# Comparison of two test methodologies for fire testing of façade systems

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# Abstract

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Key words: SP Fire 105, Façade, proposed European test method, fire spread.

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# Content

# Terms and definitions

In this report the following terminology is used:

| ***Term*** | ***Definition*** |
|---|---|
| Combustion chamber | The chamber is constructed as a simulated window opening where the wood crib is located. The dimensions and appearance of the fire room are based on the fire room used in “Draft proposed European test method” [1]. |
| Eave | The lower edge of a roof overhang the building’s exterior wall. |
| Fictious window/secondary window | A simulated window opening that is built as in practice, complete with trimmings, drip caps and flashings. |
| Fire room | A chamber with an opening where the fire source of heptane is located. The dimensions and appearance of the fire room and the burner for the heptane fuel follow the description in SP Fire 105 [2]. |
| Fire spread | The fire spread from the fire room to the face of the façade. |
| Light-weight concrete | Aerated concrete with a density of approx. 575 $kg/m^3$. |
| Mid-section flashing | Drip cap between two sections, usually at the junction location between two stories. |
| Time to flashover | Time for external flaming from the fire room and combustion chamber. |

# 1 Introduction

Two fire tests were performed with the same façade system to study the difference in behaviour when tested according to two different test methods. The test methods studied were the draft version 2 of a European test method that are currently under development in a research project [1] and SP Fire 105 [2].

The experiments were conducted inside RISE's large fire test hall in Trondheim, Norway. The main dimensions of the hall are approximately 34.5 m × 17 m × 21 m (L×W×H).

The temperature in the hall was approx. (10 ± 5) °C during the preparations and the performing of the experiments.

The date of performing the test was:

- SP Fire 105 was performed at 2022-01-18.
- Draft proposed European test method was performed at 2022-01-20.

## 1.1 Performance criteria for SP Fire 105

The performance criteria are as stated in the Annex in SP Fire 105 [2].

- Fire spread (flame and damage) may not reach further up than to the lower part of the window in the second storey above the fire room.
- There may not be any large pieces falling down from the façade.
- There may not be any fire spread to the eave, which means that the temperatures measured at the eave may not exceed 500 °C for more than 2 minutes or 450 °C for more than 10 minutes.
- The heat flux into the centre of the window in the first storey above the fire room may not exceed 80 $kW/m^2$.

## 1.2 Performance criteria for draft proposed European test method

There are no developed performance criteria for the proposed European test method in draft version 2.

# 2 Description of setup and constructions

## 2.1 Setup of SP Fire 105

Representatives from the supplier mounted the test specimen onto the supporting construction. The supporting construction of the test rig consists of aerated concrete with a thickness of 150 mm and a density of approx. 550 kg/m$^3$ as described in the test method SP Fire 105 [2]. An overview of the test rig is shown in Figure 2-1.

The fire source consisted of 60 litres of heptane placed in tray with a flame suppression inside the combustion chamber. This will correspond to a fire load of approximately 75 MJ/m$^2$ total fire room surface.

The test specimen is described in chapter 2.3.

The mounting of the test specimen was supervised by RISE.

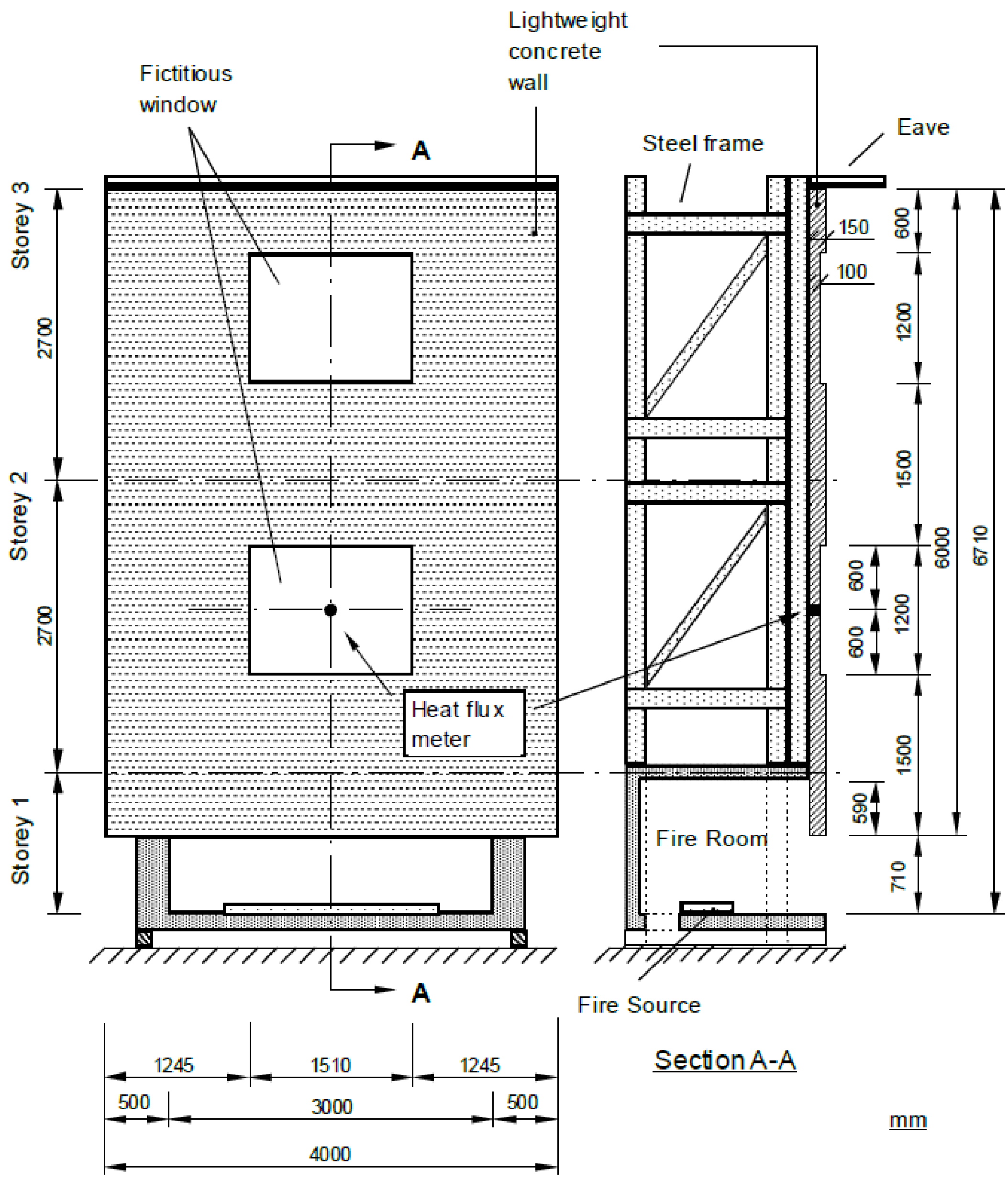


Figure 2-1 Overview of the test rig for the SP Fire 105 test.

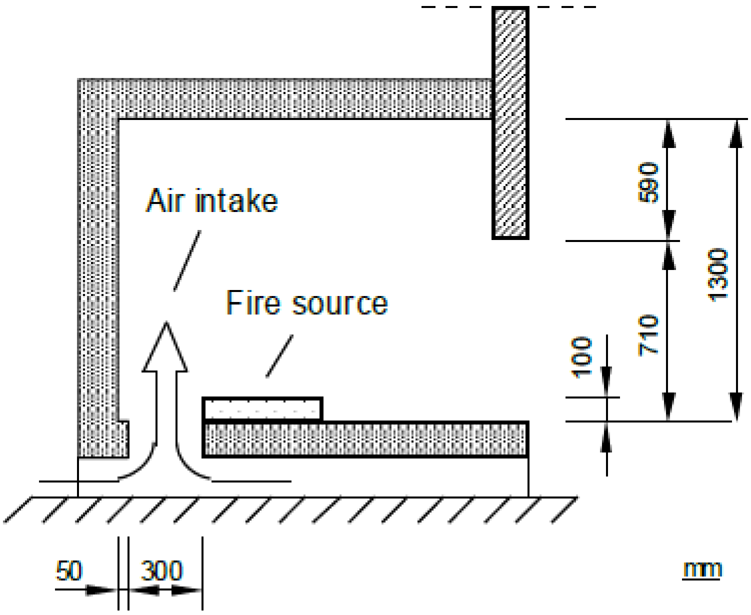


Figure 2-2 Fire room for SP Fire 105.

## 2.2 Setup of draft proposed European test method

Representatives from the supplier mounted the test specimen onto the test rig. The test rig consists of a steel frame as described in the test method "Assessment of fire performance of facades" [1]. An overview of the test rig is shown in Figure 2-3.

The fire source consisted of a wooden crib placed in the combustion chamber, see Figure 2-4. The crib was constructed with layers of sticks of soft wood with cross section 48 mm x 48 mm, alternated 90° between the layers. In total there were 23 layers. The moisture content of the crib was 10.4 %. The weight of the crib was 359 kg. This will correspond to a fire load of approximately 400 MJ/m$^2$ total fire room surface if the heat of combustion is assumed to be 17.9 MJ/kg (page 3467 in reference [3]) and the opening is included in the area.

The test specimen is described in chapter 2.3.

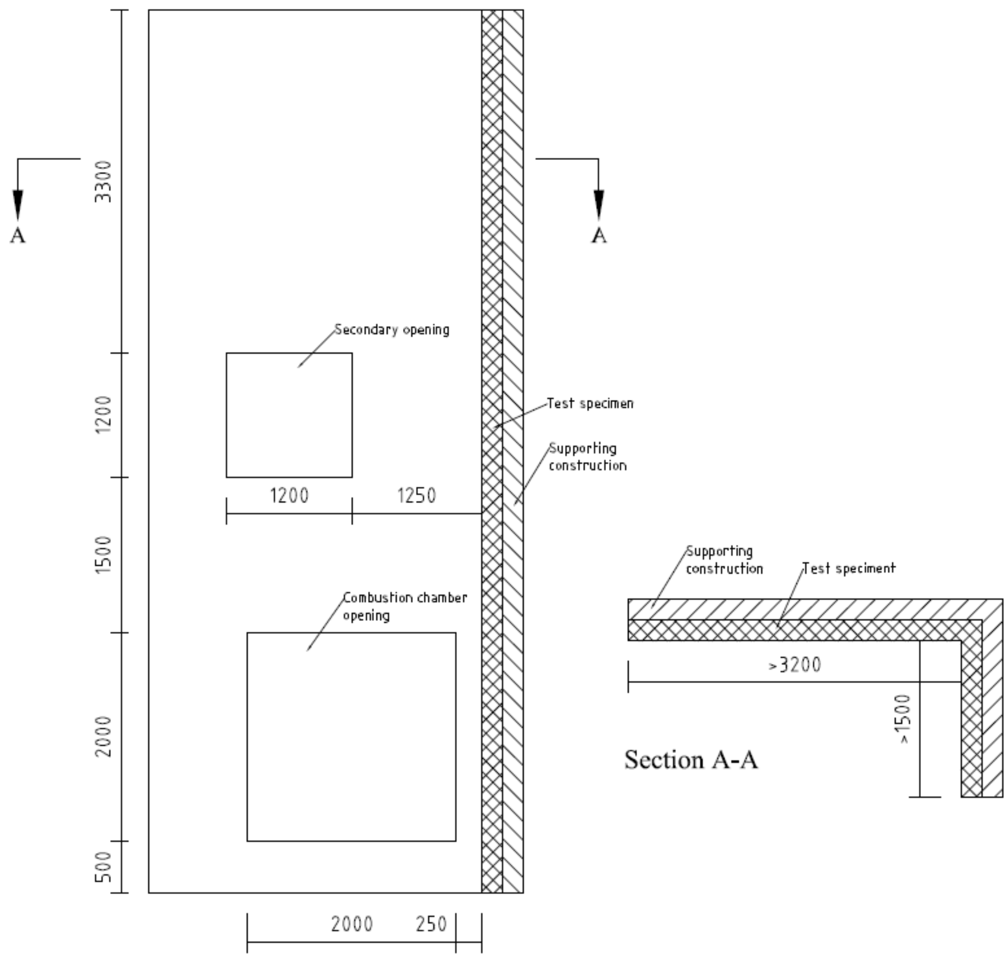


Figure 2-3 Overview of the test rig for the draft proposed European test method.

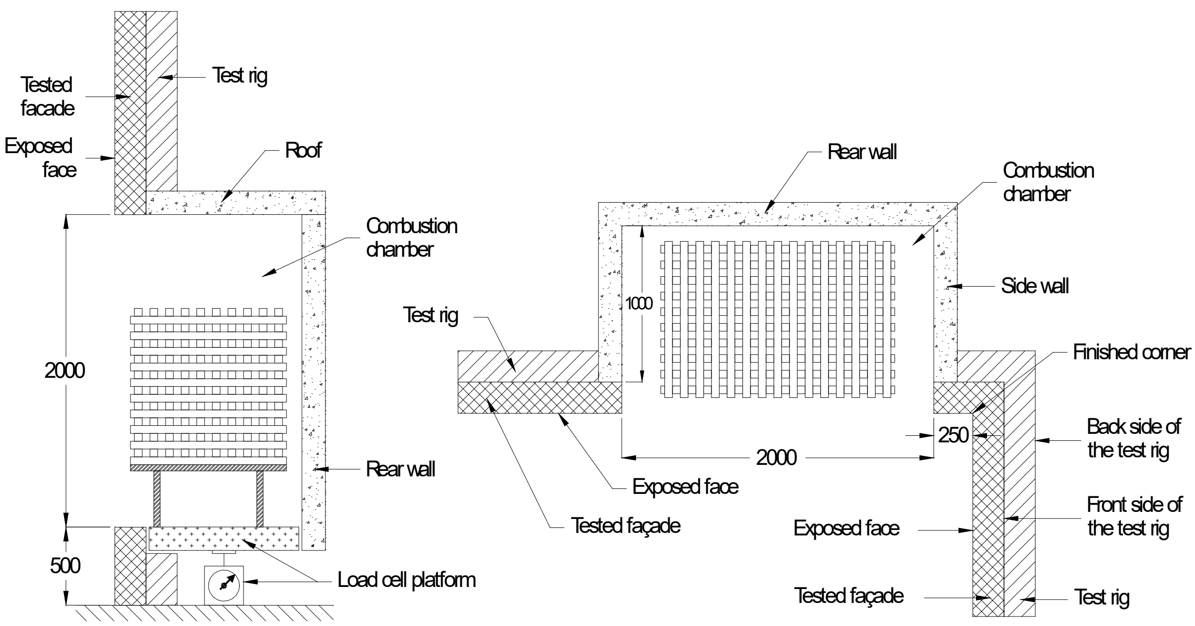


Figure 2-4 Combustion chamber (the load cell platform shown in the figure was not included in this test).

## 2.3 Constructions used in tests

The façade construction consisted of an insulated framework. A ventilated cross-lathed cavity with vertical and horizontal battens was covered with vertical wood cladding. The façade system was built as below, from inside to outside:

- Framework of spruce, insulation of stone wool
  - PAROC Extra stenull (Euroclass: A1, density: 28 kg/m$^3$)
- Wind protection cloth
  - T-vind Super (area density 60 g/m$^2$)
- Cross-lathing with a total cavity of 45 mm (24 mm + 21 mm).
- Cladding
  - Rebated boarding, 21 mm thick of spruce mounted vertical, fasted with nails of steel.
  - Painted with fire retardant paint “Rubbol WP” and “Rubbol WF”.

Details

- Windows mounted with drip caps in top and bottom made painted galvanized steel with thickness of 0.6 mm.
- The junctions between floors had a mid-section flashing with a drip cap mounted made of painted galvanized steel with thickness of 0.6 mm.

Materials and components included in the façade system were selected and delivered to RISE by the supplier of the test specimens. RISE was not involved in the selection of materials or components.

Density and moisture content were measured on a random sample of materials selected during construction. The properties were measured from relatively small samples and should only be regarded as informative.

Table 2-1 Measured properties for some of the included materials.

| ***Material*** | ***Measured density [kg/m$^3$]*** | ***Moisture content [%]**** |
|---|---|---|
| Painted panel, white | 464 | 12.0 |
| Painted trim 70 mm x 21 mm | 477 | 13.4 |
| Painted trim 120 mm x 21 mm | 521 | 13.5 |
| Untreated spruce batten 70 mm x 45 mm | 426 | 13.5 |
| Untreated spruce spacer 47 mm x 30 mm | 408 | 12.4 |
| Untreated spruce spacer 70 mm x 24 mm | 418 | 12.2 |

** Moisture content was calculated from the weight loss after the material being heated to 105 °C until two successive weighings at 24 h intervals differ by less than 0.1 %.*

# 3 Measurements and observations during experiments

## 3.1 Instrumentation

Table 3-1 Equipment used during the tests.

| *Type of equipment* | *RISE ID no.* | *Designation and supplier* | *Measurement and unit* |
|---|---|---|---|
| Heat flux meter | NBL 2845 | 64-10SB-18<br>Pentronic AB | Heat radiation<br>[kW/m$^2$] |
| Thermocouples | N/A | 23 G/G-30-KK (Type K)<br>Medtherm Corporation | Temperature<br>[°C] |
| Test rig<br>SP Fire 105 | NBL 1520 | SP Fire 105 test rig<br>RISE Fire Research AS | - |
| Test rig<br>Assessment of fire performance of facades | N/A | Assessment of fire performance of facades test rig<br>RISE Fire Research AS | - |

### 3.1.1 Instrumentation of SP Fire 105

Temperatures were measured as described in the test method with an addition of 24 thermocouples.

According to the test method two shielded thermocouples with diameter 1.5 mm were positioned 100 mm under the eave:

- E-100: 100 mm from the surface of the façade, ½ width
- E-400: 400 mm from the surface of the façade, ½ width

One heat flux meter was mounted in the lower fictious window.

- HF, heat flux meter: In line with the surface, ½ width, ½ height

In addition, 24 shielded thermocouples with diameter 1.5 mm were positioned in the centre of the insulation, in the centre of the cavity and 50 mm from the surface of the cladding as shown in Figure 3-1.

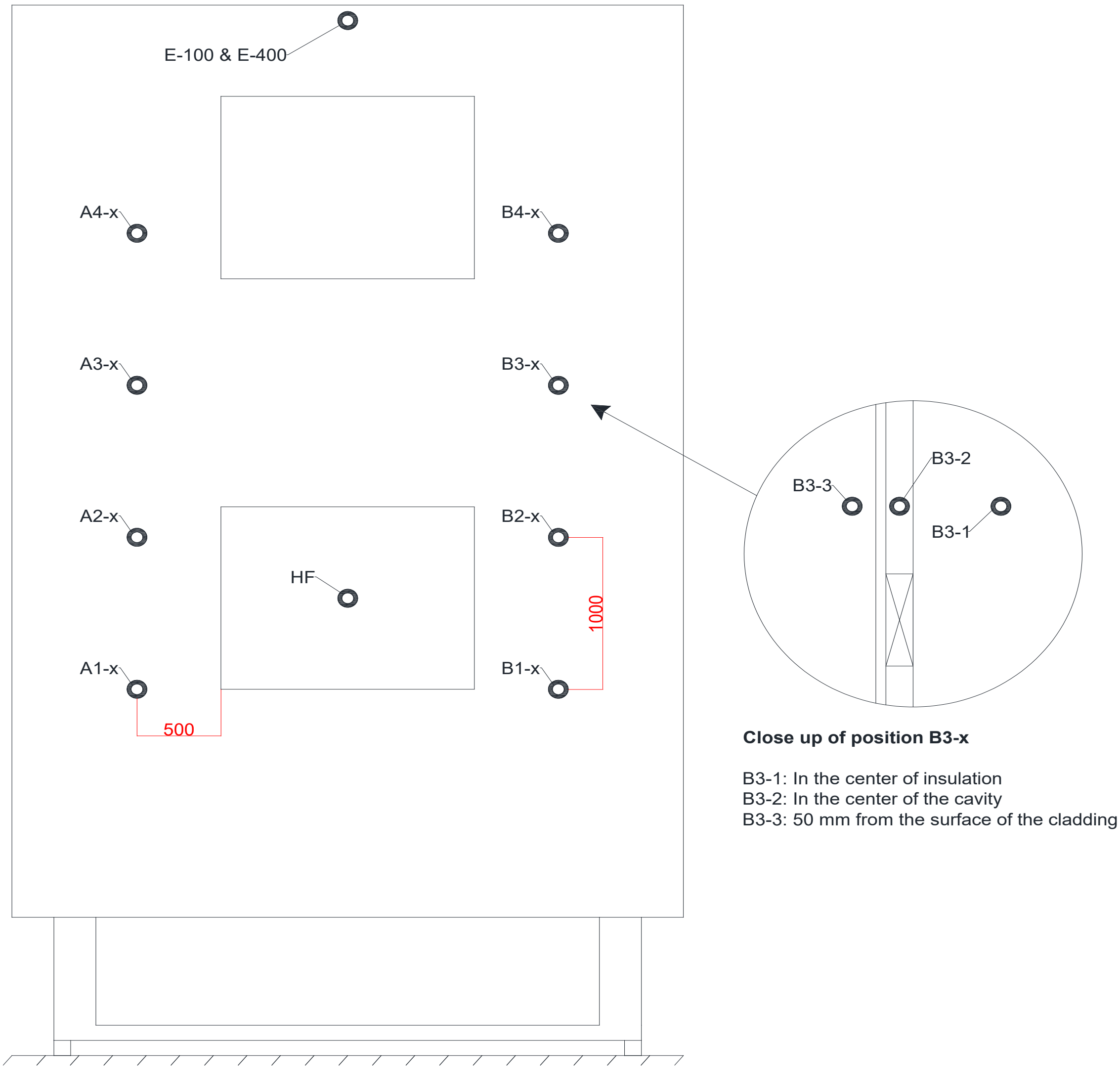


Figure 3-1 Thermocouple and heat flux meter positions, front view.

