Steel

Bake-hardening steels BHZ

Product information

thyssenkrupp

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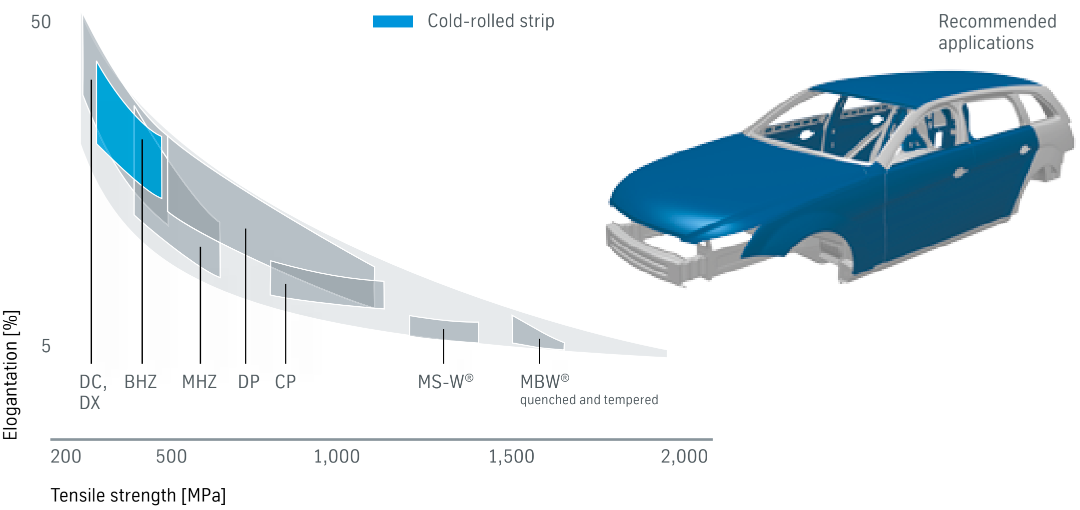
Overview of steel grades



Content

Areas of application

The particular advantage of bake-hardening steels is that they ensure good cold workability due to their relatively low yield point and good r and n values. The initial strength is adjusted with solid solutions. They achieve their final strength on the worked component during paint curing. Bake-hardening steels thus excellently reconcile conflicting requirements in terms of working behavior and component strength. Bake-hardening steels offer benefits for use in exterior bodywork parts – especially with only slightly worked components, which do not undergo any noticeable strengthening due to working – since the bake-hardening effect provides significantly improved buckling resistance and stiffness compared to other steels. The preferred applications include flat exterior skin parts such as roofs, hoods and door outer panels. Bake-hardening steels by thyssenkrupp are available on request for long-term corrosion protection in various high quality surface finishes.

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Steel grade designations and surface refinements

	DIN EN 10152, 10268, 10346	Surface refinements					
		UC	EG	GI	GA	ZM	AS
To DIN EN							
Steal grade	Standard designation						
● BHZ 180	HC180B / HX180BD	◉	◉	◉	◉	◉	
● BHZ 220	HC220B / HX220BD	◉	◉	◉	◉	◉	
● BHZ 260	HC260B / HX260BD	◉	◉	◉	◉	◉	
● BHZ 300	HC300B / HX300BD	●	●	●	●		

Steel grade designations and surface refinements

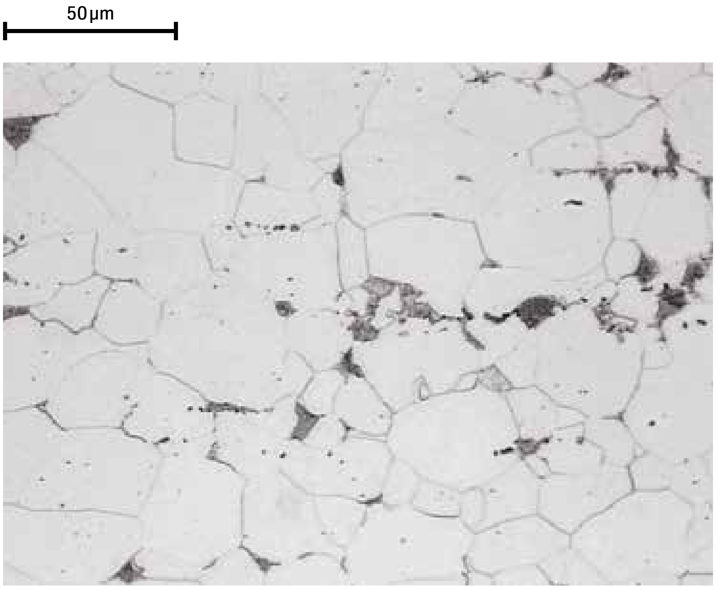
	VDA 239-100	Surface refinements					
		UC	EG	GI	GA	ZM	AS
To VDA							
Steal grade	Standard designation						
● CR180BH	CR180BH	◉	◉	◉	◉	◉	
● CR210BH	CR210BH	◉	◉	◉	◉	◉	
● CR240BH	CR240BH	◉	◉	◉	◉	◉	

