

DIN EN 10346

**DIN**

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Supersedes: see below

**Continuously hot-dip coated steel flat products –  
Technical delivery conditions  
English version of DIN EN 10346:2009-07**

Kontinuierlich schmelztauchveredelte Flacherzeugnisse aus Stahl –  
Technische Lieferbedingungen  
Englische Fassung DIN EN 10346:2009-07

Together with DIN EN 10152:2009-07, supersedes DIN EN 10336:2007-07;  
supersedes DIN EN 10292:2007-06, DIN EN 10326:2004-09 and DIN EN 10327:2004-09

Document comprises 41 pages

**VOLKSWAGEN AG**

Vervielfältigung gemäß entspr. DIN-Merkblättern



## National foreword

This standard has been prepared by Technical Committee ECISS/TC 27 "Surface coated flat products — Qualities, dimensions, tolerances and specific tests" (Secretariat: DIN, Germany).

The responsible German body involved in its preparation was the *Normenausschuss Eisen und Stahl* (Iron and Steel Standards Committee), Technical Committee NA 01-02 *Oberflächenveredelte Flacherzeugnisse aus Stahl*.

This document specifies requirements for continuously hot-dip coated products made of low carbon steels for cold forming of steels in construction and of steels for cold forming in thicknesses from 0,35 mm up to and including 3,0 mm unless otherwise agreed (previously specified in DIN EN 10326:2004-09, DIN EN 10327:2004-09, DIN EN 10292:2007-06 and DIN EN 10336:2007-07).

## Amendments

This standard differs from DIN EN 10326:2004-09, DIN EN 10327:2004-09, DIN EN 10292:2007-06 and DIN EN 10336:2007-07 as follows:

a) All standards replaced:

- 1) Specifications for hot-dip coated products are now dealt with in the same standard.
- 2) In subclause 5.2 "Options", alternative product thicknesses of < 0,35 mm or > 3,00 mm have been specified.
- 3) Clause 3 "Terms and definitions" has been revised.
- 4) Subclause 6.2 "Processing" has been added.
- 5) Three low alloy/micro-alloyed steels have been added.
- 6) The chemical composition of further steels with high yield strength has been slightly modified.
- 7) Hot-dip zinc-aluminium alloy coating (ZA) for multiphase steels has been specified.
- 8) Some specifications relating to the mechanical properties in case of low product thicknesses (< 0,70 mm) have been modified.

b) DIN EN 10336:2007-07:

- 1) Electrolytically zinc coated cold rolled steel flat products for cold forming are now dealt with in DIN EN 10152.

**Previous editions**

DIN 17162-1: 1977-09, DIN 17162-2:1980-09  
DIN 17162-2: 1980  
DIN EN 10142: 1991-03, 1995-08, 2000-07  
DIN EN 10147: 1992-01, 1995-08, 2000-07  
DIN EN 10154: 1996-05, 2002-08  
DIN EN 10214: 1995-04  
DIN EN 10215: 1995-04  
DIN EN 10292: 2000-07, 2003-09, 2005-03, 2007-06  
DIN EN 10326: 2004-09  
DIN EN 10327: 2004-09  
DIN EN 10336: 2007-07

**National Annex NA**  
(informative)

**Bibliography**

DIN EN 10152, *Electrolytically zinc coated cold rolled steel flat products for cold forming — Technical delivery conditions*

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English Version

## Continuously hot-dip coated steel flat products - Technical delivery conditions

Produits plats en acier à bas carbone revêtus en continu  
par immersion à chaud - Conditions techniques de livraison

Kontinuierlich schmelztauchveredelte Flacherzeugnisse  
aus Stahl - Technische Lieferbedingungen

This European Standard was approved by CEN on 31 January 2009.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN Management Centre has the same status as the official versions.

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## Foreword

This document (EN 10346:2009) has been prepared by Technical Committee ECISS/TC 27 “Surface coated flat products - Qualities, dimensions, tolerances and specific tests”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2009, and conflicting national standards shall be withdrawn at the latest by September 2009.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 10292:2007, EN 10326:2004, EN 10327:2004, and – together with EN 10152:2009 – EN 10336:2007.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.



## 1 Scope

This European Standard specifies requirements for continuously hot-dip coated products made of low carbon steels for cold forming, of steels for construction, of steels with high proof strength for cold forming and coated with zinc (Z), zinc-iron alloy (ZF), zinc-aluminium alloy (ZA), aluminium-zinc alloy (AZ) or aluminium-silicon alloy (AS), and for continuously hot-dip coated products made of multiphase steels for cold forming coated with zinc (Z) zinc-iron alloy (ZF) or zinc-aluminium alloy (ZA) with thicknesses of 0,35 mm to 3 mm unless otherwise agreed.

The thickness is the final thickness of the delivered product after coating.

This document applies to strip of all widths and to sheets cut from it ( $\geq 600$  mm width) and cut lengths ( $< 600$  mm width).

NOTE 1 Products coated with (pure) aluminium can also be available, but are not covered by this European standard.

NOTE 2 By agreement at the time of enquiry and order, this European Standard is applicable to continuously hot-dip coated flat products in thicknesses  $< 0,35$  mm or  $> 3$  mm with agreed mechanical properties, adhesion of coating and surface condition requirements.

NOTE 3 The products covered by this European Standard are used where cold formability, high strength, a defined minimum yield strength and corrosion resistance are the most important factors. Corrosion resistance of the product is proportional to the coating thickness, hence to its mass (see also 7.3.2). The products covered by this European Standard can be used as substrates for organic coated flat products specified in EN 10169-1 and EN 10169-2 or EN 10169-3 for building and general engineering applications.

NOTE 4 By agreement at the time of enquiry and order, this European standard is applicable to other continuously hot-dip coated hot rolled steel flat products (e.g. in accordance with EN 10149-2).

## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 10002-1:2001, *Metallic materials – Tensile testing – Part 1: Method of test at ambient temperature*

EN 10020:2000, *Definition and classification of grades of steel*

EN 10021:2006, *General technical delivery conditions for steel products*

EN 10049, *Measurement of roughness average  $R_a$  and peak count  $RP_c$  on metallic flat products*

EN 10079:2007, *Definition of steel products*

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

EN 10204:2004, *Metallic products – Types of inspection documents*

EN 10325, *Steel – Determination of yield strength increase by the effect of heat treatment (Bake-Hardening-Index)*

ISO 10113, *Metallic materials – Sheet and strip – Determination of plastic strain ratio*

ISO 10275, *Metallic materials – Sheet and strip – Determination of tensile strain hardening exponent*

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 10020:2000, EN 10021:2006, EN 10079:2007, EN 10204:2004 and the following apply.

NOTE General definitions and guidelines for the protection of iron and steel can be found in EN ISO 14713.

#### 3.1

##### **hot-dip zinc coating (Z)**

application of a zinc coating by immersing the prepared strip in a molten bath containing a zinc content of at least 99 % (see also 7.4.2)

#### 3.2

##### **hot-dip zinc-iron alloy coating (ZF)**

application of a zinc coating by immersing the prepared strip in a molten bath containing a zinc content of at least 99 % and a subsequent annealing which produces an iron-zinc coating with an iron content of normally 8 % to 12 % (see also 7.4.3)

#### 3.3

##### **hot-dip zinc-aluminium alloy coating (ZA)**

application of a zinc-aluminium coating by immersing the prepared strip in a molten bath which is composed of zinc and approximately 5 % aluminium and small amounts of mischmetal (see also 7.4.4)

#### 3.4

##### **hot-dip aluminium-zinc alloy coating (AZ)**

application of an aluminium-zinc coating by immersing the prepared strip in a molten bath which is composed of 55 % aluminium, 1,6 % silicon and the balance zinc (see also 7.4.5)

#### 3.5

##### **hot-dip aluminium-silicon alloy coating (AS)**

application of an aluminium-silicon coating by immersing the prepared strip in a molten bath which is composed of aluminium and 8 % to 11 % silicon (see also 7.4.6)

#### 3.6

##### **bake-hardening steel (B)<sup>1)</sup>**

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

NOTE 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.

