Oil- and Gas-Exploration

Providing special steel solutions

Deutsche Edelstahlwerke

Providing special steel solutions

In search of new oil and gas sources high performance steels with defined mechanical, physical and chemical properties are required.

New oil and gas fields have been identified in large depths under the sea. The tools for exploring these fields are exposed to various rock formations and aggressive media which react with the tools being used.

Depending on the ambient conditions special high strength steels with a high resistance to corrosion are required. Deutsche Edelstahlwerke possess more than 150 years of experience in the development and production of special steels and are thus ideally suited to be your partner in the supply of special steels.

This brochure provides information about the production routes for special oil tool steels and the products which we are able to deliver. Furthermore, mechanical and physical properties for alloyed and stainless grades are provided.

Our technology and experience – your guarantee for premium quality

The purity and homogeneity of our special steels stem from producing them in our modern steelworks.

We fulfill our clients' predefined demands by means of precision alloying and optimized process specifications for melting, shaping and heat treating.

Our state of the art melting and combination of ingot and vertical continuous casting allow bars of various dimensions to be hot rolled or forged. Usually an optimized vertical continuous casting method is used, but for large forging sizes, ingot casting is employed. The combination of processing facilities is unique world wide which allows us to produce all forms of long products required by the market.

With our electroslag and vacuum remelting facilities we are also an important player in other special steel markets, for example the aerospace industry.

Hot forming

Our rolling mills are capable of producing hot rolled bars up to Ø 250 mm *(10 inches)*, as well as flat plates.

Our forging shops are equipped with a 33 MN forging press, a GFM RF 70 (currently one of the largest in the world) and a GFM LSX 25 long forging machines which allow to produce bars and step forgings of a maximum diameter of 460 mm *(18 inches)*.

Heat treatment

Modern heat treatment facilities are available to carry out annealing, hardening, quenching and tempering of the special steel grades. Our furnaces are certified to the requirements of API 6A to ensure homogenous material properties for all cross-sections.

Finishing

Peeling and grinding machines as well as modern non-destructive testing lines, to ensure ultimate quality, are available for rolled and forged products and steel bars. Our machining division, which is equipped with deep hole drilling, milling, turning and grinding facilities, is also capable of producing finished or semifinished components (e.g. drive subs and drill collars).

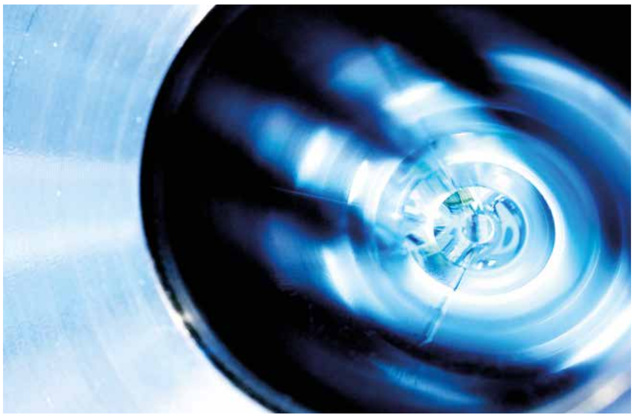
For deep drilling of drill collars and bars up to 12 m *(35 feet)* length, 4 special drilling machines are available. Every bored bar is subjected to a mandrel drift test, following the procedure of API 7-1

Steel grades and applications

Based on its extensive production facilities Deutsche Edelstahlwerke is able to supply the entire portfolio of steel grades required for oil and gas exploration.

This includes the low and high alloyed engineering, ferritic and martensitic as well as high alloyed austenitic and duplex stainless steels.

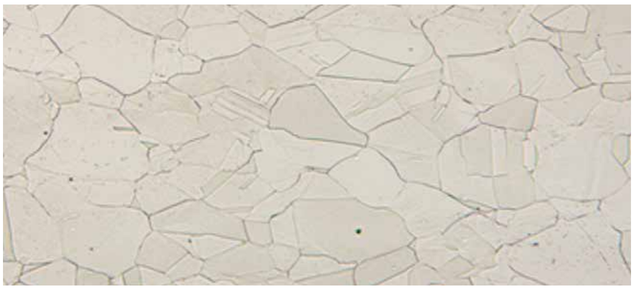
Specialties as strain-hardened (high strength (HS)) non-magnetic stainless steels play a major role in the detection of new oil and gas sources.
Low alloyed steels of the types SAE/AISI 41xx and 86xx series are based on the alloying elements Cr-Mo and Cr-Ni-Mo with carbon contents between 0.25 and 0.50 %. After quenching and tempering hardness according to NACE specifications and impact toughness values (Charpy-V) at low temperatures are required. Specific metallurgical procedures and heat treatments are necessary to obtain these properties in combination with a homogeneous fine grain microstructure. Typical applications for these grades include flanges, valves, blow out preventers and manifolds. High strength engineering steels like SAE 4340 or 4330 V with yield strength levels > 1100 MPa *(160 ksi)* require increased contents of alloying elements like Nickel, Molybdenum and Vanadium. These grades must exhibit enhanced toughness properties even at low temperatures and sometimes also in transverse direction.



