Steel

MBW®

Product information for manganese-boron steels for hot forming

thyssenkrupp

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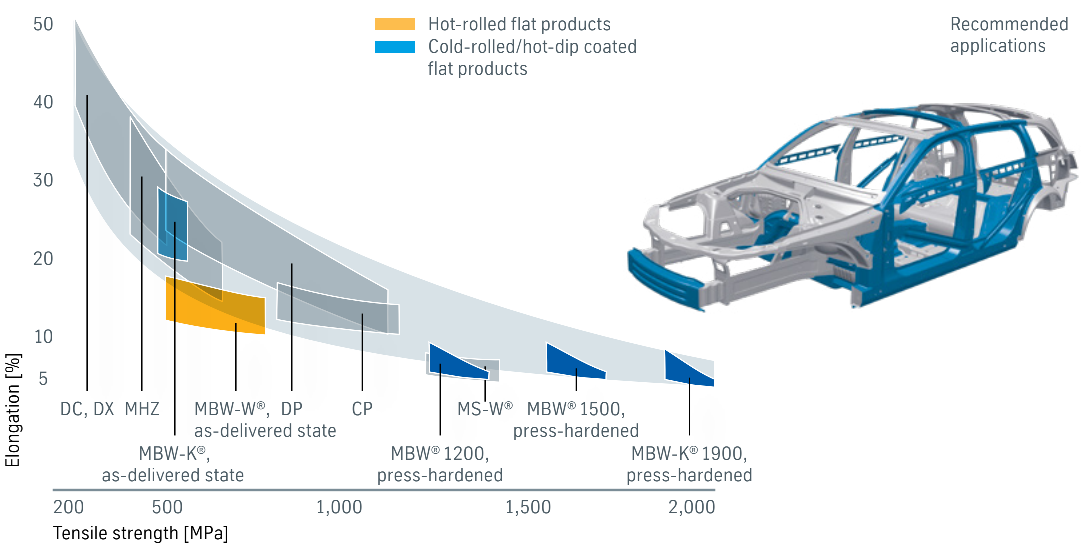
Overview of steel grades



Content

Areas of application

MBW® manganese-boron steels by thyssenkrupp offer highest strength levels with good formability, thus enabling weight savings in the use of strength-relevant structural and safety components in the automotive industry.

Hot forming allows significantly higher complexities in the component geometry and substantially higher dimensional accuracy than cold forming of high-strength and ultra-high-strength steels.

thyssenkrupp offers hot-rolled, cold-rolled and coated MBW® manganese-boron steels for hot forming. Aluminum-silicon-coated MBW® steels are protected against process-related scaling and decarburization.

Further processing by welding or electro-coating is possible without post-treatment. The AS coating also creates a barrier effect, protecting the hot-formed component from corrosion.

The new coating AS Pro guarantees highly reliable components and processes in automotive manufacturing. The alloying concept of AS Pro ensures significantly lower process-related hydrogen absorption during hot forming and provides lasting protection against embrittlement.

Typical applications for MBW® manganese-boron steels include crash-relevant structural auto parts like cross members, side members, A and B pillars, door ring concepts, tunnels or bumpers.

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Steel grade designations and surface refinements

		Surface refinements						
		UC	EG	GI	GA	ZM	AS	AS Pro
Based on VDA 239-100								
Steel grade	Standard designation							
● MBW-W® 1500	Special mill grade	●						
● MBW® 500	Special mill grade						●	
● MBW® 600	Special mill grade						●	
● MBW® 1200	Special mill grade						●	
● MBW® 1500	Special mill grade						●	●
● MBW-K® 1500	Special mill grade	●						
● MBW-K® 1900	Special mill grade	●						

● Hot-rolled flat products
● Cold-rolled/hot-dip coated flat products
● Serial production for unexposed applications

UC Uncoated
EG Electrogalvanized zinc coating
GI Hot-dip zinc coating
GA Galvannealed
ZM ZM Ecoprotect®
AS Aluminum-silicon coating
AS Pro Aluminum-silicon coating Pro

Comments

thyssenkrupp is a globally licensed supplier of AS-coated manganese-boron steels for hot forming.

Information on AS and AS Pro coating

Like all hot-dip coated sheet steel made by thyssenkrupp Steel, aluminum-silicon coated sheet steel AS and AS Pro is produced in a continuous process and coated in a bath.

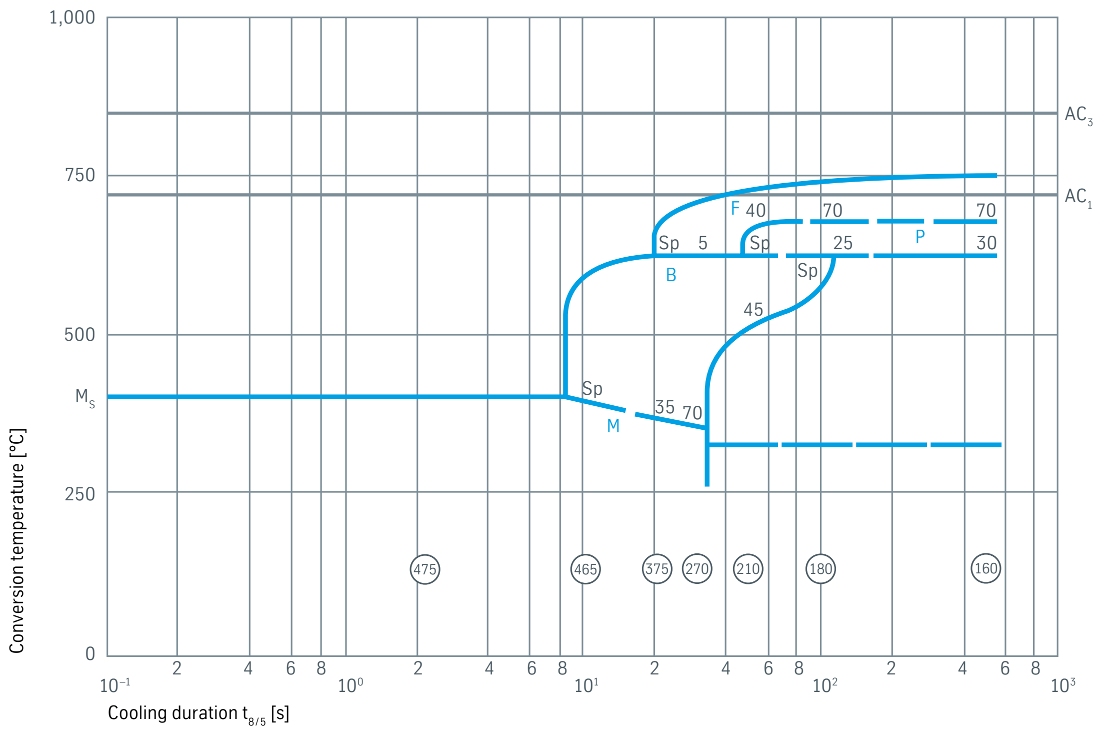
Typically, the bath for standard AS consists of up to 90% aluminum, about 10% silicon and a maximum of 3% iron. The silicon content ranges between 8 and 11%.

