

# HOT-ROLLED CARBON STEELS

## Carbon steels as hot-rolled strip for direct processing or cold rolling

Carbon steels as hot-rolled strip for direct processing or cold rolling are typically intended for heat treatment in order to achieve the desired processing and component properties.

### Case-hardening steels

- » For components with high toughness and hard wearing surfaces.
- » Supply according to EN ISO 683-3 (EN 10132 for cold rollers)

### Heat-treatable steels

- » Unalloyed or alloyed for hardness and toughness as required.
- » Supply according to EN ISO 683-1 + 2 (EN 10132 for cold rollers)



PREMIUM QUALITY  
WITH REDUCED  
CARBON FOOTPRINT

### Case-hardening steels

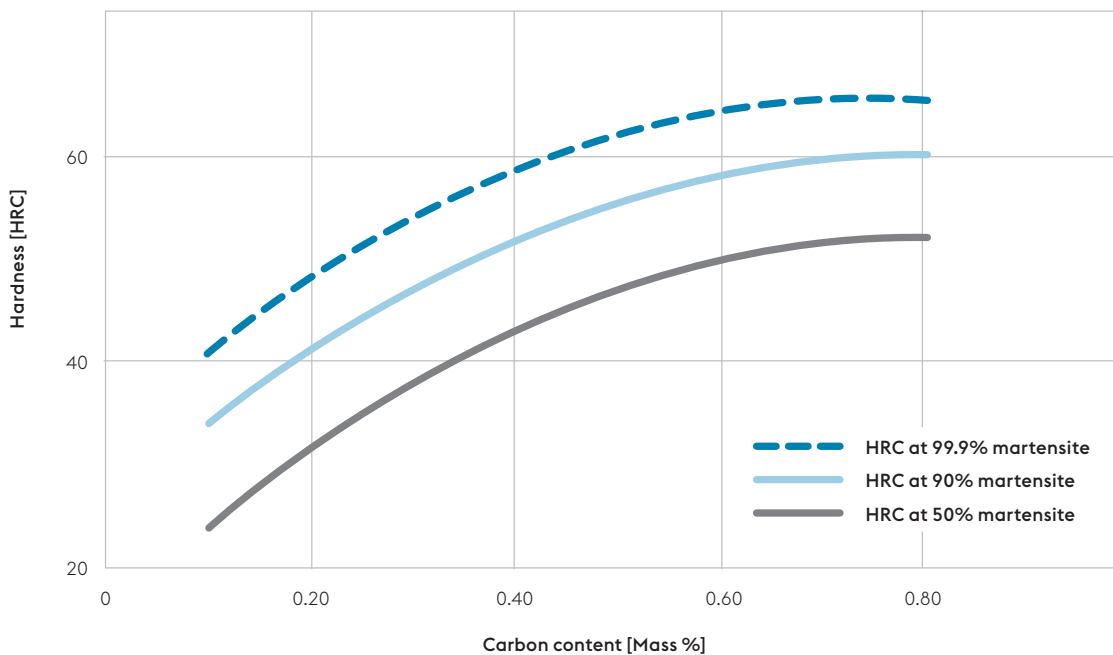
The carbon content for optimized machining and forming lies between 0.10% and 0.20%. In order to achieve the desired properties, a high degree of hardness in the case and usually a tough core, the surface area must be enriched with carbon, hardened and perhaps tempered or stress-relieved. Carbon enrichment is accomplished in the course of component manufacturing by means of carburization. Carbonitriding is carried out when nitrogen enrichment is required.

### Heat-treatable steels

EN ISO 683-1 + 2 differentiates between unalloyed heat-treatable steels (Part 1) and alloyed heat-treatable steels (Part 2). Heat treatment is required in order to adjust the desired component properties, mostly an optimized combination of strength and toughness:

- » Normalizing
- » Quench hardening and tempering

### Maximum achievable hardness varies in dependence on carbon and martensite content



## Chemical composition

Ladle analysis in weight percent

Steel grade	C	Si max.	Mn	P max.	S max.	Cr	Ni max.	Mo max.	Cu max.	other
<b>Case-hardening steels according to EN ISO 683-3 <sup>1)</sup></b>										
C10E	0.07 – 0.13	0.40	0.30 – 0.60	0.025	0.035	0.40	0.40	0.10	0.30	-
C15E	0.12 – 0.18	0.40	0.30 – 0.60	0.025	0.035	0.40	0.40	0.10	0.30	-
16MnCr5	0.14 – 0.19	0.40	1.00 – 1.30	0.025	0.035	0.80 – 1.10	-	-	0.40	-

