Finalisation of the European approach to assess the fire performance of façades SI2.825082

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List of abbreviations

The following table describes the significance of various abbreviations and acronyms used throughout this report.

Abbreviation	Meaning
ACM	Aluminium Composite Material
AM	Assessment Method
BS, BS 8414	British Standard, BS 8414-1:2020
CC	Combustion Chamber
DIN, DIN 4102	German Standard, DIN 4102-20
EGOLF	European Group of Organisations for Fire Testing, Inspection and Certification
ETICS	External Thermal Insulation Composite System
FC	Fibre Cement façade system
HFM	Heat Flux Meter
HRR	Heat Release Rate
MC	Moisture Content
MLR	Mass Loss Rate
MSZ	Hungarian Standard, MSZ 14800-6
PT	Plate thermometer
RH	Relative Humidity
RR	Round Robin
SG	Steering Group
SP Fire	Swedish Standard, SP Fire 105
TC	Thermocouple

Preface

The final report presents and summarizes the results obtained during March 2020 to May 2024.

This project was initiated after the proposal on a European assessment procedure for the fire performance of façades as presented in Boström et al (2018), which described a methodology and arguments on how and why certain choices have been made on the development of the methodology. The assessment procedure was based on the BS 8414 – Fire performance of external cladding systems series and DIN 4102-20 – Fire behavior of building components – Part 20: Complimentary verification for the assessment of the fire behavior of external wall claddings. It was focused on:

• establishing a register of the regulatory requirements in all Member States in relation to the fire performance of façade systems, and

• to identify those Member States who have regulatory requirements for the fire performance of façade systems which go beyond the current EN 13501 (reaction to fire and fire resistance) classification systems and to collate the details of these additional requirements.

In order to meet all regulatory provisions and all additional requirements within the Member States with the two methods an alternative approach, see Figure 1.1, was developed that addresses most issues that were identified between the current alternative assessment methods used by Member States and the current fire performance characteristics presented in the BS 8414 series and DIN 4102-20 test methods. The procedure introduced a medium and large-scale fire to be tested and verified in the current project, showed in the principle drawing below.

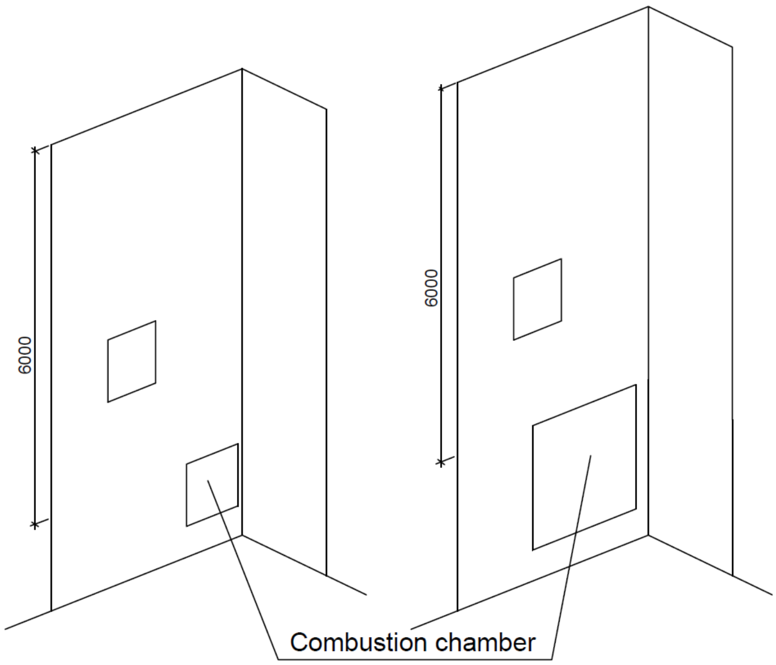


Figure 1.1. Principle drawing of the test method, medium fire exposure represented on the left and large fire exposure on the right.

Finally, the consortium would like to thank the participants in the theoretical and experimental Round Robins, the stakeholders and liaisons for their valuable input, support and commitment to the project, and Swedish Wood for supplying the wood for the wood crib tests.

Abstract

This final report summarises the work carried out during the project SI2.825082 financed by the European Commission – DG GROW. Within this project a theoretical Round Robin with the aim to analyse how the initial assessment method is interpreted by different laboratories, and the first and second phase of the initial testing activities to investigate the fire source, the design of the combustion chamber and secondary opening have been carried out. The final step in the project was an experimental Round Robin where four façade systems were tested at three different laboratories using the assessment method document, resulting in 24 tests. Additional tests were added to the project with funding from industrial partners. The tests were used to determine a calibration scheme and suitable performance criteria for classification. Furthermore, a substantial work has been done to ensure that the project is communicated in a good way to all stakeholders and Member States representatives.

The theoretical Round Robin was performed with 29 laboratories, all members of European Group of Organisations for Fire Testing, Inspection and Certification (EGOLF). Over 200 questions covering the whole assessment method were asked, and thereafter analysed. The results show clearly which parts of the assessment method needs to be improved and clarified, as well as some practical details regarding the test method that had to be addressed.

The first phase of the initial testing program defined the requirements of the fuel source and the combustion chamber. A large quantity of wood, of two different wood species (spruce and pine), had been acquired and thereafter characterised by measurement of dimensions, weight and moisture content. Over 4000 sticks have thus been density graded. After the selection of sticks to the different wood cribs a series of tests have been performed, mainly in accordance with the original test plan. Some modifications to the test plan were made during the course of the experimental study e.g., tests with a crib platform with either a grated or a solid floor. Also, a theoretical study through numerical modelling has been made to study the impact of changes of the combustion chamber geometry on the heat exposure to the test specimen. The simulations showed only small deviations between the regular and the enlarged combustion chamber. The changes of the geometry of the combustion chamber for the large exposure test can be done according to the results from the experimental program, it is beneficial for two reasons: it would make the preparatory work when mounting the test specimen simpler and it would ensure that falling parts will not damage the wood crib during a test.

Based on the results a proposal has been made on the characteristics of the fuel source and the geometry and design of the combustion chamber, to be used in the second phase.

During the second phase of the initial testing activities large and medium-scale exposure testing was performed on full façade geometries. The testing program including three repeatability tests in addition to gather information on variation in volume flow of the fan in medium-scale exposure as well as effects of the modified combustion chamber and wind in large-scale. From the repeatability tests it was decided to keep a constant height of the wood crib in large-scale due to otherwise large variations in exposure to the façade. Furthermore, the wind effects on the façade temperatures were significant even with a moderate wind of 1-2 m/s. At the end of the second phase three tests in medium and three tests in large-scale were done to investigate the effect of a secondary opening. It was indicated that asymmetrically placed opening would be the most appropriate placement.

A short test series on alternative fuel source for the large exposure test was also performed where a propane diffusion burner was used instead of wood cribs. It was shown that if the combustion chamber would be reduced in height similar exposure to the façade could be achieved using the propane burner. There are several benefits with this alternative fuel source such as decreased height, less cleaning, higher safety and therefore less costs associated to

testing. For the medium exposure test the alternative gas burner described in DIN 4102-20 might be an appropriate alternative fuel source for the wood crib. However, no further investigations were made in this project in this regard.

An update of the assessment method was made to take into account the latest information such as the repeatability tests and the second phase of the testing program. These changes such as the placement of the wood crib and the secondary opening was used in the experimental Round Robin.

In tandem to this work, two surveys on falling parts were performed to find out the needs of Member States (MS) and setting criteria to be used during the Round Robin. Furthermore, an inquiry on the capacities for indoor and outdoor testing of different testing laboratories connected with EGOLF was made and is reported here.

The work on the experimental Round Robin was completed in March 2024 and presentations of the tests and specimens are discussed in this report, more detailed information is available in the comparative documents. These include comparisons between tests on the same type of façade system at the different laboratories. This enables inter-laboratory comparisons for each monitored quantity and position. The inert tests are used to determine suitable calibration schemes for the medium and the large-scale exposure method, whereas the remaining tests are used to determine the performance criteria. Here it should be noted that average temperature is a more stable assessment criterion than a peak temperature or above a certain temperature during a certain time interval. The consortium would like to stress that arranging this type of Round Robin exercise is a severe logistic challenge which requires extensive planning.

The project has been communicated through different channels. The project web page is the main communication channel where all reports and other documentation is published (https://www.ri.se/en/what-we-do/projects/european-approach-to-assess-the-fire-performance-of-façades). In addition to the webpage a YouTube channel is available showing a few of the tests and recent seminars, see webpage for a link.

A Comments Handling Document has been kept and it includes almost 1000 comments that have been received during the project. These comments were handled continuously and communicated through the above-mentioned web page.

Kurzfassung

Dieser Abschlussbericht fasst die Arbeiten zusammen, die im Rahmen des von der Europäischen Kommission - GD GROW - finanzierten Projekts SI2.825082 durchgeführt wurden. Im Rahmen dieses Projekts wurde ein theoretischer Rundversuch mit dem Ziel durchgeführt, zu analysieren, wie der derzeitige Entwurf der Bewertungsmethode, von verschiedenen Labors interpretiert wird, sowie die erste und zweite Phase der Erstprüfungsaktivitäten, bei denen die Brandquelle, die Konstruktion der Brandkammer und die sekundäre Öffnung untersucht wurden. Der letzte Schritt des Projekts war der experimentelle Rundversuch, bei dem vier Fassadensysteme in drei verschiedenen Labors unter Verwendung der Bewertungsmethode getestet wurden, was zu 24 Tests führte. Mit finanzieller Unterstützung von Industriepartnern wurden dem Projekt weitere Tests hinzugefügt. Die Tests dienten dazu, ein Kalibrierungsschema und geeignete Leistungskriterien für die Klassifizierung zu ermitteln. Darüber hinaus wurde eine umfangreiche Arbeit geleistet, um sicherzustellen, dass das Projekt allen Interessengruppen und Vertretern der Mitgliedstaaten in geeigneter Weise kommuniziert wird.

Der theoretische Rundversuch wurde mit 29 Laboratorien durchgeführt, die alle Mitglieder der Europäischen Gruppe der Organisationen für Brandprüfung, Inspektion und Zertifizierung (EGOLF) sind. Es wurden über 200 Fragen zur gesamten Bewertungsmethode gestellt, die anschließend analysiert wurden. Die Ergebnisse zeigten deutlich, welche Teile der Bewertungsmethode verbessert und geklärt werden mussten, sowie einige praktische Details bezüglich der Prüfmethode, die untersucht werden mussten.

In der ersten Phase des ersten Testprogramms wurden die Anforderungen an die Brandquelle und die Brandkammer festgelegt. Eine große Menge Holz von zwei verschiedenen Holzarten (Fichte und Kiefer) wurde erworben und anschließend durch Messung von Abmessungen, Gewicht und Feuchtigkeitsgehalt charakterisiert. Auf diese Weise wurden über 4000 Holzstäbe nach ihrer Dichte sortiert. Nach der Auswahl der Stäbe für die verschiedenen Holzkrippen wurde eine Reihe von Tests durchgeführt, die im Wesentlichen dem ursprünglichen Testplan entsprachen. Im Laufe der experimentellen Studie wurden einige Änderungen am Versuchsplan vorgenommen, z. B. Versuche mit einer Krippenplattform, die entweder einen Gitterrost oder einen festen Boden hatte. Außerdem wurde eine theoretische Studie mittels numerischer Modellierung durchgeführt, um die Auswirkungen von Änderungen der Brandkammergeometrie auf die Wärmeeinwirkung auf den Probekörper zu untersuchen. Die Simulationen zeigten nur geringe Abweichungen zwischen der normalen und der vergrößerten Brandkammer. Die Änderungen der Geometrie der Brandkammer für die große Brandbeanspruchung können entsprechend den Ergebnissen des Versuchsprogramms vorgenommen werden. Dies ist aus zwei Gründen von Vorteil: Es würde die Vorbereitungsarbeiten bei der Montage des Probekörpers vereinfachen und sicherstellen, dass herabfallende Teile die Holzkrippe während des Versuchs nicht beschädigen.

Auf der Grundlage der Ergebnisse wurde ein Vorschlag für die Eigenschaften der Brandquelle sowie Geometrie und Gestaltung der Brandkammer gemacht, der in der zweiten Phase verwendet wurde.

In der zweiten Phase des ersten Testaktivitäten wurden Versuche mit großer und mittlerer Brandbeanspruchung an vollständigen Fassadengeometrien durchgeführt. Das Testprogramm umfasste drei Wiederholungstests, um Informationen über die Variation des Volumenstroms des Ventilators bei der mittleren Brandbeanspruchung sowie über die Auswirkungen der modifizierten Brandkammer und des Windes bei der großen Brandbeanspruchung zu sammeln. Bei den Wiederholungstests wurde beschlossen, die Höhe der Holzkrippe bei der großen Brandbeanspruchung konstant zu halten, da es sonst zu großen Schwankungen bei den Einwirkungen auf die Fassade kommen würde. Außerdem waren die Auswirkungen des Windes auf die Fassadentemperaturen selbst bei einem mäßigen Wind von 1-2 m/s erheblich. Am Ende der zweiten Phase wurden drei Tests mit mittlerer und drei

Tests mit großer Beanspruchung durchgeführt, um die Auswirkungen einer sekundären Öffnung zu untersuchen, wobei sich herausstellte, dass eine asymmetrisch angeordnete Öffnung am besten geeignet ist.

Es wurde auch eine kurze Versuchsreihe mit einer alternativen Brennstoffquelle für die großen Brandbeanspruchung durchgeführt, bei der ein Propan-Diffusionsbrenner anstelle von Holzkrippen verwendet wurde. Es zeigte sich, dass bei einer geringeren Höhe der Brandkammer mit dem Propanbrenner eine ähnliche Einwirkung an der Fassade erreicht werden kann. Diese alternative Brennstoffquelle bietet mehrere Vorteile, wie z. B. geringere Höhe, weniger Reinigungsaufwand, höhere Sicherheit und somit geringere Kosten für die Prüfung. Für die Prüfung der mittleren Brandbeanspruchung könnte der in DIN 4102-20 beschriebene alternative Gasbrenner eine geeignete alternative Brennstoffquelle für die Holzkrippe sein. In diesem Projekt wurden diesbezüglich jedoch keine weiteren Untersuchungen durchgeführt.

Eine Aktualisierung der Bewertungsmethode wurde vorgenommen, um die neuesten Informationen aus den Wiederholungstests und der zweiten Phase des Testprogramms zu berücksichtigen. Diese Änderungen, wie die Platzierung der Holzkrippe und die sekundäre Öffnung, wurden in dem experimentellen Rundversuch verwendet. Parallel zu dieser Arbeit wurden zwei Umfragen zu herabfallenden Teilen durchgeführt, um den Bedarf der Mitgliedstaaten zu ermitteln und Kriterien für die Rundversuch festzulegen. Darüber hinaus wurde eine Umfrage zu den Kapazitäten der verschiedenen mit EGOLF verbundenen Prüflabors für Innen- und Außenprüfungen durchgeführt.

Die Arbeiten am experimentellen Rundversuch wurden im März 2024 abgeschlossen, und die Präsentationen der Tests und Proben werden in diesem Bericht dargelegt; detailliertere Informationen sind in den Vergleichsdokumenten verfügbar. Diese enthalten Vergleiche zwischen den Prüfungen desselben Fassadentyps in den verschiedenen Laboratorien. Dies ermöglicht laborübergreifende Vergleiche für jede gemessene Größe und Position. Die inerten Prüfungen dienen zur Bestimmung geeigneter Kalibrierungsschemata für die mittlere und die große Brandbeanspruchung, während die übrigen Prüfungen zur Bestimmung der Leistungskriterien verwendet werden. Dabei ist zu beachten, dass die Durchschnittstemperatur ein stabileres Bewertungskriterium ist als eine Spitzentemperatur oder eine Überschreitung einer bestimmten Temperatur in einem bestimmten Zeitintervall. Das Konsortium möchte betonen, dass die Durchführung eines solchen Rundversuchs eine große logistische Herausforderung darstellt, die eine umfassende Planung erfordert.

Das Projekt wurde über verschiedene Kanäle kommuniziert. Die Projektwebseite ist der Hauptkommunikationskanal, auf dem alle Berichte und andere Unterlagen veröffentlicht werden (https://www.ri.se/en/what-we-do/projects/european-approach-to-assess-the-fire-performance-of-façades). Zusätzlich zur Webseite gibt es einen YouTube-Kanal, auf dem einige der Tests und die letzten Seminare gezeigt werden. Es wurde ein Dokument zur Behandlung von Kommentaren geführt, das fast 1000 Kommentare enthält, die während des Projekts eingegangen sind. Diese Kommentare wurden fortlaufend bearbeitet und über die oben erwähnte Webseite kommuniziert.

Résumé:

Ce rapport final résume le travail effectué dans le cadre du projet SI2.825082 financé par la Commission européenne - DG GROW. Dans le cadre de ce projet, une “Round Robin” ou C.I.L. (comparaison interlaboratoires) théorique a été organisé afin d'analyser la manière dont le projet actuel de méthode d'évaluation, considéré comme la méthode d’évaluation initiale, est interprété par les différents laboratoires, puis ont été réalisées la première et la deuxième phases des activités d'essai initiales, concernant le dimensionnement de la source d'incendie, de la chambre de combustion et de l'ouverture secondaire.

L'étape finale du projet a été la “Round Robin” ou C.I.L. au cours de laquelle quatre systèmes de façade ont été testés dans trois laboratoires différents en appliquant la méthode d'évaluation, ce qui a donné lieu à 24 essais. Des essais supplémentaires ont été ajoutés au projet grâce au financement de partenaires industriels. Les résultats des essais ont été utilisés pour mettre au point une méthode de calibration et des critères de performance appropriés pour la classification. En outre, un travail important a été réalisé pour assurer une bonne communication du projet auprès de toutes les parties prenantes et des représentants des États membres.

Le “Round Robin” théorique a été réalisé par 29 laboratoires, tous membres du Groupe européen des organismes d'essais, d'inspection et de certification en matière d'incendie (EGOLF). Plus de 200 questions couvrant l'ensemble de la méthode d'évaluation ont été posées, puis analysées. Les résultats ont montré clairement quelles parties de la méthode d'évaluation doivent être améliorées et clarifiées, ainsi que les détails pratiques concernant la méthode d'essai qui doivent être traités.

La première phase du programme d'essai initial a permis de définir les exigences relatives à la source de feu et à la chambre de combustion. Une grande quantité de bois, de deux espèces différentes (épicéa et pin), a été achetée et caractérisée ensuite par la mesure des dimensions, du poids et de la teneur en humidité. Plus de 4000 baguettes de bois ont ainsi été classées selon leur masse volumique. Après la sélection et répartition des baguettes dans les différents bûchers de bois, une série d'essais a été réalisée, principalement conformément au programme d'essais original. Certaines modifications ont été apportées au programme d'essais au cours de l'étude expérimentale, par exemple en faisant varier le support sous le bucher : soit un caillebotis soit une plaque pleine. En outre, une étude théorique par modélisation numérique a été réalisée pour étudier l'impact des modifications de la géométrie de la chambre de combustion sur l'exposition à la chaleur de l'échantillon d'essai. Les simulations n'ont montré que de faibles écarts entre la chambre de combustion normale et la chambre de combustion agrandie. Les modifications de la géométrie de la chambre de combustion pour l'essai d’exposition au feu large peuvent être effectuées suite aux résultats du programme expérimental, ce qui est bénéfique pour deux raisons : cela simplifierait le travail préparatoire lors du montage de l'échantillon d'essai et cela garantirait que les éléments de façade qui chutent n'endommagent pas le bucher en bois pendant l'essai.

Sur la base des résultats, une proposition a été faite concernant les caractéristiques de la source de feu ainsi que la géométrie et la conception de la chambre de combustion, à utiliser lors de la deuxième phase.

Au cours de la deuxième phase des activités d'essai initiales, des essais d'exposition au feu moyen et large ont été réalisés sur des géométries de façade complètes. Le programme d'essais comprenait trois essais de répétabilité, des essais pour collecter des informations sur l’impact de la variation du débit volumique du ventilateur dans les essais d'exposition au feu

moyen, ainsi que des essais pour évaluer les effets de la chambre de combustion modifiée et du vent dans les essais d'exposition au feu large. Les essais de répétabilité ont permis de décider de maintenir la hauteur du bucher en bois constante dans les essais d'exposition au feu large, en raison des variations importantes sur l'exposition de la façade dans le cas contraire. En outre, les effets du vent sur les températures de la façade étaient significatifs, même avec un vent modéré de 1 à 2 m/s. À la fin de la deuxième phase, trois essais avec une exposition au feu moyen et trois essais avec une exposition au feu large ont été effectués pour étudier l'effet de la présence et le positionnement d'une ouverture secondaire, et il a été indiqué qu'une ouverture placée de manière excentrée par rapport à la chambre de combustion serait l'emplacement le plus approprié.

Une courte série d'essais sur les sources de feu alternatives pour l'essai d'exposition au feu large a également été réalisée, en utilisant un brûleur à diffusion de propane au lieu d'un bucher en bois. Il a été démontré qu'en réduisant la hauteur de la chambre de combustion, il était possible d'obtenir une exposition similaire de la façade en utilisant le brûleur au propane. Cette source de feu alternative présente plusieurs avantages, tels que la réduction de la hauteur du banc d'essai, la simplification du nettoyage, l'amélioration de la sécurité et, par conséquent, la diminution des coûts liés aux essais. Pour l'essai d'exposition au feu moyen, le brûleur à gaz décrit dans la norme DIN 4102-20 pourrait être une source de feu appropriée comme alternative au bucher en bois. Toutefois, aucune autre étude n'a été réalisée à cet égard dans le cadre de ce projet.

Une mise à jour de la méthode d'évaluation a été effectuée pour prendre en compte les dernières informations telles que les tests de répétabilité et la deuxième phase du programme d'essais. Ces changements, tels que l'emplacement du bucher en bois et de l'ouverture secondaire, ont été utilisés dans le “Round Robin” expérimental.

Parallèlement à ce travail, deux sondages portant sur la caractérisation des éléments chutant de la façade pendant essai ont été réalisées pour connaître les besoins règlementaires de chaque État Membre et fixer les critères à utiliser lors du “Round Robin”. En outre, un sondage sur les capacités de réaliser ce type d'essais de façades en intérieur et en extérieur, des différents laboratoires d'essais membres d'EGOLF, a été réalisée et fait l'objet d'un rapport dans le présent document.

Le travail sur le Round Robin expérimental a été achevé en mars 2024 et les présentations des essais et des systèmes de façades testés sont discutées dans ce rapport, des informations plus détaillées sont disponibles dans les documents comparatifs. Ceux-ci comprennent des comparaisons entre les résultats d'essais sur le même type de système de façade dans les différents laboratoires. Cela permet des comparaisons inter-laboratoires pour chaque paramètre et emplacement contrôlé. Les essais de façade inerte sont utilisés pour développer une méthode de calibration appropriée pour la méthode d'essai d'exposition au feu moyen et la méthode d'exposition au feu large, tandis que les autres essais sont utilisés pour déterminer les critères de performance.

Il convient de noter que la température moyenne est un critère d'évaluation plus robuste qu'une température maximale ou qu'une température supérieure à une certaine valeur pendant un certain laps de temps. Le consortium souhaite souligner que l'organisation de ce type d'exercice “Round Robin” est un défi logistique de taille qui nécessite une longue et délicate planification.

Le projet a été communiqué par différents canaux. La page web du projet est le principal canal de communication où tous les rapports et autres documents sont publiés (https://www.ri.se/en/what-we-do/projects/european-approach-to-assess-the-fire-performance-of-facades). En plus de la page web, une chaîne YouTube est disponible pour montrer quelques-uns des essais de façade et des séminaires publics récents, voir la page web pour un lien.

1. Introduction

This is the final report in the project SI2.825082 financed by the European Commission. The conclusions based on the initial testing activities, the experimental Round Robin as well as the proposals of the finalized assessment method are included in this report.

The main activities performed in the project are the following:

- Establishment of an information transfer platform.
- Execution of the theoretical Round Robin on the initial assessment method and analysis of the results.
- Planning and start of initial tests.
- Wood crib tests and analysis of results.
- Definition of wood crib characteristics and design of the combustion chamber.
- Questionnaires on falling parts and capacities of test laboratories within EU.
- Updated assessment method document.
- Repeatability tests of medium and large exposure.
- Secondary opening tests.
- Definition of test specimens in collaboration with industry for the experimental Round Robin and performing the Round Robin exercise.
- Analysis of all data collected throughout the project.

Since inception of the project several reports have been published on the project homepage (https://www.ri.se/en/what-we-do/projects/european-approach-to-assess-the-fire-performance-of-façades), these are listed below in different categories.

Project reports

1. Inception report
2. Progress Report 1
3. Progress Report 2
4. Progress Report 3

Test reports

1. Test Report Large Wood Crib Test
2. Test Data Large Exposure Crib
3. Test Report Medium Wood Crib Test
4. Test Data Medium Exposure Crib
5. Test Report Large Scale Exposure
6. Test Data Large Scale Exposure Tests
7. Test Report Medium-scale exposure
8. Test Data Medium-scale exposure
9. Role of secondary opening in large exposure tests
10. Medium-scale exposure testing including secondary opening
11. Test Data - Role of secondary opening in large exposure tests

12. Test Data - Role of secondary opening in medium exposure tests
13. Test Data - outdoor large exposure test

Questionnaires and Round Robin reports

1. The Theoretical Round Robin Report
2. Theoretical Round Robin Summary Report
3. Summary Questionnaire on Falling Parts 2021 09 08
4. What is to be measured in the RR

Assessment method documents

1. Assessment method - dated 2020 05 07 - SI 2 825082
2. Assessment method - dated 2020 11 18 with comments
3. Assessment method - dated 2022 05 12 - SI 2 825082
4. Assessment method medium-scale - dated 2022 11 12
5. Assessment method large-scale exposure - dated 2022 11 12
6. Assessment method medium-scale exposure - dated 2024 03 05
7. Assessment method large-scale exposure - dated 2024 03 05
8. Assessment method medium scale exposure– draft 8 dated 2024 xx xx
9. Assessment method large-scale exposure – draft 8 dated 2024 xx xx

Comments Handling Documents and Q&A

1. Comments Handling Document - dated 2020 07 22
2. Comments Handling Document - dated 2020 10 23
3. Comments Handling Document - dated 2020 11 18
4. Comments Handling Document - dated 2020 12 11
5. Steering Group Meeting Q&A
6. Answers on questions on the façade assessment project - REV1
7. Comments Handling Document - dated 2021 12 03
8. Comments Handling Document - dated 2022 07 01
9. Comments Handling Document - dated 2022 08 30
10. Comments Handling Document – dated 2023 03 09
11. Comments Handling Document – dated 2024 02 15
12. Comments Handling Document – collated final 2024 05 24

https://www.ri.se/sites/default/files/2024-05/Comments%20Handling%20Document%20final%20collated%20final.pdf

Comparative documentation based on the 24 planned test excluding extra testing

1. Inert tests in medium-scale exposure

   https://www.ri.se/sites/default/files/2024-09/Comparative%20document%20inert%20medium%20FIN%2001.pdf

2. Wooden façade tests in medium-scale exposure

   https://www.ri.se/sites/default/files/2024-09/Comparative%20document%20timber%20medium%20FIN%2001.pdf

3. Fibre cement façade tests in medium-scale exposure

   https://www.ri.se/sites/default/files/2024-09/Comparative%20document%20fiber%20cement%20medium%20FIN%2001.pdf

4. ETICS façade tests in medium-scale exposure

   https://www.ri.se/sites/default/files/2024-09/Comparative%20document%20ETICS%20medium%20FIN%2001.pdf

5. Inert tests in large-scale exposure

   https://www.ri.se/sites/default/files/2024-09/Comparative%20document%20inert%20large%20FIN%2001.pdf

6. Timber façade tests in large-scale exposure

   https://www.ri.se/sites/default/files/2024-09/Comparative%20document%20timber%20FIN01.pdf

7. Aluminium ventilated façade tests in large-scale exposure

   https://www.ri.se/sites/default/files/2024-09/Comparative%20document%20ACM%20FIN%2001.pdf

8. Aluminium cassette façade tests in large-scale exposure

   https://www.ri.se/sites/default/files/2024-09/Comparative%20document%20aluminium%20FIN%2001.pdf

9. ETICS façade in large-scale exposure – extra tests

   https://www.ri.se/sites/default/files/2024-09/Comparative%20document%20ETICS%20FIN%2001.pdf

10. Curtain wall façade in large-scale exposure - extra test

    https://www.ri.se/sites/default/files/2024-05/EUI-24-000031%20-%20Test%20report%20-%20Draft%20V2%20--%20Generic%20report%20v2.pdf

2. Theoretical Round Robin and laboratory capacities

2.1. Theoretical Round Robin

The overall description and the most important results from the theoretical Round Robin are presented here. For a longer version we refer to full description in the theoretical Round Robin report Dumont et al 2020, referenced above.

The aim with the theoretical Round Robin was to evaluate whether the initial assessment method, as described in Boström et al 2018, is written in such way that it is interpreted similarly and correctly, and thereafter make improvements to the assessment method to minimize different interpretations.

2.1.1. Questionnaire and participation

The questionnaire was made anonymous by using Google form and participant numbers assigned by EGOLF. It contained questions on the draft description of the initial assessment method where some questions were answered through multiple choice answers and others via free text field. Answers that required drawings were sent through EGOLF Secretary General to remain anonymity of the respondents. The invitation letter and full questionnaire are both outlined in the theoretical Round Robin report Dumont et al 2020.