Martensitic stainless grades

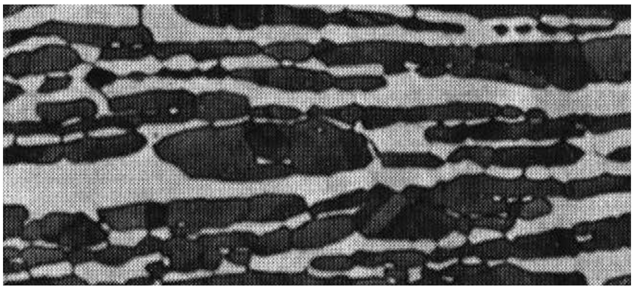
Martensitic stainless grades with 13 % Cr (AISI 410 and 420) are used in mildly corrosive environments when the required strength level is similar to low alloyed engineering steels. Details of the Specification NACE MR 0175 with a narrow tolerance of hardness and strength are to be respected. A reliable process control in all steps of production is necessary to secure these properties.
For applications like drive components (drive trains) for the drill bit within the drill string (down hole motors) precipitation hardening martensitic stainless steels with low carbon contents are used. The most common grade is the steel AISI Type 630 (UNS S174000) with 15-17 % Cr, and 3 - 5% of both Ni and Cu. Since components of this grade also have to comply with the NACE specification, only condition DH 1150 is allowed (approved). In addition to an excellent combination of strength and toughness, the pitting resistance of these steels is also good.

Austenitic stainless grades



Environmental media are often contaminated with aggressive chloride ions. Austenitic steels are genereally resistant to several types of corrosion like pitting as well as sulfide stress cracking (SSC).
However, due to lower strength and susceptibilty to stress corrosion cracking (SCC), these steels are used for a limited number of application only.

Duplex- and super duplex stainless steels



Duplex and super duplex stainless steels, like F 51 and F 53 (1.4462 / 1.4410), are specified for applications where best corrosion resistance is required. These grades combine the advantages of ferritic and austenitic steels thus providing high strength, improved fatigue and corrosionresistance and better resistance to SCC.

More than

3000 **meters under the sea**

Non-magnetic stainless steels (non-mags)

In oil and gas field application non magnetic steels (non-mags) are of particular interest.

These steels rely upon the combination of high Chromium, Manganese and Nitrogen contents in addition to small amounts of Nickel to ensure a stable austenitic microstructure. These non-mags can be work hardened to increase yield and tensile strength corresponding to the requirements of the API 7. A homogeneous austenitic microstructure is the prerequisite to guarantee a magnetic permeability of $\mu r < 1.01$. Since no magnetic inclusion or local ferritic microstructure is allowed inside the material, a particular clean steel production and stringent temperature control in the subsequent hot forming process is necessary. Non-mags steels are used to house the extremely sensitive measuring instruments contained near the drill bit. Typical tools are MWDs (Measuring while drilling) and LWDs (Logging while drilling). MWDs use the earth's magnetic field to determine the precise position of the drilling tools and then control the direction of drilling, while LWDs gather information about the geological formation being drilled. Depending on their application, low and high strength steels are specified. For simple drill collars, heavy weights, flex collars and stabilizers with a low strength level according to API 7 the non-mags grade Magnadur 501 can be used. For more demanding applications like MWDs with increased strength and corrosion resistance we recommend the use of the superior grades Magnadur 509 and Magnadur 601. In addition to the higher strength (> 150 ksi) which is obtained by a higher nitrogen content resulting in enhanced work hardening, the resistance to corrosion is also superior. Both grades exhibit good resistance to pitting corrosion, however, Magnadur 601 provides better resistance to SCC due to its higher Nickel content. All non-magnetic bars for use as heavy weight drill collar, LWD or MWD are subjected to magnetic field variation (hotspot) testing.