Steel grade	C	Si max.	Mn	P max.	S max.	Cr max.	Ni max.	Mo max.	Cu max.	other
<b>Unalloyed heat-treatable steels according to EN ISO 683-1 and EN 10132 <sup>1)</sup></b>										
C35E	0.32 – 0.39	0.40	0.50 – 0.80	0.025	0.035	0.40	0.40	0.10	0.30	-
C45E	0.42 – 0.50	0.40	0.50 – 0.80	0.025	0.035	0.40	0.40	0.10	0.30	-
C50E	0.47 – 0.55	0.40	0.60 – 0.90	0.025	0.035	0.40	0.40	0.10	0.30	-
C55E	0.52 – 0.60	0.40	0.60 – 0.90	0.025	0.035	0.40	0.40	0.10	0.30	-
C60E	0.57 – 0.65	0.40	0.60 – 0.90	0.025	0.035	0.40	0.40	0.10	0.30	-
C67S <sup>2)</sup>	0.65 – 0.73	0.15 – 0.35	0.60 – 0.90	0.025	0.025	0.40	0.40	0.10	-	-
C75S <sup>2)</sup>	0.70 – 0.80	0.15 – 0.35	0.60 – 0.90	0.025	0.025	0.40	0.40	0.10	-	-

Steel grade	C	Si max.	Mn	P max.	S max.	Cr	Ni max.	Mo	Cu max.	other
<b>Alloyed heat-treatable steels according to EN ISO 683-2 <sup>1)</sup></b>										
25CrMo4	0.22 – 0.29	0.40	0.60 – 0.90	0.025	0.035	0.90 – 1.20	-	0.15 – 0.30	0.40	-
34CrMo4	0.30 – 0.37	0.40	0.60 – 0.90	0.025	0.035	0.90 – 1.20	-	0.15 – 0.30	0.40	-
42CrMo4	0.38 – 0.45	0.40	0.60 – 0.90	0.025	0.035	0.90 – 1.20	-	0.15 – 0.30	0.40	-
51CrV4	0.47 – 0.55	0.40	0.60 – 1.00	0.025	0.025	0.80 – 1.10	-	-	0.40	V=0.10 – 0.25
20MnB5	0.17 – 0.23	0.40	0.10 – 1.40	0.025	0.035	-	-	-	0.40	B=0.0008 – 0.0050
27MnCrB5-2	0.24 – 0.30	0.40	0.10 – 1.40	0.025	0.035	0.30 – 0.60	-	-	0.40	B=0.0008 – 0.0050

Steel grade	C	Si	Mn	P max.	S max.	Cr	Ni	Mo	Cu max.	other
<b>Special steels <sup>1)</sup></b>										
D6A	0.42 – 0.49	0.15 – 0.35	0.70 – 1.00	0.025	0.01	0.80 – 1.20	0.40 – 0.70	0.80 – 1.20	0.25	V=0.10 – 0.15
58CrV4	0.54 – 0.62	0.15 – 0.35	0.70 – 1.10	0.025	0.01	0.90 – 1.20	max. 0.25	max. 0.06	0.25	V=0.10 – 0.25
63NiNb4	0.60 – 0.66	0.15 – 0.35	0.30 – 0.60	0.025	0.01	max. 0.15	0.85 – 1.10	max. 0.15	0.25	Nb=0.03 – 0.05
68NiCrMo3	0.65 – 0.71	0.15 – 0.35	0.30 – 0.60	0.025	0.01	0.40 – 0.60	0.50 – 0.80	0.15 – 0.25	0.25	-
72NiCrMo4-2	0.69 – 0.75	0.15 – 0.35	0.40 – 0.70	0.025	0.01	0.30 – 0.60	0.70 – 1.00	0.05 – 0.10	0.25	-
75Cr1	0.70 – 0.80	0.25 – 0.50	0.60 – 0.80	0.025	0.01	0.30 – 0.40	max. 0.25	max. 0.06	0.25	-
75CrNiMo	0.70 – 0.80	0.15 – 0.35	0.60 – 0.90	0.025	0.01	0.50 – 0.70	0.30 – 0.60	0.05 – 0.15	0.25	-
75Ni8 <sup>2)</sup>	0.72 – 0.78	0.15 – 0.35	0.30 – 0.50	0.025	0.01	max. 0.15	1.80 – 2.10	max. 0.06	0.25	-
80CrV2 <sup>2)</sup>	0.78 – 0.85	0.15 – 0.35	0.40 – 0.70	0.025	0.01	0.40 – 0.60	max. 0.25	max. 0.06	0.25	V=0.15 – 0.25
C100S <sup>2)</sup>	0.95 – 1.05	0.15 – 0.35	0.30 – 0.60	0.025	0.01	max. 0.40	max. 0.25	max. 0.06	0.25	-

<sup>1)</sup>Please inquire about any deviations from the indicated melt analyses or narrower limit values.

