ENVIRONMENTAL PRODUCT DECLARATION

as per ISO 14025 and EN 15804

Owner of the Declaration	**RHEINZINK GmbH & Co. KG**
Programme holder	Institut Bauen und Umwelt e.V. (IBU)
Publisher	Institut Bauen und Umwelt e.V. (IBU)
Declaration number	EPD-RHE-2012111-E
Issue date	28.12.2012
Valid to	27.12.2017

RHEINZINK-prePATINA® bright-rolled

RHEINZINK GmbH & Co. KG

Institut Bauen und Umwelt e.V.

PATINA

PATINA LINE

www.bau-umwelt.com / https://epd-online.com

1. General Information

RHEINZINK GmbH & Co. KG

Programme holder
IBU - Institut Bauen und Umwelt e.V.
Rheinufer 108
D-53639 Königswinter

Declaration number
EPD-RHE-2012111-E

This Declaration is based on the Product Category Rules:
Building metals, 07-2012
(PCR tested and approved by the independent expert committee [SVA])

Issue date
28.12.2012

Valid to
27.12.2017

Prof. Dr.-Ing. Horst J. Bossenmayer
(President of Institut Bauen und Umwelt e.V.)

Prof. Dr.-Ing. Hans-Wolf Reinhardt
(Chairman of SVA)

RHEINZINK-prePatina bright-rolled

Owner of the Declaration
RHEINZINK GmbH & Co. KG
Bahnhofstraße 90
45711 Datteln

Declared product / Declared unit
RHEINZINK®-prePATINA bright-rolled

Scope:
The **Life Cycle Assessment (LCA)** was carried out according to DIN ISO 14040 et sqq. Specific data from the company RHEINZINK in Datteln, Germany, and from the data base "GaBi 5" were used. The LCA was carried out for the manufacturing phase of the products, taking into account all background data such as raw material production and transports ("cradle to gate"). The use phase of the titanium zinc sheets is divided into several application areas: roofing applications, roof drainage and facade claddings. The treatment for the titanium zinc sheets was modeled in re-melting furnaces for the end of life phase. The thereby resulting credit of extracted zinc is counted as replacement for primary zinc. The owner of the declaration shall be liable for the underlying information and evidence.

Verification

The CEN Norm EN 15804 serves as the core PCR	
Independent verification of the declaration and data according to ISO 14025	
☐ internally	☒ externally

Dr.Ing. Ivo Mersiowsky
(Independent tester appointed by SVA)

2. Product

2.1 Product description
The basis of the RHEINZINK® alloy is electrolytic high-grade fine zinc in accordance with DIN EN 1179, with a 99.995 % degree of purity. Added to this are small amounts of titanium and copper based on EN 988.
In addition to other factors, the alloy composition is not only of importance for the technological material properties of RHEINZINK®, but also for the colour of its patina.

2.2 Application

• Titanium zinc sheets, strips and profiles for roofing and facade cladding

• Roof drainage systems (roof gutters, pipes and accessories)

2.3 Technical Data
The following table gives conversion data from product surface mass per unit area for the relevant product systems.

System	Area of Application	Thickness of metal	Weigh per m²
Double-standing seam	Roof	0,70	5,8 kg/m²
Roll-cap System	Roof	0,70	5,8 kg/m²
Square tiles	Roof	0,70	7,7 kg/m²
Gutter	Roofdrainage	0,70	1,7 kg/m
Downpipe	Roofdrainage	0,70	1,6 kg/m
Angle-standing seam	Façade cladding	0,70	5,7 kg/m²
Angle-standing seam	Façade cladding	0,80	6,6 kg/m²
Flat-lock tiles	Façade cladding	0,70	7 kg/m²
Reveal panel	Façade cladding	1,00	9,8 kg/m²
Horizontal panel	Façade cladding	1,00	9,8 kg/m²
Shipboard panel	Façade cladding	1,00	10,4 kg/m²

Technological Data

Name	Testing standard	Value	Unit
Coefficient of thermal expansion	*	22	$10^{-6}K^{-1}$
Tensile strength	EN 10002-1	≥ 150	N/mm²
Modulus of elasticity	*	≥ 80.000	N/mm²
Melting point	*	420	°C
Thermal conductivity	*	109	W/(mK)
Density	*	7200	kg/m³

