



SUMMARY
31/12/2025



GREEN CASTING LIFE PROJECT

ALLOY STEEL CASTINGS
mm | **METALÚRGICA MADRILEÑA S.A.**
ALLOY IRON CASTINGS



I- INTRODUCTION

3- MISSION

Towards zero emissions in European ferrous foundries using inorganic binder systems.

GREENCASTING

TOWARDS ZERO EMISSIONS IN EUROPEAN FERROUS FOUNDRIES USING INORGANIC BINDER SYSTEMS

OBJECTIVES

Green Casting LIFE aims to demonstrate the technical and environmental feasibility of using **inorganic binders** instead of traditional organic ones, in **ferrous foundries**.

- Develop **tailor made inorganic binder systems** solutions
- Demonstrate three different types of **sand reclamation methods**
- Implement and validate inorganic binders in **six flagship foundries** from five European countries
- Exploitation and replication; assist **15 selected foundries** in testing inorganic binders

EXPECTED RESULTS

- Full scale **IMPLEMENTATION** and **DEMONSTRATION** of tailor-made inorganic binders in six flagship foundries in Europe by step-by-step implementation plan, inorganic foundry **SAND RECLAIMABILITY** AND **WASTE** solutions. Piloting actions in 15 followers foundries.
- Emission reduction by 80-90 % (VOC, PM, NOx, SO2...)
- Indoor air quality improvement by 70 % (CO, PM, phenols, formaldehyde...)
- Training workshops in partner countries
- Feasible reclamation methods for each flagship foundries

Coordinator

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Partners

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AGH (AGENCIJA ZA VEŠTAČENJE I PROJEKTOVANJE)
FA (FABRICA ZA VEŠTAČENJE I PROJEKTOVANJE)

AZTERLAN (PARTNER OF ANOVA RESEARCH)
Cetim
FOUNDRY TERM
RAILWAY SYSTEMS

AINS GROUP
Mh (METALURGICA MADALESA, S.A.)
peak
SAND TEAM
Valu & mehaanika

Financed by the European Union



5- METALÚRGICA MADRILEÑA SA - COMPANY DESCRIPTION

- ✓ Steel foundry since 1953.
- ✓ Located in Alcalá de Henares (Madrid) España – Spain.
- ✓ Three production lines, one by green sand process and two chemical no bake sand process.
- ✓ Production capability for weight is range from 5 kgs to 2.500 Kg, both for long runs of thousand parts.
- ✓ With chemical sand, normal weights are from 100 Kg to 2.500 Kg, but it can go up to 5 Kg



GREEN SAND PROCESS





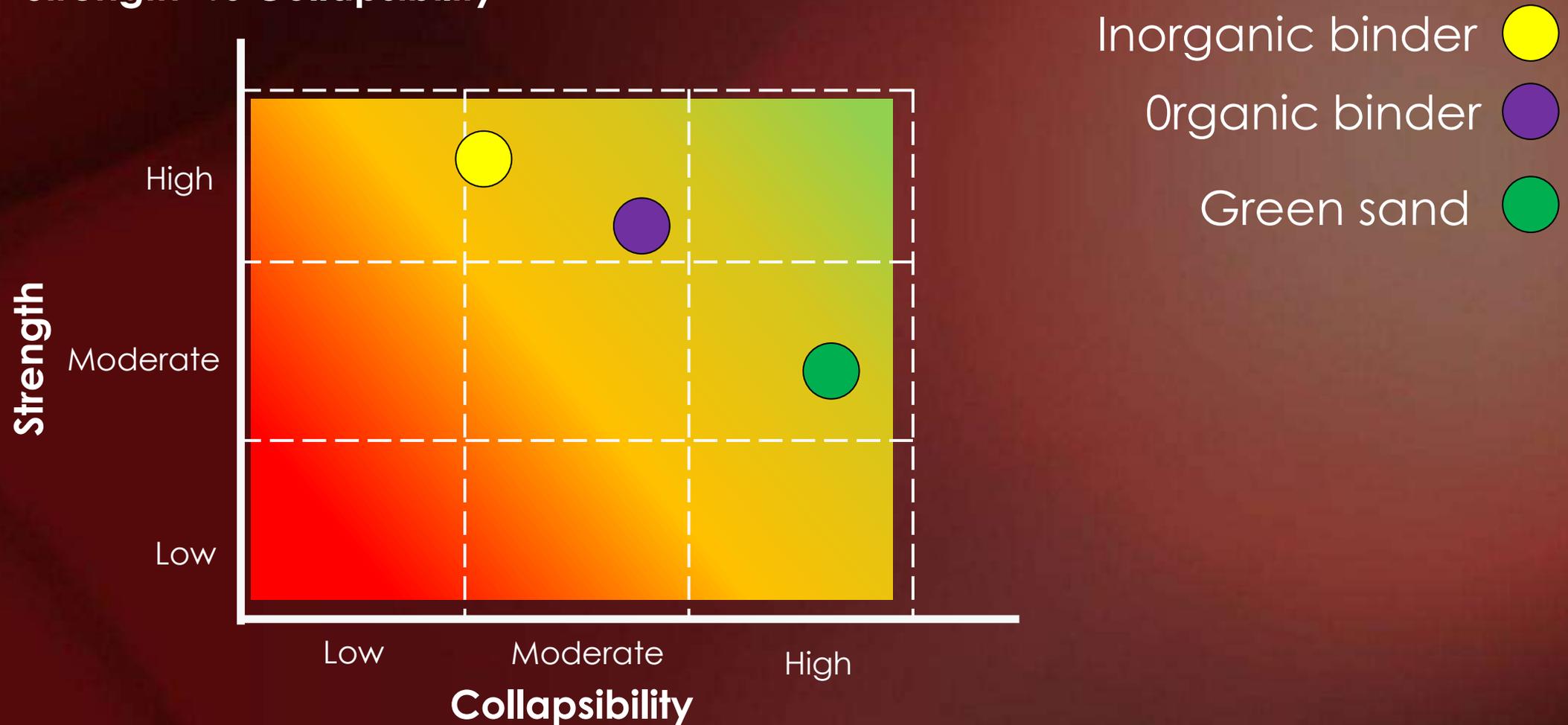
CHEMICAL SAND PROCESS



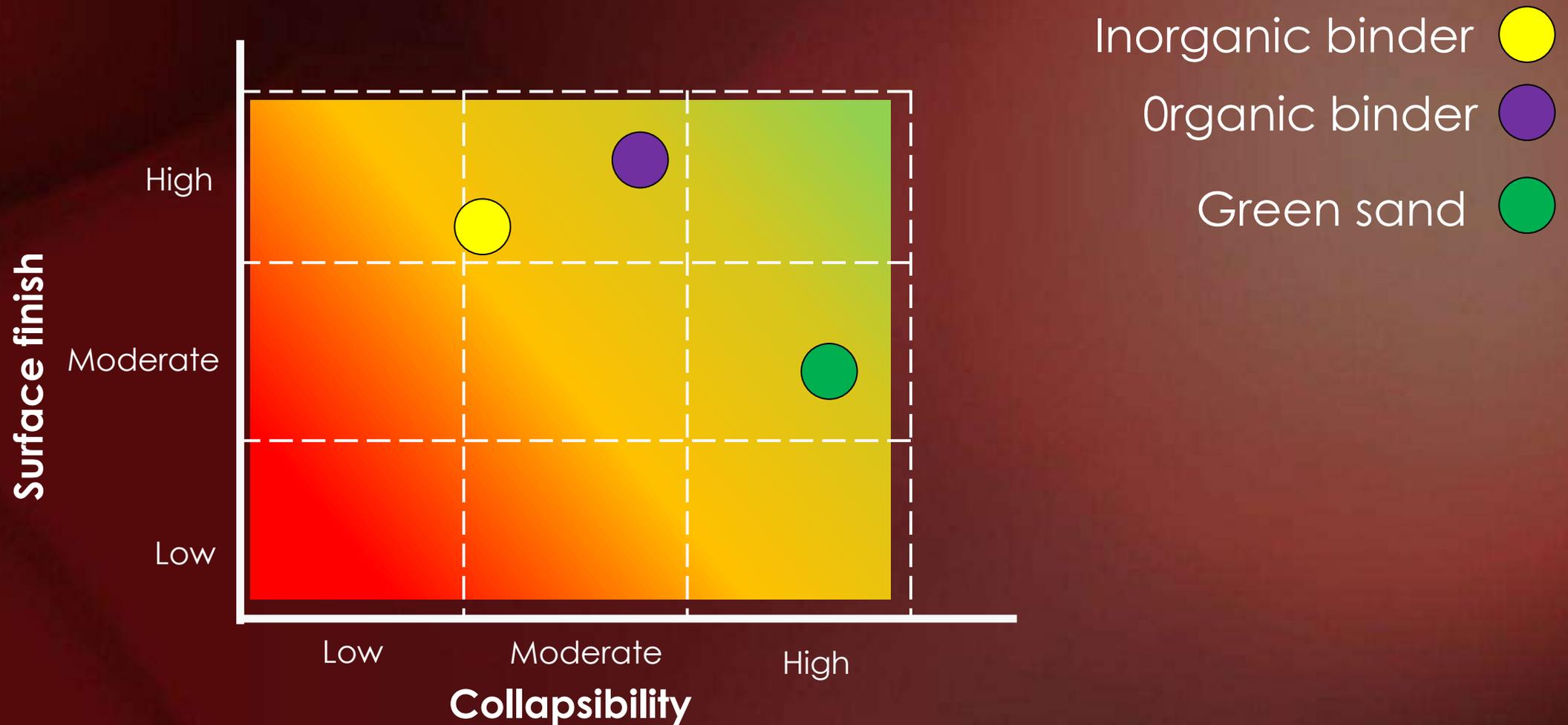


6- PROBLEM DESCRIPTION. JUSTIFICATION OF OUR PARTICIPATION IN THE PROJECT.

