



# COOLSWEEP - 2015 - BILBAO

## ADVANCED TECHNOLOGY FOR SUPERHEATED STEAM AND FLUE GAS ENERGY RECOVERY



ZABALGARBI S.A.



Nuevos Materiales, Procesos y Equipos para la Reactivación de la Industria Forestal en Euskadi - BIOPLEN



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ECONÓMICO Y COMPETITIVIDAD

***SARTECH ENGINEERING S.L. is a leading company which offers a complete scope of engineering, construction, technical and consulting services, specialized in Energy and Waste Recovery projects for environment-friendly industries.***

***SARTECH is part of SARRALLE GROUP:***



## SARRALLE GROUP LOCATION (WORLWIDE)

**Headquarters (Azpeitia, Spain)**  
**Bº Landeta, C/ Orendaundi Nº 7**

- **ITALIA** , Udine
  - Commercial & Finance Office
  - New Competence Center
- **SWITZERLAND**, Lugano
  - Commercial & Finance Office
- **USA**, Pittsburgh
  - Commercial & Finance Office
- **MEXICO**, Monterrey
  - Commercial , Finance Office & Workshop
- **BRAZIL**, Sao Paulo
  
- **U.A.E**, Dubai
  - Commercial & Finance Office
- **CHINA**, Shanghai
  - Commercial & Finance Office
- **INDIA**, Kolkata,
  - Workshop: Uluberia



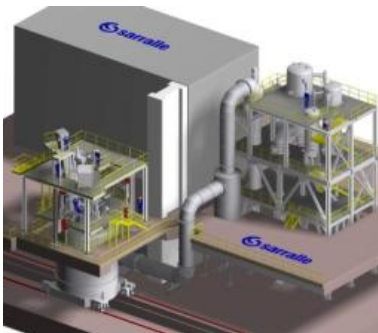
## ENGINEERING & SERVICES

- Project Management
- Civil Works
- Layout Studies
- Engineering Development
- Facilities Engineering
- EPC Solutions
- Services

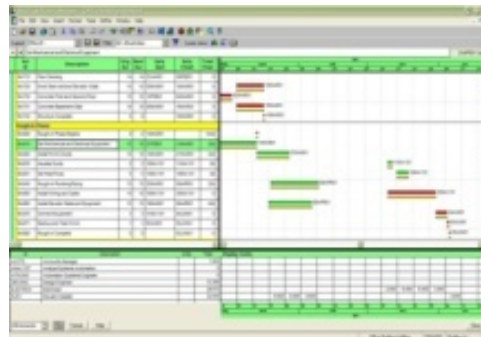


**SARTECH** uses the most adequate software for each project:

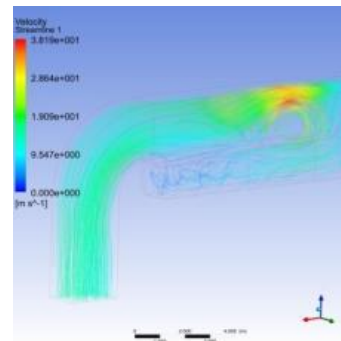
3D SOLID EDGE



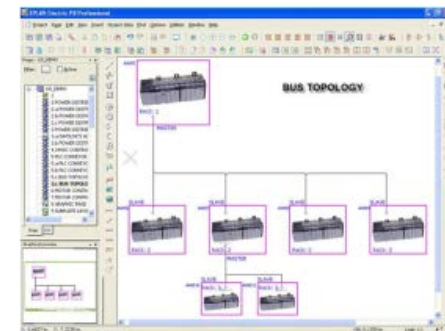
Primavera



CFD; ANSYS Fluent

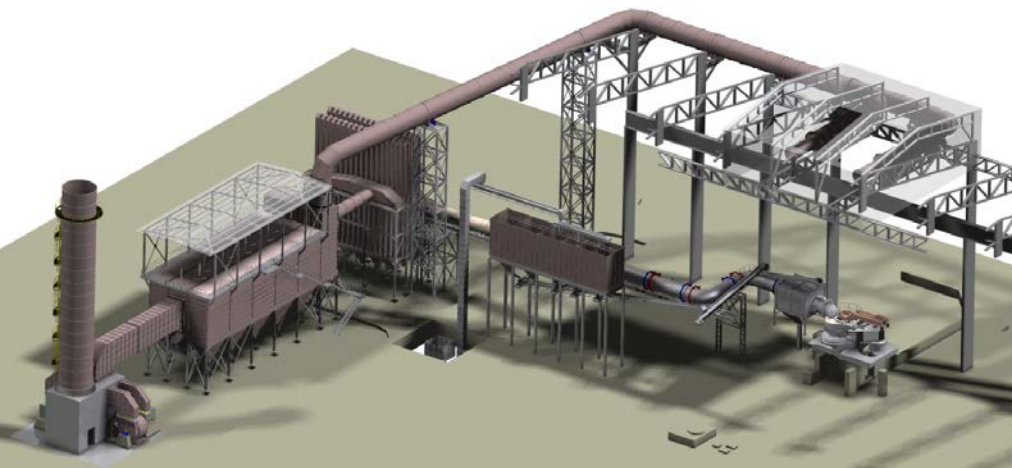


Eplan P8



## TECHNOLOGY & PROJECT PORTFOLIO

- **Waste to Energy.** Energy which can be recovered from waste by different technologies:
  - ✓ Incineration
  - ✓ Biomass
- **Heat Exchange and Co-Generation projects.** SARTECH has developed solutions for different industries in order to recover the energy produced in the production activities (steel-making, cement, DRI, glass a.s.o.)
- **Waste Recovery.** Recycling and waste treatment.



**ADVANCED TECHNOLOGY FOR  
SUPERHEATED STEAM AND FLUE GAS  
ENERGY RECOVERY**

**FUME GAS CONDENSER**

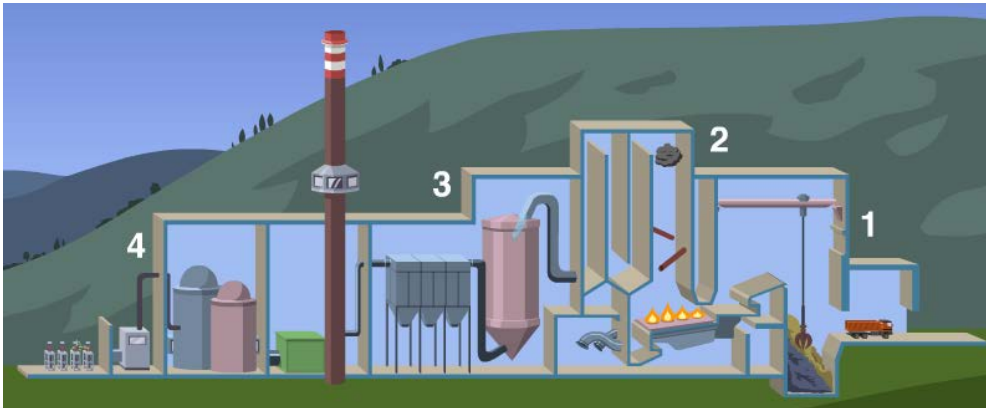
**REHEATER**

**SARTECH**  
TECHNOLOGY & ENGINEERING

+

**KERA - COAT**  
CERAMICS

**APPLICATION FIELD:** *ZABALGARBI Urban Waste Incinerator*

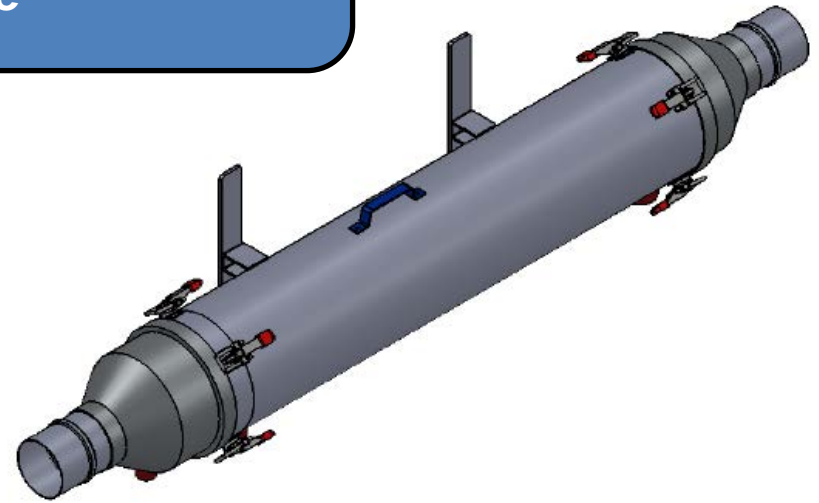
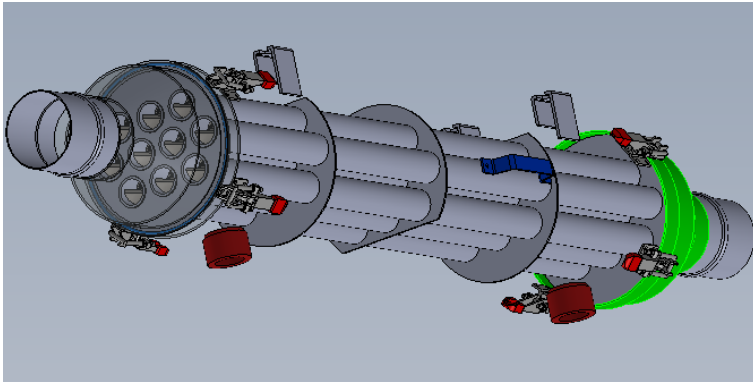


