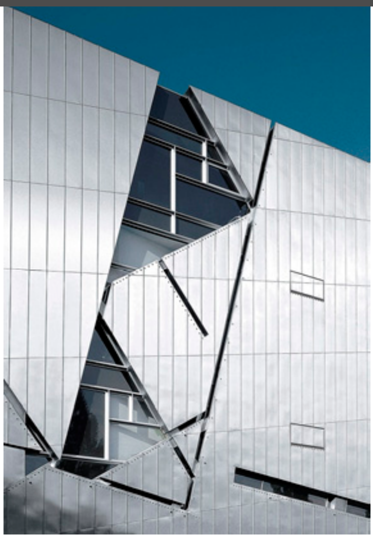
Environmental Product Declaration

according to ISO 14025



RHEINZINK® Titanium Zinc

of RHEINZINK GmbH & Co. KG

Declaration Number
AUB-RHE-11105-E

ARBEITSGEMEINSCHAFT UMWELTVERTRÄGLICHES BAUPRODUKT E.V.
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Short version

Environmental Product Declaration

ARBEITSGEMEINSCHAFT UMWELTVERTRÄGLICHES BAUPRODUKT E.V. **www.bau-umwelt.com**	**Program holder**
RHEINZINK GmbH & Co. KG Bahnhofstraße 90 45711 Datteln Germany	**Declaration holder**
AUB-RHE-11105-E	**Declaration number**
RHEINZINK®-Titanium Zinc This declaration is an Environmental Product Declaration according to ISO 14025 and describes the environmental performance of the above mentioned building products. All relevant environmental data are disclosed in this validated declaration.	**Declared building products**
This validated declaration authorises the holder to bear the official stamp of the AUB. It only applies to the above mentioned products for three years from date of issue. The declaration holder is liable for the information and evidence on which the declaration is based.	**Validity**
The **declaration** contains in detail: - Product definition and physical data - Information about raw materials and origin - Specifications on manufacturing the product - References for product processing - Information on product in use, singular effects and end of life - LCA results - Evidence and verifications	**Content of the declaration**

20th December 2005		**Date of issue**
Prof. Dr.-Ing. Horst J. Bossenmayer (Chairman of the AUB)		**Signatures**

This declaration, and the rules which it is based on, have been verified by the independent Advisory Board (SVA) according to ISO 14025.		**Verification of the declaration**
Prof. Dr.-Ing. Hans-Wolf Reinhardt (Chairman of the SVA)	Dr. Eva Schmincke (Verifier appointed by the SVA)	**Signatures**

Short version

Environmental Product Declaration

Product description

The material RHEINZINK® -Titanium Zinc is an alloy based on fine zinc with additives of copper, titanium and aluminium. All RHEINZINK® products are made of this alloy. The declaration applies to all three qualities of surfacing: RHEINZINK® -bright rolled and RHEINZINK® "preweathered[pro] blue-grey" and RHEINZINK® "preweathered[pro] slate grey".

The titanium zinc sheets are produced in different thicknesses. These vary according to the type of titanium zinc sheet from 0.7 mm (5 kg/m²) to 2.0 mm (14.4 kg/m²). The moulded density of zinc is 7.2 g/cm³.

Applications

Titanium zinc sheets are used for roofings and wall claddings as well as for roof drainage systems (roof gutters, pipes and equipment).

For roof drainage, the titanium zinc sheets are processed into roof gutters, down pipes, fascia boards, small parts or constructive sheets.

A reduction of the wetted surface relating to the material is achieved for the roof drainage by using cuttings when tailoring sheets, gutters and pipes and also by overlapping when putting together and joining with brazing as well as by mounting under a roof overhang.

For roofing applications, the wetted surface is reduced by having rebated joints, splays, covers, clippings etc. depending on the method of installation. A reduction of the wetted surface can be achieved for wall claddings through vertical assembly (roof overhang, orientation and shadowing effects e.g. through adjacent housing or trees).

Scope of the LCA

The **Life Cycle Assessment (LCA)** was carried out according to DIN ISO 14040 et sqq. Specific data from the company RHEINZINK in Datteln, Germany, statistical data form the WirtschaftsVereinigung Metalle as well as the data base "GaBi 4" were used. The LCA was carried out for the manufacturing phase of the products, taking into account all background data such as raw material exploitation and transports ("cradle to gate").

The use phase of the titanium zinc sheets is divided into several application areas: roofing applications, roof drainage and wall claddings. The treatment for the titanium zinc sheets was modelled in melting stoves for the end of life phase. The thereby resulting credit of extracted zinc is counted as replacement for primary zinc.