An invitation to participate was sent to all EGOLF members and 29 laboratories from 20 countries who signed up to participate (Table 2.1). The participants represent both laboratories already performing large-scale exposure testing according to one of the national test methods and those who intend to start performing façade testing. The material for the theoretical Round Robin was sent out to the participants on May 11th 2020 and answers were received from all 29 participants by June 26th 2020.

Table 2.1.

Participating laboratories in the theoretical Round Robin.

Laboratory	Country	Laboratory	Country
CERIB	France	CNSIPC	Romania
CSTB	France	DBI Fire & Security	Denmark
Efectis ERA Avrasya	Turkey	Efectis France	France
Efectis Nederland	Netherlands	Fire Research Center (GTC)	Lithuania
IBS	Austria	ift Rosenheim	Germany
ITB	Poland	LAPI	Italy
LGAI Technologocal Center S.A.	Spain	MA 39	Austria
MFPA Leipzig GMBH	Germany	MPA Dresden GMBH	Germany
MPA NRW	Germany	PAVUS a.s.	Czech Republic

Laboratory	Country	Laboratory	Country
Research Engineering Development Façades Consultants	Hong Kong	RIFS	Bulgaria
RISE Fire Research AS	Norway	RISE Research Institutes of Sweden	Sweden
TECNALIA	Spain	Thomas Bell-Wright International Consultants	UAE
Université de Liège	Belgium	Warringtonfire	UK
WFRGENT	Belgium	ZAG	Slovenia
AFITI-LICOF	Spain		

2.1.2. Results

The laboratories' answers to each question have been analysed and compared to the expected "correct" answers determined by the project group. Mean scores – expressed in percent – have then been computed for the 53 main questions and their 210 sub-questions.

The exercise reveals that out of the 53 main questions:

- 4 questions get 0% ≤ score ≤ 50%, they are related to requirements of the initial assessment method considered to have a poor comprehensibility
- 13 questions get 50% < score < 75%, they are related to requirements of the initial assessment method considered to have a questionable comprehensibility
- 27 questions get 75% ≤ score ≤ 100%, they are related to requirements of the initial assessment method considered to have a good comprehensibility

The analyses gave a direct overview of which aspects are affected by poor or questionable comprehensibility (lower and intermediate scores). In-depth reading of the laboratories' answers allowed to identify roots of these comprehensibility issues.

2.1.3. Proposals of improvement

The analyses above were used to draw up the most useful recommendations to improve the assessment method. These proposals are presented below, each one is referencing to the related section in the assessment method (ASSESSMENT OF FIRE PERFORMANCE OF FACADES, Draft revision 1. Date: May 7, 2020.) Please note that not all of these proposals are eventually included in the updated assessment method (AM) due to other "overriding" results obtained elsewhere in the project.

Structural frame (Section 4.3)

The assessment method should propose a description of a harmonised structural frame, including: drawings, materials, cross sections, mounting, position of the transoms in relation to the floor levels (in any relation…), any protection of the frame from heat in case of failure.

Such harmonised structural frame should not be mandatory, it would be a functional example to be used at the discretion of any laboratory.

Combustion chamber (Section 4.5)

The updated assessment method should give details on how to configure the junction between the test rig and the walls of the combustion chamber (when the structural frame is used alone, and when both supporting construction and structural frame are used together).

Mounting of the test specimen (Section 7)

The updated assessment method should provide detailed practical rules for the configuration of the interface between the test specimen and the edges of openings, including the presence of any frame. A specific sub-Section should be dedicated to these aspects. This sub-Section should refer to Annex C and this annex is currently only referred to in the Direct Field of Application (DIAP) (Section 13 in the same document ASSESSMENT OF FIRE PERFORMANCE OF FACADES, Draft revision 1. Date: May 7, 2020.).

The current DIAP rule that allows "any kind of frame at the openings if the test has been performed without any frame" may turn out to be non-conservative. Therefore, an idea could be to define standardised frames:

- a combustible frame (plastic or wooden?)
- a non-combustible frame (steel?)

These could be made of very simple sections. Test results obtained with such standardised (non-combustible) frame would then be applicable to façades with any type of non-combustible frame.

Optionally, the possibility to perform the test with the same frame as to be used in practice should be allowed.

Regarding all the detailing around the openings, it should be investigated if it would be possible to propose a standardised configuration.

Generally speaking, the updated assessment method should clearly state how the edges at the combustion chamber should be configured on the one hand, and at the secondary opening on the other hand. Practically, it should be acknowledged that some differences could appear between both openings. For instance, some detailing of the secondary opening will sometimes need to be adapted to accommodate the backing board or closing of the opening in the construction at the back, in the case of interference.

Selection of the test rig (Section 7.1)

In cases of façade systems consisting of a full stand-alone external wall, it should be mentioned that the test specimen shall be mounted directly on the structural frame, and that mounting on a supporting construction is not allowed in that case.

Test specimen (Section 7.3)

The updated assessment method requires in its Section 7.3 to install the test specimen on the test rig "as in practice". However, the test rig (structural frame or supporting construction) imposed by the assessment method doesn't exist as such in a real building. The test specimen can therefore not be strictly fixed "as in practice", and "as far as possible as in practice" doesn't tell more about how it should/could be fixed.

In case of mounting on a supporting construction for instance, suitable anchors for aerated concrete should be used and this could already differ from the ones used "in practice".

As for the case of mounting on a structural frame, the initial assessment method doesn't provide any detailed rules at all for the fixation.

Detailed explanations should be given about the fixation of the test specimen on the test rig in Section 7.3. Several ideas should be investigated:

- fix the first internal layer of the façade on the structural frame, and then fix the other successive layers from internal to external ones according to manufacturer's instructions; this would however probably not follow the usual mounting process
- recreate the building floor slab noses at appropriate heights by means of horizontal beams of the same material and thickness as in practice (concrete, timber…) fixed to front side of the structural frame, the whole façade can then be mounted as in practice; this solution would be relevant
- fix steel angles or U profiles onto the horizontal sections of the structural frame, and then fix the façade to these angles by means of suitable screws, preferably in the vertical loadbearing structure of the façade

Examples should be given in drawings in annex.

The Section 6 "Test specimen" will have to be corrected/updated consequently regarding these fixation aspects.

Junction between façade and floor (optional test procedure) (Section 7.4 and Annex D)

The annex D requires the roof of the combustion chamber to be replaced by the representative floor intended to be used in practice. Examples of such configuration should be given in drawings.

The exact positions where the thermocouples shall be placed should be exemplified by some examples given in drawings in an annex of the updated assessment method.

Conditioning of test specimen (Section 8)

The requirements on how to manage the conditioning of the test specimen, including the use of a mock-up, is interpreted differently. It should be made clear that in presence of any hygroscopic materials, the stabilization of the moisture content shall be followed up by means of a mock-up, and if not then the conditioning shall be made in accordance with the test sponsor's specifications. In presence of any hygroscopic materials, the mock-up procedure shall be used.

This will also imply to give a definition and examples of hygroscopic materials, for instance:

- the following materials shall systematically be considered as hygroscopic:
  - any timber, even if treated with any material (paint, varnish, chemicals…)
  - any concrete (cement based, aerated…)
  - any plaster/gypsum based material
  - any organic fibre (of vegetal or animal based)
- the following materials shall systematically be considered as anhygroscopic:
  - any metal or resulting alloy (steel, stainless steel…)
  - any mineral fibre (glass wool, rock wool, ceramic fibre…)
  - any petroleum base product (EPS, plastic, rubber, …)

Another solution could be to impose the use of a mock-up in any case.

Regarding the dimensions of the mock-up and the faces to cover in plastic, the drawings included in questions 8.2.5 and 8.2.8 should be given as examples in annex.

Internal thermocouples (Section 9.1.3)

The assessment method requires to position internal thermocouples at the mid-depth of each combustible layer and air cavity, and a reminder that "combustible" is defined in Section 3, which specifies "material whose Euroclass ranges from B to F or whose reaction to fire performance has not been determined". It was clear from the answers that this requirement was not always followed i.e., some participants had not applied thermocouples in materials with Euroclass B to F, or when no Euroclass had been declared.

The assessment method should require that when no information on reaction to fire is available for a layer of material, then it is mandatory to place thermocouples in this layer.

The drawings of the façades 1 and 2 used in this theoretical Round Robin should be given as examples (see drawings below the table in Section 1.3.2 above).

Performance criteria (Section 11) and Test report (Section 12)

Assessing the test results according to the definitions of the performance criteria reveals many errors for both fire spread and falling parts.

The current fire spread criteria are based on the temperature rise. Thus, it has to be computed from the measured absolute temperature measurement. It has been shown that this processing creates difficulties for some laboratories, resulting in errors. The proposal is to base the criteria on the absolute temperature instead of the temperature rise. The differences from test to test based on differences in ambient temperature is judged to be small since the failure criteria are relatively high temperatures compared to the ambient temperature.

Several simple numerical examples should be given in annex regarding the application of the criteria definitions. Examples with and without the occurrence of a failure should be given.

Direct field of application (Section 13)

The assessment method requires in Section 12 that a field of application can only be granted in cases where the tested façade has achieved at least one of the classifications provided in Section 14, otherwise, the dedicated section in the report shall mention "Not applicable". This rule should be reminded at the top of Section 13.

The application of Section 13 of the DIAP should be review according to the decision in Section 7 above (use of a standardised frame).

Classification (Section 14)

Several simple numerical examples should be given regarding the application of the classification definitions, bases on fictitious test results.

General

It should be considered how testing of flat vertical specimens on the provided flat L-shaped test rig could eventually allow to assess irregular-shape façades (curved, inclined, other kind of joints than the horizontal or vertical ones…).

2.2. Questionnaire regarding capacity in terms of height of specimen of test laboratories with EU

Some members of the project steering group raised the question of how many laboratories would be able to perform indoor or outdoor façade testing when the assessment method will be released. To answer this question, the EGOLF members have been surveyed. EGOLF has 61 European member laboratories, and additionally laboratories in Hong Kong, Israel, and UAE.

Currently, 12 laboratories are equipped with indoor test rig. The façade heights that can be tested ranges from 3 m to 13 m. 12 laboratories are able to test façades up to 3 m high, 6 laboratories are able to test façades up to 7,5 m high, 1 laboratory is able to test façades indoors up to 13 m high.

Equivalently, 7 laboratories are equipped with outdoor test rig. The façade heights that can be tested ranges from 2.4 m to 20. The distribution of number of laboratories and their maximum height capacity is shown below (Figure 2.1.).

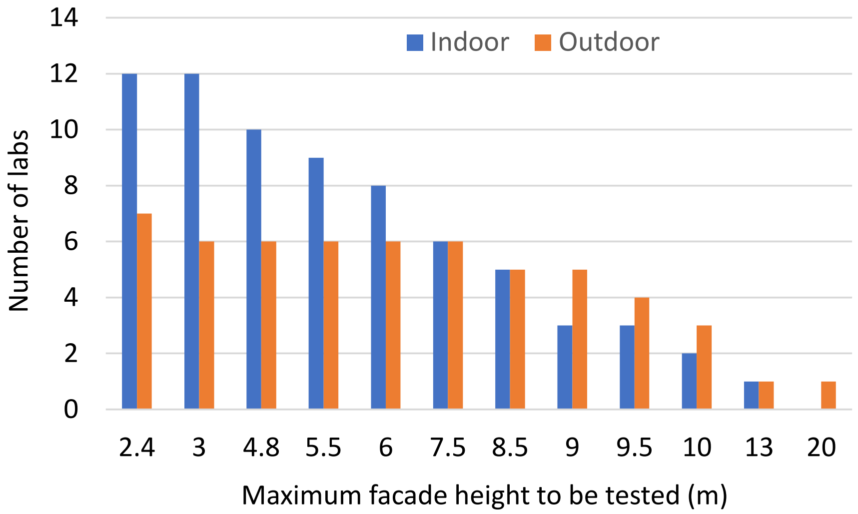


Figure 2.1. Number of laboratories that can perform indoors or outdoors testing on façades with maximum height.

The location of these laboratories are well distributed over the European union, see Appendix D – Laboratory capacities for more information.

In the case where a new European method would be published in the future, 19 laboratories state that they would eventually develop facilities to perform indoor tests on façades. Among them, 8 laboratories would plan a maximum testing capacity above 8 m in height. Equivalent numbers for outdoor testing are 12 laboratories aiming for building this capacity of which 9 said to target a maximum height of 8 meters or more.

2.3. Questionnaires regarding falling parts

Project steering group representing EU Member States and stakeholders were asked to fill out a questionnaire regarding the future measurement and assessment of falling parts. Seven authorities from different countries and five associations replied to the questionnaire. See 'Appendix E – Falling parts, questionnaire summary' for details on the questions.

In general, the respondents had very different opinions suggested criteria for falling parts and there was no clear background to the motivations. Most authorities stated that limiting falling parts was a part of their regulatory requirements, but the assessment was ambiguous. The most important aspects of the questions are summarised below:

<u>Threshold on falling parts</u>

Regarding defining a threshold on falling parts using a mass criterion, half of the respondents did not consider mass to be a suitable criterion. Among the others, half considered 1 kg to be a suitable threshold while the rest believed that 5 kg would be suitable. Two countries (Sweden and Austria) highlighted that an area of individual falling parts (0.1 and 0.4 m^2, respectively) would adhere to their national criteria.

On the time during which a falling part would need to burn in order to be considered a burning part, most respondents answered that small parts could burn without this being a problem while larger parts would need to exhibit 30 seconds of sustained flaming after falling to be considered burning falling parts.

<u>Hazards of falling parts</u>

The respondents were asked to suggest other classifications to possible hazards of falling parts. The answers differed widely, and it was pointed out that there is an expectation that falling parts should only originate from the area directly impacted by the primary fire source. Also, it was mentioned that falling parts are rarely a problem by the time the fire brigade has arrived and secured the area, but that objects larger than 5 kg would make sense. It was also mentioned that small objects of large size could travel substantial distances and therefore a criterion for 0.25 m^2 would be suitable (the third suggestion of area criterion). It was also speculated that the momentum or energy of the impact could be assessed by e.g., the height from which the part fell.

Background arguments

In the third question, respondents were asked if they had any background motivation to criteria on different aspects of falling parts.

- On the *duration* for which criteria should apply. 30 minutes was suggested by 2 respondents based on the time for fires to climb two stories and the normal burnout time. Another respondent answered equally long as the fire resistance criteria of the corresponding wall.
- On size or mass of falling parts. No background was provided.
- On burning droplets/solids. Respondents referred mostly to the Euroclass system.
- On the distance from the façade the criteria should apply. One respondent said that any distance from the façade is sensitive for progression of the fire.
- On the relevance of the criteria discussed. Several respondents answered that too much falling parts would violate their national codes of safety for people, rescue services and fire spread. One stated that this might just as well be assessed from a qualitative judgement.

Historic cases

The respondent was asked to provide any real historic cases behind the motivations of having regulatory specifications of falling parts if such existed. Very few anecdotal examples were provided but generally the problem was nevertheless addressed by the building codes.

Relation with other hazards

Should the regulations on falling parts in case of fire be different from that of other hazards (explosions, wind loads, deterioration etc)? Generally, the respondents stated that they should be the same regardless of hazard.

Alternative approaches

Do your regulations allow for alternative ways to mitigate hazards from falling parts (e.g. rules or protection for fire fighter, covered egress paths etc)? Several countries answered that mitigation of risk through other measures may be allowed under certain circumstances, several mention that the regulation of building safety should not regulate how a possible fire fighters intervention have to be designed.

3. Introductory tests

The introductory tests aimed at determining the variability of the exposure to the façade with respect to variations in design of the wood crib and other aspects of the rig design and surrounding conditions. This is needed to ensure a robust method before the experimental Round Robin exercise. The results presented here is a synthesis of the results presented in the reports:

1. Test Report Large Wood Crib Test

   https://www.ri.se/sites/default/files/2021-04/Test%20report%20Large%20Exposure%20Crib%202021-04-06.pdf
2. Test Report Medium Wood Crib Test

   https://www.ri.se/sites/default/files/2021-04/Test%20report%20Medium%20Exposure%20Crib%202021-04-06.pdf
3. Test Report Large-scale

   https://www.diva-portal.org/smash/get/diva2:1603032/FULLTEXT01.pdf
4. Test Report Medium-scale

   https://www.ri.se/sites/default/files/2022-05/EU%20Cladding%20Project%20ReportOLTLFD-v3.pdf
5. Role of secondary opening in large exposure tests https://www.ri.se/sites/default/files/2022-05/Report%20Role%20of%20secondary%20opening%20Large%20exposure.pdf

3.1. Literature survey

A critical review of the standard BS 8414-1:2020 Fire performance of external cladding systems has been done by Schulz et. al (2020), see Table 3.1. To summarize five different topics needs to be addressed as follows:

1. Fuel source – the current definition of the fire source in BS 8414 may lead to a large variability on the fire exposure to the test specimen.
2. Test construction – detailed description of what has been tested is needed, and the test specimen shall be built as in practice, where it is especially pointed on the boundary around the combustion chamber.
3. Full-scale experimental investigation into the effects of different construction detailing between tests and real buildings – it is pointed out that the incorporation of windows and vents would significantly improve the assurance of the fire safety provided by the test.
4. Revised criteria – the current failure criteria are questioned. A more diverse classification is asked for due to the diversity of buildings instead of the current pass/fail result. Furthermore, falling parts need to be assessed as well.

These are all within the scope of the present project for a European method.

One of the main questions is if it is necessary for the test to be performed indoors? Such requirement gives better control of the ambient conditions but might also reduce the number of testing laboratories in Europe that can perform these tests. Testing indoors does not guarantee good testing conditions in itself due to differences in e.g., a smoke extraction system. Below we review the requirements for some national methods in terms of the ambient conditions during testing.

Table 3.1

Ambient testing conditions

Test method	Description of ambient conditions
LEPIR test	**Ambient temperature:** No requirement. **Ambient humidity:** No requirement **Velocities:** Maximal highest wind velocity of 3 m/s measured during 15 minutes at mid-height of the first level (ground level) at a distance of 1 meter of the façade. Neither rain nor snow. **Building requirements:** Not concerned – outdoor test **Extraction system:** No requirement
MSZ 14800-6	**Ambient temperature:** +20 +/-10°C **Ambient humidity:** No requirement **Velocities:** Measurement of the air velocity at appr. 2 m height. The limit is 1m/s. Neither rain nor snow **Building requirements:** outdoor test **Extraction system:** No requirement In case of something happening during the test (light rain, unexpected flurry) it is noted in the report, and an expert evaluation is given.
DIN 4102-20	**Ambient temperature:** Temperature is measured 1 m in front of test rig at 1 m height above test room floor and the measurement has to be between 5 °C and 35 °C **Ambient humidity:** No requirement **Velocities:** Before the beginning of the test the air velocity in front of the test rig is measured, 1 m above the center of combustion chamber, 100 mm distance from the wall. The velocity is allowed to be around 0.5 m/s while a peak of 1 m/s is allowed for a short period of time. **Building requirements:** Test to be prevented from influences of weather **Extraction system:** A mechanical extraction (duct with fan) above the test rig is allowed, all changes in air inflow and extraction conditions during the test are to be documented
DIN 4102-24 (Sockelbrandversuch)	**Ambient temperature:** Temperature 1.5 m in front of test rig at 1.5 m height above test room floor has to be between 5 °C and 35 °C **Ambient humidity:** no requirement **Velocities:** Under discussion as air numerical simulation of wind effect suggests that measuring velocity in greater height of the test rig correlates better with influence on test; neither wind nor a mechanical extraction system should influence the burning of crib and specimen. **Building requirements:** The test rig is to be prevented of weather influences with a testing hall, minimum distance from surface of the test rig wall is 6 m to walls of the hall. Minimum distance from top of test rig to ceiling of testing hall is 2 m. Minimum area for incoming air is 3 m². The area for the incoming area must be fixed during the tests. **Extraction system:** A mechanical exhaust system is allowed.
BS 8414	**Ambient temperature:** The test apparatus shall be protected from adverse environmental conditions such as water, windload and ambient temperatures outside the range -5°C to +40

Test method	Description of ambient conditions
	°C during the application, curing and test period. The ambient temperature at the start of the test shall be within the range (20 ±15) °C. The test shall not be conducted during fog or precipitation. **Ambient humidity:** No requirement **Velocities:** The air velocity at level 2 when measured (1 000 ±10) mm forward from the centre line of the combustion chamber opening in any direction shall be less than 2 m/s at the start of the test. **Building requirements:** No requirements **Extraction system:** No requirements
SP Fire 105	**Ambient temperature:** No requirements but the tests should be performed indoors **Ambient humidity:** No requirement **Velocities:** No requirements and not measured but all tests are performed indoors **Building requirements:** Normally 150 000 m^3/h is extracted and that is usually sufficient. If needed capacity can increase to 240 000 m^3/h. **Extraction system:** No requirements

3.1.1. Wood cribs

The following aspects of the cribs are assumed to influence the thermal impact to the façade and are assessed in the initial testing.

Wood species:
The DIN and BS tests use spruce and pine, respectively. This might generate wider range of densities compared to those restricted for only one species. See details, also for other test methods in table 3.2.

Density of the wood:
The kind of wood and the area from where it is purchased from are important for the density range which will be available. The further north in Europe the timber is grown the denser it is. The limits for the assessment method must allow for purchasing the wood throughout all of Europe. A range of densities used in the UK for BS 8414 tests is given in table 3.3. Density changes must be investigated in the initial testing activities.

Surface treatment - planed / sawn:
It is not known if the surface treatment itself will affect the early part of the crib burning. This must be tested in the initial testing activities. A smooth surface will on the other hand better define the stick dimension, which likely plays a role for the burning behaviour.

Humidity of the wood:
The magnitude of the influence of wood moisture on the results is not totally clear. Obviously, it affects the weight and will to some degree also affect the burning rate of the wood. Limiting the range for the moisture gives probably a better reproducibility of the wood cribs but also involves large efforts for conditioning, sorting and handling. Moisture content is addressed in the initial testing.

Weight of the crib / geometry of the crib:
In the DIN method the weight of the crib is the value which is fixed. It is allowed to add and remove sticks to reach the total crib target weight. In the BS method the geometry of the crib

is fixed and the range for the weight is wider. Depending on how the conditions of combustion of the crib are defined one might be more influential than the other. The initial testing program is designed to give answers to these questions.

Construction of the crib (nailed / not nailed):
In the DIN method the crib is nailed while it is not in the BS method. Stability of the crib is enhanced when nailed, while increasing workload and costs. Advantages of nailed cribs also include movability and possibilities for pre-manufacture.

Standard climate or indoor with ambient conditions:
Several methods do not require standard climate to store the wood for the wood cribs. However, as described above the moisture content is directly linked to the weight of the wood. Therefore, it might be valuable to store the wood in a standard climate. Ambient conditions are discussed in Table 3.1.

Ignition of the wood crib:
Several ignition methods are used in different national façade test methods.

We also study (the highly limited amount of) reports on investigations and test series of wood cribs. This forms the basis for the initial testing program (Table 3.2).

Below we give characteristics of the cribs used in different national test methods.

Table 3.2

Characterization of wood cribs used in different national façade test methods

Test method	Description of wood cribs used
LEPIR test	**Kind of wood:** Spruce 480 +/- 50 kg/m^3, section 60 x 70 mm, 60 x 40 mm and 100 x 23 mm in length 1 m. Total mass of 600 kg **Surface treatment, e.g., raw/planed:** Raw **Humidity of the wood:** between 9% and 15% **Arrangement to prevent possible early collapse during test:** Nailed **Conditioned in Standard climate or indoor with ambient conditions:** Indoor only **Experience / data – HRR of wood cribs, MLR:** ~5.5 MW peak **Ignition of the wood crib:** 5 l of heptane and 5 l of diesel filled in steel panes of 500 x 500 mm
MSZ 14800-6	**Kind of wood:** 650 kg of spruce (*Picea abies*). The cross section of the sticks is 2.5 x 5cm. The length of the sticks is 1.5 m and 2.0 m. Between the sticks there is spacing 5 cm. Height varies according to the density of the wood. Moisture content and total weight is measured before test. **Surface treatment, e.g., raw/planed:** Raw surface **Humidity of the wood:** Between 12 ± 2%. **Arrangement to prevent possible early collapse during test:** No nailing **Conditioned in Standard climate or indoor with ambient conditions:** Indoor only. When the wood arriving to the laboratory, usually it is very wet, therefore it is usually kept inside a building for several weeks. **Experience / data – HRR of wood cribs, MLR:** - **Ignition of the wood crib:** 10 kg of diesel oil and 1 kg of wood chips in a metal tray. Ignited by a match.

Test method	Description of wood cribs used
DIN 4102-20	**Kind of wood:** Soft wood, e.g., spruce (*Picea abies*), 30 ± 1.5 kg, density (475 ± 25) kg/m³, sticks (40 ± 2) mm x (40 ± 2) mm x (500 ± 10) mm. Wood air ratio of app. 1:1. Sticks of the lowest level are parallel to back wall, 6 sticks per level. Number of sticks at the upper level is adjusted to weight of (30 ± 1.5) kg. Ground area 500 mm x 500 mm **Surface treatment, e.g., raw/planed:** planed **Humidity of the wood:** Not given, but see conditioning below. **Arrangement to prevent possible early collapse during test:** nailed **Conditioned in standard climate or indoor with ambient conditions:** Conditioning in standard climate until constant weight (DIN EN 13283) **Experience / data – HRR of wood cribs, MLR:** one test series was performed at MFPA Leipzig in 1999, only a summarized version of results is available. **Ignition of the wood crib:** 200 ml isopropanol each in two metal containers (w x l x h) (25 mm x 500 mm x (30 ± 5) mm in second layer of sticks is ignited by an open flame.
DIN 4102-24 (Sockelbrandversuch)	**Kind of wood:** 200 ± 5 kg spruce with density (475 ± 25) kg/m³ on ground area of 1.1 m x 1.1 m. Sticks with dimensions of w x h x l = 40 (± 2) mm x 40 (± 2) mm x 1100 (± 10) mm, wood air ratio of approximately 1:1. Sticks of the lowest level are parallel to back wall, upper level number of sticks adjusted to weight of crib. **Surface treatment, e.g., raw/planed:** planed **Humidity of the wood:** 10 – 12 %, measured according to ISO 4470 for 5 specimens with a length of 500 (± 10) mm **Arrangement to prevent possible early collapse during test:** nailed **Conditioned in standard climate or indoor with ambient conditions:** Conditioning in standard climate until constant weight (DIN EN 13283) **Experience / data – HRR of wood cribs, MLR:** yes **Ignition of the wood crib:** Four containers (w x l x h = 25 mm x 1100 mm x 20 mm) with each 400 ml isopropanol evenly distributed on lowest level (distance to edge: 0.14 m, distance between: 0.27 m)
BS 8414	**Kind of wood:** Timber, Softwood sticks, of Pine (*Pinus sylvestris*). They shall be sawn and of square section of side (50 ± 2) mm and lengths of (1500 ± 5) mm and (1000 ± 5) mm. The density of the wood shall be 400 kg/m³ to 650 kg/m³ at the time of test. The first layer has 10 long sticks of 1 500 mm. The next layer shall consist of 15 short sticks evenly distributed to cover an area of 1 500 mm × 1 000 mm. Repeat this process to give a total of 20 layers of sticks giving it a nominal height of 1 000 mm. In total use 150 short sticks and 100 long sticks. **Surface treatment, e.g., raw/planed:** raw **Humidity of the wood:** 10% - 15% **Arrangement to prevent possible early collapse during test:** Not nailed, but mounted with careful levelling **Conditioned in Standard climate or indoor with ambient conditions:** No **Experience / data – HRR of wood cribs, MLR:** ~3.MW **Ignition of the wood crib:** Ignite the crib using 16 strips of low-density fibreboard. Soak the strips uniformly for a minimum of 5 min with 5 l of white spirit. Not more than 5 min before ignition, insert 14 strips into the spaces between the timber sticks in the second layer of the crib (i.e. 50 mm above the platform) allowing approximately 30 mm to project from the front of the crib. Place the remaining two strips horizontally across the 14 projected strip ends. Ignite only these two horizontal strips across their full length.

The density and moisture content variations used in BS8414-1 testing at BRE during two years were extracted and the variations are shown below (Table 3.3). They are well within the allowable range of the standard.

Table 3.3

Density distribution in recent BS 8414 tests at BRE

	Average	Std dev (%)	Min	Max
Density (kg/m^3)	515	8.2 %	433	620
MC (%)	12.0	9.6 %	10.0	15.0

Since the crib is defined according to a fixed geometry, these variations will correspond to equivalent variations in the total fuel load during the test.

There is no compiled data for density variations in the DIN tests, but the standard specifies a narrow density range of 475 (±25) kg/m^3 of the spruce used in the test. The weight of crib / density has to be measured before beginning of test after conditioning in standard climate, which usually is a process of two weeks until equilibrium.

3.1.2. Test rig

The test rigs of the methods throughout Europe are all very different in size and shape. The height of most rigs is meant to represent an adequate part of the building that is needed to assess the performance of a façade or façade system. In most building regulations in Europe, it is tolerated that the fire jumps from one storey to the next (via the windows). That happens even with non-combustible façades. A fully developed fire in three storeys at the same time is not tolerated by the fire service and most building authorities. That means the façade fire should not propagate faster than a "jump" from one storey to another through windows. A fire can only jump from one window to the next when the room behind the first window has a fully developed fire with flames escaping through the window. Only, after a fire enters the next storey and develops fully in that compartment the fire can jump to the next storey.

