Steel

DP-W® and DP-K®

Product information for dual-phase steels

thyssenkrupp

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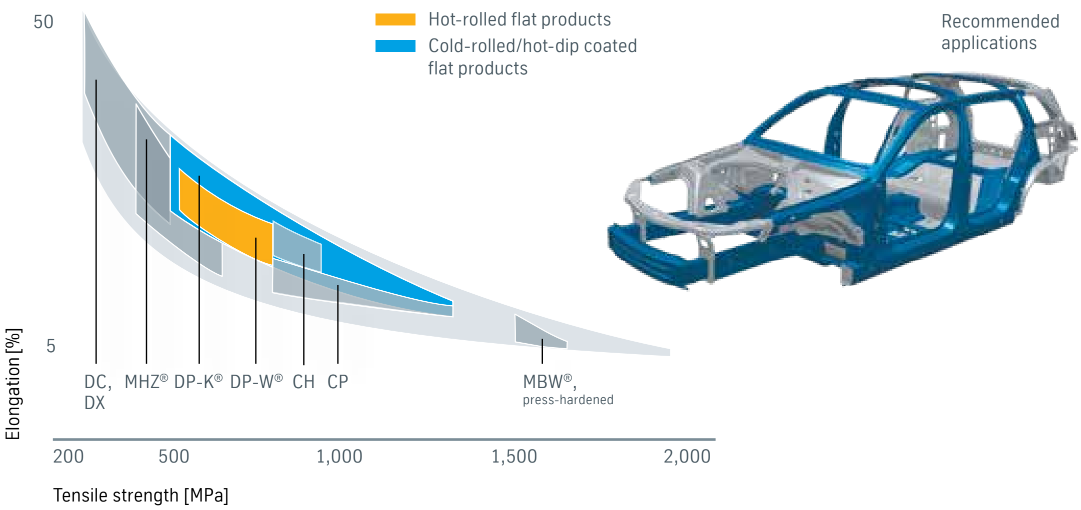
Overview of steel grades



Content

Areas of application

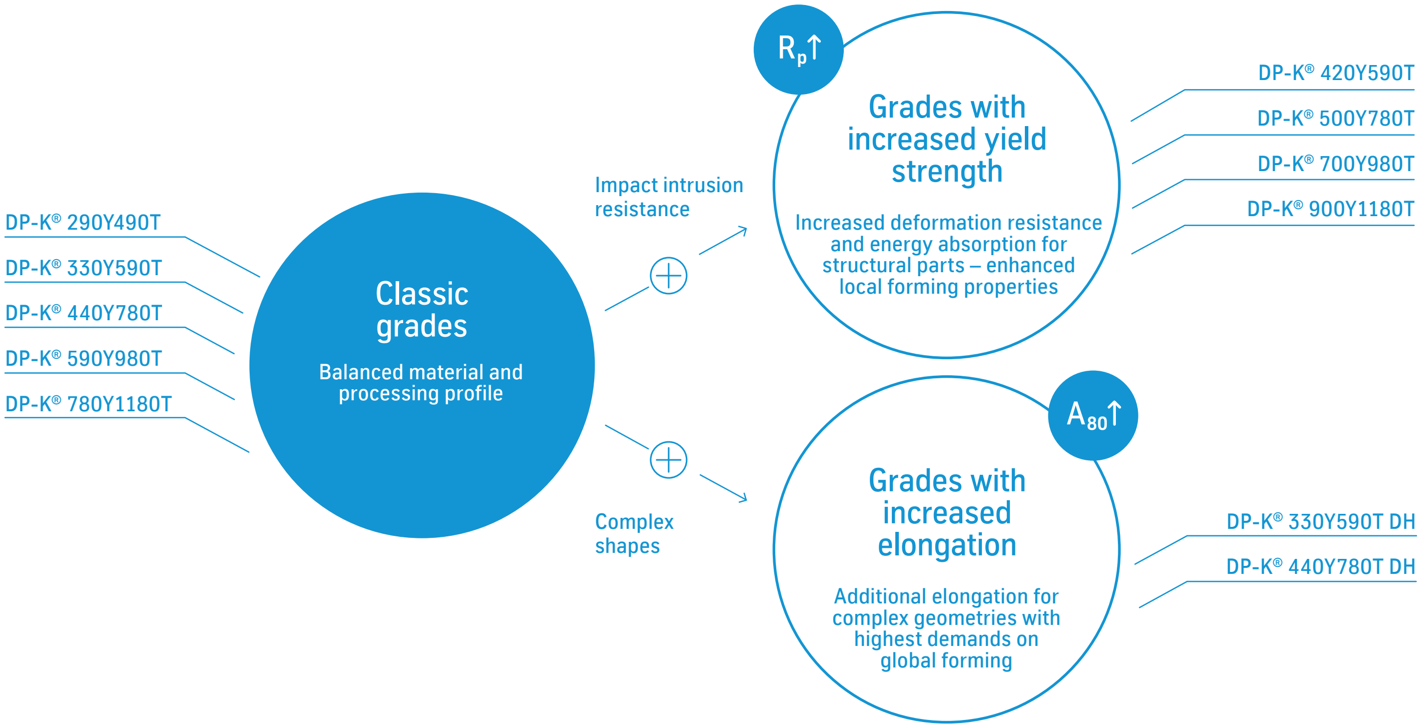
The dual-phase steels DP-W® and DP-K® by thyssenkrupp are ideally suited for the demands of modern automotive production in terms of weight optimization and safety. They are particularly suitable for cold forming with a high stretch-forming component for the production of complex structural elements and body parts. Thanks to their good dynamic behavior, dual-phase steels are also ideal for crash-relevant components such as side members, or for cyclically stressed components. Due to the achievable dent resilience, cold rolled dual-phase steels additionally offer potential for weight savings in the skin area.

Hot-rolled dual-phase steel DP-W® offers particular advantages in the thicker sheet metal segment for weight-saving production of components such as profiles, body reinforcements, chassis parts, wheels, etc.

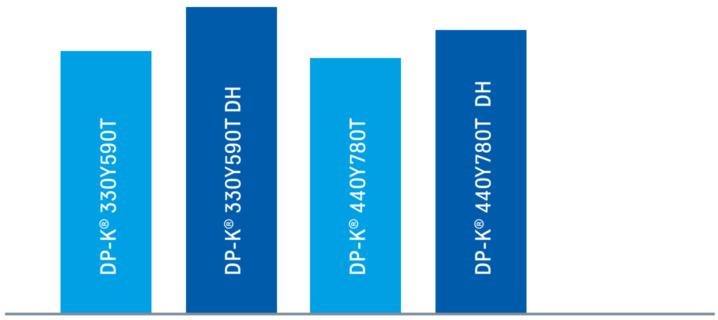
In addition to the conventional dual-phase steels, DP-K® 330Y590T DH, DP-K® 420Y590T, DP-K® 440Y780T DH, DP-K® 440Y780T HHE, DP-K® 500Y780T, DP-K® 700Y980T and DP-K® 900Y1180T provide added potentials for specific requirements for a wide variety of applications.

Dual-phase steels – tailored portfolio for modern lightweight construction

High strength, very good formability and enhanced crash performance: The specific requirements for the different applications in automotive engineering can be enhanced with our tailored and needs-oriented portfolio of cold-rolled dual-phase steels. A coordinated range that is optimally tailored to the component function and customer application. The classic variants offer a well-balanced material and processing profile and are proven solutions for longitudinal or cross members. For special applications the grades with increased yield strength offer a particularly high local formability such as an optimized hole expansion. The DH grades with increased elongation are characterized by high global formability, ideally suited for complex deep drawing parts with secondary design elements.



Strech forming of DH grades and classic grades compared – LDH test



DH grades with extended stretch properties compared to classic grades.

Benefits DH grades

- DH steel grades with higher reserve in the elongation ensures process stability in the press plant
- High lightweight potential can be achieved by increase in strength, i.e. use of DP-K® 440Y780T DH instead of CR330Y590T-DP
- Application and processing properties are as good as usual
- DH grades fullfill VDA specification

Available steel grades

thyssenkrupp supplies the following steel grades as per the product information or the reference steel grades in accordance with the respective standards.

Steel grade designations and surface refinements

Dual-phase steels

Steel grade	Reference grade DIN EN 10152 10338, 10346	Reference grade VDA 239-100	Surface refinements –/UC	Surface refinements Z/GI	Surface refinements ZF/GA[1]	Surface refinements ZM
• DP-W® 300Y530T	–	–	●			
• DP-W® 330Y580T	HDT580X	HR330Y580T-DP	●			
• DP-W® 300Y580T	–	–	●			
• DP-K® 290Y490T	HCT490X	CR290Y490T-DP	◉	▣	◉	▣
• DP-K® 330Y590T	HCT590X	CR330Y590T-DP	●	●	●	●
• DP-K® 330Y590T DH	–	–		●		
• DP-K® 420Y590T	–	–		●		
• DP-K® 440Y780T	HCT780X	CR440Y780T-DP		●		
• DP-K® 440Y780T DH	–	CR440Y780T-DH		●		
• DP-K® 440Y780T HHE	–	–	●	●		
• DP-K® 500Y780T	–	–		●		
• DP-K® 590Y980T	HCT980X	CR590Y980T-DP	●	●	●	
• DP-K® 700Y980T	HCT980XG	CR700Y980T-DP	●	●	●	
• DP-K® 780Y1180T	–	–		●		
• DP-K® 900Y1180T	–	–	●	●		

[1] With different mechanical properties on request.

- • Hot-rolled flat products
- • Cold-rolled/hot-dip coated flat products
- ● Serial production for unexposed applications
- ◉ Serial production for unexposed and exposed applications
- ▣ Serial production for unexposed and exposed applications as well as exposed applications in primetex® finish

UC Uncoated
EG Electrogalvanized zinc coating
GI Hot-dip zinc coating
GA Galvannealed
ZM ZM Ecoprotect®
DH Steel grades with improved formability
HHE Steel grades with improved hole expansion

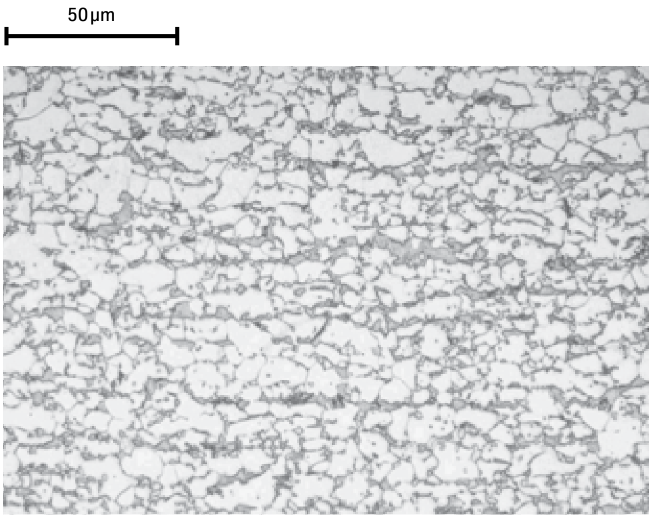
Material characteristics

Hot and cold-rolled dual-phase steels offer a particularly attractive combination of high strength, low yield point, good cold formability and weldability due to their concerted microstructure of ferrite and martensite components.

