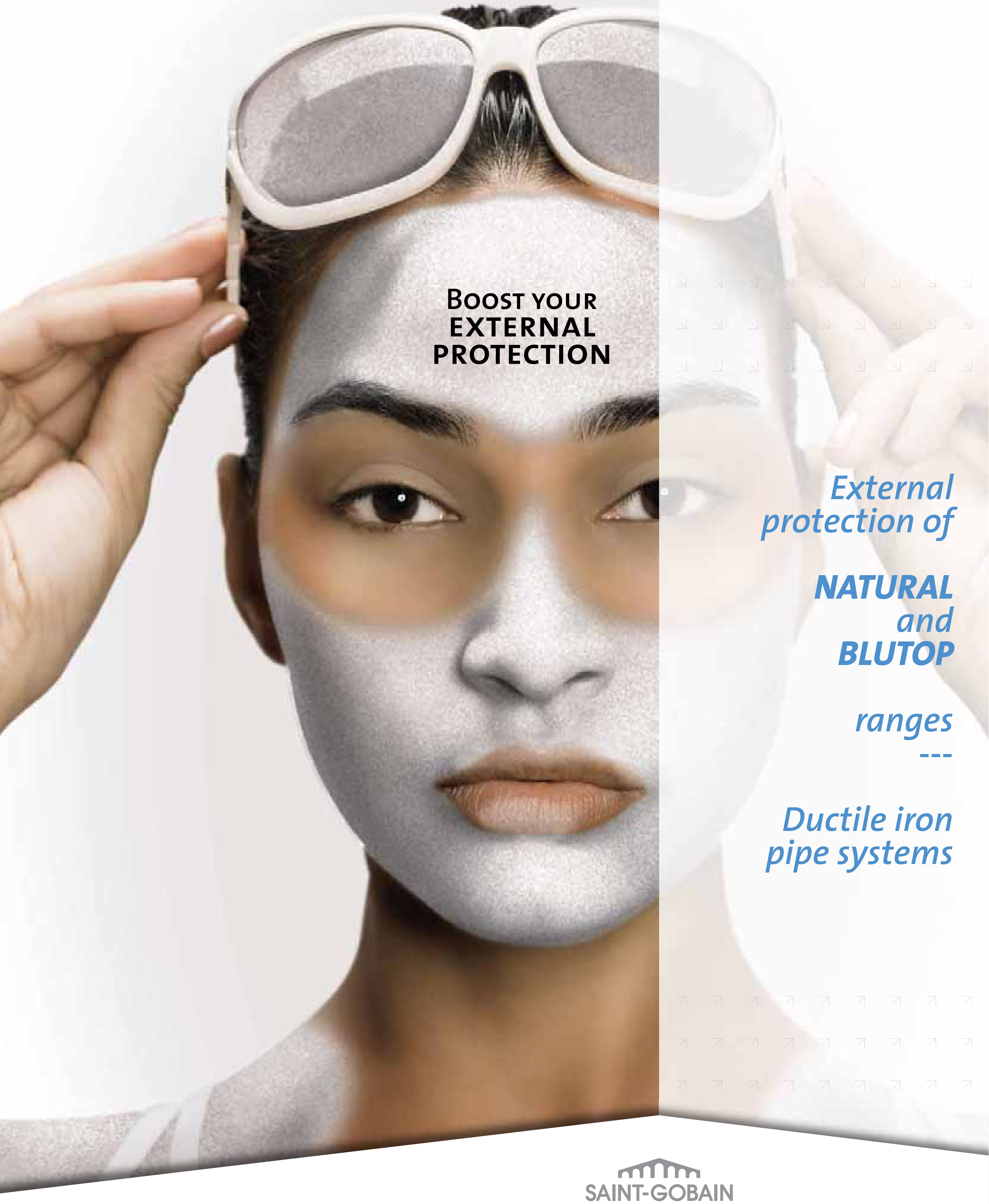
PAM

Zinalium
PAM TECHNOLOGIES



Boost your EXTERNAL PROTECTION

External protection of

NATURAL
and
BLUTOP

ranges

Ductile iron pipe systems

SAINT-GOBAIN
PAM

Zinalium
PAM TECHNOLOGIES

Technology

Sustainable Development

Innovation

Contents

Zinalium
CUSTOMER ADDED-VALUE

Durability

Confidence

Experience

Exceptional Performance and Durability

Saint-Gobain PAM, backed by over 150 years' experience of producing pipe systems for transporting water, knows how to design solid, reliable and durable products. Long-term research and technology, coupled with Saint-Gobain PAM's experience, have enabled us to invent a revolutionary new coating, called ZINALIUM, which significantly increases the durability of ductile iron pipelines.

Water, an essential resource for all forms of life, is becoming scarce to obtain and thus more and more precious. It is therefore time to take an environmentally-friendly approach to develop products that protect and preserve the earth's resources.

A modern, highly effective material, made up of 85% zinc and 15% aluminium, ZINALIUM now gives you the opportunity to take a responsible approach to shared facilities, without having to compromise on the longevity of pipelines or quality of service.

Saint-Gobain PAM is committed to sustainable development

Sustainable development is central to the corporate culture of Saint-Gobain PAM, the world leader in the production of pipe systems for water supply and wastewater sewerage. **Saint-Gobain PAM was quick to take on board the principles of the Brundtland Commission that prefigured what has become known as sustainable development.**

Back in 1987, this International Commission encouraged the current generation to "meet their needs without compromising the ability of future generations to do the same".

Modernity of the technologies and priority given to research and development have enabled Saint-Gobain PAM to consistently offer its customers high quality, durable, reliable and ergonomic solutions.

Like communication channels, water supply and distribution and wastewater sewerage pipelines are infrastructure systems designed to last several generations. **As demonstrated at the environmental round table, the "Grenelle de l'Environnement", sustainable development means first and foremost equipment and facilities that are "sustainable" and not "disposable".**

Saint-Gobain PAM is committed to work in the following key fields:

- *Environmental*
- *Economic and Industrial*
- *Social*

Saint-Gobain PAM uses these principles to provide effective environment solutions. Over 100 capital cities and more than 1,000 large towns throughout the world have already been equipped with Saint-Gobain PAM products. Many hydraulic, water conveyance and wastewater sewerage projects are currently underway. Saint-Gobain PAM is involved, **in a variety of locations, especially as part of development work in countries in South America and Africa, as well as in China and the Middle East.**

A growing need for longer-lasting pipelines

The average rate at which drinking water pipeline are renewed is around 0.6 to 0.7% per year. **This means that a pipeline laid today, taking into account the currently observed pace of investment, needs to last for around 150 years!**

The durability of ductile iron has been acknowledged for several decades. **In many hydraulic systems, ductile iron pipes that are over a hundred years old, even 150 years in some cases, are still in perfectly good working order**. And there may well be no immediate plans to replace it.

Beyond the inherent qualities offered by ductile iron, **its durability often comes from the quality of the external coating against soils aggressivity, and internal lining against reactivity of water and effluents.**

Grenelle 2

Article 58 of the "Grenelle 2" french law specifies that to define the correct level of investment required, asset inventories should be carried out for all water supply and distribution and wastewater sewerage services.