Results of the LCA

Titanium zinc sheet				
Parameter	**Unit per kg**	**Sum of production and recycling potential**	**Production**	**Recycling potential**
Primary energy, non-renewable	[MJ]	**16.3**	45.5	- 29.2
Primary energy, renewable	[MJ]	**0.9**	3.8	- 2.9
Global Warming Potential (GWP)	[kg CO_2 eqv.]	**0.96**	2.62	- 1.65
Ozone Depletion Potential (ODP)	[kg R11 eqv.]	**$0.18 * 10^{-6}$**	$0.56 * 10^{-6}$	$- 0.39 * 10^{-6}$
Acidification Potential (AP)	[kg SO_2 eqv.]	**$3.32 * 10^{-3}$**	$13.5 * 10^{-3}$	$- 10.2 * 10^{-3}$
Eutrophication Potential (EP)	[kg PO_4 eqv.]	**$0.28 * 10^{-3}$**	$1.03 * 10^{-3}$	$- 0.76 * 10^{-3}$
Photochemical Ozone Creation Potential (POCP)	[kg ethene eqv.]	**$0.29 * 10^{-3}$**	$1.10 * 10^{-3}$	$- 0.80 * 10^{-3}$

Issued by PE Europe GmbH, Leinfelden-Echterdingen, Germany

Evidence and verifications

The following **evidence** and **verifications** are also described in the Environmental Product Declaration:

- Atmospheric corrosion and surface loss (erosion), measurement of the rates of corrosion and the erosion of zinc ions due to precipitation over a test period of eight years (1991 – 1998)

Scope of validity

This AUB Environmental Product Declaration applies to building products of RHEINZINK® - Titanium Zinc from the Rheinzink factory in Datteln.

0 Product definition

Product definition

The material RHEINZINK® - Titanium Zinc is an alloy, based on fine zinc with additives of copper, titanium and aluminium, which all RHEINZINK® products are made of. The declaration applies to all three qualities of surfacing: RHEINZINK® - bright rolled and RHEINZINK® "preweathered^{pro} blue-grey" and RHEINZINK® "preweathered^{pro} slate grey".

Range of application

- Titanium zinc sheets, bands and boards for roofing and wall cladding
- Roof drainage systems (roof gutters, pipes and equipment)

Product standard / approval

DIN EN 1179, DIN EN 988, DIN EN 612

Quality control

Control by the manufacturer and by TÜV Rheinland Group. Control of zinc material according to the QUALITY ZINC list of requirements as set up by TÜV Rheinland Group. Quality management control according to DIN ISO 9001. Environmental management according to DIN EN ISO 14001.

Presentation, properties

Table 1: Material thickness and weight of different titanium zinc sheets

Material thickness and weight		
Moulded density [g/cm³]	Thickness range [mm]	Mass per unit area [kg/m³]
7.20	0.70	5.00
7.20	0.80	5.80
7.20	1.00	7.20
7.20	1.20	8.60
7.20	1.25	9.00
7.20	1.50	10.80

RHEINZINK® - Titanium zinc is available in the following colours: bright rolled (bright metallic) or "preweathered^{pro}" (blue-grey) and "preweathered^{pro}" (slate grey).

Strength: (all values measured in direction of length)

- Tensile strength: $R_m \geq 110$ N/mm²
- 0.2% technical elastic limit: $R_{p0.2} \geq 150$ N/mm²
- Breaking strain: $A_{50} \geq 40\%$
- Vickers' hardness: $H_{V\,3} \geq 40$
- Modulus of elasticity: $E \geq 80{,}000$ N/mm²
- Residual elongation in permanent test: max. 0.1%

Physical data:

Thermal expansion coefficient: $\alpha = 22 \times 10^{-6} K^{-1}$ (e.g.: 2.2 mm change in length for a difference in temperature of 10°C and for a titanium zinc sheet length of 10 m)

Building Material Class A1, e.g. non-combustible, according to DIN 4102 and DIN EN 13501-1 respectively

Limitation of processing temperature: from ≥ 10 °C up to + 300 °C (limit of recrystallisation)

1 Raw materials

Raw materials prime products

Auxiliary substances / additives

Table 2: **Raw materials for the production of one kg of titanium zinc sheet**

Raw materials in mass % for 1 kg titanium zinc	
Component	**RHEINZINK® - Titanium zinc**
Fine zinc (the zinc used has a purity of 99.995% (Z1 according to DIN EN 1179)	≤ 99.835%
Copper	0.08 – 1.0%
Titanium	0.07 – 0.12%
Aluminium	≤ 0.015%

Auxiliary substances

- Roller oil emulsion: 0.08 kg/t zinc
- Etching: sulphuric acid: 15 g/kg zinc
- Nitric acid: 5 g/kg zinc
- Alkaline degreasing substance: 0.5 g/kg zinc
- Temporary protection (including Cr^{III+}): 0.5 – 0.8 g/kg zinc

Material explanation

Roller oil emulsion is a high temperature resistant mixture of synthetic esters, fatty substances and non-ionogene emulsifying agents used for cooling and as lubricant during rolling process. The roller oil emulsion is biodegradable.

