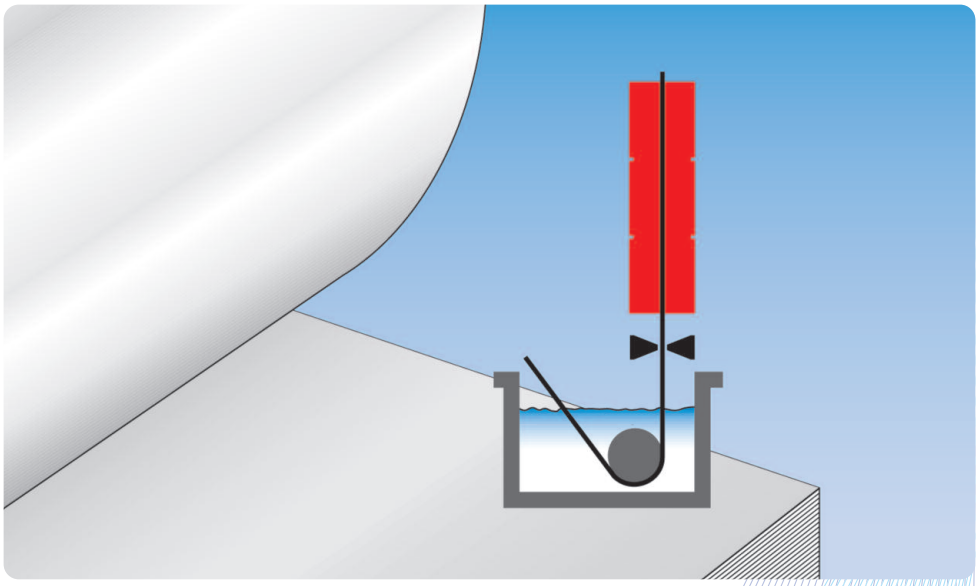

Continuously Hot-Dip Coated Steel Strip and Sheet

Characteristic Properties 095 – E

Stahl
Wirtschaftsvereinigung Stahl

The German Steel Federation (Wirtschaftsvereinigung Stahl)

The German Steel Federation is the steel industry's economic and political association in Germany with headquarters in Düsseldorf and offices in Berlin and Brussels. It represents the sector's political interests in contacts with politicians, the business world, and the public for steel producers in Germany and associated foreign member companies. Its most important tasks are:

Helping shape the economic and political environment

The central concern is to help create an economic and political environment that safeguards the future international competitiveness of the steel companies in Germany.

Attracting attention, forming opinions

The German Steel Federation represents the interests of the member companies to political decision-makers, the authorities, other business sectors, the public and the media.

Consolidation of economic interests

The member companies have common objectives. It is necessary to consolidate these and speak to politicians with a single voice.

Expertise for the member companies

The exchange of specialized expertise in committees and other bodies is a further aim of the German Steel Federation.

Nationally and internationally networked

The interests of our member companies are internationally represented through membership in the European steel association EUROFER and the World Steel Association as well as nationally in the Federal Association of German Industry (BDI).

Marketing for steel applications

We provide unbiased information on steel processing and use with a market and application focus. Publications offer a broad range of practical tips for steel designers, developers, planners and processors. They are also used for training. Lectures create a forum for exchanging field reports. Trade fairs and exhibitions present new material developments and innovative, forward-looking steel applications. The Steel Innovation Prize is awarded every three years (www.stahl-innovationspreis.de). It is one of the most important competitions of its kind and honours especially innovative steel applications.

Contents

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1 Introduction

Hot-dip coated steel strip and sheet is quality steel thin sheet protected from corrosion by a firmly adhering metallic coating. In this document, the standards for continuous hot-dipped flat products are listed along with information that processors of continuous hot-dip coated sheet metal should know.

This document provides information to users and processors of hot-dip coated strip and sheet about the current state of availability. It is a compilation of the characteristic properties for hot-dip coated strip and sheet metal and should help to prevent misunderstandings between manufacturers and processors in ordering, delivery and processing. For this reason it is in the interest of the consumers and processors to inform the manufacturer of the intended use.

The following code symbols have been introduced uniformly in Europe for the short description of continuously hot-dip coated strip and sheet metal (see Section 5.1):

- Z Zinc coating
- ZF Zinc-iron alloy coating
- ZA Zinc-aluminium coating
- ZM Zinc-magnesium coating
- AZ Aluminium-zinc coating
- AS Aluminium-silicon coating

The results of intensive work have lead to a tightening of the European standards for continuously hot-dip coated flat products. To improve the product overview, the earlier individual standards for the various hot-dip coatings as well as the last valid product specific standards have been integrated into the overaging standard EN 10346. In addition, the content of Stahl-Eisen-Werkstoffblatt SEW 022 which established the requirements for zinc-magnesium coatings, has been included in EN 10346.

Material sheet VDA 239-100 “Sheet Steel for Cold Forming” is important for automotive applications.

Standards are:

EN 10143
Continuously hot-dip coated steel sheet and strip
Tolerances on dimensions and shape

EN 10346
Continuously hot-dip coated steel flat products for cold forming
Technical delivery conditions

2 Manufacturing Procedure

Since the end of the 1950s, hot-dip coated steel sheet has been manufactured on continuously operating strip finishing plants. In this process hot-dip coated steel strip and sheet of excellent quality is produced. This material is suitable for the most difficult forming processes.

The lay-out of a hot-dip coating line is shown in **Fig. 1**. Normally the flat steel strip is cleaned, re-crystallised or heated up in an annealing furnace and cooled down to the temperature of the molten metal in the coating pot. There it is hot-dip coated while passing through the molten liquid metal bath. The desired coating thickness is set and controlled using the jet process by gas-knives (**Fig. 2**). During the solidification of the metallic coating a crystal structure develops. This crystal structure can show various appearances depending on the type of coating and the solidifying process. Depending on the requirements, the strip ist subsequently cold rolled (skin passed), bent and levelled (stretched) and usually treated with a layer of surface protection.

Through the continuous hot-dip coating process, a composite material with specific mechanical and technological properties and high protection against corrosion is produced.

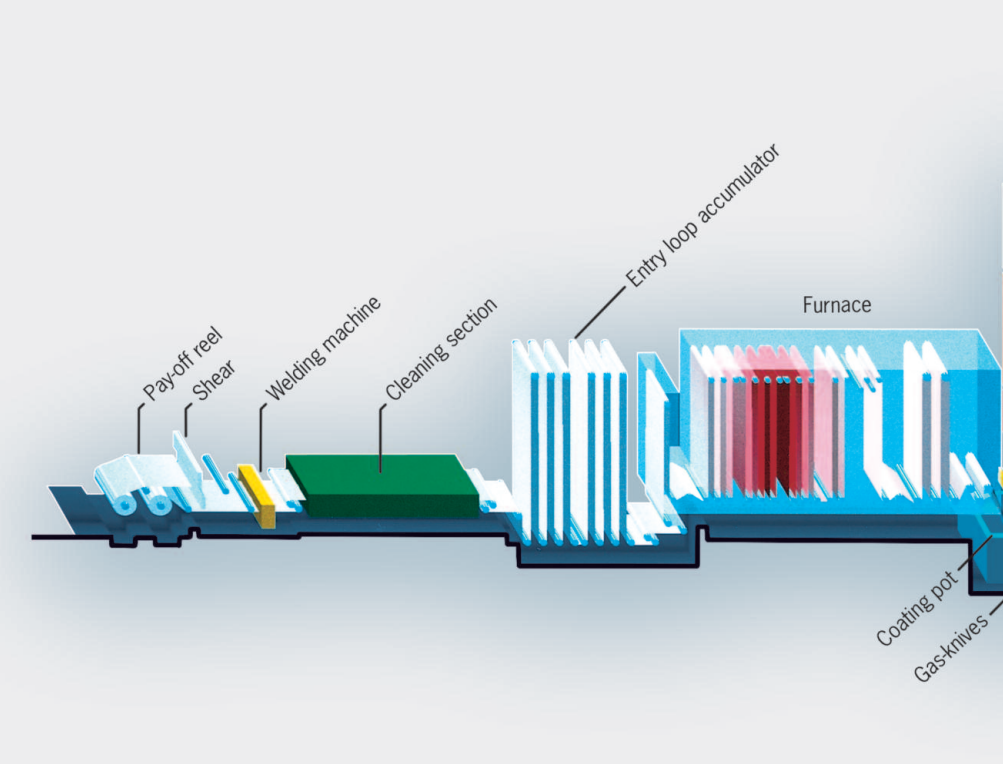


Fig. 1: Diagram of a hot-dip coating plant

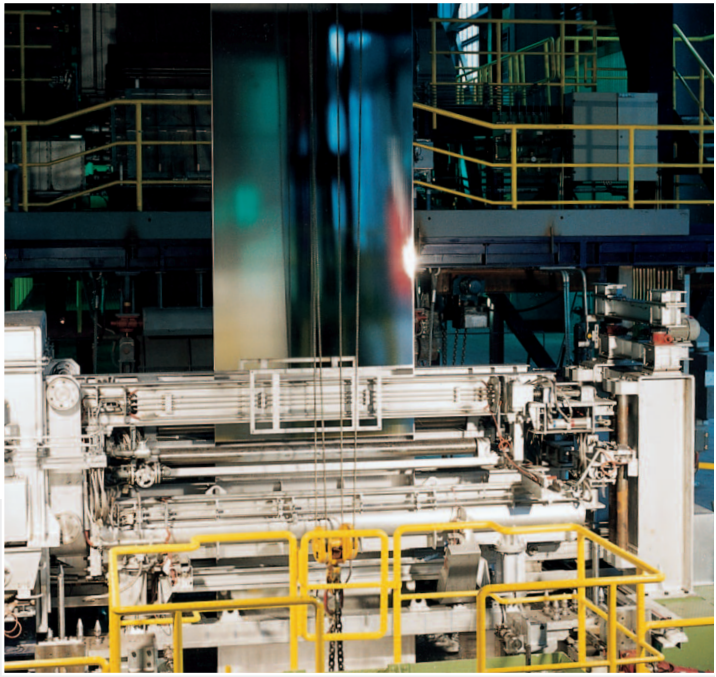
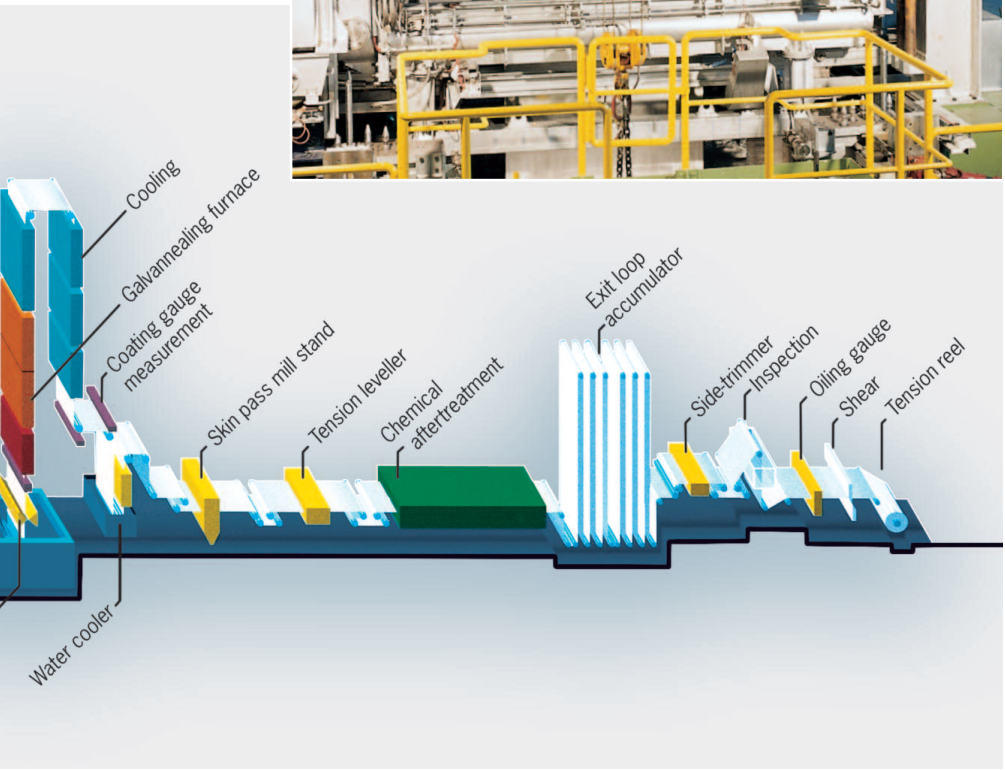


Fig. 2:
View on the gas-knives application



3 Delivery Options

3.1 Delivery Format and Dimensions[1)]

For dimensional tolerances, EN 10143 applies. For reasons attributable to production technologies, not all thicknesses and width combinations are possible. The available dimensions shall be agreed upon with the supplier.

Continuously hot-dip coated flat products are available in thicknesses from 0.20 mm to 6.5 mm. Widths and thicknesses of strip, sheet and slit strip commonly found in practice are given below.

3.1.1 Strip (Coil)

The strip is usually delivered with an inner coil diameter of 610 mm.

Z zinc coating
Widths from 600 to 2,000 mm
Thicknesses from 0.40 to 3.00 mm

ZF zinc-iron alloy coating
Widths from 600 to 2,000 mm
Thicknesses from 0.40 to 2.50 mm

ZA zinc-aluminium coating
Widths from 600 to 1,600 mm
Thicknesses from 0.40 to 3.00 mm

ZM zinc-magnesium coating
Widths from 600 to 2,000 mm
Thicknesses from 0.40 to 3.00 mm

AZ aluminium-zinc coating
Widths from 600 to 1,600 mm
Thicknesses from 0.40 to 2.00 mm

AS aluminium-silicon coating
Widths from 600 to 1,550 mm
Thicknesses from 0.40 to 3.00 mm

The following dimensions can also be supplied on agreement:

- Thicknesses from ≥ 0.20 to < 0.40 mm and from > 3.00 to ≤ 6.50 mm
- Inner diameter of coil: 508 mm

Coils are delivered in different minimum and maximum weights depending on the width, length and thickness. Small coils are manufactured by wrapping and cutting to length; their inner diameters are to be agreed with the supplier.