Hotspot Testing

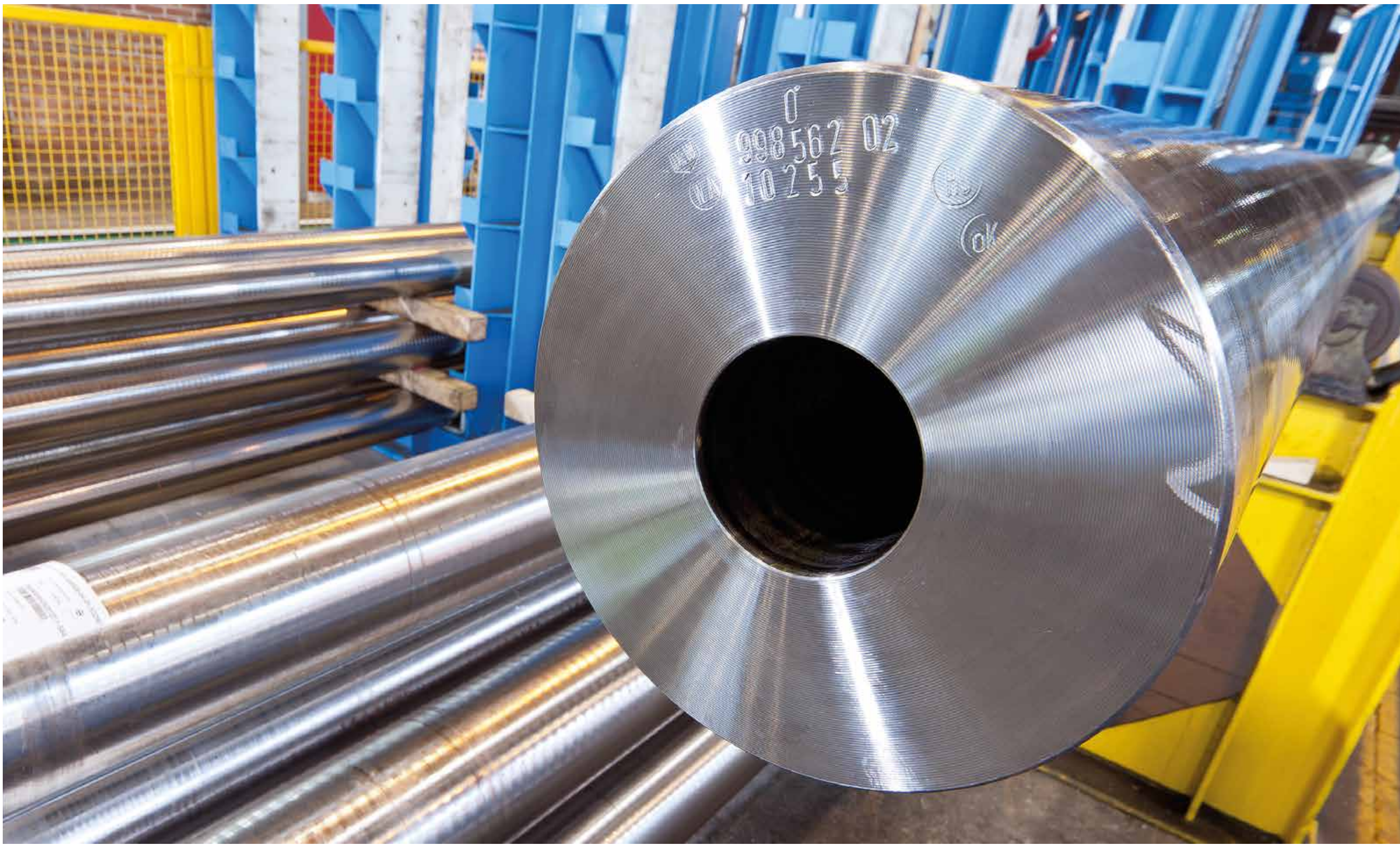
Corrosion Properties

In oil and gas field applications, the materials used are always subjected to corrosive conditions of varying severity.

In fact the dwindling reserves are forcing exploration in ever increasingly harsh environments which are sour and/or contain high levels of chlorides. In addition to this, the combination of materials used and the high strength levels which are required lead to numerous different types of corrosion which have to be considered. Some of the most common forms of corrosion which are encountered include:

Pitting corrosion resistance

This type of corrosion for otherwise stainless steels occurs when the protective passive film on stainless steels is damaged locally, allowing the corrosive environment to get into contact with the unprotected surface of the metal. The passive film is capable of regenerating itself, provided that oxygen is present in the environment. Once stable pits have formed, they continue to grow at an ever increasing rate until in extreme cases the metal is perforated and the material could fail spontaneously without any obvious surface defect. The resistance of an alloy to this unfortunately common type of corrosion can be estimated empirically by applying the so-called pitting resistance equivalent number or PREN, which is based on the chemical composition of the steel. Generally speaking, the higher this number, the better the resistance to pitting. PREN = %Cr + 3.3 x %Mo + 16 x %N. Further differentiation is given by the pitting potential or the Critical Pitting Temperature (CPT) which is determined following ASTM G61 and G150.



