



TECHNICAL REPORT

**Ventilated façade system  
with self-supporting  
composite panels**

TR 39  
Edition April 2013

# **EOTA**

## **TECHNICAL REPORT**

### **TR 039**

#### **Ventilated façade system with self-supporting composite panels**

**Testing procedures for:**

- A. Reaction to fire testing – Mounting and fixing according EN 13823**
- B. Determination of the mechanical resistance of a combination of fixing devices**
- C. Determination of the resistance to thermal shock of the panel**
- D. Determination of the compression strength of the honeycomb**
- E. Adhesive – Adherence of the honeycomb to the aluminium sheets**
  - E.1 Determination of the tensile strength**
  - E.2 Determination of the peeling strength**
  - E.3 Determination of the shear strength and the force-deflection coefficient**
  - E.4 Determination of the durability of the adherence of the honeycomb to the aluminium sheets by change in shear strength after:**
    - **A cyclic temperature exposure of 50 cycles at a temperature between - 30 °C and + 60 °C**
    - **An exposure at a temperature of 100 °C for 1500 h**

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## ***Foreword***

*EOTA Technical Reports are developed as supporting reference documents to European Technical Approval Guidelines and can also be applicable to a Common Understanding of Assessment Procedures, an EOTA Comprehension Document or an European Technical Approval, as far as reference is made therein.*

*EOTA Technical Reports go into detail in some aspects and express the common understanding of existing knowledge and experience of the EOTA bodies at a particular point in time.*

*Where knowledge and experience is developing, especially through approval work, such reports can be amended and supplemented.*

*When this happens, the effect of the changes upon the European Technical Approval Guidelines will be laid down in the relevant comprehension documents, unless the European Technical Approval Guideline is revised.*

*This EOTA Technical Report has been prepared by the approval body Kiwa to define testing procedures in support of the CUAP 04.04/41: “Ventilated façade systems with panels”.*

## **A. Reaction to fire testing – Mounting and fixing according EN 13823**

### **A.1 General**

#### **A.1.1 Possible options**

For the reaction to fire testing of the kit “ventilated façade system with panels” four possible options exist:

1. The “ventilated façade system with panels” is used as it is, with no addition of products behind it when installed;
  2. The “ventilated façade system with panels” is supplied together with a defined insulation or other material to be installed behind the “ventilated façade system with panels”;
  3. The “ventilated façade system with panels” is intended to have an insulation or other material added during installation; the manufacturer of the façade system specifies the type of insulation, but does not supply it with the “ventilated façade system with panels”;
  4. The “ventilated façade system with panels” is intended to have insulation or other material added during installation but the manufacturer of the façade system does not specify or know the type and does not supply it with the “ventilated façade system with panels”
- In case 1), the “ventilated façade system with panels” shall be tested and classified on its own.
  - In cases 2) and 3), the “ventilated façade system with panels” shall be tested together with the defined insulation or other material, except where regulations require only the “ventilated façade system with panels” itself to be tested.
  - In case 4), the “ventilated façade system with panels” shall be tested and classified on its own and regulations may limit the type and quantity of insulation or other material that may be placed behind the façade.

#### **A.1.2 Grouping of product families**

Different finished or coated “ventilated façade system with panels”, placed as such on the market, shall be classified.

Finishes or coatings may be grouped by PCS-value, in which case the “ventilated façade system with panel” with the highest PCS-value finish or coating shall be subjected to SBI-testing. If the PCS-value does not lead to differentiation, the “ventilated façade system with panels” with the darkest coloured finish or coating shall be subjected to SBI-testing. Alternatively, the influences of different colours of finishes or coatings can be determined by performing SBI-tests on a light, on a dark and on a colour in the middle of the range.

NOTE: *Directional patterns and surface textures do not influence fire behaviour in end use conditions. If "ventilated façade systems with panels" have directional patterns and surface textures, they will be mounted in a pattern, preventing influences on test results, due to the test method, as far as possible.*

### **A.1.3 Small products and components**

The reaction to fire performance of small products and components shall be assessed following the procedures as given in EOTA TR 021 "Reaction to fire requirements for small components".

## **A.2 End use application rules**

### **A.2.1 General**

The manner in which the product is tested has a direct consequence upon the manner in which the product or product family may be classified and used in the works.

When determining the testing program for all reaction to fire aspects of "ventilated façade system with panels", the following provides guidance on the potential end-use application rules which may apply dependant on the testing program undertaken.

### **A.2.2 Influence of the substrate**

The substrate used behind the "ventilated façade system with panels", in the EN 13823 testing determines the type of wall in front of which the "ventilated façade system with panels", can be used.

If the "ventilated façade system with panels", is tested in front of particleboard, the "ventilated façade system with panels", can be used in front of any wood substrate, plasterboard or any other A2 or A1 product in end use.

If the "ventilated façade system with panels", is tested in front of plasterboard the "ventilated façade system with panels", can be used in front of plasterboard or any other A2 or A1 product. It may also be used in front of a wooden substrate provided the distance between the "ventilated façade system with panels", and the substrate is greater than 250 mm.

In the case of testing for class A1 according to EN 13823, footnote, the standard substrate shall be the 11 mm silicate board. There are no end use requirements in this case as class A1 is considered for material properties only.

### **A.2.3 Influence of colour**

Tests shall be conducted on the darkest colour. That classification will apply to all colours.

### **A.2.4 Influence of coating thicknesses**

If the coating to the front and reverse faces varies significantly in mass per unit area (> 1 %) and tests conducted on the minimum and maximum quantities yield the same classification, that classification will apply to all coating thicknesses provided the value of each fire test parameter achieved is at least 10 % less than the criteria for that classification.

NOTE: *If different classifications are obtained, additional testing shall be conducted to redefine the product family to which a single classification applies.*

**A.2.5 Influence of other variables**

Other variable parameters such as organic content, type of coating, ventilated façade panel thickness, facings etc may be addressed in a similar manner to A.2.3 and A.2.4.