The timeline of these events means that at least the time for a fully developed fire to develop must be taken into account. Thus, a fire travelling along the façade should not reach the window two storeys above the first window in less time than it takes to reach a fully developed fire on the floor directly above the original fire where the façade does not contribute to the fire spread. Ideally, this time is long enough to ensure that the fire service arrives on the scene before the third storey is involved in the fire.

There are some other aspects about the rig geometry that was dealt with in the initial testing program:

- Adjusting the size of the combustion chamber to address different specimen thicknesses (in contrast to moving the return wall or wing wall of the rig). Thus, the combustion chamber must be built bigger to allow adjustments.
- Adjusting the combustion chamber to the smaller combustion chamber for medium fire load.
- Secondary opening to accommodate for testing of detailing around openings in the façade system.

- Uplift – Since there is a risk that falling parts or material is ignited or re-ignited on the floor below the combustion chamber the uplift is investigated. This was deemed unnecessary due to the maximum feasible uplift is around 0.5 m. An uplift of more than 0.5 m would severely impact the cost whereas it might only partly mitigate the risk of reignition of debris on the scale.

3.2. Wood crib tests

3.2.1. General

The wood cribs used in the current national methods vary considerably, although the wood used is always softwood, either pine or spruce. The geometry of the sticks is different in each method, and the specification on the amount of wood is different. Also, the permissible moisture content varies in the different methods.

Initial tests on cribs were performed in a combustion chamber with only a small (just over 1 meter) façade extension above the combustion chamber. These tests aim to study the largest variations concerning the cribs before parametric studies using a full façade would commence.

3.2.2. Timber

All wood for the crib tests were delivered and sponsored by Swedish Wood. Two different sawmills were used to produce the timber for the wood sticks, and they also prepared all sticks, sawing, planning (when needed) and drying of 4400 sticks.

For each stick the dimensions and moisture content were measured. The density at 12 % moisture was thereafter determined (adjusting for shrinkage on drying) for all sticks.

The density distribution for all wood sticks, divided between spruce and pine is shown below (Figure 3.1.). The density is higher for pine, a mean density of 486 kg/m^3 (median 481 kg/m^3) compared to spruce with mean density of 453 kg/m^3 (median 455 kg/m^3).

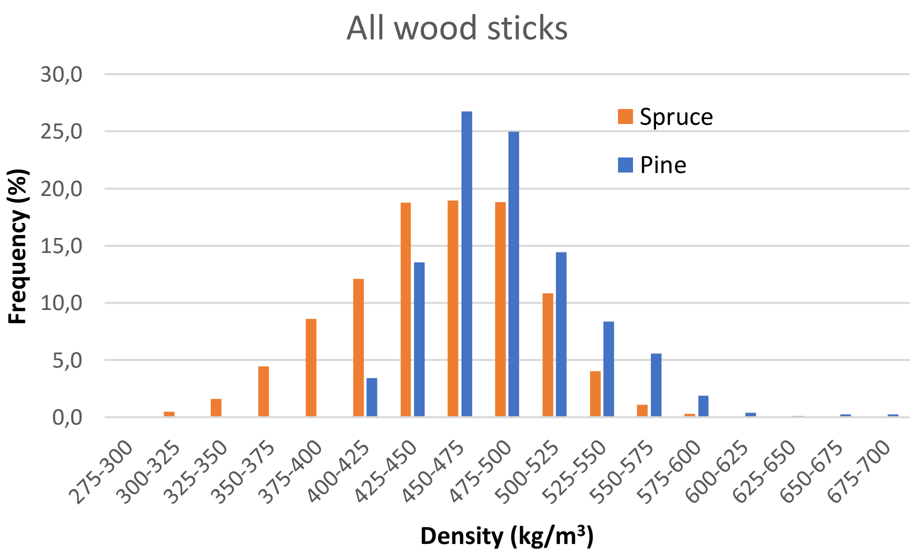


Figure 3.1. Frequency of density of all wood sticks.

The density distribution of the spruce was, as expected, different between the two sawmills (Bergqvist and Sandåsa), see Figure 3.2. Mean densities were 472 kg/m^3 and 432 kg/m^3, respectively.

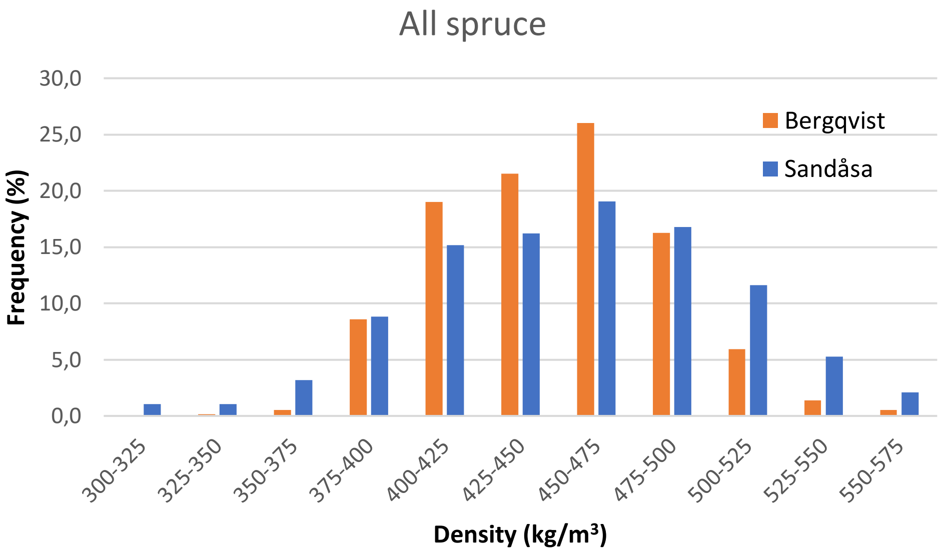


Figure 3.2. Density distribution of the spruce sticks.

3.2.3. Test program

The timber pieces provided by Swedish wood were sorted to form 3 classes of density: high, average and low. Some batches were also conditioned to 9-10 % moisture (labelled as low moisture content) while others were stored to increase moisture to ~15 % (labelled as high moisture). The rest had an average moisture content of ~12.5 %.

Tests using a smaller version of the façade, just over 1 meter high above the combustion chamber, without a wing wall were performed at Efectis. Separate reports are published with a detailed description of the tests (Fire test report no EFR-20-002989 and Fire test report no EUI-20-000358). These reports are available on the project home page together with all data obtained during the tests.
Table 3.4 and Table 3.5 show the test programmes for the large and medium wood crib tests, respectively. It should be noted that for the tests L0 and L8 with the large fire exposure, the cribs used were the standard cribs in accordance with BS 8414 test method.

Table 3.4.
Test programme for large wood crib tests.

Reference	Species	Surface	Density	Moisture	Section	Floor	Chamber
L0	Pine	Sawn	Average	Average	50x50	Grated	Large
L1	Spruce	Planed	Average	Average	47x47	Solid	Large
L2	Spruce	Planed	Low	Average	47x47	Grated	Large
L3	Spruce	Planed	High	Average	47x47	Grated	Large

Reference	Species	Surface	Density	Moisture	Section	Floor	Chamber
L4	Pine	Planed	Average	Average	47x47	Grated	Large
L5	Spruce	Planed	Low	Low	47x47	Grated	Large
L6	Spruce	Planed	Low	High	47x47	Grated	Large
L7	Spruce	Planed	Low	Average	47x47	Solid	Large
L8	Pine	Sawn	Average	Average	50x50	Solid	Standard

For all tests, stick sizes averages at 1504 mm and 1034 for long and short sticks, respectively.

Table 3.5.

Test programme for medium wood crib tests.

Reference	Species	Surface	Density	Moisture	Section	Floor	Chamber
M0	Spruce	Sawn	Low	Average	47x47	Grated	Standard
M1	Spruce	Planed	High	Average	47x47	Grated	Standard
M2	Spruce	Planed	Low	Average	47x47	Grated	Standard
M3	Spruce	Sawn	Low	Average	47x47	Grated	Standard

3.2.4. Results

Detailed comparisons are given in Appendix F – Results from wood crib tests and below a summary of the findings is given. Comparisons are made mostly using HRR from an oxygen consumption calorimeter and in some cases with temperature measurements on the short façade extension above the combustion chamber.

HRR measurements vs mass loss rate

The HRR calculated from the mass loss rate compared to the HRR measured by a calorimeter, collecting all smoke from a hood just above the small façade extension, was very similar assuming a heat of combustion 17.9 kJ/g and 16.4 kJ/g for pine and spruce, respectively. After 20 minutes the HRR increased in relation to the mass loss but similar for all test, this was the period where collapse of the cribs had commenced.

It was later discovered in the tests with full height inert façade that measuring HRR with a hood was more complicated and arbitrary if the hood was above 6 meters from the fire instead of the close location from these crib tests.

Wood species

The pine (*Pinus sylvestris*) cribs clearly yield higher HRR than the spruce (*Picea abeis*) cribs. The more vivid burning resulted in an earlier collapse of the crib. It also came to our knowledge that pine timber was not available throughout all of Europe.

Furthermore, BS 8414 states that the total heat release during the test, i.e., for 30 minutes, shall be 5 GJ. This is obtained with spruce while pine shows values of 6 GJ and higher.

Heat fluxes on façade

Heat flux to Gardon gauges 1 m above the upper edge of the opening showed that the previous allowable range for BS 8414 (45 and 90 kW/m^2 for a duration of 20 minutes) was achieved for the spruce cribs but not for the pine cribs. However, these were achieved using a grated support for the cribs so that they were ventilated from below.

Moisture content

Heat fluxes, HRR and temperatures on the façade extension were all affected by the moisture content of the cribs. However, it only had a marginal effect on the levels of HRR and temperatures but a larger influence on the timing to the plateaus and peak (Figure 3.3.). Thus, increased moisture content delayed the onset of high exposure as well as the reduction of exposure and collapse of the crib.

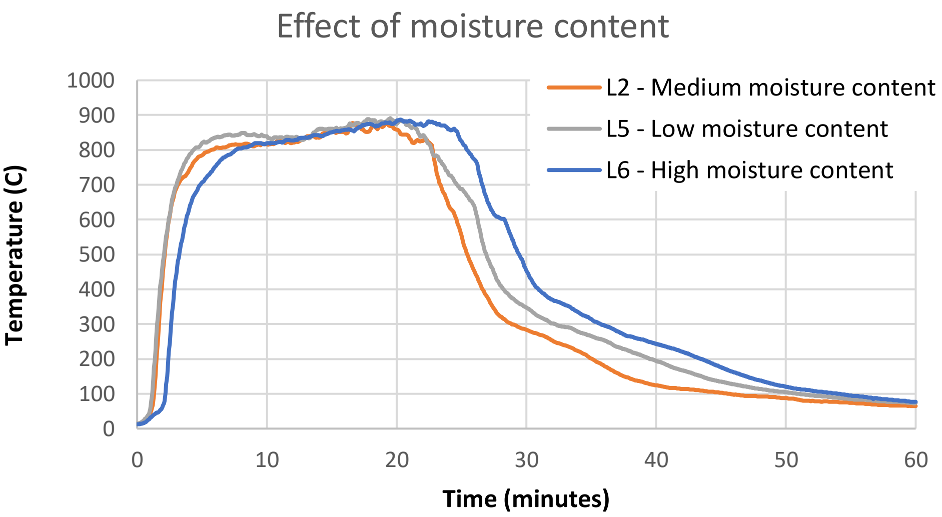


Figure 3.3. Temperatures measured with plate thermometer placed 1 m above the upper edge of the combustion chamber. The average moisture content of cribs L2, L5 and L6 was 10.0, 8.7 and 14.5 %, respectively.

Density

A high density had, for the large exposure, the same effect as the increased moisture content of the crib. It delayed both the onset of high heat release rate and the decrease of the same, see Figure 3.4.

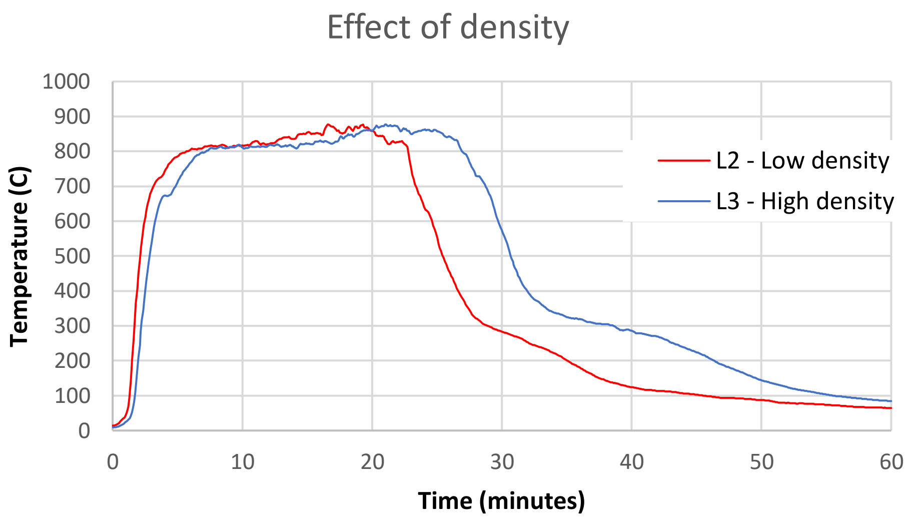


Figure 3.4. Temperature measured with plate thermometer 1 m above the upper edge of the combustion chamber. The average densities of L2 and L3 were 301 and 400 kg/m^3, respectively.

For the medium exposure, in which the cribs had identical mass, but different density of the wood, the HRR and temperatures are lower when using wood with higher density, see Figure 3.5. It is not possible to say whether the effect is due to the density per se or the fact that the specific surface size of the wood crib decreases for higher density.

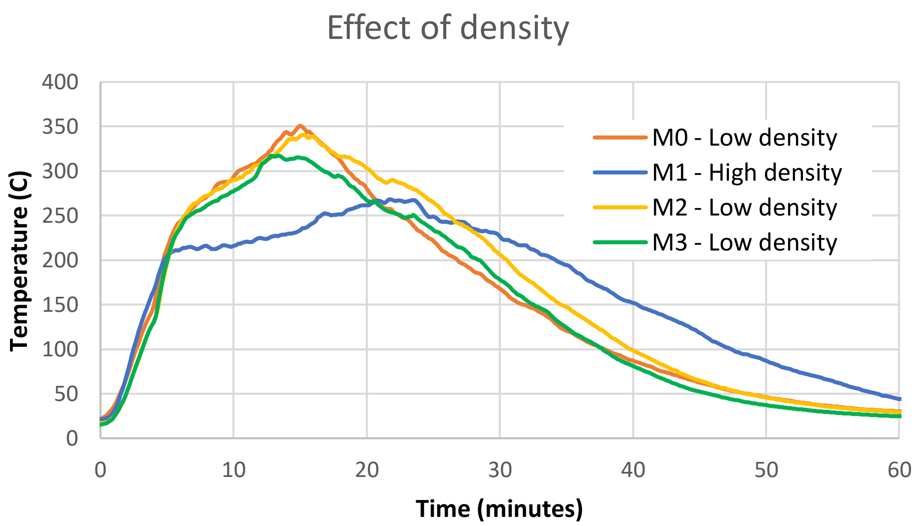


Figure 3.5. Temperature measured with plate thermometers 1 m above the upper edge of the combustion chamber with cribs M0 to M3, medium heat exposure. Crib M1 had a high density, while the other cribs had a low density.

Surface finish

Planed and sawn surfaces were examined, both with the medium and large wood cribs. The test results did not show any difference on the measured temperatures and HRR.

Platform porosity

In DIN 4102-20 a grated floor of the platform is used, i.e., the crib is enabled ventilation from below. In BS 8414 the crib is placed on a solid floor, i.e., there is no ventilation from below. We noticed a significant difference in the measured temperatures and HRR, where the grated floor exhibits higher temperatures and HRR. The wood crib also kept its stability for a longer time before collapse for the solid floor.

Stick size

The tests L4 and L0 (BS 8414-grating) are made with cribs with cross-sectional dimensions 47 x 47 mm2 and 50 x 50 mm2 respectively. There is also a small difference in average density (L4, ρ = 355 kg/m3 and L0, ρ = 368 kg/m3). The only notable difference in the measured characteristics is that the stability of the crib with a larger cross section is longer and thus the burning continues at maximum intensity for a longer period, (Figure 3.6.).

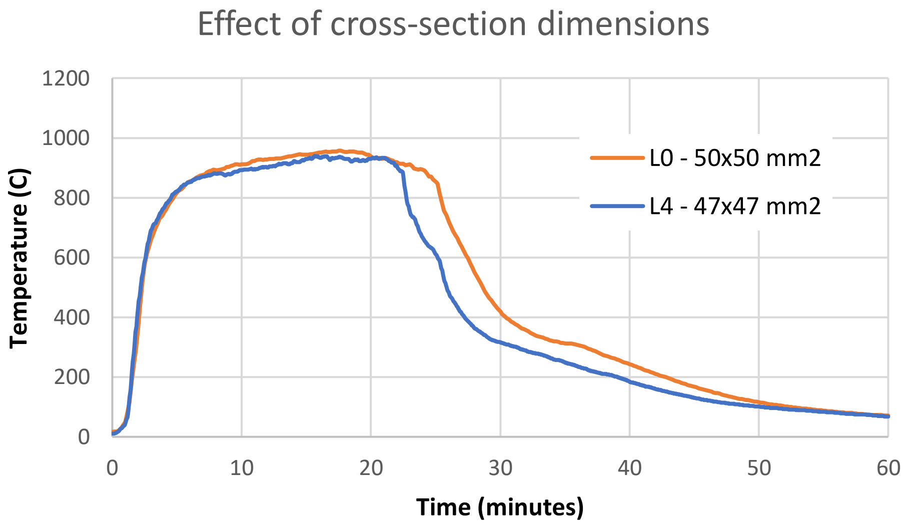


Figure 3.6. Temperatures measured with plate thermometer 1 m above the upper edge of the combustion chamber in tests L0 and L4.

The medium wood crib is likely to be more sensitive to changes in the fuel source i.e., stick dimensions, and likely requires narrower tolerances.

3.3. Numerical investigations on combustion chamber

The purpose and aim of the numerical investigation, using Fire Dynamics Simulator (6.6.0) were to determine, if possible, differences between the regular (2.0 m x 2.0 m in width and height) and the modified combustion chamber (2.4 m x 2.0 m in width and height). In addition, one simulation with a 300 mm thick façade specimen (with the thermal properties of light weight concrete) was included in the study. There might be differences in the dynamics due to the difference in volume, the results were evaluated by computing the heat release rates and temperature measurements in front of the chamber as well as heat flux to the façade. More details are presented in the Appendix G.

In order to characterize the crib, three plate thermometers (PTs) were placed symmetrically outside the chamber 0.5 m from the façade surface and 1.5 m above ground. When comparing the width extension of the combustion chamber, simulations indicate only a small difference in HRR, where some differences in the PT (0.5 m away directed towards the fire) temperatures in front of the combustion chamber are found, whereas good agreement in heat fluxes at 2.9 m above ground is found. Thus, it is indicated that this change may have a limited effect on outcomes from testing.

In comparing the effect of the façade specimen thickness, large differences in temperatures in front of the combustion chamber are found, which has been seen before in both experiments and numerical work. Moreover, there are significant differences in the heat fluxes around 2.9 m above ground. If, eventually, the test method has to compensate for this difference, then a change of wood crib placement is needed.

The proposal on geometry of the combustion chamber is for the medium heat exposure test to maintain the definition as it is in DIN 4102-20, and for the large heat exposure test to make an enlargement since only minor differences were found. There are two main advantages by extending the size of the combustion chamber for the large heat exposure test:

- Firstly, by extending the width of the combustion chamber, it is possible to have the same test rig configuration for all façade thicknesses (limited in this proposal to façades up to 400 mm thick). This will simplify the work needed during the mounting and preparation of the test specimen. The calculations show only a small effect due to this change.
- Secondly, with the extended depth of the combustion chamber, the wood crib can be moved into the chamber with two benefits: firstly it limits the risk that falling parts from the tested specimen may hit and thus affect, possibly destroy, the wood crib during the test, and secondly it allows for limited extension of the solid floor of the platform in order to collect the charred sticks falling from the crib, which would bias the weight measurement of falling parts.

The calculations show that the thickness of test specimens affects the temperatures and heat flux impingement with reduced values. It is reasonable to assume that extending the depth of the combustion chamber and moving the wood crib further in would lead to a lower heat exposure to the test specimen. Although, the tests performed with wood cribs show that the heat exposure obtained is high, and it will still be a significant heat exposure even if it is reduced to some degree.

3.4. Exposures to full façade structures

Series of tests using naked supporting construction (no façade specimen erected) were performed after the initial wood cribs tests. These included one series of six tests for large exposure performed indoors to investigate sensitivity and repeatability on an incombustible façade, one outdoor test for comparison, one series of three tests for medium and three tests for large exposure using combustible materials to investigate placement of a secondary opening, one series of four tests investigating an alternative fuel source, and one similar series of tests for the medium exposure.

3.4.1. Parametric study using full inert façade

From the results in the initial wood crib testing, additional tests using spruce was decided upon. In a series of tests, the repeatability of the test method and the sensitivity to different variations were investigated when applied to a full size inert (incombustible) façade. The details and full results are reported by Sjöström et al. (2021b) and can be found on the project webpage. Seven tests were performed whereof one was a test on unburnt construction (Test 0 – unburnt construction refers to test on the façade testing rig with virgin materials.), three were aimed for repeatability (1-3), one was with a shallower combustion chamber (4), one was with applied wind (5) and one used smaller stick sections for the wood crib (6) (Sjöström et al. (2021b)), summarized in Table 3.6.

Table 3.6.

Test parameters of the tests on a full-scale inert façade.

Test number	0	1	2	3	4	5	6
Section size (mm)	47.6±0.5	47.7±0.5	47.6±0.7	47.5±0.7	47.7±0.7	47.5±0.8	44.9±0.8
Layers	24	23	25	24	23	24	26
Crib height (cm)	114	110	119	114	110	114	117
Density (#sticks probed)	469 (24)	454 (32)	421 (74)	423 (105)	442 (65)	436 (70)	448 (80)
Total mass (kg) Probed	382	355	358	343	347	351	353
Total mass (kg) Load cells	-	-	352	340	N.A.	-	349
MC (%) #sticks probed	14.0 (24)	13.84 (32)	13.12 (303)	12.19 (105)	13.44 (65)	11.35 (70)	12.94 (80)
Nailing		2nd layer, 3rd joint	2nd layer, 3rd joint	all layers, 2nd joint	all layers, 3rd joint	all layers, 3rd joint	all layers, 3rd joint
Variation	Unburnt structure	Repeatability #1	Repeatability #2	Repeatability #3	1 m deep comb chamber	Applied wind	Smaller stick section

Density as well as moisture content was measured for a number of sticks from each crib (n = 24 – 106), see Sjöström et al. (2021b). In Test 4 the combustion chamber was only 1 m deep (as in BS 8414) instead of 1.3 m in the other tests. Thus, the crib was positioned such that the front face was outside of the façade's external surface. In test 5, wind was applied using a number of fans. The wind direction was towards the façade corner and the speed close to the façade was between 1.5 and 2.5 m/s (maximum at 1 m height above the Combustion Chamber (CC)) during a central vertical line 1 meter from the façade, see the report for details (Sjöström et al., 2021b). Square sticks with roughly 47.5 mm side were used for all tests except test 6 where 45 mm sticks were used.

For all test the average mass loss rate of the cribs was highly similar, regardless of the variations in parameters, 0.212 ± 0.02 kg/s. Test 2, 3, 4 and 6 were all similar with regards to the temperatures along the façade with test 1 at 65 – 80 °C lower temperatures. Test 5, with applied external wind, exhibited considerably less exposure to the façade.

The results suggest that

- Wind has the absolutely largest influence on both flame height and temperatures recorded by both plate thermometers and thermocouples on the façade. It is worth noting that despite the reduction in temperatures, the mass loss rate of the crib was 5 % higher in the wind test compared to tests 1 – 3.

- The change in stick size made very little difference, except for a shorter time to when substantial collapse of the crib happened (out of the combustion chamber).
- Test 1-3 had similar mass but varying moisture content (within 1.5 % points) and density (within 30 kg/m^3). The crib height (within 10 cm) influenced temperatures on the façade more than both moisture and density did.
- A less deep combustion chamber also increased the temperatures on the façade, mostly on the lower parts (Figure 3.7.).

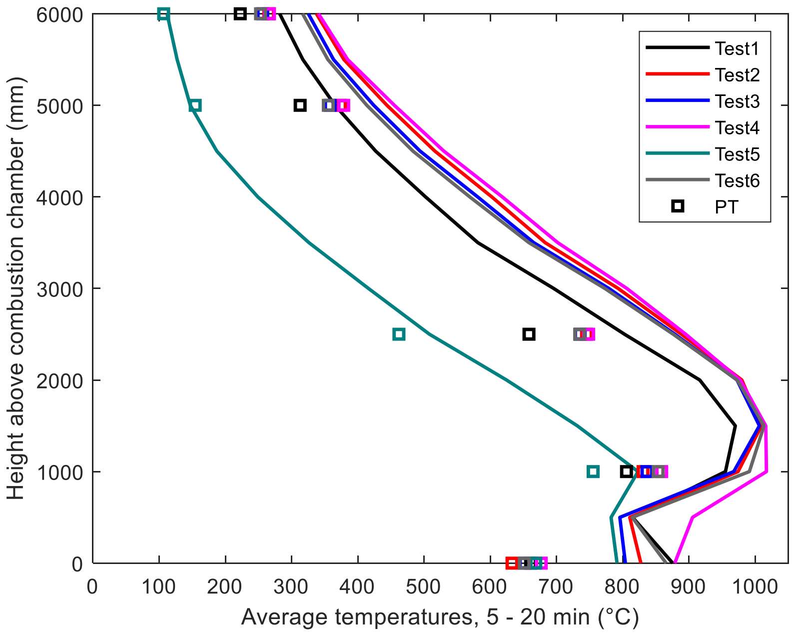


Figure 3.7. TC (solid lines) and PT (□) temperature variations with heights for all tests. The temperatures are averaged over 5 – 20 minutes after ignition.

3.4.2. Outdoor vs indoor testing

An inert façade was also tested in outdoor conditions. Details of this test can be found in the test report (Efectis, 2022) and are summarized here. The ambient weather conditions were temperatures between 1 °C and 2 °C and relative humidity between 80 - 86 %, Table 3.7. The wind was 0.5 – 1.7 m/s, measured at 5 m height. These conditions are acceptable for testing using the BS8414 and Lepir 2 but not for the MSZ 14800-6 method for which the wind speed limit at 2 m height is 1 m/s. The inert lightweight concrete structure had been placed outdoors for a long time and was, at least on the surface, in equilibrium with the outdoor climate (therefore moist).

There was also a slight change in combustion chamber geometry where plate that supports the crib was a full solid floor. Thus, the 40 cm void under the plate was absent in the outdoor test.

Table 3.7.

Test characteristics during the outdoor test.

Parameter	Value
Temperature (°C)	1 – 2
Relative humidity (%)	80 – 86
Windspeed (m/s)	0.5 – 1.7
Crib height (cm)	105
Crib moisture (%)	9.9
Stick density (kg/m³)	447
Stick dimensions (mm)	48 x 52
Crib mass	355
Mass loss rate, average 5-20 min (kg/s)	0.195

The result from the test showed significantly reduced temperatures along the horizontal line above the combustion chamber. The difference is around 150 - 200 °C for the Thermocouples (TCs) and 100 – 200 °C for Plate thermometers (PTs, a piece of thin metal with welded TCs with insulation on the back of total size 10 cm by 10 cm.), see Figure 3.8. The differences cannot be entirely attributed to the wind condition. The façade surface had been acclimatized to the outdoor conditions and was therefore quite moist, close to the surface (something that had shown little effect from test 0 to test 1 in the indoor test). There are also differences in the combustion chamber which might have changed the air supply. On the other hand, the mass loss rate of the crib was only 5 % lower than during the three repeatability indoor tests, something which had only marginal effect on the indoor results.

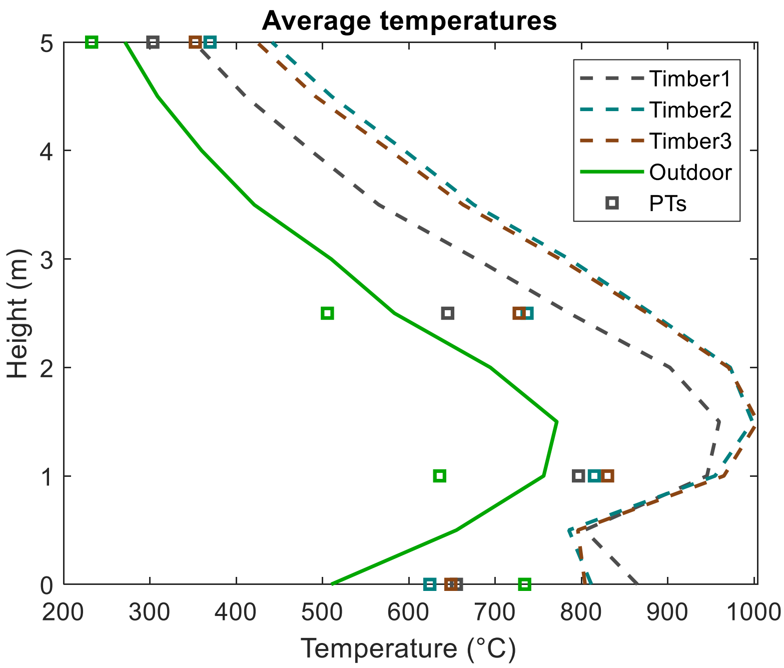


Figure 3.8. TC (solid line) and PT (□) temperature variations with heights for the three indoor repeatability tests (dashed lines) and the outdoor test (solid line)

3.4.3. Position of the secondary opening

From the countries which include a secondary opening in their test methods the experience is that it is often at these openings where the weakest point of the façade can be found. Thus, it was planned to investigate how the existence of such opening and its position would influence the exposure to the façade. However, the opening may have varying impact on different systems. In particular façade systems involving cavities or multiple layers can exhibit a disadvantage of such secondary opening. Using a real façade system could therefore produce results which were valid only for that system. We therefore tested a combustible, homogeneous material allowing for flame spread with the assumption that such system would elucidate how the position of the opening affects the result. From the obtained results it is not possible to determine if the absence of combustible material reduce temperatures or if the edge of combustible material is a source of high temperatures.