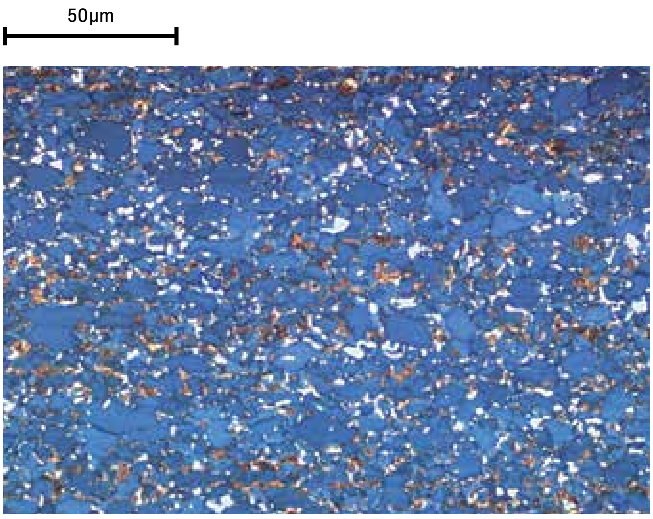
This high strain-hardening capacity reduces the risk of local constriction of the material during the forming process and induces a strong increase in the component's yield point in the worked areas even at low degrees of deformation.

The microstructure consists predominantly of a soft ferrite matrix, in which a second, hard, mainly martensitic phase is embedded in pockets. The ferrite content is up to 90%. In addition to martensite, austenite and bainite components can also exist, thus improving formability. In nital etching, the grain boundaries are well contrasted. Color etching according to Klemm contrasts the grain surfaces. The grain surfaces of the ferrite appear in brown or blue hues; martensite is brown; structurally weak martensite and austenite are shown in white.

Micrograph of DP-K®



Structural example of cold-rolled DP steels. Microstructural contrasting through etching with nital.



Structural example of cold-rolled DP steels. Microstructural contrasting with color etching according to Klemm.

Technical features

Chemical composition

Mass fractions in ladle analysis	C [%] max.	Si [%] max.	Mn [%] max.	P [%] max.	S [1] [%] max.	Al [%] total	Ti + Nb [%] max.	Cr + Mo [%] max.	V [%] max.	B [%] max.	Cu [%] max.
Steel grade											
• DP-W® 300Y530T	0.10	0.80	1.50	0.080	0.010	0.015 – 1.0	0.15	1.00	0.20	0.005	0.20
• DP-W® 330Y580T	0.11	0.80	1.50	0.085	0.010	0.015 – 0.1	0.15	1.00	0.20	0.005	0.20
• DP-W® 300Y580T	0.11	0.80	1.50	0.085	0.010	0.015 – 1.0	0.15	1.00	0.20	0.005	0.20
• DP-K® 290Y490T	0.10	0.50	1.80	0.040	0.010	0.015 – 1.0	0.15	1.00	0.20	0.005	0.20
• DP-K® 330Y590T	0.13	0.75	2.00	0.040	0.010	0.015 – 1.5	0.15	1.00	0.20	0.005	0.20
• DP-K® 330Y590T DH	0.15	0.75	2.00	0.040	0.010	0.015 – 1.0	0.15	1.00	0.20	0.005	0.20
• DP-K® 420Y590T	0.18	0.60	2.00	0.040	0.010	0.015 – 1.0	0.15	1.00	0.20	0.005	0.20
• DP-K® 440Y780T	0.18	0.50	2.30	0.040	0.010	0.015 – 1.0	0.15	1.00	0.20	0.005	0.20
• DP-K® 440Y780T DH	0.18	0.50	2.30	0.040	0.010	0.015 – 1.0	0.15	1.00	0.20	0.005	0.20
• DP-K® 440Y780T HHE	0.18	0.50	2.40	0.040	0.010	0.015 – 1.0	0.15	1.00	0.20	0.005	0.20
• DP-K® 500Y780T	0.18	0.50	2.40	0.040	0.010	0.015 – 1.0	0.15	1.00	0.20	0.005	0.20
• DP-K® 590Y980T	0.18	0.50	2.30	0.040	0.010	0.015 – 1.0	0.15	1.00	0.20	0.005	0.20
• DP-K® 700Y980T	0.10	0.50	2.90	0.040	0.010	0.015 – 1.0	0.15	1.00	0.20	0.005	0.20
• DP-K® 780Y1180T	0.20	0.80	2.60	0.040	0.010	0.015 – 1.0	0.15	1.00	0.20	0.005	0.20
• DP-K® 900Y1180T	0.20	0.80	2.60	0.040	0.010	0.015 – 1.0	0.15	1.00	0.20	0.005	0.20

[1] To achieve good cold formability, a particularly low sulfur content is set and/or favorable sulfide formation is promoted by the addition of alloying elements.

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

Mechanical properties

Test direction in rolling direction	Yield strength	Tensile strength	Elongation		Strain-hardening exponent	
	$R_{p0.2}$ [MPa]	R_m [MPa] min.	A [%] min.	A_{80} [1), 2)] [%] min.	n_{4-6} min.	$n_{10-U,}$
Steel grade						
• DP-W® 300Y530T	300 – 450	530	25	21	–	–
• DP-W® 330Y580T	330 – 450	580 – 680	23	19	–	0.13
• DP-W® 300Y580T	300 – 470	580	24	19	–	–
• DP-K® 290Y490T	290 – 380	490	–	24	–	0.15
• DP-K® 330Y590T	330 – 430	590 [3)]	–	20	–	0.14
• DP-K® 330Y590T DH	330 – 430	590	–	26	–	0.15
• DP-K® 420Y590T	420 – 500	590	–	16	–	–
• DP-K® 440Y780T	440 – 550	780	–	14	0.15	–
• DP-K® 440Y780T DH	440 – 550	780	–	18	–	0.13
• DP-K® 440Y780T HHE [4)]	440 – 550	780	–	14	–	–
• DP-K® 500Y780T	500 – 620	780	–	13	–	–
• DP-K® 590Y980T	590 – 740	980	–	10	–	–
• DP-K® 700Y980T	700 – 850	980	–	8	–	–
• DP-K® 780Y1180T	780 – 950	1,180	–	10	–	–
• DP-K® 900Y1180T	900 – 1,070	1,180	–	8	–	–

1) Reduced minimum elongation values are valid for product thicknesses t < 0.60 mm (minus 2 units).
2) For ZF coatings, minimum values for elongation are reduced by 2 units. For GA coatings on product thicknesses t < 0.60 mm, the minimum values for elongation are reduced by 4 units.
3) Tensile strength R_m min. = 570 MPa for product thicknesses t ≥ 2,0 mm.
4) For product thicknesses t ≥ 1.20 mm typical hole expansion ≥ 30 % according to ISO 16630.

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

$R_{p0.2}$ 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 ≥ 3.0 mm
A_{80} Percentage elongation after fracture using a specimen with gauge length L_0 = 80 mm for sheet thicknesses < 3.0 mm
n_{4-6} Strain-hardening exponent determined between 4 and 6% plastic strain
n_{10-UE} Strain-hardening exponent determined between 10% plastic strain and uniform elongation limit

Surfaces

Surface refinements, hot-dip zinc coating

	Specification	Minimum coating mass on both sides [g/m²]		Coating on each side of single spot sample		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	–
GI50	VDA 239-100	–	–	50–70	7.0–9.9	–
GI140	DIN EN	140	120	–	7–15	10
GI60	VDA 239-100	–	–	60–90	8.5–13	–
Galvannealed						
Designation						
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	–

Surface refinement, hot-dip zinc coating[1)]

	Specification	Minimum coating mass on both sides [g/m²]		Coating on each spot of single spot sample		Informative
		Triple spot sample	Single spot sample	Mass [g/m²]	Thickness [µm]	Typical thickness [µm]
ZM Ecoprotect®						
Designation						
ZM070	DIN EN	70	60	–	–	5.5
ZM30	VDA 239-100	–	–	30 – 55	4.5–7.7	–
ZM100	DIN EN	100	85	–	–	8
ZM40	VDA 239-100	–	–	40–65	6.2–9.2	–
ZM120	DIN EN	120	100	–	–	9
ZM50	VDA 239-100	–	–	50–80	7.7–12	–

Further coatings on request.

1) Informative selection of typical surface refinements

Surface finishes and surface qualities

	Finish type	Surface quality
Products		
Cold-rolled flat products	Uncoated	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)
		primetex®
	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)
		primetex®

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

Surface treatments

		–/UC	Z/GI	ZF/GA	ZM	AS
Type of surface treatment						
O	Oiled	•	•	•		

• Serial production

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

Notes on applications and processing

Forming

Hot-rolled dual-phase steels DP-W® are particularly suitable for weight-saving production of wheels, chassis parts, profiles, body reinforcements, etc. Cold-rolled dual-phase steels DP-K® are suitable for both complex structural parts, for instance side members and cross members, as well as stretch-formed exterior parts with special requirements in terms of buckling strength (doors, roofs, trunk lids). Choosing the right type of steel grade for a given strength level must me done 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.