**A.3 Test procedure**

**A.3.1 General requirements for mounting and fixing of the test assembly**

When testing to EN 13823, the test assembly shall be representative of end use conditions.

In accordance with manufacturer’s specifications, “ventilated façade system with panels”, shall be tested incorporating an air gap which is to be ventilated.

The choice of the substrate is for the manufacturer to decide. This choice will have a direct bearing on the end use application of the product.

In case of testing with air gap, the frame between the backing board and the specimen shall be open at the sides to allow ventilation into the gap.

The assembly may be prepared and fixed together away from the test chamber. The complete assembly can then be transported to the chamber.

**A.3.2 Dimensions of test specimens**

The test specimen consists of a corner with a long and a short wing.

The long wing consists of 2 modules, with at least one vertical and one horizontal panel to panel joint in the long wing. All panels shall be tested vertically.

The dimensions of the test specimen shall be in accordance with table A.1.

**Table A.1 – Dimensions of test specimen**

<b>Nominal dimensions of test specimen in mm</b>		
	<b>Length</b>	<b>Height</b>
<b>Short wing</b>	500	1500
<b>Long wing</b>	$200 + t^a$	
	$800 + t^a$	
<sup>a)</sup> t = thickness of the test specimen in mm.		

### **A.3.3 Testing of “ventilated façade system with panels” with a defined insulation or other material**

#### **A.3.3.1 General**

This test procedure is applicable for “ventilated façade system with panels” in accordance with cases 2) and 3) as defined in A.1.1.

#### **A.3.3.2 Test specimen**

The test specimen shall be conditioned according the provisions of EN 13238.

The test specimen with the dimensions according table A.1 shall be mounted and fixed according to EN 13823.

The test specimen shall fully represent the end use conditions of the “ventilated façade system with panels” utilising all the envisaged components in the end use condition as specified by the applicant, as far as possible. The specimen of the façade used in the test assembly shall include a representative substructure as a means of fixing the “ventilated façade system with panels”.

Where the “ventilated façade system with panels” is used together with thermal insulation backing material or other material, the “ventilated façade system with panels” shall be tested together with these additional materials under end use conditions, as far as possible.

If the “ventilated façade system with panels” is intended to be used in practice without any joints, the test assembly shall also be made without joints.

If joints are used in practice, there will be at least one joint 200 mm from the corner and 500 mm from the bottom of the assembly (see figure A.1).

Joints between “ventilated façade system with panels” in the test assembly shall be based on the dimensions of the product as placed on the market.

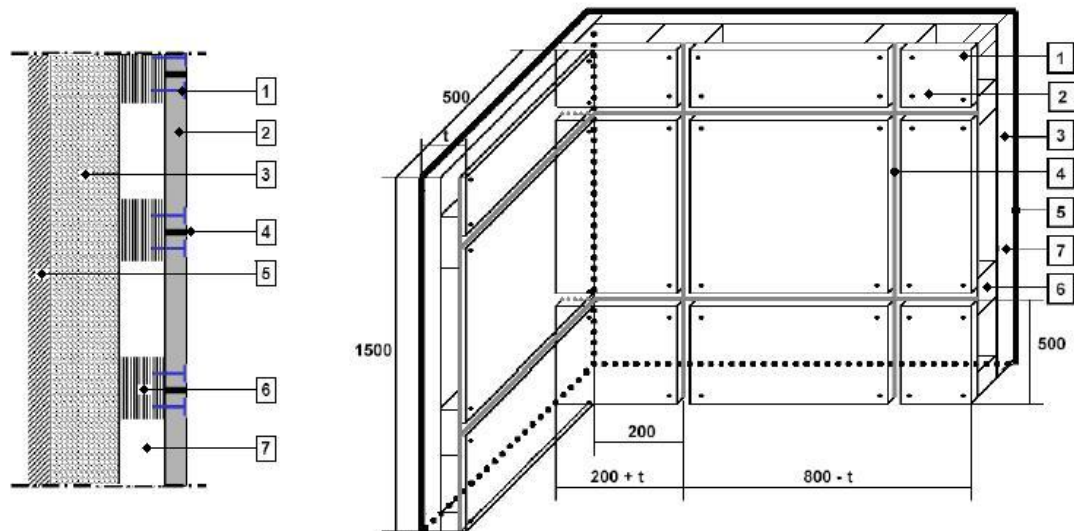
The corner detail between long and short wing shall be sealed with an A1 classified material, preventing exposure of the internal surface of the “ventilated façade system with panels”, or other material, to the fire.

The type and dimensions of materials and products used, the dimensions and location of fixings etc. shall be recorded in the test report.



Figure A.1 – Mounting and fixing with insulation and air gap

### Dimensions in mm



#### **Key**

1. Fixing
2. Ventilated façade panel
3. Insulation
4. Ventilated façade substructure
5. Substrate
6. Spacer
7. Air gap
- t. Thickness of the test specimen (incl. substrate)

#### **A.3.4 Testing of “ventilated façade system with panels” without a defined insulation or other material**

##### **A.3.4.1 General**

This test procedure is applicable for “ventilated façade system with panels” in accordance with cases 1) and 4) as defined in A.1.1.

##### **A.3.4.2 Test specimen**

The test specimen with the dimensions according table A.1 shall be mounted and fixed according to EN 13823.

The test specimen shall fully represent the end use conditions of the “ventilated façade system with panels” utilising all the envisaged components in the end use condition as specified by the applicant, as far as possible. The specimen of the façade used in the test assembly shall include a representative substructure as a means of fixing the “ventilated façade system with panels”.

If the “ventilated façade system with panels” is intended to be used in practice without any joints, the test assembly shall also be made without joints.