The supported construction was therefore cladded with a 100 mm thick combustible insulation material with Euroclass C-s2, d0 as per EN 13501-1 and its nominal density 35 kg/m^3. Three tests were executed, one without an opening, one with an opening placed eccentrically over the combustion chamber and one with an opening placed symmetrical over the combustion chamber opening. The opening size was 1200 by 1200 mm and placed 1500 mm above the combustion chamber, see Figure 3.9.

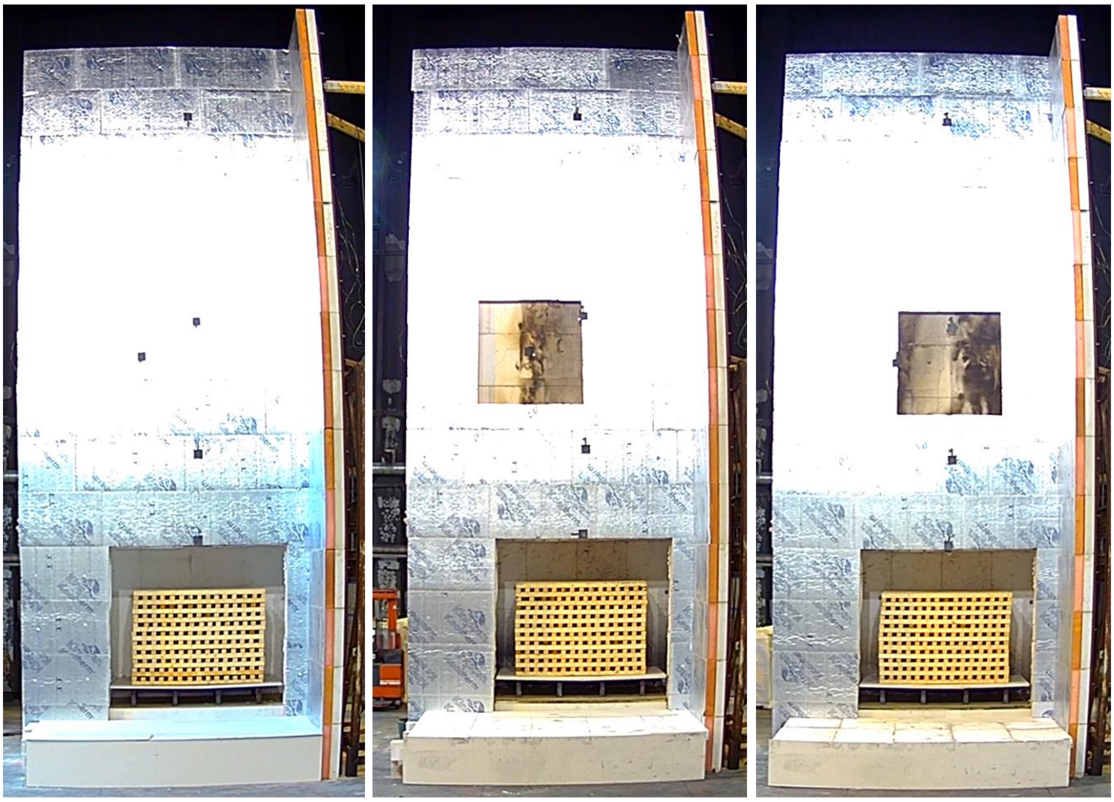


Figure 3.9. The three combustible façades, with and without secondary openings at different positions before testing. Note that the curvatures of the walls are due to the camera not having a flat projection.

Details of the tests can be found in the report on the project website (Sjöström and Anderson, 2022). The three cribs were close to identical and mass loss rate was the same within the small natural variation. All tests had the same evolution where the first 10 minutes characterised by a lack of substantial contribution from the façade. After 15 minutes, however, temperatures increased significantly as the façade material itself burnt.

The main result of the tests are the average Thermocouple (TC) temperatures before and after flaming of the façade material in three vertical arrays above the combustion chamber, see Figure 3.10. The only place where the test without an opening clearly showed higher temperatures was at the lowest array, which actually passes through the opening, and this happened only when considerable flaming from the façade material occurred. For all other times and positions the three tests showed similar results. The small, but systematic, changes that could be noted was that temperatures above the opening were somewhat increased. This was noticed both for the early phase, without significant façade involvement, and (in particular) for the latter phase, Figure 3.10.

It is therefore concluded that an eccentric placement of the secondary opening is preferred and that this should not decrease exposure to the façade. The eccentric placement of the secondary opening allows for uninterrupted flame spread on the surface as well as flame spread impeded by the secondary opening.

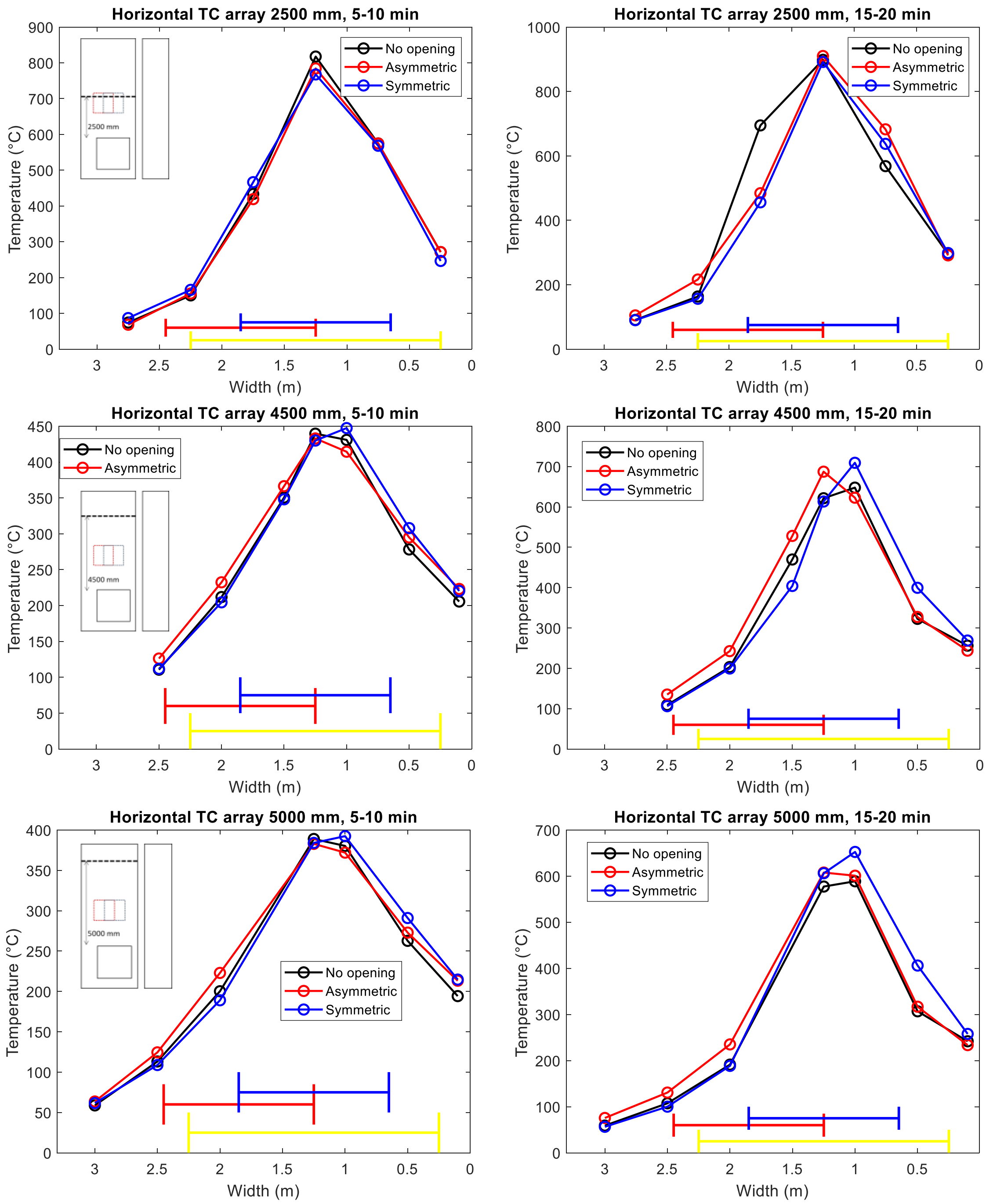


Figure 3.10. The average TC temperatures during early (left) and late (right) stages of the test for horizontal lines of TCs at 2.5 mm (upper panels), 4.5 m (central panels) and 5 m (lower panels) above the CC. The x-axis in each panel is the distance from the façade corner and the y-axis denote the average temperatures. The yellow interval represents the width of the combustion chamber whereas the blue and red interval represent the lateral position of the opening in the symmetric and asymmetric case.

3.4.4. Alternative fuel source

Using 350 kg of wood crib as fuel source for the large exposure is associated with a number of challenges. It is in the interests of authorities, the industry and laboratories to keep costs of testing low as that will favour testing of systems. Cutting, conditioning, controlling and building the crib is a time consuming and expensive task. The crib also requires a large combustion chamber, which therefore requires a tall structure, something which inherently implies higher costs and fewer laboratories that can perform the test. In addition, the cribs can never be completely identical and the variations in burning will always differ. They will collapse at some point and sometimes this occurs during the tests period. The collapse will produce a lot of glowing char in front of the façade, possibly obstructing assessment of falling parts. Finally, the heat source is difficult to instantly supress which put higher requirements on safety during the tests and more work on cleaning the combustion chamber after the test.

The (now obsolete) BS 8414-2:2002 option of alternative heat source should be assessed with three water cooled Schmidt-Boelter heat flux meters (HFMs) flush to an inert façade 1 meter above the combustion chamber opening. The criterion for adhering to the standard was total heat flux between 45 and 95 kW/m^2 for a continuous 20 minutes period. This alternative was however removed in later versions of the standard.

Figure 3.11. Photo from the gas test using 100/80 cm high combustion chamber/opening and a mass flow corresponding to 2.2 MW.

We performed tests using a 150 cm wide and 100 cm deep sand diffusion burner of steel. The burner consists of a 15 cm high rectangular steel pan and 10 cm high supports, see Figure 3.11. The pan is filled with sand and gravel. A pipe is connected to the pan fuelling it with propane regulated by a mass flux meter which in turn is calibrated under an oxygen consumption calorimeter. The propane diffuses in the sand forming relatively homogeneous flaming over the whole sand surface.

Using the combustion chamber designed for the wood cribs made it impossible to mimic the temperature distribution along the façade. Temperatures were usually too low in the upper parts or, if matching there, they were too large in the lower parts.

The combustion chamber was therefore rebuilt in to reduce its volume and creating more flaming in the external pluming. The full width was kept but the height of the chamber was reduced to (1) 100 cm (with an opening height of 80 cm) and (2) 80 cm, with an opening height of 60 cm.

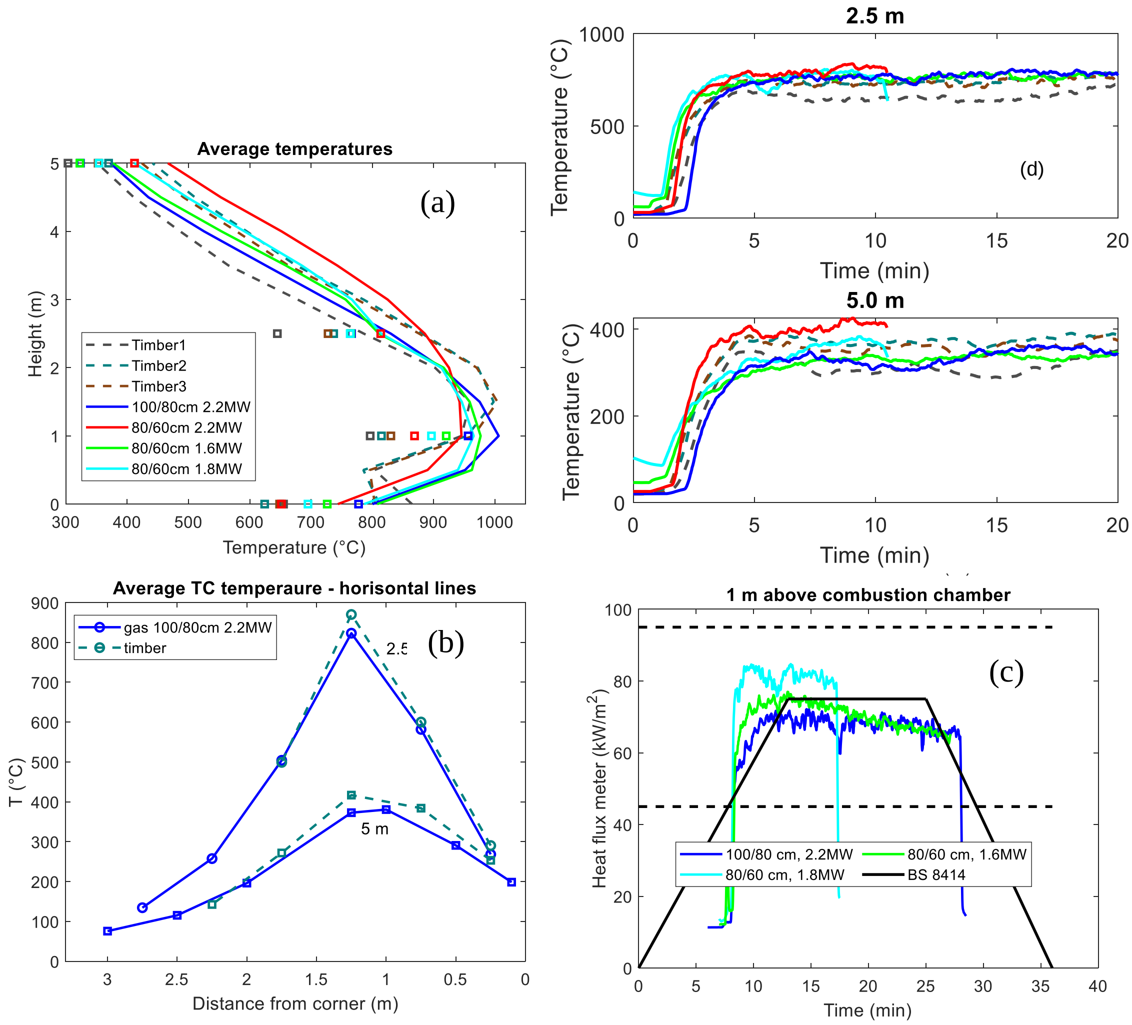


Figure 3.12 Comparing the timber tests with the gas tests using a reduced combustion chamber. (a) Average TC and PT temperatures along the height of the combustion chamber. (b) Average TC temperatures for one the horizontal lines at 2.5 and 5 m height for one of the gas tests and the average of the timber tests. (c) Heat Flux Meter (HFM) measurements at 1 m height from the (obsolete) BS 8414 and three of the gas tests. (d) time evolution of the PT temperatures during the timber and gas tests.

Key results from the tests using a reduced combustion chamber show that there is very good potential to control the temperatures on the façade to correspond to the timber tests. Both a chamber of 100/80 cm using 2.2 MW and 80/60 cm using 1.6 MW showed TC and PT results that were right among the timber tests (Figure 3.12.). However, this was done with additional internal funding using a limited test series and not part of the contract. Further investigations are needed to finalize gas as an equivalent fuel source.

3.4.5. Experimental procedure for medium fire exposure

Similar tests were also performed for the medium fire exposure. All the tests are detailed in the test report (BRE, 2022) which is also available on the project website.

The experimental programme for the medium fire exposure consisted of ten tests and aimed to explore reproducibility (Test series D), the influence of air flow into the combustion chamber (test series E-F) and the position of the secondary opening for a combustible material (Test series K). An overview of the tests is shown in Table 3.8 below.

Table 3.8.

Proposed experimental programme and the associated parameters.

Test ref.	Wood crib parameters	Moisture content (%)	Air flow (m^3/h)	Uplift (m)	Secondary opening location	Test specimen
D1	497	11.6	400	0.5	Eccentrically (50 mm deep)	Inert
D2	504	12.5	400	0.5	Eccentrically (50 mm deep)	Inert
D3	499	11.8	400	0.5	Eccentrically (50 mm deep)	Inert
E1	504	11.9	360	0.5	Eccentrically (50 mm deep)	Inert
E2	506	12.8	440	0.5	Eccentrically (50 mm deep)	Inert
F1	505	13.6	420	0.5	Eccentrically (50 mm deep)	Inert
F2	495	13.2	380	0.5	Eccentrically (50 mm deep)	Inert
K1	476	10.8	400	0.5	Without	PIR
K2	463	10.8	400	0.5	Symmetrically	PIR
K3	458	10.1	400	0.5	Eccentrically	PIR

Examples of the temperatures measured on the façade are the PT measurements at 2 m above the combustion chamber for series D (repeatability) and E-F (air flow variations), see Figures 3.13 and 3.14. More details can be found in Appendix H – Parametric studies on the medium exposure with façade.

The repeatability tests, all using 400 m^3/h for the airflow into the combustion chamber, are summarised in Characterisation of medium fire exposure fuel source – BRE Report P117805-1000 Issue: 1. Total spread in average TC- and PT-temperatures (during the peak burning rate between 5 - 15 minutes) is about 100 °C just above the combustion chamber, but less than 50 °C for heights >1 m from the opening.

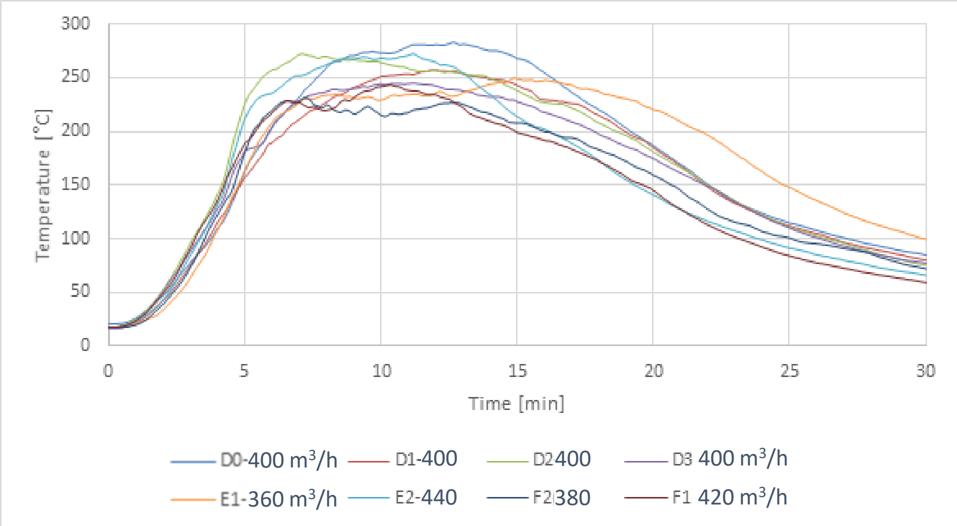


Figure 3.13. Plate thermometer (PT) measurements at 2.0 m above the combustion chamber. The numbers after the labels refer to the airflow into the combustion chamber during the tests.

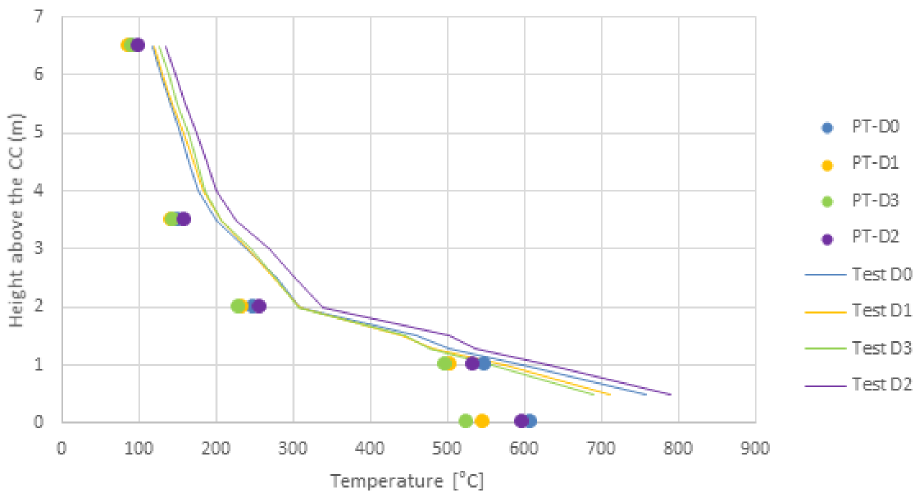


Figure 3.14. Temperature distribution on the central axis above the combustion chamber (CC) for test series D (repeatability, 400 m³/h air into the CC). Lines and symbols represent TC- and PT measurements, respectively.

The largest effect of changing the airflow is closest to the combustion chamber and that the maximum values increase with increasing airflow, but the duration of the high temperature period is simultaneously reduced.

The three tests in the K-series investigated the position of a secondary opening. It was found that the position of the opening had very little influence on the measured temperatures on the façade. See Appendix H – Parametric studies on the medium exposure with façade for more details.

3.5. Comparisons to real façade exposures

The exposures from the L1 – L7 tests are also compared to the exposure from a number of real compartment tests carried out by RISE during fall of 2020 in a project about exposure of mass timber surfaces in tall buildings (Sjöström et al, 2021a). In this test series, five compartment tests were carried out and on top of the compartment an inert façade was placed upon which temperatures of thermocouples (TCs) and plate thermometers (PTs) were collected. The tests were aimed to constitute severe but representative examples of compartment fires with different degrees of exposed mass timber. This was established from a survey of fuel loads, geometries and opening factors of real modern residential and office buildings.

The façade extension had embedded PTs and 1 mm TCs one meter above the top of each of the openings and could therefore be compared to the exposure to the façade from tests L1 – L7. Comparing the PT temperatures shows that the exposure to a surface at 1 m height in L1 – L7 are fairly similar to that of the most severe compartment tests in terms of both duration of the high exposure period and the actual temperature of the PT (Figure 3.15.).

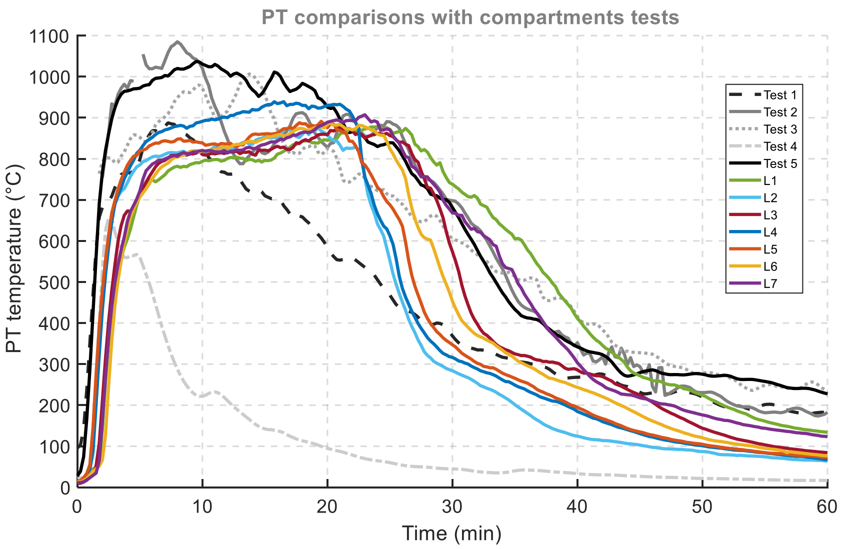


Figure 3.15. Comparisons on the exposure to the façade, 1 m above the opening (combustion chamber or compartment) by PT measurements between L1 – L7 (coloured) and four full scale compartment tests (grey scale) (Sjöström et al, 2021a). The curves corresponding to the compartment tests (Test 1-5) are shifted to each time of flashover for the compartment (here t = 0).

3.6. Conclusions exposure to full façade structures

The combination of reports and tests using full façade structures can be summarized with the following conclusions.

Large exposure

The large exposure tests show good repeatability, at least when performed indoors. Data on exposure in terms of TC and PT temperatures are available from the tests performed in the project.

The exposures to the façade show that a constant height rather than a constant mass of the crib is more important to minimising variations. We therefore change the assessment method to define the height of the crib to 110 ±2.5 cm. Also, the ranges of stick section (47 ±3 cm), timber density (500 ±100 kg/m^3) and timber moisture content (11 ±2 %) of the cribs is acceptable for the variations as long as the start of the test is defined by a starting criterion of the lower horizontal line of TCs.

We decide to increase the combustion chamber depth to 1300 mm between the insulation at the back of the combustion chamber to the front surface of the supporting construction.

The existence of a secondary opening indicates little increase in temperatures above the opening for a homogeneous combustible material and is not likely to reduce temperatures above the combustion chambers for most façade systems. Based on our tests we suggest including the secondary opening of 1200 by 1200 mm centred 2100 mm above the combustion chamber top and 1850 mm from the façade corner.

The same thermal impact to an incombustible façade could also be achieved using a diffusion gas burner and a reduced height of the combustion chamber however this option would require further investigation.

Medium exposure

Performing tests using the medium exposure indoors showed very good reproducibility using 400 m^3/h airflow into the combustion chamber.

Changing the airflow to the combustion chamber have only limited impact on the average temperatures measured on an inert façade. Only the highest airflow (440 m^3/h) showed substantial increase in the average temperatures. However, the airflow does affect the duration of the intensive burn period for the crib and the heat flux measured in front of the combustion chamber, see report for details (BRE, 2022).

As for the large exposure, only small differences could be noticed with regards to the placement of the secondary opening. Similar or higher impact was detected for the areas above the opening, and we suggest to include the opening in the asymmetric position relative to the combustion chamber.

Based on our tests we suggest including the secondary opening of 1200 by 1200 mm centred 1600 mm above the combustion chamber top and 1100 mm from the façade corner.

4. Experimental Round Robin

4.1. Selection of specimen

A properly designed Round Robin for both medium and large fire exposure is key to finalising the development of the test and assessment method. The purpose of the Round Robin is two-fold, first to assess the repeatability of the method and outdoor testing possibility; second to find the performance criteria in the new method to as far as possible match the performance levels set by the previous recognized methods in the EU member states.

To be able to calibrate the assessment method (e.g., in large-scale) it is necessary to add the measurement points used in the BS 8414-2 in the large-scale method, see Figure 4.1.

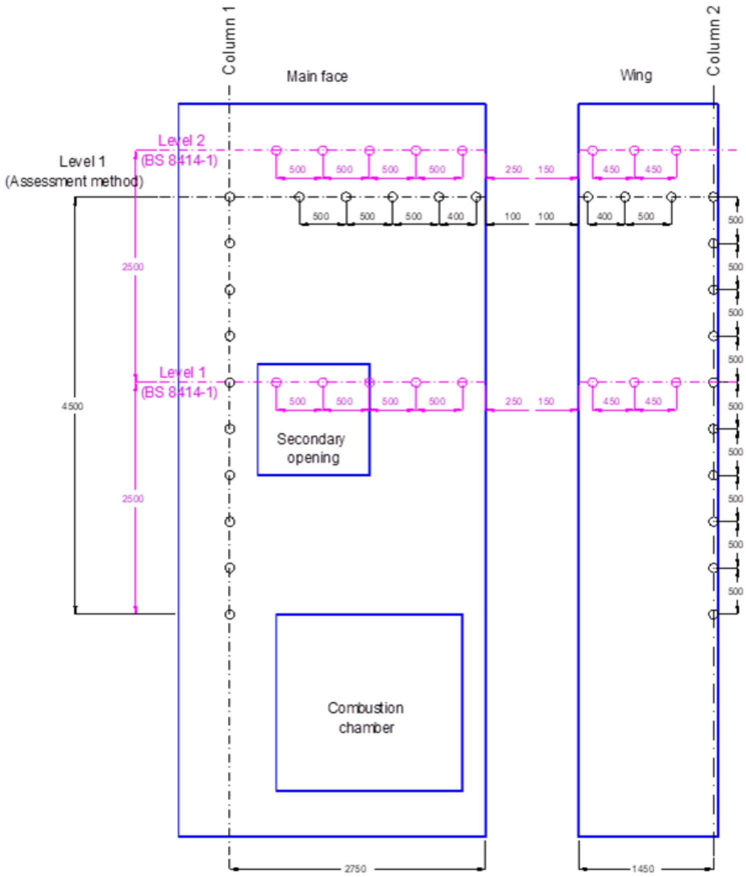


Figure 4.1. The measurement locations in the Round Robin for the large-scale testing.

These measurements will be at the surface only and to be used to obtain the starting time and surface temperatures that can be compared with those found in the test reports using other existing test methods (BS, DIN).

