

Potable water supply
and distribution

natural

Ductile iron pipes
and fittings system
DN 60 to DN 2000

A SAFE PATH FOR WATER

// 84% of the service life of a pipe is determined by its external coating.* //

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The revolution towards...

...Natural® BioZinalium® DN 60 to 2000



Always a coating ahead

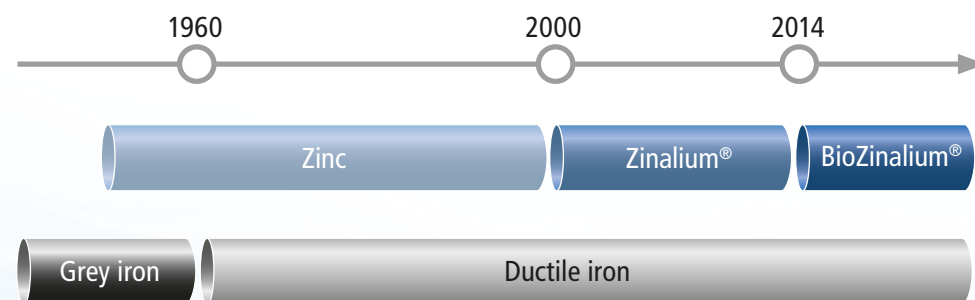
Water authorities all around the world have to keep in mind the reduction of leakage rates and the respect of a defined budget frame work. These concerns have a direct influence on maintenance, renewal and extension programmes for water networks and also encourage the choice of reliable and durable pipes.

BioZinalium® is a practical response of PAM to the genuine concerns of water network investors, managers and operators.

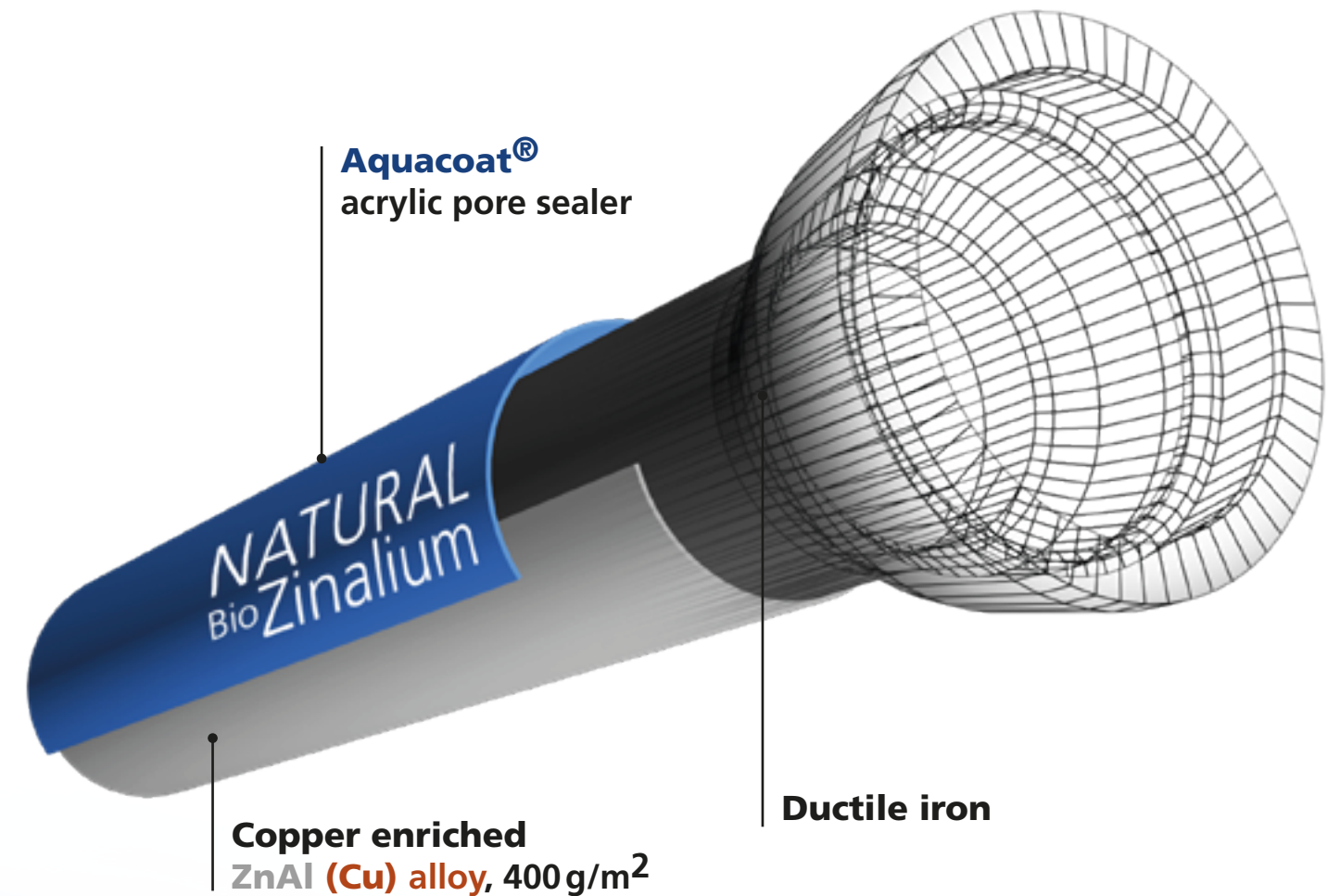
PAM's research into zinc-based coatings has constantly helped to improve the protection of buried networks of iron pipes, which still supply the majority of capital cities with potable water..



