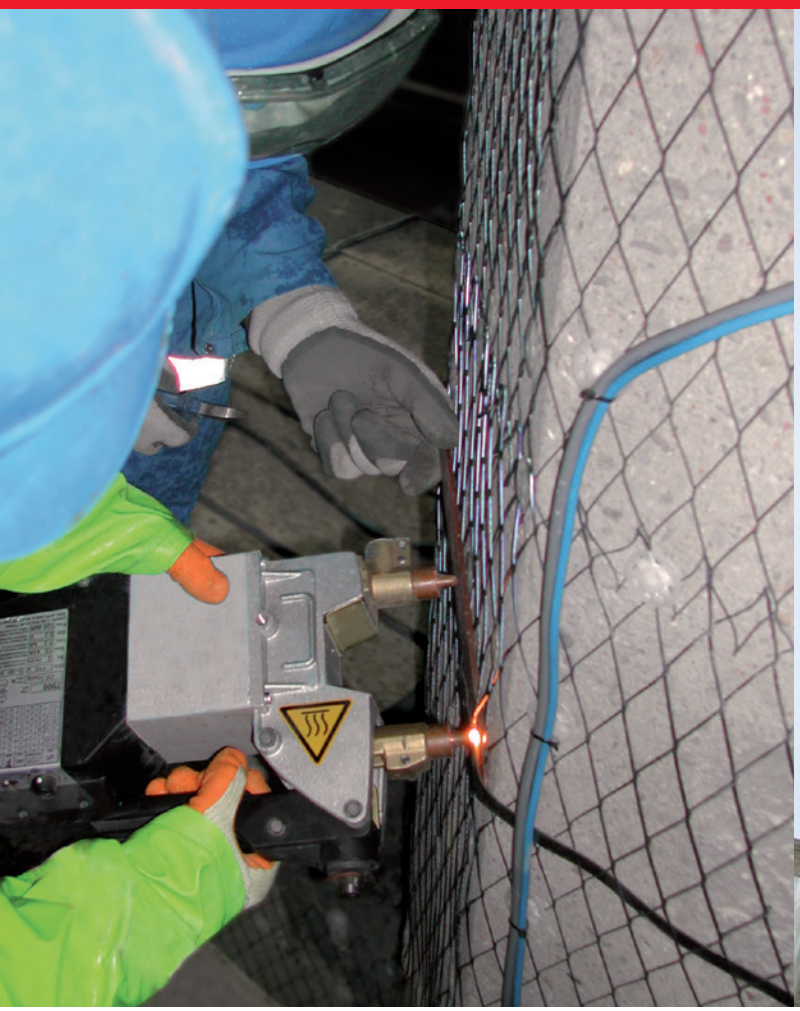
Solutions Foreva

Controlling corrosion of concrete reinforcements



Improve, preserve, secure

Freyssinet
SUSTAINABLE TECHNOLOGY

R III 2

With sixty years of experience in concrete repair, strenthening and protection techniques, general contractor for special works Freyssinet offers you a guaranteed turnkey service with Foreva®:

- **assistance with diagnosis**
- **assistance with choosing the rehabilitation solution**
- **suitability tests**
- **design**
- **execution method**
- **specialist implementation**
- **monitoring**

Freyssinet works with all concrete structures in the fields of civil engineering, ports, harbours and waterways and industrial and historic buildings.

Progression of corrosion

Reinforced concrete structures age. The deterioration of reinforced concrete is principally due to the corrosion of the reinforcements, which occurs when the concrete has lost its natural protective properties. External pollutants (CO_2, Cl^-, SO_4^{2-}, NH_4^+, etc.) found in the air or water in contact the concrete facing and penetrate through the micropores in the concrete. In time, the chemical properties of the concrete in the vicinity of the reinforcement are altered and the passivating layer that protects the surface of the steel is destroyed. Once the ambient moisture penetrates through to the steel, corrosion begins.

The ageing of a reinforced concrete structure can be represented by an ageing/time curve, consisting of the three principal stages below:

Concrete pH phenolphthalein test

Phase 1/Incubation

The reinforcement is in a protective environment. This situation lasts for as long as the penetration of pollutants to the steel is slowed or even prevented. This is particularly the case for reinforcement when it is coated following repairs.

