Data Sheet: A2.2

High carbon and quenchable steels

Hot Rolled Steel Plate and Coil for Hardening and Wear Resistance

General description

Steel is generally classified as high carbon steel if the nominal carbon content exceeds 0,30%. High carbon steel is generally supplied in the as rolled condition to analysis only. After processing (e.g. blanking, forming or shaping), the high carbon steel is generally heat treated to obtain the desired mechanical properties. In certain applications high carbon steels are used in the as rolled condition on account of the cost saving this brings about. WEARPLATE® 200 is a typical example of a high carbon, as rolled, low cost, wear resistant steel.

Steels with a nominal carbon content in the 0,30% to 0,53% range are selected for applications where higher mechanical strengths are required. Steels in this group are suitable for a wide variety of automotive applications and are frequently heat treated to obtain the required mechanical properties. The selection of steel is governed by the mechanical properties required, the heat treatment facilities available and the design of the component. Different heat treatments should be applied to obtain optimum properties for a particular composition and application. Where parts are cold formed, it is recommended that the steel be normalised or annealed before forming.
Stamping should be limited to flat parts or simple bends.

Due to the fact that good wear resistance is obtained on high carbon steels when heat-treated, they are suitable for farm implements such as plough beams, plough shares, scraper blades, discs, mower knives and harrow teeth.

Steel making

High carbon steels are silicon killed, but can be manufactured to fine grain practice by the addition of aluminium. In applications where toughness is important, steel with low sulphur content may be specified. Low sulphur practice, typically 0,010% maximum, reduces the presence of sulphide stringers thereby improving toughness.

For further information, contact:
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Chemical composition

The high carbon steels are produced to the following chemical analysis specifications:

Table 1. Chemical composition (ladle analysis, percent)

Specification	C	Mn	P max	S max	Si	Ti	B	Al min
SAE1030 (CT 625)	0,28 - 0,34	0,60 - 0,90	0,030	0,050		-	-	-
WEARPLATE 200	0,40 - 0,55	0,70 - 1,00	0,050	0,050	0,15 - 0,35	-	-	-
22MnB5 AMSA HR*	0,20 – 0,25	1,10 – 1,40	0,025	0,008	0,15 – 0,35	0.02 – 0,05	0,002 – 0,005	0,015
15MnB5 AMSA Plate*	0,12 – 0,18	1,20 – 1,50	0,025	0,008	0,20 – 0,50	0,01 – 0,04	0,001 – 0,005	0,015

Note: MCR24 is replaced by above qualities.*

Dimensions

The high carbon steels are available in plate and coil form, sides uncut.

Table 2. Available dimensions for Hot Rolled Coil[1]

Specification	Width (mm)	Thickness (mm)
SAE 1030	1 185 - 1 280	2,4 - 3,8
WEARPLATE 200	830 - 940 1 185 - 1 280	2,0 - 6,0 2,5 - 6,0
22MnB5 AMSA HR	830 – 940 1 185 - 1 280	2,5 -6,0 2,5 – 6,0

1. Within the ranges shown certain specific sizes are Standard Items (Refer to Price Lists 120 and 121).

Table 3. Available dimensions for Plate Products

Specification	Width (mm)	Thickness (mm)
WEARPLATE 200	1000 - 2400	6,0 – 60
15MnB5 AMSA Plate	1800 - 2400	6,0 – 20

For specific details on available dimensions, refer to the data sheet: Plate Mill Product Dimensions (file reference A1.3).

Table 4. Available dimensions for Cold Rolled Products

Specification	Width (mm)	Thickness (mm)
22MnB5 CR (Hot Forming)	834 - 1280	1,2 – 2,0

For further details on availability, refer to Price List 131.

Dimensional tolerances

Material produced on the hot strip mill is produced with dimensional tolerances as described in the data sheet: Hot Strip Mill Tolerances (file reference A1.2). Dimensional tolerances for plates produced on the plate mill are described in the data sheet: Plate Mill Product Tolerances (file reference A1.4).

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Certification

All material described in this data sheet is supplied with analysis certificates only. No mechanical properties are guaranteed.

Heat treatment

Heat treatments commonly performed on high carbon steels include:

- normalising
- annealing
- austempering
- quenching and tempering

Normalising

Normalising heat treatment entails the uniform heating of the steel to above the austenitising temperature to obtain complete transformation to austenite (austenitising), soaking at this temperature until the component has a uniform temperature throughout, followed by cooling in still air, with adequate free circulation of air to ensure uniform cooling. Normalising results in grain refinement and a homogeneous structure with uniform mechanical properties.

The normalising temperature depends on the steel chemistry. The holding time is determined by the size of the heat-treated component. Normalising cycles and the resulting steel properties may vary considerably with the steel chemistry, part size, furnace conditions and cooling facilities. A metallurgist and/or heat treatment guide should be consulted.