PAM, driving innovation in external coatings



**In response to our
customers' requirements**



The BioZinalium® coating consists of 2 layers:

- A layer of zinc-aluminium 85/15 alloy, enriched with copper, with a minimum surface density of 400g/m²,** applied by spraying molten metal onto the surface of the iron, using an electric arc spray gun, from ZnAl (Cu) alloy.
- A protective layer of Aquacoat® (semi-permeable)** of water-based blue acrylic of average thickness of 80 microns applied using a spray gun.

Ductile iron... ...a material you can trust

PAM, more than 165 years of history and technical expertise

Founded in 1856, SAINT-GOBAIN PAM Canalisation is the world leader in the manufacture and commercialisation of ductile iron pipeline systems.

The emphasis placed on research and development has enabled the company to combine traditional know-how and technical innovation to continuously offer its customers high quality, reliable and ergonomic products.

Ductile iron

Ductile iron is an iron/carbon/silicon alloy containing pure carbon in a spheroidal graphite form.

> Pipes with exceptional mechanical properties

- Elasticity ($Re \geq 270$ MPa)
- Breaking strength ($Rm \geq 420$ MPa)
- Impact resistance
- High elongation capacity ($> 7\%$)

> A fully recyclable natural material

An alloy of iron, carbon and silicon, ductile iron is an exceptional material that can be 100% reused indefinitely.

It can be completely recycled with no loss of properties and is recyclable for the same application in non-restricting and non-hazardous industrial processes.

Recycled cast iron is used as a raw material in traditional steel and iron processes.

The PIPE division of the SAINT-GOBAIN group produces a large volume of cast iron in its factories which are mostly derived from recycled ferrous materials. These are ISO 14001 certified.



1 - In "ductile" iron, the graphite particles consist of small spheres, which prevent the risks of crack propagation. The material is not "fragile". It is "ductile" and resistant.

2 - Ductile iron can withstand major deformations: torsion of a bar.

3 - Deformation under exterior load of a large DN pipe.



A material that has stood the test of time

Ductile cast iron benefits from the traditional longevity of cast irons with exceptional mechanical properties: elasticity of the metal, bending strength due to high elongation capacity, resistance to ovalisation, solidity and proven performance for over a century.

Due to these exceptional mechanical qualities, ductile iron is suitable for all types of terrain and can withstand high stress without damage (deep or shallow depths of cover, traffic loads, other site contingencies, etc.).

This explains why ductile iron and the NATURAL[®] range has long been considered as the reference material for hydraulic networks and, especially, pressure pipelines.

More than 10,000 km of ductile iron pipelines designed by PAM are laid every year, from DN 60 to DN 2000.

The quality

For PAM, the notion of performance extends far beyond the products. It involves the entire company from product design to delivery.

The PAM Quality Assurance system is based on the standard NF EN ISO 9001-2015 which certifies control of the main processes (design, production, commercialisation).

The plants responsible for manufacturing products of the NATURAL[®] range have been awarded this certification which was issued by a third party.



Quality Assurance based on the standard NF EN ISO 9001-2015.

Compliance with the standards and regulations

The PAM products comply with national, european and international standards NF, EN and ISO. The compliance with these standards is certified by third-party organisations.

These standards define the product or service in terms of result; each product, pipe or fitting is individually tested in the plant during an internal pressure test.

Specification	French or European standard	International standard
Recommendations and test methods	NF EN 545 (1)	ISO 2531 (1)
Cement mortar coating	NF EN 545 (1)	ISO 4179 (1)
Zinc-aluminium enriched with copper external coating of the pipes	NF EN 545 (1)	ISO 8179-1
Joint gaskets - material specification	NF EN 681-1 (1)	ISO 4633(1)
Locking system	-	ISO 10804-1

(1) compliance certified by a third-party organisation

The materials used by PAM which are intended for contact with drinking water (coatings, elastomers, lubricating paste) have received a Sanitary Compliance Certificate (ACS, WRAS,...) and are in compliance with european directives.