**zabalgarbi**

## FUME GAS CONDENSER

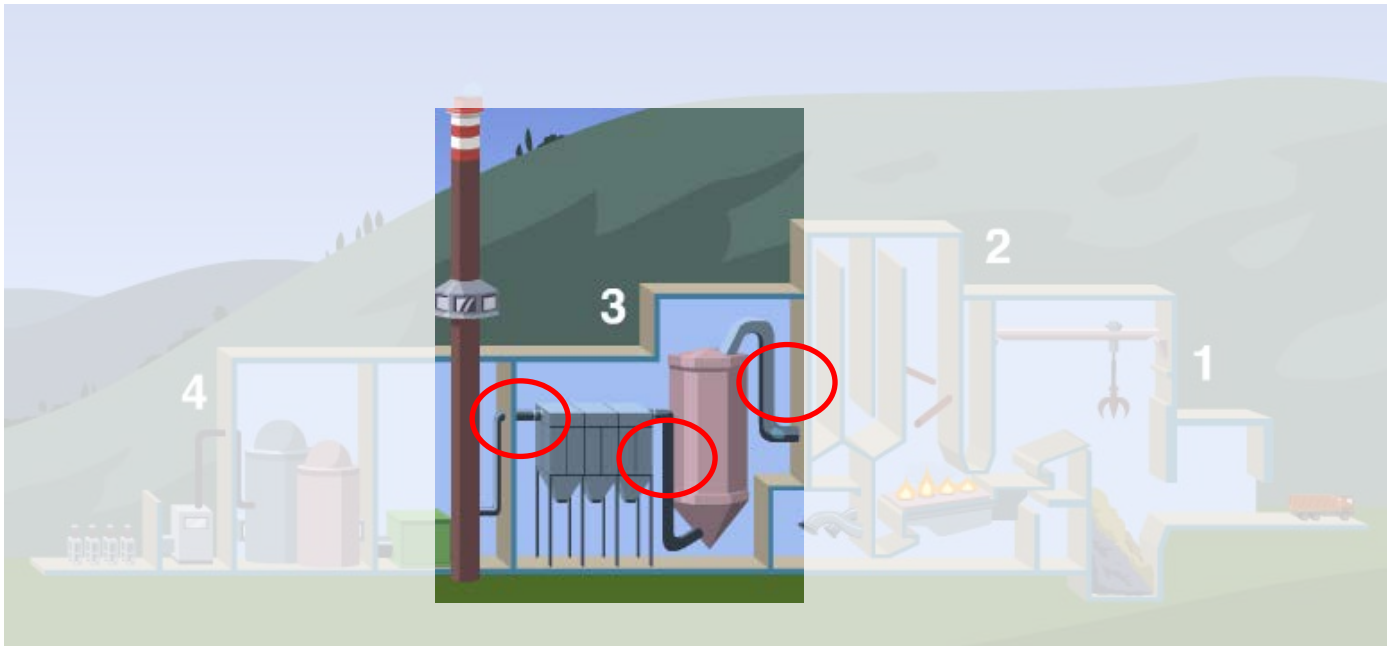
### TECHNOLOGY DESCRIPTION

*Condenser capable of supporting extreme conditions of corrosion without losses in the heat exchange*



**FUME GAS CONDENSER**

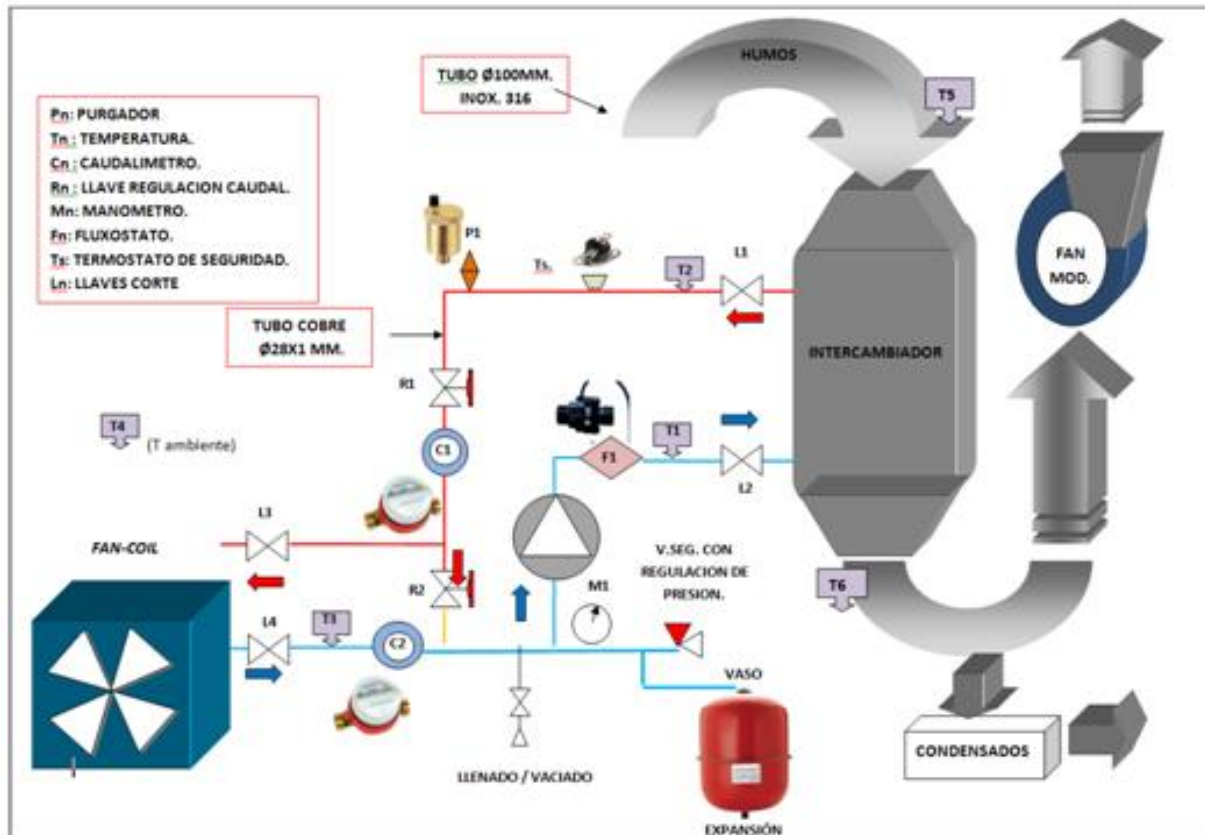
**APPLICATION FIELD (TEST BED)**





# FUME GAS CONDENSER

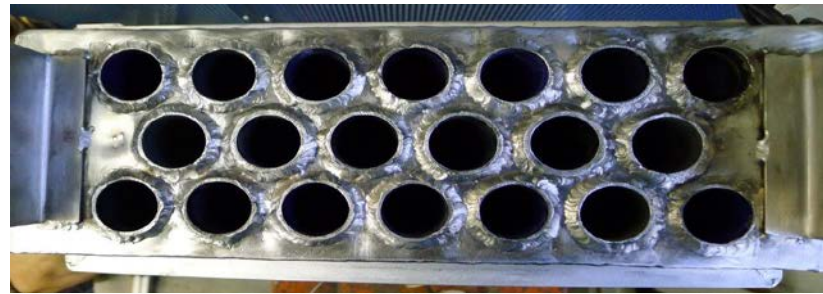
## INSTALLATION DESCRIPTION



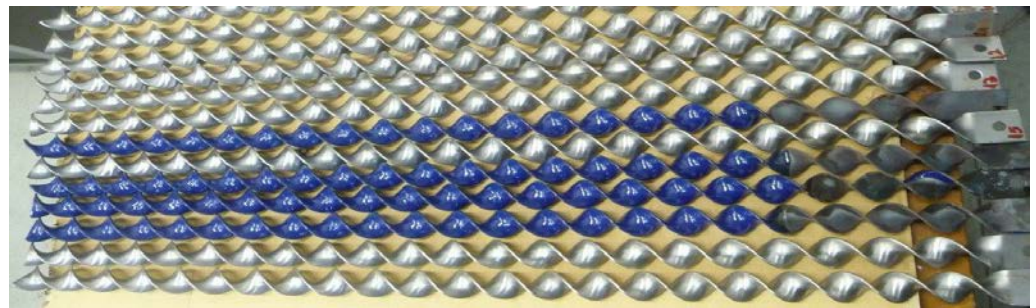
## FUME GAS CONDENSER

### INSTALATION DESCRIPTION

*Fume gas condenser installed in  
an Urban Waste Power Plant  
(September 2014)*