#### 3.7

##### **complex-phase steel**

###### **CP 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 or precipitation of micro-alloying elements

#### 3.8

##### **dual-phase steel**

###### **DP steel**

steel with a ferritic matrix containing a martensitic second phase present in the form of islands and eventually bainite as a complementary phase

NOTE According to their high tensile strength levels, dual phase steels show a low yield strength ratio and a high work hardening rate.

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1) Symbol used in the steel name (see Table 3).

### 3.9

#### **ferritic-bainitic steel**

##### **FB steel**

steel containing bainite or strengthened bainite in a matrix consisting of ferrite and/or strengthened ferrite

NOTE The strengthening of the matrix is caused by a high density of dislocations, by grain refinement and precipitation of micro-alloying elements.

### 3.10

#### **interstitial free steel (Y)<sup>1)</sup>**

##### **IF steel**

steel whose composition is controlled to achieve improved  $r$ - and  $n$ -values

NOTE 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.

### 3.11

#### **low alloy/micro-alloyed steel (LA)<sup>1)</sup>**

steel containing one or more of alloys Nb, Ti and V to achieve required proof strength levels

NOTE Combined precipitation and grain refinement hardening modes allow reaching a high mechanical resistance while reducing the content of alloying elements.

### 3.12

#### **martensitic steel**

##### **MS steel**

steel with a martensitic matrix containing small amounts of ferrite and/or bainite produced by thermomechanical rolling

NOTE Within the group of multiphase steels the MS steels show the highest tensile strength level.

### 3.13

#### **transformation induced plasticity steel**

##### **TRIP steel**

steel with a mainly ferritic matrix containing retained austenite where, during the forming process, retained austenite can transform to martensite (TRIP effect)

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

### 3.14

#### **coating mass**

total mass of coating (expressed in grams per square metre) given for both surfaces (see 7.9)

NOTE In combination with the symbol for the coating type (Z, ZF, ZA, AZ, AS), the nominal coating mass is used as coating designation.

---

1) Symbol used in the steel name (see Table 3).

## 4 Classification and designation

### 4.1 Classification

#### 4.1.1 General

The steels covered by this document are alloy quality steels (steels in accordance with Tables 1, 3 and 4) or non-alloy quality steels (steels in accordance with Table 2) in accordance with EN 10020.

#### 4.1.2 Low carbon steels for cold forming

The steel grades are classified in accordance with their increasing suitability for cold forming as follows (see Table 6):

- DX51D: bending and profiling quality;
- DX52D: drawing quality;
- DX53D: deep drawing quality;
- DX54D: special deep drawing quality;
- DX55D: special deep drawing quality (only +AS);
- DX56D: extra deep drawing quality;
- DX57D: super deep drawing quality.

#### 4.1.3 Steels for construction

The steel grades are classified in accordance with their increasing minimum proof strength  $R_{p0,2}$  (see Table 7).

#### 4.1.4 Steels with high proof strength for cold forming

The steel grades are classified in accordance with their increasing minimum proof strength  $R_{p0,2}$  (see Table 8).

#### 4.1.5 Multiphase steels for cold forming

The steel grades are classified in accordance with their increasing minimum tensile strength  $R_m$  (see Tables 9 and 10).

### 4.2 Designation

#### 4.2.1 Steel names

The steel names in accordance with this document are allocated in accordance with EN 10027-1.

#### 4.2.2 Steel numbers

The steel numbers in accordance with this document are allocated in accordance with EN 10027-2.

## 5 Information to be supplied by the purchaser

### 5.1 Mandatory information

The following information shall be supplied by the purchaser at the time of enquiry and order:

- a) quantity to be delivered;
- b) type of product (strip, sheet, cut length);
- c) number of the dimensional standard (EN 10143);
- d) nominal dimensions and the tolerances on dimensions and shape and, if applicable, letters denoting relevant special tolerances;
- e) term "steel";
- f) number of this document, i.e. EN 10346;
- g) steel name or steel number and symbol for the type of hot-dip coating as given in Tables 1 to 4;
- h) number designating the nominal mass of coating (e.g. 275 = 275 g/m<sup>2</sup> including both surfaces, see Table 11);
- i) letter denoting the coating finish (N or M, see 7.4 and Tables 12 to 14);
- j) letter denoting the surface quality (A, B or C, see 7.5 and Tables 12 to 14);
- k) letter denoting the surface treatment (C, O, CO, P, PO or S, see 7.6).

EXAMPLE 1 sheet, delivered with dimensional tolerances in accordance with EN 10143 with nominal thickness of 0,80 mm, ordered with special thickness tolerances (S), nominal width 1 200 mm, ordered with special width tolerances (S), nominal length 2 500 mm, ordered with special flatness tolerances (FS), made of steel DX53D+ZF (1.0355+ZF) in accordance with EN 10346, coating mass 100 g/m<sup>2</sup> (100), surface quality B, surface treatment oiled (O):

1 sheet EN 10143-0,80Sx1200Sx2500FS-steel EN 10346-DX53D+ZF100-B-O

or:

1 sheet EN 10143-0,80Sx1200Sx2500FS-steel EN 10346-1.0355+ZF100-B-O

### 5.2 Options

A number of options are specified in this document and listed below. If the purchaser does not indicate a wish to implement any of these options, the products shall be supplied in accordance with the basis specification of this document (see 5.1).

- 1) Specification of product thicknesses deviating from those generally covered in the scope (i.e. thicknesses < 0,35 mm or > 3 mm) (see NOTE 2 to Clause 1);
- 2) Specification of hot rolled products deviating from those generally covered in the scope (see NOTE 4 to Clause 1);
- 3) verification of the product analysis (see 7.1.2);
- 4) date of supply for products free from stretcher strains when cold forming (see 7.2.1.3);
- 5) products supplied suitable for the manufacture of a specific part (see 7.2.2.2 and 7.2.4.2);

- 6) specification of the values in Tables 9 and 10 for longitudinal instead of transverse test pieces (see 7.2.5.3);
- 7) coating masses different from those of Table 11 and/or special requirements for different coating masses on each surface (see 7.3.2);
- 8) special coatings and/or surface qualities (see Tables 12 and 14, footnote a));
- 9) hot-dip zinc coated products with pronounced spangle (see 7.4.2.1 or 7.4.5);
- 10) special requirements for a maximum Al-Fe-Si alloy layer mass occurring during hot-dip aluminium-silicon coating (see 7.4.6);
- 11) requirement for special applications on bright appearance for aluminium-silicon coated products (type B surface, see NOTE to 7.5.2.2);
- 12) range and verification of surface roughness (see 7.5.3);
- 13) selection of the protective oil (see 7.6.1)
- 14) type of S coating (see 7.6.6);
- 15) products free from coil breaks (see 7.7.1);
- 16) maximum or minimum value for the coating mass on each product side (see 7.9);
- 17) type of inspection and, if applicable, inspection document to be delivered (see 8.1);
- 18) determination of the tensile properties and/or the Bake-Hardening Index  $BH_2$  and/or the coating mass by calculation (see 8.3);
- 19) notification of which surface has been inspected (see 8.5.4.2);
- 20) marking desired by branding of the products (see 9.2);
- 21) requirement for packing (see Clause 10).

