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pv magazine webinars

Steel foundations: from corrosion to confidence

23 October 2025

3:00 pm – 4:00 pm | CEST, Berlin
9:00 am – 10:00 am | EDT, New York City
10:00 am – 11:00 am | BRT, Sao Paulo

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Welcome!

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Do you have any questions? ❓ 🙋

Send them in via the Q&A tab. 👉 We aim to answer as many as we can today!

You can also let us know of any tech problems there.

We are recording this webinar today. 📹

We‘ll let you know by email where to find it and the slide deck, so you can re-watch it at your convenience. 👀 💡

From corrosion to confidence:

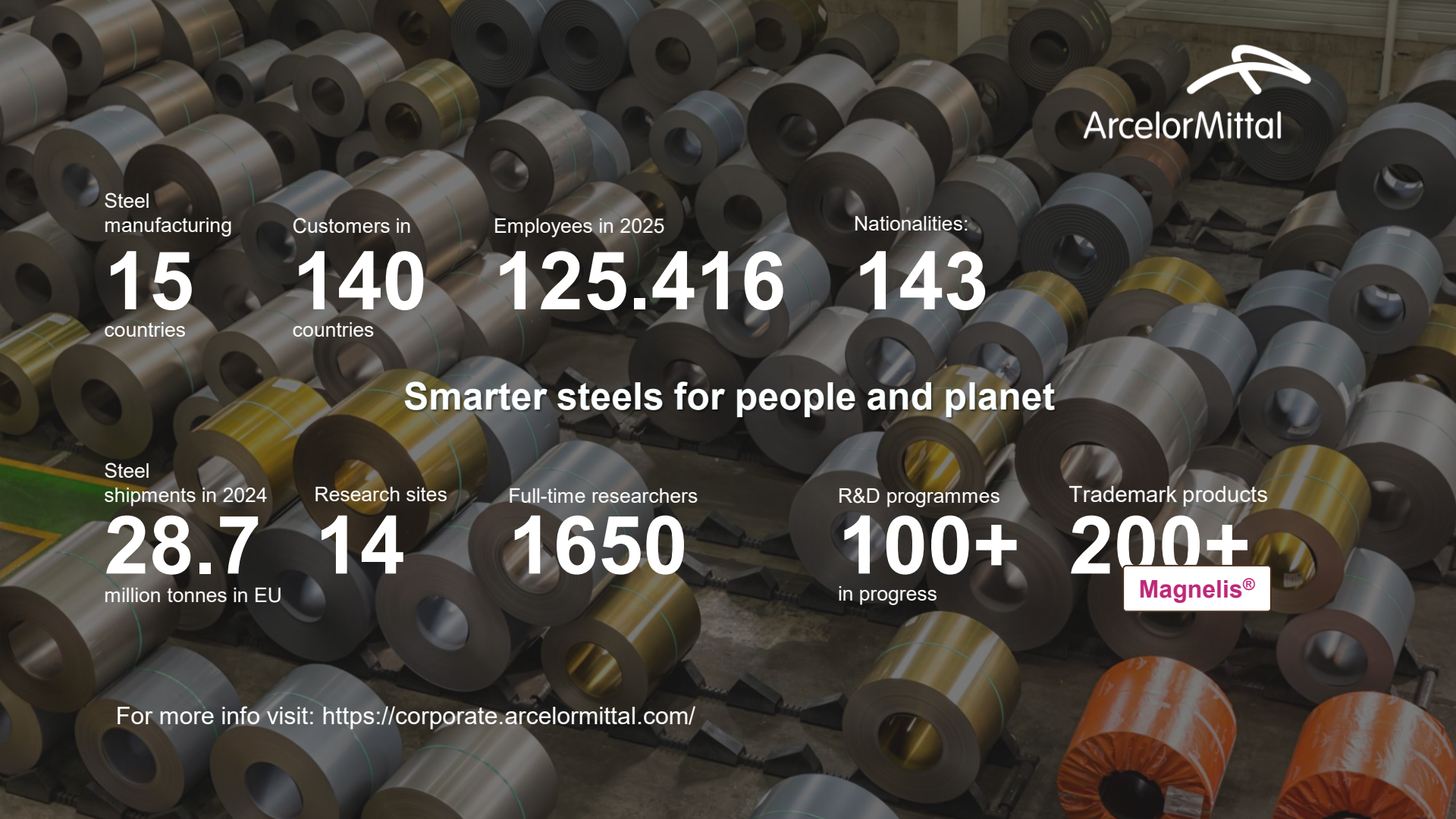
the case for Magnelis® excelling over batch galvanisation in PV foundations

23 October 2025
ArcelorMittal Europe – Flat Products

@ArcelorMittal Corab site

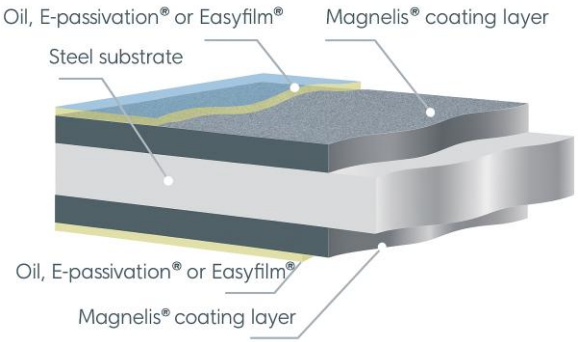
Agenda

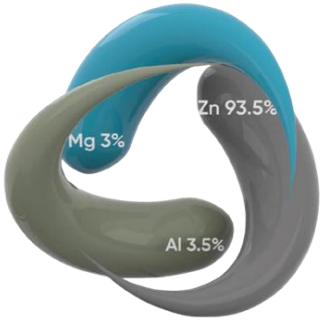
- Steel corrosion and how to prevent it
- Magnelis® industrial coating
- Comparison with traditional galvanisation
- Predicting product lifetime and guarantees
- Q&A


ArcelorMittal
Steel manufacturing
15
countries
Customers in
140
countries
Employees in 2025
125.416
Nationalities:
143
Smarter steels for people and planet
Steel shipments in 2024
28.7
million tonnes in EU
Research sites
14
Full-time researchers
1650
R&D programmes
100+
in progress
Trademark products
200+
Magnelis®
For more info visit: https://corporate.arcelormittal.com/