*Passage of the fumes*



*Turbulator*

**FUME GAS CONDENSER**

**INSTALATION DESCRIPTION**

*Fume gas condenser installed in  
an Urban Waste Power Plant  
(September 2014)*



## FUME GAS CONDENSER

### ANALYSIS OF CONDENSED FLUID

SAMPLE	Condensate Without Neutralized	Neutralized Condensate
pH	3.65	7.23
Conductivity ( $\mu\text{S}/\text{cm}$ )	329	372
Turbidity (NTU)	13.9	1.69
Colour (Pt-Co)	30	<5
Total suspended solids (mg/L)	8.5	3.7
Total solids (mg/L)		
Sulphates ( $\text{mg SO}_4^{2-}/\text{L}$ )	66.8	41.3
Chloride ( $\text{mg Cl}^-/\text{L}$ )	35.2	32.3
Fluoride ( $\text{mg F}^-/\text{L}$ )	0.15	<0.1
Nitrite ( $\text{mg NO}_2^-/\text{L}$ )	<0.01	0.096
Nitrate ( $\text{mg NO}_3^-/\text{L}$ )	1.01	0.44
$\text{HPO}_4^{2-}$ ( $\text{mg HPO}_4^{2-}/\text{L}$ )	1.13	<0.1
Bromide ( $\text{mg Br}^-/\text{L}$ )	0.13	0.18
NTK ( $\text{mg N}/\text{L}$ )	29.2	30.2
Ammonium ( $\text{mg NH}_4^+/\text{L}$ )	32.4	27.4
Total DQO ( $\text{mgO}_2/\text{L}$ )	<25	<25
Soluble DQO ( $\text{mgO}_2/\text{L}$ )	<25	<25
TOC ( $\text{mgC}/\text{L}$ )	<5	<5

SAMPLE	Condensate Without Neutralized	Neutralized Condensate
Mg	1,82	39,4
Ca	7,37	2,31
Na	5,22	0,78
K	0,55	0,52
As	< 0,012	< 0,012
Al	< 0,012	< 0,012
Cu	0,093	< 0,012
Cr	< 0,012	< 0,012
Fe	< 0,012	< 0,012
Ni	< 0,01	< 0,012
Cd	< 0,012	< 0,012
Pb	< 0,012	< 0,012
Zn	0.13	< 0,012

**FUME GAS CONDENSER**

**RESULTS (NO CERAMIC ELEMENTS)**

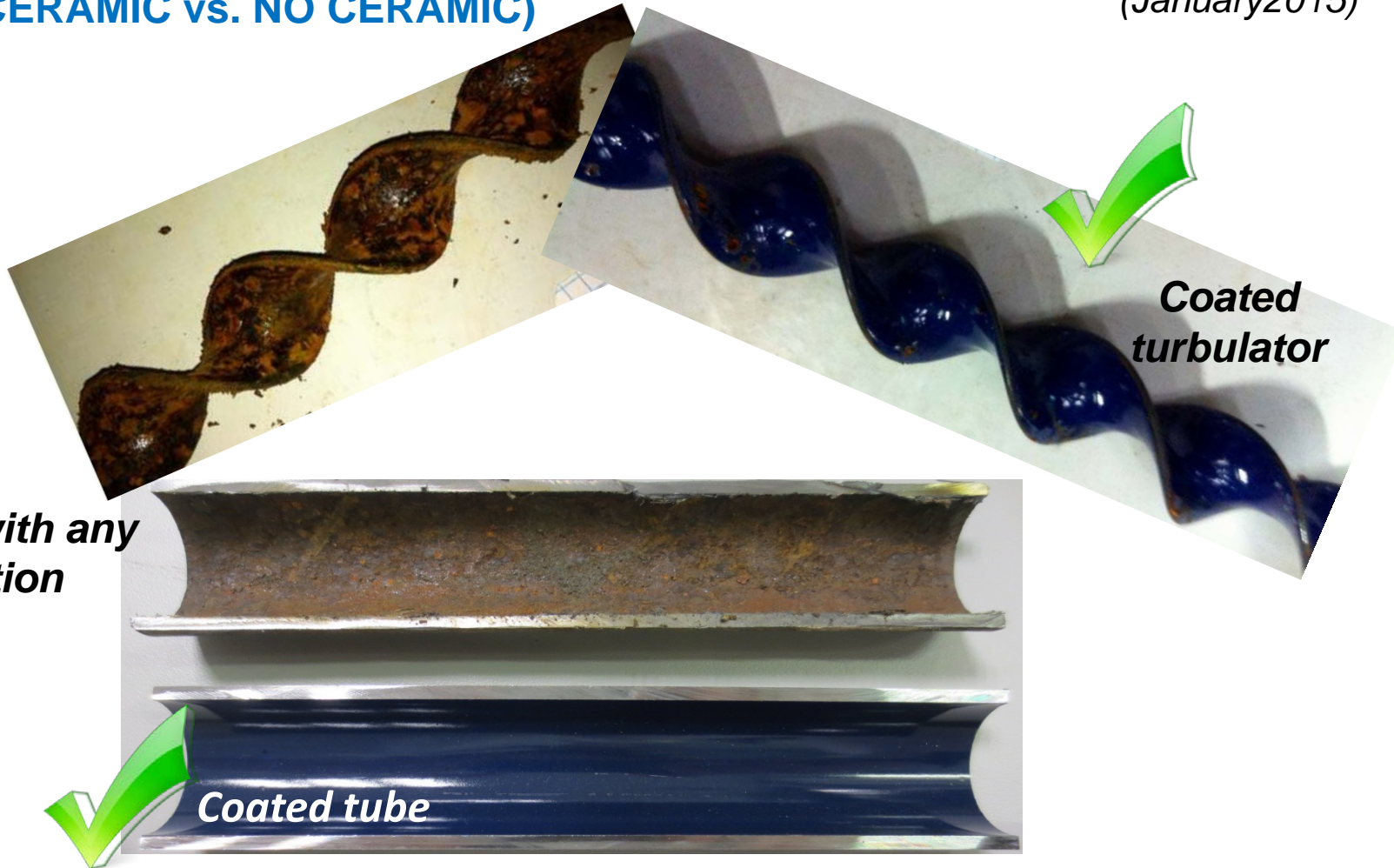
*Fume gas condenser installed in  
an Urban Waste Power Plant  
(September 2014)*



**FUME GAS CONDENSER**

**RESULTS (CERAMIC vs. NO CERAMIC)**

*Fume gas condenser installed in  
an Urban Waste Power Plant  
(January 2015)*



**FUME GAS CONDENSER**

*Fume gas condenser installed in  
an Urban Waste Power Plant  
(January 2015)*



## FUME GAS CONDENSER

*Theoretical results from a condenser:*  
*Flow fumes: 150000 Nm<sup>3</sup>/h a 145°C; 16% H<sub>2</sub>O*

### *Quantity of HEAT extracted from the fumes as a function of the final temperature*

Final T° (°C) (°F)	W dew point (H <sub>2</sub> O g/kgHS)	Condensed H <sub>2</sub> O (g/kgHS)
55°C 131°F	115,33	2,54
50°C 122°F	86,85	31,01
45°C 113°F	65,42	52,45
40°C 104°F	48,15	68,72

