

Fire performances of sandwich panels

Testing and classification

- Materials for sandwich panels
- Reaction to fire
- Fire resistance
- Extended application of results from fire testing
- Resistance to external fire exposure
- Fire resisting construction

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Materials for sandwich panels

- Facing materials
 - Metal sheet (**steel**, stainless steel, aluminium, copper)
 - Wood (chipboard, plywood, OSB)
 - Gypsum boards
 - Plastic boards
- Core materials
 - **Rigid plastic foam**
 - **Inorganic fibre material**

Steel facings for sandwich panels

Most frequently used are 0,5 mm thick steel sheet with metallic and organic corrosion protection layer on both side.

The greatest part of organic material on steel sheet is coating on external face – commonly used is polyvinyl chloride plastisol PVC(P), polyvinylidene flouride PVDF and polyester SP.

- Top coat **25 ÷ 200 µm**
- Primer 5 ÷ 10 µm
- Metallic corrosion protection (Zn, Al-Zn, Zn-Al) ≈ 25 µm
- Steel sheet 0,5 ÷ 1,5 mm
- Metallic corrosion protection (Zn, Al-Zn, Zn-Al) ≈ 25 µm
- Primer 5 ÷ 10 µm
- Backing coat 7 ÷ 15 µm

Core materials

- Rigid plastic foam
 - polyurethane (PUR) and polyisocyanurate (PIR) - $35 \div 50 \text{ kg/m}^3$
(polyol + isocyanate 1 : 1 \div 1 : 1,5)
 - polystyrene (EPS and XPS) - $15 \div 20 \text{ kg/m}^3$ and $30 \div 50 \text{ kg/m}^3$
 - Phenolic resin foam (PF) 50 kg/m^3
- Inorganic fibre material
 - glass fibre $30 \div 50 \text{ kg/m}^3$ ($\approx 8\%$ binder)
 - stone fibre $80 \div 150 \text{ kg/m}^3$ ($\approx 3\%$ binder, melting point $>1000 \text{ }^\circ\text{C}$)
- Adhesives (for inorganic and polystyrene)
 - one- and twocomponent polyurethan adhesive $200 \div 350 \text{ g/m}^2$
(fire retardants may be added)

EN 14509:2006

Self-supporting double skin metal faced insulating panels – Factory made products - Specification

Fire characteristics:

Reaction to fire

The reaction to fire classification of the product shall be determined according to EN 13501-1.

The test methods: EN ISO 1182, EN ISO 1716, EN 13823 in EN ISO 11925-2

Fire resistance

The fire resistance classification of the product shall be determined according to EN 13501-2. The test methods are:

EN 1364-1 (wall), EN 1364-2 (ceiling), ENV 13381-1 (horizontal membrane),
EN 1365-2 (loadbearing roof).

External fire performance - roofs

The roof made of panels shall be tested according to EN 1187 and classified in accordance with EN 13501-5. Sandwich panels are generally considered to satisfy the requirements for the characteristic external fire performance without the need for further testing

Reaction to fire – testing procedures

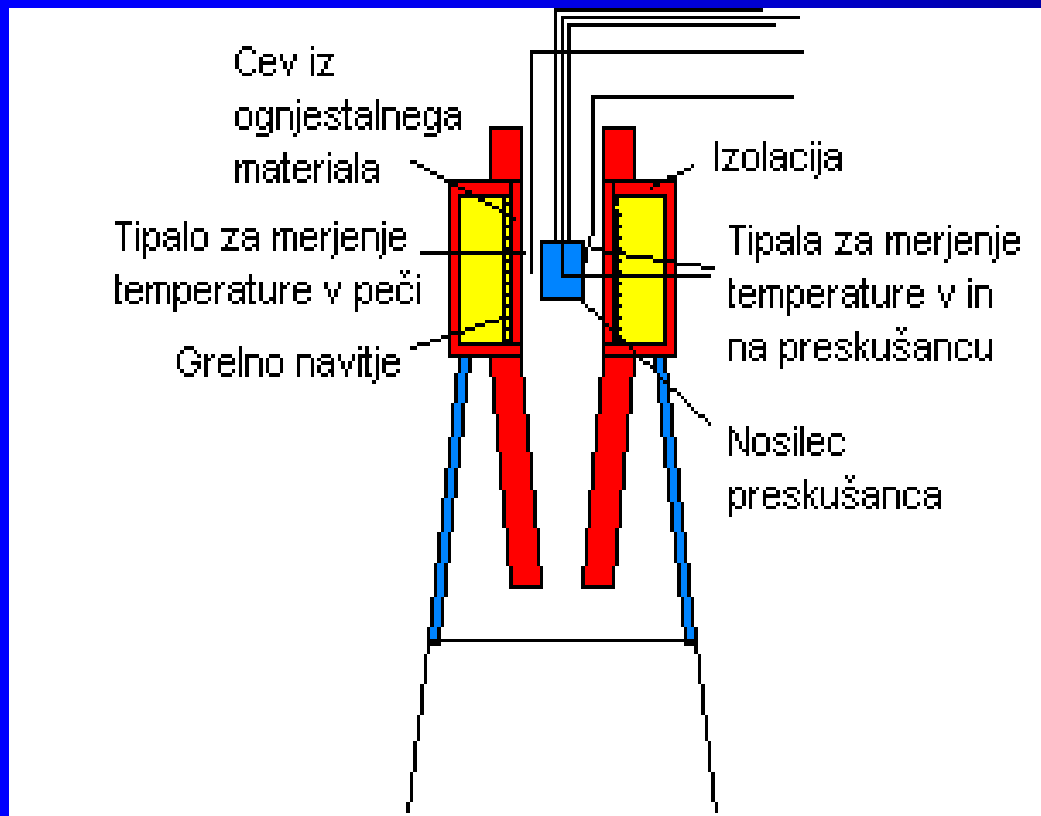
Non-combustibility test	EN ISO 1182
Heat of combustion	EN ISO 1716
Single burning item (SBI)	EN 13823
Ignitibility	EN ISO 11925-2

