ArcelorMittal Europe

ArcelorMittal

Indaten® and Arcorox®
Self-protecting steels with raw aesthetic

Cover: *Picture of Pôle Molière – Le Havre 76600*
Architects: *ACAUM- Atelier BETTINGER DESPLANQUES Architectes associés*
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1. About weathering steels

1.1 Introduction

A magical steel, in harmonious dialogue with nature



Reading between the Lines, Borgloon, Belgium / Artist: Gijs Van Vaerenbergh / Copyright pictures: Kristof Vrancken

Like a fine wine, weathering steel is enriched by air and enhanced with age. When exposed to the natural environment, this magical steel develops a beautiful patina which serves as protective armour and is the basis for the steel's trademark purplish brown colouring. The marvellous paradox of weathering steels is that rust protects the steel from rust!

Weathering steel is also known as corten steel. This comes from the original brand name COR-TEN© which was registered in 1933 by US Steel Corporation. 'COR' comes from CORrosion resistance, while 'TEN' comes from TENsile strength – two of the properties of weathering steels.

Since its development, weathering steel has been used in almost every steel application. Bridges, railway cars, smokestacks, buildings, and works of art have all utilised weathering steels. The first major work in weathering steels was realised by Eero Saarinen who designed the John Deere World Headquarters in Moline (USA) in 1960. It was also used in the 1977 New River Gorge Bridge in West Virginia (USA).

Since the 1970s, the use of weathering steels has spread through Europe. Engineers appreciate its high yield strength and corrosion resistance. Weathering steels also reduce maintenance to nearly zero and can lighten the weight of structures. These advantages make it a very economic material and led to the construction of thousands of bridges and viaducts around the world. Architects like the expressiveness of the material and its ability to fit into urban landscapes and natural environments.

Today, weathering steel is more fashionable than ever. It fits with modern ideas that architecture and infrastructure should blend in with the natural and built environment.

Using our decades of experience with corrosion resistance mechanisms, ArcelorMittal has developed its own brands of weathering steels: **Indaten®** for flat products, and **Arcorox®** for sections.

This publication aims to provide you with a good understanding of ArcelorMittal's weathering steels and how they can be used. We've also included several examples of successful projects realised in weathering steels to inspire your future projects.

1.2 What are weathering steels?

Weathering steel – a structural steel with improved atmospheric corrosion resistance

Architect: CBA architecture et associés
Copyright picture: Grégoire Auger

Understanding product numbers:
Example: **S 355 JO WP**
Steel toughness
S XXX Y ZZ (+N) N= normalized or rolled

minimal yield strength (in MPa)
W= weathering steel
P= high content of phosphor

Weathering steels offer improved resistance to corrosion thanks to the addition of copper during manufacture. Additional alloying elements can be added to increase the steel's tensile strength or make forming processes easier.

Weathering steels are classed as high strength low alloy (HSLA) carbon steels. Their characteristics are specified in the European standard EN 10025-5 and in the American standard ASTM G101:04 (American Society for Testing and Materials).

The metallurgical composition of weathering steels includes less than 0.2% carbon. Alloying elements (mainly copper, chromium, nickel, phosphorus, silicon, and manganese) typically comprise less than 5% of the steel.

Weathering steels are known as corrosion resistant steels. Like standard carbon steels, weathering steels oxidise when exposed to the atmosphere. Due to their specific chemistry, the corrosion rate of weathering steels is generally much lower than that of standard carbon steel.

Annual steel loss due to corrosion (in mm) Measured in accordance with ISO 12944-2 for a C4 environment.

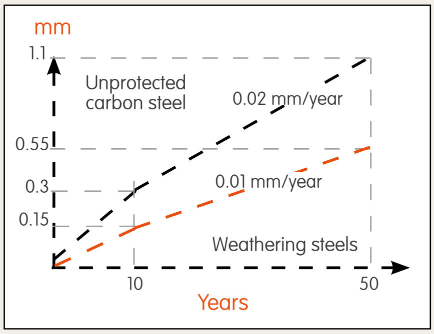


Table 1 - Standard correspondence: Atmospheric corrosion resistant steels according to EN 10025-5 2004

		Previous standards					
	Harmonised European standard	European	German	Spanish	French	British	Current US standard
	EN 10025-5: 2004	EN 10155: 1993	DIN 17119: 1984	UNE 36082: 1984	NFA 35 502: 1984	BS 4360: 1990	ASTM G101:04
S235J0W (EN 10025-5)	S235J0W	S235J0W		AE 235 WC	E 24 W 3	WR 40 B	
S235J2W (EN 10025-5)	S235J2W	S235J2W	WTSt 37-3	AE 235 WD	E 24 W 4		
S355J0WP (EN 10025-5)	S355J0WP	S355J0WP		AE 355 W1C	E 36 W A 3	WR 50 A	A588 – A242 1
S3555J2WP (EN 10025-5)	S3555J2WP	S3555J2WP		AE 355 W1D	E 36 W A 4		A242 1
S355J0W (EN 10025-5)	S355J0W	S355J0W		AE 355 W2C	E 36 W B 3	WR 50 B	A709 50W
S355J2W (EN 10025-5)	S355J2W	S355J2G2W		AE 355 W2D	E 36 W B 4	WR 50 C	A709 50W
S355J2W+N (EN 10025-5)	S355J2W+N	S355J2G1W		AE 355 W2D	E 36 W B 4		A588 A
S355K2W (EN 10025-5)	S355K2W	S355K2G2W	WTSt 52-3				A709 50W
S355K2W+N (EN 10025-5)	355K2W+N	355K2G1W					

Théatre de l'archipel, Perpignan, France / Architect: Ateliers Jean Nouvel and Brigitte Metra + Associées / Copyright picture: Philippe Ruault

ArcelorMittal has created different grades of Indaten® weathering steels to meet different applications. Their chemical composition [Table 2] and mechanical performance [Table 3] are specified in EN 10025-5.

An update to the European standards will be released by 2017. It will specify new grades for higher yield strengths including S420 and S460.

Weathering steels can be classified into two categories: those with limited phosphorous content (typically less than 0.035%); and those with a higher phosphorous content. Weathering steels with a phosphorous content of between 0.06 and 0.15% are identified by the letter P at the end of the product name.

High levels of phosphorous improves the corrosion resistance of weathering steels. Phosphorous is not used in heavy plate for structural uses as it can form iron phosphide (FeP_3) during welding. This can hamper weldability and cause the weld zone to become brittle. For this reason, phosphorous weathering steels are usually only available in thicknesses lower than 12 mm*.

**standard limit for Flat Products*

Table 2 - Chemical composition: according to EN 10025-5 2004

Range	C (%)	Mn (%)	P (%)	S (%)	Si (%)	Al (%)	Cu (%)	Cr (%)	Ni (%)	Mo (%)	N (%)	Ceq (%)	Batch galvanisa-tion
S235J0W	≤ 0.130	0.20 - 0.60	≤ 0.035	≤ 0.035	≤ 0.40	≥ 0.020	0.25 - 0.55	0.40 - 0.80	≤ 0.65	-	≤ 0.009	≤ 0.44	No
S235J2W	≤ 0.130	0.20 - 0.60	≤ 0.035	≤ 0.030	≤ 0.40	≥ 0.020	0.25 - 0.55	0.40 - 0.80	≤ 0.65	-	≤ 0.009	≤ 0.44	No
S355J0W	≤ 0.160	0.50 - 1.50	≤ 0.035	≤ 0.035	≤ 0.50	≥ 0.020	0.25 - 0.55	0.40 - 0.80	≤ 0.65	≤ 0.30	≤ 0.009	≤ 0.52	No
S355J0WP	≤ 0.120	≤ 1.00	0.060 - 0.150	≤ 0.035	≤ 0.75	≥ 0.020	0.25 - 0.55	0.30 - 1.25	≤ 0.65	-	≤ 0.009	≤ 0.52	No
S355J2W	≤ 0.160	0.50 - 1.50	≤ 0.030	≤ 0.030	≤ 0.50	≥ 0.020	0.25 - 0.55	0.40 - 0.80	≤ 0.65	≤ 0.30	≤ 0.009	≤ 0.52	No
S355J2W+N	≤ 0.160	0.50 - 1.50	≤ 0.030	≤ 0.030	≤ 0.50	≥ 0.020	0.25 - 0.55	0.40 - 0.80	≤ 0.65	≤ 0.30	≤ 0.009	≤ 0.52	No
S355J2WP	≤ 0.120	≤ 1.00	0.060 - 0.150	≤ 0.030	≤ 0.75	≥ 0.020	0.25 - 0.55	0.30 - 1.25	≤ 0.65	-	≤ 0.009	≤ 0.52	No
S355K2W	≤ 0.160	0.50 - 1.50	≤ 0.030	≤ 0.030	≤ 0.50	≥ 0.020	0.25 - 0.55	0.40 - 0.80	≤ 0.65	≤ 0.30	≤ 0.009	≤ 0.52	No
S355K2W +N	≤ 0.160	0.50 - 1.50	≤ 0.030	≤ 0.030	≤ 0.50	≥ 0.020	0.25 - 0.55	0.40 - 0.80	≤ 0.65	≤ 0.30	≤ 0.009	≤ 0.52	No
Indaten® 355A	≤ 0.120	≤ 1.00	0.060 - 0.150	≤ **0.015**	**0.20 - 0.50**	≥ 0.020	0.25 - 0.55	**0.30 - 0.80**	≤ **0.30**	-	≤ 0.009	≤ **0.45**	No
Indaten® 355D	≤ 0.160	0.50 - 1.50	≤ 0.030	≤ 0.030	≤ 0.50	≥ 0.020	0.25 - 0.55	0.40 - 0.80	≤ 0.65	≤ 0.30	≤ 0.009	≤ 0.52	No

Values in bold are tighter than standard

Table 3 - Mechanical properties: according to EN 10025-5 2004

1. Hot rolled products: Coils

	Direction	Thickness (mm)	R_e (MPa)	R_m (MPa)	A_{80} (%)	A 5.65√So (%)	Bending ratio (th)	KV 0°C (J)	KV -20°C (J)
S235J0W EN 10025-5 S235J2W EN 10025-5	L	6 - 25	-	-	-	-	-	≥ 27	-
	T	1.5 - 2	≥ 235	360 - 510	≥ 17	-	-	-	-
		2 - 2.5			≥ 18				
		2.5 - 3			≥ 19				
		3 - 16			-	≥ 24			
		16 - 25	≥ 225						
S355J0W EN 10025-5 S355J0WP EN 10025-5	L	6 - 20	-	-	-	-	-	≥ 27	-
	T	1.5 - 2	≥ 355	510 - 680	≥ 14	-	-	-	-
		2 - 2.5			≥ 15				
		2.5 - 3			≥ 16				
		3 - 16		470 - 630	-	≥ 20			
		16 - 20	≥ 345						
S355J2W EN 10025-5	L	6 - 20	-	-	-	-	-	-	≥ 27
	T	1.5 - 2	≥ 355	510 - 680	≥ 14	-	-	-	-
		2 - 2.5			≥ 15				
		2.5 - 3			≥ 16				
		3 - 16		470 - 630	-	≥ 20			
		16 - 20	≥ 345						
S355J2WP EN 10025-5	L	6 - 12	-	-	-	-	-	-	≥ 27
	T	1.5 - 2	≥ 355	510 - 680	≥ 14	-	-	-	-
Indaten® 355A	L	6 - 16	-	-	-	-	-	≥ 27	-
	T	1.7 - 3	≥ 355	510 - 680	**≥ 18**	-	**≥ 1.5**	-	-
		3 - 10		**490** - 630	-	**≥ 22**	**≥ 2**		
		10 - 16					**≥ 3**		
Indaten® 355D	L	5 - 12.7	-	-	-	-	-	-	≥ 27
	T	1.8 - 2	≥ 355	510 - 680	≥ 14	-	-	-	-
		2 - 2.5			≥ 15				
		2.5 - 3			≥ 16				
		3 - 12.7		470 - 630	-	≥ 20			