The "*Technical Proposal*" submitted by the consortium for the tender included:

„At least three different laboratories shall perform tests in accordance with the method defined in Task 2.5. Each of the chosen laboratories shall perform tests with four different façade systems:

- *Rainscreen and render*

- *ETICS*
- *Solid wood with ventilation gap*
- *Inert façade"*

The number of systems that can be tested in the planned Round Robin is limited, partly due to the time and financial resources required for the tests and due to the high cost of the test specimens. Therefore, it is necessary to select such systems that are expected to provide the most usable and relevant results and experience. Systems which have previous results from similar test set-ups are highly preferable.

The consortium approached stakeholders to contribute to the selection of the façade systems to be included in the Round Robin:

"The project consortium has a very good knowledge on fire dynamics and testing procedures but need additional support from the European industry regarding façades and façade systems. Your input will enable the final method to be suitable and applicable for the requirements of different types of façades.

Several façade tests will be conducted in the project, and for these tests we will need suitable test specimens. We are now looking for three different types of systems to be included in the test program;

- *Rainscreen with render*
- *ETICS*
- *Ventilated wooden façade*

The tests to be conducted shall be on systems which are on the borderline on the failure criteria, i.e. the systems shall not be too good or too bad with respect to the fire spread on or within the system. Therefore, we must ensure before the choice of the systems to be included in the test series that we will get relevant results. It is advantageous if the systems to be used have been tested in accordance with at least one relevant national test method in the past which show that the system is on the borderline of acceptance."

Some sample figures were included in the consortium's letter and several comments were received.

The implementation of the Round Robin (and the baseline studies) will impose a considerable challenge to the members of the consortium, as the tender did not provide the funds to build the testing equipment and to purchase the test models. Furthermore, resourcing the materials from the market was not a feasible option because fire test reports most likely would not be available.

It is very important to underline that all stakeholders have shown considerable interest in the progress of the project and were ready to offer not only the specimens of façade kits, data and information about the previous test results but also their installation and mounting on the test rig.

The 24+ element round robin test carried out was the largest of its kind ever carried out in Europe.

4.2. Selected specimen types

The consortium decided that all the Round Robin tests would be carried out on a "supporting wall". The reason for this was that most of the expected façade tests will be ETICS and ventilated cladding. Due to the financial constraints of the project the systems to be tested had to be fully supported by the industry with mounting and specimens.

Furthermore, the scope of the RR could not include curtain walling or the self-supporting façade solutions to be tested on structural frame, however, in tandem tests with curtain walls and ETICS in large-scale exposure was performed sponsored by industrial partners. The results of these additional tests have been fully taken into account by the consortium in the assessment of the test results and in the elaboration of the conclusions. The effect of the slab connection, which is an optional test in the initial proposal of the test method, is not investigated.

4.2.1. Detailed description of the tested systems

The selected systems are summarized in Table 4.1 and 4.2, the full information on the tested systems can be found in the comparative documents, referenced above and available online.

Table 4.1.

Program of the experimental Round Robin

Medium exposure			Large exposure		
Façade type	Number of indoor tests	Number outdoor tests	Façade type	Number of indoor tests	Number outdoor tests
Inert	2	1	Inert	2	1
ETICS	2	1	Aluminium	2	1
Timber	2	1	Timber	2	1
Fiber Cement	2	1	ACM	2	1
			ETICS*	2	0
			Curtain wall with structural glazing*	1	0

*additional tests

Table 4.2.

Participating laboratories of the experimental Round Robin

Participating laboratories	Tested Façade types / number of tests	
	Medium exposure	Large exposure
BRE (UK)	-	Inert/aluminium/Timber/ACM
RISE Boras (Sweden)	Inert/ETICS/Timber/Fiber Cement (4 indoor tests)	--
RISE FR Norway (Norway)	Inert/Timber/Fiber Cement (3 indoor tests)	Inert/aluminium/Timber/ACM (4 indoor tests)
EFECTIS (France)	Inert/ETICS/Timber/Fiber Cement (4 outdoor tests)	--

ÉMI (Hungary)	--	Inert/aluminium/Timber/ACM (4 outdoor tests)
MFPA (Germany)	ETICS (1 indoor test)	ETICS (1 indoor test)*
EFECTIS NI	--	ETICs (1 indoor test)*,Curtain wall with structural glazing (1 indoor test)

*additional tests

Large Exposure

Inert façade

The laboratories used blank light-concrete walls for these tests, see comparative document on inert tests.

Timber façade

The system is a wooden façade with air gap. The façade cladding is supported by a two-way timber lath frame. The timber cladding consists of 36 mm thick vertically spaced planks with intumescent strips between their profiles. A cavity barrier is placed above the openings. The timber materials of the cladding have not been treated with a flame retardant.

Two additional full-width cavity barriers were used in the specimen constructed in the laboratories of the ÉMI and RISE FR NORWAY as shown in Figure 4.2.

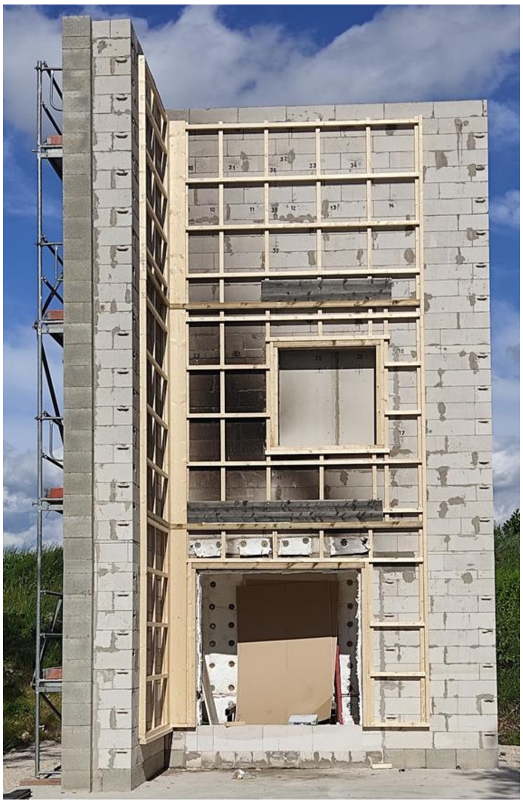


Figure 4.2. Specimen without the timber cladding at ÉMI's laboratory. Additional cavity barriers and additional support for the cladding. Open cavity at the top.

The cladding was made with closed bottom and side junctions. The air gap at the top edge of the specimen node was closed for BRE while it was left open for ÉMI and RISE. No insulation or other material was placed in the air gap. In the corner the cladding had a solid timber support. The total thickness of the cladding was 108 mm.

The substructure consisted of horizontal and vertical timber battens 36x48mm. In the first step of the installation, the vertical timber battens are installed to the masonry construction fixed with screws. In the second step, the horizontal members are mechanically fixed on top of the vertical members. The cladding panels are mechanically fixed to the horizontal members.

Aluminium façade

The specimen comprises prefabricated solid aluminium cassettes panels with a ventilated cavity and incombustible insulation 200 mm thick. The prefabricated 2 mm thick aluminium cladding panels are installed onto a set of aluminium rails fixed back with helping hand brackets to masonry substructure. The insulation is fixed back to the support construction leaving a ventilated cavity approximately 35mm, Figure 4.3.

A set of open state horizontal cavity barriers have been installed as part of the system. The first cavity barrier is installed at approximately 250 mm above the combustion chamber. The second cavity barrier is installed at approximately 2700 mm above the first cavity barrier (just above the secondary opening). The third cavity barrier is installed at approximately 2500 mm above the second cavity barrier (on the top of the specimen).

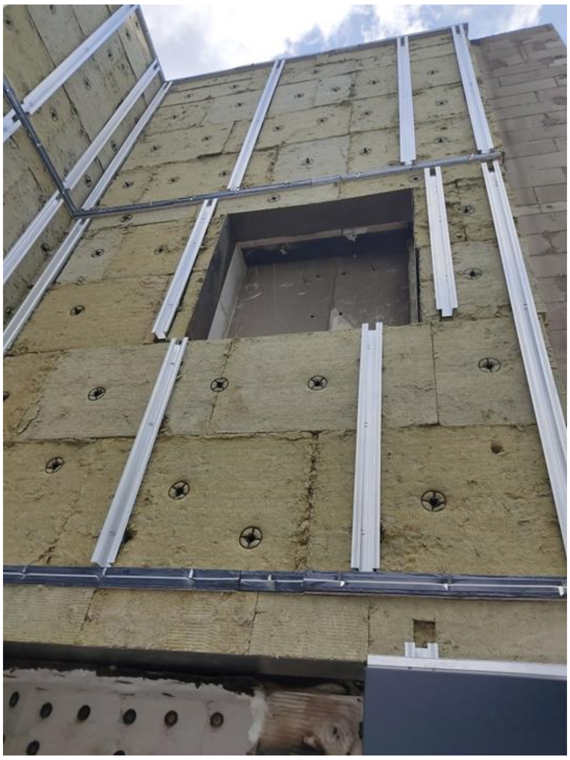


Figure 4.3. Specimen without the aluminium cassette cladding at ÉMI's laboratory.

The cladding was made with closed bottom and side junctions. The façade was delivered and built according to detailed plans. All the components (except the insulation) were pre-cut and delivered to the laboratories.

Total thickness of the façade was 283 mm.

First the brackets were installed on the façade, then the stone wool insulation and the cavity barriers. Then the vertical support frame and the cladding cassettes could be installed. A steel plate profile was installed at the openings to protect the air gap.

ACM façade

The specimen comprises 4 mm thick prefabricated Aluminium Composite Material cassette panels with a ventilated cavity and a combustible insulation 100 mm thick. The prefabricated cassette panels are installed onto a set of aluminium rails fixed back with brackets to the masonry substrate, see Figure 4.4. The phenolic foam insulation is cut to size and fixed back to the support construction leaving a ventilated cavity of approximately 85 mm. The total thickness of the cladding was 188 mm. Vertical cavity barriers were placed at the corner and at the two sides of the specimen and at the sides of the openings. Full width open state horizontal cavity barriers were placed at three different level: above the combustion chamber, approximately 500 mm above the secondary opening and at the top of the specimen. Additional open state cavity barriers were placed above and under the secondary opening.

Figure 4.4. Specimen is under construction at the laboratory of ÉMI.

ETICS

The specimen comprises an EPS-based ETICS with mineral adhesive, glass-fibre mesh, 250 mm thick graphite-containing polystyrene and mineral wool lamella for fire barriers, see Figure 4.5. The base coat was 3-5 mm thick, the organic finishing coat was 2 mm thick. Mechanical fixing devices are used only in the fire barriers see also Table 4.3 for a summary.

Table 4.3.

Main components of the tested ETICS façade

	ETICS kit component (without brand name)
Adhesive	Mineral adhesive, mortar to bond the insulation to the test rig. Application method: Bead and point method. Application thickness: approx. 10-15 mm

Thermal insulation board	EPS; thickness 250 mm
Mechanical fixing devices	Plastic anchor with steel screw, dimension Ø 8 x 295 mm, in combination with additional anchor plates. Used only in area of fire barriers.
Base coat	Application thickness: approx. 3-5 mm Reaction to fire class: A2-s1, d0 according to EN 13501-1
Reinforcement mesh	Weight per unit area: approx. 150 g/m². Mesh size: grid 3.6 mm x 4.3 mm, width: 1000 mm
Finishing coat	Organic finishing render to achieve a stippled texture, layer thickness: 3 mm in applied stage
Corner profiles	Edge profile with integrated glass fibre mesh. Side lengths: 11 cm x 13 cm. Weight per unit area: 280 g/m². Mesh size: 13 mm x 5 mm
Fire barrier (surrounding)	Mineral wool lamella insulation fire barriers with thickness 300 mm and height 200 mm, according to EN 13162 Panel format: 1200 mm x 200 mm x 250 mm. Fire behavior: A1 (according to EN 13501-1) Melting temperature: ≥ 1000 °C

Figure 4.5. Specimen is under construction at the laboratory of MFPA.

Curtain wall

The specimen comprises an assembly of curtain wall with structural glazing, see Table 4.4 and Figure 4.6.

Table 4.4.
Main components of the tested structural glazing

	Curtain wall – component (without brand name)

Aluminium profiles	Dimension : 35 x 164 mm. Composition : Aluminium (EN AW 6060 - T66) Colour: Aluminium, mill finished and anodized Thermal conductivity: 220 W/(mK), Density: 2.70 g/cm³, Reaction to fire class: A1
Thermal break within aluminium profiles	Dimension: 61.4 mm Colour: Black Thermal conductivity: 0,175 W/(mK) Density: 1.18 g/cm³ Reaction to fire class: E
EPDM gaskets	Colour: Black Thermal conductivity: 0,038 W/(m*K) Density: 1.4 g/cm³ Reaction to fire class: E
Silicone sealant	Density: 1.5g/ml. Colour: Black
Thermal insulation	Dimension: 1200 x 600 mm. Thickness: 75 mm. Overall thickness: 150 mm. Thermal conductivity:0.035 W/mK. Reaction to Fire: A
Glass panels	Vision glass (transparent areas), of 8.76 mm thickness Annealed, low-e solar control glass -16 mm Argon 90% -laminated 44.2 Spandrel glass (opaque areas), of 8.76 mm thickness Thermally toughened, low-e solar control glass -12 mm Argon 90% -silicone 6 mm heat strengthened float
Chamber surrounding angle frame	Steel, Dimension: 2400 x 60 x 30 mm Thickness: 1.5 mm.
Chamber surrounding angle frame	Steel, Dimension: 2400 x 51 x 215 mm Thickness: 1.5 mm.

The multiple layers of mineral wool insulation was fixed to the spandrel panels with the help of steel profile. At ground level a steel box section, of nominal dimension 6000 x 50 x 50 mm and of thickness 3 mm was installed on to the laboratory floor using bolts. The prefabricated curtain wall panels were hook mounted into the slots on the aluminium brackets installed on the steel beams. At ground level the panels sit in the slots cut on the SHS (Steel Hollow Section). At the interface between panels both horizontally and vertically, synthetic rubber gasket was installed. The gaskets were sealed using silicone sealant. On the non-exposed side of the joints, synthetic rubber gasket was installed.

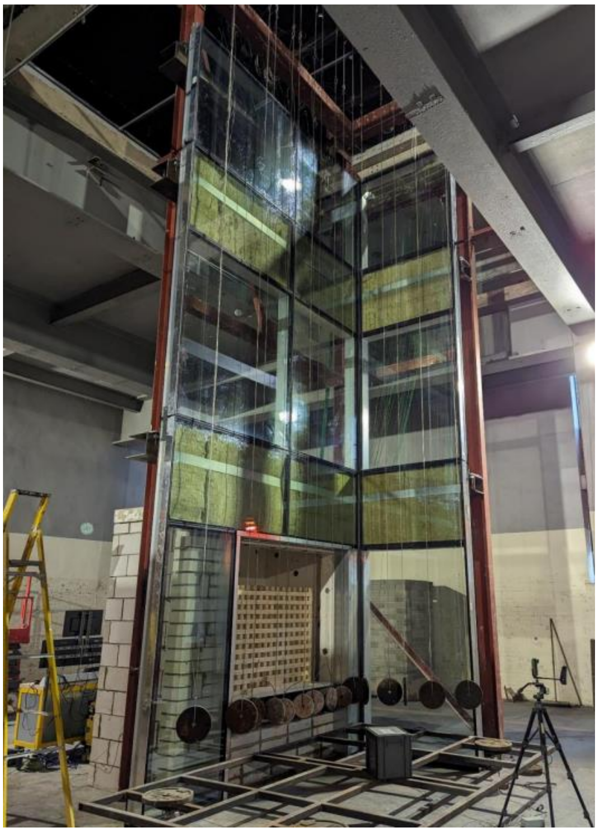


Figure 4.6. Specimen is ready for testing at the laboratory of EFECTIS NI.

The information on the testing rigs of the participant laboratories (large exposure) are given in Table 4.5.

Table 4.5.

Testing rigs of the participating laboratories

	Location of the rig	Wing Wall width/height above CC /location	Main wall width/height above CC	Uplift from ground
RISE FR NORWAY	indoor	2.00m /5.80m /right side	3.85m / 5.80m	0.50m
BRE	indoor	1.70m / 7.10 m/ left side	3.20m / 7.10m	0.30m
ÉMI	outdoor	2.10m / 5.80m /left side	4.00m /5.80m	0.50m
MFPA	indoor	2.5 m /7.4 m /left side	4.0 m / 7.40 m	0.50 m
EFECTIS NI	indoor	2.60m /7.90m /right side	4.06m /7.90m	0.51 m

Medium exposure

Inert façade

The laboratories used blank light-concrete walls for these tests, see the comparative document for more information.

Timber façade

The structure examined is a wooden façade with air gap. The façade cladding is supported by a two-way timber lath frame. The timber cladding consists of 19 mm thick vertically spaced planks with intumescent strips between their profiles. A ventilated (open state) cavity barrier (combined with metal mesh) is placed above the openings. The timber materials of the cladding have not been treated with a flame retardant.

The cladding was made with closed bottom and side junctions. The air gap at the top edge of the specimen node was left open. No insulation or other material was placed in the air gap. Description of the applied materials are found in Table 4.6.

Table 4.6.

Main components of the tested Timber façade

Element	Material	notes
Ventilation strips	28x48mm spruce boards	Attaches to the light-weight concrete wall with light weight concrete screws 8.0x65
Fixing studs	34x70mm spruce studs, Quality C14	Attaches to the light-weight concrete wall with light weight concrete screws 8.0x120
Panel	WFX heat modified 19/141 mm double bever overlap panel	Nails with 2 stainless steel nails 2.3x70 to every vertical stud
Stop gap boards	20/70mm WFX heat modified rectangular	Attached with stainless steel thread nails 2.3x70 to every vertical stud
Casing	20/92 WFX heat modified rectangular	Attached with stainless steel thread nails 2.3x70
Window sill	metal t=0,6mm	
Sheeting	metal t=0,6mm	Attached with aluminium thread nails with sealing washers
Cover board	20/78 WFX heat modified rectangula	Attached with stainless steel thread nails 2.3x70

ETICS

The façade comprised, Figure 4.7, of the following main components Table 4.7.

Table 4.7.

Main components of the tested ETICS façade

	ETIC– component (without brand name)
Adhesive	Mineral bonding and reinforcing mortar/base coat, layer thickness 3 - 5 mm
Thermal insulation board	EPS; thickness 300 mm
Mechanical fixing devices	Not used

Base coat	Organic, cement-free reinforcing compound/base coat; layer thickness 3-4 mm in applied stage
Reinforcement mesh	Alkali-resistant reinforcing mesh; mesh width 6 mm x 6 mm
Finishing coat	Organic finishing render to achieve a stippled texture, layer thickness: 3 mm in applied stage
Corner profiles	Edge profile with integrated glass fibre mesh
Fire barrier (surrounding)	Mineral wool insulation with thickness with thickness 300 mm and height 200 mm

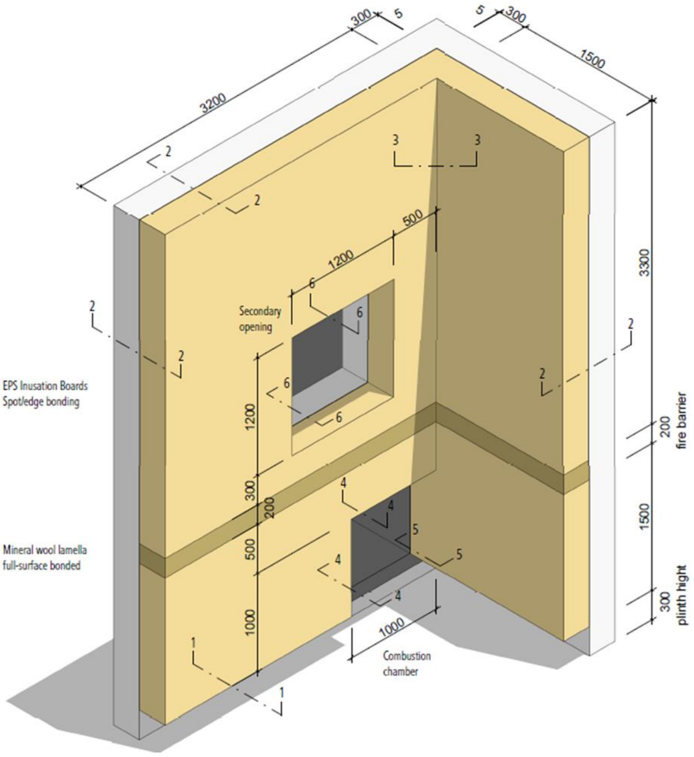


Figure 4.7. Overview of the ETICS specimen

Fiber cement façade

The 12 mm thick fiber cement cladding panels are mounted with a system of aluminium rails and brackets, see Figure 4.8. The façade specimen is insulated with 100 mm thick stonewool sheets. Intumescent cavity barriers are installed above the combustion chamber and above the secondary opening and between floor levels, see Table 4.8. A closed state cavity barrier was used at the two lateral edges of the specimen.

Table 4.8.

Main components of the tested Fiber cement façade

Element	Material / Reference	Installation
Brackets	Aluminium	Attached to the light-weight concrete wall with screws 10x80

	L =120mm	
Vertical cavity barrier	Closed state cavity barrier. 130x70x1200mm	Fixed according to the manufacturer's guideline by steel brackets every 600 mm
Horizontal cavity barrier	Open state cavity barrier.	Fixed according to the manufacturer's guideline by steel brackets every 250 mm
Insulation	Rock-based mineral wool. Th = 100 mm	Fixed by steel anchors type
Vertical frame	Aluminum profiles	Fixed to the brackets by stainless steel screws Rubber gaskets (x2) installed vertically before installation of cladding panels. L type: 50x42x2mm, T type : 100x52x2mm
Cladding panels	Fibre cement panels Th = 12 mm EN 13501-1 class.: A2-s1, d0	Fixed to the frame by stainless steel rivets Open gap between adjacent panels: 10 mm max.
Window finish – Part 1	Galvanized steel pre-manufactured sheets Th = 1.5 mm	Attached to the light-weight concrete wall with screws
Window finish – Part 2	Fibre cement panels Th = 12 mm, W = 200 mm EN 13501-1 class: A2-s1, d0	Fixed to the window steel finish by stainless steel rivets

Figure 4.8. The tested Fiber cement façade at the laboratory of Efectis

The testing rigs of the participant laboratories (medium exposure) see Table 4.9.

Table 4.9.

Testing rigs of the participating laboratories

	Location of the rig	Wing Wall width/height above CC /location	Main wall width/height above CC	Uplift from ground
RISE BORAS	indoor	1.85m / 4.90m / right side	3.80m / 4.90m	0.30 m
RISE FR NORWAY	indoor	2.00m / 4.90m / left side	3.85m / 4.90m	0.60 m
EFECTIS	outdoor	2.24m / 6.90m / left side	4.00m / 6.90m	1.60 m
MFPA LEIPZIG	indoor	1.5 m / 5.3 m / left side	3.2m / 5.3m	0.30 m

The participating laboratories have drawn up individual test reports of the tests carried out. For each type of façade and for each type of fire exposure, 9 so-called comparative documents, referenced above and available online were drawn up to facilitate comparison.

5. Analysis

Here an analysis and a discussion on calibration of method, repeatability, reproducibility, and classification criteria are presented.

5.1. Repeatability of the method

Results of the same specimens (collected in the RR) can be studied side by side in the 9 comparative documents. The comparative figures clearly show a certain level of variation between comparable test specimen to a greater or lesser extent.

The façade tests contain much more variables than the other fire tests, so the inevitable difference between the monitored parameters are not necessarily a problem as long as it does not lead to a significant difference in test results and further in applicable classification system.

Another set of deviations may stem from different environmental conditions such as wind, the effect of which significantly determines the nature of the results and also the maxima in temperatures reached.

The reasons for these variations are summarised in the following points:

Nature of temperature rise after start-up

When using Spruce, the temperature increase rapidly after ignition. With higher density wood or more moisture, the temperature rise is slower but the temperatures achieved can be higher and more durable. This is addressed by introducing a starting time, see 5.3.3.

General shape of the temperature curves

In outdoor tests, significant fluctuations in the temperatures are observed even with weak lateral air movement. Temperatures recorded in outdoor tests are often significantly lower than those recorded in indoor tests and are characterised by high peaks and fluctuations. It should be noted that in one outdoor test the conditions were perfect until around 5 minutes into the test after which the test was deemed to be outside the normal variation in fire exposure. The consortium advises against allowing further testing outdoors due to the unpredictability in the results.

Challenges in measuring the mass loss rate

When measuring the mass loss rate, a sensitive balance should be placed in the combustion chamber. During the Round Robin tests, weight cells failed on several occasions. The reason for this is that the temperature in the combustion chamber can reach up to 1000 degrees Celsius. Two measurements gave incorrect results because the steel table under the woodpile touched the back of the combustion chamber during the test and became partially stuck.

Otherwise, the successful measurements confirmed fairly uniform mass loss rates. It is used in the experimental Round Robin as an indicator of similarities between the different tests.

Based on the above, the Consortium recommends that mass loss rate measurements should not be required for either testing or calibration. However, it should be kept for scientific exploration studies and further Round Robin exercises.

Method of placing the thermocouples

In some tests, thermocouples were also placed in the centre line of thick rockwool insulation (where they are not required according to the draft assessment method). In cases where thermocouples were placed from the back without drilling through the entire layer system, lower temperatures were recorded than where the entire layer system was drilled through from the front. It is advised that great care is taken during application of the thermocouples to make sure that they monitor temperature in a consistent manner.

Deviations at a late phase of the test (45-60min)

In façade tests, the events of the first 30 minutes are usually the decisive ones, after which the fire exposure decreases rapidly. This was not the case for the timber façades tested in the Round Robin reignition phenomena were observed around 45-60 minutes in the large-scale tests, but to different extents and at different times. These secondary phenomena may indicate façade's real fire behaviour without any interference of the rescue services.

Variations due to different specimen design

The façade designs of the timber façade (large exposure) were not completely uniform. One specimen had significantly fewer cavity barriers and the air gap was sealed at the top edge of the specimen. This discrepancy led to much more damage to the cladding than in the other two specimen. The burning of the cladding is also well manifested in the measured temperatures. It can be clearly seen that the minor technical deviation resulted in significantly different behaviour, this deviation may be present in any combustible cladding system and not particular to the timber façade.

The time of switching on the forced ventilation

For the medium fire exposure, the draft assessment method requires forced ventilation to be turned on at minute four of the test. When the test was started with ventilation already on, there was no jump in the temperature curve at around the fourth minute.

5.2. Calibration of the method

For the method to remain robust, a calibration exercise of the rig using a naked supporting construction (no façade erected) is suggested in which the thermal exposure to the surface from the fuel source placed in the combustion chamber is evaluated. The results of such exercise should fall between calibration thresholds in addition to the criteria that are suggested for the wood crib, the methodology and the materials and dimensions of the rig.

There is no clear definition of thermal exposure and the severity of the fire source to a façade can be assessed in multiple ways, e.g., heat release rate from the fuel source, mass loss rate of the fuel source, net irradiation to a cold surface (water cooled heat flux meter), temperatures of thermocouples on the façade, temperatures of plate thermometers at the façade, visible flame heights etc.

Heat release rates from the fuel will depend on too many assumptions on combustion and is difficult to accurately determine in different laboratories (see Appendix F, 13.2). The same is true for measuring total heat flux to cold surfaces (i.e., by water cooled heat flux meters mounted flush to the façade) for which cooling water temperature, exact mounting and measuring range of the gauge will play a significant role (Sjöström et al 2021b). Mass loss rate of the crib is not part of the assessment method itself and would therefore involve significant rebuilding of the rig, which might not be exactly representative of the rig used for assessment and is therefore not deemed suitable for calibration. Determination of flame height from video image processing (Sjöström et al 2021a) is not always representative on the actual temperature on a façade surface.

We are thus left with measuring temperatures in front of the test rig. While plate thermometers have been shown to robustly represent temperatures of surfaces such measurement are not a part of the assessment method and we therefore choose to calibrate the methods with the same measurements that are used in the assessment, TC measurement 50 mm in front of the surface of the test rig.

5.2.1. Large exposure

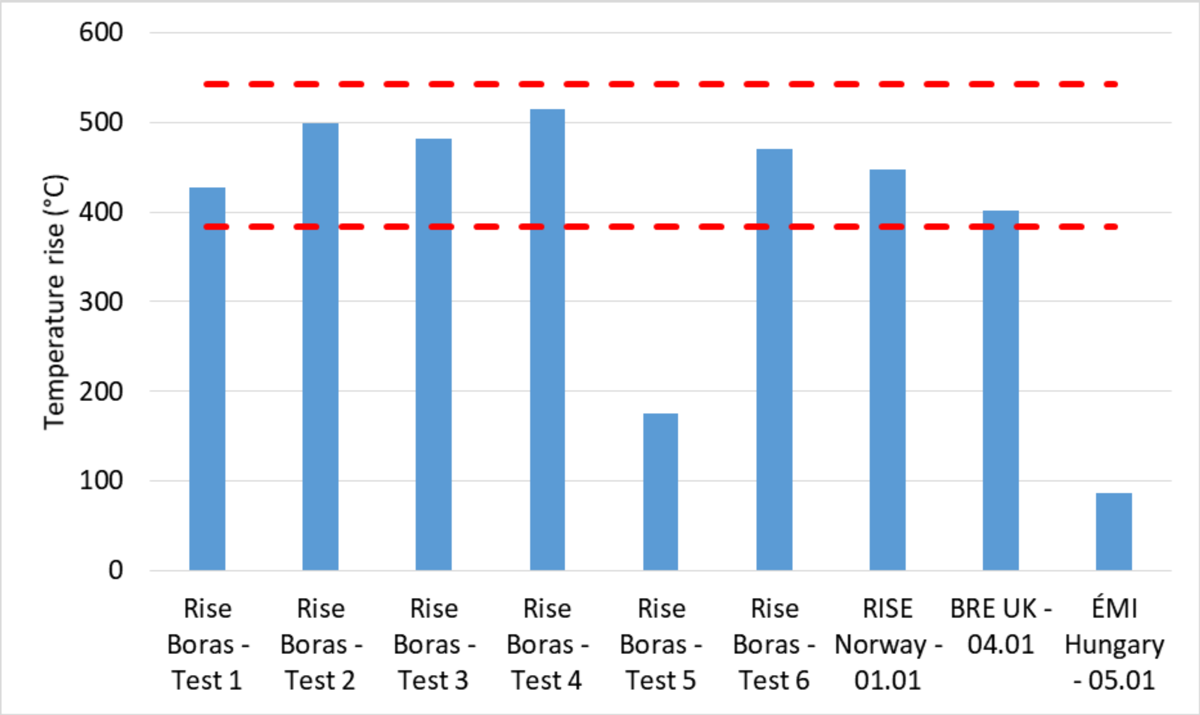
All experiments on full height naked supporting construction (no façade erected) performed in the project are gathered and assessed. These include the six inert tests done at RISE Sweden indoors during the initial testing activities (Sjöström et al 2021b), the inert tests performed indoors at RISE Norway and BRE UK as well as the outdoor test performed at EMI Hungary. Consistency test demonstrates that RISE Sweden's test 5 is an outlier (due to an applied forced convection up to 2 m/s, significantly reducing the exposure) as well as EMI Hungary’s test (outdoor test whose environmental conditions deviated substantially from the assessment method requirements).