Reaction to fire

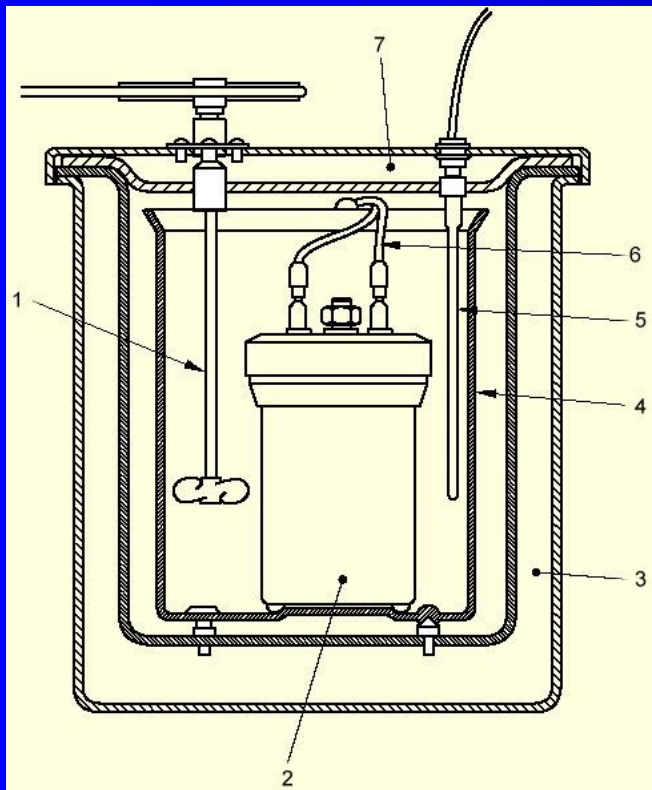
EN 13501-1:2002:

- A1: EN ISO 1182 (furnace 750 °C) and
EN ISO 1716 (calorimeter)
- A2: EN ISO 1182 (furnace 750 °C) or
EN ISO 1716 (calorimeter) and
EN ISO 13823 (SBI) + EN ISO 11925-2
- B, C in D: EN ISO 13823 (SBI) and
EN ISO 11925-2 (small flame 30 seconds)
- E: EN ISO 11925-2 (small flame 15 seconds)