Due to the good strain-hardening behavior, expressed by a relatively high n value, dual-phase steels exhibit high resistance to local constriction, as a larger area of material is involved in the deformation zone due to greater strain hardening. The microstructure of dual-phase steels, composed of hard martensite and soft ferrite, which promotes strain hardening, as well as the distinct cutting-edge hardening in mechanical cutting substantially impact the good forming potential in the trim cutting-edge area. For engineering design, for instance in case of through-hole extensions or the height of drawn flanges in corner areas, this must be taken into consideration. Small bending and drawing radii relative to the respective thicknesses should thus be avoided. In such cases, it is recommended to choose the yield-optimized variants. Plasticization must be designed to be as homogeneous as possible in order to improve the dimensional accuracy of the worked components. The presses should have high pressing and hold-down force potentials. As a guideline, the tensile strength level should be considered here, compared with known materials. Upstream straightening equipment must also be designed accordingly. Special attention must be paid, as the strength level of dual-phase steels increases, to the design of the forming and cutting tools.
Tool requirements are exacting, especially in cutting.
In addition to a sufficient hardness of > 60 HRC, it is important to select suitable tool materials to simultaneously ensure high ductility, thus preventing premature breaking of the cutting-edges. By means of specific rounding of the cutting edge in the order of about 50 μm, the edge strength of the tools can be optimized. The cutting gap must be designed to take the material thickness into account and should be (as a guideline) ≥ 10% of the sheet thickness.

A sufficient supporting hardness must be achieved for the forming tools. A segmented structure of the forming tools is common today. In highly stressed areas, the use of high speed steels may be necessary. These include 1.3343 or equivalent materials produced by powder sintering. In addition, tool coatings such as CVD (TiC-TiN coating) can minimize tool wear.

Processing instructions for joining

DP steels principally support welding well in same-grade joints or in hybrid joints with other common steel grades. The precondition is welding parameters matched to the material.

Resistance spot welding

For spot welding of dual-phase steels, the same equipment can be used as for welding unalloyed deep drawing steels. Compared to same-thickness steel grades of lower strength, the welding zone tends to shift toward lower currents. At the same time, the setting range narrows slightly, but this can be largely compensated for by increasing the electrode force and welding currents. An extension of the current flow times, or for example the use of multi-pulse welding in line with SEP 1220-2, can also have a favorable effect on the width of the welding zone.

Typical properties of a resistance spot weld

	Plate thickness	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	1.5	2.0	9.9	13.7	165	330
• DP-K® 330Y590T-GI	1.5	1.4	10.8	14.9	205	425
• DP-K® 440Y780T-GI	1.5	1.9	9.4	15.9	235	425
• DP-K® 590Y980T-GI	1.5	1.9	7.3	17.9	355	475

Test results as per SEP 1220-2.

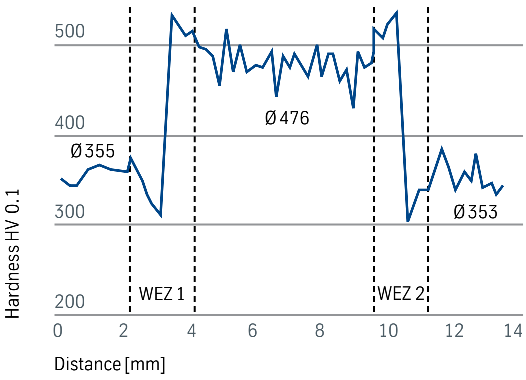
• Cold-rolled flat products
$d_{w\,min}$ Welding spot diameter of 4 √t

DP-K® 440Y780T

DP-K® 590Y980T

Good weld nugget formation.

Hardness profile of the weld nugget in a DP-K® 590Y980T-GI



Pronounced hardness increase compared to the base material.

In resistance spot welding of galvanized sheets, the welding currents must be increased due to the higher conductivity of the coating compared with the base material (substrate). In addition to this, increasing the electrode force and welding time has a favorable effect on the welding zone. In addition to the sheet type, surface and thickness combination, other factors, e.g., the type of electrode used, play an important role in determining optimum joining parameters.

MIG arc brazing

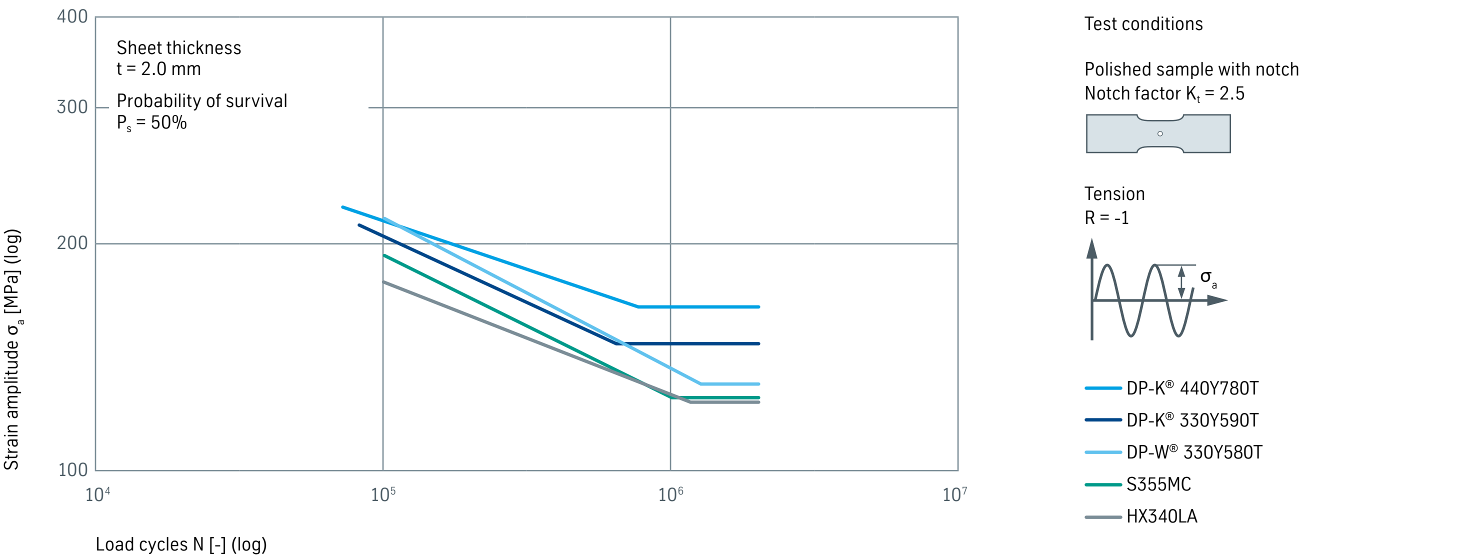
Information sheet DVS 0938-2 "Arc brazing" describes brazing of steels up to a tensile strength of approximately 500 MPa. As the material described is above this tensile strength, it is advisable to check the component-specific suitability of brazing.

Fatigue strength and crash performance

As already described in the product information, dual-phase steels have a high strain-hardening capacity combined with high yield point values. The high yield point and high tensile strength are evidenced by high fatigue limits. The following graphic displays the typically very good fatigue strength of dual-phase steels compared to micro-alloyed steels.

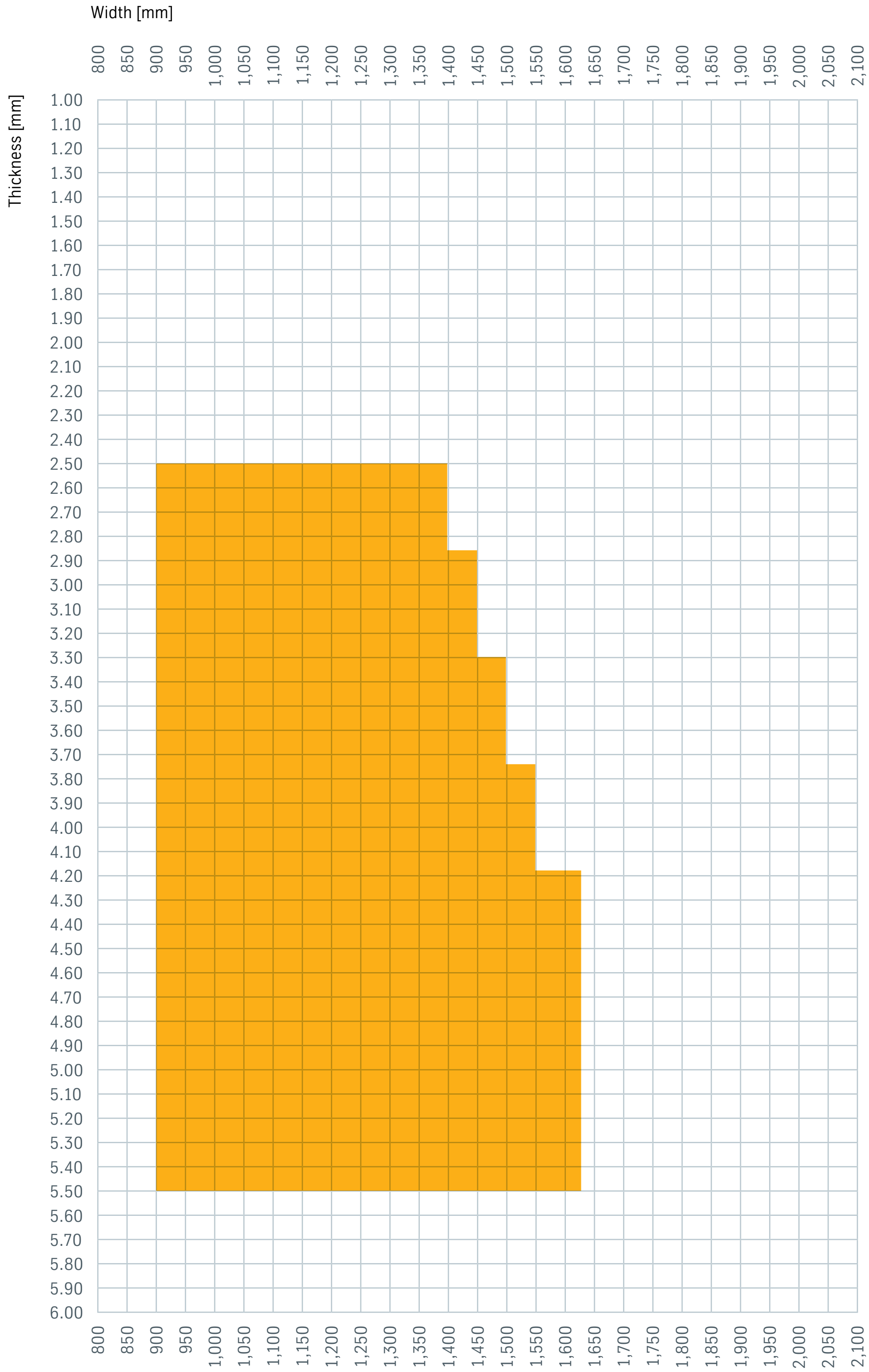
Fine and dispersed distribution of martensite and ferrite avoids any adverse effect on the fatigue limit on account of the strength difference between the structural components of ferrite and martensite. Higher strength values due to work hardening as an effect of deformation, including the bake-hardening effect, contribute to the advantageous material behavior. The high level of strength and the high strain-hardening capacity make dual-phase steels ideal for crash energy absorbing components.