### *Quantity of Water to extract total fume emissions*

**3860 kg/h** If the fumes flow's Temperature decreased until 55°C (131°F)

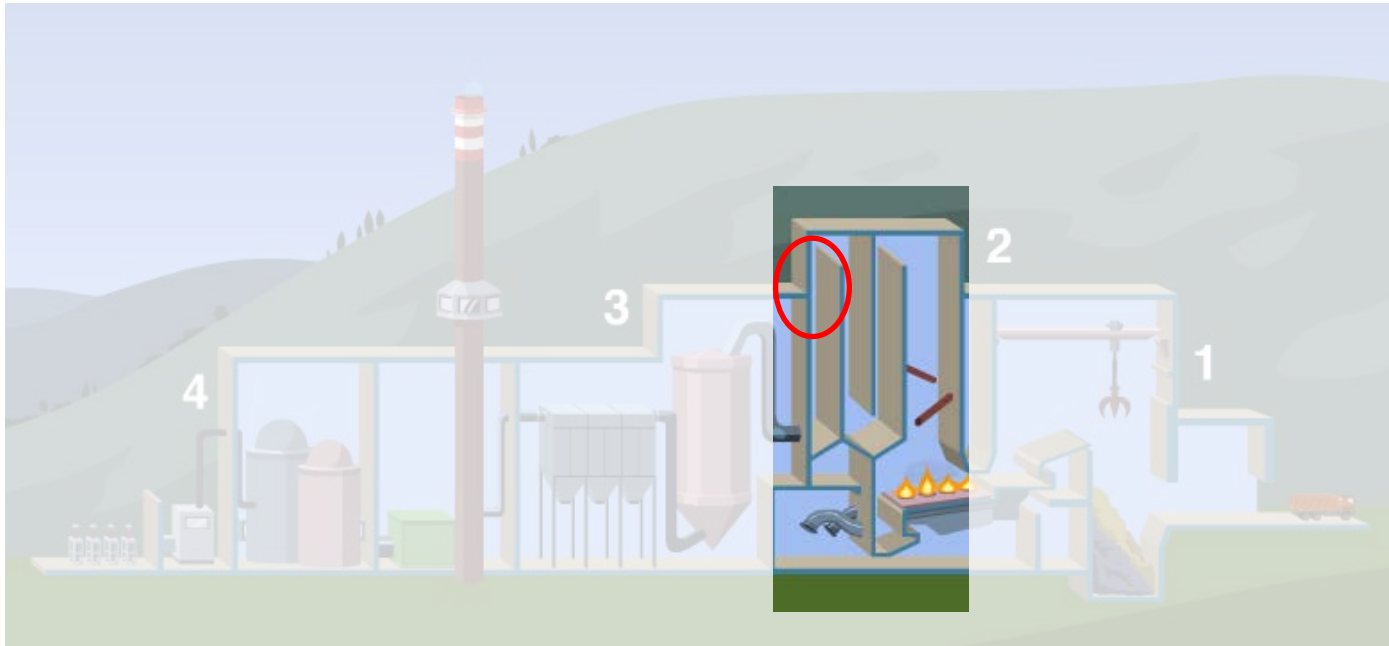
**4708 kg/h** If the fumes flow's Temperature decreased until 50°C (122°F)

