SANITSER

Project: LIFE12 ENV/IT/001095

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SANITaryware production: use of waste glass for Saving Energy and Resources

Final conference
10 Marzo 2017

Coordinating beneficiary: Minerali Industriali S.r.l.

Associated beneficiaries: G.E.M.I.C.A. S.r.l.
Life Cycle Engineering
SE.TE.C. S.r.l.

MINERALI INDUSTRIALI

G.E.M.I.C.A. GAGLIARDI ERMANNO MATERIE INDUSTRIA CERAMICA AFFINI

SETEC Group — VICENTINI — IPEG

LIFE CYCLE ENGINEERING we support your sustainable business

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Programma Conferenza Finale

h 10.30

Registrazione partecipanti
presso ***SE.TE.C. Group***
Via Enrico Fermi 6/18 - Civita Castellana (VT)

h 11.00

Saluti
SE.TE.C. Group

h 11.15

Presentazione progetto e risultati
Minerali Industriali

h 12.00

Visita guidata all'impianto

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h 13.00

Trasferimento e pranzo
presso il ***Ristorante Sabina*** *- SS3 Flaminia km 65,5 Magliano Sabina*
(di fronte all'uscita dell'autostrada A1, casello Magliano Sabina)

h 15.00

Tavola rotonda "Prospettive future di applicazione"

La conferenza si terrà in italiano con traduzione simultanea in inglese

with the contribution of the LIFE financial Instrument of the European Community
LIFE12 ENV/IT/001095

EARLIER STUDIES

2009: Minerali Industriali and the Earth Science Department of the University of Milan started a collaboration to study the introduction of glass cullet in partial replacement of Na-feldspar (traditional flux agent) for sanitary-ware ceramic production.

Problems to overcome:

- **Eventual changes in rheology of the slips;**
- **Pyro-plasticity effects on large ceramic bodies;**
- **Effects of thermal gradient upon firing on large and complex shape bodies having SLG;**
- **Glaze reformulation to match the new thermal cycles.**

2012: SANITSER PROJECT

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Main Project Objectives

Reduction of firing temp. of 80-100°C

Saving of natural resources

CO_2 emission reduction

Recycling of urban waste

Reduction of Industrial production costs

Environmental impact improvement

Improving the environmental impact of the sanitaryware production process replacing natural raw materials (up to 40-50%) with glass cullet from urban waste disposal and other recycled materials in the ceramic blends formulation.

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Expected results:

SAVING ENERGY: 16-18%

Standard firing temperatures for Vitreous China Sanitaryware are between 1230°C and 1250°C with firing cycles around 16-20 h.
The SANITSER formulation will make possible a firing cycle between 1150°C and 1190°C with a reduction also of the dwell time at max temperature. **The estimated saving of thermal energy is about 16% -18% with firing cycles around 14-16 h.**

ENERGY SAVING - ECONOMIC BENEFIT

Type of Kiln	Medium n° of fired pieces per day	Consumption of energy for each kg of fired product [kcal]	Energy saving of 18% [kcal/kg of fired product]	Energy saving [kcal/day] (Considering a medium weigh of one ceramic article of 20 kg)	Energy saving [Nm^3 of methane per day]	Energy Saving in €/day (Considering methane cost of 0,35 €/Nm^3)
Shuttle	400	2100-2400	≈ 396	3.168.000	386,3	135,1
Tunnel	1000	1200-1600	≈ 250	5.000.000	609,8	213,4

ENERGY SAVING - ENVIRONMENTAL BENEFIT

Decrease of firing temperature of about 80-100°C makes possible a significant reduction of gas emissions form the kilns during the firing process.

Type of kiln	Saving of Nm^3 of methane per day	Saving of Nm^3 of methane per year	Reduction of emission of CO_2 [kg/year]
Shuttle (400 pieces)	386,3	84.986 (considering 220 working days per year)	**169.972**
Tunnel (1000 pieces)	609,8	201.234 (considering 330 working days per year)	**402.468**

SAVED PRIMARY RESOURCES: 40-50%

In the formulation of bodies and glazes studied a significant part of recycled glass, granite and vitreous china scraps were used in order to **reduce the total consumption of natural raw materials up to about 40% -50%.**
The intent is also to reduce production costs, rising industrial competitiveness and promoting a shift from a traditional man-labor-oriented to a technology-driven manufacturing.

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RAW MATERIALS INVOLVED IN TESTING

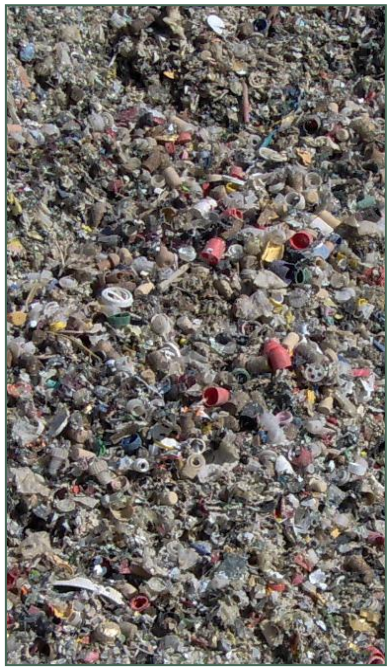
Re-use of recycled products and production waste for ceramic industry

