

# PROTECTING METALLIC ANCHORS AND VESSEL FROM ALKALI CORROSION BY INNOVATIVE REFRACTORY PAINTS

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## ABSTRACT

In thermal industries mainly, metallic parts of installation (anchors, tubes, vessel...) are faced with many types of corrosion.

Two main corrosion mechanisms (often linked) occur in these fields, induced by alkali species: dry corrosion and hot corrosion.

In these installations, metallic parts are left naked or are protected by refractory linings retained by an anchoring system often in stainless steel. These metallic anchors are often the reason for refractory lining failure even if, in many cases, the refractory is still in good working condition.

In order to avoid or limit these corrosion phenomena, refractory paints were designed to apply on different metallic parts of installations which are subjected to alkali corrosion attack.

This new technology can be used:

- As a sublayer before refractory application (by casting, gunning...).

- As a protective layer of naked parts (no refractory applied over).

These refractory paints have for main property to form an impervious and glassy phase at low temperature to limit the penetration of alkali species. This material, only mixed with water, is very easy to use and could be applied by different techniques: brush, roller or with a spray-gun. Moreover, it has a strong adhesiveness on supports after application.

Tests at lab scale were carried out, simulating different types of corrosion (essentially hot corrosion): corrosion by chloride salts, by sulfates salts in reducing or oxidizing atmospheres.

Results have shown that a metallic piece coated with the refractory paint technology presents a corrosion resistance twice higher than a naked metallic piece.

This new technology was tested in real conditions (in incinerators) in order to have some feedback on corrosion resistance improvement on site.

## 1 – INTRODUCTION

In many thermal industries, (incinerators, cement plants and boilers), installations parts (shell, tubular walls or anchors) are often protected by refractory linings in order to protect the vessel against high temperature encountered.

This refractory lining is, in most cases, retained by an anchoring system often in stainless steel. In these types of industries, corrosive atmospheres (gases, alkali salts...) are present and lead to installation damage. Corrosion problems can have an impact on different parts of the installation:

- On the refractory lining directly: Indeed, gases have a negative influence on the performance of refractory materials. They penetrate into the refractory, through the porosity, and create an area of attack. Specifically alkali compounds react with the matrix to form a phase of lower density and of higher volume than the original minerals. This leads to “alkali bursting”; an extreme expansion phase causing the destruction of the monolithic lining<sup>[1]</sup>.

- On the anchoring system: In most cases, metallic anchors are at the primary origin of refractory lining failure. In many cases, the refractory material is still in good working condition but metallic anchors are damaged due to metal corrosion attack. Indeed, alkali vapors can pass through the porosity of the refractory material to the metallic anchor without causing any problems in the refractory lining (no alkali bursting). The corrosion of the metallic anchor leads to its degradation and therefore to the refractory lining failure.

- On the vessel: in several cases, shell, walls or tubes are not protected by a refractory lining. These metallic parts are therefore directly exposed to corrosive atmospheres.

This paper describes principally the corrosion occurring on metallic parts of installations and the innovative way developed to protect them.

## 2 – TYPE OF THERMAL INDUSTRIES

### 2-1) INCINERATION

Several different types of incinerators exist: waste incinerators, biomass incinerators, hazardous waste incinerators, etc.

Figure 1 presents the different parts of the first pass of a waste incinerator and range of temperature encountered.

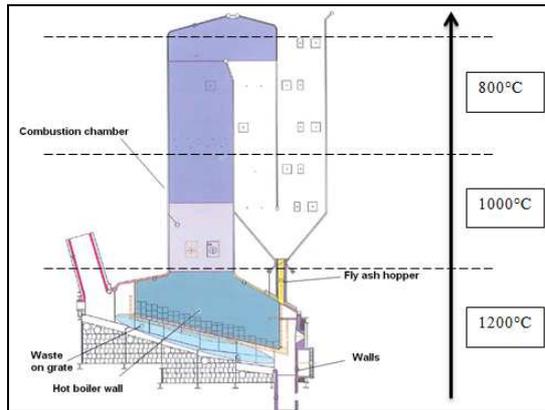


Fig 1: First pass of waste incinerator

As it is presented in Table 1, molten salt composition is not very defined because the waste nature changes from day to day. Moreover, as a function of the furnace section, molten salts concentrations change (increase when the temperature decreases).<sup>[2] [3]</sup>.