If joints are used in practice, there will be at least one joint 200 mm from the corner and 500 mm from the bottom of the assembly (see figure A.2)

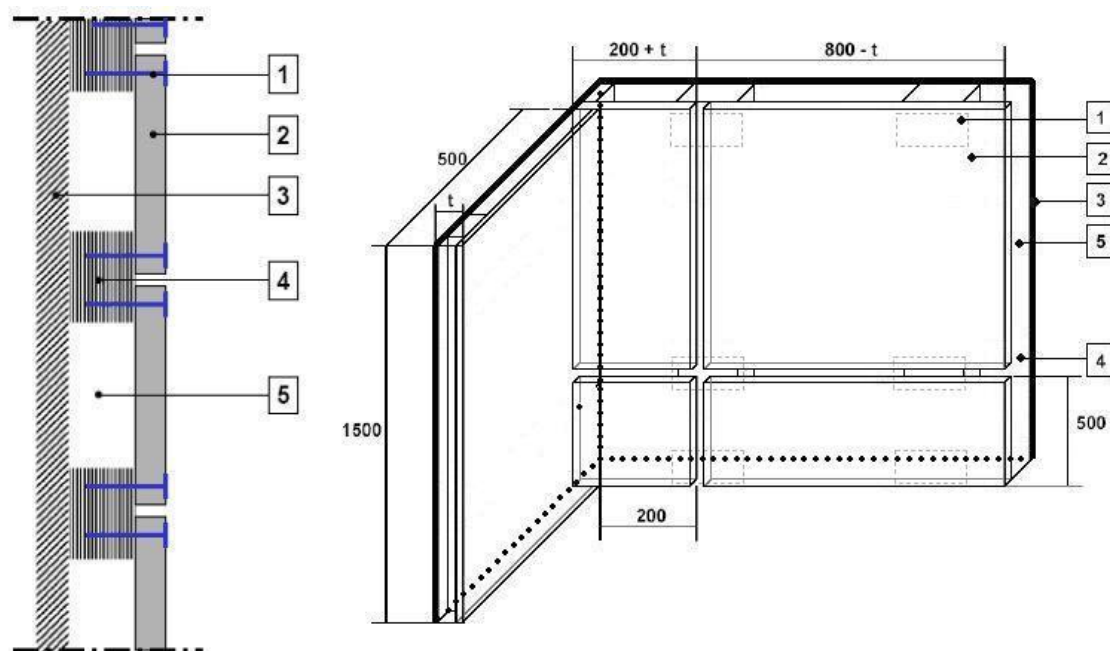
Joints between “ventilated façade system with panels” in the test assembly shall be based on the dimensions of the product as placed on the market.

The corner detail between long and short wing shall be sealed with an A1 classified material, preventing exposure of the internal surface of the “ventilated façade system with panels”, or other material, to the fire.

The type and dimensions of materials and products used, the dimensions and location of fixings etc. shall be recorded in the test report.

**Figure A.2 – Mounting and fixing without insulation, with air gap**

Dimensions in mm



**Key**

1. Fixing
2. Ventilated façade panel
3. Substrate
4. Ventilated façade substructure
5. Air gap
- t. Thickness of the test specimen (incl. substrate)

**A.4 Declaration of conformity**

In the declaration of conformity it shall be specified which product or component have been specified as a “small product or component” that does need to be tested. In the technical file it shall be specified how this “small product or component” is part of the “ventilated façade system with panels” and/or how this “small product or component” is incorporated in the works.

## A.5 Normative references

- EN 13238:2010** Reaction to fire tests for building products – Conditioning procedures and general rules for selection of substrates
- EN 13501-1:2007 + A1: 2009** Fire classification of construction products and building elements – Part 1: Classification using test data from reaction to fire testing
- EN 13823:2010** Reaction to fire tests for building products – Building products excluding floorings exposed to the thermal attack by a single burning item
- EOTA TR 021: June 2005** Reaction to fire requirements for small components

## B. Determination of the mechanical resistance of a combination of fixing devices

### B.1 Principle

The mechanical resistance of a combination of fixing devices, being:

- Panel edge to fixing plate;
- Panel edge to fixing element;
- Fixing plate to rail;
- Rail to bracket;
- Panel edge to clamp

shall be determined by measuring the tensile load at failure

### B.2 Apparatus

The apparatus shall be a **tensile testing machine**, capable for a maximum force of 10 kN, capable of having a constant crosshead speed adjusted to 5 mm/min  $\pm$  10 % and capable of measuring the force with an accuracy of  $\pm$  1 %.

The clamps shall be such that they are self aligning to avoid uneven distribution of tensile stress during the test.

For not symmetrical or asymmetrical test specimens it is necessary to test two test specimens in “reflected image” to avoid bending during the test.

### B.3 Test specimen

Per combination of fixing devices there shall be 10 test specimens

### B.4 Conditioning

Prior to testing the test specimens shall be stored at a temperature of  $(23 \pm 5)$  °C for at least 12 h.

### B.5 Procedure

The test shall be carried out at a temperature of  $(23 \pm 5)$  °C.

Indicate the test specimen being a combination of fixing devices.

Place the test specimen in the testing apparatus in such a way that during test there is no secondary bending. The test specimen shall be loaded with a tensile speed of 5 mm/min until failure.

The load  $F_t$  in kN at failure shall be measured.

### B.6 Expression of results

For type testing purposes the value of the load at failure in kN of each of the 10 test specimens,  $F_t$ , shall be indicated.

The tensile load of the specific combination of fixing devices is the mean value and the 5% fractile value of the 10 test specimen and shall be indicated as respectively  $F_{tm}$  and  $F_{t5}$  in kN.

## **C. Determination of the resistance to thermal shock**

### **C.1 Definitions**

#### **C.1.1 Ambient temperature**

The ambient temperature at testing shall be  $(23 \pm 5)$  °C.

#### **C.1.2 Steady state temperature of the external surface of the panel**

The temperature of the external surface of the panel is steady state if during at least 2 minutes the temperature at each temperature measuring point changes not more than 2 °C.

#### **C.1.3 Steady state temperature of the external surface of the panel after cooling (cold steady state temperature)**

The temperature of the external surface of the panel after cooling ( $T_{\text{cold}}$ ) is at a steady state if the temperatures in the centre of the panel and in the centre of all edges of the panel are lower than the actual ambient temperature + 4 °C.

#### **C.1.4 Change of deflection**

The change of deflection is defined as the deviation from the initial deflection and deflection after the last cycle, measured on the middle of the span.