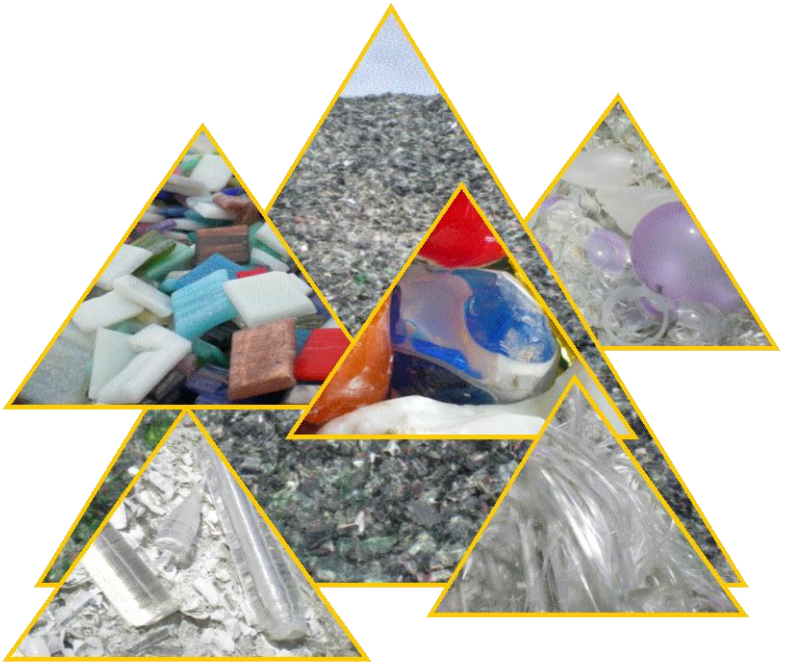
GLASS CULLET WASTE FROM URBAN WASTE DISPOSAL: 100% RECYCLED POST CONSUMER

As defined in section 7.8.1.1 c, UNI EN ISO 14021

SPECIAL GLASSES FOR GLAZE (tv monitor, lamp, neon, boric glass): 100% RECYCLED PRE and POST CONSUMER

As defined in section 7.8.1.1 c, UNI EN ISO 14021





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RAW MATERIALS INVOLVED IN TESTING

Re-use of recycled products and production waste for ceramic industry

CERAMIC PITCHER: 100% RECYCLED PRE CONSUMER

As defined in section 7.8.1.1 c, UNI EN ISO 14021

Ceramic pitcher BVC – vitreous china

Minerali Industriali Group has facilities to recycle the ceramic pitcher throughout Italy, Europe and Latin America.
The ceramic pitcher is regularly recovered, crushed and ground, to be reused alone or in mixture, as a component of the ceramic blends.

Benefits in using ceramic pitcher:

- The pitcher is not completely inert → slight fluxing action that allows the feldspar content of the body to be reduced while maintaining the same degree of vitrification
- High alumina content (23-24% by weight) → allows the vitrification/deformation ratio to be optimised, if used to suitably replace quartz and feldspar
- By using scrap in place of a portion of the quartz it is possible to vary the coefficient of expansion of the body and above all to mitigate the negative impact of α→β quartz transformation, especially in the case of rapid firing

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RAW MATERIALS INVOLVED IN TESTING

Re-use of recycled products and production waste for ceramic industry

F60PB: 100% RECYCLED PRE CONSUMER

As defined on section7.8.1.1 c, UNI EN ISO 14021

Na/K - feldspar resulting from the recovery and treatment of the ornamental stone "wastes“, obtained from the historical white granite quarries Montorfano and pink granite Baveno, in the north of Lake Maggiore. In 1992 (renovated in 2012) the Mining Concessions for the exploitation of feldspar and associated minerals are issued by the Mining District of Turin, with **mining projects aimed exclusively at the recovery of the landfills material.**

The result is an innovative project that converts something considered a mining waste into a raw material, creating a benefit to the environment avoiding the opening of new mines.

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MINERALI INDUSTRIALI PILOT PLANT

Installed and covered magnetical separator

Drier with connection
to the improved de-dusting system

Connections within the plant

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Main actions of SANITSER project:

- Definition of new formulations for slips bearing glass;
- Definition of the new production processes using the modified firing time-temperature cycles at lower temperature;
- Glaze composition revision in the light of new firing time - temperature cycles;
- Determination of environmental impact parameters (Life Cycle Assessment).

Definition of new formulations

Among all the formulations of bodies and glazes containing glass and other recycled materials tested during the project, we identified those most suitable for production and capable of ensuring the technological characteristics of the finished ceramic pieces, when compared with current standards required by the market.

To define the new compositions we also considered the content of recycled materials:

- **SANITSER 13** slip contains **more than 40%** of recycled materials (glass, pitcher and granite);
- **PSI 113** glaze contains **more than 15%** of recycled glass.

SETEC PILOT PLANT

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Ball clay dissolving

After 1 day
or in the same day

Kaolin + other raw materials dissolving
second phase preparation

After 2-3
days

Casting

Demoulding and hardening

After 1 day

Drying

After 1 day

Finishing + inspection

After 1 day

Glazing

After 1 day

Firing

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GEMICA PILOT PLANT

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WEIGHT THE RAW MATERIAL

DUST ASPIRATION SYSTEM
near the balance and
up the tubolar mill

WET GRINDING

SIEVING THE GLAZE

MAGNETIC SEPARATOR

FINAL PRODUCT

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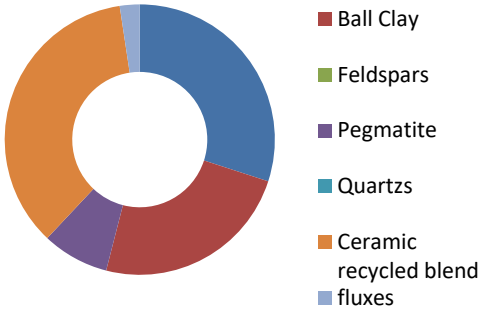
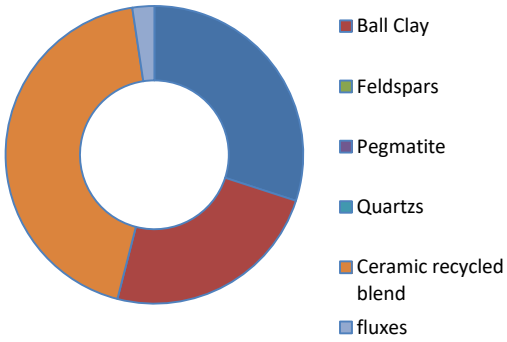
Starting from the excellent results obtained with Sanitser 7, which has determined the optimal content of recycled glass, we continued the research with the aim of improving the formulation, further increasing the content of recycled products.