● (blue) Cold-rolled strip
● (grey) Serial production for interior parts
◉ Serial production for interior and exterior parts
UC Uncoated
EG Electrogalvanized zinc coating
GI Hot-dip zinc coating
GA Galvannealed
ZM ZM EcoProtect®
AS Aluminum-silicon coating

Material characteristics

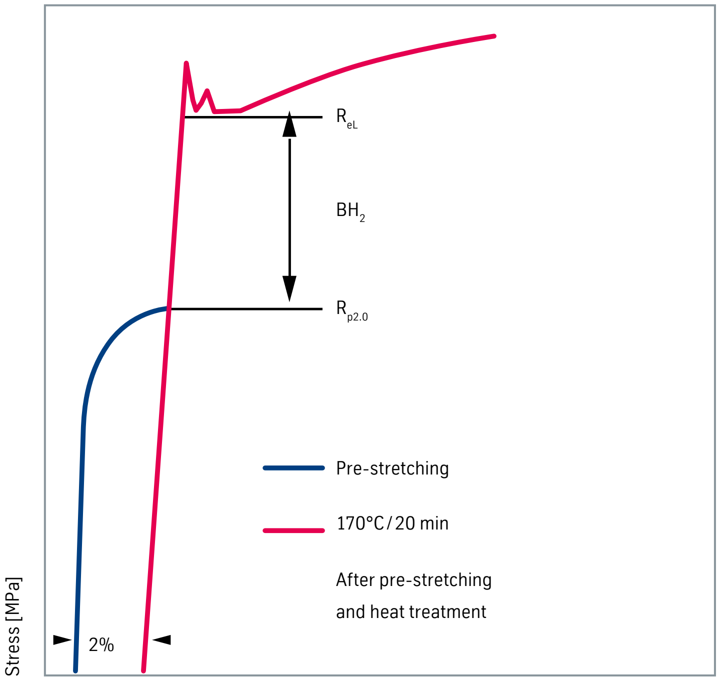
Bake-hardening steels by thyssenkrupp are resistant to aging at room temperature over a long period. Solid solution hardening elements such as P, Mn and Si are used to achieve the desired initial strength. A specifically chosen amount of dissolved carbon in the ferritic matrix causes an additional increase in the yield limit through controlled carbon aging during curing of the automobile paintwork in conjunction with prior deformation hardening (BH effect).

Micrograph of BHZ



The picture shows the typical microstructure of a bake-hardening steel after etching with nital, with perlite and isolated granular cementite in the ferritic matrix.

Determination of the bake-hardening value[1]



[1] As per DIN EN 10325 BH_2 after 2% stretching in a tensile test.

Technical features

Chemical composition

Mass fractions in ladle analysis	Surface refinements	C [%] max.	Si [%] max.	Mn [%] max.	P [%] max.	S [%] max.	Al [%] total	Ti [%] max.	Nb [%] max.
To DIN EN									
Steel grade									
● BHZ 180	UC/EG	0.06	0.50	0.70	0.060	0.030	≥ 0.015	–	–
● BHZ 220	UC/EG	0.08	0.50	0.70	0.085	0.030	≥ 0.015	–	–
● BHZ 260	UC/EG	0.10	0.50	1.00	0.100	0.030	≥ 0.015	–	–
● BHZ 300	UC/EG	0.10	0.50	1.00	0.120	0.030	≥ 0.015	–	–
● BHZ 180	GI/GA/ZM	0.06	0.50	0.70	0.060	0.025	≥ 0.015	0.12	0.09
● BHZ 220	GI/GA/ZM	0.08	0.50	0.70	0.085	0.025	≥ 0.015	0.12	0.09
● BHZ 260	GI/GA/ZM	0.10	0.50	1.00	0.100	0.030	≥ 0.010	0.12	0.09
● BHZ 300	GI/GA/ZM	0.11	0.50	0.80	0.120	0.025	≥ 0.010	0.12	0.09

● Cold-rolled strip
UC Uncoated
EG Electrogalvanized zinc coating
GI Hot-dip zinc coating
GA Galvannealed
ZM ZM EcoProtect®

Chemical composition

Mass fractions in ladle analysis	C [%] max.	Si [%] max.	Mn [%] max.	P [%] max.	S [%] max.	Al [%] max.
To VDA						
Steal grade						
● CR180BH	0.06	0.50	0.70	0.060	0.025	0.015
● CR210BH	0.08	0.50	0.70	0.085	0.025	0.015
● CR240BH	0.10	0.50	1.00	0.10	0.030	0.010