For some of the RHEINZINK®-Titanium zinc products, the etching substance is used to give the bright rolled surface a "weathered" looking surface. The etching consists of sulphuric acid, nitric acid, an alkaline degreasing substance and a temporary protection (including Cr^{III+}).

Raw material extraction and origin

The fine zinc is almost exclusively provided by Ruhr-Zink GmbH, which is also situated in Datteln. The raw materials for the fine zinc come in the form of fine-grained concentrated zinc bulk goods (zinc ores processed in the ore pit) according to DIN EN 1179. They originate from Canada, Australia, Central and South America. Fine zinc is produced from the concentrated zinc following torrefaction, leaching, lye clearing, electrolysis and subsequent re-melting and casting processes. In addition, secondary raw materials are used. The raw materials titanium and aluminium, used for RHEINZINK® - titanium zinc production in very small portions, originate from various countries worldwide. The copper, which is also used in very small portions, is purchased as a secondary raw material (recycling material) in the form of fragmented metal scrap.

Local and general availability of raw materials

The availability of the raw materials is limited. However, there is no shortage of resources: the zinc reserve that can be mined with today's technical means is estimated to be 3,400 million tons worldwide. Based on the quantities that are actually produced, the zinc stock will last for about 700 years. The partial use of zinc and copper as recycling material will save resources. According to newest official data, the average zinc recycling rate lies at approximately 80%; a recent spot check by RHEINZINK GmbH & Co. KG with individual tradesman enterprises revealed a recycling rate for zinc used in building construction of more than 96%.

2 Manufacturing the building product

Manufacturing the building product

Structure of the manufacturing process:

The manufacturing process comprises seven steps:

- **Pre-alloy:** To improve the quality, and for energy-saving reasons, a pre-alloy is produced at 760°C in an induction crucible stove (meltdown of fine zinc, copper, titanium and aluminium). The pre-alloy blocks produced contain the titanium and copper portions of the subsequent rolled alloy.
- **Melting:** The pre-alloy blocks and fine zinc are melted together in large melting stoves (induction channel stoves) at 500 – 550°C and mixed together completely with induction currents.
- **Casting:** The final alloy is cooled down below melting point with a closed water circuit in the casting machine, resulting in a solid cast string.
- **Rolling:** There is a cooling distance between casting machine and roller racks. The rolling is done by 5 roller pairs, so-called roller racks. With adequate pressures the material thickness is reduced by up to 50% at each of these roller racks. Simultaneously, the material is cooled and greased using a special emulsion.
- **Coiling:** Subsequently, the readily rolled RHEINZINK® is wound up into coils of 20 tons weight (so-called big-coils). They are still at a temperature of 100°C and are stored for further cooling.
- **Stretching and cutting:** The tensions developed inside the RHEINZINK® bands during rolling are “stretched-out” by a stretching-bending-straightening-process.
- **“Preweathering”** (only for products with “preweathered” surface): After a cleaning process the bands are etched and rinsed. The complete etching process is carried out in an continuously operating enclosed processor.

Health protection production

Means to avoid stress or damage to health during production:

Beyond the legally binding job safety regulations required for industrial plants, no additional protective devices for health protection are required during the entire manufacturing process.

Packaging

Packaging of the titanium zinc sheets:

The packaging materials in use, paper/cardboard, polyethylene (PE foils), polypropylene (PP foils) and steel, are recyclable (non-reusable wooden pallets, reusable wooden and metal pallets). If gathered separately, return in Germany is organised by INTERSEROH (INTERSEROH certificate 27729): INTERSEROH collects the packaging material at given sites with exchangeable containers upon request and complies with legal regulations.

The reusable wooden and steel pallets are taken back and are reimbursed by RHEINZINK GmbH & Co. KG and the wholesale trade (refund system).