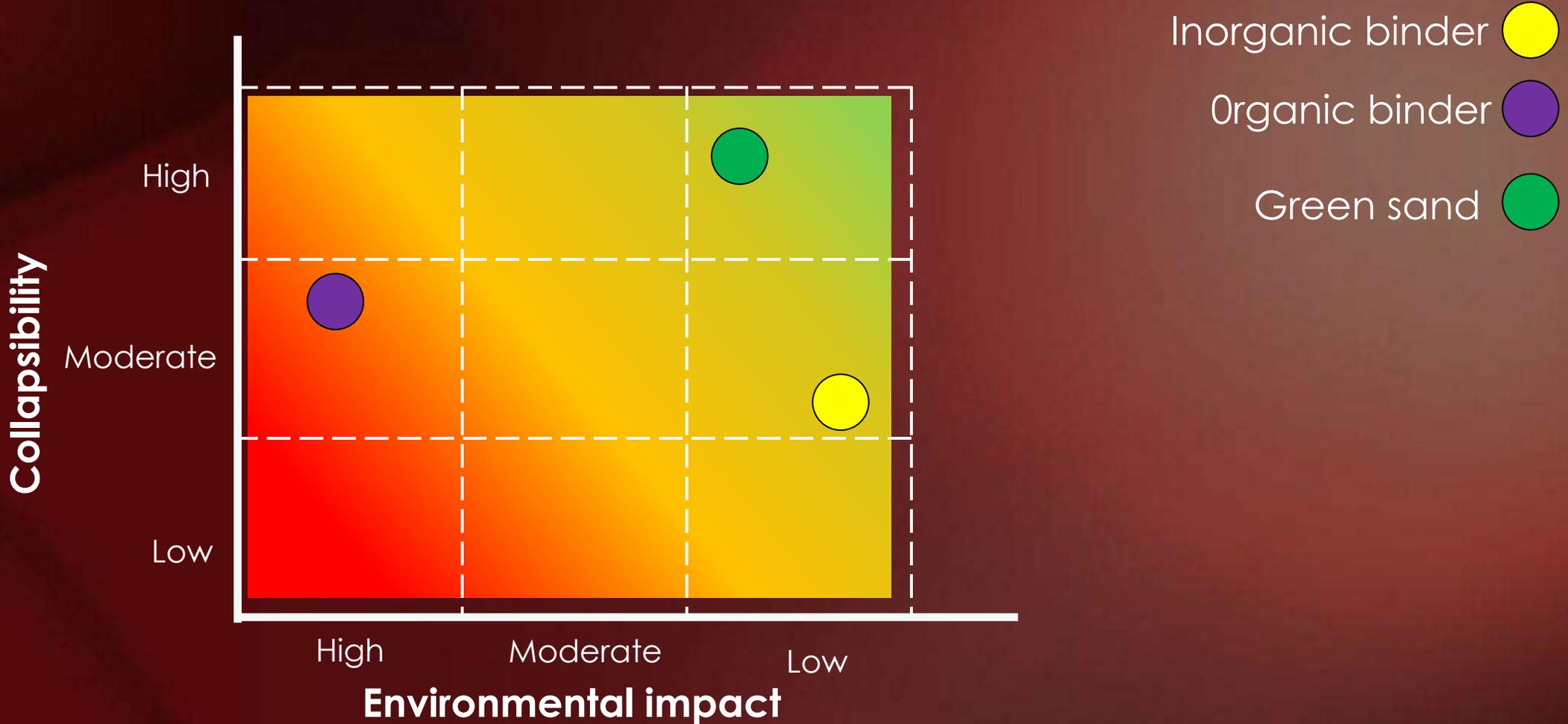
Strength vs Collapsibility



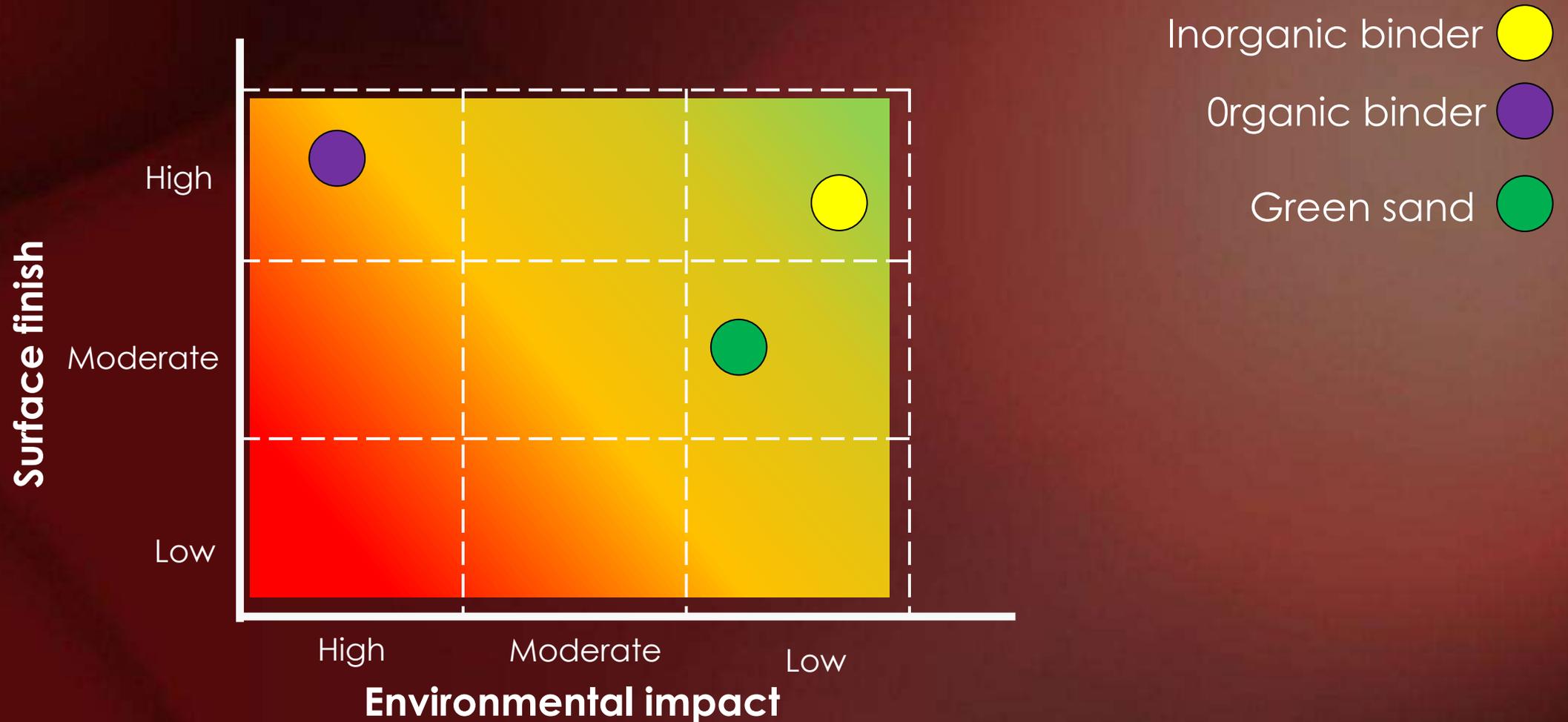
Surface finish vs Collapsibility



Collapsibility vs Environmental impact



Surface finish vs Environmental impact



CONCLUSION.

It is necessary to launch a project to demonstrate, promote and support iron and steel foundries in the transition from organic binders to inorganic binders.



II- WORK DEVELOPMENT (WP1)

1-WORK PACKAGES FOR METALÚRGICA MADRILEÑA SA

- WP1 - Project management
- WP4 - Full scale implementation and validation of the of innovative inorganic binders in flagship foundries
- WP5 - Foundry sand reclaimability and reuse assessment
- WP7 - Sustainable, replication and exploitation of project results
- WP8 - Dissemination and communication

2- COMPANY PROCESSES AFFECTED

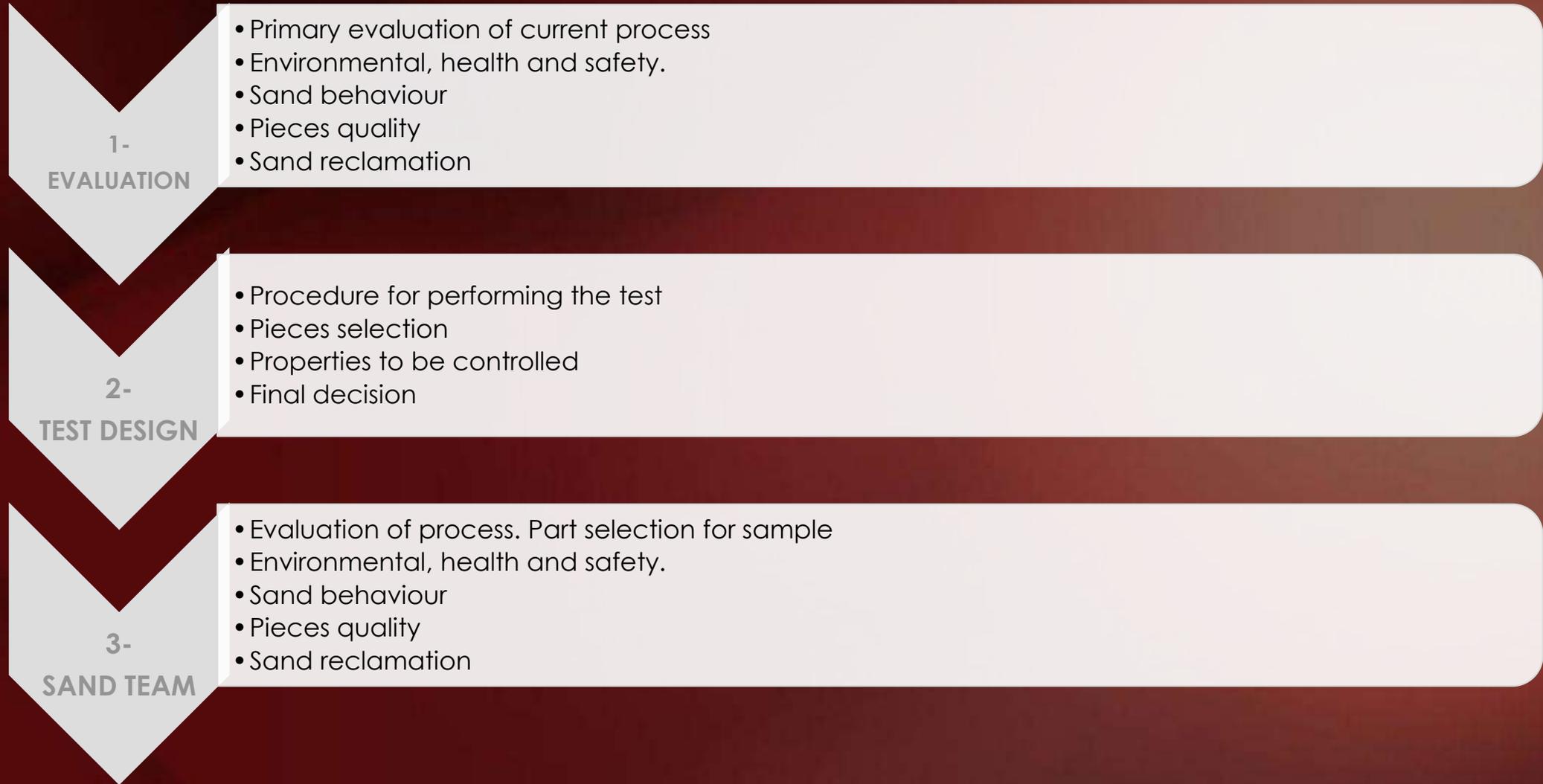
1. Chemical moulding sand preparation.
2. Core chemical sand preparation. (silica and chromite sand)
3. Mold preparation.
4. Core preparation.
5. Pouring
6. Shake out.
7. Sand reclaiming.
8. Parts cleaning.
9. Parts quality control. Cracks, blow holes and/or sand trawls.



III- TEST PLANNING (WP1)



TEST PLANNING





7- CONCLUSIONS

- Main conclusions
- Dissemination and communication
- Next steps planification

8- DISSEMINATION & COMUNICATION

- Web page
- Brochures.
- Cast Forge
- Publications in technical dissemination journals.
- Local technical schools.

9- NEXT STEPS

- Study the behaviour of the inorganic binders with chromite sand.
- Study the behaviour of the inorganic binders with olivine sand.
- Increase the percentage of sand reclaimed
- Study the possibility of external use of the rejected sand in cement or ceramic manufacturing, avoiding sending to landfill.



IV- WORK TEAM (WP1)

1. PERSONNEL PARTICIPATING IN THE PROJECT

Total 17 persons have participated in the project.



3. EXTERNAL COOPERATION

- ✓ AZTERLAN
- ✓ FEAF
- ✓ MEEHANITE





V- PROJECT DEVELOPMENT (WP2)

1. PRIMARY EVALUATION. EVALUATION OF CURRENT PROCESS

1.a) SAND TYPES

- Silica Sand
- Chromite Sand
- Olivine Sand (it will not be tested at first stage)
- Ceramic Sand (it will not be tested at first stage)

1.b) BINDERS

- Molds (reclaimed, new or mixed sand). Silicate – catalyst binder
 - 3,5 % binder on sand
 - 11% ester based on binder.
- Cores (always new sand). Organic and inorganic binders
 - 4% binder base on sand
 - carbon dioxide,
 - sometimes collapse. (6% on total sand weight)

1.c) EQUIPMENT FOR SAND AGLOMERATE

- For molds

- 2 continuous mixers
- 1 discontinuous sand mill

- For cores (and for test on molds)

- 1 Automatic discontinuous mill
- 3 Semi-automatic discontinuous mills

2. TEST DESIGN.

2.1 STAGES OF THE CONTROL PLAN

- a) General data.
- b) Pretest in supplier or external laboratory.
- c) Review of regulations and technical and legal standards.
- d) Design of a test plan.
- e) Validation and documentation
- f) Analysis of results and conclusions
- g) Final decision

2.2 MAIN PARAMETERS TO BE CONTROLLED AND REQUESTED VALUES

a) Results 1: TECHNICAL PROPERTIES OF CORES.