## 2-2) CEMENT PLANT

Figure 2 presents the temperatures encountered in different parts of an installation of clinker production.

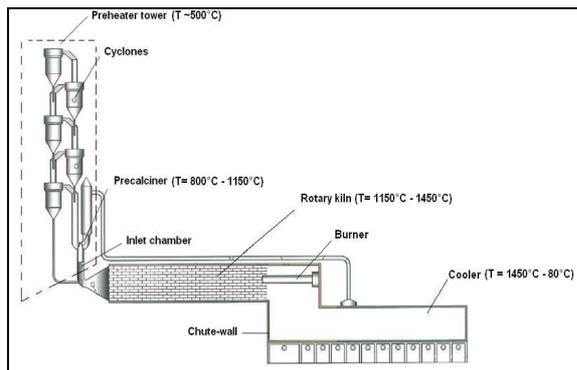


Fig 2: Clinker production installation

As function of sections and temperatures, alkali species will not be of the same nature.

Figure 3 presents the temperature profile of an

anchor installed in a part of clinker production installation<sup>[4]</sup>.

The metallic anchor is submitted to a big gap of temperature between the hot face and the cold face.

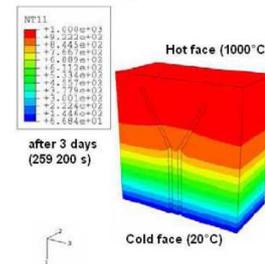


Fig 3: Temperature profile of an anchor installed in part of clinker production installation.

## 3 – CORROSION MECHANISMS

Corrosion processes in thermal industries are very complex because many different corrosion mechanisms occur and conditions lead often to mixed corrosion mechanisms (corrosion by gases, by molten salts, etc...).

Corrosion at high temperature (higher than 300°C) is the main cause of metallic anchor damage and vessel corrosion.

This corrosion includes 2 types of corrosion:

- “Dry corrosion”, which results from the corrosion of the metal by hot gases: O<sub>2</sub>, CO<sub>2</sub>, H<sub>2</sub>, chlorine gases (HCl, Cl<sub>2</sub>) and sulfur gases (SO<sub>2</sub>, SO<sub>3</sub>)...
- “Hot corrosion” involving the formation of condensed molten salt: sulfates (Na<sub>2</sub>SO<sub>4</sub>, K<sub>2</sub>SO<sub>4</sub>), chlorides (KCl, NaCl) or carbonate (Na<sub>2</sub>CO<sub>3</sub>, K<sub>2</sub>CO<sub>3</sub>).

These two types of corrosion are linked. Indeed, molten salts are produced by reaction of hot gases and impurities (Na, K, S, Cl) present in the atmosphere (Fig 4).

	Incinerators	Cement Plant
Atmosphere	Often oxidizing	Often oxidizing
Fuel type	Coal, oil, gas, waste	Gas, waste
Temperature	Up to 1200°C	Up to 1400°C
Gas	N <sub>2</sub> , H <sub>2</sub> O, O <sub>2</sub> , CO <sub>2</sub> , SO <sub>2</sub> , HCl, Cl <sub>2</sub> , KCl, NaCl, CO Na <sub>2</sub> O, K <sub>2</sub> O	N <sub>2</sub> , H <sub>2</sub> O, O <sub>2</sub> , NOx, CO CO <sub>2</sub> , , SO <sub>2</sub> , Na <sub>2</sub> O, K <sub>2</sub> O
Impurities	Na, S, Cl, K	Na, S, Cl, K
Molten species	Chlorine molten salt (NaCl, KCl, CaCl <sub>2</sub> ) Sulfate molten salt (K <sub>2</sub> SO <sub>4</sub> , Na <sub>2</sub> SO <sub>4</sub> , CaSO <sub>4</sub> )	Carbonates (Na <sub>2</sub> CO <sub>3</sub> , K <sub>2</sub> CO <sub>3</sub> ) Chlorine molten salt (NaCl, KCl) Sulfate molten salt (K <sub>2</sub> SO <sub>4</sub> , Na <sub>2</sub> SO <sub>4</sub> )

Table 1: Atmosphere and temperature encountered in different thermal industries.