Small coils (baby coils) produced as a condition of the production process should generally be accepted by the customer.

3.1.2 Sheet

Z zinc coating
Widths from 600 to 2,000 mm
Thicknesses from 0.40 to 3.00 mm
Lengths to 6,000 mm

ZF zinc-iron alloy coating
Widths from 600 to 2,000 mm
Thicknesses from 0.40 to 2.50 mm
Lengths to 6,000 mm

ZA zinc-aluminium coating
Widths from 600 to 1,600 mm
Thicknesses from 0.40 to 3.00 mm
Lengths to 6,000 mm

ZM zinc-magnesium coating
Widths from 600 to 2,000 mm
Thicknesses from 0.40 to 3.00 mm
Lengths to 6,000 mm

AZ aluminium-zinc coating
Widths from 600 to 1,600 mm
Thicknesses from 0.40 to 2.00 mm
Lengths to 6,000 mm

AS aluminium-silicon coating
Widths from 600 to 1,550 mm
Thicknesses from 0.40 to 3.00 mm
Lengths to 6,000 mm

The following dimensions can also be supplied on agreement:
- Thicknesses from ≥ 0.20 to < 0.40 mm and from > 3.00 to ≤ 6.50 mm
- Longer lengths
- Special formats

3.1.3 Slit Coil

The strip is usually delivered with an inner coil diameter of 610 mm.

Z zinc coating
Widths from 20 to under 600 mm
Thicknesses from 0.40 to 3.00 mm

ZF zinc-iron alloy coating
Widths from 20 to under 600 mm
Thicknesses from 0.40 to 2.50 mm

ZA zinc-aluminium coating
Widths from 20 to under 600 mm
Thicknesses from 0.40 to 3.00 mm

ZM zinc-magnesium coating
Widths from 20 to under 600 mm
Thicknesses from 0.40 to 3.00 mm

AZ aluminium-zinc coating
Widths from 20 to under 600 mm
Thicknesses from 0.40 to 2.00 mm

AS aluminium-silicon coating
Widths from 20 to under 600 mm
Thicknesses from 0.40 to 3.00 mm

The following dimensions can also be supplied on agreement:
- Thicknesses from ≥ 0.20 to < 0.40 mm and from > 3.00 to ≤ 6.50 mm
- Lower widths
- Inner diameter of coils: 508 mm

Depending on the slit strip width, the processing equipments and shipping options, different maximum and minimum weights are delivered.

3.1.4 Bars

The available dimensions are to be coordinated with the supplier.

3.2 Steel Grades

An overview of the available steel grades is given in Tables 1 to 10.

3.2.1 Continuous hot-dip coated steel strip and sheet made of low carbon steels for cold forming

In **Table 1**, the current steel names for steel grades are presented alongside with the ones used previously. The mechanical properties are listed in **Table 3**. Here the steels in question are sorted according to increasing suitability for cold forming.

The following general information refers to the application of these steels:

3.2.1.1 DX51D (bending and profiling quality)

This steel grade is suitable for the fabrication of simple profile shapes as well as for simple manual forming operation. Machine folds can be made generally without any flaws up to a thickness of 1.50 mm as well as snap seams (locking seams) of up to 0.90 mm. Crimping machines place high demands on the formability of a flat product. If the speed of forming and the setting and form of the roller sets are adjusted to the material properties, there will be no problem in processing.

3.2.1.2 DX52D (drawing quality)

This steel grade is considered for the use in drawing, stamping and profiling heavy parts as well as for the fabrication of snap seams with thicknesses of more than 0.90 mm.

3.2.1.3 DX53D (deep drawing quality)

This steel grade meets high demands on formability and is suitable for the fabrication of complex profiles with greater thicknesses.

3.2.1.4 DX54D (special deep drawing quality)

This steel grade is suitable for increased forming demands.

3.2.1.5 DX55D (special deep drawing quality)

This steel grade is characterised by increased heat resistance and is suitable for increased forming demands. It is only available with aluminium-silicon coating (AS).

3.2.1.6 DX56D (extra deep drawing quality)

This steel grade is suitable for supreme forming demands.

3.2.1.7 DX57D (super deep drawing quality)

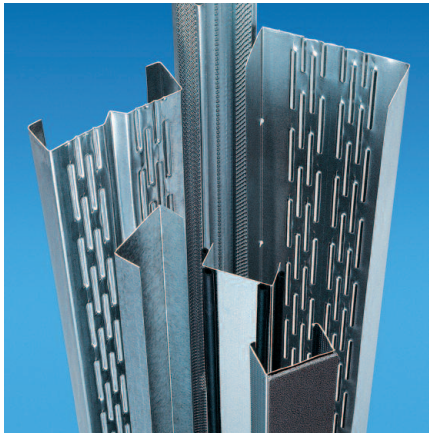
This steel grade is for extremely high forming demands.

3.2.2 Hot-dip coated steel strip and sheet for use in construction (structural steel)

In **Table 2**, the current steel names are shown alongside previously used designations. The mechanical properties are listed in **Table 4**. The steel grades are ordered according increasing yield strength.

Fig. 3:
Ducts made of hot-dip galvanized sheet for ventilation/air conditioning

Fig. 4:
Hot-dip galvanized sheet – material for the household appliance industry



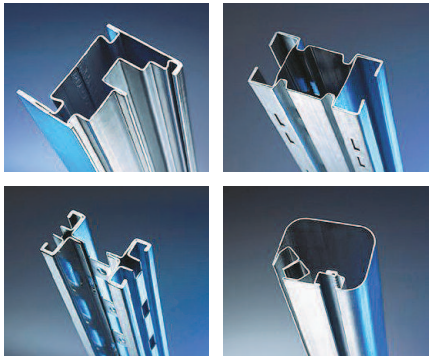


Fig. 5 and 6: Profiles made of hot-dip galvanized sheet

Table 1: Comparison of steel grades designation and steel numbers; low carbon steels for cold forming

Coatings	Current		Old			
	EN 10346 Edition 2015		EN 10346 Edition 2009	EN 10142 Edition 2000	EN 10142 Edition 1991	EN 17162 Edition 1988
	Steel grade designations	Steel numbers	Steel numbers	Steel grade designations	Steel grade designations	Steel grade designations
Z	DX51D+Z DX52D+Z DX53D+Z DX54D+Z DX56D+Z DX57D+Z	1.0917+Z 1.0918+Z 1.0951+Z 1.0952+Z 1.0963+Z 1.0853+Z	1.0226+Z 1.0350+Z 1.0355+Z 1.0306+Z 1.0322+Z 1.0853+Z	DX51D+Z DX52D+Z DX53D+Z DX54D+Z DX56D+Z –	Fe P02 G Fe P03 G Fe P05 G Fe P06 G – –	St 02 Z St 03 Z St 05 Z St 06 Z – –
ZF	DX51D+ZF DX52D+ZF DX53D+ZF DX54D+ZF DX56D+ZF DX57D+ZF	1.0917+ZF 1.0918+ZF 1.0951+ZF 1.0952+ZF 1.0963+ZF 1.0853+ZF	1.0226+ZF 1.0350+ZF 1.0355+ZF 1.0306+ZF 1.0322+ZF 1.0853+ZF	DX51D+ZF DX52D+ZF DX53D+ZF DX54D+ZF DX56D+ZF –	Fe P02 G Fe P03 G Fe P05 G Fe P06 G – –	St 02 ZF St 03 ZF St 05 ZF St 06 ZF – –
				EN 10214 Edition 1995		
ZA	DX51D+ZA DX52D+ZA DX53D+ZA DX54D+ZA DX56D+ZA DX57D+ZA	1.0917+ZA 1.0918+ZA 1.0951+ZA 1.0952+ZA 1.0963+ZA 1.0853+ZA	1.0226+ZA 1.0350+ZA 1.0355+ZA 1.0306+ZA 1.0322+ZA 1.0853+ZA	DX51D+ZA DX52D+ZA DX53D+ZA DX54D+ZA DX56D+ZA –	– – – – – –	St 02 ZA St 03 ZA St 05 ZA St 06 ZA – –

Coatings	Current		Old			
	EN 10346 Edition 2015		SEW 022 Edition 2010	EN 10215 Edition 1995	EN 10142 Edition 1991	EN 17162 Edition 1988
	Steel grade designations	Steel numbers	Steel numbers	Steel grade designations	Steel grade designations	Steel grade designations
ZM	DX51D+ZM	1.0917+ZM	1.0226+ZM	–	–	–
	DX52D+ZM	1.0918+ZM	1.0350+ZM	–	–	–
	DX53D+ZM	1.0951+ZM	1.0355+ZM	–	–	–
	DX54D+ZM	1.0952+ZM	1.0306+ZM	–	–	–
	DX56D+ZM	1.0963+ZM	1.0322+ZM	–	–	–
	DX57D+ZM	1.0853+ZM	1.0853+ZM	–	–	–
			EN 10346 Edition 2009			
AZ	DX51D+AZ	1.0917+AZ	1.0226+AZ	DX51D+AZ	–	St 02 AZ
	DX52D+AZ	1.0918+AZ	1.0350+AZ	DX52D+AZ	–	St 03 AZ
	DX53D+AZ	1.0951+AZ	1.0355+AZ	DX53D+AZ	–	St 05 AZ
	DX54D+AZ	1.0952+AZ	1.0306+AZ	DX54D+AZ	–	St 06 AZ
	DX56D+AZ	1.0963+AZ	–	–	–	–
			EN 10346 Edition 2009	EN 10154 Edition 2002		
AS	DX51D+AS	1.0917+AS	1.0226+AS	DX51D+AS	–	St 02 AS
	DX52D+AS	1.0918+AS	1.0350+AS	DX52D+AS	–	St 03 AS
	DX53D+AS	1.0951+AS	1.0355+AS	DX53D+AS	–	St 05 AS
	DX54D+AS	1.0952+AS	1.0306+AS	DX54D+AS	–	St 06 AS
	DX55D+AS	1.0962+AS	1.0309+AS	DX55D+AS	–	–
	DX56D+AS	1.0963+AS	1.0322+AS	DX56D+AS	–	–
	DX57D+AS	1.0853+AS	1.0853+AS	–	–	–

Table 2: Comparison of steel grade designations and steel numbers; steels for use in construction (structural steels)

Coatings	Current		Old		
	EN 10346 Edition 2015		EN 10147 Edition 2000	EN 10147 Edition 1991	EN 10162 Edition 1988
	Steel grade designations	Steel numbers	Steel grade designations	Steel grade designations	Steel grade designations
Z	S220GD+Z	1.0241+Z	S220GD+Z	Fe E220 G	–
	S250GD+Z	1.0242+Z	S250GD+Z	Fe E250 G	StE 250 Z
	S280GD+Z	1.0244+Z	S280GD+Z	Fe E280 G	StE 280 Z
	S320GD+Z	1.0250+Z	S320GD+Z	Fe E320 G	StE 320 Z
	S350GD+Z	1.0529+Z	S350GD+Z	Fe E350 G	StE 350 Z
	S390GD+Z	1.0238+Z	–	–	–
	S420GD+Z	1.0239+Z	–	–	–
	S450GD+Z	1.0233+Z	–	–	–
	S550GD+Z	1.0531+Z	S550GD+Z	Fe E550 G	–
ZF	S220GD+ZF	1.0241+ZF	S220GD+ZF	Fe E220 G	–
	S250GD+ZF	1.0242+ZF	S250GD+ZF	Fe E250 G	StE 250 ZF
	S280GD+ZF	1.0244+ZF	S280GD+ZF	Fe E280 G	StE 280 ZF
	S320GD+ZF	1.0250+ZF	S320GD+ZF	Fe E320 G	StE 320 ZF
	S350GD+ZF	1.0529+ZF	S350GD+ZF	Fe E350 G	StE 350 ZF
	S390GD+ZF	1.0238+ZF	–	–	–
	S420GD+ZF	1.0239+ZF	–	–	–
	S450GD+ZF	1.0233+ZF	–	–	–
	S550GD+ZF	1.0531+ZF	S550GD+ZF	Fe E550 G	–
			EN 10214 Edition 1995		
ZA	S220GD+ZA	1.0241+ZA	S220GD+ZA	–	–
	S250GD+ZA	1.0242+ZA	S250GD+ZA	–	–
	S280GD+ZA	1.0244+ZA	S280GD+ZA	–	–
	S320GD+ZA	1.0250+ZA	S320GD+ZA	–	–
	S350GD+ZA	1.0529+ZA	S350GD+ZA	–	–
	S390GD+ZA	1.0238+ZA	–	–	–
	S420GD+ZA	1.0239+ZA	–	–	–
	S450GD+ZA	1.0233+ZA	–	–	–
	S550GD+ZA	1.0531+ZA	S550GD+ZA	–	–

Coatings	Current		Old		
	EN 10346 Edition 2015		SEW 022 Edition 2010	EN 10147 Edition 1991	EN 10162 Edition 1988
	Steel grade designations	Steel numbers	Steel grade designations	Steel grade designations	Steel grade designations
ZM	S220GD+ZM	1.0241+ZM	–	–	–
	S250GD+ZM	1.0242+ZM	–	–	–
	S280GD+ZM	1.0244+ZM	–	–	–
	S320GD+ZM	1.0250+ZM	–	–	–
	S350GD+ZM	1.0529+ZM	–	–	–
	S390GD+ZM	1.0238+ZM	–	–	–
	S420GD+ZM	1.0239+ZM	–	–	–
	S450GD+ZM	1.0233+ZM	–	–	–
	S550GD+ZM	1.0531+ZM	–	–	–
			EN 10215 Edition 1995		
AZ	S220GD+AZ	1.0241+AZ	S220GD+AZ	–	–
	S250GD+AZ	1.0242+AZ	S250GD+AZ	–	–
	S280GD+AZ	1.0244+AZ	S280GD+AZ	–	–
	S320GD+AZ	1.0250+AZ	S320GD+AZ	–	–
	S350GD+AZ	1.0529+AZ	S350GD+AZ	–	–
	S390GD+AZ	1.0238+AZ	–	–	–
	S420GD+AZ	1.0239+AZ	–	–	–
	S450GD+AZ	1.0233+AZ	–	–	–
	S550GD+AZ	1.0531+AZ	S550GD+AZ	–	–
			EN 10154 Edition 2002		
AS	S250GD+AS	1.0242+AS	S250GD+AS	–	–
	S280GD+AS	1.0244+AS	S280GD+AS	–	–
	S320GD+AS	1.0250+AS	S320GD+AS	–	–
	S350GD+AS	1.0529+AS	S350GD+AS	–	–