Phase 2/Initiation of corrosion

The reinforcement is in an environment that has lost its protective properties. Due to the penetration of pollutants or a fall in pH due to the carbonation of the cover concrete, and with the penetration of water, corrosion begins. At this stage, the corrosion cannot seen from the outside, but can be measured by non-destructive methods.

Concrete delamination

Phase 3/Propagation of corrosion

The reinforcement is no longer in a protective environment and the steel corrodes. The reinforcement can gradually disintegrate in the presence of water or the products of corrosion can swell and crack the concrete, which accelerates water penetration and therefore corrosion. At this stage, the cross-sections of the reinforcements are reduced and the strength of the structure diminishes.

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FOREVA® SOLUTIONS FOR CORROSION CONTROL

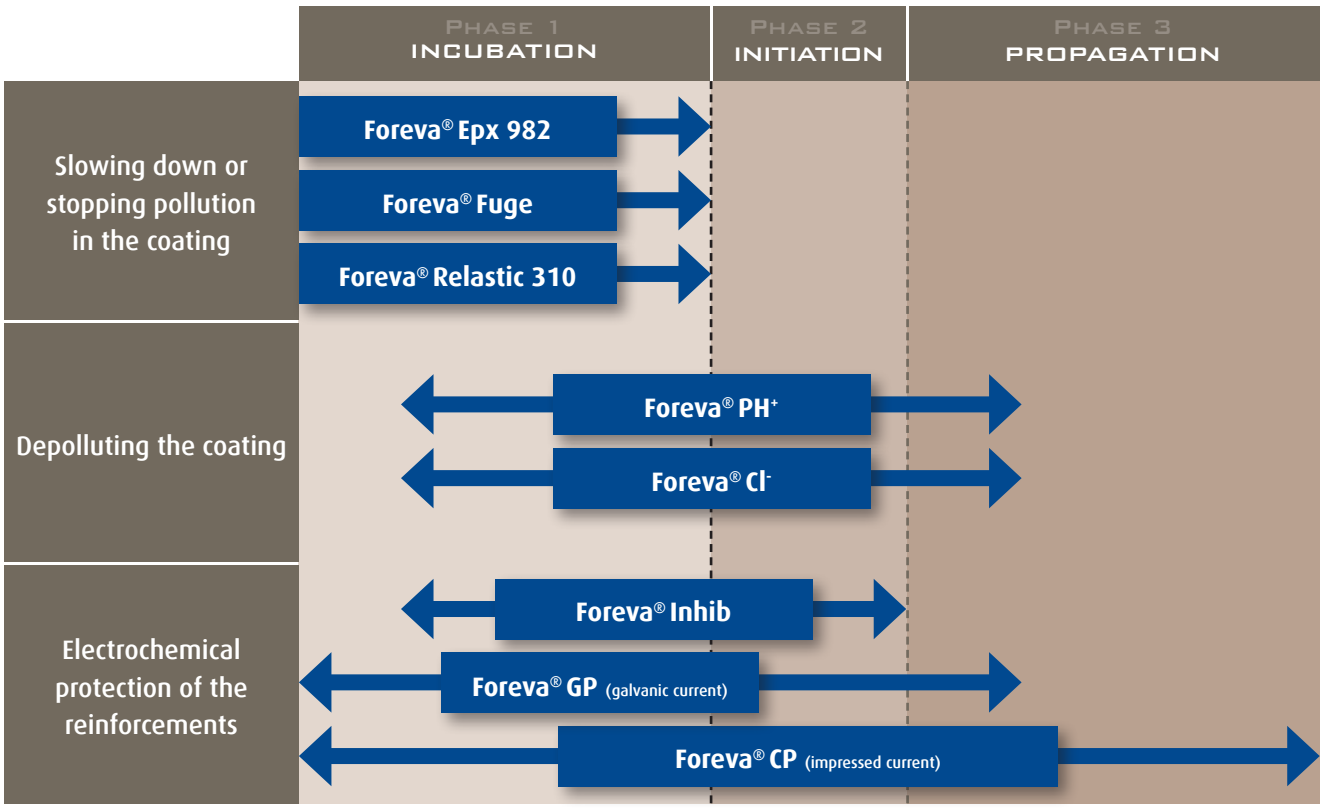
With **Foreva®** solutions, you can control the progression of corrosion of reinforcements in reinforced concrete structures at all the stages of it's development:

Phase 1) **by extending the period of protection of the cover concrete around the reinforcements;**
Phase 2) **by stopping the corrosion initiation process in the reinforcements;**
Phase 3) **by preventing the progression of corrosion in the long term after repairing the structural damage it has caused.**

Foreva® solutions work on the area surrounding the steel or on the reinforcements themselves:

- **by treating the facing to slow down or stop the penetration of pollutants before they reach the reinforcements;**
- **by depolluting the coating to restore the protective environment around the reinforcements;**
- **by protecting the reinforcements by means of an electrochemical process to stop the corrosion, without acting on progression of the pollution.**

Foreva® solutions are compliant with standard EN 1504.



Foreva® solutions are frequently used in combination to treat different areas of the same structure. Generally speaking, the pollution of a concrete structure is not uniform in intensity and depth, and the reinforcements show varying stages of corrosion. Precise monitoring and a diagnosis are therefore required to identify the areas to treat and define their criticality. Specific inspection methods are required at each stage of the deterioration process.

Freyssinet can, on request, offer advice in preparing an investigation, diagnosis and recommendation plan.

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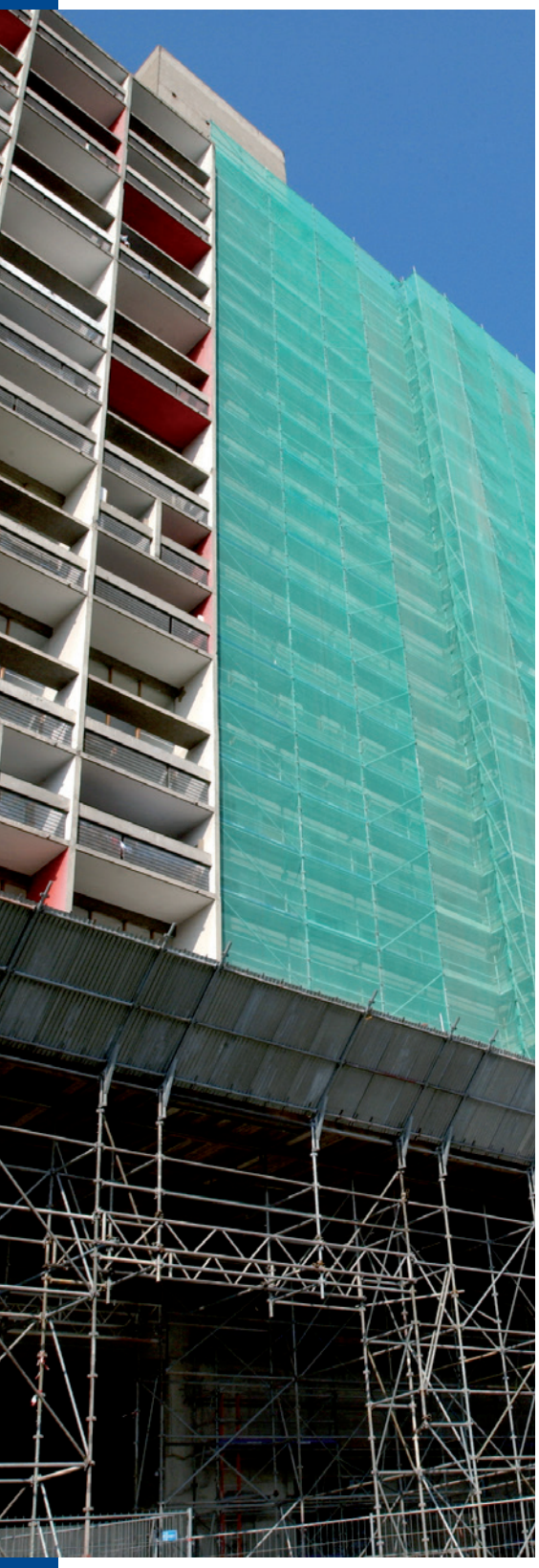
PHASE 1

Extending the period of protection of the coating



Protection by thin epoxy film
(Principle 1 - method 1.1 – EN 1504-2)

The **Foreva® Epx 982** solution uses a thermosetting organic resin film with high wetting power that allows for impregnation deep into the concrete surface to seal surface pores.