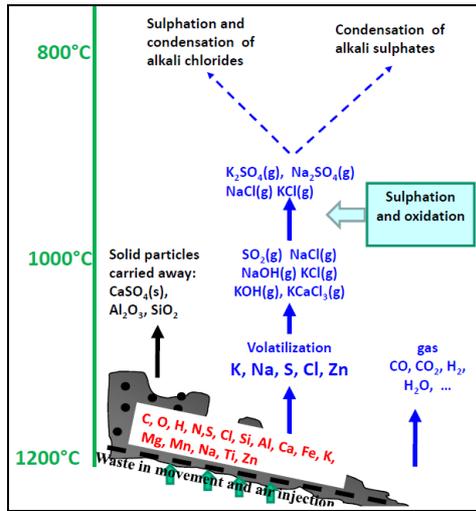


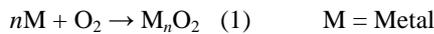
Fig 4: Illustration of alkali formation in waste incinerator<sup>[3]</sup>

### 3-1) DRY CORROSION

This type of corrosion could occur in oxidative atmosphere or in reductive atmosphere. There are different types of dry corrosion:

#### 3-1-a) Corrosion by oxidation

In presence of O<sub>2</sub> gases an oxide layer is formed on the metallic surface following reaction (1).



The metal oxide layer grows at the oxide/gas interface and serves partially as a protective layer (passive oxide layer) against the external aggressive environment.

Depending on the metal composition, the oxide layer is more or less volatile, brittle, porous, non-adherent to the substrate.

#### 3-1-b) Corrosion by sulfidation

This type of dry corrosion is caused by sulfur gases such as SO<sub>2</sub>, SO<sub>3</sub>, H<sub>2</sub>S... The sulfidation process is similar to the oxidation process<sup>[5]</sup>.

SO<sub>2</sub> or H<sub>2</sub>S reacts with the metal to form a metal sulfate layer as following reactions:



The result is a non-protective and cracked layer.

#### 3-1-c) Corrosion by chlorination

In its gaseous state, chlorine can take different forms (HCl, Cl<sub>2</sub>, NaCl, KCl ...). These gaseous chlorides come from reactions between vapor contamination (Na, K, Cl...) and gas (Cl<sub>2</sub>, H<sub>2</sub>, H<sub>2</sub>O).

Gaseous chlorine could also come from the reaction between sulfur gases and chloride molten salts (ex. KCl). The diffusion through the oxide layer cracks to the surface of the metal leads to the formation of metal chlorides. This mechanism operates mainly in environments rich in sulfur<sup>[5]</sup>.

#### 3-1-d) Corrosion by carburization

The carburization reaction takes place in the presence of CO and CO<sub>2</sub> gases. It consists of carbide formation inside the metal at temperatures higher than 900°C (intergranular corrosion).

As a function of the metal composition, the nature of carbide formed is different (iron carbide, chromium carbide...) <sup>[6]</sup>.

### 3-2) HOT CORROSION BY MOLTEN SALTS

Corrosion by molten salts is closely linked to dry corrosion.

Alkali salts are formed by condensation or de-sublimation of gaseous species (when the temperature decreases) and have low melting points (ex: KCl, NaCl, Na<sub>2</sub>SO<sub>4</sub>, K<sub>2</sub>SO<sub>4</sub>...) as shown in Table 2.

This corrosion leads to the loss of the protective oxide layer formed by the oxidation mechanism describe earlier and therefore to the degradation of the metallic parts by the molten salt deposit<sup>[5]</sup>.

	KCl	NaCl	Na <sub>2</sub> CO <sub>3</sub>	K <sub>2</sub> SO <sub>4</sub>	K <sub>2</sub> CO <sub>3</sub>	Na <sub>2</sub> SO <sub>4</sub>
Melting Temp. (°C)	772	801	854	884	896	1069

Table 2 : Melting point of several alkali salts<sup>[5]</sup>

#### 3-2-a) Corrosion by chloride salts

Chloride molten salts are formed by sulfation of gaseous species (fig 4 above).