#### **C.1.5 Change of flatness**

The change of flatness is defined as the deviation of the initial total panel flatness or local panel flatness and the total and local panel flatness after the last cycle.

#### **C.1.6 Change of dimensions**

The change of dimensions is defined as the deviation from the initial dimensions as measured following C.6.1 the last cycle.

### **C.2 Test principle**

The test panel, mounted in a test rig, is exposed to a number of temperature cycles, the temperature loaded on one side (the side which in practice is exposed to the sunlight). At periods of every cycle, visual observations relating to a change in characteristics (blistering, delamination or formation of cracks) are recorded and deflection is continuously measured on the non-exposed side.

The deflection and the flatness of the panel is measured at the highest temperature at the last cycle.

### **C.3 Apparatus**

#### **C.3.1 Test rig**

A substrate which is a steel frame work to support a panel in a plane that may vary from horizontal to vertical orientation, with the fixing points as to be used in practice. The orientation of the plane is to be decided by the manufacturer.

#### **C.3.2 Heating and cooling equipment**

Equipment shall be provided to heat and cool the exposed panel surface of the test specimen.

For the heating IR – lamps of 375 Watts are used in a screen as illustrated in figure C.1. The distance between the row of lamps and each of the lamps is approx. 400 mm. The number of lamps is depending on the size of the test specimen.

Figure C.1 – Configuration of lamps in the screen

```

#   #   #   #   #
#   #   #   #   #
#   #   #   #   #

```

The heating temperature of the panel by the lamps is continuously controlled by connecting the lamps to the temperature sensors (C.3.3) by means of an automatic on-and-off switch.

For the cooling, sprinklers are installed between the lamps, which have an output of tap water of 1,25 l/min.m<sup>2</sup>. The temperature of the tap water is approx. 15 °C.

### C.3.3 Measurement of temperature

The temperature shall be measured with a temperature sensor having an accuracy of ( $\pm 1$ ) °C.

### C.3.4 Instruments capable of measuring dimensions, deflection and flatness

- A metal rule or tape graduated in millimetres and permitting a reading to 0,5 mm
- A dial gauge having an accuracy of at least 0,1 mm
- A measuring device for continuously measuring the deflection and a means of recording
- A rigid straight bar of respectively 100 mm and 500 mm
- A steel wire
- Two spacers with dimensions (100 × 25 × thickness) mm. The upper and lower surface shall be parallel.

### C.4 Test specimen

The test specimen shall be a panel which can be:

- A combination of one or two aluminium skins, with or without a honeycomb core which is bonded with an adhesive to at least one of the skins, assembled with or without a frame;
- Framed kit, consisting of a sheet of thermally toughened safety glass or a sheet/element of another material, an aluminium frame and an elastomeric sealing element.

Distinction can be made between panels which are supported linear (fixed support over the length in one direction) on one side or panels which are supported by supporting points.

- Linear supported panels – The size of the test specimen shall be such that the length of the panel shall be equal or greater than the largest width as described in the system and the width shall be the largest width.

- Panels supported by supporting points – The size of the test specimen shall be such that the length of the test specimen shall be the greatest possible length between two supports as described in the system and the width shall be the greatest width as described in the system.

For each type of panel the solar absorption coefficient ( $\sigma_e$ ) of the outer surface shall be determined by using the following formula.

$$\sigma_e = 1,0 - \tau_e - \rho_e$$

whereby:  $\sigma_e$  is the solar absorption coefficient;  
 $\tau_e$  is the solar transmittance coefficient;  
 $\rho_e$  is the solar reflectance coefficient.

The solar transmittance coefficient ( $\tau_e$ ) and the solar reflectance coefficient ( $\rho_e$ ) shall be determined in accordance with the procedures detailed in EN 410.

The number of test specimen shall be one.

Prior to testing, the test specimen shall be conditioned for at least 24 hours at a temperature of  $(23 \pm 5)$  °C.

### C.5 Cycling procedure

The cycling procedure will be as follows:

- starting temperature is the ambient temperature;
- heat the panel to a temperature T °C and keep the panel at that temperature for 4 hours;
- cool the panel freely to cold steady state ( $T_{cold}$ ) and keep the panel at that temperature for 1 hour;
- **1<sup>st</sup> cycle:**
  - heat the panel to a temperature T °C and keep the panel at that temperature for 0,5 hour;
  - cool the panel forcedly within 10 minutes to cold steady state ( $T_{cold}$ ) and keep the panel at that temperature for 0,5 hour.
- **2<sup>nd</sup> to 10<sup>th</sup> cycle**  
Repeat the 1<sup>st</sup> cycle for another 9 cycles.

The high temperature T °C shall be:

- A temperature of  $(70 \pm 3)$  °C if the solar absorption coefficient ( $\sigma_e$ ) of the outer surface of the panel is lower than 0,7;
- A temperature of  $(80 \pm 3)$  °C if the solar absorption coefficient ( $\sigma_e$ ) of the outer surface of the panel is equal to or greater than 0,7.

## **C.6 Determination of the dimensions, flatness and deflection of the panel**

### **C.6.1 Determination of the dimensions**

The length, width and diagonals shall be measured with a metal rule or tape at the following positions:

- Horizontally – upper, middle and lower edge;
- Vertically – left, middle and right edge;
- Diagonals – both diagonals of the panel.

The measured values are rounded up to nearest 0,5 mm.

### **C.6.2 Determination of the flatness**

#### **C.6.2.1 Determination of the total panel flatness ( $f_p$ )**

The total panel flatness ( $f_p$ ) shall be determined by tightening the steel wire with the help of the two timber spacers over the diagonals of outer surface of the panel. The distance between the steel wire and the panel surface is measured.

#### **C.6.2.2 Determination of the local panel flatness ( $f_c$ )**

The local panel flatness ( $f_c$ ) shall be determined on the outer surface of the panel with the two rigid straight bars (100 mm and 500 mm) with the help of the two timber spacers. The distance between the straight bar and the panel surface shall be measured

### **C.6.3 Determination of the deflection**

The deflection shall be measured at the mid point between the supporting points.

