

# PRELIMINARY TECHNICAL EVALUATION OF MATERIAL No. 22/0081 of 08 November 2022

concerning the metal coating product on steel sheet

« **MAGNELIS<sup>®</sup>** »

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**WARNING**

This Preliminary Technical Evaluation of Material, since it does not intend to determine the intrinsic characteristics of a product or of a material, does not have the value of a Technical Notice in terms of the order amended of 21 March 2012. It does not exempt the checking of the aptitude of the product or material to be incorporated into a determined structure, by consulting reference documents of the application under consideration (NF-DTU, CPT, Technical Notice, etc.).

## TECHNICAL EVALUATION

### Brief definition

Magnelis® metal coating is intended to protect steel coils from corrosion. These steel coils with Magnelis® coating can be used for applications in infrastructures and construction, indoors or outdoors, structural or not, as a supplement to roofing and cladding, with a thickness up to 6.0 mm, in the form of cold-formed elements.

It is comprised of an alloy of 3.0% Magnesium, 3.5% Aluminium and Zinc.

This composition was filed with CSTB, and any change regarding the Magnelis® coating must be reported to CSTB throughout the entire duration of this evaluation.

The manufacture of elements with Magnelis® coated sheets must be compatible with the specifications of § 4.2 and 4.3 of the Technical Dossier. The weight of the Magnelis® coating is 70, 90, 120, 175, 200, 250, 310, 430 or 620 g/m<sup>2</sup> double-face in crude version (3-point measurement).

The purpose of this ETPM is to justify the field of use, to provide recommendations for implementation and to define the performance of the Magnelis® coated steel of which the delivery technical conditions are compliant with NF EN 10346 and this, including for the weight ZM620 which is not included in NF EN 10346.

### Technical evaluation

All of the tests conducted are indicated in part B of the Technical Dossier. The analysis of the tests conducted results in a corrosion behaviour of the Magnelis® coating that is identical or superior to a galvanised zinc coating according to NF P34-310 for an identical application field. The improvement in this behaviour justifies the weights proposed which can be less than those required for hot galvanisation according to NF EN 10346.

DX51D steel is used solely for the manufacture of non-structural elements, products in compliance with NF EN 10346. Table 2 at the end of this report indicates, according to the corrosivity class (according to NF EN ISO 9223), the service life for which the Magnelis® coated sheet is adapted.

### Controls

The manufacture is the object of controls that cover the regularity of the manufacture. The controls are described in paragraphs 3.2 of the Technical Dossier.

The composition was filed with CSTB at the time of the first ETPM request, and any change regarding the Magnelis® coating must be reported to CSTB throughout the entire duration of this evaluation. This composition is compliant with note 1 of paragraph 3.4 of NF EN 10346:2015.

### Conclusions

In the framework of this evaluation, the elements in the Technical Dossier do not reveal any incompatibility of a nature that would exclude the use of this coating for the fabrication of structural or non-structural elements used for applications indoors or outdoors.

Remember that this Preliminary Technical Evaluation of Material does not have for purpose to cover all the aptitude criteria for use for each one of the applications considered. This is normally the object of the DTUs, professional rules and RAGE/PACTE professional recommendations for the conventional field, and the object of the Technical Notices or Technical Application Documents, Technical Experimentation Assessments that could be introduced based on this Preliminary Technical Evaluation of Material and any additional supporting documents required, for the non-conventional field.

**Validity: 5 years**

**Valid until 08/11/2027**

Valérie Gourves

## TECHNICAL DOSSIER DRAWN UP BY THE REQUESTOR

### A. Description

#### 1. General points

Magnelis® metal coating is intended to protect steel coils from corrosion. These steel coils with Magnelis® coating can be used for applications in infrastructures and construction, indoors or outdoors, structural or not, with a thickness up to 6.0 mm, in the form of cold-formed elements.

It is comprised of an alloy of 3.0% Magnesium, 3.5% Aluminium and Zinc.

This composition was filed with CSTB, and any change regarding the Magnelis® coating must be reported to CSTB throughout the entire validity duration of this evaluation.

The manufacture of elements with Magnelis® coated sheets must be compatible with the specifications of § 4.2 and 4.3 of the Technical Dossier.