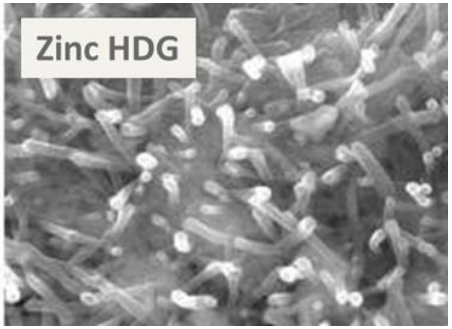
Magnelis®, the logical evolution of galvanised coated products

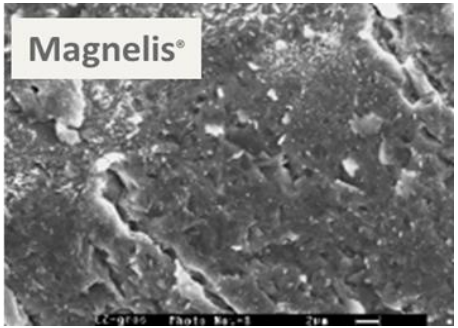
A mastered process





An optimized composition





Specific corrosion products

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Magnelis® is more than a coating, it is a corrosion defence system: The Magnelis® triple shield

Benefit from the unique triple protection of Magnelis®

It acts as **a barrier**.

It provides **sacrificial cathodic protection**.

Its interaction with the environment **actively** protects the steel.

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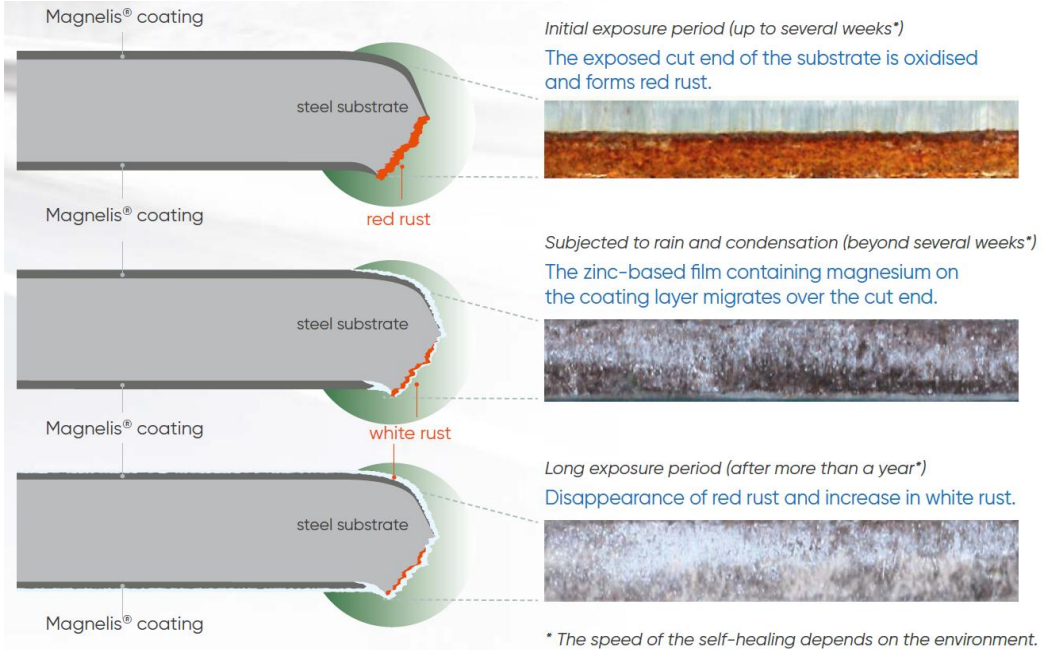
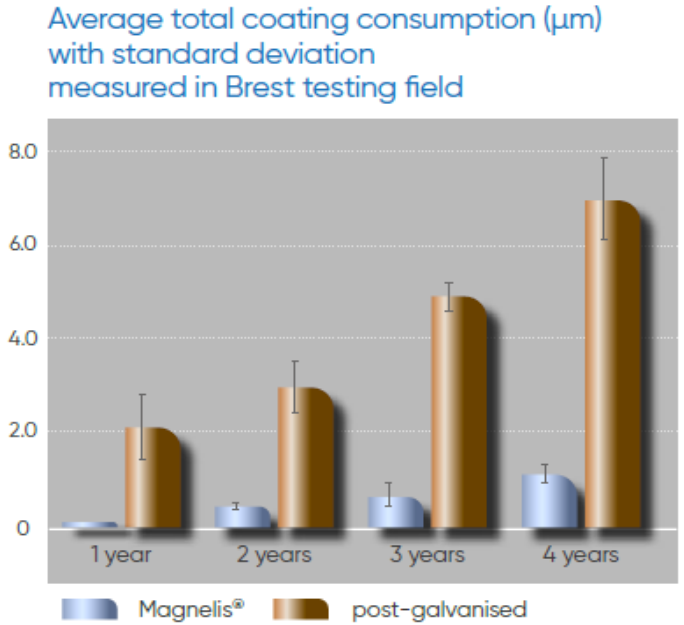
The corrosion defence system in action