## 6 Manufacturing and processing

### 6.1 Manufacturing

The processes used in steelmaking and, unless there are restrictions by the selected steel grade (see footnote a to Table 4), the manufacture of the products shall be left to the discretion of the manufacturer.

### 6.2 Processing

#### 6.2.1 Ageing

Due to ageing, a reduction in formability can take place for all the products supplied according to this document. Coil breaks or fluting can occur additionally during processing. The risk of coil breaks increases, especially for thicknesses > 0,9 mm, with the duration of storage.

Therefore the user should process the products after their receipt as quick as possible (see 7.2.1.3).

## 6.2.2 Coating appearance

The coating surface can vary and change to a dark appearance by oxidation.

Due to ageing of the coating a certain cracking of the surface can appear during processing which can consequently reduce abrasion resistance.

The user should take these characteristics into account.

## 6.2.3 Surface protection

Regarding surface protection during transport and storage the following should be taken into consideration:

- Only a temporary corrosion resistance during transportation or storage is provided by any surface protection applied. Colour changes can occur.
- In particular, protection by oiling is dependent on storage time. The primarily uniform oil film becomes more and more unequal, and bare spots can develop. Different oils can show different behaviour.

## 7 Requirements

### 7.1 Chemical composition

7.1.1 The chemical composition according to the cast analysis shall be as specified in Tables 1 to 4.

7.1.2 If a product analysis is agreed at the time of enquiry and order, the permitted deviations from the cast analysis given in Tables 1 to 4 shall meet the requirements in Table 5.

**Table 1 — Chemical composition (cast analysis) of low carbon steels for cold forming**

Designation			Chemical composition % by mass					
			max.					
Steel grade		Symbols for the types of available coatings	C	Si	Mn	P	S	Ti
Steel name	Steel number							
DX51D	1.0226	+Z,+ZF,+ZA,+AZ,+AS	0,18	0,50	1,20	0,12	0,045	0,30
DX52D	1.0350	+Z,+ZF,+ZA,+AZ,+AS	0,12					
DX53D	1.0355	+Z,+ZF,+ZA,+AZ,+AS						
DX54D	1.0306	+Z,+ZF,+ZA,+AZ,+AS						
DX55D	1.0309	+AS						
DX56D	1.0322	+Z,+ZF,+ZA,+AS						
DX57D	1.0853	+Z,+ZF,+ZA,+AS						

**Table 2 — Chemical composition (cast analysis) of steels for construction**

Designation			Chemical composition % by mass max.				
Steel grade		Symbols for the types of available coatings	C	Si	Mn	P	S
Steel name	Steel number						
S220GD	1.0241	+Z,+ZF,+ZA,+AZ	0,20	0,60	1,70	0,10	0,045
S250GD	1.0242	+Z,+ZF,+ZA,+AZ,+AS					
S280GD	1.0244	+Z,+ZF,+ZA,+AZ,+AS					
S320GD	1.0250	+Z,+ZF,+ZA,+AZ,+AS					
S350GD	1.0529	+Z,+ZF,+ZA,+AZ,+AS					
S550GD	1.0531	+Z,+ZF,+ZA,+AZ					



**Table 3 — Chemical composition (cast analysis) of steels with high proof strength for cold forming**

Designation		Chemical composition % by mass								
Steel grade		Symbols for the types of available coatings	C	Si	Mn	P	S	Al <sub>total</sub>	Nb	Ti
Steel name <sup>a</sup>	Steel number		max.	max.	max.	max.	max.		max.	max.
HX160YD	1.0910	+Z, +ZF, +ZA, +AZ, +AS	0,01	0,15	0,70	0,06	0,025	≤ 0,1	0,09	0,12
HX180YD	1.0921		0,01	0,20	0,70	0,06	0,025	≤ 0,1	0,09	0,12
HX180BD	1.0914		0,1	0,50	0,70	0,06	0,025	≤ 0,1	0,09	0,12
HX220YD	1.0923		0,01	0,20	0,90	0,08	0,025	≤ 0,1	0,09	0,12
HX220BD	1.0919		0,1	0,50	0,70	0,08	0,025	≤ 0,1	0,09	0,12
HX260YD	1.0926		0,01	0,25	1,30	0,10	0,025	≤ 0,1	0,09	0,12
HX260BD	1.0924		0,1	0,50	0,80	0,10	0,025	≤ 0,1	0,09	0,12
HX260LAD	1.0929		0,11	0,50	0,60	0,030	0,025	≥ 0,015	0,09	0,12
HX300YD	1.0927		0,015	0,30	1,60	0,10	0,025	≤ 0,1	0,09	0,12
HX300BD	1.0930		0,11	0,50	0,80	0,12	0,025	≤ 0,1	0,09	0,12
HX300LAD	1.0932		0,11	0,50	1,00	0,030	0,025	≤ 0,1	0,09	0,15
HX340BD	1.0945		0,11	0,50	0,80	0,12	0,025	≤ 0,1	0,09	0,12
HX340LAD	1.0933		0,11	0,50	1,00	0,030	0,025	≥ 0,015	0,09	0,15
HX380LAD	1.0934		0,11	0,50	1,40	0,030	0,025	≥ 0,015	0,09	0,15
HX420LAD	1.0935		0,11	0,50	1,40	0,030	0,025	≥ 0,015	0,09	0,15
HX460LAD	1.0990		0,15	0,50	1,70	0,030	0,025	≥ 0,015	0,09	0,15
HX500LAD	1.0991		0,15	0,50	1,70	0,030	0,025	≥ 0,015	0,09	0,15

<sup>a</sup> H flat products of high strength for cold forming;  
X rolling condition (hot rolled or cold rolled) not specified;  
nnn minimum proof strength  $R_{p0,2}$  in MPa;  
D intended for hot-dip coating; for symbols B, Y and LA, see 3.6, 3.10 and 3.11.

**Table 4 — Chemical composition (cast analysis) of multiphase steels for cold forming**

Designation		Chemical composition																	
		% by mass																	
Steel grade	Symbols for the types of available coatings	C max.	Si max.	Mn max.	P max.	S max.	Al <sub>total</sub>	Cr+Mo max.	Nb+Ti max.	V max.	B max.								
Steel name <sup>a</sup>		Steel number																	
FB steels																			
HDT450F	1.0961	+Z, +ZF	0,18	0,50	1,20	0,030	0,010	≥ 0,015	0,30	0,05	0,15	0,005							
HDT560F	1.0959		0,18	0,50	1,80	0,025	0,010	≥ 0,015	0,30	0,15	0,15	0,005							
DP steels																			
HCT450X	1.0937	+Z, +ZF, +ZA	0,14	0,80	2,00	0,080	0,015	≤ 2,00	1,00	0,15	0,20	0,005							
HCT500X	1.0939																		
HCT600X	1.0941																		
HDT580X	1.0936	+Z, +ZF	0,17		2,20														
HCT780X	1.0943	+Z, +ZF, +ZA	0,18		2,50														
HCT980X	1.0944		0,23																
TRIP steels																			
HCT690T	1.0947	+Z, +ZF, +ZA	0,32	2,20	2,50	0,12	0,015	≤ 2,00	0,60	0,20	0,20	0,005							
HCT780T	1.0948																		
CP steels																			
HCT600C	1.0953	+Z, +ZF, +ZA	0,18	0,80	2,20	0,080	0,015	≤ 2,00	1,00	0,15	0,20	0,005							
HDT750C	1.0956	+Z, +ZF																	
HCT780C	1.0954	+Z, +ZF, +ZA																	
HDT780C	1.0957	+Z, +ZF																	
HDT950C	1.0958																		
HCT980C	1.0955	+Z, +ZF, +ZA							0,25							1,20		0,22	
MS steels																			
HDT1200M	1.0965	+Z, +ZF	0,25	0,80	2,00	0,060	0,015	≤ 2,00	1,20	0,15	0,22	0,005							

<sup>a</sup> H flat products of high strength for cold forming;  
C cold rolled products;  
D hot rolled products;  
T(n)nnn minimum tensile strength  $R_m$  (rounded up) in MPa.  
Last symbol of the steel name: F ferritic-bainitic;  
X dual phase;  
T TRIP;  
C complex phase;  
M martensitic.