* No testing standard required: Test related to F. Porter, Zinc Handbook, Marcel Dekker Inc., 1991 (ISBN 0824783409)

2.4 Placing on the market / Application rules
EN 988:1996-08, Zinc and zinc alloys - Specification for rolled flat products for building
EN 506:2000-12, Roofing products from metal sheet-Specification for self-supporting products of copper and zinc sheet
EN 612:2005-04, Eaves gutters with bead stiffened fronts and rainwater pipes with seamed joints made of metal sheet

2.5 Delivery status
The material RHEINZINK® is delivered in thicknesses from 0,5 – 1,5 mm. The maximum width of strips and sheets is 1.000 mm. The standard sheets are delivered in 1x2 m and 1x3 m, strips are coiled up to 1 to weight. Finished products are delivered to customer specification.

2.6 Base materials / Ancillary materials

Components of RHEINZINK-alloy

- Special-High-Grade zinc 99.995% (Z1 according to DIN EN 1179): ≤ 99,835%
- Copper: 0,08 - 1,0%
- Titanium: 0,07 - 1,2%
- Aluminium: ≤ 0,015%

Auxiliary substances
Lubricant emulsion: 0.08 kg/t zinc

2.7 Manufacture
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.

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.

2.8 Environment and health during manufacturing

Environmental management according to DIN EN ISO 14001. Energy management according to ISO 50001.

2.9 Product processing/Installation

Basic principles:
During transportation and storage, RHEINZINK® must be kept dry and ventilated to avoid the formation of zinc hydroxide 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.

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.

2.10 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. which 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).

RHEINZINK®

2.11 Condition of use

RHEINZINK® is UV-resistant and does not rot. It is resistant against a rust film, nonflammable and resistant to radiating heat and against most of the chemical substances used in building construction. Effects on the durability of RHEINZINK® products with regard to snow, rain and hail are not known. The effects of snow and rain may be neglected. This material has a repellent effect to electrosmog (electromagnetic radiation in excess of 98%).
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 patina, zinc-oxide develops in contact with the oxygen in the air. Next, due to the influence of water (precipitation), zinchydroxide 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 and cleaning.

2.12 Environment and health during use

Environmental aspects:
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 30 years, the zinc concentration of precipitation has subsequently been reduced by the same amount in the rainwater. The total-zinc-concentration has been lower that the prescriptive limits for drinking water.
In aquatic systems only a small part of the total zinc concentration is available for an organism - this amount is called bioavailable. It is related to the physical-chemical conditions of the receiving water body. The bioavailability is for example influenced by the amount of zinc which is organically or inorganically bound, linked to particles or competes which other ions.

	Roof drainage	Roofing	Facade cladding
Average Material thickness	0,70 mm	0,70 mm	0,80 mm
Density	7,2 g/cm³	7,2 g/cm³	7,2 g/cm³
Exposed surface	50%	75%	10%
Max. Run-off rate	3,0 g/m²/a	3,0 g/m²/a	3,0 g/m²/a
Min. Run-off rate	2,0 g/m²/a	2,0 g/m²/a	2,0 g/m²/a
Max. zinc Run-off (per m²)	**1,5 g/m²/a**	**2,25 g/m²/a**	**0,3 g/m²/a**
Min. zinc Run-off (per m²)	**1,0 g/m²/a**	**1,5 g/m²/a**	**0,2 g/m²/a**
Max. zinc Run-off (per kg)	**0,3 g/kg/a**	**0,45 g/kg/a**	**0,05 g/kg/a**
Min. zinc Run-off (per kg)	**0,2 g/kg/a**	**0,3 g/kg/a**	**0,03 g/kg/a**

Lit.: R. H. J. Korenromp et al, „Diffusive Emissions of zinc due to atmospheric corrosion of zinc coated (galvanised) materials“, TNO- Report R 99/441 (1999)

Health aspects:
There will be no effects to health if the RHEINZINK® products are used according to their designated function. Zinc, like iron, belongs to the essential metals. Zinc is not accumulated in the body. The recommended daily intake of zinc according to the Deutsche Gesellschaft für Ernährung (DGE - German Society for Nutrition) is 15 mg.

2.13 Reference service life

Service lifetime according to BBSR: > 50 years, theoretical lifetime according to available literature > 100 years. The standard ISO 15686 has not been considered.
Influences on ageing when applied in accordance with the rules of technology.