The bath for AS Pro, however, consists of up to 90% aluminum, about 10% silicon, a maximum of 3% iron and a maximum of 0.5% alkaline earth metals, like magnesium, for example. The silicon content ranges between 8 and 11%.

Material characteristics

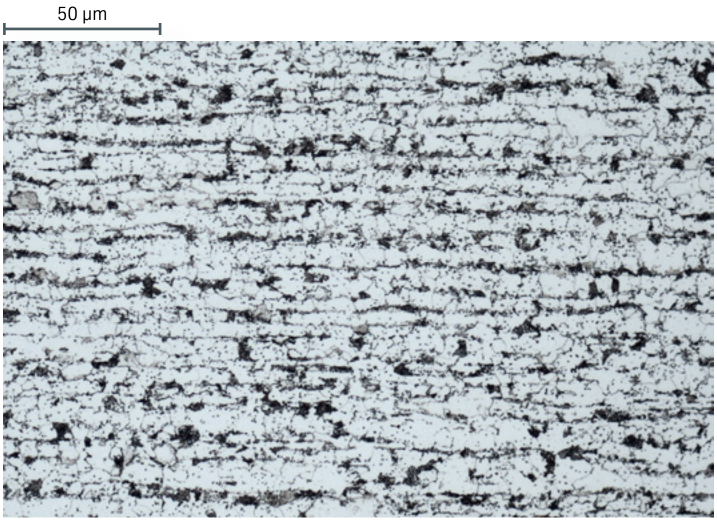
Manganese-boron steels are quenched and tempered steels. The underlying material concepts in this family of steels exhibit a selected and matched chemical composition that enables curing after hot forming. This ferritic-pearlitic structure which exists in as- received condition is converted into a purely martensitic structure in the process. Thanks to this process MBW® 1500+AS, for example, can increase its minimum tensile strength from 500 MPa in as-received condition to 1,500 MPa. The TTT dia-gram illustrates the transformation behavior for austenitizing temperature 900°C, dwell time 5 min, heated in 1 min. Even at low cooling rates a fully martensitic structure can be achieved.

TTT diagram of transformation behavior for MBW® 1500

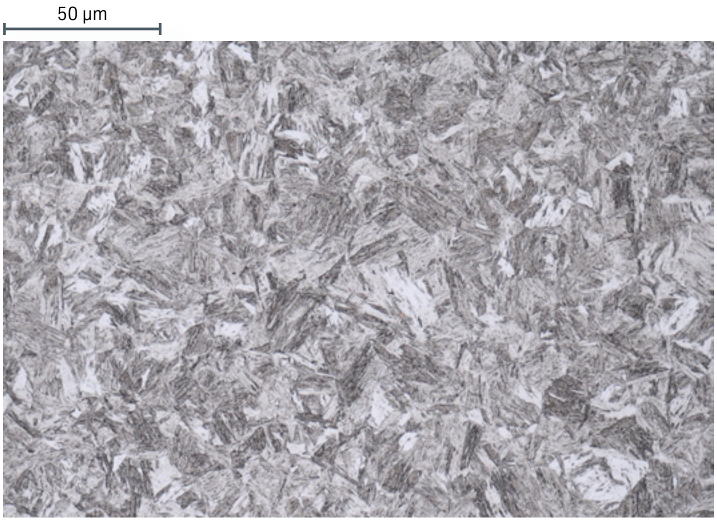


○	Hardness HV
M_S	Martensite starting temperature 400°C
AC_1 =	Start of austenitization 720°C
AC_3 =	End of austenitization 845°C
F	Ferrite
P	Pearlite
B	Bainite
M	Martensite

Micrograph of MBW® 1500: Microstructural contrasting through nital etching



As-received condition: Ferrite, pearlite.



Microstructure after press hardening: Martensite.

As a partner for hot forming, thyssenkrupp not only offers the best materials but also the facilities needed to determine, for example, the optimum process parameters for hot forming. These facilities include a proprietary test area with state-of-the-art hot forming equipment, which allows the processes used in series production to be simulated on a laboratory scale. Vehicle development can thus be accompanied comprehensively from the component design stage through to production readiness with the aid of analyses (thermography, forming, diffuse hydrogen, crash test) and troubleshooting. In addition, the process, component feasibility, crash behavior and structure can be studied by means of FEM simulations at thyssenkrupp.

We also support our customers by offering a mobile forming analysis service for hot formed components which can be conducted directly in the press plant.

Technical features

Chemical composition

Mass fractions in ladle analysis	C [%] max.	Si [%] max.	Mn [%] max.	P [%] max.	S [%] max.	Al [%] min.	Nb [%] max.	Ti [%] max.	Cr + Mo [%] max.	B [%] max.
Based on VDA 239-100										
Steel grade										
● MBW-W® 1500	0.25	0.40	1.40	0.025	0.010	0.015	–	0.05	0.50	0.005
● MBW® 500	0.10	0.35	1.00	0.030	0.025	0.015	0.10	0.15	–	0.005
● MBW® 600	0.10	0.50	2.00	0.030	0.025	0.015	0.10	0.15	–	0.005
● MBW® 1200	0.14	0.40	1.80	0.025	0.010	0.15[1]	0.05	0.05	0.50	0.005
● MBW® 1500	0.25	0.40	1.40	0.025	0.010	0.015	–	0.05	0.50	0.005
● MBW-K® 1500	0.25	0.40	1.40	0.025	0.010	0.015	–	0.05	0.50	0.005
● MBW-K® 1900	0.38	0.40	1.40	0.025	0.010	0.015	–	0.05	0.50	0.005

[1] Maximum aluminum content.