**Table 5 — Permissible deviations of the product analysis from specified limits on cast analysis given in Tables 1 to 4**

Element	Specified limit of the cast analysis in Tables 1 to 4 % by mass	Permissible deviation of the product analysis % by mass
C	$\leq 0,32$	+ 0,02
Si	$\leq 0,60$	+ 0,03
	$> 0,60 \leq 0,80$	+ 0,05
	$> 0,80 \leq 2,20$	+ 0,10
Mn	$\leq 2,50$	+ 0,10
P	$\leq 0,12$	+ 0,01
S	$\leq 0,015$	+ 0,003
	$> 0,015 \leq 0,045$	+ 0,005
Al <sub>total</sub>	$\geq 0,015$	- 0,005
	$\leq 2,00$	+ 0,10
Cr+Mo	$\leq 1,20$	+ 0,05
Nb	$\leq 0,09$	+ 0,02
Ti	$\leq 0,15$	+ 0,02
Nb + Ti	$\leq 0,20$	+ 0,02
V	$\leq 0,22$	+ 0,02
B	$\leq 0,005$	+ 0,001

## 7.2 Mechanical properties

### 7.2.1 General

**7.2.1.1** The tensile test values apply to the test direction given in Tables 6 to 8 and 7.2.5.2 or 7.2.5.3. They are related to the test piece cross-section without coating.

**7.2.1.2** The strain ratio  $r$  (see Table 6) and the strain hardening exponent  $n$  (see Tables 6 and 8 to 10) shall be determined in the range of homogeneous deformation, within the strain range of 10 % to 20 %.

The uniform elongation  $A_g$  of the material to be tested may be lower than 20 %. In this case the uniform elongation  $A_g$  represents the upper limit of the strain range, and the lower limit of the strain range shall be agreed at the time of enquiry and order.

**7.2.1.3** The specified mechanical properties (and freedom from stretcher strains for surface quality B or C, see 7.5.2 and 7.8) apply for following steel grades and periods commencing from the agreed date on which the products are made available:

a) mechanical properties:

- 1) 1 month for steel grades DX51D, DX 52D and DX53D and for the steel grades for construction;
- 2) 3 months for bake-hardening steels and multiphase steels;
- 3) 6 months for steel grades DX54D, DX55D, DX56D and DX57D and high strength steels, except bake hardening steels.

b) freedom from stretcher strains for surface quality B or C:

- 1) 3 months for bake-hardening steels, if storage temperature is below 50°C;
- 2) 6 months for steel grades DX54D, DX55D, DX56D and DX57D and interstitial free steels;
- 3) no requirement for a fixed period for all other steels.

## **7.2.2 Low carbon steels for cold forming**

**7.2.2.1** The products shall comply with the requirements in Table 6.

**7.2.2.2** If so agreed at the time of enquiry and order, products specified in Table 6, except those made of steel grade DX51D, may be supplied with suitability for manufacturing a specific part. In this case the values given in Table 6 do not apply. The reject tolerances arising when the material is processed shall not exceed a specific proportion to be agreed at the time of enquiry and order.

**Table 6 — Mechanical properties (transverse direction) of low carbon steels for cold forming**

Designation			Yield strength	Tensile strength	Elongation	Plastic strain ratio	Strain hardening exponent
			$R_e^a$	$R_m$	$A_{80}^b$	$r_{90}$	$n_{90}$
Steel grade		Symbols for the types of available coatings	MPa	MPa	%	min.	min.
Steel name	Steel number						
DX51D	1.0226	+Z,+ZF,+ZA,+AZ,+AS	—	270 to 500	22	—	—
DX52D	1.0350	+Z,+ZF,+ZA,+AZ,+AS	140 to 300 <sup>c</sup>	270 to 420	26	—	—
DX53D	1.0355	+Z,+ZF,+ZA,+AZ,+AS	140 to 260	270 to 380	30	—	—
DX54D	1.0306	+Z,+ZA	120 to 220	260 to 350	36	1,6 <sup>d</sup>	0,18
DX54D	1.0306	+ZF	120 to 220	260 to 350	34	1,4 <sup>d</sup>	0,18
DX54D	1.0306	+AZ	120 to 220	260 to 350	36	—	—
DX54D	1.0306	+AS	120 to 220	260 to 350	34	1,4 <sup>d, e</sup>	0,18 <sup>e</sup>
DX55D <sup>f</sup>	1.0309	+AS	140 to 240	270 to 370	30	—	—
DX56D	1.0322	+Z,+ZA	120 to 180	260 to 350	39	1,9 <sup>d</sup>	0,21
DX56D	1.0322	+ZF	120 to 180	260 to 350	37	1,7 <sup>d, e</sup>	0,20 <sup>e</sup>
DX56D	1.0322	+AS	120 to 180	260 to 350	39	1,7 <sup>d, e</sup>	0,20 <sup>e</sup>
DX57D	1.0853	+Z,+ZA	120 to 170	260 to 350	41	2,1 <sup>d</sup>	0,22
DX57D	1.0853	+ZF	120 to 170	260 to 350	39	1,9 <sup>d, e</sup>	0,21 <sup>e</sup>
DX57D	1.0853	+AS	120 to 170	260 to 350	41	1,9 <sup>d, e</sup>	0,21 <sup>e</sup>

<sup>a</sup> If the yield point is not pronounced, the values apply to the 0,2 %-proof strength  $R_{p0,2}$ ; if the yield strength is pronounced, the values apply to the lower yield point  $R_{eL}$ .

<sup>b</sup> Decreased minimum elongation values apply for product thickness  $t \leq 0,50$  mm (minus 4 units) and for  $0,50$  mm  $< t \leq 0,70$  mm (minus 2 units).

<sup>c</sup> This value applies to skin passed products only (surface qualities B and C).

<sup>d</sup> For  $t > 1,5$  mm, the minimum  $r_{90}$ -value reduced by 0,2 applies.

<sup>e</sup> For  $t \leq 0,70$  mm, the minimum  $r_{90}$ -value reduced by 0,2 and the minimum  $n_{90}$ -value reduced by 0,01 apply.

<sup>f</sup> 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.

### 7.2.3 Steels for construction

The products shall comply with the requirements in Table 7.

**Table 7 — Mechanical properties (longitudinal direction) of steels for construction**

Designation			Mechanical properties		
Steel grade		Symbols for the types of available coatings	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	1.0241	+Z,+ZF,+ZA,+AZ	220	300	20
S250GD	1.0242	+Z,+ZF,+ZA,+AZ,+AS	250	330	19
S280GD	1.0244	+Z,+ZF,+ZA,+AZ,+AS	280	360	18
S320GD	1.0250	+Z,+ZF,+ZA,+AZ,+AS	320	390	17
S350GD	1.0529	+Z,+ZF,+ZA,+AZ,+AS	350	420	16
S550GD	1.0531	+Z,+ZF,+ZA,+AZ	550	560	—

<sup>a</sup> If the yield point is pronounced, the values apply to the upper yield point  $R_{eH}$ .

<sup>b</sup> For all grades except S550GD, a range of 140 MPa can be expected for tensile strength.

<sup>c</sup> Decreased minimum elongation values apply for product thickness  $t \leq 0,50$  mm (minus 4 units) and for  $0,50$  mm  $< t \leq 0,70$  mm (minus 2 units).