The blast furnace mortar cement of our plants of Foug, Santander and Pont-à-Mousson is in compliance with the positive reference lists.

The safety...

The resistance to internal pressure

A safety coefficient of 3!

$$PFA = \frac{\text{design bursting pressure}}{S_F} = \frac{20 \times e \times R_m}{D \times S_F}$$

S_F A safety coefficient of = 3

e = minimal thickness (mm)

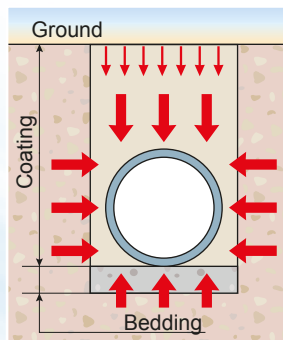
R_m = tensile strength = 420 MPa

D = diameter (mm)

PFA = allowable pressure (bar)

- > In conformity with the specifications of the standard NF EN 545-2010, the pipes and fittings offer a considerable safety margin beyond the AOP (Allowable Operating Pressure): the safety coefficient is greater than 3.
- > In addition, the ductile iron material is not subject to any ageing and retains its mechanical strength over time.
- > The PFA* values of the pipes and fittings of the NATURAL® range comply with the standard NF EN 545-2010 (appendix A) and are always greater than 40 bar in sizes DN 60 to 300, greater than 30 bar in sizes DN 350 to 600, and greater than 25 bar above.

* refer to the table on page 17 for the PFA values.



Safe and economical laying

A buried pipeline is subject to vertical loads (weight of backfill, traffic loads) which it transmits to the ground via the trench bottom and the backfill.

Considerable forces are involved and there is interaction between pipe and soil.

Generally, to perform their role, the layers must be chosen and compacted according to:

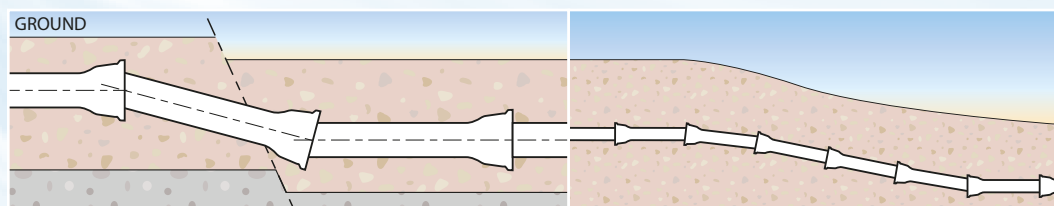
- > the ability of the pipe to withstand local forces: risks of piercing or damage which could lead to cracks or create faults in the pipe wall,
- > the rigidity and strength of the pipe.

Robust and strong ductile iron pipes minimise the trench bottom and surrounding work so that the work involved in laying is safer and cheaper.

Flexible pipeline

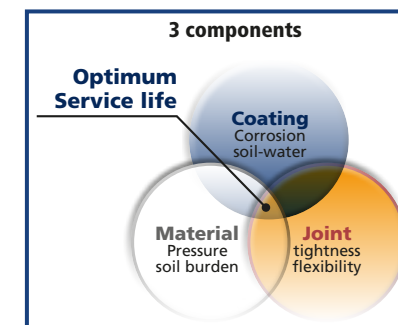
The pipeline layout may include soft or unstable ground (marshy areas, subsidence caused by pumping ground water, mining lands, consolidation of road backfill, etc.). Pipelines must adapt to the ground movements and be able to withstand the mechanical stresses applied during these movements.

Within their limits of angular deflection and withdrawal, the STANDARD cup joints allow the pipeline to adapt to the deformations imposed by the ground movements.



...and longevity

Contribution of the lining to the life expectancy



The optimum service life is achieved when the three components - material, coatings and assemblies - are perfectly reliable.

For the manufacturer of pipelines, the service life depends on the performance of the following three elements:

- The material: resistance to mechanical stresses (hydraulic pressure and ground weight),
- the coatings: resistance to chemical attacks (of water and soil),
- the assemblies: maintain waterproofness under all circumstances (excessive pressure or ground movement).