As it is described in figure 5 (a), the gaseous chlorine from the molten salt deposit (NaCl or KCl) or from the reactive atmosphere is able to diffuse through the oxide layer (figure 5b) (by micropores or cracks) and react with the metal to form metal chlorides (as FeCl<sub>2</sub>). As these chlorides penetrate deeper, the temperature decreases and metal chlorides sublime immediately (figure 5c). They then migrate outside the oxide layer through these pores and cracks, causing severe corrosion (figure 5d). Approaching the surface, the metal chloride is less stable than the corresponding oxide. It follows the formation of oxide with the release of chlorine gas which can diffuse again to the metal (figure 5e). Oxides formed (Fe<sub>3</sub>O<sub>4</sub>) grow in cracks and pores of the initial layer and destroy the protective oxide layer, thus preventing passivation, hence the term "active oxidation". The chlorine makes an endless cycle where only the metal is consumed<sup>[7]</sup>.

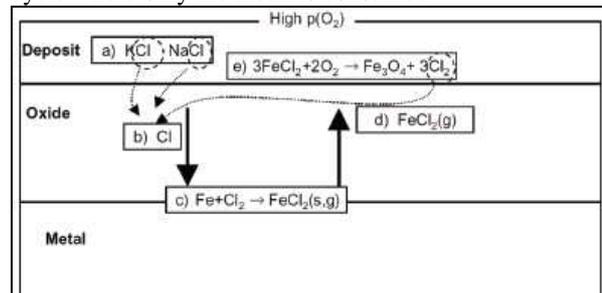


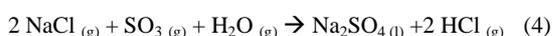
Fig 5: Illustration of the corrosion by chlorine deposit<sup>[5]</sup>

	Martensitic	Ferritic	Austenitic
Metallic element	Fe – Cr	Fe – Cr	Fe – Cr - Ni
Chromium content	5 – 22%	17 – 30%	20-25% Ni content: 10 – 20%
Max. using Temp.	850°C	1100°C	1100°C
Example	1.4006 (AISI 410)	1.4016 (AISI 430)	1.4301 (AISI 304) 1.4845 (AISI 310)

Table 3: Stainless steel categories

### 3-2-b) Corrosion by sulfate salts

The most common sulfate salts are sodium sulfate ( $\text{Na}_2\text{SO}_4$ ) and potassium sulfate ( $\text{K}_2\text{SO}_4$ ) formed in the combustion process from sulfur gas (from the fuel) and gaseous sodium species (ex. NaCl) from the fuel or the ingested air (reaction 4).



The molten salt dissociates in  $\text{SO}_4^{2-}$  and reaches the metal by diffusion through the oxide cracking. In contact with the metal surface,  $\text{SO}_4^{2-}$  is reduced to sulfides by metal oxidation. Then it forms liquid metal sulfides (ex.  $\text{FeS}_2$ ) which partially replace the oxide layer normally present on the metal surface causing severe corrosion<sup>[5]</sup>.

### 3-2-c) Corrosion by carbonates

Sodium carbonate ( $\text{Na}_2\text{CO}_3$ ) and potassium carbonate ( $\text{K}_2\text{CO}_3$ ) are the most common salts encountered in thermal industries. These carbonate species lead to the formation of alkali species:  $\text{Na}_2\text{O}$  and  $\text{K}_2\text{O}$  which cause severe corrosion problems, mainly in the presence of oxygen and carbon. In the presence of iron and chromium containing steel, oxides formed in the presence of sodium carbonate are  $\text{Na}_4\text{FeO}_3$  and  $\text{NaCrO}_2$ . These new species replace the protective oxide layer at the surface of the metal. This leads to degradation and embrittlement of the metal piece<sup>[6]</sup>.

A mix of sulfur, chloride and carbonate molten salt could be present in corrosive atmospheres. As a function of alkali proportion, the salt mix is more or less aggressive. For example, an equimolar mix of NaCl, KCl, and  $\text{Na}_2\text{SO}_4$  has a low melting point ( $T_f = 520^\circ\text{C}$ ) which makes it very aggressive.

According to some authors, the corrosion caused by chloride salts could be more severe than those caused by sulfate and carbonate salts. One of the reasons is that chlorine molten salts have a lower melting point (Table 2).

## 4 – CORROSION OF DIFFERENT TYPES OF METALS

The composition of the metallic parts (vessel, anchors...) is one of the most important parameters which has an impact on the corrosion process. Indeed, the most efficient materials are those capable of

forming a continuous and resistant oxide layer with as few pores as possible to protect the metallic part against aggressive media.

The most common metal used for refractory applications is stainless steel based on iron, chromium, and/or nickel (AISI 304 or 310 mostly used for anchor systems).

