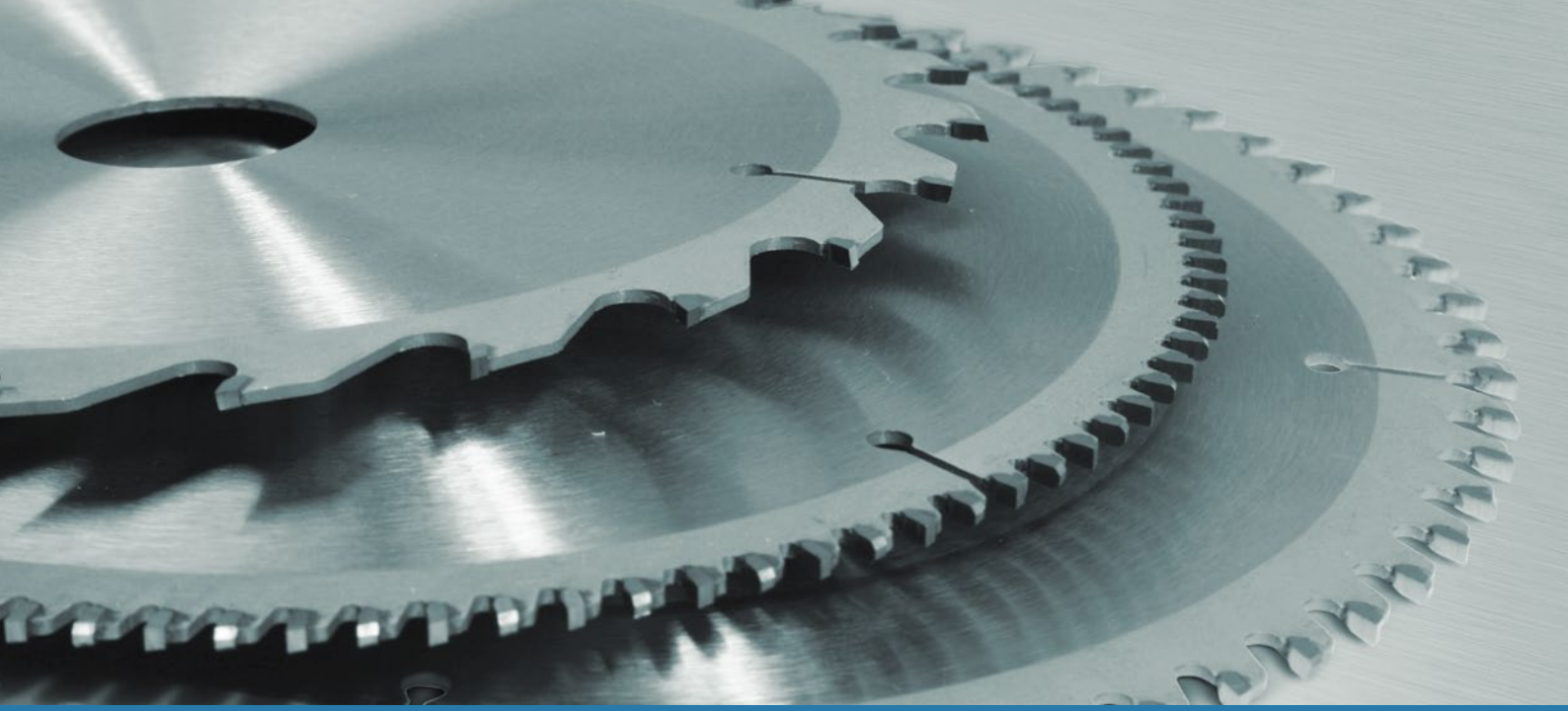




# HOT-ROLLED CARBON STEELS

## 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 10132-2 for cold rollers)

**Heat-treatable steels**
- Unalloyed or alloyed for hardness and toughness as required.
- Supply according to EN ISO 683-1 + 2 (EN 10132-3 + 4 for cold rollers)