Values in bold are tighter than standard

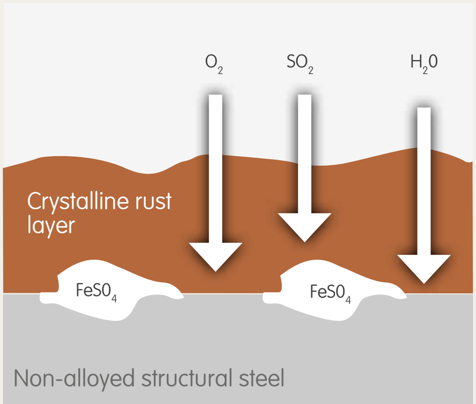
2. Cold rolled products: Coils

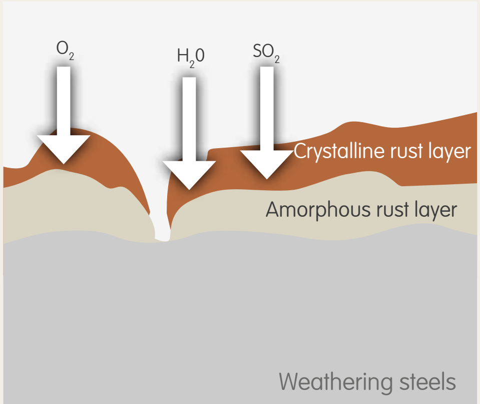
Mechanical properties

	Direction	Thickness (mm)	R_e (MPa)	R_m (MPa)	A_{80} (%)
Indaten® HC315WP	T	0.4 - 3	≥ 315	≥ 450	≥ 22

1.3 Corrosion resistance properties

Enhanced resistance in changeable atmospheric conditions

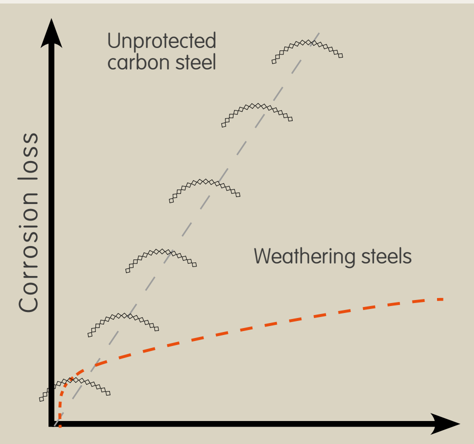




Oxidation layer on the surface of non-alloyed structural steel and of weathering steels

When weathering steel is exposed to the ambient atmosphere it develops an initial layer of iron oxide in the same way as carbon steel. The rate of oxidisation depends on how much oxygen, moisture, and atmospheric contaminants can access the surface of the metal. In the initial stages, a complex mix of iron oxides covers the surface to create a layer of rust. As the process progresses, the rust layer forms a barrier against the corrosive agents and the rate of corrosion slows.

On a low alloy carbon steel, the iron oxide layer is porous. Over time that layer detaches from the surface of the metal and the corrosion process starts again. The oxidation rate progresses in increments which depend on the chemical and mechanical aggressiveness of the environment. It can end with the complete destruction of the metal.



Comparative corrosion loss from weathering steels and unprotected structural steel

To increase the resistance of weathering steels to corrosion, alloying elements such as copper, phosphorous, nickel, or chromium are incorporated. These alloys create an oxide layer which remains stable and adheres to the metal's surface.

A rust 'patina' develops as the weathering steel is exposed to alternate wetting and drying cycles. As well as being aesthetically pleasing, the patina creates a protective barrier which impedes the access of oxygen, moisture, and pollutants to the metal's surface.

This results in a much lower corrosion rate than that of untreated structural steels.

Influence of alloying elements

The different alloying elements added to weathering steels influence the properties of the steel in the following ways:

- Copper increases the adherence, compactness, and elasticity of the patina.
- Phosphorous acts as a catalyst for copper and increases the initial reactivity of the weathering steels. It leads to evenly spread corrosion without spots, giving the patina a more homogeneous look. It also accelerates the healing process if the oxide layer is accidentally damaged
- Silicon has a positive effect on corrosion resistance
- Chromium and nickel help to form insoluble basic sulphates which reduce the porosity of the oxide layer, ensuring the underlying metal surface is protected against water and oxygen
- Chromium, nickel and silicon boost the mechanical characteristics of the steel substrate

Alternate wet and dry cycles are required to form the patina. Moisture helps to create the oxide layer. As it dries, the oxide layer starts to dehydrate, resulting in a compact adherent layer with low-permeability: the protective patina.

During patina formation, some of the oxides are washed out by rain. This is important, especially during the first two to six years as the oxide layer stabilises.

The amount of oxide leached out by the rain diminishes over time, but never stops completely. This can stain neighbouring materials. Careful design of the structure is needed to ensure that the brownish rainwater is collected and directed away from other materials to eliminate staining.

1.4 Development of the patina

The changing face of weathering steels

Initial aspect

Aspect after one month of exposure

Aspect after two years of exposure

Images: Courtesy of Metal Structure Centre, Zwijnaarde Technologiepark (Belgium)
Architect: Patrick Lefebure, Archipl Architecten
Copyright pictures: Gert De Vos

The aspect of weathering steels changes over time. It evolves from its dark grey mill finish to an orange patina in just a few weeks. The patina continues to evolve, reaching its final dark brown colour after a few years – the exact time depends on local weather conditions. Due to its brownish, non-uniform patina, and rough texture, weathering steels fit perfectly into both urban and natural environments.

It is impossible to predict the final colour of weathering steel because of its extremely reactive surface. The evolution of the patina is strongly influenced by the complex chemical relationship between the weathering steels surface, exposure to the sun, orientation to prevailing winds, and atmosphere.

The patina's appearance also depends on time, the average temperature, and on exposure to moisture. Appearance is also influenced by the concentration of sulfur dioxide (SO_2) and chlorides. For example, in an industrial environment the patina tends to develop a darker colour compared to weathering steels used in a rural area. Surfaces directly exposed to the weather will have a finer grain than sheltered surfaces.

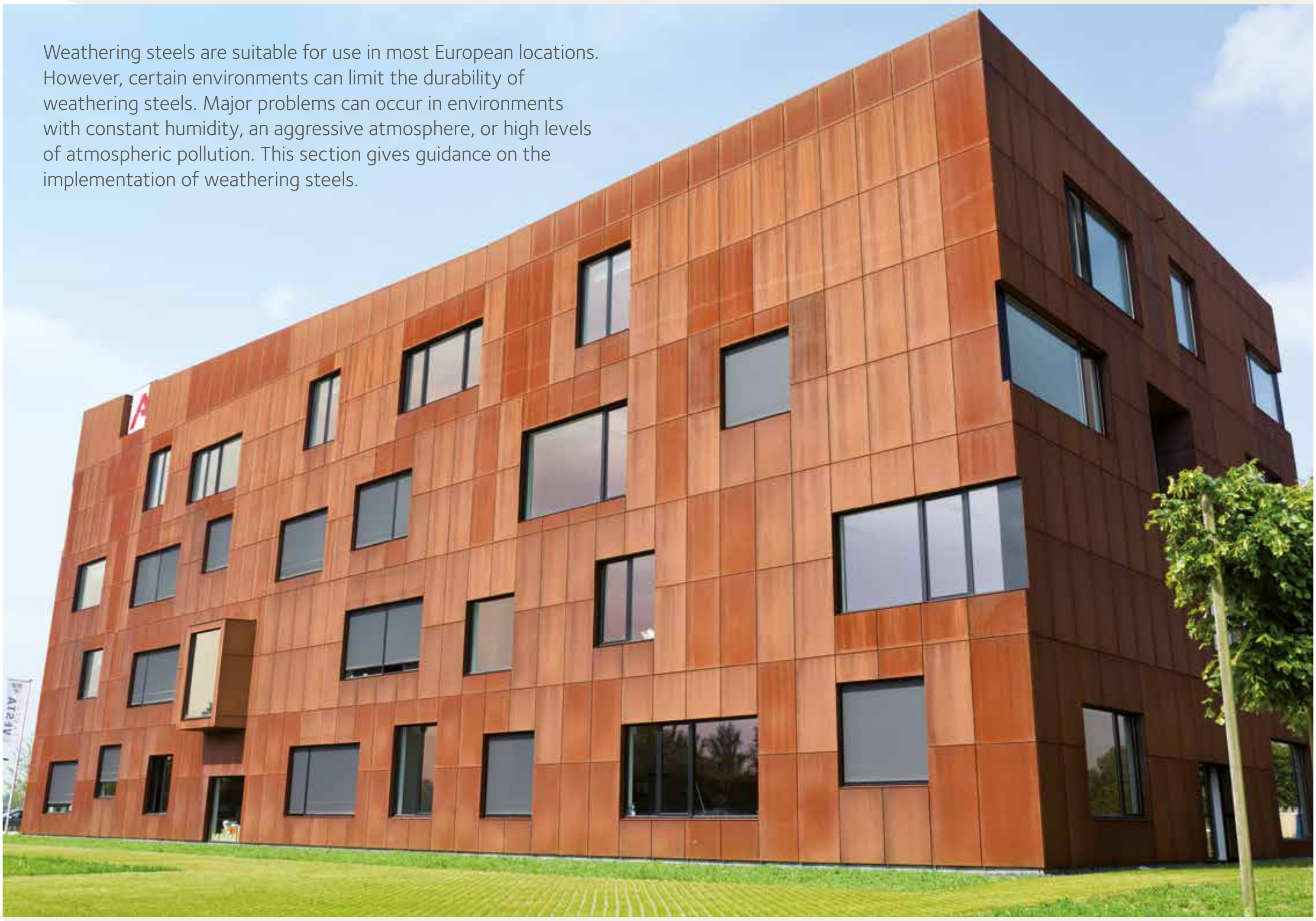
It is essential that the patina develops at a steady pace to ensure effective corrosion protection. For example, in exposed marine environments the patina develops faster than in a rural environment. However, it does not adhere as well to the steel substrate and may not protect the steel from corrosion. The best results are obtained where the steel is exposed to a succession of wet/dry cycles, and has no permanent contact with stagnant water.