Stress-strain curves in comparison: DP-K® 440Y780T, DP-K® 330Y590T, DP-W® 330Y580T, S355MC and HX340LA



Available dimensions

DP-W® 300Y530T



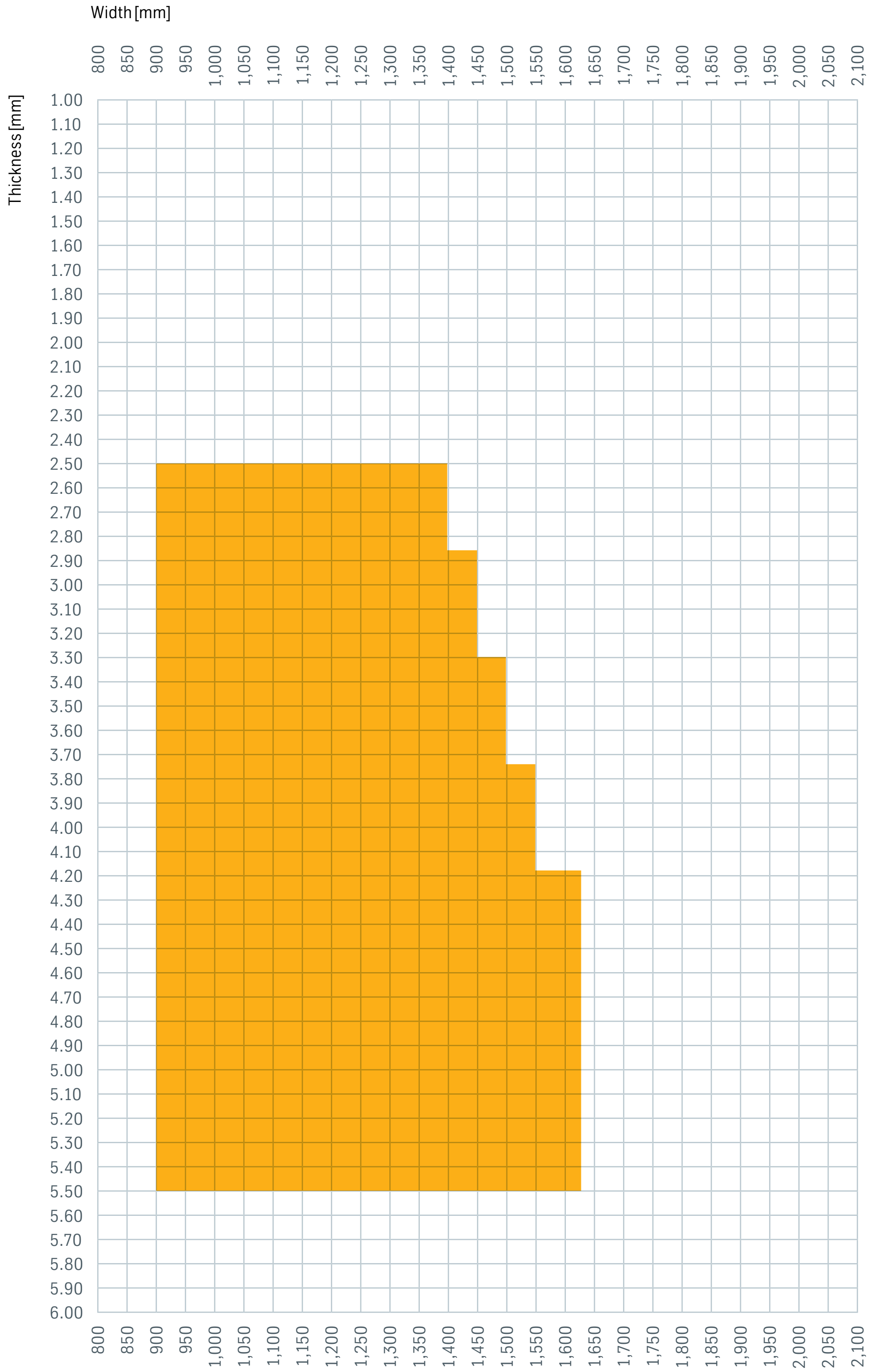
Uncoated with mill edge

For coated products for interior parts.

Typical dimensions for automotive customers. Restrictions may apply to steel grades as per VDA 239-100.

Further dimensions on request.

DP-W® 300Y580T

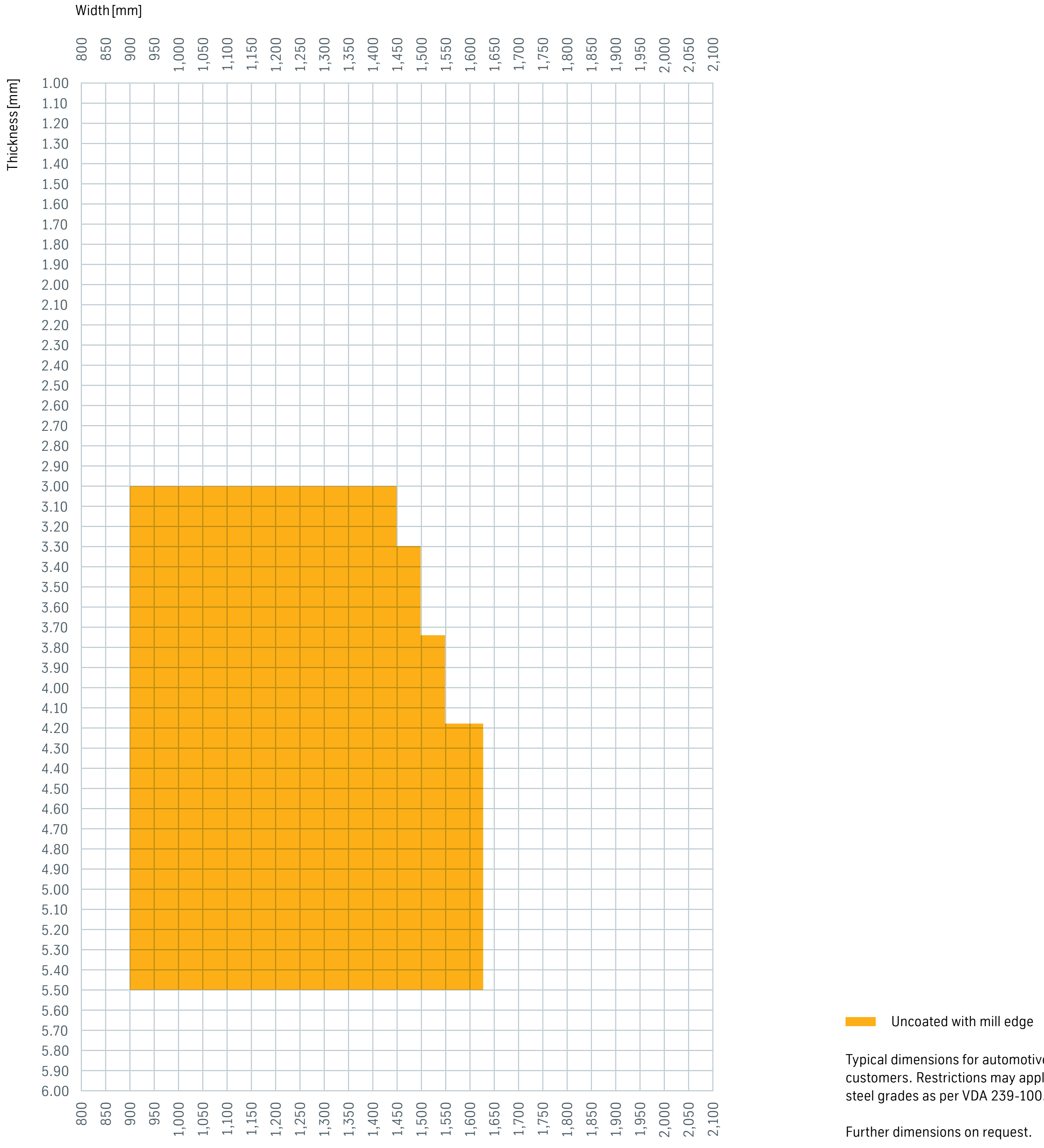


Uncoated with mill edge

Typical dimensions for automotive customers. Restrictions may apply to steel grades as per VDA 239-100.

Further dimensions on request.