Table 3: Steel grades and mechanical properties (transverse direction); low carbon steels for cold forming (EN 10346)

Steel grades		Yield strength[a] R_e MPa*	Tensile strength R_m MPa*	Elongation A_{80} % min.[b]	Plastic strain ratio r min.	Strain hardening exponent n min.
Steel name	Steel number					
DX51D[g]+... Z ZF ZA ZM AZ AS	1.0917	–	270 – 500	22	–	–
DX52D[g]+... Z ZF ZA ZM AZ AS	1.0918	140 – 300[c]	270 – 420	26	–	–
DX53D[g]+... Z ZF ZA ZM AZ AS	1.0951	140 – 260	270 – 380	30	–	–
DX54D[h]+... Z ZF ZA ZM AZ AS	1.0952	120 – 220	260 – 350	36 34 36 34 36 34	1.6[d] 1.4[d] 1.6[d] 1.6[d] – 1.4[d, e]	0.18 0.18 0.18 0.18 – 0.18[e]
DX55D[h]+... AS[f]	1.0962	140 – 240	270 – 370	30	–	–

The chemical composition of the steel grades (with the exception of DX51D) in max. % by mass:
C ≤ 0.12 %, P ≤ 0.10 %, Si ≤ 0.50 %, S ≤ 0.045 %, Mn ≤ 0.60 %, Ti ≤ 0.30 %

*1 MPa = 1 N/mm²

Steel grades			Yield strength[a] R_e MPa*	Tensile strength R_m MPa*	Elongation A_{80} % min.[b]	Plastic strain ratio r min.	Strain hardening exponent n min.
Steel name		Steel number					
DX56D[h]+...	Z	1.0963	120 – 180	260 – 350	39	1.9[d]	0.21
	ZF				37	1.7[d, e]	0.20[e]
	ZA				39	1.9[d]	0.21
	ZM				37	1.7[d]	0.20
	AZ[g]				39	1.7[e]	0.20
	AS				39	1.7[d, e]	0.20[e]
DX57D[h]+...	Z	1.0853	120 – 170	260 – 350	41	2.1[d]	0.22
	ZF				39	1.9[d, e]	0.21[e]
	ZA				41	2.1[d]	0.22
	ZM				39	1.9[d]	0.21
	AS				41	1.9[d, e]	0.21[e]

D (Drawing)
X Rolling condition (hot rolled or cold rolled) not determined
nn Atomic number
D (Dip)

[a] If the yield point is not pronounced, the values apply to the 0.2 % proof strength ($R_{p0.2}$); if the yield point is pronounced, the values apply to the lower yield point R_{eL}.
[b] Decreased minimum elongation values apply for product thickness
0.50 mm < t ≤ 0.70 mm (minus 2 units),
0.35 mm < t ≤ 0.50 mm (minus 4 units) and
t ≤ 0.35 mm (minus 7 units).
[c] For surface quality A, the upper value for the yield point R_e is 360 MPa.
[d] Decreased minimum r_{90} values apply for product thickness
1.5 mm < t < 2 mm (minus 0.2)
t ≥ 2 mm (minus 0.4)
[e] Decreased minimum r_{90} values apply for product thickness
0.50 mm < t ≤ 0.70 mm (minus 0.2),
0.35 mm < t ≤ 0.50 mm (minus 0.4) and
t ≤ 0.35 mm (minus 0.6)
Decreased minimum n_{90} values apply for product thickness
0.50 mm < t ≤ 0.70 mm (minus 0.01),
0.35 mm < t ≤ 0.50 mm (minus 0.03) and
t ≤ 0.35 mm (minus 0.04)
[f] The minimum elongation of products made of DX55D+AS which does not follow the systematic order should be noted. DX55D+AS is characterized by the best heat resistance.
[g] The stated mechanical properties are limited to one month, beginning with date of product availability, on which has been agreed.
[h] The stated mechanical properties are limited to six months, beginning with date of product availability, on which has been agreed.

Table 4: Steel grades and mechanical properties (longitudinal direction); steel for use in construction (structural steel) (DIN EN 10346)

Steel grade[a]		Proof strength	Tensile strength	Elongation
Steel name	Steel number	$R_{p0.2}$[a] MPa* min.	R_m[b] MPa* min.	A_{80}[c] % min.
S220GD+... Z, ZF, ZA, ZM, AZ	1.0241	220	300	20
S250GD+... Z, ZF, ZA, ZM, AZ, AS	1.0242	250	330	19
S280GD+... Z, ZF, ZA, ZM, AZ, AS	1.0244	280	360	18
S320GD+... Z, ZF, ZA, ZM, AZ, AS	1.0250	320	390	17
S350GD+... Z, ZF, ZA, ZM, AZ, AS	1.0529	350	420	16
S390GD+... Z, ZF, ZA, ZM, AZ	1.0238	390	460	16
S420GD+... Z, ZF, ZA, ZM, AZ	1.0239	420	480	15
S450GD+... Z, ZF, ZA, ZM, AZ	1.0233	450	510	14
S550GD+... Z, ZF, ZA, ZM, AZ	1.0531	550	560	–

S (Structure)
nnn Minimum value of yield point $R_{p0.2}$ in MPa
G Normative placeholder
D (Dip)

The stated mechanical properties are limited to one month, beginning with date of product availability, on which has been agreed.

[a] If the yield point is pronounced, the values apply to the upper yield point R_{eH}.

[b] For all grades except S550GD, a range of 140 MPa can be expected for tensile strength.

[c] Decreased minimum elongation values apply for product thickness:
0.50 mm < t ≤ 0.70 mm (minus 2 units),
0.35 mm < t ≤ 0.50 mm (minus 4 units) and
t ≤ 0.35 mm (minus 7 units).

The chemical composition of the steel grades in max. % by mass:
C ≤ 0.20 %, P ≤ 0.10 %, Si ≤ 0.60 %, S ≤ 0.045 %, Mn ≤ 1.70 %

*1 MPa = 1 N/mm²

Fig. 7: Oil filter housing made of steel sheet with Zinc-Aluminium coating (ZA)

Fig. 8: Cover of oil filter housing made of steel sheet with Zinc-Aluminium coating (ZA)

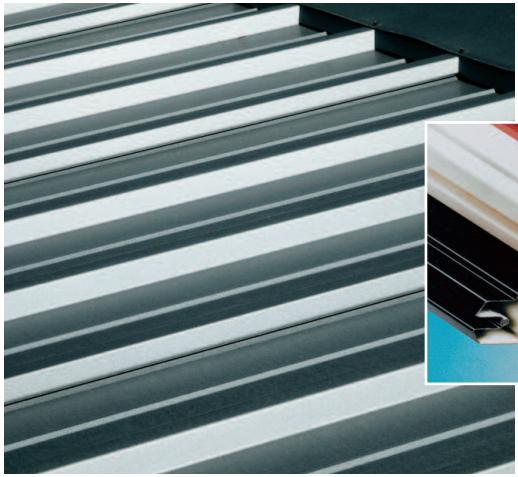


Fig. 9: Window profile with Zinc-Aluminium coating (ZA) and accompanying organic coating

Fig. 10: Roof lining made of steel sheet with Aluminium-Zinc coating (AZ)

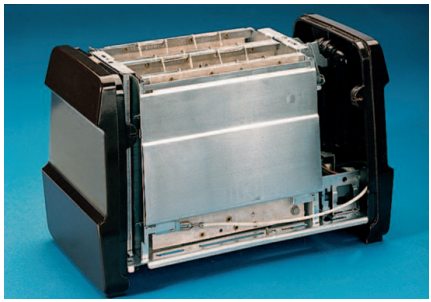


Fig. 11: Heat-resistant internal lining for toasters made of steel sheet with Aluminium-Silicon coating (AS)

Fig. 12: Motor vehicle fuel tank made of steel sheet with Aluminium-Silicon coating (AS)

3.2.3 Hot-dip coated steel strip and sheet made of steels with high proof strength for cold forming

These steel grades show good cold formability with defined yield strength, according to **Table 5/6**. The steel grades are ordered according to increasing yield strength.

In certain applications, they enable a reduction of weight without reducing the component strength. Different procedures are used to achieve the high yield strengths, these are identified with letters, which follow directly on the proof strength value.

Table 5: Steel grades and mechanical properties (transverse direction); steels with high proof strength for cold forming (EN 103462) for all hot-dip coatings

Steel grade		Proof strength	Tensile strength	Elongation	Plastic strain ratio	Strain hardening exponent	Bake-Hardening Index
Steel name	Steel number	$R_{p0.2}$[a)] MPa*	R_m MPa*	A_{80}[b.c)] % min.	r_{90}[c,d,e)] min.	n_{90}[e)] min.	BH_2 MPa* min.
HX160YD[f)]	1.0910	160 – 220	300 – 360	37	1.9	0.20	–
HX180YD[f)]	1.0921	180 – 240	330 – 390	34	1.7	0.18	–
HX180BD[g)]	1.0914	180 – 240	290 – 360	34	1.5	0.16	30
HX220YD[f)]	1.0923	220 – 280	340 – 420	32	1.5	0.17	–
HX220BD[g)]	1.0919	220 – 280	320 – 400	32	1.2	0.15	30
HX260YD[f)]	1.0926	260 – 320	380 – 440	30	1.4	0.16	–
HX260BD[g)]	1.0924	260 – 320	360 – 440	28	–	–	30
HX260LAD[f)]	1.0929	260 – 330	350 – 430	26	–	–	–
HX300YD[f)]	1.0927	300 – 360	390 – 470	27	1.3	0.15	–
HX300BD[g)]	1.0930	300 – 360	400 – 480	26	–	–	30
HX300LAD[f)]	1.0932	300 – 380	380 – 480	23	–	–	–
HX340BD[g)]	1.0945	340 – 400	440 – 520	24	–	–	30
HX340LAD[f)]	1.0933	340 – 420	410 – 510	21	–	–	–
HX380LAD[f)]	1.0934	380 – 480	440 – 560	19	–	–	–
HX420LAD[f)]	1.0935	420 – 520	470 – 590	17	–	–	–
HX460LAD[f)]	1.0990	460 – 560	500 – 640	15	–	–	–
HX500LAD[f)]	1.0991	500 – 620	530 – 690	13	–	–	–

3.2.3.1 “B” – Bake-Hardening Steels

Steels that demonstrates an increase in proof strength following heating in the region of 170°C for 20 min.

These steels have a good suitability for cold forming and present a high resistance to plastic straining (which is increased on finished parts during heat treatment) and a good dent resistance.

H Flat products of steel with high proof strength for cold forming
X Rolled condition (hot rolled or cold rolled) not determined
nnn Minimum value of the yield point $R_{p0.2}$ in MPa
B Bake-hardening
Y Interstitial-free (IF steel)
LA Low alloyed (microalloyed)
D Hot-dip coatings

a) If the yield strength is pronounced the values apply to the lower yield point R_{eL}.
b) Decreased minimum elongation values apply for product thickness:
0.50 mm < t ≤ 0.70 mm (minus 2 units),
0.35 mm < t ≤ 0.50 mm (minus 4 units) and
t ≤ 0.35 mm (minus 7 units).
c) For AS, AZ, ZF and ZM coatings, the minimum A_{80} value reduced by 2 units and the minimum r_{90} value reduced by 0.2 apply.
d) Decreased minimum r_{90} values apply for product thickness
1.5 mm < t < 2 mm (minus 0.2)
t ≥ 2 mm (minus 0.4)
e) Decreased minimum r_{90} values apply for product thickness
0.50 mm < t ≤ 0.70 mm (minus 0.2),
0.35 mm < t ≤ 0.50 mm (minus 0.4) and
t ≤ 0.35 mm (minus 0.6)
Decreased minimum n_{90} values apply for product thickness:
0.50 mm < t ≤ 0.70 mm (minus 0.01),
0.35 mm < t ≤ 0.50 mm (minus 0.03) and
t ≤ 0.35 mm (minus 0.04).
f) The stated mechanical properties are limited to six months, beginning with date of product availability on which has been agreed.
g) The stated mechanical properties are limited to three months, beginning with date of product availability on which has been agreed.

The mechanical values for the tensile test are normally determined transversely to the direction of rolling. The customer can alternatively arrange for values in the longitudinal direction. These then do not correspond to the values in this table. However, only one direction will be tested and the values determined apply only for the tested direction.

*1 MPa = 1 N/mm^2

Table 6: Chemical composition (cast analysis) of steels with high proof strength for cold forming (EN 10346) for all hot-dip coatings

Steel grade		Chemical composition % by mass							
Steel name	Steel number	C max.	Si max.	Mn max.	P max.	S max.	Al_{total}	Ti max.	Nb max.
HX160YD	1.0910	0.01	0.30	0.60	0.060	0.025	≥ 0.010	0.12	0.09
HX180YD	1.0921	0.01	0.30	0.70	0.060	0.025	≥ 0.010	0.12	0.09
HX180BD	1.0914	0.06	0.50	0.70	0.060	0.025	≥ 0.015	0.12	0.09
HX220YD	1.0923	0.01	0.30	0.90	0.080	0.025	≥ 0.010	0.12	0.09
HX220BD	1.0919	0.08	0.50	0.70	0.085	0.025	≥ 0.015	0.12	0.09
HX260YD	1.0926	0.01	0.30	1.60	0.10	0.025	≥ 0.010	0.12	0.09
HX260BD	1.0924	0.10	0.50	1.00	0.10	0.030	≥ 0.010	0.12	0.09
HX260LAD	1.0929	0.11	0.50	1.0	0.030	0.025	≥ 0.015	0.15	0.09
HX300YD	1.0927	0.015	0.30	1.60	0.10	0.025	≥ 0.010	0.12	0.09
HX300BD	1.0930	0.11	0.50	0.80	0.12	0.025	≥ 0.010	0.12	0.09
HX300LAD	1.0932	0.12	0.50	1.40	0.030	0.025	≥ 0.015	0.15	0.09
HX340BD	1.0945	0.11	0.50	0.80	0.12	0.025	≥ 0.010	0.12	0.09
HX340LAD	1.0933	0.12	0.50	1.4	0.030	0.025	≥ 0.015	0.15	0.10
HX380LAD	1.0934	0.12	0.50	1.5	0.030	0.025	≥ 0.015	0.15	0.10
HX420LAD	1.0935	0.12	0.50	1.6	0.030	0.025	≥ 0.015	0.15	0.10
HX460LAD	1.0990	0.15	0.50	1.7	0.030	0.025	≥ 0.015	0.15	0.10
HX500LAD	1.0991	0.15	0.50	1.7	0.030	0.025	≥ 0.015	0.15	0.10

H Flat products of steel with high proof strength for cold forming
X Rolled condition (hot rolled or cold rolled) not determined
nnn Minimum value of the yield point $R_{p0.2}$ in MPa
B Bake-hardening
Y Interstitial-free (IF steel)
LA Low alloyed (microalloyed)
D Hot-dip coatings

3.2.3.2 "Y" – High strength interstitial-free Steels

Steel whose composition is controlled to achieve improved r- and n-values.

