



## Product specification TiNOX energy

Version 6 of the 12<sup>th</sup> April 2018

### 1. Technical properties of the coating

TiNOX energy is a highly selective absorber coating deposited in an environmental friendly air to air roll coating PVD process on Copper or Aluminum strips. The coating consists of different layers: adhesion layer / Cermet absorber multilayer / anti reflection and protection layer.

The total thickness of the coating is around 250nm.

### 2. Performance benchmarks

Two factors, solar absorption and thermal emission, describe the performance of a selective absorber coating. The solar absorption indicates the share of the solar radiation absorbed and converted into heat by the selectively coated surface. To determine the degree of solar absorption, the coating's reflection is measured in the wavelength range of the solar radiation between 300 to 2700 nm. Solar absorption is determined by weighting the reflection spectrum against the sun's radiation spectrum (AM 1.5 in accordance with ASTM E 891-87 and ISO 9845-1). To determine thermal emissivity, the coating's reflection is measured in the wavelength range from 2.5 to 20  $\mu\text{m}$ , where a black surface emits heat at a temperature of 100 degrees Celsius. The ratio of heat radiation from the selective absorber surface and heat radiation from a black surface at 100 degrees Celsius gives the thermal emissivity.

The efficiency  $f$  (figure of merit) of a selective surface is expressed by the ratio of solar absorption  $\alpha_{\text{sol}}$  and the thermal emissivity  $\varepsilon_{100^\circ\text{C}}$ :

$$f = \alpha_{\text{sol}} / \varepsilon_{100^\circ\text{C}}$$

The absorber coating is more efficient the larger  $f$  is. For a value of  $f > 18$ , the absorber surface is considered highly selective.

TiNOX energy Cu and TiNOX energy Al fulfill the criterion for highly selective absorbers ideally:

solar absorption  $\alpha_{\text{sol}}$  : 95 %  $\pm$  2 %

thermal emissivity  $\varepsilon_{100^\circ\text{C}}$  : 4 %  $\pm$  2 %

### 3. Technical definition of color

Almecco uses the L\*C\*h system from DIN 5033 for a technical definition of color. Standard illuminant D65 at a 10° viewing angle is assumed for the light conditions. During production, color values are constantly measured and automatically adjusted.

For the TiNOX color, the following limit values are specified for color angle  $h$ :

TiNOX energy: 270° <  $h$  < 300° deep blue

Almecco GmbH  
Hauptsitz  
Claude-Breda-Straße 3  
D-06406 Bernburg, Germany  
Tel.: +49 (0)34 71 34 65 500  
Fax: +49 (0)34 71 34 65 509  
<http://www.almecogroup.com>  
[info.de@almecogroup.com](mailto:info.de@almecogroup.com)

Geschäftsführer:  
Dr. Giorgio Gabriele Locci  
Amtsgericht Stendal  
HRB 5020 / DE 245852413  
Commerzbank Magdeburg  
IBAN: DE92 8104 0000 0252 570700  
BIC: COBADEFFXXX

INTESA SAN PAOLO Frankfurt /M.  
IBAN: DE89 5002 0800 4315 200199  
BIC: BCITDEFF  
Salzlandsparkasse Bernburg  
IBAN: DE19 8005 5500 0201 004364  
BIC: NOLADE 21SES





#### 4. Substrate material - dimensions

TiNOX energy is deposited on copper and aluminum substrates up to 1,250 mm width. With our in-house cutting facilities, the width and length of the substrates can be customized.