Manganese-boron steels are fully-killed steels.

Mechanical properties

Test direction transverse to rolling direction		Characteristics in as-received condition: Yield strength $R_{p0.2}$ [MPa]	Tensile strength R_m [MPa]	Elongation A min. [%]	A_{80} min. [%]
Based on VDA 239-100					
Steel grade	Surface refinements				
● MBW-W® 1500	UC	≥ 320	≥ 500	12	10
● MBW® 500	AS	300–520	400–600	–	16
● MBW® 600	AS	340–580	520–720	–	12
● MBW® 1200	AS	300–580	500–750	–	12
● MBW® 1500	AS, AS Pro	350–550	500–700	–	12
● MBW-K® 1500	UC (with recrystallizing annealing)	250–450	450–600	–	18
● MBW-K® 1900	UC	300–500	450–650	–	16

● (orange) Hot-rolled flat products
● (blue) Cold-rolled/hot-dip coated flat products

$R_{p0.2}$ Proof strength at 0.2% plastic elongation
R_m Tensile strength
A Percentage elongation after fracture using a proportional specimen with $L_0 = 5.65 \sqrt{S_0}$ for sheet thicknesses t ≥ 3.0 mm
A_{80} Percentage elongation after fracture using a specimen with gauge length L_0 = 80 mm for sheet thicknesses t < 3.0 mm

The stated mechanical properties in as-received condition are negligible for the direct hot-forming process. However, they could be relevant for the blank cutting processes and for the upstream cold-forming stage in indirect hot forming.

Mechanical properties

Test direction transverse to rolling direction	Typical characteristics after heat treatment[1]				Typical characteristics after heat treatment and paint baking simulation[1]			
	Yield strength	Tensile strength	Elongation	Bending angle[2]	Yield strength	Tensile strength	Elongation	Bending angle[2]
	$R_{p0,2}$ [MPa]	R_m [MPa]	A_{80} [%]	α [°]	$R_{p0,2}$ [MPa]	R_m [MPa]	A_{80} [%]	α [°]
Based on VDA 239-100								
Steel grade								
● MBW-W® 1500	1,000	1,500	5	60	1,100	1,500	5	65
● MBW® 500	400	550	17	130[3]	400	550	17	130[3]
● MBW® 600	450	650	16	130[3]	450	650	16	130[3]
● MBW® 1200	900	1,150	5	70	950	1,150	5	75
● MBW® 1500	1,000	1,500	5	50	1,100	1,500	5	55
● MBW-K® 1500	1,000	1,500	5	60	1,100	1,500	5	65
● MBW-K® 1900	1,200	1,900	4	50	1,300	1,850	4	55

[1] Austenitization followed by water cooling in the tool. thyssenkrupp does not guarantee the properties after hot forming and paint baking simulation (170 °C, 20 min.); the responsibility lies with the manufacturer of components.
[2] Bending angle according to VDA 238-100 at t = 1.5 mm; bending axis transverse to the rolling direction.
[3] No failure at maximum test.

● (orange) Hot-rolled flat products
● (blue) Cold-rolled/hot-dip coated flat products

$R_{p0.2}$ Proof strength at 0.2% plastic elongation
R_m Tensile strength
A Percentage elongation after fracture using a proportional specimen with $L_0 = 5.65 \sqrt{S_0}$ for sheet thicknesses t ≥ 3.0 mm
A_{80} Percentage elongation after fracture using a specimen with gauge length L_0 = 80 mm for sheet thicknesses t < 3.0 mm

Surfaces

Surface refinements, hot-dip galvanized

	Specification	Minimum coating mass on both sides [g/m²]		Coating on each side of single spot sample		Informative
	Based on	Triple spot sample	Single spot sample	Mass [g/m²]	Thickness [µm]	Typical thickness [µm]
Aluminum-silicon coating AS/AS Pro						
Designation						
AS30	VDA 239-100	–	–	30–65	10–20	–
AS45	VDA 239-100	–	–	45–85	15–28	–
AS060	DIN EN	60	45	–	7–15	10
AS080	DIN EN	80	60	–	10–20	14
AS100	DIN EN	100	75	–	12–23	17
AS120	DIN EN	120	90	–	15–27	20
AS150	DIN EN	150	115	–	19–33	25

Uncoated material requires the use of a protective atmosphere in the furnace of the hot-forming plant and final sanding (e.g. with dry iceor with steel grits) to remove the oxide layers that occur.

Aluminum-silicon coating protects the base material against both scale formation and decarburization. In addition, the AS layer forms a basic corrosion protection barrier after hot forming.

Surface finishes and surface qualities

Products	Finish type	Surface quality
Cold-rolled flat products	Uncoated	U Unexposed (interior parts)
Hot-dip coated flat products	Aluminum-silicon coating	U Unexposed (interior parts)

U as per VDA 239-100

Surface treatments

Type of surface treatment		UC	EG	GI	GA	ZM	AS/AS Pro
U	Without surface treatment						●
O	Oiled	●					●

● Serial production

UC Uncoated
EG Electrogalvanized zinc coating
GI Hot-dip zinc coating
GA Galvannealed
ZM ZM Ecoprotect®
AS/AS Pro Aluminum-silicon coating

Notes on processing and applications

Forming

Manganese-boron steels display outstanding hot forming behavior. In the austenitizing temperature range, the formability of these grades is comparable with that of mild deep-drawing steels at room temperature. This allows complex-shaped parts to be formed with low press forces in a single operation. By contrast with conventional cold forming, the part properties are mainly produced by cooling in the die and less by the forming process.

Modifying process parameters allows the targeted production of the desired part properties, e.g. strength or residual elongation, to provide optimum crash behavior, etc. in structural and safety parts.

Both the direct and indirect hot forming processes are commonly used today. The one-stage process (direct hot forming) is used most commonly and is ideal for processing aluminum-silicon-coated manganese-boron steels. This coating offers good protection against scaling – a typical occurrence in hot forming – and thus improves die life.

Hot-formed parts are also characterized by extremely low springback, making it possible to produce parts with extremely high dimensional accuracy.