Galvanic corrosion

It is almost impossible to avoid glavanic corrosion. It occurs in direct metal-to-metal contact in an electrolyte, resulting in a difference in electrical potential between two different materials. Very frequently weldings are susceptible to galvanic corrosion. Galvanic corrosion can be reduced by ensuring that the difference in electric potential between two contacted metals is as small as possible and by insulating the metals so that they are not in electrical contact with one another. Tests to determine the susceptibility of metals to this form of corrosion include visual examination after immersion in an electrolyte (140,000 ppm chloride, 71 °C, 14 days).

Stress corrosion cracking

This type of corrosion arises when a susceptible material is placed in a chloride or other halide containing environment and subjected to tensile stresses. These stresses can either be residual or applied. The removal of any one of these conditions avoids SCC. From this we can see that the residual and applied stresses must be kept as low as possible or that steps are taken to ensure that only compressive stresses are present. The latter requirement is the reason for purposeful deformation of the inner surface of the hollow bars to produce high compressive residual stresses. High Nickel contents are also known to promote stress corrosion cracking this is why the Nickel content of the high grade non-mags must be carefully controlled. Susceptability to SCC can be measured according to ASTM G36.

Intergranular corrosion

Although this type of corrosion is readily avoidable by accurate control of the chemical analysis and by performing adequate heat treatment, many customers require proof that the steels supplied are free from intergranular corrosion (IGC). The most common tests to determine absence of IGC are performed according to ASTM A 262, Practice A and E.

Engineering Steels

Brandname	AISI	DIN / EN	UNS	GOST	ASTM
Firmodur® 7223	4140 H	1.7223; 41CrMo4	G41400	40XΦA	A 29
Firmodur® 7225	4145 H mod	1.7225; 42CrMo4	G41450	38XM I 40XΓM	A 29
Firmodur® 6562	4330 V mod	1.6562; 40NiCrMo8-4		≈ 34X2H2M	
Firmodur® 6595	4340		G53400	≈ 40X2H2M	
Firmodur® 7380	F22	1.7380; 10CrMo9-10		≈ 10X2M	A 182
Firmodur® 6591	8630 / 8630 mod		G86300	(33X1H1M)	

AISI 4140 H, Firmodur® 7223

	Chemical composition in %								
	C	Si	Mn	P	S	Cr	Mo	Ni	Cu
Min	0.38	0.15	0.75	≤	≤	0.90	0.20	≤	≤
Max	0.43	0.30	1.00	0.025	0.025	1.20	0.25	0.25	0.25

Mechanical properties in quenched and tempered (QT) condition

0.2%-Offset-Yield Strength $R_{p0.2}$ in MPa *(ksi)*	≥ 517 *(75)*
Tensile Strength R_m in MPa *(ksi)*	≥ 655 *(95)*
Elongation L_0 = 4 d (A_4) in %	≥ 18
Reduction of Area (Z) in %	≥ 35
Impact Toughness (Charpy-V at 23 °C) in J *(ft-lbs)*	≥ 54 *(40)*
Impact Toughness (Charpy-V at -60 °C) in J *(ft-lbs)*	≥ 27 *(20)*
Hardness in BHN *(HRC)*	197 – 234 *(18 – 22)*

AISI 4145 H mod, Firmodur® 7225

	Chemical composition in %								
	C	Si	Mn	P	S	Cr	Mo	Ni	Cu
Min	0.42	≤	0.70	≤	≤	0.90	0.20	0.25	≤
Max	0.49	0.40	1.20	0.025	0.025	1.20	0.35	0.40	0.35

Mechanical properties in quenched and tempered (QT) condition

Diameter OD range	**75 - 203 mm *(3 - 8 in)***
0.2%-Offset-Yield Strength $R_{p0.2}$ in MPa *(ksi)*	≥ 828 *(120)*
Tensile Strength R_m in MPa *(ksi)*	≥ 965 *(140)*
Elongation L_0 = 4 d (A_4) in %	≥ 13
Reduction of Area (Z) in %	≥ 40
Impact Toughness (Charpy-V at 23 °C) in J *(ft-lbs)*	≥ 54 *(40)*
Impact Toughness (Charpy-V at -20 °C) in J *(ft-lbs)*	≥ 42 *(30)*
Hardness in BHN *(HRC)*	285 - 340 *(30 - 36)*

Upon request all dimensions are available according to API 7-1

AISI 4330 V mod, Firmodur® 6562

	Chemical composition in %								
	C	Si	Mn	P	S	Cr	Mo	V	Ni
Min	0.29	≤	0.70	≤	≤	0.80	0.30	0.05	1.60
Max	0.35	0.40	1.00	0.015	0.010	1.10	0.50	0.10	3.00

