RECTICEL INSULATION AB

FIRE ASSESMENT REGARDING IP PIR IN FULL CONCRETE SANDWICH SYSTEM

REPORT

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Table of contents

Disclaimer

Please note that this document serves as a performance-based design assessment of a specified exterior wall setup, aimed at demonstrating that the alternative solution is equally good (or better) than the prescriptive design outlined in section 5:551 of the Swedish Building Regulations (BBR). It targets Br1 buildings, ensuring the separation function between fire compartments, limiting fire spread inside the wall and along the façade surface, and reducing the risk of injury from falling parts of the exterior wall. This guidance is based on tests performed by Recticel in a test laboratory environment and conducted by a worldwide accredited testing service.

A wall setup might be subject to alterations from project to project and the following analysis shall therefore be reviewed by the fire safety consultants linked to that specific building project since it is their responsibility that the construction as such meet the requirements stated in the BBR.

1 SCOPE AND PURPOSE

This guideline is focused on the assessment and verification of openings and penetrations in exterior walls constructed of full concrete sandwich systems, specifically in Br1 buildings with IP PIR serving as the combustible core. This type of wall setup will in general be compliant to all of the requirements stated in chapter 5:551 for building class Br1. When introducing an exposed combustible material however, it has to be fire protected, which is the case for openings and penetrations.

The assessment from this report cannot, in any way, be translated or extrapolated into solutions for openings and penetrations in ventilated façade systems.

The purpose of this report is to verify the usage of exposed IP PIR in openings and penetrations in full concrete-sandwich panels. The purpose is also to conclude the limitations of using IP PIR when exposed in openings and penetrations in such an exterior wall setup to still meet the requirements set in section 5:551 point 2 of the Swedish building regulation.

1.1 Limitations

Due to the test procedure setup and the material being combustible it naturally limits the possibility to extrapolate the results in this report to any given wall setup.

The statements given in this report are therefore limited to full concrete sandwich systems which has a minimum insulation thickness of 100 mm and an inner concrete layer of at least 80 mm. Insultation boards thinner than 100 mm are not acceptable due to the uncertainty that the outer layers can affect the core foam differently. There are no limitations on maximum thickness for the insulation.

Likewise, a thicker concrete layer is acceptable since the concrete's material properties result in a high thermal conductivity which in other words has a cooling effect.

1.2 Description design exterior wall setup

A full concrete-sandwich wall is comprised of a minimum of three layers. A typical product is done with precast concrete with an inner core of combustible insulation. This means that the outer layers have a fire rating of minimum A2-s1,d0 which protect the combustible insulation in between. An illustration is given in Figure 1.

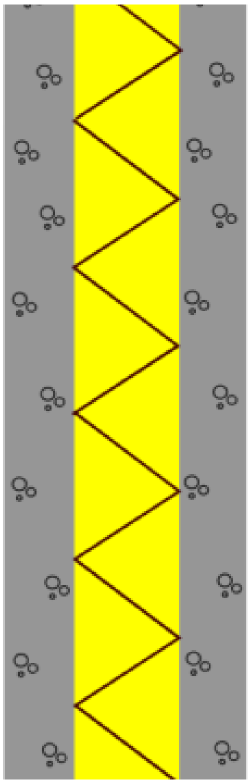

Figure 1: Full concrete-sandwich panel consists of three layers (Concrete- insulation-concrete).

1.3 Basic data

Basic data for the document is based on the following documents acquired from Recticel Insulation AB:

- Test Report EUFI29-21006107-T3, Recticel 4.2.2022
- Linear large scale test (Picture report)

1.4 Document control and verification

This report is reviewed by another fire safety engineer within Bengt Dahlgren Brand & Risk AB in accordance with company quality assurance policy. This involves an overall review of the reasonableness of the fire protection requirements and the proposed fire protection measures. Quality control has been performed according to table 1-1 below.

Table 1-1

Document, date	*Author*	*Quality control*
Report, date 2023-10-27	Mattias Spelmans	Erik Almgren

1.5 Revisions

This is the first version of the report.