These steels have both, a high mechanical strength and an excellent suitability for cold forming, due to their solid solution hardening and interstitial free microstructure.

3.2.3.3 "LA" – Low/microalloyed Steels (low alloy)

Steel containing one or more of the alloying elements Nb, Ti and V to achieve required proof strength levels.

Combined precipitation and grain refinement hardening modes make it possible to reach a high mechanical resistance while reducing the content of alloying elements (low alloy). Alternatively, carbon-manganese concepts can be used in combination with grain refinement.

3.2.4 Hot-dip coated steel strip and sheet made of multiphase steels for cold forming

These steel grades show a high tensile strength along with good cold formability; see **Table 7/8** for cold-rolled products and **Table 9/10** for hot rolled products. In certain applications they ensure a reduction of component weight. The steel grades are sorted according to increasing tensile strength values.

3.2.4.1 "F" – Ferritic-bainitic Steels

Steel containing bainite or strengthened bainite in a matrix consisting of ferrite or strengthened ferrite.

The matrix is strengthened by a high density of dislocations, by grain refinement and precipitation of micro-alloying elements.

3.2.4.2 "X" – Dual-phase Steels

Steel with a ferritic matrix containing a martensitic second phase present in the form of islands and eventually bainite as a complementary phase. Relative to their high tensile strength levels, dual phase steels show a low yield strength ratio and a high work hardening rate (Work-Hardening-Effect) during cold forming.

3.2.4.3 "T"-Steels (transformation induced plasticity steels)

T is the abbreviation for "transformation induced plasticity" (previously: TRIP). Steel with a ferritic matrix containing retained austenite capable of transformation into martensite during the forming process (TRIP effect).

Due to its high work-hardening rate the steel reaches high uniform elongation values and high tensile strength levels.

3.2.4.4 "C" – Complex-phase Steels

C is the abbreviation for complex phase steel. Steel with a ferritic/bainitic matrix containing small amounts of martensite, retained austenite and/or perlite where an extreme grain refinement is caused by retarded recrystallisation of precipitation of micro-alloying elements.

Complex phase steels have significantly higher yield point values than dual phase steels with the same tensile strength.

Table 7: Steel grades and mechanical properties (longitudinal sample[a]) of multiphase steels for cold forming (EN 10346) – cold rolled products

hot-dip coatings: +Z, +ZF, +ZA, +ZM

Steel grade		Proof strength	Tensile strength	Elongation	Strain hardening exponent	Bake-hardening Index
Steel name	Steel number	$R_{p0.2}$ MPa*	R_m MPa* min.	A_{80}[b.c)] % min.	$n_{10\text{-}UE}$	BH_2 MPa* min.
DP steels						
HCT450X	1.0937	260 – 340	450	27	0.16	30
HCT490X	1.0995	290 – 380	490	24	0.15	30
HCT590X	1.0996	330 – 430	590	20	0.14	30
HCT780X	1.0943	440 – 550	780	14	–	30
HCT980X	1.0944	590 – 740	980	10	–	30
HCT980XG	1.0997	700 – 850	980	8	–	30
TRIP steels						
HCT690T	1.0947	400 – 520	690	23	0.19	40
HCT780T	1.0948	450 – 570	780	21	0.16	40
CP steels						
HCT600C	1.0953	350 – 500	600	16	–	30
HCT780C	1.0954	570 – 720	780	10	–	30
HCT980C	1.0955	780 – 950	980	6	–	30

H Flat products made of steels with high proof strength for cold forming
C Cold-rolled products
T Minimum tensile strength
nnn Minimum tensile strength in MPa
X Symbol for DP steel
XG Symbol for DP steel with higher proof strength
T Symbol for steel with transformation-induced plasticity (TRIP)
C Symbol for complex phase steel

[a] The mechanical values for the tensile test are normally determined longitudinally to the direction of rolling. The customer can alternatively arrange for values in the longitudinal direction. These then do not correspond to the values in this table. However, only one direction will be tested and the values determined apply only for the tested direction.

[b] Decreased minimum elongation values apply for product thickness $t < 0.60$ mm (minus 2 units).

[c] For ZF-coatings, the minimum elongation value reduced by 2 units applies. For ZF-coatings in product thickness $t < 0.60$ mm, the minimum elongation value reduced by 4 units applies.

The stated mechanical properties are limited to three months, beginning with date of product availability, on which has been agreed.

*1 MPa = 1 N/mm^2

Table 8: Chemical composition (cast analysis) of multiphase steels for cold forming (EN 10346)
– cold rolled products

hot-dip coatings: +Z, +ZF, +ZA, +ZM

Steel grade		Chemical composition % by mass									
Steel name	Steel number-	C max.	Si max.	Mn max.	P max.	S max.	Al_{gesamt}	Cr+ Mo max.	Nb+ Ti max.	V max.	B max.
DP steels											
HCT450X	1.0937	0.14	0.75	2.00	0.080	0.015	0.015 – 1.0	1.00	0.15	0.20	0.005
HCT490X	1.0995	0.14	0.75	2.00	0.080	0.015	0.015 – 1.0	1.00	0.15	0.20	0.005
HCT590X	1.0996	0.15	0.75	2.50	0.040	0.015	0.015 – 1.5	1.40	0.15	0.20	0.005
HCT780X	1.0943	0.18	0.80	2.50	0.080	0.015	0.015 – 2.0	1.40	0.15	0.20	0.005
HCT980X	1.0944	0.20	1.00	2.90	0.080	0.015	0.015 – 2.0	1.40	0.15	0.20	0.005
HCT980XG	1.0997	0.23	1.00	2.90	0.080	0.015	0.015 – 2.0	1.40	0.15	0.20	0.005
TRIP steels											
HCT690T	1.0947	0.24	2.00	2.20	0.080	0.015	0.015 – 2.0	0.60	0.20	0.20	0.005
HCT780T	1.0948	0.25	2.20	2.50	0.080	0.015	0.015 – 2.0	0.60	0.20	0.20	0.005
CP steels											
HCT600C	1.0953	0.18	0.80	2.20	0.080	0.015	0.015 – 2.0	1.00	0.15	0.20	0.005
HCT780C	1.0954	0.18	1.00	2.50	0.080	0.015	0.015 – 2.0	1.00	0.15	0.20	0.005
HCT980C	1.0955	0.23	1.00	2.70	0.080	0.015	0.015 – 2.0	1.00	0.15	0.22	0.005

H Flat products of steel with high proof strength for cold forming
C Cold-rolled products
T Minimum tensile strength
nnn Minimum tensile strength in MPa
X Symbol for DP steel
XG Symbol for DP steel with higher proof strength
T Symbol for steel with transformation-induced plasticity (TRIP)
C Symbol for complex phase steel

Table 9: Steel grades and mechanical properties (longitudinal direction[c]) of multiphase steels for cold forming (EN 10346) – hot rolled products

hot-dip coatings: +Z, +ZF, +ZM

Steel grade		Proof strength	Tensile strength	Elongation	Strain hardening exponent
Steel name	Steel number	$R_{p0.2}$ MPa*	R_m MPa* min.	A_{80}[a] % min.	$n_{10\text{-}UE}$[d]
FB steels					
HDT450F	1.0961	300 – 420	450	24	–
HDT580F	1.0994	460 – 620	580	15	–
DP steels					
HDT580X	1.0936	330 – 450	580	19	0.13
CP steels					
HDT750C	1.0956	620 – 760	750	10	–
HDT760C	1.0998	660 – 830	760	10	–
HDT950C	1.0958	720 – 950	950	9	–

H Flat products of steel with high proof strength for cold forming
D Hot-rolled products
T Minimum tensile strength
nnn Minimum tensile strength in MPa
F Symbol for ferritic-bainitic steel
X Symbol for dual phase steel
C Symbol for complex phase steel

[a] For ZF-coatings, the minimum elongation value at break can be reduced by 2%.
[b] n-value determined at 10% up to uniform elongation
[c] The mechanical values for the tensile test are normally determined longitudinally to the direction of rolling.
The customer can alternatively arrange for values in the transverse direction.
These then do not correspond to the values in this table. However, only one direction will be tested and the values determined apply only for the tested direction.

The stated mechanical properties for all steel grades listed here are limited to three months, beginning with the agreed upon date of product availability.

*1 MPa = 1 N/mm^2

Table 10: Chemical composition (cast analysis)
of multiphase steels for cold forming (EN 10346)
– hot rolled products

hot-dip coatings: +Z, +ZF, +ZM

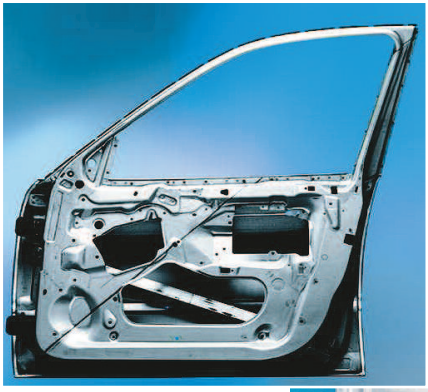
Steel grade		Chemical composition % by mass									
Steel name	Steel number	C max.	Si max.	Mn max.	P max.	S max.	Al_{total}	Cr+ Mo max.	Nb+ Ti max.	V max.	B max.
FB steels											
HDT450F	1.0961	0.18	0.50	2.00	0.050	0.010	0.015 – 2.0	1.00	0.15	0.15	0.005
HDT580F	1.0994	0.18	0.50	2.00	0.050	0.010	0.015 – 2.0	1.00	0.15	0.15	0.010
DP steels											
HDT580X	1.0936	0.14	1.0	2.20	0.085	0.015	0.015 – 1.0	1.40	0.15	0.20	0.005
CP steels											
HDT750C	1.0956	0.18	0.80	2.20	0.080	0.015	0.015 – 2.0	1.00	0.15	0.20	0.005
HDT760C	1.0998	0.18	1.00	2.50	0.080	0.015	0.015 – 2.0	1.00	0.25	0.20	0.005
HDT950C	1.0958	0.25	0.80	2.70	0.080	0.015	0.015 – 2.0	1.20	0.25	0.30	0.005

H Flat products of steels with high proof strength for cold forming
D Hot-rolled products
T Minimum tensile strength
nnn Minimum tensile strength in MPa
F Symbol for ferritic-bainitic steel
X Symbol for dual phase steel
C Symbol for complex phase steel

4 Conversion of grades used in the standards EN 10346 and VDA 239-100

The material data sheet VDA 239-100 was developed and published in August 2011 in the framework of a project group at the VDA (Verband der Automobilindustrie – German Association of the Automotive Industry). The objective was to reduce the number of national, regional and in-house standards. Material designations and descriptions that are applicable and accepted globally allow development, purchasing and quality management processes for steel for cold forming that are standardized world-wide.

Table 11 compares the steel grades as defined by EN 10346 with the grades according to VDA 239-100. The comparison is based on VDA 239-100 of 2016. The table serves as a guide; there is no 100% correlation.