Stainless steel is an alloy composed of iron and carbon with 10% chromium at least. Such chromium content leads to the formation of a protective oxide layer ( $\text{Cr}_2\text{O}_3$ ) resistant to corrosion.

Stainless steel alloys could be classified in 3 categories as described in Table 3. The maximum service temperature is a function of the chromium content and of the presence of nickel<sup>[6]</sup>.

A chromium content higher than 10% leads to a protective oxide layer. The introduction of nickel in a stainless steel (austenitic alloy) leads to enhanced resistance against oxidation (low oxidation rate of nickel) and against alkali salts (chloride, carbonates)<sup>[2]</sup>.

There is another quality of alloy called “super-alloys” which are more resistant mechanically and at high temperature compared to stainless steel. Their resistances against corrosive media are also improved but these nobler alloys are very expensive.

Among super-alloys there are nickel based alloys which includes pure nickel alloy, Ni-Cr (Inconel); and cobalt based alloys which contained chromium and/or nickel (Stellite). Cobalt based alloys present higher corrosion resistance in sulfurous atmospheres and in presence of sodium molten salts compared to nickel based alloys which exhibit poor resistant in this case<sup>[6]</sup>.

Additional compounds could be used in stainless steel and in super-alloys: molybdenum (Mo), titanium (Ti), tungsten (W) and niobium (Nb) lead to a stiffening of the matrix; aluminum (Al) and silicon (Si) improve the oxidation resistance.

## 5 – AN INNOVATIVE REFRACTORY PAINT AGAINST COROSION ATTACK

In order to protect metallic parts of installations against different types of corrosion seen in the past; an innovative refractory paint was developed.

This new technology is based on different binders (hydraulic bond or chemical bond) regarding chemicals

authorization of some countries or customer preference. It has the capacity to form a glassy and impervious barrier to alkali species (gases or salts) between the refractory (or the atmosphere) and the metal to be protected. This glassy phase can be formed at low temperature thanks to the presence of low melting point components (fluxing agent and glass frit). As shown in figure 6, it is much more useful to have these glassy and impervious properties than to have an extremely expensive material (such as SiC, which can be considered as very resistant to alkali atmosphere) which would not be impervious.

## 5-1) EXPERIMENTAL PROCEDURES AT LAB SCALE

### 5-1-a) Preparation of refractory paints and application

Innovative refractory paints are delivered in dry powder form and have to be mixed only with water (from 30% to 55% depending on the binding system) before use. They may be applied by brush, roller or by spray-gun in a fine film of 2mm. The drying time is approximately 2h but it could depend of the thickness of the layer.

### 5-1-b) Evaluation of the adhesion on metallic substrate

In order to evaluate the adhesion and the robustness of refractory paints after drying and permit an eventual application of a refractory product without coating damage, a simple test was carried out consisting of the cleaning capacity of a coated metallic piece by water. The coated metallic piece is simply immersed/washed in water and the percentage of remaining coating is observed visually.

As refractory paints could be applied on metallic parts which will remain naked (not covered by a refractory lining), a test at high temperature was performed. A metallic cylinder (in AISI 304) was coated, dried for 2h at ambient temperature and directly placed for 2h at 300°C or 5h at 500°C in a preheated furnace.

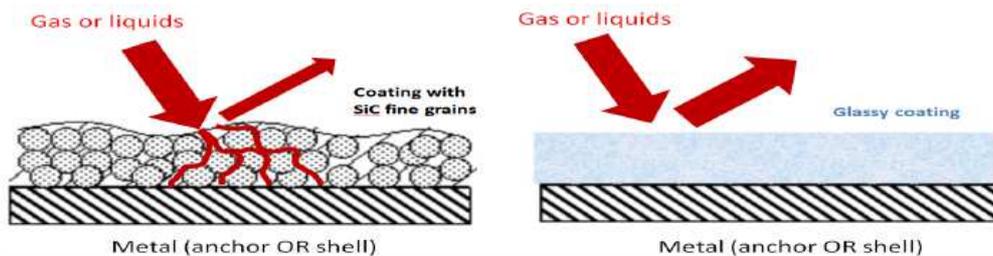


Fig 6: Illustration of the refractory paint technology

### 5-1-c) Corrosion tests

In order to simulate and reproduce the corrosion which occurs in thermal industries (especially the corrosion induced by molten salts), a lab corrosion test was developed. Metallic rods of 100mm length and 8mm in diameter in AISI 304 were chosen to represent the metallic piece. These metallic rods were coated with the refractory paint and compared with uncoated pieces and coated pieces with a benchmark paint not forming glassy phases.