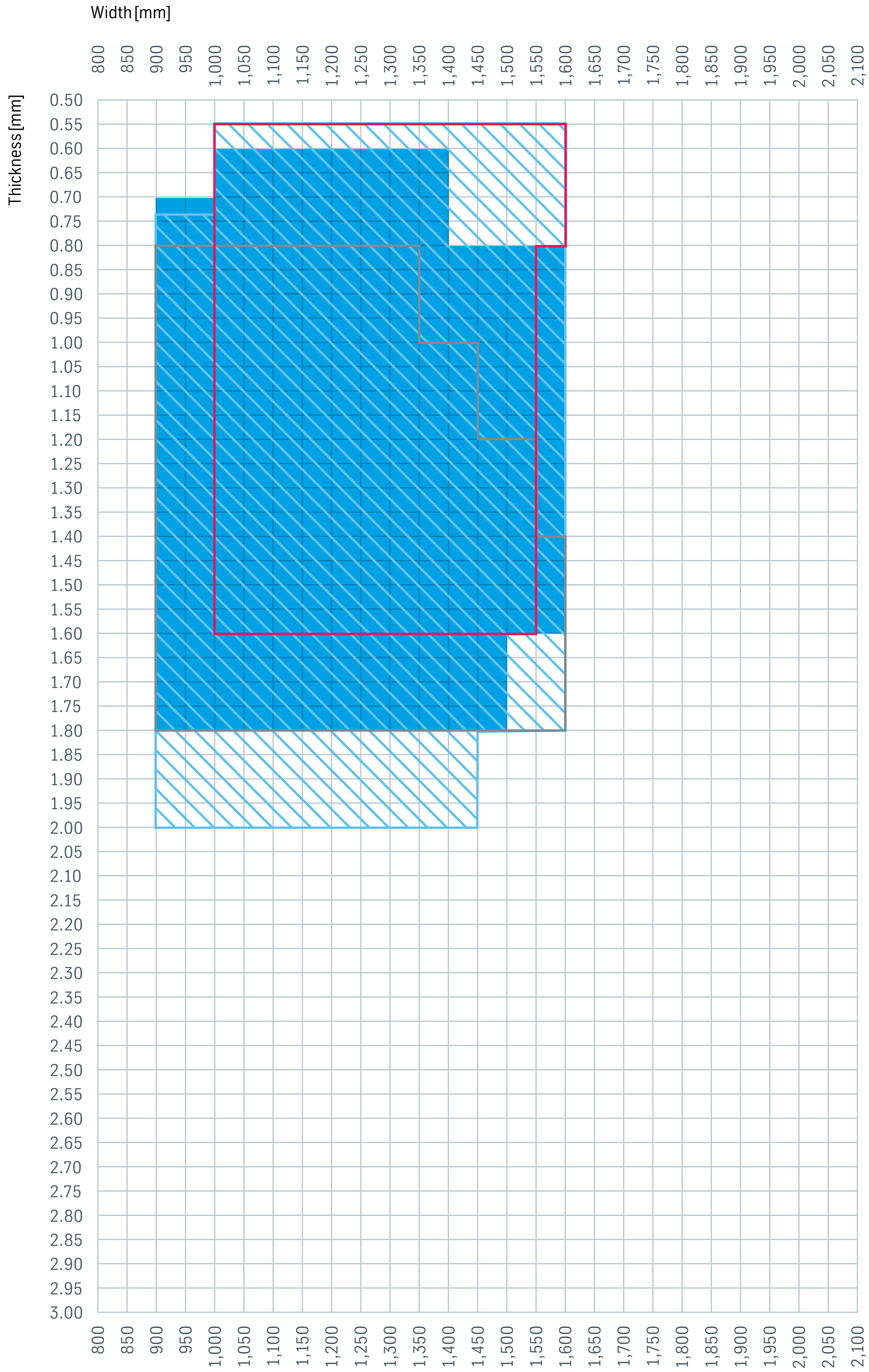
DP-W® 330Y580T



Typical dimensions for automotive customers. Restrictions may apply to steel grades as per VDA 239-100.

Further dimensions on request.

DP-K® 290Y490T



ZM ZM Ecoprotect®
GA Galvannealed
GI Hot-dip zinc coating

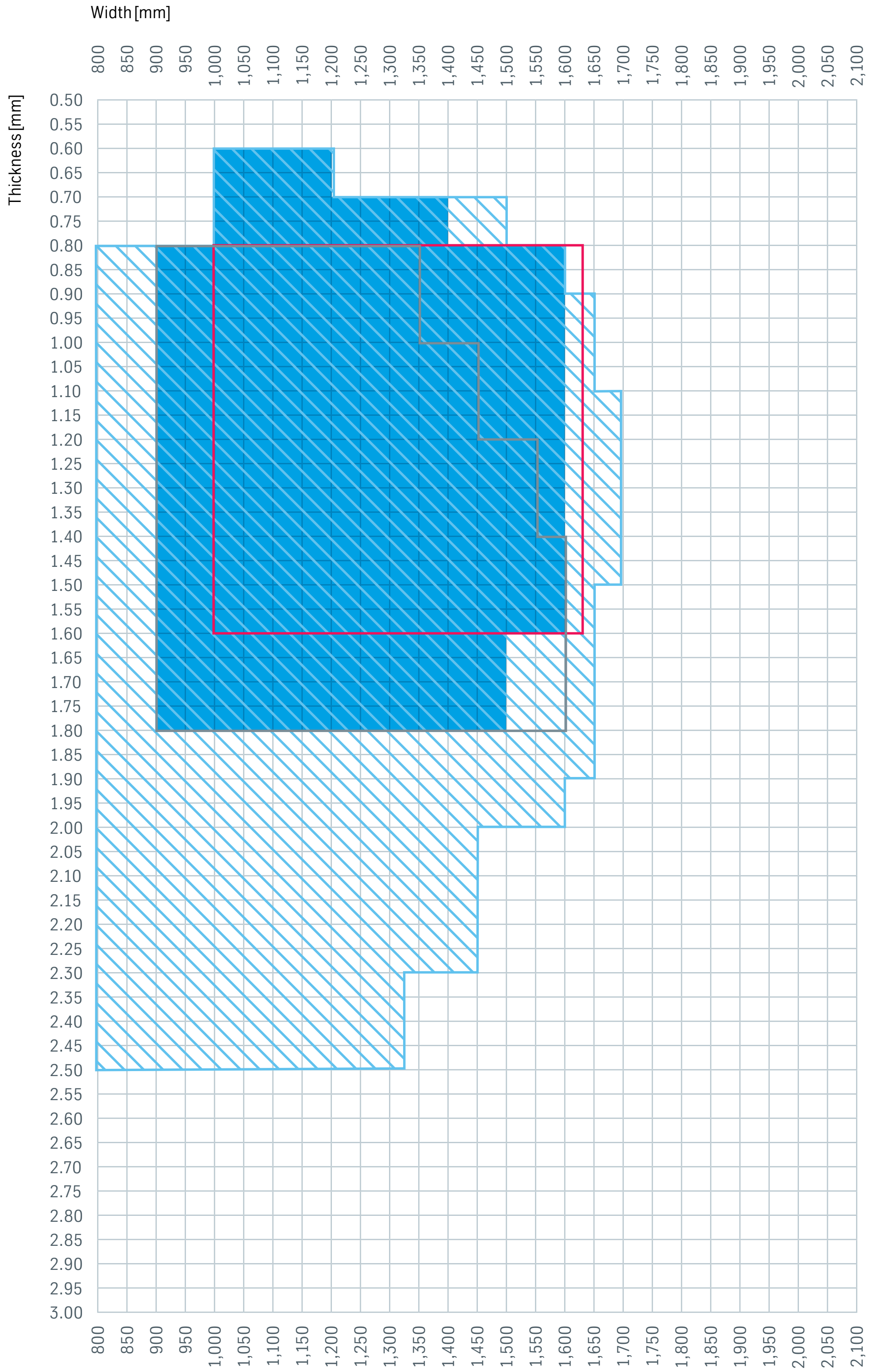
ZM trimmed
GA trimmed
GI trimmed
Uncoated with mill edge

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

For exterior parts
Similar to figure in the ranges:
Thickness 0.60 to 1.20 mm
Width 900 to 1,600 mm

Further dimensions on request.

DP-K® 330Y590T



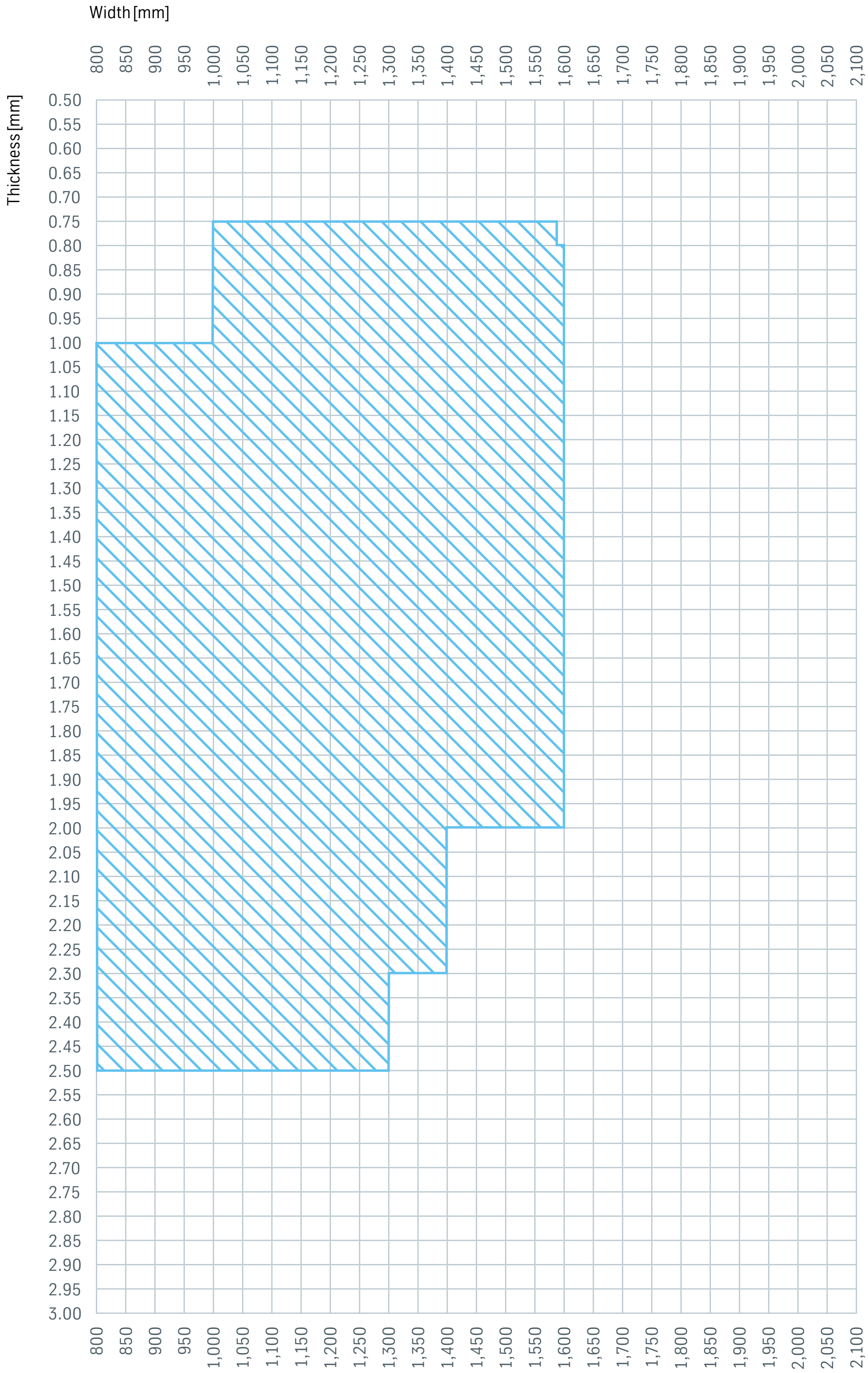
ZM ZM Ecoprotect®
GA Galvannealed
GI Hot-dip zinc coating

ZM trimmed
GA trimmed
GI 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.