This article goes on to state that services are required to carry out this inventory so as to minimize water losses in the system. Should leaks exceed the level set by decree for the department, work must be carried out to correct this. This new measure operates alongside a bonus-penalty system, creating a sort of "virtuous circle" that actively encourages agencies to manage assets in a more efficient manner. Water Agencies are the lead representatives in terms of carrying out these inventories and assessing the investment requirements. Currently, only a few large local authorities and some departmental authorities have completed these inventories.

Saint-Gobain PAM's research labs have been working patiently and painstakingly for several decades to develop new generations of protective coatings. **This work has been both theoretical and experimental. Research includes laboratory-based tests, but above all it involves very long-term field testing**. This research makes a decisive contribution to extending the life of pipes.

The new external coating ZINALIUM is the result of research.

The fountains at the "Château de Versailles": exceptional durability

The water systems at the "Château de Versailles" are a prime example of the technical qualities and durability of ductile iron pipes.

Finding the necessary water resources for the fountains at Versailles was a constant worry for the Sun King. Even when in battle, it occupied his thoughts and at one stage considered harnessing water from the Loire river, some 200km away. **All the new techniques that appeared at this time were used to meet the demands of the king**. The Grand Canal was inaugurated on 17 April, 1666, after five years of work. Several systems were tested and applied, and then abandoned.
The king commissioned the best sculptors and put the most inventive engineers to work. Like the building of the Palace itself, the gardens were like a huge open-air laboratory.

In 1683, the first pipes to be laid, made of lead, were quickly replaced by cast iron pipes. The gardens of Versailles' current hydraulic system dates from the Louis XIV period and features 35 kilometres of pipes, of which close to 90% are made of cast iron (the rest are made of lead). **This technical equipment is still in good working order. You can see just how robust it remains, particularly during the large summer festivals, when it needs to operate at full capacity**. It is constantly maintained by the Palace's hydraulic engineers in accordance with methods dating from the 17th century, as well as more modern techniques. **Some of the cast iron pipes, which have been in use for around 350 years, must now be replaced as they are worn out. However, some 80% of the original cast iron pipes will remain in use**.

Durability stems from the use of ductile iron pipes

The durability of ductile iron pipe systems stems from a combination of the exceptional mechanical properties of ductile iron, the leaktightness of the joints used, the resistance to soil damages provided by the external coating, as well as the quality of the lining that comes into contact with water.

MECHANICAL RESISTANCE
incredible strength

- High burst pressure
- Water hammer resistance
- High rigidity
- Impact resistance
- Each pipe is subjected to a works hydraulic pressure test
- Systematic quality control of ductile iron for mechanical resistance and elongation (ductility)

...

LEAKTIGHTNESS OF JOINTS
Unrivalled reliability

- Tested in all conditions
  - High positive internal pressure
  - Negative internal pressure
  - Positive external pressure
  - Cyclical pressure
- Long-term ageing research
- Angular deflection and axial movement are possible, enabling in-the-field movement to be tracked
- High-technology anchoring system

RESISTANCE TO SOIL DAMAGE
In all types of soil

- Naturally low susceptibility to corrosion of the ductile iron
- Active external protection provided by:
  - Pure zinc + pore-sealer
  - Zinc Aluminium alloy + epoxy (ZINALIUM)
- Special external coating (TT PE or PUX) for the most aggressive soils

...

RESISTANCE TO WATER DAMAGE
for all types of water

- Surfaces in contact with water are protected
- Inner protection of pipes provided by:
  - Blast furnace cement
  - Special inner coating (Polyurethane) for soft and hard, abrasive water
  - DUCTAN inner coating for the BLUTOP range
- Epoxy coating of fittings
- All coatings have ACS accreditation (health & safety attestation of conformity awarded in France), and in most European countries (Germany, United Kingdom, Belgium, the Netherlands, etc.)

...

Active protection of ductile iron pipes

Structure of the external zinc coating:

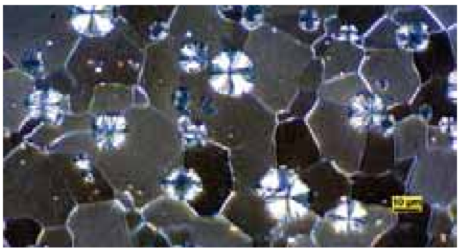
- *Pure zinc, 200g/m²*
- *Application by spraying of pure zinc droplets*
- *Layer of black pore-sealer, 120µm thick on average*

Zinc-based protective coating of ductile iron works thanks to two active processes: galvanic protection and healing.

Galvanic protection

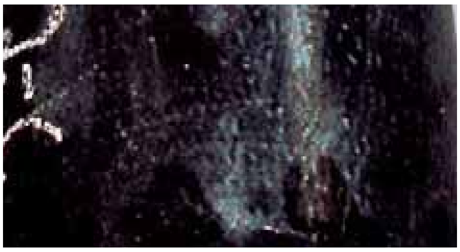
Zinc, a metal that possesses more electronegativity than iron in terms of its electrochemical potential, can be used to offer galvanic protection to the ductile iron (refer to the page with technical data, p. 22).

For example, when a zinc-coated ductile iron pipe is buried in the ground, the **galvanized zinc, when in comes into contact with aggressive soil, is slowly transformed into a layer of zinc-conversion products**, such as zinc oxides, zinc carbonates, zinc oxychlorides, etc. **It thus forms a stable, dense, impermeable and binding layer, which takes up exactly the same space as the initial porous layer of galvanized zinc**. It evenly covers the entire surface of the pipe.



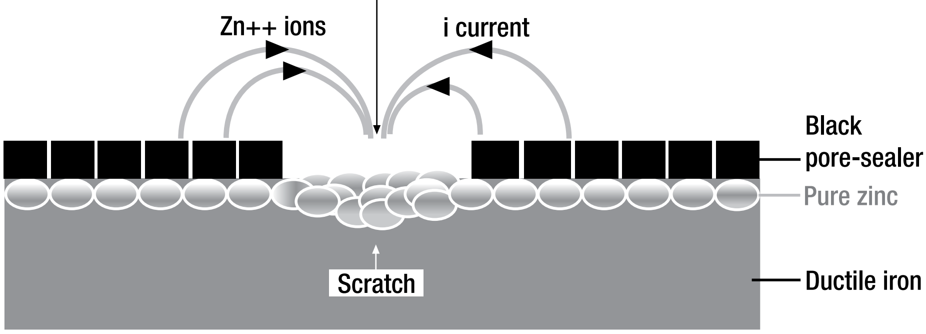
The zinc layer is highly porous, **as it enables zinc-conversion products to form without increasing the space occupied, which prevents the protective layer from cracking**. The newly-formed layer fills up the pores and binds the zinc salts very effectively, ensuring the long-term protection of the ductile iron pipes.

The pore-sealer is used to limit the exchanges with the soil and enables the zinc to be transformed into insoluble zinc crystals slowly. This process generally involves a phase during which soluble zinc hydroxides are formed. If no pore-sealer is used, these crystals could be dissolved by the water.



