



Product specification TiNOX robust

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TiNOX robust is a highly selective absorber coating designed for harsh environmental conditions as found in flat plate solar collectors mounted near seaside or in industrial environment. Compared to other absorber coatings designed for harsh environmental conditions based on black chromium or lacquer TiNOX robust features nearly the same optical properties as the well-established TiNOX energy coating due to a complex multilayer structure applied by PVD coating process. Due to the special ceramic top layer the material has good corrosion resistance and fingerprints are nearly not visible.

1. Performance benchmarks

Two factors - solar absorption and thermal emission - describe the performance of a selective absorber coating. The degree of 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 in the wavelength range of the solar radiation between 300 to 2,700 nm is measured. 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 μm where a black surface emits heat at a temperature of 100 degrees Celsius. According DIN ISO 22975-3 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.

TiNOX robust fulfill the criterion for highly selective absorbers:

solar absorption α_{sol} : 94 % \pm 2 %

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

2. Technical definition of colour

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

For the TiNOX robust colour, the following colour range is specified:

TiNOX robust: a = 6 to 14; b = -10 to -30 dark blue purple



3. Substrate material - dimensions

TiNOX robust is deposited on aluminium substrates up to 1,250 mm width (copper or stainless steel are available on request). With our in-house cutting facilities, the width and length of the substrates can be customized.

Type of delivery: coils and plates
(protected by paper or foil as requested)

Aluminum:

Thickness: 0.30 - 0.60 mm, thickness tolerance: +/- 0.03 mm

Width: up to 1,250 mm

Width tolerance in accordance with DIN 1791

4. Substrate material - mechanical properties

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 **R_m**: $\geq 140 \text{ N/mm}^2$

Yield strength **R_{p 0.2}**: $\geq 120 \text{ N/mm}^2$

Admissible bending radius: $\geq 10 \text{ mm}$

Temper: hard

Roughness: $\text{Ra} < 0.5 \mu\text{m}$

5. Substrate material – physical properties

Aluminum:

Density: 2.71 g/cm^3

Heat Conductivity: $\geq 230 \text{ W/m}\cdot\text{K}$

Thermal Heat Capacity: $0.896 \text{ kJ}/(\text{kg}\cdot\text{K})$



6. Processing

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

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

- Laser welding
- Ultrasonic welding
- Plasma welding
- Soft soldering
- Forming
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Deep drawing and embossing are also possible. We recommend contacting us beforehand for such processing.

Optionally the TiNOX robust surface can be delivered with protection foil. The foil can remain on the absorber if tubes are laser-welded onto the absorber.

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

The TiNOX robust absorbers must not come into direct contact with strongly oxidizing or reducing chemicals.

The temperature limits for further processing are as follows:

Air: 300°C for up to 2 hours

Vacuum: 400°C for up to 2 hours

7. Transport and Storage

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

During transport and storage the absorber material should not be exposed to extreme climates. The material temperature should not fall below the dew point temperature to avoid condensation. The relative air humidity should not exceed 75%r.H.

The absorbers 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 latest 6 months after delivery.



8. Protective tape

By using a special protective foil, Almeco prevents the absorber coating from being damaged during mechanical processes, storage, and shipping. The foil 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 an exact 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 foil deliverers 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 foil should not be exposed directly by sunlight or UV radiation.

9. Cleaning

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

10. Warranty

Almeco guarantees an optical efficiency of the TiNOX robust absorber material of minimum 95% of the efficiency at delivery over a period of **10 years**, if the instructions for the processing and storage of TiNOX robust absorber material and the conditions for glazed flat-plate collectors defined in Task 10 were minded.

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

Obvious defects must be reported to Almeco immediately after delivery.



11. 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 Robust Agency DIN ISO 22975-3) to come up with 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 different temperature levels and moisture inside the collector affect 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 robust is tested regularly according to the Task 10 test by well-known solar institutes such as the Institute of Solar Technology at the University of Rapperswill (SPF) in Switzerland or the Fraunhofer Institute for Solar Robust Systems (ISE) in Freiburg, Germany.

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 colour values.

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

- The layer's optical parameters (absorption and emissivity) are measured at the edges and in the middle of the substrate.
- The aging stability of the coating is determined by means of the Task 10 method on samples. Because these tests need very long time, the TiNOX robust layer also undergoes a simplified one week lasting, procedure based on the Task 10 test.
- adhesion test in accordance with DIN 58196-6

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



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 for the goods to be tracked.

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

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

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

Almeco also fulfils the quality standards in DIN EN ISO 9001:2014. This certificate confirms the high quality requirements at Almeco.

12. Use in Solar-Keymark tested collectors

After extensive tests on flat plate collectors, the Solar Keymark Network recognized that TiNOX robust 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_N0137R_14_EqAbs.pdf