● Cold-rolled strip

Mechanical properties

	Surface refinement	Yield strength	Tensile strength	Elongation	Vertical anisotropy	Strain harding exponent	Bake-hardening
Test direction transverse to rolling direction		$R_{p\,0.2}$ [MPa]	R_m [MPa]	A_{80} [%] min.	r_{90} min.	n_{90} min.	BH_2 [MPa] min.
To DIN EN							
Steel grade							
● BHZ 180	UC/EG	180–230	290–360	34	1.6	0.17	35
● BHZ 220	UC/EG	220–270	320–400	32	1.5	0.16	35
● BHZ 260	UC/EG	260–320	360–440	29	–	–	35
● BHZ 300	UC/EG	300–360	390–480	26	–	–	35
● BHZ 180	GI/GA/ZM	180–240	290–360	34	1.5	0.16	30
● BHZ 220	GI/GA/ZM	220–280	320–400	32	1.2	0.15	30
● BHZ 260	GI/GA/ZM	260–320	360–440	28	–	–	30
● BHZ 300	GI/GA/ZM	300–360	400–480	26	–	–	30

The technological characteristics are valid for the thickness range from 0.7 to 1.2 mm.
Refer to the applicable standards for supplements and deductions for individual coatings and values.
The specified mechanical properties apply for a period of 3 months starting on the agreed date on which the products are made available.

● Cold-rolled strip
UC Uncoated
EG Electrogalvanized zinc coating
GI Hot-dip zinc coating
GA Galvannealed
ZM ZM EcoProtect®

Mechanical properties	Yield strength	Tensile strength	Elongation		Vertical anisotropy		Strain hardening exponent	Bake-hardening
Test direction in rolling direction	$R_{p\,0.2}$ [MPa]	R_m [MPa]	A_{50} [%] min.	A_{80} [%] min.	$r_{0/20}$ min.	$r_{m/20}$ min.	$n_{10\text{-}20/Ag}$ min.	BH_2 [MPa] min.
To VDA								
Steel grade								
● CR180BH	180–240	290–360	35	34	1.1	1.3	0.17	20/30
● CR210BH	210–270	320–400	34	32	1.1	1.2	0.16	20/30
● CR240BH	240–300	340–440	31	29	1.0	1.1	0.15	20/30

Restrictions as per VDA 239-100 Section 7.2.

● Cold-rolled strip
$R_{p\,0.2}$ Proof strength at 0.2% plastic elongation
R_m Tensile strength
A_{50} Percentage elongation after fracture using a specimen with gauge length L_0 = 50 mm
A_{80} Percentage elongation after fracture using a specimen with gauge length L_0 = 80 mm for sheet thicknesses S < 3.0 mm
$n_{10\text{-}20/Ag}$ Strain hardening exponent determined between 10% and 20% plastic strain e.g. uniform elongation limit if A_g<20%
$r_{0/20}$ Vertical anisotropy in longitudinal direction at 20% plastic strain
$r_{m/20}$ Average vertical anisotropy at 20% plastic strain, $r_{m/20} = (r_{0/20} + r_{90/20} + 2 \times r_{45/20}) / 4$
BH_2 Increase in yield strength between a reference condition after 2% plastic pre-strain and the condition obtained after heat treatment

Surfaces

Surface refinements, electrogalvanized zinc coating	Specification	Nominal coating on each side of single spot sample		Coating on each side of single spot sample	
		Mass [g/m²]	Thickness [µm]	Mass [g/m²]	Thickness [µm]
Electrogalvanized zinc coating					
Designation					
EG25/25	DIN EN	18	2.5	≥ 12	≥ 1.7
EG18	VDA 239-100	–	–	18–38	2.5–5.4
EG50/50	DIN EN	36	5.0	≥ 29	≥ 4.1
EG29	VDA 239-100	–	–	29–49	4.1–6.9
EG75/75	DIN EN	54	7.5	≥ 47	≥ 6,6
EG53	VDA 239-100	–	–	53–73	7.5–10
EG100/100	DIN EN	72	10	≥ 65	≥ 9.1
EG70	VDA 239-100	–	–	70–90	9.9–13

On request, material can be supplied with zinc coating on one side or on both sides with different coating weights.

