

Deutsches Kupferinstitut  
Am Bonnehof 5  
40474 Düsseldorf

Technical delivery terms for uncoated copper and  
copper alloy strips  
– surface condition –

DKI-Information Sheet No:  
100

## 1. Scope

This sheet describes the surface condition of flat-rolled products and establishes a framework that can be used to define a set of general terms and conditions for the supply of these materials.

This sheet applies to copper and copper alloy strip used in the following areas:

- cables
- contacts, springs and connectors
- solar thermal applications
- leadframes
- transformers
- clad materials

It is concerned with quality requirements regarding the visual features and defects/imperfections that can arise during the manufacture of copper and copper-alloy strip using state of the art technology, specifically the type, permitted depth and permitted size of the affected surface region. Other imperfections (e.g. those arising from transport, storage, etc.) are not dealt with in this sheet.

This document is to be applied only insofar as the relevant material or product standards do not stipulate other requirements regarding the surface condition.

This sheet serves as a supplement to the relevant material and product standards. The buyer and supplier shall agree whether the individual quality attributes are to be tested in accordance with this sheet, the relevant standard or the customer's own specifications.

## 2. Terminology

Casting, milling, rolling or some other downstream production process can obscure surface imperfections, which may only become apparent during the subsequent processing of the copper or copper-alloy strip material.

Surface imperfections include:

### *Incipient cracks, cracks*

Material separation at the surface of limited physical extent.

Cracks are predominantly caused by material stresses that frequently arise when rolling stock is cooled or as a result of localized overstraining during hot or cold rolling.

### *Blisters*

Raised dome-like areas on the surface of the strip. When viewed in cross-section, blisters appear as cavities and occur individually, in rows or as unordered arrangements.

### *Brush or milling marks*

Visible but barely measurable zones of varying structure that run parallel or at an angle to the milling direction.

### *Roll indentations and Roll Imprints*

Depressions or raised areas created by faulty rolls or small particles attached to the rolls. These imperfections can be distributed periodically at certain distances or irregularly along the length and width of the roll.

### *Rolled-in extraneous material (foreign particles, metal chips)*

Metallic or non-metallic foreign particles or metal chips from the rolling stock that are impressed into the surface of the metal.

### *Flow lines, stretcher lines*

Herringbone-type structure caused by local material flow.

### *Friction marks*

Local mechanical surface damage caused by the relative movement of two coil windings

### *Annealing adhesions*

Local roughening or damage caused by the tearing apart of the (pressure) welded coil windings when the windings are uncoiled after annealing.

### *Rolling adhesions*

Elongated zones in the direction of rolling exhibiting greater roughness due to improper lubrication during cold rolling.

### *Score marks, scratch*

Depressions in the material usually oriented in the direction of rolling and that appear as linear imperfections if material is overlapped.

### *Visible surface marks*

Visible marking of the surface that cannot, however, be quantified by measurement and that shows no repetitive structure.

### *Orange peel*

Surface roughening caused when forming products from metal stock with a coarse grain size and/or when the material is subjected to extreme plastic deformation (bending).

*Grooves and Scratches*

Mechanical surface markings that are predominantly aligned parallel or transverse to the direction of rolling. May be obscured by material overlapping.

*Chatter marks*

Regularly occurring streaks that run transversely to the direction of rolling and are caused by vibrations or by kinks in the material. The distance between neighbouring marks (corrugations) is usually a few millimetres or centimetres.

*Spills, Laminations*

Elongated and overlapped doublings oriented in the direction of rolling, often showing incipient cracking.

*Scales, Flakes*

Fine, irregularly distributed flake-like surface discontinuities. Elongated in the direction of rolling. Extent of elongation depends on degree of forming to which material is subjected. Scale appears as minute particles of shell that are still connected to the base metal at certain points.

*Discolorations*

Streaking or staining caused by auxiliary and operating materials, or heat and moisture-induced tinting of the surface.

**3. Tests**

Acceptance criteria and test procedures are to be agreed at the time the request-for-quote and order confirmation are issued.