2 BUILDING REGULATIONS

According to the Swedish building regulations, Boverket´s mandatory provisions and general recommendations, BBR (BFS 2011:6 with amendments up to BFS 2020:4), exterior walls in building class Br1 shall be designed to fulfill mandatory provision 5:551, as listed below.

5:551 Exterior walls in building class Br1

Exterior walls in buildings of class Br1 shall be designed to ensure

1. the separation function is maintained between fire compartments,
2. fire spread inside the wall is limited,
3. the risk of fire spread along the façade surface is limited,
4. the risk of injury due to parts falling from the exterior wall is limited.

3 BBR 5:551 – POINT 1, 3 AND 4

A full concrete-sandwich panel meets the requirements in BBR 5:551 point 1,3 and 4 according to the arguments below.

3.1 The separation function is maintained between fire compartments (point 1)

According to Eurocode 1992-1-2 a concrete construction of a minimum of 80 mm acquires a fire resistance rating of EI 60. This is the most common fire resistance rating for Br1 buildings.

3.2 The risk of fire spread along the façade surface is limited (point 3)

The concrete façade surface is at least class A2-s1,d0 and therefore meets the provision's requirement in point 3.

3.3 The risk of injury due to parts falling from the exterior wall is limited (point 4)

Falling parts from the exterior wall is prevented by mechanically connecting the concrete elements. Connections are protected by the outer concrete layer.

4 BBR 5:551 – POINT 2

To ensure that point 2 in BBR 5:551 is fulfilled it is required that the exterior walls only contain material with a reaction to fire of at least class A2-s1,d0 or are sectioned in such a way that fire spread inside the wall is limited.

The performance based design aspect of this report is that the inner core of a full concrete-sandwich wall system contains combustible material, which when exposed does not meet the provision's requirement in point 2 for protection against fire spread inside the wall, see Figure 1 for setup. The IP PIR shall have a thickness of at least 100 mm.

All other material in specified setup will be of at least class A2-s1,d0.

4.1 Linear large scale test

Recticel Insulation has performed a series of tests on resistance to fire classifications assigned to element wall constructions in accordance with the procedures given in EN 13501-2:2016. Given the report's scope and objective information from these, the report will only cover the test including Recticel Eurothane EWall. The insulation Eurothane EWall consist of the same core as IP PIR but with different facers. The facers have no significance for the result since the facers are not exposed in a full concrete-sandwich system or in the test. Therefore the results from the test including Eurothane EWall are applicable for similar systems with the insulation IP PIR.

In shortness this test exposes the horizontal surface of a sample to fire during a given time period. It is the bottom side of the sample that is exposed to fire and temperature measurements are then measured to study the temperature development and fire spread. This test can also be compared to the SP Fire 119, which is of smaller scale but same objectives. From the results, the setup can achieve a specific fire rating.

The test with Recticel Eurothane EWall was carried out with a setup which is illustrated below in Figure 2. Outer layers consisted of concrete slabs.

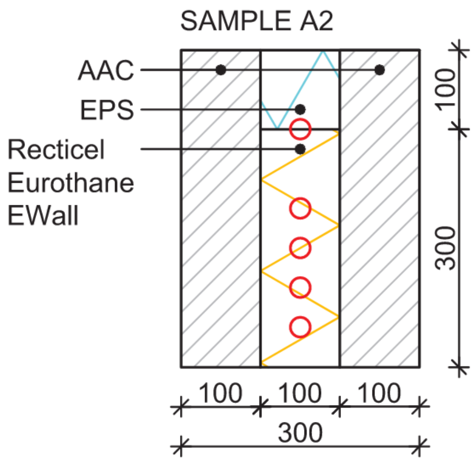

Figure 2: Concrete-Eurothane EWall-concrete test setup with given dimensions.

The full test specimen had a length of 900 mm, a height of 400 mm and a width of 300 mm (sample A2). The insulation Eurothane EWall had a width of 100 mm and a height of 300 mm. A slice of EPS with length of 900 mm, a height of 100 mm and a width of 100 mm was placed upon the Eurothane EWall insulation.

