**Polo Territoriale di Lecco**
**Laboratorio di Recupero Edilizio ed Efficienza Energetica_RE3_Lab**
**Laboratorio di Misure Termiche e Meccaniche_MetroSpace Lab**

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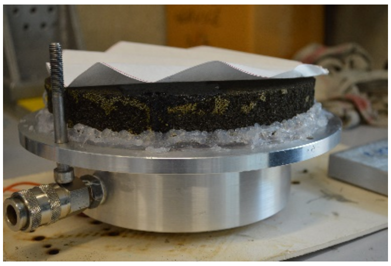
Report:

# Experimental characterization of FOAMGLAS® T4+: Air and Water sealing tests.



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**Sommario**

## 1. Introduction

The report presents the results of the characterization tests, i.e. the air sealing test (WP1) and the water sealing test (WP2), performed on FOAMGLAS® T4+ product.

The T4+ is a material used in general for different applications among which: flat roofs, facades, below grade floors and walls, metal and special roofs, interior insulation (walls, floors, and ceilings). The material is manufactured from specially graded recycled glass (≥ 60%) and natural raw materials which are easily available (sand, dolomite, lime…). The insulation is totally inorganic, contains no ozone depleting propellants, flame resistant additives or binders. Without VOC or other volatile substances.

The material has been prepared for the tests starting from boards (450±2 mm width; 300±2 mm length) with thickness of 30 mm, which have been cut with a laser machine in circular samples. In particular, for the water sealing test the samples prepared were of 200 mm diameter and for the air sealing test they were of 85 mm diameter. For both the experiments, the material has been tested firstly in a homogenous part and secondly with a joint between two FOAMGLAS® plates. Figure 1 represents a scheme of the two specimen used for the tests. For the case with the joint, the two FOAMGLAS® plates have been connected together with PC® 56, a solvent-free two part-component adhesive. Component 1 is a bitumen-based emulsion and the second component is a powder. The joint width ranges from 2-4 mm due to the roughness of the material finishing.


*Figure 1 – Scheme of the two types of specimen tested. Size varies with the performed WP.*

The air sealing test (WP1) required the measurement of the air flux through the material component, mounted as sealing element of a vacuum chamber in which a depression is generated by a vacuum pump.

The water sealing test (WP2) has been carried out according to the BS EN 1928:2000 regulation: Flexible sheets for waterproofing - Bitumen, plastic and rubber sheets for roof waterproofing - Determination of water tightness. The characterization foreseen the realization of a chamber filled with water and sealed with the sample to be tested.

Table 1 summaries the product characteristics according to EN 13167: Thermal insulation products for buildings. Factory made cellular glass (CG) products. Specification.

*Table 1 – FOAMGLAS® T4+ characteristics according EN 13167*

| | |
|---|---|
| LENGTH | 300 OR 600 (±2) mm |
| WIDTH | 450 (±2) mm |
| THICKNESS | From 40 till 180 (±2) mm |
| GEOMETRY | Flatness ≤ 2 mm<br>Squareness $S_{l,b}$ ≤ 6 mm/m; $S_{ih}$ ≤ 2 mm |
| THERMAL CONDUCTIVITY | 0,041 W/mK |
| REACTION TO FIRE | Class A1 |
| POINT LOAD | PL ≤ 1,5 mm |
| COMPRESSIVE STRENGTH | CS ≥ 600 kPa |
| BENDING STRENGTH | BS ≥ 450 kPa |
| TENSILE STRENGTH PERPENDICULAR TO FACES | TR ≥ 150 kPa |
| DIMENSIONAL STABILITY (48H – 70°C – 90% RH) | $\Delta\varepsilon_{l,b}$ ≤ 0,5; $\Delta\varepsilon_{th}$ ≤ 1 |
| WATER ABSORPTION | ≤ 0,5 kg/m$^2$ |

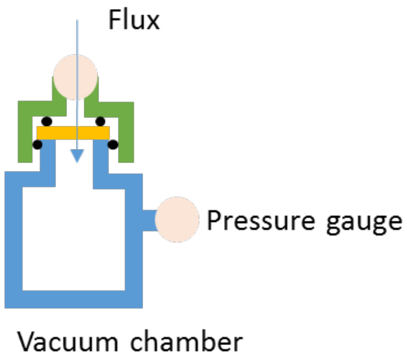
## 2. WP1 – Air sealing test: Introduction

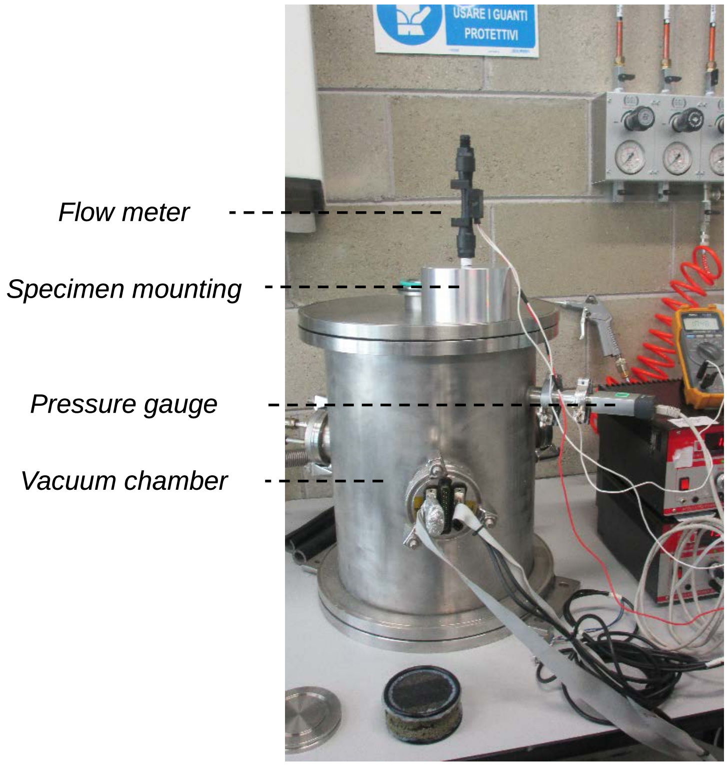
Section 2 contains the description of the WP1 – Air sealing test according to the following structure and requirements: standard and regulations; set up description; set up assembly and finally results and discussions respectively for the two kind of specimen (with and without joint - Figure 1).