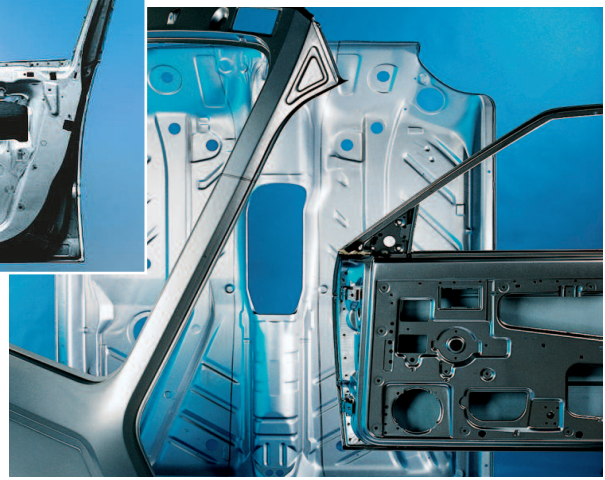


Fig. 13: Automobile interior door made of hot-dip galvanized sheet with laser-welded seam

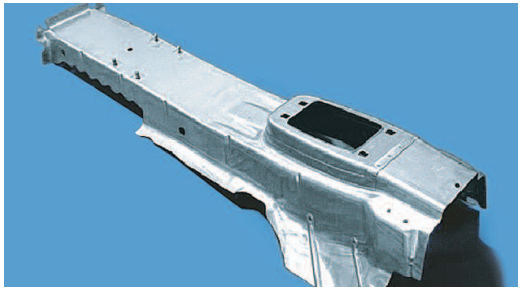


Fig. 14: Chassis parts, in part laser-welded, made of hot-dip galvanized sheets

Fig. 15: Main-frame part of an automobile made of hot-dip galvanized multiphase steel

Table 11: Conversion of grades in the standard EN 10346 to those in the VDA 239-100* material sheet

Grade according to EN 10346	Grade according to VDA 239-100
Low carbon steels for cold forming	
DX51D	not in VDA[b]
DX52D	CR1
DX53D	CR2
DX54D	CR3
DX56D	CR4
DX57D	CR5
Steels with high proof strength for cold forming	
not standardised[a]	CR210LA
HX260LAD	CR240LA
HX300LAD	CR270LA
HX340LAD	CR300LA
HX380LAD	CR340LA
HX420LAD	CR380LA
HX460LAD	CR420LA
HX500LAD	CR460LA
HX160YD	CR160IF
HX180YD	CR180IF
HX220YD	CR210IF
HX260YD	CR240IF
HX300YD	not in VDA[b]
HX180BD	CR180BH
HX220BD	CR210BH
HX260BD	CR240BH
HX300BD	CR270BH
HX340BD	not in VDA[b]

Grade according to EN 10346	Grade according to VDA 239-100
Multiphase steels for cold forming (cold-rolled)	
HCT690T	CR400Y690T-TR
HCT780T	CR450Y780T-TR
HCT450X	not in VDA[b]
HCT490X	CR290Y490T-DP
HCT590X	CR330Y590T-DP
HCT780X	CR440Y780T-DP
not standardised[a]	CR440Y780T-DH
HCT980X	CR590Y980T-DP
HCT980XG	CR700Y980T-DP
not standardised[a]	CR700Y980T-DH
HCT600C	not in VDA[b]
HCT780C	CR570Y780T-CP
HCT980C	CR780Y980T-CP
not standardised[a]	CR900Y1180T-CP
Multiphase steels for cold forming (hot-rolled)	
HDT580X	HR330Y580T-DP
HDT750C	not in VDA[b]
HDT760C	HR660Y760T-CP
HDT950C	not in VDA[b]
HDT450F	HR330Y450T-FB
HDT580F	HR440Y580T-FB
not standardised[a]	HR600Y780T-FB

* no 100% correlation between the grades according to EN 10346 and those according to VDA 239-100

[a] Steel grade that is listed in VDA 239-100 but not in EN 10346

[b] European standardised steel grades that were not included in VDA 239-100

5 Coatings

5.1 Composition of the Coatings

5.1.1 Hot-Dip Zinc Coating (Z)

The coating consists of a zinc layer with a content of at least 99 percent by mass zinc (**Fig. 16**).

5.1.2 Hot-Dip Zinc-Iron Alloy Coating (ZF)

The zinc coating is transformed into a formable zinc-iron layer through heat treatment (diffusion annealing). Due to the heat treatment, the surface will appear matt gray. The zinc-iron coating normally contains 8–12 percent by mass iron. Internationally, this coating is referred to as "galvannealed" (**Fig. 17**).

5.1.3 Hot-Dip Zinc-Aluminium Coating (ZA)

The coating consists of a zinc alloy with roughly 5 percent by mass aluminium and an addition of mischmetal (**Fig. 18**).

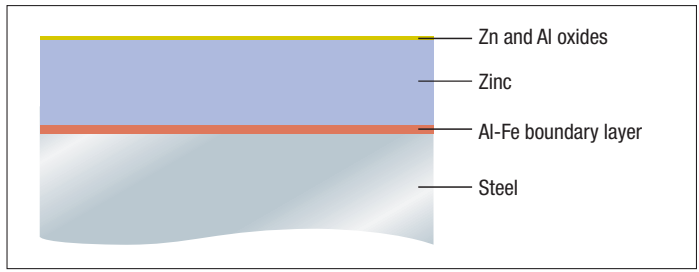


Fig. 16: Schematic structure: Coating consisting of zinc (Z)

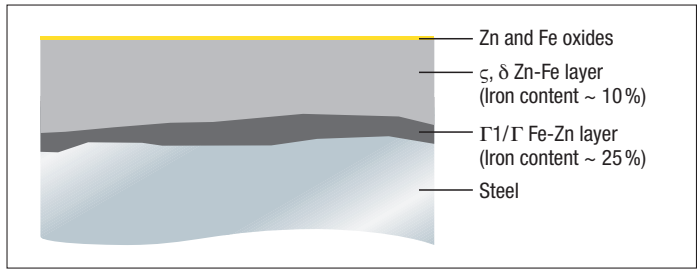


Fig. 17: Schematic structure: Coating consisting of zinc-iron alloy (ZF)

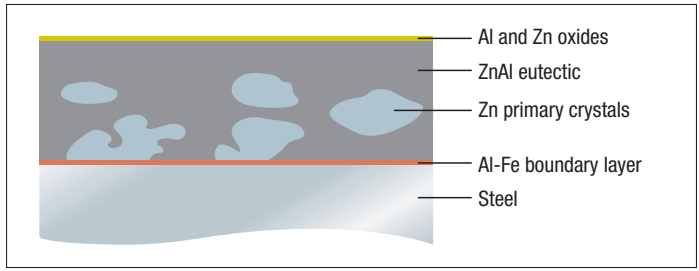


Fig. 18: Schematic structure: Coating consisting of zinc-aluminium (ZA)

5.1.4 Hot-Dip Zinc-Magnesium Coating (ZM)

The coating consists of a zinc alloy with a content of magnesium and aluminium from 1.5 to 8 percent by mass, with a minimum content of magnesium of 0.2 percent by mass. The rest is zinc (**Fig. 19**).

5.1.5 Hot-Dip Aluminium-Zinc Coating (AZ)

The coating consists of an alloy with 55 percent by mass aluminium, 43.4 percent by mass zinc and 1.6 percent by mass silicon (**Fig. 20**).

5.1.6 Hot-Dip Aluminium-Silicon Coating (AS)

The coating consists of an aluminium alloy with 8–11 percent by mass silicon (**Fig. 21**).

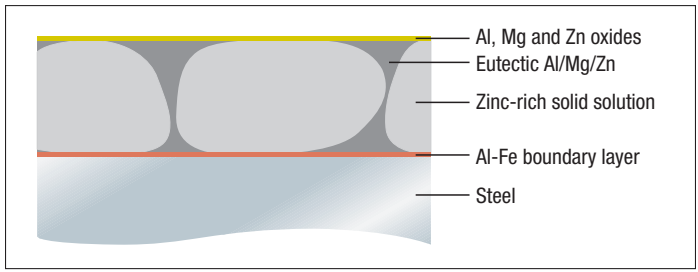


Fig. 19: Schematic structure: Coating consisting of zinc-magnesium (ZM)

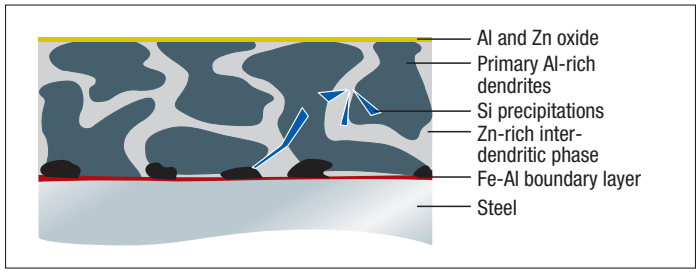


Fig. 20: Schematic structure: Coating consisting of aluminium-zinc (AZ)

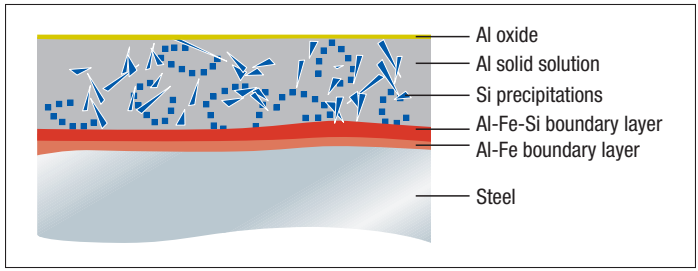


Fig. 21: Schematic structure: Coating consisting of aluminium-silicon (AS)

5.2 Coating mass

Table 12 provides an overview of the available coatings. The correct selection of the coating is the decisive factor for any additional processing and must be coordinated with the intended use (see section 10). In **Tables 13 to 15**, the available coatings with their surface qualities and coating finishes are shown. Deviating coating masses must be arranged separately when ordered.

Hot-dip coated steel products are available with different coating weights on each side (differential zinc coating) on arrangement made when ordering. Both surfaces can have a different appearance, depending on manufacturing conditions.

5.3 Testing the Coatings

Table 12 shows the typical available coating masses (g/m² on both sides) and the corresponding values of the layer thicknesses in µm per side. Other coatings can be arranged. Testing of the coating weight is according to the applicable standards for the material, e.g. EN 10346, section 8.5.5.

The coating weight is determined from the weight difference in samples before and after chemically stripping off the coating. In testing according to **Fig. 22**, the value of the triple-spot-test is determined from three samples as arithmetic average of the three test results. Each individual result must meet the requirements of the single-spot-test.

For ongoing tests at the manufacturer, other procedures – e.g. non-destructive tests – can be used. In a case of dispute the procedure described in the valid standard and applicable to that material is to be used. The position of the samples for determination of the coating weight is to be taken from Fig. 22, if there is

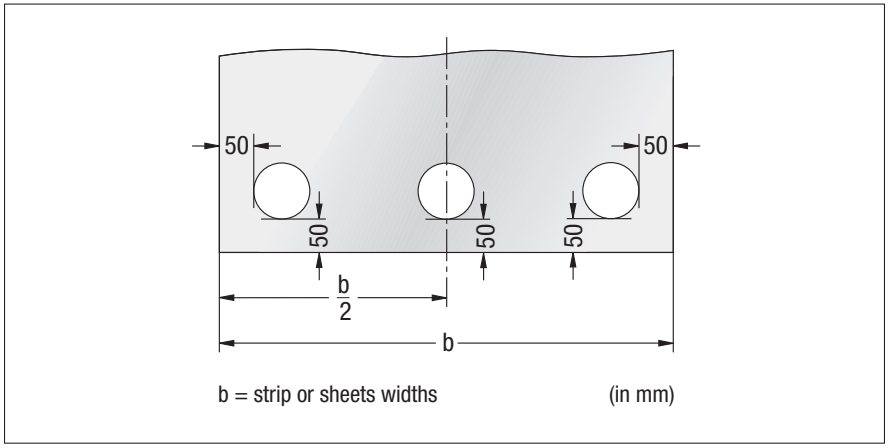


Fig. 22: Position of the samples for testing the coating weight (triple-spot-test)

adequate product width. The individual sample must be at least 5,000 mm^2 in size.

Testing the zinc-iron-coating in galvannealed steel is done analogously. The use of an inhibitor is recommended in order to avoid measurement errors caused by dissolution of iron from the base material. Especially good results are obtained using the coulometric assay method.

5.4 Testing Coating Adhesion

Coating adhesion is tested using a documented procedure of the manufacturer.

6 Coating finish

Depending on the manufacturing conditions, coatings can appear in different grain size and varying gloss. The quality of the coating is not influenced by this.

6.1 Finish in Z

6.1.1 Normal Spangle (N)

This finish is obtained when the zinc coating is left to solidify freely. Either no spangle or zinc crystals of different sizes and brightness appear depending on the galvanizing conditions. The quality of the coating is not affected by this. Remark: If a pronounced spangle is desired, this shall be indicated separately at the time of enquiry and order. However, this finish is used only in very few cases yet. Products with a pronounced spangle do not comply with the EU directives 2011/65/EU for electrical and electronic equipment and 2000/53/EU on end-of-life vehicles.

6.1.2 Minimized Spangle (M)

The finish is obtained by influencing the solidification process in a specific way. The surface will have reduced spangles, which in some cases are not visible to the unaided eye. This finish may be ordered if normal spangle (see section 6.1.1) does not satisfy the requirements of surface appearance.

6.2 Finish in ZF

This coating with a zinc-iron alloy coating quality results from heat treatment in which the iron diffuses through the zinc. The surface has a uniform matt grey appearance.

6.3 Finish in ZA

This coating has a metallic lustre and results from uninfluenced solidification of the zinc-aluminium coating. Depending on the manufacturing conditions, crystals of different sizes and brightness develop. This does not affect the quality of the coating.

Table 12: Available coatings Z, ZF, ZA, ZM, AZ and AS

Coating designation	Minimum coating mass (both sides) g/m²		Theoretical guidance values for coating thicknesses per surface in the single spot test (µm)[a]		Density g/cm³
	Triple spot test	Single spot test	Typical value	Range	
Zinc coating mass (Z)					
Z100	100	85	7	5 – 12	7.1
Z140	140	120	10	7 – 15	
Z200	200	170	14	10 – 20	
Z225	225	195	16	11 – 22	
Z275	275	235	20	13 – 27	
Z350	350	300	25	17 – 33	
Z450	450	385	32	22 – 42	
Z600	600	510	42	29 – 55	
Coating mass zinc-iron coatings (ZF)					
ZF100	100	85	7	5 – 12	7.1
ZF120	120	100	8	6 – 13	
Coating mass zinc-aluminium coatings (ZA)					
ZA095	95	80	7	5 – 12	6.6
ZA130	130	110	10	7 – 15	
ZA185	185	155	14	10 – 20	
ZA200	200	170	15	11 – 21	
ZA255	255	215	20	15 – 27	
ZA300	300	255	23	17 – 31	

The weight of the coating is determined by chemically removing of the coating.

[a] The layer thicknesses can be calculated as follows based on the coating weight.
For example, a zinc-coating weight of 100 g/m² total on both sides corresponds to a zinc-layer thickness of approximately 7.1 µm per side:

$$\frac{\text{Zinc-coating weight (g/m}^2\text{, both sides)}}{\text{2 x 7.1 (= zinc-density)}} = \text{zinc-layer thickness (µm per side)}$$

Analogous principles apply to other coatings.