## 3.1.2 Instrumentation of the draft proposed European test method

Temperatures were measured as described in the test method.

One plate thermometer was mounted in front of the combustion chamber:

- PT: 1000 mm out from the opening, ½ width, ½ height. Directed towards the combustion chamber.

In addition, 96 shielded thermocouples with diameter 1.5 mm were positioned as shown in Figure 3-2.

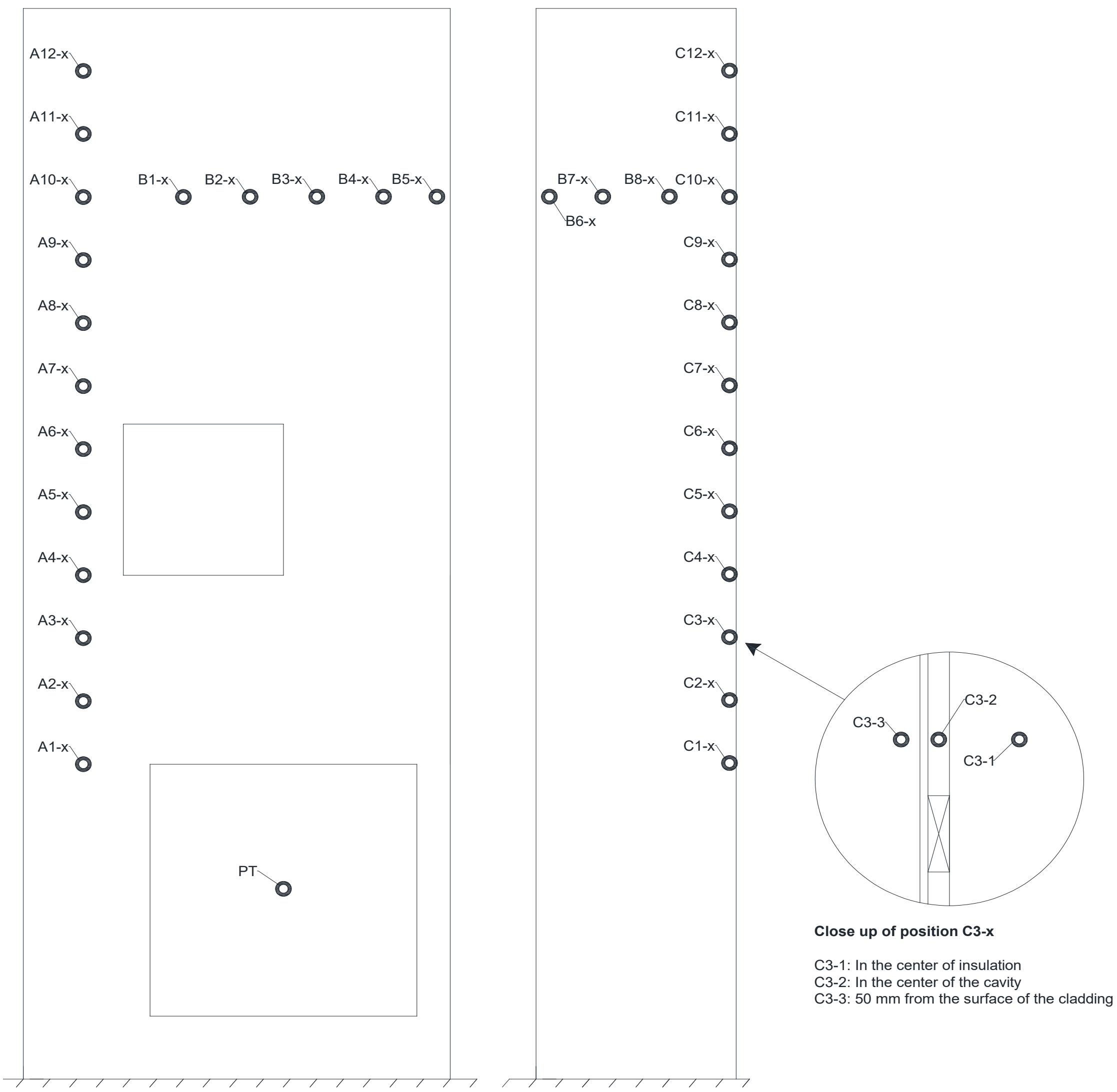


Figure 3-2 Thermocouple positions, front view. Section to the left is the main wing, the section to the right is the return wing.

## 3.2 Graphical depictions of temperature measurements

Graphical depictions of the temperature measurements made in the tests are enclosed on the following pages.

### 3.2.1 Graphical depictions of temperature measurements SP Fire 105

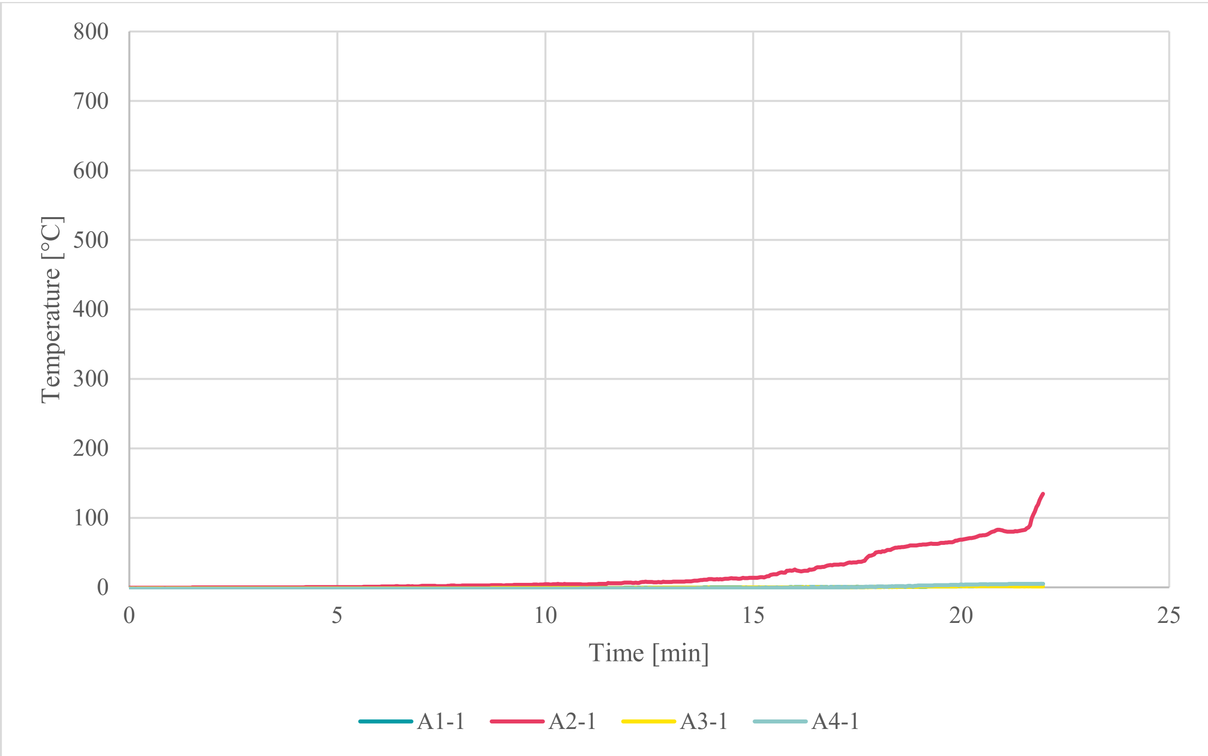


Figure 3-3 Temperature measurements of column A (A1-A4), centre of insulation during the test.

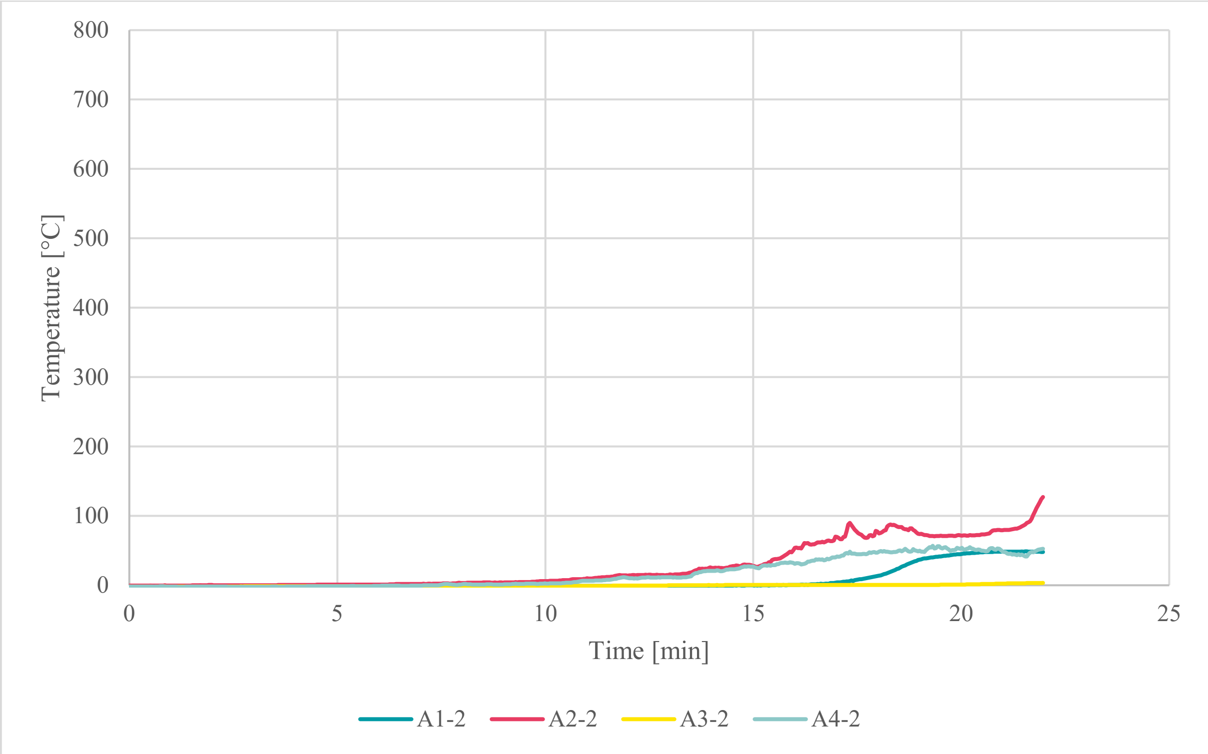


Figure 3-4 Temperature measurements of column A (A1-A4), centre of cavity during the test.

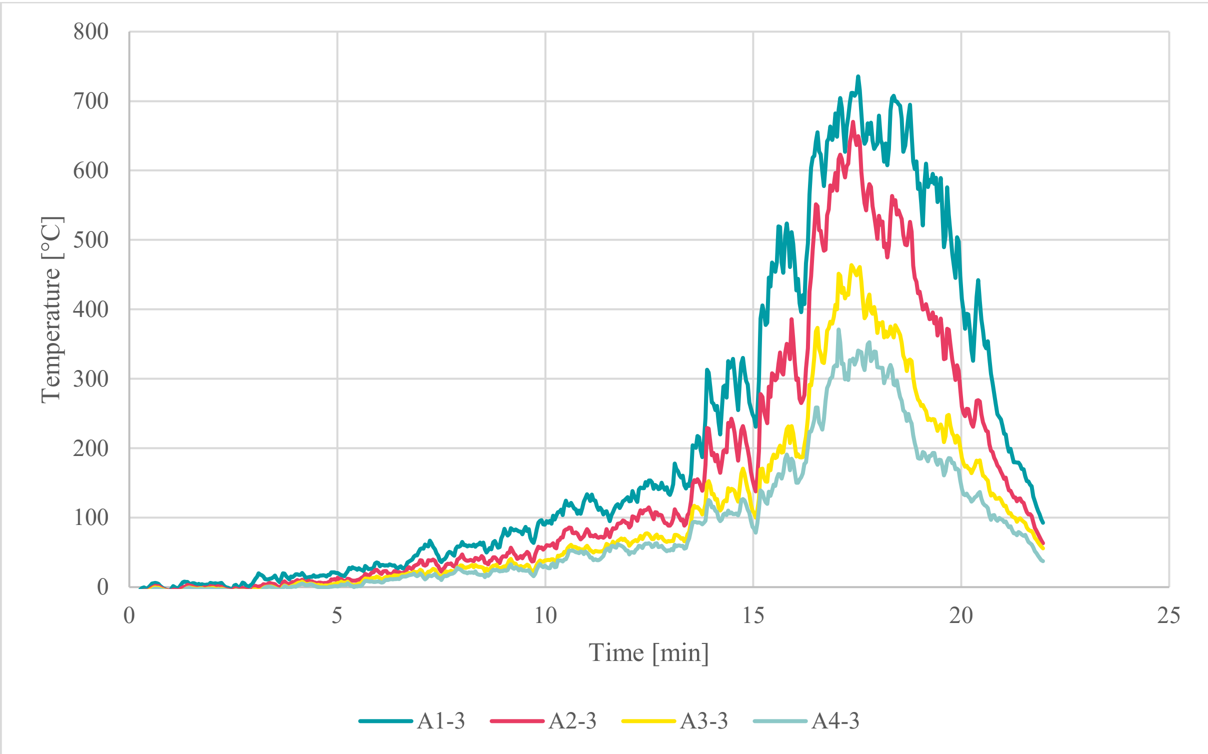


Figure 3-5 Temperature measurements of column A (A1-A4), 50 mm outside the cladding during the test.

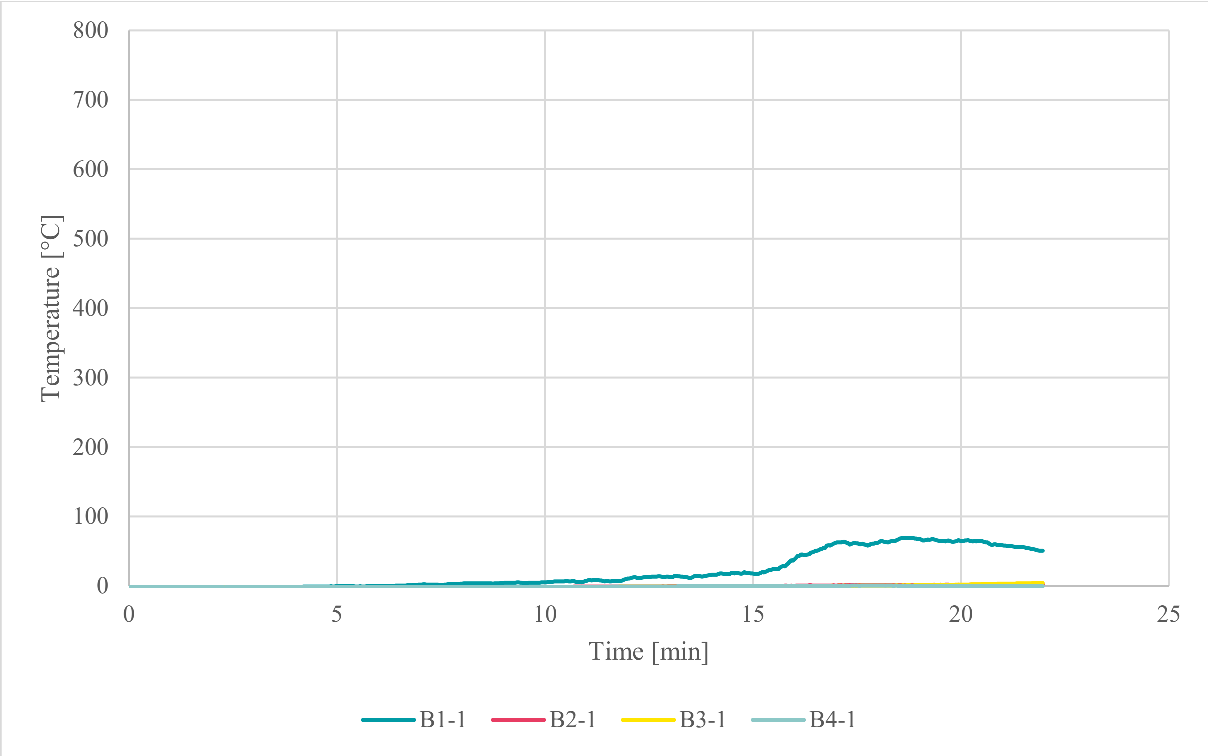


Figure 3-6 Temperature measurements of column B (B1-B4), centre of insulation during the test.

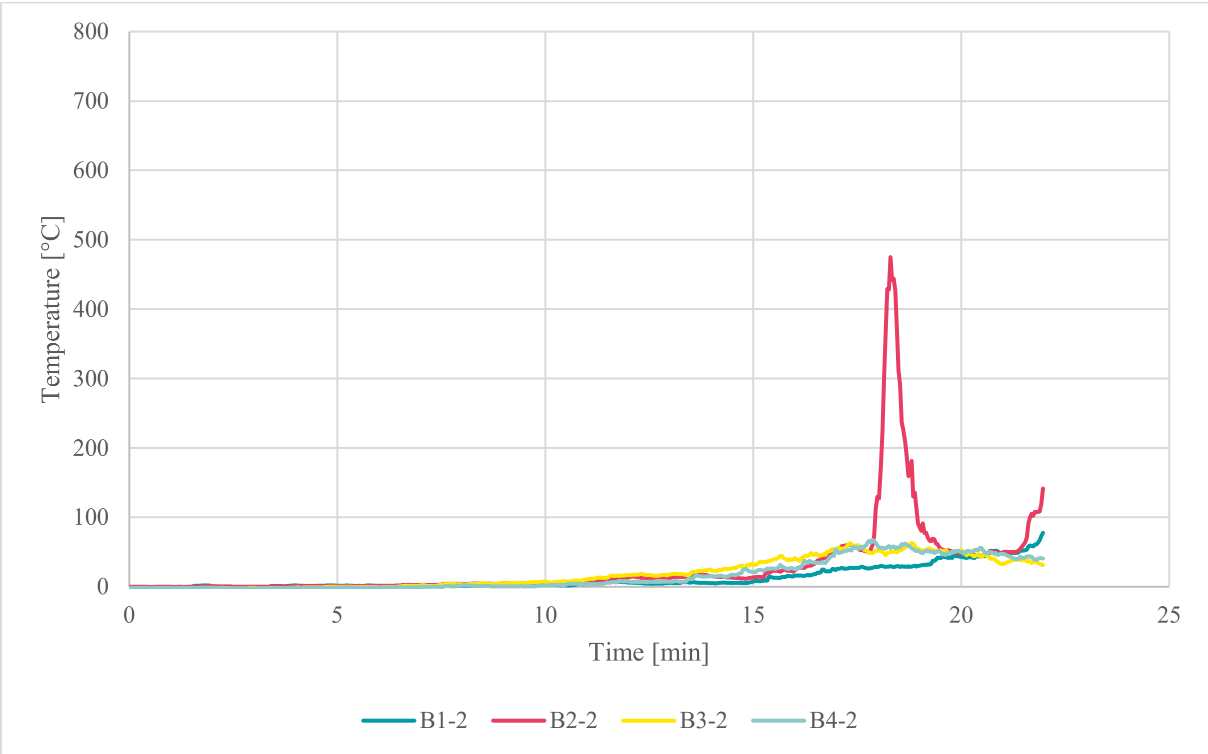


Figure 3-7 Temperature measurements of column B (B1-B4), centre of cavity during the test.

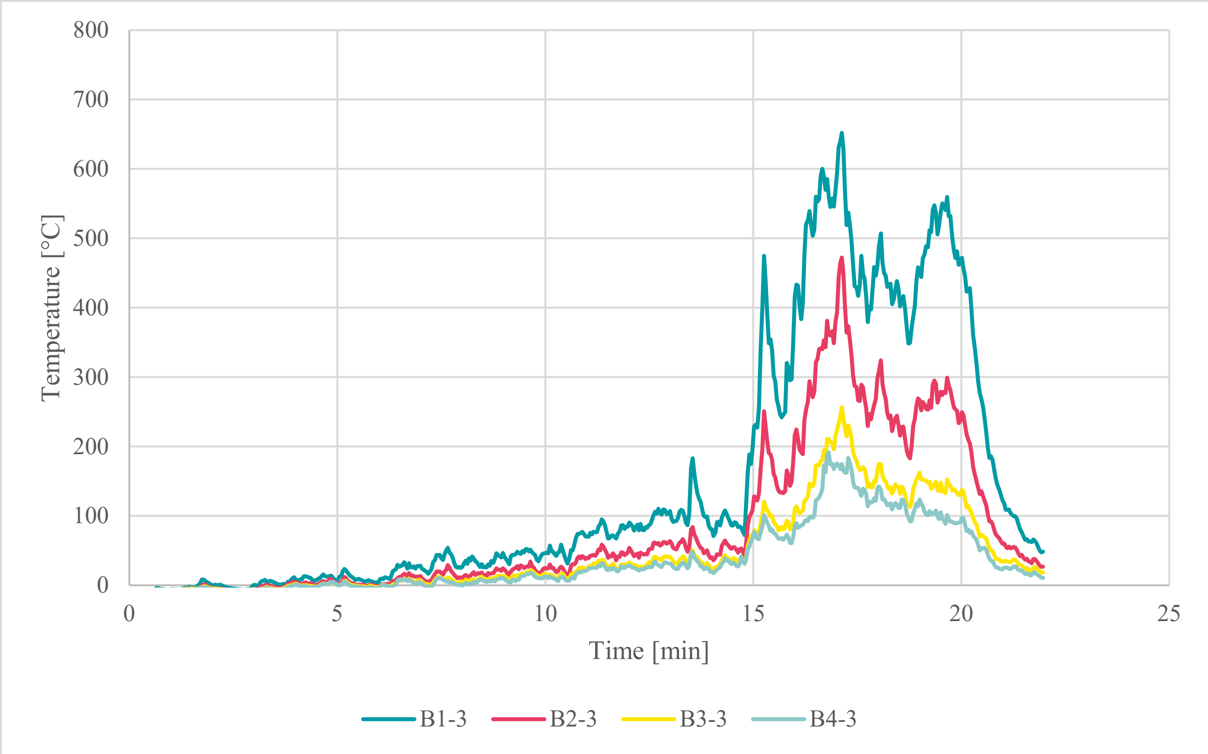


Figure 3-8 Temperature measurements of column B (B1-B4), 50 mm outside the cladding during the test.