Reading between the Lines, Borgloon, Belgium
Artist: Gijs Van Vaerenbergh
Copyright picture: Kristof Vrancken

1.5 Conditions of use

When and where can Indaten® be used?

Weathering steels are suitable for use in most European locations. However, certain environments can limit the durability of weathering steels. Major problems can occur in environments with constant humidity, an aggressive atmosphere, or high levels of atmospheric pollution. This section gives guidance on the implementation of weathering steels.



Campus Vesta, Emblem, Belgium / Architect: STRAMIEN, Architectuur en Ruimtelijke Planning cvba / Copyright picture: Chak Lopez

No constant humidity

If it is left in permanently wet or damp conditions, weathering steel will oxidise like any other unprotected carbon steel. A succession of wet and dry phases is required to form a stable oxide layer on the surface.

Weathering steels should not be used in:

- Sheltered locations with damp conditions
- Permanent contact with water
- Soil or covered by vegetation

Weathering steels used in these locations should be protected with paint. The paint must extend above the level of the water, soil, or vegetation.

No aggressive atmosphere

High concentrations of chloride ions negatively affect patina adherence.

According to EN ISO 9223, weathering steels should not be used within two kilometres of coastal waters unless airborne chloride levels do not exceed the S_2 salinity classification (that is, Cl < 300 mg/m^2/day). Direct contact between weathering steels and de-icing salts used on roads should be avoided.

No atmospheric pollution

Air-borne pollutants and industrial fumes can affect patina development. Corrosion is much higher if the metal surface is covered by solid particles such as dust or dirt. These particles can retain moisture and salts. In an industrial atmosphere, large amounts of sulfur dioxide (SO_2) are detrimental to the compactness of the patina. EN ISO 9223 advises that weathering steels should not be used without protection in an environment above P3 (that is, SO_2 > 200 mg/m^2/day).

Pre-treatment

Weathering steels are supplied un-weathered. Over time the patina will transform from an initial red-orange colour to a dark brown. Although the process normally takes up to two or three years, it can be accelerated using a well-tested pre-treatment procedure.

In the pre-treatment, the surface of the weathering steel is degreased and then sandblasted to ensure homogeneous development of the patina. After this, the metallic sheets are exposed to a succession of accelerated wet and dry cycles. The water used may contain small amounts of oxidising agents such as vinegar or salt water to increase the rate of patina formation. After two months, this pre-treatment will result in a red-orange patina.

The main reason this pre-treatment is used is to reduce the time needed to reach the final colouration. However, the pre-treatment will not stabilise the rust layer. It will reduce the amount of staining to nearby materials, but will not eliminate it completely.

Clear varnish

When touching weathering steels, some rust particles may linger on the hand which can be a problem for indoor applications. A clear varnish can be applied to the steel sheets. It will stop patina evolution, but it will protect users from rust and reduce dust. Suitable clear varnishes are available from your regular steel paint supplier.

ArcelorMittal strongly recommends that transparent coatings and varnishes are not used on outdoor applications. The varnish will behave like any other coating and protect the metal against corrosion. This stops patina formation, the main reason weathering steels are used.

Another reason is that transparent coatings do not contain pigments and this makes them ineffective against ultraviolet (UV) radiation. The weathering steels must be re-painted every two years (depending on the level of solar exposure).

Varnishes can be used for indoor applications, and applied to pre-patinated surfaces to avoid staining.

In-use precautions

Unlike other steel alloys which resist corrosion (such as stainless steel) weathering steels have a similar chemical composition to that of carbon steel. It can be produced and handled with the same equipment as carbon steel, resulting in relatively low transformation and assembly costs.

When handling weathering steels onsite, care must be taken to avoid unsightly gouges and scrapes. The material should be kept as clean as possible and away from mud, grease, oil, paint, concrete, mortar splatter, and other foreign substances to minimise cleaning costs.

Paint or crayon identification marks should be placed on parts of the weathering steels which will not be visible in the finished structure. If they are visible, the marks must be removed during the final cleaning operation.

Storage in transit, at yards, or onsite should be minimised. When storage is unavoidable, uneven weathering can be minimised by positioning the material in an exposed area with good drainage. Blocking, to avoid contact with the ground, is essential. Cover cloths can be used to prevent water staining and dirt accumulation. They also reduce the chance that the steel will initially develop an uneven patina.

Luxembourg's national pavilion at the 2010 Shanghai Expo, China / Architect: Hermann & Valentiny et Associés
Copyright picture: ArcelorMittal / Pierre Engel

1.6 Processing
Cutting, bending, forming, and painting weathering steels

Oxygen cutting

Weathering steels can be cut with conventional oxygen-gas equipment using similar procedures to those used on structural steels of the same thickness.

As for standard carbon steels, weathering steels should be pre-heated to between 120 and 150 °C if:

- The steel sheets have been stored in a cold environment (< 5 °C)
- Edges will undergo high stress or deformation in subsequent processes
- An exact thickness is important

Cold forming – Bending

Weathering steels can be processed using conventional manufacturing methods.

ArcelorMittal recommends a minimum inner radius for 90° bending which depends on the thickness of the metal:

Minimum bending radius			
Thickness (in mm)	1.3 to 3	3 to 10	10 to 13
Inner radius µ (in mm)	1.5	2	3

The radius can be reduced in the bending direction. Local surface grinding is advised before bending.

Press settings must be adapted to the type of material. A normalisation phase might be necessary depending on the deformation level.

Hot forming

ArcelorMittal recommends hot forming for:

- Plates above 20 mm
- Sheets below 20 mm if the equipment does not have sufficient power for cold work

Normalising heat treatment

The reheating temperature should be set between 900 and 950 °C and followed by air cooling. Annealing to restore the initial mechanical characteristics of the weathering steels is not required.

Stress relieving

Heat treatments can be applied to either relieve internal stress (after cold forming for example) or comply with regulations or other requirements.

The recommended treatment is 580 °C for two minutes per millimetre of thickness. Temperature speed is 80 °C/hour (over 300 °C).

Slitting and machining operations

The same processes are used for weathering steels and structural steels which have the same mechanical characteristics and thickness.

Sandwich panels

Weathering steels (with and without oil) are not compatible with foam. Pre-painted steels which provide a similar aesthetic finish must be used for the external skin of sandwich panels.

Painting

Post painting of weathering steels greatly improves resistance to corrosion. The effect is superior to that achieved by painting regular structural steels. On weathering steels, the paint creates a protective layer of oxides which stop the rust underneath swelling. The excellent corrosion resistance of post-painted weathering steel is enhanced by the self-healing effect where scratches occur.

1.6.1 Processing: Joining

Bolting and welding weathering steels

Welding and bolting are both acceptable methods of joining welding steels. To avoid excessive corrosion development, any gaps must be small enough to prevent oxygen and moisture reaching the surface.

Welding is the better option as it is easy to carry out. Welded joints eliminate gaps where water and moisture can gather and create favourable conditions for corrosion.

Bolting

Eurocode EN 1993-1-8 provides specific spacing values for bolt holes in weathering steels. If the shape or contour makes it difficult to closely fit nuts and bolts, the joint should be sealed. Alternatively, an anti-corrosive paint should be used on the contact surface.

Bolts, nuts, and washers are available in weathering steels. They meet the requirements detailed in ASTM standards A325 and A490 (type 3). Experience shows that stainless steel bolts are also suitable for use with weathering steels. As their mass is negligible, no significant galvanic corrosion occurs. However, galvanized steel should be avoided for bolts and fasteners.

Welding

Weathering steel has excellent weldability thanks to its low carbon content and fine grain. It is compatible with all standard welding processes including submerged arc, shielded metal arc, gas metal arc, and flux-cored arc welding. All joints should be continuously welded to avoid moisture and local contact corrosion.

Before welding, the existing patina should be removed from the first 10 to 20 mm along the welding area.

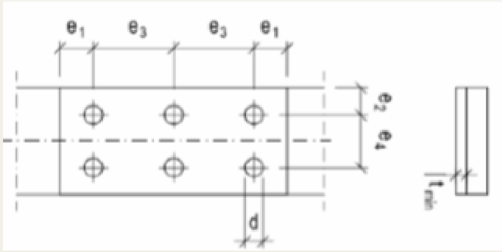
In bare steel applications, special electrodes must be used if the welds need to reach a required level of (see table 4):

- Strength
- Corrosion resistance
- Weathered appearance (similar to that of the base metal)

In these cases, the weld metal must be adapted to the mechanical properties of the base metal. It should also have a level of atmospheric corrosion resistance which matches or exceeds that of the weathering steels. Where multiple passes are needed, the submerged runs do not need to have such a high level of corrosion resistance. Only the last superficial run needs to match the corrosion resistance of the weathering steels. Welding consumables for weathering steels are specified in EN 1090-2.

After welding, the welds must be ground to the level of surrounding surfaces to avoid water and dust accumulation.

Bolts – maximum hole spacing

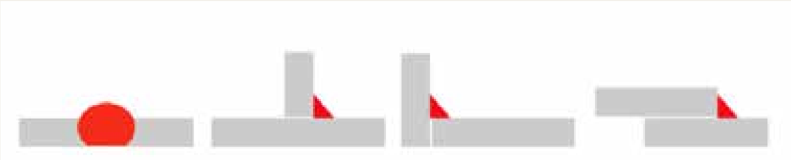


$e_1, e_2 \leq \min(3\ d, 8\ t_{min}, 125\ mm)$

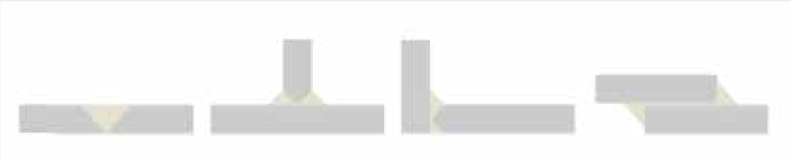
$e_3, e_4 \leq \min(6\ d, 14\ t_{min}, 175\ mm)$

Source: *Hole spacing - Eurocode E N1993-1-8*

Welding – poor detailing



Welding – good detailing



Source: *DAST-Richtlinie 007; RFCS; ECCS; HERA report RA*

Welding weathering steels

Table 4 - Welding filler wires

Gas metal arc welding (GMAW)

Process: #135

The thin wires used for equivalent carbon steel grades can also be used for weathering steels. Copper-plated wires deposit more copper on the surface of the welded zone, which contributes to the development of a patina on the welds. The cored wires used are the same as those used for the equivalent carbon-manganese steel grade.