Non-combustibility furnace EN ISO 1182



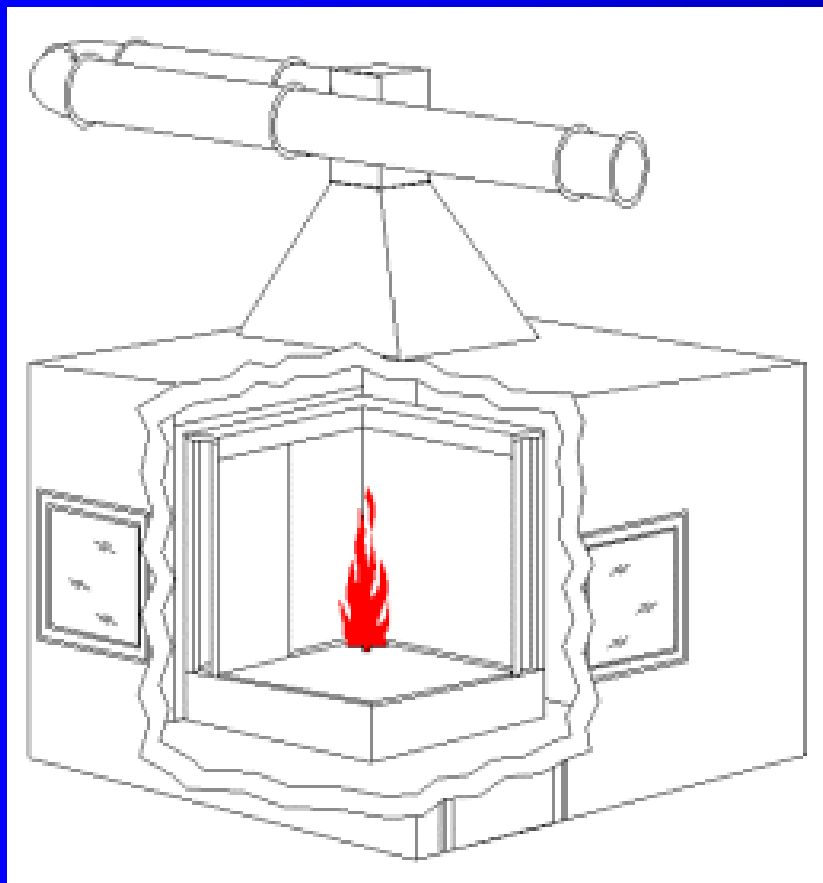
Calorimeter EN ISO 1716



Gross heat of combustion - PCS

Material	PCS [MJ/kg]	PCS of panels 10 cm thick [MJ/m ²]
Varnish	≈ 30	≈ 3
PUR in PIR	24 - 26	90 - 130
XPS in EPS	40	60 - 200
PF resin	29	≈ 150
UF resin	14	≈ 70
Mineral wool	0,09	≈ 0,9
glue	26	≈ 6

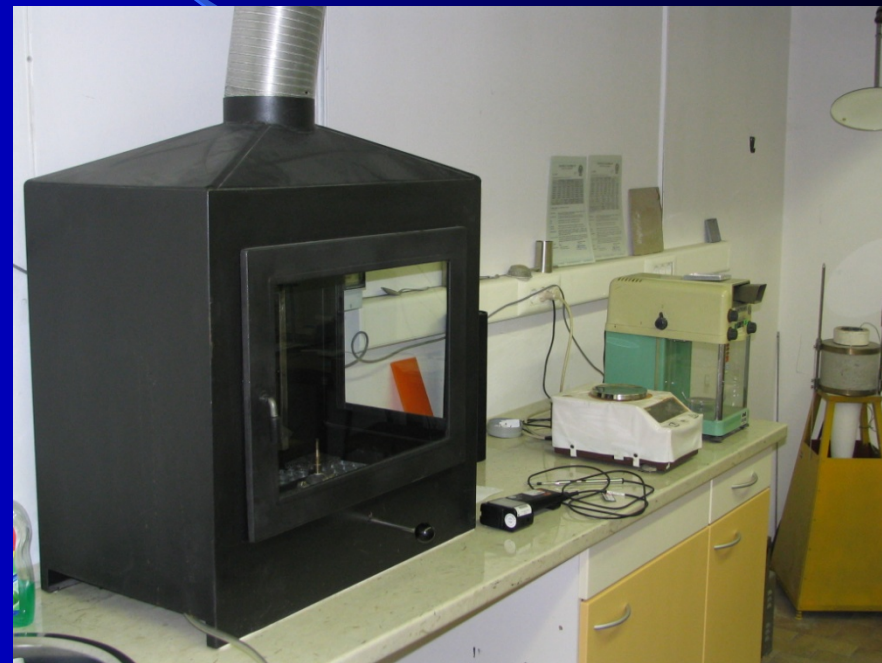
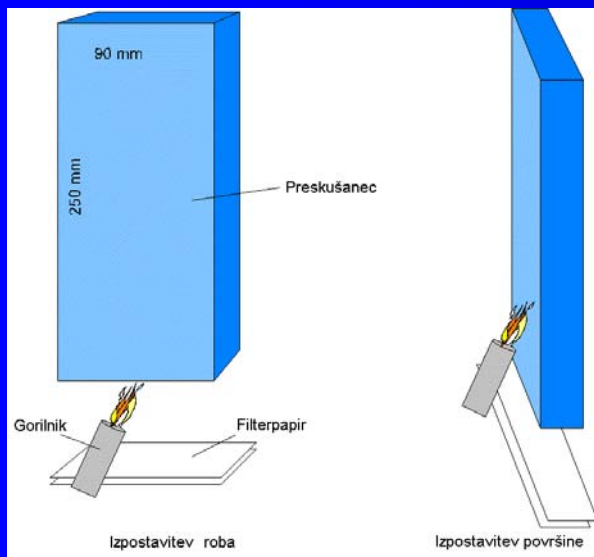
Single burning item test (SBI) EN 13823