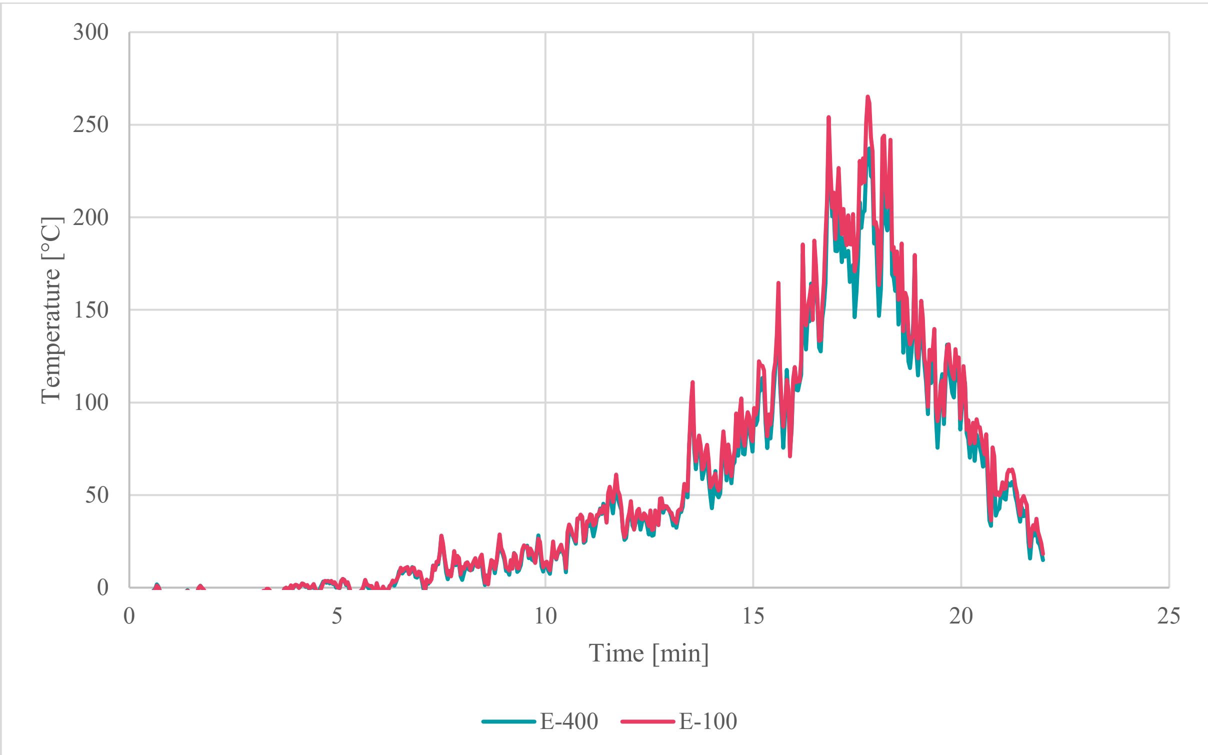


Figure 3-9 Temperature measurements at the eave during the test.

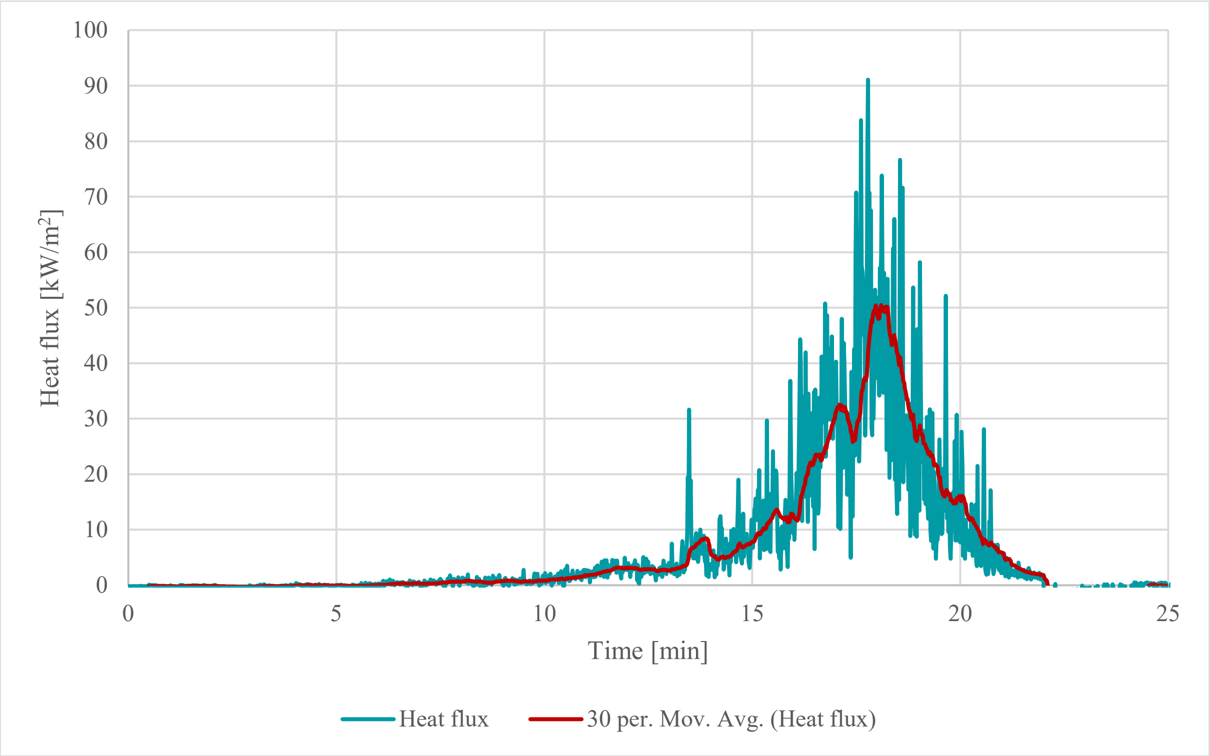


Figure 3-10 Heat flux measurements during the test.

### 3.2.2 Graphical depictions of temperature measurements - draft proposed European test method

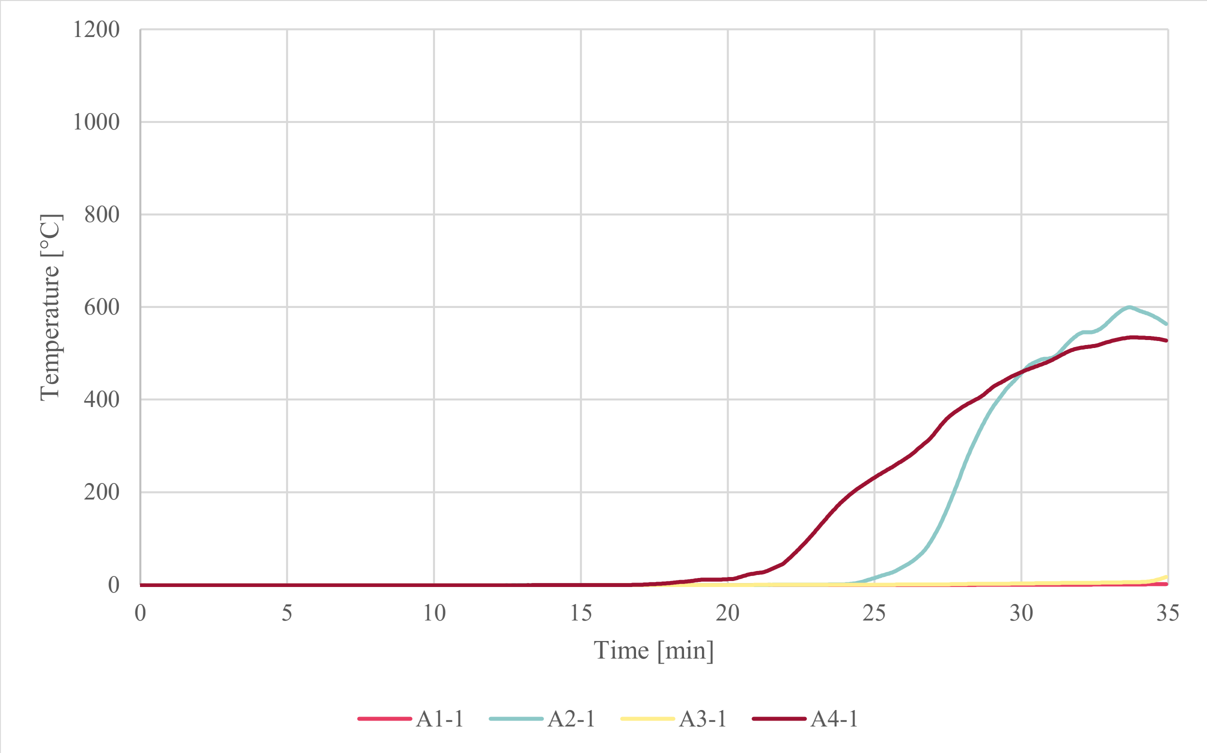


Figure 3-11 Temperature measurements of column A (A1-A4), centre of insulation during the test.

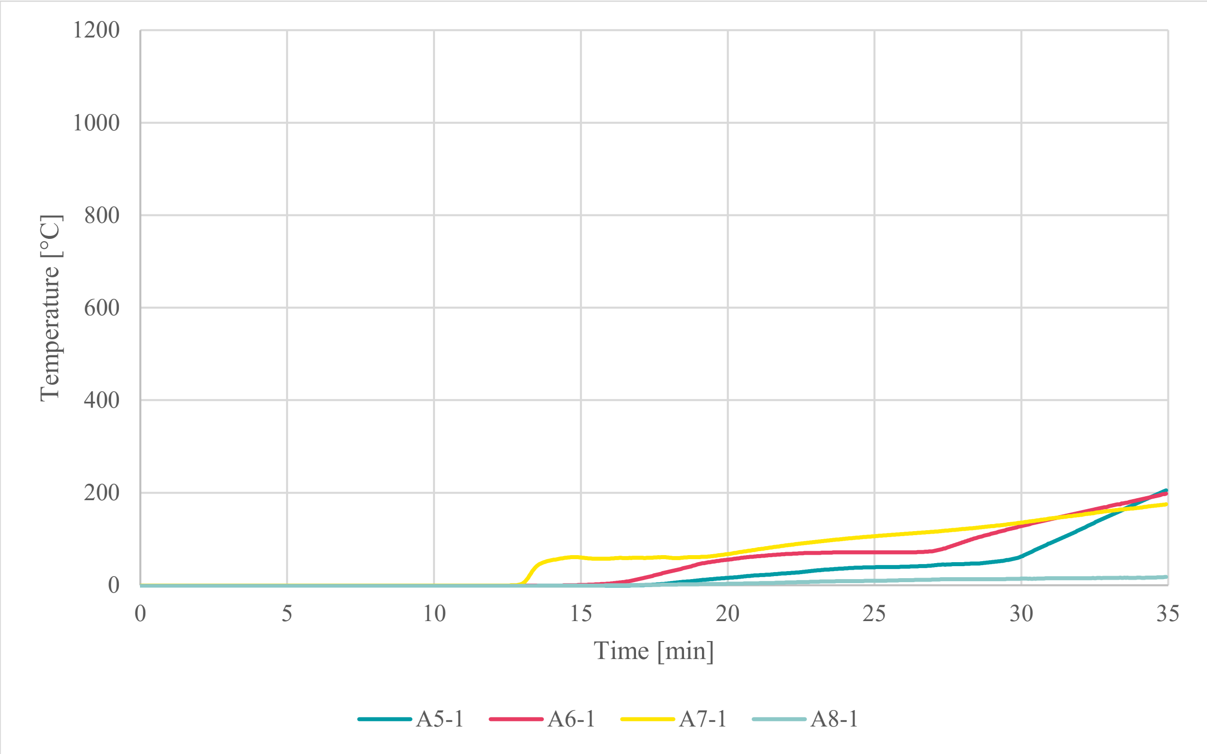


Figure 3-12 Temperature measurements of column A (A5-A8), centre of insulation during the test.

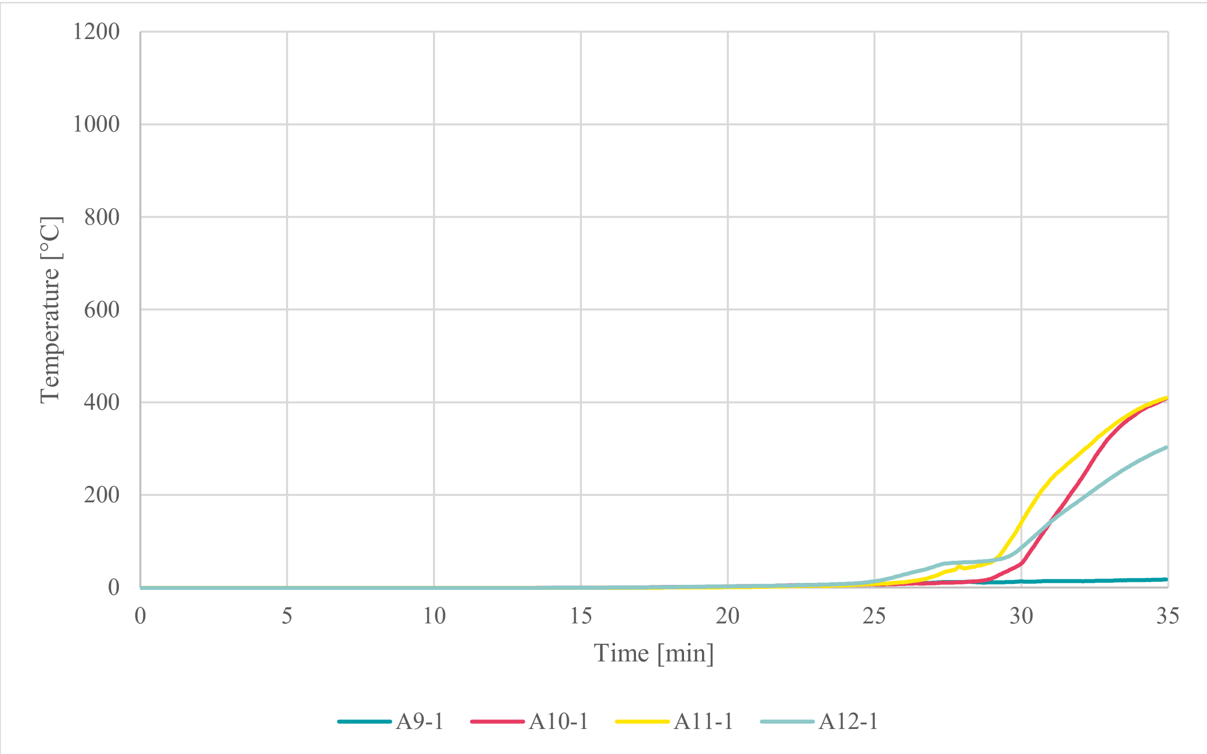


Figure 3-13 Temperature measurements of column A (A9-A12), centre of insulation during the test.

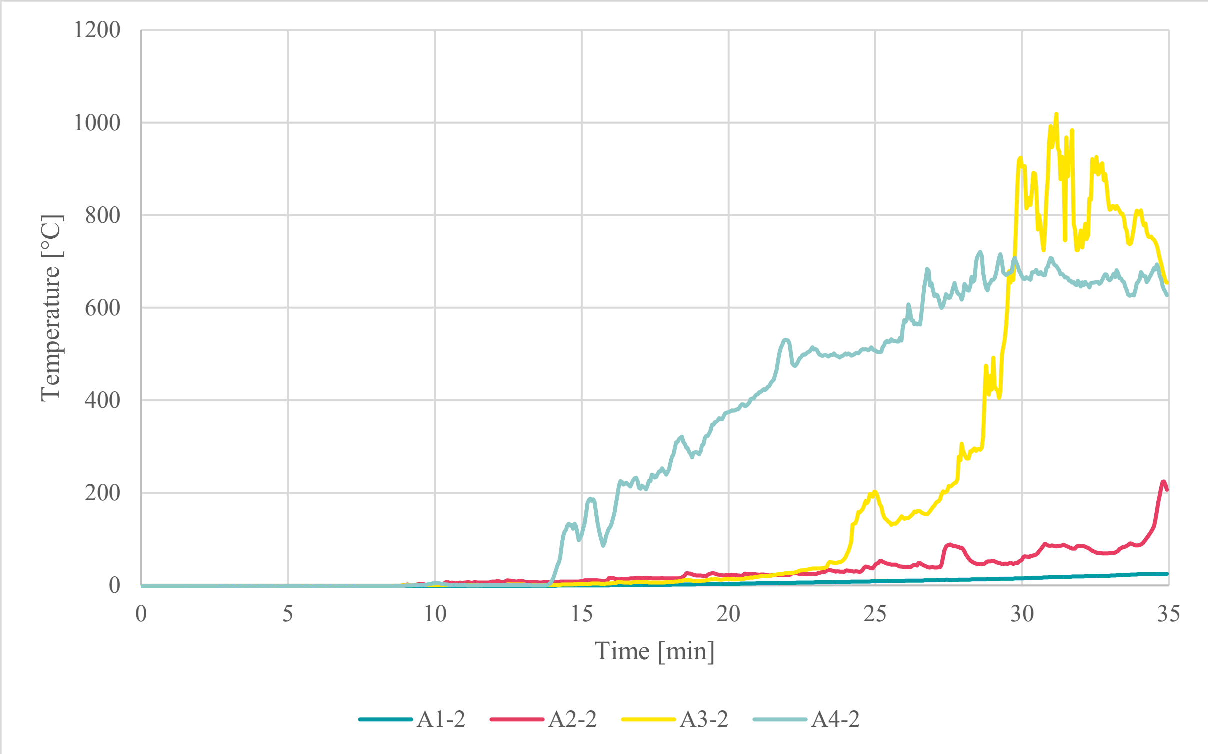


Figure 3-14 Temperature measurements of column A (A1-A4), centre of cavity during the test.

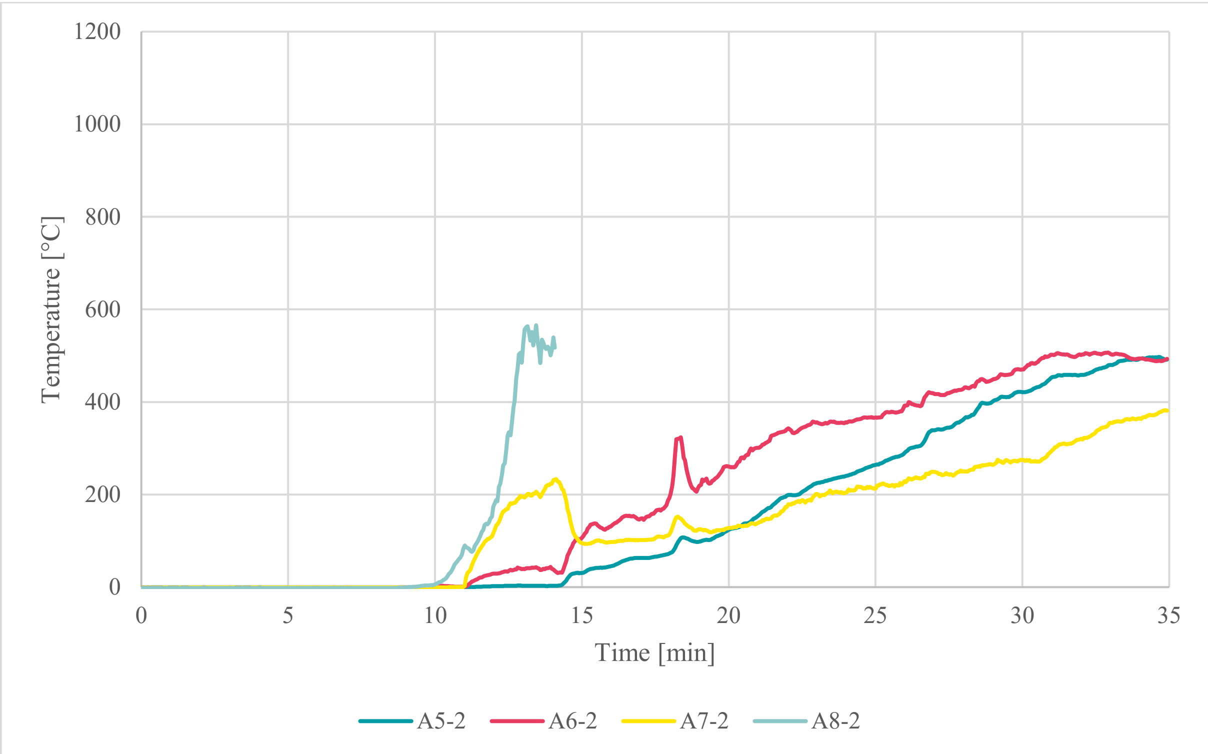


Figure 3-15 Temperature measurements of column A (A5-A8), centre of cavity during the test. A8-2: no data collection after 14 minutes.