** Specific welding wire*
*** Specially adapted welding wire*

Supplier	Reference	EN ISO	AWS
Esab	OK Autrod 12.51**	440 / G3Si1	A5.18 / ER70S-6
	OK AristoRod 13.29**	12534 / GMn3Ni1CrMo	A5.28 / ER110S-G
Lincoln Electric	LNM 28*	12070 / G465MG3Ni1	A5.28 / ER80S-Gt
	LNM Ni1**		A5.28 / ER80S-Ni1t
S.A.F. Air Liquide	Nertalic 70 A**	440 / G3Si1	A5.18 / ER70S-6
Thyssen	Union Patinax*	440 / G423CGO	A5.18 / ER70S-G

Shielded metal arc welding (SMAW)

Process: #111

** Specific electrode*
*** Specially adapted electrode*

Supplier	Reference	EN ISO	AWS
Esab	OK 73.08*	2560-A / E 46 5 Z B 32	A5.5 / E8018-Gt
	OK 48.08*	2560-A / E 42 4 B 32 H5	A5.1 / E7018
Lincoln Electric	Conarc 55CT SRP*	499 / E 46 5 Mn1Ni B 32 H5	A5.5 / E8018-W2-H4R
	Conarc 60G**	757 / E 55 4 Z B 32 H5	A5.5 / E9018M-H4
	Conarc 70G**	757 / E 55 4 1NiMo B 32 H5	A5.5 / E9018-G-H4
S.A.F. Air Liquide	Safer CU 56**	499 / E 464 Z B 32 H5	A5.5 / E8018-G
	Safer NF 52**	499 / E 424 B 54 H5	A5.5 / E7028
		499 / E 423 B 74 H5	
	Safer NF 510**	499 / E 423 B 32 H5	A5.5 / E7018
Thyssen	SH Patinax KB**	499 / E 38 3 Z 1 NiCu B 42	A5.5 / E7015-G

Submerged arc welding (SAW)

Process #21

Filler materials for weathering steels are the same as those recommended for welding steels with the same mechanical properties. As SAW involves strong inherent dilution, welds will develop a patina. The mechanical properties obtained in fusion zones meet the normal requirements of the base metal.

** Specific welding wire/flux couple*
*** Specially adapted welding wire/flux couple*

Supplier	Reference	EN ISO	AWS
Esab	Fil Autrod 13.36*	756 / S2Ni1Cu	A5.23 / EG
	OK Flux 10.71 and 10.81 to 10.83*		
Lincoln Electric	Fil LNS 163*		
	Flux P230*	760 / S A AB 1 67 AC H5	
	Fil L60**	756 / S1	A5.17 / EL12
	Flux 780**	760 / S A AR/AB 1 78 AC H5	
	Fil L61**	S2Si	A5.17 / EM12K
	Flux 860**	760 / S A AB 1 56 AC H5	
S.A.F. Air Liquide	Fil AS 26**	756 / S1	A5.17 / EL12
	Flux AS 50**	756 / SF 35 0 MS 1 S 1	A5.17 / F6-A0-EL12
	Fil AS 35**	756 / S2	A5.17 / EM12K
	Flux AS 50**	756 / SF 38 0 MS 1 S 2	A5.17 / F7-A0-EM12K
Thyssen	Union Patinax U*	756 / S 42 2 FB S0	A5.23 / F7A2-EG-G
	Flux UV 420 TT / UV 420 TT-LH*	760 / SA FB 1 65 DC / SA FB 1 65 DC H5	

Flux-cored arc welding (FCAW)

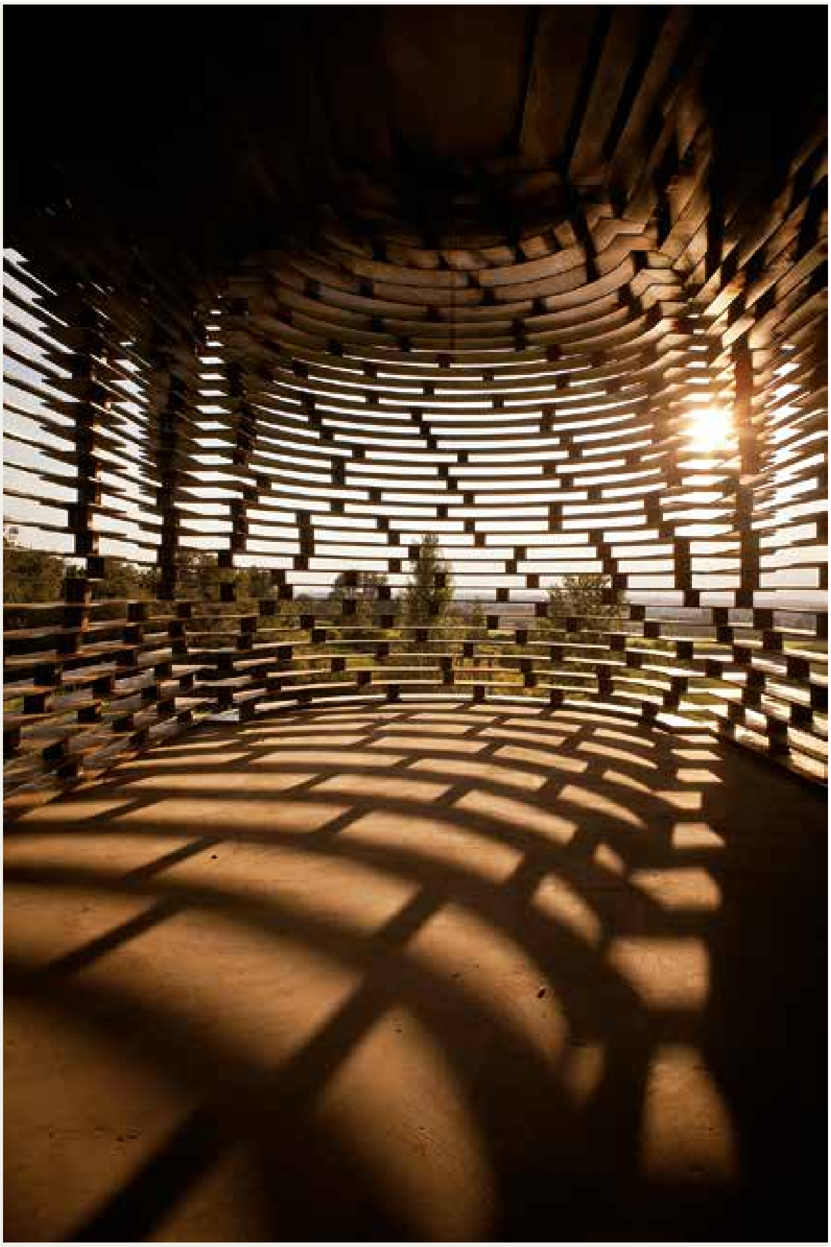
Process: #136

The process is suitable for the assembly of thin products. The same welding parameters are recommended for weathering steels and their equivalent carbon-manganese grades. If a filler wire is used, it must be the same type as the base metal.

** Specific welding wire*
*** Specially adapted welding wire*

Supplier	Reference	EN ISO	AWS
Esab	OK Tubrod 14.01*	17632-A / T 42 2 Z M M 2 H10	A5.18 / E70C-GM
	OK Tubrod 15.00**	758 / T 42 3 B M 2 H5	A5.20 / E71T-5H4
		758 / T 42 3 B C 2 H5	A5.20 / E71T-5MH4
	OK Tubrod 15.17**	758 / T 46 4 1Ni P M 2 H5	A5.29 / E81T1-Ni1M
		758 / T 46 3 1Ni P C 2 H5	
Lincoln Electric	Outershield 500CT-H*	758 / T 50 5 Z P M 2 H5	A5.29 / E81T1-G-H4
S.A.F. Air Liquide	Safdual 31*	758 / T 42 4 B M 2 H5	A5.20 / E71T5
	Safdual 248*	758 / T 46 A Z MM 1 H5	A5.29 / E81T1G-W2M

Joining dissimilar metals



Reading between the Lines, Borgloon, Belgium
Artist: Gijs Van Vaerenbergh
Copyright picture: Kristof Vrancken

Joining dissimilar metals: Some precautions

Joining different metals – even different grades of steel – may induce galvanic corrosion. Galvanic corrosion occurs when two metals with different electrolytic potential come into contact in the presence of an electrolyte such as water. The metals form a galvanic couple. In the couple, the anode corrodes faster than it would alone, while the cathode corrodes at a slower rate than it does alone.

The cathode is the 'noble' metal: the one with the highest electrolytic potential. Metals frequently found in the building industry are ranked from noblest to least noble as follows:

Stainless steel > Weathering or carbon steel > Galvanised steel > Aluminium

The galvanic corrosion rate depends on the ratio of cathode area to anode area. The following overview summarises the risks of pairing weathering steels with the other metals commonly found in building and construction applications.

Pair	Risk
• Stainless steel and weathering steels	• Galvanic corrosion of the weathering steels. There is usually no significant galvanic corrosion from stainless steel nuts and bolts as the cathode area remains small.
• Galvanised steel and weathering steels	• Galvanic corrosion of the galvanised steel.
• Carbon steel and weathering steels	• No significant risk of galvanic corrosion if their chemical composition remains close.

Source: DAST-Richtlinie 007; RFCS; ECCS; HERA report RA

2. ArcelorMittal's weathering steels offer

2.1 Feasibilities

ArcelorMittal has more than 80 years of experience in producing weathering steels. It started in the 1930s when the company Denain-Anzin created Inda steel, the first copper-phosphorous steel. ArcelorMittal has continued the production of this type of steel, now called **Indaten®**. We have also improved its chemical composition to achieve better strength and corrosion resistance.

Indaten® is supplied in flat formats such as heavy plates or steel coils. They are used to create cassettes, flat panels, blades, solar shading elements, profiled sheets, framing, and a range of other applications.

In the 1970s ArcelorMittal began to produce **Arcorox®** steel for long products such as beams and girders. Its use spread rapidly as the European infrastructure market began to grow.

Table 5 shows the standard weathering steels grades produced by ArcelorMittal which meet the requirements of EN 10025-5.

Table 5 – Standardised & Indaten® grades (EN 10025-5 20004)

Grades	Standards correspondence	Hot rolled	Cold rolled	Heavy plates	Long products
S235J0W	EN 10025-5	X		X	X
S235J2W	EN 10025-5	X		X	X
S355J0WP	EN 10025-5	X			X
S355J0WP	EN 10025-5	X			X
S355J0W	EN 10025-5	X		X	X
S355J2W	EN 10025-5	X		X	X
S355K2W	EN 10025-5			X	X
S460J0W	EN 10025-5	on request		on request	

Indaten® and Arcorox® grades meet all requirements of EN 10025-5 2004 and offer tighter chemical composition and better guarantees on mechanical properties.