Environmental protection production

Means to reduce environmental impact as a result of the production process:

- **Air:** By means of adequate reduction of emissions (filter plants), the air is purified to below the limit values required by law (TA Luft).
- **Water/soil:** No additional impact on water or soil will occur. The cooling of the casting process is based on a closed water circuit. The waste water produced by the etching plant will be cleaned in a neutralisation plant and will be discharged into the city sewage system after daily analysis and provision of retention samples.
- **Noise:** Due to adequate acoustical absorption devices, measurements of sound levels have shown that all values inside and outside the production plant are far below the limits required by public law.

3 Working with the building product

Processing recommendations

Basic principles:

- During transportation and storage, RHEINZINK® must be kept dry and ventilated to avoid the formation of zinc hydroxide (see also item 4. “Building product in use”).
- For the same reason, when laying RHEINZINK® on wet surfaces or in the rain it should be ensured that the base material does not have hygroscopic properties ie. will dry off.
- The thermic stretching of the material has to be taken into consideration when handling/installing the product.
- Due to the typical brittleness of zinc under cold conditions, the temperature of the product should be ≥ 10 °C. In other cases, adequate mechanical equipment should be used, e.g. hot air blasts.

Combining zinc with other metals and with bitumen:

The combination of zinc with other metals, particularly in wet surroundings, may lead to corrosion.

For detailed information on this topic, see the Technical Processing Handbook published by RHEINZINK GmbH & Co. KG.

Zinc positioned below surfaces with bitumen coverings has to be protected against bitumen decomposition substances due to UV radiation (oxidising acids) with an adequate coat of paint. RHEINZINK GmbH & Co. KG can provide technical information about such coatings.

Detailed processing information concerning fixing, shaping and jointing as well as information on tools/machinery equipment may be found in the Technical Information Papers published by RHEINZINK GmbH & Co. KG.

When choosing additional structural components, ensure that the environmental soundness of the RHEINZINK® building products will not be strongly influenced.

Job safety

Means to protect health and maintain job safety:

When working with or installing RHEINZINK® products, no additional means to protect health are required beyond the job safety measures required by public law (e.g. protective gloves).

Environmental protection

Means to protect the environment:

No substantial environmental impacts occur when working with or installing RHEINZINK® products. No special measures are necessary for the protection of the environment.

Residual material

Residual material and packages:

On the building site, residual RHEINZINK® material and packages should be kept separately. Local regulations should be followed during disposal and the recommendations stated in item 6. “End of life phase” should be adhered to.

Product Group	Building Metals	Version
Declaration Holder:	RHEINZINK GmbH & Co. KG	16-12-2005
Declaration Number:	AUB-RHE-11105-E	

4 Building product in use

Constituents

RHEINZINK® is an alloy of fine zinc, copper, titanium and aluminium. The substances of the building product in use correspond to the raw materials named under item 1., together with the given mass-percentages. RHEINZINK® develops a superficial protective coating, the so-called patina, which darkens only slightly over the years and which is responsible for the high resistance of zinc against corrosion.

In the chemical process that forms this coating, zinc-oxide develops in contact with the oxygen in the air. Next, due to the influence of water (precipitation), zinc hydroxide develops, which will be transformed into a tight, strongly adhering and non water-soluble coating of basic zinc carbonate (patina) on reaction with the carbon dioxide in the air. Therefore RHEINZINK® does not require any maintenance. The colour shade for the RHEINZINK® products with the "preweathered^{pro}" surface quality is created during the industrial etching process, the coating itself subsequently develops as described above.

Long term durability

RHEINZINK® is UV-resistant and does not rot. It is resistant against a rust film and against most of the chemical substances used in building construction. See item 3 "Processing the building product" for processing zinc with other metals and bitumen. Effects on the durability of RHEINZINK® products with regard to wind erosion are not known. The effects of snow and rain may be neglected.

The erosion rate of RHEINZINK® Titanium zinc due to atmospheric conditions lies below 0.64 µm/year = 4.59 g/m²/year. As such, the affects are only noticeable after a long period of time (> 100 years).

Environment - health effects

Health aspects:

There will be no affects to health if the RHEINZINK® products are used according to their designated function.

Zinc, like iron, belongs to the heavy metals, i.e. metals with a specific weight > 5 kg/dm³. Zinc is not accumulated in the body. The recommended daily amount of zinc according to the Deutsche Gesellschaft für Ernährung (DGE - German Society for Nutrition) is 15 mg.

Explanation: Humans and animals have to incorporate zinc with the food since the organism can not store it adequately. Zinc, after iron, is the most important trace element for the human organism. It is omnipresent in the organism, for example it makes up a part of at least 70 enzymes. In contrast to the various zinc deficiency diseases, a high concentration of zinc in the body is very seldom.

The influence of zinc on plants and animals is difficult to assess. Zinc deficiency is more damaging than a surplus of zinc.