DP-K® 330Y590T DH



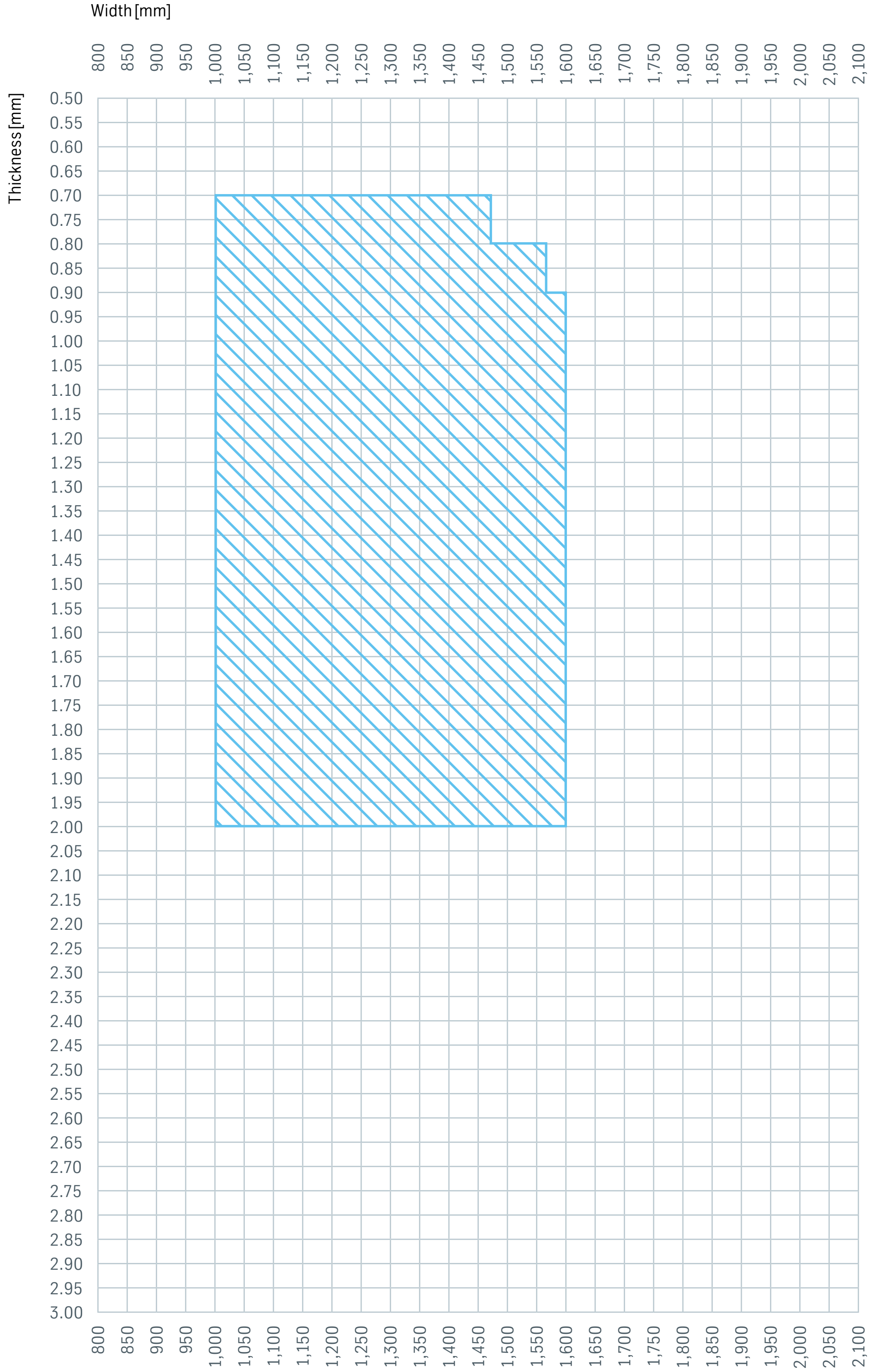
GI Hot-dip zinc coating

GI trimmed

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

Further dimensions on request.

DP-K® 420Y590T



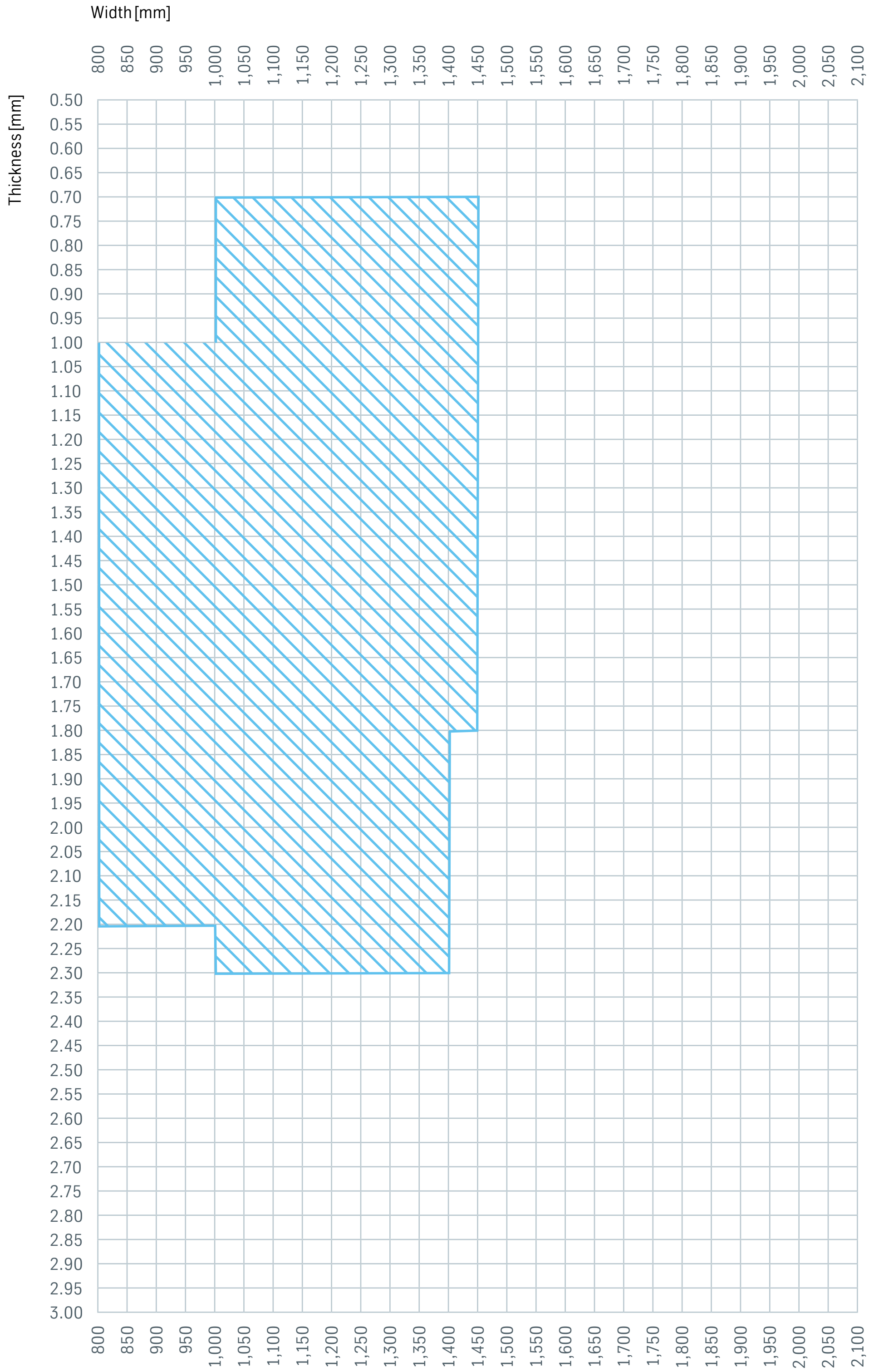
GI Hot-dip zinc coating

GI trimmed

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

Further dimensions on request.

DP-K® 440Y780T



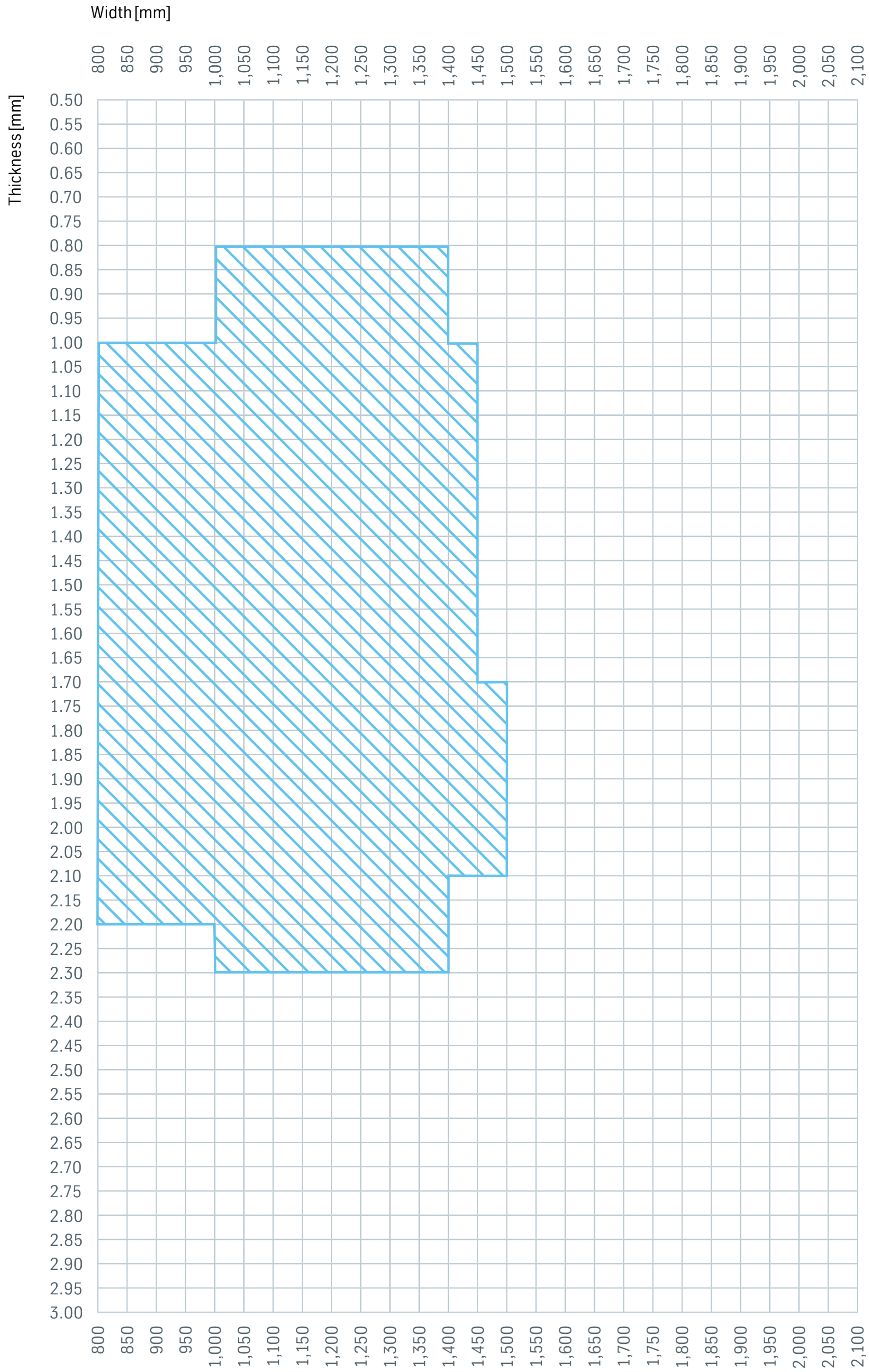
GI Hot-dip zinc coating

GI trimmed

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

Further dimensions on request.