Brands	Standards correspondence	Hot rolled	Cold rolled	Heavy plates	Long products
Indaten® HC315WP			X		
Indaten® 355A	S355J0WP EN 10025-5	X			
Indaten® 355D Indaten® 355HD	S355J2W EN 10025-5	X		X X	
Arcorox®	S355J0W EN 10025-5 S355J2W EN 10025-5 S355K2W EN 10025-5 A588 grade B				X

ArcelorMittal weathering steels production sites

ArcelorMittal produces weathering steels at our mills across Europe.
ArcelorMittal Sagunto mill is dedicated to producing weathering steels in lower thicknesses.

The dimensions depend on the capability of each mill. Minimum quantities are subject to a preliminary agreement.

For further information about Indaten® contact: *flateurope.technical.assistance@arcelormittal.com*
For more information about Arcorox® contact: *sections.tecom@arcelormittal.com*

2.1.1 Indaten®
HC315WP

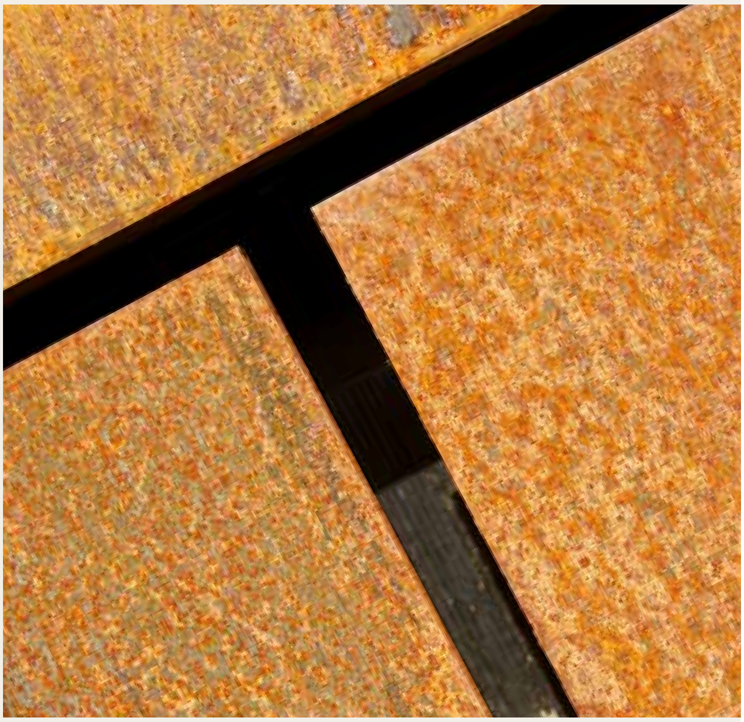
Application

Metal Structures Centre (MSC), Gent, Belgium
Copyright pictures: Gert De Vos

Indaten® HC315WP is a range of weathering steels with improved resistance to atmospheric corrosion. It is a thinner version of the hot rolled steel defined in the EN 10025-5:2004 standard (S355J0WP).

Indaten® HC315WP is a fine-grain, high-strength structural steel that has been optimised to give improved processing and in-service performance.

Indaten® HC315WP is particularly suited to architectural and artistic applications.



Chemical composition

	C (%)	Mn (%)	P (%)	S (%)	Si (%)	Cu (%)	Cr (%)	Ni (%)
Indaten® HC315WP	≤0.12	≤1.00	0.060-0150	≤0.015	0.20-0.50	0.25-0.55	0.40-0.80	≤0.30

Mechanical properties

	Direction	Thickness (mm)	R_e (MPa)	R_m (MPa)	A_{80} (%)
Indaten® HC315WP	T	0.4 - 3	≥ 315	≥ 450	≥ 22

	Min. thickness (mm)	Max. thickness (mm)	Min. width (mm)	Max. width (mm)
Indaten® HC315WP	0.4	3	525	1880

2.1.2 Indaten® 355A

City Hall, Esch sur Sûre, Luxembourg / © BALLINIPITT architectes urbanistes

Application

Indaten® 355A is a grade of weathering steels with improved resistance to atmospheric corrosion. It meets all requirements of the EN 10025-5:2005 standard while offering tighter chemical composition and better guarantees on mechanical properties.

The grade is characterised by its high phosphorous content which increases its corrosion resistance. **Indaten®** 355A develops a more homogeneous patina and is particularly suited to architectural and artistic applications.

The presence of phosphorous negatively affects the weldability of the steel. **Indaten®** 355A should not be used for structural or heavy loads in thicknesses above 12 mm.

Brand correspondence

Indaten® 355A	
EN 10025-5:2005	Better than the standard
ASTM	A242 Grade A/A606 T2/A606 T4

Chemical composition

	C (%)	Mn (%)	P (%)	S (%)	Si (%)	Al (%)	Cu (%)	Cr (%)	Ni (%)	Mo (%)	Ni (%)
Indaten® 355A	≤0.120	≤1.00	0.060-0150	≤0.015	0.20-0.50	≤0.020	0.20-0.55	0.40-0.80	≤0.30	-	≤0.45

Mechanical properties

	Direction	Thickness (mm)	R_e (MPa)	R_m (MPa)	A_{80} (%)	A.6.65$\sqrt{S_0}$ (%)	Bending ratio (th)	KV 0°C (J)	KV -20°C (J)
Indaten® 355A	L	6-16	-	-	-	-	-	≥ 27	-
		1.7-3		510-680	≥ 18	-	≥ 1.5		
		3-10	≥ 355			≥ 22	≥ 2	-	-
		10-16					≥ 3		
		16-20	≥ 355	-	-	≥ 22	≥ 3	-	-

	Min. thickness (mm)	Max. thickness (mm)	Min. width (mm)	Max. width (mm)
Indaten® 355A	1.7	20	900	1880

2.1.3 Indaten® 355D

Indaten® 355D is a grade of weathering steels with improved resistance to atmospheric corrosion. It meets all requirements of the EN 10025-5:2005 standard.

This range is perfectly suitable for structural applications and exhibits good welding performance thanks to its low phosphorous content. **Indaten®** 355D is also adapted for heavy plate production and is commonly used in bridges.

Application

Villa Chanzy, Rouen, France / Architect: Jean Baubion architecte(s)
Copyright picture: Gregoire Auge

Brand correspondence

Indaten® 355D	
EN 10025-5:2005	Better than the standard
ASTM G101-4	A588 grade A

Chemical composition

	C (%)	Mn (%)	P (%)	S (%)	Si (%)	Al (%)	Cu (%)	Cr (%)	Ni (%)	Mo (%)	Ni (%)
Indaten® 355D	≤0.160	0.50-1.50	≤0.030	≤0.030	≤0.50	≤0.020	0.25-0.55	0.40-0.80	≤0.65	≤0.30	-

Mechanical properties

	Direction	Thickness (mm)	R_e (MPa)	R_m (MPa)	A_{80} (%)	$A.6.65\sqrt{S_0}$ (%)	Bending ratio (th)	KV 0°C (J)	KV -20°C (J)
Indaten® 355D	L	5-12.7	-	-	-	-	-	≥ 27	-
	T	1.8-2	≥ 355	510-680	≥ 14	-	-	-	-
		2-2.5			≥ 15				
		2.5-3			≥ 16				
		3-12.7		470-630	-	≥ 20			
		12.7-20	≥ 355	470-630	-	≥ 20	-	-	-

Dimensional feasibility

	Min. thickness (mm)	Max. thickness (mm)	Min. width (mm)	Max. width (mm)
Indaten® 355D	1.8	16*	900	1780

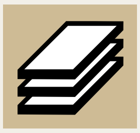
**Please consult above 16mm*

2.1.4 Indaten® 355H

Indaten® 355H is a grade of weathering steels with improved resistance to atmospheric corrosion. It meets all requirements of the EN 10025-5.

This range is perfectly suitable for structural applications and exhibits good welding performance thanks to its low phosphorous content. **Indaten®** 355H is adapted for heavy plate production and is commonly used in bridges.

Application



Restoration of the Trencat Bridge, Sant Celoni, Spain
Design and engineering: Xavier Font - Alfa Polaris S.L.
Copyright picture: Xavier Font

Brand correspondence

Indaten® 355H	EN 10025-5
Indaten® 355HA	S355J0WP
Indaten® 355HD	S355K2W+N

Chemical composition

	C (%)	Mn (%)	P (%)	S (%)	Si (%)	Al (%)	Cu (%)	Cr (%)	Ni (%)	Mo (%)	Nb (%)	V (%)	N(%)
Indaten® 355HA	≤0.12	≤1.00	0.060-0.150	≤0.040	≤0.75	≤0.020	0.25-0.55	0.30-1.25	≤0.65	-	0.015-0.060	0.02-0.25	-
Indaten® 355HD	≤0.16	0.75-1.50	≤0.025	≤0.025	≤0.50	≤0.020	0.25-0.55	0.40-0.80	≤0.65	-	0.015-0.060	0.02-0.25	-

Mechanical properties

	Direction	Thickness (mm)	R_e (MPa)	R_m (MPa)	A.5.65$\sqrt{S_0}$ (%)	KV 0°C (J)	KV -20°C (J)
Indaten® 355HA	L	5-12	-	-	≥ 22	≥ 27	-
	T	5-12	≥ 355	490-630	≥ 20	-	-
Indaten® 355HD	L	5-80	-	-	≥ 22	-	≥ 40
	T	5-16	≥ 355	490-630	≥ 20	-	-
		16-40	≥ 345				
		40-63	≥ 335				
		63-80	≥ 325				
		80-100	≥315	490-630	≥20	-	-

Dimensional feasibility

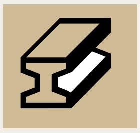
	Min. thickness (mm)	Max. thickness (mm)	Max. width (mm)
Indaten® 355H	5	100	up to 4000

2.1.5 Arcorox®

Brand correspondence

Norms	Arcorox®
EN 10025-5:2005	S355J0W S355J2W S355K2W
ASTM A588-15	Grade B

Application



©ArcelorMittal Europe – Long Products

Arcorox® is a range of weathering steels which offer improved resistance to atmospheric corrosion. **Arcorox®** meets the requirements of the EN 10025-5:2005 and ASTM standards.

Arcorox® weathering steels are only produced in sections and merchant bars. They are utilised in sustainable applications which require a long service life and low maintenance costs.

Dimensional feasibility

The following sections are available:

- HD/UC: Wide flange columns
- HE: Wide flange beams (100-1000)
- HL: Extra wide flange beams
- HP/UBP: Wide flange bearing piles
- IPE/UB: Parallel flange I sections
- L: Equal and unequal leg angles
- UPE/PFC: Channels with parallel flanges
- UPN/CH: European standard channels
- W: Wide flange beams

All sections are limited to flange thicknesses ≤ 40mm, except 70 mm for W 14x16 and W 36x16.5.
Minimum order quantity is subject to agreement.