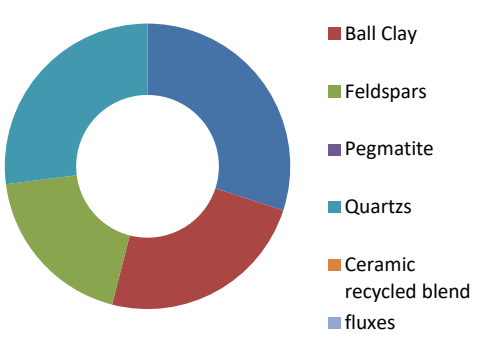
SANITSER 7 (%)



SANITSER 13 (%)



Traditional VC (%)



Sanitser 13, whose composition is shown in the table above and which has a **content of recycled products > 40%,** appears to be the best among all of the compositions tested. Therefore, it was selected as the formulation to be used for the pre-industrial tests to be held at SETEC pilot and then on industrial scale.

Decrease of risk from silica exposure

This is a very important achievement in the aim of reducing the risk connected to the use of substances containing free crystalline silica

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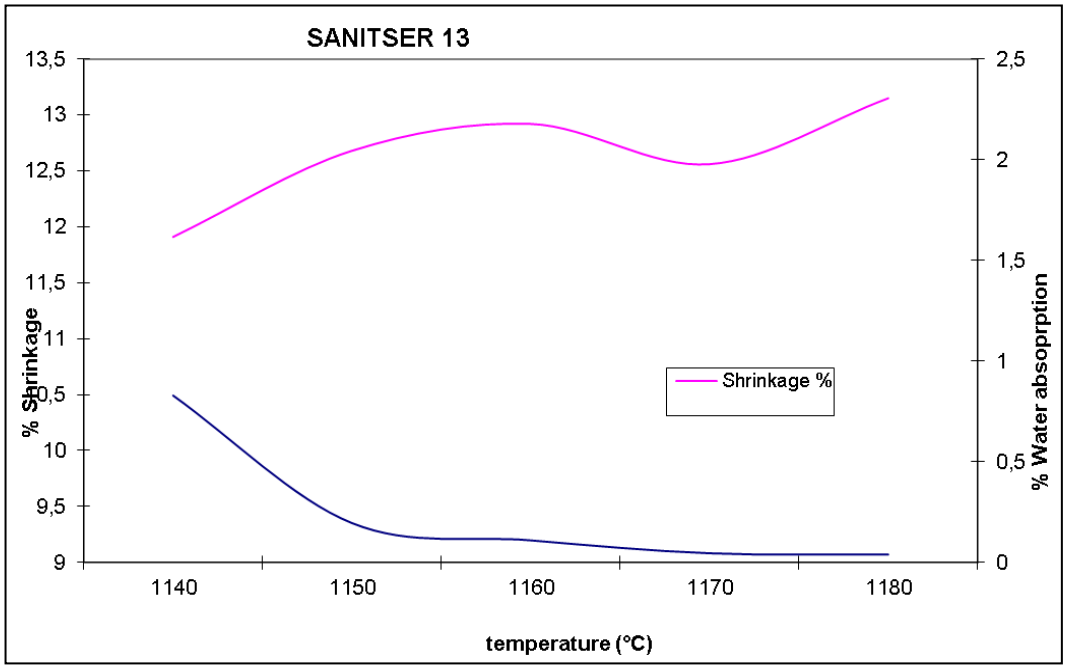
VITREOUS CHINA BODIES: RHEOLOGICAL CHARACTERISTICS

Rheological characteristic	Vitreous china Standard	SANITSER 7	SANITSER 13
Specific Weight	1800	1825	1820-1830
Viscosity	280-310	280-300	230-260
Thixotropy	20-35	15-25	10-20
Polyacrylate	/	0.10	0.02
Sodium silicate (%)	0.165	/	/
Sodium carbonate (%)	0.07	0.07	0.02
Barium carbonate (%)	0.05	0.05	/

Oxides (%)	SANITSER 7	SANITSER 13
Na_2O	0.316	0.341
K_2O	0.242	0.224
Cao	0.197	0.198
MgO	0.245	0.237
Al_2O_3	2.075	2.004
SiO_2	9.763	9.187

The new bodies, formulated for the SANITASER project, show rheological characteristics similar to the standard, without sodium silicate required.
In the table we reports the SEGER formula for SANITSER 7 compared with SANITSER 13 body slip



The SANITSER 13 shows an optimal temperature of firing lower than the other bodies, of about 1150-1170°C. The water absorption and total shrinkage values, obtained in the body, show a vitrification plateau in 20-30 degrees.

Temperature (°C)	Shrinkage %	Water absorption %
1150	12.56	0.196
1160	12.68	0.110
1170	12.96	0.05

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Table. Characteristic data obtained from Sanitser slip compared with industrial vitreous china slip.

(Each value is the mean of five determinations).