DP-K® 440Y780T DH



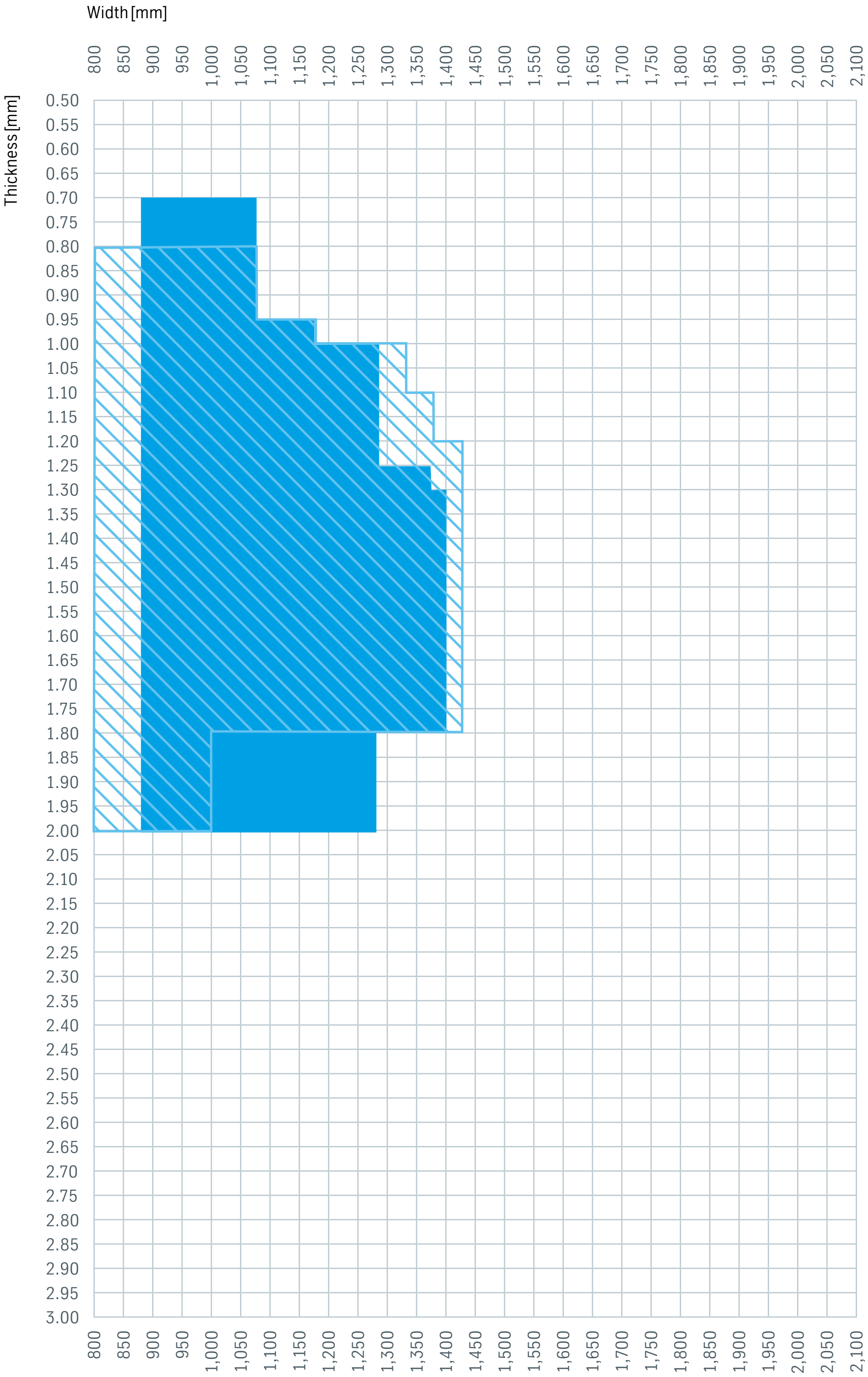
GI Hot-dip zinc coating

GI trimmed

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

Further dimensions on request.

DP-K® 440Y780T HHE and DP-K® 500Y780T



GI Hot-dip zinc coating

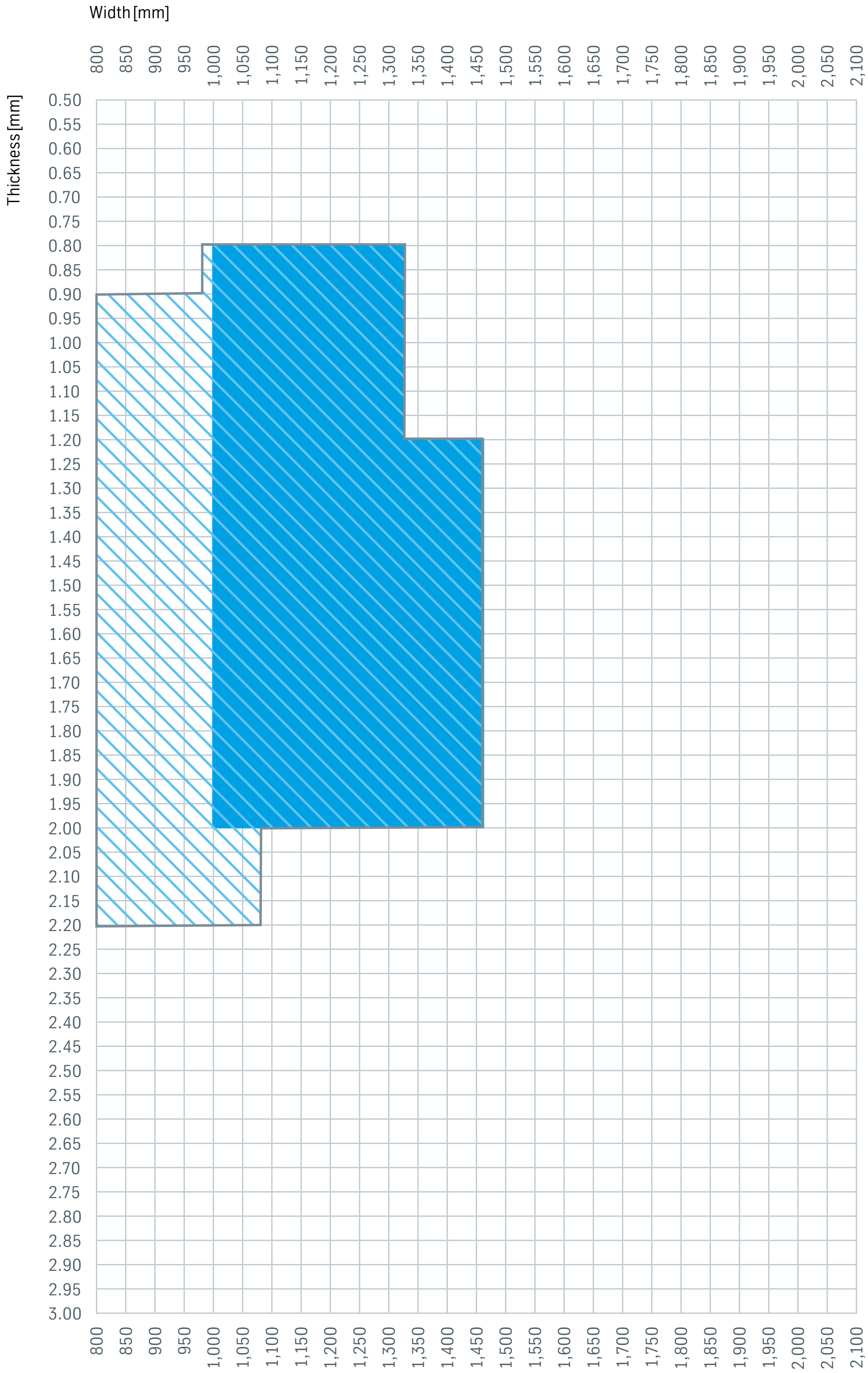
GI trimmed

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.