Unless otherwise indicated in this sheet, testing of application-related material properties (solderability, weldability, bondability, etc.) shall be conducted in accordance with the applicable standard. The assessment of test results must take account of the processing, materials, pre-treatment, transport and storage conditions of the product.

Surface assessments shall involve random sampling of an area with a width equal to the actual width of the strip but no wider than 50 mm and a length of 1000 mm. Visual inspections shall be carried out without the use of instruments (naked eye inspections).

**4. Acceptance criteria**

Unless specified in the relevant product standard, the acceptance criteria shall conform to the values, specifications and characteristics listed in table 1 (see annex).

**5. Additional information**

Oil can be used to protect the surface. To prevent tarnishing, an anti-tarnish agent such as benzotriazole may be used.

**6. References**

- W. v. Asten, W. Dürrschnabel, A. Leogrande: Walzfehlerkatalog, DGM-Informationsgesellschaft, 1986
- EN ISO 1101, Geometrical Product Specifications (GPS) - Geometrical tolerancing - Tolerances of form, orientation, location and run-out
- EN ISO 1302, Geometrical Product Specifications (GPS) - Indication of surface texture in technical product documentation
- EN ISO 4287, Geometrical Product Specifications (GPS) - Surface texture: Profile method - Terms, definitions and surface texture parameters
- EN ISO 4288, Geometrical Product Specifications (GPS) - Surface texture: Profile method - Rules and procedures for the assessment of surface texture
- ASME B46.1, Surface texture (surface roughness, waviness, and lay)
- EN 10049, *Measurement of roughness average Ra and peak count R<sub>p</sub>c on metallic flat products*
- EN ISO 8785, Geometrical Product Specifications (GPS) - Surface imperfections - Terms, definitions and parameters
- DIN 32506-2, *Testing of solderability for soft soldering; Vertical dipping test for specimens of copper alloys; Testing; Assessment*
- DIN 32506-3, *Testing of solderability for soft soldering; Vertical dipping test for pre-tinned specimens; Testing; Assessment*
- EN ISO 6270-2; *Paints and varnishes - Determination of resistance to humidity - Part 2: Procedure for exposing test specimens in condensation-water atmospheres*

**7. Quality characterization parameters**

Tables 7.1 to 7.6 below specify the quality requirements for copper and copper-alloy strip used in the application areas listed in section 1 above.

Table 7.1: Solar thermal applications

Table 7.4: Contact strip and spring strip

Table 7.2: Strip for Leadframes

Table 7.5: Clad strip

Table 7.3: Cable strip

Table 7.6: Transformer strip

Information on transporting and storing of the above mentioned products can be found in **annex A**.