Surface refinements, hot-dip zinc coating

	Specification	Minimum coating mass on both sides [g/m²]		Coating on each side of single spot example		Informative
		Triple spot sample	Single spot sample	Mass [g/m²]	Thickness [µm]	Typical thickness [µm]
Hot-dip zinc coating						
Designation						
GI100	DIN EN	100	85	–	5 – 12	7
GI40	VDA 239-100	–	–	40 – 60	5.6 – 8.5	–
GI140	DIN EN	140	120	–	7 – 15	10
GI60	VDA 239-100	–	–	60 – 90	8.5 – 13	–
GI200	DIN EN	200	170	–	10 – 20	14
GI85	VDA 239-100	–	–	85 – 115	12 – 16	–
Galvannealed						
GA100	DIN EN	100	85	–	5 – 12	7
GA40	VDA 239-100	–	–	40 – 60	5.6 – 8.5	–
GA120	DIN EN	120	100	–	6 – 13	8
GA50	VDA 239-100	–	–	50 – 80	7 – 10	–
ZM EcoProtect®						
ZM070	SEW022	70	60	–	–	–
ZM30	VDA 239-100	–	–	30 – 55	4.5 – 7.7	–
ZM100	SEW022	100	85	–	–	–
ZM40	VDA 239-100	–	–	40 – 65	6.2 – 9.2	–
ZM120	SEW022	120	100	–	–	–
ZM50	VDA 239-100	–	–	50 – 80	7.7 – 12	–

A coating weight of 100 g/m² is recommended. For interior parts that are particularly exposed to corrosion, thicker coatings or our innovative ZM EcoProtect® zinc-magnesium coating can be supplied on request.

Surface finishes and surface qualities

Products	Finish type	Surface quality
Cold-rolled flat products	Uncoated	A Normal surface
		U Unexposed (interior parts)
		B Best surface
		E Exposed (exterior parts)
Electrolytically zinc coated flat products	Electrogalvanized zinc coating	A Normal surface
		U Unexposed (interior parts)
		B Best surface
		E Exposed (exterior parts)
Hot-dip coated flat products	Hot-dip zinc coating	B Improved surface
		U Unexposed (interior parts)
		C Best surface
		E Exposed (exterior parts)
	Galvannealed	B Improved surface
		U Unexposed (interior parts)
		C Best surface
		E Exposed (exterior parts)
	ZM EcoProtect®	B Improved surface
		U Unexposed (interior parts)
		C Best surface
		E Exposed (exterior parts)

A / B / C as per DIN EN
U / E as per VDA 239-100

Surface treatments

Type of surface treatment		UC	EG	GI	GA	ZM	AS
O	Oiled	●	●	●	●	●	
P	Phosphated		●				
µPhos	Mirco-phosphated		●				
JAZ®	JFE Advanced Zinc				●		
PO	Phosphated and oiled		●				
µPhosO	Micro-phosphated and oiled		●				

● Serial production

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

Notes on applications and processing

Forming

With bake-hardening steels, diffusion of the free carbon atoms, typically implemented by paint curing heat treatment of an automobile body, is used to increase the strength of the finished component. They have the great advantage that parts with only minor shape changes achieve an additional increase in strength through the downstream painting process. Bake-hardening steels are therefore particularly suitable for flat parts which are not heavily stretched. The choice of the right type for a given strength must also be made with a special focus on the actual anticipated forming stresses. This allows optimum leveraging of specific benefits so that the steels can also be used for difficult drawn parts.