PAM has therefore developed an original and rational approach to individually assess the contribution of the coating to the service life:

their researchers have been working with a mathematical forecasting model that is totally unique of its kind world wide (in-house software). It is based on an algorithm which calculates cumulative probabilities capable of assessing the risk of perforation, taking into account:

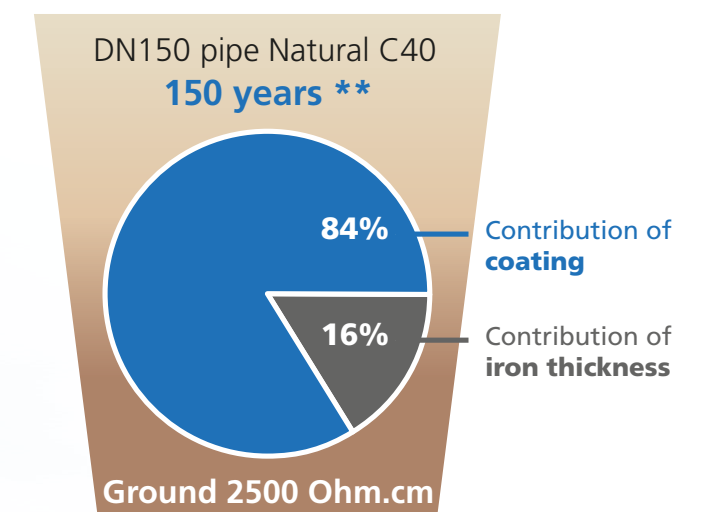
- the laws of cast iron corrosion (rate of attack depending on the environment);
- the performance of the coatings in the different soil types encountered;
- the geological distribution of the soils and their blends;
- the vagaries of installation.

Taking into account these numerous variables, the probabilistic model can be used to assess the "life expectancy" of a pipe by adding the zinc/aluminium alloy conversion time, the delay in the passive conversion of the hydroxide layer of the alloy and the cast iron corrosion time.

**With this model, the life expectancy of a DN150 NATURAL® C40 EN 545:2010 pipe buried in soil of resistivity of 2,500 Ω.cm is estimated at 150 years.

The software has been calibrated from an analysis of around one hundred samples taken from existing networks.

Contribution of coating to life expectancy of an underground pipe



BioZinalium® protection...

...durable, reliable, preventative

Corrosion protection

The BioZinalium® coating retains the "active" properties of the Zinalium® coating when in contact with the ground, i.e.:

- formation of an adhesive and stable all-round protective layer (zinc hydroxides, etc.) that covers the entire surface of the buried pipe;
- restored continuity of this protective layer at points which have been slightly damaged (impacts during transportation, scrapes when backfilling).