Mechanical properties in quenched and tempered (QT) condition

Diameter OD range	**75 – 203 mm *(3 - 8 in)***	
0.2%-Offset-Yield Strength $R_{p0.2}$ in MPa *(ksi)*	≥ 1035 *(150)*	
Tensile Strength R_m in MPa *(ksi)*	≥ 1138 *(165)*	
Elongation L_0 = 4 d (A_4) in %	≥ 15	
Reduction of Area (Z) in %	≥ 45	
Impact Toughness (Charpy-V at 23 °C) in J *(ft-lbs)*	≥ 60 *(45)*	
Impact Toughness (Charpy-V at -40 °C) in J *(ft-lbs)*	≥ 27 *(20)*	
Hardness in BHN *(HRC)*	360 – 390 *(37 – 42)*	

AISI 4340, Firmodur® 6595

	Chemical composition in %							
	C	Si	Mn	P	S	Cr	Mo	Ni
Min	0.38	≤	0.60	≤	≤	0.70	0.20	1.60
Max	0.43	0.40	0.90	0.020	0.015	1.00	0.30	2.00

Mechanical properties in quenched and tempered (QT) condition

Diameter OD range	**75 – 203 mm *(3 – 8 in)***	**> 203 mm *(8 in)***
0.2%-Offset-Yield Strength $R_{p0.2}$ in MPa *(ksi)*	≥ 1000 *(145)*	≥ 900 *(130)*
Tensile Strength R_m in MPa *(ksi)*	≥ 1100 *(160)*	≥ 1000 MPa *(145)*
Elongation L_0 = 4 d (A_4) in %	≥ 15	
Reduction of Area (Z) in %	≥ 45	
Impact Toughness (Charpy-V at 23 °C) in J *(ft-lbs)*	≥ 60 *(45)*	
Impact Toughness (Charpy-V at -40 °C) in J *(ft-lbs)*	≥ 27 *(20)*	
Hardness in BHN *(HRC)*	330 - 395 *(35- 42)*	300 - 370 *(31 - 39)*

AISI 8630 / 8630 mod, Firmodur® 6591

	Chemical composition in %									
	C	Si	Mn	P	S	Cr	Mo	Ni	V	Cu
Min	0.28	0.15	0.75	≤	≤	0.85	0.35	≤	≤	≤
Max	0.33	0.45	1.00	0.025	0.025	1.50	0.65	1.00	0.06	0.25

Mechanical properties in quenched and tempered (QT) condition

0.2%-Offset-Yield Strength $R_{p0.2}$ in MPa *(ksi)*	≥ 517 *(75)*
Tensile Strength R_m in MPa *(ksi)*	≥ 655 *(95)*
Elongation L_0 = 4 d (A_4) in %	≥ 18
Reduction of Area (Z) in %	≥ 35
Impact Toughness (Charpy-V at 23 °C) in J *(ft-lbs)*	≥ 54 *(40)*
Impact Toughness (Charpy-V at -60 °C) in J *(ft-lbs)*	≥ 27 *(20)*
Hardness in BHN *(HRC)*	207 – 234 *(19 – 22)*

F22, Firmodur® 7380

	Chemical composition in %									
	C	Si	Mn	P	S	Cr	Mo	Ni	V	Cu
Min	0.10	0.15	0.30	≤	≤	2.00	0.90	≤	≤	≤
Max	0.15	0.45	0.50	0.025	0.025	2.50	1.10	0.50	0.03	0.35

Mechanical properties in quenched and tempered (QT) condition

0.2%-Offset-Yield Strength $R_{p0.2}$ in MPa *(ksi)*	≥ 517 *(75)*
Tensile Strength R_m in MPa *(ksi)*	≥ 655 *(95)*
Elongation L_0 = 4 d (A_4) in %	≥ 18
Reduction of Area (Z) in %	≥ 35
Impact Toughness (Charpy-V at 23 °C) in J *(ft-lbs)*	≥ 80 *(59)*
Impact Toughness (Charpy-V at -60 °C) in J *(ft-lbs)*	≥ 27 *(20)*
Hardness in BHN *(HRC)*	207 – 234 *(18 – 22)*

All grades meet the requirements of API 6A and NACE MR0175

Conditions of supply

Surface conditions	black, shot-blast (descaled) or peeled		
Straightness	max. 2.0 mm per meter *(1/8˝ per 5 ft)*, 1.0 mm per meter *(1/16˝ per 5 ft)* upon request		
Availability	hot-rolled:	round:	22 – 250 mm *(14/16 – 9 13/16˝)*
		+ peeled:	Ø 20 – 230 mm *(13/16 – 9 1/16˝)*
		square:	50 – 160 mm *(1 15/16 – 6 5/16˝)*
	forged:	round:	60 – 1100 mm *(2 6/16 – 43 5/16˝)*
		+ peeled/turned:	Ø 55 – 1050 mm *(2 3/16 – 41 11/32˝)*
		square:	65 – 650 mm *(2 9/16 – 25 9/16˝)*