PROPERTIES AND PROCESS BEHAVIOR	LIMITS
Silica core hardness	40 – 70
Chromite core hardness	50 – 80
Bending resistance on silica test coupon (N/cm ²)	13 – 30
Bending resistance on chromite test coupon (N/cm ²)	13 – 30
Workshop temperature:	5 - 30°C
Laboratory temperature:	18 - 22°C

b) Results 2: EVALUATIVE RESULTS CORES MANUFACTURING

PROPERTIES AND PROCESS BEHAVIOR

Manufacturing process

Sand plasticity

Sand consistency

Sand permeability

Core cohesion

Superficial core state

Easy of core extraction from core box

Piece surface condition internal holes (cores)

Shop enviromental (smell or smoke)

c) Results 3: TECHNICAL PROPERTIES OF MOLDS.

PROPERTIES AND PROCESS BEHAVIOR	LIMITS
Silica top mold hardness	60 – 80
Silica bottom mold hardness	60 – 80
Bench life silica test coupon (min)	5 – 8 min
Bending resistance on silica test coupon (N/cm ²)	13 – 30
Bench life chromite test coupon (min)	5 – 8 min
Bending resistance on chromite test coupon (N/cm ²)	13 – 30
Workshop temperature:	5 - 30°C
Laboratory temperature:	18 - 22°C

All technical values are average of 4 measurements

d) Results 4: EVALUATIVE RESULTS MOLDS MANUFACTURING

PROPERTIES AND PROCESS BEHAVIOR

Manufacturing process

Sand plasticity

Sand consistency

Sand permeability

Mold cohesion

Superficial mold state

Easy of mold extraction from pattern

Piece surface condition

Shop enviromental (smell or smoke)

e) Results 5: EVALUATIVE RESULTS AFTER CLEANING

PROPERTIES AND PROCESS BEHAVIOR

Melting temperature

Pouring process

Easy of shake out

Sand collapsability after pouring

Sand refractoriness

Cleaness of pieces, sand removal

General appearance

Shop enviromental (smell or smoke)

f) Results 6: EVALUATIVE RESULTS FINISHED PIECES

PROPERTIES AND PROCESS BEHAVIOR

Superficial state

Sand inclusions

Cracks, tears and other defects

General appearance



3. TEST I - SAND TEAM



d) DESIGN OF A TEST PLAN AT MMSA.

d.1) Selection of representative parts for tests.

CHAPE MOULEE TETE DX AGRI 52515441.

Quantity: 2 pcs

Part data sheet

Part weight:	Actual = 65Kg.
Metal weight:	Actual = 145 Kg
Material:	AM22Mn5 +QT(A4)

Boxes size (mm): 1020*750*300

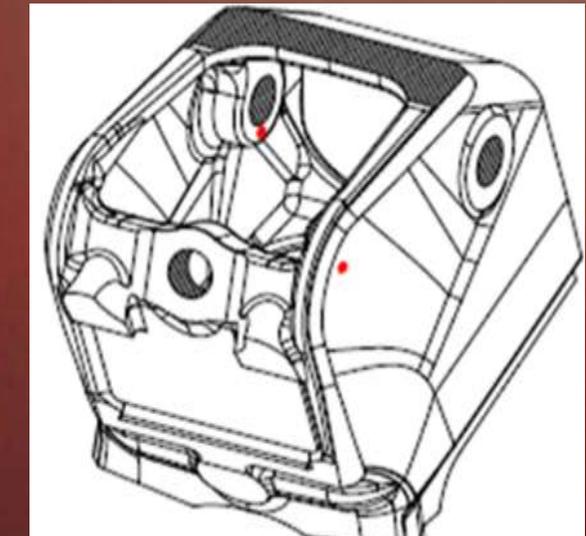
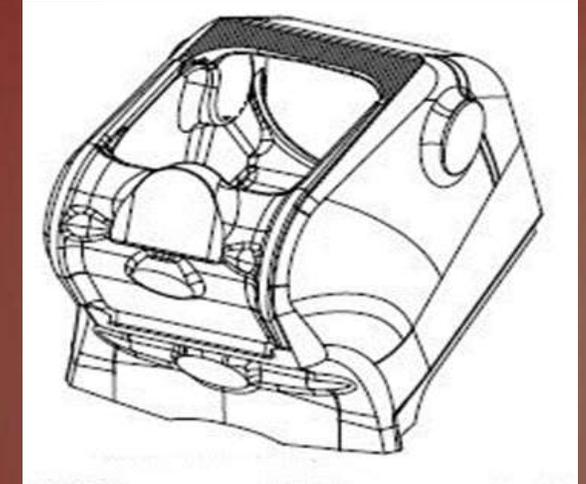


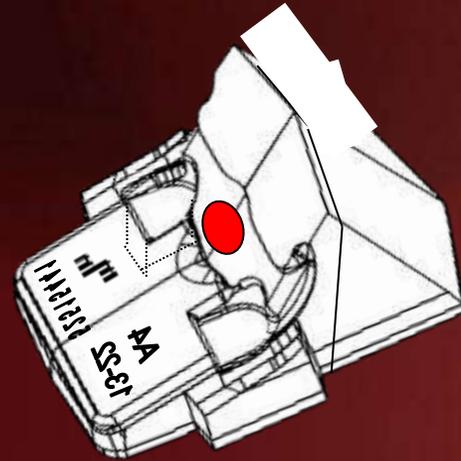
Figure 1: Piece drawing

e) DEVELOPMENT OF A SAMPLES PRODUCTION PLAN AT MMSA FOR SAND TEAM.

e.1) Test development 1: cores preparation



Core N°1
Silica sand and chromite sand



Core N°2 Silica sand



Core 1 box



Core 2 box



Binder and additive control



Core N°1
Silica sand and chromite sand



Core N°2 Silica sand



Pretest emplacement Patters and metal boxes



Sand mixer

CORE MANUFACTURING PROBLEM

- Core number 1 came out in perfect condition.
- The first time we made core number 2, we took it out of the box and it broke, that's why we kept it in the core box until we put it in the mold.
- When we saw the broken core, we saw that the sand came off easily and that it had little strength.
- After some adjustment, result was acceptable.



Figure 17: Core nº 2 broken

e.2) Test development 2: molds preparation and pouring



Bottom pattern



Bottom pattern



Sand filled



Bottom mold



Figure: Core 1 placing



Molds preparation



Molds preparation



Melting



Pouring



Cooling

MOLD MANUFACTURING PROBLEM



When it came to filling the mold with the sand with the new binder and hardener, we saw that the bench life was very short, so that the operator had a hard time distributing the sand compactly and correctly throughout the mold.

e.3) Test development 3: pieces finishing



Molds shake out



After shotblasting



Pouring



Machining

Final part quality is good, similar to current system

f.5) Test development 4: Environmental control: AZTERLAN

f.5.1 - During the preparation of the mould:



During the preparation of the mould next emissions were measured: crystalline silica, formaldehyde, total VOC, gases (NO_x, SO₂, O₂, CO) and particulate matter (PM₁, PM_{2,5}, PM₄, PM₁₀).

Final results below acceptance limits: OK.

- Emission measurements - Moulds preparation

MOULDING			
Compound	Formaldehyde	Crystalline Silica	Particles
Start time	10:55	10:55	10:55
End time	11:25	12:45	12:45
Sampling time (min)	0:30	1:50	1:50
Sampling time (min)	30	110	110
Initial flow rate (l/min)	0,66	2,25	2,25
End flow rate (l/min)	0,64	2,21	2,21
Sampling volume (l)	19,5	245,3	245,3
Lab result (µg)	0,77	13	<100
Concentration (mg/m ³)	<0,04	0,05	<0,41
Limit Value Spain 8 h (mg/m ³)	0,37	0,05	10 fraccion inhalable y 3 fraccion respirable
Limit Value Spain 15 min (mg/m ³)	0,74	-	-

Azterlan

Sample pumps results: Final results below acceptance limits: OK.

f.5.2- During pouring of the metal and the solidification:



During the pouring of the metal and the solidification of the part, next emissions were measured :

- NO, NO₂, CO, SO₂, COV and particulate matter (PM₁₀, PM_{2,5}, PM₄ and PM₁) O₂, CO, CO₂,.
- BTEX, PAHs and crystalline silica

Final results below acceptance limits: OK.

- Emission measurements - Pouring and solidification

POURING								
Compound	BTEX						Crystalline Silica	Particles
	Bencene	Etilbencene	Toluene	m- xilene	o- xilene	p- xilene		
Start time	13:35	13:35	13:35	13:35	13:35	13:35	13:35	13:35
End time	15:05	15:05	15:05	15:05	15:05	15:05	15:05	15:05
Sampling time (min)	1:30	1:30	1:30	1:30	1:30	1:30	1:30	1:30
Sampling time (min)	90	90	90	90	90	90	90	90
Initial flow rate (l/min)	0,192	0,192	0,192	0,192	0,192	0,192	2,43	2,43
End flow rate (l/min)	0,197	0,197	0,197	0,197	0,197	0,197	2,41	2,41
Sampling volume (l)	17,5	17,5	17,5	17,5	17,5	17,5	217,8	217,8
Lab result (µg)	3	5	5	5	5	5	4,7	<100
Concentration (mg/m3))	0,17	0,29	0,29	0,29	0,29	0,29	0,02	<0,46
Limit Value Spain 8 h (mg/m3)	3,25	441	192	221	221	221	0,05	10 fraccion inhalable y 3 fraccion respirable
Limit Value Spain 15 min (mg/m3)	-	884	384	440	440	440	-	-

Azterlan

Sample pumps results: Final results below acceptance limits: OK.

- Emission measurements - Pouring and solidification

POURING							
HAP							
Compound	Acenaphthene + Fluorene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	benzo(b)fluoranthene	benzo(g,h,i)perylene
Start time	13:35	13:35	13:35	13:35	13:35	13:35	13:35
End time	15:05	15:05	15:05	15:05	15:05	15:05	15:05
Sampling time (min)	1:30	1:30	1:30	1:30	1:30	1:30	1:30
Sampling time (min)	90	90	90	90	90	90	90
Initial flow rate (l/min)	2,13	2,13	2,13	2,13	2,13	2,13	2,13
End flow rate (l/min)	2,08	2,08	2,08	2,08	2,08	2,08	2,08
Sampling volume (l)	189,5	189,5	189,5	189,5	189,5	189,5	189,5
Lab result (µg)	<1,5	<1	<0,05	<0,03	<0,03	<0,02	<0,03
Concentration (mg/m3)	<0,0079	<0,0053	<0,0003	<0,0002	<0,0002	<0,0001	<0,0002
Limit Value Spain 8 h (mg/m3)	-	-	-	-	-	-	-
Limit Value Spain 15 min (mg/m3)	-	-	-	-	-	-	-

POURING								
Compound	Benzo(k)fluoranthene	Chrysene	Dibenzo (a; h) anthracene	Phenanthrene	Fluoranthene	Indene (1,2,3-cd)pyrene	Naphthalene	Pyrene
Start time	13:35	13:35	13:35	13:35	13:35	13:35	13:35	13:35
End time	15:05	15:05	15:05	15:05	15:05	15:05	15:05	15:05
Sampling time (min)	1:30	1:30	1:30	1:30	1:30	1:30	1:30	1:30
Sampling time (min)	90	90	90	90	90	90	90	90
Initial flow rate (l/min)	2,13	2,13	2,13	2,13	2,13	2,13	2,13	2,13
End flow rate (l/min)	2,08	2,08	2,08	2,08	2,08	2,08	2,08	2,08
Sampling volume (l)	189,5	189,5	189,5	189,5	189,5	189,5	189,5	189,5
Lab result (µg)	<0,03	<0,03	<0,03	<0,05	<0,03	<0,2	<0,4	<0,03
Concentration (mg/m3)	<0,0002	<0,0002	<0,0002	<0,0003	<0,0002	<0,0011	<0,0021	<0,0002
Limit Value Spain 8 h (mg/m3)	-	-	-	-	-	-	-	-
Limit Value Spain 15 min (mg/m3)	-	-	-	-	-	-	-	-

Azterlan

Sample pumps results: Final results below acceptance limits: OK.

h) CONCLUSIONS SANDTEAM TEST

- With the new binder, when several cores broke, it was decided to leave them in the box until it was time to put them in the mold, but could be managed and solved.
- With the new resin, there was no good cohesion of the sand and we had to wait longer to remove the male from its box.
- Bench life is very short, could be adjusted.
- Shake out, collapsibility: No special problems, difficult as current system.
- Outside and Inside, no differences were found from the current ones.
- Final casting quality control: No issue found, similar to current ones.
- Final quality control after machining: No issue found, similar to current ones.
- Good environmental behavior, similar to current one. Values below acceptance limits.
- Incompatibility with agglomerated sand with the current process!!.
- **This procedure could be used for production adjusting to solve problems detected.**

4- TEST II - FOSECO



ENVIRONMENTAL AND HEALTH IMPACT CHARACTERISTICS

ECOLOTEC 750 (organic)

SECCIÓN 2: Identificación de los peligros

2.1. Clasificación de la sustancia o de la mezcla

Clasificación según Reglamento (UE) n° 1272/2008 [CLP]

Corrosivos para los metales, categoría 1	H290
Toxicidad aguda (oral), categoría 4	H302
Irritación o corrosión cutánea, categoría 1	H314
Lesiones oculares graves o irritación ocular, categoría 1	H318
Sensibilización cutánea, categoría 1	H317
Toxicidad para la reproducción, categoría 1B	H360FD

Texto completo de las frases H y EUH: ver sección 16

Efectos adversos fisicoquímicos, para la salud humana y el medio ambiente
Que se sepa, el producto no presenta ningún riesgo especial siempre que se respeten las normas generales de higiene industrial.