### 2.1 WP1 – Setup description

In this subsection, the measuring setup for the air tightness testing of a FOAMGLAS® T4+ specimen is described.

The characterization activity is based on the measurement of air flux through the material component, mounted as sealing of a vacuum chamber in which depression is generated by a vacuum pump. Figure 2 represents the setup of the WP1 air sealing test: a) set up and assembly scheme of test composed by: vacuum chamber, the sample over, flux direction and pressure gauge; b) picture of the instruments set up in laboratory for the air sealing test.




*a) WP1 Set up scheme* *b) Instruments set up in laboratory*

*Figure 2 – Set up scheme and laboratory instruments for WP1*

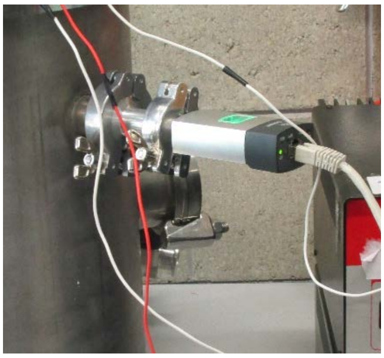
The laboratory testing procedure consists of:

- sealing a specimen into one face of the test air chamber at a pressure of 800 mbar;
- measuring pressure and air flow at the test condition;
- measuring humidity and temperature at the test condition.

Considering the above described set up, the designed system is able to measure the air flow in defined pressure conditions.

Figure 3 summarized the test set up composed by the following components:

a) Stainless steel vacuum chamber with 200 mbar pressure difference with respect to ambient one.



b) Pressure gauge (Varian PCG-750 series with accuracy of $5x10^{-5}$ mbar ) for monitoring of the pressure inside the chamber.

c) Flow meter sensor (AWM5000 Honeywell Micro Switch with repeatability ±0.5% of reading) to measure leakage through the FOAMGLAS® specimen (min. measurable flow $1.6*10^{-6}$ $m^3/s$).

d) Measurement of temperature and humidity in test conditions.

e) Specimen mounting and flowmeter supports.

f) FOAMGLAS® T4+ specimen.

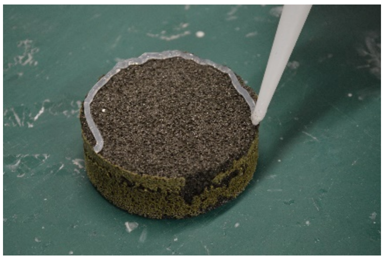
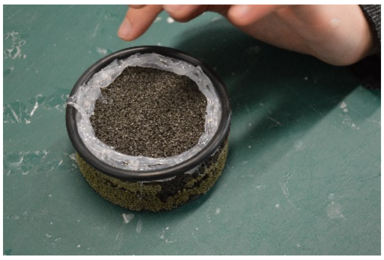
*Figure 3 – Components set up for the air sealing test*

## 2.2 WP1 – Set up assembly

The WP1 set up for the air sealing test contemplates the following phases (Figure 4).

1. Preparing the material cutting it in circular sample with a laser machine and in the case with the joint, preparation of PC® 56 g bitumen cold adhesive.


2. Spreading of the silicone on the edge of the sample and positioning of the plastic ring for both sides of the specimen.

3. Positioning of the sample inside a support to be mounted on the chamber being careful that the specimen is properly sealed.


4. Turning on the pump and checking that the pressure doesn't drop under 600 mbar with a pressure gauge.


5. Opening the valve we can reach a pressure around 800 mbar and from this condition, we can start monitoring the flux through the sample and the pressure inside the vacuum. The pressure has to remain constant for 5 minutes without flux.

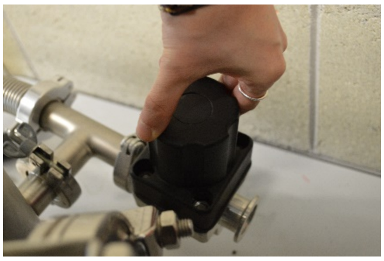
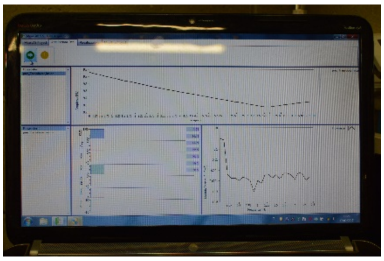



*Figure 4 – Set up phases for the air sealing test*

## 2.3 WP1 – Results and Discussion

### 2.3.1 WP1 – FOAMGLAS® T4+ sample without joint

The first WP1 test has been realized on a sample without joint as schematically represented in Figure 5.

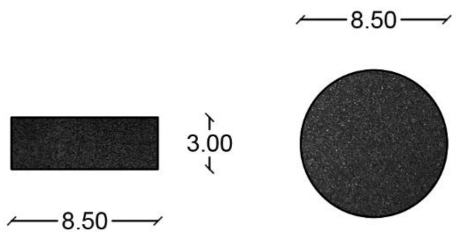



*Figure 5 – Scheme of the sample without joint for the air sealing test [dimension in cm]*

After the setup, the sample was tested 5 times (in order to assess measurement repeatability) for 5 minutes each. Flowmeter output voltage was measured and statistics were computed (average and standard deviation on 5 samples).

Measured statistics are summarized in Figure 6.

In particular, the graph allows to compare the voltage measured during the 5 different tests with the value at the 0 condition, which is the case when the chamber is at ambient pressure and the flow is not present. It can be seen that the measured voltages with the sample are compatible with the measured value at the 0 condition.

In Figure 7 the average values of the pressure within the chamber for the 5 tests are represented.