Self-healing effect acting in a cut edge



Improved performance in harsh environments

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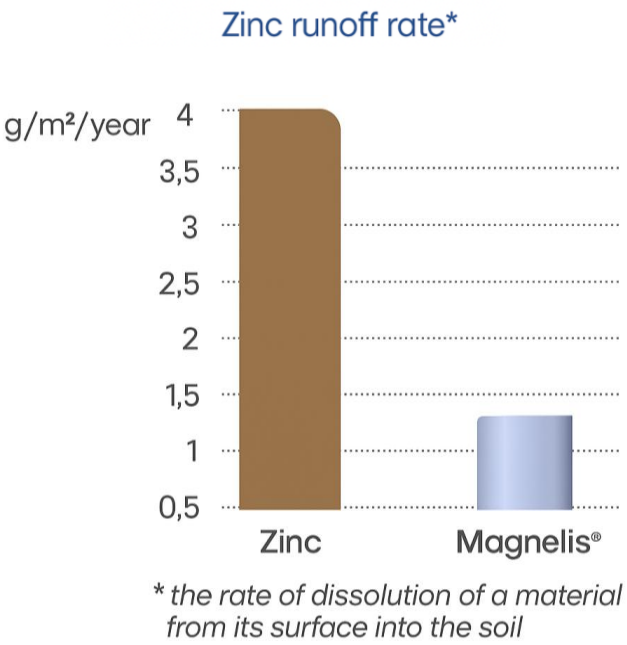
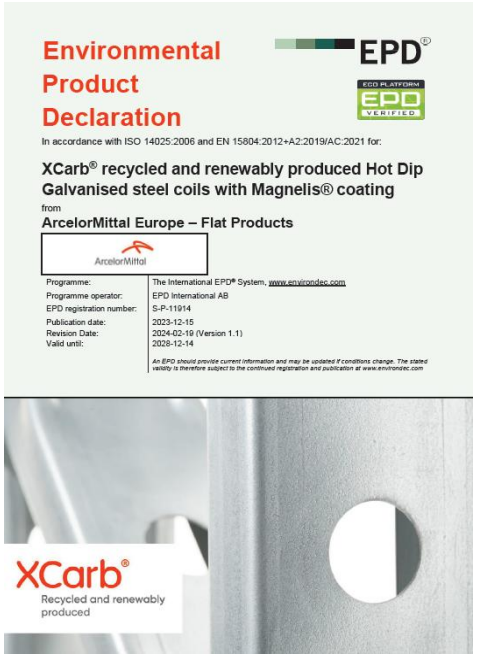
Magnelis® helps mitigate the environmental impact of the projects



Magnelis® reduces zinc runoff into soil



XCarb® Recycled and renewably produced Magnelis® with **65% less CO_{2eq}/ton** than the traditional route

Click to watch our past webinar:
Mitigating the CO_2 footprint in solar

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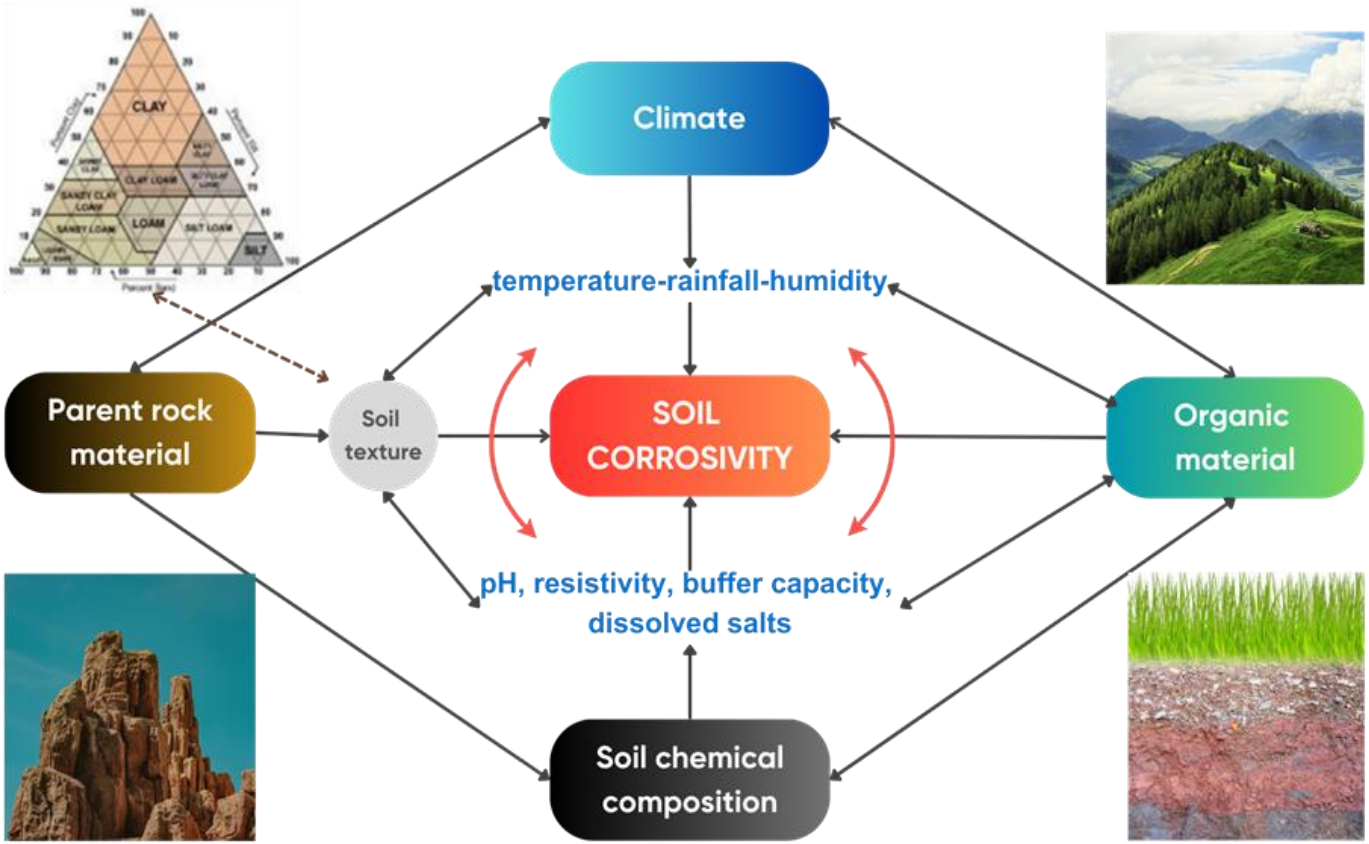
Beneath the surface: understanding the complexity of soil corrosion