## **C.7 Test procedure**

### **C.7.1 Installing of the test specimen**

Mount the test specimen in accordance with the manufacturers instructions on the test rig, such that the distance between outer surface of the panel and the screen of heating lamps (C.3.2) is approx. 1 metre.

Measure the dimensions, the flatness and the deflection of the panel in accordance with C.6.

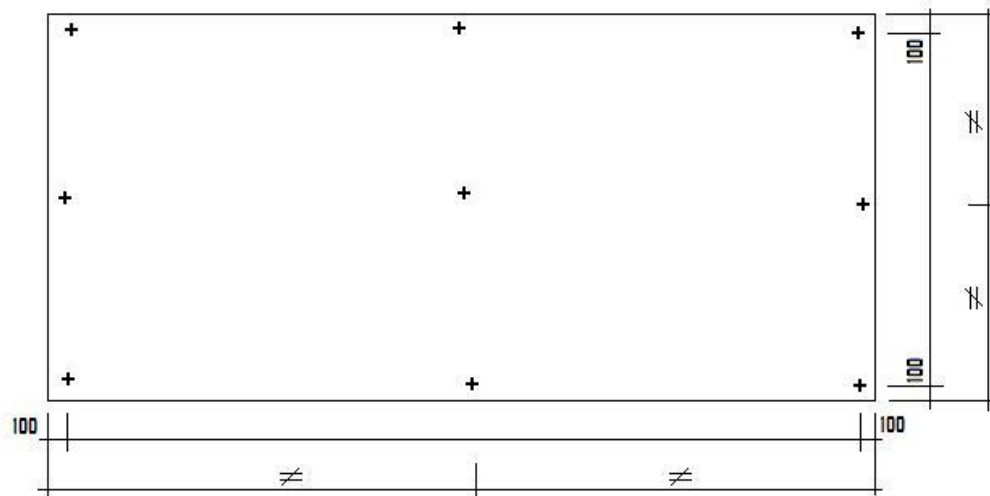
Install the temperature sensors on the outer surface of the panel on at least the following positions (see figure C.2):

- center of the external surface;
- middle of each edge – 100 mm from edge;
- each corner – 100 mm from corner.

Install on the backside of the panel in the middle of the diagonals the measuring device for continuous determination of the deflection during the test.



Figure C.2 – Positions of the temperature sensors



### C.7.2 Surface temperature

The surface temperature shall be the mean value of the temperatures measured at the all positions on the outer surface of the panel rounded up to the nearest degree Centigrade.

### C.7.3 Execution of the test

Start the cycling procedure as detailed in C.5.

Observe visually during the cycling procedure if there is a cracking, blistering or delaminating and record this.

Record the deflection measurement on the backside of the panel.

Measure at the end of the 10<sup>th</sup> cycle the dimensions, the local and the total panel flatness and the deflection in accordance with C.6

### C.8 Expression of results

Calculate the change in deflection, the local and total panel flatness from the initial values to the values at the end of the tenth cycle.

### C.9 Normative references

**EN 410:1998**      Glass in building – Determination of luminous and solar characteristics of glazing

## **D. Determination of the compression strength of the honeycomb**

### **D.1 Principle**

A compressive force is applied at a given rate of displacement in axial direction perpendicular to the panel consisting of the honeycomb on both sides adhered to an aluminium skin.

The ultimate load at failure of the honeycomb shall be measured and recorded. From this ultimate load at failure the compression strength shall be calculated.

### **D.2 Apparatus**

The apparatus shall be a compression testing machine in accordance with clause 5 of EN 826.

The movable plate shall be capable of moving at a constant speed of displacement of  $(d/10)$  mm per minute, whereby  $d$  is the thickness of the test specimen in mm.

### **D.3 Test specimens**

The test specimen is taken from a standard production panel comprising of a honeycomb on both sides adhered to an aluminium skin.

The test specimens shall be taken from the panel after the adhesive has been completely cured.

The dimensions of the test specimen shall be

- length  $l$  :  $(75 \pm 2)$  mm;
- width  $w$  :  $(75 \pm 2)$  mm;
- thickness  $d$ : thickness in mm of the panel with a tolerance of  $\pm 2$  mm.

The number of test specimens shall be 10 for type test purposes and 3 for quality control purposes.

### **D.4 Conditioning**

For type testing purposes the test specimens shall be stored for at least 12 h at a temperature of  $(23 \pm 5)$  °C before starting the compression test.

### **D.5 Test procedure**

For type testing purposes the test shall be carried out a temperature of  $(23 \pm 5)$  °C.

Measure the three dimensions of the test specimens in mm and calculate the initial area of cross section  $A_c$  in mm<sup>2</sup>.

Place the test specimen centrally between the two parallel plates of the compression testing machine.

Compress the test specimen with a loading rate of  $(d/10)$  mm/minute.

The ultimate load  $F$  in kN at failure of the honeycomb shall be measured.

## D.6 Calculation and expression of results

For type testing purposes the mean value of the ultimate load in kN of each of the ten test specimens,  $F_{c,m}$ , shall be calculated.

The compressive strength of the honeycomb,  $\sigma_c$  in kPa, for each of the ten test specimens shall be calculated as follows.

$$\sigma_c = \frac{F_c}{A_c}$$

Where:

$F_c$  is the ultimate load, in kN;

$A_c$  is the initial area of the cross section of the test specimen in mm<sup>2</sup>.

The compressive strength of the honeycomb is the mean value of the compression strength of the ten test specimen and shall be indicated as  $\sigma_{cm}$  in kPa.

The 5 % fractile value,  $\sigma_{cm,5\%}$ , shall be calculated as follows.

$$\sigma_{cm,5\%} = \sigma_{cm} - k_{\sigma} \cdot s$$

Where:

$\sigma_{cm,5\%}$  is the 5% fractile value of the tensile strength

$\sigma_{cm}$  is the mean value the tensile strength of each of the ten test specimens in kN

$k_{\sigma}$  is the statistical factor (acceptance factor) in accordance with table 9 of EN 13964.