Partial press hardening

Partial press hardening makes it possible to integrate different strength and elongation properties into different areas of the same monolithic part. There are various ways to create function-optimized properties in one part.

In the patented tailored tempering process this is achieved using partially heated dies. Targeted control of the cooling rate for each die segment enables the creation of parts with localized functional properties, i.e. requirements-oriented mechanical properties.

Further options include influencing the heating process (partial furnace technology), limiting heating using shielding plates or separate furnace chambers, or the tail-hang-out method (air cooling).

Processing notes for joining

In both the as-delivered and the hot-formed (hardened) condition, manganese-boron steels for hot forming are suitable for welding with steels of the same or different grades on condition that the welding parameters are matched to the material. Resistance spot welding, shield gas welding and laser beam welding are particularly suitable.

Resistance spot welding

Compared to lower-strength steels, higher electrode forces and longer welding times must be used in resistance spot welding – optionally as multi-pulse welding in accordance with DIN EN ISO 18278-2. The welding zones are large for this strength class both in same-grade and hybrid joints. Spot welds are relatively ductile. However, they fail in chisel tests, despite the high material strength and hardness in the weld, typically due to mixed fracture with a relatively high detachment component. Joint strengths tend to be on a par with the strengths of the base materials involved, and are naturally influenced by the softer member in hybrid joints.

Typical properties of a resistance spot weld

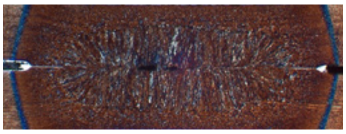
	Sheet thickness t	Welding zone ΔI	Cross tensile strength for $d_{w\,min.}$	Shear tensile strength for $d_{w\,min.}$	Mean hardness HV 0.1	
	[mm]	[kA]	[kN]	[kN]	Base material	Weld nugget
Steel grade						
● HX340LAD+Z	1.50	2.0	9.9	13.7	165	330
● MBW® 1500+AS150	1.50	1.5	4.4	16.8	485	525
● MBW® 500+AS150	1.55	1.8	9.6	15.2	180	330

Test results as per SEP 1220-2.

● Cold-rolled strip

t Sheet thickness of test specimens
$d_{w\,min.}$ Welding spot diameter of 4 √t

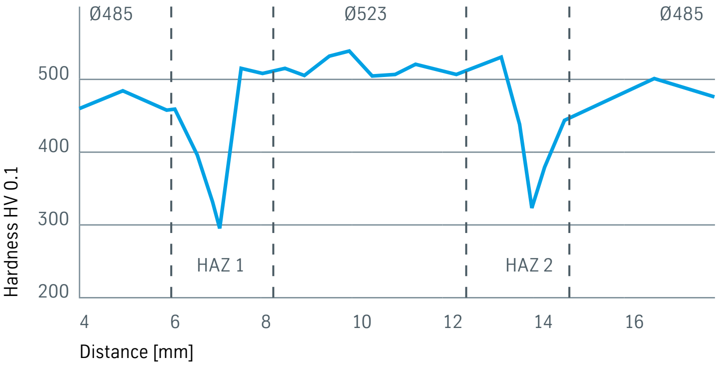
MBW® 1500



MBW® 500

Good weld nugget formation.

Hardness profile of the weld nugget in a MBW® 1500



MIG/MAG arc brazing and welding

In the arc process, some material softening occurs in the heat-affected zone; this should be considered by the designer in addition to the filler which is used. The AS coating is thermally influenced by hot working and can impact arc stability, especially in joints with Z-coated sheet steels.

MIG brazing or the special "Cold Metal Transfer" process show clear advantages with respect to process stability and weld geometry compared to the standard metal active gas welding (MAG) process.

The standard additives typically used, namely G4Si1 (MAG) and copper solder CuAl7 (MIG brazing), usually achieve sufficient bonding strength. In order to exploit the high potential strength of the material, notch-free connections should be made where possible. In special cases, and given the use of suitable fillers, subsequent heat treatment or quenching and press hardening of the component and the weld can avoid local hardness drops in the heat-affected zone, thus leveraging the strength potential of the base material.

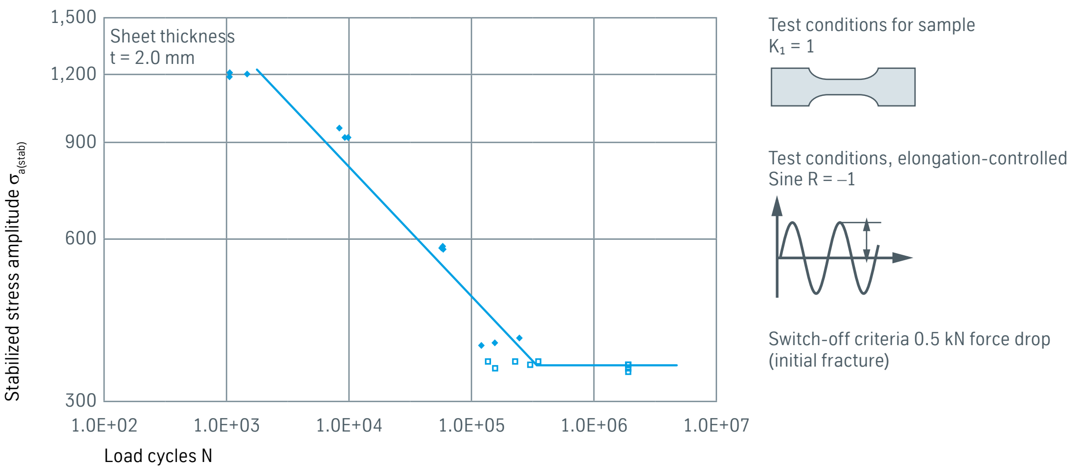
Laser beam welding

Laser beam welding of MBW® steels is possible with both CO_2 and solid state lasers. Welding with CO_2 lasers is performed using typical shielding gases. In unquenched and tempered state, hot-dip aluminum coating should be removed locally prior to welding as it can otherwise result in AlSi inclusions that impact strength. In quenched and tempered condition, the coating is alloyed throughout and need not be removed. It must be noted that a decrease in strength of the base material occurs in the heat-affected zone of the weld. This can be remedied by repeating quenching and tempering.