To avoid dependencies on sample rates and sudden stochastic events, we choose a calibration threshold defined as an average temperature rather than minimum/maximum. Also, we choose an averaging period of 15 minutes in order to include differences in how fast the fuel source burns. Note that discrepancy between variation from the tests are noticed between using a 10-minutes or a 15-minutes assessment time.

We assess the maximum 15 minutes average registered from the only TC located at mid-width of the combustion chamber and assessment level 1 (4.5 m above the top of combustion chamber opening) (Figure 5.1.).

The calibration criteria are here defined as the mean of all consistent tests ± 2 standard deviations of the ensemble (rounded away from the average). Thus, the highest 15-minutes average of the TC at mid-with of the combustion chamber should fall between 380 - 550 °C for assessment method level 1.

As a comparison it is interesting to compare the exposure in the BS and the large fire exposure in the proposed European method. To this end, we assess the maximum 15 minutes average registered from the only TC located at mid-width of the combustion chamber on level 1 of the BS method (located 2.5 m above the top on combustion chamber opening) (Figure 5.1.).


600
500
400
300
200
100
0
Temperature rise (°C)
Rise Boras - Test 1
Rise Boras - Test 2
Rise Boras - Test 3
Rise Boras - Test 4
Rise Boras - Test 5
Rise Boras - Test 6
RISE Norway - 01.01
BRE UK - 04.01
ÉMI Hungary - 05.01

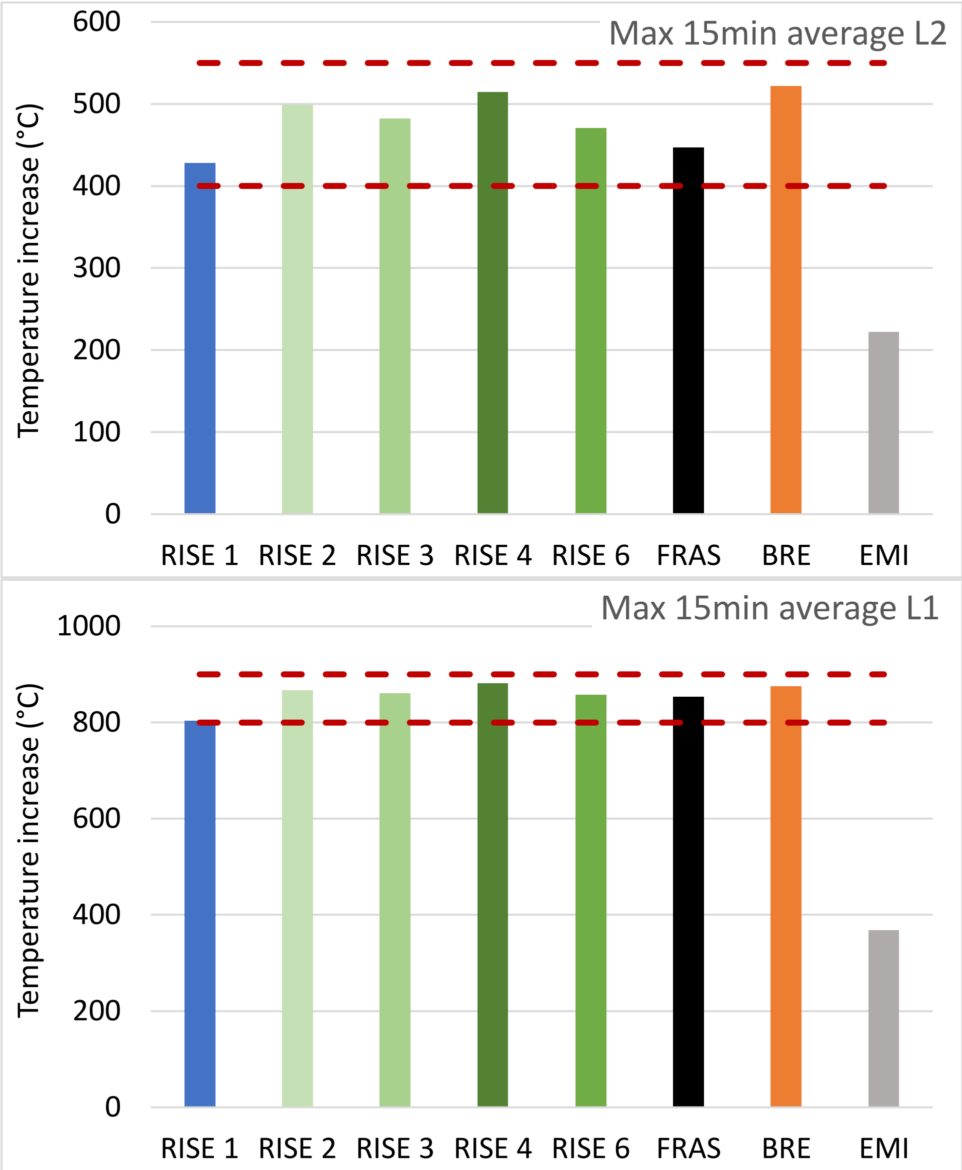


Figure 5.1. Maximum 15-minutes average of the only TC placed 50 mm from a naked supporting construction at assessment level L1 (top – 4.5 m above combustion chamber opening) at mid-with of the combustion chamber. Mid and lower figures compares the heat exposures found level 1 and level 2 of the BS method. RISE refers to tests performed in Sweden, FRAS – Norway, BRE – UK and EMI – Hungary. Temperature increase refers to the increase in temperature compared to those before ignition. The red dashed lines are proposed calibration criteria levels.

5.2.1. Medium exposure

All experiments on full height naked supporting construction (no façade erected) performed in the project are gathered and assessed. These include three tests done at BRE UK indoors during the initial testing activities, the inert tests performed indoors at RISE Sweden and RISE Norway as well as the outdoor test performed at Efectis France. Consistency test demonstrates that no test was an outlier.

Similarly to the large exposure calibration procedure described above, we assess the maximum 15 minutes average registered from the only TC located at mid-width of the combustion chamber measured in the DIN method at 3.5 m (3.5 m above the top on combustion chamber opening) and assessment level 1 (same level) (Figure 5.2.).

The calibration criteria are here defined as the mean of all consistent tests ± 2 standard deviations of the ensemble (rounded away from the average). Thus, the highest 15-minutes average of the TC at mid-with of the combustion chamber should fall between 80 - 230 °C for assessment level 1.

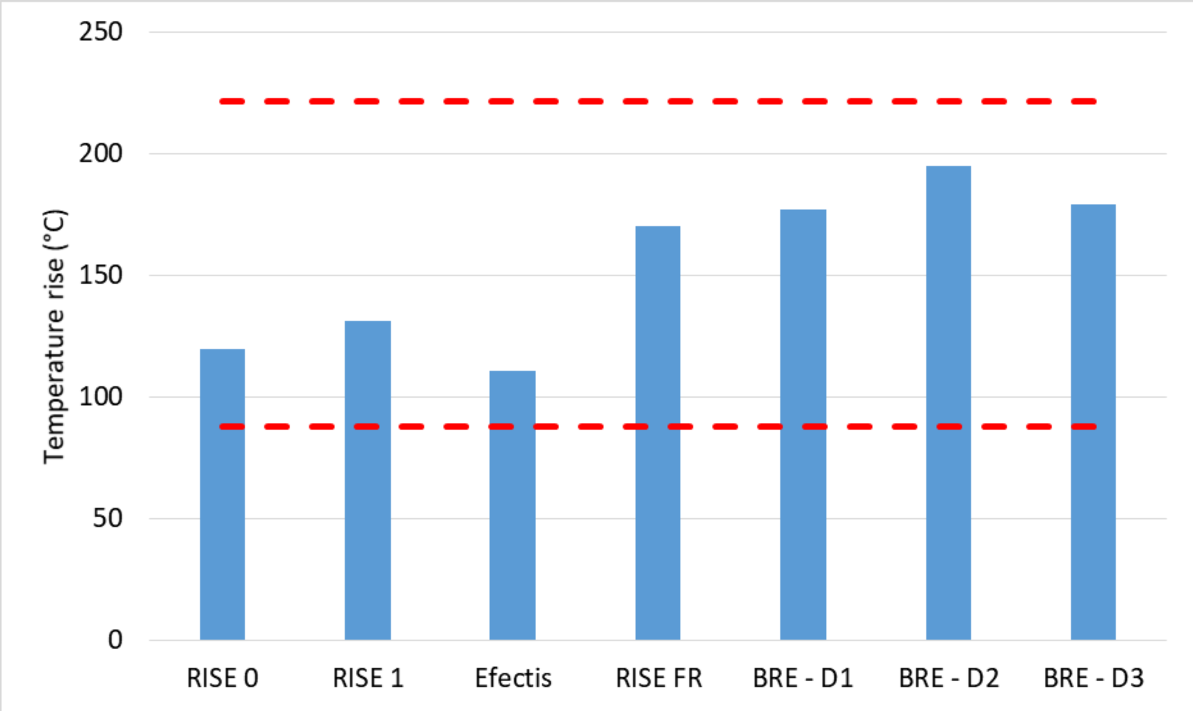


Figure 5.2. Maximum 15-minutes average of the only TC placed 50 mm from an inert façade at assessment method level L1 (top – 3.5 m above combustion chamber opening), at mid-with of the combustion chamber. RISE refers to tests performed in Sweden, FRAS – Norway, BRE – UK and Efectis – France. Temperature increase refers to the increase in temperature compared to those before ignition. The red dashed lines are proposed calibration criteria levels.

5.3. Performance criteria

5.3.1. Purpose

One aim of the project was to develop performance criteria that adhere to the level of performance determined by the existing methods. That means that there should not be a significant change in the severity of the methodology between the proposed assessment method and the existing methods. Those retained for the present analyses are the BS 8414-2 and the BRE 135 documents for the large fire exposure on the one hand, and the DIN 4102-20 for the medium fire exposure on the other hand. As for the performance criteria, those of interest in this section are the fire spread and the falling parts, because they are systematically required to be evaluated by the assessment method while façade-to-floor junction and smouldering are optional.

During the Round Robin exercise, we aimed to use façade systems that had been previously tested and in which some were close to and some far from the pass/fail criteria in the current DIN and BS 8414 + BRE 135 in order to better investigate the performance level. Below the mass of data provided by the Round Robin tests is investigated to understand the sensitivity of the performance criteria to variations of the parameters on which they are based.

5.3.2. Fire spread

Principle

During the experimental Round Robin, the façade systems have been tested with instrumentation according to the proposed assessment method as well as part of the DIN 4102-20 and BS 8414-2 (in combination with BR 135) methods in order to enable comparison.

As a reminder, the current version of the assessment method at the time when the Round Robin was carried out defined:

> *10.1.1 Vertical fire spread*
>
> *The failure of vertical fire spread criterion occurs when any external or internal thermocouple positioned on level 2 exceeds a temperature rise - above its initial temperature - of XXX K continuously over a period of YYY seconds during the 60 minutes test period after the start of the test.*

Same type of criterion is defined for horizontal spread. Thus, the fire spread criteria are based on both a temperature threshold, and a duration of exceedance of this threshold, only in combination both of them lead to a failure of the criteria. These criteria need to be chosen such that the results converge towards that of the existing methods.

Towards more robust criteria

In short, BS 8414-1, 2 with BR 135 define the failure for fire spread as "*occurring when the temperature rise of any thermocouple at level 2 exceeds 600 °C for a period of at least 30 seconds*", while DIN 4102-20 defines the failure for fire spread as "*occurring when the temperature of any thermocouple 3.5 m or more above the combustion chamber exceeds 500 °C instantaneously*".

The definitions above lead to unrobust criteria. A drop of temperature below the threshold during a single sample will cause the failure to be missed according to the BS definition, while an equally short peak of temperature above the threshold will force the failure according to the DIN definition. Yet, such short and sudden random variations in temperature are inherent to fire, without any expected consequence on the global safety. Also, the detection of such short random temperature variations depends on the sampling rate, and thus on the laboratory which carries it out. To increase robustness, we instead consider the average of temperatures over a given period of time.

From there, the following general improvement is adopted for the fire spread criteria in the assessment method:

> *"The failure of vertical fire spread criterion occurs when any external or internal thermocouple […] exceeds a temperature rise – above its initial temperature – of XXX K <u>on average</u> over a period of YYY seconds…".*

Recommendations of discrete numbers for XXX and YYY are discussed after the assessment of the Round Robin test results further below. The method for finding these numbers is explained in the next section.

Method

For each test, the fire spread criteria have first been computed according to the definitions of the existing methods (BS 8414-2 through BRE 135 and DIN 4102-20). Besides that, times to reach criteria with varying temperature threshold and its duration of exceedance were also calculated. The root mean square of all the differences between reaching the threshold in the existing methods and the proposed assessment method (based on threshold and duration) have been calculated to find the set of criteria which will minimise differences between existing and proposed methods, this is called the residual parameter and is in the unit minutes.

Large exposure tests

Based on the Grubbs' statistical test, the fire spread results reported by BRE (UK) on the timber façade test as well on the ETICS are undeniably outliers. Grubb's statistic for this test represents 1 in 450 chances to occur and is therefore removed from the assessment. Thereafter, the residual sums of Root-Mean-Square (RMS)-differences show the following pattern (Figure 5.3.).

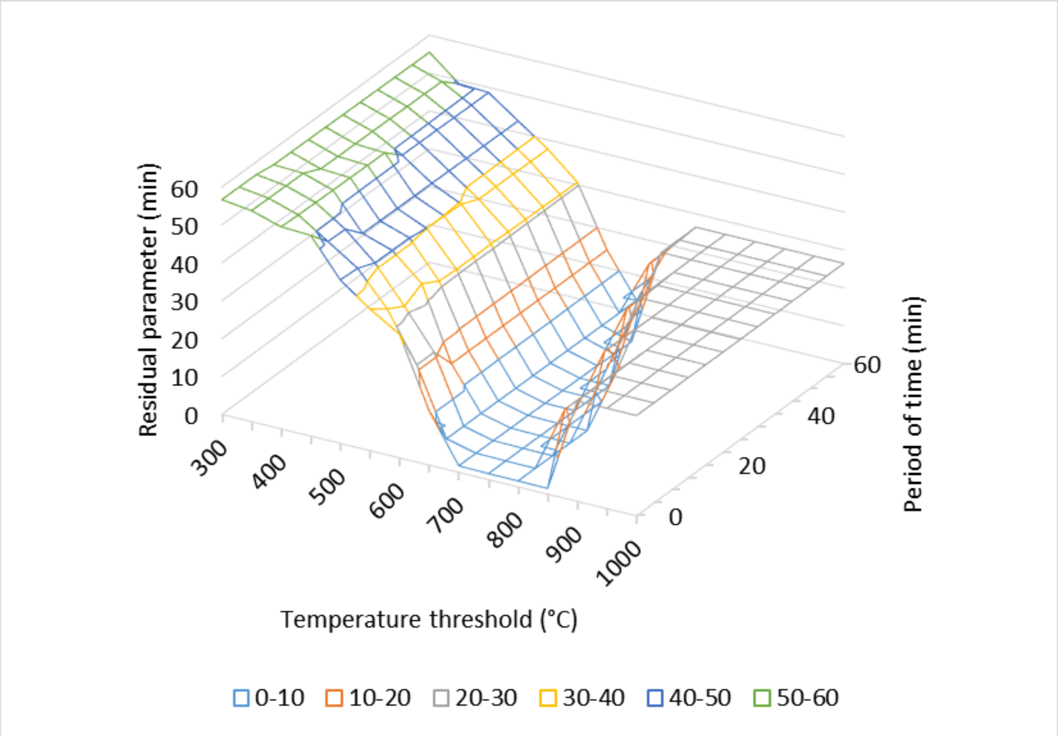


Figure 5.3. The root-mean-square of the differences (or residual parameter) between the BS 8414-2 and the AM methods in time.

For better resolution we zoom in on the global minima (Figure 5.4.).

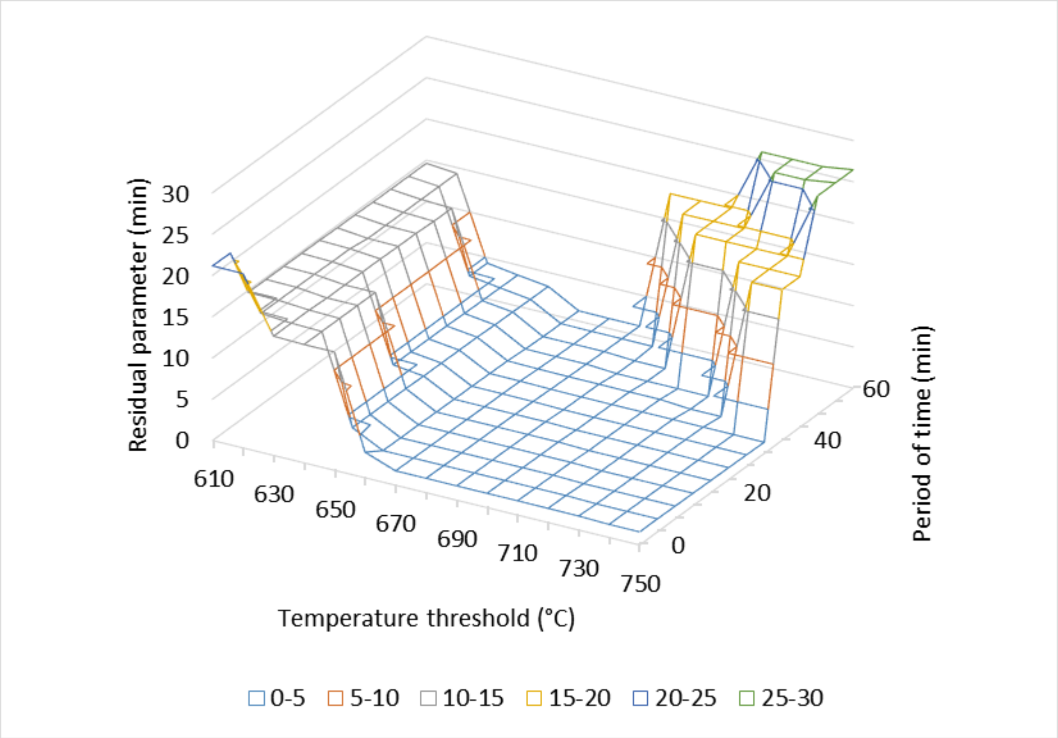


Figure 5.4. Zoom of the global minima in Figure 5.3.

As can be seen in the Figure 5.4 the most robust measures are provided for durations of 30 seconds or below. As too short duration will once again yield unrobust measures as one individual sampling point will be given high weight, 30 seconds is therefore considered the most robust duration.

As for the temperature threshold (also in the Figure 5.4), any threshold between 670 and 730 °C appears equally good. Other arguments are therefore put forward.

1. Lowering the height of assessment from 5000 mm to 4500 mm above the combustion chamber will automatically increase the absolute temperatures. From the tests on inert façades the average difference between these two levels are on average 70 °C, implying 670 °C as a minimum.
2. Changing the criteria from a lowest sample to a 30 second average will increase the threshold even more. The difference between a 30 second averages and the 30 second minima from the tests on inert façades vary with the sampling rate between ~20 °C to ~50 °C.

We therefore suggest adding another 30 °C to the threshold and thus use 700 °C for 30 seconds. This covers both the minimum discrepancy to the BS 8414 method as well as the arguments related to increased exposure from the flame and the more robust average criterion.

<u>Medium fire exposure tests</u>

In the medium exposure tests, the method above is processed between the DIN 4102-20 results and the proposed assessment method results.

Fire spread results reported by Efectis (France) on the timber façade test is undeniably an outlier, concluded by Grubbs' statistical test as above.

Once this test is discarded, the method above produces the values shown on the pictures below for the residual parameter.

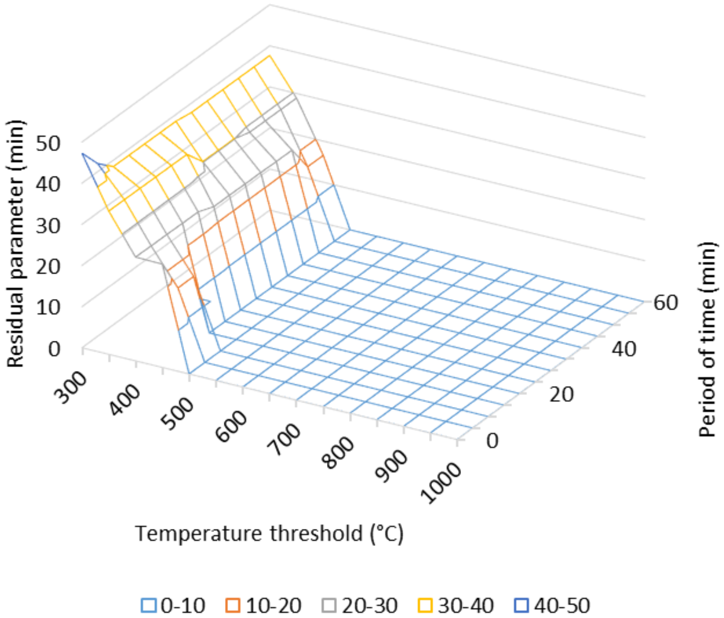


Figure 5.5. The root-mean-square of the differences between the DIN 4102-20 and the AM methods in time.

The singular shape of the map above, showing systematic zero values for temperature thresholds above 500°C, logically results from that all Round Robin tests passed 60 minutes without fire spread failure one the other hand (once Efectis' test discarded), see Figure 5.5. No thermocouple instantaneously exceeds 500°C (no DIN failure), and thus no thermocouple can obviously exceed 500°C in average either (no assessment method failure). Thus, all ranges above 500 °C will minimize the result.

However, note that the initial aim was to test façade systems that had been previously tested and which fire spread were close to and some far from the pass/fail criteria of the current DIN method in order to better calibrate the assessment method. None of the medium exposure Round Robin tests failed the fire spread failure criterion according to either the assessment method or the DIN. Since no upper limit information is available, the smallest value of the temperature threshold which matches DIN and AM fire spread should be chosen since it is the most conservative one.

While using an average (for robustness reasons) would increase the threshold we must also bear in mind that DIN 4102-20 assesses absolute temperatures. Using temperature increase instead would lower the threshold. As these two changes are within a few tens' degrees, these two effects should about even out and converge with a 500 °C temperature increase threshold for 30 seconds.

<u>Conclusions and proposals</u>

In the analyses above, appropriate values for the temperature threshold and its duration of exceedance have been deduced by comparing the Round Robin test results for the assessment method with results according to BS 8414 with BRE 135 and DIN 4102-20. To deduce the appropriate values a statistical methods has been applied which is described above in section "Method" on page 71. It has been shown that using these values allows to minimize the difference of fire spread results between the assessment method and the existing methods to less than 1 minute in a façade test.

Consequently, the consortium agrees to propose the following fire spread criteria in the assessment method:

- for the large exposure tests:

10.1.1 Vertical fire spread

The failure of vertical fire spread criterion occurs when any external or internal thermocouple positioned on level 1 exceeds a temperature rise - above its initial temperature - of 700 K on average over a period of 30 seconds during the assessment time.

10.1.2 Horizontal fire spread

The failure of horizontal fire spread criterion occurs when any external or internal thermocouple positioned on the columns 1 and 2 exceeds a temperature rise - above its initial temperature – of 700 K on average over a period of 30 seconds during the assessment time.

- for the medium exposure tests:

10.1.1 Vertical fire spread

The failure of vertical fire spread criterion occurs when any external or internal thermocouple positioned on level 1 exceeds a temperature rise - above its initial temperature - of 500 K on average over a period of 30 seconds during the assessment time.

10.1.2 Horizontal fire spread

The failure of horizontal fire spread criterion occurs when any external or internal thermocouple positioned on the columns 1 and 2 exceeds a temperature rise - above its initial temperature – of 500 K on average over a period of 30 seconds during the assessment time.

We also propose to set a criterion to the sampling rate to not greater than 5 seconds:

4.7.2 Data acquisition system

Instruments shall be connected to a data acquisition system capable of recording data at intervals not exceeding 5 s.

Note: DIN 4102-20 is a test standard without giving criteria for assessing the test results regarding a pass or fail of the test. German building authorities provided a set of criteria which include assessment of tests and test results by building authorities themselves on a case-to-case basis. Therefore, it was not possible to include all aspects of these assessments in the assessment method.

5.3.3. Test time

Principle

Previous versions of the assessment method described a 60 minute evaluation of the thermocouples after ignition. Summing up the results from the initial testing and the Round Robin exercise, a few challenges concerning this decision has come forth.

1. The collapsing of the cribs could, in some cases, yield a pile of glowing material falling in front of the combustion chamber. This can potentially cause problems for the platform registering falling parts. Even a well-build platform can fail with a glowing pile sitting for 30-40 minutes without extinguishing.
2. Some systems will deviate from the previous methods as very slow fire spread could be an issue. While this can also cause problems for fire suppression, it is not the primary behaviour sought to be assessed in the method.

Large exposure fire tests

Adhering to the BS 8414 method, we use the concept of a starting time, there defined as a temperature reached in a level positioned lower than the assessment level in the test. Here, we instead use the values proposed from the calibration scheme. Once temperatures at 4500 mm above the combustion chamber reaches the lower temperature limit of the calibration method, the crib is assumed to have reached full burning behaviour.

For large exposure tests, we use the lower level, 380 K increase, exceeded in a 30 second average at any TC at 4500 mm. Scaling the tests on inert façades with the time corresponding to this criterion for each test, the differences between the tests are greatly reduced (Figure 5.6.).

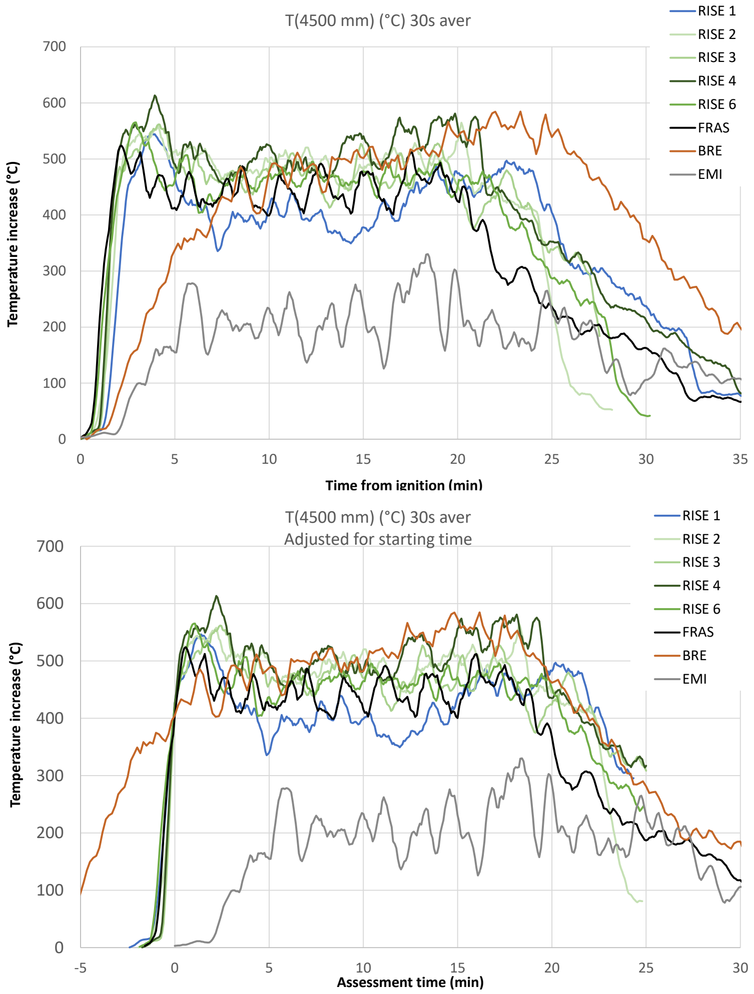


Figure 5.6. (upper) The 30 seconds average of the hottest TC at 4500 mm above the combustion chamber for the tests using large exposure on an inert façade. (lower) The same data but against assessment time, where time after ignition is shifted by the time in which the first TC reaches 380 °C for a 30 second average.