Table 7.1: Strip for solarthermal application, reference to EN 1652 - 13599

Characterization	Assessment	Unit	Measurand	Measuring method	Testing standard	
Characteristics						
Applied characteristics: <sup>1</sup>						
Roughness	usual	µm	R <sub>a</sub> max. = 0.35 µm	Profile method	EN ISO 3274 EN ISO 4287 EN ISO 4288	
Tarnishing protection	by agreement	-	-	-	-	
Surface cleanness	- Residual carbon		mg/dm <sup>2</sup>	max. 0.10 mg/dm <sup>2</sup>	C-Analyzer	EN 723
	- Oxides	Uniform discoloration without corrosive attack allowed	-	-	visual	
Suitability for joining	- Welding <sup>2</sup>	suitable (Cu-ETP conditionally)	-	-	-	DIN 32506-2 / IEC60068-2-2
	- Soldering and Brazing	suitable (Cu-ETP conditionally)	-	-	Wetting tests, solderingtest	DIN 32506, Teil 2
Suitability for coating <sup>3</sup>	- electroplating	suitable	-	-	-	-
	- sputtering	suitable	-	-	-	-
<b>Discontinuities (reference surface: actual width, but max. 50 mm, length 1000 mm)</b>						
Roll indentations	depth	µm	Depth max. = 40 µm	visual, optical control	-	
Flakes	not allowed, if the coatability is affected	-	-	visual	-	
Spills	not allowed	-	-	visual	-	
Blisters	not allowed	-	-	visual	-	
Holes	not allowed	-	-	visual	-	
Roll imprints	allowed inside the thickness tolerance	µm	see thickness tolerance	visual, Micrometer	-	
Chatter marks	allowed inside the thickness tolerance	µm	see thickness tolerance	visual, Micrometer, profile method	-	
Cold-shut defects	allowed inside the roughness tolerance from surface	µm	see surface roughness	visual, profile method	EN ISO 4287 EN ISO 4288	
Score marks (along and across), Grooves	as per measurand	µm	Depth: R <sub>max</sub> 4 µm	visual, profile method	EN ISO 4287 EN ISO 4288	
Rolled-in extraneous matter (organic, metallic (chips), etc.)	not allowed	-	-	Visual	-	
<b>Optical characteristics</b>						
Streaks	allowed, if the coatability is not affected	-	-	visual	-	
Satin	allowed inside the required surface roughness	in µm	see required surface roughness	visual, profile method	EN ISO 4287 EN ISO 4288	
Discolorations/Tarnishes/Stains	allowed, if removable by pre-treatment before further processing or surface is not affected or technically irrelevant	-	-	visual	-	

<sup>1</sup> Attention should be paid to transport and storage conditions    <sup>2</sup> Attention should be paid to process and material    <sup>3</sup> Attention should be paid to pre-treatment

**Note:** Due to the large number of alloys and tempers as well as applications special agreement on the size and number of discontinuities and measuring method can be arranged between customers and suppliers in some cases.

Table 7.2: Strip for leadframes , reference to EN 1758

Characterization Characteristics	Assessment	Unit	Measurand	Measuring method	Testing standard
-------------------------------------	------------	------	-----------	------------------	------------------

Applied characteristics:<sup>1</sup>

Roughness	usual	µm	S <sup>4</sup> = 0.1 to 1.0 mm: R <sub>a</sub> = max. 0.15 µm S > 1.0 to 2.0 mm: R <sub>a</sub> = max. 0.25 µm	Profile method	EN ISO 4287 EN ISO 4288
tarnishing protection	by agreement	-	-	-	-
Suitability for joining	- Welding <sup>2</sup>	suitable (by agreement)	-	-	-
	- Soldering and Brazing	suitable (by agreement)	-	-	Solderingtest by agreement
	- Bonding	suitable (by agreement)	-	-	by agreement
Suitability for coating <sup>3</sup>	- Electroplating	suitable (by agreement)	-	-	-
	- Sputtering	suitable (by agreement)	-	-	-

Discontinuities (reference surface: actual width, but max. 50 mm, length 1000 mm)

Roll indentations	number 15	µm	S ≤ 0.25 mm, depth max. 5 µm S ≤ 0.8 mm, depth max. 15 µm S > 0.8 mm, depth max. 20 µm Lateral expansion = 5x maximum depth	profile method, measuring microscope	-
Flakes	not allowed	-	-	visual	-
Spills	not allowed	-	-	visual	-
Blisters	not allowed	-	-	visual	-
Holes	not allowed	-	-	visual	-
Roll imprints	allowed inside the half thickness tolerance	µm	see thickness tolerance	visual, Micrometer	-
Chatter marks	not allowed	µm	see thickness tolerance	visual	-
Cold-shut defects	not allowed	µm	-	visual	EN ISO 4287 EN ISO 4288
Score marks (along and across), Grooves	to measurand	µm	S ≤ 1 mm, depth: R <sub>max</sub> = 1.5 µm S > 1 mm, depth: R <sub>max</sub> = 2.5 µm	profile method	EN ISO 4287 EN ISO 4288
Rolled-in extraneous matter (organic, metallic (chips), etc.)	not allowed	-	-	vsuell visual	-