No further details regarding the test procedure given in EN 13501-2:2016 will be discussed since it followed the standard.

Temperature readings were carried out throughout the test and measured with thermoelements placed inside the insulation material (Eurothane EWall). Placings started 50 mm from the fire exposed surface and with 4 consecutive thermoelements, see Figure 3. The effect of the fire source and its temperature increase on the samples follows the standard fire curve and the duration of the test was 60 minutes.

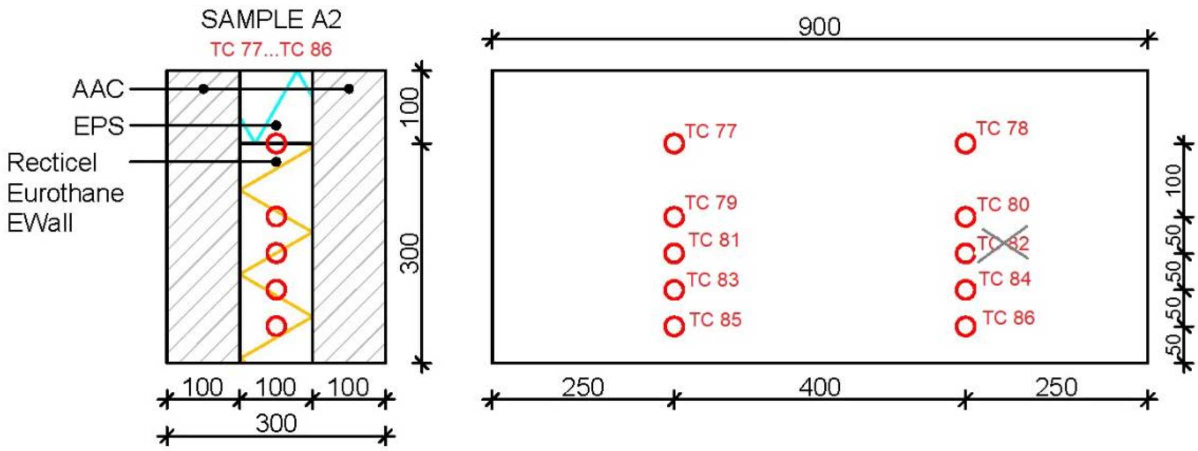

Figure 3: Test setup with thermoelements. Specified heights from different angles are illustrated (functional disorder in TC 82 during the whole test).

4.1.1 Results from the linear large scale test

Measured temperatures for each of the thermoelements in the sample were as illustrated in Figure 4. This graph is directly copied as observed in the report “EUFI29-21006107-T3”.