Fatigue strength and crash performance

Manganese-boron steels are offered specifically for hot forming. It is only by heat treatment during tempering that the material properties are created, which then characterize the load capacity (in terms of strength, durability and crash behavior). Due to the unequivocal major influence of press hardening on the material properties, these properties must be described by the manufacturer. However, due to the very high levels of strength, these steels are suitable for components which must not deform in a crash scenario. The SN curve shows the good fatigue strength of MBW® 1500.

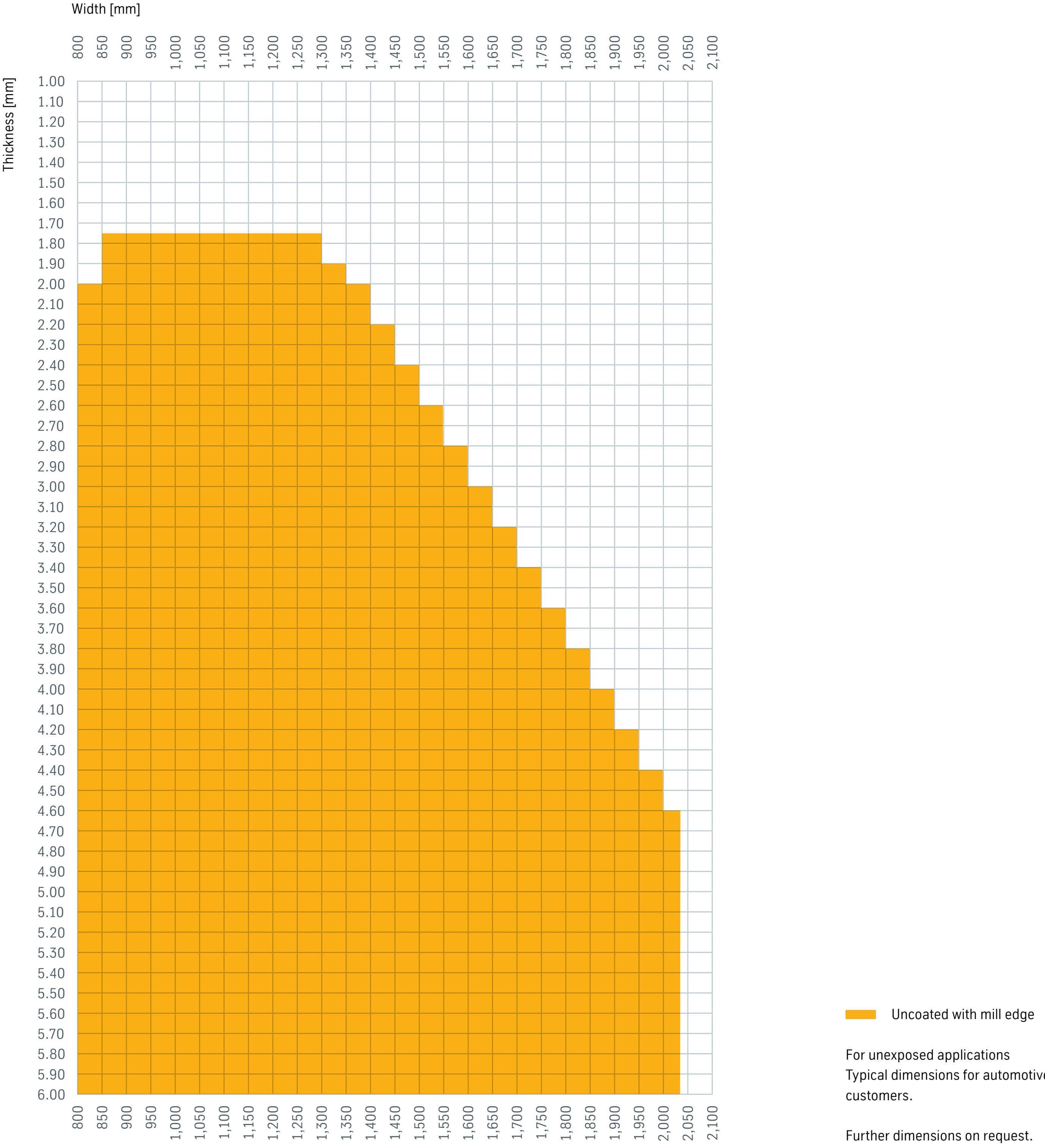
Elongation controlled stress-strain of press-hardened MBW® 1500