Healing

One of the key advantages offered by zinc external coating is its capacity to restore protection in places where there are isolated scratches or tears. This capability is known as healing. Damage can be caused during handling, transport and installation of pipes, or even after installation during maintenance work carried out close to the buried pipes.



When part of the pipe's external coating is damaged, the ductile iron becomes exposed and is gradually covered with a zinc salts based layer, due to the zinc ions recombining with the anions found in the soil.

This layer is comparable with the layer that forms on the rest of the surface of the pipe. In the vast majority of soils, the layer is stable and provides long-term protection.

How can we improve the performance of zinc coating?

In certain soil conditions, where the zinc is transformed too quickly into its conversion products, the quality of the layer formed is reduced. This results in a shorter lifespan and therefore restricts the fields in which zinc coating can be used.

Limiting the speed at which the zinc is transformed and increasing the stability of the layers formed quickly appeared to be ways of extending the fields in which zinc-based active coating can be used.

That's exactly what the new active coating ZINALIUM, is aiming to achieve!

Boost your pipes' external protection with ZINALIUM

The inventions behind research undertaken on ZINALIUM

Saint-Gobain PAM started manufacturing ductile iron pipes with zinc-based external coating in the 1960's. Always looking for innovative ways to improve the durability of its pipes, Saint-Gobain PAM focussed its research efforts on increasing the weight of zinc, gradually taking this to 200g/m². However, the positive effects of increasing the amount of zinc used fades beyond 200g/m², both in terms of extending durability and in terms of extending the field of use.

40 years of Research and Development

- 1969 – Discovery of the alloy DUNOY (zinc - aluminium)
- 1970/72 – Lab testing
- 1971/72 – Initial in-the-field tests
- 1978 – Initial results from in-the-field tests
- 1982/1998 – Complete characterization of the zinc-aluminium alloys
- 1998 – Decision to launch a new product using the zinc-aluminium coating
- 2000 – Launch of the NATURAL range in the DN 60 to 300
- 2005 – Extension of the NATURAL range to the DN 350 to 600
- 2009 – Launch of the BLUTOP range

Research into ZINALIUM started at the end of the 1960's.

Using zinc aluminium alloys instead of zinc means:

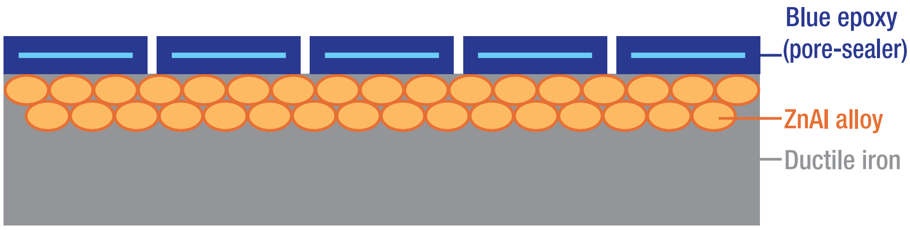
- *A Galvanic protection offered by zinc*
- *An Improved chemical and mechanical stability of the coating thanks to the use of aluminium*

Tests conducted by Saint-Gobain PAM showed that when composed of 85% zinc and 15% aluminium (mass percentages), the alloy provides optimum protection levels.

The new external coating, ZINALIUM

ZINALIUM coating is applied to the outer surface of the ductile iron pipes during two successive manufacturing operations:

- Galvanization by electric arc spraying of the alloy ZnAl 85-15 at 400g/m² (approximately 70μm)
- Deposit by spraying an external epoxy layer on the galvanized layer (120μm on average)



The protective layers stick to the ductile iron pipe perfectly, covering the entire barrel and socket.

The scientific explanation

As with pure zinc coatings, ZINALIUM offers so-called "active" protection to ductile iron pipes.

This protection is "active" thanks to the powers of galvanic protection offered by the alloy ZnAl 85-15. Although it has slightly less electronegativity than pure zinc (by around fifty millivolts), due to the presence of the aluminium, it enables the ductile iron's electrochemical potential to be moved into iron's field of immunity, thus providing a form of cathodic protection. This protection is combined with the migration process of the metallic ions Zn^{2+} and Al^{3+} towards the cathodic sites, resulting from the ZINALIUM scratches uncovering the ductile iron. By recombining the anions present on the surface of the scratch, insoluble products are formed and a layer of products is deposited and reseals the scratch. This is the healing process.

Long-term protection stems from the controlled formation of a layer of conversion products from the alloy ZnAl 85-15, stable in the soil conditions in which ZINALIUM is used. The layer formed, thanks to its physical and chemical properties (type of products formed, compactness, adhesion, etc.), once initiated, reduces the exchanges between the outside environment and the metallic ZnAl 85-15 alloy layer by lowering the diffusion speed of chemical species. These properties result in part from the composition of the alloy - zinc combined with 15% aluminium - but are above all due to the specific metallurgic microstructure of the metallic layer, obtained by electric arc spraying using alloy wires. The conditions used for cooling the molten alloy droplets sprayed onto the surface of the pipes gives a specific fineness to the dual-phase structure expected with this composition of the 15% aluminium zinc alloy. The two phases are closely entangled. One phase high in aluminium, close to the composition of the eutectoid, is the first to solidify, developing a skeleton within the droplets. This is followed by a phase high in zinc, close to the composition of the eutectic, featuring a finely separated lamellar structure.

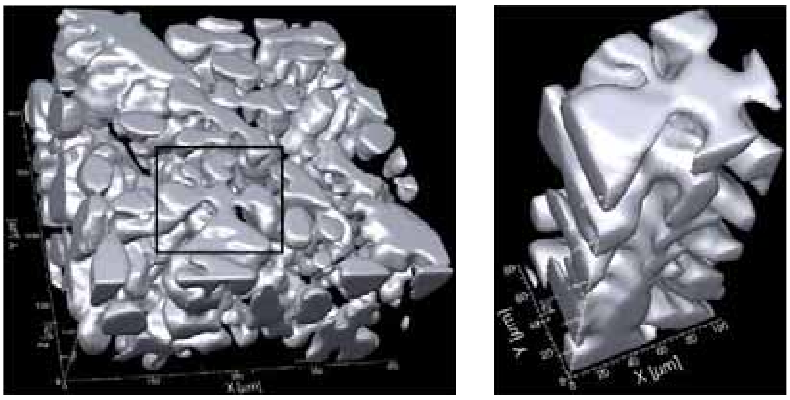
This finely separated structure of the metallic layer, specific to the technology used with ZINALIUM, enables the kinetics of the alloy transformation to be controlled. The zinc-rich phase, which has the most electronegativity, contributes to galvanic protection. The aluminium-rich phase controls the mobility of the ions formed during this process, as well as the transformation of the alloy by the soil's aggressive chemical species. The products formed by this conversion are confined by the skeleton formed by the aluminium-rich phase, benefitting from protection offered by its alumina passivation layer. The transformation kinetics of the ZnAl 85-15 alloy layer are thus reduced in comparison to pure zinc, have a smaller surface exposed to reactive phase, restrict the access of aggressive species to the heart of the layer and allow less migration of conversion products towards the soil.