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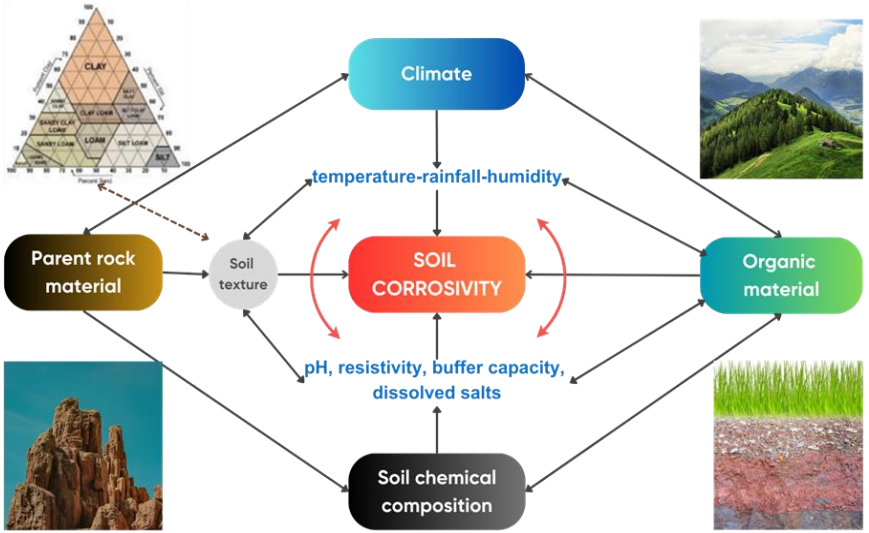
Beneath the surface: understanding the complexity of soil corrosion

- **Corrosion** is the gradual destruction or deterioration of a metal through direct chemical or electrochemical reactions with its surrounding environment.
- Soil corrosion is complex, driven by many interrelated factors that can vary even across small areas.
- Bare carbon steel Corrosion rates in soil typically range from **50 to 200 µm/year**, depending on soil conditions (moisture, texture, aeration, pH, chlorides, sulfates...) but could go over **250 µm/year for extremely aggressive conditions**
- The use of **Magnelis®** dramatically slows corrosion, turning **years into decades** of durability.



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Heavy coatings of Magnelis® for the highest protection against corrosion

Coating designation		ZM310	ZM430	ZM620	ZM800
Minimal total coating mass	g/m²	310	430	620	800
Theoretical guidance values for coating thickness	µm per side	25	35	50	65
Aspect	MA and MB aspect				
Surface treatment	C (E-Passivation® CrVI-free), O (oiled), S (Easyfilm®)				
Thickness	0.4 to 6.0 mm (0.016 to 0.236 inches)				
Width	Up to 1680 mm (66 inches)				
Steel grades	S220GD to S550GD+ZM (according to EN 10346:2015) S420GD-HyPer® to S700GD-HyPer®+ZM (Eurocode compliant)				

Scan to view our Magnelis® book or download it here

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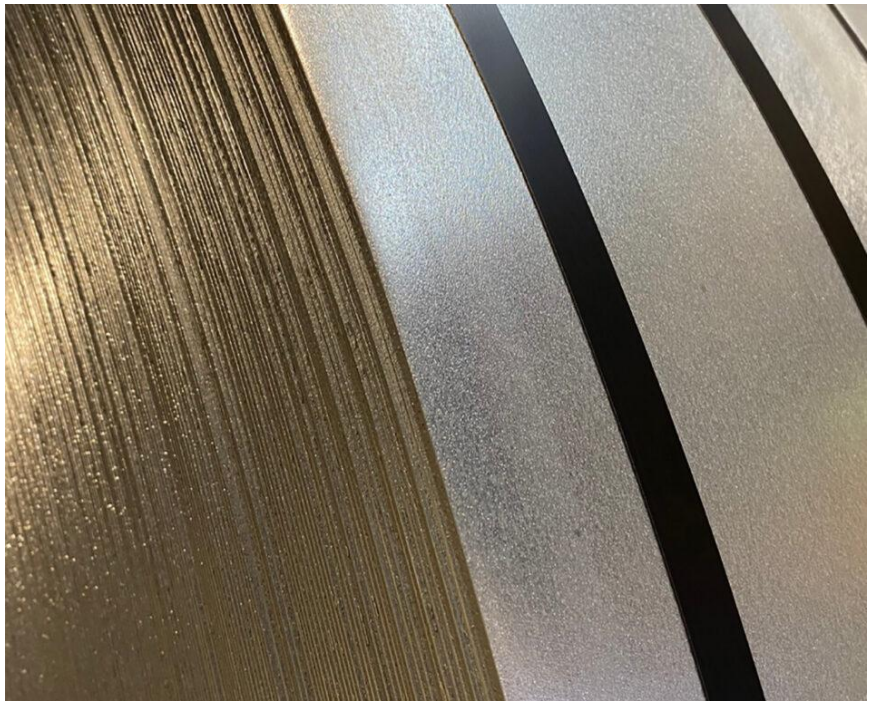
Magnelis® ZM800, a heavy-duty coating for heavy-duty projects



- Magnelis® layer description, based on the future latest version of EN10346 standard:
  - ✓ Triple spot mini: 800 g/m^2
  - ✓ Single spot mini: 680 g/m^2
  - ✓ Nominal thickness: 65 microns per side
  - ✓ Thickness range: from 44 to 85 microns/side (indicative values)
- Product thickness: between 1.9 and 4.5 mm
- Width: up to 1200 mm
- Surface finish: A aspect
- Surface treatment: oiled and / or E-passivation®
- Steel grades: to consult

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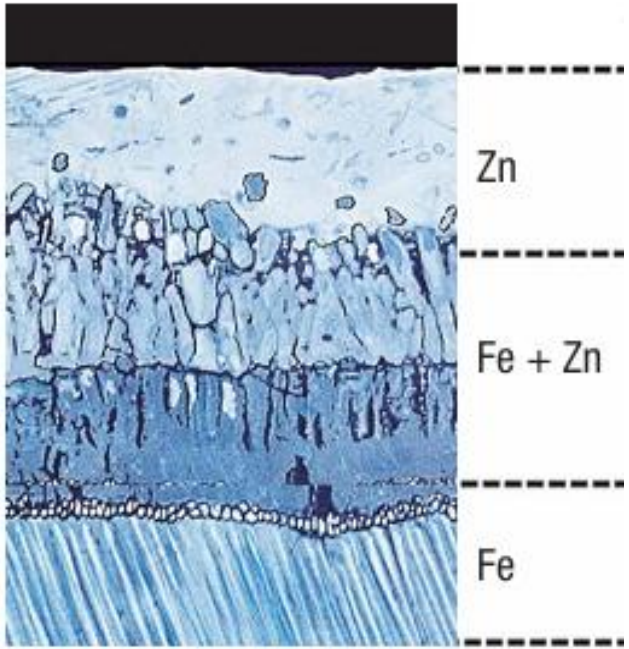
Magnelis® vs Batch galvanisation