[b] Not for multiphase steels

Coating designation	Minimum coating mass (both sides) g/m²		Theoretical guidance values for coating thicknesses per surface in the single spot test (µm)[a]		Density g/cm³
	Triple spot test	Single spot test	Typical value	Range	
Coating mass zinc-magnesium coatings (ZM)					
ZM060	60	50	4.5	4 – 8	6.2 – 6.6
ZM070	70	60	5.5	4 – 8	
ZM080	80	70	6	4 – 10	
ZM090	90	75	7	5 – 10	
ZM100	100	85	8	5 – 11	
ZM120	120	100	9	6 – 14	
ZM130	130	110	10	7 – 15	
ZM140	140	120	11	8 – 16	
ZM150	150	130	11.5	8 – 17	
ZM160	160	130	12	8 – 17	
ZM175	175	145	13	9 – 18	
ZM190	190	160	15	10 – 20	
ZM200	200	170	15	10 – 20	
ZM250	250	215	19	13 – 25	
ZM300	300	255	23	17 – 30	
ZM310	310	265	24	18 – 31	
ZM350	350	300	27	19 – 33	
ZM430	430	365	35	26 – 46	
Coating mass aluminium-zinc coatings (AZ)[b]					
AZ100	100	85	13	9 – 19	3.8
AZ150	150	130	20	15 – 27	
AZ185	185	160	25	19 – 33	
Coating mass aluminium-silicium coatings (AS)[b]					
AS060	60	45	10	7 – 15	3.0
AS080	80	60	14	10 – 20	
AS100	100	75	17	12 – 23	
AS120	120	90	20	15 – 27	
AS150	150	115	25	19 – 33	

Table 13: Available coatings, finishes and surface qualities for zinc coatings (Z)

Coating designation[a)]	N	M		
	Surface quality[a)]			
	A	A	B	C
Z100	x	x	x	x
Z140	x	x	x	x
Z200	x	x	x	x
Z225	x	x	x	x
Z275	x	x	x	x
(Z350)	(x)	(x)	(x)	–
(Z450)	(x)	(x)	–	–
(Z600)	(x)	(x)	–	–

[a)] The coatings and surface qualities given in brackets are available on agreement.

Table 14: Available coatings, finishes and surface qualities for zinc-iron alloy (ZF)

Coating designation	Surface quality		
	A	B	C
ZF100	x	x	x
ZF120	x	x	x

6.4 Finish in ZM

This finish is obtained when the zinc-magnesium coating is left to solidify unrestricted. The surface has a metallic appearance and may be matt to bright. Variations in appearance, such as a tendency to darkening, are possible.

6.5 Finish in AZ

The products are delivered with a normal spangle. “Normal spangle” means a finish with a metallic lustre, which is the result of unrestricted aluminium-zinc crystal growth during normal solidification.

If a pronounced spangle is desired, this shall be indicated especially at the time of enquiry and order.

6.6 Finish in AS

Unlike other hot-dip coated products, in this case a relatively pronounced Al-Fe-Si alloy layer forms over the base material during hot-dip coating. This must be taken into account during further processing. If a maximum value for the mass of this layer is required, this shall be especially agreed upon at the time of enquiry and order.

7 Types of surface

7.1 Usual surface A

Imperfections such as pimples, marks, scratches, pits, variations in surface appearance, dark spots, stripe marks and light passivation stains are permissible. Stretch levelling breaks or run-off marks may appear as well as coil breaks and stretcher strains.

Surface A may be achieved (delivered) with or without skin passing at the discretion of the manufacture.

It needs to be specifically agreed at the moment of enquiry and order, if a skin passed surface is not wished in case of surface A.

7.2 Surfaces B and C

These surfaces are achieved by means of skin passing.

7.2.1 Improved surface B

With this surface quality, small imperfections such as stretch levelling breaks, skin pass marks, slight scratches, surface structure, run-off marks and light passivation stains are permissible. Remark: For special applications and by agreement at the time of enquiry and order, hot-dip aluminium-silicon coated products (AS) may be supplied with a bright appearance. In that case the surface is of type “B”.

Table 15: Available coatings and surface qualities for zinc-aluminium (ZA), zinc-magnesium (ZM), aluminium-zinc (AZ) and aluminium-silicon (AS)

Coating designation	Surface quality		
	A	B	C
Zinc-aluminium coatings (ZA)			
ZA095	x	x	x
ZA130	x	x	x
ZA185	x	x	x
ZA200	x	x	x
ZA255	x	x	x
ZA300	x	–	–
Zinc-magnesium coatings (ZM)			
ZM060	x	x	x
ZM070	x	x	x
ZM080	x	x	x
ZM090	x	x	x
ZM100	x	x	x
ZM120	x	x	x
ZM130	x	x	x
ZM140	x	x	x
ZM150	x	x	x
(ZM160)	(x)	(x)	(x)
(ZM175)	(x)	(x)	(x)
(ZM190)	(x)	(x)	(x)
(ZM200)	(x)	(x)	(x)

Coating designation	Surface quality		
	A	B	C
Zinc-magnesium coatings (ZM)			
(ZM250)	(x)	(x)	(x)
(ZM300)	(x)	(x)	(x)
(ZM310)	(x)	(x)	(x)
(ZM350)	(x)	(x)	(x)
(ZM430)	(x)	(x)	(x)
Aluminium-zinc coatings (AZ)			
AZ100	x	x	x
AZ150	x	x	x
AZ185	x	x	x
Aluminium-silicon coatings (AS)			
AS060	x	x	(x)
AS080	x	x	x
AS100	x	x	x
AS120	x	x	(x)
AS150	x	(x)	(x)

(x) available on agreement

7.2.2 Best quality surface C

The controlled surface shall not interfere with a uniform appearance of a high-class paint finish. The other surface shall at least have the characteristics of surface quality B.

When aluminium-silicon alloy (AS) is used, small, uncoated spots (diameter < 1 mm) are possible. These products cannot be used as exposed parts in automobile manufacturing.

7.3 Flatness and freedom from coil breaks

The use of suitable levelling units is necessary to achieve complete freedom from coil breaks and a good flatness in delivery condition. For material with surface A, coil breaks occur perpendicular to the rolling direction, which normally does not impair the intended use.

8 Surface treatment

Hot-dip coated steel strip and sheet can be delivered with the following surface treatments by the manufacturers:

- chemically passivated C
- oiled O
- chemically passivated and oiled CO
- sealed S
- phosphated P
- phosphated and oiled PO

Hot-dip coated steel strip and sheet is only delivered without surface treatment (untreated, U) at the expressed wish of the customer. In the case of orders for unprotected products, the manufacturer is not liable for the risk of corrosion. The ordering party will be instructed additionally that there is a higher risk of occurrence of scratches in loading, transport and use with such shipments, when ordering "untreated" surface.

8.1 General

Hot-dip coated flat products usually receive surface protection compliant with the information given in 8.2 to 8.7 in the manufacturer's plant. The protective effect is temporary. For surface treatments by the manufacturer the following warranty periods apply with reference to corrosion in correct storage, transport and loading as well as packing in compliance with publication 114 and 130, maximum:

C – 3 months
O – 3 months
CO – 3 months
S – 3 months
PO – 3 months
U – no warranty
P – no warranty

after the notice of availability for dispatch by the manufacturer. The actual protection period depends on the atmospheric and storage conditions.

Surface treatment by the manufacturer can have an influence on treatments applied later on such as painting or phosphating. For this reason, these must be coordinated with the provider of the later treatment.

8.2 Chemically passivated (C)

Chemical passivation protects the surface against humidity and reduces the risk of formation of corrosion products during storage and transportation. Local colour variations as a result of the treatment are permissible and do not impair the quality.

By switching to CrVI-free passivation methods (see publication 130) German suppliers comply with the guidelines of the European Parliament and Council for avoiding among other things CrVI-containing materials (RL 2002/95/EG and RL 2003/53/EG).

8.3 Oiled (O)

This treatment also reduces the risk of formation of corrosion products. It shall be possible to remove the oil layer with a suitable degreasing solvent which does not adversely affect the coating.

On special request, pre-lubes and hotmelts (drylubes, dry lubricants) can be used, improving formability.

8.4 Chemically passivated and oiled (CO)

This combination of surface treatments can be agreed upon if increased protection against the formation of corrosion products is required.

8.5 Sealed (S)

In the case of sealing, a transparent organic film coating of approximately 1 g/m^2 per side is applied. This treatment offers additional corrosion protection and increases the protection against fingerprints. It improves the sliding characteristics during forming operations and can be used as a priming coat for subsequent painting.

In order to comply with the directives of the European Parliament and Council for avoiding materials containing substances such as CrVI (Directive 2002/95/EC and Directive 2003/53/EC), CrVI-free seals are supplied by German suppliers.

8.6 Phosphated (P)

This treatment improves the adherence and protective effects of a coating applied by the processor. It reduces the risk of corrosion during transport and storage. Hot-dip coated steel strips and sheets that have been phosphated should be used or processed immediately after they have been made available. Arrangements can be made with the supplier to carry out the phosphating as microphosphating where appropriate.

8.7 Phosphated and Oiled (PO)

This combined surface treatment reduces the risk of the formation of products of corrosion and can improve formability.

9 Dimensions and Tolerances

9.1 General Notes

The following tables for dimensions and tolerances apply for continuous hot-dip coated steel products according to **Tables 3 through 10.** The relevant standard is EN 10143. The tables for dimensions and tolerances are consequently updated. Delivery proceeds in conformity with the properties according to this publication.

9.2 Thickness Tolerances

The measured thickness applies to every point with a distance of more than 40 mm from the edge. In the case of coils slit longitudinally and cut to length with a width ≤ 80 mm, the thickness is measured on the longitudinal axis.

Table 16: Thickness tolerance for steel grades depending on minimum proof strength (EN 10143)

Nominal thickness mm	Minimum proof strength[a]	Normal tolerances[a] for a nominal width		
		≤ 1,200[b] mm	> 1,200 ≤ 1,500 mm	> 1,500 mm
0.35 ≤ 0.40	$R_{p0.2}$ < 260 MPa	± 0.04	± 0.05	± 0.06
	260 MPa ≤ $R_{p0.2}$ < 360 MPa	± 0.05	± 0.06	± 0.07
	360 MPa ≤ $R_{p0.2}$ ≤ 420 MPa	± 0.05	± 0.06	± 0.07
	420 MPa < $R_{p0.2}$ ≤ 900 MPa	± 0.06	± 0.07	± 0.08
> 0.40 ≤ 0.60	$R_{p0.2}$ < 260 MPa	± 0.04	± 0.05	± 0.06
	260 MPa ≤ $R_{p0.2}$ < 360 MPa	± 0.05	± 0.06	± 0.07
	360 MPa ≤ $R_{p0.2}$ ≤ 420 MPa	± 0.06	± 0.07	± 0.08
	420 MPa < $R_{p0.2}$ ≤ 900 MPa	± 0.06	± 0.08	± 0.09
> 0.60 ≤ 0.80	$R_{p0.2}$ < 260 MPa	± 0.05	± 0.06	± 0.07
	260 MPa ≤ $R_{p0.2}$ < 360 MPa	± 0.06	± 0.07	± 0.08
	360 MPa ≤ $R_{p0.2}$ ≤ 420 MPa	± 0.07	± 0.08	± 0.09
	420 MPa < $R_{p0.2}$ ≤ 900 MPa	± 0.07	± 0.09	± 0.11
> 0.80 ≤ 1.00	$R_{p0.2}$ < 260 MPa	± 0.06	± 0.07	± 0.08
	260 MPa ≤ $R_{p0.2}$ < 360 MPa	± 0.07	± 0.08	± 0.09
	360 MPa ≤ $R_{p0.2}$ ≤ 420 MPa	± 0.08	± 0.09	± 0.11
	420 MPa < $R_{p0.2}$ ≤ 900 MPa	± 0.09	± 0.11	± 0.12
> 1.00 ≤ 1.20	$R_{p0.2}$ < 260 MPa	± 0.07	± 0.08	± 0.09
	260 MPa ≤ $R_{p0.2}$ < 360 MPa	± 0.08	± 0.09	± 0.11
	360 MPa ≤ $R_{p0.2}$ ≤ 420 MPa	± 0.10	± 0.11	± 0.12
	420 MPa < $R_{p0.2}$ ≤ 900 MPa	± 0.11	± 0.13	± 0.14
> 1.20 ≤ 1.60	$R_{p0.2}$ < 260 MPa	± 0.10	± 0.11	± 0.12
	260 MPa ≤ $R_{p0.2}$ < 360 MPa	± 0.11	± 0.13	± 0.14
	360 MPa ≤ $R_{p0.2}$ ≤ 420 MPa	± 0.13	± 0.14	± 0.16
	420 MPa < $R_{p0.2}$ ≤ 900 MPa	± 0.15	± 0.16	± 0.18
> 1.60 ≤ 2.00	$R_{p0.2}$ < 260 MPa	± 0.12	± 0.13	± 0.14
	260 MPa ≤ $R_{p0.2}$ < 360 MPa	± 0.14	± 0.15	± 0.16
	360 MPa ≤ $R_{p0.2}$ ≤ 420 MPa	± 0.16	± 0.17	± 0.19
	420 MPa < $R_{p0.2}$ ≤ 900 MPa	± 0.18	± 0.19	± 0.21
> 2.00 ≤ 2.50	$R_{p0.2}$ < 260 MPa	± 0.14	± 0.15	± 0.16
	260 MPa ≤ $R_{p0.2}$ < 360 MPa	± 0.16	± 0.17	± 0.18
	360 MPa ≤ $R_{p0.2}$ ≤ 420 MPa	± 0.18	± 0.20	± 0.21
	420 MPa < $R_{p0.2}$ ≤ 900 MPa	± 0.21	± 0.22	± 0.24
> 2.50 ≤ 3.00	$R_{p0.2}$ < 260 MPa	± 0.17	± 0.17	± 0.18
	260 MPa ≤ $R_{p0.2}$ < 360 MPa	± 0.19	± 0.20	± 0.20
	360 MPa ≤ $R_{p0.2}$ ≤ 420 MPa	± 0.22	± 0.22	± 0.23
	420 MPa < $R_{p0.2}$ ≤ 900 MPa	± 0.24	± 0.25	± 0.26

Special tolerances (S)[a] for a nominal width		
≤ 1,200[b] mm	> 1,200 ≤ 1,500 mm	> 1,500 mm
± 0.030 ± 0.035 ± 0.040 ± 0.045	± 0.035 ± 0.040 ± 0.045 ± 0.050	± 0.040 ± 0.045 ± 0.050 ± 0.060
± 0.035 ± 0.040 ± 0.045 ± 0.050	± 0.040 ± 0.045 ± 0.050 ± 0.060	± 0.045 ± 0.050 ± 0.060 ± 0.070
± 0.040 ± 0.045 ± 0.050 ± 0.060	± 0.045 ± 0.050 ± 0.060 ± 0.070	± 0.050 ± 0.060 ± 0.070 ± 0.080
± 0.045 ± 0.050 ± 0.060 ± 0.070	± 0.050 ± 0.060 ± 0.070 ± 0.080	± 0.060 ± 0.070 ± 0.080 ± 0.090
± 0.050 ± 0.060 ± 0.070 ± 0.080	± 0.060 ± 0.070 ± 0.080 ± 0.090	± 0.070 ± 0.080 ± 0.090 ± 0.110
± 0.060 ± 0.070 ± 0.080 ± 0.090	± 0.070 ± 0.080 ± 0.090 ± 0.110	± 0.080 ± 0.090 ± 0.110 ± 0.120
± 0.070 ± 0.080 ± 0.090 ± 0.110	± 0.080 ± 0.090 ± 0.110 ± 0.120	± 0.090 ± 0.110 ± 0.120 ± 0.140
± 0.090 ± 0.110 ± 0.120 ± 0.140	± 0.100 ± 0.120 ± 0.130 ± 0.150	± 0.110 ± 0.130 ± 0.140 ± 0.170
± 0.110 ± 0.130 ± 0.140 ± 0.170	± 0.120 ± 0.140 ± 0.150 ± 0.180	± 0.130 ± 0.150 ± 0.160 ± 0.190

[a] The tolerances for thickness may be increased by a maximum of 50% over a length of 10 m in the vicinity of the coils welds. This increase applies for all thickness and – if nothing else was specified in the inquiry and order – both for normal and also for special (negative and positive) tolerances.