Environmental aspects:

- **Zinc content (zinc ions) in rain water flowing over RHEINZINK® products**

The transfer of zinc ions via rain water is constantly reduced due to the development of the natural protecting coat of zinc carbonate (Patina). The further transfer of zinc ions depends mainly on air contamination with 'acid' pollutants, particularly with SO_2. As a result of the reduction of SO_2 concentration in the air to one fifth of the former values during the last 10 years, the zinc concentration of precipitation has subsequently been reduced by the same amount.

- **Injection of zinc into running waters:**

No exceedences of flowing water quality limitations as a result of precipitation runoff to flowing water have been disclosed. See also item 8. "Evidence".

- **Seepage into soil:**

Due to the seepage of precipitation, the amount of zinc in soils may increase slightly, but there is no danger of a zinc surplus for soil/plants/animals.

5 Singular effects

Fire

Fire performance:

The RHEINZINK® products comply with DIN 4102, Part 1 and to DIN EN 13501-1 the Requirements of Building Material Class A1 "non-combustible".

Smoke production/smoke concentration:

When heated above 650°C vaporization as zinc oxide (ZnO) occurs, producing smoke.

Toxicity of the fumes:

The ZnO smoke may cause zinc fever (diarrhoea, fever, dry throat) when inhaled over some period of time, this disappears completely 1 to 2 days after inhalation.

Change of state (burning drip down/drop-out):

The melting point is + 419 °C.

Water

Water impact:

See indications given under item 4 "Building product in use" as well as under item 8. "Evidence".

6 End of life phase

Disassembly When renovating or disassembling a building, RHEINZINK® products can easily be collected.

Circulation The trimming scrap produced during manufacturing the material is 100% remelted at RHEINZINK GmbH & Co. KG and processed into new products. The cuttings occurring at building sites as well as used zinc from renovation sites are gathered and may be sent directly or via scrap gathering organisations to secondary melting plants - several exist in Germany. The energy necessary for recycling titanium zinc sheets is only 5% of the primary energy content of zinc. The demand for zinc scrap, resulting from zinc recycling's low energy requirement, is also mirrored by the fact that generally about 70% of the value of the zinc content is reimbursed. According to the newest information, the total recycling rate is up to 96%. Nearly every recyclable zinc material is being recycled approx. 1/3 for steel production, approx. 1/3 for brass production and the rest as zinc oxide for the production of zinc compounds (chemical industry, rubber industry, production of ceramics and glass, pharmaceutical industry, animal foodstuff and cosmetics industry, lacquer production etc.). The discrepency between quantities produced and the amount actually returning can be attributed to erosion.

Disposal

Disposal/dumping:

Due to the effective recycling process, no zinc has to be disposed. When analysing domestic and industrial waste, zinc is only be found in traces.

7 Life cycle assessment

7.1 Production of titanium zinc sheets

Declared unit The declared unit is the production, use and treatment of one kg titanium zinc sheet with an average thickness.

System boundaries The life cycle analysis for the **production** of the titanium zinc sheet comprises the life cycle phases from "cradle to gate". It begins with the consideration of the ore mining and the processing to fine zinc. The manufacture of the other raw and auxiliary materials is also included.

The production of the sheets is included in the analysis. Transports of the ore concentrate and of the fine zinc for sheet production are considered.

The **use phase** exclusively refers to the zinc erosion for application in roofing and wall claddings as well as in roof drainage systems.

The system boundaries for the **end of life phase** refer to the life cycle phase material recycling, i.e. the processing of zinc scraps. The assessment scope begins at the gate of the reprocessing plant. It is assumed that the zinc scraps are delivered to the reprocessing plant. On the input side, the treatment for reprocessing starts with the process of re-melting in melting stoves. It is assumed for the output side that secondary zinc is re-used because zinc scraps can be re-melted without any loss in quality. Since by-products such as melting residues, and other products such as hard zinc, ashes and dusts are still of value, they can be further processed, too.

Cut-off criteria

All material flows that enter the system on the input side and whose contribution is more than 1% of their total mass or more than 1% to the primary energy use were considered. All material flows, which exit the system on the output side and whose environmental impacts contribute more than 1% of the total impacts of the considered impact categories are included.

Transports

Expenditure for transports of the zinc concentrates was principally considered. The origins of the zinc concentrates are mainly Canada, Australia, Central und South America.

Period under consideration

The base data for this Life Cycle Assessment (LCA) are based on the data acquisitions of RHEINZINK GmbH & Co. KG from the year 2000 and from WirtschaftsVereinigung Metalle. Statistical data are from the year 2004.