Batch galvanisation



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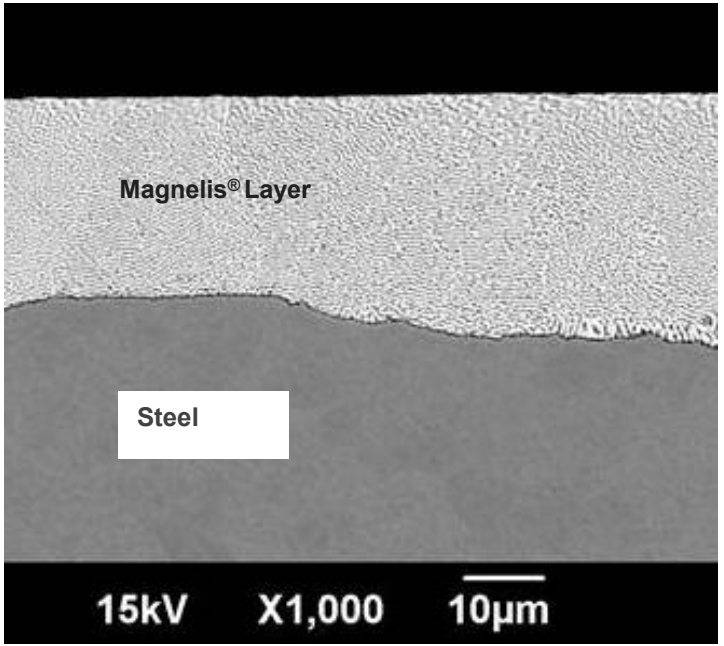
Continuously galvanised Magnelis



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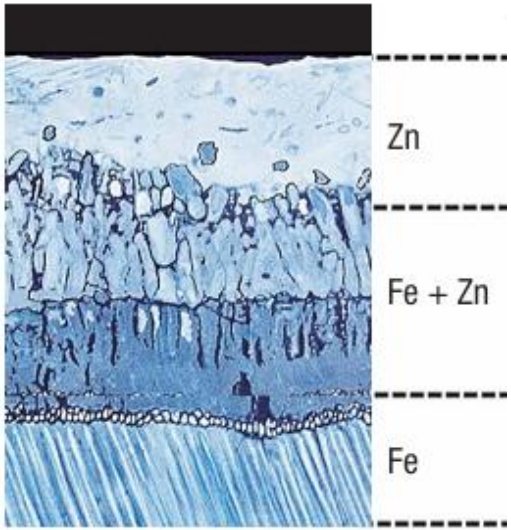
Magnelis® vs Batch galvanisation

Article and its thickness	Local average coating thickness	Average coating thickness
> 6 mm	70 µm	85 µm
> 3 mm but ≤ 6 mm	55 µm	70 µm
> 1.5 mm but ≤ 3 mm	45 µm	55 µm
< 1.5 mm	35 µm	45 µm
castings ≥ 6 mm	70 µm	80 µm
castings < 6 mm	60 µm	70 µm

Typical coatings acc. to DIN 1461 batch galva

Batch galvanisation



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Beware comparison of coatings thickness between pre & post galvanised steels: **not comparable**

Post galvanisation: inhomogenious layer
Magnelis®: Homogenious layer => improved corrosion resistance

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Recommendation about batch galvanised parts according to DIN 14713-2 / EN 1461

7.2 Exposure to soils

The wide range in physical and chemical properties of soils (e.g. the pH variation from 2,6 to 12 and resistivity from tens of ohms to approximately 100 kΩ) and the gross inhomogeniety of soils means that corrosion of zinc coatings in soils is rarely uniform in nature. Corrosion in soil is dependent on the mineral content, on the nature of these minerals and on the organic components, water content and oxygen content (aerobic and anaerobic corrosion). Corrosion rates in disturbed soil conditions are usually higher than in undisturbed soil. General guidance on the corrosion likelihood in soil can also be found in EN 12501-1.

Lime-containing soils and sandy soils (provided that they are chloride-free) are, in general, the least corrosive, whilst clay soils and clay marl soils are corrosive to a limited extent. In bog and peat soils, the corrosiveness depends on the total acid content.

Where major iron and steel structures such as pipelines, tunnels and tank installations pass through different types of soil, increased corrosion (localized) can occur at isolated points (anodic areas) by the formation of differential aeration cells. For some uses, e.g. earth reinforcement, a controlled backfill is used in conjunction with a zinc coating.

Corrosion cells can also form at the soil/air and soil/ground-water-level interfaces, leading possibly to increased corrosion, and these areas should be given special consideration. Conversely, the application of cathodic protection for structures in soil (or in water) can both modify the protective coating requirements and lengthen their life. Specialist advice should be sought for full guidance on all conditions involved.

While the average annual corrosion rates for zinc coatings in most soils are less than 10 µm per annum, the factors influencing corrosion in specific soil environments are complex and detailed expert advice should be sought regarding individual exposure conditions.

Batch galvanisation:

- Assumptions of < 10µm zinc run off per year in soft soils
- Influencing factors in soils are generally complex and heterogeneous
- Expert analysis is needed for specific soils
- Current norms are descriptive
- No methodology to calculate duration of corrosions resistance

Standards mentioned are more descriptive than quantitative
=> with Magnelis® we can calculate lifetime expectations

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Following DIN 50929-3, B0 is the key parameter to characterize a soil

$$B_0 = Z_1 + Z_2 + Z_3 + Z_4 + Z_5 + Z_6 + Z_7 + Z_8 + Z_9 + Z_{10}$$

Table 3 — Classification of soils, corrosion load and likelihood of free corrosion of unalloyed and low-alloy ferrous materials

B_0 or B_1 values	Soil category	Corrosion load[a]	Likelihood of corrosion based on the B_1 value	
	based on the B_0 value		Pitting corrosion	Uniform corrosion
≥ 0	Ia	very low	very low	very low
−1 to −4	Ib	low	low	very low
−5 to −10	II	medium	medium	low
< −10	III	high	high	medium
The order of magnitude of the corrosion rate to be expected is specified in Table 1. In the case of pipes and tanks, priority shall be given to the assessment of permanent leak tightness. In this case, the rate of pitting corrosion is to be considered. In the case of structural components, priority shall be given to the assessment of permanent strength. In this case, the rate of uniform corrosion is to be considered.				
[a] The corrosion load corresponds to the likelihood of free corrosion in the absence of extensive concentration cells (see 6.1.2).				