In order to optimize the contact coating/substrate, a porous material (33% of porosity - 95% tabular alumina 0-1mm and 5% CAC) was cast around coated or uncoated metallic rods as shown in figure 7.

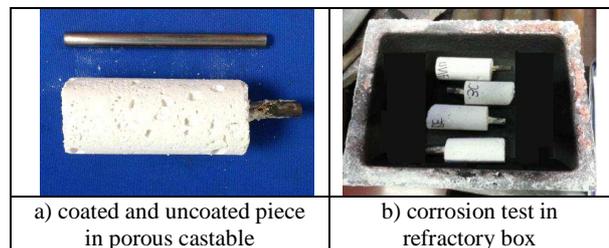


Fig 7: Illustration of the a corrosion test

Different corrosion tests were carried out in a refractory box at 800°C during 200h in the following corrosive environments:

- Environment 1: Corrosion by chlorine salts in oxidizing atmosphere.
- Environment 2: Corrosion by sulfate salts in reductive atmosphere.
- Environment 3: Corrosion by both sulfate and chloride salts in reductive atmosphere.

Table 4 shows the chemical composition of each salt mix.

After each corrosion test, the porous material was removed and all pieces were cleaned in a water bath containing 15% HCl (85%) at 70 to 80C for 1h in order to remove most of the remaining salts.

In order to evaluate to degree of corrosion, the loss of weight of the metallic rods was measured after the corrosion tests were complete.

	Environment 1	Environment 2	Environment 3
	Chloride salts	Sulfate salts	Both salts
	Oxidizing	Reductive	Reductive
Coke	/	35%	35%
Graphite	/	35%	35%
NaCl	45%	/	3.1%
KCl	55%	/	2.3%
Na <sub>2</sub> SO <sub>4</sub>	/	12%	9.3%
K <sub>2</sub> SO <sub>4</sub>	/	8%	6.8%
CaSO <sub>4</sub>	/	11%	8.5%

Table 4: Composition of salt mixes (in weight)

#### 5-1-d) Determination of characteristic temperatures by heat microscopy measurements

Heat microscopy measurements were carried out on the refractory paint in order to evaluate its characteristic temperatures. The equipment used was delivered by HESSE Instruments, type EM-201-17 with a furnace category HR 18 (maximum temperature = 1750°C) and a furnace control unit EPA-8. These measurements made it possible to determine the sintering temperature (S point), the deformation temperature (A point), the sphere (B point) and hemisphere temperature (C point) and the flowing temperature (D point).

### 5-2) RESULTS AND DISCUSSIONS

#### 5-2-a) Adhesion of refractory paints at ambient and at high temperature.

The adhesion of refractory paints was evaluated after drying and after exposure to high temperature (300°C/2h and 500°C/5h).

After drying at ambient temperature, refractory paints are very robust and their adhesion to the metallic substrate is almost 100% after washing in water.

As shown in figure 8, after 2h at 300°C or 5h at 500°C, refractory paints do not present any spalling. This means that refractory paints exhibit a thermal expansion coefficient close to that of the metal.

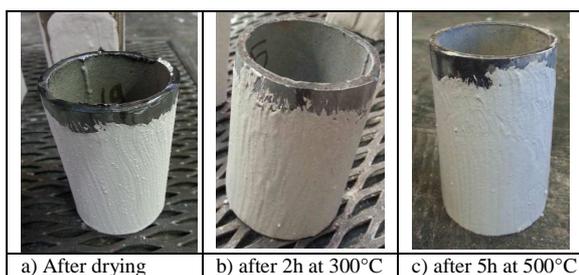


Fig 8 : Coated metallic pieces after drying and heating up

#### 5-2-b) Corrosion resistance of refractory paints

Results presented in Table 5 show the loss of weight of each metallic rod (uncoated piece, coated piece by refractory paint and coated piece by a benchmark product) in different corrosive atmospheres. Figure 9 shows metallic rods after corrosion tests in Environments 1 and 3 after porous material removal and after cleaning in an acidic water bath.

Environments 1 and 3 are discriminant. It can be clearly seen that improved results are obtained for coated pieces with refractory paints (whatever the type of bond).