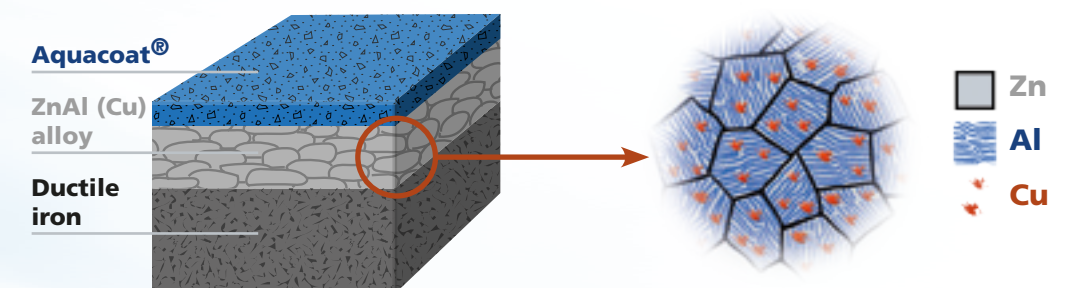
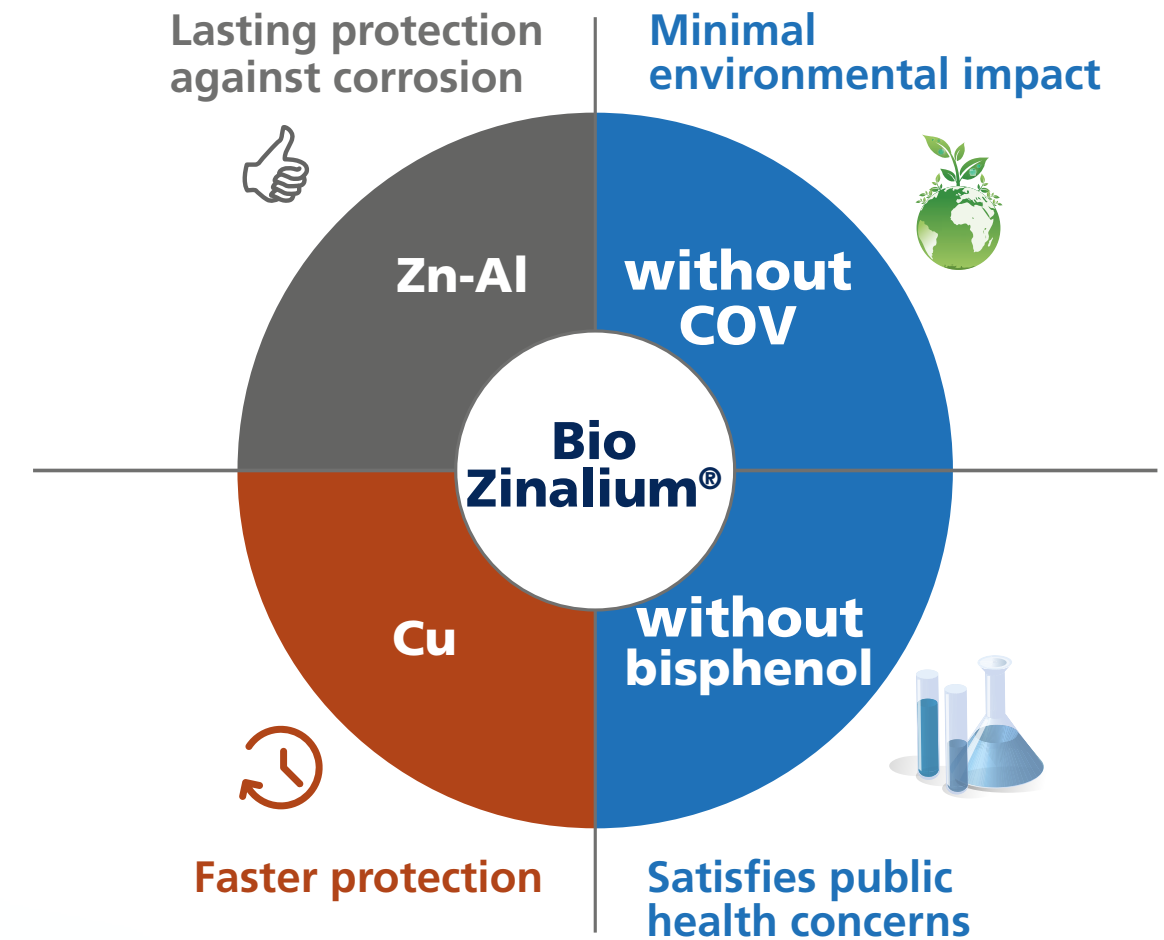
The combination of aluminium and zinc in the ZnAl (Cu) alloy increases the strength of the protective layer. In comparison with pure zinc, it extends the areas of use (or the service life) in highly corrosive soils as defined in European standard EN545:2010 (appendix D.2.2.).

The copper enrichment of the ZnAl (Cu) alloy allows the protective layer to be implemented faster following damage.

BioZinalium® means a lifetime of the pipeline multiplied by 3 compared to the 200 g/m² zinc allowed by the standard.

The healthy and eco-friendly choice

- The Aquacoat® protective layer is VOC-free (volatile organic compounds). VOCs are compounds that have direct and indirect effects on health and the environment (source ADEME).
- Aquacoat® does not contain bisphenols (neither bisphenol A or BPA nor other bisphenols), chemical compounds considered as endocrine disruptors.

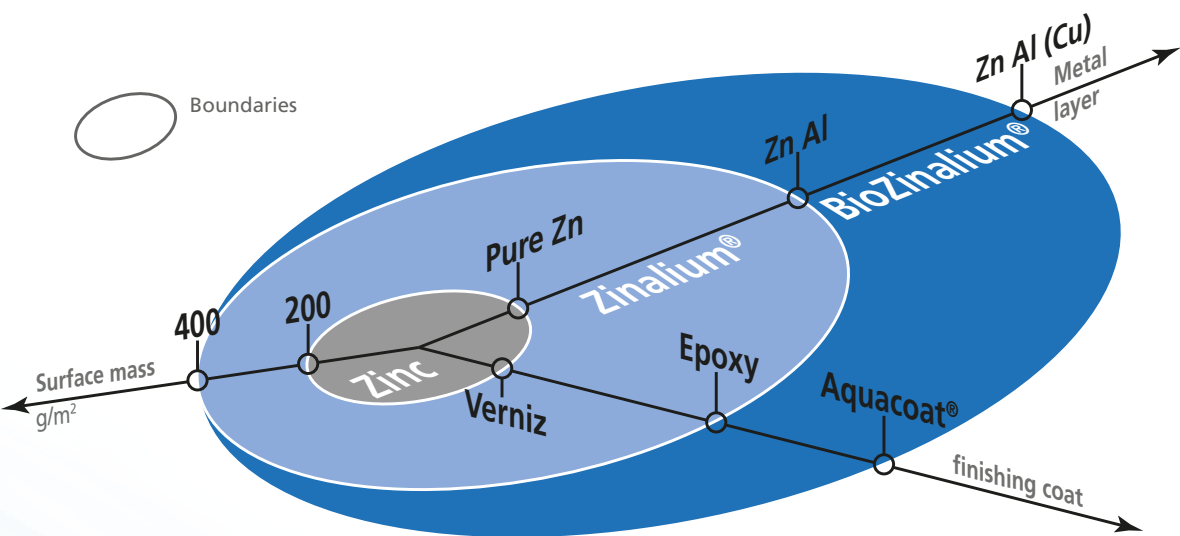


BioZinalium® protection...