**7963 kg/h** If the fumes flow's Temperature decreased until 45°C (113°F)

**10433 kg/h** If the fumes flow's Temperature decreased until 40°C (104°F)



# Reheater

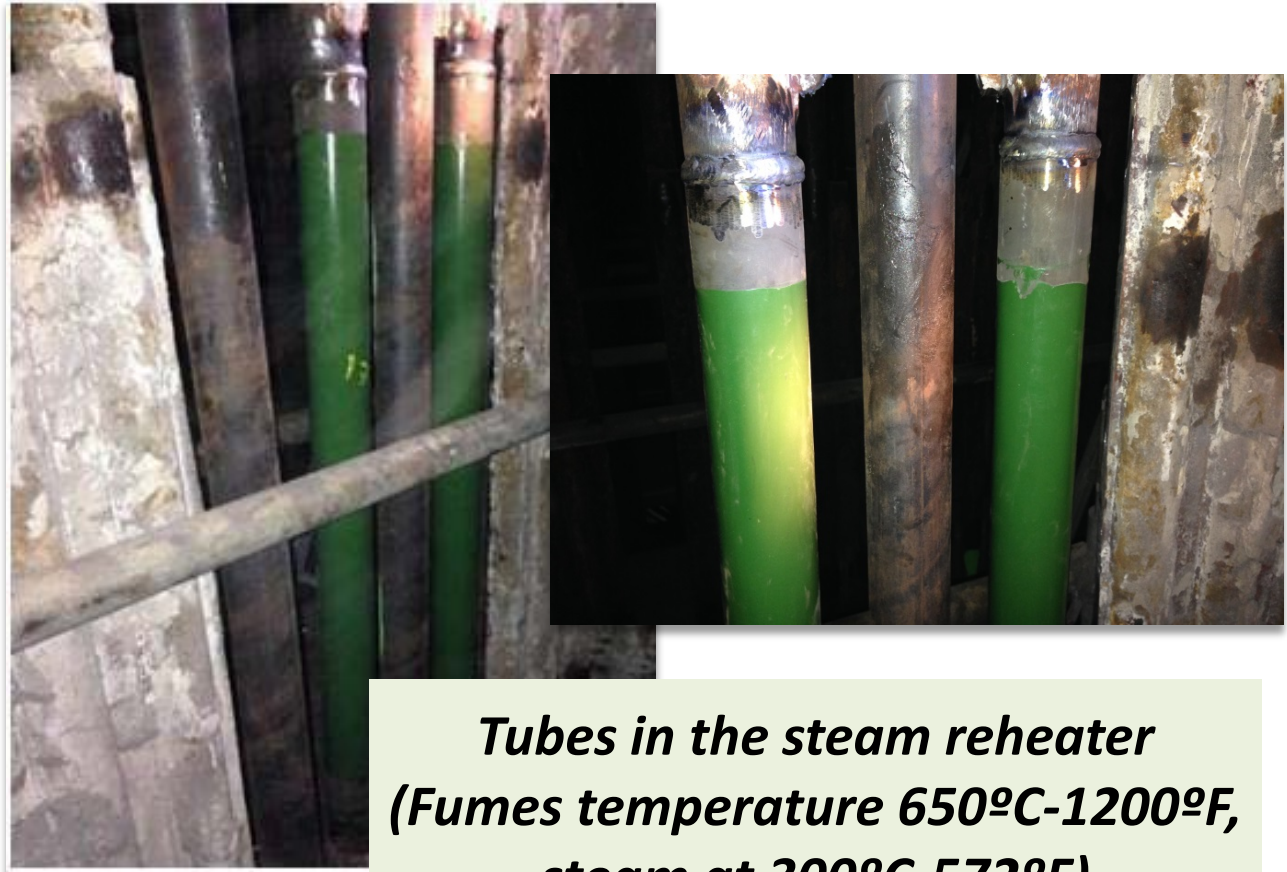


## Reheater

*Urban Garbage Power plant.  
Installed March 2014*



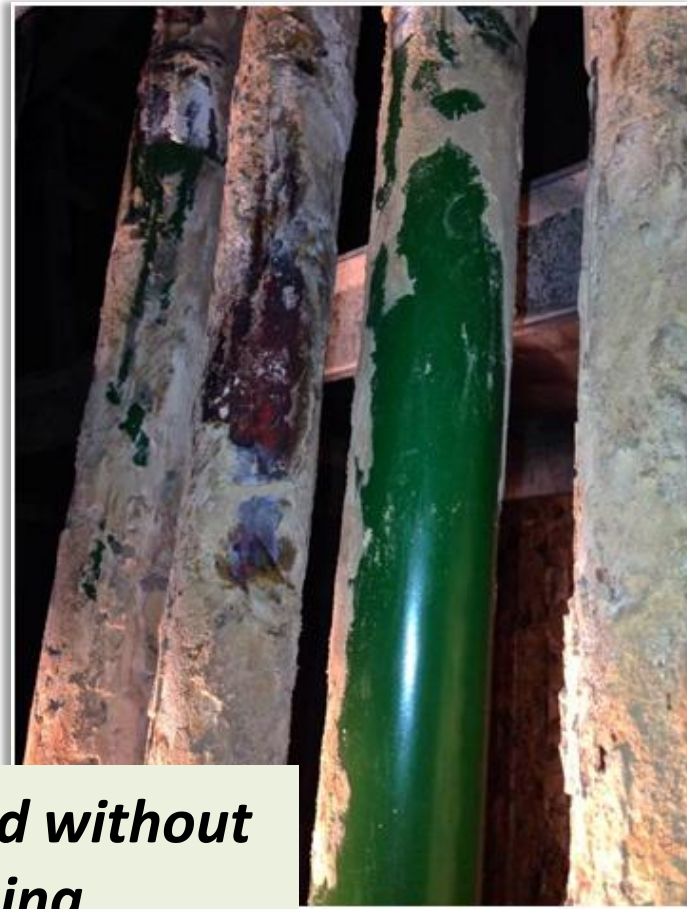
***Before heat treatment.***



***Tubes in the steam reheater  
(Fumes temperature 650°C-1200°F,  
steam at 300°C-572°F)***

## Reheater

*Urban Garbage Power plant.  
Tubes were in service during 13 months*



***Tubes untouched without  
any cleaning***

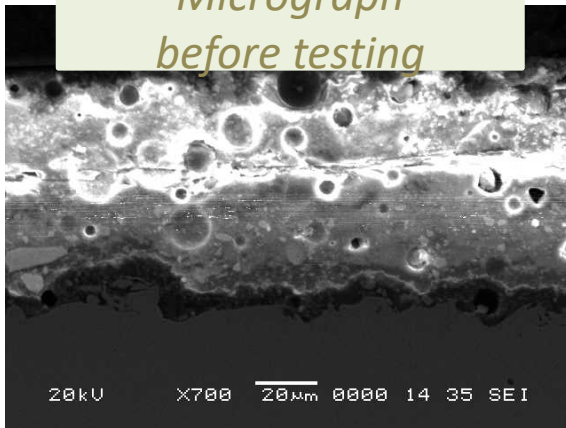
## Reheater

*Urban Garbage Power plant.  
Tubes were in service during 13 months*

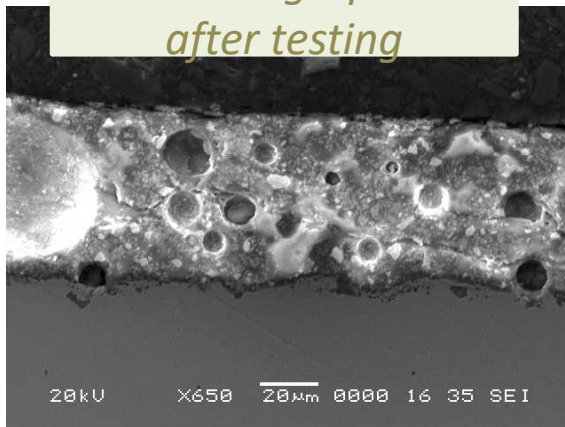


## Reheater

*Micrograph  
before testing*



*Micrograph  
after testing*



*Urban Garbage Power plant.  
Tubes were in service during 13 months*



## Reheater

*Urban Garbage Power plant.  
To be installed on April 2015*



## Reheater

*Urban Garbage Power plant.  
Installed April 2015*

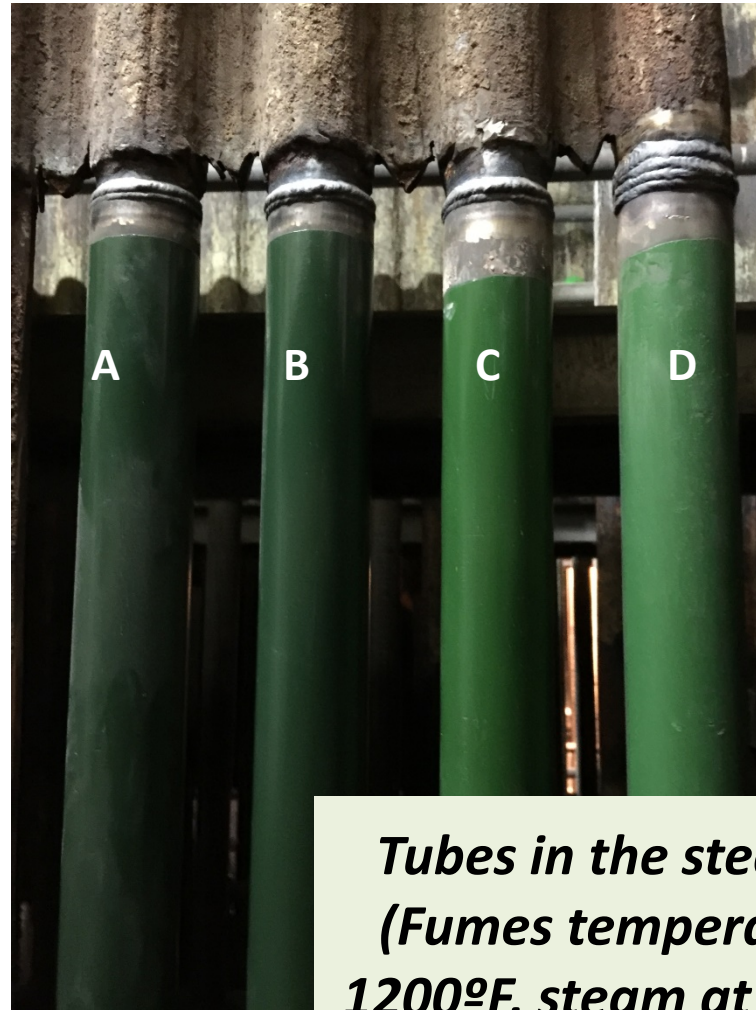


## Reheater

*Urban Garbage Power plant.  
Installed April 2015*

### Ceramic coatings:

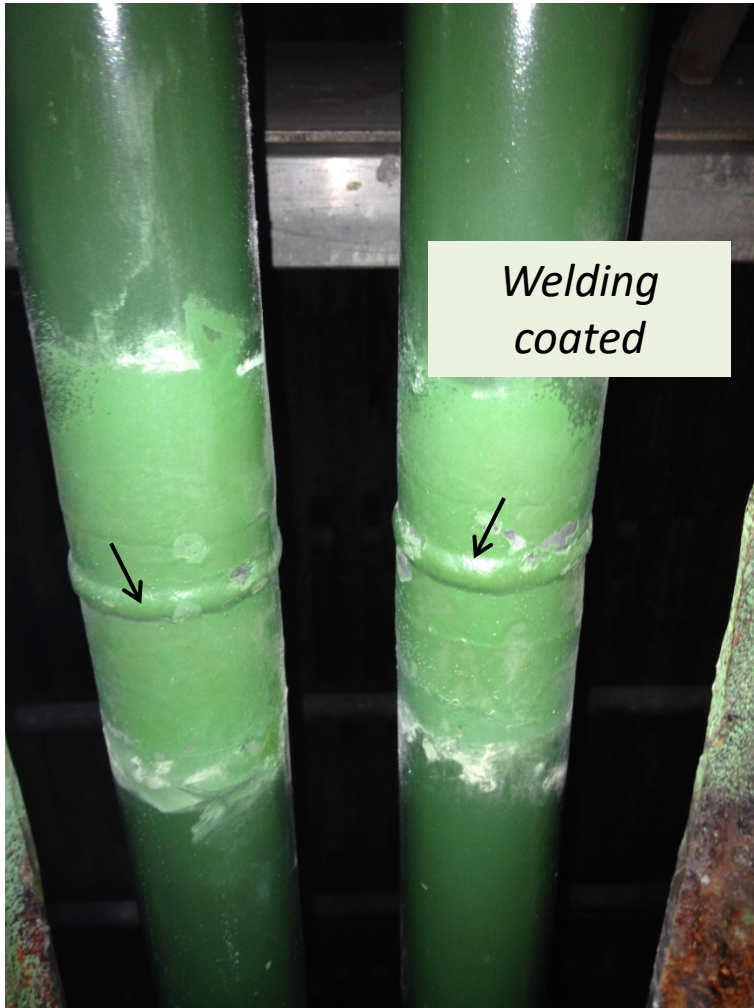
- A and B are the same coating
- C Tube re-used from last year
- D the same coating than tube C



*Tubes in the steam reheater  
(Fumes temperature 750°C-  
1200°F, steam at 300°C-572°F)*