<sup>2)</sup>Steel grade according to EN 10132 (standard for cold-rolled strip)

The listed steel grades are an excerpt from our production range. Further steel grades defined by national and international standards and special analyses according to customer specifications are also available upon request.

## Steel grade table of comparison

Steel grade	Material number	Euronorm	SAE
<b>Case-hardening steels</b>			
C10E	1.1121	EN ISO 683-3	1010
C15E	1.1141	EN ISO 683-3	1015
16MnCr5	1.7131	EN ISO 683-3	5115
<b>Unalloyed heat-treatable steels</b>			
C35E	1.1181	EN ISO 683-1	1035
C45E	1.1191	EN ISO 683-1	1045
C50E	1.1206	EN ISO 683-1	1050
C55E	1.1203	EN ISO 683-1	1055
C55S	1.1204	EN 10132	1055
C60E	1.1221	EN ISO 683-1	1060
C60S	1.1211	EN 10132	1060
C67S	1.1231	EN 10132	1065/1070
C75S	1.1248	EN 10132	1074
<b>Alloyed heat-treatable steels</b>			
25CrMo4	1.7218	EN ISO 683-2	4130
34CrMo4	1.7220	EN ISO 683-2	4135
42CrMo4	1.7225	EN ISO 683-2	4140/4142
51CrV4	1.8159	EN ISO 683-2	6150
58CrV4	1.8161	Special grade	-
20MnB5	1.5530	EN ISO 683-2	-
27MnCrB5-2	1.7182	EN ISO 683-2	-
<b>Special steels</b>			
D6A	1.2791	-	-
58CrV4	1.8161	Special grade	-
63NiNb4	-	-	8660+Nb
68NiCrMo3	-	-	8667/8667mod
72NiCrMo4-2	-	-	8670
75CrNiMo	-	-	-
75Cr1	1.2003	-	-
75Ni8	1.5634	EN 10132	-
80CrV2	1.2235	EN 10132	-
C100S	1.1274	EN 10132	-

**Mechanical properties: Tensile test**

Indicative values depending on as-delivered condition

Steel grade	As-rolled		Annealed
	Yield strength $R_{p0.2}$ [MPa]	Tensile strength $R_m$ [MPa]	Tensile strength $R_m$ [MPa]
C10E	300	400	380
C15E	330	470	450
16MnCr5	400	600	480
C35E	450	680	500
C45E	460	750	600
C50E	490	830	600
C55E / C55S	500	840	600
C60E / C60S	520	860	650
C67S	550	950	660
C75S	550	950	680
25CrMo4	650	850	550
34CrMo4	770	970	650
42CrMo4	790	990	660
51CrV4	850	1050	680
27MnCrB5-2	490	670	520
20MnB5	530	680	570
58CrV4	870	1070	680
63NiNb4	700	1000	680
68NiCrMo3	700	1000	680
72NiCrMo4-2	700	1000	680
75CrNiMo	840	1140	680
75Cr1	700	1000	680
75Ni8	740	1100	680
80CrV2	990	1300	720
C100S	700	1200	720
D6A	980	1250	650

Carbon steels are usually supplied in as-delivered condition without any guarantee of mechanical properties. Guaranteed values are subject to a separate agreement.

Soft-annealed is available in as-delivered condition. Upon request, we also supply spheroidized grade GKZ, soft-annealed on spherical cementite.

## Dimensions

Examples of maximum width per thickness; additional dimensions and minimum order quantities upon request

Steel grade	Thickness [mm]						
	2.00	2.50	3.00	3.50	4.00	6.00	8.00
C10E	1370	1620	1620	1620	1620	1620	1620
C15E	1370	1620	1620	1620	1620	1620	1620
16MnCr5	1240	1410	1590	1620	1620	1620	1620
C35E	1240	1410	1590	1620	1620	1620	1620
C45E	1240	1390	1540	1620	1620	1620	1620
C50E	1200	1350	1500	1620	1620	1620	1620
C55E / C55S	1200	1350	1500	1620	1620	1620	1620
C60E / C60S	1110	1260	1410	1560	1620	1620	1620
C67S	1110	1260	1410	1560	1620	1620	1620
C75S	1090	1220	1350	1485	1620	1620	1620
25CrMo4	1110	1260	1410	1560	1620	1620	1620
34CrMo4	1110	1260	1410	1560	1620	1620	1620
42CrMo4	1090	1220	1350	1485	1620	1620	1620
51CrV4	1090	1220	1350	1485	1620	1620	1620
20MnB5	1110	1260	1410	1560	1620	1620	1620
27MnCrB5-2	1110	1260	1410	1560	1620	1620	1620
58CrV4	1090	1220	1350	1485	1620	1620	1620
63NiNb4	1090	1220	1350	1485	1620	1620	1620
68NiCrMo3	1090	1220	1350	1485	1620	1620	1620
72NiCrMo4-2	1090	1220	1350	1485	1620	1620	1620
75CrNiMo	1090	1220	1350	1485	1620	1620	1620
75Cr1	1090	1220	1350	1485	1620	1620	1620
75Ni8	1090	1220	1350	1485	1620	1620	1620
80CrV2	-	1025	(1150)	(1270)	(1400)	(1620)	(1620)
C100S	-	1220	1350	1485	1620	(1620)	(1620)
D6A	-	1100	1260	1430	1620	1620	1620

