicrofer 6023 – alloy 601	42
2.4851	N06601	Nicrofer 6023 H – alloy 601 H	44
2.4856	N06625	Nicrofer 6020 hMo – alloy 625	33
2.4858	N08825	Nicrofer 4221 – alloy 825	30
2.4867	N06604	Cronifer II	51
2.4869	N06003	Cronix 80	50
2.4886	(N10276)	Nicrofer B 5716 – WS C-276	75
2.4890	–	Cronifer 45	51
(2.4891)	–	NiCr 8020	27
2.4951	N06075	Nicrofer 7520 – alloy 75	43
2.4952	N07080	Nicrofer 7520 Ti – alloy 80 A	48
(2.4999)	–	NiCr 9010	27
2.6305	M27200	Pernima 72	66
–	–	Pernifer 42 TiNb	62
–	N09902	Pernifer 4205 Ti	62
–	–	Magnifer 77 TiNb	70
–	–	Magnifer 8105	71

Comparison of standards by UNS designations.

UNS	Material No.	ThyssenKrupp VDM alloy	Page
C72150	2.0842	Konstantan	54
K91670	1.4725	Aluchrom W	53
K93600	1.3912	Pernifer 36 – alloy 36	59
K94000	1.3917	Pernifer 40 – alloy 42	60
K94100	1.3917	Pernifer 42	60
K94610	1.3981	Pernifer 2918	58
K94750	1.3946	Pernifer 4206	63
K94800	1.3922	Pernifer 48 – alloy 48	64
K94840	1.3922	Magnifer 50	68
M27200	2.6305	Pernima 72	66
N02200	(2.4060)	Nickel 99.6 Rö C2	25
N02200	2.4066	Nickel 99.2 – alloy 200	25
N02201 (N02205)	2.4068	LC-Nickel 99.2 – alloy 201	24
N02233	(2.4060)	Nickel 99.6 K – alloy 233	24
(N04060)	2.4377	Nicorros B 6530 – WS 60	72
N04400	2.4360	Nicorros – alloy 400	26
N06002	2.4665	Nicrofer 4722 Co – alloy X	46
N06003	2.4869	Cronix 80	50
N06004	2.4867	Cronifer II	51
N06008	2.4658	Cronix 70	50
N06022	2.4602	Nicrofer 5621 hMoW – alloy 22	32
N06025	2.4633	Nicrofer 6025 HT – alloy 602 CA	45
N06059	2.4605	Nicrofer 5923 hMo – alloy 59	33
(N06059)	2.4607	Nicrofer B 5923 – WS 59	74
N06075	2.4951	Nicrofer 7520 – alloy 75	43
(N06082)	2.4806	Nicrofer B 7020 – WS 82	73
N06455	2.4610	Nicrofer 6616 hMo – alloy C-4	34
(N06455)	2.4611	Nicrofer B 6616 – alloy WS C-4	73
N06600	2.4817	Nicrofer 7216 LC – alloy 600 L	34
N06600	2.4816	Nicrofer 7216 – alloy 600	43
N06600	2.4816	Nicrofer 7216 H – alloy 600 H	45
N06601	2.4851	Nicrofer 6023 – alloy 601	42
N06601	2.4851	Nicrofer 6023 H – alloy 601 H	44
N06617	2.4663	Nicrofer 5520 Co – alloy 617	47
N06625	2.4856	Nicrofer 6020 hMo – alloy 625	33
(N06625)	2.4831	Nicrofer B 6020 – WS 625	74
N06985	2.4619	Nicrofer 4823 hMo – alloy G-3	31
N07080	2.4952	Nicrofer 7520 Ti – alloy 80 A	48
N07263	2.4650	Nicrofer 5120 CoTi – alloy C-263	46
N07718	2.4668	Nicrofer 5219 Nb – alloy 718	31, 47
N07750	2.4669	Nicrofer 7016 TiNb – alloy X-750	48
N08020	2.4660	Nicrofer 3620 Nb – alloy 20	30
N08028	1.4563	Nicrofer 3127 LC – alloy 28	29
N08031	1.4562	Nicrofer 3127 hMo – alloy 31	29
N08800	1.4876	Nicrofer 3220 – alloy 800	41
N08810	1.4958	Nicrofer 3220 H – alloy 800 H	44
N08825	2.4858	Nicrofer 4221 – alloy 825	30
N08904	1.4539	Cronifer 1925 LC – alloy 904 L	38