2.2. Elementos de la etiqueta

Etiquetado según el Reglamento (CE) n° 1272/2008 [CLP]

Pictogramas de peligro (CLP)

06/01/2024 (Fecha de emisión) ES - es 1/20

ECOLOTEC 750

Fichas de Datos de Seguridad

según el Reglamento REACH (CE) 1907/2006 modificado por el Reglamento (CE) 2020/878

Palabra de advertencia (CLP)	: Peligro
Contiene	: Metanol; Fenol; Hidróxido de potasio; 2-fenoxietanol; Fenol, polímero con formaldehído; Formaldehído
Indicaciones de peligro (CLP)	: H290 - Puede ser corrosivo para los metales. H302 - Nocivo en caso de ingestión. H314 - Provoca quemaduras graves en la piel y lesiones oculares graves. H317 - Puede provocar una reacción alérgica en la piel. H360FD - Puede perjudicar a la fertilidad. Puede dañar al feto.
Consejos de prudencia (CLP)	: P280 - Llevar guantes/ropa de protección/equipo de protección para los ojos/la cara/los oídos. P301+P312 - EN CASO DE INGESTIÓN: Llamar a un CENTRO DE TOXICOLOGÍA o a un médico si la persona se encuentra mal. P301+P330+P331+P310 - EN CASO DE INGESTIÓN: Enjuagarse la boca. NO provocar el vómito. Llamar inmediatamente a un CENTRO DE TOXICOLOGÍA/médico. P303+P361+P353+P310 - EN CASO DE CONTACTO CON LA PIEL (o el pelo): Quitar inmediatamente todas las prendas contaminadas. Aclararse la piel con agua/dúchase. Llamar inmediatamente a un CENTRO DE TOXICOLOGÍA/médico. P305+P351+P338+P310 - EN CASO DE CONTACTO CON LOS OJOS: Enjuagar con agua cuidadosamente durante varios minutos. Quitar las lentes de contacto cuando estén presentes y pueda hacerse con facilidad. Proseguir con el lavado. Llamar inmediatamente a un CENTRO DE TOXICOLOGÍA o a un médico. P308+P313 - EN CASO DE exposición manifiesta o presunta: Consultar a un médico.



SOLOSIL 433 ECO (inorganic)

Efectos adversos fisicoquímicos, para la salud humana y el medio ambiente
Provoca quemaduras graves en la piel y lesiones oculares graves. Provoca lesiones oculares graves.

2.2. Elementos de la etiqueta

Etiquetado según el Reglamento (CE) n° 1272/2008 [CLP]

Pictogramas de peligro (CLP)

Palabra de advertencia (CLP) : Peligro

Contiene : ácido silícico, sal de sodio

16/02/2024 (Fecha de emisión) ES - es 1/8

SOLOSIL 433 ECO

Fichas de Datos de Seguridad

condone al Reglamento (CE) n° 1907/2006 (REACH), modificado por el Reglamento (UE) 2020/878

Indicaciones de peligro (CLP)	H314 - Provoca quemaduras graves en la piel y lesiones oculares graves.
Consejos de prudencia (CLP)	: P280 - Llevar guantes/ropa de protección/equipo de protección para los ojos/la cara/los oídos. P301+P330+P331+P310 - EN CASO DE INGESTIÓN: Enjuagarse la boca. NO provocar el vómito. Llamar inmediatamente a un CENTRO DE TOXICOLOGÍA/médico. P303+P361+P353+P310 - EN CASO DE CONTACTO CON LA PIEL (o el pelo): Quitar inmediatamente todas las prendas contaminadas. Aclararse la piel con agua/dúchase. Llamar inmediatamente a un CENTRO DE TOXICOLOGÍA/médico. P305+P351+P338+P310 - EN CASO DE CONTACTO CON LOS OJOS: Enjuagar con agua cuidadosamente durante varios minutos. Quitar las lentes de contacto cuando estén presentes y pueda hacerse con facilidad. Proseguir con el lavado. Llamar inmediatamente a un CENTRO DE TOXICOLOGÍA o a un médico. P321 - Se necesita un tratamiento específico (ver instrucciones de primeros auxilios en esta etiqueta).

2.3. Otros peligros

No contiene sustancias PBT/mPmB ≥ 0,1% evaluadas con arreglo al Anexo XIII de REACH

La mezcla no contiene sustancia(s) incluídas en la lista establecida con arreglo al artículo 59, apartado 1, debido a sus propiedades de alteración endocrina, ni se ha identificado que tengan propiedades de alteración endocrina con arreglo a los criterios establecidos en el Reglamento Delegado (UE) 2017/2100 de la Comisión y en el Reglamento (UE) 2018/605 de la Comisión en una concentración igual o superior al 0,1%.

d) DESIGN OF A TEST PLAN AT MMSA.

d.1) Selection of representative parts for tests.

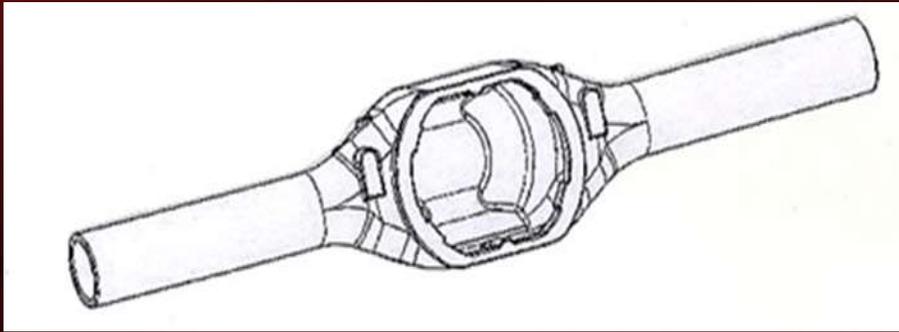


Figure: Piece

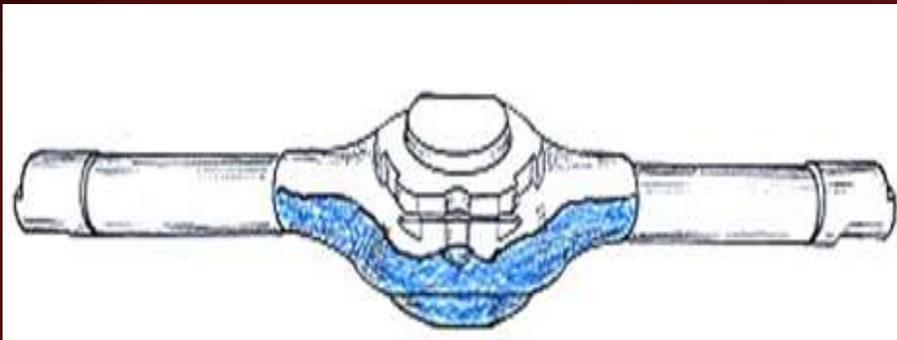


Figure: Core

Part data sheet

Reference:	B80570055
Part weight:	actual: 110 Kg
Metal weight:	actual: 234 Kg
Material:	20M6M (STA01-354)A4

Boxes size (mm):	Upper: 1920 x 720 x 250
	Lower: 1920 x 720 x 300

e) DEVELOPMENT OF A PRODUCTION PLAN AT MMSA: SAMPLES.

e.1) TEST DEVELOPMENT 1: CORE MANUFACTURING PROCESS:



Core box



Box filling



fixing rod inserted



Sand filling



Core gassing.
T= 1 ½ mint



Final cores

MACHON BRUT – AXLE HOUSING B80570055

Work-shop temperature: 16°C

e.2) TEST DEVELOPMENT 2: MOLD MANUFACTURING PROCESS



MACHON BRUT – AXLE HOUSING B80570055

Work-shop temperature: 16°C

e.3) TEST DEVELOPMENT 3: MELTING. COOLING, SHAKE OUT AND FINISHING:



Pouring



Cooling



Shake out



Cleaning



Part finished

h) CONCLUSIONS FOR OLIVINE SAND

- Adequate bench life, within limits.
- Demoulding and collapsibility: No special problems.
- Inside and core areas: No problems.
- Final casting quality control: No problems.
- Good environmental performance.
- Good sand recovery
- **FOSECO inorganic binder can be used with no special problems in molds and cores manufacturing.**
- **Good behavior in core manufacturing to replace the organic binder**



5- TEST III - PEAK TEST



d) DESIGN OF A TEST PLAN AT MMSA.

d.1) SELECTION OF REPRESENTATIVE PARTS FOR TESTS.

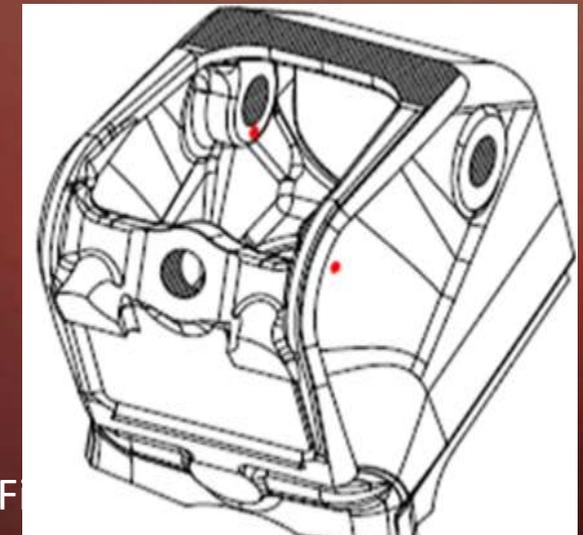
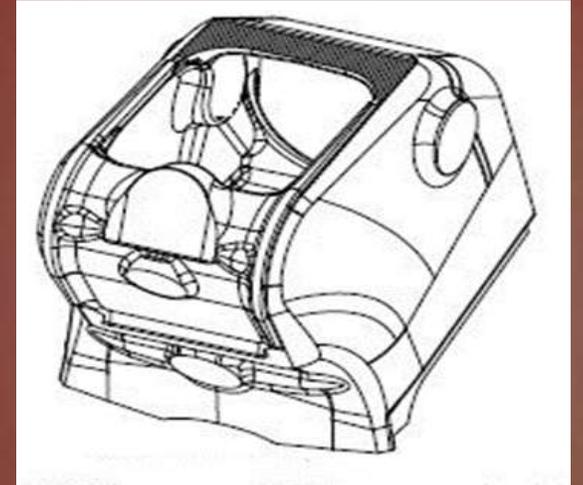
CHAPE MOULEE TETE DX AGRI 52515441.