- Fatigue strength, stable stress
- Fatigue limit

Available dimensions

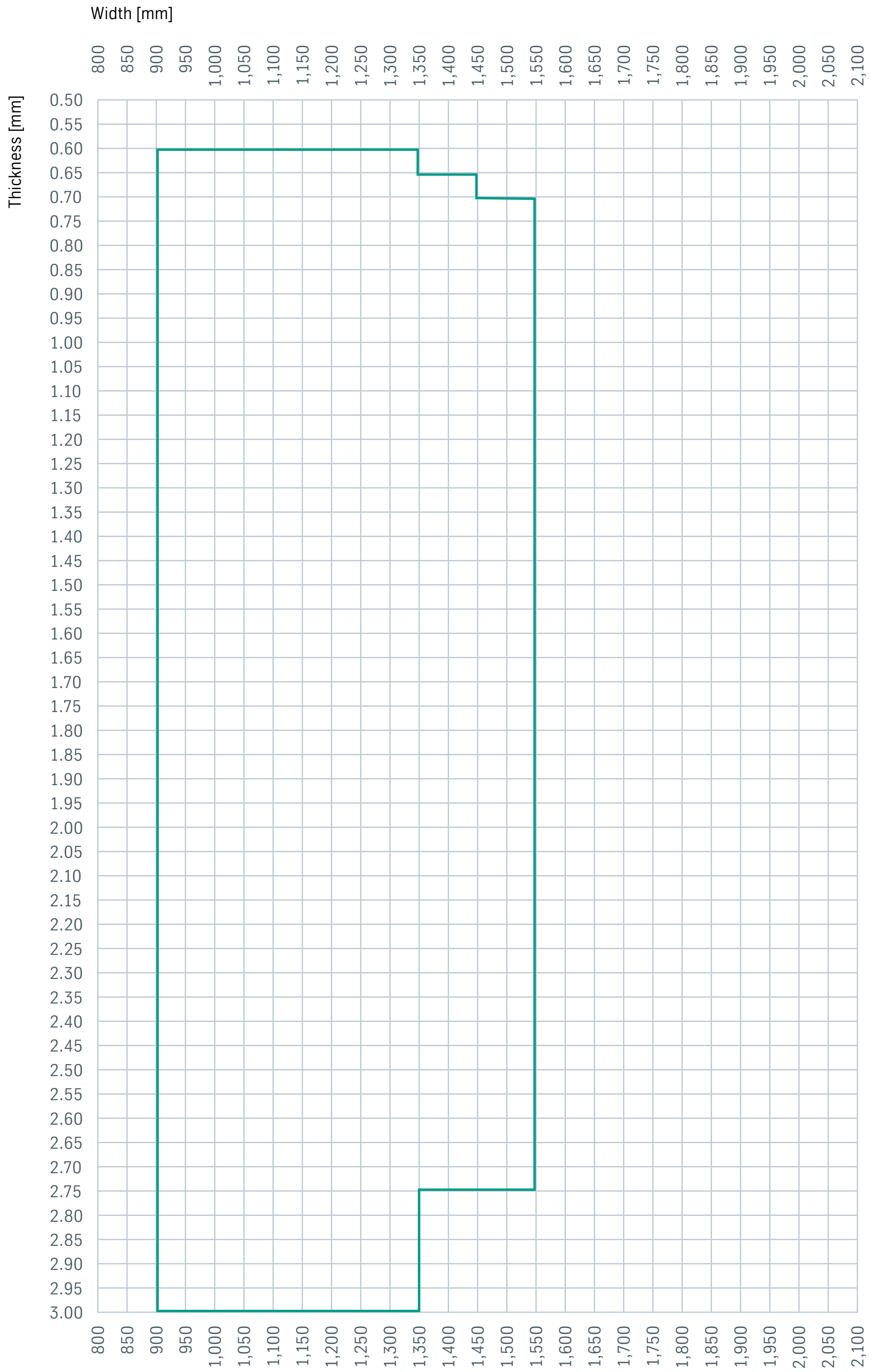
MBW-W® 1500



For unexposed applications
Typical dimensions for automotive customers.

Further dimensions on request.

MBW® 500, MBW® 600



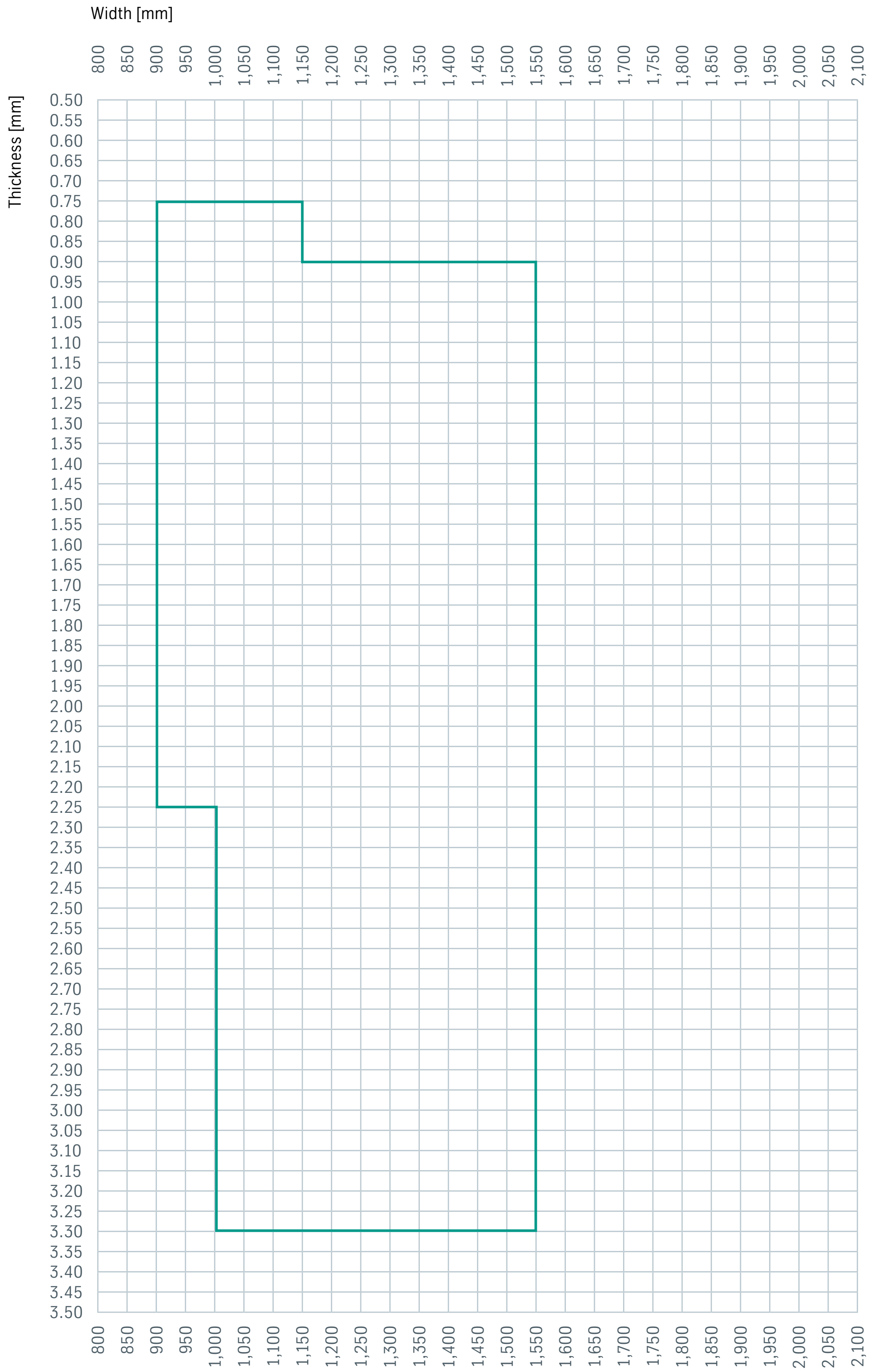
AS Aluminum-silicon coating

AS trimmed

For unexposed applications
Typical dimensions for automotive customers.

Further dimensions on request.