The kinetics are even more greatly reduced with ZINALIUM thanks to the optimized properties of the pore-sealer layer. The thickness adopted using the selected blue epoxy restricts the access of the soil's aggressive species to the alloy, whilst enabling galvanic protection and, above all, without preventing the physical and chemical transfers that occur in the layer which are liable to cause the appearance of blistering and an overly quick transformation of the alloy.

Boost your pipes' external protection with ZINALIUM

ZINALIUM's unique microstructure

The microstructure of the zinc-aluminium alloy layer is a finely constructed entanglement of zinc- and aluminium-rich phases. The 3D view of the zinc-rich phase enables us to see how the zinc is trapped in the microstructure, enabling its consumption to be slowed down and therefore the duration of protection to be extended.



EPFL (Ecole Polytechnique Fédérale de Lausanne), photograph provided free of charge by Professor M. Rappaz.

Switch to 400g/m²

Saint-Gobain PAM has increased the quantity of metallic coating from 200g/m² to 400g/m² in order to optimize the zinc-aluminium coating. This represents a thickness of around 70µm.

The very significant increase in weight means:

- *Improved formation of long-term protective layers*
- *Improved performance of the galvanic protection provided by the zinc-aluminium alloy*
- *Greater mechanical resistance of the protective layer*

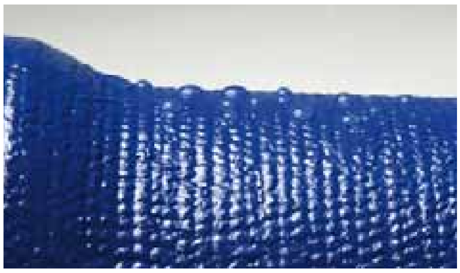
The role of the epoxy layer

With ZINALIUM, the conventional black pore-sealer is replaced by a blue epoxy coating - light blue for the NATURAL range and ultramarine for the BLUTOP range.

This epoxy coating makes a significant contribution to improving the performance of ZINALIUM compared with pure zinc coating.

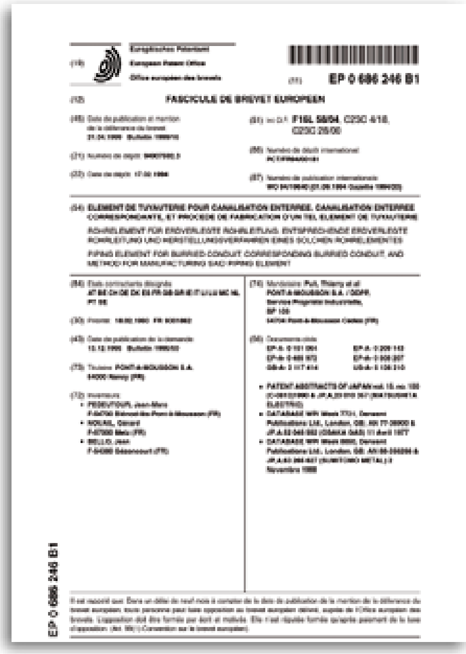
The main improvements provided by the epoxy include:

- Greater chemical stability
- Better long-term performance in soil as it ages
- Better control of the zinc-aluminium alloy conversion process
- Better mechanical resistance of the coating (during transport and use)
- Improved resistance to solvents present in the soil (contaminated soil)
- Possibility of colouring the pipe to enable easier identification
- Better organoleptic performance



Zinalium

CUSTOMER ADDED-VALUE


European Patent Office

EP 0 686 246 B1

FASCICULE DE BREVET EUROPEEN

ELEMENT DE TUYAUTERIE POUR CANALISATION ENTERREE, CANALISATION ENTERREE CORRESPONDANTE, ET PROCEDE DE FABRICATION D'UN TEL ELEMENT DE TUYAUTERIE

PIPING ELEMENT FOR BURRIED CONDUIT, CORRESPONDING BURRIED CONDUIT, AND METHOD FOR MANUFACTURING SAID PIPING ELEMENT

EP 0 686 246 B1

The ZINALIUM patent

The intellectual property rights of the ZINALIUM coating are protected via the European patent EP 0686246B1, issued on 21 April, 1999. This patent provides an extensive worldwide coverage.

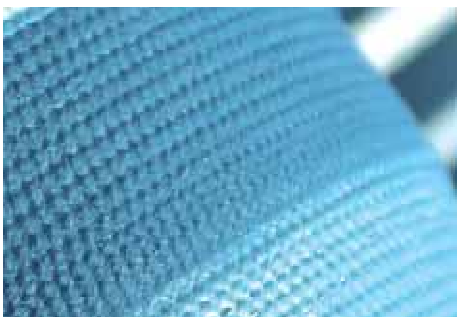
ZINALIUM, zinc-aluminium coating, manufactured in accordance with Saint-Gobain PAM's patent, is able to offer an extremely effective protective structure thanks to:

- A very finely structured zinc-aluminium alloy, with an entanglement of zinc-rich and aluminium-rich phases
- A manufacturing procedure featuring direct spraying of a zinc and aluminium alloy

NATURAL, the first range to use ZINALIUM

NATURAL was Saint-Gobain PAM's first range to use ZINALIUM coating. Designed for the conveyance of drinking water, NATURAL is a comprehensive range that offers great flexibility and versatility, and thus is adapted to all types of network, soil and pressure level.

The NATURAL range of fittings is the most comprehensive on the market. The various joints and accessories (EXPRESS, STANDARD, flange and UNIVERSAL) provide an unlimited number of combination of configurations to meet the needs of the most complicated building sites.



Characteristics of the NATURAL RANGE

- DN 60 to 600

- Pipes
  - *NATURAL with STANDARD joints*
  - *NATURAL with EXPRESS joints*
  - *NATURAL UNIVERSAL*

- Varieties of external coatings
  - *ZINALIUM with light blue epoxy*
  - *TT*
  - *ISOPAM*

- Varieties of internal coatings
  - *Blast furnace cement*
  - *Polyurethane*

- Fittings
  - *Manual NATURAL EXPRESS fittings*
  - *Automatic NATURAL STANDARD fittings*
  - *Flange fittings*
  - *NATURAL UNIVERSAL fittings*

- Varieties of coatings
  - *Epoxy applied by cataphoresis*
  - *Epoxy applied by powder spraying*

- Anchoring systems
  - *STANDARD Vi*
  - *EXPRESS Vi*
  - *UNIVERSAL Vi and UNIVERSAL Ve*

Zinalium

CUSTOMER ADDED-VALUE

BLUTOP and ZINALIUM, a new approach to ductile iron

Blutop is Saint-Gobain PAM's new range, dedicated to small diameter distribution systems. The new range also benefits from the performance offered by ZINALIUM external coating.

BLUTOP is a range of pipe systems designed for small diameter distribution, which put emphasis on its workability, portability and simple use, as well as the professional expertise provided during installation. The internal lining of BLUTOP pipes is made of a thermoplastic polymer, DUCTAN, which is another Saint-Gobain PAM's major innovation.