SBI test



Small flame test EN ISO 11925-2



Reaction to fire – non-combustible material

Class	Test method(s)	Classification criteria	Additional classification
A1	EN ISO 1182 (a) and	$\Delta T \leq 30 \text{ }^\circ\text{C}$ and $\Delta m \leq 50\%$ and $t_f = 0$	-
	EN ISO 1716	$\text{PCS} \leq 2 \text{ MJ/kg}$ (a) and $\text{PCS} \leq 2 \text{ MJ/kg}$ (b,c) and $\text{PCS} \leq 1,4 \text{ MJ/m}^2$ (d) and $\text{PCS} \leq 2 \text{ MJ/kg}$ (e)	-
A2	EN ISO 1182 (a) or	$\Delta T \leq 50 \text{ }^\circ\text{C}$ $\Delta m \leq 50\%$ $t_f \leq 20 \text{ s}$	-
	EN ISO 1716 and	$\text{PCS} \leq 3 \text{ MJ/kg}$ (a) and $\text{PCS} \leq 4 \text{ MJ/m}^2$ (b) and $\text{PCS} \leq 4 \text{ MJ/m}^2$ (d) and $\text{PCS} \leq 3 \text{ MJ/kg}$ (e)	-
	EN 13823 (SBI test)	$\text{FIGRA} \leq 120 \text{ W/s}$ and LFS < edge of specimen and $\text{THR}_{600\text{s}} \leq 7,5 \text{ MJ}$	Smoke production ^(f) and Flaming droplets ^(g)

Reaction to fire – combustible materials

B	EN 13823 (SBI) and	FIGRA \leq 120 W/s and LFS < edge of specimen and THR _{600s} \leq 7,5 MJ	Smoke production ^(f) and Flaming droplets ^(g)
	EN ISO 11925-2 ⁽ⁱ⁾ Exposure 30s	Fs < 150 mm within 60 s	
C	EN 13823 (SBI) and	FIGRA \leq 250 W/s and LFS < edge of specimen and THR _{600s} \leq 15 MJ	Smoke production ^(f) and Flaming droplets ^(g)
	EN ISO 11925-2 ⁽ⁱ⁾ Exposure = 30s	Fs \leq 150 mm within 60 s	
D	EN 13823 (SBI) and	FIGRA \leq 750 W/s	Smoke production ^(f) and Flaming droplets ^(g)
	EN ISO 11925-2 ⁽ⁱ⁾ Exposure = 30s	Fs < 150 mm within 60 s	
E	EN ISO 11925-2 ⁽ⁱ⁾ Exposure = 15s	Fs < 150 mm within 20 s	Flaming droplets/particles ^(h)
F	Noi performance determined		

Reaction to fire

- (a) For homogeneous products and substantial components of non-homogeneous products.
- (b) For any external non-substantial component of non-homogeneous products
- (c) Alternatively, any external non-substantial component having a PCS ≤ 2 MJ/m², provided that the products satisfies the following criteri of EN 13823 (SBI): FIGRA ≤ 20 W/s, LFS < rob vzorca, THR_{600s} $\leq 4,0$ MJ and s1, and d0
- (d) For any internal non-substantial component of non-homogeneous products
- (e) For the products as a whole
- (f) s1 = SMOGRA ≤ 30 m²/s² and TSP_{600s} ≤ 50 m²;
s2 = SMOGRA ≤ 180 m²/s² and TSP_{600s} ≤ 200 m²;
s3 \neq s1 ali s2.
- (g) d0 = No flaming droplets/particles in EN 13823 within 600 s;
d1 = No flaming droplets/particles, persisting longer than 10 s in EN 13823;
d2 \neq nor d0 or d1; Ignition of the papir in EN ISO 11925-2 results in a d2.
- (h) Fail = Ignition of the papir (d2 classification);
Pass = no ignition of the papir.
- (i) Under conditions of surface flame attack and, if appropriate to the end-use application of the product, edge flame attack;

Reaction to fire - classification

A1	A1				
A2	A2-s1,d0 A2-s2,d0 A2-s3,d0	A2-s1,d1 A2-s2,d1 A2-s3,d1	A2-s1,d2 A2-s2,d2 A2-s3,d2		Non-combustible materials
B	B-s1,d0 B-s2,d0 B-s3,d0	B-s1,d1 B-s2,d1 B-s3,d1	B-s1,d2 B-s2,d2 B-s3,d2		Hardly combustible materials
C	C-s1,d0 C-s2,d0 C-s3,d0	C-s1,d1 C-s2,d1 C-s3,d1	C-s1,d2 C-s2,d2 C-s3,d2		
D	D-s1,d0 D-s2,d0 D-s3,d0	D-s1,d1 D-s2,d1 D-s3,d1	D-s1,d2 D-s2,d2 D-s3,d2		Normally flammable materials
E	E E-d2				
F	F				Easily inflammable materials