Technical parameters	Industrial slip fired at 1250°C RSD% ≤ 5.0	Sanitser 13 slip fired at 1165°C RSD% ≤ 5.0
Density (g/cm^3)	1.800	1830
Moisture (%)	32-35	34.3
Viscosity (°G)	305	240-260
Sodium silicate deflocculant (%)	0.17	/
Sodium carbonate deflocculant (%)	0.07	0.02
Polyacrylate deflocculant (%)	/	0.02
Thixotropy (after 1 minute) (°G)	25-35	10-20
Deformation (mm)	40-43	43
Thickness after 1 h (mm)	6.5-7.0	6.6
Modulus of rupture (MOR) (kg/cm^2)	24-25	25.3
Resistance to bending after firing (MPa) (UNI 4543 required a value > 39.50 MPa)	49.5	55.7
Linear fired Shrinkage (%)	12-13	12.6
Water absorption (%) (EN 997 and UNI 4543 required a value < 0.5%)	< 0.5	0.1

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Fritsch Particle Sizer 'analysette 22'

Meas.No. 176	Date 10-29-2014	Time 18:14	Operator Mutter	ID 7645	Serial No. 123456

SE.TE.C. S.r.l. Civita Castellana Renzicchi/Martini
Cliente : SETEC srl
Campione : VC BODY for SANITSER 13 prog LIFE
Data : 28-10-2014
Analisi : via " UMIDA " alimentatore A/22Compact
veicolo : H2O distill. us-30"

Measuring Range	0.31 [µm] - 300.74 [µm]	Pump	100[rpm]
Resolution	62 Channels (17 mm / 114 mm)	Stirrer	0[rpm]
Absorption	12.00 [%]	Ultrasonic	100
Measurement Duration	8 [Scans]		

Modell Independant

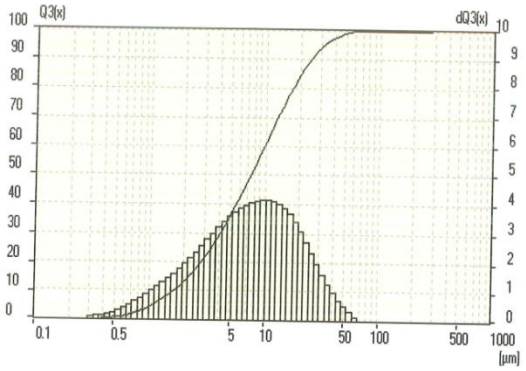
Fraunhofer Calculation selected.

Interpolation Values... C:\Programmi\a22___32\FRITSCH\fritsch\HIMNT_1.FPS

****** %	<	0.30 µm	0.71 %	<	0.50 µm	4.38 %	<	1.00 µm
35.82 %	<	5.00 µm	60.43 %	<	10.00 µm	75.29 %	<	15.00 µm
84.66 %	<	20.00 µm	90.43 %	<	25.00 µm	93.97 %	<	30.00 µm
98.60 %	<	45.00 µm	99.91 %	<	63.00 µm	100.00 %	<	75.00 µm
100.00 %	<	90.00 µm	100.00 %	<	105.00 µm	100.00 %	<	125.00 µm
100.00 %	<	150.00 µm	100.00 %	<	200.00 µm	100.00 %	<	250.00 µm

Interpolation Values... C:\Programmi\a22___32\FRITSCH\fritsch\10_90.FPV

10.00 %	<	1.64 µm	20.00 %	<	2.82 µm	30.00 %	<	4.14 µm
40.00 %	<	5.68 µm	50.00 %	<	7.54 µm	60.00 %	<	9.89 µm
70.00 %	<	12.93 µm	80.00 %	<	17.23 µm	90.00 %	<	24.55 µm
100.00 %	<	67.42 µm						



Micron	% Fraction passing for SANITSER 13	% Passing Fraction for VC Standard
5	**35.82**	41.39
10	**60.43**	62.83
25	**90.43**	89.88
30	**93.97**	93.89
45	**98.60**	99.12
63	**99.91**	99.99

Percentage of particles	Average diameter (micron) SANITSER 13	Average diameter (micron) VC Standard
D50	**7.54**	6.61
D90	**24.55**	25.14

Vitreous China body: SANITSER 13 granulometric distribution

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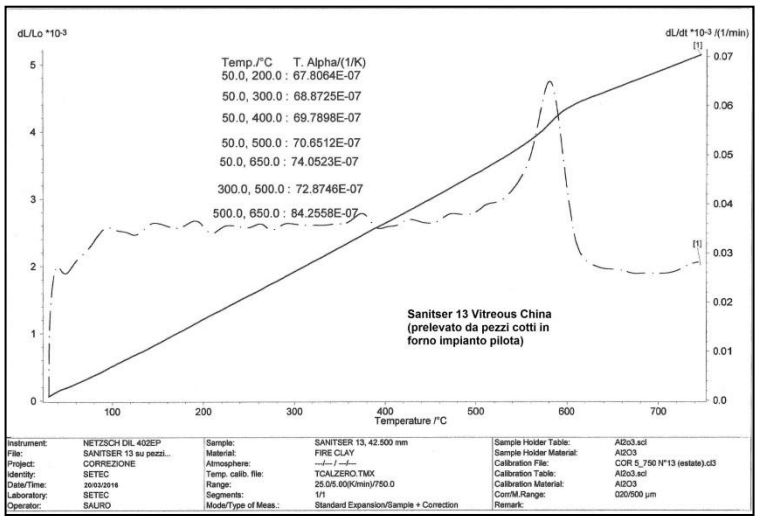
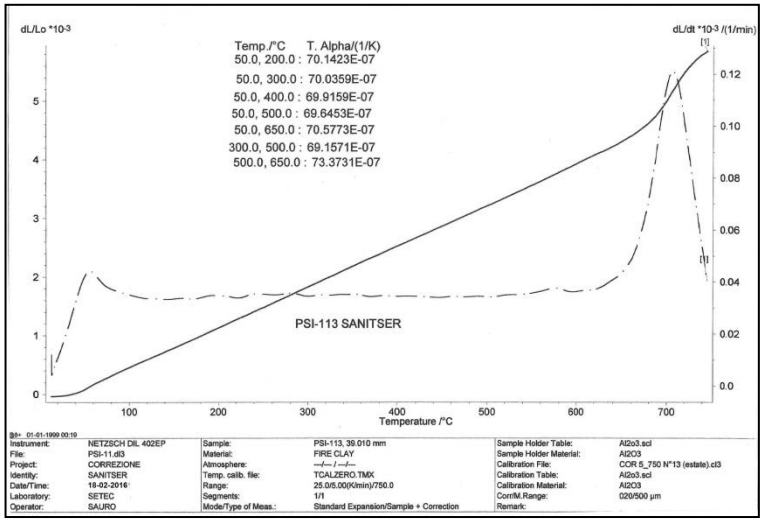
Table. Comparison of dilatometric coefficients obtained from Sanitser 13 slip compared with industrial standard vitreous china slip.