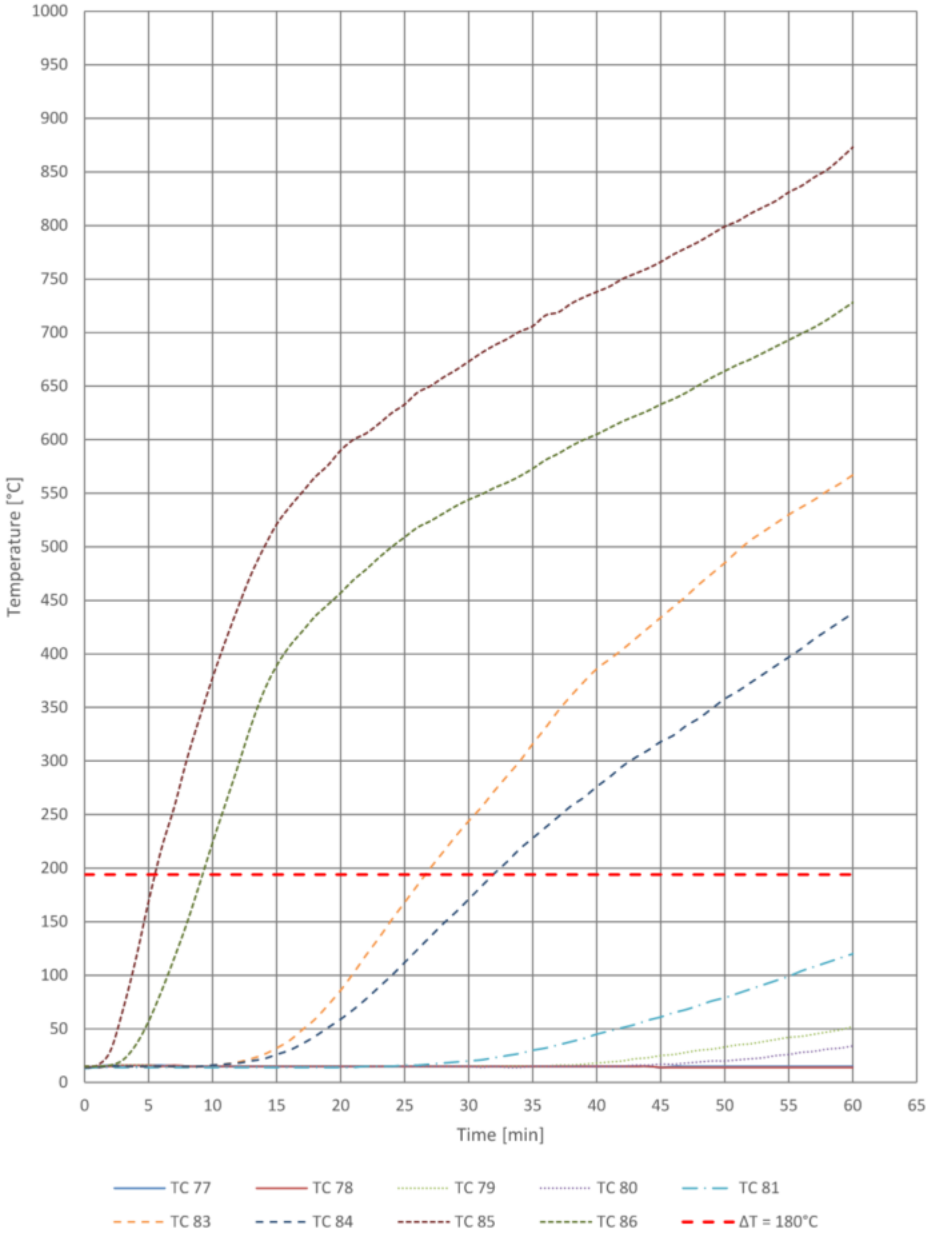

Figure 4: Measured specimen temperature. TC 77…TC 86 (functional disorder in TC 82 during the whole test).

During the test temperatures ranges from ambient (room temperature) to as high as 875 °C (50 mm into the sample) before the test is stopped. After the test was stopped the insulation self-extinguished without further charring.

Figure 5: Sample aftermath of test with Eurothane EWall. Front view.

Figure 6: Sample aftermath of test with Eurothane EWall. Side view.

Figure 5 and Figure 6 displays the physical results of 60 minutes of fire exposure directly on the setup containing a full concrete-sandwich system with Eurothane EWall. The correlating temperature curves in Figure 4 show that the temperature after 150 mm decreases from a critical 875 °C, which is similar to the oven temperature, to a more modest 120 °C. 200 mm into the sample the temperatures rose to around 50 °C.

Down below is a short summary of the results given by the linear large scale test performed with Eurothane EWall.

- The temperature rise ranged from 875 °C in the closest thermoelement (closest to fire exposed side) to no temperature rise at the furthest thermoelement.
- At a depth of 150 mm, temperatures had declined to 120 °C.
- Height of the charred area is estimated to total at the worst spot to approximately 100 mm. This would equal approximately a third of the available height of the insulation sample.
- After the test was stopped the insulation self-extinguished without further charring.