## 7.2.4 Steels with high proof strength for cold forming

**7.2.4.1** The products shall comply with the requirements in Table 8.

**7.2.4.2** If so agreed at the time of enquiry and order, products with suitability for manufacturing a specific part can be supplied. In this case the values in Table 8 do not apply. The reject tolerances arising when the material is processed shall not exceed a specific proportion to be agreed upon at the time of enquiry and order.

**Table 8 — Mechanical properties (transverse direction) of steels with high proof strength for cold forming**

Designation		Symbols for the types of available coatings	Proof strength <sup>a</sup> $R_{p0,2}$ MPa	Bake-Hardening Index $BH_2$ MPa min.	Tensile strength $R_m$ MPa	Elongation $A_{80}^{b,c}$ % min.	Plastic strain ratio $r_{90}^{c,d}$ min.	Strain hardening exponent $n_{90}$ min.
Steel grade								
Steel name	Steel number							
HX160YD	1.0910	+Z, +ZF, +ZA,  +AZ, +AS	160 to 220	—	300 to 360	37	1,9	0,20
HX180YD	1.0921		180 to 240	—	330 to 390	34	1,7	0,18
HX180BD	1.0914		180 to 240	35	290 to 360	34	1,5	0,16
HX220YD	1.0923		220 to 280	—	340 to 420	32	1,5	0,17
HX220BD	1.0919		220 to 280	35	320 to 400	32	1,2	0,15
HX260YD	1.0926		260 to 320	—	380 to 440	30	1,4	0,16
HX260BD	1.0924		260 to 320	35	360 to 440	28	—	—
HX260LAD	1.0929		260 to 330	—	350 to 430	26	—	—
HX300YD	1.0927		300 to 360	—	390 to 470	27	1,3	0,15
HX300BD	1.0930		300 to 360	35	400 to 480	26	—	—
HX300LAD	1.0932		300 to 380	—	380 to 480	23	—	—
HX340BD	1.0945		340 to 400	35	440 to 520	24	—	—
HX340LAD	1.0933		340 to 420	—	410 to 510	21	—	—
HX380LAD	1.0934		380 to 480	—	440 to 560	19	—	—
HX420LAD	1.0935		420 to 520	—	470 to 590	17	—	—
HX460LAD	1.0990		460 to 560	—	500 to 640	15	—	—
HX500LAD	1.0991		500 to 620	—	530 to 690	13	—	—

<sup>a</sup> If the yield strength is pronounced, the values apply to the lower yield point  $R_{eL}$ .

<sup>b</sup> Decreased minimum elongation values apply for product thickness  $t \leq 0,50$  mm (minus 4 units) and for  $0,50$  mm  $< t \leq 0,70$  mm (minus 2 units).

<sup>c</sup> For AS-, AZ- and ZF-coatings, the minimum  $A_{80}$  value reduced by 2 units and the minimum  $r_{90}$ -value reduced by 0,2 apply.

<sup>d</sup> For product thickness  $> 1,5$  mm, the minimum  $r_{90}$ -value reduced by 0,2 applies.

## 7.2.5 Multiphase steels for cold forming

**7.2.5.1** The products shall comply with the requirements in Table 9 or Table 10.

**7.2.5.2** The values for the tensile test apply for transverse pieces. If ordered in accordance with 7.2.5.1, the mechanical property values in Tables 9 and 10 apply for a period of three months for all grades commencing from the date on which the products are made available by the manufacturer.

**7.2.5.3** Alternatively, by agreement at the time of enquiry and order, the values in Tables 9 and 10 shall apply for longitudinal instead of transverse test pieces, but not both at the same time.

**Table 9 — Mechanical properties of multiphase steels for cold forming (cold rolled products)**

Steel grade +Z, +ZF, +ZA		Proof strength $R_{p0,2}$ MPa	Tensile strength $R_m$ MPa	Elongation $A_{80}^{a,b}$ %	Strain hardening exponent $n_{10-UE}$	Bake-Hardening Index $BH_2$ MPa
Steel name	Steel number		min.	min.	min.	min.
DP steels						
HCT450X	1.0937	260 to 340	450	27	0,16	30
HCT500X	1.0939	300 to 380	500	23	0,15	30
HCT600X	1.0941	340 to 420	600	20	0,14	30
HCT780X	1.0943	450 to 560	780	14	–	30
HCT980X	1.0944	600 to 750	980	10	–	30
TRIP steels						
HCT690T	1.0947	430 to 550	690	23	0,18	40
HCT780T	1.0948	470 to 600	780	21	0,16	40
CP steels						
HCT600C	1.0953	350 to 500	600	16	–	30
HCT780C	1.0954	500 to 700	780	10	–	30
HCT980C	1.0955	700 to 900	980	7	–	30
<p><sup>a</sup> Decreased minimum elongation values apply for product thickness <math>t \leq 0,50</math> mm (minus 4 units) and for <math>0,50</math> mm <math>&lt; t \leq 0,70</math> mm (minus 2 units).</p> <p><sup>b</sup> For ZF coatings, the minimum elongation value reduced by 2 units applies.</p>						

**Table 10 — Mechanical properties of multiphase steels for cold forming (hot rolled products)**

Steel grade +Z, +ZF		Proof strength $R_{p0,2}$ MPa	Tensile strength $R_m$ MPa	Elongation $A_{80}$ %	Strain hardening exponent $n_{10-UE}$ min.	Bake-Hardening Index $BH_2$ MPa
Steel name	Steel number		min.	min.		min.
FB steels						
HDT450F	1.0961	320 to 420	450	23	–	30
HDT560F	1.0959	460 to 570	560	16	–	30
DP steels						
HDT580X	1.0936	330 to 460	580	19	0,13	30
CP steels						
HDT750C	1.0956	620 to 760	750	10	–	30
HDT780C	1.0957	680 to 830	780	10	–	30
HDT950C	1.0958	720 to 920	950	9	–	30
MS steels						
HDT1200M	1.0965	900 to 1 150	1 200	5	–	30



### **7.3 Type of coatings and coating mass**

**7.3.1** The products shall be supplied with coatings of zinc (Z), zinc-iron-alloy (ZF), zinc-aluminium-alloy (ZA), aluminium-zinc-alloy (AZ) or aluminium-silicon-alloy (AS) as specified in the relevant Table 1, 2, 3 or 4.

**7.3.2** The available coating masses are given in Table 11. Deviating coating masses and/or different coating masses on each surface may be supplied if agreed at the time of enquiry and order.

Thicker coatings may limit the formability and weldability of the products. Therefore, the forming and weldability requirements shall be taken into account when ordering the coating mass.

The surfaces may have a different appearance as a result of the manufacturing process.