Other diameters upon request

Stainless Steels

Brandname	AISI	DIN / EN	UNS	GOST	ASTM	Other
Corrodur® 4006	410	1.4006;	S41000	12X13	A 276 / A 479	
Corrodur® 4021	420	1.4021	S42000	20X13	A 276 / A 479	
Corrodur® 4418 mod	Super13Cr	1.4415	S41426	07X16H6		NORSOK M-650
Acidur® 4542	630	1.4542	S17400	07X16H4Д4б (≈ 08X15H5Д2T)	A 564	
Acidur® 4462	F51	1.4462	S31803	02X22H5M3 03X22H5AM2 03X22H5AM3	A 479	NORSOK M-630 MDS D47
Magnadur® 3964	XM-19		S20910		A 276 / A 479	

AISI 410, Corrodur® 4006

	Chemical composition in %						
	C	Si	Mn	P	S	Cr	Ni
Min	0.08	≤	≤	≤	≤	11.5	≤
Max	0.15	1.00	1.50	0.040	0.030	13.5	0.75

Mechanical properties in quenched and tempered (QT) condition

Diameter OD range in mm *(inch)*	**≤ 380 *(15)***
0.2%-Offset-Yield Strength $R_{p0.2}$ in MPa *(ksi)*	≥ 517 *(65)*
Tensile Strength R_m in MPa *(ksi)*	≥ 655 *(95)*
Elongation L_0 = 4 d (A_4) in %	≥ 18
Impact Toughness (Charpy-V at -29 °C) in J *(ft-lbs)*	≥ 27 *(20)*
Hardness in BHN *(HRC)*	≥ 241 *(22)*

AISI 420, Corrodur® 4021

	Chemical composition in %						
	C	Si	Mn	P	S	Cr	Ni
Min	0.16	≤	≤	≤	≤	12.0	≤
Max	0.25	1.00	1.50	0.040	0.030	14.0	0.75

Mechanical properties in quenched and tempered (QT) condition

Diameter OD range in mm *(inch)*	**≤ 380 *(15)***	
0.2%-Offset-Yield Strength $R_{p0.2}$ in MPa *(ksi)*	≥ 517 *(65)*	
Tensile Strength R_m in MPa *(ksi)*	≥ 655 *(95)*	
Elongation L_0 = 4 d (A_4) in %	≥ 15	
Impact Toughness (Charpy-V at -10 °C) in J *(ft-lbs)*	≥ 20 J *(15)*	
Hardness in BHN *(HRC)*	≥ 241 *(22)*	

Super13Cr, Corrodur® 4418 mod

	Chemical composition in %								
	C	Si	Mn	P	S	Cr	NI	Mo	V
Min	≤	≤	≤	≤	≤		4.5	1.5	≤
Max	0.03	0.50		0.020	0.005			3.0	0.50

Mechanical properties in quenched and tempered (QT) condition

Condition	**95 ksi**	**110 ksi**
Diameter OD range in mm *(inch)*	≤ 230 *(9)*	≤ 311.15 *(12 1/4)*
0.2%-Offset-Yield Strength $R_{p0.2}$ in MPa *(ksi)*	≥ 655 *(95)*	≥ 755 *(110)*
Tensile Strength R_m in MPa *(ksi)*	≥ 724 *(105)*	≥ 862 *(125)*
Elongation L_0 = 4 d (A_4) in %	≥ 19	≥ 17
Impact Toughness (Charpy-V at 23 °C) in J *(ft-lbs)*	≥ 108 *(80)*	≥ 81 *(60)*
Hardness in BHN *(HRC)*	≥ 300 *(27)*	≥ 310 *(32)*

Production route qualified following NORSOK M-650 qualification protocols; material qualified acc. to NACE MR0175 Annex B.2.3

AISI 630, Acidur® 4542

	Chemical composition in %									
	C	Si	Mn	P	S	Cr	Mo	Ni	Nb	Cu
Min	≤	≤	≤	≤	≤	15.0	≤	3.0	5 x C	3.0
Max	0.07	0.50	1.50	0.030	0.030	17.0	0.60	5.0	0.45	5.0

Mechanical properties after age hardening heat treatment according to ASTM A564 / A564M