Quantity: 2 pcs

Part data sheet

Part weight:	Actual = 65Kg.
Metal weight:	Actual = 145 Kg
Material:	AM22Mn5 +QT(A4)

Boxes size (mm): 1020*750*300



d.2) BINDERS AND HARDENERS FOR MOLDS OF SILICA SAND: RECIPES:

- Sand type: 100% new sand
- Sand quantity: 785 Kg per piece → prepare $785 \text{ Kg} \times 2 = 1570 \text{ Kg}$
- Chromite sand: 0 Kg per piece
- Number of pieces: 2 pcs
- Continuous mixer machine

Recipe:

- binder Cast Clean[®] S27F 2,5% (over sand).
- Additive Cast Clean[®] K6: 10% (over binder).

- binder Cast Clean[®] S27F 2,5% (over sand).
- Additive Cast Clean[®] K3: 10% (over binder).



Upper mold



Bottom mold

e) DEVELOPMENT OF A PRODUCTION PLAN AT MMSA: SAMPLES.

e.1) TEST DEVELOPMENT 1: CORE. MOLDS AND MELTING:



Core N°1 Silica and chromite sand



Core N°2 Silica sand



Mold with core



Box closed waiting for pouring



Burn the painted mold



Pouring

e.2) TEST DEVELOPMENT 2: SHAKE OUT AND CLEANING

SHAKE OUT AND CLEANING PROBLEM :

- Calcined sand adhered to the external surface of the piece
- Inside, no differences were found from the current ones. No special problems.



Part inside the mold



Part after shake out



Part after cleaning

After abrasive cleaning, all the stuck sand was removed but imperfections were already visible due to the mold sand.

e.3) TEST DEVELOPMENT 3:



Part inside the mold



Part after shake out

After abrasive cleaning, all the stuck sand was removed but imperfections were already visible due to the mold.

RESULTS 4: FINAL PRE-PRODUCTIONPIECES QUALITY

PROCESS BEHAVIOR	PEAK	CONCLUSION
Superficial state	Normal	ACCEPTABLE
Sand inclusions	High	NOT ACCEPTABLE
Cracks, tears and other defects	Good	ACCEPTABLE
General appearance	Good	ACCEPTABLE

h) CONCLUSIONS FOR PEAK

- Same percentages and preparation process.
- No enough good cohesion of the sand and we had to wait longer to remove the core from its box.
- Bench life is very long, could be adjusted.
- Shake out, collapsibility: No special problems, difficult as current system.
- Outside and inside surfaces, no differences were found from the current ones.
- Final casting quality control: No issue found, similar to current ones.
- Final quality control after machining: No issue found, similar to current ones.
- Expected good environmental behavior, no smell or smoke, similar to current one, but no measurement.
- **This procedure could be used for production adjusting to solve problems detected.**



6- RESULTS CONSOLIDATION



f) QUALITY AND ENVIROMENTAL RESULTS SAMPLES FOR SAND TEAM:

f.1) RESULTS 1: TECHNICAL PROPERTIES OF CORES. (MMSA LAB)

PROPERTIES AND PROCESS BEHAVIOR	LIMITS	SAND TEAM	FOSECO	PEAK
Silica core hardness	40 – 70	33	51,5	35,75
Chromite core hardness	50 – 80	67,5	71,5	62,5
Bending resistance on silica test coupon (N/cm ²)	13 – 30	7,4	21,54	15,7
Bending resistance on chromite test coupon (N/cm ²)	13 – 30	13	25	8
Workshop temperature:	5 - 30°C	15°C	16°C	18°C
Laboratory temperature:	18 - 22°C	20°C	21°C	20°C

f.2) Results 2: EVALUATIVE RESULTS CORES MANUFACTURING

PROPERTIES AND PROCESS BEHAVIOR	SAND TEAM	FOSECO	PEAK
Manufacturing process	Problems	Normal	Normal
Sand plasticity	Normal	Normal	Normal
Sand consistency	Low	High	Normal
Sand permeability	Normal	Normal	Normal
Core cohesion	Low	High	Normal
Superficial core state	Uniform, sand come off, it seems like it would break	Good	Uniform, sand come off
Easy of core extraction from core box	Good	Good	Good
Piece surface condition internal holes (cores)	Normal	Normal	Normal
Shop enviromental (smell or smoke)	Normal. Odorless	Normal. Odorless	Normal. Odorless

f.3) Results 3: TECHNICAL PROPERTIES OF MOLDS.

PROPERTIES AND PROCESS BEHAVIOR	LIMITS	SAND TEAM	FOSECO	PEAK
Silica top mold hardness	60 – 80	25,75	66,75	50,25
Silica bottom mold hardness	60 – 80	38	66,5	48,25
Bench life silica test coupon (min)	5 – 8 min	3-4 min	5 - 6 min	12-16 min
Bending resistance on silica test coupon (N/cm ²)	13 – 30	7,3	21,5	15,7
Bench life chromite test coupon (min)	5 – 8 min	5 min	5 - 6 min	12 mint
Bending resistance on chromite test coupon (N/cm ²)	13 – 30	13	27	9
Workshop temperature:	5 - 30°C	15°C	16°C	18°C
Laboratory temperature:	18 - 22°C	20°C	21°C	20°C

All technical values are average of 4 measurements

f.4) Results 4: EVALUATIVE RESULTS MOLDS MANUFACTURING

PROPERTIES AND PROCESS BEHAVIOR	SAND TEAM	FOSECO	PEAK
Manufacturing process	Normal	Normal	Normal
Sand plasticity	Normal	Good	Normal
Sand consistency	Low	Normal	Normal
Sand permeability	Normal	Normal	Normal
Mold cohesion	Normal	Normal	Normal
Superficial mold state	Uniform, sand come off	Some sand come off	Uniform, sand come off
Easy of mold extraction from pattern	Good	Good	Good
Piece surface condition	Some sand inclusions	Some sand inclusions	Normal
Shop enviromental (smell or smoke)	Normal	Normal	Normal. Odorless

f.5) Results 5: EVALUATIVE RESULTS AFTER POURING, SHAKE OUT AND CLEANING

PROPERTIES AND PROCESS BEHAVIOR	SAND TEAM	FOSECO	PEAK
Melting temperature	1620°C	1635°C	1620°C
Pouring process	Normal	Normal	Normal
Easy of shake out	Normal – Difficult	Normal - Difficult	Normal - Difficult
Sand collapsability after pouring	Normal - difficult	Normal - Difficult	Normal - difficult
Sand refractoriness	Good	Good	Good
Cleanness of pieces, sand removal	Normal	Normal	Normal
General appearance	Normal	Normal	Normal
Shop enviromental (smell or smoke)	Normal	Normal	Normal

f.6) Results 6: EVALUATIVE RESULTS FINAL PIECE STATUS

PROPERTIES AND PROCESS BEHAVIOR	SAND TEAM	FOSECO	PEAK
Superficial state	Normal	Normal	Normal
Sand inclusions	Normal	Normal	Normal
Cracks, tears and other defects	Good	Good	Good
General appearance	Good	Good	Good

6.2) PRE-PRODUCTION BATCH

a) RESULTS 1: CORE MANUFACTURING PRE-PRODUCTION

PROCESS BEHAVIOR	SAND TEAM	FOSECO	PEAKS
Manufacturing process	Normal	Normal	Normal
Sand plasticity	Normal	Normal	Normal
Sand consistency	Sand come off	Normal	Sand come off
Sand permeability	Normal	Normal	Normal
Sand collapsibility after pouring	Difficult - normal	Difficult - normal	Difficult - normal
Core cohesion	Sand come off	Normal	Normal
Superficial core state	Inclusions	Inclusions	Inclusions
Shop enviromental (smell or smoke)	Normal	Normal	Normal

b) RESULTS 2: PRE-PRODUCTION MOLD MANUFACTURING

PROCESS BEHAVIOR	SAND TEAM	FOSECO	PEAKS
Manufacturing process	Some problems	Some problems	Some problems
Sand plasticity	Normal	Normal	Normal
Sand consistency	Some problems	Normal	Some problems
Sand permeability	Normal	Normal	Normal
Sand collapsibility after pouring	Difficult – Normal	Difficult - normal	Difficult - normal
Bench life	Too short	Normal	Too long
Mold cohesion	Normal	Normal	Normal
Superficial core state	Inclusions	Normal	Inclusions
Shop enviromental (smell or smoke)	Normal	Normal	Normal

c) RESULTS 3: PRE-PRODUCTION MMSA LABORATORY CONTROLS

PROPERTIES AND PROCESS BEHAVIOR	LIMITS	SAND		
		TEAM	FOSECO	PEAK
Silica core hardness	40 – 70	32	55	36
Chromite core hardness	50 – 80	68	72	63
Silica top mold hardness	60 – 80	26	69	29
Silica bottom mold hardness	60 – 80	37	68	45
Bench life silica test bar (min)	5 – 8 min	3-4 min	5-6 min	12-13 min
Bending silica test bar (kg/cm ²)	13 – 30	10,6	21,5	7,7
Bending silica test bar (N/cm ²)	127 – 294	104	211	75
Workshop temperature:	5 - 30°C	15°C	16°C	18°C
Laboratory temperature:	18 - 22°C	20°C	21°C	20°C

d) RESULTS 4: PRE-PRODUCTION STEEL POURING AND SHAKE OUT

PROPERTIES AND PROCESS BEHAVIOR	SAND TEAM	FOSECO	PEAK
Pouring process	Normal	Normal	Normal
Shake out process	Difficult-normal	Difficult-normal	Difficult-normal
Cleaness of pieces, sand removal	Normal	Normal	Normal

e) RESULTS 5: PRE-PRODUCTION FINAL PIECE STATUS

FINAL PIECE STATUS	SAND TEAM	FOSECO	PEAK
Superficial state	normal	Good	Normal
Sand inclusions	Normal	Normal	Normal
Cracks, tears and other deffects	Good	Good	Good
General appearance	Good	Good	Good