## Reheater



# Reheater

## Thermocouple



**600°C**



**400°C**

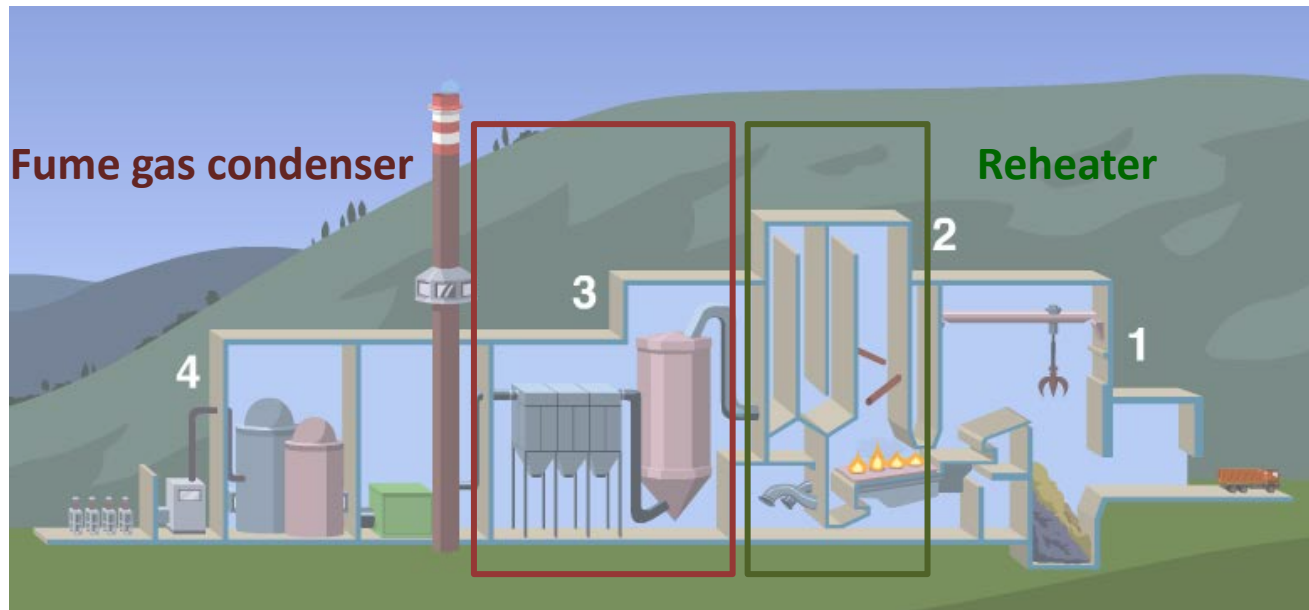
## Reheater

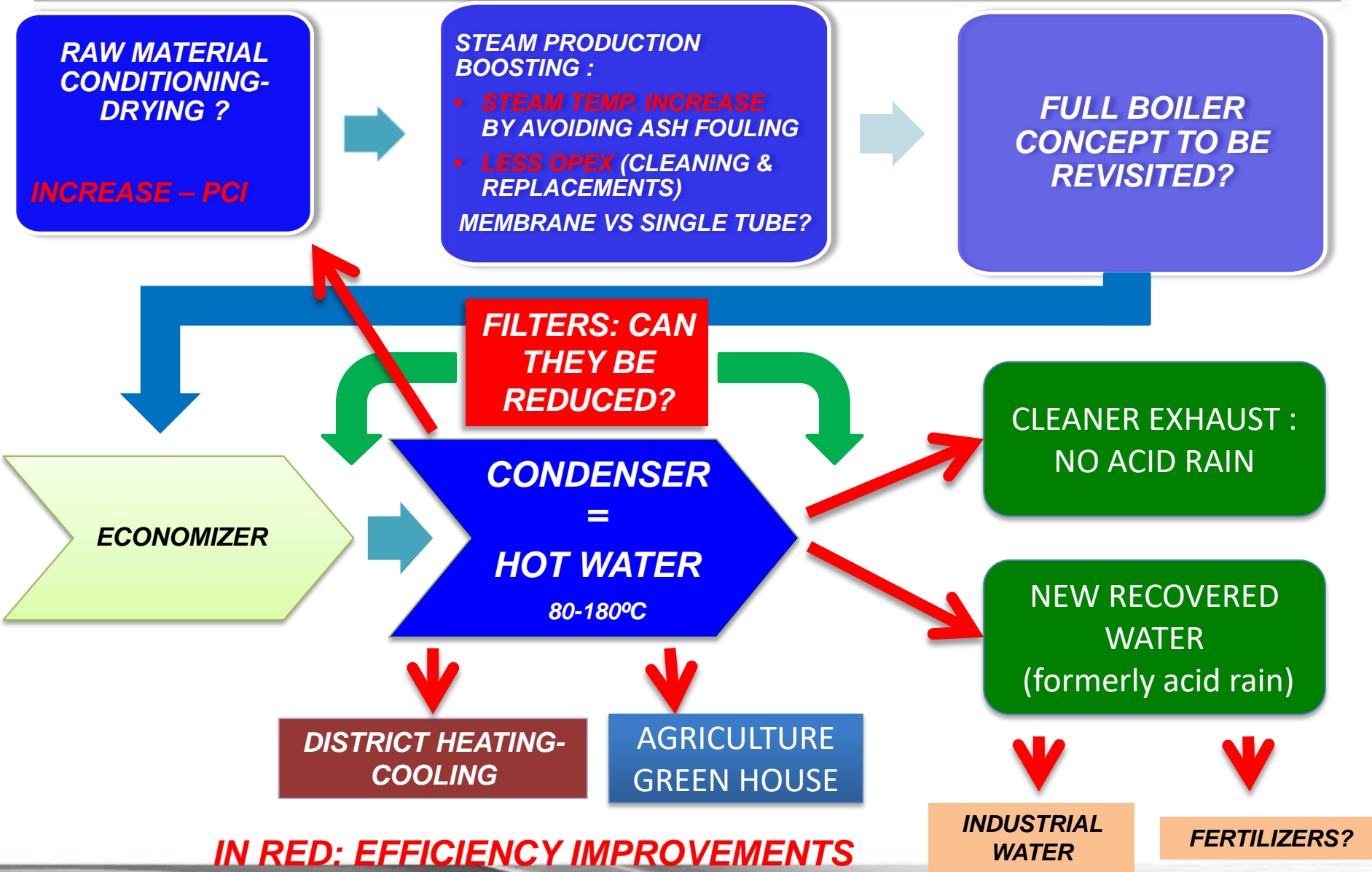
### ***New improvement*** opportunities opened by these results ***in the boiler operational efficiency***

- Much longer life expectation for the tubing
- As ashes ***do not stick to the tubes***: cleaning “shakes” can be reduced if not avoided
- As ashes ***do not stick to the tubes***: Thermal efficiency will remain more constant as ash insulation will not grow, at least not as per today
- As ashes ***do not stick to the tubes***: It might become possible to increase the steam temperature thus increasing the Turbine efficiency

This coating is also successfully applied to coat Thermocouple tubes made in AISI 310 with longer life than high Nickel alloy ones

## SUMMARY OF THE TEST RESULTS IN ZABALGARBI





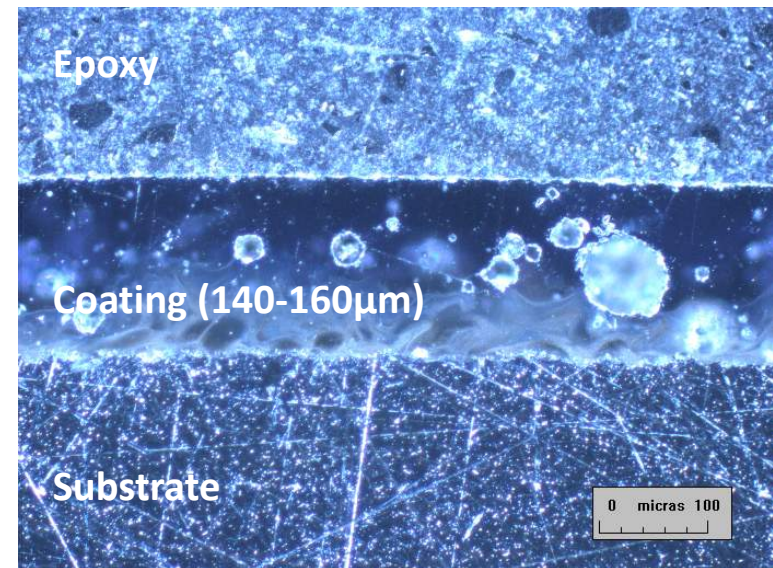
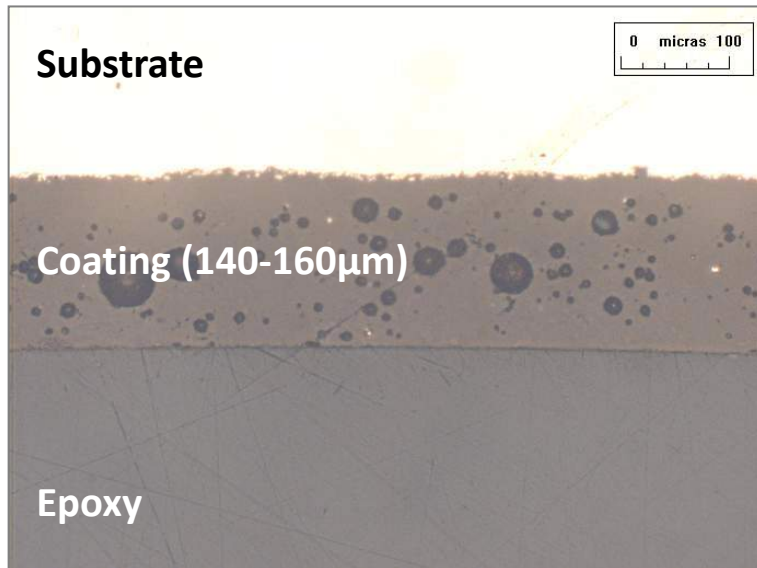
## CERAMIC PROPERTIES



## Basics on Specialty ceramic coatings

### Microstructure

Thickness: **Optical microscopy**

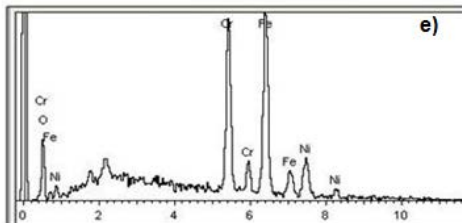
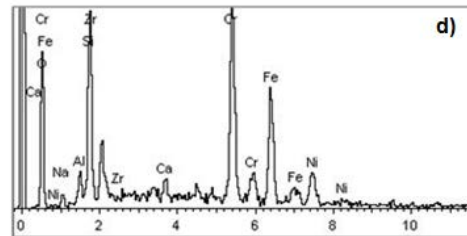
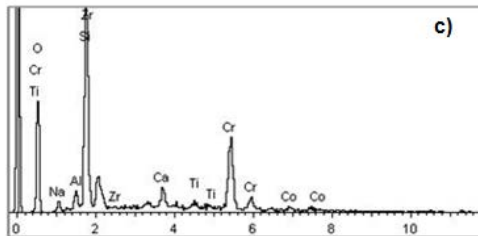
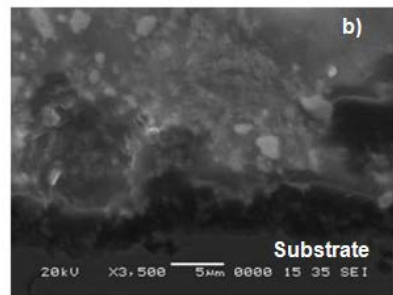
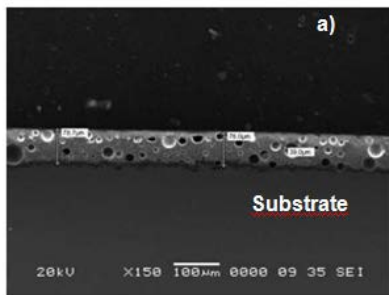