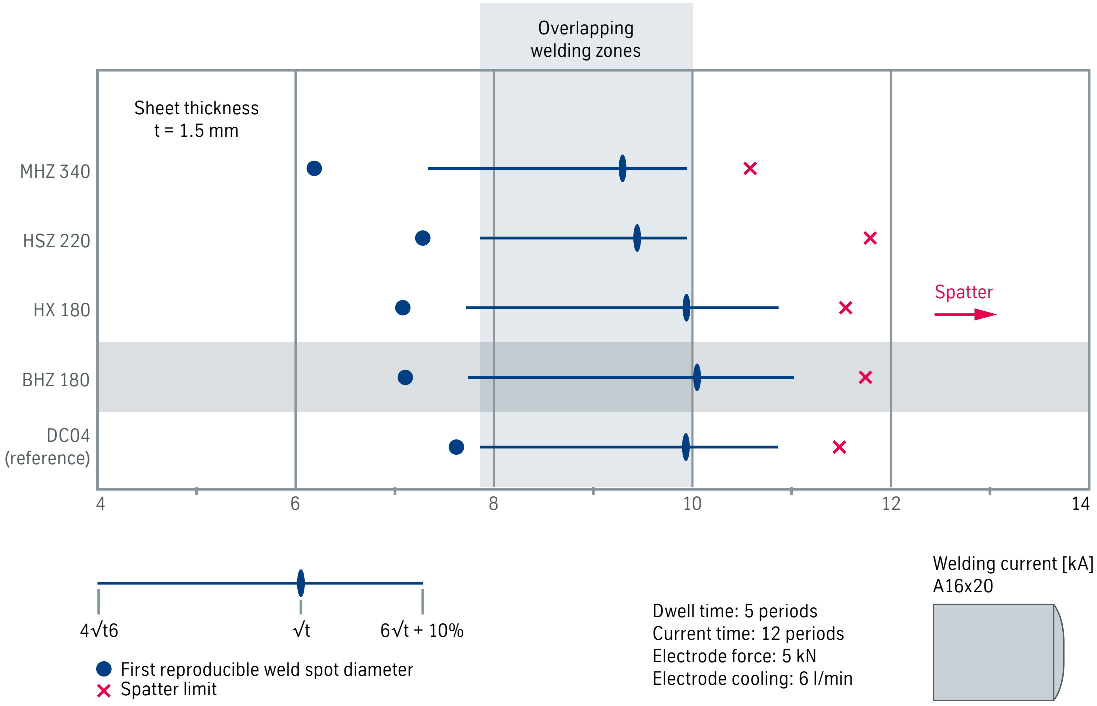
Processing instructions for joining

When it comes to joining bake-hardening steels, the processor can choose from a large number of joining processes. They are suitable for welding in both same-grade and hybrid joints with other common steel grades. The precondition is welding parameters matched to the material.

Resistance spot welding

The focus is traditionally on resistance spot welding, especially in car body manufacture. In particular, thin sheets with a thickness of less than 3 mm can be joined more economically and more reliably using this mass production process. However, doing so typically involves modifying the three welding parameters: welding current, welding time and electrode force. The influence of the electrode force and welding time on the welding zone is of central interest here. Higher electrode forces and longer welding times are normally required as the sheet thickness and strength increase, to ensure a sufficiently large welding zone. Similarly, the use of multi-pulse welding as per SEP 1220-2 can have a positive effect on the width of the welding zone. For zinc and zinc alloy coatings, the electrode forces, welding currents and welding times need to be increased compared to the non-alloyed base material to compensate for contraction of the welding zone due to the coating. The width of the welding zone does not only depend on the combination of sheet grade, surface and thickness; process parameters such as the current type and electrode geometry also play a significant role. The figure shows that the welding zones of BHZ steels are similar to those of other conventional high-strength steels in a comparable welding current range. In addition to good welding suitability of the individual steel grades, welding suitability is also assured for combinations of the various materials offered by the steel industry today for similar welding parameter settings.

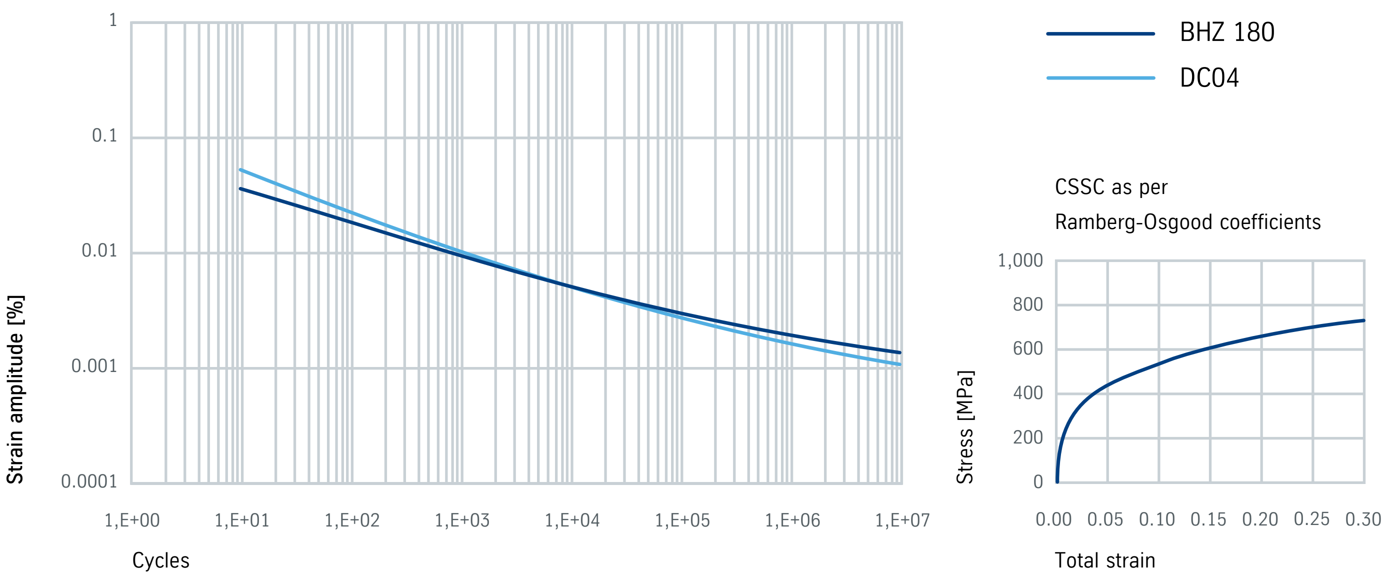
Welding zones of conventional higher-strength and high-strength steels compared



Fatigue strength and crash performance

Higher-strength is assured for BHZ steels in addition to the specific deformation properties. As the yield strength and tensile strength increase, the fatigue limit and crash energy absorption capacity also increase. The bake-hardening effect further increases the yield strength values, which are particularly significant for strength analyses. The increased buckling strength is just one example.