Table 11 — Coating mass

Coating designation	Minimum total coating mass <sup>a</sup> , both surfaces g/m <sup>2</sup>		Theoretical guidance values for coating thickness per surface in the single spot test µm		Density g/cm <sup>3</sup>
	Triple spot test	Single spot test	Typical value <sup>b</sup>	Range <sup>c</sup>	
Zinc coating masses (Z)					
Z100	100	85	7	5 to 12	7,1
Z140	140	120	10	7 to 15	
Z200	200	170	14	10 to 20	
Z225	225	195	16	11 to 22	
Z275	275	235	20	15 to 27	
Z350 <sup>d</sup>	350	300	25	19 to 33	
Z450 <sup>d</sup>	450	385	32	24 to 42	
Z600 <sup>d</sup>	600	510	42	32 to 55	
Zinc-iron coating masses (ZF)					
ZF100	100	85	7	5 to 12	7,1
ZF120	120	100	8	6 to 13	
Zinc-aluminium alloy coating masses (ZA)					
ZA095	95	80	7	5 to 12	6,9
ZA130	130	110	10	7 to 15	
ZA185	185	155	14	10 to 20	
ZA200	200	170	15	11 to 21	
ZA255	255	215	20	15 to 27	
ZA300 <sup>d</sup>	300	255	23	17 to 31	
Aluminium-zinc alloy coating masses (AZ), not for multiphase steels					
AZ100	100	85	13	9 to 19	3,8
AZ150	150	130	20	15 to 27	
AZ185	185	160	25	19 to 33	
Aluminium-silicon alloy coating masses (AS), not for multiphase steels					
AS060	60	45	8	6 to 13	3,0
AS080	80	60	14	10 to 20	
AS100 <sup>d</sup>	100	75	17	12 to 23	
AS120 <sup>d</sup>	120	90	20	15 to 27	
AS150 <sup>d</sup>	150	115	25	19 to 33	
<sup>a</sup> See 7.9. <sup>b</sup> Coating thicknesses can be calculated from the coating masses (see 7.9). <sup>c</sup> The user can expect that these limiting values are obtained on the upper surface and on the reverse surface. <sup>d</sup> Only steel grades in accordance with Tables 6 and 7 and LAD steel grades in accordance with Table 8.					

## **7.4 Coating finish**

### **7.4.1 General**

Possible coating finishes are given in Tables 12 to 14 for the relevant types of coating.

Depending on the coating conditions, crystals of different sizes and brightness arise. The quality of the coating is not affected by this.

### **7.4.2 Zinc coated products (Z)**

#### **7.4.2.1 Normal spangle (N)**

The finish is obtained when the zinc coating is left to solidify normally. 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.

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

#### **7.4.2.2 Minimized spangle (M)**

The finish is obtained by influencing the solidification process in a specific way. The surface will have reduced spangles, in some cases, not visible to the unaided eye. The finish may be ordered if the normal spangle (see 7.4.2.1) does not satisfy the surface appearance requirements.

### **7.4.3 Zinc-iron alloy coated products (ZF)**

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

### **7.4.4 Zinc-aluminium coated products (ZA)**

The coating finish has a metallic lustre that is the result of unrestricted growth of the zinc-aluminium crystals during normal solidification. Crystals of different sizes and brightness may appear depending on the manufacturing conditions. The quality of the coating is not affected by this.

### **7.4.5 Aluminium-zinc coated products (AZ)**

The products are supplied with a normal spangle. Normal spangle is a coating finish, having a metallic lustre, which is the result of unrestricted growth of the aluminium-zinc crystals during normal solidification.

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

### **7.4.6 Aluminium-silicon coated products (AS)**

Deviating from other hot-dip coated products, a relatively pronounced (Al-Fe-Si) alloy layer is formed over the base material during hot-dip coating. This shall be taken into account for 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. The test method is described in Annex C.

## **7.5 Surface quality**

### **7.5.1 General**

The products may be supplied with one of the surface qualities described in 7.5.2 (see Tables 12 to 14).

**Table 12 — Available coatings, finishes and surface qualities for zinc coatings (Z)**

Coating designation <sup>a</sup>	N	M Surface quality <sup>a</sup>		
	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)	—	—
(Z450)	(X)	(X)	—	—
(Z600)	(X)	(X)	—	—

<sup>a</sup> The coatings and surface qualities given in brackets are available on agreement.

**Table 13 — Available coatings and surface qualities for zinc-iron alloy coatings (ZF)**

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

**Table 14 — Available coatings, finishes and surface qualities for zinc-aluminium coatings (ZA), aluminium-zinc coatings (AZ) and aluminium-silicon coatings (AS)**

Coating designation	Surface quality <sup>a</sup>		
	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	—	—
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)

<sup>a</sup> The surface qualities given in brackets are available on agreement.

## 7.5.2 Types of surface qualities

### 7.5.2.1 As coated 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. Coil breaks and stretcher strains may appear as well.

### 7.5.2.2 Improved surface (B)

Surface quality B is obtained by skin passing. 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.

NOTE 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".

### 7.5.2.3 Best quality surface (C)

Surface quality C is obtained by skin passing. The controlled surface shall make it possible to apply a uniform high-class paint finish. The other surface shall at least have the characteristics of surface quality B (see 7.5.2.2).

## 7.5.3 Roughness

A range for surface roughness ( $R_a$  values) and their verification may be agreed at the time of enquiry and order. This does not apply for the non-skin passed condition (surface quality A).

## 7.6 Surface treatment (surface protection)

### 7.6.1 General

At the time of enquiry and order one of the following surface treatment conditions shall be agreed:

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

NOTE 1 The effect of the surface protection "oiled" especially depends on the temporary impact by storage and transport. (see 6.2.3).

The products are only supplied without surface treatment (untreated (U)) if expressly desired by the purchaser on his own responsibility (see also NOTE 2 at the end of this sub-clause).

Usually the products are supplied chemically passivated and/or oiled. In the case of oiling, both sides are corrosion protected by a layer of neutral non-drying oil, free of impurities and uniformly spread. Under normal packing, transportation, loading and storage conditions, there will be no corrosion for up to three months starting from the date when the product is available at the manufacturer's work. However the period of protection afforded depends on the atmospheric and storage conditions.

The layer of oils shall be capable of being removed by alkaline solutions or usual solvents. The choice of protective oils may be agreed at the time of enquiry and order.

If the purchaser does not require the surfaces to be oiled and/or chemically passivated, this shall be clearly indicated at the time of enquiry and order.

If the conditions of transportation or storage are such that special protection against corrosion is required, the purchaser shall inform the manufacturer accordingly at the time of enquiry and order.

NOTE 2 In the case of orders for non-protected products, the manufacturer is not responsible for the risk of corrosion. The purchaser is also advised that there is a greater risk of the appearance of scratches during handling, transportation and application.

### **7.6.2 Chemical passivation (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 this treatment are permissible and do not impair the quality.

### **7.6.3 Oiling (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.

### **7.6.4 Chemical passivation and oiling (CO)**

Agreement may be reached on this combination of surface treatment in accordance with 7.6.2 and 7.6.3 if increased protection against the formation of corrosion products is required.

### **7.6.5 Phosphating (P)**

This treatment improves the adherence and protective effect of a coating applied by the processor. It also reduces the risk of corrosion during transport and storage.

The combination of phosphating and oiling (PO) may improve formability.

### **7.6.6 Sealing (S)**

Application of a transparent organic film coating by agreement, on one or both sides, of approximately 1 g/m<sup>2</sup>.

This treatment offers additional corrosion protection, depending on its nature, increases the protection against fingerprints. It may improve the sliding characteristics during forming operations and can be used as a priming coat for subsequent painting.

The type of S coating should be agreed at the time of enquiry and order.

## **7.7 Coil breaks and bends (kinks)**

### **7.7.1 Freedom from coil breaks**

If particular requirements for freedom from coil breaks (fluting) are agreed at the time of enquiry and order, it is recommended to order improved surface quality B (see 7.5.2.2).

### 7.7.2 Bends (kinks) by winding on coiler drums

For the thickness of the strips  $\geq 0,90$  mm bends (kinks) must be expected due to winding the strip on the coiler drum. When processing, appropriate equipment for levelling (with small diameter rolls) has to be used.

### 7.8 Stretcher strains

In order to avoid the formation of stretcher strains when cold forming, it is recommended to order improved surface quality B (see 7.5.2.2). As there is a tendency for stretcher strains to form again after some time, it is in the interest of the purchaser to use the products as soon as possible.