Table 6 — Rating of coatings on hot-dip galvanized steels

B_D, W_D, W_L values of the anode	Pitting corrosion
≥ 0	very good
−1 to −4	good
−5 to −8	satisfactory
< −8	not adequate

Extract of DIN 50929-3 "Corrosion of metals - Corrosion likelihood of metallic materials outside"

In blue are the minimum required parameters:

Z1 = Elutriable matter
Z2 = Resistivity
Z3 = moisture content
Z4 = pH
Z5 = Buffer capacity: alkalinity
Z6 = Buffer capacity: acidity
Z7 = Sulfides
Z8 = Sulfates
Z9 = Chlorides + Sulfates
Z10 = Presence of Groundwater

Z11 / Z12 / Z13 / Z14 = soil homogeneity

$$B_1 = B_0 + Z_{11} + Z_{12} + Z_{13} + Z_{14}$$

$$B_D = Z_2 + Z_4 + Z_5 + Z_6 + Z_7$$

Z2 = Resistivity
Z4 = pH
Z5 & Z6 = Buffer capacity
Z7 = Sulfides

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Magnelis® has a much lower coating consumption over time versus batch galvanisation

In a similar way to batch galva recommendations table, using available Magnelis® knowledge, Magnelis® coating consumptions extrapolated to 25 years on a **3,0 mm steel substrate** per soil category according to DIN 50929-3. :

Soil category following DIN50929-3	**Ia**	**Ib**		**II**		**III**
Corrosion Load	Very low	Low		Medium		High
B0 value	> 0	-1	-4	-5	-10	≤-11
	Coating consumption extrapolated to 25 years in microns					
Magnelis®	**35**	**41**	**49**	**52**	**64**	Tbd

Reminder, Magnelis® ZM430 = 35 µm/side – ZM620 = 50 µm/side – ZM800 = 65 µm/side

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Magnelis® has a much lower coating consumption over time versus batch galvanisation

As comparison, from the existing table for batch galva, extrapolation to 25 years would mean:

Bodenklasse Aggressivität	I schwach	II bedingt	III stark
	Anfangsabtragungsrate w_o in µm/Jahr		
Fe	50	60	68
Zn	7	15	55
verz. Stahl	13	30	55
	stationäre Korrosionsrate w_{lin} in µm/Jahr		
Fe	7	15	68
Zn	5	7	44
verz. Stahl	2	3	36
	extrapolierter Dickenabtrag für 50 Jahre in mm		
Fe	0,44	1,92	3,68
Zn	0,24	0,37	2,23
verz. Stahl *)	0,12	0,20	1,86

*) Nur zum Vergleich, da die Werte über der Dicke von Zinküberzügen liegen

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Soil class	I	II	III
Total for 25 years (in microns)	72	129	938

Batch galvanisation coating thickness beyond 100 µm is hardly achievable industrially.

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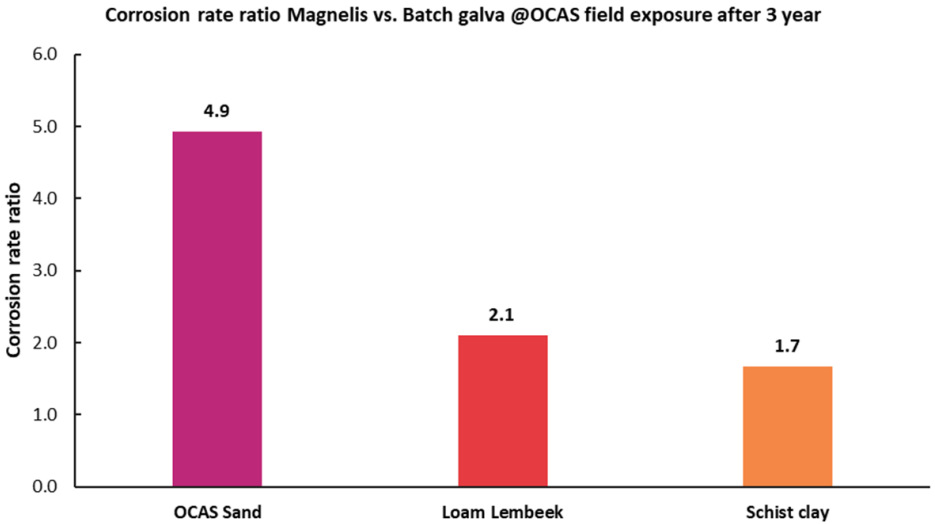
What years of testing have taught us about metallic coatings in soil

Extensive 10 years research by ArcelorMittal Global R&D

Lab accelerated corrosion - real outdoor - controlled outdoor



Magnelis® outperforms batch galva in field exposure

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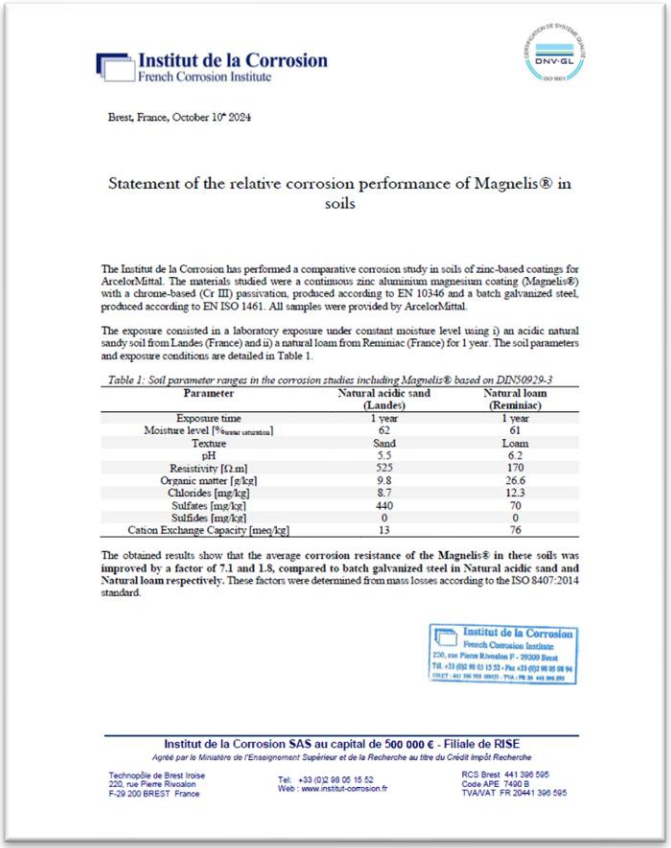
The improved protection of Magnelis® in soils was assessed by a third party