[b] wide strip: width ≥ 600 mm;
longitudinally slit wide strip: rolling width ≥ 600 mm, longitudinally slit in widths of up to 600 mm

Fig. 23 and 24: Shelves and ventilation pipes made of sheet steel coated with zinc-magnesium

The thickness tolerances apply over the whole length. In the cases of coating identification numbers Z450 and Z600 and its intermediates with limited tolerances according to **Table 16,** the value will be increased by ± 0.01 mm. Tighter tolerances can be agreed upon during the inquiry and order.

For steel grade DX51D (without yield strength specification), the tolerances (minimum proof strength: 260 MPa ≤ $R_{p0.2}$ < 360 MPa) according to Table 16 apply. For all other steel grades without proof strength specification, minimum proof strength 420 MPa ≤ $R_{p0.2}$ < 900 MPa according to Table 16 apply and/or other arrangements on inquiry and order.

Table 17: Width tolerances for steel sheet and wide strip (EN 10143)

Nominal width[a)] mm	Normal tolerances mm	Special tolerances (S) mm
≥ 600 ≤ 1,200	+ 5	+ 2
> 1,200 ≤ 1,500	+ 6	+ 2
> 1,500 ≤ 1,800	+ 7	+ 3
> 1,800	+ 8	+ 3

[a)] The nominal width shall not be undercut.

Table 18: Width tolerances for longitudinally slit steel strip (EN 10143)

Tolerance class	Nenndicke mm	Nominal width[a] mm			
		< 125	≥ 125 < 250	≥ 250 < 400	≥ 400 < 600
Normal	< 0.6	+ 0.4	+ 0.5	+ 0.7	+ 1.0
	≥ 0.6 < 1.0	+ 0.5	+ 0.6	+ 0.9	+ 1.2
	≥ 1.0 < 2.0	+ 0.6	+ 0.8	+ 1.1	+ 1.4
	≥ 2.0 ≤ 3.0	+ 0.7	+ 1.0	+ 1.3	+ 1.6
Special (S)	< 0.6	+ 0.2	+ 0.2	+ 0.3	+ 0.5
	≥ 0.6 < 1.0	+ 0.2	+ 0.3	+ 0.4	+ 0.6
	≥ 1.0 < 2.0	+ 0.3	+ 0.4	+ 0.5	+ 0.7
	≥ 2.0 ≤ 3.0	+ 0.4	+ 0.5	+ 0.6	+ 0.8

[a] The nominal width shall not be undercut.

9.3 Width Tolerances

The tolerances listed in **Tables 17 and 18** apply to the continuously hot-dip coated flat products in accordance with **Tables 3 to 10.**

9.4 Length Tolerances

The length is measured along the longitudinal axis of the sheet or bar.

Table 19: Tolerances of Length (EN 10143)

Nominal length[a] mm	Normal tolerances mm	Special tolerances (S) mm
< 2,000	+ 6	+ 3
≥ 2,000 ≤ 8,000[b]	+ 0.3 % of the length	+ 0.15 % of the length

[a] The nominal length shall not be undercut.
[b] For nominal lengths > 8,000 mm, by arrangement.

9.5 Flatness Tolerances (see also section 11.6)

To measure the flatness tolerance, the sheet is laid on a horizontal surface. The maximum distance between the sheet and horizontal surface may not exceed the flatness tolerance. The measurement is only taken on the edges. The flatness tolerances in the **Tables 20 and 21** apply only to sheets.

Smaller flatness tolerances than those listed in the tables can be agreed upon in the inquiry and/or the order.

For steel grades with minimum proof strength of $R_{p0.2} \geq 360$ MPa or with non-established minimum yield strength, the flatness tolerance must be arranged in the inquiry and/or the order.

9.6 Tolerances on Out-of-squareness

The out-of-squareness "u", which is the vertical projection of a transverse edge onto a longitudinal edge, shall not exceed 1% of the actual width of the sheet **(Fig. 25)**.

9.7 Tolerances on edge camber

The edge camber "q" is measured on the concave side of the edge. It is the maximum distance between a longitudinal edge and a straight line that connects both ends of the measuring section (Fig. 25).

At a measured length of 2 m to any point on the edge, the deviation from straightness shall not exceed 5 mm. For lengths under 2 m, the deviation shall not amount to more than 0.3% of the actual length.

For longitudinally slit wide strip with a nominal width of < 600 mm, a straightness tolerance of 2 mm at 2 m length can be ordered. It does not apply to longitudinally slit wide strip made of steels with high yield strengths.

9.8 Overlay of the Dimensions of Squareness and Straightness

For deliveries in sheet, it can be agreed upon enquiry and order that a complete square in the ordered length and width can be overlaid with the shipped sheet metal.

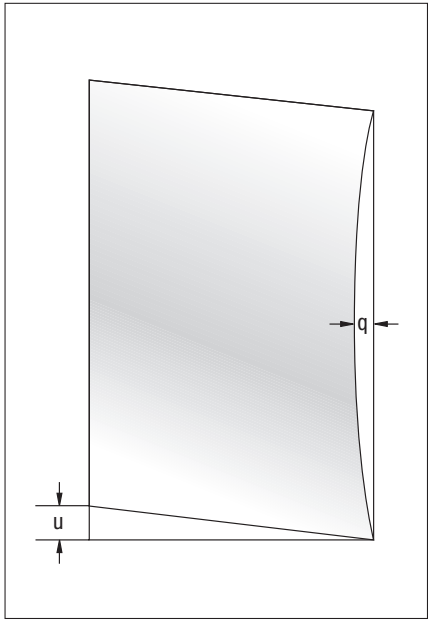


Fig. 25: Out-of-squareness "u" and edge camber "q"

Table 20: Flatness tolerances for steel grades with an established minimum proof strength of $R_{p0.2}$ < 260 MPa (EN 10143)

Tolerance class	Nominal width mm	Maximum wave height at nominal thickness t mm		
		< 0.7	≥ 0.7 < 1.6	≥ 1.6 < 3.0
Normal	< 1,200	10	8	
	≥ 1,200 < 1,500	12	10	
	≥ 1,500	17	15	
Special (FS)	< 1,200	5	4	3
	≥ 1,200 < 1,500	6	5	4
	≥ 1,500	8	7	6

Table 21: Flatness tolerances for steel grades with an established minimum proof strength of 260 MPa ≤ $R_{p0.2}$ < 360 MPa and for the steel grades DX51D and S550GD (EN 10143)

Tolerance class	Nominal width mm	Maximum wave height at nominal thickness t mm		
		< 0.7	≥ 0.7 < 1.6	≥ 1.6 < 3.0
Normal	< 1,200	13	10	
	≥ 1,200 < 1,500	15	13	
	≥ 1,500	20	19	
Special (FS)	< 1,200	8	6	5
	≥ 1,200 < 1,500	9	8	6
	≥ 1,500	12	10	9

10 General Instructions for Processing

In principle, hot-dip coated strip and sheet can be processed like cold-rolled or electrolytically galvanized sheet. In practice, however, the specific characteristics of this material create essential aspects that must be taken into consideration for certain types of processing. For that reason it is useful to indicate the type of forming and processing to the manufacturer. Some important instruc-

Table 22: General assessment of the properties of hot-dipped products ZF, ZA, ZM, AZ and AS in comparison to Z

	Z	ZF	ZA	ZM	AZ	AS
General properties						
• Best surface	3	5	4	3	2	2
• Suitable for varnishing						
– Conventional	3	3	3	3	3	3
– Coil Coating	3	3	4	4	2	2
– Electrostatical	3	3	3	3	3	3
– Eletrophoretical	3	3	0	3	0	0
• Resistance to acids	3	3	4	3[a)]	5	5
• Resistance to bases	3	3	2	3[a)]	1	1
• Temperature resistance	3	3	3	3	4	5
Corrosion behaviour						
• Without varnish						
– Surface without deformation	3	0	4	5	5	5
– Bending shoulder	3	0	4	4	4	4
– Cutting edge	3	0	3	5	2	2
• Varnished, Coil coated						
– Surface without deformation	3	0	4	5	4	0
– Bending shoulder	3	0	4	4	4	0
– Cutting edge	3	0	3	4	2	0
Automotive use	3	4	0	4	0	0
Forming Properties						
• (Micro-) cracking	3	2	5	2	2	2
• Abrasion	3	2	3	4	2	2
• Best formability requested	3	3	5	4	1	2
Joining						
• Spot welding	3	4	3	3	2	2
• Soldering	3	2	2	0	1	2
• Bonding	3	4	3	3[b)]	3	3
• Mechanical joining	3	3	3	3	3	3

tions for additional processing through forming, joining and coating are given in the following.

Some typical examples of processing are shown in the product photos.

Table 22 shows a general comparative assessment of the characteristics of hot-dip coated steel products.

[a] For use in acidic or basic media, a specific test is required for lower coating masses considering, that depending on the requirement or test conditions the classification into a higher or lower class may be possible.

[b] Bonded joints of low carbon steel and/or thin steel sheets with structural adhesives tend to adhesive failures.

Note:
The information given in this table characterizes the present level of experiences and apply for comparable product thicknesses and coating masses. It should be considered that the use of ZM coating offers the application of reduced coating masses. The given classification is not valid for all kinds of application. In cases of doubts, the manufacturer should be consulted for advice.

5	Especially recommended
4	Recommended
3	Standard
2	Less appropriate
1	Not recommended
0	Not used in practice

10.1 Forming

The selection of material is guided by the forming demands and the final geometry of the work piece. In selecting the type of steel, the different mechanical properties compared to cold-rolled and electrolytically galvanized sheet are to be taken into consideration. Furthermore the coatings and constitution of the surface must be coordinated with the processing conditions. It may be necessary to reduce the coating thickness.

The physical properties of the coatings require an adjustment of the processing tools, i.e. drawing gap and tightening radii are to be kept larger than for uncoated sheet. Slipstick effects can be counteracted through selection of the suitable coating and tool materials. Special materials such as sintered metal or specially treated surfaces have been used successfully. The use of remedies to support drawing operations is generally necessary but their compatability and subsequent removal have to be taken into consideration. The different forming properties of hot-dip coated steel strip and sheet must be taken into account in certain fabrication processes with respect to machine settings (e.g. blank holder force). Special processes with specific tools (e.g. plastic die cushions) and hydro-mechanical deep drawing processes are available for the fabrication of deep drawn components that have very sensitive surfaces.

10.2 Joining

Hot-dip coated steel strip and sheet requires joining procedures that protect the surface and preserve the anti-corrosive properties, such as screwing, riveting, folding, flanging, beading, clamping, bonding, etc. This should be taken into account during part designing already.

As a general rule, the problems of bi-metal corrosion (contact corrosion) are to be taken into account when combining different materials.

All steel grades mentioned in this document (with the exception S550GD) should be suitable for welding using regular welding procedures. In the case of heavier coating weights, it is possible that specially suited measures will be needed during welding. In the case of joint welding, a low coating weight has an positive effect on lifetime of the electrodes and quality of the welded joints.

Typical welding procedures are resistance spot welding, projection welding, foil butt welding, bolt welding, roller seam welding and wire seam welding. Projection and foil butt welding procedures largely preserve the original corrosion protection. In resistance welding of hot-dip coated steel strip and sheet, the welding parameters (electrode strength, higher welding current and increased electrode cooling as well as the selection of electrode material and form) must be adjusted. To restore corrosion protection in the welded area, a suitable post treatment is recommended where necessary (e.g. by coating with zinc dust paint).

For additional details see:

- DVS-Merkblatt 2910:
  Widerstandspunkt-, Buckel- und Rollennahtschweißen von feuerverzinktem Stahlblech

Laser welding of sheet metal using Nd:YAG- or CO_2-lasers has become very important in industrial production. Welding hot-dip coated steel sheet is state of the art today and is used increasingly in the automotive industry, e.g. in the production of formed blanks.

Compared to the conventional procedure, the advantages in laser welding lie in the narrow heat affected zone and the very limited damage to the coating in the vicinity of the welding seam. The cathodic protection remains completely intact. An additional important advantage of this method of welding is the good formability of the welded seam.

Details on soft and hard brazing of hot-dip coated steel sheets can be found in publication Merkblatt 235 “Weich- und Hartlöten von bandverzinktem Feinblech”.

Hot-dip coated steel strip and sheet can be adhesively bonded following appropriate surface treatments.