UNS	Material No.	ThyssenKrupp VDM alloy	Page
N08926	1.4529	Cronifer 1925 hMo – alloy 926	38
N09902	–	Pernifer 4205 Ti	62
N10276	2.4819	Nicrofer 5716 hMoW – alloy C-276	32
(N10276)	2.4886	Nicrofer B 5716 – WS C-276	75
N10665	2.4617	Nimofer 6928 – alloy B-2	35
(N10665)	2.4615	Nimofer B 6928 – alloy WS B-2	75
N14052	2.4478	Pernifer 50 – alloy 52	65
N14076	2.4501	Magnifer 75	69
N14080	2.4545	Magnifer 7904	70
R20033	1.4591	Nicrofer 3033 – alloy 33	28
R30188	2.4683	Conicro 4023 W – alloy 188	49
S30500	1.4303	Cronifer 1811 LC – alloy 305	37
S31635	1.4571	Cronifer 1810 Ti – alloy 316 Ti	36
S32100	1.4541	Cronifer 1809 Ti – alloy 321	36
S66286	1.4980	Cronifer 1525 Ti – alloy 286	40
–	(2.4639)	NiCr 8020	27
–	(2.4891)	NiCr 8020	27
–	(2.4999)	NiCr 9010	27
–	1.4847	Nicrofer 2020 – alloy 840	41
–	1.4862	Nicrofer 3718 So – alloy DS	42
–	(1.4770)	Crofer 22 APU	40
–	2.4890	Cronifer 45	51
–	1.4860	Cronifer III	52
–	1.4767	Aluchrom Y	52
–	1.4767	Aluchrom YHf	53
–	1.3930	Pernifer 1407	56
–	1.3933	Pernifer 2002	56
–	1.3932	Pernifer 2006	57
–	1.3942	Pernifer 2203	57
–	1.3902	Pernifer 2508	58
–	1.3913	Pernifer 39	59
–	(1.3917)	Pernifer 42 Ti	61
–	(1.3917)	Pernifer 42 TVR	61
–	–	Pernifer 42 TiNb	62
–	1.3920	Pernifer 46 – alloy 46	63
–	2.4486	Pernifer 4706	64
–	2.4475	Pernifer 51 – alloy 51	65
–	2.4480	Pernifer 5101	66
–	1.3910	Magnifer 36	68
–	1.3922	Magnifer 50	68
–	2.4420	Magnifer 53	69
–	–	Magnifer 77 TiNb	70
–	–	Magnifer 8105	71

Selected conversion factors.
International System of Units (SI)*
Customary U. S./English Units

To convert from	to	multiply by
Mass: SI unit – kg		
kg	pound (lb avoirdupois)	2.2046
lb (avoirdupois)	kg	4.536×10^{-1}
ton (short, 2000 lbs)	kg	9.07185×10^{2}
kg	ton (short)	1.102×10^{-3}
lbs/in. coil width	kg/mm coil width	1.78549×10^{-2}
kg/mm coil width	lbs/in. coil width	5.6007×10
Length: SI unit – meter (m) = 100 cm = 1000 mm		
m	inches (in.)	3.937×10
m	feet (ft)	3.281
mm	in.	3.937×10^{-2}
mm	mils	3.937×10
mils	mm	2.54×10^{-2}
mils	µm	25.4
in.	mm	25.4
ft	m	0.305
Density: $kg/m^3 = g/cm^3 \times 10^{-3}$		
g/cm^3	$lb/in.^3$	3.613×10^{-2}
kg/m^3	$lb/in.^3$	3.613×10^{-5}
$lb/in.^3$	g/cm^3	2.77×10
$lb/in.^3$	kg/m^3	2.77×10^{4}
Specific heat: kJ / kg • K = J x 10^3 / kg • K; cal. / g • K = Btu / lb • °F		
calorie (cal.)	joule (J)	4.187
joule	Btu (British thermal units)	9.486×10^{-4}
Btu	J	1.055056×10^{3}
cal. / g • K	kJ / kg • K	4.187
Thermal conductivity: watt (W) / m • K		
Btu • in. / ft^2 • h • °F	W / m • K	1.4422×10^{-1}
W / m • K	Btu • in. / ft^2 • h • °F	6.9339
Electrical resistivity: µohm (Ω) • cm		
Ω • circ mil / ft	µ Ω • cm	1.662426×10^{-1}
µ Ω • cm	Ω • circ mil / ft	6.015305
Coefficient of thermal expansion: µm/m • K		
µm/m • K	µin./in. • °F	0.5555
µin./in. • °F	µm/m • K	1.8
Mechanical properties: Units of resistance and stress: N/mm^2; pound-force (lbf)/$in.^2$ (psi)		
ksi (= psi x 10^3)	N/mm^2	6.8964
N/mm^2	psi	1.45003×10^{2}
Magnetic conversion factors:		
Gauss (G)	Weber (Wb)/m^2 = Tesla (T)	10^{-4}
Oersted (Oe)	Ampere (A)/m	7.9577×10
A/m	Oe	1.2566×10^{-2}
A/m	A/cm	10^{-2}
G/Oe	Wb/A • m	1.2566×10^{-6}
Wb/A • m	G/Oe	7.9577×10^{5}
Temperature: SI unit - Kelvin (K)		
K to degrees Celcius (°C): subtract 273		
°C to degrees Fahrenheit (°F): multiply by 9/5 and add 32		
°F to °C: subtract 32 and multiply by 5/9		

Selected conversion factors applicable to Material Data Sheets and technical publications.
* SI = Systeme International d'Unités

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