The differences caused by the allowable range in moisture content and density of the cribs is greatly reduced using this scaling. Any test in which no TC reaches 380 °C will likewise be considered invalid since it does not reach the criteria for the calibration.

<u>Medium exposure fire tests</u>

There is no concept of starting time in the DIN 4102-20. For the same reasons as above, and for purposes of harmonization with the large exposure tests, we define a similar starting time for medium-scale tests, using the values proposed from the calibration scheme. Once temperatures at 3500 mm above the combustion chamber reaches the lower temperature limit of the calibration method, the crib is assumed to have reached full burning behaviour.

For medium-scale exposure, we will thus use the lower level, 80 K increase, exceeded in a 30 second average at any TC at 3500 mm.

<u>Impact on the analyses</u>

All the analyses of the Round Robin tests above (fire spread) and below (falling parts and burning parts) have been computed using these starting times.

5.3.4. Burning parts

Previous versions of the assessment method assumed 3 criteria for the fire spread performance: the vertical fire spread, the horizontal fire spread, and the burning parts.

The analyzes of the burning parts results of the Round Robin tests have been carried out. They show that the burning parts criterion is likely to fail quite early for some kind of tested specimen. See the 3 examples here below.

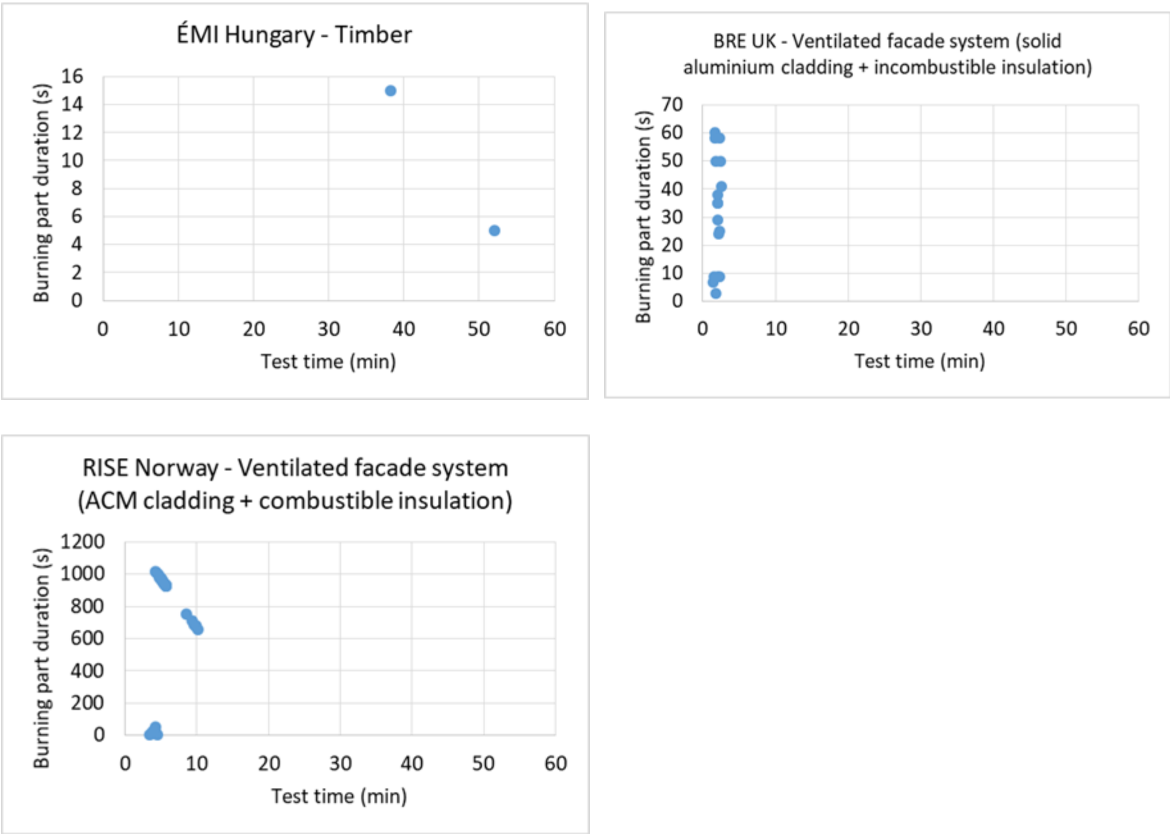


Figure 5.7. The graphical representation of the burning parts occurrences and their durations for three large-scale tests.

In Figure 5.7, the tests display can be summarized as EMI test: only 2 occurrences less than 30 seconds, no failure (i.e., no burning parts that burns longer than 30 s). BRE test: 17 occurrences, some of them more than 30 seconds, which lead to failure at 2 minutes. RISE test: 49 occurrences, most of them more than 30 seconds, which lead to failure at 4 minutes.

This finding makes it clear that keeping the burning parts as one of the failing criteria of the fire spread performance could lead to a misunderstood failure of this performance in some cases. Moreover, the BS method doesn't consider such burning parts assessment on the one hand, while on the other hand the DIN method assesses a similar "duration of a secondary fire on the floor" but separately from the fire spread assessment.

For these reasons, the burning parts criterion has finally been removed from the criteria of the fire spread performance. It has rather been turned into a separate and stand-alone performance, namely the "burning parts performance". This one can now be assessed and reported without influence on the fire spread performance anymore, each regulator being able to decide how to eventually use this burning parts performance according to their regulation.

The assessment method now defines this performance as follows:

> *The failure of burning parts criterion occurs when a falling part burns for 30 s or longer after hitting the ground.*

The burning parts can either be in liquid or solid phase.

5.3.5. Falling parts

Principle

As a reminder, the updated version of the assessment method at the time when the Round Robin was carried out specified:

> *10.2.2 Mass measurement of falling parts*
>
> *A weighing load cell platform with an accuracy of ± 50 g shall be used to measure the mass of falling parts during the test. A plate that covers the rectangular area which is defined by the main face and the wing shall be used on top of the weighing cell platform to collect falling parts during the test. A software shall be used that allows the automatic and continuous measurements and recording of the weight. The weight over time shall be documented.*
>
> *10.2.3 Visual equipment*
>
> *Digital cameras shall be used to provide a continuous visual record of the test.*
>
> *The recorded pictures may be used to assess the size and test time of falling parts for the purpose of reporting of observations in the test report.*

From there, the assessment method defines:

> *10.2.4 Falling parts – Level 1*
>
> *The failure of falling parts (level 1) criterion occurs when any falling part exceeds 1 kg in mass.*
>
> *10.2.5 Falling parts – Level 2*
>
> *The failure of falling parts (level 2) criterion occurs when any falling part exceeds 5 kg in mass.*

Such load cells platforms were designed and implemented by the laboratories involved in the Round Robin. The resulting mass measurements are investigated below to assess the suitability of the platform and the eventual limits to its fitness-for-purpose.

A first glance on the mass measurements

Examples of the raw mass measurements, scaled to zero at test start provide an overview on the global trends in these measurements, as exemplified below (Figure 5.8.).

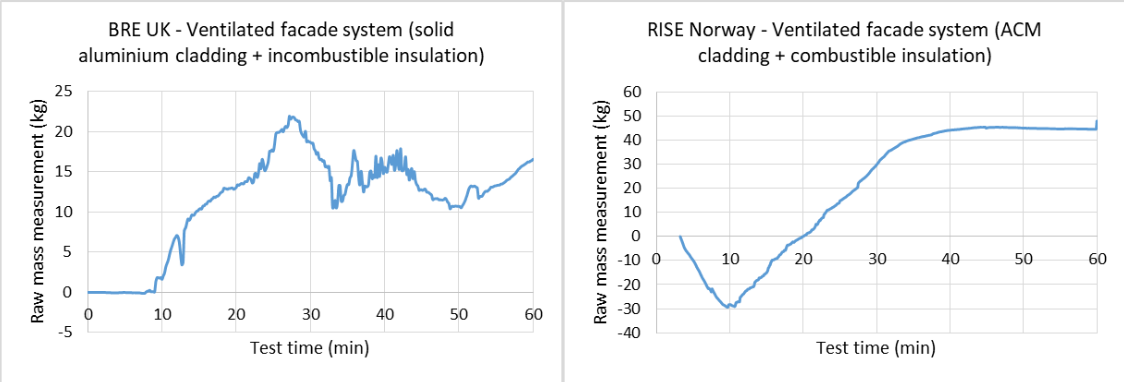


Figure 5.8. Examples of raw data on mass changes of the platform for falling parts for large exposure tests.

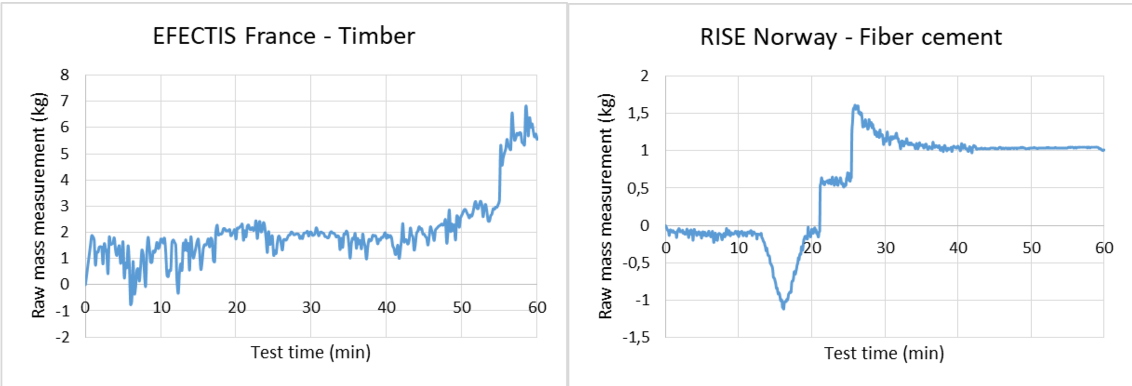


Figure 5.9. Examples of raw data on mass changes of the platform for falling parts for medium exposure tests.

At the first look, the charts show unexpected behaviours (Figure 5.9.). Mainly two observations arise:

- the raw mass measurements go downwards (meaning a loss of mass) as well as upwards (meaning a gain of mass) during the tests,
- the raw mass measurements appear to be only very slightly noised in some tests and more heavily in other tests.

The reason is that the load cell platforms are sensitive not only to the parts falling from the façade, but also to other disturbing phenomena, either acting on the global shape of the curves or the ones creating local scattering.

The following events have been identified as acting on the global shape.

- The convection flow due to the heat of the fire creates a lift force on the platform, due to pressure differences on the platform. This develops rather continuously and makes the curve going down slowly (in presence of wind, the convection could become more turbulent, but the wind effect is discussed apart below).
- The water contained in the platform evaporates due to the heat. This slow phenomenon makes the curve going down slowly.

- The combustible elements that fall on the platform can ignite and burn, providing a continuous loss of mass.
- A soft and stable wind - in case of outdoor tests – or any mechanical or natural ventilation - in case of indoor tests - creates different possible forces on the platform. These develop rather continuously and make the curve going up or down rather slowly.

The following events have been identified as creating local jumps.

- The falling parts from the façade create a sudden step of mass on the platform. These happen suddenly and make the curve jumping sharply and instantly.
- Some parts of the crib may fall too and create a sudden step of mass on the platform, just like other falling parts.
- Gusts of wind - in case of outdoor tests - create sudden forces on the platform. These happen suddenly and make the curve jumping up or down sharply during a short period of time, typically from a few seconds to a few tens of seconds.

Note:

Such gusts of wind are not supposed to happen because the assessment method requires:

- *to shield the test specimen from the effects of high wind, and*
- *to measure the ambient air velocity during the test and make sure that it stays below the limit.*

However, gusts of wind happened in outdoor tests, as shown and discussed below.

Finally, the random variations of the load cells, inherent to their uncertainty of measurement, can be disregarded from the possible causes of local jumps in the curves because of their required low accuracy of ± 50 g. However, should glowing parts enter below the platform, these could increase the temperature which, in turn, affect the read-out from the load cells.

<u>Method</u>

For the purpose of assessing the falling parts performance, only the mass of the parts falling from the façade specimen should be measured. The process used should thus identify and quantify the sharp jumps, and make sure that they are caused by falling parts from the façade only. Two examples are shown below (Figure 5.10.).

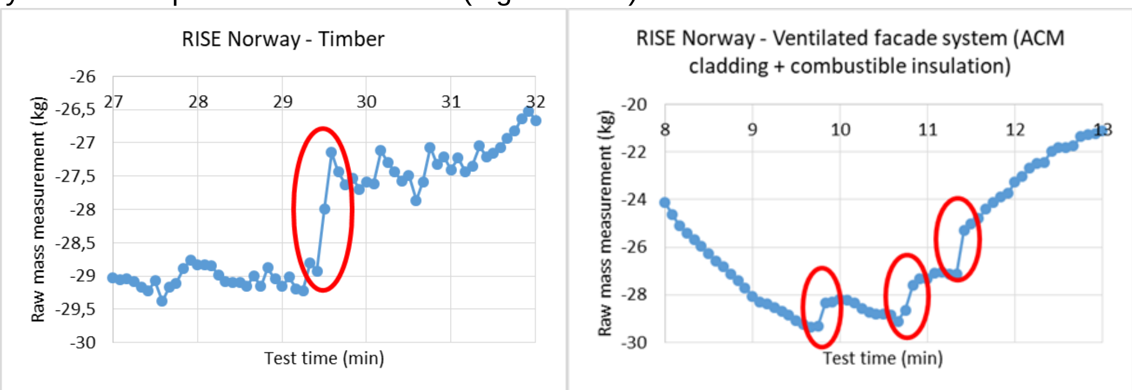


Figure 5.10. Examples of local sharp jumps possibly caused by falling parts.

The simplest way to identify and quantify these jumps is to compute the rise of mass all along the test data by subtracting successive raw mass measurements. This processing provides the increment of mass over the period of time elapsed between two successive samples. This processing applied on the two examples above leads to the results shown on the charts below (Figure 5.11.).

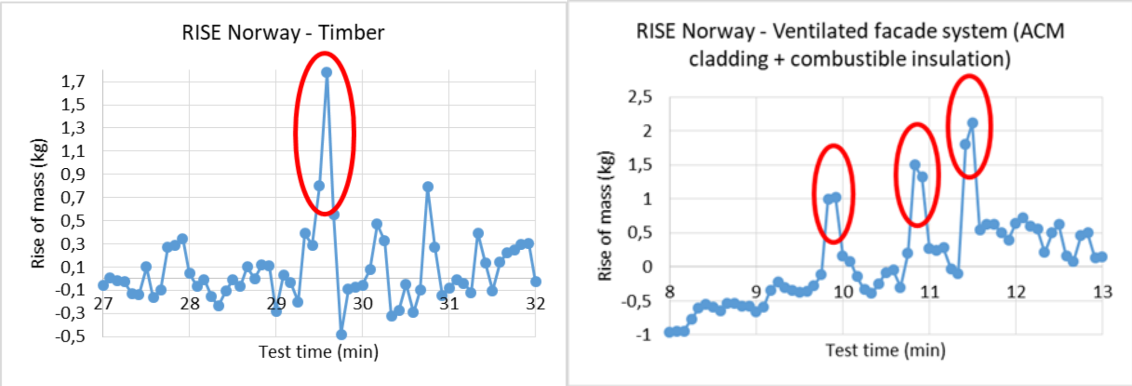


Figure 5.11. Examples of differentiated mass between consecutive samples.

The local jumps are now clearly highlighted and quantified. This simple processing of the raw mass data could thus be used as a basis for our purpose.

<u>Improving the robustness of the processing method</u>

As a reminder, the draft assessment method specifies:

4.7.2 Data acquisition system

Instruments shall be connected to a data acquisition system capable of recording data at intervals not exceeding 10 s.

In practice laboratories may record data at different intervals: some at 1 second, some at 5 seconds, … and some at 10 seconds. Consequently, the rise of mass computed by subtracting successive samples will depend on the sampling period of the data acquisition. This makes this simple method particularly unrobust. For instance, two parts of 0,6 kg falling 5 seconds apart would be reported as two successive mass rises of 0,6 kg by a laboratory recording at a 5-second sampling period, while reported as one single mass rise of 1,2 kg by a laboratory recording at a 10-second sampling period.

Computing the rise of mass by subtracting raw mass data in time steps of 10 seconds, instead of subtracting successive samples would increase robustness. Such difference scheme has also the advantage to dampen the low frequencies in the data, and thus to filter down the components responsible of the global shape of the raw data, namely the heat convection, the water vaporization, the combustion on fallen parts, the soft wind and the ventilation.

From there, the following improvement is adopted for the falling parts criteria in the assessment method:

10.2.1 Falling parts – Level 1

The failure of falling parts (level 1) criterion occurs when the increment of mass of falling parts over a period of 10 seconds exceeds 1 kg.

10.2.2 Falling parts – Level 2

The failure of falling parts (level 5) criterion occurs when the increment of mass of falling parts over a period of 10 seconds exceeds 5 kg.

Now that the impacts of the global shape events have been scaled down, only the local jump events remain, namely the falling parts from the façade, the falling parts of the crib, and the eventual gusts of wind in case of outdoor tests. For each test, the increment of masses over 10 seconds have first been computed and plotted on charts. These data have then been compared to each occurrence detected by the videos recorded continuously during the tests.

<u>Indoor tests</u>

9 large-scale tests and 9 medium-scale tests have been performed indoors.

In all tests the development of the increment of masses during the test perfectly matches with the occurrences visible on the videos (Figure 5.12 and 5.13.). Peaks are detected and their mass rise values are reported at the precise moment when any part falls from the façade or from the crib on the platform. The video easily allows to sort the first ones from the second ones.

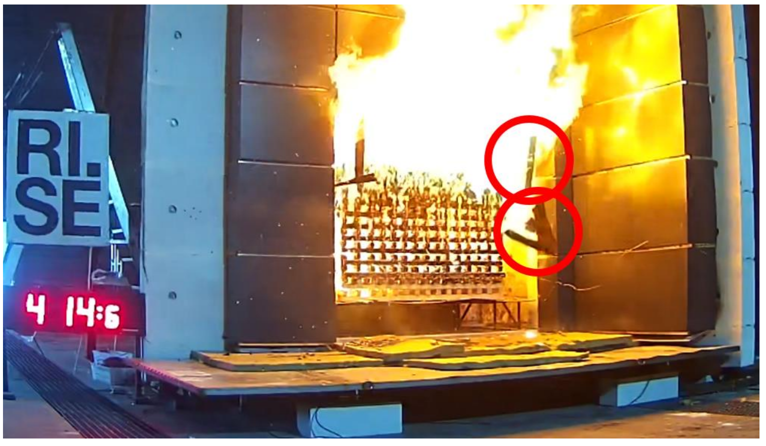


Figure 5.12. Example of a video capture showing 2 parts falling from the façade at time 4:14.

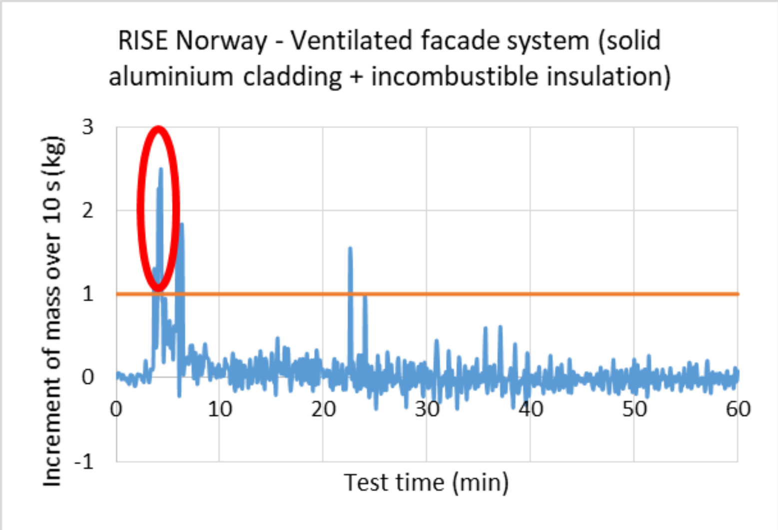


Figure 5.13. Example showing the increment of mass chart with the corresponding peak of 2.32 kg at time 4:15.

In some tests, suspicious observations were made, with no correlation between the video and measurements. Sudden unexplained peaks or drop of mass up to several kg were measured on a rather noisy signal. For all these tests, it was demonstrated that platform touched the façade or the supporting construction already before the start of the test. During the test, thermal expansion changed the stresses between platform and structure which were also measured by the load cells. These undue forces have interfered with the experiment and make the data unsuitable for use.

It will be important to emphasise that the platform must be designed and positioned with the greatest care. The exact positioning is specified in the assessment method for good reasons, and laboratories shall systematically comply with it. Among other, it must be clear that the platform must under no circumstances enter in contact with any other element.

<u>Outdoor tests</u>

3 large-scale tests and 3 medium-scale tests have been performed outdoors.

In outdoors large-scale tests, the mass measurements turned out to be strongly noised all along the tests, with tens of peaks exceeding the level 1 (1 kg) criterion and even 1 peak exceeding 5 kg while essentially no falling parts are visible on the video.

The investigation clearly demonstrated that the wind can strongly affect the load cells platform measurements. The outdoors tests were all carried out under sunny and quiet weather but the wind speed measured during the tests reported values above 1 and even 2 m/s.

Comparison of the wind speed measurement and the mass differences allows to quantify how strongly the wind can affect the load cells platform measurements in these specific examples:

- a wind of 1.5~2,0 m/s could generate forces > 3 kg,
- a wind of 2.0~2.5 m/s could generate forces > 4 kg,
- a wind of 2.5~3.0 m/s could generate forces > 6 kg.

The example below shows the disturbing influence of the wind on the load cell platform measurements. The picture on the left shows the large-scale test at ÉMI (Hungary) on EU Aluminium façade (Figure 5.14 and 5.15.) at test time 21:30 during a blast of wind, the mass rise reported is 6.80 kg. The picture on the right shows the same test at test time 22:05, i.e. 35 seconds later, without wind, the mass rise reported is 0.37 kg. No falling parts are visible in any of these instances.

Figure 5.14. Video captures of large-scale test at ÉMI Hungary on EU Aluminium façade at times 21:30 (left) and 22:05 (right) from ignition.

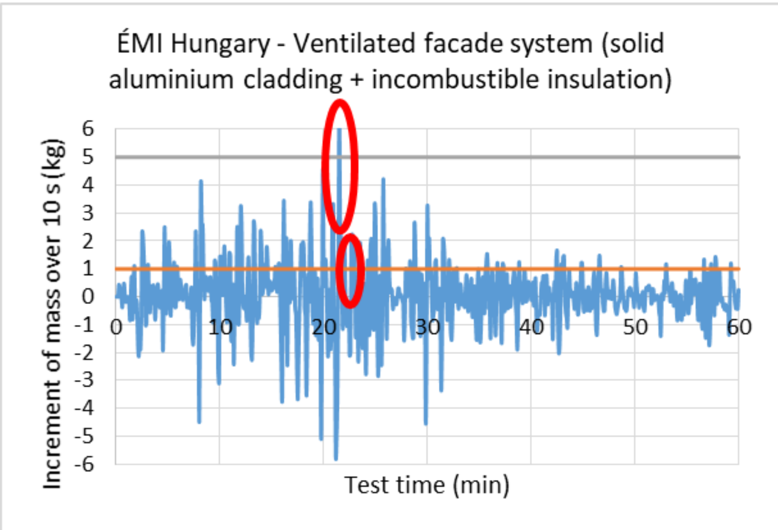


Figure 5.15. Corresponding increment of mass chart with the corresponding values marked in red.

The observation and analyses above demonstrate that even slight windy conditions make the load cell platform unsuitable for use in outdoor tests.

Conclusions and proposal

The load cell platform proves to be effective and accurate for use in indoor tests. It has been shown above that the increment of measured mass over a period of 10 seconds matches with the observation on the video and make the falling parts criteria more robust.

This conclusion only holds if the greatest care is taken in the design and positioning of the platform. An improper positioning of the platform creates undue forces on the load cells and make the data unsuitable for use.

Contrarily, wind can strongly affect the load cells platform measurements, generating parasitic forces that can reach level of several kilograms. Thus, normal outdoor conditions make the load cell platform unsuitable. For outdoor tests, any other equipment could be used provided it has been validated for the purpose of the falling part measurements. This is left for future work.

Consequently, the consortium agrees to propose the following falling parts criteria in the assessment method:

> *10.2.1 Falling parts – Level 1*
>
> *The failure of falling parts (level 1) criterion occurs when the increment of mass of falling parts over a period of 10 seconds exceeds 1 kg.*
>
> *10.2.2 Falling parts – Level 2*
>
> *The failure of falling parts (level 2) criterion occurs when the increment of mass of falling parts over a period of 10 seconds exceeds 5 kg.*

Regarding the videos, the section 4.3.7 of the assessment method should clarify that the use of the videos is mandatory to sort the parts falling from the façade from the parts falling from the crib. It should also be advised that the timer displaying the test time shall be visible on the video, and easy to read. If not, the risk of error in tracking the right test time on the video is increased.

5.4. Proposed classification

A separate document for the classification has been created, see Appendix I.

6. Proposed assessment method

6.1. Background to the assessment method

Several aspects of the initial draft assessment method (ASSESSMENT OF FIRE PERFORMANCE OF FACADES, Draft revision 1. Date: May 7, 2020.) have been updated and refined on the basis of test program, e.g. the tolerances on the fuel source and the placement of the secondary opening have been set. A methodology for assessing falling parts is presented with levels based on two questionnaires, and the suggested criteria are implemented in the assessment method. Here some of main changes of the method will be discussed. There are also many smaller changes in wordings and more specific language throughout the assessment method documents which will not be discussed further here.

6.1.1. The combustion chamber

The combustion chamber with the following specifications is defined in Table 6.1. Note that no change has been done to the medium fire and that the size of the large combustion chamber has been tested accordingly after the preliminary computer simulated design, see appendices F and G.

Table 6.1.
Specification of combustion chambers.

Parameter	Medium fire exposure	Large fire exposure
Distance of combustion chamber opening from finished corner (mm)*	0	250 ± 100 mm
Height of combustion chamber opening (mm)	1000 ± 50 mm	1900 ± 50 mm
Width of combustion chamber opening (mm)	1000 ± 50 mm	2000 ± 50 mm
Internal height of the combustion chamber (mm)	1000 ± 50 mm	2100 ± 50 mm
Internal width of the combustion chamber (mm)	1000 ± 50 mm	2400 ± 50 mm
Depth of combustion chamber (mm) (inside back wall to front surface)	800 ± 50 mm	1300 ± 50 mm
Opening for Forced Ventilation	Round of 300 mm in diameter. A fan shall be located behind the rear wall of the combustion chamber and blow 400 ± 40 m³/h fresh air in the combustion chamber	Not applicable

* To fulfil this requirement for any thickness of the tested façade, it is recommended to design a flexible test rig (see note in assessment method document 4.2).

The combustion chamber walls and roof shall be made of a non-combustible construction. The inner surfaces of the combustion chamber shall be cladded with insulation (ceramic insulation (with low heat conductivity ~ 0.15 W/mK) or equivalent). Note that we have added the same tolerance to the distance of combustion chamber to the finished wall as in the BS 8414, this is done to accommodate for the most common thicknesses of façade specimens.

6.1.2. Fuel source

The fuel source consists of a wood crib detailed in Table 6.2 below and located in the combustion chamber defined as in section 4.5 of the updated assessment method, see Appendix B. The fuel source is similar to the cribs presented in Progress Report 2 where the medium exposure crib is as specified in the DIN 4102-20. Regarding the large exposure crib we have, however, also imposed a height restriction to the large crib as 110±2.5 cm in addition to the total weight of the crib of 350±20 kg to reduce the variation in fire load in the method, although the effect of this is significantly reduced by introducing a test time of 30 minutes. This is also indirectly a tolerance on the average density.

Table 6.2.
Specification of wood cribs.

Parameter	Medium fire exposure	Large fire exposure
Wood species	Spruce (Picea abies)	Spruce (Picea abies)
Cross section of sticks	40 x 40 mm2 ± 2 mm	47 x 47 mm2 ± 3 mm
Length of sticks	500 ± 5 mm	Long: 1500 ± 5 mm Short: 1000 ± 5 mm
Nominal density of sticks	475 ± 25 kg/m3	500 ± 100 kg/m3
Weight of crib	30 ± 1.5 kg	350 ± 20 kg
Number of sticks per layer and number of layers	6 sticks per layer The number of layers and number of sticks in the top layer are adjusted so the weight of the crib is within the tolerances.	Long: 10 sticks/layer Short: 15 sticks/layer The number of layers is adjusted to keep the crib within 110 ± 2.5 cm.
Joining of sticks	Nailing	Nailing
Moisture content	11 ± 2 %	11 ± 2 %
Surface finish	Planed	Sawn or planed
Floor for crib	Grating	Solid

6.1.3. The secondary opening

The objective of the secondary opening is to simulate the presence of any kind of feature – such as windows - at levels above the fire source opening. The main face of the test specimen and of the test rig (structural frame/supporting construction) shall incorporate a secondary opening as described below. The secondary opening is asymmetrically placed in relation to the fuel source. The objective is, both in medium and large-scale exposure, thus to be able to test the interaction between the secondary opening fittings, wall cladding and the fuel source. Note that in large-scale the same tolerance ±100 mm is added to enable a standard rig to be constructed by the laboratories.