Direct field of application of reaction to fire test results

parameter	factors	Validity of test
Metal facings	Grade of metal	Valid for all grades of tested metal type
	Thickness of metal facing	Valid for all thicknesses between tested and up to +100%
	Profile geometry - flat or light profiling up to 5 mm - profiles greater than 5 mm	Valid for other types of flator light profile Valid for any greater profile depth
	Surface coating– tested face: a) PCS 0 – 4 MJ/m ² b) PCS > 4 MJ/m ² c) Colour of coating	Valid for all coatings 0 - 4 MJ/m ² Valid for all lower values Valid for all colours

Direct field of application of reaction to fire test results

Joint deign	Butt joint – worst case scenario	Valid for all types of joint
Adhesive	Change of tested quantity and/or type a)Quantity only b)Type only c)Quantity and type	Valid for lower quantity Valid for alternative adhesive with calorific value \leq to that tested Valid for alternative adhesive with calorific value \leq to that tested
Seals and gaskets		Valid for the types of joint seals tested and for those of lower PCS

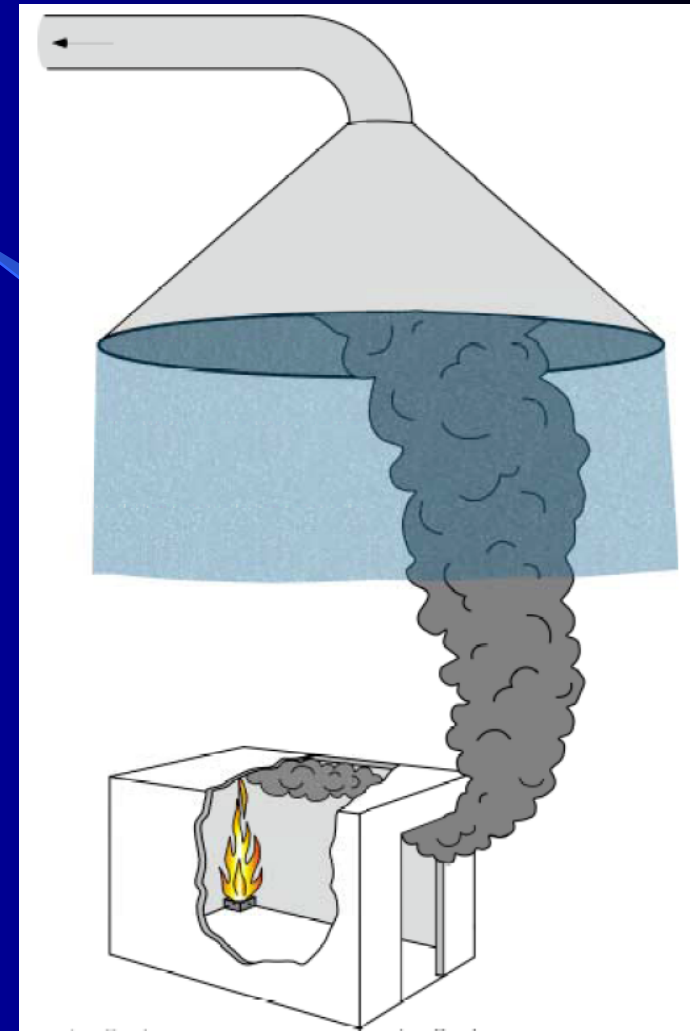
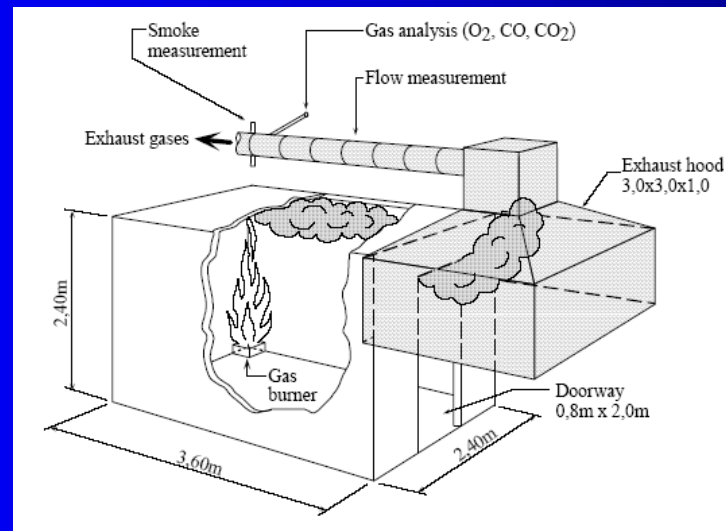
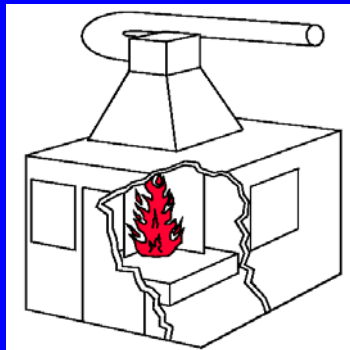
Direct field of application of reaction to fire test results