The pipes and fittings in the BLUTOP range have all been designed to be compatible with plastic pipes. They can be interconnected with old PVC or PE networks which need to be replaced.

Characteristics of the BLUTOP range

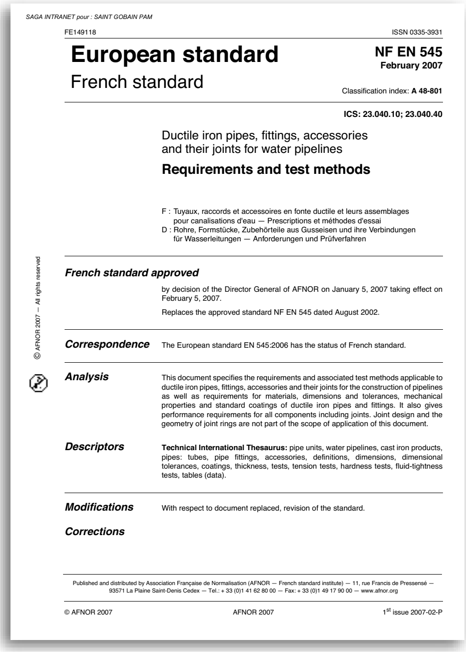
- **DN 90, 110 and 125**
- **Pipes**
  - *BLUTOP*
- **External coating**
  - *ZINALIUM with ultramarine epoxy*
- **Internal coating**
  - *DUCTAN, ultramarine*
- **Fittings**
  - *BLUTOP joint fittings*
  - *Flange fittings*
- **Coating of fittings**
  - *Epoxy applied by powder spraying*
- **Anchoring systems**
  - *BLUTOP Vi*

NATURAL and BLUTOP

Materials in contact with drinking water

When developing the NATURAL and BLUTOP ranges, Saint-Gobain PAM took great care to ensure that the materials selected were suitable for contact with drinking water. All the materials (coatings, lining, joints, lubricants, etc.) have been granted ACS (health & safety attestation of conformity awarded in France) and, where appropriate, the equivalent certificates in those European countries which have an accreditation system. This **ensures that the water distributed in the pipelines is of impeccable quality.**

Reference to the European standard EN 545



SAGA INTRANET pour : SAINT GOBAIN PAM

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European standard **NF EN 545**
French standard **February 2007**

Classification index: **A 48-801**

ICS: 23.040.10; 23.040.40

Ductile iron pipes, fittings, accessories and their joints for water pipelines

Requirements and test methods

F : Tuyaux, raccords et accessoires en fonte ductile et leurs assemblages pour canalisations d'eau — Prescriptions et méthodes d'essai
D : Rohre, Formstücke, Zubehörteile aus Gusseisen und ihre Verbindungen für Wasserleitungen — Anforderungen und Prüfverfahren

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French standard approved

by decision of the Director General of AFNOR on January 5, 2007 taking effect on February 5, 2007.

Replaces the approved standard NF EN 545 dated August 2002.

Correspondence The European standard EN 545:2006 has the status of French standard.

Analysis This document specifies the requirements and associated test methods applicable to ductile iron pipes, fittings, accessories and their joints for the construction of pipelines as well as requirements for materials, dimensions and tolerances, mechanical properties and standard coatings of ductile iron pipes and fittings. It also gives performance requirements for all components including joints. Joint design and the geometry of joint rings are not part of the scope of application of this document.

Descriptors **Technical International Thesaurus:** pipe units, water pipelines, cast iron products, pipes: tubes, pipe fittings, accessories, definitions, dimensions, dimensional tolerances, coatings, thickness, tests, tension tests, hardness tests, fluid-tightness tests, tables (data).

Modifications With respect to document replaced, revision of the standard.

Corrections

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Ductile iron pipes coated with an alloy of zinc and aluminium with or without other metals having a minimum mass of 400 g/m² with finishing layer, together with ductile iron fittings coated with an electro-deposited coating having a minimum thickness of 50 µm and applied on a blast-cleaned and phosphated treated surface, or coated with an epoxy coating in compliance with EN 14901, may be buried in contact with the majority of soils, except:

- acidic peaty soils;
- soils containing refuse, cinders, slag, or polluted by wastes or industrial effluents;
- soils below the marine water table with a resistivity lower than 500 Ω·cm.

In such soils, and also in the occurrence of stray currents, it is recommended to use other types of external coatings adapted to the most corrosive soils (see D.1, D.2.4 and 4.5.1).

Evidence of the long term performance of the above mentioned solution (e.g. tests and references) should be provided by the manufacturer.

In the relatively rare situations where use of ZINALIUM coating is not suitable, Saint-Gobain PAM also offers the TT range:

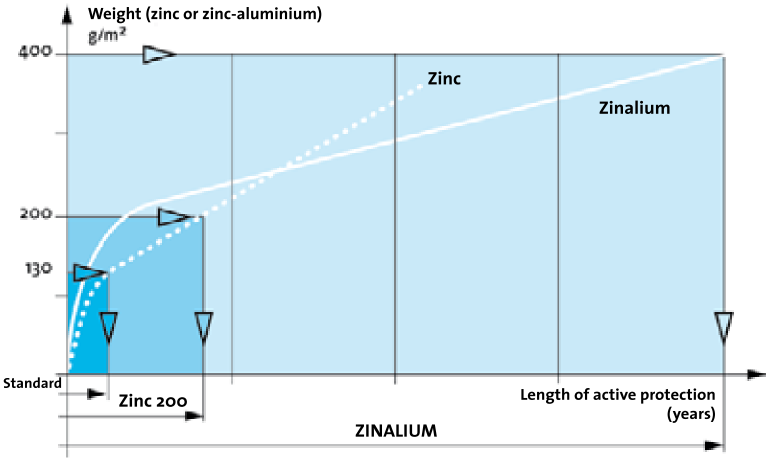
- *TT PE: for pipe diameters between 80 and 700*

  ↘ External coating made with high density polyethylene that complies with the European standard EN 14628

- *TT PUX: for pipe diameters between 800 and 2,000*

  ↘ External coating made with polyurethane that complies with the European standard EN 15189

Boost your external protection! Increase durability three to fourfold!