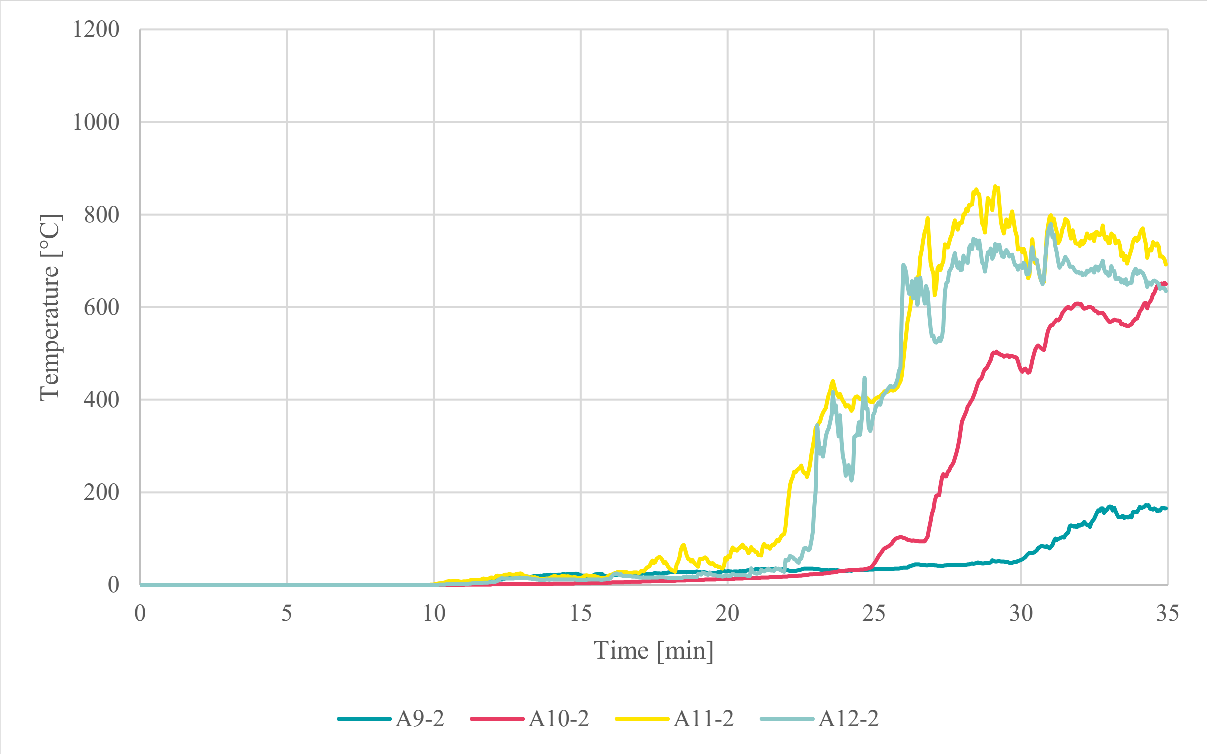


Figure 3-16 Temperature measurements of column A (A9-A12), centre of cavity during the test.

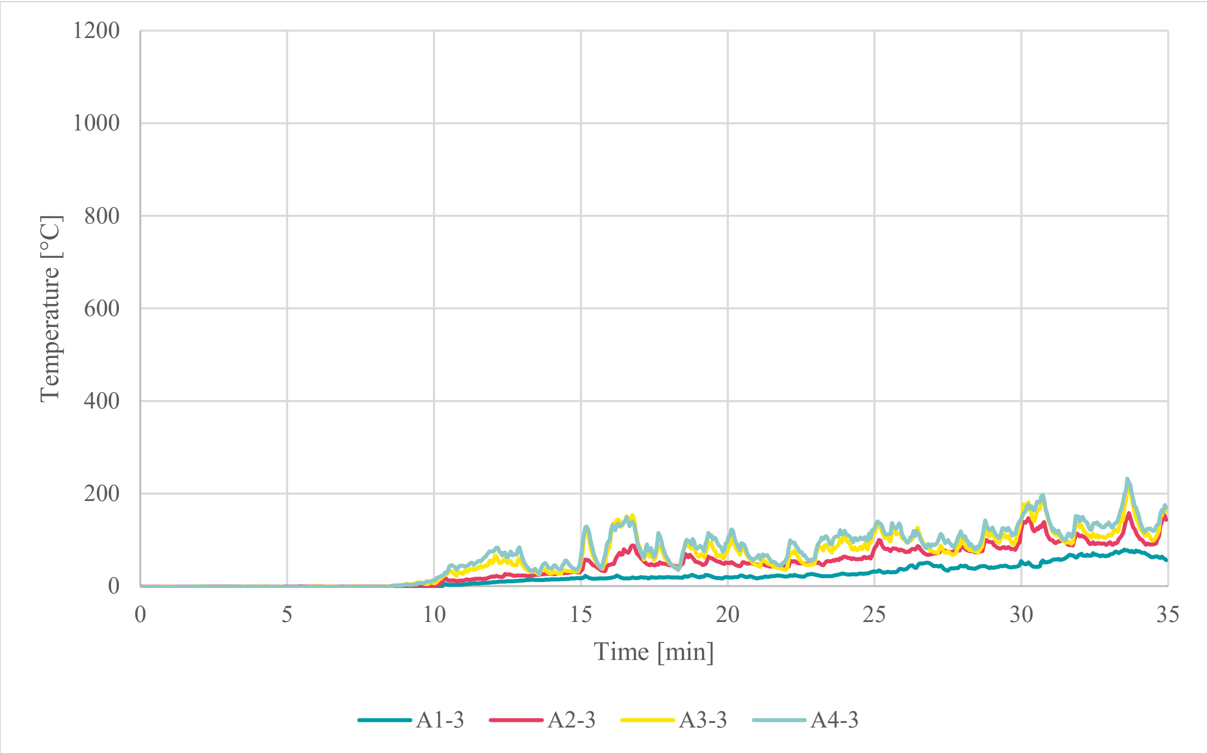


Figure 3-17 Temperature measurements of column A (A1-A4), 50 mm outside the cladding during the test.

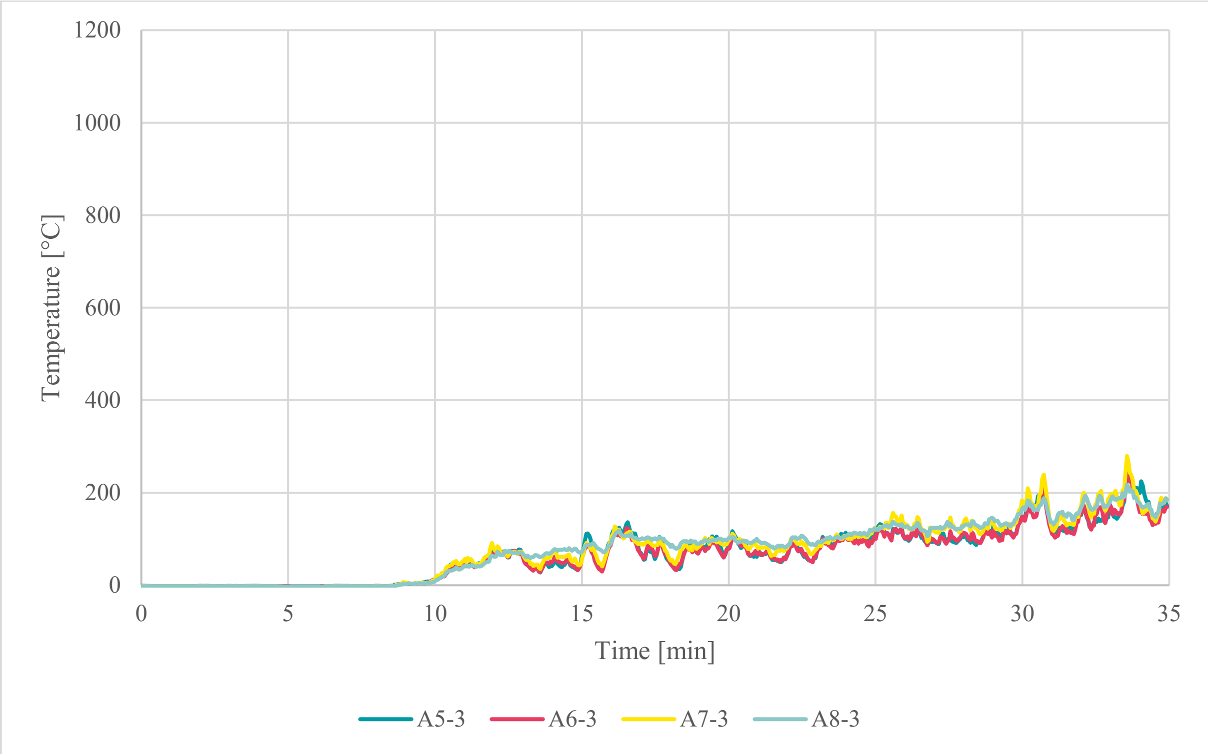


Figure 3-18 Temperature measurements of column A (A5-A8), 50 mm outside the cladding during the test.

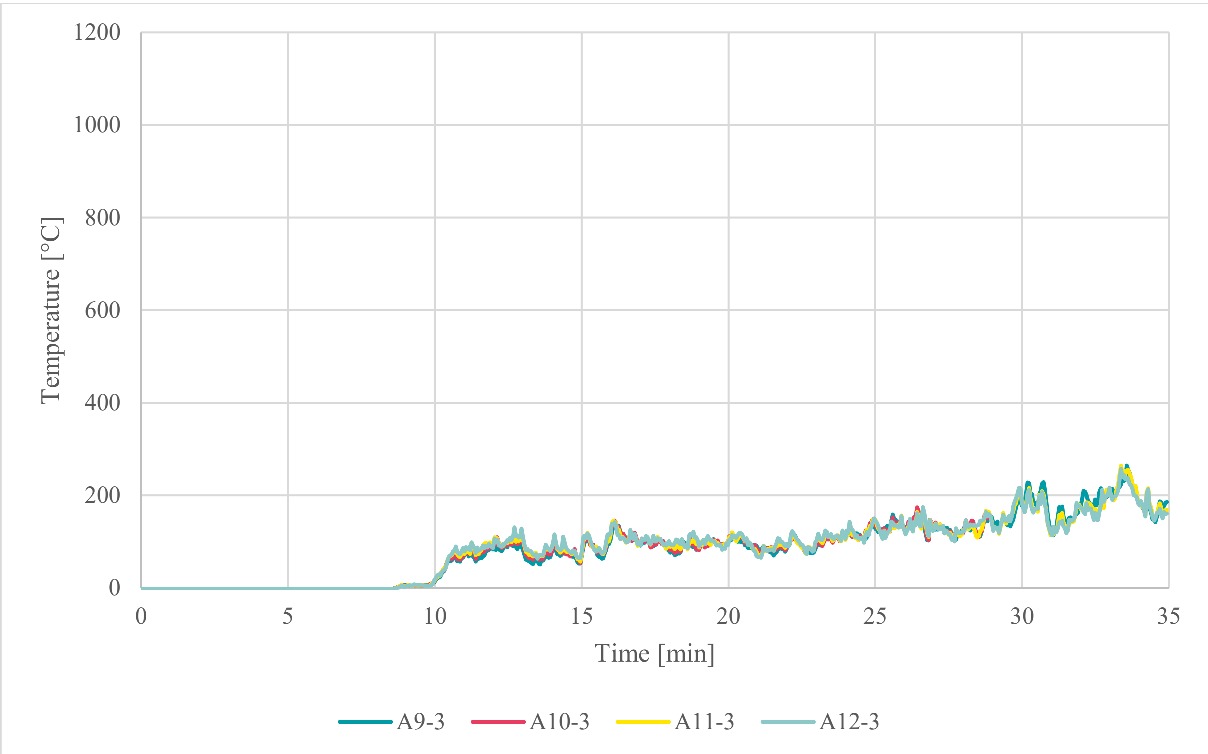


Figure 3-19 Temperature measurements of column A (A9-A12), 50 mm outside the cladding during the test.

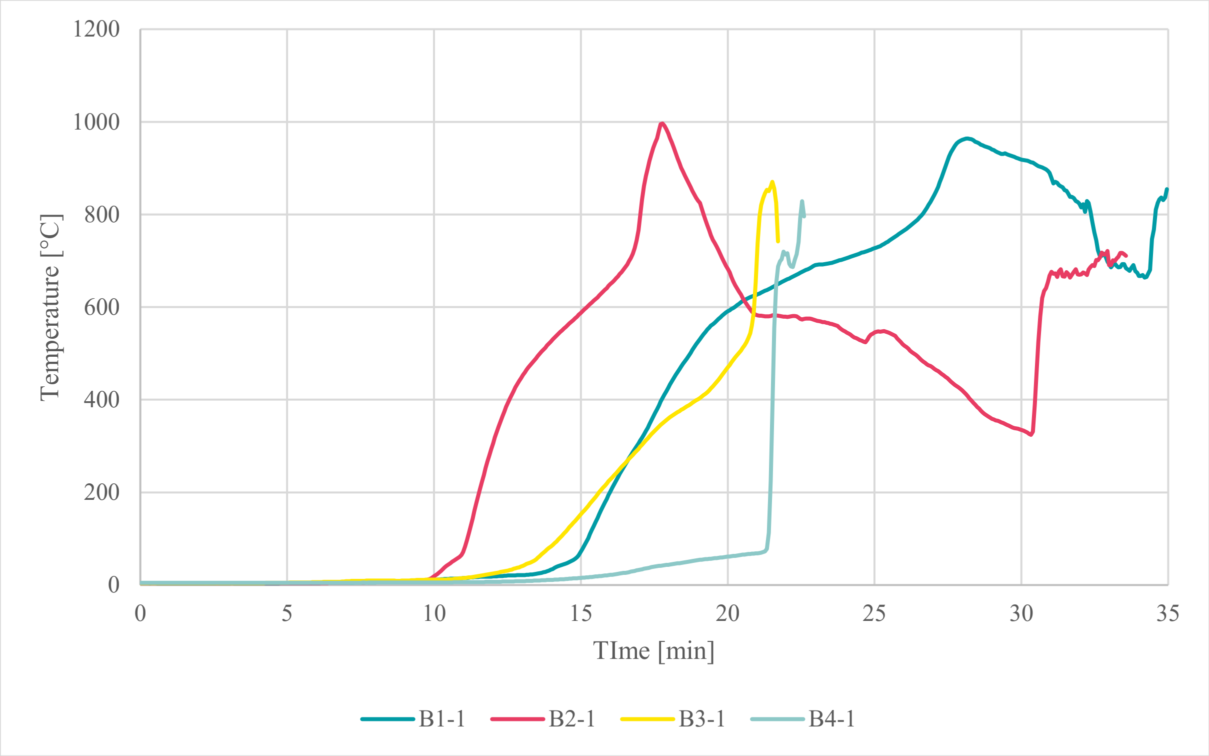


Figure 3-20 Temperature measurements of row B (B1-B4), centre of insulation during the test. B2-1: no data collection after 33 minutes. B3-1: no data collection after 21 minutes. B4-1: no data collection after 22 minutes.

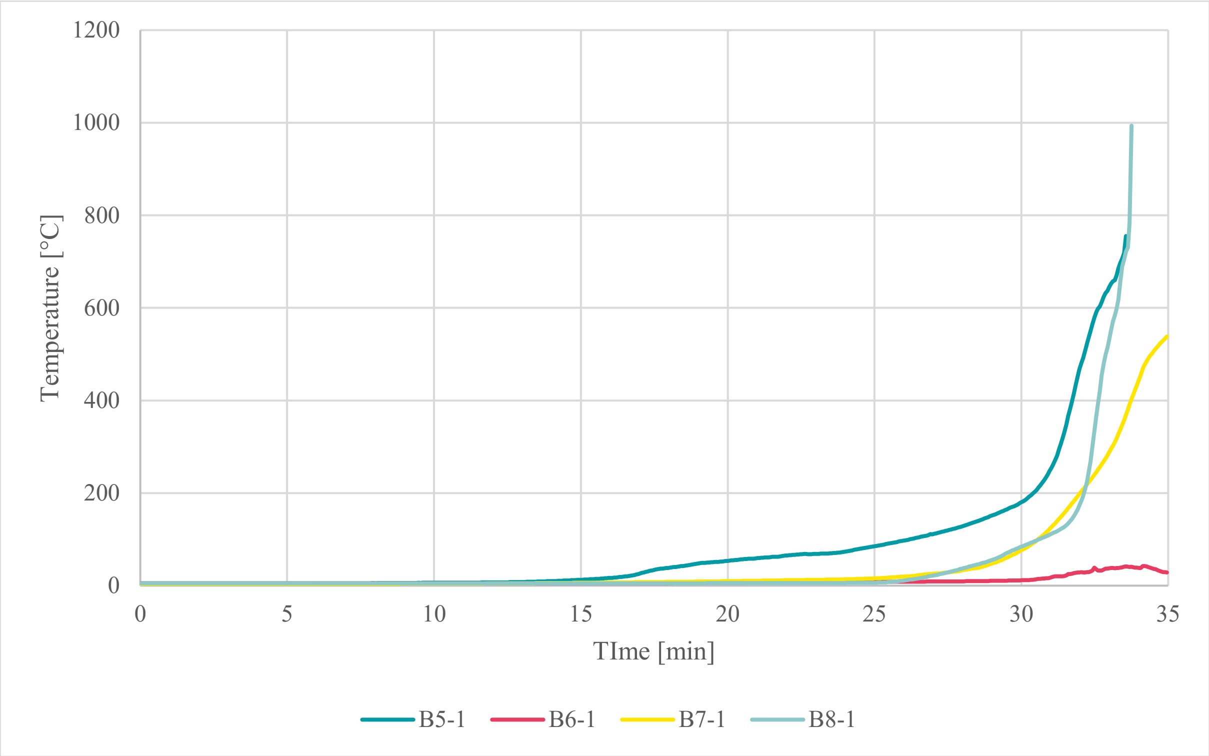


Figure 3-21 Temperature measurements of row B (B5-B8), centre of insulation during the test. B5-1: no data collection after 33 minutes. B8-1: no data collection after 33 minutes.

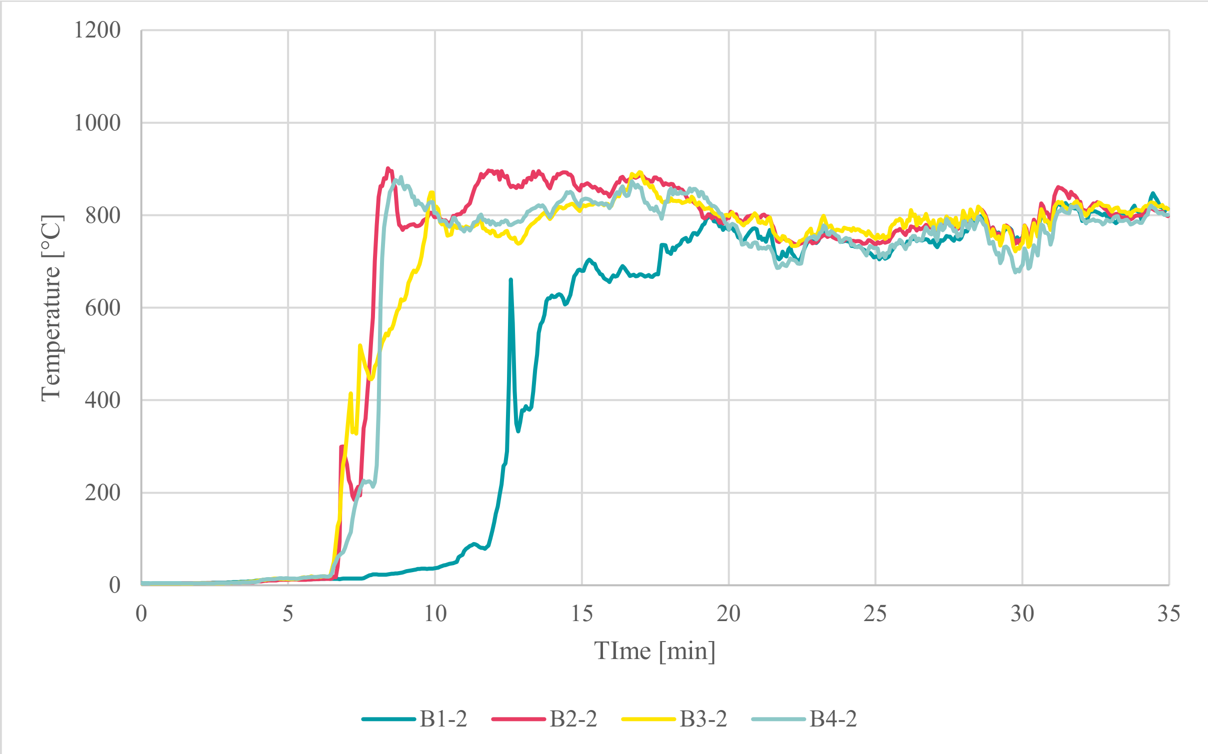


Figure 3-22 Temperature measurements of row B (B1-B4), centre of cavity during the test.