2.14 Extraordinary 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 time, this disappears completely 1 to 2 days after inhalation.

Change of state (burning drip down/drop-out):
The melting point is 420°C.

Water
None.

Mechanical destruction
None.

2.15 Re-use 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 organizations 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%.

2.16 Disposal

Due to the effective recycling process, no zinc has to be disposed.

2.17 Further information

Additional information: www.rheinzink.de

3. LCA: Calculation rules

3.1 Declared Unit
The declared unit is 1 kg of prePatina bright rolled.

3.2 System boundary

Type of the EPD: cradle to gate - with options
In this study, the product stage information modules A1, A2, and A3 are considered. These modules include production of raw material extraction and processing (A1), processing of secondary material input (A1), transport of the raw materials to the manufacturer (A2), manufacturing of the product (A3) and the packaging materials (A3).
The EoL of the product (Modul D) is also included.

3.3 Estimates and assumptions
No assumptions and estimations were necessary for the LCA.

3.4 Cut-off criteria
Criteria for the exclusion of inputs and outputs (cutoff rules) in the LCA and information modules and any additional information are intended to support an efficient calculation procedure.
All inputs and outputs to a (unit) process are included in the calculation, for which data were available. The applied cut – off criteria is 1 % of renewable and non-renewable primary energy usage and 1 % of the total mass input of that unit process in case of insufficient input data or data gaps for a unit process. The total of neglected input flows per module, e.g. per module A, B, C or D is a maximum of 5 % of energy usage and mass.

3.5 Background data
Background processes are taken from the publicly Professional GaBi 5 databases as far as available. Country and region specific data on energy sources including electricity and region specific data on raw materials such as high grade zinc were taken from GaBi databases.

3.6 Data quality
The process data and the used background data (GaBi 5) are consistent. In addition, the origin of the data is documented. Additional information is gathered regarding the age of the data.
The input and output data of the whole process Plant was strongly emphasized. The supplied data (Processes) were provided by RHEINZINK and checked for plausibility. Therefore, the data quality can be described as good.
The age of the data employed in this study is due to 2010.

3.7 Period under review
Modelling is based on production data from 2010. Background data refer from 2008 to 2011.

3.8 Allocation
In this study, allocation was avoided wherever possible as required in EN 15804.
However, the following allocations had to be done:

- Credits from energy recovery of production waste (Modul A3)
- Credits from recycling from the end of life of the product (ModulD)

3.9 Comparability
Basically, a comparison or an evaluation of EPD data is only possible if all the data sets to be compared were created according to EN 15804 and the building context, respectively the product-specific characteristics of performance, are taken into account.

4. LCA: Scanrios and additional technical information

The modules A4, A5, B1, B2, B3, B4, B5, reference service life, B6, B7 and C1 – C4 are not considered and declared in this study.
The credits given in Module D are a result of the 100% recyclability of each zinc-product. After the scrap collection (a collection rate of 96% was assumed), zinc scrap is sent to a re-melting process, where the scrap is converted to secondary zinc. The credit for the zinc gained through re-melting is calculated with the dataset of the primary production.

5. LCA: Results

DESCRIPTION OF THE SYSTEM BOUNDARY (X = INCLUDED IN LCA; MND = MODULE NOT DECLARED)

PRODUCT STAGE			CONSTRUCTION PROGRESS STAGE		USE STAGE							END OF LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARYS
Raw material supply	Transport	Manufacturing	Transport	Construction-installation process	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
A1	**A2**	**A3**	**A4**	**A5**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**C1**	**C2**	**C3**	**C4**	**D**
X	X	X	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	X

RESULTS OF THE LCA - ENVIRONMENTAL IMPACT: 1kg prePatina bright-rolled

		Manufacturing	Credits
Parameter	**Einheit**	**A1-A3**	**D**
GWP	[kg CO_2-Äq.]	3,6E+00	-2,6E+00
ODP	[kg CFC11-Äq.]	3,3E-07	-3,0E-07
AP	[kg SO_2-Äq.]	2,5E-02	-1,9E-02
EP	[kg PO_4^{3-}- Äq.]	2,5E-03	-2,1E-03
POCP	[kg Ethen Äq.]	1,4E-03	-1,1E-03
ADPE	[kg Sb Äq.]	1,9E-04	-1,6E-04
ADPF	[MJ]	3,5E+01	-2,5E+01
Caption	GWP = Global warming potential; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential of land and water; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone photochemical oxidants; ADPE = Abiotic depletion potential for non fossil resources; ADPF = Abiotic depletion potential for fossil resources		