Stress-strain curve of a bake-hardening steel BHZ 180 compared to a deep-drawing steel DC04

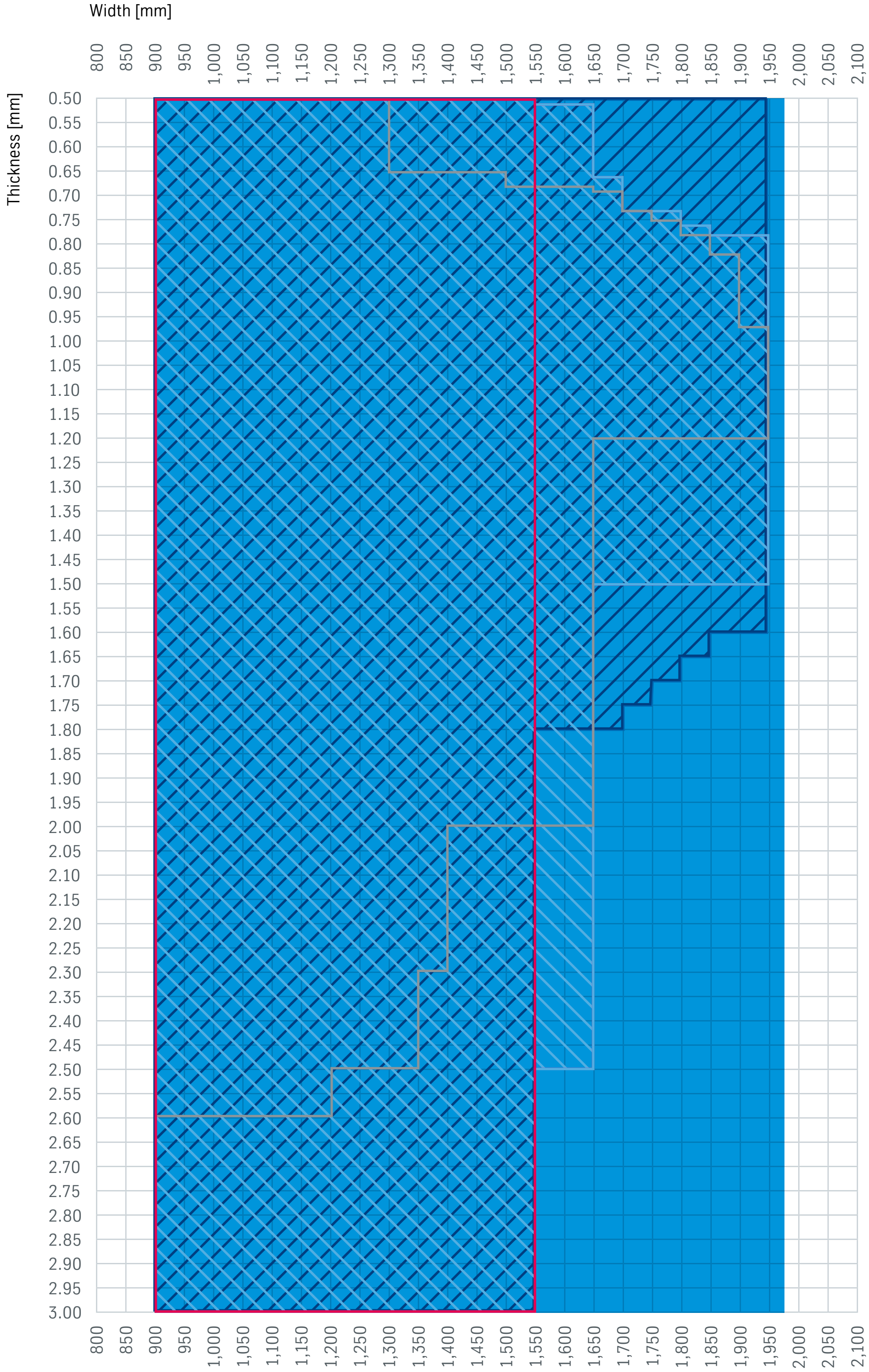


BHZ 180
Manson-Coffin parameters
σ_f' = 485 MPa
b = -0.09
ε_f' = 0.061 mm/mm
c = -0.34