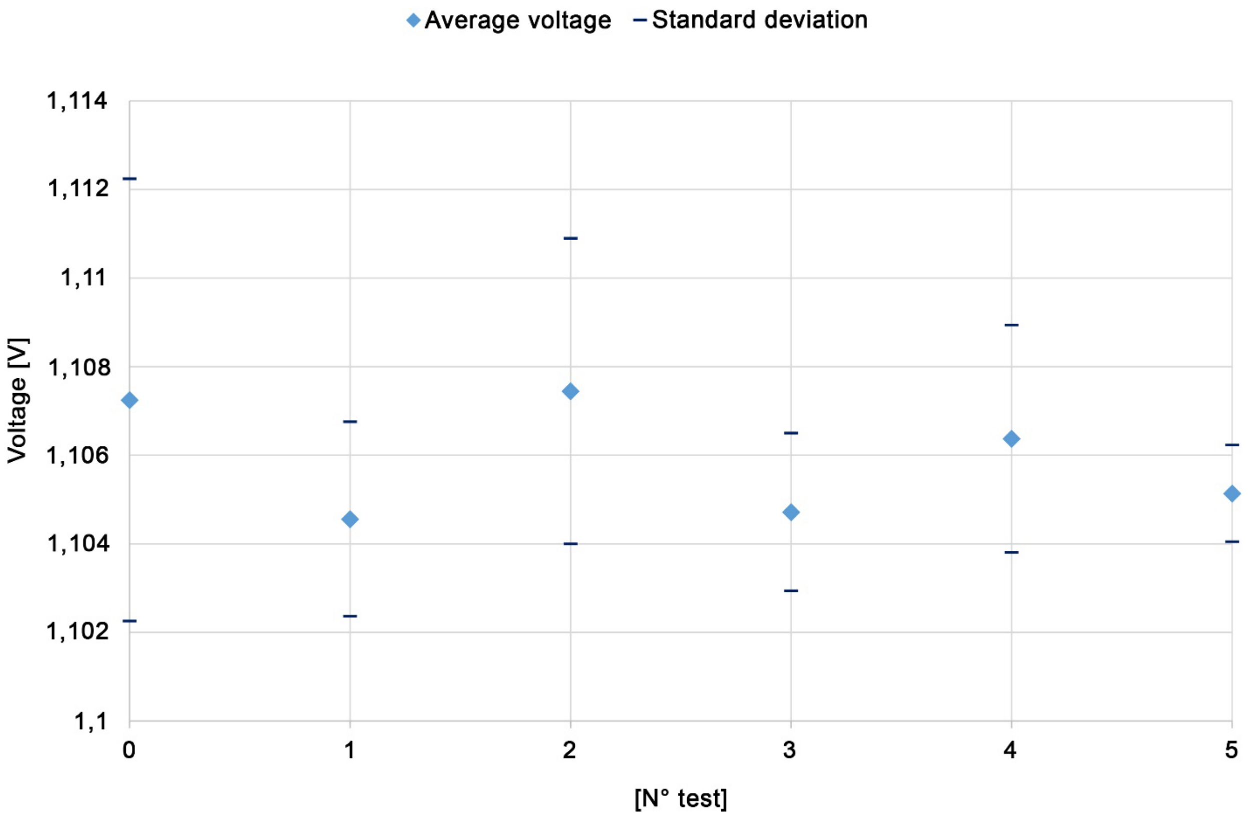



*Figure 6 – Graph of the average values of flux for the 5 tests on the sample without joint*

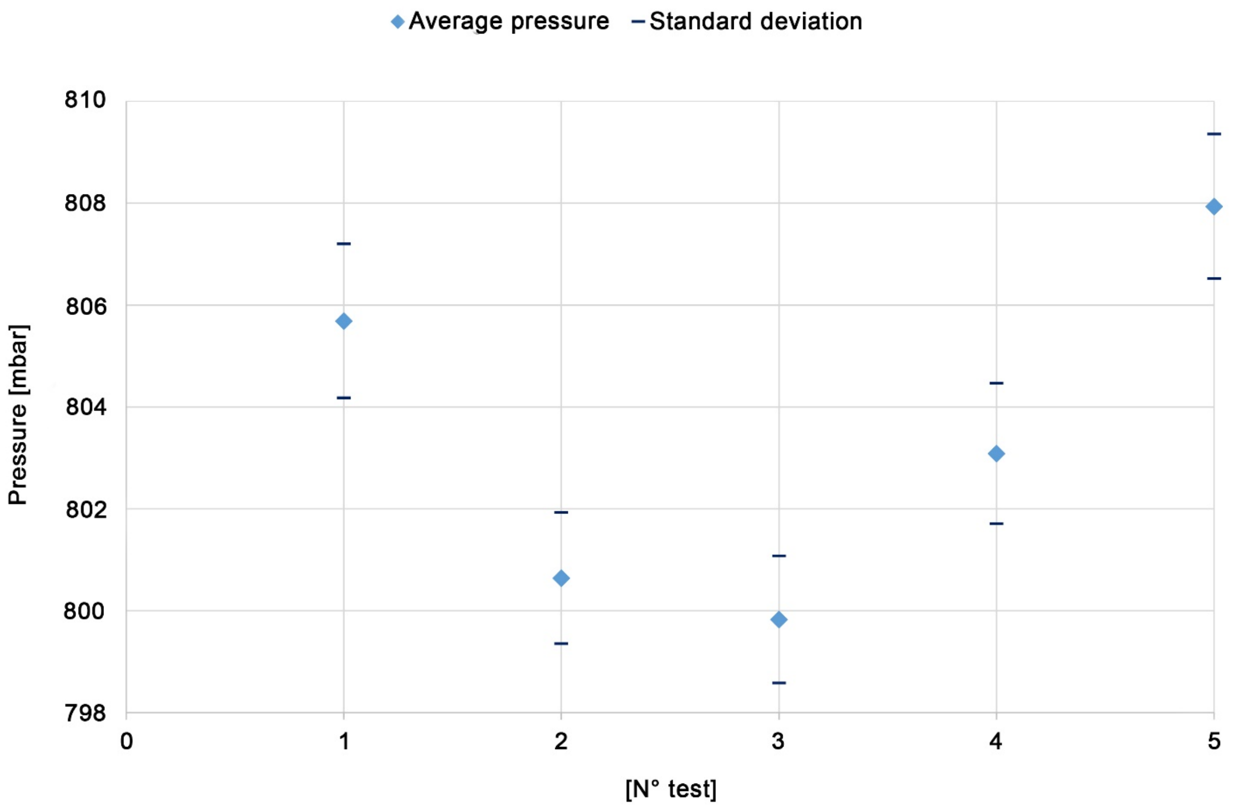



*Figure 7 – Graph of the average values of pressure for the 5 tests on the sample without joint*

Table 2 summarizes the results for the different tests: the measured voltages compatible among the different tests.