Mechanical properties

Standards	Grades	Minimum Yield strength R_e MPa					Tensile strength R_m MPa	Minimum elongation A LO = 5.65*√S_0 %		
		Nominal thickness (mm)					Nominal thickness (mm)	Nominal thickness (mm)		
		≤16	≤16 ≤40	>40 ≤63	>63 ≤80	>80 ≤100	≥3 ≤40	≥3 ≤40	>40 ≤63	>63 ≤100
EN 10025-5: 2004 Arcorox®	S355J0W*/1) S355J2W*/1) S355K2W*/1)	355	345	-	-	-	470-630	22	-	-

1) Available up to 40 mm

Standards	Grades	Yield strength R_e	Tensile strength R_m	Ratio R_e/R_m	Minimum elongation A		Notch impact test[3]	
					min. 200 mm [8 in.]	min. 50 mm [2 in.]	ASTM A67 Aile longitudinal	
		MPa [ksi]	MPa [ksi]		%	%	Temperature °C (°F)	Energy average J [ft-lbf]
A588-15	Grade B*/4)	≥345 [50]	≥485 [70]		18[1)]	21[1)2a)]		

1) See elongation requirement adjustments under the "Tension Tests" section of standard A6 / A6M.
2a) For shapes with flange thickness >75 mm (3 in): A min. 18% on 2 in. (50 mm)
3) Upon agreement: supplementary requirement S30 of ASTM A 6/A 6M: "CVN test, alternate core location" = min. ave energy 27J [20 ft-lbf] at 21 °C [70°F], applicable to flange thickness ≥ 38.1 mm [1.5 in.], (formerly AISC Sup.2 for shapes of size groups 4 and 5 of A6)
4) Available for a nominal thickness up to ≤40 mm. For series W 14 x 16 and W 36 x 16.5 up to ≤70 mm.

Chemical composition

Standards	Grades	Ladle analysis									
		C max. %	Si max. %	Mn %	P %	S max. %	N max. %	Addition of n.b.e.[1)]	Cr max. %	Cu %	Other
EN 10025-5: 2004	S355J0W*				max.0.040	0.040	0.009[2) 5)]	-			
	S355J2W*/6)	0.16	0.50	0.50-1.50	max.0.035	0.035	-	yes	0.40-0.80[7)]	0.25-0.55	3) 4)
Arcorox®	S355K2W*/6)				max.0.035	0.035	-	yes			

1) Addition of nitrogen binding elements: the steels shall contain at least one of the following elements: Al total ≥ 0,020%, Nb: 0.015 – 0.060%, V: 0.02-0.12%, Ti: 0.02 – 0.10%. If these elements are used in combination, at least one of them shall be present with the minimum content indicated.
2) It is permissible to exceed the specified values provided that for each increase of 0,001 % N, the Pmax content will be reduced by 0.005%; the N content of the ladle analysis, however, shall not be more than 0.012%.
3) The steels may show a Ni content of max. 0.65%.
4) The steels may contain max. 0,30% Mo and max. 0.15% Zr.
5) The max. value for nitrogen does not apply if the chemical composition shows a minimum total Al content of 0.020% or if sufficient other N binding elements are present. The N binding elements shall be mentioned in the inspection document.
6) Fully killed steel containing nitrogen binding elements in amounts sufficient to bind available nitrogen (for example 0.02% Al). If other elements are used they shall be reported in the inspection document.
7) See specific limitations in the standard.

Standards	Grades	Ladle analysis											
		C max. %	Mn %	S max. %	P max. %	Si %	Cu %	Ni %	Cr %	Mo max. %	Nb max. %	V %	CE max. %	Other elements
A588-15	Grade B*	0.20[1)]	0.75-1.35[1)]	0.05	0.04	0.15-0.50	0.20-0.40	≤0.5	0.40-0.70			0.01-0.10		1)

1) See specific limitations in the standard.
Available on agreement.

2.2 Key benefits of using Indaten®

Portia Winery, Ribera del Duero, Spain / Architect: © Nigel Young Foster + Partners / Copyright picture: Foster + Partners

Attractive, aesthetic appearance

- Authentic, natural colour
- Evolving patina over time
- In harmony with natural and urban environments

Economic advantages

- No need to re-protect, no painting costs
- Long term durability, life expectancy of 80 years
- No maintenance costs (carbon steels usually require repainting after 15 years)
- No maintenance = no disturbance: an indirect economic benefit. Bridges and infrastructure do not need to be closed to maintain the weathering steels

Material costs

- Weathering steels cost 10 to 15% more than unprotected structural steel, but maintenance costs are reduced significantly
- Thicknesses may need to be over-specified to compensate for patina formation, particularly on hot rolled steels. Additional thickness required depends on the application and the required durability

Processing

- Easy to process with the same tools as structural steels
- No extra processing or equipment costs

Design and conception

- Similar standards (for example, Eurocodes) to structural steels
- Similar calculation tools
- Speed of construction

Sustainability

- 100% recyclable
- No waste management needed on site
- No additional corrosion protection needed, no repainting
- No volatile organic compounds (VOCs) emitted to air
- Low carbon footprint

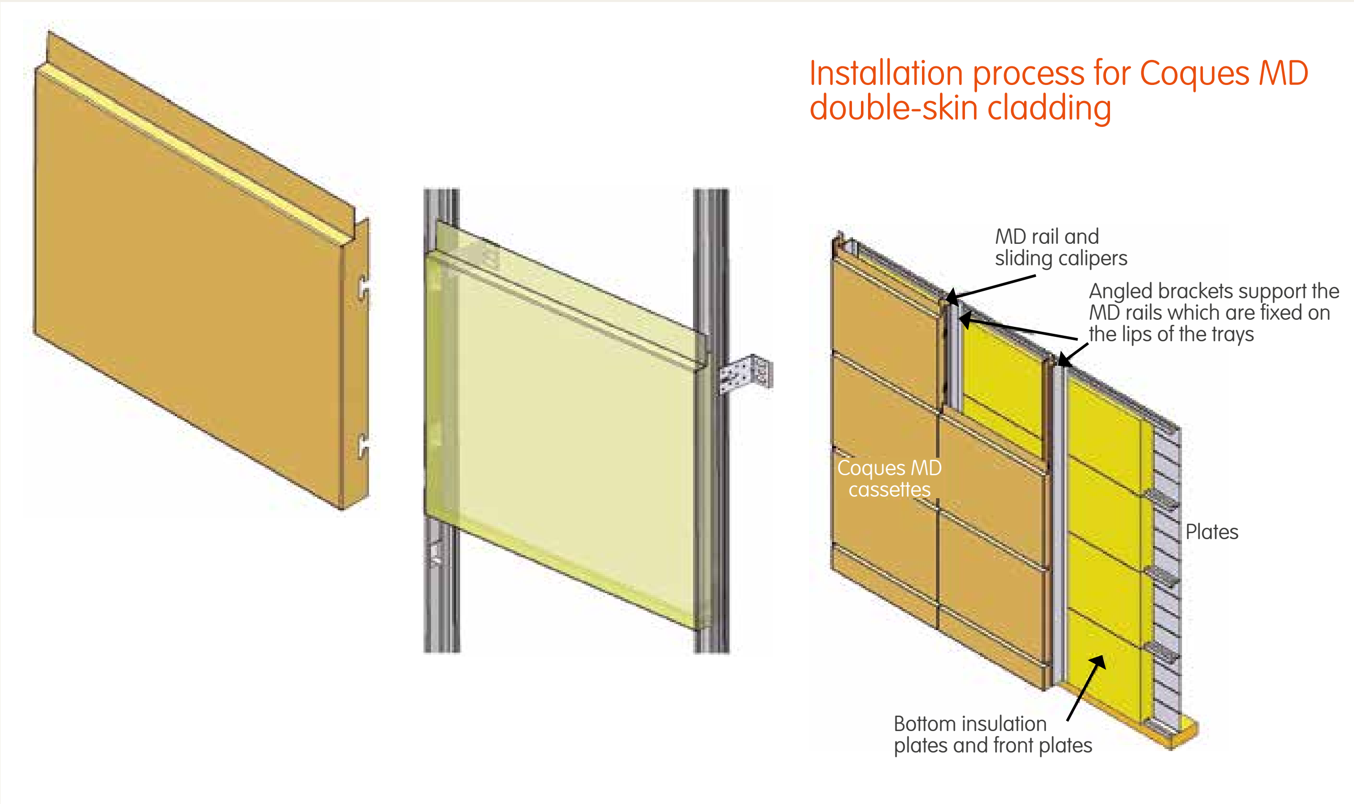
3. Made from weathering steels
3.1 Design and detail
Indaten® steel is versatile and resilient

Weathering steel is versatile and can be used for facade or roof applications. It can be adapted to any building type: from residential to leisure and everything in between.

In both new and refurbishment projects, weathering steels create an innovative and different aspect. Thanks to its high strength, weathering steel is also ideal for lightweight extensions, particularly vertical extensions. Weathering steels for cladding can be shaped into a wide range of geometries to achieve the required aesthetic.

Profiled sheets, cassettes, single sheet panels... a large range of building systems can utilise **Indaten®**.

Technical diagram of Coques MD cassette from ArcelorMittal Construction Arval



3.2 Success stories
3.2.1 Offices, commercial, and residential

Campus Vesta

Location: Emblem, Belgium
Client: Province of Antwerpen
Architect: Stramien
Metallic constructor: Eiffage Benelux Construction
Year: 2011
Copyright pictures: Chak Lopez

The new fire officer and ambulance driver training centre in Emblem, Belgium, is a five-level building clad entirely in Indaten®. Weathering steel was selected to guarantee the long-term sustainability of the building.