**Continuous and homogeneous coating.  
Thickness can be adjust modifying suspension  
parameters based on final coating properties**

# Basics on Specialty ceramic coatings

## Microstructure

## Chemical bonding

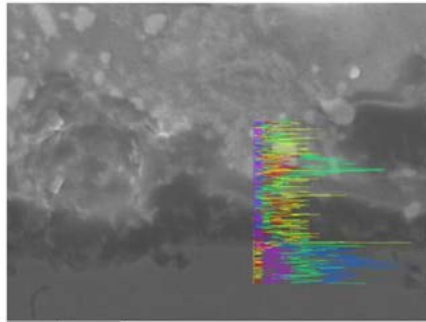


SEM images of inner structure sintered in normal conditions. a) Ceramic coating micrograph, b) Micrograph of the interface between the steel substrate and the ceramic coating showing the diffusion area c) Ceramic coating EDX results, d) the interface e) Metal substrate

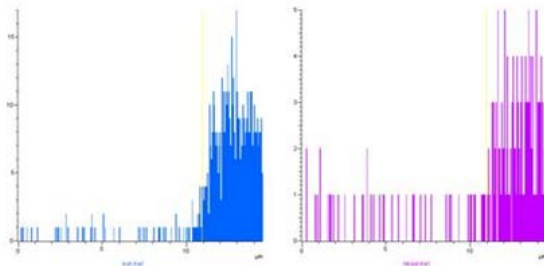
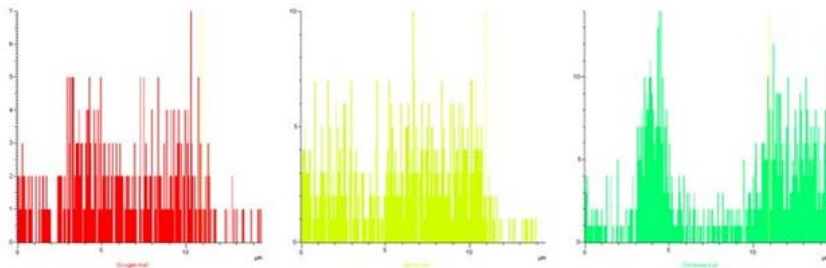


## Basics on Specialty ceramic coatings

### Microstructure



Oxygen  
Silicon  
Chromium  
Iron  
Nickel



### Chemical bonding

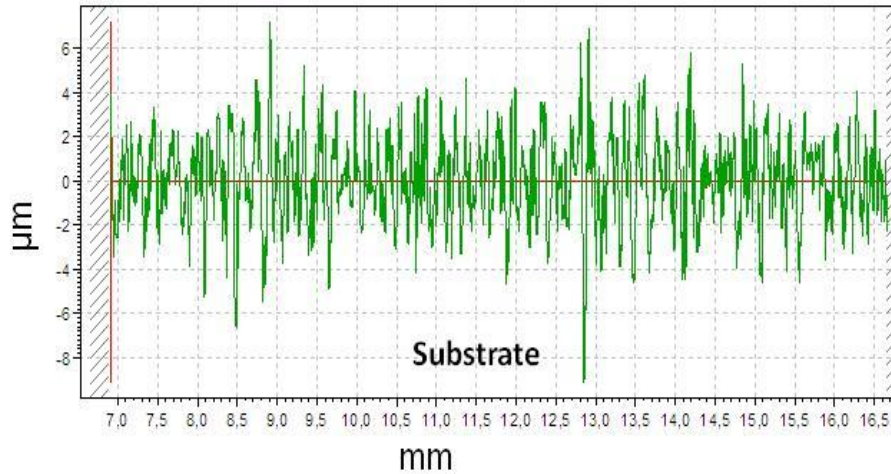


Mapping of SEM-EDX images of ceramic coating sintered in normal conditions in the interface between the substrate and the ceramic coating

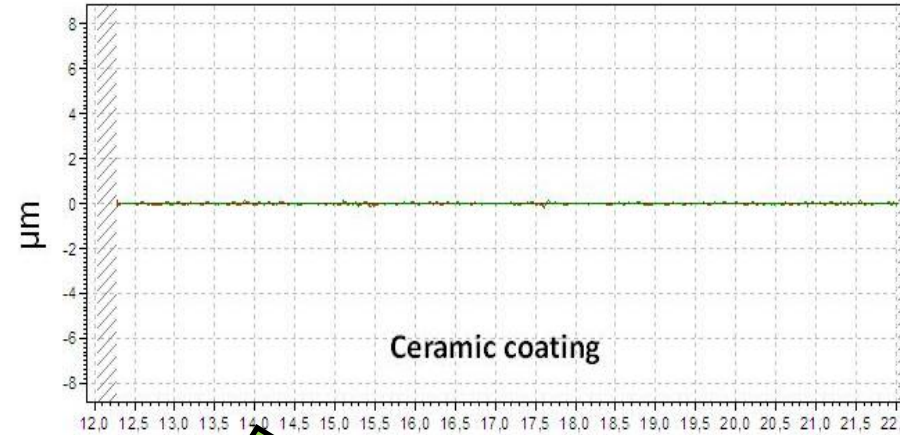
# Basics on Specialty ceramic coatings

## Microstructure

## Roughness: Profilometry and AFM

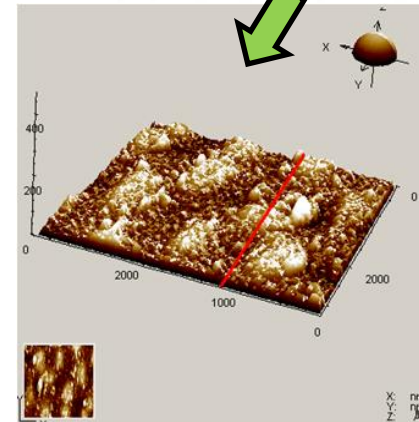


Substrate



Ceramic coating

**IMPORTANT DECREASE OF  
ROUGHNESS, AVOIDING CORROSIVE  
PARTICLES ADHESION**



## Basics on Specialty ceramic coatings

### Mechanical

**CERAMIC COATING  
IS HARDER THAN  
THE SUBSTRATE**

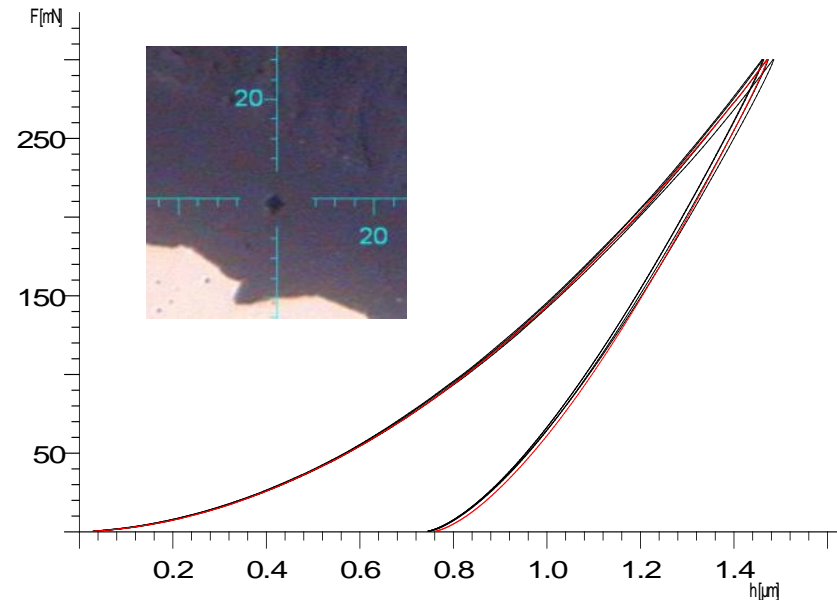
**HARDNESS (HRC)**

64,1

**ELASTIC MODULUS EIT  
(GPa)**

87

### Hardness test



**THE IMPROVEMENT OF HARDENESS AND ELASTICITY IS POSSIBLE  
MODIFYING THE STRUCTURE AND COMPOSITION OF CERAMIC  
COMPOUNDS IN ORDER TO CERAMIC COATING FINAL  
PROPERTIES REQUIRED**