10.3 Coating (Organic)

In order to increase corrosion protection further and/or for optical or decorative reasons, organic coatings (paint, foils) can be applied to hot-dip coated steel strip and sheet. With respect to the expected exposure to corrosive environments and the intended subsequent processing (especially forming, joining), coil coated steel strip and sheet is available by the manufacturer. See Characteristic Properties 093 – E “Continuously Organic Coated Steel Flat Products”.

Basically, hot dip coated surfaces can be organically coated later at any time (both shortly after delivery as well as after use as a structural component).

The processor should note that the existing structures on the surface can become visible more prominently through

coating. For this reason the selection of the coating finish and the type of surface (identifier codes A, B, C) are dependent on the demands of the decorative appearance. For highest demands, surface type C shall be selected.

Should coating systems with a baking temperature of more than 200 °C be applied, this is to be indicated to the manufacturer in the order, since this can have influence on the bend-free rolling. To achieve perfect coating adhesion, surface treatment and/or cleaning and pretreatment adapted to the surface treatment and/or degree of weathering has to be carried out. Clean, chemically passivated surfaces form a good subsurface for conventional coatings. Oils from the "oiled" surface treatment or other chemical deposits are to be removed using a suitable cleaning agent or through an ammonia-based wetting agent rinse as well as thorough rinsing by water. Concerning this, see the publication Merkblatt 229 "Beschichten von oberflächenveredeltem Stahlblech", additional details can be obtained from the technical instructions of application from the paint manufacturer.

10.4 Aging, Freedom from Coil Breaks and Stretcher Strains

For steel grades of hot-dip coated steel sheet that recrystallize in the continuous annealing furnace, the rapid cooling and possible subsequent over-aging treatment will determine the carbide distribution in the structure the amount of super-saturated dissolved carbon contained and thereby the aging. The dissolved nitrogen content in the microstructure has an additional influence on aging. By removing the nitrogen through chemical combination with aluminium and/or boron in the metallurgic smelt, this aging effect can largely be avoided. In modern steels, therefore, the aging process is largely determined by the supersaturation of carbons. By reducing carbon super-saturation, the potential for aging is also reduced. This can be a disadvantage, if the aging starts to occur before cold forming, e.g. formation of coil breaks and stretcher strains. Because the formation of coil breaks and stretcher strains can be time-dependent, the products should be processed as soon as possible.

Aging potential can also exhibit a desired effect, e.g. in bake-hardening steel grades and multi-phase steels, if the aging proceeds after cold forming and by means of artificial aging, e.g. through baking the paint, and thus increases the yield strength.

If the customer wants "free of coil breaks", this should be indicated in the order.

Freedom from stretcher strains is assured after cold rolling for surfaces B and C for the following periods. The periods for freedom of stretcher strains begin with the agreed upon notice of availability for dispatch:

- 3 months for bake-hardened-steels, if the storage temperature is under 50 °C,
- 6 months for the grades DX54D, DX55D, DX56D and DX57D and the high-strength IF-steels (Y).

There is no guarantee regarding freedom from stretcher strains in all other steels.

The risk of coil breaks increases with the duration of storage, especially for product thicknesses ≥ 0.90 mm.

In the case of Z coated steel sheet, aging can occur in the zinc coating which can lead to formation of cracks in the coating during forming.

11 Special Instructions for Processing Steel Strip

11.1 Decoiling Equipment, Interior Diameter of Rolls (Coils)

The mandrel should be expandable and adjustable, in order to tighten the coils fast and be able to retard them when they are decoiled. This prevents sheet strip surfaces from rubbing against each other. An advantage is a mandrel from which coils can be decoiled from above or below. The difference in diameter between the contracted and widened mandrel may be at least 25 mm. In widened condition, the mandrel drum should be round. When winding up strips with larger sheet thicknesses, the danger of bends (kinks) is given. In order to reduce this danger, the interior diameter of the coils may always be 610 mm at these thicknesses, which is the industry's standard.

Coils with an inner diameter of 508 mm can also be selected upon agreement.

At strip thicknesses ≥ 0.90 mm, bends (kinks) when rolling the strip on the strip drum may not be avoidable. During processing, suitable equipment must be used for levelling (by rolls with small diameters).

11.2 Exterior Diameter of Rolls (Coils), Coil Weights and Quantities of Order

The different production facilities for manufacturers as well as consumers necessitate that the exterior diameter and/or weights of the coils being delivered must be determined when the order is placed. The suppliers basically work with different product units whose weights depend on the sheet width. This must be taken into account when placing the order in the determination of the coil weights and quantity by item. Quantity by item should be a production unit or a multiple thereof. The coil weight may correspond to the production unit or be derivable from it through division with no remainder (baby/short coil).

11.2.1 Order According to Maximum Weight

It is recommended that the ordering party designate the maximum exterior coil diameter and/or maximum weight. Using this type of ordering, the maximum exterior diameter or the maximum coil weight will not be exceeded. The supplier will divide production units in such a manner that, if possible, evenly sized coils without remainders are generated.

11.2.2 Orders According to Maximum and Minimum Exterior Diameters and/or Weights

If along with the maximum exterior diameter and/or maximum weight, a minimum exterior diameter and/or minimum weight is desired, the tolerances must be adequately. Moreover, special arrangements must be made with the manufacturer. In this type of order, up to 10% of the item weight can be delivered with

shortfalls of diameter and/or weight, at least however a single coil. This results from the production conditions and possibly from the ordering specifications. A short/baby coil may have an exterior diameter of no less than 800 mm.

11.3 Welds (Butt Weld)

To optimise coil weights, delivery with welds can be agreed upon. In this case a special agreement must be reached with the individual suppliers that conforms to their options.

The location of such a weld can be marked by agreement with the processor, e.g. by hole punching or painted markings.

11.4 Edge Finishing

Steel strip is usually delivered with hot-dip coated edges. Here, small cracks in the edges and slight irregularities can appear in the coating. Hot-dip coated steel strip can also be delivered with edges cut after the hot-dip coating (SE – Slit Edge).

11.5 Winding State

The coils may be wound straight-edged and tight. Since it is not always possible to avoid telescoping in the coils, the processor must reckon with a slight protrusion of individual windings beyond the roll width.

11.6 Flatness

By coiling on a mandrel, the steel strip absorbs tension. This tension causes deviations from flatness after decoiling, e.g. coil set and clamping bends.

In many processing operations, such as in deep drawing, punching and profiling, these deviations do not disturb. If the consumer wishes to have a flat sheet, the consumer must employ a suitable levelling machine.

11.7 Acceptance and Sampling

Acceptance is restricted to the mechanical properties that are determined based on samples from the beginning or end of the coil. The specifications in the particular standards for that material apply in the test procedures.

11.8 Portion of Defects in Shipments of Hot-Dip Coated Steel Strip

Technologically it is not possible to deliver a perfect steel strip. This fact must be accepted by the consumer. For this reason it can be expedient to agree on rules for deficits. In the case of sheet delivery a portion of the defective pieces can be sorted out so that the defect rate is lower. In the delivery of coils, defective spots in the vicinity of weld seams or on the first exterior or interior coil-lap are unavoidable. For that reason, parts or pieces of this kind cannot be included in the calculations for the portion of defects.

For evaluation of quality and therewith as basis for any claims, only representative batches can be referred to. When higher defect rates occur, even in smaller batches, the necessary details are to be reported to the supplier.

Should recurring defects appear when unwinding a coil, leading to the inference that the entire coil will bring a heavily increased amount of reject material when processed, the processor shall set the coil aside and contact the supplier immediately. Defects may only be subject of complaints in those cases when they cause more than insignificant detriment to the regular processing and use.

11.9 Surface Appearance

The surface appearance can vary and may become darker with oxidation. Aging of the coating can cause cracking of the surface to a certain extent during processing, which can reduce the resistance to abrasive wear. The user should take this behaviour into consideration.

11.10 Surface Protection

With respect to surface protection during storage and transportation, the following should be taken into account:

- all grades of surface protection only secure a temporary resistance to corrosion during transport and storage; changes in colour can occur;
- protection provided by oils is especially dependent on storage time. The oil film is evenly dispersed at first but becomes increasingly uneven due to the technically conditioned steel strip profile and blank spots can develop. Different oils can exhibit different behaviour.

12 Identification Codes for Ordering

Supplying hot-dip coated steel strip and sheet will be executed according to the applicable standards.

Use of identification in ordering:

Example 1

Steel strip of dual phase steel with zinc coating (Z) according to EN 10346	Steel strip EN 10346
Steel grade HCT780X	HCT780X+Z
Coating 100 g/m^2, both sides	100
Zinc-coated products with minimized spangle M	M
With improved surface: Surface type B	B
With surface treatment oiled O	O

The complete identification code for the order would be:
Steel strip EN 10346 – HCT780X+Z100 - MB - O
(Tolerances on dimensions and shape according to EN 10143)

Example 2

Steel strip of low carbon steel with zinc-iron alloy coating (ZF) according to EN 10346	Steel strip EN 10346
Steel grade DX56D	DX56D+ZF
Coating 100 g/m^2, both sides	100
With improved surface: Surface type B	B
With surface treatment oiled O	O

The complete identification code for the order would be:
Steel strip EN 10346 – DX56D+ZF100 - B - O
(Tolerances on dimensions and shape according to EN 10143)

Use of identification in ordering:

Example 3

Steel strip of low carbon steel with zinc-aluminium coating (ZA) according to EN 10346	Steel strip EN 10346
Steel grade DX53D	DX53D+ZA
Coating 130 g/m^2, both sides	130
With improved surface: Surface type B	B
With surface treatment chemically passivated C	C

The complete identification code for the order would be:
Steel strip EN 10346 – DX53D+ZA130 - B - C
(Tolerances on dimensions and shape according to EN 10143)

Example 4

Steel strip of structural steel with aluminium-zinc coating (AZ) according to EN 10346	Steel strip EN 10346
Steel grade S250GD	S250GD+AZ
Coating 185 g/m^2, both sides	185
With best surface: Surface type C	C
With surface treatment chemically passivated and oiled CO	CO

The complete identification code for the order would be:
Steel strip EN 10346 – S250GD+AZ185 - C - CO
(Tolerances on dimensions and shape according to EN 10143)

Example 5

Steel strip of low carbon steel with aluminium-silicon coating (AS) according to EN 10346	Steel strip EN 10346
Steel grade DX53D	DX53D+AS
Coating 80 g/m^2, both sides	80
With improved surface: Surface type B	B
With surface treatment chemically passivated and oiled CO	CO

The complete identification code for the order would be:

Steel strip EN 10346 – DX53D+AS80 - B - CO

(Tolerances on dimensions and shape according to EN 10143)

Example 6

Steel strip of steel with high proof strength with zinc coating (Z) according to EN 10346	Steel strip EN 10346
Steel grade HX340LAD	HX340LAD+Z
Coating 140 g/m^2, both sides	140
Coating finish with minimized spangle M	M
With improved surface: Surface Type B	B
With surface treatment oiled O	O

The complete identification code for the order would be:

Steel strip EN 10346 – HX340LAD+Z140 - M B - O

(Tolerances on dimensions and shape according to EN 10143)

Use of identification in ordering:

Example 7

Steel strip of structural steel with zinc-magnesium coating (ZM) according to EN 10346	Steel strip EN 10346
Steel grade S220GD	S220GD+ZM
Coating 140 g/m^2, both sides	140
Surface type regular surface	A
Surface treatment chemically passivated	C

The complete identification code for the order would be:
Steel strip EN 10346 – S220GD+ZM140 - A - C
(Tolerances on dimensions and shape according to EN 10143)

13 Packaging, Storage, Transport

Packaging is to be agreed upon in each case with the suppliers.

The publication Merkblatt 114 "Verpackung, Lagerung und Transport von unbeschichtetem und beschichtetem Band und Blech" should likewise be consulted.

14 Standards, Regulations and Technical Literature

EN 10021
General technical delivery conditions for steel products

EN 10027-1 and EN 10027-2
Designation systems for steels –
Part 1: Steel names
Part 2: Numerical system

EN 10143*
Continuously hot-dip coated steel sheet and strip – Tolerances on dimensions and shape

EN 10169
Continuously organic coated (coil coated) steel flat products –
Technical delivery conditions

EN 10204
Metallic products –
Types of inspection documents

EN 10346*
Continuously hot-dip coated steel flat products for cold forming –
Technical delivery conditions

VDI 2700
Securing of loads on road vehicles

VDI 3319 Sheet 1
Packaging guideline for steel coils and split strips

VDA 239-100: Material sheet
Sheet Steel for Cold Forming

DVS-Merkblatt 2910
Widerstandspunkt-, Buckel- und Rollnahtschweißen von feuerverzinktem Stahlblech

Zinc – Magnesium – Aluminium Coatings for Automotive Industry, Stahlinstitut VDEh, 2013

Directive 2011/65/EU
of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment

Directive 2000/53/EC
of the European Parliament and of the Council of 18 September 2000 on end-of-life vehicles regulates the reuse of the materials in motor vehicles by means of recycling within the European Union (EU)

Publications from the Wirtschaftsvereinigung Stahl:

Charakteristische Merkmale 090
„Schwingungsdämpfendes Verbundband und Verbundblech“

Charakteristische Merkmale 092
„Elektrolytisch veredeltes Band und Blech“

Characteristic Properties 093 – E
“Continuously Organic Coated Steel Flat Products”

Charakteristische Merkmale 094
„Feuerverzinkter Bandstahl“

Merkblatt 109
Stahlsorten für oberflächenveredeltes Feinblech

Merkblatt 110
Schnittflächenschutz und kathodische Schutzwirkung von oberflächenveredeltem Stahlfeinblech

Merkblatt 114
Verpackung, Lagerung und Transport von unbeschichtetem und beschichtetem Band und Blech

Publication 127 – E
Lubrication of sheet strip and panels

Publication 130 – E
Chemical Passivation of Metallic Coatings on Steel Sheet

Merkblatt 180
Walzprofilieren von Flacherzeugnissen aus Stahl

Merkblatt 235
Weich- und Hartlöten von bandverzinktem Feinblech

Merkblatt 382
Kleben von Stahl und Edelstahl Rostfrei

Documentation 566 – E
Zinc-Magnesium Coated Steel Sheets – Less is More

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