This treatment prevents the majority of liquid or gas exchanges with the external environment and therefore extends the reinforcement incubation period.

Protection by water repellent impregnation
(Principle 2 - method 2.1 – EN 1504-2)

The **Foreva® Fuge** solution prevents the penetration of water running down the vertical walls of the concrete by impregnating the surface with a water repellent product that forms a water repellent barrier. The totally colourless **Foreva® Fuge** respects the colour and architectural forms of concrete and stone facings.

This treatment significantly reduces liquid exchanges with the external environment and thereby increases the reinforcement incubation period.

Protection by surface coating
(Principle 2 - method 2.2 – EN 1504-2)

The **Foreva® Relastic 310** solution prevents the penetration of water in liquid form through the application of a thin coating which, due to its microporous properties, allows the structure to "breathe" and thereby prevents blistering caused by temperature variations on the facings. The concrete grey coating gives the structure an even colour and hides any signs of repair. The elasticity of the **Foreva® Relastic 310** coating provides an additional guarantee against water penetration through its ability to bridge and move with active cracks in the substrate.

This surface treatment allows you to control moisture on the concrete facing, thereby increasing the reinforcement incubation period.

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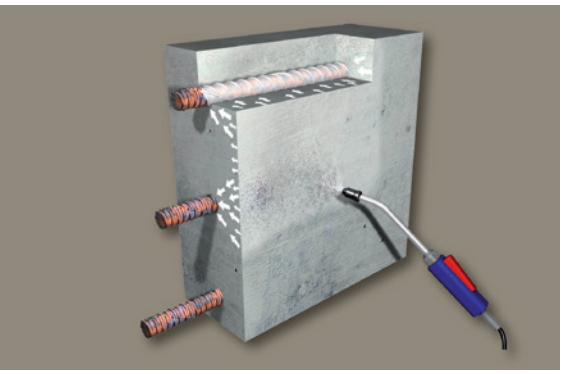
The Freyssinet turnkey service guarantee

Stopping the initiation process



By treating the surface of the reinforcement

By the application of inhibitors to the concrete
(Principle 9 - method 9.1 and principle 11 – method 11.3 - EN 1504)

The **Foreva® Inhib** solution uses a totally colourless corrosion inhibitor that prevents anodic corrosion reactions on the surface of the steel. The molecules penetrate the concrete pores by diffusion and attach themselves to the surface of the reinforcement to form a protective shield.

This treatment offers effective protection of reinforcement found in carbonated concrete or can be used to prevent the formation of an induced anode on the reinforcement in the vicinity of a repair.

By depolluting the coating

Electrochemical realkalisation of carbonated concrete
(Principle 7 - method 7.3 - EN 1504)

Foreva® PH⁺ Régébéton and **Foreva® PH⁺ Floc** solutions are short-term electrochemical treatments that use an external anode placed in a poultice in contact with the facing. They allow for the realkalisation of the carbonated concrete in the vicinity of the reinforcement surface.

With these electrochemical curing treatments, a high pH can be restored in the vicinity of the reinforcement and the protective environment around them can be restored.

Realkalisation by diffusion of carbonated concrete
(Principle 7 - method 7.4 - EN 1504)

The **Foreva® PH⁺ Régébéton** poultice is impregnated with a powerful electrolyte that penetrates into the concrete coating due to its surfactant properties. This treatment also realkalises the coating by diffusion.

Electrochemical chloride extraction
(Principle 7 - method 7.5 - EN 1504)

The **Foreva® Cl⁻ Régébéton** and **Foreva® Cl⁻ Floc** solutions are short-term electrochemical treatments that use an external anode placed in a poultice in contact with the facing. They allow for the extraction of the free chloride ions and other pollutants in anionic form from the concrete coating.

These electrochemical curing treatments can be used to restore the protective environment around the reinforcements.