Background data

In order to model the life cycle for the production and treatment of the titanium zinc sheets, the GaBi 4 software system was used /GaBi 4/. All relevant background data necessary for the production of zinc and its treatment were taken from the software GaBi 4; specific data sets for production at RHEINZINK have been balanced according to the specifications of RHEINZINK.

Data quality

All data used are less than five years old. The manufacturing processes at RHEINZINK essentially correspond to those of other manufacturers.

Allocation

Various attributions to by-products (allocations) are necessary for the system of production of titanium zinc sheets. This includes:

- an allocation when melting zinc according to mass of zinc, hard zinc and melt-off residues;
- an allocation of the leaching including lye clearing (by-products copper, lead-silver-alloy, cadmium briquette) according to price;
- an allocation when producing zinc concentrate to the products zinc concentrate, copper concentrate and lead concentrate according to price;

The recycling potential was calculated according to the requirement of the AUB PCR document “Building metals”.

It describes the ecological value of a material’s “accumulation” in the “technosphere”. It states how many environmental burdens may be avoided in relation to a new production of the material (here, the avoidance of primary fine zinc production). For this purpose, a collection rate of 96% is assumed (see item 6.). Taking into account this collection rate and today’s technologies in metal recycling, an amount of 65% primary zinc for the production of one kg titanium zinc sheet is assumed. Since the recycling potential when manufacturing the product represents a saving, it is composed of a complete dataset with several characteristics.

If the complete recycling potential is used, the characteristics for manufacturing the product are lowered by those for the recycling potential. This demonstrates the life cycle view and is shown in the result tables as "Sum of production and recycling potential".

Use phase

The lifetime of building products depends on the respective construction, use, service and maintenance.

For the calculation of zinc erosion of a typical use phase, the application areas have to be considered separately (roof drainage, roofings, wall claddings); for cuttings, wetted surface and service lifes, typical assumptions have to be met.

Table 3: Zinc erosion for specific uses of titanium zinc sheets

	Roof drainage	Roofings	Wall claddings
Average sheet thickness	0.70 mm	0.705 mm	0.767 mm
Moulded density	7.2 g/cm³	7.2 g/cm³	7.2 g/cm³
Wetted surface	50%	75%	10%
Maximum weathering factor	4.59 g/m² * a	4.59 g/m² * a	4.59 g/m² * a
Minimum weathering factor	3.76 g/m² * a	3.76 g/m² * a	3.76 g/m² * a
Maximum zinc erosion	**0.46 g/kg * a**	**0.68 g/kg * a**	**0.08 g/kg * a**
Minimum zinc erosion	**0.37 g/kg * a**	**0.56 g/kg * a**	**0.07 g/kg * a**

Only the material-specific part of the use phase (weathering of zinc) is described in this declaration.

7.2 Recycling of titanium zinc sheets

Choice of treatment method

In addition to the manufacturing of the titanium zinc sheets, their collection and treatment was also modelled. A collection rate of 96% was assumed. The zinc scrap that is available for the end-of-life recycling after it has been subtracted from the scrap required for production is re-melted; the amount of zinc gained is credited.

Credits

The credit for the zinc that was gained through re-melting is calculated with the dataset of the primary zinc production.

7.3 Results of the assessment

Life Cycle Inventory

Table 4 shows the energy use for the production of one kilogram zinc sheet. The use of non-renewable energies for the sheet production mounts to 45.5 MJ per kg. It derives mainly from the primary fine zinc production (electricity mix and mining of zinc concentrate). 81% of the non-renewable energies can be allocated to the fine zinc manufacturing, 12% result from the zinc re-melting in the manufacturing phase.

In addition, 3.8 MJ of renewable energies (85% hydro power, 4% wind energy and 10% wood) are used for the production of one kilogram zinc sheet.

The following table shows the primary energy demand for both the manufacturing and the recycling potential.

The composition of the recycling potential applies to all following tables and figures.

Table 4: Primary energy use of the life cycle of 1 kg titanium zinc sheet

Titanium zinc sheet				
Parameter	Unit per kg	**Sum of production and recycling potential**	Production	Recycling potential
Primary energy, non-renewable	[MJ]	**16.3**	45.5	- 29.2
Primary energy, renewable	[MJ]	**0.94**	3.81	- 2.87

The evaluation of the non-renewable energy demand for the production of one kilogram zinc sheet (Figure 1) shows that the main primary energy sources are uranium and black coal, which cover together about 60% of the required primary energy. The relatively high amount of uranium originates from the consumption of energy for the fine zinc production, which is covered by an electricity mix that also includes nuclear power.