Temperature range (°C)	Dilatometric coefficient α in Vitreous china standard (1/K)	Dilatometric coefficient α in SANITSER 13 body (1/K)	Dilatometric coefficient α in SANITSER PSI-113 (1/K)
50-200	65.6 $x10^{-7}$	67.8 $x10^{-7}$	70.1 $x10^{-7}$
50-300	64.5 $x10^{-7}$	68.9 $x10^{-7}$	70.0 $x10^{-7}$
50-400	65.5 $x10^{-7}$	69.8 $x10^{-7}$	69.9 $x10^{-7}$
50-500	66.7 $x10^{-7}$	70.7 $x10^{-7}$	69.6 $x10^{-7}$
50-650	71.2 $x10^{-7}$	74.1 $x10^{-7}$	70.6 $x10^{-7}$
300-500	69.5 $x10^{-7}$	72.9 $x10^{-7}$	69.2 $x10^{-7}$
500-650	84.6 $x10^{-7}$	84.3 $x10^{-7}$	73.3 $x10^{-7}$





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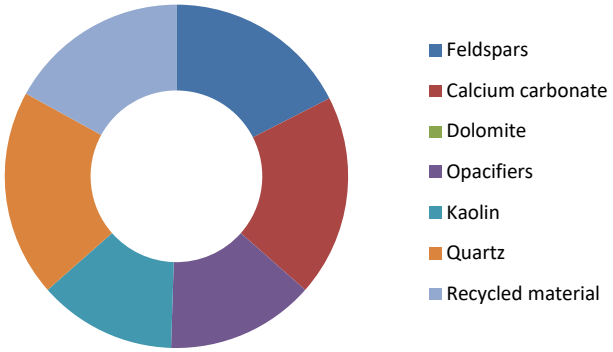
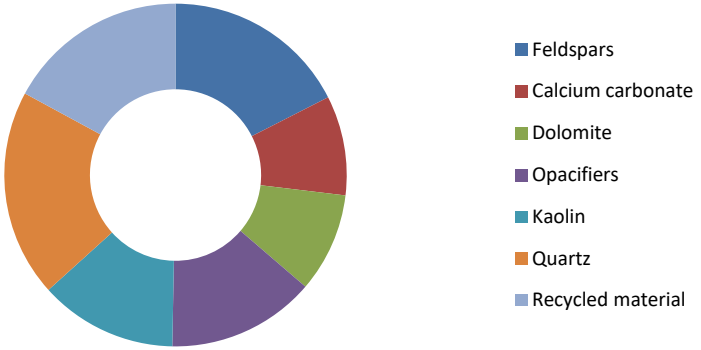
The challenging research to find a new glaze that can be used with the new slip formulation and processed with the new firing cycle ended with the glaze **PSI 113,** whose composition is shown in the table below and which has a **content of recycled products >15%.**

PSI-109B

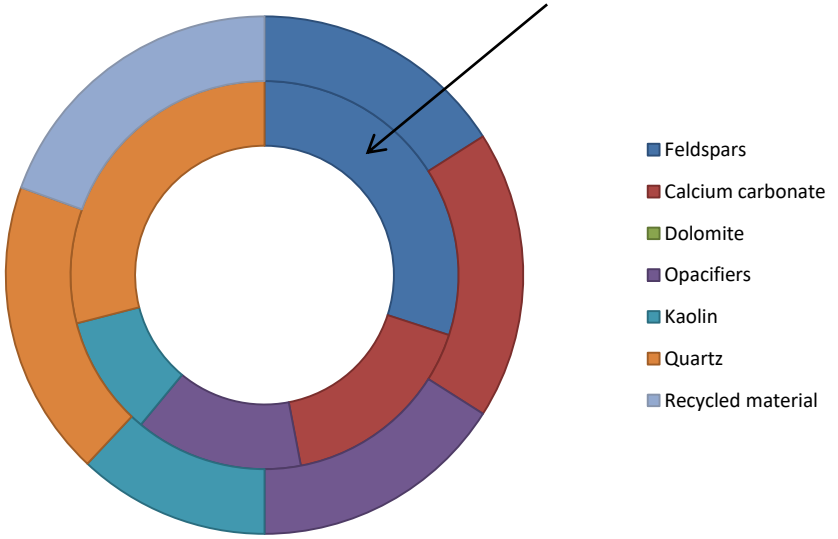


PSI-111-matt



Glaze PSI-109B was utilized in the pilot plant phase. Glazes PSI-113 and PSI-111 (matt white) were used in the preindustrial and industrial phases; they were also prepared in different colors. A special anti-bacterial product was added.