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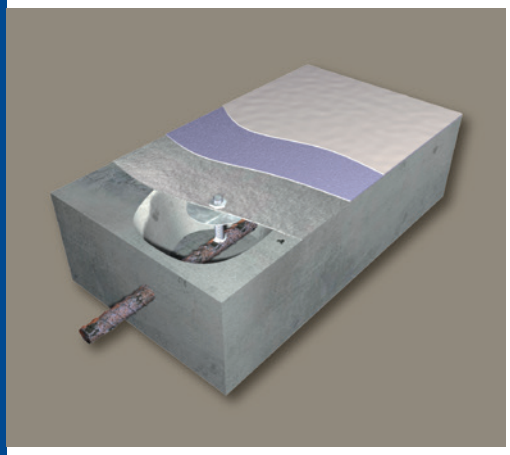
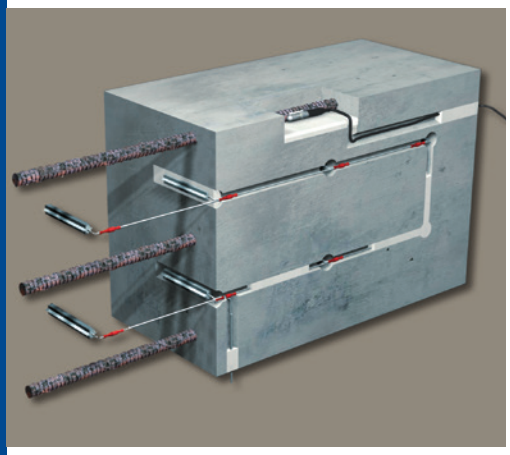
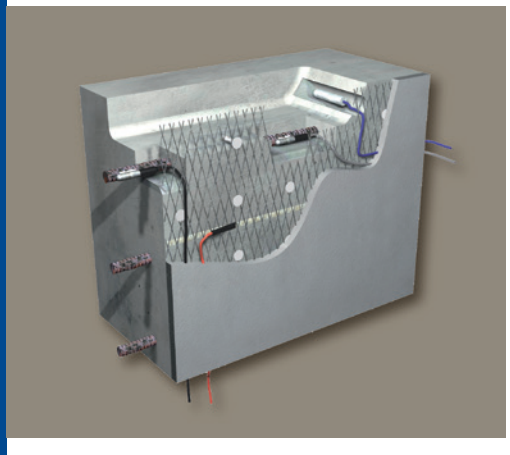
PHASE 3

Preventing the progression of corrosion







By galvanic protection

With an anode on the concrete surface

(Principle 10 - method 10.1 - EN 1504)

The **Foreva® GP Zinc** solution is a galvanic protection system that works with an anode on the concrete surface applied by hot spraying of zinc.

The large exchange surface of the anode allows for the distribution of uniform galvanic currents. This solution is particularly suited to structures with a medium reinforcement density in aerial environments. This technique lends itself exceptionally well to a wide variety of forms and does not stress the structure through over-drilling or overloading.

The protection system is designed on a case-by-case basis depending on the density of the reinforcement to be protected and the service life imposed by the project.

With internal anodes

(Principle 10 - method 10.1 - EN 1504)

The **Foreva® Galvastar** solution is a galvanic protection system that uses discrete sacrificial anodes arranged in a cluster and inserted in the facing in slots near the reinforcement.

These anodes distribute a low intensity current and are used for structures with a medium reinforcement density or exposed to low-corrosion environments. This system is particularly suited to areas exposed to damp.

The galvanic protection system is designed on a case-by-case basis depending on the density of the reinforcement to be protected and the service life imposed by the project.

By cathodic protection

Foreva® CP solutions are compliant with standard NF EN 12696: "Cathodic protection of steel in concrete". The anodes are supplied by a low-voltage, regulated direct current generator. They offer effective protection for a number of decades provided they are monitored properly.

With an anodic mesh

(Principle 10 - method 10.1 - EN 1504)

The **Foreva® CP Mesh** solution is an impressed current cathodic protection system that uses a stabilised titanium mesh anode coated with 2 to 3 cm of shotcrete. The anodes distribute uniform high-density protective currents to the surface of the facing. The solution is suited to both highly chlorinated and carbonated structures and is recommended for treating heavily polluted structures.