MW insulating core	<ul style="list-style-type: none"> a) Density b) Orientation of fibres c) Joints between lamellas d) Type of MW and binders 	<p>Valid for $\pm 15\%$ of tested density</p> <p>Not valid for change of orientation</p> <p>Valid for change in number of joints</p> <p>Velja za isti tip vlaken in nižji PCS</p>
<ul style="list-style-type: none"> PUR XPS EPS PF 	<p>Chemical composition</p> <p>density</p>	<p>Valid for the same chemical system</p> <p>Valid for $\pm 15\%$ of tested density</p>
Thickness of the panell	<ul style="list-style-type: none"> a) Panels < 100 mm b) panels ≥ 100 mm 	<p>Valid for $\pm 15\%$ of tested thickness</p> <p>Where the same panels are produced in different thickness either the maximum and minimum thickness shall be tested.</p> <p>The results from specimens $100 < D < 150$ mm shall be valid for any panel greater than 100 mm</p>

Direct field of application of reaction to fire test results

Orientation of panels	Vertical or horizontal application of sandwich panels	Vertical test is also valid for horizontal wall and ceiling
Metal corner flashing		Valid for end use flashings of same material as that tested Tests carried out with no corner flashing or steel flashing shall be valid for all types of steel flashing
Plastic corner flashing		Valid for end use flashings of same material as that tested
Fixings for metal flash	Standard spacing is 400 mm	Valid for 400 mm or less
Seals	Seals which are applied in end use; not part of the manufactured panel	Valid for seals of the same type as tested or the seal with the same or lower PCS.

Reaction to fire – Nordtest project 1432-99



Reaction to fire – Nordtest project 1432-99

Sandwich panel	SBI test	Test ISO 9705	Free-standing set-up
Rock wool 100	B-s1,d0	≥B	≥B
EPS 100	B-s2,d0	D	C
PIR 100	B-s3,d0	≥B	C
PUR 100	B-s2,d0	C	D

The free standing test procedure is more severe than ISO 9705

Fire resistance

Test methods:

- EN 1364-1 (non-loadbearing walls),
- EN 1364-2 (non-loadbearing ceilings),
- EN 1365-2 (floors and roofs),
- prENV 13381-1 (horizontal membrane),

Resistance to fire performance characteristics

R – Load bearing capacity

Is the ability of the element of construction to withstand fire exposure under specified action.

E - Integrity

Is the ability of the separating construction to prevent transmission of fire by passage of flames or hot gases (ignition of a cotton pad, cracks or sustained flaming)

I - Insulation

Is the ability of the separating construction to prevent transmission of fire by transfer of heat (140 ali 180 K).

W - Radiation

Is the ability of the separating construction to prevent transmission of fire by transfer of radiant heat (15 kW/m²).

M – Mechanical action

Is the ability of the separating construction to withstand impact, representing the case where failure of an another element causes an impact on the element concerned.

Fire resistance

Combination of these designatory letters shall be used as part of the classification of performance. They shall be supplemented by the time in minutes: 15, 20, 30, 45, 60, 90, 120, 180, 240 ali 360.

For loadbearing elements:

REI ttt ttt ... time during which all criteria loadbearing, integrity and insulation are satisfied

RE ttt ttt ... time during which the criteria loadbearing capacity and integrity are satisfied

R ttt ttt ... time during which the criteria loadbearing capacity is satisfied

For non loadbearing elements: without R

Fire resistance

Fire resistance classification shall be done according to EN 13501-2.