Traditional glaze



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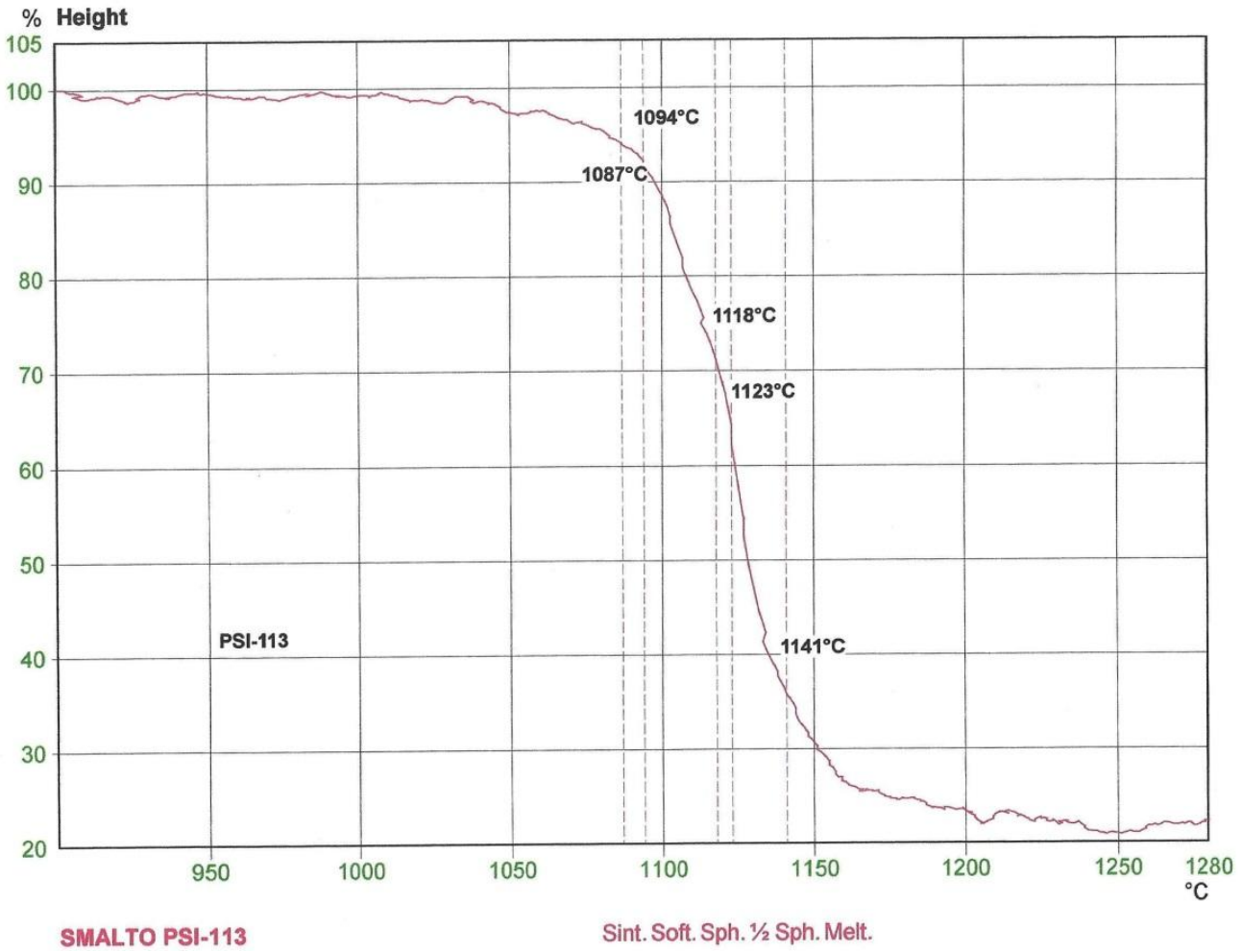
PSI-113 enamel was chosen for the industrial production, since it is the one which provides the best tone of white. It is also even the fuse. The higher fusibility of the glaze (a lower softening and melting temperature) allows to fire the sanitary ware pieces at 1165 ° C.



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Preservation of surface brightness and luminosity (norm UNI 4543)

(1) alkalis contact (NaOH 5%) at 160°C for 30m;
(2) acids contact (HCl 50% and H_2SO_4 1:3 at room temperature and for72h;
(3) Resistance to thermal shocks (5 cycles repeated of heating at 110°C in a calcium-chloride water-solution and quenching in ice-water;
(4) Resistance to water and vapour.
(5) Dyes contact at room temperature and for 72h;
(6) Resistance to abrasion by Al_2O_3-sand for 210s:

Test	Results
alkalis contact (1)	Any loss of reflectivity on the glaze surface;
acids contact (2)	Any loss of reflectivity on the glaze surface;

Test	Results
Resistance to thermal shocks (3)	No sign of crazing, peeling or settling-crack in the samples analysed.
Resistance to water and vapour (4)	No sign of crazing, peeling or settling-crack in the samples analysed.

Test (5)	Results
Potassium permanganate	No stain due to chemical materials remain after the washing and use of cleaning device.
Methylene blue	No stain due to chemical materials remain after the washing and use of cleaning device.