Annealing

Full annealing consists of austenitising, followed by controlled, slow, uniform cooling. Annealing, which is used to soften the steel, produces steel with improved formability and machinability as a result of the change in microstructure.

Austempering

Austempering entails heating steel to the austenitising temperature and quenching it to an intermediate temperature lower than the pearlite transformation temperature, but higher than the martensite transformation temperature, and holding it at this temperature until transformation is complete before cooling it to ambient temperature. For this purpose, a quenching medium is required which has a heat extraction capacity that is high enough to prevent the formation of high temperature transformation products.

Austempering is used to obtain a microstructure corresponding to that of low temperature transformation products, which results in a favourable combination of high strength and toughness.

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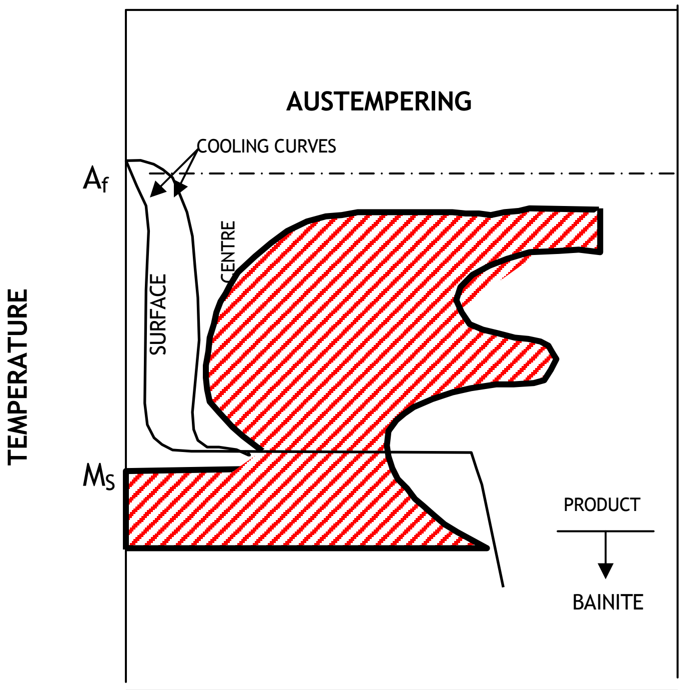
Schematic illustration of an austempering cycle



Quenching and tempering

Quenching is a hardening heat treatment process that entails the rapid cooling of steel from the austenitising temperature to that of a quenching medium, such as water, brine or oil. If the carbon content of the steel is higher than 0,50%, oil quenching only is recommended. The quenching process ensures that the maximum hardness of the steel is obtained by transformation to a low temperature transformation product such as bainite or martensite. The high strength and hardness are accompanied by low ductility and toughness.

Specification	Delivery condition	Recommended heat treatment
SAE 1030	As rolled	Austenitise @ 860◦C Water quench & temper
WEARPLATE 200	As rolled	Austenitise @ 850◦C Oil quench or water quench & temper
22MnB5 AMSA	As rolled	Austenitise @ 880◦C Water quench
15MnB5 AMSA	As rolled	Austenitise @ 880◦C Water quench

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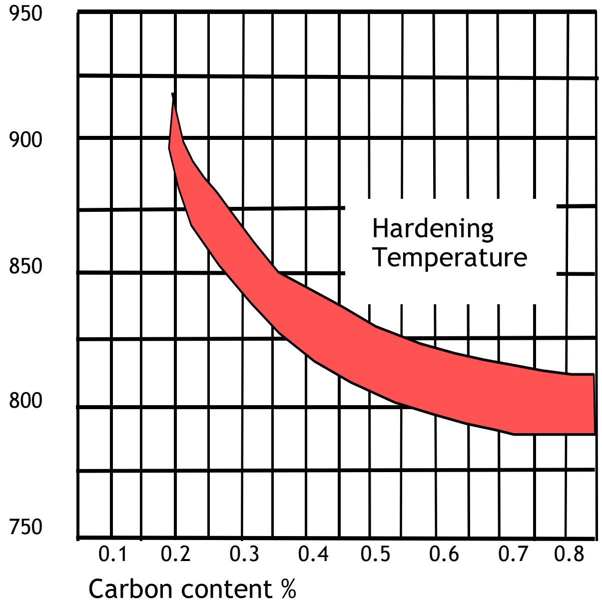
The recommended hardening temperatures (30°C - 60°C above the A_3 line) are illustrated in the figure below:

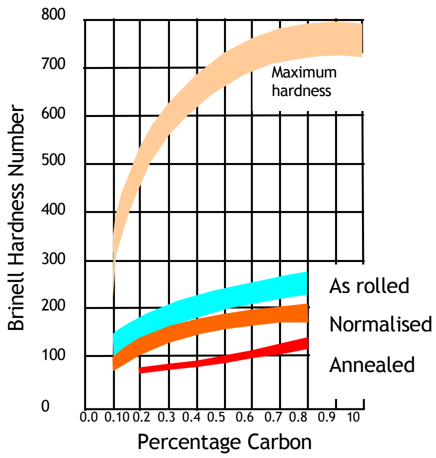


Tempering consists of the reheating of the as quenched steel to a temperature below the A_1 transformation temperature, followed by cooling in still air. The tempering heat treatment restores the toughness and reduces the hardness of the as quenched steel. Tempering cycles are chosen so as to produce the desired combination of hardness and toughness. The reduction in strength and hardness and accompanying increase in ductility and toughness increase with the tempering temperature and the time at that temperature.

Mechanical properties

The high carbon steels are produced to the analysis specifications. Mechanical properties such as hardness, yield strength, tensile strength, elongation or impact resistance are not tested and are, therefore, not guaranteed. The as rolled hardness will vary with the chemical composition and cooling conditions during rolling.

The accompanying graph serves as an indication of the hardness that can be expected in the different heat-treated conditions.



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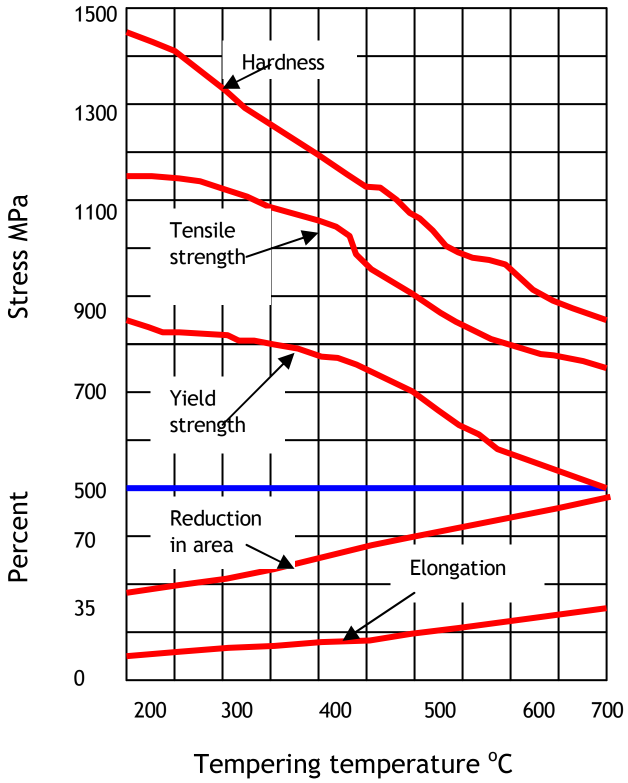
For many applications a hardened product may be tempered to obtain adequate toughness.

The following graph illustrates the effect of the tempering temperature on the mechanical properties of WEARPLATE 200 quenched in water from 830°C



An approximate correlation between hardness and tensile strength is shown in Table 4:

Table 4. Approximate correlation between hardness and tensile strength

Brinell hardness (BHN)	120	150	200	250	300	350	400	450	500	560
Approximate tensile strength (MPa)	400	495	650	835	950	1 100	1 300	1 610	1 700	1 950

Shearing and flame cutting

High carbon steels are normally harder than other steels and require more attention during shearing operations. In thicknesses of up to 12mm, these steel grades can be sheared in the as rolled condition, provided sufficient power is available. Cutting edges must be sharp and the clearance correctly set. Problems may, however, be experienced in winter when the material is very cold. Thicker material must be flame cut and should be preheated to at least 100°C.

Material in thicknesses of up to 25mm can be flame cut without preheating if adequate care is taken and the plates are put into a heat-treating furnace at a temperature exceeding 100°C immediately after cutting. Failing this, cracking may occur.

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Note:
Customers ordering coils should ensure that their equipment is suitable for handling and processing high carbon steel coils.

Punchability

Material in thicknesses of up to 12mm can be punched if proper attention is given to tool sharpness and clearances.

Weldability

On account of the high carbon content, which increases the hardenability, high carbon steels are not readily weldable. Rapid cooling in the heat affected zone results in the formation of hard, brittle phases, which are susceptible to cracking. High carbon steels should only be welded using special procedures. A welding engineer should be consulted for advice on welding procedures.

Bending and forming

Cold bending and forming of high carbon steels are not recommended.

Supply conditions

All material described in this data sheet is supplied in terms of price lists 110, 120, 121 and ArcelorMittal South Africa's General Conditions of Sale.

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