RESULTS OF THE LCA - RESOURCE USE: 1kg prePatina bright-rolled

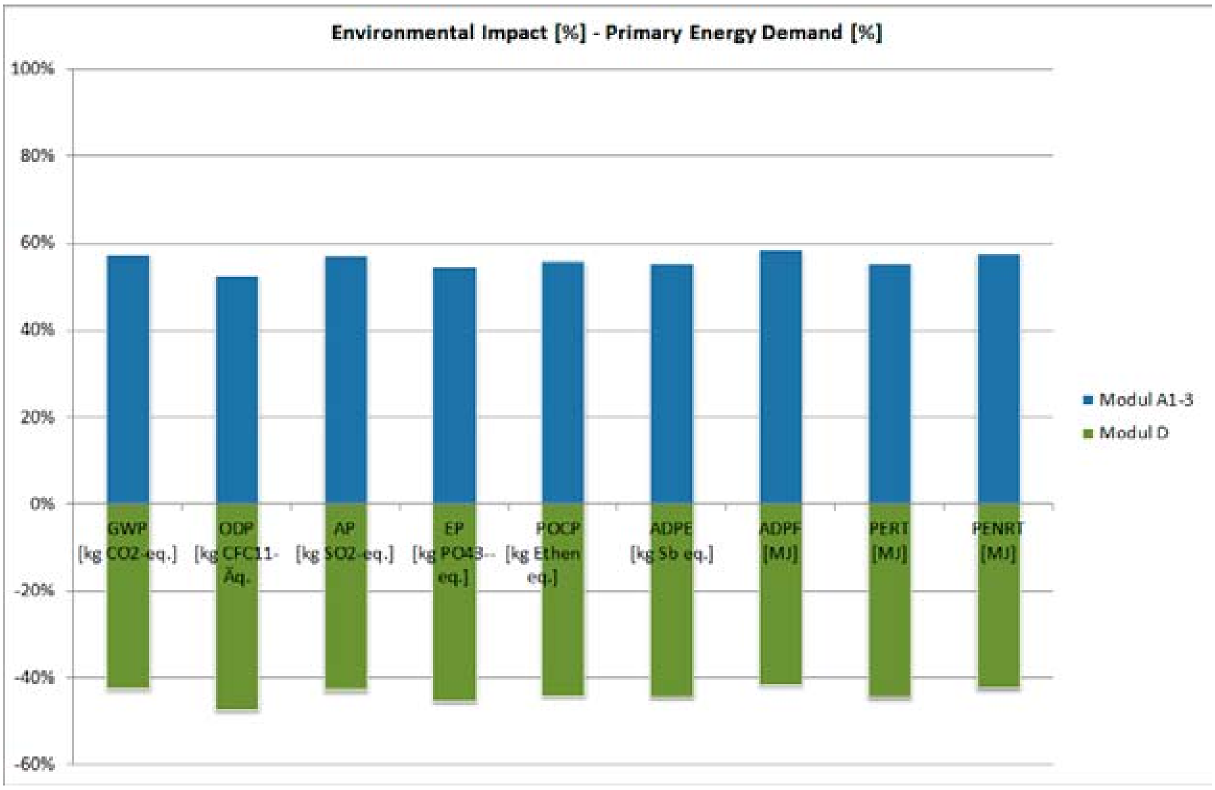
		Manufacturing	Credits
Parameter	**Einheit**	**A1-A3**	**D**
PERE	[MJ]	8,3E+00	-6,7E+00
PERM	[MJ]	0	0
PERT	[MJ]	8,3E+00	-6,7E+00
PENRE	[MJ]	4,7E+01	-3,5E+01
PENRM	[MJ]	0	0
PENRT	[MJ]	4,7E+01	-3,5E+01
SM	[kg]	0	0
RSF	[MJ]	2,5E-04	4,0E-03
NRSF	[MJ]	2,6E-03	4,2E-02
FW	[m^3]	-*	-*
Caption	PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non renewable primary energy excluding non renewable primary energy resources used as raw materials; PENRM = Use of non renewable primary energy resources used as raw materials; PENRT = Total use of non renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non renewable secondary fuels; FW = Use of net fresh water		