*Table 2 – Measured signal (flowmeter) and pressure for the air sealing tests on the sample without joint*

| N° test | Average voltage value [V] | Voltage standard deviation [V] | Average pressure value [mbar] | Pressure standard deviation [mbar] |
|---|---|---|---|---|
| 0 | 1,107 | 0,005 | 1000 | / |
| 1 | 1,103 | 0,002 | 805,6 | 1,5 |
| 2 | 1,107 | 0,004 | 800,6 | 1,2 |
| 3 | 1,105 | 0,002 | 799,8 | 1,2 |
| 4 | 1,106 | 0,003 | 803,0 | 1,3 |
| 5 | 1,105 | 0,001 | 807,9 | 1,4 |

### 2.3.2 WP1 – FOAMGLAS® T4+ sample with joint

The same test described above has been performed on a sample with joint, manufactured as schematically represented in Figure 8.

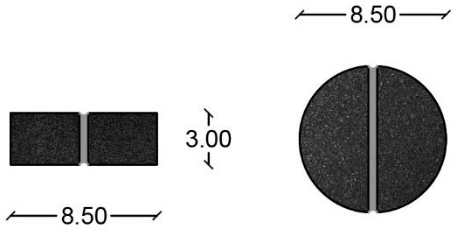



*Figure 8 – Scheme of the sample for the air sealing test with joint [dimension in cm]*

After the specimen mounting, the sample was tested 5 times for around 5 minutes each.

Similarly to the previous test on the sample without joint, Figure 9 represents the measured voltage by means of the flowmeter for each test. In particular, the graph allows comparing the voltage measured during the 5 different tests with the value at the 0 condition (i.e. without flux since at ambient pressure). Compatibility between measured signals is assured by the obtained results.

Figure 10 the average values of the pressure in the chamber for each of the 5 tests are represented.

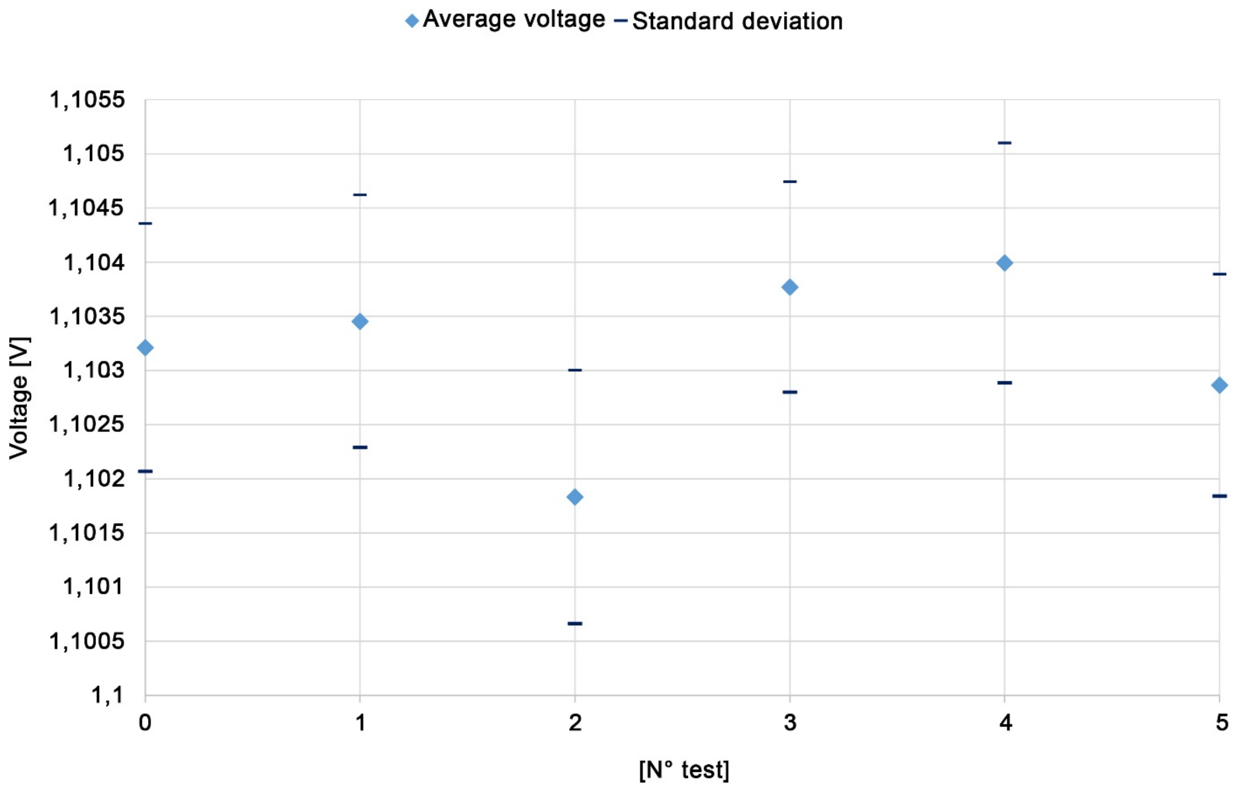



*Figure 9 – Graph of the average values of flux for the 5 tests on the sample with joint*