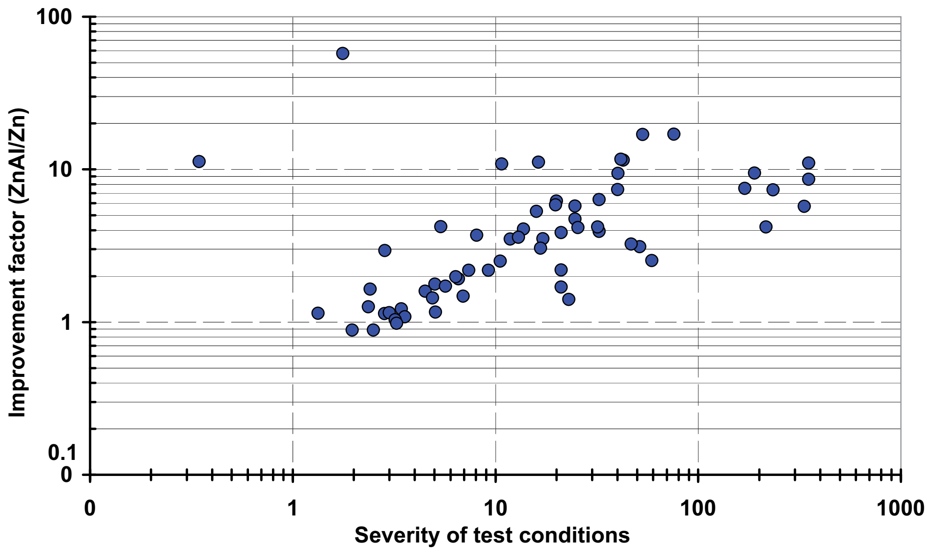


On average, ZINALIUM has been shown to improve the lifespan of pipelines by three to four times compared with a 200g/m² zinc + bitumen pore-sealer, resulting from the contribution of 3 effects:

- **Specific effect of zinc-aluminium**
- Doubling of the weight of zinc
- Replacing the bitumen pore-sealer with epoxy, which offers greater long-term stability.

The more aggressive the soil, the greater the benefit of using ZINALIUM compared with pure zinc!

The extensive lab-based and in-the-field tests conducted to offer Saint-Gobain PAM a considerable degree of objectivity when assessing the performances of ZINALIUM. The diagram shown below highlights the improvement factor (with identical levels of zinc) in relation to the aggressivity of the soil (relatively, compared with a soil with a standard level of aggressivity, for a soil with an electrical resistance of 1,000 Ω.cm). This diagram was created using results from various comparative tests involving pure zinc and zinc-aluminium alloy coatings.



Several key points are worth noting:

- ZINALIUM is always better than pure zinc coating, where the weight of the metallic layer is identical
- In mean test conditions reviewed, the average improvement factor is greater than 2
- In two thirds of cases studied, the improvement factor lies between 2 and 60
- In one third of the cases studied, the improvement factor lies between 1 and 2, but this is mainly the case for soils that do not have extreme levels of aggressivity.

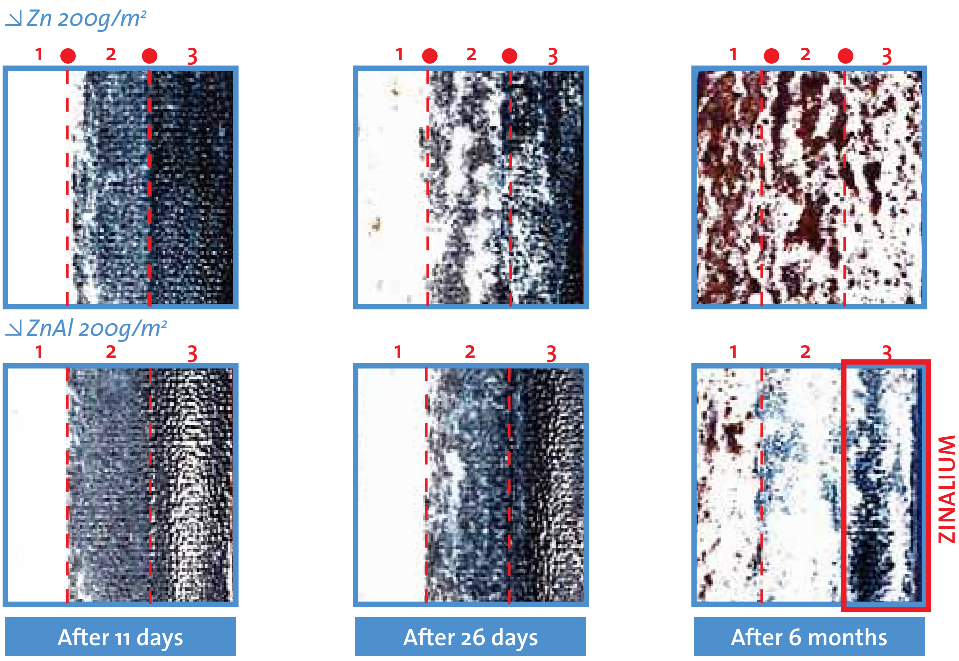
Resistance in accelerated corrosion testing

Salt spray testing

The salt spray test is a preliminary corrosion resistance test to assess the level of external protection. It is straightforward to perform and enables different coating solutions to be quickly compared and contrasted.

Pure zinc and zinc-aluminium coatings, both with 200g/m2 of zinc, were compared in 3 configurations:
- Without an external protective layer (zinc or zinc-aluminium only) (1)
- With an external layer of bitumen pore-sealer (2)
- With an external layer of black epoxy (3)

The photos provided opposite show changes in the transformation process after 11, 26 and 180 days.

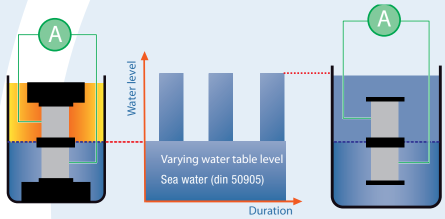


These tests lead us to conclude that:
- Zinc-aluminium alloy performs better than pure zinc, irrespective of the external protective layer used (none, bitumen pore-sealer, epoxy)
- White conversion products appear later, and are less intense, with the zinc-aluminium alloy
- The external protective layer slows considerably the appearance of red-coloured rust
- The protection provided by the external layer of epoxy is greater than the one provided by the bitumen pore-sealer

However, salt spray tests are not able to reproduce the real soil damage to which buried pipes will be exposed to. **Further tests are therefore necessary in order to evaluate a new coating.**

Sand and sea water immersion test

Sand that has been saturated in salty water is a particularly aggressive environment. It reproduces soil conditions found alongside the coast. By varying the level of water it is possible to increase the aggressivity of the environment, and thus to simulate variation in the level of groundwater (experimental system shown opposite).

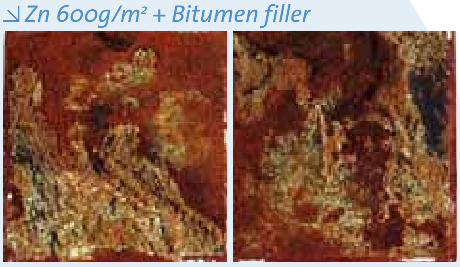


Pure zinc and zinc-aluminium coatings were compared in 3 configurations, each with a black bitumen pore-sealer over a two-year period:
- Pure zinc, 200g/m²
- Pure zinc, 600g/m²
- Zinc-aluminium alloy, 600g/m²

Visual inspection of the specimens demonstrates the excellent performance of the ZnAl coating (600g/m²):
- No damage observed to the ductile iron, protected by the zinc-aluminium alloy
- Extensive rusting observed for both levels of zinc-based coatings, 200 and 600g/m²

↘ Zn 200g/m² + Bitumen filler

↘ Zn 600g/m² + Bitumen filler



↘ ZnAl 600g/m² + Bitumen filler

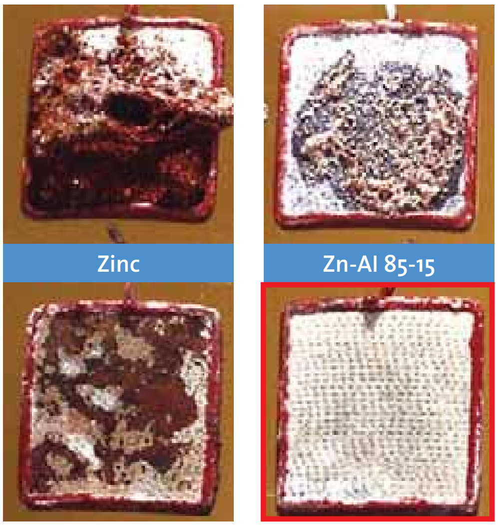
Detailed analysis of the corrosion electric currents demonstrates that galvanic protection is still effective after two years with the zinc-aluminium solution, whereas it only lasts between 400 and 500 days for both types of pure zinc-based protective layers.