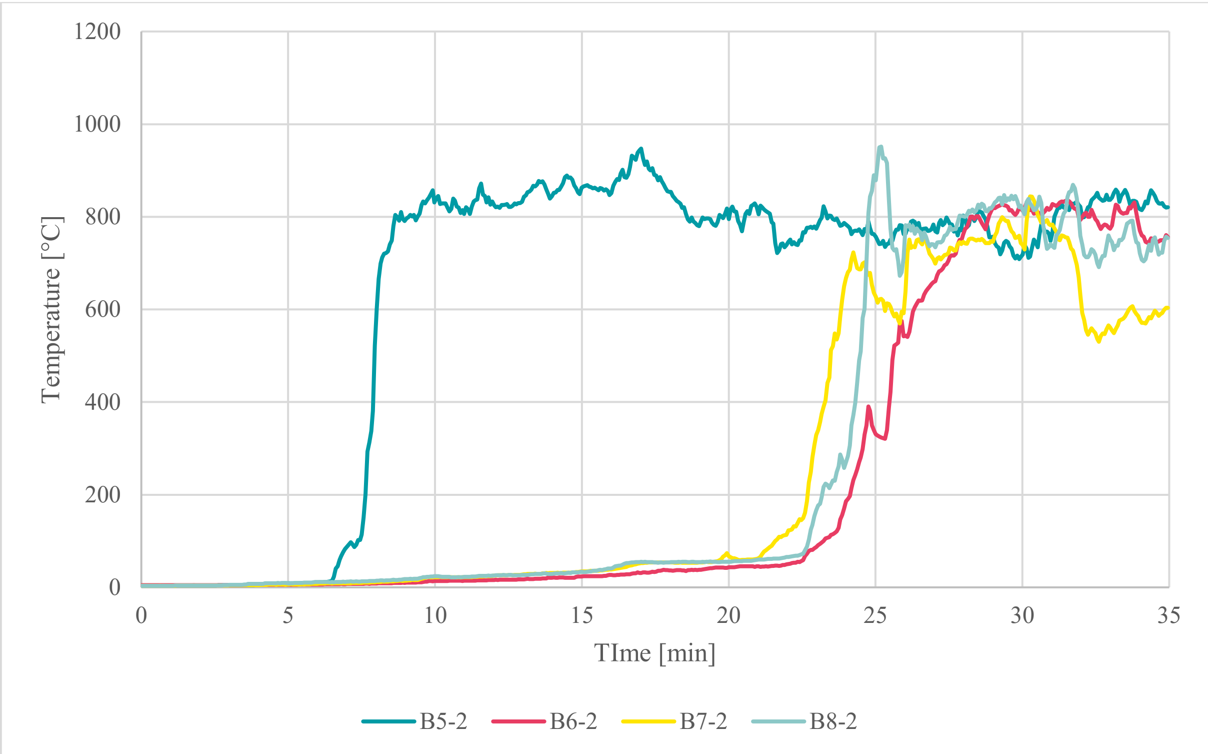


Figure 3-23 Temperature measurements of row B (B5-B8), centre of cavity during the test.

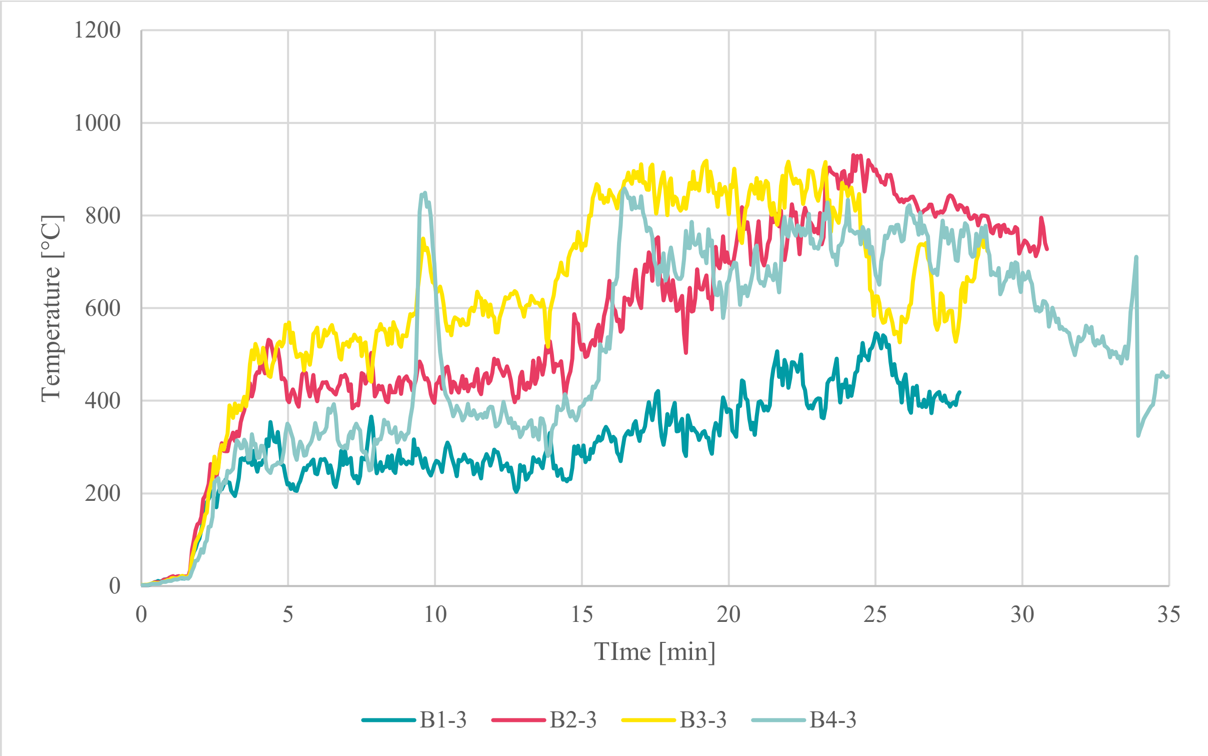


Figure 3-24 Temperature measurements of row B (B1-B4), 50 mm outside the cladding during the test. B1-3: no data collection after 27 minutes. B2-3: no data collection after 30 minutes. B3-3: no data collection after 28 minutes.

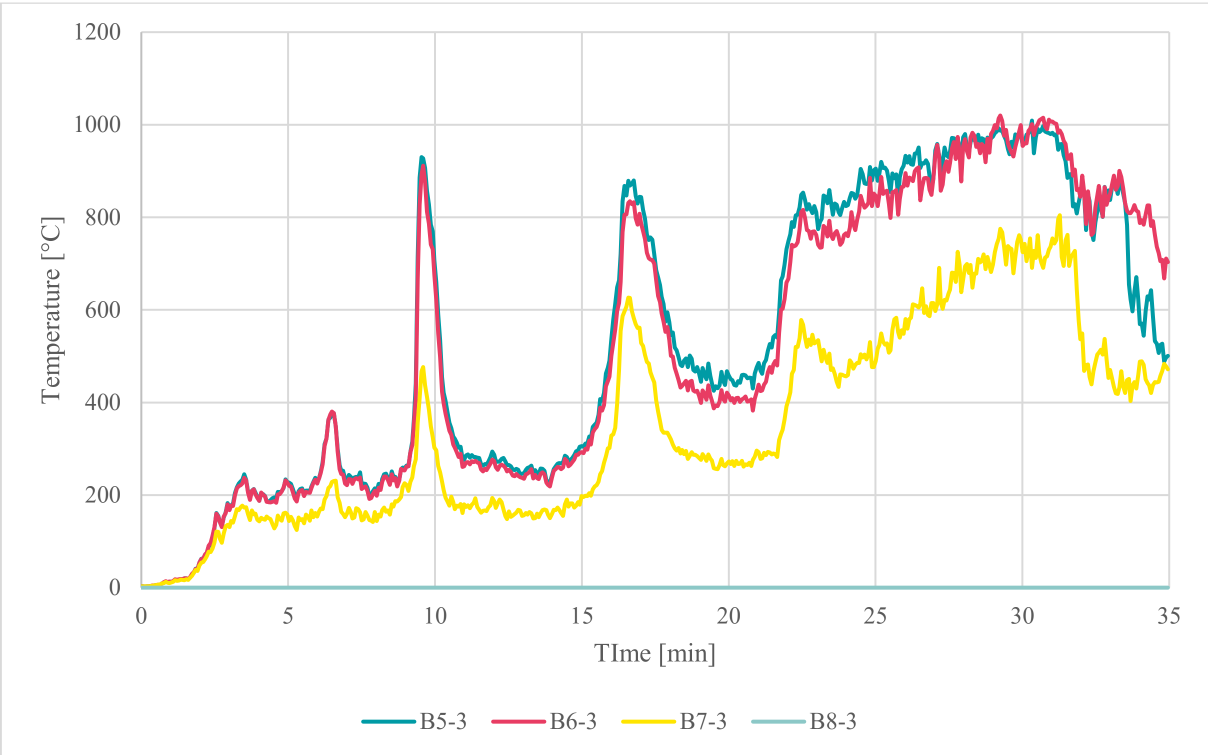


Figure 3-25 Temperature measurements of row B (B5-B8), 50 mm outside the cladding during the test.

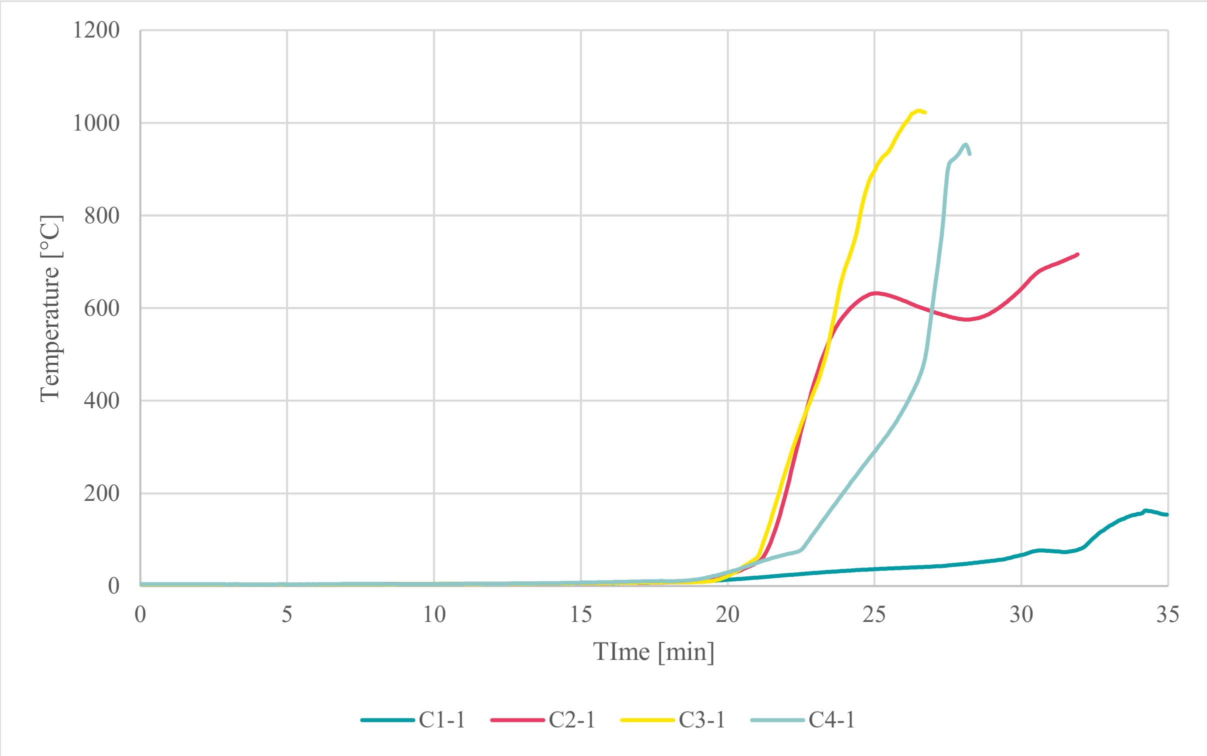


Figure 3-26 Temperature measurements of column C (C1-C4), centre of insulation during the test. C2-1: no data collection after 32 minutes. C3-1: no data collection after 26 minutes. C4-1: no data collection after 28 minutes.

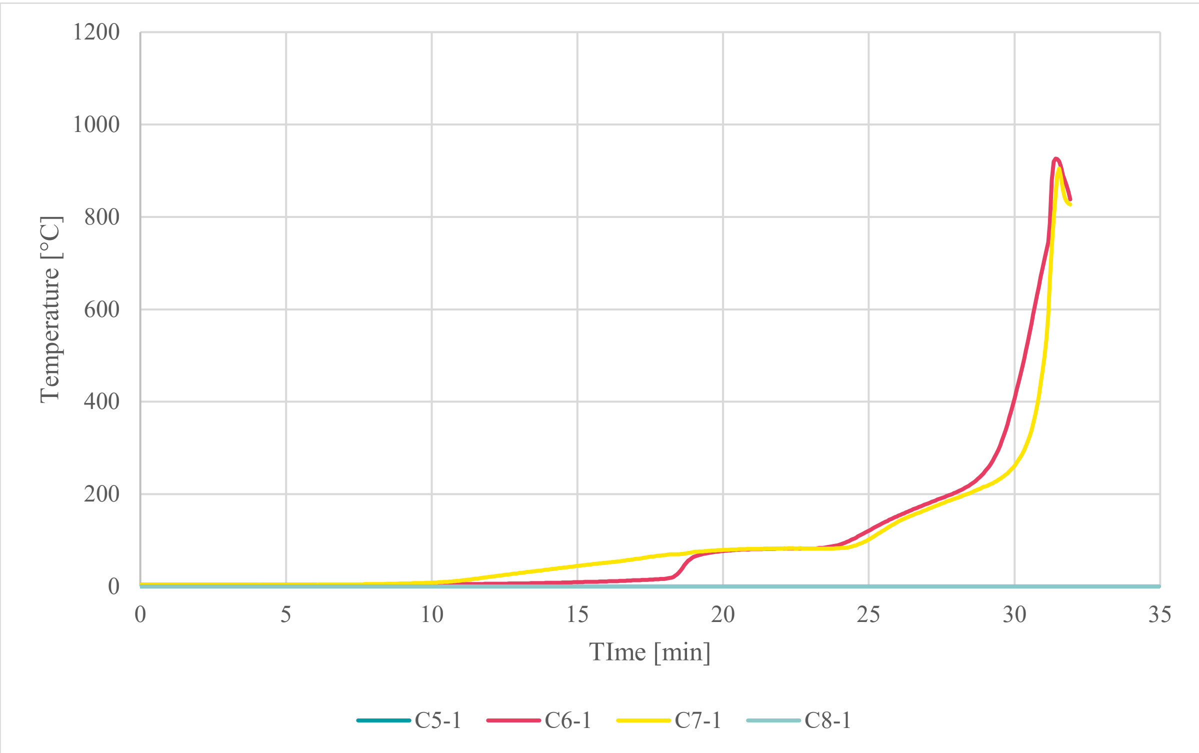


Figure 3-27 Temperature measurements of column C (C5-C8), centre of insulation during the test. C5-1: no data collection for the whole test. C6-1: no data collection after 32 minutes. C7-1: no data collection after 32 minutes. C8-1: no data collection for the whole test.

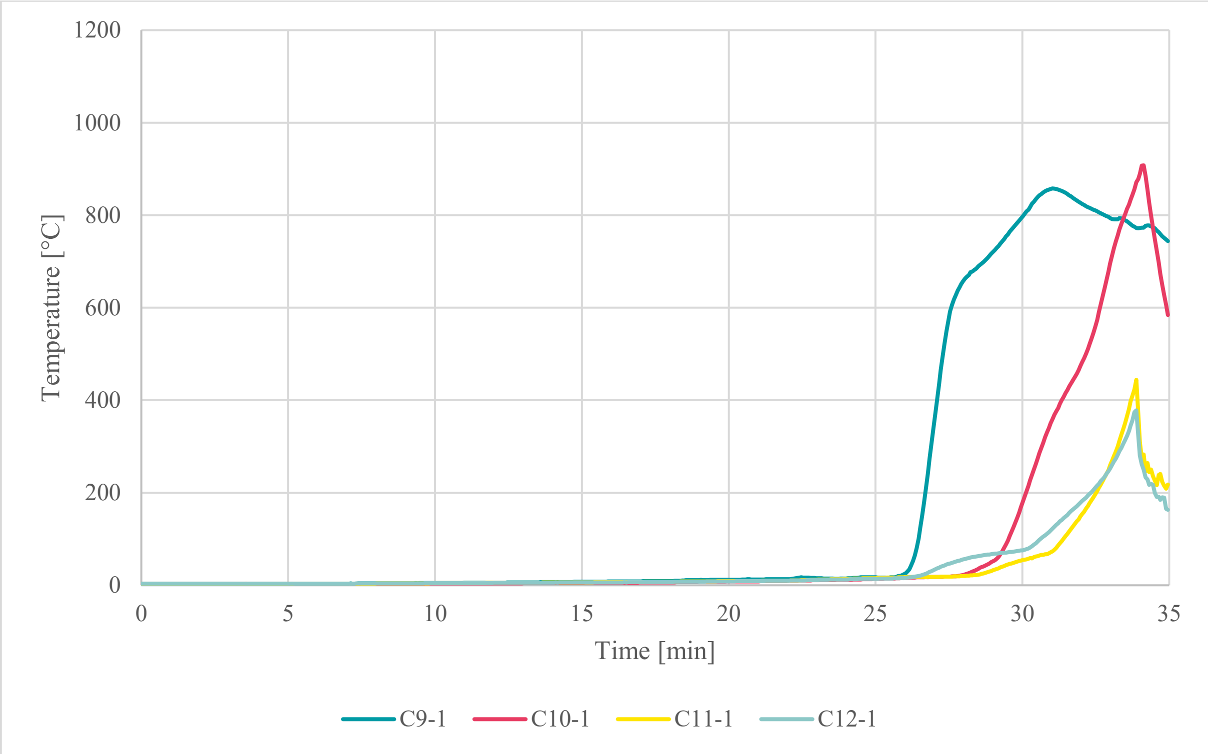


Figure 3-28 Temperature measurements of column C (C9-C12), centre of insulation during the test.

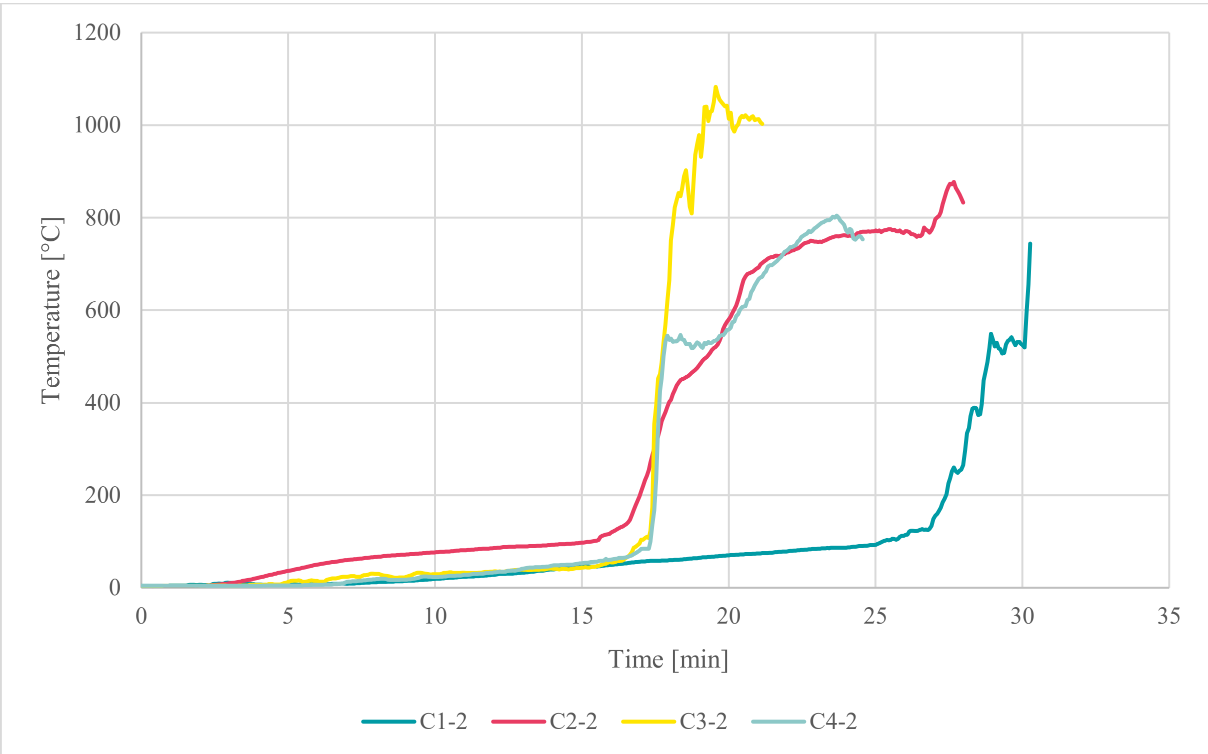


Figure 3-29 Temperature measurements of column C (C1-C4), centre of cavity during the test. C1-2: no data collection after 31 minutes. C2-2: no data collection after 28 minutes. C3-2: no data collection after 21 minutes. C4-2: no data collection after 25 minutes.