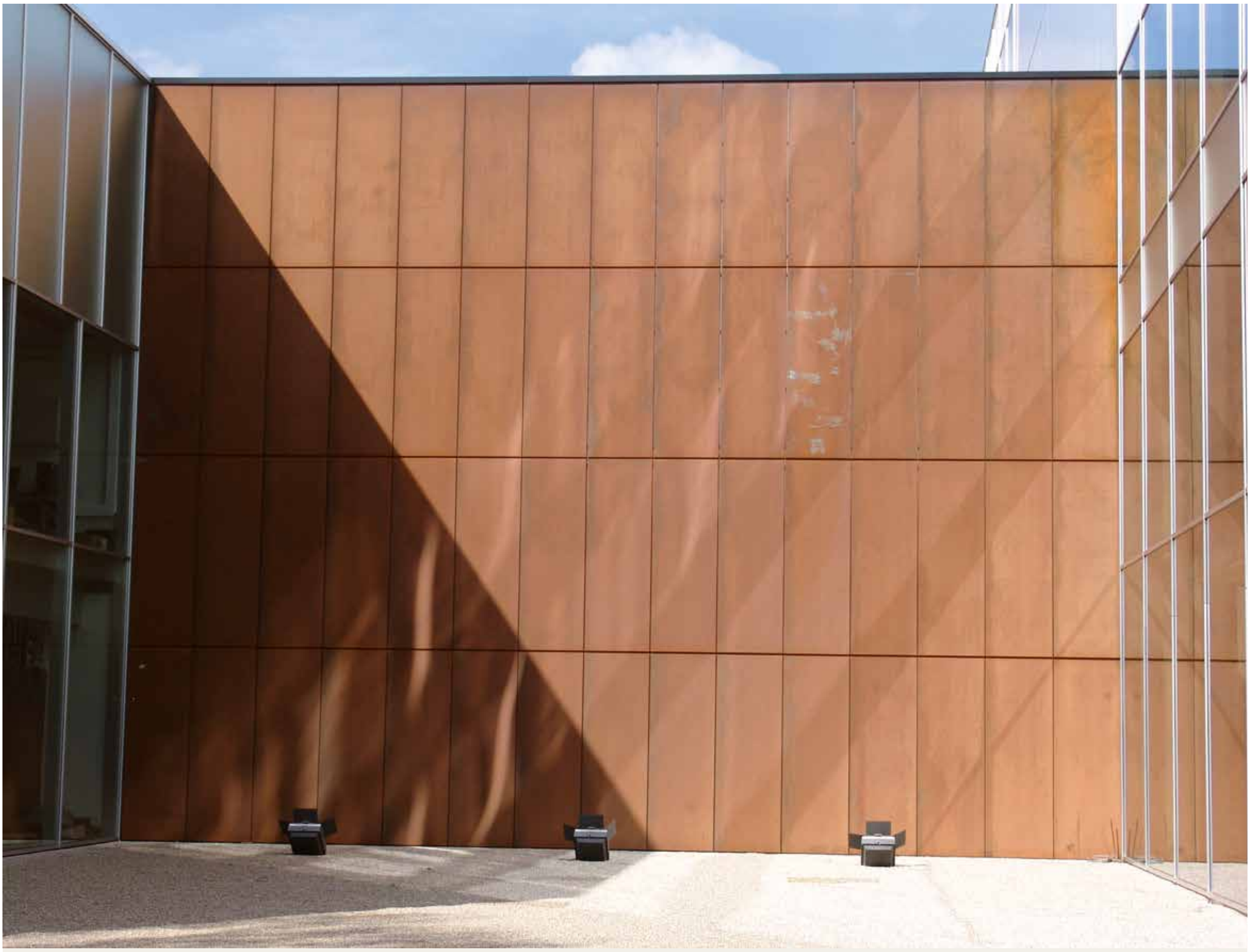
The Campus for the Integration of Embedded Systems (CISE) is located in the French town of Saint Etienne du Rouvray. It is a leading research centre for the automotive industry. To reflect this use, the building has been designed to resemble the body of a car. The facade, made from **Indaten®** weathering steel supplied by ArcelorMittal, helps to integrate the structure into its wooded environment.

The part of the building which houses the laboratories is made of steel beams and columns. To provide contrast, the office spaces, meeting rooms, and lobby have a reinforced concrete structure.

The **Indaten®** weathering steel was supplied in Coque MD panels, an aesthetic cladding product from ArcelorMittal Construction Arval product range. Coques MD panels have been specifically developed for use with weathering steels.

Campus for the Integration of Embedded Systems (CISE)

Location: Saint Etienne du Rouvray, France
Client: Rouen Chamber of Commerce and Industry
Architect: Christophe Bidaud Architecte (CBA)
Coque provider: ArcelorMittal Construction Arval
Construction year: 2012
Copyright pictures: Grégoire Auger



The **Indaten®** weathering steel on the facade of MSC was not pre-treated to advance the aging process. Instead, the steel is naturally acquiring its distinctive rusty colour. Starting from a very light shade of red-brown, **Indaten®** will darken over the years as the protective oxide layer is formed.

Metal Structures Centre (MSC)

Location: Ghent, Belgium

Client: DAF GROUP nv

Architect: archipl architecten (Paul Van Eygen & Patrick Lefebure)

Construction year: 2011

Copyright pictures: Gert De Vos, Jeroen Op de Beeck

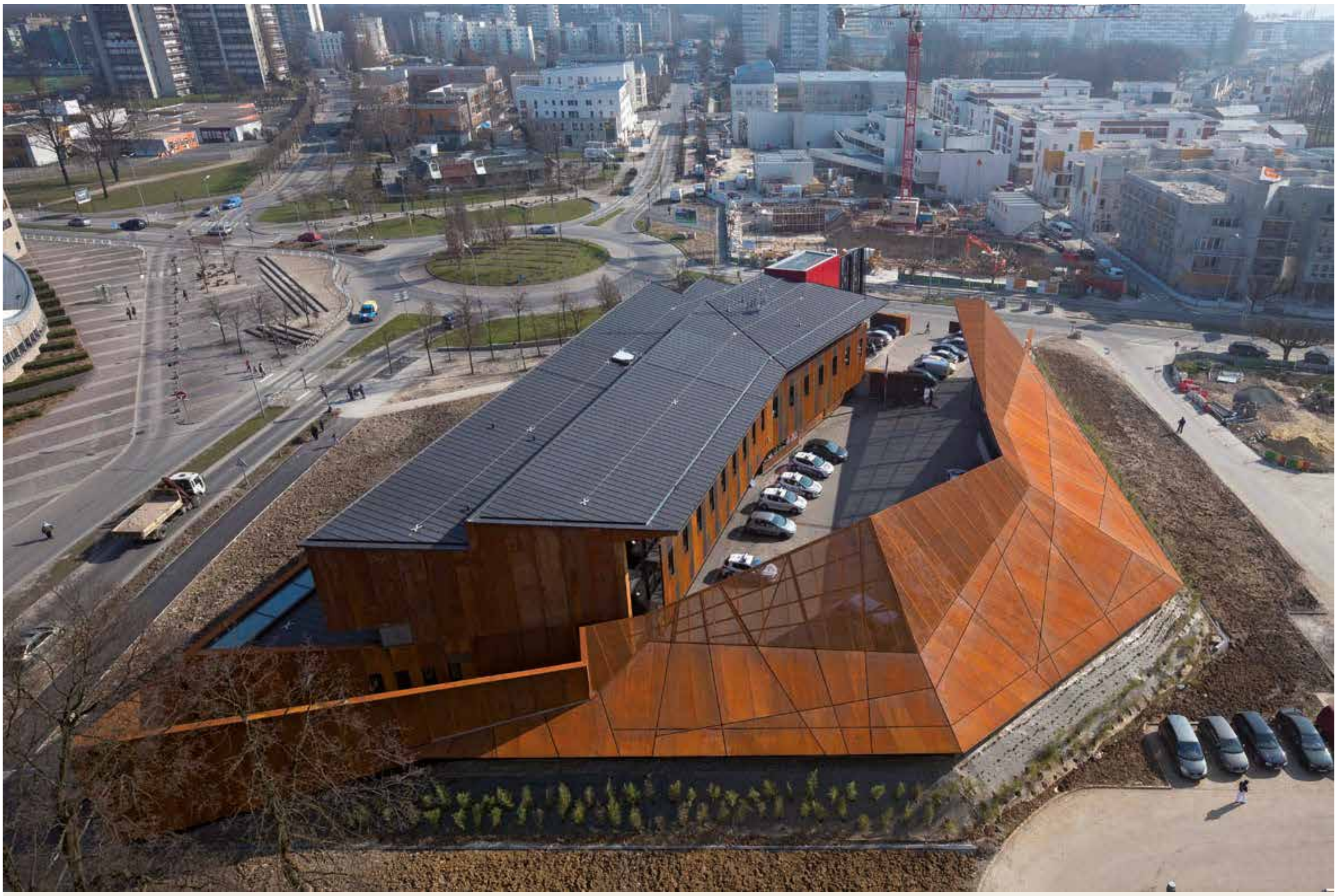
The design of this new steel research centre in Belgium utilised as many steel solutions as possible. The building is a showroom for the versatility of steel in construction. More than 300 tonnes of steel were used, with different coatings providing the required aesthetics.

Portia Winery

Location: Gumiel de Izan, Ribera del Duero, Spain Client: Bodegas Portia S.L
Architect: Nigel Young, Foster + Partners
Main contractor: FCC
Roof and facade contractor: CISA Cubiertas Internacional
Construction years: 2006-2009
Copyright pictures: Foster + Partners

The first winery project for Foster + Partners gave the firm an opportunity to look afresh at this building type. Using the natural topography of the site to aid the winemaking process, the architects have created the optimum working conditions while reducing the building' s energy demand and visual impact.

The structure of the building is made of concrete while steel is used for the cladding. Shingles of **Indaten®** weathering steels from ArcelorMittal are utilised on all major elevations to echo the brownish shades of the surrounding landscape. Thanks to the self-protective patina of **Indaten®**, no maintenance is required.



Police station Clichy-Montfermeil

Location: Clichy-Montfermeil, France
Client: Police Department, Paris
Architect: Fabienne Bulle
Facade component provider: ArcelorMittal Construction Arval
Construction year: 2011
Copyright pictures: Hervé Abbadie