Type of delivery: coils and plates  
(with paper or film interleave as requested)

##### **Copper:**

Thickness: 0.12 - 0.50 mm, thickness tolerance: +/- 0.02 mm  
Width: up to 1,250 mm  
Width tolerance in accordance with DIN 1791

##### **Aluminum:**

Thickness: 0.30 - 0.60 mm, thickness tolerance: +/- 0.02 mm  
Width: up to 1,250 mm  
Width tolerance in accordance with DIN 1791

#### 5. Substrate material - mechanical properties

##### **Copper:**

Copper substrate: Cu-DHP or Cu-OF,  
Composition and properties in accordance with EN 1652 /  
EN 10204

Elongation at break:  $\geq 8\%$  (A10)  
Tensile strength: 240 - 300 N/mm<sup>2</sup>  
0.2% yield strength:  $\geq 180$  N/mm<sup>2</sup>  
Admissible bending radius:  $\geq 5$  mm  
Hardness: half hard  
Roughness: Ra < 0.5  $\mu$ m

##### **Aluminum:**

Aluminum substrate: Al 99.8% pure aluminum,  
Composition and properties in accordance with EN 573/3  
and EN485/2

Elongation at break:  $\geq 1\%$   
Tensile strength:  $\geq 140$  N/mm<sup>2</sup>  
0.2% yield strength:  $\geq 120$  N/mm<sup>2</sup>  
Admissible bending radius:  $\geq 10$  mm  
Hardness: hard  
Roughness: Ra < 0.5  $\mu$ m

**Almeco GmbH**  
Hauptsitz  
Claude-Breda-Straße 3  
D-06406 Bernburg, Germany  
Tel.: +49 (0)34 71 34 65 500  
Fax: +49 (0)34 71 34 65 509  
http://www.almecogroup.com  
info.de@almecogroup.com

Geschäftsführer:  
Dr. Giorgio Gabriele Locci  
Amtsgericht Stendal  
HRB 5020 / DE 245852413  
Commerzbank Magdeburg  
IBAN: DE92 8104 0000 0252 570700  
BIC: COBADEFFXXX

INTESA SAN PAOLO Frankfurt /M.  
IBAN: DE89 5002 0800 4315 200199  
BIC: BCITDEFF  
Salzlandsparkasse Bernburg  
IBAN: DE19 8005 5500 0201 004364  
BIC: NOLADE 21SES





## 6. Substrate material – physical properties

### Copper:

Density:	8.92 g/cm <sup>3</sup>
Heat Conductivity:	≥ 320 W/m·K
Thermal Heat Capacity:	0.382 kJ/(kg·K)

### Aluminum:

Density:	2.71 g/cm <sup>3</sup>
Heat Conductivity:	≥ 230 W/m·K
Thermal Heat Capacity:	0.896 kJ/(kg·K)

## 7. Processing

Highly selective, coated TiNOX energy absorbers are the heart of solar thermal collectors. TiNOX energy Absorbers can be used equally well in vacuum tube, glass covered flat-plate and air collectors.

TiNOX energy absorber substrates can be further processed using all common industry methods:

- Laser welding
- Ultrasonic welding
- Plasma welding
- Soft soldering
- Forming
- Gluing

Deep drawing and embossing are also possible. We recommend contacting us beforehand for such processing.

Optionally the TiNOX energy surface can be delivered with protection film (see 8).

In the case that the temperature of the TiNOX energy absorber material exceeds 40°C during processing, the protection tape must be removed before processing!

The TiNOX energy absorbers must not come into direct contact with strongly oxidizing or reducing chemicals. This applies particularly for soft soldering.

The temperature limits for processing are as follows:

Air:	300°C for up to 20 minutes
Vacuum:	380°C for up to 60 minutes

**Almeco GmbH**  
Hauptsitz  
Claude-Breda-Straße 3  
D-06406 Bernburg, Germany  
Tel.: +49 (0)34 71 34 65 500  
Fax: +49 (0)34 71 34 65 509  
<http://www.almecogroup.com>  
[info.de@almecogroup.com](mailto:info.de@almecogroup.com)

Geschäftsführer:  
Dr. Giorgio Gabriele Locci  
Amtsgericht Stendal  
HRB 5020 / DE 245852413  
Commerzbank Magdeburg  
IBAN: DE92 8104 0000 0252 570700  
BIC: COBADEFFXXX

INTESA SAN PAOLO Frankfurt /M.  
IBAN: DE89 5002 0800 4315 200199  
BIC: BCITDEFF  
Salzlandsparkasse Bernburg  
IBAN: DE19 8005 5500 0201 004364  
BIC: NOLADE 21SES





## 8. Transport and Storage

For transport and storage, the absorbers have to be protected from impact and mechanical loads. TiNOX energy material delivered in coils cannot be stacked for transport and storage.