Environment 2 (only sulfate salts in reductive atmosphere) is not very discriminant. Indeed, all the weight losses are around 10%.



Fig 9: Metallic rods after corrosion test

N°		Environment 1	Environment 2	Environment 3
1	Uncoated piece	-22.8%	-10.1%	-19.7%
2	Refractory paint (hydraulic bond)	-14.3%	-11.8%	-12.4%
3	Refractory paint (chemical bond)	-18.9%	-9.2%	-10.5%
4	Benchmark paint	-32.4%	-11.1%	-13.6%

Table 5 : Loss of weight of metallic pieces after corrosion test in various corrosive atmospheres

**5-2-c) Heat microscopy measurements**

Characteristic temperatures observed by heat microscopy measurement are presented in Table 6. The deformation of the sample occurs at 653°C for the chemical bond paint and at higher temperature (787°C) for the hydraulic bond paint. We can suppose that an important part of glassy phases are formed at these temperatures. The presence of a fluxing agent makes it possible to form earlier glassy phases (at around 200°C) but only in small amounts (not observed by heat microscopy).

At hemisphere point (C point), we can consider that almost all glassy phases are formed (Fig 10).

	S	A	B	C	D
Refractory paint (hydraulic bond)	615	787	934	1005	1099
Refractory paint (chemical bond)	625	653	n.d	1007	1044

Table 6: Characteristic temperatures of refractory paints

**6 – INDUSTRIAL TRIALS**

The refractory paint was installed and tested in different industrial sites, especially in power plants, in order to evaluate its properties at industrial scale.

**6-1) TRIAL N°1**

Trial N°1 was carried out in a CHP plant (combined heat and power) equipped with a boiler. The boiler produces steam at 60 bars delivered to a steam turbine with a generator for producing electricity.

At the bent tubes, in the water cooled furnace roof, steam leakage has occurred in both line 11 and 12. The refractory lining has been replaced in both lines at the furnace roof to check the tubes and establish a better refractory lining with a gunning product.

The refractory paint (chemical bond) was tested and applied in areas before the refractory relining (c.a 15m²) in order to check its corrosion resistance: at the

furnace roof, at the rear wall near the roof and on parts of the upper side walls (Fig 11).

The gas temperature in this area is expected to be 1100°C to 1300°C.

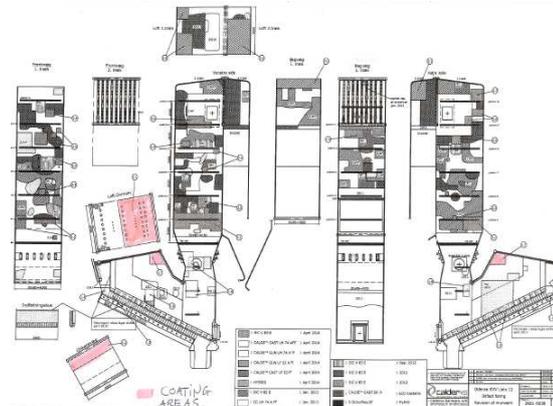


Fig 11: Location of coating area in the boiler

**6-2) TRIAL N°2**

Trial N°2 was done in a waste-to-energy plant. Recurring problems with corroded tubes are present, and therefore the developed refractory paint (hydraulic bond) was tested. A benchmark paint was also applied in the same area for comparison (fig 12). The location of the test was in the upper part of the second pass, just below the existing refractory boundary. Gas temperature in this area is around 850°C. An additional test area was located in the third pass where the gas temperature is maximum 650°C. The tubes have been particularly exposed to corrosion in this test region and they were repaired several times (fig 13). The tubes are left naked (not covered by a refractory lining) when the incinerator is in use.