Clay and sand testing

Clay and sand are often found in soils in which pipes are laid. Corrosion cells are commonly created by such a mixture in the soil.
This situation was reproduced in lab tests with clay samples taken from the Lesmenils site (North East France) and with silica sand. A sodium chloride saline solution of 1,000 Ω.cm was used to humidify the sand.

↘ Sand

↘ Clay



Inspection of the specimens after 400 days of operation of the corrosion cells revealed a clear difference in the performances of the pure zinc and the alloy.

- With pure zinc, clear rusting of the coupons was observed, when placed in clay or sand.
- With the zinc-aluminium alloy, no sign of brown rust was visible. A slight whitish colouring suggested a limited degree of transformation of the alloy, but the metallic aspect of the alloy could still be seen on the coupons.

For the same weight of zinc, in this case 400g/m², on the galvanized layer of the ductile iron, the clay-sand concentration cell clearly demonstrated the beneficial role played by the zinc-aluminium alloy in comparison to pure zinc. Corrosion current measurements and the visual inspection enables us to calculate an improvement factor of at least four in this specific situation:
- cell corrosion speed divided by four and
- at least four times as long before the appearance of brown rust.

On-site testing at Mont-Saint-Michel

The resistance of the soil in the salt marshes surrounding the Mont-Saint-Michel is close to 100 Ω.cm. This makes it an ideal setting for evaluating the performances of ZINALIUM.

As part of a series of on-site tests started in 1986, pipe sections were burried in the Mont-Saint-Michel test site and left in place for 14 years. The pipes were installed at a depth of around 1.2m. Some of the pipes were placed vertically in the trenches, in contrast with standard practice, so as to simulate the phenomena of differential aeration cells.

Pure zinc and zinc-aluminium coatings, on which artificial scratches were made, were compared in 2 configurations:

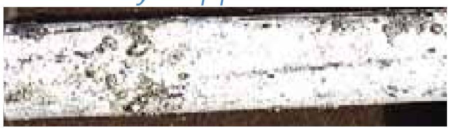
- Pure zinc, 200g/m² and bitumen pore-sealer
- Zinc-aluminium alloy, 400g/m² and epoxy

Zn 200g/m²
+ bitumen paint VBI 80µm

Vertically-laid pipe

Horizontally-laid pipe

Horizontally-laid pipe

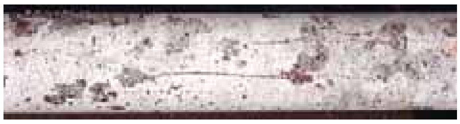


ZnAl 85-15 400g/m² + epoxy 100µm

Vertically-laid pipe

Horizontally-laid pipe

Horizontally-laid pipe



The photographs feature views of the pipes after 14 years in the ground. The following points can be observed:

- The pipes have a white colouring due to the formation of zinc salts.

Horizontally-laid pipes

- After 14 years spent in the ground, the pipes do not have any trace of brown rust in this particularly corrosive soil, both for the pure zinc coating and the zinc-aluminium coating.
- Scratches caused by scraping were protected by a healing layer.

Vertically-laid pipes

- With the pure zinc coating, we can see there is extensive localized rusting of the ductile iron. This area corresponds to the part of the pipe that is furthest from the surface of the soil. A differential aeration cell is the reason for this reaction.
- The zinc-aluminium alloy-based coating has not been affected by the concentration cell. **There are no visible signs of attack on the ductile iron.**

This field test confirms:

The good performance of ZnAl 85-15 alloy-based coatings in highly corrosive conditions, after 14 years of exposure.

The protection and healing of scratches were apparent with both the zinc-aluminium alloy and the pure zinc.

The zinc-aluminium 85-15 alloy performed significantly better in concentration cell conditions.

On-site testing in Rhodes (North East France)

The performance of the zinc-aluminium 85-15 alloy has also been studied in soils containing low electrical resistance gypseous marl, 500 Ω.cm, in Rhodes (North East France). The pipes were laid in 1985 and removed in 1998.

Pure zinc and zinc-aluminium coatings were compared:

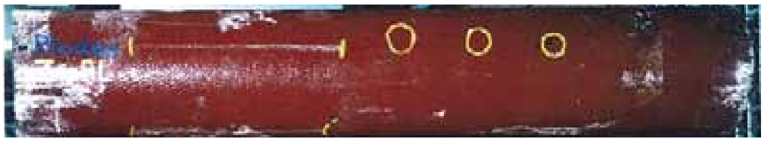
- Pure zinc, 350g/m² and epoxy
- Zinc-aluminium alloy, 350g/m² and epoxy

The photographs feature views of the pipes after 13 years in the ground. With the same weight of zinc and the same pore-sealer, the following points can be observed:

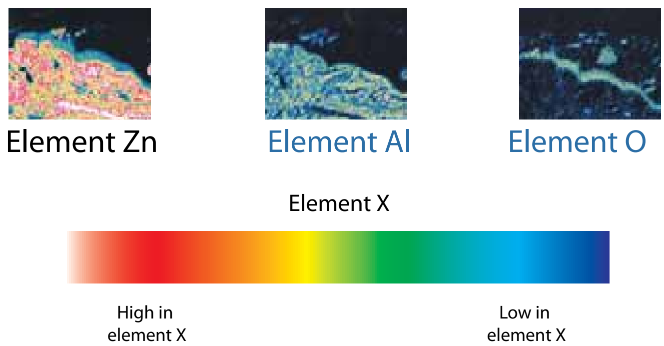
- Pipes coated with pure zinc have significant white colouring due to the formation of zinc salts
- Pipes coated with the zinc-aluminium alloy have no white colouring, which is explained by the very low consumption of the zinc reserve
- Scratches that appeared on the zinc-aluminium alloy coated pipes (white marks on the left) are covered with a protective layer by the zinc salts

↘ Pure zinc

↘ Zinc-aluminium alloy



Analysis using a microprobe (electronic microscope used to map chemical element content) highlights a limited progression of oxidation only on the external coating.



On-site testing confirmed:

- ***The clear superiority of the zinc-aluminium alloy 85-15, compared with pure zinc***
- ***The reality of the phenomenon of healing of scratches, both with the zinc-aluminium alloy and the pure zinc***

In all the tests, the pure zinc coating (200g/m²) returns good performance levels. **The ZINALIUM coating goes further still, providing excellent protection.**

Electrochemical data

Ductile iron

Iron is the main component of ductile iron, which also contains around **3% carbon** and **3% silicon**.