Optical characteristics

Streaks	allowed, if the further processing is not affected	-	-	visual	-
Satin	allowed inside the required surface roughness	µm	see required surface roughness	profile method	EN ISO 4287 EN ISO 4288
Discolorations/ Tarnishes/Stains	allowed, if removable by pre-treatment before further processing or surface is not affected or technically irrelevant	-	-	visual	-

<sup>1</sup> Attention should be paid to transport and storage conditions<sup>2</sup> Attention should be paid to process and material<sup>3</sup> Attention should be paid to pre-treatment<sup>4</sup> S = Sheet thickness

**Note:** Due to the large number of alloys and tempers as well as applications special agreement on the size and number of discontinuities and measuring method can be arranged between customers and the suppliers in some cases.

Table 7.3: Cable strip , reference to EN 13599

Characterization Characteristics	Assessment	Unit	Measurand	Measuring method	Testing standard
Applied characteristics: <sup>1</sup>					
Roughness	Measuring	µm	R <sub>a</sub> max. = 0.40 µm	profile method	EN ISO 4287 EN ISO 4288
tarnishing protection	by agreement	-	-	-	-
Surface cleanness	Residual carbon measuring	mg/dm <sup>2</sup>	carbon content max. 0.20 mg/dm <sup>2</sup>	C-Analyzer	EN 723
Suitability joining	-Welding <sup>2</sup>				
	-Soldering and Brazing				
<b>Discontinuities (reference surface: actual width, but max. 50 mm, length 1000 mm)</b>					
Roll indentations	Depth	µm	Depth max. = 40 µm	-	
Flakes	not allowed, if the weldability is affected	-	-	visual	-
Spills	not allowed, if the weldability is affected	-	-	visual	-
Blisters	not allowed	-	-	visual	-
Holes	not allowed, if detrimental to fabrication	-	-	visual, test method for hohles	-
Roll imprints	not allowed, if the distance corresponds to the transmission frequency. In undersea cable strip imprints are not critical even if they appear periodically	cm	-	periodicity-test method	-
Chatter marks	not allowed, if the distance corresponds to the transmission frequency	cm	-	periodicity-test method	-
Cold-shut defects	allowed inside the required surface roughness	µm	see surface roughness	visual, profile method	EN ISO 4287 EN ISO 4288
Score marks (along and across), Grooves	visual (Dimension)	µm	depth: R <sub>max.</sub> = 4 µm	profile method	EN ISO 4287 EN ISO 4288
Rolled-in extraneous matter (organic, metallic (chips), etc.)	not allowed	-	-	visual	-
<b>Optical characteristics</b>					
Streaks	allowed, if the weldability is not affected	-	-	visual	-
Satin	allowed inside the required surface roughness	µm	see required surface roughness	visual, profile method	EN ISO 4287 EN ISO 4288
Discolorations/ Tarnishes/Stains	allowed, if the weldability is not affected	-	-	-	-

<sup>1</sup> Attention should be paid to transport and storage conditions<sup>2</sup> Attention should be paid to process and material

**Note:** Due to the large number of alloys and tempers as well as applications special agreement on the size and number of discontinuities and measuring method can be arranged between customers and the suppliers in some cases.