5 DISCUSSION

The following chapter will cover discussions in regard to fire compartmentation in a building and its exterior wall setup as well as temperature results from the performed test. As stated earlier in the report the results and conclusions from Eurothane EWall can be extrapolated to the use of IP PIR as an inner core in a full concrete-sandwich system as well. This statement is made from the point of view that the different core foams are identical between the two products (Eurothane EWall and IP PIR) and the area of the facers are minimally exposed to the fire in relation to the core foam. Therefore, it can be stated that these products have similar rate of fire spread within a wall setup of the specified type.

5.1 Fire compartmentation

In the specified setup, the IP PIR is not protected when exposed through openings or penetrations. That also leads to the IP PIR not being divided vertically which would be required according to BBR 5:551 point 2 and the practical solution is in general to protect said exposed surfaces with stone wool. Below in figure 7 is a general illustration to better illustrate the fire compartmentation and the risk for fire spread. Please note that other sources in the construction could also be a risk for fire spread inside the wall and has to be reviewed in detail.

Red lines mark the fire compartmentation while the gray and yellow area marks concrete and IP PIR. Fire spread could occur vertically inside the wall via window connections/sill which in turn would penetrate the fire compartmentation. The concrete layer is presumed to fulfill the minimum requirement of EI 60 in itself and is therefore not subject for further investigation.

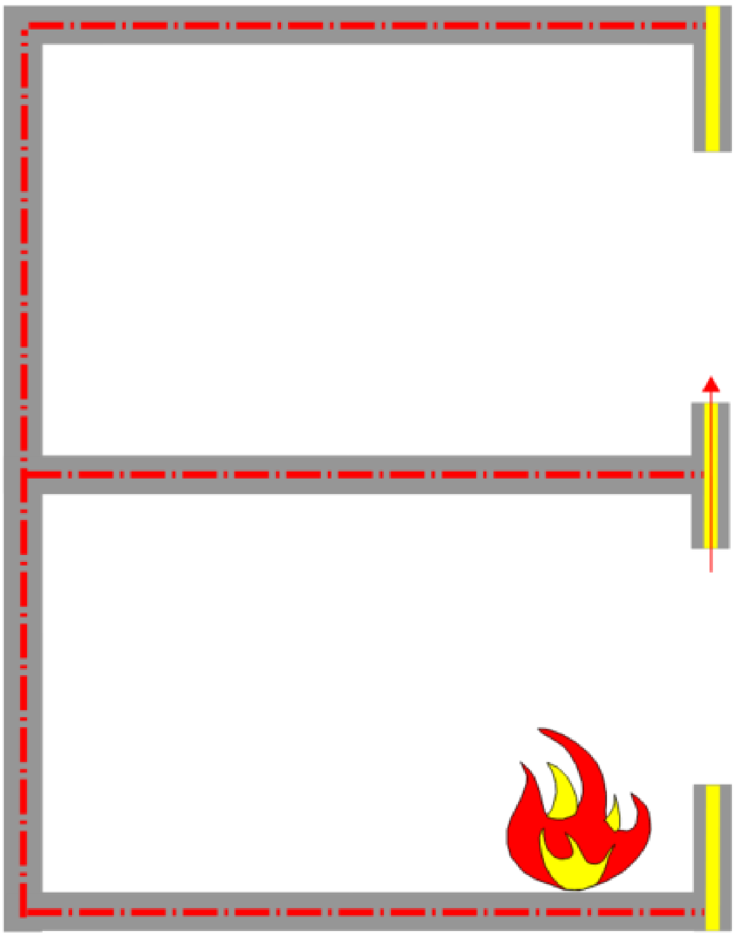

Figure 7: Illustration of fire compartmentation and risk of fire spread inside the wall (red arrow). Yellow markings are IP PIR while grey markings illustrate concrete. Fire compartmentation are the red dotted lines.

5.2 Temperature

As seen in Figure 5 and Figure 6 the char layer and char base of the sample are estimated to have reached a height of approximately 100 mm. This indicates that the combustion process and pyrolysis from the IP PIR is relatively slow. Given a 60 minute duration of the fire exposure and 100 mm char zone + pyrolysis zone it would mean a fire propagation rate of 100/60=1,7 mm/min, or rounded to 2 mm/min to be conservative and to consider inconsistencies in the insulation material as well as potential installation errors resulting in air pockets between the concrete and the IP PIR. Note that this is only a visual observation for the char zone and that the temperature criteria also has to be studied.