The weight of the Magnelis® coating is 70, 90, 120, 175, 200, 250, 310, 430 or 620 g/m<sup>2</sup> double-face in crude version (3-point measurement).

#### 2. Materials

##### 2.1 Technical characteristics

###### 2.1.1 Characteristics of the steel substrate

The steels used for the manufacture of the Magnelis® coated steel coils are compliant with NF EN 10346:2015, article 7.1. The formability capacities of the steel are conditioned by the properties of the steel grade chosen.

###### 2.1.2 Characteristics of the Magnelis® coating

The double-faced nominal surface mass of the coating is 70 g/m<sup>2</sup>, 90 g/m<sup>2</sup>, 120 g/m<sup>2</sup>, 175 g/m<sup>2</sup>, 200 g/m<sup>2</sup>, 250 g/m<sup>2</sup>, 310 g/m<sup>2</sup>, 430 g/m<sup>2</sup> or 620 g/m<sup>2</sup>.

The density of the Magnelis® coating is 6.2 g/cm<sup>3</sup>. The surface masses of the Magnelis® coating and the corresponding thicknesses for each weight are provided in table 1 at the end of the Technical Dossier.

Magnelis® coating must be classed as a zinc-magnesium (ZM) coating according to NF EN 10346:2015, article 3.4.

##### *Equivalence between commercial designation and coating surface mass*

Commercial designation	ZM70	ZM90	ZM120	ZM175	ZM200	ZM250	ZM310	ZM430	ZM620
Coverage (g/m <sup>2</sup> )	70	90	120	175	200	250	310	430	620

##### 2.2 Surface aspect of the Magnelis® coating

Magnelis® coating has a metal shine that is the result of the growth of zinc-magnesium crystals during the solidification phase, which is normal. According to the conditions of manufacture, brilliance crystals of various sizes can appear, which do not affect the properties of the coating. The surface can tend to darken.

A non-skin-pass aspect is possible upon request.

#### 3. Manufacture, controls and packaging of Magnelis® coated sheets

##### 3.1 Manufacture

Manufacture is similar to that of continuous hot rolled galvanised steel sheets. The coils of Magnelis® coated steel sheets are manufactured continuously in the RAMET and GHENT plants in Belgium, in the AVILES plant in Spain and in the BREMEN plant in Germany.

Passivation without chromium VI is applied. Oiling as well as a thin organic surface treatment are possible upon request, according to NF EN 10346, article 7.6.1.

##### 3.2 Controls

The controls conducted by the manufacturer are of a nature as to ensure constant satisfactory quality.

### 3.21 Controls on implementation line of the coating

See table 5 at the end of the Technical Dossier.

### 3.22 Controls on finished products

See table 6 at the end of the Technical Dossier.

## 3.3 Packaging and storage

### 3.31 Packaging

The Magnelis® coated coils and sheets must be protected from humidity (inclement weather, condensation) and from all exterior aggression. For this purpose, they are provided with packaging that is suitable for the risks incurred during transport and storage and for the duration of the latter.

### 3.32 Transport and storage

The coils must be transported, stored and handled in conditions that preserve the material from permanent deformation or damage affecting the aspect and the durability of the coating. These precautions for transport and storage are identical to those used for all types of steel coils that have a conventional metal coating.

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## 4. Implementation of Magnelis® coated sheets

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This ETPM does not cover any welding operations carried out on Magnelis® elements.

### 4.1 Profiling

Magnelis® coated steel sheets have an aptitude for forming and profiling that is identical to that of conventional galvanised sheets.

Profiling must be carried out on a polished roller machine. A vanishing oil is recommended in order to prevent surface markings.

### 4.2 Folding/profiling radii and thickness

The recommended minimum folding and profiling radius for the steel comes from NF EN 10025-2, article 7.4.2.3.3. For all Magnelis® coated products, based on the experimental results taken in references b), f) and h) in chapter B, the minimum recommended value of the inner radius of curvature is:

- 1 x the nominal thickness (t) for steel sheet thicknesses less than or equal to 4 mm;
- 1.5 x the nominal thickness (t) for steel sheet thicknesses greater than 4 mm and less than or equal to 6.0 mm.

The maximum thickness of the steel sheet used is 6.0 mm.