Table 7.4: Contact strip and spring strip , reference to EN 1654

Characterization Characteristics	Assessment	Unit	Measurand	Measuring method	Testing standard
Applied characteristics: <sup>1</sup>					
Roughness	Measuring	µm	R <sub>a</sub> max. = 0.40 µm	profile method	EN ISO 4287 EN ISO 4288
tarnishing protection	by agreement	-	-	-	-
Surface cleanness	- Oxides acceptable, if punching ability is not affected	-	-	Ball-Wearstest (only by tin oxide)	-
Suitability for joining	-Welding <sup>2</sup>	suitable (by agreement)	-	-	-
	-Soldering and Brazing	suitable (by agreement)	-	-	Solderingtest (by agreement) DIN 32506-2
Suitability for coating <sup>3</sup>	- Electroplating	suitable (by agreement)	-	-	-
	- Sputtering	suitable (by agreement)	-	-	-
	- Hot dip tinning	suitable (by agreement)	-	-	-
<b>Discontinuities (reference surface: actual width, but max. 50 mm, length 1000 mm)</b>					
Roll indentations	Number 15	µm	S <sup>4</sup> ≤ 0.2 mm, depth max. 7 µm S ≤ 0.4 mm, depth max. 10 µm S ≤ 0.8 mm, depth max. 15 µm S > 0.8 mm, depth max. 30 µm Lateral expansion = 10x maximum depth	profile method, measuring microscope	-
Flakes	Plural streak-/nest-shaped not allowed	-	-	visual	-
Spills	not allowed	-	-	visual	-
Blisters	not allowed	-	-	visual	-
Roll Imprints	allowed inside the thickness tolerance	µm	see thickness tolerance	Visual, Micrometer	-
Chatter marks	allowed inside the thickness tolerance	µm	see thickness tolerance	Visual, Micrometer, profile method	-
Cold-shut defects	allowed inside the surface roughness	µm	see surface roughness	visual, profile method	EN ISO 4287 EN ISO 4288
Score marks (along and across), Grooves	to measurand	µm	Depth: R <sub>max</sub> = 4 µm	visual, profile method	EN ISO 4287 EN ISO 4288
Rolled-in extraneous matter (organic, metallic (chips), etc.)	not allowed	-	-	visual	-
<b>Optical characteristics</b>					
Streaks	allowed, because technically irrelevant	-	-	visual	-
Satin	allowed inside the required surface roughness	R <sub>a</sub> , R <sub>z</sub> , R <sub>max</sub> in µm	see required surface roughness	visual, profile method	EN ISO 4287 EN ISO 4288
Discolorations/ Tarnishes/Stains	allowed, if removable by pre-treatment before further processing or surface is not affected or technically irrelevant	-	-	visual	-

<sup>1</sup> Attention should be paid to transport and storage conditions<sup>2</sup> Attention should be paid to process and material<sup>3</sup> Attention should be paid to pre-treatment<sup>4</sup> S = Sheet thickness

**Note:** Due to the large number of alloys and tempers as well as applications special agreement on the size and number of discontinuities and measuring method can be arranged between customers and the suppliers in some cases.

**Table 7.5: Clad strip , reference to EN 1652**

Characterization Characteristics	Assessment	Unit	Measurand	Measuring method	Testing standard
Applied characteristics: <sup>1</sup>					
Roughness		µm	R <sub>a</sub> = 0.20 - 0.80 µm	profile method	EN ISO 4287 EN ISO 4288
tarnishing protection	by agreement	-	-	-	-
Surface cleanness	- Residual carbon	by agreement	mg/dm <sup>2</sup>	C-Analyzer	EN 723
	- Oxides	allowed, if the cladding ability is not affected	-	-	-
Suitability for coating <sup>3</sup>	- Cladding	suitable	-	-	-
<b>Discontinuities (reference surface: actual width, but max. 50 mm, length 1000 mm)</b>					
Roll indentations	allowed, if the cladding ability is not affected	µm	-	visual	-
Flakes	allowed, if by further surface wrinkling removable and the cladding ability is not affected	-	-	visual	-
Spills	allowed, if by further surface wrinkling removable and the cladding ability is not affected	-	-	visual	-
Blisters	not allowed	-	-	visual	-
Holes	not allowed	-	-	visual	-
Roll imprints	allowed inside the thickness tolerance	µm	see thickness tolerance	visual Micrometer	-
Chatter marks	allowed inside the thickness tolerance	µm	see thickness tolerance	Visual, profile method, Micrometer	-
Cold-shut defects	allowed inside the surface roughness	µm	see surface roughness	visual, profile method	EN ISO 4287 EN ISO 4288
Score marks (along and across), Grooves	allowed	-	-	visual	-
Rolled-in extraneous matter (organic, metallic (chips), etc.)	allowed, if by further surface wrinkling removable	-	-	visual	-
<b>Optical characteristics</b>					
Streaks	allowed	-	-	visual	
Satin	allowed inside the required surface roughness	µm	see the required surface roughness	visual, profile method	EN ISO 4287 EN ISO 4288
Discolorations/ Tarnishes/Stains	allowed, if the cladding ability is not affected	-	-	visual	