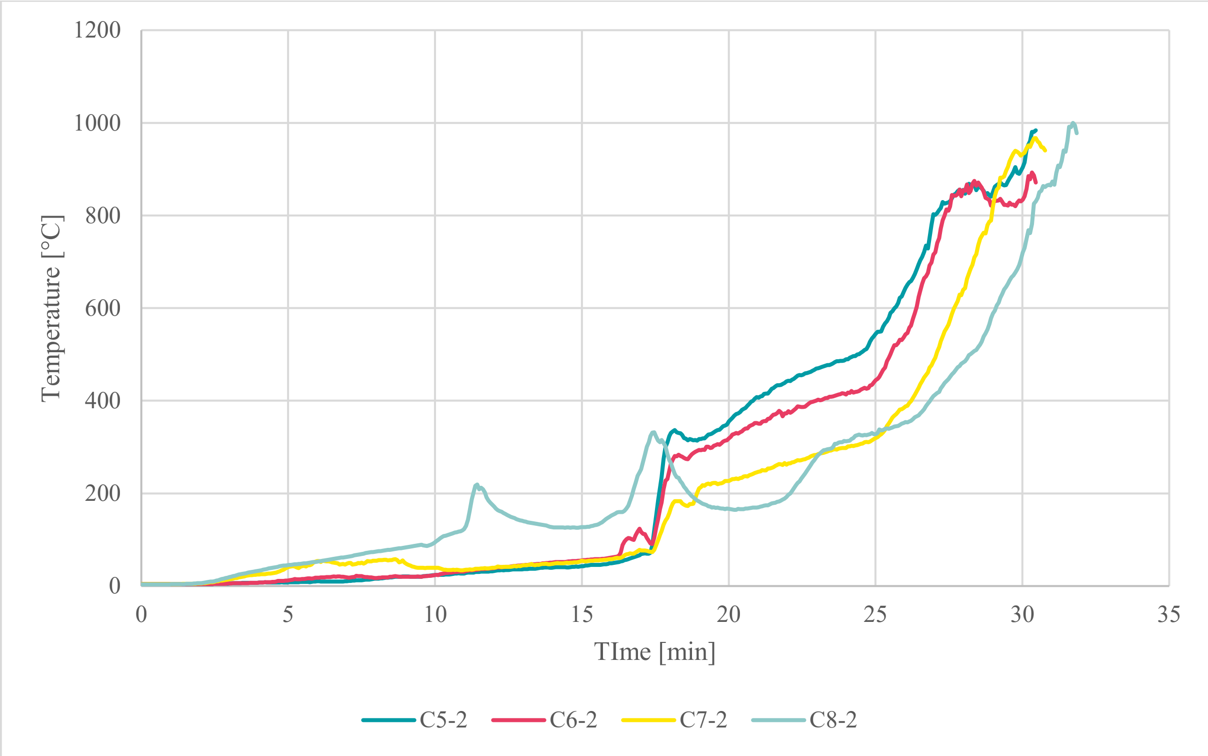


Figure 3-30 Temperature measurements of column C (C5-C8), centre of cavity during the test. C5-2, C6-2, C7-2: no data collection after 30 minutes. C8-2: no data collection after 31 minutes

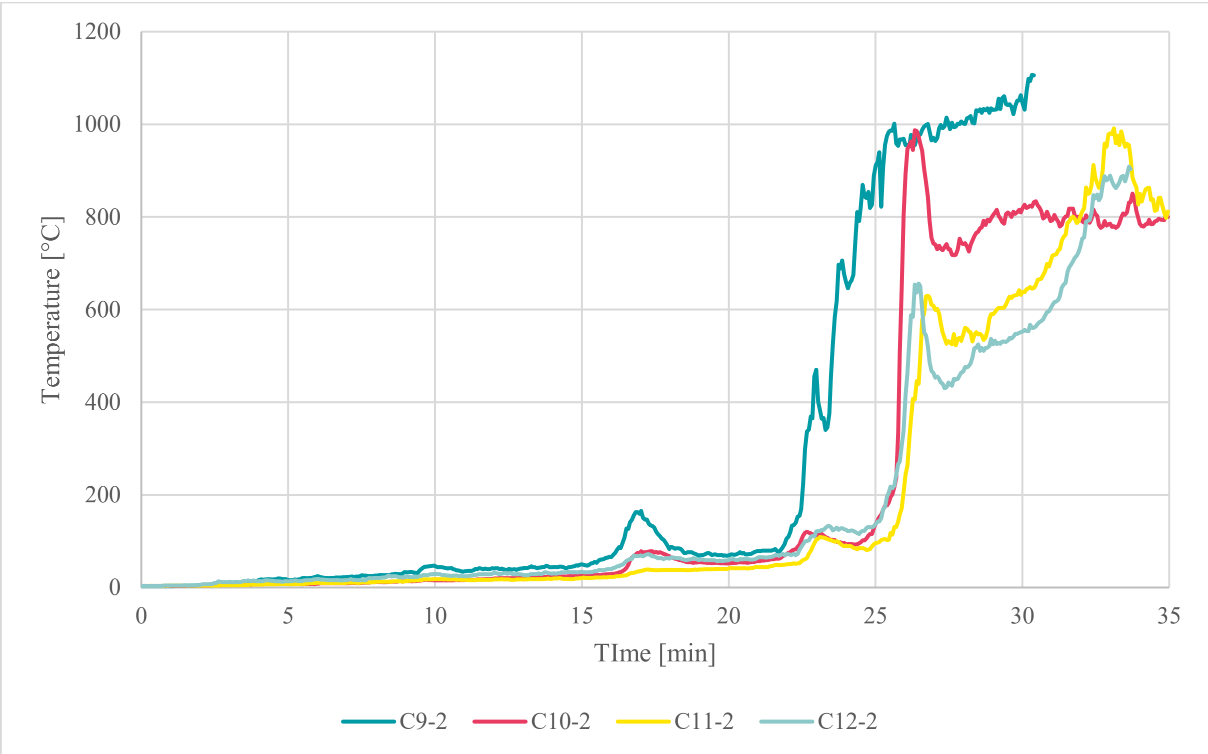


Figure 3-31 Temperature measurements of column C (C9-C12), centre of cavity during the test. C9-2: no data collection after 30 minutes. C12-2: no data collection after 33 minutes.

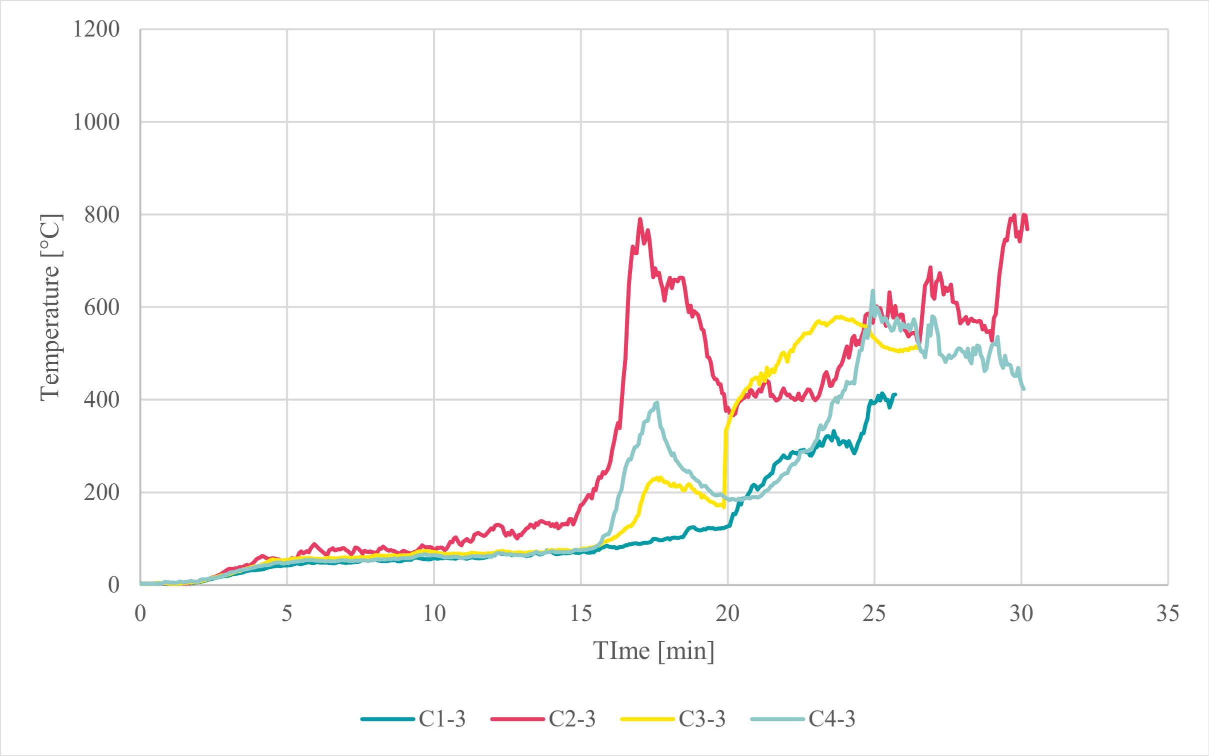


Figure 3-32 Temperature measurements of column C (C1-C4), 50 mm outside the cladding during the test. C1-3: no data collection after 25 minutes. C2-3: no data collection after 30 minutes. C3-3: no data collection after 26 minutes. C4-3: no data collection after 30 minutes.

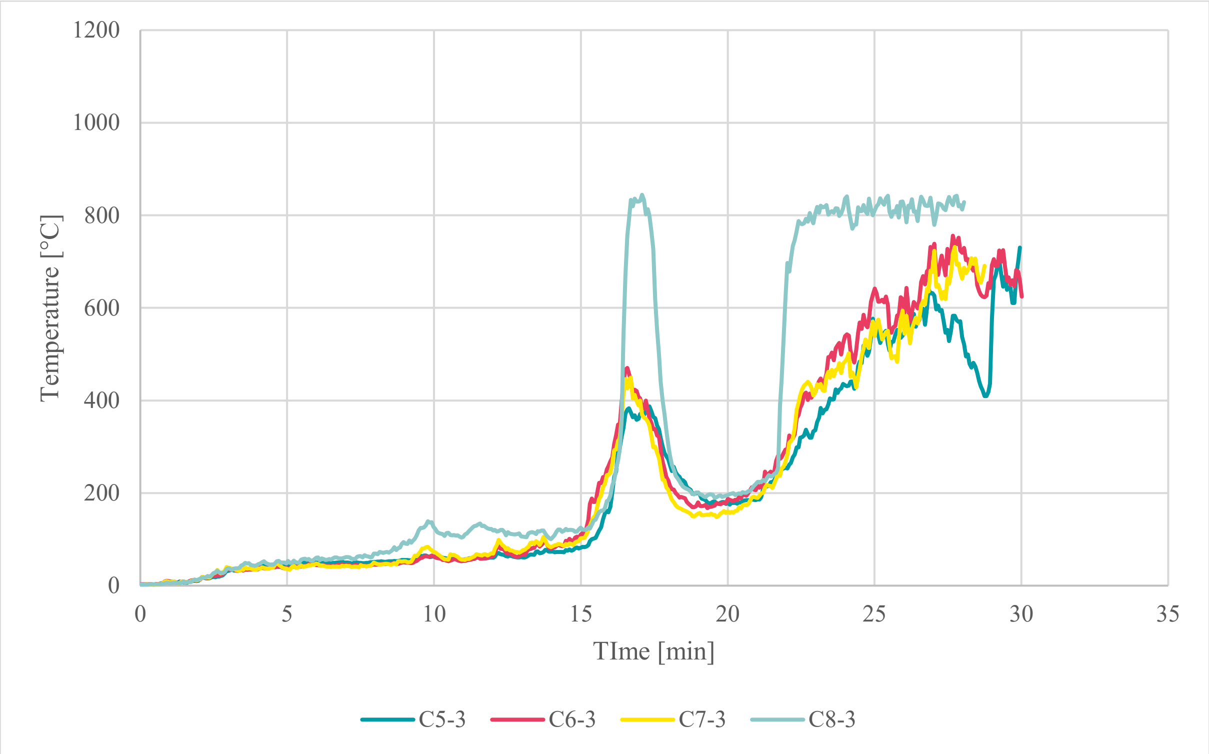


Figure 3-33 Temperature measurements of column C (C5-C8), 50 mm outside the cladding during the test. C5-3: no data collection after 29 minutes. C6-3: no data collection after 30 minutes. C7-3: no data collection after 28 minutes. C8-3: no data collection after 28 minutes.

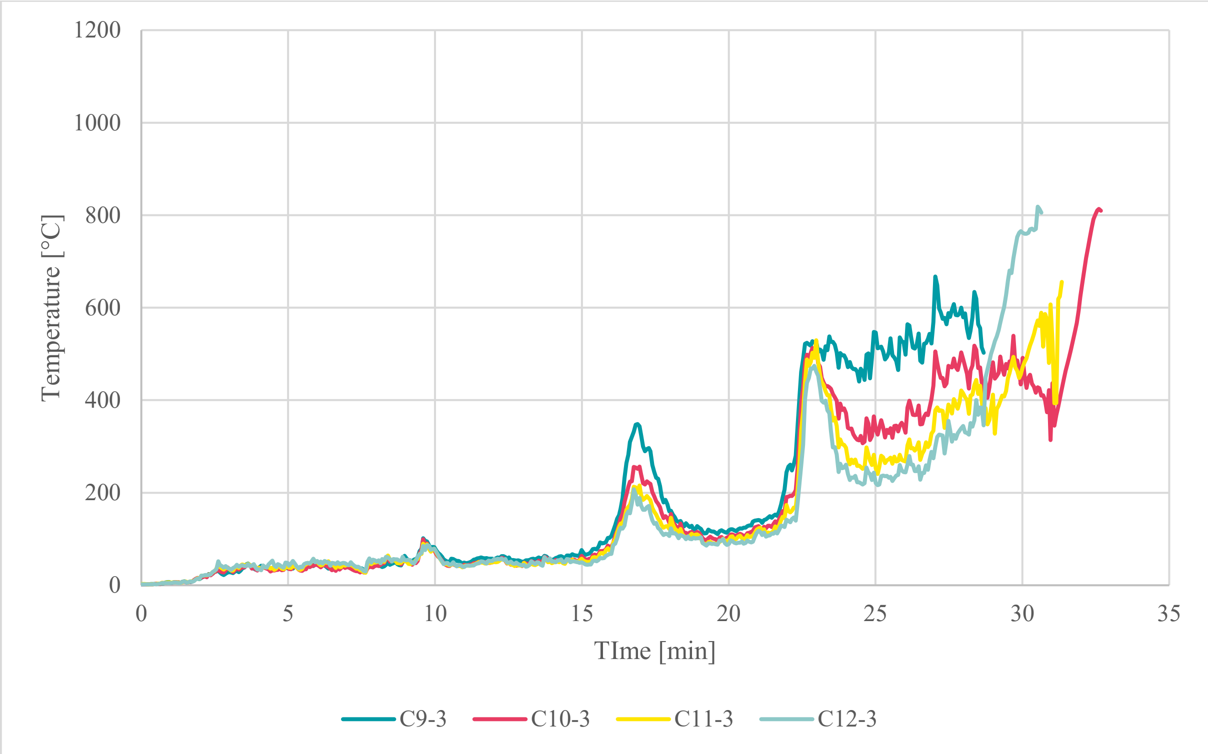


Figure 3-34 Temperature measurements of column C (C9-C12) 50 mm outside the cladding during the test. C9-3: no data collection after 28 minutes. C10-3: no data collection after 32 minutes. C11-3: no data collection after 31 minutes. C12-3: no data collection after 30 minutes.

## 3.3 Observations during and after experiments

A selection of photos from the tests are enclosed in Appendix A and Appendix B.

### 3.3.1 Observations SP Fire 105

Observations during and after the test are presented in Table 3-2, and a diagram of the damage to the specimen surface is shown in Figure 3-35.

Table 3-2 Visual observations during and after the test according to SP Fire 105

| *Time [min:sec]* | *Observations during the test* |
|---|---|
| 00:00 | Start of test. The fuel is ignited. |
| 11:20 | First flames are emerging out of the fire room. |
| 12:50 | Flames reach the bottom of the lower fictitious window. |
| 13:20 | Flames reach the top of the lower fictitious window. |
| 13:50 | Flames reach the bottom of the upper fictitious window. |
| 15:00 | The window lining on the lower fictitious window has caught fire. |
| 16:00 | The windowsill on the lower fictitious window is deformed. |
| 17:00 | The mid-section flashing between the two fictitious windows is deformed. |
| 18:20 | Flames reach the top of the upper fictitious window. |
| 19:30 | The flames start to decrease in size and intensity. |
| 21:45 | The fuel has been consumed. The test is ended by spraying the façade surface with water. |
| *Observations after the test* | |
| 1. Drip cap at lower fictious window was deformed on the left side.<br>2. Charing of the cladding did not reach further up than at the mid-section flashing. | |

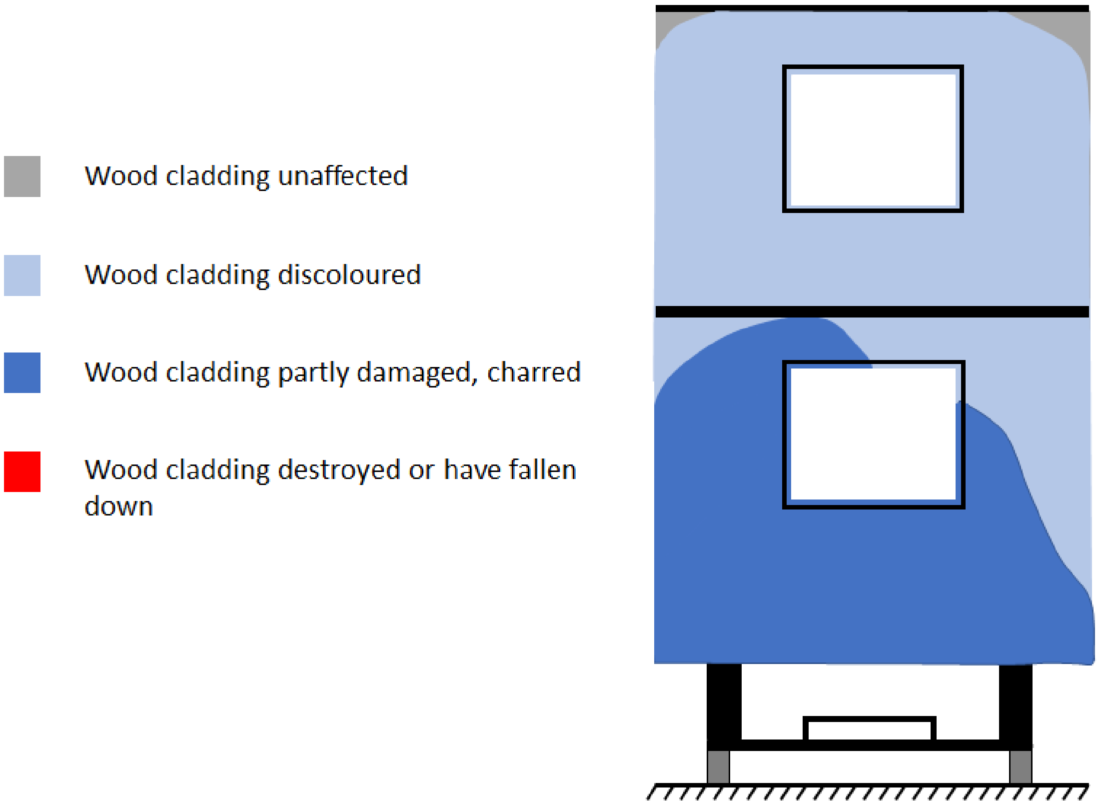


Figure 3-35 Fire damage of the surface of the façade after the test according to SP Fire 105.

### 3.3.2 Observations for draft proposed European test method

Observations during and after the test are presented in Table 3-3, and a diagram of the damage to the specimen surface is shown in Figure 3-36.