...pushing the boundaries

Advantages of BioZinalium®

The active nature of the metallic coating + the deposited surface mass + the properties of the finishing coat are the three dimensions that contribute to the efficiency of the zinc-based coating systems.



The advantages of BioZinalium®

CRITERIA	Zn	Zinalium®	BioZinalium®
PERFORMANCES			
Corrosion protection: Resistivity higher than: 2500 Ω.cm below the phreatic layer 1500 Ω.cm above the phreatic layer (cf standard EN 545: 2010 D.2.1)			
Resistivity higher than: 500 Ω.cm below the phreatic layer (cf standard EN 545:2010, D.2.2)			+
Regeneration of the protection on coating scars			
Acceleration of the installation of galvanic protection			+
Without COV (volatile organic compounds)			+
Without bisphenol			+

In compliance with the standards



The BioZinalium® coating is in compliance with the European standard EN545:2010 and the international standard ISO 2531. The BioZinalium® coating is suitable for the majority of soils as defined in appendix D.2.2. of the standard EN545:2010, with the exception of:

- soils located underneath the marine phreatic layer that has a resistivity of less than 500 Ω.cm;
- peaty and acidic soils;
- soils containing waste, ash, slag or contaminated with certain industrial wastes or effluents.

The BioZinalium® coating features sanitary compliance certificates that certify its suitability for contact with potable water.

The internal coatings...

The cement mortar spun centrifugally inside the pipes

The standard internal protection of the NATURAL[®] pipes is composed of best furnace slag cement (BFSC) applied by centrifugation and produced with potable water in conformity with the European Directive 98/83/CE.

The centrifugal process offers the advantage of producing a compact mortar and a smooth internal surface.

This process results in the following properties:

- > low porosity of the mortar,
- > excellent adhesion of the cement,
- > low surface roughness.



The internal cement improves the flow

The internal surface of the cement mortar has low roughness, which improves flow and reduces head losses. This mortar guarantees consistent hydraulic performance over time (absence of deposits).

The roughness coefficient (COLEBROOK formula) of a pipe alone is $k = 0.03$. In practice however, PAM recommends using the value $k = 0.1$ when designing networks, to take into account the singular head losses of a complete pipeline.

The internal cement protects the pipeline and potable water

> Protective mechanism

The internal cement coating does not act as a simple barrier but protects the ductile iron by a passivation mechanism: after being put into service, water gradually saturates the cement mortar and becomes richer in alkaline elements; on reaching the metal wall, it is no longer corrosive.

> Filling of cracks

Crazing, which can be seen on the surface of the mortar even when formed during transport, storage or laying, closes up under the combined effect of two reactions:

- swelling (fast) of the cement mortar on filling with water,
- hydration (slow) of the component elements of the cement.

Special cases

European Directive 98/83/CE relating to water intended for human consumption sets water quality criteria. However, if the water transported is aggressive (hardness $< 7^{\circ}\text{F}$) or corrosive and if the residence time in the network is abnormally long (more than several days), or if the chemical composition must not change during transit in the pipeline (mineral water), the NATURAL[®] with PUR lining should be used.

...preserving potable water

The reinforced coating for the fittings

NATURAL[®] is a coherent range: just like for the pipes, EXPRESS or STANDARD joint fittings are delivered with reliable coatings.

The protection of the fittings comes in the form of blue deposited epoxy powder coating with a regular thickness.



Standard fitting
of the NATURAL[®]
range

- > On leaving the foundry, cast parts are carefully shot-blasted and heated.
- > The epoxy powder is then deposited either using an electrostatic gun or by dipping in a fluidized bath.
- > The average thickness of the epoxy powder coating is at least 250 microns. The epoxy powder coating complies with standards NF EN 14901-1, NF EN 545 and ISO 2531.
- > Fittings coated with this type of coating can be installed in all types of soils - including corrosive or very corrosive soils - or to transport aggressive or corrosive water.
- > The fusion bonded blue epoxy powder is compatible with the transport of potable water and has received sanitary compliance certificates (ACS, WRAS,...).