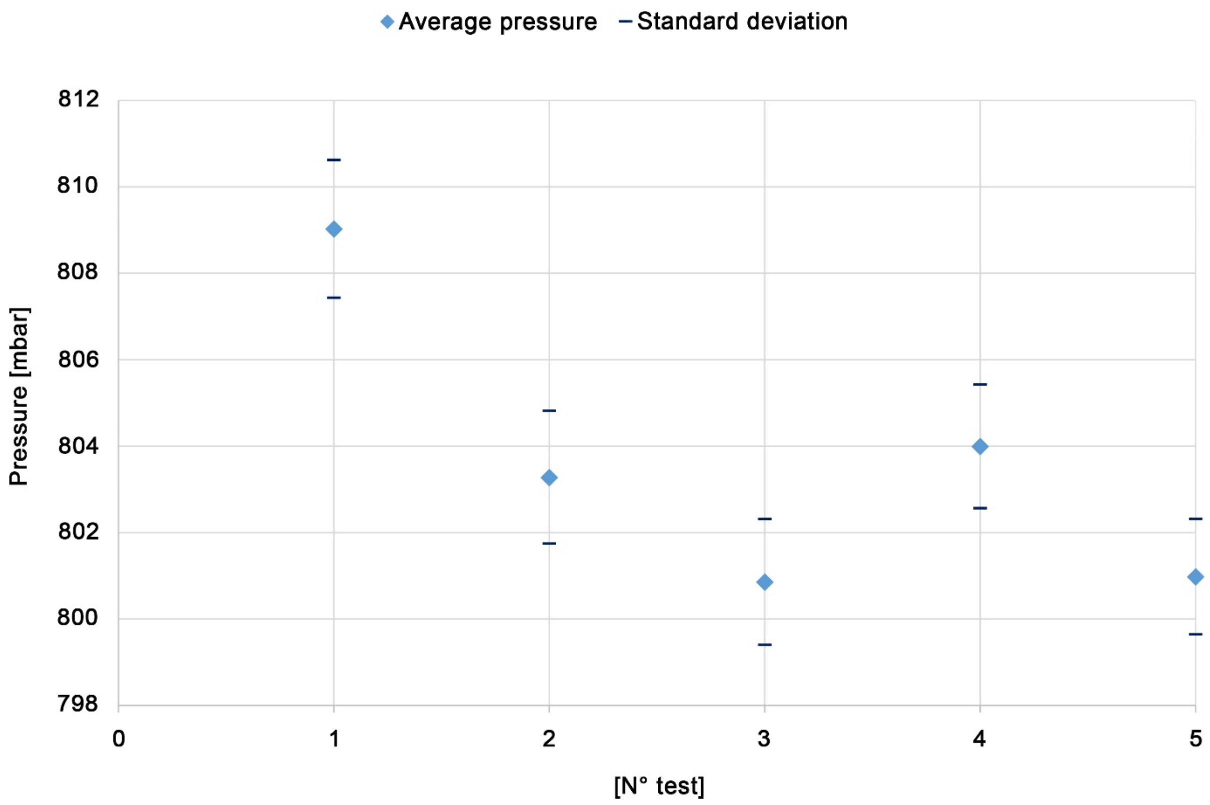



*Figure 10 – Graph of the average values of pressure for the 5 tests on the sample with joint*

Table 3 summarizes the results for the different tests: the measured voltages are compatible among the different tests.

*Table 3 – Measured voltage and pressure for the air sealing tests on the sample with joint.*

| N° test | Average voltage value [V] | Voltage standard deviation [V] | Average pressure value [mbar] | Pressure standard deviation [mbar] |
|---|---|---|---|---|
| 0 | 1,103 | 0,001 | 1000 | / |
| 1 | 1,104 | 0,001 | 809,0 | 1,5 |
| 2 | 1,102 | 0,001 | 803,2 | 1,5 |
| 3 | 1,104 | 0,001 | 800,8 | 1,4 |
| 4 | 1,104 | 0,001 | 803,9 | 1,4 |
| 5 | 1,103 | 0,001 | 800,9 | 1,3 |

### 2.3.3 WP1 – Discussion

Measured signals by the flowmeter for the sample with and without joints evidence measurement compatibility between the test with the samples and with the zero flux condition. This is testified by graphs in Figure 6 and 9. Moreover, measurement repeatability was obtained for both the tested samples. This is evidenced by the measurement compatibility within the five tests performed for each sample.

Thus, it can be concluded that, both the samples with and without joint, allow achievement of the air tightness condition with air flow less than $1.6*10^{-6}$ $m^3/s$, minimum measurable value of the designed setup.

## 3. WP2 – Water sealing test: Introduction

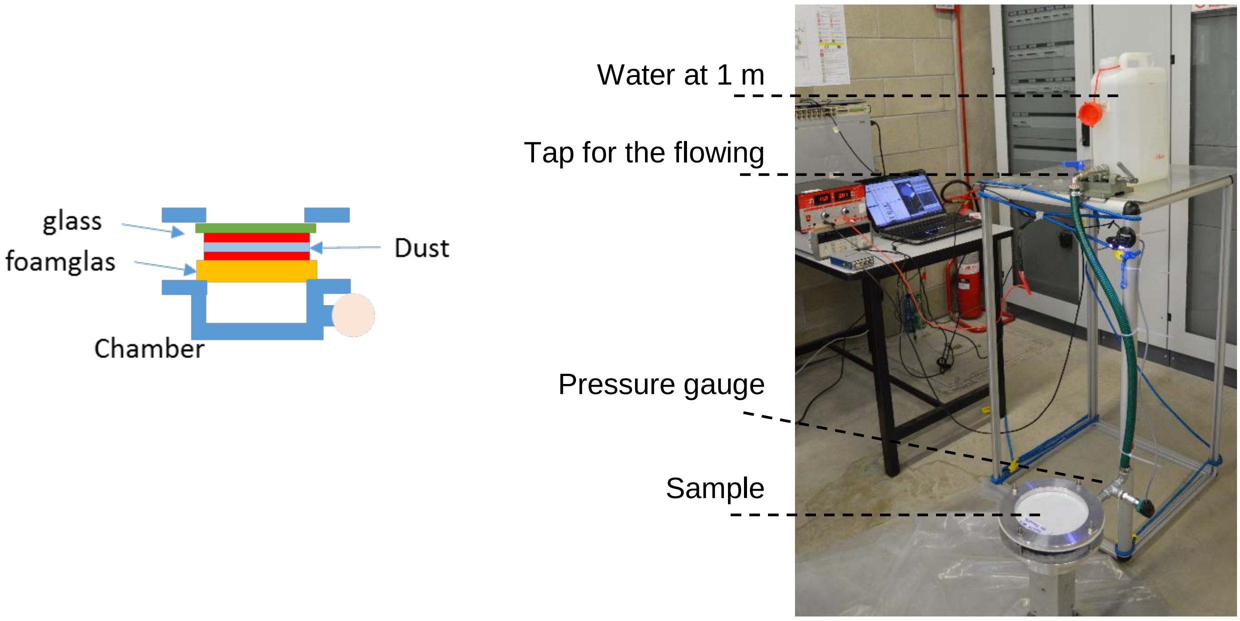
Section 3 contains the description of the WP2 – Water sealing test based on the realization of a chamber filled with water and sealed with the sample to be tested. The paragraph presents the following structure: standard and regulations; set up description; set up assembly and finally results and discussions respectively for the two kind of specimen (with and without joint - Figure 1).