Table 3 shows the conditions for folding steel sheets coated with Magnelis®.

### 4.3 Cutting tranches

#### 4.31 Shear cutting

The recommendations given hereinafter, established based on experimental results taken in references b) and d) in chapter B, are valid for shear cuts with an angle of 90° with respect to the sheet, without any additional corrosion protection.

Protecting the cut edges is not required in the following cases:

- No aspect requirement of the cut edge is requested;
- Sheet thickness less than or equal to 1.5 mm;
- Maximum sheet thickness of 3.0 mm (inclusive) for a Magnelis® coating of a minimum of 250g/m<sup>2</sup>;
- Sheet thickness between 3.0 (exclusive) and 6.0 mm (inclusive) for Magnelis® coatings of minimum 310g/m<sup>2</sup>, and with access to the elements for inspections.

For steel sheets thicker than 3 mm, for structural applications, a sheet reserve width for corrosion must be taken into account on the cut edges:

- 1 mm for corrosivity categories C1 and C2;
- 2 mm for corrosivity categories C3 to C5.

When the conditions hereinabove are not satisfied, additional corrosion protection of the cut edges must be implemented. Paragraph 5 provides examples of protective solutions that are compatible with Magnelis®.

#### 4.32 Laser cutting

The recommendations given hereinafter, established based on experimental results taken in references b), d) and g) in chapter B, are valid for laser cuts, with an angle of 90° with respect to the sheet, without any additional corrosion protection.

Protecting the cut edges is not required in the following cases:

- No aspect requirement of the cut edge is requested;
- Sheet thickness less than or equal to 1.5 mm;
- Maximum sheet thickness of 3.0 mm (inclusive) for a Magnelis® coating of at least 250g/m<sup>2</sup>,
- Sheet thickness between 3.0 (exclusive) and 5.0 mm (inclusive) for Magnelis® coatings of at least 310g/m<sup>2</sup> and with access to the elements for the inspections;

For sheet thicknesses between 5.0 (exclusive) and 6.0 mm (inclusive), the protective measures must be set down after consulting and obtaining approval from the manufacturer.

In the event additional protection of the cut edges is required, protection solutions are provided in paragraph 5.

For steel sheets thicker than 3 mm, for structural applications, a sheet reserve width for corrosion must be taken into account on the cut edges:

- 1 mm for corrosivity categories C1 and C2;
- 2 mm for corrosivity categories C3 to C5.

The operating procedure and the cutting parameters have to be adapted in order to minimise the evaporation phenomenon of the Magnelis® coating during the cutting operation.

#### 4.33 Drilling

The recommendations given hereinafter, established based on experimental results taken in references b) and d) in chapter B, are valid for drilling with an angle of 90° with respect to the sheet, without any additional corrosion protection.

Protecting the drilled edges is not required in the following cases:

- No aspect requirement of the drilled edge is requested;
- Sheet thickness less than or equal to 1.5 mm;
- Maximum sheet thickness of 3.0 mm (inclusive) for a Magnelis® coating of a minimum of 250g/m<sup>2</sup>;
- Sheet thickness between 3.0 (exclusive) and 6.0 mm (inclusive) for Magnelis® coatings of minimum 310g/m<sup>2</sup>, and with access to the elements for inspections.

When the conditions hereinabove are not satisfied, additional corrosion protection of the cut edges must be implemented. Paragraph 5 provides examples of protective solutions that are compatible with Magnelis®.

### 4.4 Contact with concrete

Products with Magnelis® can be used in areas where the steel products will be in contact with concrete.

Due to the superior resistance to corrosion of Magnelis® with respect to galvanisation demonstrated by the tests described in reference a) of the experimental results (chapter B), the required thickness of the Magnelis® coating for pieces in contact with concrete will be at most equal to the galvanisation thickness for the same pre- or post-galvanised elements.

The results described in reference i) of chapter B indicate that Magnelis® ZM120 can replace Z275 galvanised steel in case of contact with concrete.

According to the expected durability, table 2 allows the suitable Magnelis® coating to be chosen.

#### 4.5 Post-treatments

In case of post-treatment of the Magnelis® coated steel sheet by application of paint or a lacquer, in the plant or on the construction site, the methods implemented do not differ from those provided for the same elements made from pre- or post-galvanised elements. The performance control on post-treated Magnelis® sheets are of the same natures as those carried out on post-treated pre- or post-galvanised steel sheets.