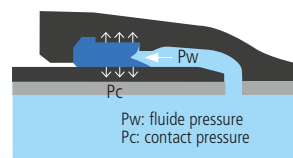
Express fitting
of the NATURAL[®]
range

Easy to assemble joints...



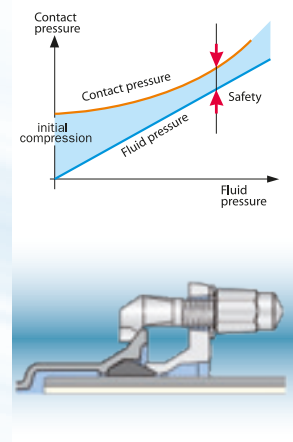
The choice of elastomers

The EPDM elastomers used for the joint gaskets are fully compatible with the transport of potable water and are selected by PAM according to strict criteria taking into account their intrinsic physico-chemical characteristics and their durability over time. They ensure that the joints in the system are completely tight to internal and external pressures throughout the lifetime of the pipeline. The joint gaskets comply with standard NF EN 681-1.



The STANDARD joint

The STANDARD joint is an automatic joint. The watertightness is produced by compression of the elastomeric gasket during assembly (by insertion of the spigot in the socket). The joint is designed so that the contact pressure between the elastomer and the ductile iron increases as the pressure in the pipeline increases. The pipe will burst before the joint leaks during a destructive pressure test.



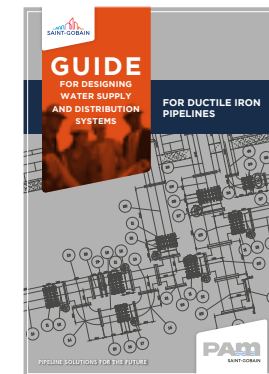
The EXPRESS joint for the fittings

The EXPRESS joint is a mechanical joint. The watertightness is achieved via radial compression of an elastomer joint gasket using a gland tightened by ductile iron bolts. Little force is required to assemble the EXPRESS joint. The orientation and final positioning of the fitting are easy before tightening the bolts, making this joint highly appreciated in cramped conditions and during maintenance work.



Angular deviation at least 4° with STANDARD joint up to DN1200!

...and lockable joints



To go further, please check our designing guide and our installation guide.

The Vi solution for self-restrained pipelines

Self-anchored pipe and fitting joints (STANDARD Vi and EXPRESS Vi) can be used to produce self-restrained ductile iron pipelines. This solution is particularly interesting when construction of concrete thrust blocks would be difficult (land with poor cohesion, risk of future excavation work, problems of space) or when this would delay the project. The advantage of STANDARD Vi and EXPRESS Vi joints is that they can be fitted on unlocked pipes and fittings in the NATURAL® range.

The STANDARD Vi joint gasket for anchoring

The STANDARD Vi self-anchored joint gasket and the STANDARD joint gasket have an identical shape and are lodged in the same pipe socket. In addition, the STANDARD Vi gasket has metal inserts that cling to the spigot of the adjacent pipe after assembly and pressurisation.

It can be used from DN 60 to 700 for the pipes and the fittings.

UNIVERSAL Standard for anchoring at very high and extreme pressures

When the network operating pressures exceed the performance of the STANDARD Vi or EXPRESS Vi systems, UNIVERSAL anchoring must be used.

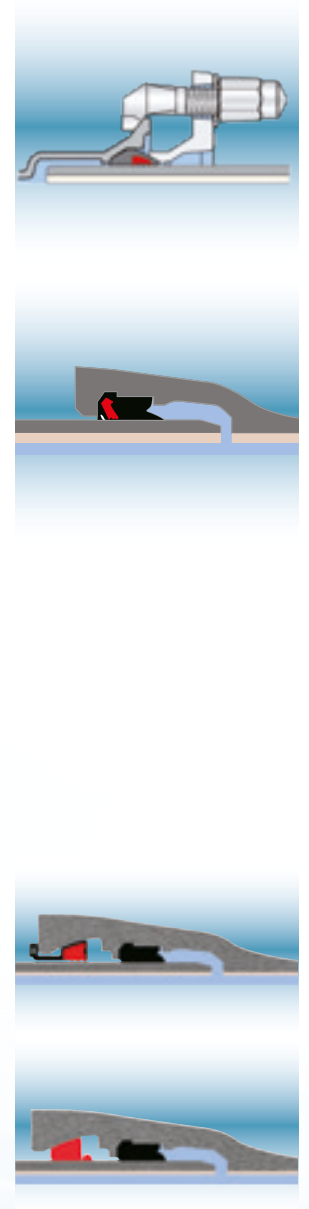
In the UNIVERSAL range, sealing and restraint are achieved in two separate chambers in order to reach unequalled performance levels. UNIVERSAL is available for pipes and fittings.