MBW® 1200



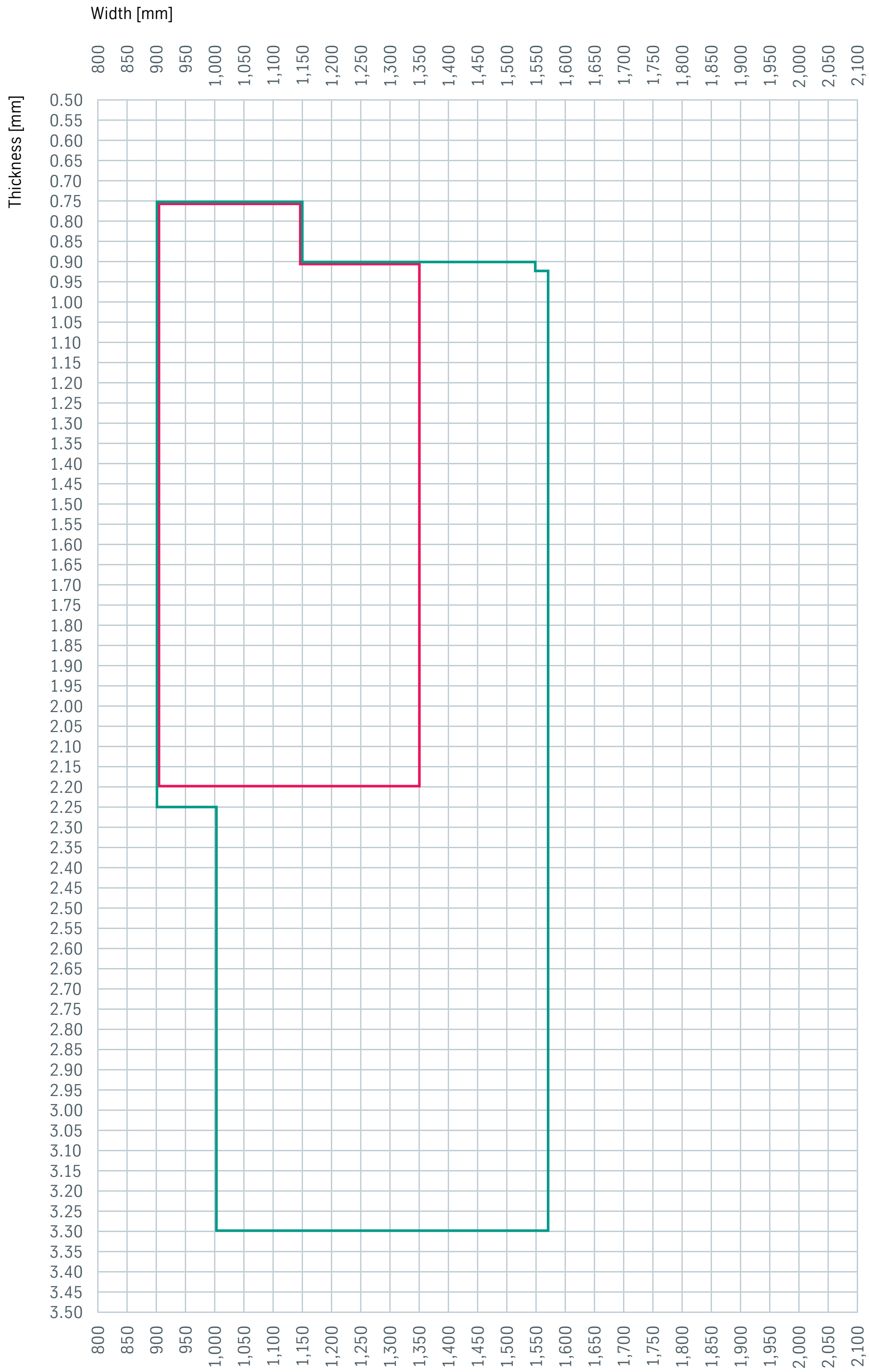
AS Aluminum-silicon coating

AS trimmed

For unexposed applications
Typical dimensions for automotive customers.

Further dimensions on request.