### 3.1 WP2 – Standard and regulations

The standard used is the BS EN 1928-2000: Flexible sheets for waterproofing - Bitumen, plastic and rubber sheets for roof waterproofing - Determination of watertightness. This standard has been prepared by the Technical Committee CEN/TC 254 to determine the watertightness for applications in roofing but it may also be used in other areas where it is relevant. This standard has been intended for characterization of flexible sheets for waterproofing as manufactured or supplied before use. This European Standard applies to bitumen, plastic and rubber sheets and specifies procedures for determining the watertightness, for example the resistance to ponding water or to hydarulic pressure absorbed by a limited part of the of the surface, of factory made products.

### 3.2 WP2 – Set up description

In this subsection, it is described the measuring set up for the water sealing testing of a FOAMGLAS® T4+ component. The characterization is based on the realization of a chamber filled with water and sealed with the sample to be tested, in accordance to standard BS EN 1928-2000.

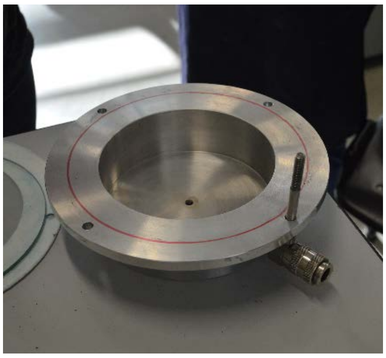


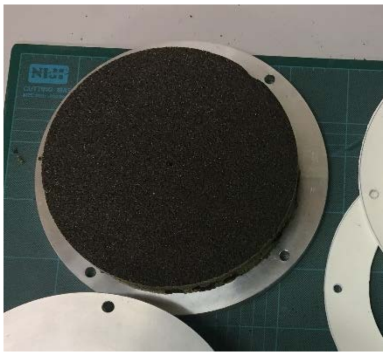

*a) WP2 Set up scheme* *b) Instruments set up in laboratory*

*Figure 11 – Set up scheme and laboratory instruments for WP2*

Figure 11 shows the setup of the water sealing test: a) set up scheme with a focus on the components assembly (Foamglas sample with the dust between two paper layers and a glass to close the set up); b) pictures of the instruments set up in laboratory for the water sealing test.

The setup is composed in detail by the following elements (Figure 12).

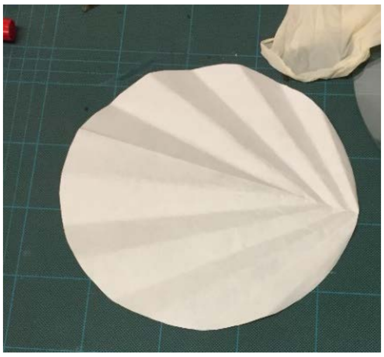


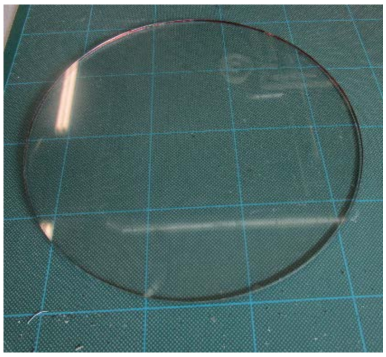


a) Testing chamber to be filled with water.

b) Pressure gauge (Gefran TK-E-1-E-B16U-H-V with accuracy ± 0.25% FSO) for the internal pressure's chamber monitoring.

c) Foamglas sample: two samples were tested, one with homogenous material and another one with a joint.



d) Two filter cards.

e) Dust with fine blue and white sugar and Methylene Blue BP (code INCI:CI 52015) sieved and dried with calcium chloride.

f) Window glass with 5 mm thickness.

*Figure 12 – Components set up of the water sealing test*

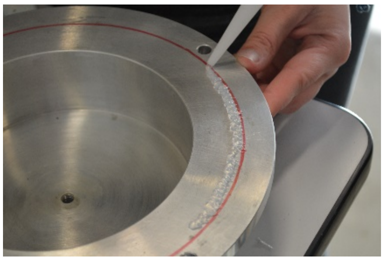
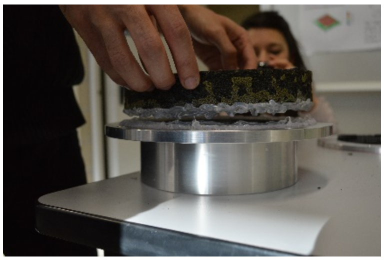
The tank with the water was positioned at the level of 1 meter (with respect to the sample wet interface) to guarantee the pressure of 10 kPa.

## 3.3 WP2 – Set up assembly

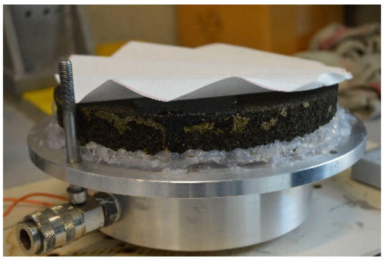
The WP2 set up for the water sealing test contemplates the following phases (Figure 13).

1. Preparing the material in the same way of the previous tests and in case with the joint, preparation of the bitumen cold adhesive.

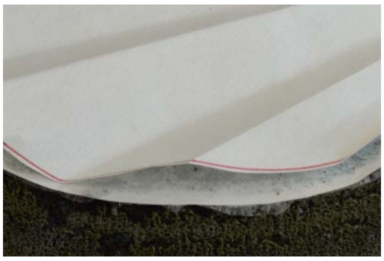

2. Spreading of the silicone[1](*) on the chamber and on the edge of the sample and positioning it on the chamber;

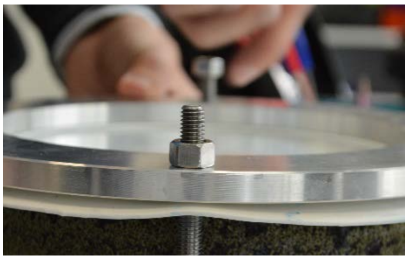
3. Positioning of the first filter card and homogeneus spreading of the dust with fine blue and white sugar methylene sieved




4. Positioning of the second filter card and the glass




5. Positioning of the closing part of the chamber and locking of the nuts

[1] Silicone layer was used to avoid lateral water leakage at the contact interface between the sample and the chamber