"Corrosion resistance of Magnelis® in soils was **improved by 1.8 – 7.1** compared to batch galvanised in different soils"
Accelerated corrosion test: 12 months exposure

Statement from the French Corrosion Institute.
"*This lab, subsidiary of RISE Research Institutes of Sweden AB, is among the largest laboratories in the field of corrosion and corrosion protection of materials in the world.*" https://www.institut-corrosion.fr/?lang=en



Institut de la Corrosion
French Corrosion Institute

Brest, France, October 10th 2024

Statement of the relative corrosion performance of Magnelis® in soils

The Institut de la Corrosion has performed a comparative corrosion study in soils of zinc-based coatings for ArcelorMittal. The materials studied were a continuous zinc aluminium magnesium coating (Magnelis®) with a chrome-based (Cr III) passivation, produced according to EN 10346 and a batch galvanized steel, produced according to EN ISO 1461. All samples were provided by ArcelorMittal.

The exposure consisted in a laboratory exposure under constant moisture level using i) an acidic natural sandy soil from Landes (France) and ii) a natural loam from Reminiac (France) for 1 year. The soil parameters and exposure conditions are detailed in Table 1.

Table 1: Soil parameter ranges in the corrosion studies including Magnelis® based on DIN50929-3

Parameter	Natural acidic sand (Landes)	Natural loam (Reminiac)
Exposure time	1 year	1 year
Moisture level [% water saturation]	62	61
Texture	Sand	Loam
pH	5.5	6.2
Resistivity [Ω.m]	525	170
Organic matter [g/kg]	9.8	26.6
Chlorides [mg/kg]	8.7	12.3
Sulfates [mg/kg]	440	70
Sulfides [mg/kg]	0	0
Cation Exchange Capacity [meq/kg]	13	76

The obtained results show that the average corrosion resistance of the Magnelis® in these soils was improved by a factor of 7.1 and 1.8, compared to batch galvanized steel in Natural acidic sand and Natural loam respectively. These factors were determined from mass losses according to the ISO 8407:2014 standard.

Institut de la Corrosion
French Corrosion Institute

Institut de la Corrosion SAS au capital de 500 000 € - Filiale de RISE
Agréé par le Ministère de l'Enseignement Supérieur et de la Recherche au titre du Crédit Impôt Recherche

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With Magnelis® in soil, you get predictable lifetime range

Magnelis® ZM430, ZM620 and ZM800 expected lifetime[1] on a 3,0mm steel substrate per Soil Category according to DIN 50929-3

Soil Category (acc DIN 50929-3)	Magnelis® ZM430 Expected lifetime[1]	Magnelis® ZM620[2] Expected lifetime[1]	Magnelis® ZM800[2] Expected lifetime[1]
Ia	25 to 30 years	30 to 35 years	35 to 40 years
Ib	20 to 25 years	25 to 30 years	30 to 35 years
II	15 to 20 years	20 to 25 years	25 to 30 years
III	< 15 years	< 20 years	< 25 years

1 The expected lifetime = duration until the perforation of the coated steel, exposed to soil conditions corresponding to the mentioned DIN50929-3 category. At this point in time, due to the risk of rupture, a major maintenance is necessary.

2 Feasibility on request.
Please note that in January 2024, Magnelis® ZM620 & ZM800 were not included in the EN10346:2015 norm.

Expected lifetimes are indicative and non binding.

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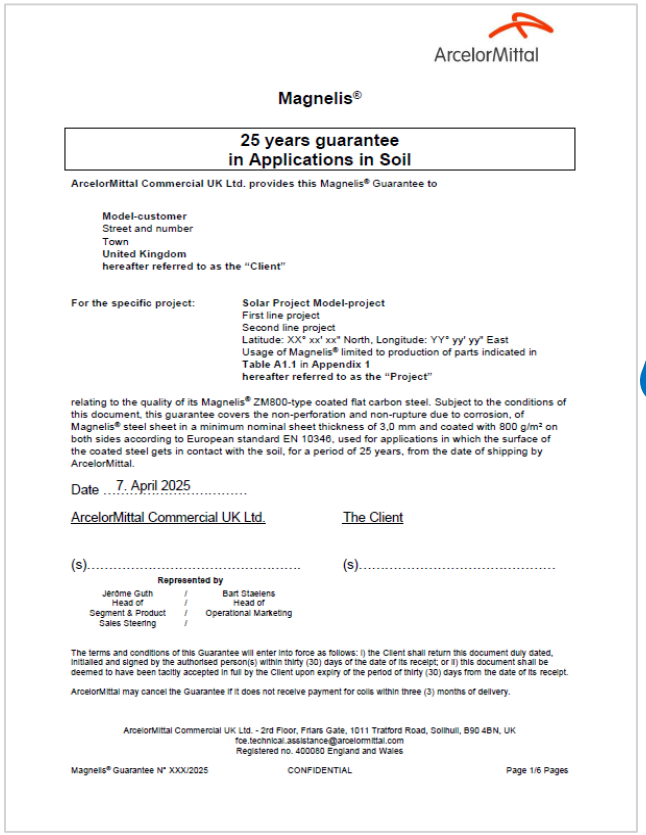
ArcelorMittal goes further: contractual guarantees against perforation and structural collapse



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Magnelis®

25 years guarantee in Applications in Soil

ArcelorMittal Commercial UK Ltd. provides this Magnelis® Guarantee to

Model-customer
Street and number
Town
United Kingdom
hereafter referred to as the "Client"

For the specific project: **Solar Project Model-project**
First line project
Second line project
Latitude: XX° xx' xx" North, Longitude: YY° yy' yy" East
Usage of Magnelis® limited to production of parts indicated in **Table A1.1** in **Appendix 1**
hereafter referred to as the "Project"

relating to the quality of its Magnelis® ZM800-type coated flat carbon steel. Subject to the conditions of this document, this guarantee covers the non-perforation and non-rupture due to corrosion, of Magnelis® steel sheet in a minimum nominal sheet thickness of 3,0 mm and coated with 800 g/m² on both sides according to European standard EN 10346, used for applications in which the surface of the coated steel gets in contact with the soil, for a period of 25 years, from the date of shipping by ArcelorMittal.