Test	Results
Al2O3-sand for 210s (6)	No defects appear, never abrasion

Colorimetric control

Characteristics	PSI-109 glaze	PSI-113 glaze	Standard glaze
Luminosity (by Spectroeye)	92.98	94.22	91.22
Brightness (gloss degree at 60°)	143.2	144.6	> 140
Surface roughness (micron)	Ra < 0.10 Rt < 0.83	Ra < 0.08 Rt < 0.66	Ra < 0.12 Rt < 0.8

PSI-109

PSI-113

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Fired pieces (pre-industrial tests in SETEC pilot plant)

Pieces made with SANITSER 13 and glaze PSI-113

Washbasins produced using slip SANITSER 13 and coloured glaze PSI

Washbasin produced using slip SANITSER 13 and glaze PSI with anti-bacterial additive

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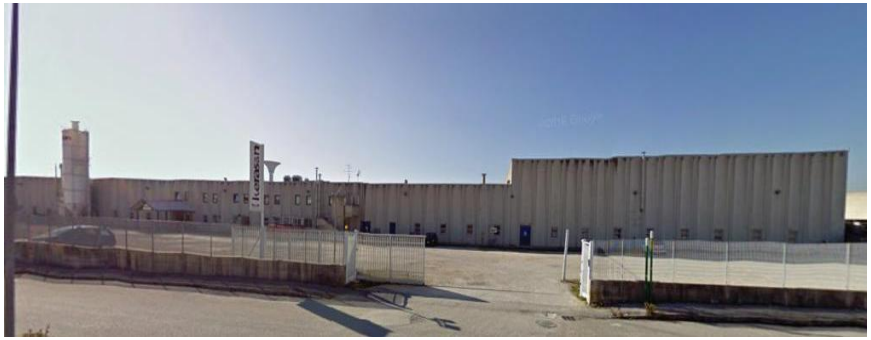
Industrial test:

Production of at least **1760** pieces in 8 different shapes

Companies involved in the tests:

KERASAN SRL
SCARABEO CERAMICHE SRL
ALICE CERAMICA SRL
CERAMICA AMERINA SRL



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ENVIRONMENTAL ACHIEVEMENTS

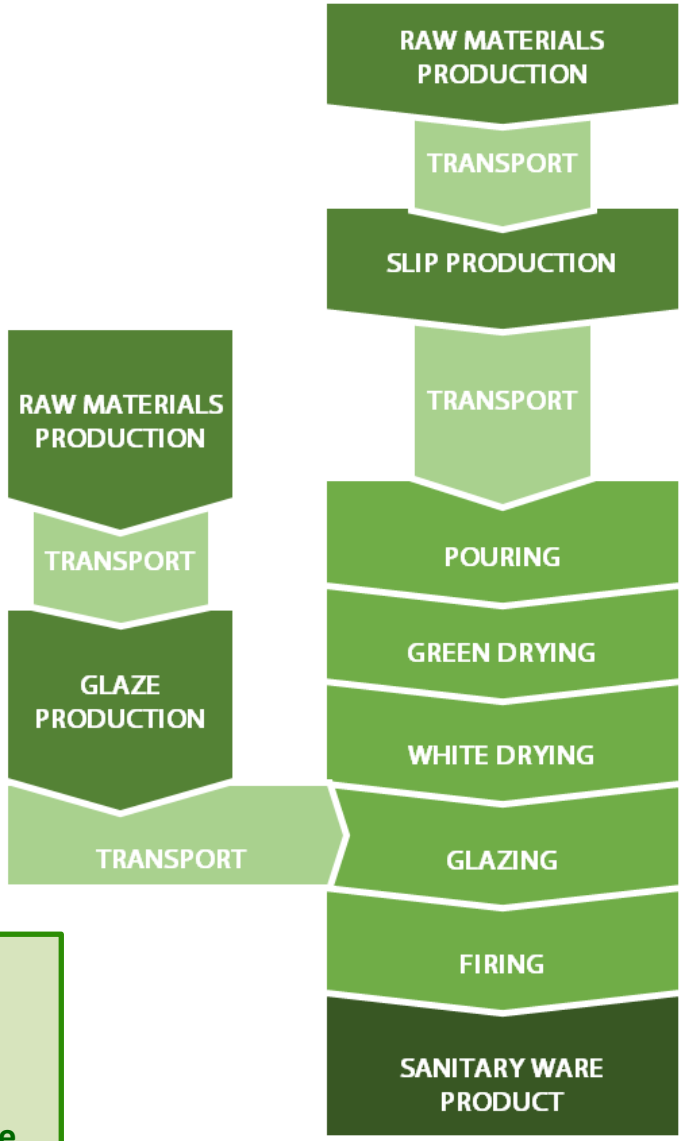
*Environmental benefits of SANITSER process respect to traditional technology are quantified through a **Life Cycle Assessment (LCA)**, a scientific and internationally recognized methodology.*

Reference standards:

ISO 14040:2006 Life cycle assessment - Principles and framework

PCR 2012:01 V 2.01, "Construction products and construction services"

System boundaries:
From cradle to industry gate



Comparison:

Traditional production process
VS
SANITSER innovative process – Industrial stage

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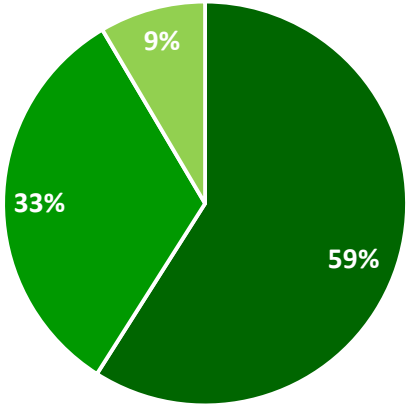
ENVIRONMENTAL ACHIEVEMENTS

Recycled content of SANITSER product **41 %**



- Primary material
- Pre-consumer secondary material
- Post-consumer secondary material

ISO 14021:2016

Reduction of **CO_{2eq} emission** from firing: **- 18 %**

Reduction of raw materials **transportation distances**: **- 45 %**

Pre-consumer material:
Material diverted from the waste stream during a manufacturing process, excluded reutilization.