6. Closing of the hole (for the air removal in pressurized condition) under the chamber to avoid the spillage of the water and connection to the tank

7. Opening of the tap for flowing the water (*) into the chamber

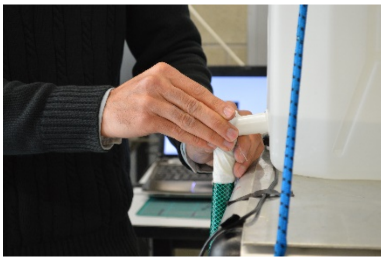


*Figure 13 – Set up phases of water sealing test*

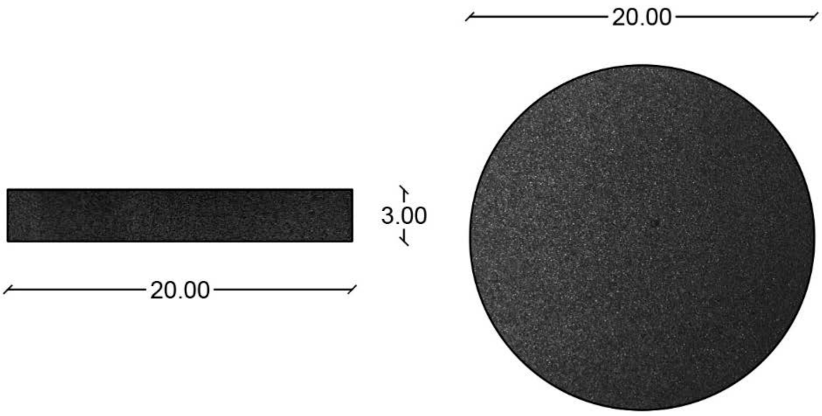
(*) After the flowing of the water, all the air inside the chamber was removed using the .

Once the sample is mounted and the testing pressure is equal to 10 kPa, as required by the standard, the sample is kept 24 hours in that condition. The chamber pressure was monitored for all the test duration. Moreover, a camera viewing the filter paper under the glass window, allowed monitoring the testing. The test is considered passed if the pressure is stable and the filter paper remains white for all the test time.

## 3.4 WP2 – Results and Discussion

### 3.4.1 WP2 – FOAMGLAS® T4+ sample without joint

The first WP2 test has been realized on a sample without joint as schematically represented in Figure 14.




*.Figure 14 – Scheme of the sample without joint for the air sealing test [dimension in cm]*

Figure 15 provides an overview of the monitoring results (every 2 hours) captured with the webcam during the 24 hours water sealing test on the sample without the joint.


*Figure 15 – Overview of the monitoring results of the WP2 test on the sample without joint*

Figure 16 shows the measured pressure during the WP2 water sealing test. It can be seen that the value remained constant for the whole test.

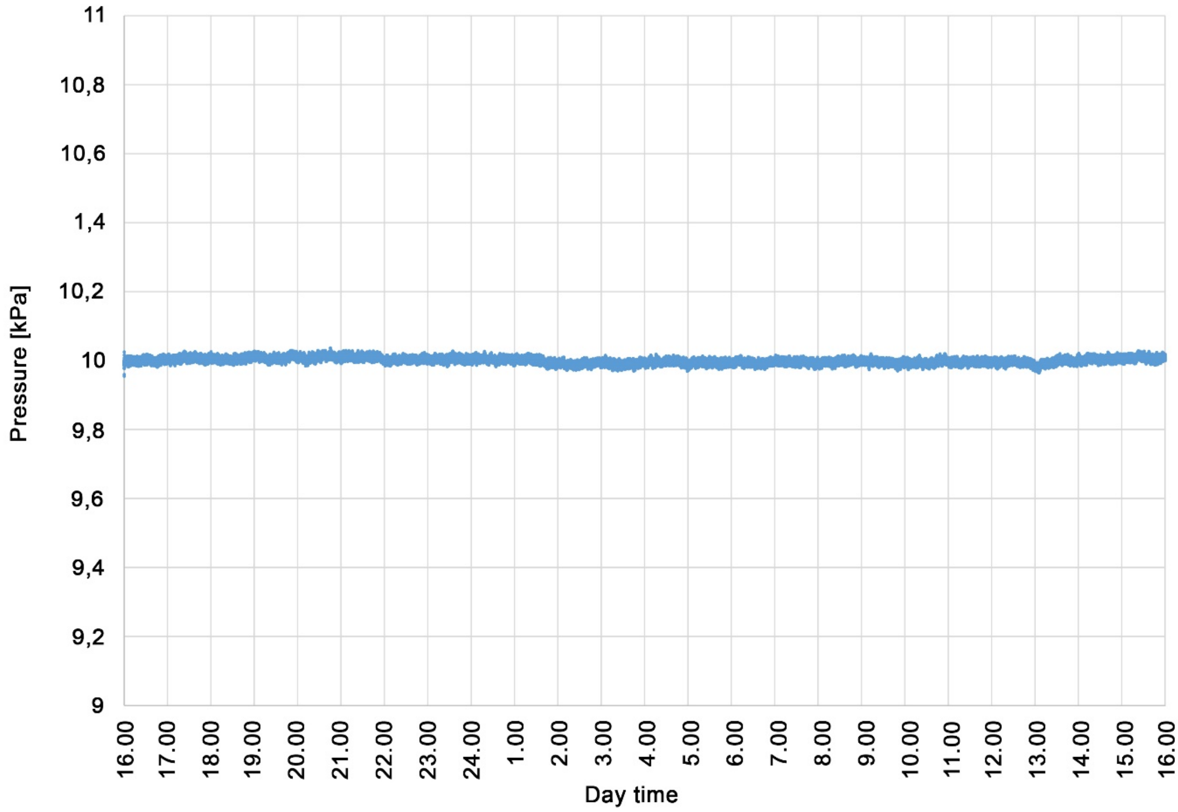



*Figure 16 – Pressure trend during the 24 hours of the water sealing test on the sample without joint*

### 3.4.2 WP2 – FOAMGLAS® T4+ sample with joint

The second test for the WP2 has been realized on a sample with the joint, as schematically represented in Figure 17.