f) ADDITIONAL CONTROL FOR ALL THE PROCEDURES

f.1) TEST COUPONS AND LABORATORY

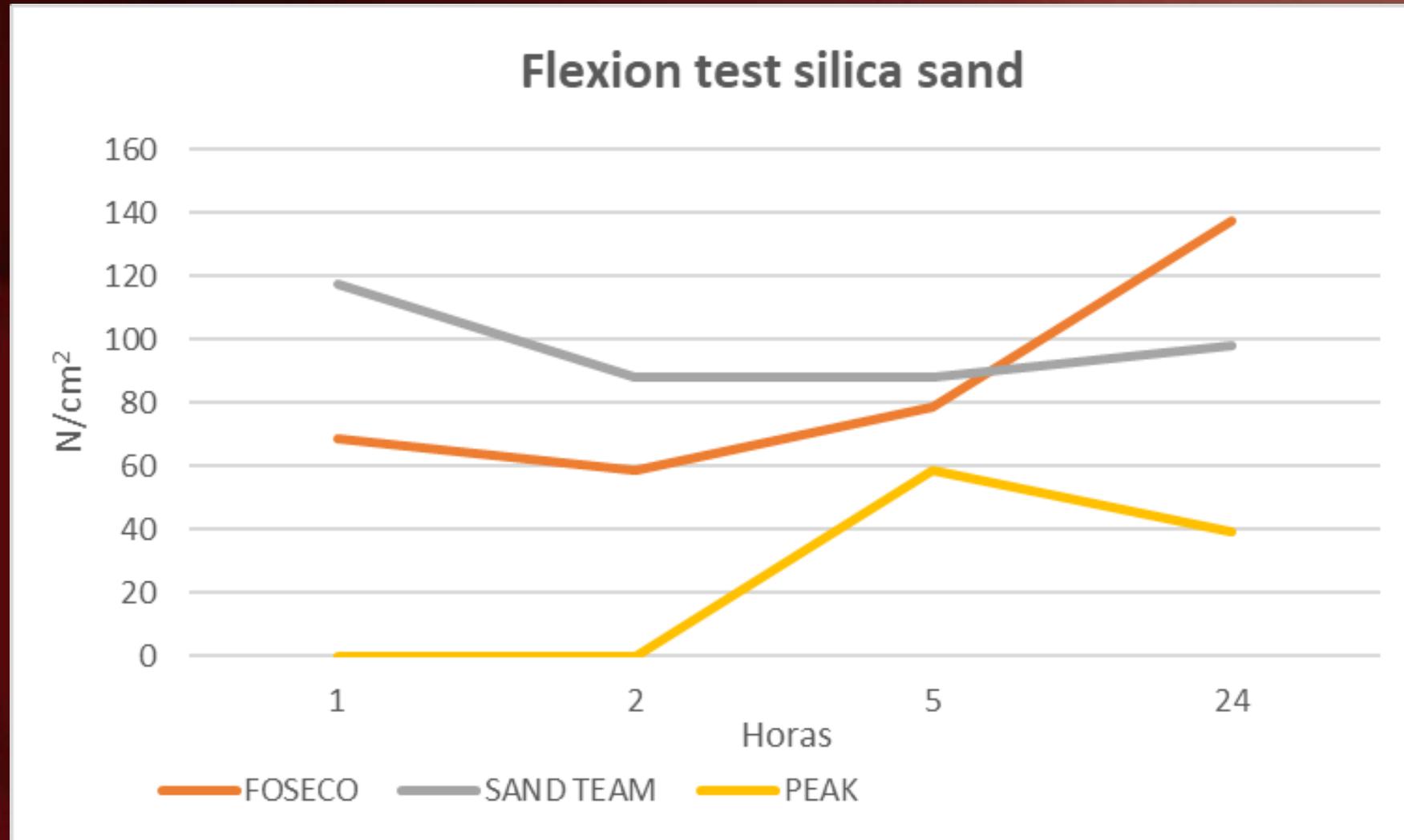


- SOLOSIL 433 ECO: 3% on sand and 6% collapser on sand for both silica and chromite
- GEOPOL 510: 2.8% on silica sand and geotek 007: 0.7% on silica sand
- GEOPOL 510: 2% on chromite sand and geotek 007: 0.7% on chromite sand
- CAST CLEAN S27F: 2.5% over sand and cc3: 10% over cast clean s27f for both silica and chromite