Fire resistance classes of non-loadbearing walls:

E		20	30		60	90	120		
EI	15	20	30	45	60	90	120	180	240
EI-M			30		60	90	120		
EW		20	30		60	90	120		

Fire resistance

Classes of loadbearing roofs with fire separating function:

RE		20	30		60	90	120	180	240
REI	15	20	30	45	60	90	120	180	240

Fire resistance

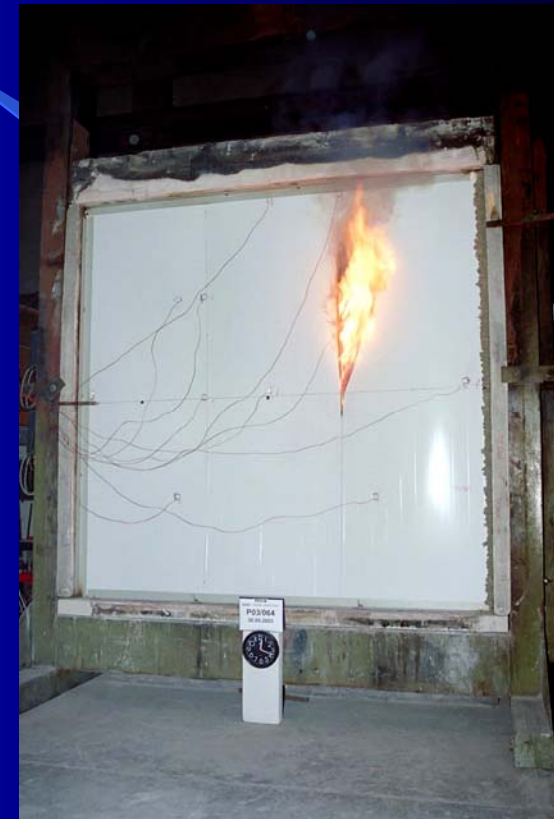
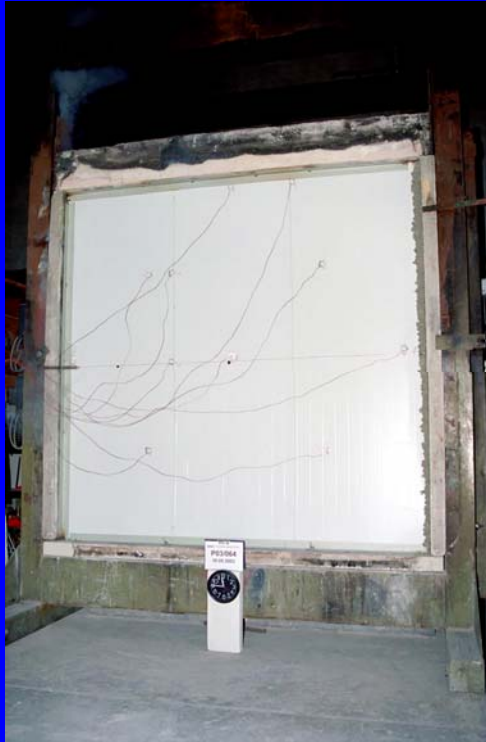


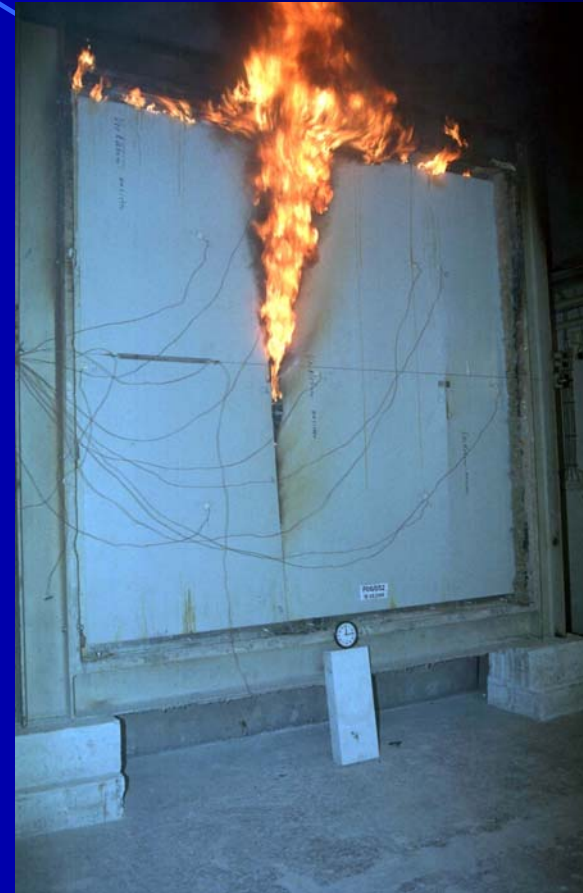
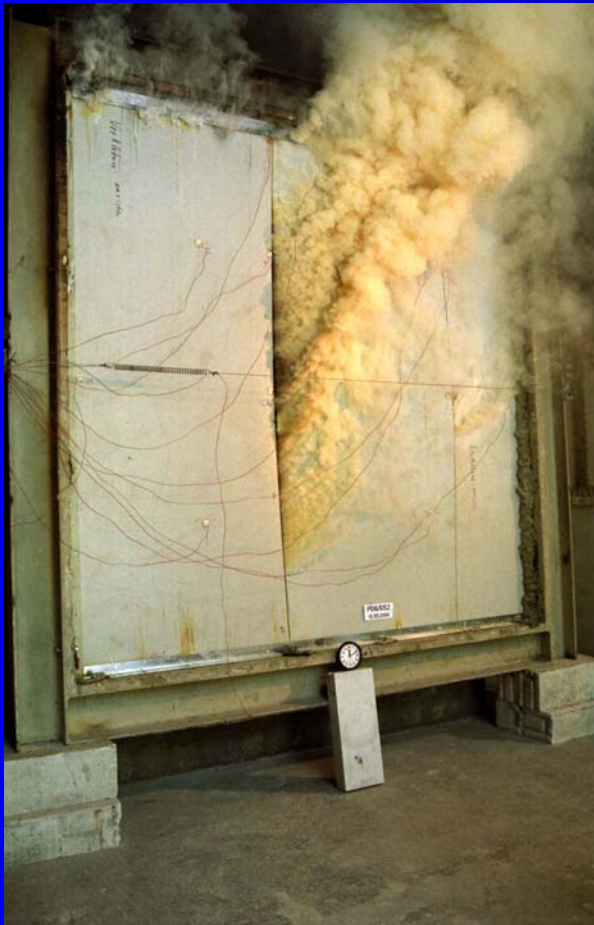
Foto Matjaž Zupanc