BHZ 180
Ramberg-Osgood parameters
K' = 1,020
n' = 0.266

Available dimensions

BHZ 180, BHZ 220, CR180BH, CR210BH

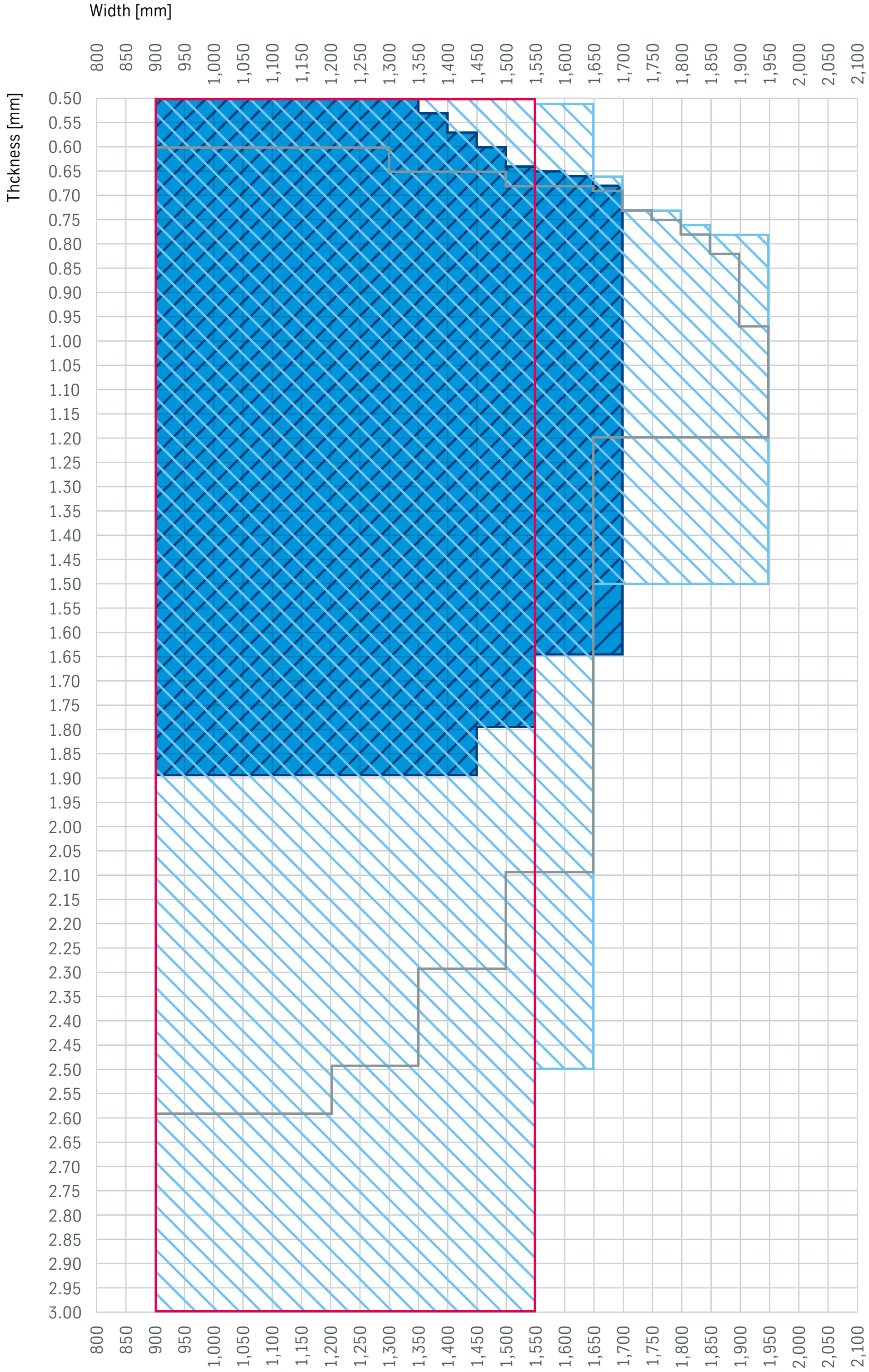


EG Electrogalvanized zinc coating
GI Hot-dip zinc coating
GA Galvannealed
ZM EcoProtect®

ZM trimmed
GA trimmed
GI trimmed
EG trimmed
Uncoated with mill edge

For interior parts
Typical dimensions for automotive customers. Restrictions may apply to steel grades as per VDA 239-100. Further dimensions on request.