Condition	**H1025**	**H1075**	**H1100**	**H1150**	**H1150M**	**H1150D**
Diameter OD range in mm *(inch)*	≤ 304.8 *(12)*	≤ 304.8 *(12)*	≤ 304.8 *(12)*	≤ 304.8 *(12)*	≤ 304.8 *(12)*	≤ 304.8 *(12)*
0.2%-Offset-Yield Strength $R_{p0.2}$ in MPa *(ksi)*	≥ 1000 *(145)*	≥ 860 *(125)*	≥ 795 *(115)*	≥ 725 *(105)*	≥ 520 *(75)*	≥ 725 *(105)*
Tensile Strength R_m in MPa *(ksi)*	≥ 1070 *(155)*	≥ 1000 *(145)*	≥ 965 *(140)*	≥ 930 *(135)*	≥ 795 *(115)*	≥ 860 *(125)*
Elongation L_0 = 4 d (A_4) in %	≥ 12	≥ 13	≥ 14	≥ 16	≥ 18	≥ 16
Reduction of Area (Z) in %	≥ 45	≥ 45	≥ 45	≥ 50	≥ 55	≥ 50
Impact Toughness (Charpy-V at 23 °C) in J *(ft-lbs)*	≥ 20 *(15)*	≥ 27 *(20)*	≥ 34 *(25)*	≥ 41 *(30)*	≥ 75 *(55)*	≥ 41 *(30)*
Hardness in BHN *(HRC)*	≥ 331 *(35)*	≥ 311 *(32)*	≥ 302 *(32)*	≥ 277 *(28)*	≥ 255 *(24)*	≥ 255 *(24)*

F51, Acidur® 4462

	Chemical composition in %								
	C	Si	Mn	P	S	Cr	Ni	Mo	N
Min	≤	≤	≤	≤	≤	21.0	4.5	2.5	0.08
Max	0.03	1.00	2.00	0.030	0.020	23.0	6.5	3.5	0.20

Mechanical properties in the solution annealed condition

Diameter OD range in mm *(inch)*	**20 – 240 (⁷/₈ - 9 ¹/₂)**
0.2%-Offset-Yield Strength $R_{p0.2}$ in MPa *(ksi)*	≥ 450 *(65)*
Tensile Strength R_m in MPa *(ksi)*	≥ 620 *(90)*
Elongation L_0 = 4 d (A_4) in %	≥ 25
Reduction of Area (Z)	≥ 45
Impact Toughness (Charpy-V at 23 °C) in J *(ft-lbs)*	≥ 80 *(60)*
Hardness in BHN *(HRC)*	≥ 280

Conditions of supply

Surface conditions	black, shot-blast (descaled) or peeled		
Straightness	max. 2.0 mm per meter *(1/8˝ per 5 ft)*, 1.0 mm per meter *(1/16˝ per 5 ft)* upon request		
Availability	hot-rolled:	round:	22 – 250 mm *(14/16 – 9 13/16˝)*
		+ peeled:	Ø 20 – 230 mm *(13/16 – 9 1/16˝)*
		square:	50 – 160 mm *(1 15/16 – 6 5/16˝)*
	forged:	round:	60 – 1100 mm *(2 6/16 – 43 5/16˝)*
		+ peeled/turned:	Ø 55 – 1050 mm *(2 3/16 – 41 11/32˝)*
		square:	65 – 650 mm *(2 9/16 – 25 9/16˝)*

Other diameters upon request

Non-magnetic stainless steels

There is no standardization for non-magnetic stainless steels Magnadur® 501, 509 and 601.
All grades are qualified for common OEM specifications/applications.

XM19, Magnadur® 3964 mod

	Chemical composition in %										
	C	Si	Mn	P	S	Cr	Ni	Mo	V	Nb	N
Min	≤	≤	4.0	≤	≤	20.5	11.5	1.50	0.10	0.10	0.20
Max	0.06	1.00	6.0	0.045	0.030	23.5	13.5	3.00	0.30	0.30	0.40

Mechanical properties in solution annealed and strain-hardened condition

Condition	**A**	**High Strength**
Diameter OD range in mm *(inch)*	20 - 247.65 *($^7/_8$ - 9 $^3/_4$)*	20 - 210 *($^7/_8$ - 8 $^1/_2$)*
0.2%-Offset-Yield Strength $R_{p0.2}$ in MPa *(ksi)*	≥ 380	≥ 725 *(105)*
Tensile Strength R_m in MPa *(ksi)*	≥ 690	850 – 1150 *(120 – 165)*
Elongation L_0 = 4 d (A_4) in %	≥ 35	≥ 20
Reduction of Area in %	≥ 55	≥ 50
Impact Toughness (Charpy-V at 23 °C) in J *(ft-lbs)*	≥ 115 *(110)*	≥ 80 *(60)*
Hardness in BHN *(HRC)*	≥ 250	260 - 325 *(26 - 35)*

Forms of delivery: Hot rolled bars, solution annealed, or strain-hardened, machined