### 7.9 Coating mass

The coating mass shall correspond to the data in Table 11. The values apply for the total mass of the coating on both surfaces for the triple spot test and the single spot test (see 8.4.3 and 8.5.5).

The coating mass is not always equally distributed on both the product surfaces. However, it may be assumed that a coating mass of at least 40 % of the value given in Table 11 for the single spot test exists on each surface of the product.

A maximum or minimum value for the coating mass per surface of the product (single spot test) for each coating given in Table 11 may be agreed at the time of enquiry and order.

The thickness of the coating can be calculated from coating masses, e.g. as follows:

A zinc coating mass of  $100 \text{ g/m}^2$  on both surfaces corresponds to a zinc coating thickness of about  $7,0 \text{ }\mu\text{m}$  per surface.

$$\frac{\text{zinc coating mass, g/m}^2 \text{ (both surfaces)}}{2 \times 7,1 \text{ g/cm}^3 \text{ (= zinc-density)}} = \text{zinc-coating thickness (}\mu\text{m per surface)} \quad (1)$$

For other coatings similar calculations may be applied (see Table 11).

### 7.10 Adhesion of coating

The adhesion of the coating shall be tested by using an appropriate method. The selection of the test method is left to the discretion of the manufacturer.

### 7.11 Surface condition

7.11.1 The surface shall comply with the requirements in 7.4 to 7.6.

7.11.2 When supplying strip in coils, there is greater risk of surface defects than if sheet and cut lengths are supplied as it is not possible for the manufacturer to eliminate all the defects in a coil. This shall be taken into account by the purchaser when evaluating the products.

### 7.12 Tolerances on dimensions and shape

The requirements of EN 10143 shall apply.

### 7.13 Suitability for further processing

7.13.1 The products according to this document (except products made of the grade S550GD) shall be suitable for welding using the normal welding methods. With heavier coating masses, special measures shall be taken for welding, as appropriate.

**7.13.2** Products complying with the requirements of this document can be bonded together provided an appropriate prior surface treatment is applied to the surfaces to be bonded.

**7.13.3** All steel grades and surface conditions are suitable for organic coating provided a prior appropriate surface treatment is applied. The final appearance of the product and its suitability for use will depend on the coating finish (see 7.4).

## 8 Inspection

### 8.1 Types of inspection and inspection documents

**8.1.1** Unless otherwise specified at the time of enquiry and order (see 8.1.2 and 8.1.3), the products shall be delivered with non-specific inspection without inspection document.

**8.1.2** Specific testing in accordance with the requirements in 8.2 to 8.6 may be specified at the time of enquiry and order.

**8.1.3** The type of inspection document to be delivered in accordance with EN 10204, if requested for non-specific inspection (inspection document 2.1 or 2.2) or mandatory to be delivered for specific inspection (inspection document 3.1 or 3.2), shall be specified at the time of enquiry and order.

If an inspection certificate 3.2 is specified, the purchaser shall notify the manufacturer of the name and address of the organization or person who is to carry out the inspection and produce the inspection document. It shall also be agreed which party shall issue the certificate.

### 8.2 Test units

The test unit consists of a maximum of 20 t or a fraction of 20 t of hot-dip coated flat products of the same grade and nominal thickness, coating mass and surface condition. In the case of strip, a coil weighing more than 20 t shall be regarded as one test unit.

### 8.3 Tests to be carried out

One series of tests shall be carried out per test unit as specified in 8.2 to determine:

- the mechanical properties (see 8.5.1);
- the  $r$ - and  $n$ -values, if specified in Tables 6, 8, 9 or 10 (see 8.5.2);
- the Bake-Hardening Index  $BH_2$ , if specified in Tables 8, 9 or 10 (see 8.5.3);
- the coating mass (see 8.5.5).

By agreement at the time of enquiry and order, the manufacturer may determine the tensile properties and/or the Bake-Hardening Index  $BH_2$  and/or the coating mass by calculation in accordance with an approved method.

### 8.4 Sampling

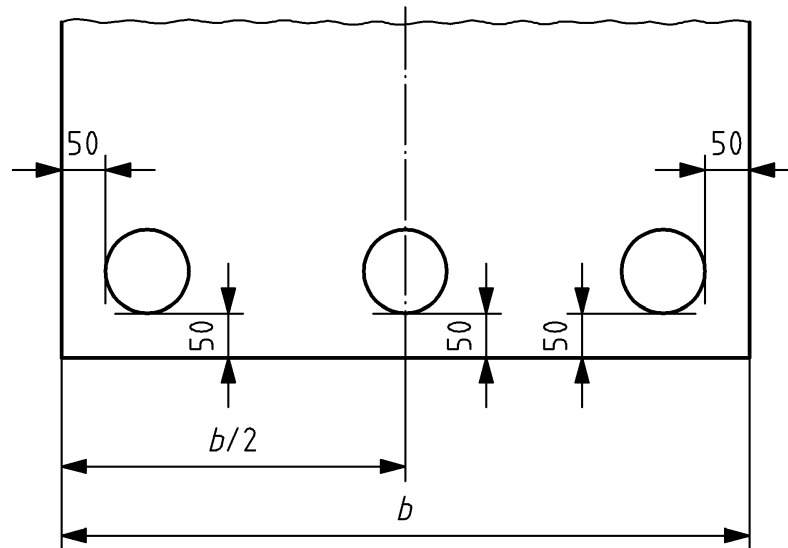
**8.4.1** In the case of strip, the samples shall be taken from the beginning or the end of the coil. In the case of sheet and cut lengths, the selection of the sample shall be left to the discretion of the supplier.

**8.4.2** The sample for the tensile test (see 8.5.1) shall be taken in the specified direction (see 7.2.5.2 and 7.2.5.3 and Tables 6, 7 and 8) at a distance of at least 50 mm from the edge of the product.



**8.4.3** The three samples for testing the coating mass (see 8.5.5) shall be taken as shown in Figure 1 if the product width permits. The samples may be round or square and the individual sample shall be at least 5 000 mm<sup>2</sup> in area.

Dimensions in mm



**Key**

*b* Strip or sheet width

**Figure 1 — Position of the samples for determining the coating mass**

If sampling as shown in Figure 1 is not possible because the product width is too small, only one sample shall be taken with an area of at least 5 000 mm<sup>2</sup>. The coating mass determined from it shall comply with the requirements for the single spot test as specified in Table 11.

**8.4.4** All the samples shall be taken and machined, if necessary, in such a way that the results of the tests are not affected.

**8.5 Test methods**

**8.5.1 Tensile test**

The tensile test shall be carried out as specified in EN 10002-1 using type 2 test pieces (initial gauge length  $L_0 = 80$  mm, width  $b = 20$  mm) in accordance with EN 10002-1:2001, Annex B (see also 7.2.1.1).

**8.5.2 Plastic strain ratio and hardening exponent**

The determination of the plastic strain ratio  $r$  and the strain hardening exponent  $n$  shall be carried out in accordance with ISO 10113 and ISO 10275, respectively.

**8.5.3 Bake Hardening index**

The determination of the yield strength increase by the effect of heat treatment (Bake-Hardening-Index  $BH_2$ ) shall be carried out in accordance with EN 10325.

#### 8.5.4 Surface inspection

**8.5.4.1** The product surface shall be visually inspected for verification of conformance with the requirements in 7.4 to 7.6.

**8.5.4.2** Unless otherwise agreed at the time of enquiry and order, only one surface shall be inspected at the manufacturer's works. If requested, the manufacturer shall inform the purchaser whether the inspected surface is the top surface or the bottom surface.

Small edge cracks which may occur in the case of mill edges are not justification for rejection.

**8.5.4.3** Roughness (*Ra*) measurements, where applicable (see 7.5.3), shall be carried out in accordance with EN 10049.