BHZ 260, CR240BH

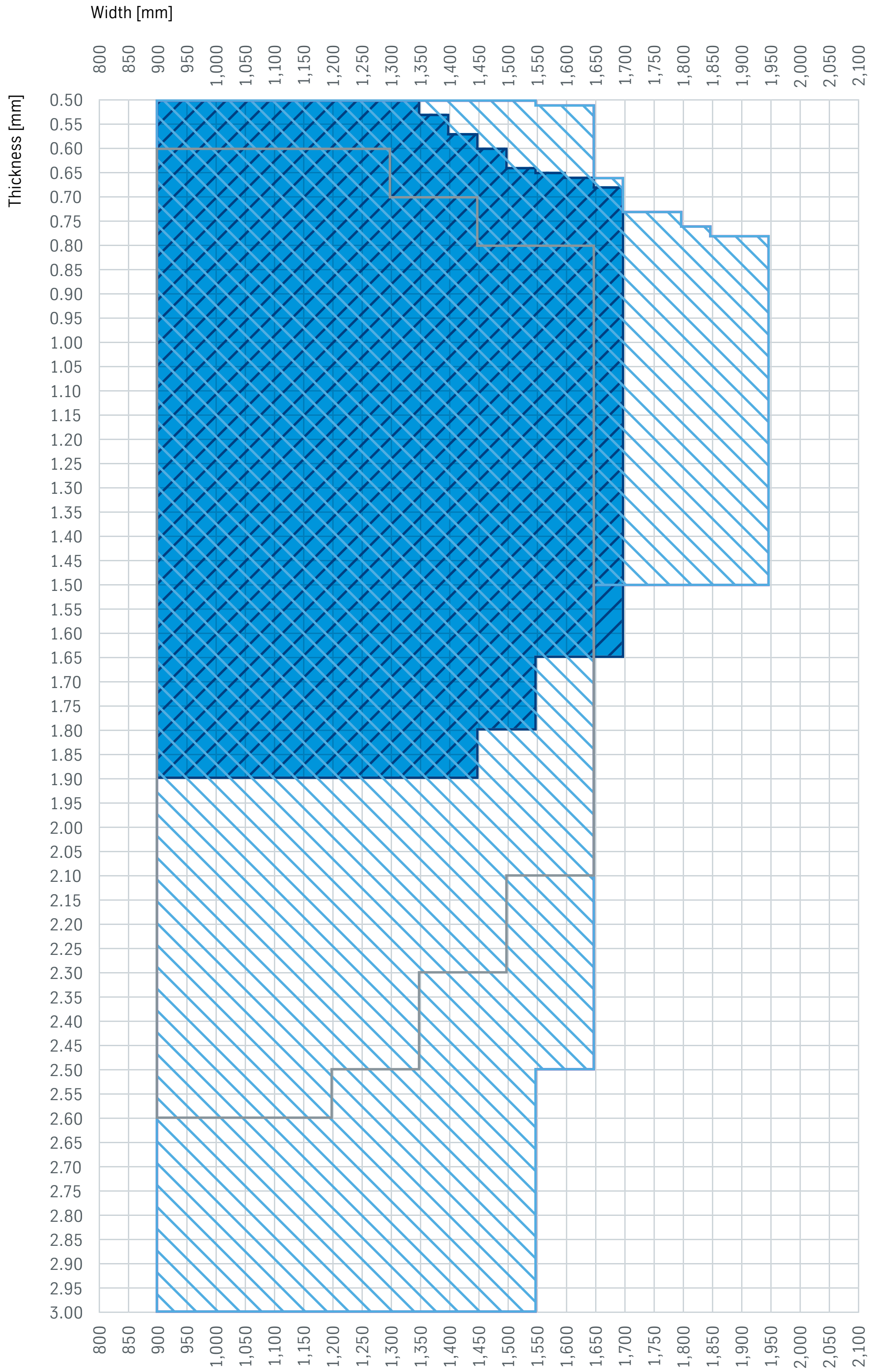


EG Electrogalvanized zinc coating
GI Hot-dip zinc coating
GA Galvannealed
ZM EcoProtect®

ZM trimmed
GA trimmed
GI trimmed
EG trimmed
Uncoated with mill edge

For interior parts
Typical dimensions for automotive customers. Restrictions may apply to steel grades as per VDA 239-100. Further dimensions on request.

BHZ 300



EG Electrogalvanized zinc coating
GI Hot-dip zinc coating
GA Galvannealed

GA trimmed
GI trimmed
EG trimmed
Uncoated with mill edge

For interior parts
Typical dimensions for automotive customers. Further dimensions on request.

thyssenkrupp Steel Europe AG, Kaiser-Wilhelm-Straße 100, 47166 Duisburg, Germany
Postal address: 47161 Duisburg, Germany, T: +49 203 52-45541
www.thyssenkrupp-steel.com, info.auto@thyssenkrupp.com

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.

General information