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## 5. Durability and guide for choosing materials and coatings according to atmospheres

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The definition of the corrosivity classes is given in NF EN ISO 9223 of March 2012.

Table 2 at the end of the dossier was established based on the results of the experimental tests conducted in comparison with pre-galvanised steels and taken in references b) and c) in chapter B. This table 2 gives the service life of a Magnelis® coated element for each environment category and for each type of coating.

These service life durations are given for new elements, outside of any damage appearing during machining operations, transport or setting parts into place.

To achieve the service life durations given in the table, the following conditions must be satisfied:

- The constructive layout must prevent the formation of a water trap;
- Permanent contact with wet components must be avoided;
- Cut edges must be protected against corrosion by suitable measures in accordance with the manufacturer's instructions, when the conditions given in paragraph 4.3 are not complied with.

If additional protection is required (see paragraph 4), the following methods are compatibles with Magnelis®:

- Application of a zinc-rich paint with a brush/pencil brush or by spraying
- Metallisation

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## 6. Implementation and maintenance

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### 6.1 Implementation

The provisions for implementing flat Magnelis® coated products are those provided for in the conventional field for the same elements made of pre- or post-galvanised steel sheet.

### 6.2 Maintenance

The conditions for maintaining Magnelis® coated steel sheets do not differ from those for pre- or post-galvanised steel sheets.

As with galvanised steel sheets, regular maintenance of elements made of Magnelis® coated sheets must in particular include removing various vegetation and any incompatible materials that would be deposited on the surface.

Note however that if the Magnelis® coating is locally deteriorated, repairs must be made after cleaning the surface to be treated with metal brushing or sand blasting. After removing dust with a clean cloth, rinsing with clean water and drying, a sufficient thickness of a suitable re-protection is then applied, of the type of a paint rich in zinc or others (see paragraph 5).

## B. Experimental results

- a) Test report concerning contact with concrete: « Magnelis® in contact with concrete », reference 93282, dated May 2016 – ArcelorMittal Global R&D Gent;
- b) Characterisation test report « Expert´s Report on the corrosion resistance of the metal coating Magnelis® on strip and sheet with a sheet thickness of up to 6.0 mm and a coating mass of up to 430 g / m<sup>2</sup> » ; reference K18-6062, dated 24 April 2020 – IPU Ingenieurgesellschaft Karlsruhe mbH;
- c) Summary article on atmospheric corrosion tests: « Long - term atmospheric corrosion rates of hot dip galvanised steel and zinc - aluminium - magnesium coated steel », dated 23 May 2019 – Corrosion Institute;
- d) Research report on the ageing of perforated Magnelis® coated sheets: « Outdoor exposure of perforated panels in Brest for 10 years », referenced 121201 and dated 5 October 2020 –ArcelorMittal Global R&D Gent;
- e) German technical approval: « DIBt – National technical approval/General construction technique permit » reference: Z-30.11-51 – Validity: From 17 September 2019 to 17 September 2024.
- f) Test report on folding behaviour: « Bending behaviour of Magnelis® - Comparison ZM620 with ZM430 » dated 11 January 2021 – ArcelorMittal Global R&D Gent
- g) Test report on the influence of the type of cut on the Magnelis® coating: « Magnelis® & Laser cutting - Processing test & Corrosion behaviour vs shear cutting » dated January 2022 – ArcelorMittal
- h) Test report on folding behaviour: « Bending of Magnelis® - Comparaison with standards & Available data » dated March 2022 – ArcelorMittal Global R&D
- i) Test report concerning contact with concrete: « Comparative corrosion performance of Magnelis® /Galva in concrete», reference GT33559, dated November 2022 –ArcelorMittal Global R&D Gent;

## C. References

The production of Magnelis® began in 2008, for uses as cladding, roofing and sandwich panels.

Starting in 2012, Magnelis® was produced on steels up to 6.0mm.

In 2021, total ArcelorMittal production of Magnelis® steel exceeded 2,000,000 T.