Electrochemical potential of iron (Fe):

$Fe^{2+} + 2e^- \rightleftarrows Fe_{(s)}$ -0.44v

Zinc-aluminium alloy

Electrochemical potential of zinc (Zn):
Pure zinc (99.99%)

Electrochemical potential of zinc:

$Zn^{2+} + 2\_e^- \rightleftarrows Zn_{(s)}$ -0.76v

Electrochemical potential of aluminium (Al):
Pure aluminium (99.5%)

Electrochemical potential of aluminium:

$Al^{3+} + 3\_e^- \rightleftarrows Al_{(s)}$ -1.66v

Conclusion

Iron, which has a higher electrochemical potential than zinc, is protected by the fact that zinc will always corrode the first. Aluminium should also corrode before iron, but **after the formation of a fine layer of alumina (aluminium oxide, Al2O3) corrosion ceases and no longer spreads**.

Zinc aluminium alloy

Alloy wires produced in plant, then atomized in fine droplets using an electric arc spray torch.

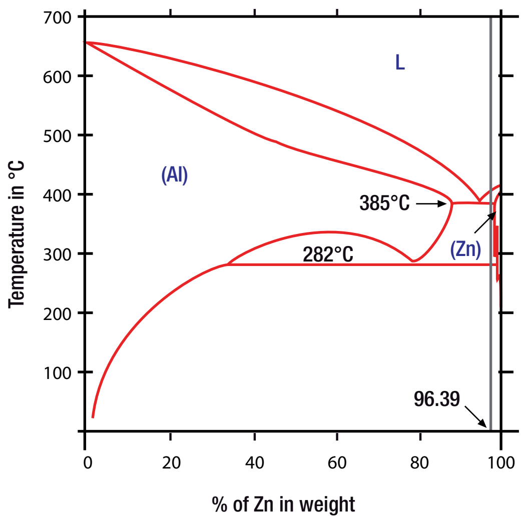
Weight

400g/m²
(at least)

Thickness

Approximately 70µm

Zinc aluminium diagram



Epoxy

Chemical properties
Epoxy coating: two-pack epoxy with high-covering capacities

Thickness
Nominal thickness of 120µm, with 100µm average minimum and 80µm occasional minimum

Colour

Light blue – RAL 5012 for Natural pipes
Ultramarine blue – RAL 5002 for Blutop pipes

BUREAU VERITAS Certification

Certification

SAINT-GOBAIN PAM

NF EN ISO 9001 : 2000

ISO 9001

Development undertaken by Saint-Gobain PAM is performed in accordance with an ISO 9001-compliant quality management system. Compliance with ISO 9001 is certified by an independent body, Bureau Veritas. This certification covers design, manufacturing and distribution.

BUREAU VERITAS Certification

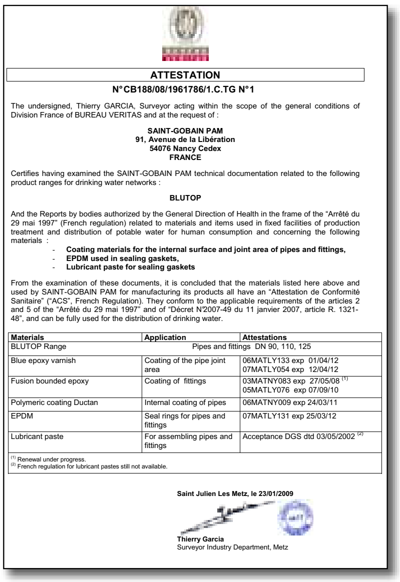
Certification

SAINT GOBAIN PAM

NF EN ISO 14001 : 2004

ISO 14001

All of Saint-Gobain's sites in France have been ISO 14001-certified since 2009 by independent, accredited bodies (Bureau Veritas and AFAQ). An environmental policy has been implemented, with measurable targets that are regularly monitored. This has helped to create a "virtuous circle", in which continuous improvement of our environmental performance is actively encouraged and supported. This certification also acts as the basis of the environmental stream of Saint-Gobain PAM's commitment to sustainable development.



ATTESTATION

N°CB188/08/1961786/1.C.TG N°1

The undersigned, Thierry GARCIA, Surveyor acting within the scope of the general conditions of Division France of BUREAU VERITAS and at the request of :

SAINT-GOBAIN PAM
91, Avenue de la Libération
54076 Nancy Cedex
FRANCE

Certifies having examined the SAINT-GOBAIN PAM technical documentation related to the following product ranges for drinking water networks :

BLUTOP

And the Reports by bodies authorized by the General Direction of Health in the frame of the "Arrêté du 29 mai 1997" (French regulation) related to materials and items used in fixed facilities of production treatment and distribution of potable water for human consumption and concerning the following materials :

- **Coating materials for the internal surface and joint area of pipes and fittings,**
- **EPDM used in sealing gaskets,**
- **Lubricant paste for sealing gaskets**

From the examination of these documents, it is concluded that the materials listed here above and used by SAINT-GOBAIN PAM for manufacturing its products all have an "Attestation de Conformité Sanitaire" ("ACS", French Regulation). They conform to the applicable requirements of the articles 2 and 5 of the "Arrêté du 29 mai 1997" and of "Décret N°2007-49 du 11 janvier 2007, article R. 1321-48", and can be fully used for the distribution of drinking water.

Materials	Application	Attestations
BLUTOP Range	Pipes and fittings DN 90, 110, 125	
Blue epoxy varnish	Coating of the pipe joint area	06MATLY133 exp 01/04/12 07MATLY054 exp 12/04/12
Fusion bounded epoxy	Coating of fittings	03MATNY083 exp 27/05/08 (1) 05MATLY076 exp 07/09/10
Polymeric coating Ductan	Internal coating of pipes	06MATNY009 exp 24/03/11
EPDM	Seal rings for pipes and fittings	07MATLY131 exp 25/03/12
Lubricant paste	For assembling pipes and fittings	Acceptance DGS dtd 03/05/2002 (2)

(1) Renewal under progress.
(2) French regulation for lubricant pastes still not available.

Saint Julien Les Metz, le 23/01/2009

Thierry Garcia
Surveyor Industry Department, Metz

ACS

ZINALIUM coating complies with French legislation regarding materials that are suitable for contact with drinking water. The external epoxy pore-sealer, which may come into contact with drinking water (especially pipe spigots) has been granted a health & safety attestation of conformity (ACS). Similar certificate have been obtained in European countries with equivalent health and safety systems (Germany, the United Kingdom, Italy, Belgium, the Netherlands, etc.).

ATTESTATION DE CONFORMITE
ATTESTATION OF CONFORMITY

SAINT GOBAIN PAM
91, Avenue de la Libération

Thierry Garcia

EN 545

ZINALIUM coating complies with the European standard EN 545. Appendix D.2.3. details the fields in which ZINALIUM-coated pipelines may be used.

worldwide - always close at hand

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