MBW® 1500



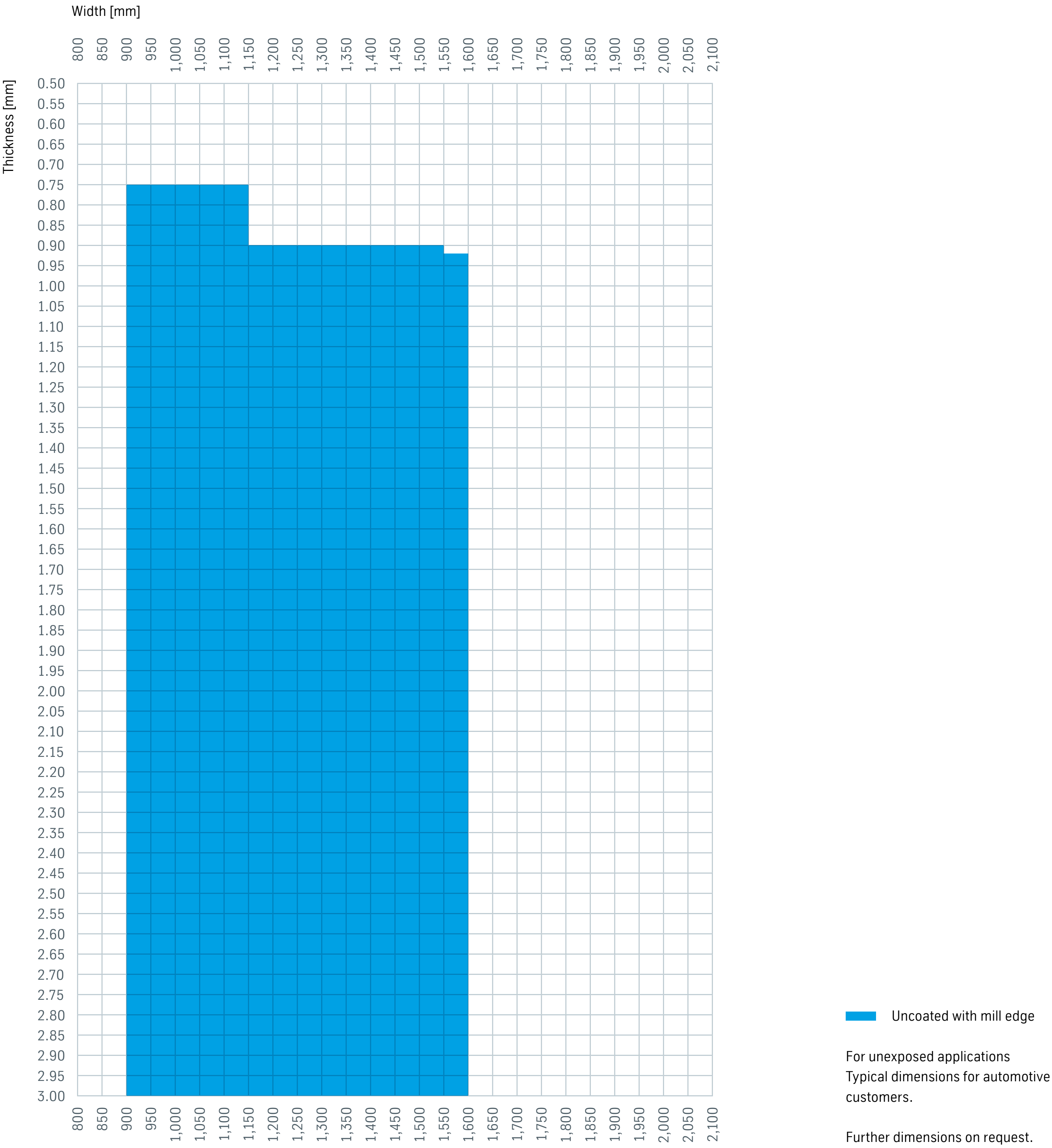
AS/AS Pro Aluminum-silicon coating

AS trimmed
AS Pro trimmed

For unexposed applications
Typical dimensions for automotive customers.

Further dimensions on request.

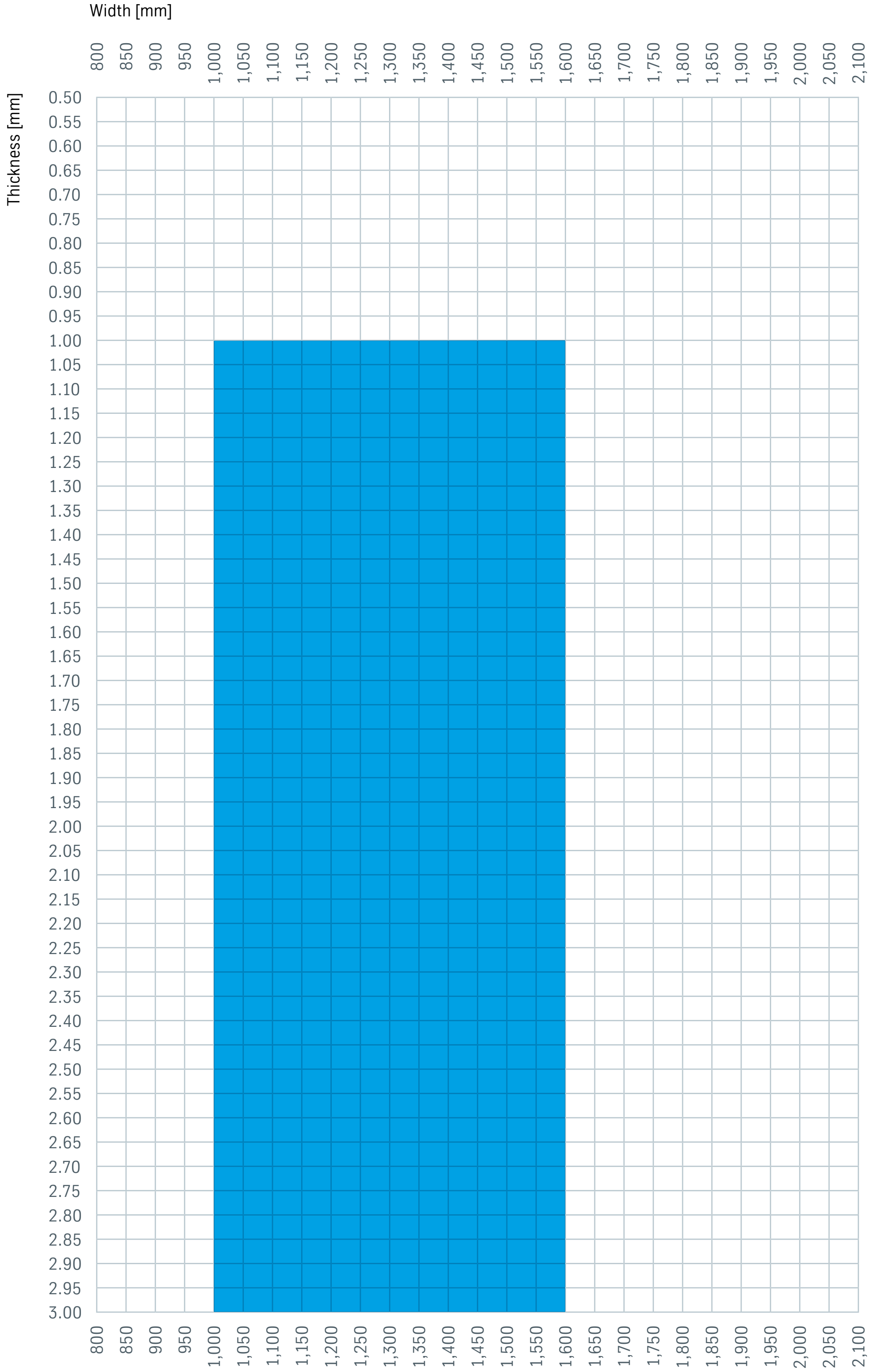
MBW-K® 1500



For unexposed applications
Typical dimensions for automotive customers.

Further dimensions on request.

MBW-K® 1900



Uncoated with mill edge

For unexposed applications
Typical dimensions for automotive customers.

Further dimensions on request.

Sample application

Hot-formed B-pillar made of MBW® manganese-boron steel.

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Special mill grades are supplied subject to the special conditions of thyssenkrupp. Other delivery conditions not specified here will be based on the applicable specifications. The specifications used will be those valid on the date of issue of this product information brochure.