$s$  is the standard deviation in kPa

## D.7 Normative references

- |                      |   |
|----------------------|---|
| <b>EN 826:1996</b>   | Thermal insulating products for building applications –<br>Determination of compression behaviour |
| <b>EN 13964:2004</b> | Suspended ceilings – Requirements and test methods  |

## E. Adhesive – Adherence of the honeycomb to the aluminium skins

### E.1 Determination of the tensile strength

#### E.1.1 Definition

The tensile strength,  $\sigma_t$ , is the maximum recorded tensile force perpendicular to the aluminium sheets during the pulling operation, divided by the cross-sectional area of the test specimen.

#### E.1.2 Principle

The test specimen, being a honeycomb glued between two aluminium sheets, is attached between two rigid plates or blocks, fastened in a tensile testing machine and pulled apart at a given speed.

The maximum tensile force is recorded and the tensile strength of the test specimen is calculated.

#### E.1.3 Apparatus

- **Tensile testing machine**, appropriate for the range of force and displacement involved, capable of having a constant crosshead speed adjusted to 1,5 mm/min  $\pm 10\%$  and capable of measuring the force with an accuracy of  $\pm 1\%$ .
- **Rigid plates or blocks** with self aligning attachment to avoid uneven distribution of tensile stress during the test.  
Examples of a suitable arrangement to bond the test specimen are shown in figure 1 of EN 1607.
- **Adhesive**, used to bond the test specimen between the rigid plates or blocks.

#### E.1.4 Test specimens

The test specimen shall be a honeycomb which on both sides is adhered to an aluminium skin.

The test specimens shall be taken from the panel after the adhesive has been completely cured.

The dimensions of the test specimen shall be

- length  $l$  :  $(75 \pm 2)$  mm;
- width  $w$  :  $(75 \pm 2)$  mm;
- thickness  $d$  : thickness in mm of the panel with a tolerance of  $\pm 2$  mm.

The number of test specimens shall be 10 (see clause E.4.2.2) for type test purposes and 3 for quality control purposes.

#### E.1.5 Conditioning

For type testing purposes the test specimens shall be stored for at least 12 h at a temperature of  $(23 \pm 5)$  °C before starting the tensile test.

#### E.1.6 Test procedure

For type testing purposes the test shall be carried out a temperature of  $(23 \pm 5)$  °C.

Determine the cross section area,  $A_t$  in mm<sup>2</sup>, of the test specimen.

Attach the test specimen in the tensile testing machine by means of the plate/block fixings and increase the tensile force with a constant speed of 1,5 mm/min until failure occurs.

The load  $F_t$  in kN at failure shall be measured.

### E.1.7 Calculation and expression of results

For type testing purposes the value of the load at failure,  $F_t$ , in kN of each of the ten test specimens shall be indicated.

The tensile strength per test specimen of the honeycomb,  $\sigma_t$  in kPa, shall be calculated as follows.

$$\sigma_t = \frac{F_t}{A_t}$$

Where:

$F_t$  is the load at failure, in kN;

$A_t$  is the initial area of the cross section of the test specimen in mm<sup>2</sup>.

The tensile strength of the adherence of the honeycomb to the aluminium sheets is the mean value of the tensile strength of each of the ten test specimen and shall be indicated as  $\sigma_{tm}$  in kPa.

The 5 % fractile value,  $\sigma_{tm,5\%}$ , shall be calculated as follows.

$$\sigma_{tm,5\%} = \sigma_{tm} - k_{\sigma} \cdot s$$

Where:

$\sigma_{tm,5\%}$  is the 5% fractile value of the tensile strength

$\sigma_{tm}$  is the mean value the tensile strength of each of the ten test specimens in kPa.

$k_{\sigma}$  is the statistical factor (acceptance factor) in accordance with table 9 of EN 13964.

$s$  is the standard deviation in kPa

### E.1.8 Normative references

- |                      |   |
|----------------------|---|
| <b>EN 1607:1996</b>  | Thermal insulating products for building applications –<br>Determination of tensile strength perpendicular to faces |
| <b>EN 13964:2004</b> | Suspended ceilings – Requirements and test methods  |

## E.2 Determination of the peeling strength

*The test procedure for the determination of the peeling strength as described in E.2 is based on the test procedure as stated in EN 2243-3.*

### E.2.1 Definition

The peeling strength,  $\sigma_p$ , is the average value of the peeling force during the “peeling operation divided by the width of the test specimen.

*NOTE: In contrast with the procedure as described in EN 2243-3 the value of “ $F_0$ ”, being the rolling load, has not been taken into account for the calculation of the peeling force. In this case the peeling force is to determine the “ $F_0$  force” of the panel.*

### E.2.2 Principle

The test specimen, being a honeycomb glued between two aluminium sheets, is attached in a peeling jig which is fastened in a tensile testing machine and pulled apart.

The peeling load is recorded and the peeling strength is calculated.

### E.2.3 Apparatus

- **Tensile testing machine**, appropriate for the range of force and displacement involved, capable of a constant crosshead speed adjusted to 25 mm/min  $\pm$  10% and capable of measuring the force with an accuracy of  $\pm$  1%.
- **Peeling jig**, in accordance with clause 6.1.2 of EN 2243-3 with a drum radius of 100 mm.
- **Recorder**, to measure continuously the displacement relative to the load applied in accordance with clause 6.1.3 of EN 2243-3.

### E.2.4 Test specimens

The test specimen shall be a honeycomb which on both sides is adhered to an aluminium skin.

The test specimens shall be taken from the panel after the adhesive has been completely cured, following the standard curing procedure as detailed by the manufacturer.

The dimensions of the test specimen shall be

- length  $l$  : (350  $\pm$  2) mm;
- width  $w$  : (75  $\pm$  2) mm;

The number of test specimens shall be 10 (see clause E.4.2.2) for type test purposes and 3 for quality control purposes.