UNIVERSAL Vi for very high pressures

Anchoring is obtained by a system of inserts housed in a chamber located upstream from the sealing chamber.

UNIVERSAL Ve for extreme pressures

Anchoring is obtained by a system comprising a metal ring housed in a chamber, located upstream from the sealing chamber, which presses against a metal bead on the spigot of the pipe or fitting.



NATURAL[®], a complete and...

The products of the NATURAL[®] range



Description	Junctions					
	Non-anchored		Anchored			
	Express	Standard	Express Vi	Standard Vi	Universal Vi	Universal Ve
NATURAL [®] pipe	-	DN 60 - 2000	-	DN 60 - 700	DN 80 - 700	DN 100 - 1600
Double socket bend 1/4, 1/8, 1/16, 1/32	DN 60 - 1200	DN 60 - 2000	DN 60 - 300	DN 60 - 700	DN 80 - 700	DN 100 - 1400
Double socket tee with flanged branch	DN 60 - 1000 PN10, PN16, PN25	DN 60 - 2000 PN10, PN16, PN25, PN40	DN 60 - 300 PN10, PN16, PN25	DN 60 - 700 PN10, PN16, PN25, PN40	DN 100 - 700 PN10, PN16, PN25, PN40	DN 100 - 1400 PN10, PN16, PN25, PN40
All socket tee	-	DN 60 - 600	-	DN 200 - 600	DN 100 - 300	DN 100 - 300
Double socket taper	Dn 250 - 1000	DN 60 - 2000	DN 60 - 300	DN 60 - 700	DN 100 - 700	DN 100 - 900
Collar	DN 60 - 2000	-	DN 60 - 300	-	-	-
Flanged socket	DN 350 - 1000	DN 60 - 2000	DN 60 - 300	DN 60 - 700	DN 80 - 700	DN 100 - 1400
Flanged spigot	DN 60 - 600	DN 60 - 2000	DN 60 - 300	DN 60 - 700	DN 80 - 700	DN 100 - 1400

➡ Other DN, contact us

Special coatings for extreme situations (contact us):

Coating
NATURAL[®] PUR
for aggressive
or corrosive water



Coating TT
(PE or PUX)
for very corrosive soils



Coating ZMU
for rocky soils



For more details, go to our
site www.pamline.com

...reliable range

STANDARD and EXPRESS joints - STANDARD Vi and EXPRESS Vi joints

Standard		Express		Anchoring Standard Vi		Anchoring Express Vi	
DN	Pressure class	PFA* (bar)	Deviation (degree)	PFA* (bar)	Deviation (degree)	PFA* (bar)	Deviation (degree)
60	C40	40	5	40	5	22	5
80	C40	40	5	40	5	16	5
100	C40	40	5	40	5	16	5
125	C40	40	5	40	5	16	5
150	C40	40	5	40	5	16	5
200	C40	40	5	40	4	16	4
250	C40	40	5	40	4	16	3
300	C40	40	5	40	4	16	3
350	C30	30	4	25	3	16	3
400	C30	30	4	25	3	16	2
450	C30	30	4	25	3	13	2
500	C30	30	4	25	3	11	2
600	C30	30	4	25	3	10	2
700	C25	25	4	25	2	10	2
800	C25	25	4	25	2	-	-
900	C25	25	4	25	1,5	-	-
1000	C25	25	4	25	1,5	-	-
1100	C25	25	4	25	1,5	-	-
1200	C25	25	4	25	1,5	-	-
1400	C25	25	3	25	3	-	-
1500	C25	25	3	-	-	-	-
1600	C25	25	3	25	2	-	-
1800	C25	25	2,5	25	1,5	-	-
2000	C25	25	2	25	1	-	-

* For pressures higher than the indicated PFA, see the PFA of Universal joints below or contact us

UNIVERSAL Vi and Ve joints

Anchoring Universal Vi			Anchoring Universal Ve	
DN	Pressure class	PFA (bar)	Deviation (degree)	Deviation (degree)
80	C100	100	3	-
100	C100	56	3	3
125	C64	52	3	3
150	C64	48	3	3
200	C64	43	3	3
250	C50	39	3	3
300	C50	34	3	3
350	C40	25	3	3
400	C40	20	3	3
450	C40	16	3	3
500	C40	16	2	3
600	C40	16	2	2
700	C30	10	2	2
800	C30	-	-	2
900	C30	-	-	1,5
1000	C30	-	-	1,2
1100	C30	-	-	1,1
1200	C25	-	-	1,1
1400	C25	-	-	1,2
1500	C25	-	-	**
1600	C25	-	-	0,9
1800	C25	-	-	**
2000	C25	-	-	**

For pressures higher than the indicated PFA, contact us
** Contact us

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