Fire resistance



Foto Matjaž Zupanc

Fire resistance



Fire resistance



Foto Matjaž Zupanc

EN 15254-5:2010

Extended application of results from fire resistance tests – Non-loadbearing walls – Part 5: Metal sandwich panel construction

Standard is dealing with influence of different factors on integrity and insulation:

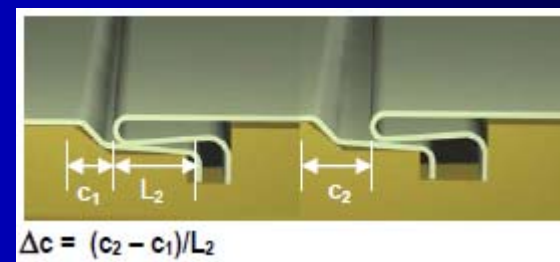
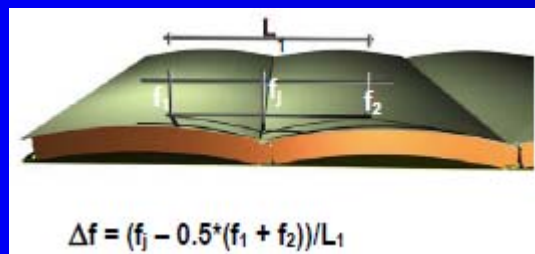
- changes in metal facings (coating, geometry, ..)
- changes in adhesive (type, amount)
- changes in core material (type, composition)
- span length (decrease, increase)
- orientation,
- panel width and thickness,
- joint construction,
- fixing system, length and height of assembly, support,

EN 15254-5:2010

Annex B – Evaluation of extension of span length

To be able to do an extension in the span length above 4 m there shall be an overrun of at least 20% subject to a minimum 10 min compared to the classification.

During the reference test the deflection difference at midspan between the joint and the centres of the adjoining panels shall be measured throughout the test.



Extension are allowed only if $\Delta c \leq 0,5$

If $\Delta f \leq 0,01$ the span may be increased up to 12 m

External fire performance for roofs

Two possibility:

- 1) Roof made of sandwich panels is tested in accordance with ENV 1187 and classify according to EN 13501-5.
- 2) CWFT – Classification without further testing
Roof panel with core material of PUR or MW is approved B_{ROOF} if:
 - a metal cover cap covering the joint crown,
 - thickness of external facings is at least 0,4 mm,
 - PCS of external PVC coat is less than 8 MJ/m²
 - minimum reaction to fire class D-s3,d0
 - core material of PUR and mineral wool is less than 35 kg/m³ and 80 kg/m³ respectively

External fire performance for roofs



Fire resisting construction

For certain applications, external walls are required to provide a period of Fire Resistance.

There is normally no requirement for roofs.

Standard fire resistance tests only assess the performance of the insulated panels themselves including the panel-to-panel joints.

Some mineral fibre cored panels are capable of providing 120 minutes integrity and insulation.

Certain types of system with PIR core can achieve 120 minutes integrity and 15 minutes insulation.

For requirements in excess of 15 minutes insulation and for all internal compartment walls it is necessary to use panels with high density mineral fibre cores.

**Thank you for your
attention**