Workshop temperature: 28°C
Laboratory temperature: 22 °C

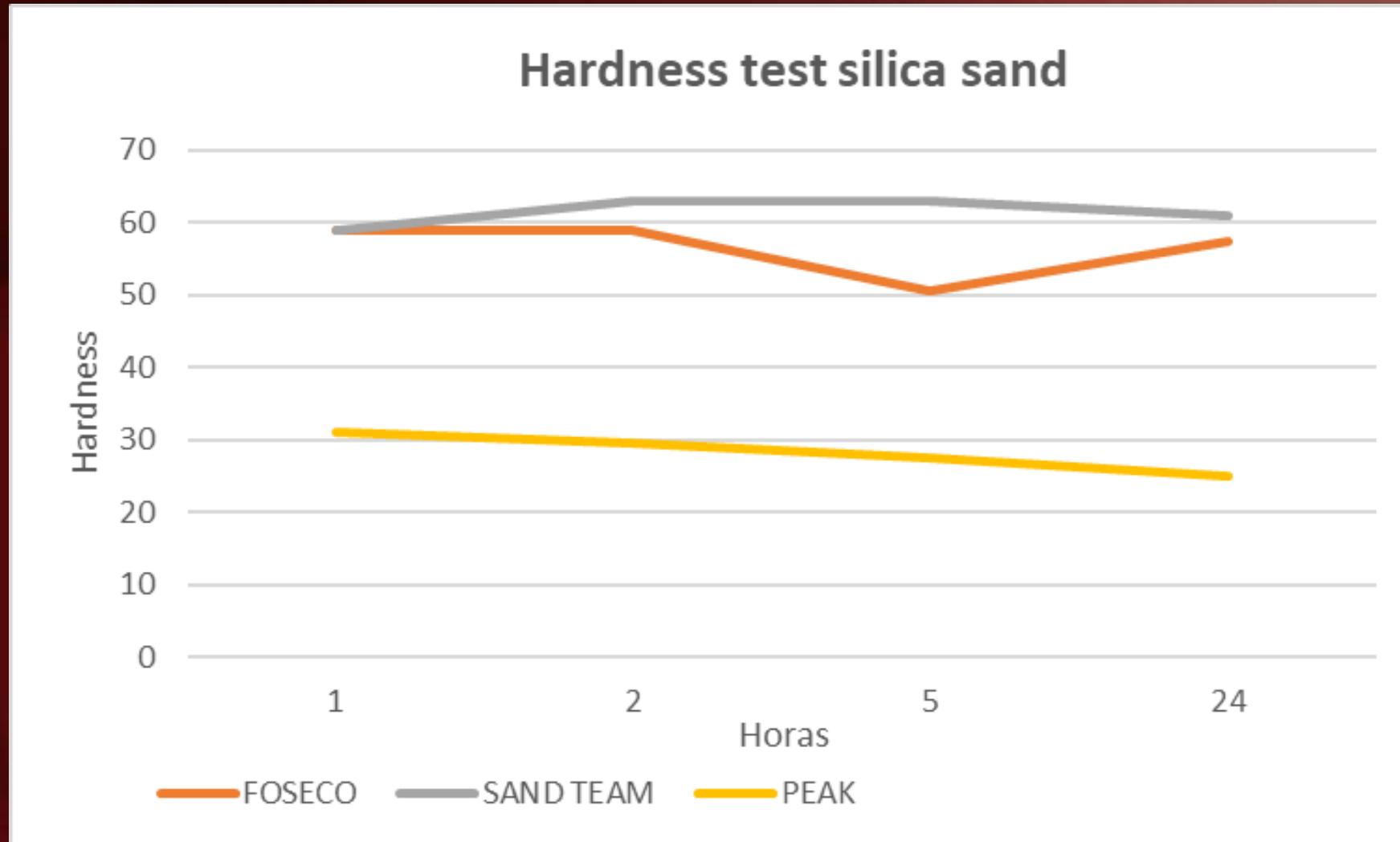


Flexion test with silica sand on test coupons



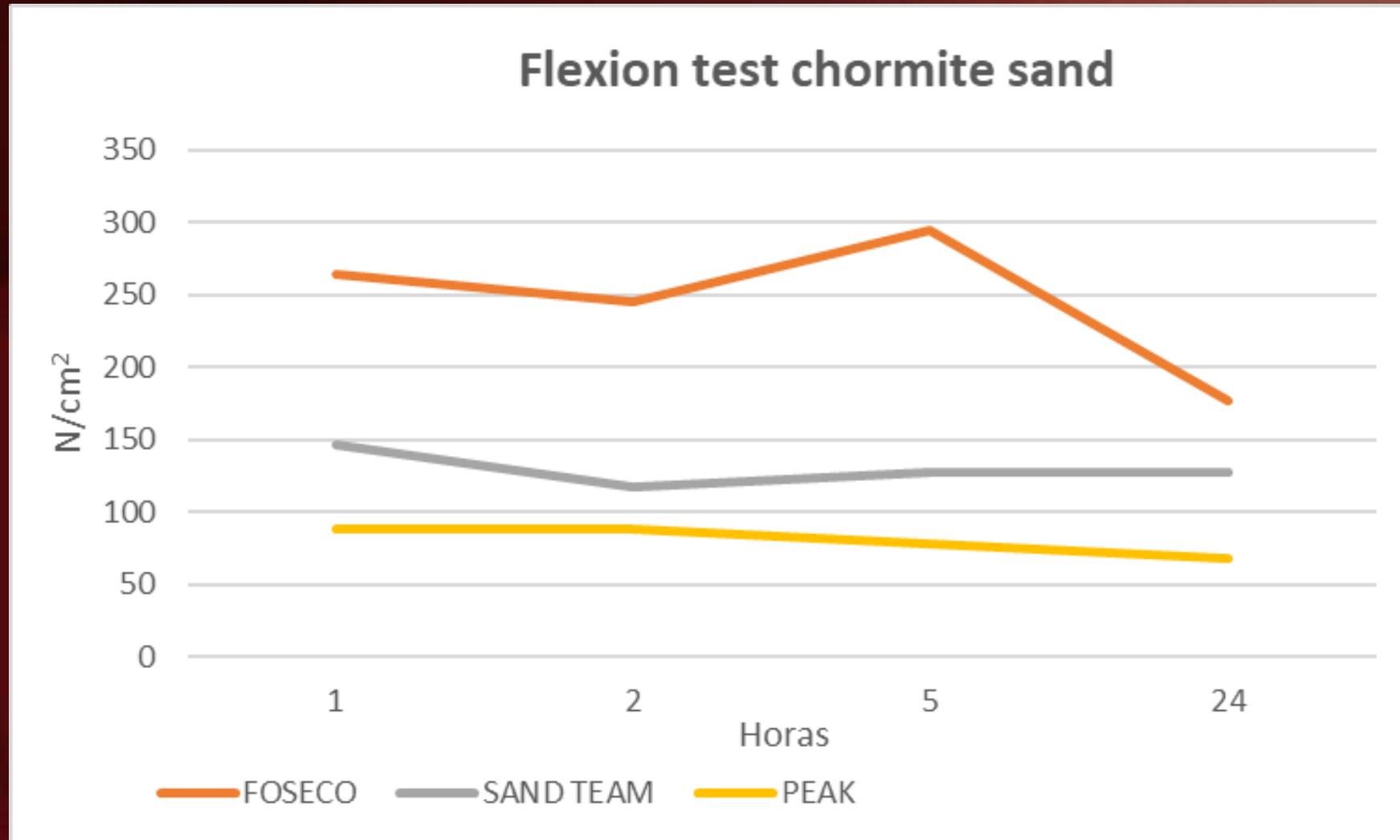


Hardness test with silica sand on test coupons



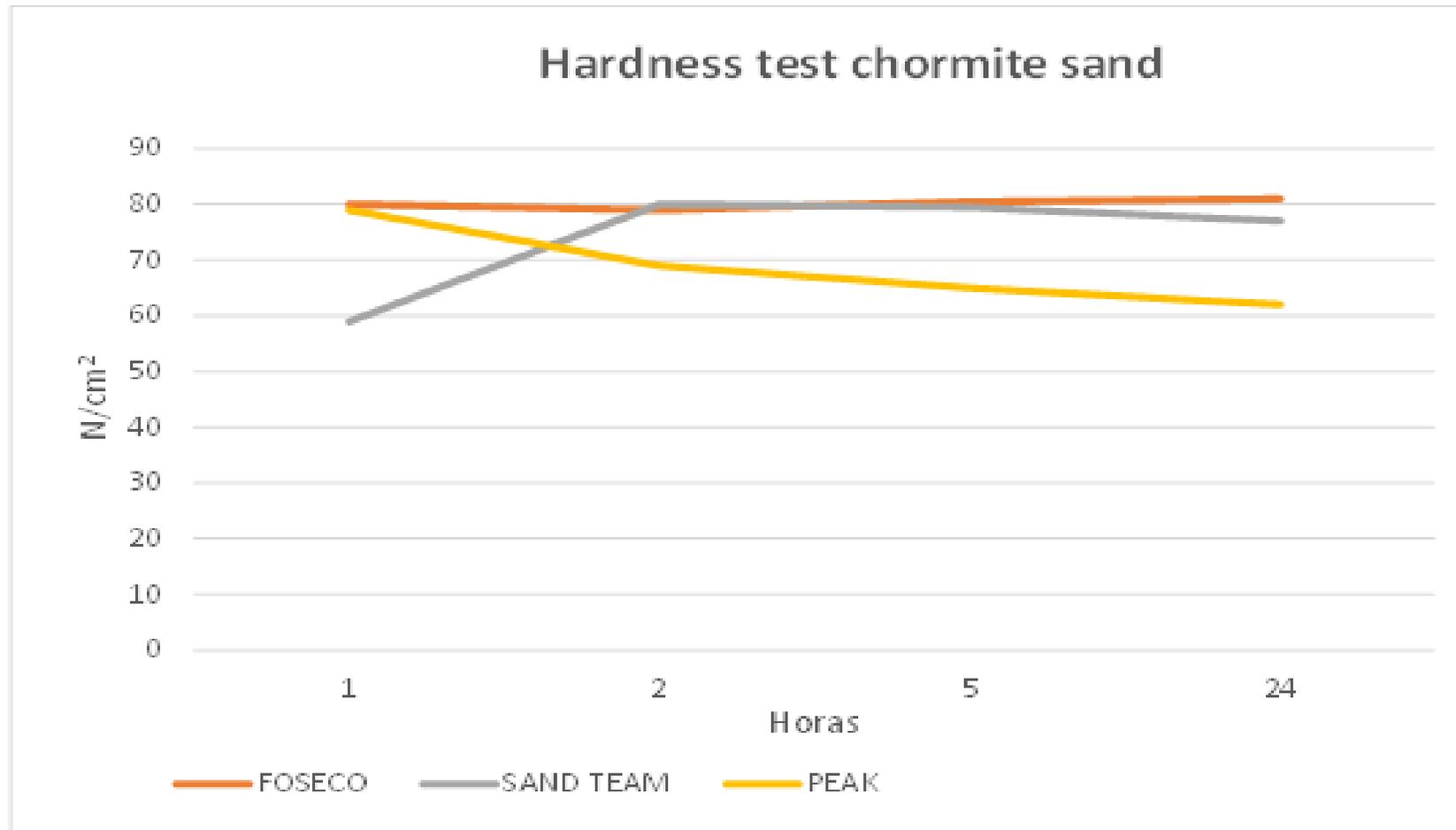


Flexion test with chromite sand on test coupons





Hardness test with chromita sand on test coupons



f.2) CORE PRODUCTION



f.3) CORE PLACEMENT IN THE MOLD



f.4) AFTER SHAKE OUT AND CLEANING



f.5) FINISHED PIECES



VI- ADDITIONAL STUDIES (WP2)

(ADDITIONAL RESEARCHS - LIFE PROJECT)

VI- ADDITIONAL STUDIES

A- OLIVINE SAND





e) DESIGN OF A TEST PLAN AT MMSA.

e.1) SELECTION OF REPRESENTATIVE PARTS FOR TESTS.

**NOT STARTED YET
Planned week 7**

Part data sheet

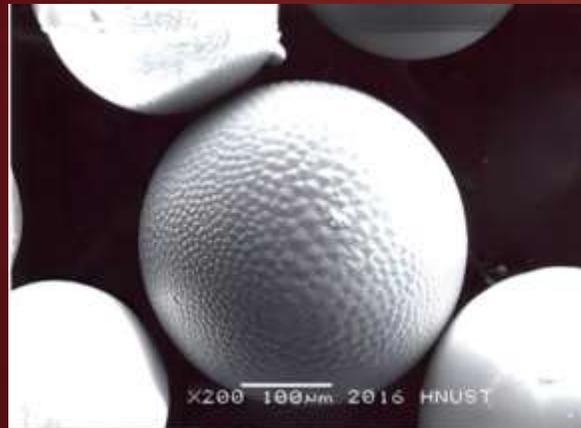
Reference:	
Part weight:	Kg
Metal weight:	Kg
Material:	

Boxes size (mm):	Upper:
	Lower:

Figure 1: Piece drawing

VI- ADDITIONAL STUDIES

B- CERAMIC SAND





b) CERAMIC SAND WITH INORGANIC BINDER FOR CORES MANUFACTURING

- **Binder:** Inorganic binder silicate **Solosil 433**; hardener: CO₂.
- **Application:** Cores manufacturing
- **Where:** MMSA core shop
- **When:** **15/01/2026**
- **External supervision & technical support:** FOSECO
- **Sand laboratory:** MMSA
- **Sand:** 100% Ceramic sand



c) CERAMIC SAND WITH INORGANIC BINDER FOR MOLD MANUFACTURING

- **Binder:** Inorganic binder silicate: Carsil 4000; hardener: VELOSET 400 and VELOSET 0.
- **Application:** Molds manufacturing
- **Where:** MMSA core shop
- **When: 15/01/2026**
- **External supervision & technical support:** FOSECO
- **Sand laboratory:** MMSA
- **Sand:** 100% ceramic sand



d) REVIEW OF REGULATIONS AND TECHNICAL AND LEGAL STANDARDS:

- ✓ Health and safety review and environmental impact assessment.
- ✓ Definition of specific procedures and preventive and response measures for accidents in occupational risk prevention.
- ✓ Definition of specific procedures and preventive and response measures for accidents in environmental protection.

Conclusion:

- ✓ Security and technical documents received and evaluated.
- ✓ Our technical procedures for environment, health, security and emergency situations cover potential risk for these products.



e) DESIGN OF A TEST PLAN AT MMSA.

e.1) SELECTION OF REPRESENTATIVE PARTS FOR TESTS.

Piece....

Quantity: 2 pcs

in progress

Part data sheet

Reference:	
Part weight:	Kg
Metal weight:	Kg
Material:	

Boxes size (mm):	Upper:
	Lower:

Figure 1: Piece drawing



e.4) WORK TEAM

- **Selection of personnel who will perform the test.**
 - MMSA: Core and mold workers;
 - MMSA coordination: Shop manager. José Antonio Cuesta.
 - MMSA control: Laboratory. Luis Cerezo.
- **External Support**
 - FOSECO: Enrique Pardo
- **Responsible:**
 - MMSA: Factory manager: Javier Abello



f) DEVELOPMENT OF A PRODUCTION PLAN AT MMSA: SAMPLES.

f.1) RESULT OF CORES:

- Good behaviour.
- Good properties.
- No problem making cores.

Core 1



Core 2



VI- FOUNDRY SAND RECLAIMABILITY AND VALORIZATION ASSESSMENT (WP5)



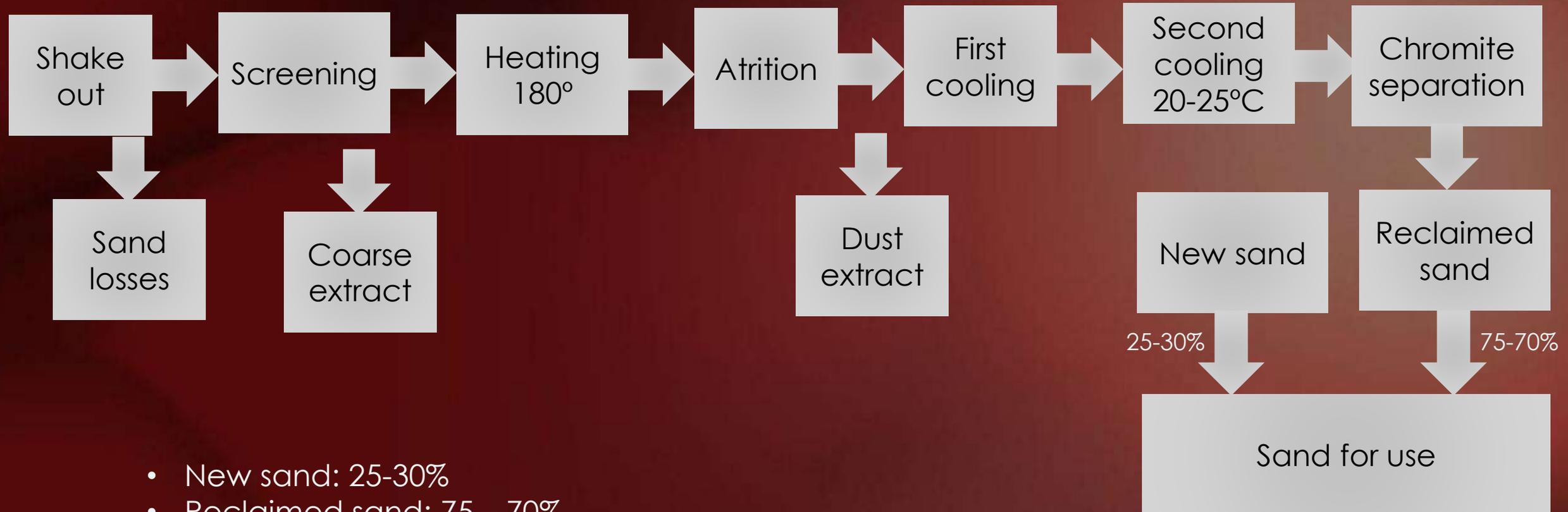


1) SAND RECLAMATION PARAMETERS

- Thermomechanical
- Sand preparation and cleaning.
- Sand drying temperature: $\approx 160\text{ }^{\circ}\text{C}$
- Fluid bed for attrition and sand cooling up to $50 - 60\text{ }^{\circ}\text{C}$.
- Chromite sand removal
- Sand cooling up to $20\text{ }^{\circ}\text{C}$
- Maximum sand temperature: $25\text{ }^{\circ}\text{C}$



2) SAND RECLAMATION PROCESS



- New sand: 25-30%
- Reclaimed sand: 75 – 70%
- Target: > 80% reclamation



3) SAND RECLAMATION PROCESS

Several test of sand reclamation were carried out. Conclusions:

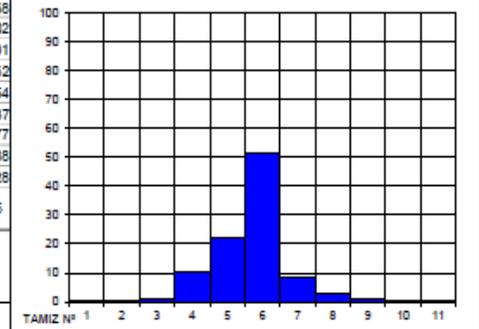
- Sand agglomerated with inorganic silicate resin and hardener could be reclaimed with approx. 70% of sand recovered.
- Test has been done of mold manufacturing with 100% of reclaimed sand (with only 1 cycle of reclamation).
- Sand lost in different stages of the process (fines, coarse grains, sand calcinated adhered to the pieces) reach approx. 25 – 30%

4) TECHNICAL CHARACTERISTICS OF RECLAIMED SAND:

- Laboratory: MMSA



METAMSA		CONTROL DE ARENAS		LABORATORIO									
27/10/2025		Proveedor <u> </u> Arena recuperada	Empleo <u> </u> OMEGA										
CONTROL ARENA RECUPERADA		Procedencia <u> </u>	Tipo <u> </u>										
		Color <u> </u>	Forma de los granos <u> </u>										
		% Agua <u> </u>	Superficie de los granos <u> </u>										
		Cuerpos extraños <u> </u>											
		Rechazos Tamiz 3mm <u> </u>											
TAMIZADO Y LIXIVIACION													
TAMIZ		RECHAZOS		Factor b	Producto	%	Grava	Arena muy gruesa	Arena gruesa	Arena media	Arena fina	Polvos Gruesos	Polvos finos
Div.	mm	Gramos	% a										
1	3	0		3									
2	1,5	0,0061	0,030	6	0,182								
3	1	0,0327	0,163	9	1,463								
4	0,60	0,2682	1,333	17	22,668								
5	0,4	2,1074	10,477	31	324,802								
6	0,3	4,5108	22,427	41	919,491								
7	0,2	10,3688	51,551	52	2680,662								
8	0,15	1,654	8,223	71	583,854								
9	0,1	0,5117	2,544	103	262,037								
10	0,075	0,1471	0,731	146	106,777								
11	0,06	0,0759	0,377	186	70,188								
12	FONDO	0,0313	0,156	281	43,728								
TOTAL DE GRANOS > 0,02		19,714	^c 98,013	$\Sigma a \times b =$	5015,85								
IMPALPABLES < 0,02				Nº DE FINEZA $\Sigma (a \times b)/c =$	51								
GRANOS + IMPALPABLES													
Tamiz nº		Fotografía		X 30									
Resistencia al fuego													
Contenido en cal													
PROPIEDADES FISICAS													
Mezclado:		a mano		en mezclador									
Tiempo de mezcla:				Tiempo de homogeneización:									
Aglutinante:													
% Aglutinante:													
% Agua:													
Permeabilidad:													
Compresión:													
Tracción:													
Flexión:													
Cizallamiento:													
ANALISIS QUIMICO													
Al ₂ O ₃	TiO ₂	CaO	MgO	SiO ₂ libre	SiO ₂ total	Na ₂ O	Fe ₂ O ₃	K ₂ O					
OBSERVACIONES:											FINOS:	12,032	3,808
Gramos de arena pesados:		20,1136											
CALCULO DEL % Na ₂ O		CALCULO DE L.O.I.											
HCl 0,1N gastado (ml):		41,60		Peso Crisol		24,3069							
				Peso Crisol + arena (Inicial)		44,3369							
				Peso Crisol + arena (final)		44,2563							
				L.O.I. (%)		0,4024							