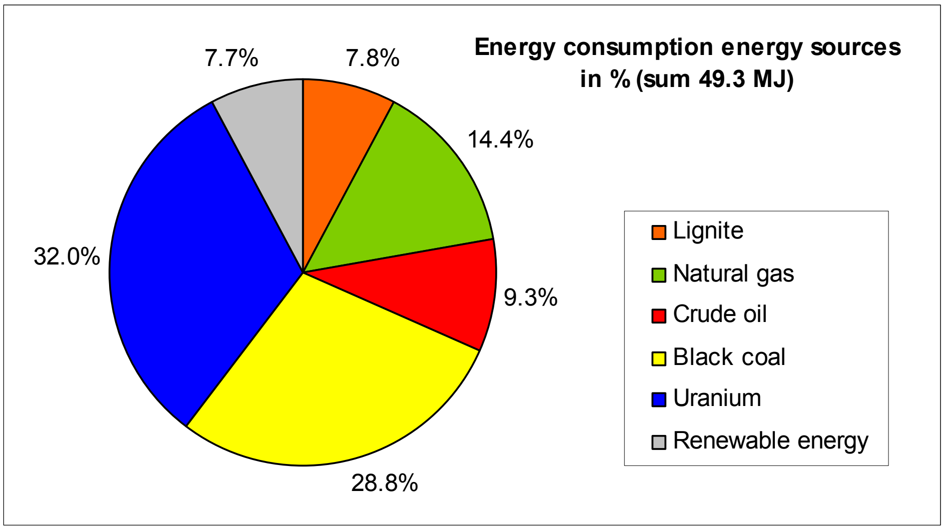

Figure 1: Breakdown of the use of renewable and non-renewable primary energy for the production of 1 kg titanium zinc sheet

Considering production and end of life (re-melting of the zinc scraps with credit of primary zinc) it is remarkable that the recycling potential for primary zinc is 32 MJ of primary energy per kg titanium zinc sheet. The net primary energy consumption (from a life cycle viewpoint) is thus reduced by almost two-thirds.

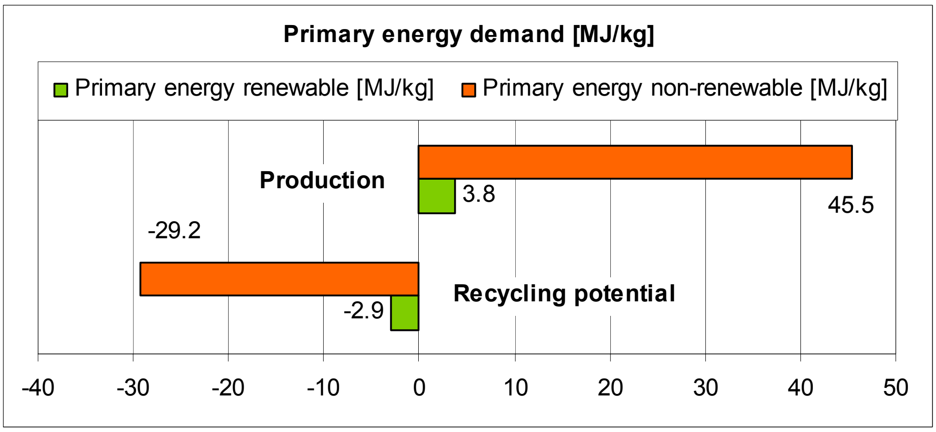

Figure 2: Balance for the primary energy consumption of 1 kg titanium zinc sheet

The analysis of the waste produced during the production of one kg zinc sheet is shown for three parts; overburden/stockpile dump (containing ore processing residues), municipal waste (containing household rubbish and commercial waste), hazardous waste including radioactive waste (Table 5).

It can be said that the stockpile dump represents the largest amount of the **overburden**. The stockpile dump is mainly attributed to the electricity generation (extraction of coal). Ore processing residues accrue from the extraction and processing of the ore concentrates.

The most important parameter for the **municipal waste** is the unspecific waste. All other parameters are of minor importance.

Hazardous waste consists mainly of waste from preliminary processes, above all sludges from the production of the zinc concentrate as well as from electricity generation. The radioactive waste exclusively results from the consumption of electricity (nuclear power).