## TABLES OF THE TECHNICAL DOSSIER

**Table 1 – Coating masses that can be delivered for elements that have a maximum thickness of 6.0 mm**

Designation of the Magnelis® coating	Minimum coating surface mass, in g/m <sup>2</sup> , total of the two faces <sup>1)</sup>		Theoretical indicative values for the coating thickness by surface in the test at one point, in µm	
	Three-point test	One-point test	Characteristic value	Extended
ZM70	70	60	5.5	4 to 8
ZM90	90	75	7	5 to 10
ZM120	120	100	10	6 to 14
ZM175	175	145	14	9 to 18
ZM200	200	170	16	10 to 20
ZM250	250	215	20	13 to 25
ZM310	310	265	25	18 to 31
ZM430	430	365	35	26 to 46
ZM620	620	525	50	34 to 66

1) Surface coating mass given for a density of Magnelis® 6.2 g/cm<sup>3</sup>

**Table 2 – Service life before the first maintenance for the choice of different Magnelis® coatings according to the corrosivity class (according to NF EN ISO 9223)**

Designation of the Magnelis® coating	Selected corrosion category (NF EN ISO 9223) Maximum/minimum service life (years) and durability class (TL, L, M, H, TH)									
	C1		C2		C3		C4		C5	
ZM70	>100/>100	TH	>100/20	TH	20/5	H	NA	(L)	NA	(L)
ZM90	>100/>100	TH	>100/25	TH	25/5	H	NA	(M)	NA	(L)
ZM120	>100/>100	TH	>100/30	TH	30/10	TH	10/5	M	NA	(L)
ZM175	>100/>100	TH	>100/45	TH	45/15	TH	15/5	H	NA	(M)
ZM200	>100/>100	TH	>100/55	TH	55/15	TH	18/9	H	NA	(M)
ZM250	>100/>100	TH	>100/65	TH	65/20	TH	22/10	H	10/5	M
ZM310	>100/>100	TH	>100/85	TH	85/30	TH	30/15	TH	15/7	H
ZM430	>100/>100	TH	>100/>100	TH	>100/40	TH	40/20	TH	20/10	H
ZM620	>100/>100	TH	>100/>100	TH	>100/>60	TH	60/30	TH	30/15	TH

**Durability class:**

- Highly limited (TL): 0 to < 2 years
- Limited (L): 2 to < 5 years
- Medium (M): 5 to < 10 years
- High (H): 10 to < 20 years
- Very high (TH): ≥ 20 years

NA: Not adapted  
 Attributing the designation of the durability is based on the average of the minimum and maximum service life, calculated before the first maintenance.  
 The durability classes were taken from NF EN ISO 14713-1.

**Table 3 – Folding**

	Minimum recommended values for the inner radius of curvature <sup>1</sup> for nominal thicknesses (t) in mm		
		t ≤ 4	4 < t ≤ 6
Magnelis® Coating	ZM70, ZM90, ZM120, ZM175, ZM200, ZM250, ZM310, ZM430 and ZM620	1T	1.5T

<sup>1</sup> The values apply to folding angles of 180° in accordance with NF EN 13523-7.  
 The acceptance criteria for the dimensions of cracks during folding tests come from NF EN 1090-4 (table E8).