Table 3-3 Visual observations during and after the test according to the draft proposed European method

| *Time [min:sec]* | *Observations during the test* |
|---|---|
| 00:00 | Start of experiment. The fuel is ignited. |
| 00:49 | First flames are emerging out of the combustion chamber. |
| 00:50 | Flames reach the bottom of the secondary opening. |
| 02:00 | Flames reach the top of the secondary opening. |
| 02:22 | Flames reach the mid-section flashing above the secondary opening. |
| 03:15 | Flames reach the top of the test specimen. |
| 16:15 | The surface has ignited the full length of the test specimen. |
| 30:00 | Started extinguishing the timber crib with water. |
| 35:00 | The test is ended by spraying the façade surface with water. |
| *Observations after the test* | |
| 1. Cladding and insulation have fallen off the middle part of the main wing from the combustion chamber and all the way to the top. Some cladding was remaining towards the left side of the main wing.<br>2. Cladding and insulation on the return wing have fallen off from half the height of the combustion chamber all the way to the top. Some cladding was remaining on random locations. | |

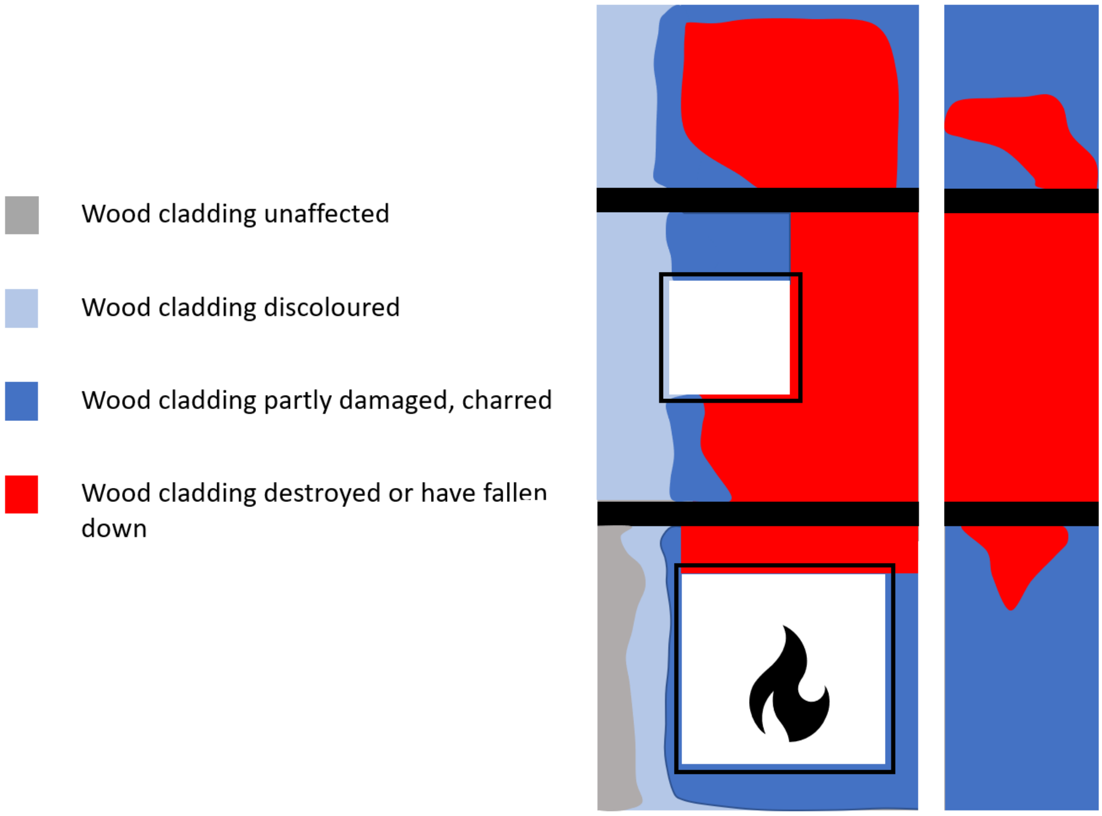


Figure 3-36 Fire damage of the surface of the façade after the test according to the draft proposed European method

# 3.4 Visual comparisons between the two methods

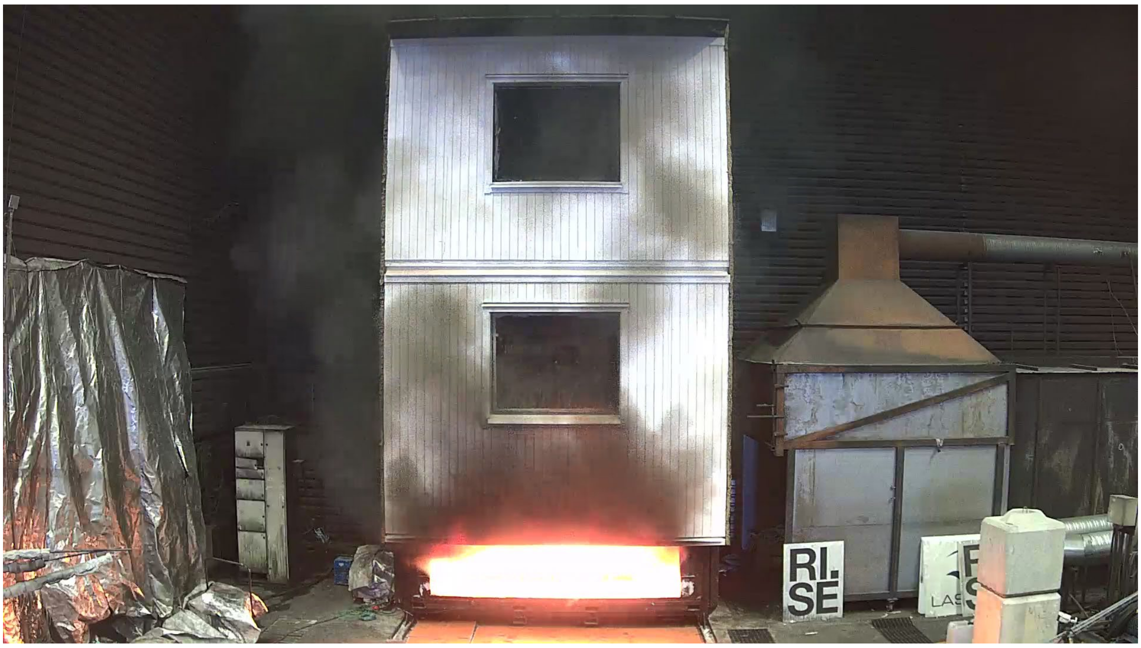


Photo 1 SP Fire 105, 0 minutes after first flames emerge out of the fire room.

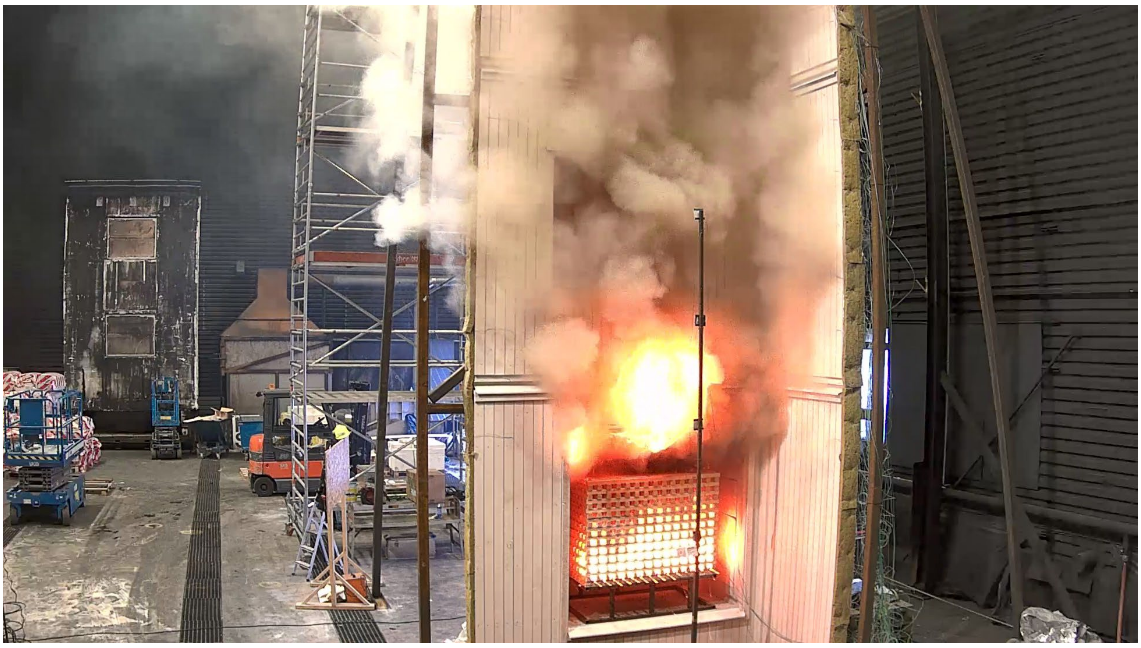

Photo 2 Draft proposed European test method, 0 minutes after first flames emerge out of the combustion chamber.

Photo 3 SP Fire 105, 2 minutes after first flames emerge out of the fire room.

Photo 4 Draft proposed European test method, 2 minutes after first flames emerge out of the combustion chamber.


Photo 5 SP Fire 105, 4 minutes after first flames emerge out of the fire room.

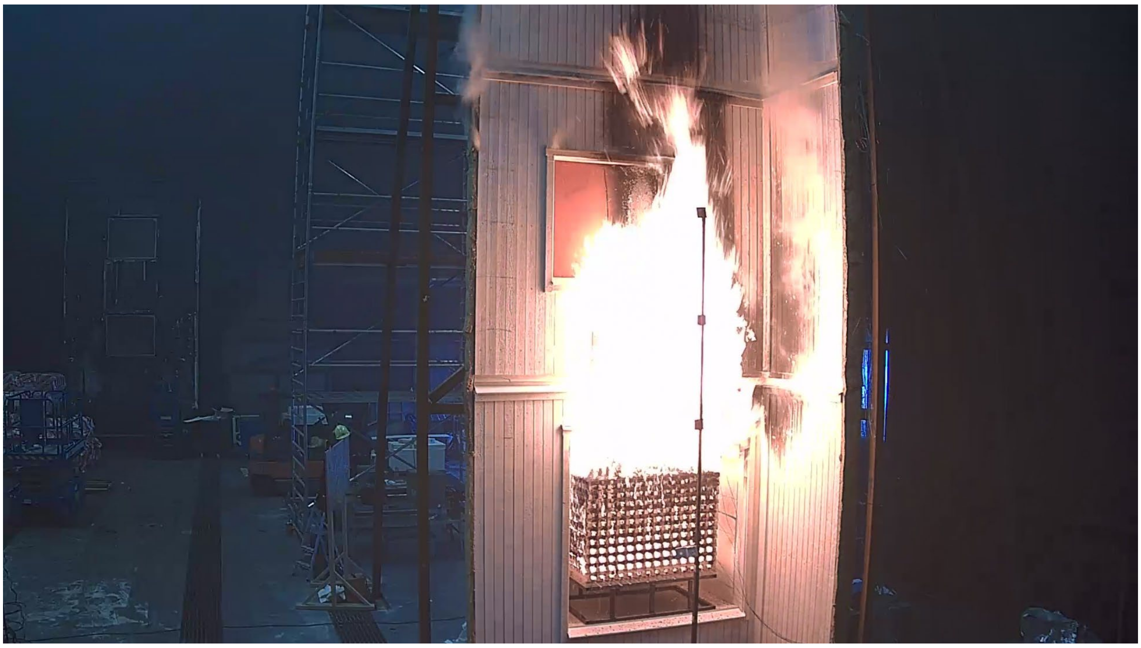

Photo 6 Draft proposed European test method, 4 minutes after first flames emerge out of the combustion chamber.

Photo 7 SP Fire 105, 6 minutes after first flames emerge out of the fire room.

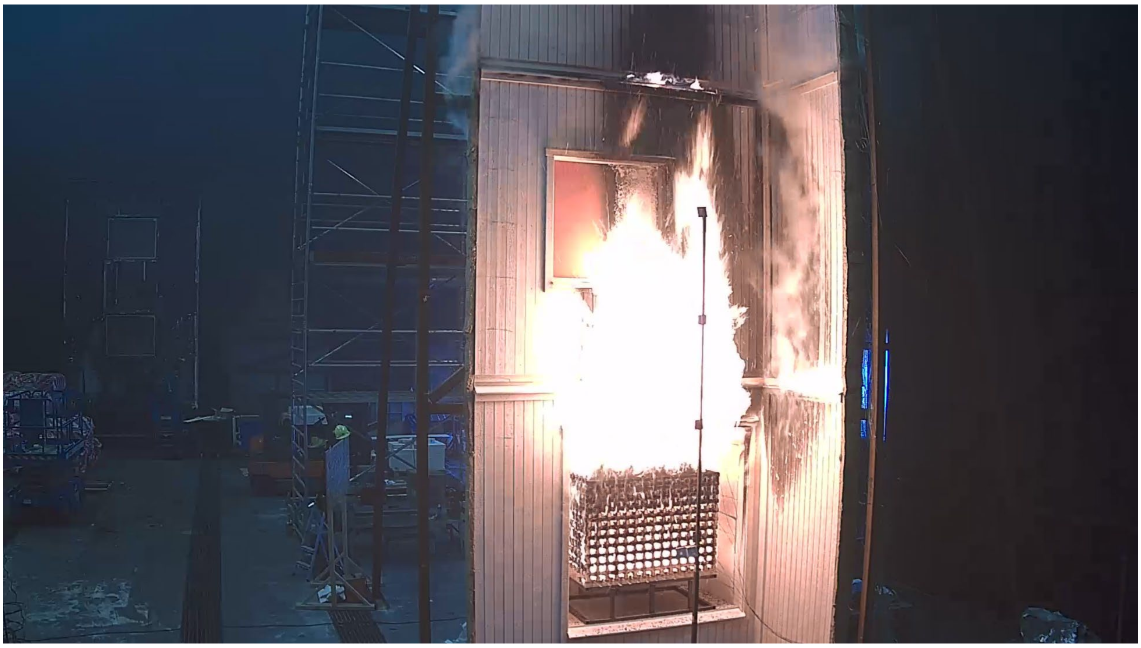

Photo 8 Draft proposed European test method, 6 minutes after first flames emerge out of the combustion chamber.

Photo 9 SP Fire 105, 8 minutes after first flames emerge out of the fire room.

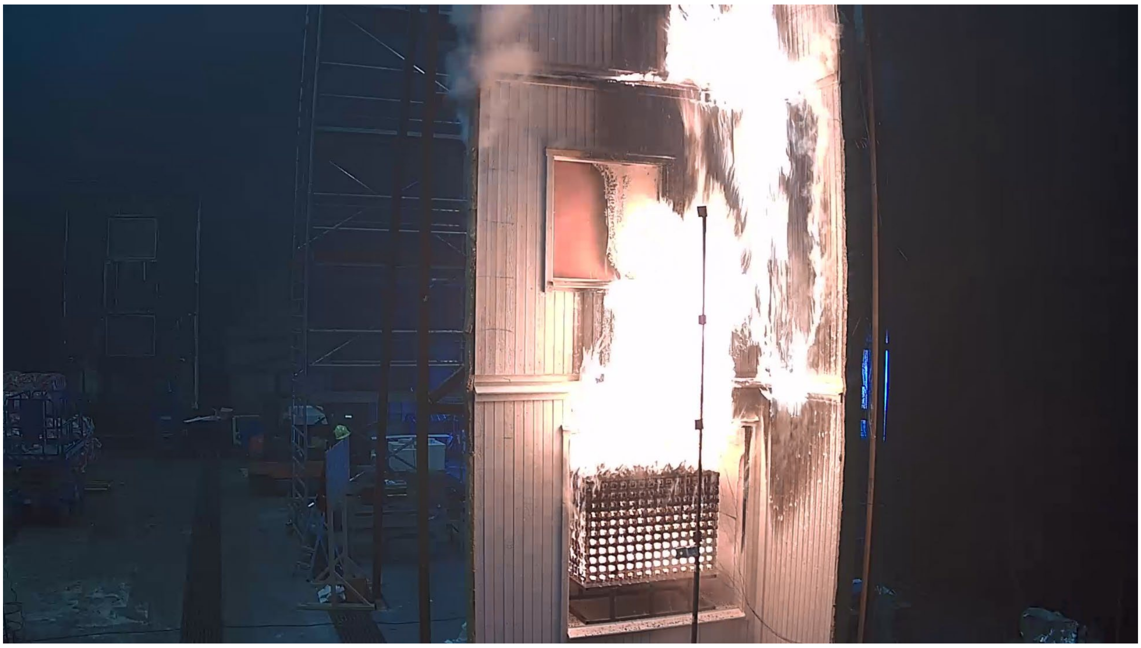

Photo 10 Draft proposed European test method, 8 minutes after first flames emerge out of the combustion chamber.


Photo 11 SP Fire 105, 10 minutes after first flames emerge out of the fire room.

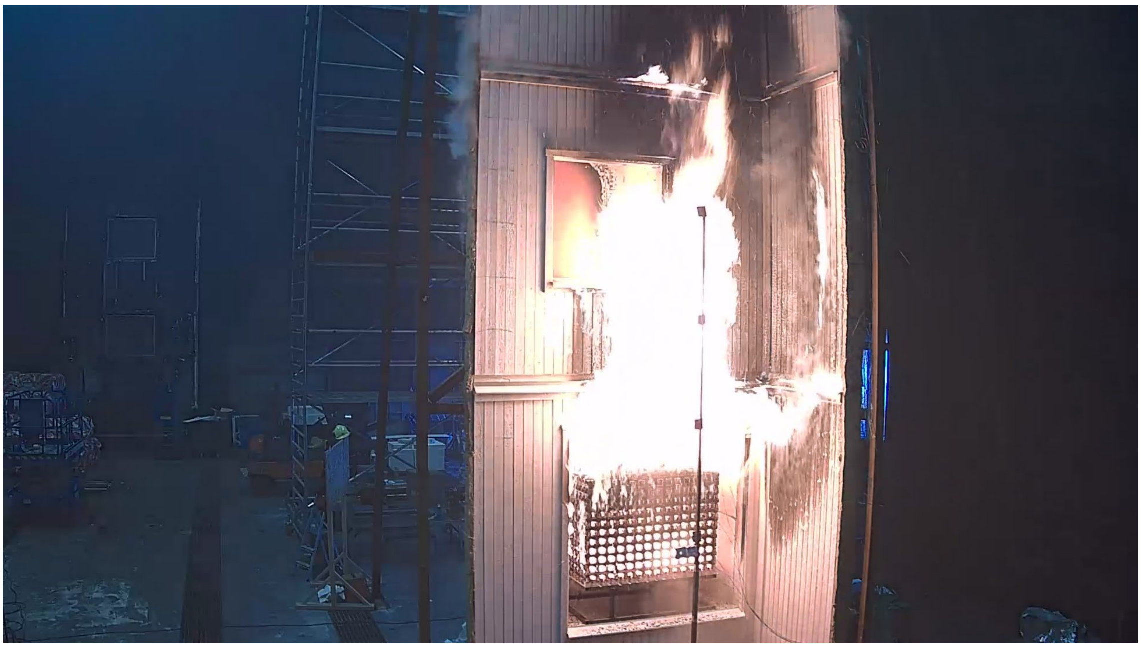

Photo 12 Draft proposed European test method, 10 minutes after first flames emerge out of the combustion chamber.

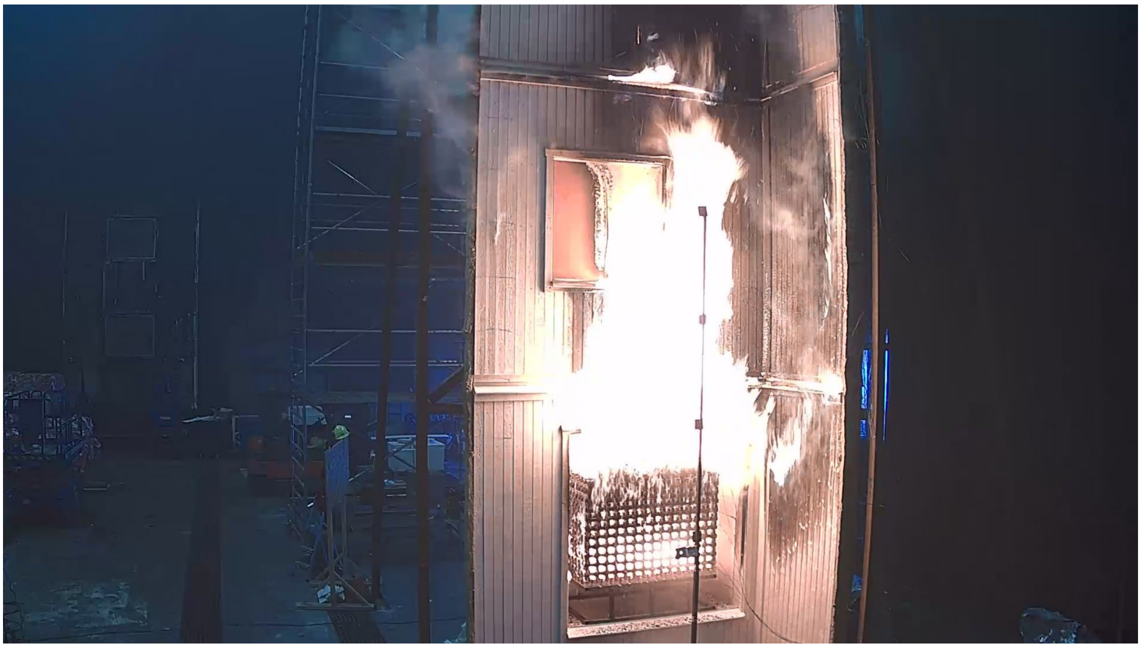

Photo 13 Draft proposed European test method, 12 minutes after first flames emerge out of the combustion chamber.

Photo 14 Draft proposed European test method, 14 minutes after first flames emerge out of the combustion chamber.

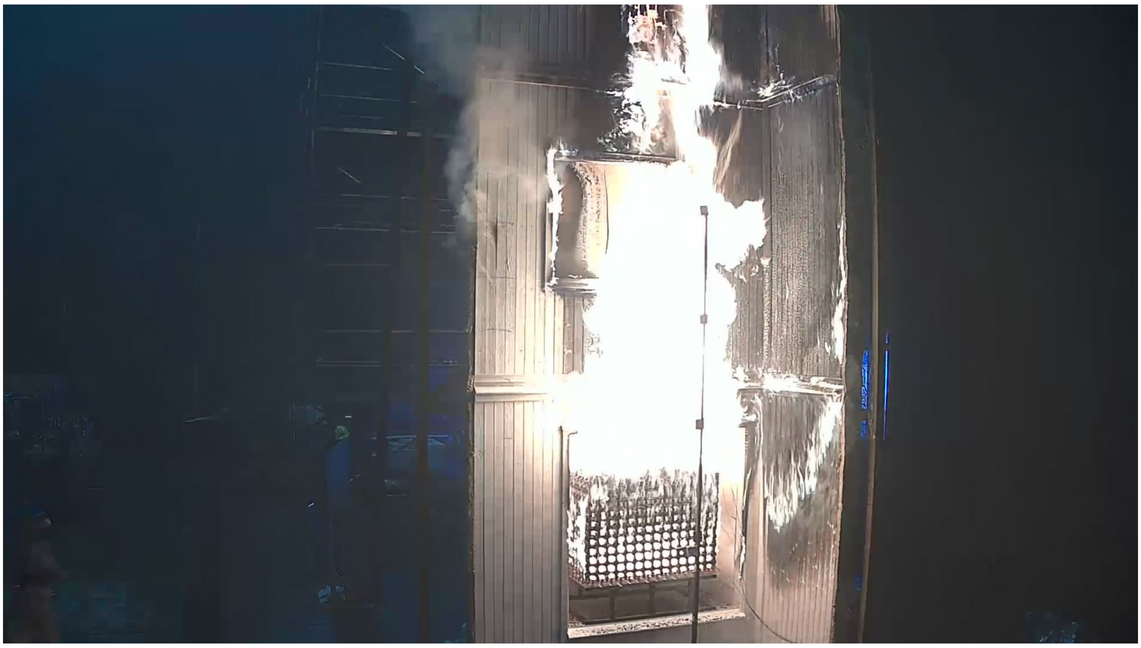

Photo 15 Draft proposed European test method, 16 minutes after first flames emerge out of the combustion chamber.