Table 5: Waste produced during the production and end of life of 1 kg titanium zinc sheet

Titanium zinc sheet				
Parameter	Unit per kg	**Sum of production and recycling potential**	Production	Recycling-potential
Overburden/stockpile dump	[kg]	**3.66**	8.42	- 4.76
Municipal waste	[kg]	**$0.209 * 10^{-3}$**	$0.3 * 10^{-3}$	$- 91.1 * 10^{-6}$
Hazardous waste	[kg]	**$7.28 * 10^{-3}$**	$17.4 * 10^{-3}$	$- 10.1 * 10^{-3}$

Impact assessment

The following table shows the contributions of the production and treatment of titanium zinc sheets to the Global Warming Potential, Ozone Depletion Potential, Acidification Potential, Eutrophication Potential and Photochemical Ozone Creation Potential impact categories.

Table 6: Results of the impact assessment for the production and end of life of 1 kg titanium zinc sheet

Titanium zinc sheet				
Parameter	Unit per kg	**Sum of production and recycling potential**	Production	Recycling potential
Global Warming Potential (GWP)	[kg CO_2 eqv.]	**0.96**	2.62	- 1.65
Ozone Depletion Potential (ODP)	[kg R11 eqv.]	**$0.176 * 10^{-6}$**	$0.562 * 10^{-6}$	$- 0.387 * 10^{-6}$
Acidification Potential (AP)	[kg SO_2 eqv.]	**$3.32 * 10^{-3}$**	$13.5 * 10^{-3}$	$- 10.2 * 10^{-3}$
Eutrophication Potential (EP)	[kg PO_4 eqv.]	**$0.277 * 10^{-3}$**	$1.03 * 10^{-3}$	$- 0.758 * 10^{-3}$
Photochemical Ozone Creation Potential (POCP)	[kg ethene eqv.]	**$0.294 * 10^{-3}$**	$1.10 * 10^{-3}$	$- 0.796 * 10^{-3}$

The **Global Warming Potential** (GWP) is dominated by carbon dioxide (over 98%). The savings of CO_2 emissions in the end of life phase oppose the CO_2 emissions of the production plus those from the re-melting. In total, this adds up to a GWP of 0.96 kg CO_2 for the entire life cycle of one kg titanium zinc sheet.

The consumption of energy during the production of fine zinc represents the most important part of the **Ozone Depletion Potential** of the production.

The production of the zinc concentrate and the electricity generation contribute to the **Acidification Potential** and **Eutrophication Potential**.

The Photochemical Ozone Creation Potential is dominated - like the other impact categories - by the production of fine zinc. Analogous to the Acidification and Eutrophication impact categories, the electricity generation represents the process with the biggest impact. At the end of the life cycle only small impact potentials remain thanks to the re-melting of the zinc scrap and the resulting avoidance of primary fine zinc production.

8 Evidence and verifications

8.1 Erosion rates

Test set up: test period 1991 – 1998, test site Hanover, titanium zinc sheets, thickness 0.7 mm with surface qualities bright rolled and preweathered, roof slope 7° and 45°, west orientation.

Test laboratory: Prof. Dipl.-Ing. Wolf-Hagen Pohl; Department of Building Material Science and Building Physics, University of Hanover.

Test report: dated May 1999

Test results: As a general feature the rates of corrosion and erosion of zinc ions due to precipitation are dependent on the rapidity of patina formation, on the slope of the surface and on the orientation (aspect), on the rates of precipitation as well as on the composition of the air and precipitation (in particular, the amount of SO_2). During the formation of the patina (a period lasting approx. 3 years) the corroding rates regress continuously and then become stagnant on a low level. The corroding rates diminish with rising slopes. Compared with other orientations, the corroding rates are higher if the orientation is to the west (weatherside).

They also increase with high precipitation rates and with high rates of SO_2. Depending on the surface quality and on the roof slope, the corroding rates measured for the first year are 0.64 – 0.90 mm = 4.62 – 6.46 g/m²/year and will be reduced after 3 years, i.e. after formation of the patina, to 0.54 – 0.69 mm/year = 3.9 – 4.98 g/m²/year. Over a period of eight years the median values of the corroding rates are 0.52 – 0.64 mm/year = 3.76 – 4.59 g/m²/year. Due to the reduction of SO_2 concentration in the air/atmosphere the corroding rates are nowadays less than one fifth of the values in the seventies and eighties. Resulting from these eroding rates the amount of zinc (zinc ions) in precipitation shows concentrations of 6 – 8 mg/l on average; these do not bear any risks for the environment/living organisms.

9 PCR document and verification

This declaration is based on the PCR document “Building Metals”.

Review of the PCR document by the independent Advisory Board (SVA). Chair of the SVA: Prof. Dr.-Ing. Hans-Wolf-Reinhardt (University Stuttgart, IWB).
Independent verification of the declaration according to ISO 14025: ☐ internal ☒ external
Validation of the declaration: Dr. Eva Schmincke

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