**Table 4 – Controls on the application line of the crude coating**

Parameter	Control according to production plant				Reference standard
	Ramet	Aviles	Ghent	Bremen	
<b>Input thickness</b>	RX Gauge– Continuously Micrometer – Manually – All coils – When gauge broken down	RX Gauge– Continuously	RX Gauge– Continuously	RX Gauge– Continuously Micrometer – Manually – All coils – When gauge broken down	Internal method
<b>Input width</b>	Metres – Manually – 1 x per coil	Metres – Manually – 1 x per coil	By photocell – 1 x per coil	Metres – Manually – 1 x per coil	Internal method
<b>Annealing temperature</b>	IR Pyrometer – Continuously	IR Pyrometer – Continuously	IR Pyrometer – Continuously	IR Pyrometer – Continuously	Internal method
<b>Adherence</b>	90° folding machine – 1x per 5 coils	Folding test - 1 x per coil	Folding machine – 1x per 5 coils	90° folding machine – 1x per coil	Internal method
<b>Tightness of the annealing furnace</b>	Distalarm type gas detector – 1 x per shift	Atmosphere analysis – Continuously	Gas detector – Continuously	Gas detector – Continuously	Internal method
<b>Magnelis® bath temperature</b>	Thermocouple – Continuously	Thermocouple – Continuously	Thermocouple – Continuously	Thermocouple – Continuously	Internal method
<b>Magnelis® bath composition</b>	Off-line chemical composition – 1 X per shift	Off-line chemical composition – 1 X per shift	Off-line chemical composition – 1 X per shift	Off-line chemical composition – 1 X per day	Internal method
<b>Line speed</b>	Tachometer – Continuously	Tachometer – Continuously	Tachometer – Continuously	Tachometer – Continuously	Internal method
<b>Surface aspect</b>	Spinning pressure – Continuously	Spinning pressure – Continuously	Spinning pressure – Continuously	Spinning pressure – Continuously	Internal method
<b>Zinc load</b>	In-line RX gauge – Continuously – Sweeping of each face Off-line RX gauge – 1 x per 5 coils or at each load change	In-line RX gauge – Continuously	In-line Eberline gauge – Continuously Off-line gravimetry – 1 X per shift	In-line RX gauge – Continuously – Sweeping of each face Off-line gravimetry – 1 X 50 coils (2% of the production)	EN10346:2015
<b>Tightening force at Skin Pass/Planer</b>	Tensiometer – Continuously	Elongation – Continuously	Elongation – Continuously	Tensiometer – Continuously	Internal method
<b>Surface aspect</b>	High-resolution cameras – Continuously	High-resolution cameras – Continuously	High-resolution cameras – Continuously	High-resolution cameras – Continuously	Internal method
<b>Roughness</b>	Roughness meter – 1 x per 5 coils	Roughness meter – Continuously	Roughness meter – 1 x per 3 coils	Roughness meter – Continuously	Internal method

**Table 5 – Controls on the application line of the crude coating, cont.**

Parameter	Control according to production plant				Reference standard
	Ramet	Aviles	Ghent	Bremen	
<b>Flatness</b>	Tensiometer – 1x per 2 coils	Visual – Continuously	Visual – Continuously Specific equipment – According to the specification ordered and the visual follow-up	Visual – Continuously	EN10143 - 2006
<b>Oiling</b>	Precision balance – 1 x per day IR measurement device – 1 x per shift Flowmeter – Continuously	Flowmeter – Continuously Visual control - 1 x per 5 coils	Flowmeter – Continuously	Flowmeter – Continuously Off-line calibration control - 1 X per 2 months	Internal method
<b>Passivation without Cr6</b>	Visual detection test – 1x per coil	Concentration measurement – Continuously Off-line layer weight control – 1 x per shift	Measurement by flowmeter – Continuously Thickness measurement – 3 X per shift	Layer weight measurement via RX fluorescence – Continuously	Internal method
<b>Marking</b>	Visual – 1 x per coil	Visual – 1 x per coil	Visual – 1 x per coil	Visual control - 1 x per coils	Internal method

**Table 6 – Controls on finished products after application of the crude coating**

Parameter	Control according to production plant				Reference standard
	Ramet	Aviles	Ghent	Bremen	
<b>Mechanical properties</b>	Traction – 1 x per coil	Traction – 1 x per coil	Traction – According to the grade	Traction – 1 x per coil	Internal reference standard
<b>Roughness</b>	Roughness meter – 1 x per coil	Roughness meter – 1 x per coil	Roughness meter – on sample- 1 x per 6 coils	Roughness meter - 1 x per coil	Internal reference standard
<b>Coating</b>	Off-line RX gauge – on sample – 1 x per 5 coils or at each load change	In-line RX gauge – Continuously	Gravimetry – On sample – 1 X per shift	Gravimetry – On sample – 1 X By 50 coils (2% of the production)	EN10346:2015
<b>Coating adherence</b>	Erichsen machine – Folding at 90° or 180° - 1 X per 5 coils minimum	Adherence test - 1 x per coil	Folding at 90° or 180° - 1 X per 5 coils minimum	Erichsen machine – Folding at 180° - 1 X per coil	Internal reference standard

**In case of dispute and if necessary a control of the surface coating mass according to NF EN 10346, the prescriptions given in Appendix A should be complied with.**