Date 7. April 2025

ArcelorMittal Commercial UK Ltd. The Client

(s)..... (s).....

Represented by

Jérôme Guth / Head of Segment & Product Sales Steering / Bart Staelens / Head of Operational Marketing

The terms and conditions of this Guarantee will enter into force as follows: i) the Client shall return this document duly dated, initialled and signed by the authorised person(s) within thirty (30) days of the date of its receipt; or ii) this document shall be deemed to have been tacitly accepted in full by the Client upon expiry of the period of thirty (30) days from the date of its receipt.

ArcelorMittal may cancel the Guarantee if it does not receive payment for coils within three (3) months of delivery.

ArcelorMittal Commercial UK Ltd. - 2rd Floor, Friars Gate, 1011 Tratford Road, Solihull, B90 4BN, UK
foe.technical.assistance@arcelormittal.com
Registered no. 400080 England and Wales

Magnelis® Guarantee N° XXX/2025 CONFIDENTIAL Page 1/6 Pages

25 years guarantee in Applications in Soil

ArcelorMittal

How to get a guarantee for poles & solar foundations with Magnelis®

Project ID : Project name: Project version

ENVIRONMENTAL QUESTIONNAIRE Page 1 of 2

Soil Chemistry for Magnelis® Poles in Soil

The questionnaire is to be completed by the customer and returned to the Vendor's Commercial Department with a view to granting the present Guarantee. Only questionnaires duly completed in full and signed by the customer shall be taken into consideration.

The information in these two additional Tables is needed for projects, for which a soil report is not available.

Details of the soil samples (chemical analysis)

	Unit	1	2	3	4	5	Method for Determination
Elutriable substances (clay and silt with a grain size < 0,06 mm)	mass %						WSE 1017 (2018-01)
Water content	mass %						EN 12880 (2001-02)
pH-value	-						ISO 10390 (2006-12)
Acidity up to pH 4,3	mmol/kg						DVGW GW 9 (A):2021-08
Alkalinity up to pH 7,0	mmol/kg						DVGW GW 9 (A):2021-08
Sulphide (S^{2-}) total	mg/kg						DIN 4030-2 (2008-06)
In the water extract C							
• Chloride (Cl^-)*	mg/kg (ppm)						
	mmol/kg						DIN 50929-3 (2024-05)
• Sulphate (SO_4^{2-})*	mg/kg (ppm)						
	mmol/kg						DIN 50929-3 (2024-05)
In the hydrochloric acid							
• Sulphate (SO_4^{2-}) calc.*	mg/kg (ppm)						DIN 4030-2 (2008-06)
	mmol/kg						
Type of soil							
• Heavily contaminated soil: fuels ash, slag, pieces of coal, coke, refuse, rubble wastewater							DVGW GW 9 (A):2021-08 Tick one of the two options, if applicable
• Soil contains > 5% of peat, fen, mud and marsh or organic carbon							

* Data can be provided either in mg/kg, ppm or mmol/kg

For experimental procedures check:

- EN 12880:2001, Characterization of sludges – Determination of dry residue and water content
- EN ISO 10309:2020, Soil, sludge and treated biowaste – Determination of pH
- DVGW GW 9 (A):2021, Assessment of Corrosion Loads on Buried Pipelines and Tanks Made of Unalloed low-alloyed Ferrous Materials in Soils
- DIN 4030-2:2008, Assessment of water, soil and gases for their aggressiveness to concrete – Part 2: Sampling and analysis of water and soil samples
- DIN 50929-3:2024, Corrosion of metals – Corrosion likelihood of metallic materials when subject to corrosion from the outside – Part 3: Buried and underwater pipelines and structural components

Questionnaire with most critical details to evaluate the soil corrosivity

Following DIN 50929-3 Methodology of soil reports is well known by most Institutes

Questionnaire will be available in our e-guarantee tool

We guide you through the guarantee process

Support on optimisation is given Especially on design or coating thickness

ArcelorMittal

We accompanied our partner Corab last May, 8 years after commissioning

Click to watch video

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Magnelis® ZM430 was buried in a soil CAT III the most corrosive type according to DIN50929-3 referential

Very corrosive soil!

Sample Location / Depth	B0	Soil category
Bartoszyce TOP soil sample	-2	Ib
Bartoszyce BOTTOM red/brown	-17	III
Bartoszyce BOTTOM Grey sample	-19	III

Water saturated
Strong acidity
Minimal resistivity

Soil characterization must be handled professionally to predict foundation lifetime properly.

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Magnelis® did the job ➔ After 8 years in harsh conditions, no red rust, even on unprotected cut edges

No corrosion on buried Magnelis® profiles, even on cut edges

Benefit from the unique triple protection of Magnelis®

It acts as **a barrier**.

It provides **sacrificial cathodic protection**.

Its interaction with the environment **actively** protects the steel.

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Wrap-up

- ✓ **Magnelis®**: Patented alloy offering decades of protection in harsh environments
- ✓ **Corrosion expertise**: ArcelorMittal pushes chemical and industrial boundaries
- ✓ **Proven performance**: Heavy Magnelis® coatings used globally in buried foundations
- ✓ **Validated R&D**: 10 years of research show superior results vs. batch galvanising, certified by external labs
- ✓ **Commercial commitment**: Up to 25-year guarantees, based on joint project analysis
- ✓ **Advanced prediction**: Beyond DIN50929-3, ArcelorMittal developed a dedicated Magnelis® model
- ✓ **Long-term co-engineering support**: We're here for you, today and decades from now
- ✓ **Project partnership**: Let’s analyse your solar project and meet your expectations

Foundations protected with Magnelis®, from corrosion to confidence!

ArcelorMittal

We are happy to answer your questions!

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Thank you

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Steel foundations: from corrosion to confidence

Q&A

23 October 2025

3:00 pm – 4:00 pm | CEST, Berlin
9:00 am – 10:00 am | EDT, New York City
10:00 am – 11:00 am | BRT, Sao Paulo

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Tuesday, 4 November 2025
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5:00 pm – 6:00 pm CET, Berlin

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Mark Hutchins

Magazine Director

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Thank you for joining today!