In general, the temperature rise curve presented in figure 4 indicates that the temperature criteria for fire separation is fulfilled around 150 mm in the insulation material for this sample. The criteria for fire separation of 180 °C at unexposed surface is derived from EN 13501. In the test the measured temperature at 150 mm was 120 °C. To have a redundancy and robustness in regard to these comments the minimum height for use of IP PIR between fire compartments and its separations should be at least 200 mm.

The specified distance of 200 mm shall be fulfilled from a fire compartment via the insulation to the next opening or penetration in the adjoining fire compartment. This is important to note as it applies to both openings but also penetrations which can be overseen if not handled correctly. Below the extent of a fire separation is illustrated in figure 8. It is derived from figure 4 above.

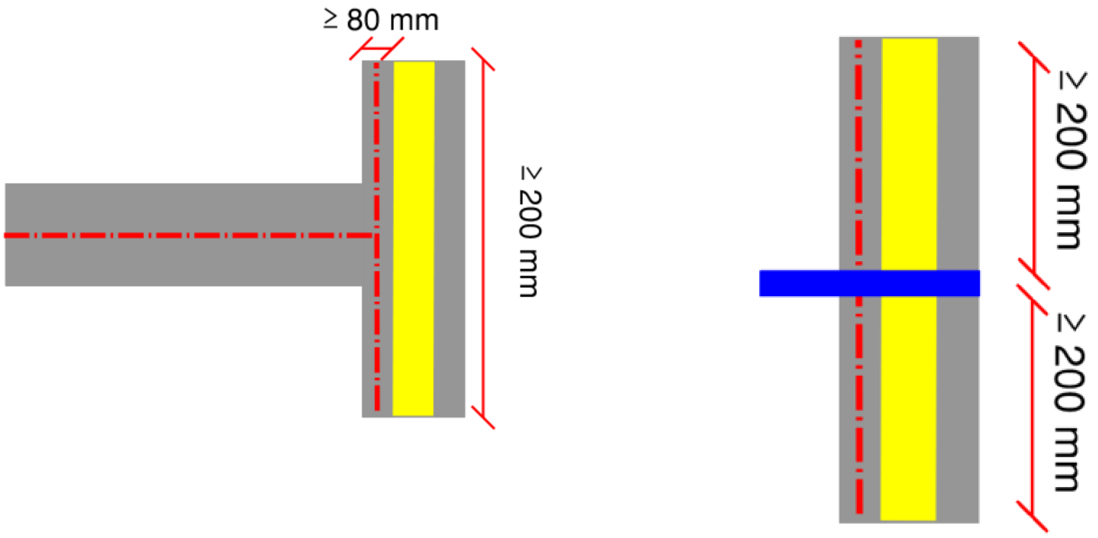

Figure 8: Detailed description of the required dimensions of IP PIR for fire separation between compartments in regard to openings (left picture) and penetrations (right picture). The blue marking represents a pipe penetration. Based on figure 4.

6 CONCLUSION

The scope of this report has been to perform an assessment and verification of openings and penetrations in exterior walls comprised of full concrete-sandwich systems in Br1 buildings with IP PIR as a combustible core of the system.

Bengt Dahlgren Brand & Risk AB concludes the following regarding the use of IP PIR:

- IP PIR with a minimum thickness of 100 mm serves as the core of the full-sandwich panel.
- The outer concrete layer in the specified wall setup is mechanically attached to the load bearing concrete layer.
- The load bearing (inner) concrete layer consists of a minimum of 80 mm concrete.
- A minimum height of 200 mm of IP PIR between fire compartments must be maintained, including around penetrations.
- No additional fire protection is required for the exposed combustible insulation material within the concrete sandwich panel. There’s no need for wood or stone wool around openings or penetrations as a fire protective measure.

The assessments in this report cannot be translated or extrapolated to solutions for openings or penetrations in ventilated façade systems.