Depending on the dimensions and strength, we also supply pickled/oiled/trimmed

Steel strip	Slit steel strip	Cut sheets
Width: 900 - 1620 (1750) mm	Thickness: up to 12 mm	Thickness: up to 20 mm
Weight/Width: 18 - 20 kg/mm	Strip widths: beginning at 30 mm	Length: up to 12 m (18 m)

## Dimensional tolerances

Dimensional tolerances of the hot-rolled strip comply with EN 10051.

With respect to the thickness, 50% of the tolerance according to EN 10051 (when measured 25 mm in from the cut edge) is guaranteed. Narrower thickness tolerances are possible upon request.

A very flat strip shape (crown) is decisive for a number of further processing steps (such as cold rolling).

Dimensions and material properties are subject to agreement.

## General information about material properties

### Chemical composition

The basis for achievement of the desired hardness values after heat treatment is the chemical composition. The carbon content influences achievable hardness, and alloying elements such as manganese, chromium and molybdenum influence the through hardenability. The indicated analysis boundaries apply to the ladle analysis. A number of modifications to the chemical composition are available for several grades. Further steels not included in the list can be supplied upon request according to standards and individual customer specifications.

### Mechanical properties

Carbon steels are generally manufactured according the specified chemical composition without any guarantee of mechanical properties in the as-delivered condition of the hot-strip pre-material. The properties of the hot-rolled strip are determined in large part by the cooling strategy used. This especially applies to the formation of pearlite.

### As-delivered condition

Depending on customer requirements and further processing steps, the following as-delivered conditions can be supplied for a wide range of steel grades:

- » As-rolled condition with largely fine-lamellar pearlite, such as for optimized microstructure during spheroidizing-annealing
- » As-rolled condition with largely globular pearlite, for example, in lower-strength steels in as-delivered condition
- » Soft-annealed: Batch annealing without guaranteed level of spheroidization
- » Spheroidized-annealed: Batch annealing with guaranteed level of spheroidization according to grade upon request

Prior descaling is recommended for deliveries in annealed condition.

### Degree of purity

The carbon steels produced at voestalpine Stahl GmbH with reduced sulfur and phosphorus content (special steels according to EN 10020). This is in view of the microscopic degree of purity and formation of segregations. Requirements with regard to the degree of purity can be met upon request according to EN 10247 (DIN 50602), ASTM E 45, ISO 4967.

### Formation of soft spots

The maximum aluminum content is defined or aluminum and chromium are matched in a ratio of 1/10 (for unalloyed case-hardening steel grades) in order to avoid soft spots during heat treatment of the final product.

### Graphitization

Undesirable graphite precipitation can result from carbon content above 0.50%. This precipitation depends on the chemical composition in combination with a high cold-rolling ratio and long annealing cycles. In order to avoid the tendency toward this precipitation, an agreement should be made with respect to chemical composition (especially in order to determine lower Al content or Cr and/or Mn alloying).

# OUR PATH TO A GREENER FUTURE

## Premium products in the greentec steel Edition

With greentec steel, voestalpine is pursuing an ambitious step-by-step plan in the long-term decarbonization of steel production. The declared objective is to achieve carbon-neutral production by 2050, and the initial steps have already been taken. Process-optimized production operations already prevent up to 10% of the direct CO<sub>2</sub> emissions at the Linz site. The material and processing properties of the steel are not affected in any way in this production route. Each voestalpine steel strip product is available in premium quality in the greentec steel Edition with a reduced carbon footprint and unique benefits.



Premium quality with reduced carbon footprint

Hot-rolled steel strip – greentec steel Edition

Max. carbon footprint 2.10 kg CO<sub>2</sub>e per kg of steel <sup>1)</sup>

<sup>1)</sup> per EN 15804+A2 (EPD methodology) cradle to gate

All products, dimensions and steel grades listed in each voestalpine supply range are available as greentec steel Edition.

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