### E.2.5 Conditioning

For type testing purposes the test specimens shall be stored for at least 12 h at a temperature of (23  $\pm$  5) °C before starting the tensile test.

### E.2.6 Test procedure

For type testing purposes the test shall be carried out a temperature of  $(23 \pm 5) ^\circ\text{C}$ .

Attach the test specimen in the peeling rig in such a way that at testing the unrolling will be from the inside. The “inside” being the upper sheet in the production process. Adjust the peeling rig in the tensile testing machine.

The load shall be applied at a uniform jaws separation of 25 mm/min.

A minimum length of 150 mm shall be peeled.

Record the load-displacement curve (peeling diagram).

### E.2.7 Calculation and expression of results

For type testing purposes the value of the average peeling load in N,  $F_p$ , of each of the ten test specimens shall be determined.

The average peeling load,  $F_p$ , shall be determined over a peeling length of 125 mm, by inserting the estimated average value into the diagram as shown in figure 3 of EN 2243-3.

The results of the first 25 mm of the peel separation on the specimen as shown in the peeling diagram (figure 3 of EN 2243-3) after the first maximum load are to be excluded from the assessment of the average value.

In case of dispute the average peeling load shall be determined by means of a planimeter.

The peeling strength per test specimen of the honeycomb,  $\tau_p$  in N/mm, shall be calculated as follows.

$$\tau_p = \frac{F_p}{W}$$

Where:

$F_p$  is the average peeling load at failure, in N;

$W$  is the width of the test specimen in mm.

The peeling strength is the mean value of the peeling strength of each of the ten test specimen and shall be indicated as  $\sigma_{pm}$  in N/mm.

The 5 % fractile value,  $\tau_{pm,5\%}$ , shall be calculated as follows.

$$\tau_{pm,5\%} = \tau_{pm} - k_\sigma \cdot s$$

Where:

$\tau_{tm,5\%}$  is the 5% fractile value of the peeling strength.

$\tau_{tm}$  is the mean value the peeling strength of each of the ten test specimens in N/mm.

$k_\sigma$  is the statistical factor (acceptance factor) in accordance with table 9 of EN 13964.

$s$  is the standard deviation in N/mm.

## E.2.8 Normative references

- EN 2243-3: 2005 Aerospace series – Non-metallic materials – Structural adhesives – Test method – Part 3: Peeling test metal-honeycomb core
- EN 13964: 2004 Suspended ceilings – Requirements and test methods

## E.3 Determination of the shear strength and the force-deflection coefficient

### E.3.1 Definition

The force-deflection coefficient ( $FD_s$ ) in shear is the difference in force measured at two loading levels divided by the difference in deflection at the same loading levels and expressed in kN/mm.

The force-deflection coefficient of specimen  $x$  ( $FD_{s,x}$ ) is the arithmetic mean value of the force-displacement coefficient of four loading levels equally divided over the linear part of the load-deflection curve and divided by the corresponding deflections.

The average force-deflection coefficient, ( $FD_{s,av}$ ), is the arithmetic mean of the individual values of the  $y$  test specimens.

NOTE: *The force-deflection coefficient is a characteristic to indicate the bending stiffness of the panel.*

### E.3.2 Principle

The shear strength of the test specimen,  $\sigma_s$ , in kPa, being a honeycomb glued between two aluminium sheets, is determined using a four-point bending test. The ultimate load carried by the specimen failing in shear shall be measured and the shear strength shall be calculated.

At four loading levels, equally divided over the linear part of the loading curve, the force-deflection coefficient,  $FD_s$ , in kN/mm, shall be calculated. From these four values the force-deflection coefficient of the specimen  $x$  ( $FD_{s,x}$ ) shall be calculated.

### E.3.3 Apparatus

The four-point bending test apparatus shall be in accordance with EN 14509 clause A.3.2 with a loading speed of 7,5 mm/min.

### E.3.4 Test specimens

The test specimen shall be a honeycomb which on both sides is adhered to an aluminium skin.

The test specimens shall be taken from the panel after the adhesive has been completely cured.

The dimensions of the test specimen shall be

- length  $l$  :  $(800 \pm 2)$  mm;
- width  $w$  :  $(150 \pm 2)$  mm;
- thickness  $d$  : thickness of the honeycomb +  $t_i$  +  $t_o$  in mm, whereby  $t_i$  is the thickness of the inside skin and  $t_o$  is the thickness of the outside skin.



The number of test specimens ( $y$ ) shall be 10 for type test purposes and 3 for quality control purposes.

#### **E.3.4 Conditioning**

For type test purposes before starting the shear test the test specimens shall be stored at a temperature of  $(23 \pm 5)$  °C for at least 12 h.

#### **E.3.5 Procedure**

For type test purposes the test shall be carried out at a temperature of  $(23 \pm 5)$  °C.

Measure the dimensions of the test specimen.

Place the test specimen in the four-point bending test apparatus as shown in EN 14509 figure A.4 in such a manner that the thinnest aluminium sheet is on the upper side.

The specimen shall be loaded with a loading rate 7,5 mm/min until failure. During the test the deflection shall be measured with a precision of 1 %. The loading shall be continued until failure and a load-deflection curve shall be drawn.

The ultimate load  $F_s$  in kN at failure in shear shall be measured. At four loads, equally divided over the linear part of the load-deflection curve the four concerning deflections shall be determined.

#### **E.3.6 Calculation and expression of results**

For type testing purposes the mean value of the load at failure in kN of each of the 10 test specimens,  $F_s$ , shall be indicated.

##### **E.3.6.1 Shear strength**

The shear strength per test specimen of the combination honeycomb/aluminium sheets,  $\sigma_s$ , in kPa shall be calculated as follows.

$$\sigma_s = \frac{F_s}{2 \times w(d - 2 t_i - 2 t_o)}$$

Where:

- $F_s$  is the load at failure, in kN;
- $w$  is the width of the test specimen in mm;
- $d$  is the thickness of the test piece in mm;
- $t_i$  is the thickness of the inside aluminium skin in mm;
- $t_o$  is the thickness of the outside aluminium skin in mm.