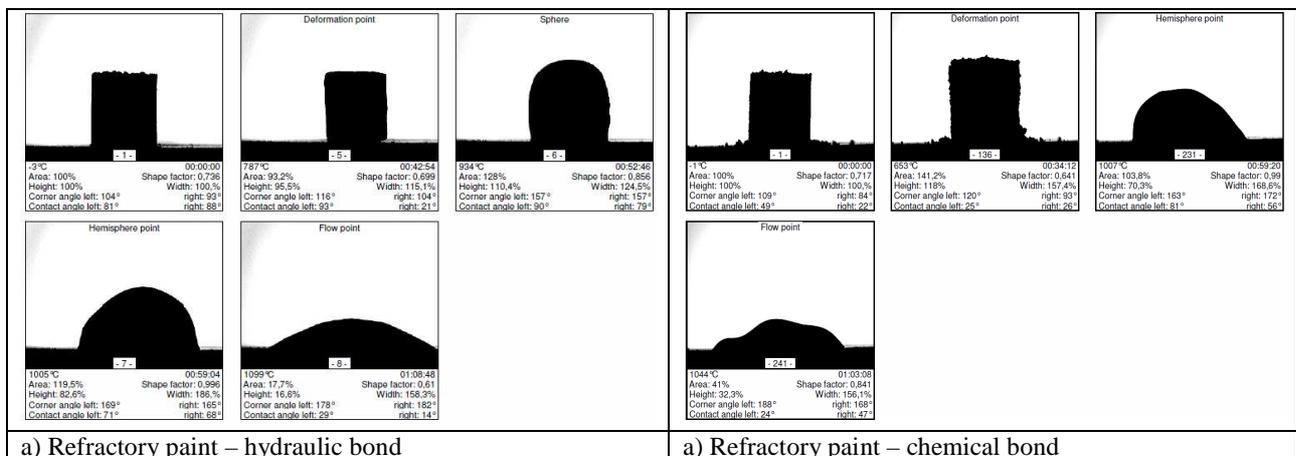


Fig 10: Heat microscopy measurements on the refractory paint: a) hydraulic bond; b) chemical bond



Fig 12: Coated tubes with hydraulic bond paint (right side) and benchmark product (left side).



Fig 13: Corroded tubes after refractory boundary

### 6-3) TRIAL N°3

The 2 types of refractory paints (hydraulic bond and chemical bond) were applied in a municipal incinerator in the second pass, on the south wall. Refractory paints were applied on shot blasted tubes. These tubes are not covered by a refractory lining when the incinerator is in use (naked tubes). The hydraulic bond refractory paint was applied on the east side and the chemical bond refractory paint was applied on the west side.

### 6-4) OUTCOMES OF INDUSTRIAL TRIALS

Regarding consistency and application aspects, the hydraulic bond refractory paint, prepared with 55% water, exhibits a better surface coverage compared to the competitive product. In the case of the chemical bond refractory paint, the water amount was 33%. Refractory paints were applied with a spray-gun equipped with a bottle container as shown in figure 14. During the application, it was demonstrated that the chemical bond refractory paint was easier to apply. It has been also proved that it was better to apply a thin layer (1-2mm) several times, after the previous layer has dried completely, instead of a single thick layer, which can present cracks after drying. Moreover, if there are any anchors between tubes, the spraying must be done in 4 directions in order to be sure to cover all surfaces. In the case where refractory paints have been covered by a gunning product, it appears that the gunning operation does not remove any of the refractory paint.

When these units are opened up again for maintenance work (about seven months after start-up), it will be possible to learn more about the corrosion properties of

these refractory paints and confirm the results obtained at lab scale.



Fig 14: Spray-gun equipped with a bottle container for refractory paint application

### 7- CONCLUSION

Often, in thermal industries (incinerators, boilers, cement plants), metallic parts (vessel shells, anchors) are submitted to corrosive attack (alkali gas or molten salts) which reduce the life time of installations.

In order to reduce this damage, an innovative refractory paint technology based on different bonding systems has been developed (hydraulic bond and chemical bond). To limit the penetration of corrosive compounds, this new technology is capable of forming a glassy and impervious phase at low temperature thanks to the presence of low melting point components. Regarding corrosion resistance at lab scale, this new technology exhibits improved corrosion resistance compared to benchmark paints, especially in oxidizing atmospheres in the presence of chloride salts. Industrial trials have been carried out, in most cases in incineration plants. These two types of refractory paints were applied on tubes and anchors in areas particularly exposed to corrosion problems. The application step was carried out in most cases by spray gun equipped with a bottle container or sometimes by brush. Coated parts of each unit remained exposed to the gas stream or, in some cases, were covered by a refractory lining (gunning product). In the gunning product installations, it was observed that the gunning operation did not remove the refractory paint.

For the moment, no results are available regarding the corrosion properties of the refractory paint on site. Observations will be made in few months, when these units shut down for maintenance work.

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