Magnadur® 501

	Chemical composition in %									
	C	Si	Mn	P	S	Cr	Mo	Ni	N	PREN
Min		0.30	18.5	≤	≤	13.0	0.35	0.25	0.32	19
Max	0.04	0.60	22.0	0.030	0.005	15.0	0.50	0.50	0.40	23

Mechanical properties in strain-hardened condition

Diameter OD range in mm *(inch)*	80 – 175 *(3 $^1/_2$ – 6 $^7/_8$)*	176 – 255 *(7 – 9 $^3/_4$)*
0.2%-Offset-Yield Strength $R_{p0.2}$ in MPa *(ksi)*	≥ 758 *(110)*	≥ 689 *(100)*
Tensile Strength R_m in MPa *(ksi)*	≥ 828 *(120)*	≥ 758 *(110)*
Elongation L_0 = 4 d (A_4) in %	≥ 25	
Reduction of Area in %	≥ 50	
Impact Toughness (Charpy-V at 23 °C) in J *(ft-lbs)*	≥ 120 *(89)*	
Hardness in BHN *(HRC)*	≥ 300	

Forms of delivery: Forged bars (strain-hardened), machined

Magnadur® 509

	Chemical composition in %									
	C	Si	Mn	P	S	Cr	Mo	Ni	N	PREN
Min			18.0	≤	≤	17.0	0.9	2.5	0.50	28
Max	0.05	0.30	20.0	0.030	0.005	19.0	1.2	3.5	0.60	33

Mechanical properties in strain-hardened condition

Diameter OD range in mm *(inch)*	80 – 247.65 *(3 $^1/_2$ - 9 $^3/_4$)*
0.2%-Offset-Yield Strength $R_{p0.2}$ in MPa *(ksi)*	≥ 965 *(140)*
Tensile Strength R_m in MPa *(ksi)*	≥ 1034 *(150)*
Elongation L_0 = 4 d (A_4) in %	≥ 20
Reduction of Area in %	≥ 60
min. Impact Toughness (Charpy-V at 23 °C) in J *(ft-lbs)*	≥ 134 *(100)*
Hardness in BHN *(HRC)*	≥ 300

Forms of delivery: Forged bars (strain-hardened), machined

Magnadur® 601

	Chemical composition in %									
	C	Si	Mn	P	S	Cr	Mo	Ni	N	PREN
Min		≤	18.0	≤	≤	15.5	2.0	4.2	0.40	29
Max	0.05	0.30	20.0	0.030	0.005	17.5	2.8	5.0	0.50	35

Mechanical properties in strain-hardened condition

Diameter OD range in mm *(inch)*	80 – 247.65 *(3 $^1/_2$ – 9 $^3/_4$)*
0.2%-Offset-Yield Strength $R_{p0.2}$ in MPa *(ksi)*	≥ 965 *(140)*
Tensile Strength R_m in MPa *(ksi)*	≥ 1034 *(150)*
Elongation L_0 = 4 d (A_4) in %	≥ 20
Reduction of Area in %	≥ 60
min. Impact Toughness (Charpy-V at 23 °C) in J *(ft-lbs)*	≥ 134 *(100)*
Hardness in BHN *(HRC)*	≥ 300

Forms of delivery: Forged bars (strain-hardened), machined

Quality Assurance
Providing special steel solutions

Sales Network Swiss Steel Group Production, processing, distribution + services.

Quality Assurance
All materials in this catalogue fulfil as a minimum typical standards of the oil and gas sector, e.g. API 6A, API 7-1 and NACE MR0175. Furthermore Deutsche Edelstahlwerke are certified and approved by independent authorities and significant customers of the oil tool industry.

All over the world
Deutsche Edelstahlwerke are part of the Swiss Steel Group which operates all over the world. The distribution companies are present in all important regions. The unique corporate concept with its three pillars of production, processing and distribution + services qualifies us as solution provider and technology driver – and above all as a reliable and quality-conscious partner to our customers worldwide. As a single-source provider of solutions, know-how and service for steel, we want to constantly further expand and strengthen our global position.

The Swiss Steel Group distribution companies help us to be close to our customers – all over the world. Please do not hesitate to contact our competent sales and technical team if you require any additional information or assistance.

General note (liability)
Not liable for printing errors, omissions and/or changes. All statements regarding the properties and/or utilization of the materials or products mentioned are for purpose of description only. Product specific data sheet have priority over the information provided in this brochure. The desired performance characteristics are binding only if exclusively agreed upon in writing at the conclusion of the contract.

Deutsche Edelstahlwerke
Specialty Steel GmbH & Co. KG
info@dew-stahl.com
dew-stahl.com

Member of Swiss Steel Group
swisssteel-group.com

2021-006_en