DP-K® 590Y980T



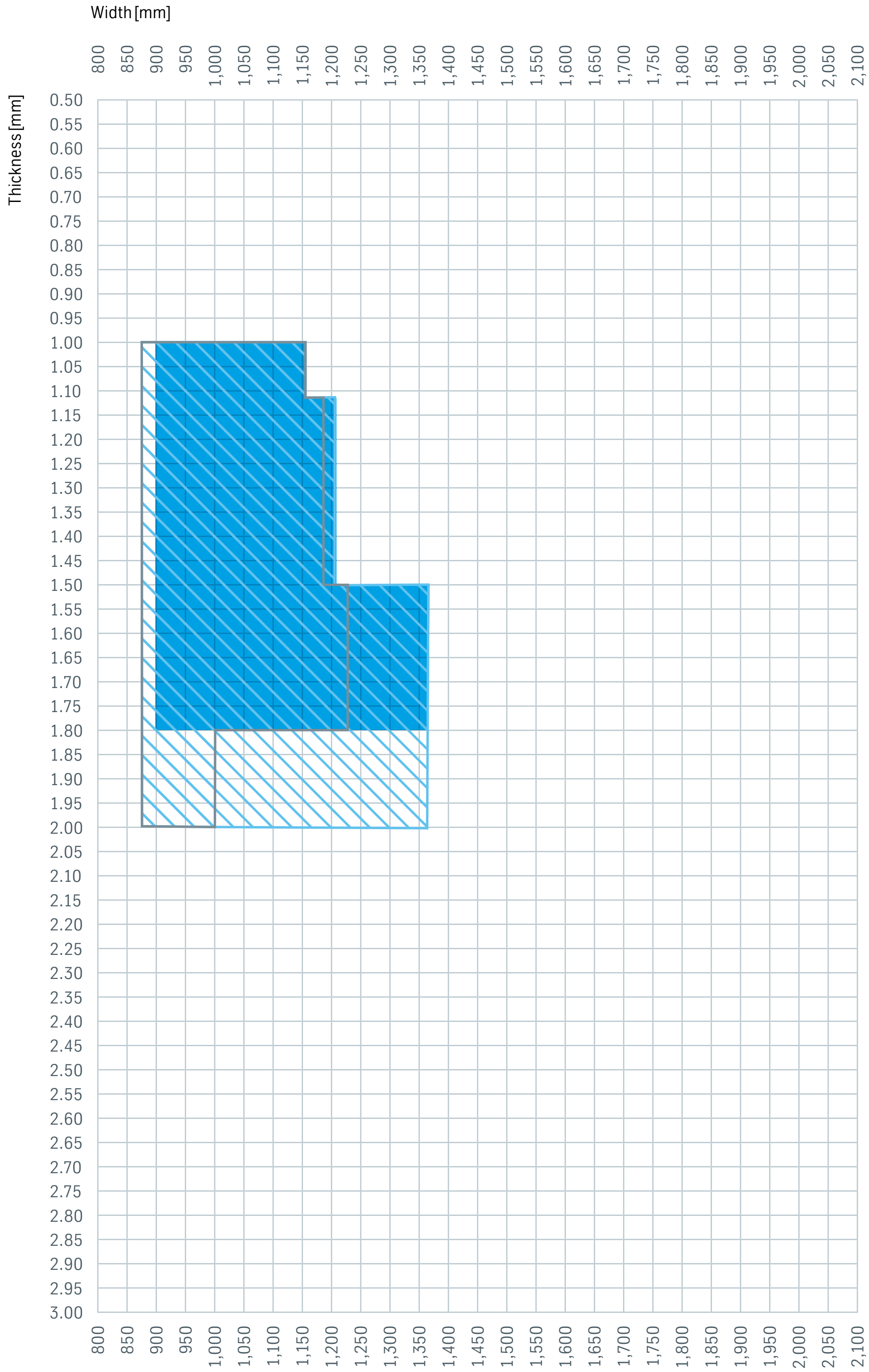
GA Galvannealed
GI Hot-dip zinc coating

GA trimmed
GI 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.

DP-K® 700Y980T



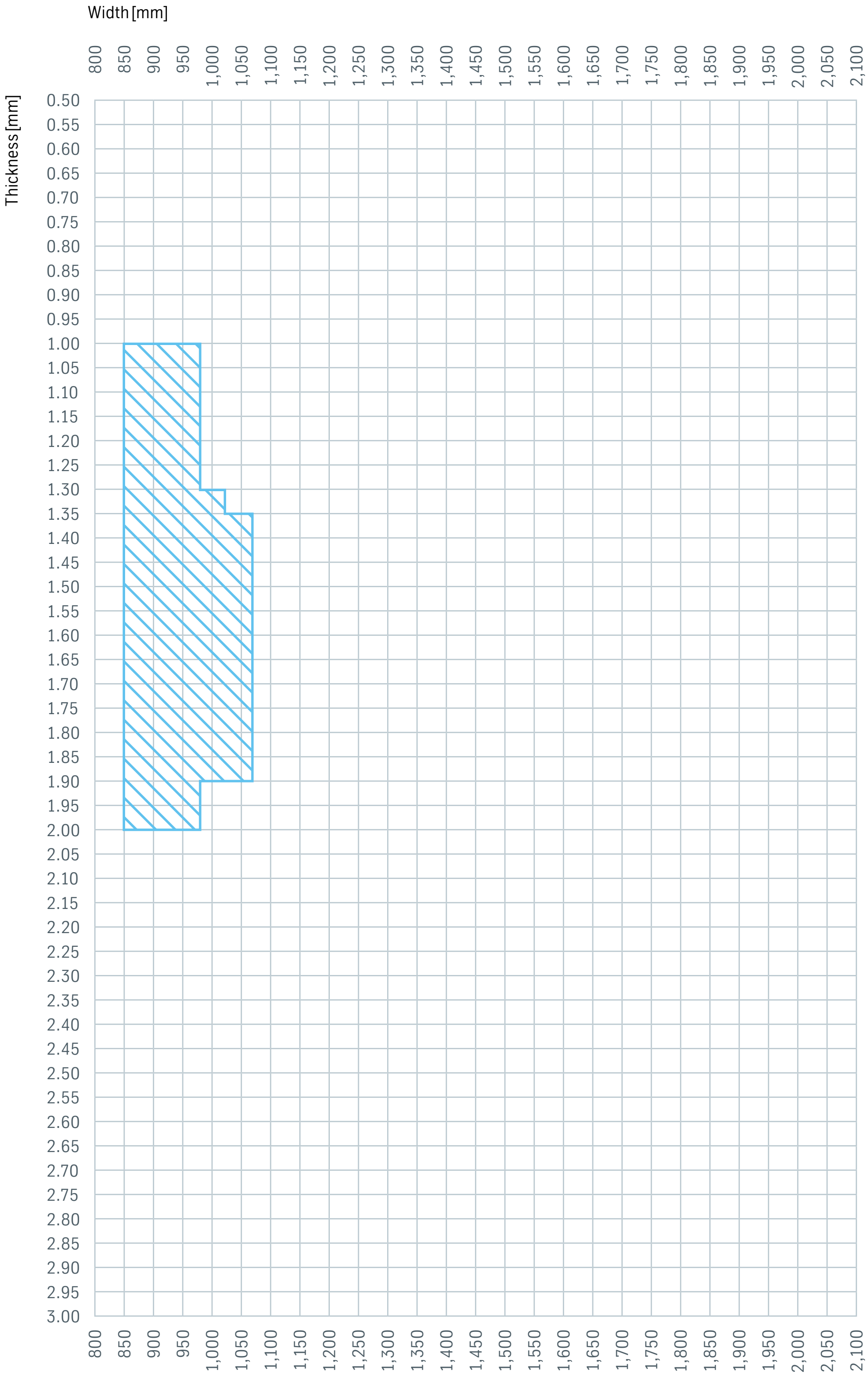
GA Galvannealed
GI Hot-dip zinc coating

GA trimmed
GI 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.

DP-K® 780Y1180T



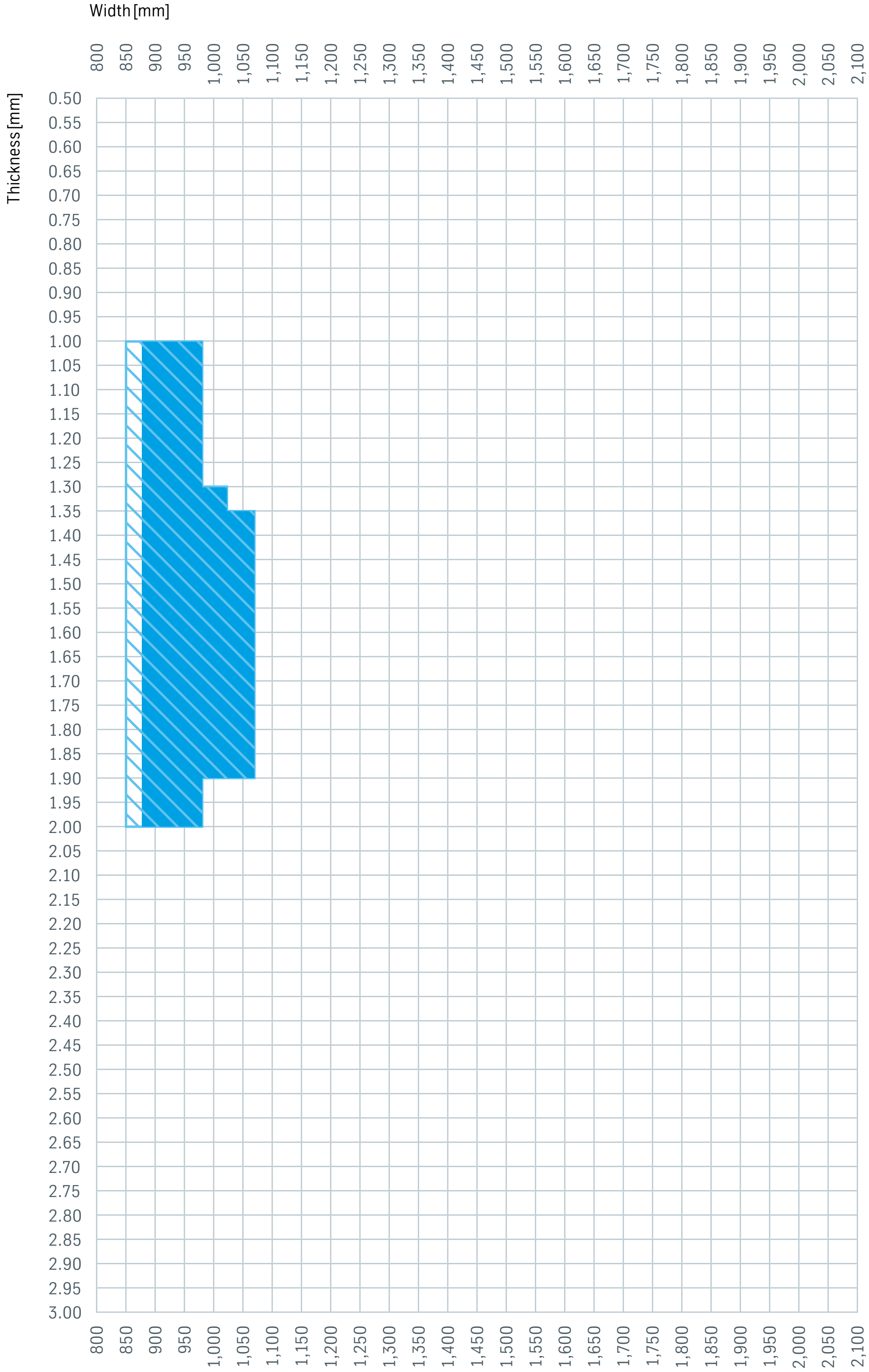
GI Hot-dip zinc coating

GI trimmed

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

Further dimensions on request.

DP-K® 900Y1180T



GI Hot-dip zinc coating

GI 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.

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.

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