**Spring steels**
- Springs, components with high abrasion resistance and rigidity.
- Supply according to EN 10089

### 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

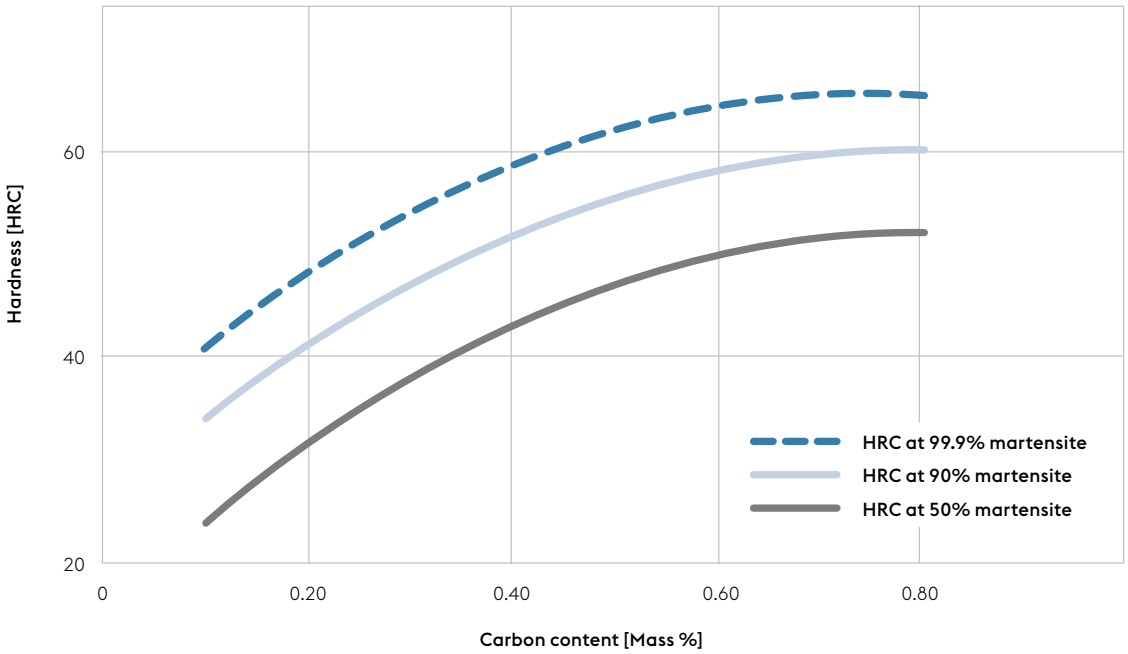
EN ISO 683-1 + 2 differentiates between unalloyed heat-treatable steels (Part 1) and alloyed heat-treatable steels (Part 2). Heat treatment is required in order to adjust the desired component properties, mostly an optimized combination of strength and toughness:

» Normalizing
» Quench hardening and tempering

### Spring steels

EN 10089 describes spring steels as materials that are suitable in quenched and tempered condition for the manufacturing of spring components of all kinds. The resiliency of components made of such steels is based on their modulus of elasticity, which can only be influenced by alloying and heat treatment, and on their high yield strength. The desired properties are achieved through higher weight percentages of carbon and alloying constituents such as silicon, manganese, chromium, molybdenum or vanadium as well as by heat treatment in the form of 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Case-hardening steels according to EN ISO 683-3** [1] | | | | | | | | | | |
| 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 | Mn | P max. | S max. | Cr max. | Ni max. | Mo max. | Cu max. | other |
|---|---|---|---|---|---|---|---|---|---|---|
| **Unalloyed heat-treatable steels according to EN ISO 683-1 and EN 10132-4** [1] | | | | | | | | | | |
| 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 [2] | 0.65 – 0.73 | 0.15 – 0.35 | 0.60 – 0.90 | 0.025 | 0.025 | 0.40 | 0.40 | 0.10 | – | – |
| C75S [2] | 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Alloyed heat-treatable steels according to EN ISO 683-2** [1] | | | | | | | | | | |
| 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 max. | Mn | P max. | S max. | Cr | Ni max. | Mo max. | V |
|---|---|---|---|---|---|---|---|---|---|
| **Spring steels according to EN 10089** [1] | | | | | | | | | |
| 51CrV4 | 0.47 – 0.55 | 0.40 | 0.70 – 1.10 | 0.025 | 0.025 | 0.90 – 1.20 | – | – | 0.10 – 0.25 |

| Steel grade | C | Si | Mn | P max. | S max. | Cr | Ni | Mo | Cu max. | other |
|---|---|---|---|---|---|---|---|---|---|---|
| **Special steels** [1] | | | | | | | | | | |
| 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 [2] | 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 [2] | 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 [2] | 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 | – |

[1] Please inquire about any deviations from the indicated melt analyses or narrower limit values.

[2] Steel grade according to EN10132-4 (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 |
|---|---|---|---|
| **Case-hardening steels** | | | |
| C10E | 1.1121 | EN ISO 683-3 | 1010 |
| C15E | 1.1141 | EN ISO 683-3 | 1015 |
| 16MnCr5 | 1.7131 | EN ISO 683-3 | 5115 |
| **Unalloyed heat-treatable steels** | | | |
| 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 Part 4 | 1055 |
| C60E | 1.1221 | EN ISO 683-1 | 1060 |
| C60S | 1.1211 | EN 10132 Part 4 | 1060 |
| C67S | 1.1231 | EN 10132 Part 4 | 1065/1070 |
| C75S | 1.1248 | EN 10132 Part 4 | 1074 |
| **Alloyed heat-treatable steels** | | | |
| 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 | – |
| **Spring steels** | | | |
| 51CrV4 | 1.8159 | EN 10089 | 6150 |
| **Special steels** | | | |
| 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 10132-4 | – |
| 80CrV2 | 1.2235 | EN 10132-4 | – |
| C100S | 1.1274 | EN 10132-4 | – |

**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 EN10051.
With respect to the thickness, 50% of the tolerance according to EN 10 051 (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.



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## 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).

Please find further information and downloadable files at
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