<sup>1</sup> Attention should be paid to transport and storage conditions

<sup>3</sup> Attention should be paid to pre-treatment

**Note:** Due to the large number of alloys and tempers as well as applications special agreement on the size and number of discontinuities and measuring method can be arranged between customers and the suppliers in some cases.

Table 7.6: Transformer strip, reference to EN 13599

Characterization Characteristics	Assessment	Unit	Measurand	Measuring method	Testing standard
<b>Applied characteristics:<sup>1</sup></b>					
Roughness		µm	R <sub>a</sub> min. = 0.20 µm	Profile method	EN ISO 4287 EN ISO 4288
tarnishing protection	by agreement	-	-	-	-
Surface cleanness	- Oxides	-	-	-	-
Suitability for Joining	- Welding <sup>2</sup>	-	-	-	-
<b>Discontinuities (reference surface: actual width, but max. 50 mm, length 1000 mm)</b>					
Roll indentations	acceptable without sharp edges	-	-	visual	-
Flakes	Plural streak-/nest-shaped not allowed	-	-	visual	-
Spills	not allowed	-	-	visual	-
Blisters	not allowed	-	-	visual	-
Holes	not allowed	-	-	visual	-
Roll imprints	allowed inside the thickness tolerance	µm	see thickness tolerance	visual, Micrometer	-
Chatter marks	allowed inside the thickness tolerance	µm	see thickness tolerance	visual, profile method, Micrometer	-
Cold-shut defects	not allowed	-	-	-	-
Score marks (along and across), Grooves	allowed without sharp edges	µm	see thickness tolerance	visual, profile method	-
Rolled-in extraneous material (organic, metallic (chips), etc.)	not allowed	-	-	visual	-
<b>Optical characteristics</b>					
Streaks	allowed	-	-	visual	-
Satin	allowed	-	-	visual	-
Discolorations/ Tarnishes/Stains	allowed , if adhesion is not affected	-	-	visual	-

<sup>1</sup> Attention should be paid to transport and storage conditions

<sup>2</sup> Attention should be paid to process and material

**Note:** Due to the large number of alloys and tempers as well as applications special agreement on the size and number of discontinuities and measuring method can be arranged between customers and the suppliers in some cases.

**Annex A****Transport and storage information****1. General information**

- 1.1 Depending on the product, copper or copper-alloy strips are transported in an upright position or lying on their side, as self-wound or spool-wound coils placed on suitable pallets and protected against mechanical damage.

**2. Shipping overseas**

- 2.1 If shipped overseas, the coils must be protected against moisture, for example by using plastic film and desiccant bags or plastic film and VCI paper. Additional protection may be provided by wooden crates, cardboard or comparable materials, provided that they do not have a negative effects on the product.

**3. Inland transport**

- 3.1 For inland transport, shrink-wrapped film or a similar material can be used to protect the coils against splashing water.

**4. Intermediate layers**

- 4.1 Layers of paper, cardboard or corrugated card can be placed between the windings of the coil. These intermediate layers can, if necessary, be treated with benzotriazole (BTA). Spacer battens of wood, plastic or cardboard can also be used as spacers between the stacked coils. All materials inside the pallets must be dry. Wooden spacers can be wrapped inside plastic film if there is any suspect of humidity in them.

**5. Storage**

- 5.1 Coils must always be stored in dry, constant-temperature environments. Rapid changes in temperature must be avoided. Even if the above conditions are met, the coils have a limited storage time. It is important to ensure that the packaging is not damaged. Once the coil packaging has been opened the material must be processed immediately.