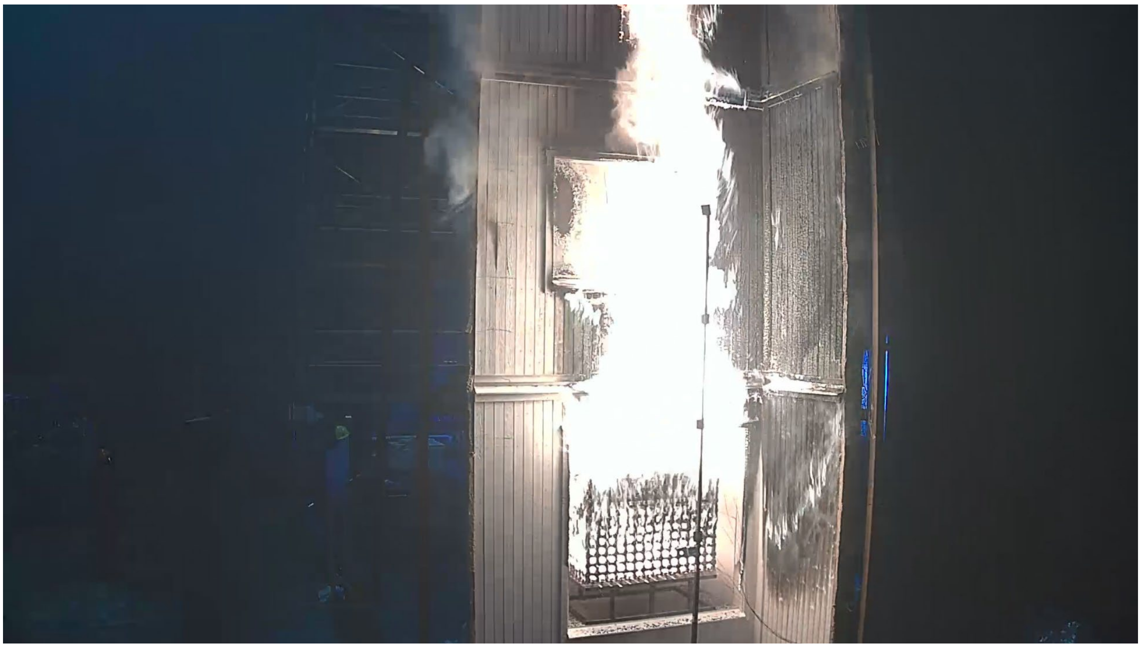

Photo 16 Draft proposed European test method, 18 minutes after first flames emerge out of the combustion chamber.

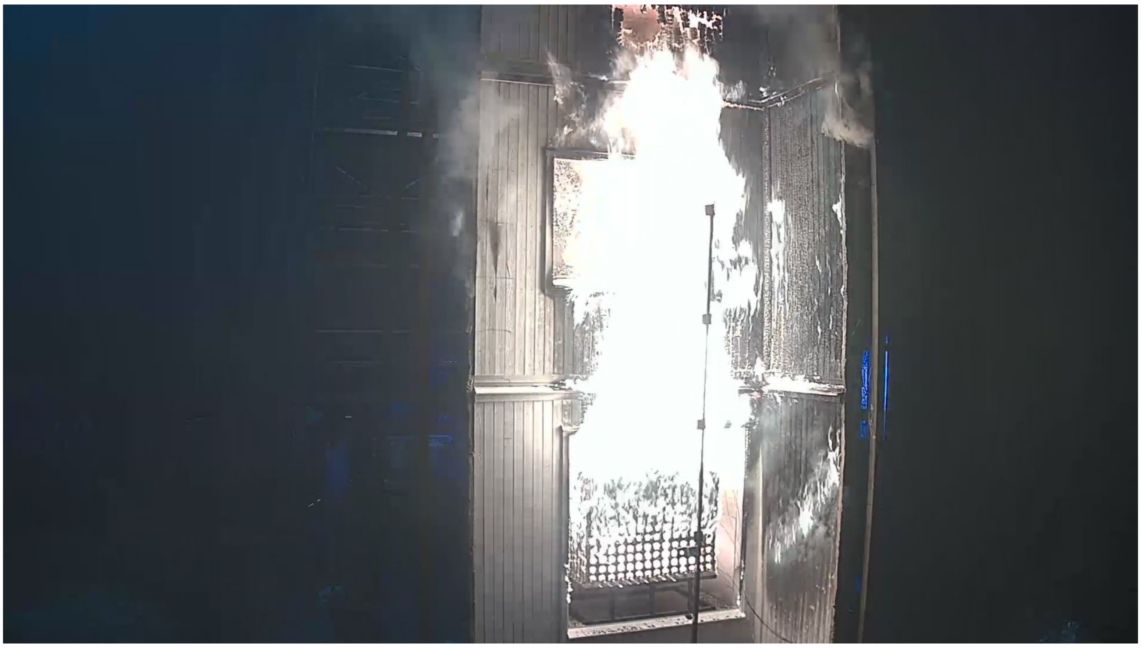

Photo 17 Draft proposed European test method, 20 minutes after first flames emerge out of the combustion chamber.

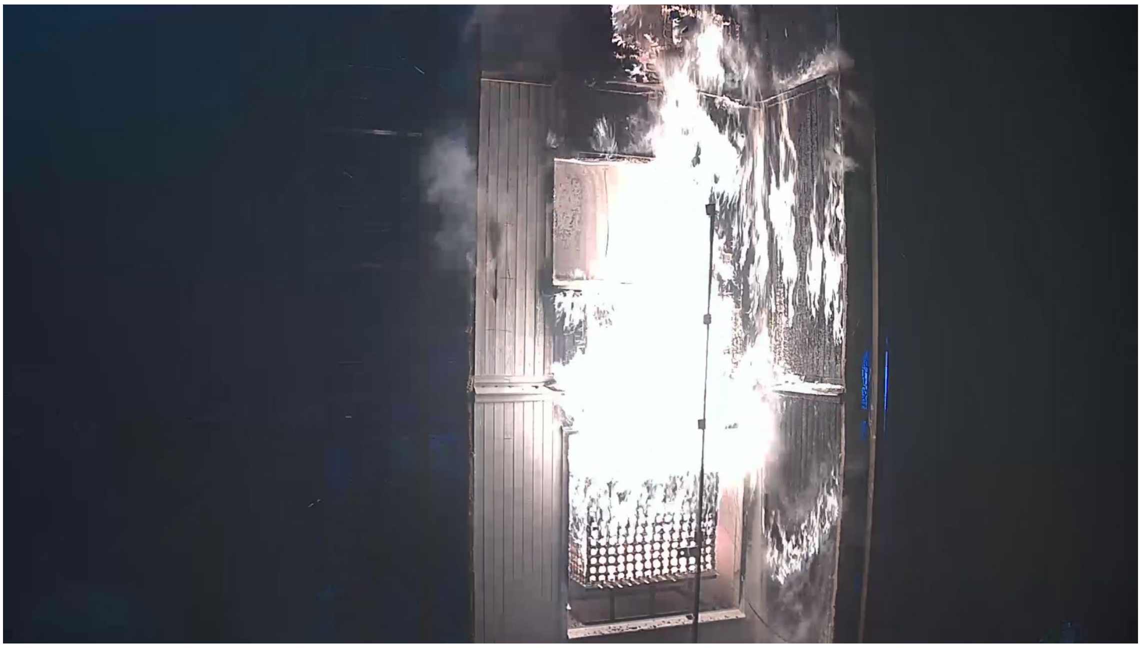

Photo 18 Draft proposed European test method, 22 minutes after first flames emerge out of the combustion chamber.

Photo 19 Draft proposed European test method, 24 minutes after first flames emerge out of the combustion chamber.

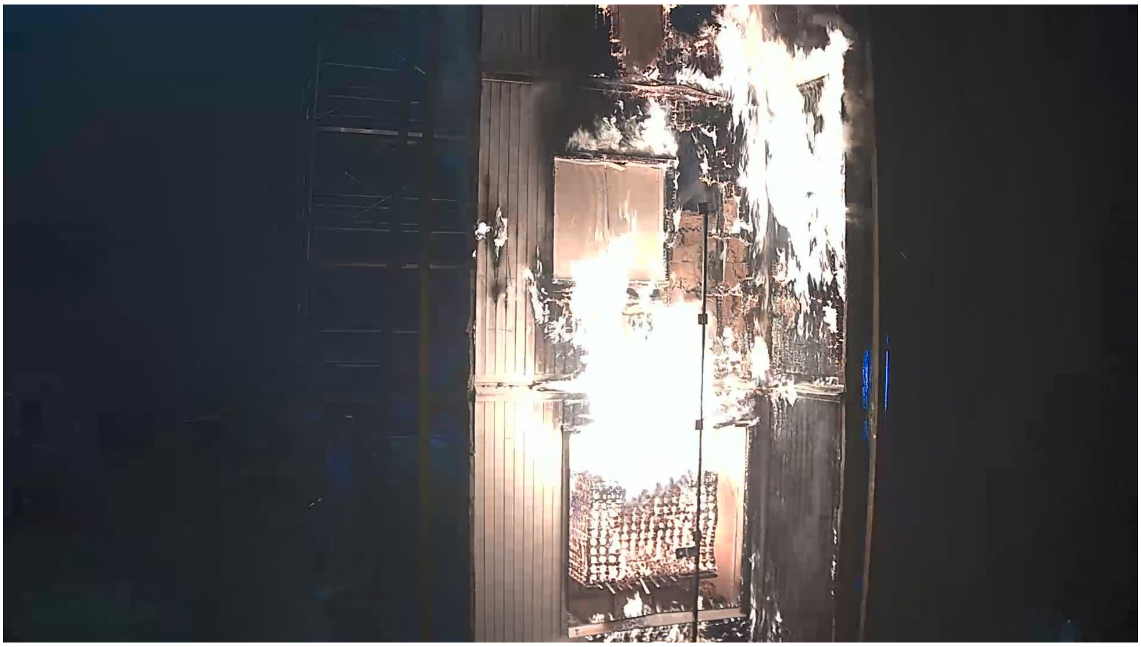

Photo 20 Draft proposed European test method, 26 minutes after first flames emerge out of the combustion chamber.

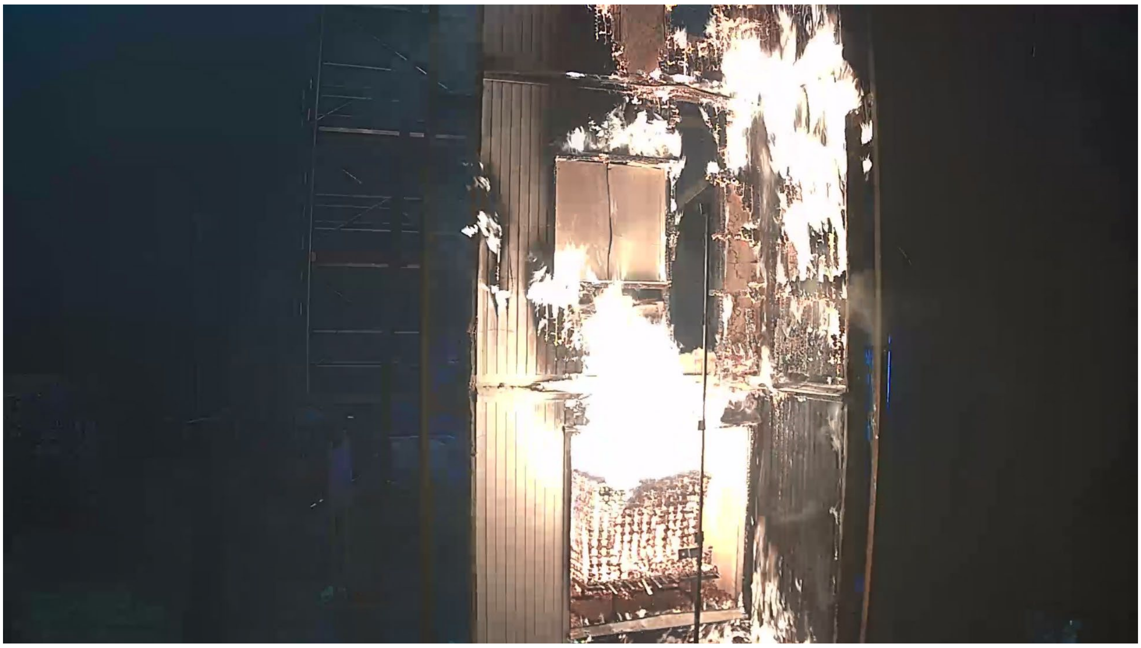

Photo 21 Draft proposed European test method, 28 minutes after first flames emerge out of the combustion chamber.

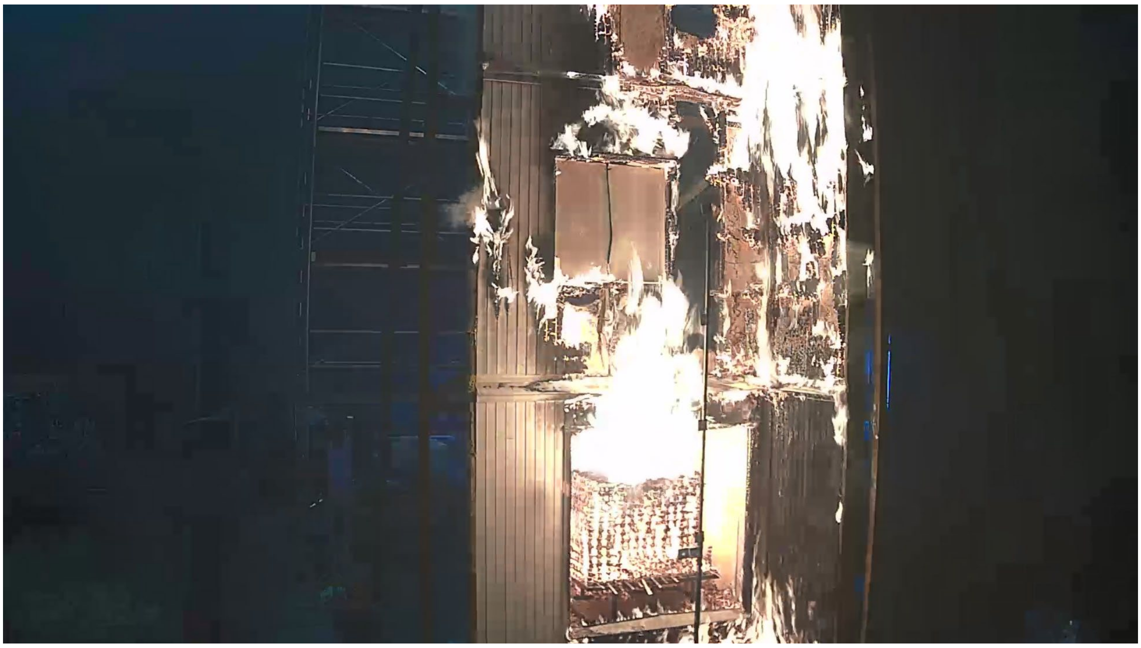

Photo 22 Draft proposed European test method, 30 minutes after first flames emerge out of the combustion chamber.

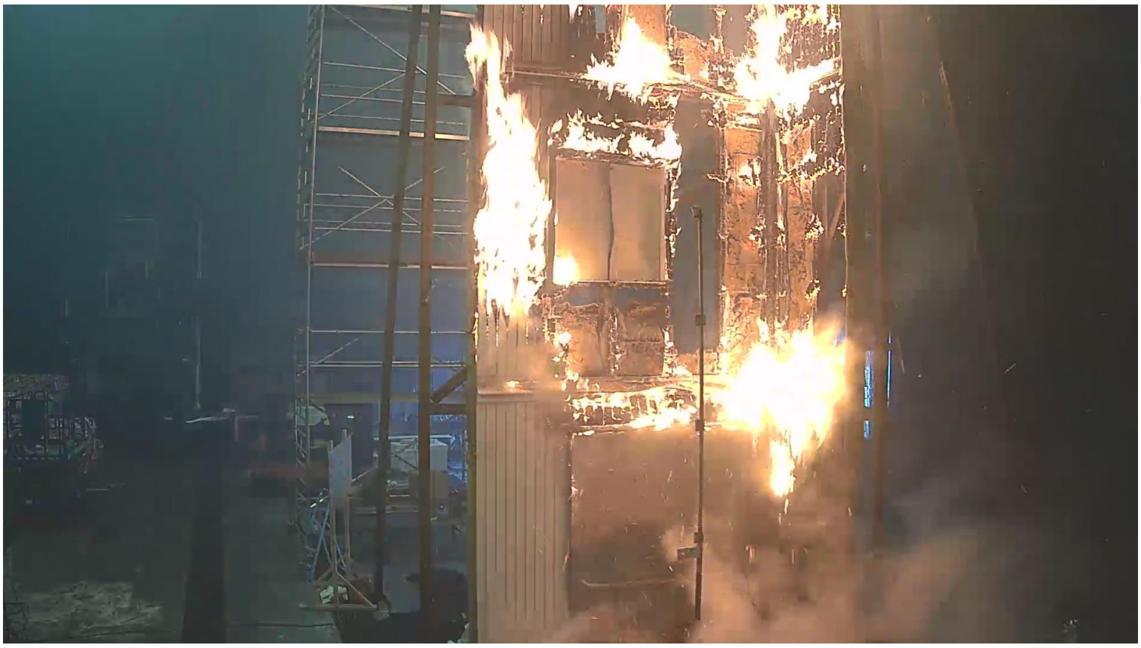

Photo 23 Draft proposed European test method, 32 minutes after first flames emerge out of the combustion chamber and 3.5 minutes after the wood crib was extinguished with water.

Photo 24 Draft proposed European test method after the wood crib and surface was extinguished with water.

# 4 Summary of the two tests methods

Below is a short summary of each test.

## 4.1 Summary of the test according to SP Fire 105

The test lasted for 21 minutes and 45 seconds from the ignition of fuel till the fuel had burned out. The flames emerged from the fire room after 10 minutes and 20 seconds.

- The maximum measured temperature below the eave was 265 °C 100 mm from the eave after 17 minutes and 8 seconds.
- The maximum measured heat flux was 51 $kW/m^2$. No pieces/material fell from the test specimen during the test.
- The fire spread on the surface of the test specimen and inside the test specimen did not reach above the lower edge of the fictitious window two floors above the fire room.

## 4.2 Summary of draft proposed European test method

The test lasted for 30 minutes from the ignition of the crib until the fuel was extinguished with water. The test continued for another 5 minutes before the surface of the test specimen was extinguished with water. The flames emerged out from the fire room after 49 seconds.

- The fire spread on the surface of the test specimen and inside the test specimen did reach the full length of the test specimen.

## 4.3 Comparison of the two tests

The results from testing of this façade system according to SP Fire 105 fulfilled the performance criteria.

In the draft proposal for the European test, no performance criteria were stated. However, due to the large damages, it is unlikely that this façade system would pass any upcoming performance criteria.

# 5 References

[1] "Finalisation of the European approach to assess the fire performance of facades." [Online]. Available: https://www.ri.se/en/what-we-do/projects/finalisation-of-the-european-approach-to-assess-the-fire-performance-of-facades. [Accessed: 28 Apr. 2022].
[2] "SP FIRE 105. External wall assemblies and façade claddings. Reaction to fire." Swedish National Testing and Research Institute, Fire Technology, Borås, Sweden, 09 Sep. 1994.
[3] M. J. Hurley *et al.*, *SFPE handbook of fire protection engineering*, 5th ed. USA: Springer, 2016.

# Appendix A: Photos from the test according to SP Fire 105


Photo A- 1 Overview from the start of the test.

Photo A- 2 Close up of the lower part of the test specimen after the test.

Photo A- 3 Close up of the lower part of the test specimen after the test.

Photo A- 4 Close up of the upper part of the test specimen after the test.

Photo A- 5 Close up of the lower part of the test specimen with the cladding removed.

# Appendix B: Photos from the test according to draft proposed European test method

Photo B-1 Close up of the lower part of the test specimen before the test.

Photo B-2 Close up of the upper part of the test specimen before the test.

Photo B-3 Overview of the test specimen in the early stage of the test.

Photo B-4 Close up of the lower part of the test specimen in the early stage of the test.

Photo B-5 Close up of the mid section flashing above the secondary opening halfway of the test

Photo B-6 Overview of the test specimen in the towards the end of the test.

Photo B-7 Overview of the test specimen at the end of the test.

Photo B-8 Overview of the test specimen after the crib has been extinguished.

Photo B-9 Close up of the test specimen after the crib has been extinguished.

Photo B-10 Close up of the upper part of the test specimen after the crib has been extinguished.

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