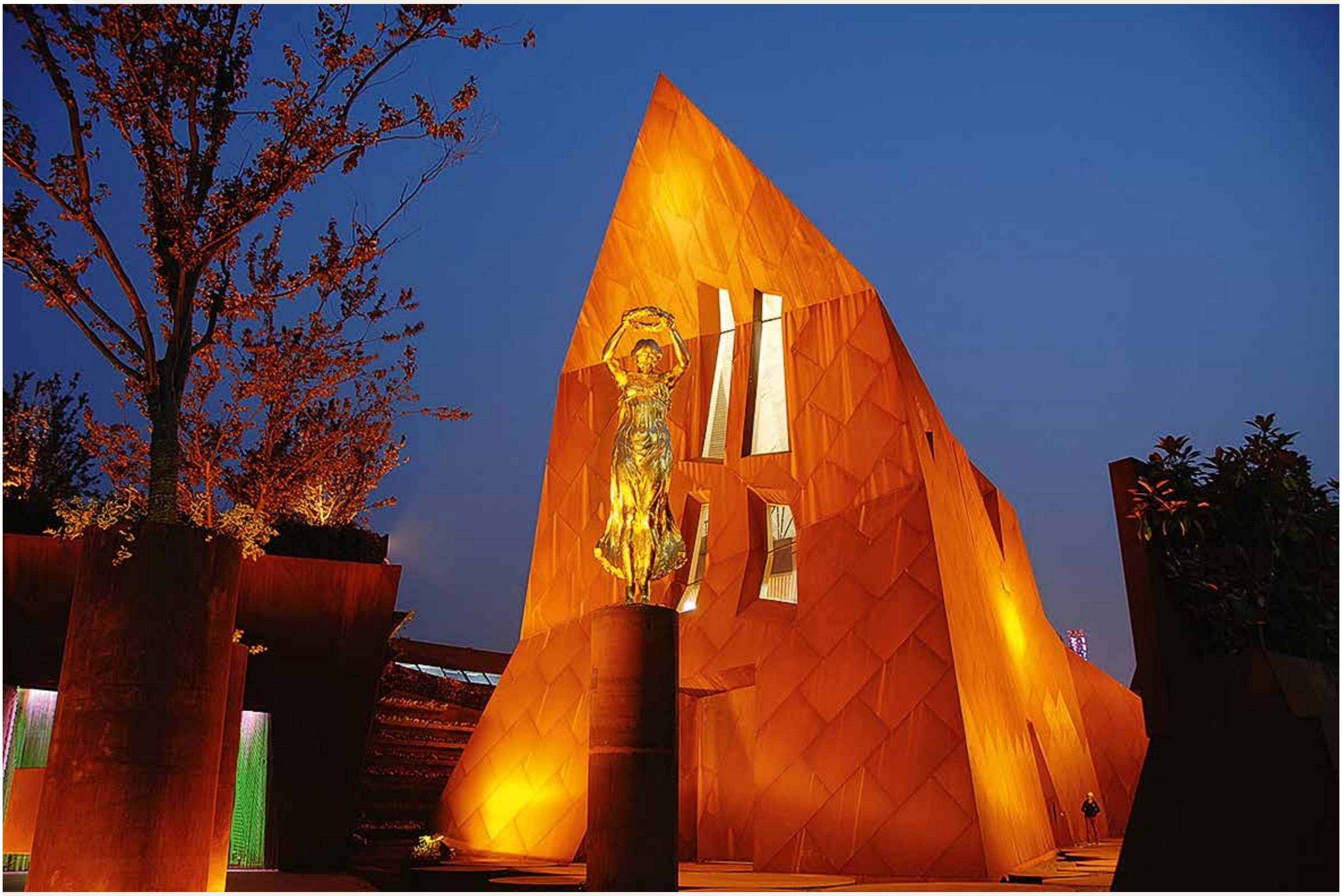



Hôtel de Police Paris

Location: Paris, France
Architect: ap architecture
Construction year: 2013
Copyright pictures: Arval by ArcelorMittal

3.2.2 Architectural sculptures

Luxembourg World Expo Pavilion



Location: Shanghai, Republic of China

Client: Luxembourg State

Architect: Valentiny

Copyright pictures: ArcelorMittal/Pierre Engel

World Expo 2010 opened in Shanghai with exhibitors from almost 200 countries. One of the most striking buildings on the 5.3 square-kilometre site was the national pavilion of Luxembourg. Designed by architect Francois Valentiny, a native Luxembourger, the pavilion used **Indaten®** weathering steels from ArcelorMittal to create a dramatic dialogue between the Expo visitor and nature.

The pavilion takes the form of an enlarged single-family house surrounded by a fortress-like wall. The hardness of the weathering steels is softened by trees planted on top of the enclosure, a garden along the inner core, and a pond covered by giant steel lily-pads.

"I planted trees and vegetation so the central building looks like a castle," explains Valentiny. "In Chinese, Luxembourg means fortress and forest, so I am playing with images, signs, and forms."

The imaginative design drew in more than 10% of the 72 million visitors to world Expo 2010 and generated more than €5.8 million. At the end of the Expo, the pavillion was presented to the Chinese people as a gift from Luxembourg. It is one of only six national pavilions to remain onsite.

Temporary sculpture Bernar Venet

Construction year: 2010
Permanent installation: Promenade des Anglais, Nice, France
Copyright picture: City of Nice

9 Lignes obliques

Four Indeterminate Lines

Construction year: 2011
Location: Arcs in Disorder, Exhibition Château de Versailles, France
Copyright picture: Archives Bernar Venet, New York

84 Arcs / Désordre

Construction year: 2013
Installation: Palais du Pharo, Marseille, France
(This work continues to be on public view at present, loan extended with the city of Marseille.)
Copyright picture: Jérome Cavalière/Archives Bernar Venet, New York

3.2.3 Culture, leisure, and sports

Théâtre de l'Archipel is a unique architectural project which highlights two of ArcelorMittal's aesthetic steel solutions: **Indaten®** and **Aluzinc®**. The combination of these two steels shows how metallic diversity can contribute to architectural beauty.

Théâtre de l'Archipel

Location: Perpignan, France
Client: City of Perpignan
Architect: Ateliers Jean Nouvel & Brigitte Metra Associées
Contractors: AUXIFIP/AGIR (General); ROSSI (Indaten® facade)
STEREC NORD (Aluzinc® roofing)
Construction year: 2008-2011
Copyright pictures: Philippe Ruault

The **Indaten®** was processed into Medoc (MD) cassettes of different sizes. MD cassettes were specifically developed by ArcelorMittal Construction Arval for use with weathering steels. The cassettes slide into vertical rails fixed to the wall with metal brackets to ensure fast construction.

Multi-generational Centre

Location: Le Poinçonnet, France
Client: City of Le Poinçonnet
Architect: Antoine Reale
Coque provider: ArcelorMittal Construction Arval
Construction year: 2012
Copyright pictures: Cabinet Antoine Real

The Centre for Multi-generational Activities in the French town of Le Poinçonnet is characterised by its contemporary architecture. The facade is dominated by the interaction of flowing lines and the materials used. ArcelorMittal supplied the steel part of the centre's cladding: Coque MD panels made from **Indaten®** weathering steels.

Coque MD panels are part of ArcelorMittal Construction's aesthetic cladding product range. They were specially developed for weathering steels to increase the transformation possibilities of the material. The panels are invisibly fixed on support rails connected to the building's load-bearing structure.

Centre for Contemporary Art

Location: Montreuil, France
Client: Ville de Montreuil
Architect: Bernard Desmoulin
Construction year: 2013
Copyright pictures: Bernard Desmoulin

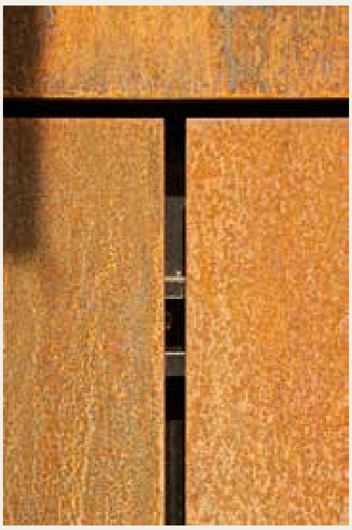
Sports Centre

Location: Cannes, France
Client: City of Cannes
Architect: RFArq- Roberto Ferreira
Contractors: CAMPENON BERNARD Méditerranée/EIFFAGE
Construction year: 2002 – 2005
Copyright pictures: Roberto Ferreira

The Cannes 'Palais des Sports' is the result of an architectural and functional dialogue between two main elements: the roof coverings and facades. Both were created in **Indaten®** 355A steel. The main volume, which has a polygon shape, surrounds the main hall. The second volume, in the form of a prism, is highly longitudinal and flexibly organised.

Scout Headquarters

Location: Grand Duchy of Luxembourg, Luxembourg
Client: NEL, Luxembourg
Architect: hsa – heisbourg strotz architectes
Metallic contractor: Prefalux
Construction year: 2013
Copyright pictures: Eric Chenal, Gilles Martin (Courtesy of Infosteel)



The new home of the National Federation of Boy and Girl Scouts in Luxembourg is a low energy building and an elegant example of how sustainable construction materials can be combined. The solid wood structure and **Indaten®** weathering steels from ArcelorMittal refer to the scouts' connection to nature and Luxembourg's steel industry.

The project won the Luxembourg Steel Construction Award 2013 in category Sustainable Construction. The competition is organised by Infosteel.

3.2.4 Renovation

Theatre Extension

Location: Brussels, Belgium
Client: Brigittines Theatre
Architect: Andrea Bruno, Torino SUM Project, Brussels
Metallic contractor: Denys
Construction year: 2007
Copyright pictures: Archive Studio Bruno

Indaten® weathering steel has become the protagonist in this project to refurbish and extend the Brigittines Theatre. Like copper before, **Indaten®** has become an authentic basic construction material. And like copper, it allows you to 'feel' time passing as its unique patina changes and develops over the years. Weathering steels also contribute aesthetically and functionally to the integration of the renovation into the surrounding built environment.

The Brigittines Theatre occupies an old church in the historic heart of Brussels. The choice of **Indaten®** derives from the architect's desire to give the building a warm and welcoming appearance. During the refurbishment, a new building was added.

The new structure and rear of the old church are completely enveloped in **Indaten®**, while the front maintains its traditional appearance. As the colour of the **Indaten®** changes with the light, and over time, it seamlessly integrates the theatre into the historic stone and brick buildings which are its neighbours.

Villa Chanzy

Location: Rouen, France
Client: Investir Immobilier
Architects: Agence Jean Baubion – refki Chelly – Agence Diagram – architecte urbaniste
Panel provider: ArcelorMittal Construction Arval
Construction year: 2008
Copyright pictures: Grégoire Auge

3.2.5 Bridges

Railway bridge

Location: Yeste, Albacete, Spain
Client: Confederación Hidrográfica del Segura
Steel constructor: Ferrovial-Agroman S.A
Construction year: 2007

Puente de La Vicaria. Image by De Jesus (Albacete, Spain). This file is licensed under the Creative Commons Attribution 2.0 generic licence.

Trencat bridge restoration

Location: Sant Celoni and Santa Maria de Palautordera, Spain

Client: Ayuntamiento de Sant Celoni, Ayuntamiento de Santa Maria de Palautordera, Associació Pont Romà 2000

Architect: Xavier Font Solà - Alfa Polaris S.L.

Construction year: 2003

Copyright picture: Xavier Font

Trencat Bridge (Broken Bridge)

When it came to restoring the Trencat Bridge, the architects designed a two-span box girder deck, supported by three pairs of bearings. A bearing was placed at each end, while the intermediate bearing was placed over the crown of a hollow, box-pointed arch which spans 24 metres. To emphasise the old silhouette, the parapets of the deck were extended along the remaining structure. The top line of the new deck and the interior curve of the steel arch follow the original shape of the old bridge. The use of **Indaten®** evokes the missing silhouette without impacting on the heritage of the original bridge.

Acoustic walls

Location: A14 highway Bologna-Tarento, Italy
Client: Autostrade per l'Italia
Acoustic panel provider: CIR Ambiente
Construction year: 2013-2014
Copyright pictures: Images courtesy of CIR Ambiente

Technical support and contact

Technical support

We are happy to provide you with free technical advice to optimise the use of our products and solutions in your projects and to answer your questions about the use of weathering steels. Our technical advice covers the design of structural elements, construction details, corrosion protection, and metallurgy, processing, and welding.

Our specialists are ready to support your initiatives anywhere in the world.

Contact

For enquiries about hot rolled steel or heavy plates, please contact our dedicated construction support team at:

steel.envelope@arcelormittal.com

For enquiries concerning the use of sections and merchant bars, please contact our dedicated specialists:

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