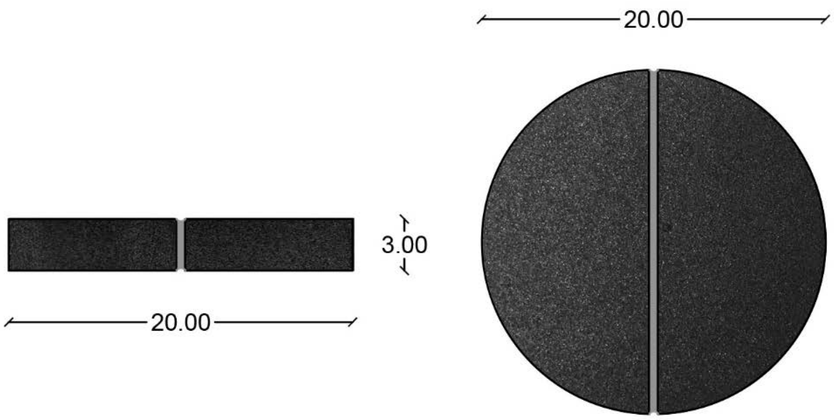



*Figure 17 – Scheme of the sample with joint for the air sealing test [dimension in cm]*

Figure 18 provides an overview of the monitoring results (every 2 hours) captured with the webcam during the 24 hours water sealing test on the sample with the joint.

10.00

12.00

14.00

16.00

18.00

20.00

22.00

00.00

02.00

04.00

06.00

08.00

*Figure 18 – Overview of the monitoring results of the WP2 test on sample with joint*

Figure 19 represents the pressure during the WP2 water sealing test on the sample with the joint. It can be seen that the pressure remained stable for the whole test.

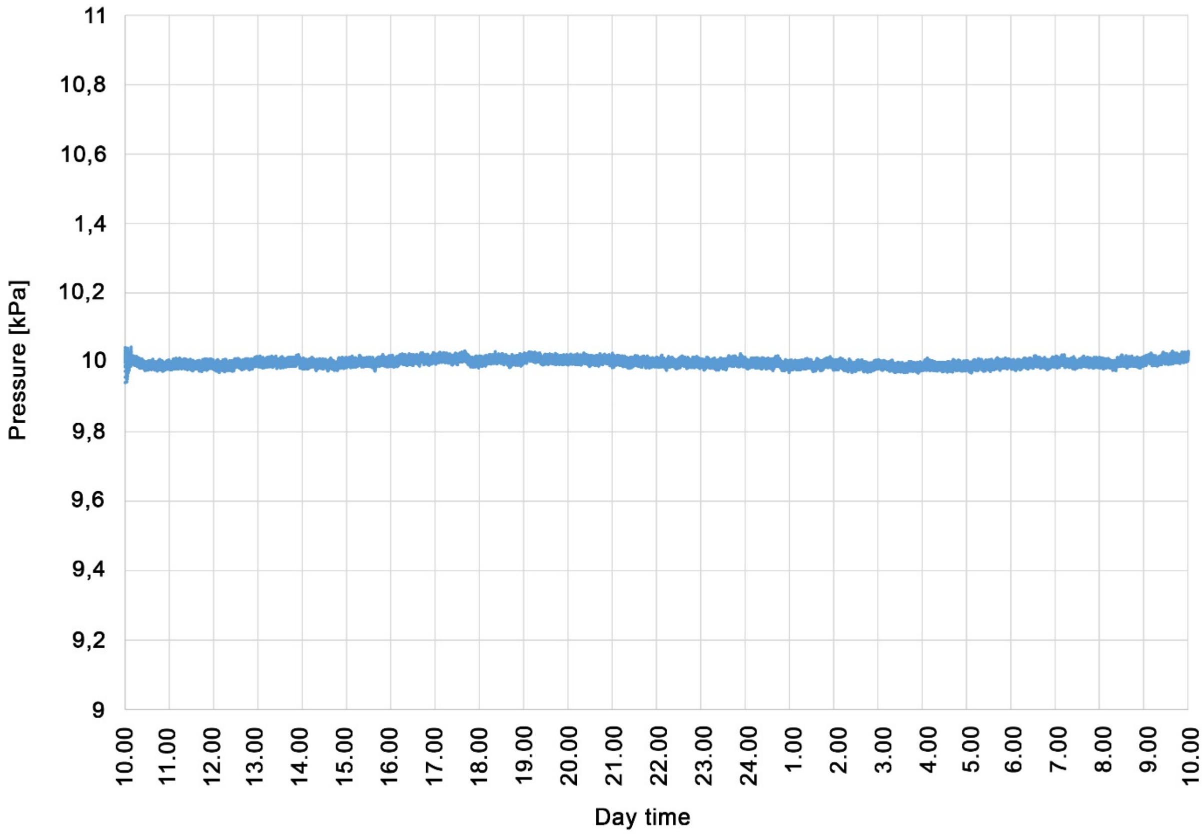



*Figure 19 – Pressure trend during the 24 hours of the water sealing test on the sample with joint*

### 3.4.3 WP2 – Discussion

Testing results evidenced that both the samples (with and without joint) assure water proofing as for BS EN 1928-2000. This is demonstrated by chamber pressure stability and acquired images by means of the installed camera.

## 4. Conclusions

The results included in this report are representative for the Air and Water sealing of the product: FOAMGLAS® T4+. We remark that the testing activities has been carried out following the standard and references described in the report.

The whole results evidenced that:

- for the WP1 the product allows achievement of the air tightness condition with air flow less than $1.6*10^{-6}$ $m^3/s$, minimum measurable value of the designed setup. Measured signals by the flowmeter for the sample with and without joints evidence measurement compatibility between the test with the samples and without the air flux;

- for the WP2 the product assures water proofing as for BS EN 1928-2000 in both the samples (with and without joint) The results are stated by chamber pressure stability and acquired images.

## 5. References

[1] BS EN 1928-2000: Flexible sheets for waterproofing. Bitumen, plastic and rubber sheets for roof waterproofing. Determination of water tightness.

[2] Declaration of performance of FOAMGLAS® Flat Packed T4+, available at:

http://www.industry.foamglas.com/__/frontend/handler/document.php?id=1093&type=118

[3] Technical report of PC® 56 bitumen cold adhesive, available at:

http://global.foamglas.com/__/frontend/handler/document.php?id=2159&_ga=1.262356488.50596972.1490868629