#### 8.5.5 Coating mass

##### 8.5.5.1 General

The coating mass shall be determined from the difference in mass of the samples before and after the coating has been removed chemically. In the test with specimen according to Figure 1, the triple spot test value is the arithmetic mean of the three test results. Each individual result shall meet the requirements of the single spot test as given in Table 11.

Other methods – e.g. non-destructive tests – may be used for continuous checks at the manufacturer's works.

In cases of dispute, the methods described in Annex A (Z, ZF, ZA and AZ) or Annex B (AS) shall be used.

##### 8.5.5.2 Special method for determination of the mass of the Fe-Al-Si alloy layer

If it has been agreed to determine the mass of the Al-Fe-Si alloy layer resulting from aluminium-silicon alloy (AS) coating (see 7.4.6), the method for its determination given in Annex C shall be applied.

#### 8.6 Retests

The requirements of EN 10021 shall apply. In the case of coils, the retest specimens shall be taken from a distance of at least one lap away, but with a maximum of 20 m from the end of the coil.

### 9 Marking

**9.1** A label shall be attached to each coil or bundle containing at least the following information:

- a) name or mark of the manufacturer's works;
- b) designation (consisting of 5.1b) and 5.1f) to 5.1k));
- c) nominal dimensions of the product;
- d) identification number;
- e) order number;
- f) mass of the coil or bundle.

Bar coding according to EN 606 can supplement marking, when the abovementioned minimum information is also given in clear text.

9.2 Marking of the products by branding may be agreed at the time of enquiry and order.

## **10 Packing**

The packing requirements for the product shall be agreed at the time of enquiry and order.

## **11 Storage and transportation**

**11.1** Moisture, in particular condensation between the sheets, laps of the coil or other adjacent parts made of hot-dip coated flat products, can lead to the formation of corrosion products. The possible types of temporary surface protection are given in 7.6. As a precaution, the products should be transported and stored dry and protected from moisture.

**11.2** During transportation, dark spots may appear on the hot-dip coated surfaces as a result of friction. Generally, they only impair the appearance. Friction is reduced by oiling the products. Additionally, secure packing, transporting the coils laid flat and avoiding local pressure points, reduce the risk of dark spots.

## Annex A (normative)

### Reference method for determination of the zinc, zinc-iron, zinc-aluminium and aluminium-zinc coating mass

#### A.1 Principle

The sample shall be at least 5 000 mm<sup>2</sup> in area. Using a sample with a surface area of 5 000 mm<sup>2</sup>, the loss of mass in grams when the coating is dissolved, multiplied by 200, will represent the coating mass in grams per square metre of the product, including both sides.

#### A.2 Reagent and preparation of the solution

##### A.2.1 Reagent

A.2.1.1 Hydrochloric acid (HCl  $\rho_{20} = 1,19$  g/ml).

A.2.1.2 Hexamethylenetetramine (C<sub>6</sub>H<sub>12</sub>N<sub>4</sub>).

##### A.2.2 Preparation of the solution

The hydrochloric acid is diluted with deionized or distilled water in the ratio one part pure HCl to one part water (50 % dilution). Hexamethylenetetramine is then added, stirring, in the ratio of 3,5 g/l of dilute hydrochloric acid solution.

This prepared solution permits the execution of numerous successive dissolutions under satisfactory conditions of attack of the coating, both from the point of view of speed and accuracy.

#### A.3 Apparatus

Balance capable of weighing samples to an accuracy of 0,001 g. For the test, use a take-off device.

#### A.4 Procedure

The following operations are applied to each sample:

- a) If necessary, degrease the sample with an organic solvent which will not attack the coating, then dry the sample;
- b) Weigh the sample to an accuracy of 0,001 g;
- c) Place the sample in the hydrochloric acid solution with hexamethylenetetramine inhibitor (see A.2) at ambient temperature (20 °C to 25 °C). Leave the sample immersed in the solution until the release of hydrogen ceases or only a few bubbles are released;
- d) After the attack, the sample is washed and brushed under running water, dried with a cloth and then by heating to around 100 °C and cooled or dried by blowing with warm air;

- e) Weigh the sample again to an accuracy of 0,001 g; determine the difference between the mass of the coated sample and that of the sample without its coating. This difference, calculated in grams, represents the mass  $m$  of the coating.

## Annex B (normative)

### Reference method for determination of the aluminium-silicon coating mass

#### B.1 Principle

The method described below is used for determining the coating mass of hot-dip aluminium-silicon coated flat products. The samples are weighed before and after the coating is removed.

#### B.2 Reagents

**B.2.1** Hydrochloric acid (HCl  $\rho_{20} = 1,19$  g/ml).

**B.2.2** Sodium hydroxide solution with 20 % concentration made by dissolving 20 g sodium hydroxide in 80 ml of water.

#### B.3 Procedure

##### B.3.1 Samples

The samples are taken from the product in accordance with 8.4.3 and 8.4.4.

The samples shall be clean. If necessary, they are to be washed firstly with suitable solvents, which will not attack the coating, then secondly in alcohol. Finally, they are thoroughly dried.

##### B.3.2 Method

After washing as specified in B.3.1, the samples are weighed to an accuracy of 0,001 g and then placed in the hot sodium hydroxide solution until the reaction ceases. Then the test samples are taken out of this solution, rubbed under water, roughly dried off with a cloth and placed in cold hydrochloric acid for 2 s to 3 s.

The samples are then rinsed under water and again immersed in the sodium hydroxide solution until no further reaction can be established. This process is to be repeated until no reaction is visible when the sample is dipped into the sodium hydroxide solution. The samples are then washed, dried and re-weighed (accuracy 0,001 g).

#### B.4 Evaluation

The coating mass in grams per square metre of the product (on both sides) is obtained from the formula:

$$\frac{m_0 - m_1}{A} \tag{B.1}$$

where

$m_0$  is the mass of the sample before the coating is stripped off, in grams;

- $m_1$  is the mass of the sample after the coating has been removed, in grams;
- $A$  is the area of the sample used in square metres.

## Annex C (normative)

### Method for determination of the mass of the Al-Fe-Si alloy layer

#### C.1 Principle

The method described below is used for determining the mass of the alloy layer on samples of hot-dip aluminium-silicon coated flat products. Firstly, the so-called non-alloy layer and secondly the alloy layer are removed, according to the method in Annex B. The method is based on the reaction of tin (II) chloride solution with aluminium to form metallic tin (sponge); this solution does not react with the alloy or with the iron base material. The samples are weighted before and after removal of the alloy layer.

#### C.2 Reagents

##### C.2.1 Tin (II) chloride solution

**C.2.1.1** To produce the stock solution, 1 000g  $\text{SnCl}_2 \cdot \text{H}_2\text{O}$  are dissolved in 500 ml of diluted hydrochloric acid (1:1). Make up to 1 000 ml adding 5 g to 10 g metallic tin. Heat until the solution is clear.

**C.2.1.2** To produce the test solution, 20 ml of stock solution are added to 200 ml  $\text{H}_2\text{O}$  immediately prior to use.

#### C.3 Procedure

##### C.3.1 Removal of the non-alloy layer

The samples taken in accordance with 8.4.4 are cleaned with petroleum ether and immersed in 200 ml of test solution (see C.2.1.2) until the reaction ceases.

Once the test samples have been removed from the solution, the sponge tin is scraped off with a small spatula. The process is repeated until no further reaction takes place. The samples are then washed and dried.

##### C.3.2 Determination of alloy layer

The test samples prepared in accordance with C.3.1 are treated as described in B.3.2.

#### C.4 Evaluation

The mass of the alloy layer is calculated using formula (B.1) from the difference in mass of the samples before and after the test.



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