## Basics on Specialty ceramic coatings

### Mechanical

### Abrasion resistance: Taber

0 cycles



10000 cycles



Mass loss for 10000 cycles:

$$\Delta w_n = \langle w_0 \rangle - \langle w_n \rangle$$

- **Substrate**

$$\Delta w_{10000} = 94.783 - 94.725$$

$$\Delta w_{10000} = 58 \text{ mg}$$

- **Ceramic coating**







$$\Delta w_{10000} = 119.377 - 119.374$$

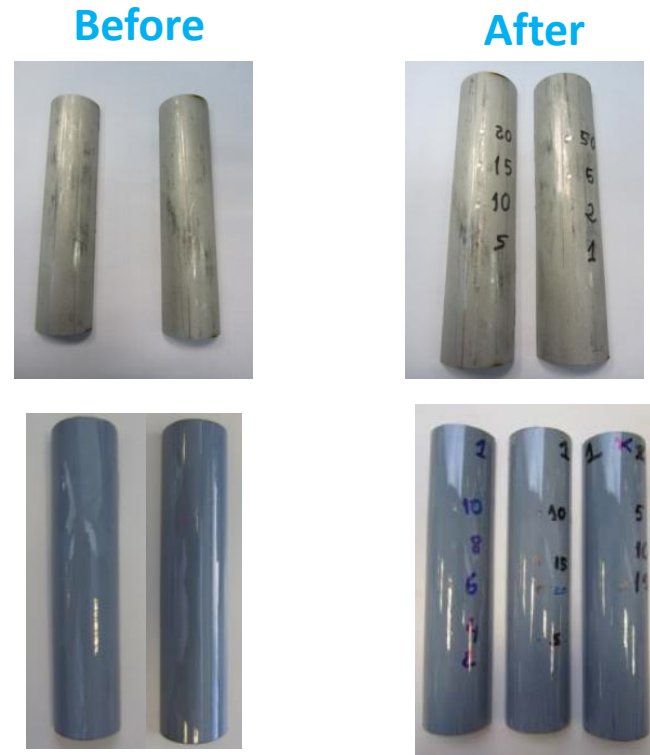
$$\Delta w_{10000} = 3 \text{ mg}$$

# Basics on Specialty ceramic coatings

## Mechanical

## Impact resistance

High	Stainless Steel	Ceramic coating
5 cm		
10 cm		
15 cm		

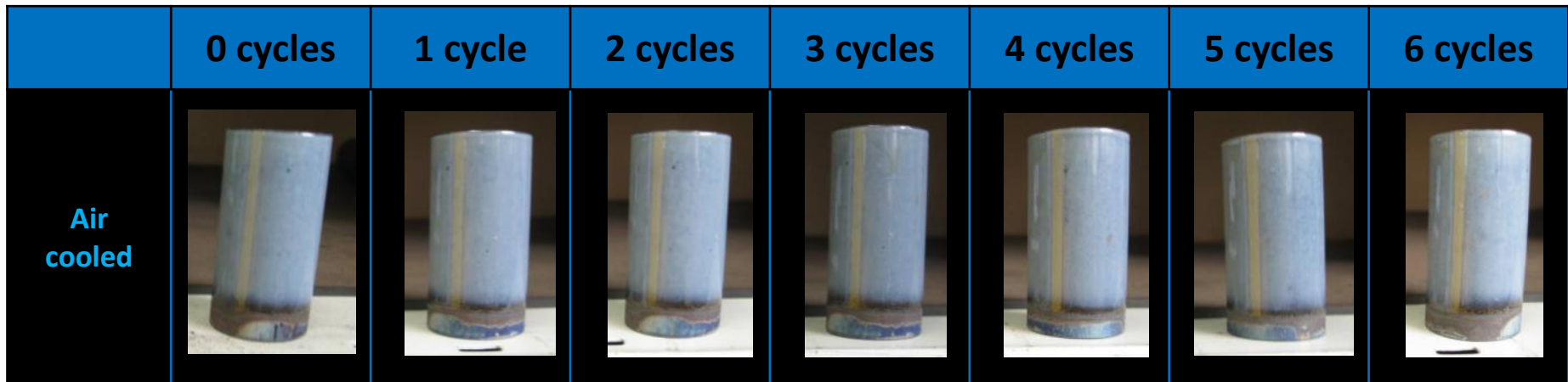


**NO CERAMIC COATING  
DETACHMENTS AT MEDIUM LOADS:  
GOOD ADHERENCE**

## Basics on Specialty ceramic coatings

Mechanical

Thermal cycling (450°C)



**MODIFYING CERAMICS  
COMPOUNDS IS POSSIBLE TO  
OBTAIN CERAMIC COATING WITH  
DIFFERENTS TEMPERATURE  
RESISTANCE**

# Basics on Specialty ceramic coatings

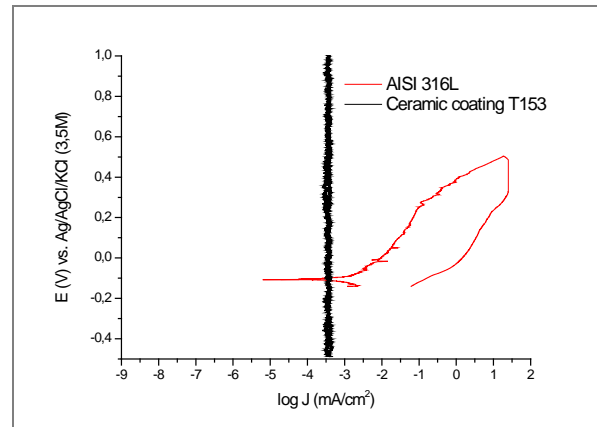
## Corrosion Resistance

### -Pitting potential measurement:

- JIS G-0577:2005

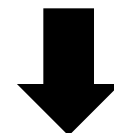
#### - Conditions:

- Solution: 5% NaCl, 25 °C
- Counter electrode: Platinum
- Reference electrode: Ag/AgCl
- The tested surface was fully immersed in test solution for 2 h
- The test was conducted by potentiokinetic method from natural electrode potential to 1 mA/cm<sup>2</sup> of anodic current density
- Potential sweeping velocity: 1mV/s

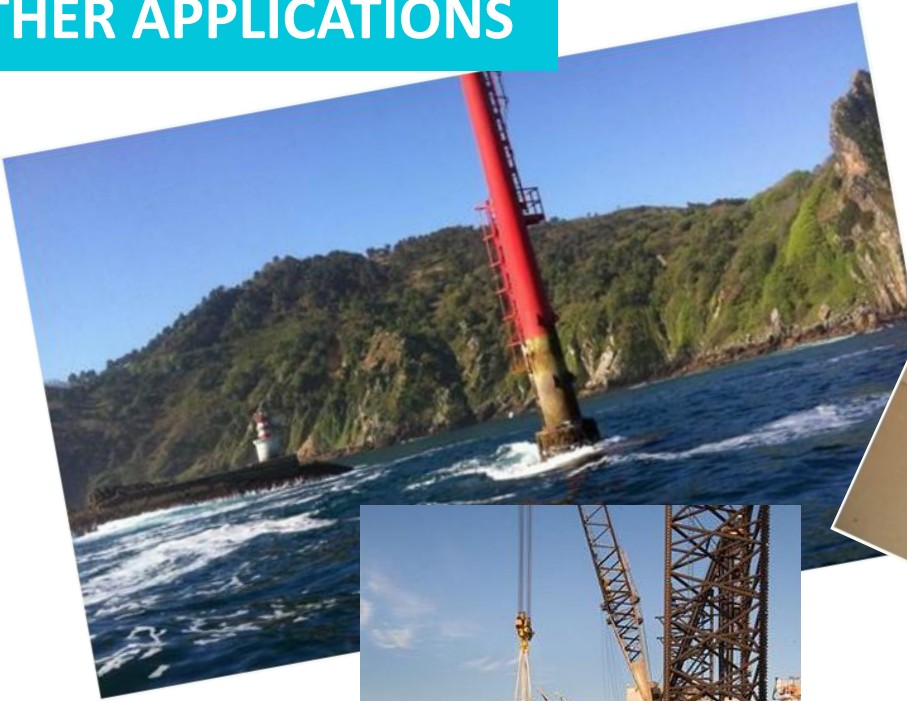


	$E_{corr}$ (mV vs Ag/AgCl)	$\text{Log } J_{corr}$ (mA/cm <sup>2</sup> )
<b>Stainless Steel</b>	-106	-2.54
<b>Ceramic coating</b>	<b>UNALTERED</b>	

**CORROSION**



## OTHER APPLICATIONS







- <http://www.sartechengineering.com>



- <http://www.kera-coat.com/index.html>



CERAMIC COATINGS  
BY INDUSTRIAL ELECTROPHORETIC DEPOSITION

**ESKERRIK ASKO  
MUCHAS GRACIAS  
THANK YOU VERY MUCH  
MERCİ BEACOUPI  
DANKESCHÖN**