During transport and storage, the absorber material should not be exposed to extreme climates: the material temperature should never fall below the dew point temperature to avoid condensation. The relative air humidity should not exceed 75%r.H.

The absorber material must be stored in dry, closed areas without dust. Only acid-free materials without outgassing (insulation, paper, wood, etc.) may be used for packaging, shipping, and storage.

The absorber material should be processed within 6 months after delivery.

## 9. Protective tape

By using a special protective film, Almeco prevents the absorber coating from being damaged during mechanical processing, storage, and shipping. The film protects the absorber from being scratched or becoming dirty throughout the supply chain. It consists of a transparent PE foil coated with adhesive. The adhesive has a defined adhesion strength and low tension; it does not separate from the absorber on its own, but it can be easily pulled off without leaving any residue.

Due to the specification of the film suppliers, the temperature of the protected material should not fall below a value of 10°C and not exceed a value of 40°C. Absorber material protected with film should not be exposed directly to sunlight or UV radiation.

## 10. Cleaning

Fingerprints, organic residue, and dust can easily be removed from the absorber's surface with a soft cloth and alcohol (isopropanol).

## 11. Warranty

Almeco guarantees an optical efficiency of the TiNOX absorber material of minimum 95% of the efficiency at delivery over a period of **10 years**, if it can be demonstrated that the instructions for processing and storage of highly selective coated absorber material and the working conditions for glazed flat-plate collectors defined in Task 10 were observed.

To the extent allowed by the type of defect in question, Almeco shall fulfill its warranty obligations by reworking the product or replacing it. No further claims shall be honored.

Obvious defects must be reported to Almeco immediately after delivery.

**Almeco GmbH**  
Hauptsitz  
Claude-Breda-Straße 3  
D-06406 Bernburg, Germany  
Tel.: +49 (0)34 71 34 65 500  
Fax: +49 (0)34 71 34 65 509  
<http://www.almecogroup.com>  
[info.de@almecogroup.com](mailto:info.de@almecogroup.com)

Geschäftsführer:  
Dr. Giorgio Gabriele Locci  
Amtsgericht Stendal  
HRB 5020 / DE 245852413  
Commerzbank Magdeburg  
IBAN: DE92 8104 0000 0252 570700  
BIC: COBADEFFXXX

INTESA SAN PAOLO Frankfurt /M.  
IBAN: DE89 5002 0800 4315 200199  
BIC: BCITDEFF  
Salzlandsparkasse Bernburg  
IBAN: DE19 8005 5500 0201 004364  
BIC: NOLADE 21SES





## 12. Quality management and certificates

### Test of long-term stability and durability:

Various research institutes joined forces under the aegis of the IEA's Task 10 ("Qualification of solar absorber surface durability" International Energy Agency 05.09.2005) to develop a special procedure to test the durability of selective coatings without having to conduct year-long field tests. This method simulates how such environmental parameters as varying temperature levels and moisture inside the collector affect the selective layers over the long term. Absorber coatings which pass the Task 10 test still have at least 95 percent of their original efficiency after a simulated service life of 25 years.

TiNOX energy is tested regularly according to the Task 10 test by well-known solar institutes such as the Institute of Solar Technology of the University of Rapperswill (SPF) in Switzerland or the Fraunhofer Institute for Solar Energy Systems (ISE) in Freiburg, Germany.

The current test results can be downloaded on the Almeco website.