The shear strength of the adherence of the honeycomb to the aluminium sheets is the arithmetic mean value of the shear strength of each of the 10 test specimen and shall be indicated as  $\sigma_{sm}$  in kPa.

### E.3.6.2 Force-deflection coefficient

Per test specimen and two levels of load ( $F$ ) with the respective deflections ( $\epsilon$ ) the force-deflection coefficient,  $FD_s$  in kN/mm, shall be calculated as follows.

$$FD_s = \frac{(F_n - F_{n-1})}{(\epsilon_n - \epsilon_{n-1})}$$

Where:

$F_n$  is the load at failure at loading level n, in kN;

$F_2$  is the load at failure at loading level (n-1), in kN;

$\epsilon_n$  is the deflection at loading level n, in mm;

$\epsilon_{n-1}$  is the deflection at loading level (n-1), in mm.

The force-deflection coefficient of test specimen 1 ( $FD_{s,1}$ ), is arithmetic mean value of the calculated force-displacement coefficients.

The average force-deflection coefficient of ten test specimens ( $FD_{s,av}$ ), is the arithmetic mean value of the force-displacement coefficients of the ten individual test specimens.

### E.3.7 Normative references

**EN 14509: 2006** Self-supporting double skin metal faced insulating panels – Factory made products - Specifications

## E.4 Determination of the durability of the adherence of the honeycomb to the aluminium sheets by change in shear strength

### E.4.1 Principle

The durability of the adherence of the honeycomb to the aluminium sheets is assessed by measuring the change in shear strength of test specimens which are subjected to the following exposures.

- A cyclic temperature exposure of 50 cycles at a temperature between – 30 °C and + 60 °C ;
- An exposure at a temperature of 100 °C for 1500 h under dry conditions ;
- An exposure in water at a temperature of 70 °C for 1000 h.

### E.4.2 Test specimens

#### E.4.2.1 Dimensions of the test specimens

The test specimens shall be an honeycomb adhered to two aluminium sheets with the dimensions in accordance with the dimensions as stated in E.3.

The test specimens shall be taken from the panel after the adhesive has been completely cured.

#### **E.4.2.2 Number of test specimens**

For the determination of the initial shear strength 10 test specimens shall be used.  
For the determination the shear strength after each exposure 10 test specimens shall be used.

#### **E.4.2.3 Conditioning of test specimens**

Prior to the tensile test the test specimens shall be stored for at least 12 h at  $(23 \pm 5) ^\circ\text{C}$  and  $(50 \pm 10) \%$  R.H.

### **E.4.3 Cyclic temperature exposure**

#### **E.4.3.1 Apparatus**

Test chamber, where the temperature can be held at  $-(30 \pm 2) ^\circ\text{C}$  and  $+(60 \pm 2) ^\circ\text{C}$  and where the change in temperature from  $-30 ^\circ\text{C}$  to  $+60 ^\circ\text{C}$  and from  $+60 ^\circ\text{C}$  to  $-30 ^\circ\text{C}$  with a rate of  $1,5 ^\circ\text{C} / \text{minute}$  can be achieved.

#### **E.4.3.2 Exposure procedure**

The exposure shall be carried out for 50 cycles between  $-30 ^\circ\text{C}$  and  $+60 ^\circ\text{C}$ .  
One cycle shall comprise of 5 h at  $-30 ^\circ\text{C}$ , change from  $-30 ^\circ\text{C}$  to  $+60 ^\circ\text{C}$  with a rate of  $1,5 ^\circ\text{C} / \text{minute}$ , 5 h at  $+60 ^\circ\text{C}$ , change from  $+60 ^\circ\text{C}$  to  $-30 ^\circ\text{C}$  with a rate of  $1,5 ^\circ\text{C} / \text{minute}$ .

#### **E.4.3.3 Determination of the shear strength**

##### **E.4.3.3.1 Determination of the initial shear strength**

The initial shear strength of the ten test specimens shall be determined in accordance with E.3.

The mean value of the initial shear strength shall be denoted as  $\sigma_{cs0}$ .

##### **E.4.3.3.2 Determination of the shear strength after cyclic exposure**

The shear strength of the 10 test specimens after cyclic exposure shall be determined in accordance with E.4.

The mean value of the shear strength after cyclic exposure shall be denoted as  $\sigma_{cs50}$ .

#### **E.4.3.4 Expression of results**

The change of shear strength in percentage after the cyclic temperature exposure shall be calculated as follows;

$$\Delta \sigma_{cs} = \frac{\sigma_{cs0} - \sigma_{cs50}}{\sigma_{cs0}} \times 100 \%$$

### **E.4.4 Exposure at high temperature and dry conditions**

#### **E.4.4.1 Apparatus**

Test chamber in which the temperature can be kept at  $(100 \pm 2) ^\circ\text{C}$  and dry conditions (relative humidity not greater than 15 %).

#### **E.4.4.2 Exposure procedure**

The exposure shall be carried out at 100 °C and dry conditions for an exposure time of (1500 ± 12) h.

#### **E.4.4.3 Determination of the shear strength**

##### **E.4.4.3.1 Determination of the initial tensile strength**

The initial shear strength of the six test specimens shall be determined in accordance with E.3.

The mean value of the initial shear strength shall be denoted as  $\sigma_{100\ s\ 0}$ .

##### **E.4.4.3.2 Determination of the shear strength after an exposure at 100 °C and dry conditions**

The shear strength of the 10 test specimens after an exposure at 100 °C and dry conditions for 1500 h shall be determined in accordance with E.3.

The mean value of the shear strength after an exposure at 100 °C and dry conditions for 1500 h shall be denoted as  $\sigma_{100\ s\ 1500}$ .

#### **E.4.4.4 Expression of results**

The change of shear strength in percentage after an exposure at 100 °C and dry conditions for 1500 h shall be calculated as follows;

$$\Delta \sigma_{100\ s} = \frac{\sigma_{100\ s\ 0} - \sigma_{100\ s\ 1500}}{\sigma_{100\ s\ 0}} \times 100 \%$$