Post-consumer material:
Material generated by households or by facilities in their role as end-users of the product which can no longer be used for its intended purpose.

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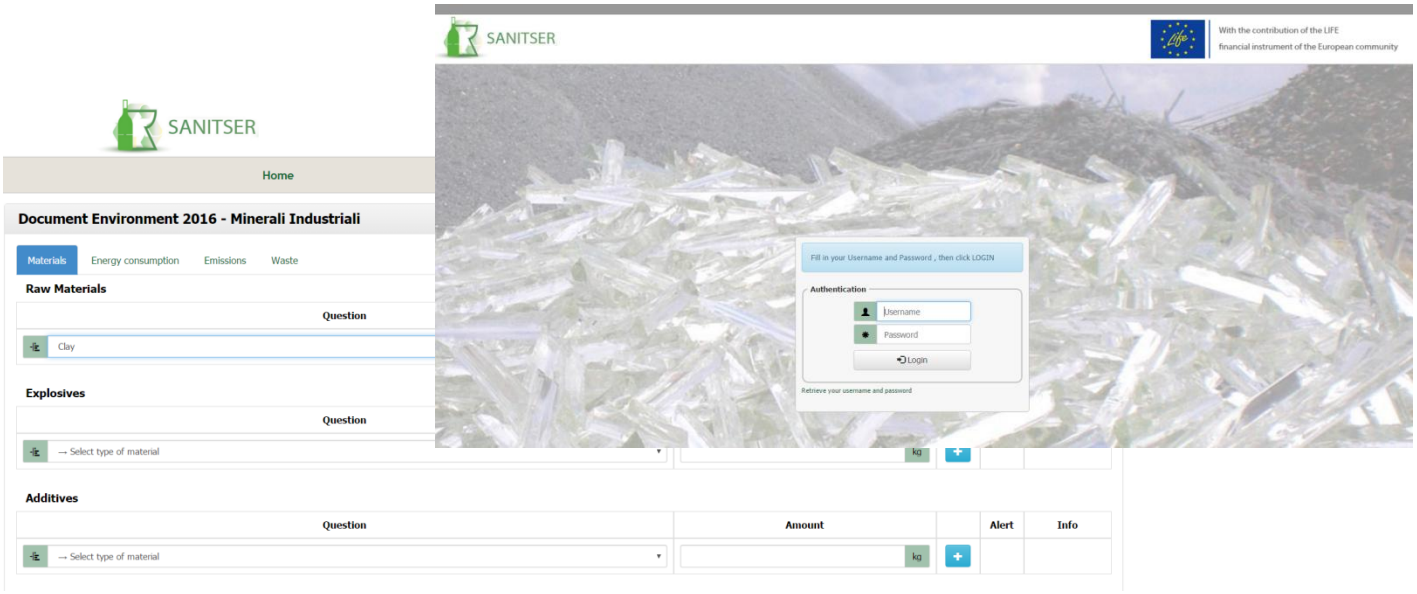
ENVIRONMENTAL ACHIEVEMENTS

Web based tool

During the project a web based tool was designed and developed to:

- **Collect quantitative data** according to the Life Cycle Assessment (LCA) approach
- **Calculate the main environmental indicators** for evaluating the performance of the processes involved at different production level

Link: www.sanitser-tool.eu



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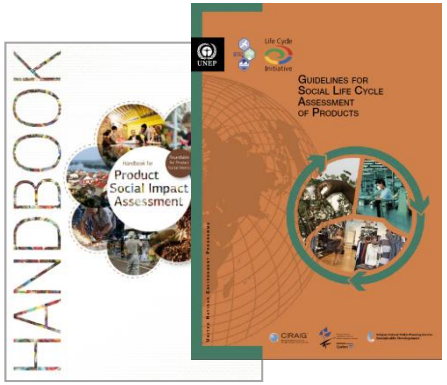
SOCIAL ACHIEVEMENTS

*Social aspects related to the new SANITSER process are assessed throughout the **Social Life Cycle Assessment (SLCA)**, a quali-quantitative recognized approach along the whole life cycle*

Reference standards:

Guidelines for Social Life Cycle Assessment of Products (UNEP/SETAC, 2009)

Handbook for Product Social Impact Assessment (Roundtable for Product Social Metrics 2014)



Decrease of risk from silica exposure

Silicosis is a form of **occupational lung disease** occurring after inhalation of crystalline silica dust, potentially present in all production processes involving materials containing silica.

All over the traditional sanitary ware production process, risk of Silicosis can be find in stages involving **quartz** or semi-finished products containing it (e.g. slip), since quartz is mainly composed by Silica in its **crystalline form**.

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ECONOMIC ACHIEVEMENTS

*Costs over the life cycle of SANITSER process compared to the traditional technology are evaluated using the **Life Cycle Costing (LCC)**.*
(reference standards: ISO 15685-6:2008).

Total operational and maintenance cost reduction: 5 – 10 %

Reduction is mainly due to:

- Raw materials used for body composition
- Energy saved during the firing process

TAVOLA ROTONDA
10 MARZO 2017
h 15.00

- Prospettive future di applicazione ed estensione dello studio anche al fire clay e ad un silica free body

- EPD – Dichiarazione ambientale di prodotto

- Problematiche del distretto di Civita Castellana e opportunità legate alla ricerca

- Tool per il calcolo della LCA (Life Cycle Assessment)

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Thank you