### Seamless quality assurance

To ensure a constantly high level of product quality, Almeco monitors all relevant process parameters continually during the coating process. For instance, Zeiss spectrometers seamlessly record and document such optical benchmarks as the degree of absorption, emissivity, and color values.

After the coating process, the absorber substrate is also visually inspected. Almeco conducts the following tests on samples:

- The coating's optical parameters (absorption and emissivity) are measured at the edges and in the middle of the metal strip.
- The aging stability of the coating is determined by means of the Task 10 method on samples. Since these studies take place over very long time frames, the TiNOX energy layer also undergoes a simplified one-week procedure based on the Task 10 test. The optical parameters have to remain within specified tolerances after accelerated ageing.
- Samples from every tenth production campaign additionally undergo a complete Task 10 test.
- The products are subjected to an adhesion test. This includes bending tests of the coated plates.

The quality assurance methods described above are conducted according to detailed operational procedures.

**Almeco GmbH**  
Hauptsitz  
Claude-Breda-Straße 3  
D-06406 Bernburg, Germany  
Tel.: +49 (0)34 71 34 65 500  
Fax: +49 (0)34 71 34 65 509  
<http://www.almecogroup.com>  
[info.de@almecogroup.com](mailto:info.de@almecogroup.com)

Geschäftsführer:  
Dr. Giorgio Gabriele Locci  
Amtsgericht Stendal  
HRB 5020 / DE 245852413  
Commerzbank Magdeburg  
IBAN: DE92 8104 0000 0252 570700  
BIC: COBADEFFXXX

INTESA SAN PAOLO Frankfurt /M.  
IBAN: DE89 5002 0800 4315 200199  
BIC: BCITDEFF  
Salzlandsparkasse Bernburg  
IBAN: DE19 8005 5500 0201 004364  
BIC: NOLADE 21SES





### Outgoing goods inspections

Quality inspections of packaging and shipping ensure that

- the products are not damaged or their performance detrimentally affected;
- the proper labels have been applied to ensure the traceability of the goods.

The packaging and labeling of goods are part of our planning and contractual documents. Detailed packaging regulations specify how the goods and the packaging are to be handled.

When selecting third-party Transport Companies, Almeco applies strict standards for fulfilling deadlines, delivery quality, and cost.

### Quality management in compliance with DIN EN ISO 9001: 2014.

Almeco also follows the quality guidelines of DIN EN ISO 9001:2014. This certificate confirms the high quality standards at Almeco.

### **13. Use in Solar-Keymark tested collectors**

After extensive tests on flat plate collectors, the Solar Keymark Network recognized that TiNOX Energy products are considered equivalent to the other highly selective absorber coatings. This means that no further homologation is needed when they are used in a "Solar Keymark"-approved collector to replace another coating listed in the "Decision List" of the Solar Keymark Organization.

Please refer to

[http://www.estif.org/solarkeymark/Links/Internal\\_links/network/sknwebdoclist/SKN\\_N0100R2.pdf](http://www.estif.org/solarkeymark/Links/Internal_links/network/sknwebdoclist/SKN_N0100R2.pdf)

#### **Almeco GmbH**

Hauptsitz

Claude-Breda-Straße 3  
D-06406 Bernburg, Germany  
Tel.: +49 (0)34 71 34 65 500  
Fax: +49 (0)34 71 34 65 509  
<http://www.almecogroup.com>  
[info.de@almecogroup.com](mailto:info.de@almecogroup.com)

Geschäftsführer:

Dr. Giorgio Gabriele Locci  
Amtsgericht Stendal  
HRB 5020 / DE 245852413

Commerzbank Magdeburg  
IBAN: DE92 8104 0000 0252 570700  
BIC: COBADEFFXXX

INTESA SAN PAOLO Frankfurt /M.  
IBAN: DE89 5002 0800 4315 200199  
BIC: BCITDEFF

Salzlandsparkasse Bernburg  
IBAN: DE19 8005 5500 0201 004364  
BIC: NOLADE 21SES