RESULTS OF THE LCA – OUTPUT FLOWS AND WASTE CATEGORIES: 1kg prePatina bright-rolled

		Manufacturing	Credits
Parameter	**Einheit**	**A1-A3**	**D**
HWD	[kg]	-*	-*
NHWD	[kg]	-*	-*
RWD	[kg]	4,6E-03	3,6E-03
CRU	[kg]	-	-
MFR	[kg]	0	9,6E-01
MER	[kg]	-	-
EE [Typ]	[MJ]	-	-
EE [Typ]	[MJ]	-	-
Caption	HWD = Hazardous waste disposed; NHWD = Non hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EE = Exported energy per energy carrier		

**These indicators are temporarily not reported as agreed in the advisory board meeting from 04.10.2012.*

6. LCA: Interpretation



Impact categories for the life cycle of 1kg prePatina bright-rolled Zinc sheet

The **GWP** is dominated by the use of the high grade Zinc (89%). Almost the rest is due to the energy consumption (8,3% come from the electricity grid mix). Around 40% of the impact is credited because of the high recycle rate of the product.
The **ODP** is most notably influenced by the use of the refined Zinc (99%), as raw material. These results come mainly from the used power grid mix and other energy carriers by the extraction and production of high grade zinc. The relevant emissions are the R 11 and R 114.
The **AP** is also dominated by the production due to the emissions related to use of the high grad zinc and to the energy consumption at the manufacture side. Mostly the impact refers to emissions to air: 50% from sulfur dioxide and 39% from nitrogen oxides.
The **EP** is significantly influenced by the use of the high grade zinc (97%). Almost the rest is due to the use of electric energy (1,9%). Nitrogen oxides emissions contribute with around 89% to the total impact.
The **POCP** is particularly dominated by the use of the refined zinc (96%) and present a similar profile as the eutrophication potential. The main emissions contributing to this impact category are NMVOCs (11%), sulfur dioxide (31%) and nitrogen oxides (34%).

The **ADP elements** are dominated by the raw material high grade Zinc, coming from the consumption of copper-gold-silver-ore (82%) and lead zinc ore (20%).
The **ADP fossil** is dominated with around 88% by the raw material Zinc (44% coming from the consumption of hard coal) and 8,5% by the electricity grid mix used during the production of the product bright rolled zinc sheet. The most important energy sources are hard coal (44%), natural gas (26%), crude oil (13%) and lignite (16%).
The **total primary energy demand** is divided into around 89% of non-renewable energy and 11% of renewable energy.
The primary energy demand non-renewable **(PENRT)** is dominated by the raw material high grade zinc.
The renewable energy demand **(PERT)** present a similar profile as the non-renewable, the dominating contributor is the high grade zinc production (88%). Around 10% of the total impact comes from the use of electric energy in the production of bright rolled zinc sheet.

7. Requisite evidence

Runoff rates
In a report of TNO of 1999, a literature study was undertaken to determine the runoff rates of zinc in Europe. The following conclusions were taken in this report:

Corrosion rates refer to the loss of metallic zinc, initially accumulating as ionic zinc in the patina layer. Run-off rates refer to the "wash-off" of ionic zinc from the patina layer, the difference being the amount of zinc remaining in the patina layer. Run-off rates will in general be lower than corrosion rates or at maximum equal to the corrosion rates.
Available data for corrosion and run-off rate result from exposure of standard test panels mounted on standard test racks. Only little data are available from testing (on) real objects under the variety of typical microclimate conditions to which they are exposed. Recent experimental data with very large test racks (simulating zinc roofs) suggest that small test racks may overestimate the run-off rate.

The decrease of the corrosion rates runs parallel to the decrease of the ambient concentrations of SO2, which is generally accepted as the dominant air pollution factor determining corrosion of zinc.

Corrosion rates decrease with time due to the increasing protection of the patina layer. Therefore long term (20 years) average corrosion rates will be substantially lower (60% of initial value) than those during the first years of fresh not patinated materials. After a period of about 10 years, the run-off rate will be approximately 2/3 of the corrosion rate.
Run-off rates can be calculated to be 3 g/m²/a in areas with higher SO2 concentrations and 2 g/m²/a in areas with lower concentrations.

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