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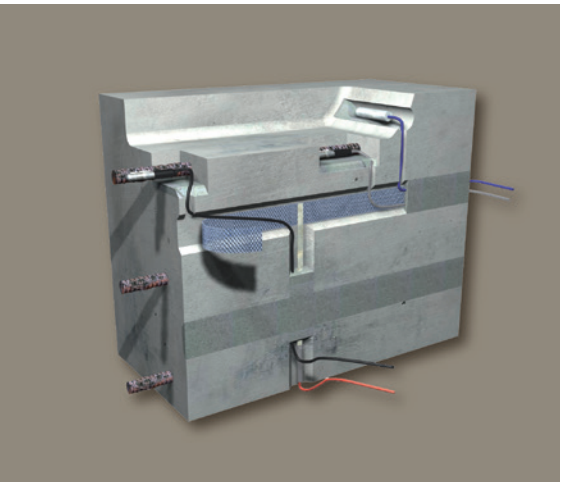


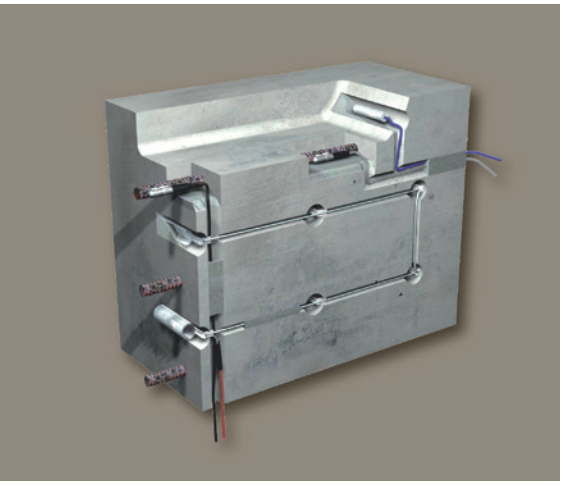
With anodic ribbons

(Principle 10 - method 10.1 - EN 1504)

The **Foreva® CP Ribbon** solution is an impressed current cathodic protection system that uses stabilised titanium anodic ribbons inserted in the facing in slots near the reinforcement.

The anodes are perfectly suited to complex facing shapes and allow for the adjustment of current distribution by reducing their spacing.

The **Foreva® CP Ribbon** solution can be used to protect new structures by cathodic prevention by placing the anodes in the reinforcement cage before concreting.

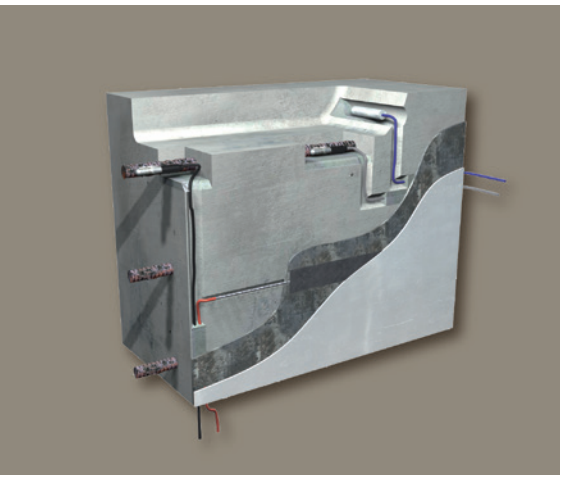


With internal anodes

(Principle 10 - method 10.1 - EN 1504)

The **Foreva® CP Tube** solution is an impressed current cathodic protection system that uses stabilised titanium discrete anodes arranged in a cluster and inserted in the facing in slots near the reinforcement.

It can be used to treat areas with high reinforcement density and to protect reinforcements deep in the facing.



With anodic paint

(Principle 10 - method 10.1 - EN 1504)

The **Foreva® CP Coat** solution is an impressed current cathodic protection system that uses an electrically conductive paint as an anode. The anode is well suited to complex facing shapes requiring low-intensity protective currents.

Due to their organic nature, the anodes have a limited service life. They can offer effective protection for over 10 years provided they are monitored properly.

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