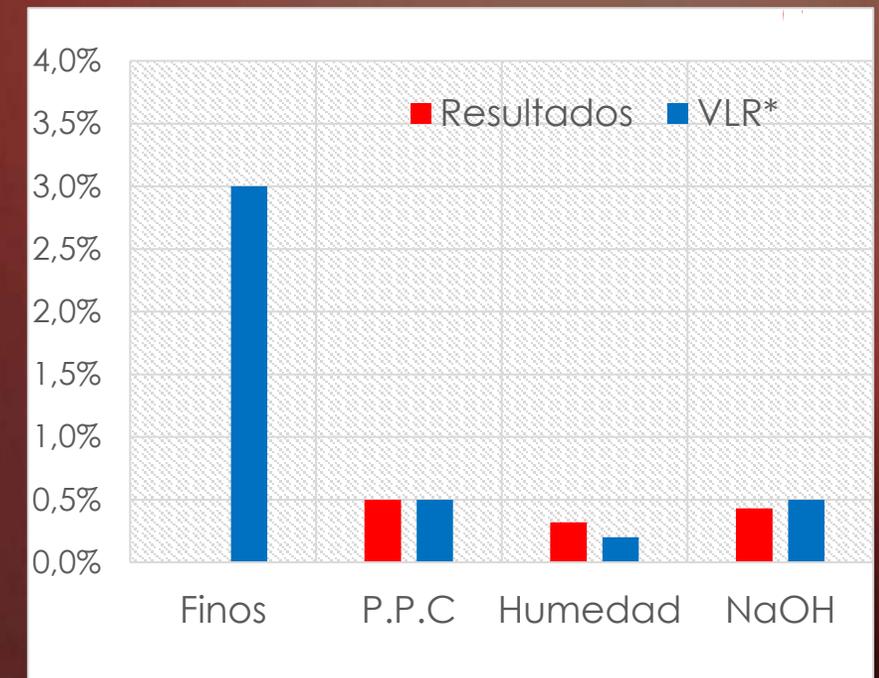
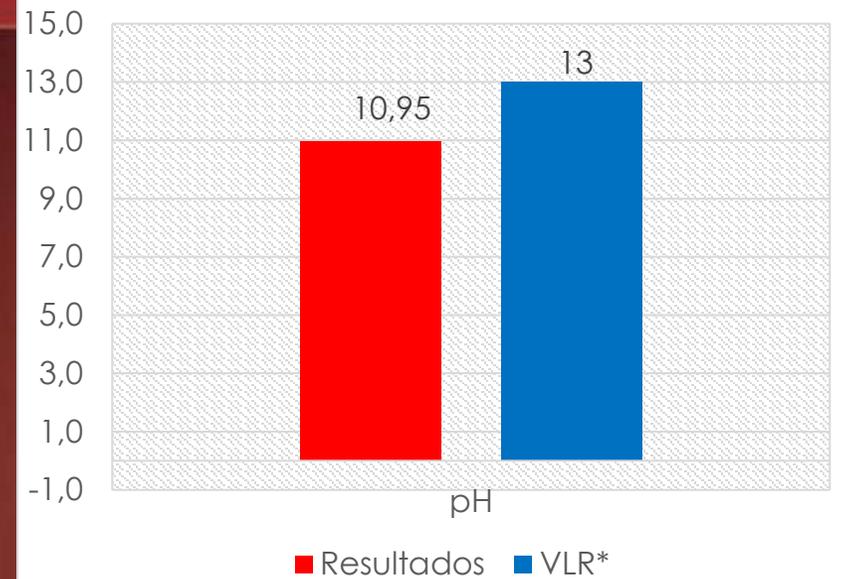
Technical characteristics of new silica sand:

- Laboratory: MMSA



METAMSA		CONTROL DE ARENAS				LABORATORIO	
09/08/2025		Proveedor <u>__SIFUCEL__</u>	Empleo <u>__MOLDEO Y MACHOS__</u>				
		Procedencia <u>__PORTUGAL__</u>	Tipo <u>__SILICE__</u>				
EXAMEN DE RECEPCION		Color <u> </u>	Forma de los granos		<u>__REDONDOS__</u>		
		% Agua <u> </u>					
		Cuerpos extraños <u> </u>	Superficie de los granos		<u>__LISA__</u>		
		Rechazos Tamiz 3mm <u> </u>					
TAMIZADO Y LIXIVIACION							
TAMIZ		RECHAZOS		Factor b	Producto		
Div.	mm	Gramos	% a				
1	1,4		0,000	6	0,000		
2	1		0,000	9	0,000		
3	0,71	0,0052	0,018	15	0,273		
4	0,5	0,1123	0,392	25	9,809		
5	0,355	3,2621	11,397	35	398,900		
6	0,25	15,9803	55,762	45	2509,297		
7	0,18	7,3184	25,589	60	1534,143		
8	0,125	1,5296	5,344	81	432,874		
9	0,09	0,2453	0,857	118	101,130		
10	0,063	0,1006	0,351	164	57,642		
11	FONDO	0,0498	0,174	275	47,848		
TOTAL DE GRANOS		28,5836	^c 99,885	$\Sigma a \times b =$	5091,91		
FINOS $\leq 0,09$		0,1504	1,382	Nº DE FINEZA $\Sigma (a \times b)/c =$	51		
GRANOS + IMPALPABLES							
Porcentaje tamizes centrales		min. 85%	99,062749	Rango espec.	(48-60)		
Resistencia al fuego <u> </u>							
Contenido en cal <u> </u>							
PROPIEDADES FISICAS							
Mezclado:		a mano <u> </u>		en mezclador <u> </u>			
Tiempo de mezcla:		<u> </u>		Tiempo de homogeneización:		<u> </u>	
Aglutinante:		<u> </u>					
% Aglutinante:		<u> </u>					
% Agua:		<u> </u>					
Permeabilidad:		<u> </u>					
Compresión:		<u> </u>					
Tracción:		<u> </u>					
Flexión:		<u> </u>					
Cizallamiento:		<u> </u>					
Tamiz nº		Fotografía		X 30			
ANALISIS QUIMICO							
Al ₂ O ₃	TiO ₂	CaO	MgO	SiO ₂ libre	SiO ₂ total	Na ₂ O	Fe ₂ O ₃
OBSERVACIONES:							
Gramos de arena pesados:		28,8221	crisol	12,9723	FINOS:	1,382	<4,5%
Humedad:		0,11%	P1	33,5612	GRUOSOS:	0,411	<8,5%
		0,50%	P2	33,539			

Características	VLR*	Resultados
A.F.S.		47
Finos	3%	0,00%
P.P.C	0,50%	0,50%
pH	13	10,95
Humedad	0,20%	0,18%
NaOH	0,50%	0,43%
ADV	150%	125,0%
Total Magnetita		0,0%
Total Cromita		2,57%
Total Imantables	3%	2,57%
Conductividad		1990





- Evolution of reclaimed sand hardness over time



- Evolution of reclaimed sand bending resistance over time



Evaluative results molds manufacturing

PROPERTIES AND PROCESS BEHAVIOR	FOSBED	CONCLUSION
Manufacturing process	Normal	ACCEPTABLE
Ceramic sand plasticity	Normal	ACCEPTABLE
Ceramic sand consistency	Normal	ACCEPTABLE
Ceramic sand permeability	Normal	ACCEPTABLE
Mold cohesion	Normal	ACCEPTABLE
Superficial mold state	Normal	ACCEPTABLE
Easy of mold extraction from pattern	Good	ACCEPTABLE
Piece surface condition	Normal	ACCEPTABLE
Shop enviromental (smell or smoke)	Normal. Odorless	ACCEPTABLE



5) RESIDUAL SAND CHARACTERIZATION:

The residual sands have been characterized on two occasions by an external independent laboratory, to determine their level of contamination and environmental impact, using inorganic binder sand.

11-01-2024: Result: *“The waste called “Foundry sands”, according to the basic characterization described in this report, is ADMISSIBLE in a landfill for non-hazardous waste of type B1b, that is, landfills of non-hazardous inorganic waste with low content of organic or biodegradable matter with joint dumping with stable non-reactive hazardous waste and of type B3, that is, landfills of mixed non-hazardous waste with a substantial content of both organic or biodegradable waste and inorganic waste.”*





13-05-2024: Result:

*“8.1 Declaration of hazardous/non-hazardous nature and assignment of LER code
The assessment of the results obtained from the laboratory analysis of the representative samples of the indicated waste, assessed according to Annex III of Commission Regulation (EU) No 1357/2014, in Regulation (EC) 1272/2008 (CLP), is as follows:
The waste called “Foundry sand”, according to the hazard characterisation described in this report, is found to be NON-HAZARDOUS, and is assigned the LER code 10 09 08 “Foundry cores and moulds with casting other than those specified in code 10 09 07”, within subchapter 10 09 “Wastes from the foundry of ferrous parts”, within chapter 10 “Wastes from thermal processes.”.”*





6) RESIDUAL SAND VALORIZATION:

- Several test have been done with the rejected sand sent to bricks manufacture shop
- Sand could be use for bricks manufacturing
- Necessary to eliminate:
 - Clumps of sand.
 - Ceramic hard material
 - Avoid fines
 - Steel bars (mainly non-magnetic steel bars)





7) CONCLUSIONS OF RECLAIMED SAND STUDY:

1. Residual sand is NON-HAZARDOUS.
2. Molds can be produced with 100% reclaimed sand and inorganic binder, but a limited number of reclaim cycles.
3. Percentage of reclamation: 70 – 75% (other foundries reach 85-90%)
4. Sand lost in different stages of the process (fines, coarse grains, sand calcinated adhered to the pieces) reach approx. 25 – 30%
5. It is necessary to reduce sand lost in order to increase percentage of sand reclamation.
6. Residual sand could be sent to a normal landfill for non-hazardous waste.
7. Residual sand could be used for concrete or bricks manufacturing, but it is necessary to improve quality of the residual sand.



8) PROCESS TO IMPROVE RECLAMATION RATE AND VALORIZATION

1. Install equipment to break up clods and clumps of sand.
2. Install equipment to screen out unwanted elements: pieces of refractory material (such as impacts or channels) and non-magnetic steel bars.



VII- CONCLUSIONS

CONCLUSIONS LIFE PROJECT

1. The use of inorganic binders represents a substantial improvement in air quality in foundries and in the environment.
2. This applies, in particular, to parameters such as the volume of gases released and their composition, with special emphasis on the content of substances from the BTEX, PAH, phenol, formaldehyde, MDI/TDI, CO, CO₂, NO_x, SO₂ and Tvoc groups, as well as dust (PM 10, PM 2.5)
3. The improvement in air quality is manifested, above all, in the pouring of sand on the models to manufacture the piece and in the pouring of molten steel into the molds.
4. The use of inorganic binders is compatible with all the pieces manufactured at Metalúrgica Madrileña, except for some small cores.
5. The use of inorganic binders is compatible with silica and chromite sands.
6. The use of inorganic binders allows the recovery of sand up to 80%, and could get use of up to 100%.
7. The residual sand from inorganic binders is qualified as NON-HAZARDOUS and could be used in other applications like ceramic industry.



CONCLUSIONS LIFE PROJECT – ADDITIONAL WORKS

in progress



IX- NEXT STEPS

*Thank you for your
attention!*



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