Large-scale
The secondary opening shall be 1200 mm width, 1200 mm height. It shall be located 1500 mm above the top of the combustion chamber and 1250 ± 100 mm from the finished corner

i.e. the corner of the installed system. See Figure 6.1 (8a in the assessment method, see Appendix B).

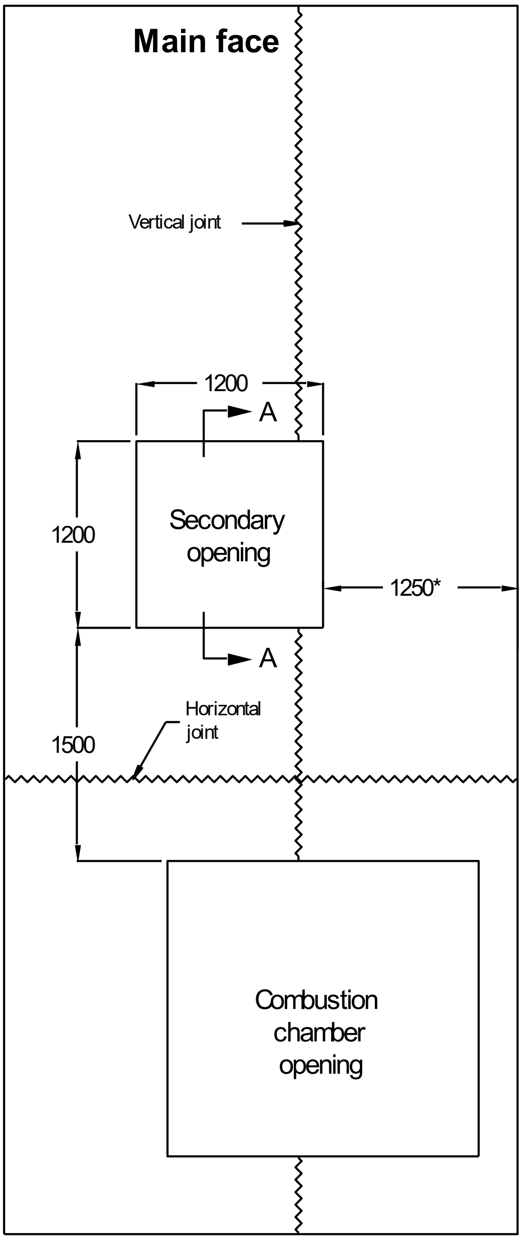


Figure 6.1 Main face with secondary opening including the location of vertical and horizontal joints. Distances in the drawing have to be considered with a tolerance of ±50 mm except the vertical distance between corner and secondary opening which is 1250 ± 100 mm.

Medium-scale

The secondary opening shall be 1200 mm width, 1200 mm height. It shall be located 1000 mm above the top of the combustion chamber and 500 mm from the finished corner. Note that the secondary opening for medium scale is moved closer to the fuel source, see Figure 6.2.

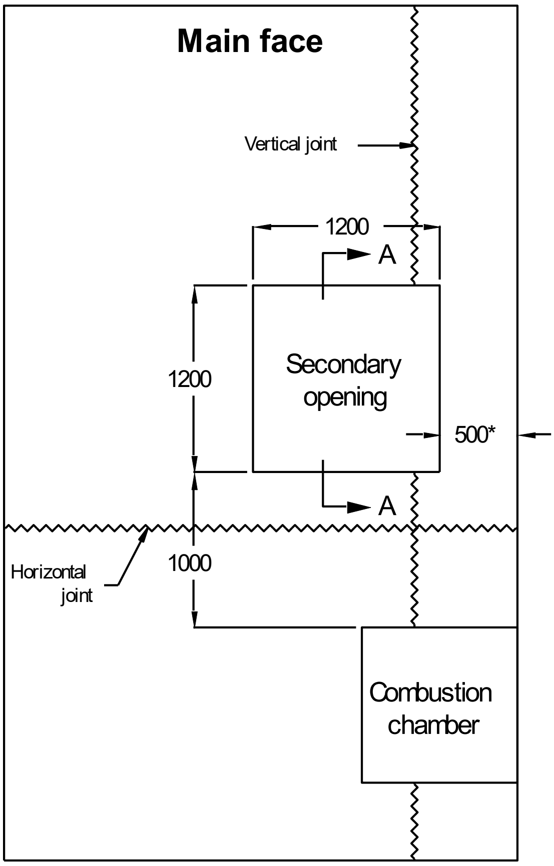


Figure 6.2. Main face with secondary opening including the location of vertical and horizontal joints. Distances in the drawing have to be considered with a tolerance of ±50 mm except the vertical distance between corner and secondary opening which is 500 ± 100 mm.

6.1.4. Falling parts

A weighing load cell platform with an accuracy of ± 50 g shall be used to measure the mass of falling parts during the test. A plate that covers the rectangular area which is defined by the main face and the wing as shown in Figure 6.3 shall be used on top of the weighing cell platform to collect falling parts during the test. A software shall be used that allows the automatic and continuous measurements and recording of the weight. The weight over time shall be documented.

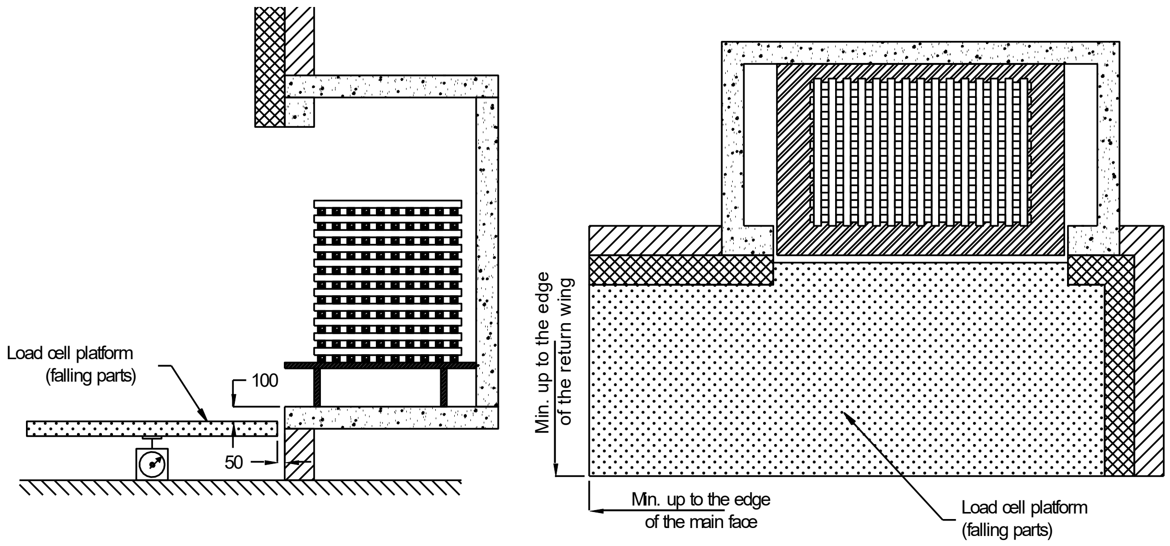


Figure 6.3. Placement of measurement platform for falling parts.

After evaluation of the questionnaire on falling parts the following improvements on the criteria in the Assessment method are recommended:

- Limits for individual falling part (not burning), mass of 1 and 5 kg.

6.1.5. Uplift

It was determined from the full inert tests (section 3.4) that several combustible materials such as paper, XPS or polyethylene, ignited at 1-2 m distance from the façade using a 0.5 m uplift. It is also concluded that collapse of the crib at the later stages will destroy assessment of the falling parts even if they have not ignited previously. Therefore, it was decided that the falling parts should be assessed at the moment they touch the floor and that there therefore is no need for an uplift. This will also save considerable costs to the test facilities and increase the number of laboratories that can already now perform the test.

6.1.6. Mounting and specimen

In general, the test specimen shall be installed on both the main wall and the wing as in practice. Among others, it shall be mounted with access only from areas that are actually accessible in real buildings and be installed as far as possible by the same method and procedures as in practice. It is not allowed to mount the specimen on the main face and the wing separately, and afterwards assemble the main face and the wing, since such mounting would not be possible in any real building.

The openings on all sides of the secondary opening and the left, right and top edge of the combustion chamber should be similar to end use. In case end use conditions are not known, a general closing may be used such as thin aluminium or steel plate, that would allow for different details to be fitted at the edge.

If vertical and horizontal joints are incorporated into the outer layer of the façade system (i.e. the first layer on the side of the exposed face), the test specimen shall incorporate such vertical and horizontal joints at intervals specified by the manufacturer, with at least one joint on the main face extending upwards within a tolerance of ±250 mm on the centre line of the combustion chamber opening and one such joint between the combustion chamber and the secondary opening. See Figure 6.1, (8a, in the Assessment method document for large exposure). This is a less strict requirement than previously to accommodate for standard manufacturing sizes.

7. Communication

7.1. Project group

The project group had biweekly video meetings where the progress of the project was being followed up. In addition to the project group, other stakeholders, who were working on research projects related to the present project, were also being invited.

During the project, researchers from DBI in Denmark and Imperial College in the UK were taking part in the meetings. Technical meetings were frequently being held, where specific technical questions as well as test results were being discussed.

The project steering group was also being invited to participate in all experimental tests performed via video, which was being of great value.

7.2. Steering group

A first meeting was being held with the steering group on September 15th, 2020, where the first progress report was being presented. In addition, regular meetings with the steering group were being held, as listed below. A physical workshop was also being held in Brussels on March 13th, and a follow-up online review meeting was being held on May 28th.

1. 2020-09-15
2. 2020-12-01
3. 2021-04-20
4. 2021-09-17
5. 2022-01-28
6. 2022-06-17
7. 2023-01-20
8. 2023-04-13
9. 2023-09-25
10. 2024-03-13
11. 2024-05-28

7.3. Stakeholders

Regular video meetings were being held since the inception report was being published. The meetings were being held with different stakeholders, mainly different associations, with the aim of having more detailed discussions. The project team was presenting the current status and progress of the project, and stakeholders were having the opportunity to give their input and get answers to their questions. These meetings were being of great value for the project group.

7.4. Other communication

The project was being presented in façade webinars, two of which were being organized by the Royal Netherlands Standardization Institute in 2020 and 2021, see Webinar façade fire safety (nen.nl). Two webinars were arranged by Fire Safe Europe on September 17th 2020 and on October 13th, 2021, see https://www.firesafeeurope.eu/events. The project was being presented to a broader audience in the Fire Information Exchange Platform webinar on May 20th, 2021. In addition to this webinar, Fire Safe Europe was also recording a podcast. The project was being presented at several scientific conferences: IAFSS 2021, AOFST 2021, ELIPYKA 2022, and Fire Safety of Facades 2024.

Due to the Corona pandemic, only a few physical meetings were possible. All regular consortium meetings were being held as video meetings. A webpage was being launched where all documentation in the project would be made available, https://www.ri.se/en/what-we-do/projects/european-approach-to-assess-the-fire-performance-of-facades.

Two webinars were being held where all stakeholders were invited. An introduction to the project was being held on April 1st, 2020. The second webinar was being held on July 8th, 2020, where the progress of the project was being presented, as well as some clarifications on questions sent to stakeholders regarding the façade systems to be used in the test program. On May 16th, 2022, a Brandforsk webinar on this project was being arranged, presenting the latest results in the testing program. Follow-up meetings were being held bi-weekly in the project group. In parallel, many remote meetings were being performed with each task group.

8. Literature

Test standards

- PN-B-02867:2013
- BS 8414-1:2015 and BS 8414-2:2015
- BS 8414-1:2020 and BS 8414-2:2020
- BR 135
- DIN 4102-20:2017
- ÖNORM B 3800-5
- Prüfbestimmung für Aussenwandbekleidungssysteme Technical regulation A 2.2.1.5 (Sockelbrand)
- LEPIR 2
- MSZ 14800-6:2009
- MSZ 14800-6:2020
- SP Fire 105
- Engineering guidance 16 (unofficial test method)
- ISO 13785-2:2002
- ISO 13785-1:2002

Test reports

Ministry of Housing, Communities and Local Government (2019) *Final Research Report Fire Performance of Cladding Materials Research –Appendix A Literature review*, Prepared for: Technical Policy Division, MHCLG Date:9 December 2019 MHCLG Contract: CCZZ17A36 Report Number: P111324-1019 (M9D12V1)

BRE global (2012). A comparison of BS 8414-1 &-2, ISO 13785 -1&-2, EN 13823 and EN ISO 11925-2, 28 June 2012 Report number CC 275194 issue 2

Dumont, F., Boström, L., Anderson, J. & Chiva, R. (2020). Report of the Round-Robin Nr. TC2 20-1 on façades. Egolf.

Ministry of Housing, Communities and Local Government (2020a). *Final Research Report Fire Performance of Cladding Materials Research – Appendix D Construction and design of experimental rig and calibration exercise*, Prepared for: Technical Policy Division, MHCLG Date: 20 March 2020 MHCLG Contract: CCZZ17A36 Report Number: P111324-1019 (M9D12V2)

Ministry of Housing, Communities and Local Government (2020b). *Final Research Report Fire Performance of Cladding Materials Research – Appendix E Main experimental programme*, Prepared for: Technical Policy Division, MHCLG Date: 20 March 2020 MHCLG Contract: CCZZ17A36 Report Number: P111324-1019 (M9D12V2)

Kotthoff. I. (1999). *DIN 4102-20 test report (Versuchdokumentation)* 29.09.1999, MFPA Leipzig

Test reports UK websites

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(Façade components tests and façade tests performed after Grenfell fire 2017.)

Investigations of test methods

Brandon, D., Sjöström, J., Hallberg, E., Temple, A. & Kahl, F. (2020). *Summary Report Fire Safe implementation of visible mass timber in tall buildings – compartment fire testing*, RISE Report 2020:94, RISE Research institutes of Sweden, ISBN: 978-91-89167-79-7

Boström, L., Chiva, R., Colwell, S., Móder, I., Tóth, P., Hofmann-Böllinghaus, A., Lange, D., Anderson, J., Sjöström, J. (2018). Development of a European approach to assess the fire performance of façades. DOI: https://doi.org/10.2873/954759.

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Efectis (2022) Fire test report EUI-20-000358, https://www.ri.se/sites/default/files/2021-04/Test%20report%20Large%20Exposure%20Crib%202021-04-06.pdf (accessed 2022-06-05).

Dumont, F., Boström, L., Anderson, J. and Chiva, R. (2020) REPORT OF THE ROUND-ROBIN NR. TC2 20-1 ON FAÇADES, https://www.ri.se/sites/default/files/2020-09/RR%20TC2%2020-1%20Full%20report%20v2.pdf

EOTA (2013), Amended January 11th, 2013, after EOTA PT4 meeting on April 18th, 2013, Berlin, *Technical Report Large Scale Fire Performance Testing of External Wall Cladding Systems*. EOTA PT4 Task Group

Harmathy, T. Z., *Experimental study on the effect of ventilation on the burning of piles of solid fuels*, NRC Publications Archive Archives des publications du CNRC https://doi.org/10.4224/40001767.

McAllister S., Finney M., *The Effect of Wind on Burning Rate of Wood Cribs*. USDA Forest Service, RMRS Missoula Fire Sciences Lab, 5775 W US Highway 10, Missoula, MT 59808, USA. Fire Technology, 52, 1035–1050, 2016

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Sjöström, J., Anderson, J., Kahl, F., Boström, L., Hallberg, E. (2021b). *Large scale exposure of fires to façade testing of proposed European method*, RISE Report 2021:85, RISE Research Institutes of Sweden, Borås. ISBN: 978-91-89385-75-7.

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Thomas, P.H. (1973). *On the burning of cribs,* Fire Research Note, No 965, March 1973, Fire Research Station

9. Appendix A – Comments Handling Document

The comments handling documents are available on the web page. The following documents have been published (dated accordingly):

- Comments Handling Document - dated 2020 07 22
- Comments Handling Document - dated 2020 10 23
- Comments Handling Document - dated 2020 11 18
- Comments Handling Document - dated 2020 12 11
- Steering Group Meeting Q&A
- Answers on questions on the façade assessment project - REV1
- Comments Handling Document - dated 2021 12 03
- Comments Handling Document - dated 2022 07 01
- Comments Handling Document - dated 2022 08 30
- Comments Handling Document – dated 2023 03 09
- Comments Handling Document – dated 2024 02 15
- Comments Handling Document collated final – dated 2024 05 24

A summary document including all comments was also published on February 24th May 2024 along with the questions and answers from the steering group meetings have been published. The collated Comments Handling Document is located here: https://www.ri.se/sites/default/files/2024-05/Comments%20Handling%20Document%20final%20collated%20final.pdf

10. Appendix B – Updated assessment methods

The updated assessment method is published on the project web page, the draft "Assessment method - draft 1 dated May 7 2020 - SI 2 825082" and a version where all received comments are added "Commented version of the Assessment method November 18 2020". All questions and issues have been taken into account during the testing phase of the project. An updated version of the assessment method was published May 12th 2022 after the initial testing phase was completed to be used during the Round Robin. During the autumn of 2022 separate versions of the assessment method was published for medium and large-scale both dated November 18th 2022. The assessment method was again updated after the experimental Round Robin in May 2024.

ASSESSMENT OF FIRE PERFORMANCE OF FAÇADES USING MEDIUM FIRE EXPOSURE

Draft revision 8
Date: 2024 – xx - xx

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TABLE OF CONTENT

1 SCOPE

This assessment method is applicable for any façade system, like for instance external walls, façade cladding systems vertically fixed to and supported by a structural frame or a supporting construction. The façade is a complete external wall construction of any type (massive wall or curtain walling …etc.) or constitution (masonry, combustible material etc). The method will not address the load-bearing capacity of the tested system, nor inclined façade systems. This method addresses requirements which go beyond the requirements that can be addressed and classified according to EN 13501-1,2, like for instance EN 1364-3 and 4 for fire resistance of curtain walling.

The method includes a secondary opening for assessment of detailing of the façade system around openings to simulate the presence of any kind such features at levels above the fire source, but not any window detailing. Vertical and horizontal fire spread on the surface and within façade systems is assessed. The method also evaluates falling parts (mass of falling parts and risk for fire spread downwards through burning material falling down from the façade) of a façade when exposed to fire. This method cannot directly assess the fire re-entry into the compartments above the combustion chamber, because window detailing is not tested. Vertical fire spread is limited to reduce the risk of fire re-entry into the building, see note below.

> *Note 1: Generally, a fire re-entry into the building from one storey (origin of the fire) to the next one above via windows cannot be prevented. Limitation of vertical fire spread concentrates usually on the task to prevent further fire spread.*

> *Note 2: Vertical fire spread is assessed only in the upward direction by the present method, not in the downward direction, since the combustion chamber is kept at the base of the test rig. Assessing a downward fire spread would require to raise the combustion chamber at 3 m from the ground for instance.*

Examples of typical products and systems covered by this proposal include (but is not limited to):

- Exterior Thermal Insulation Composite Systems (EIFS, ETICS or synthetic stucco)
- Metal composite material cladding systems (MCM)
- High-pressure laminate façade and cladding systems
- Structural Insulation Panel Systems (SIPS) and insulated sandwich panel systems
- Rain screen cladding or ventilated façades
- Weather-resistive barriers (WRB)
- Wooden façades
- External walls
- Curtain walling

This proposal covers the fire performance of the façade system, not its individual insulating components, products or elements.

This proposal defines the procedure using a *medium fire exposure* test, based on a flashover scenario in which the primary fire source has been down-scaled. The method has thus virtually removed one storey from the test set-up, and only focus on the façade part located two storeys above the fire room, i.e. the top of the flames. The project report BI5-8001 96-18 (Kotthoff, 2000) states in Section 8.3.5.4 (translated): "*The thermal impact of a 25 kg wood crib is of course not comparable to a fire in a fully furnished room. At the area where the flames emerge the opening and directly above the lintel the exposure is similar to the exposure of a room fire*".

The method includes an optional assessment for the smouldering. This is a feature regulated in some Member States and therefore also included here. However, any eventual classification for smouldering is not included.

The direct field of application is limited in the present document, and more information and studies are required to give a wider direct field of application. The extended field of application, i.e., when the results from two or more tests are combined, has not been addressed in this document.

There is no clear definition of a façade system. In some Member States the regulation covers the complete exterior wall, while in other Member States it is the outer skin that needs to be assessed. Therefore, the European assessment method needs to cover all, and it will be important to have a good description of the field of application together with the test and classification report.

2 NORMATIVE REFERENCES

ISO 13943 Fire safety - Vocabulary

EN 60584-1 Thermocouples – Part 1: EMF specifications and tolerances

EN 1364-3 Fire resistance tests for non-loadbearing elements – Part 3: Curtain walling – Full configuration (complete assembly)

EN 1364-4 Fire resistance tests for non-loadbearing elements – Part 4: Curtain walling – Part configuration

EN 16733 Reaction to fire tests for building products – Determination of a building product's propensity to undergo continuous smouldering

EN 1363-1 Fire resistance tests – Part 1: General requirements

EN 13238 Reaction to fire tests for building products – Conditioning procedures and general rules for selection of substrates

EN 13501-1 Fire classification of construction products and building elements – Part 1: Classification using data from reaction to fire tests

EN 13501-2 Fire classification of construction products and building elements – part 2: Classification using data from fire resistance tests, excluding ventilation services

3 TERMS, DEFINITIONS, SYMBOLS AND DESIGNATIONS

cavity systems	Systems with a cavity (i.e., a volume containing air). This includes (but is not limited to) what is generally referred to as ventilated façades.
charred material	Material that is judged to have been changed by pyrolysis. The assessment should be motivated by some charring characteristic, including (but not limited to) density changes, fissures, porosity etc.
collapse	Any part of the façade system which becomes detached and/or falls off
combustible (layer)	Material whose Euroclass ranges from B to F or whose reaction to fire performance has not been determined. Materials have to be assessed individually, i.e., a composite material may have a Euroclass A due to a good protection of a backing combustible insulation, and in these cases each material must be assessed individually.
discoloration	Visual change of specimen not caused by burning, charring or melting
discrete area	Portion of the total surface of a building element (e.g., façade, floor…) which may be expected to have different thermal insulation than the other areas in presence in this building element, whether visible or invisible (i.e., hidden inside the building element)
element, component or product	In this context part of the façade system
Euroclass	Reaction to fire class of a material according to EN 13501-1 (e.g., A1, A2, B, C, D, E, F).
exposed face	Finished external face of the tested façade
external cladding system	Complete cladding assembly *Note: This includes sheeting rails, fixings, cavities, insulation and membranes, coatings, flashings or joints*
external wall assembly	Complete system including any sheeting rails, cavities, fire barriers and weathering membranes and/or coatings
façade	A complete external wall construction of any type (massive wall or curtain wall …etc.) or constitution (masonry, combustible material …etc.*).* Since there is no general definition available on the term façade or a façade system, it is used in a very general way in this document. Due to different uses of the term in the Member States, and as the present assessment method shall be applicable in all Member States, the definition has to cover everything from the outer skin of the building envelope to the full external wall. What to test in accordance with this assessment method is then defined by the regulations and requirements in the individual Member States and the field of application.
façade system	see façade
falling parts	Material (solid or molten) separating from the specimen, burning - with or without a visible flame - or not burning, during a fire or a Fire test.
finished corner	90° corner formed between both exposed faces of the tested façade, namely the main face and the return wing
fire barrier	Separating element which inhibits the passage of flame and/or heat and/or effluents for a period of time under specified conditions
fire load	Quantity of heat which could be released by the complete combustion of all the combustible materials in a volume, including the facings of all boundary surfaces *Note 1: Fire load is expressed in joules* *Note 2: Fire load may be based on effective, gross or net heat*

	of combustion (thermal energy produced by combustion of unit mass of a given substance as required by the specifier)
fire scenario	Detailed description of conditions, including environmental, of one or more stages from before ignition to after completion of combustion in an actual fire at a specific location or in a real-scale simulation
fire stop	Fire safety measure to limit the fire propagation within the system
fire spread	Propagation of a fire front on a material surface or within a material defined by the width or height to which any thermocouple exceeds a temperature increase of 500 K on average over a period of 30 seconds
flashover	Transition to a state of total surface involvement in a ventilated controlled fire within an enclosure
fully developed fire	State of total involvement of combustible materials in a fire
hygroscopic material	A material which is able to absorb significant amount of moisture from the ambient air.
inner corner	90° corner formed between both front sides of the test rig, namely the main face and the return wing
main face	The large vertical surface of the test rig and test specimen in which the combustion chamber Is placed.
mass loss rate	Mass of material lost per time unit under specified conditions *Note: It is expressed in kilograms per second*
protection to openings	Any feature provided to accommodate the termination of the façade specifically at the boundaries of openings (combustion chamber opening and secondary opening) and that is deemed to offer to this termination any protection against fire spread. Examples of protection to openings are: window frame, sealant, caulking, profile that encapsulates or screens the termination, window sill etc. covering partially or totally the façade termination
smouldering	Combustion of a material without flame and without visible light, including glowing combustion. *Note: Smouldering is generally evidenced by an increase in temperature and/or by effluent*
structural frame	A stable frame onto which a full external wall, or a supporting construction, can be mounted.
starting time	The starting time of the test is determined as the time when 80 K increase is exceeded over a 30 second average at any thermocouple at 3500 mm from the top of combustion chamber.
supporting construction	A secondary structure mounted on the structural frame onto which a façade test specimen can be mounted. A supporting construction may be necessary when not the full external wall Is tested.
system	see façade
test rig	The total assembly of the structural frame, the eventual supporting construction, and the combustion chamber.
window frame	In the test it is possible to have a protection of edges around openings which would be the case in practice through details from windows.
wing (= return wing)	The smaller vertical part of the test rig and test specimen placed at a 90° angle to the main face.

4 TEST EQUIPMENT

4.1 General

The test equipment consists of the following main components:

- Structural frame
- Supporting construction in some cases
- Combustion chamber and fuel source
- Instrumentation

The test rig consists of a structural frame, eventually covered by a supporting construction, composed of a main face and a return wing, fitted with a combustion chamber. The rig utilizes a vertical structural frame, representative of a structural steel framed building and shall be capable of enduring the effects of the test procedure without itself suffering undue damage or distortion, see 4.3 for details.

Note: In the Figures in this document, the hatched areas referenced as "test rig" are simplified representations of the main face and the wing of the test rig which – for convenience – have been schematically reduced to their surrounding rectangular envelope. It should be understood that this schematic representation always includes a structural frame and, depending on the kind of façade being evaluated, may or may not include a supporting construction (see 6.6 for detail).

4.2 Main face and wing

The test rig shall include a main face and a wing, see Figure 1, where the wing is mounted at 90° to the main face. Figure 1 shows the minimum size of test rigs for medium fire exposure and large fire exposure. The front side of the test rig shall extend horizontally from the inner corner of the test rig, over sufficient widths to accommodate the minimal required dimensions of the tested façade (see 6.1), and this as much for the main face as for the return wing. The needed minimal horizontal dimensions of the test rig will consequently depend on the thickness of the tested façade.

Note 1: It is recommended to design a flexible test rig, with main face and return wing widths sufficient to accommodate any façade thickness, and with a return wing that can be shifted to increase/decrease the main face width, or with a larger combustion chamber to be reduced depending on the façade system thickness.

Note 2: The return wing may be accommodated either on the left or on the right of the main face. In the present document, the figures only show the configuration with the return wing located on the right side of the main face.

The front side of the test rig (both main face and wing) shall extend vertically from the base of the test rig to a height of at least 4000 mm above the top of the combustion chamber opening.

The main face shall include one secondary opening, see 6.7 for details.

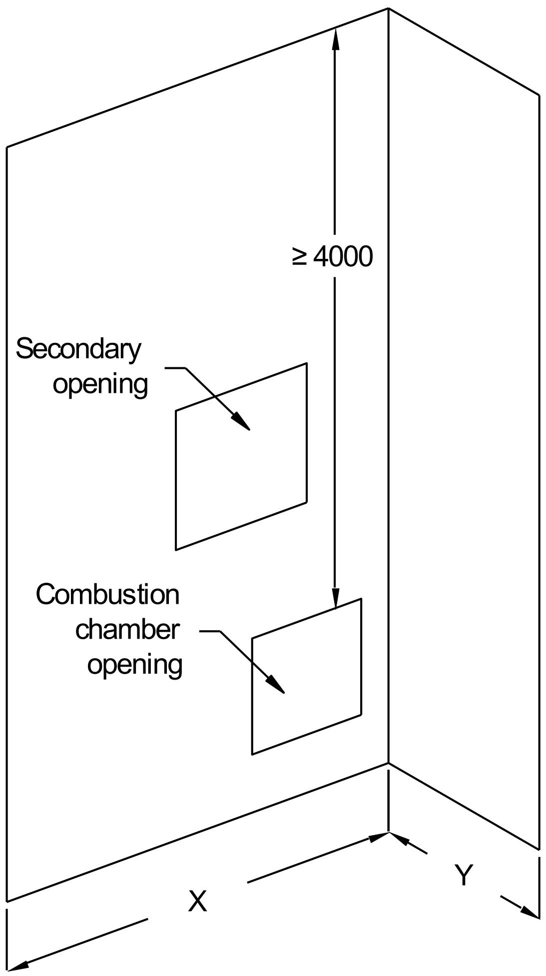


Figure 1. Principle drawing of the test rig. The front side of the test rig is represented here. The widths X (main face) and Y (return wing) are chosen to accommodate the dimensions of the tested façade. Note that there is a gap between the combustion chamber and the wing wall to accommodate for the thickness of the façade.

4.3 Structural frame

A structural steel frame shall be designed and constructed to withstand the expected loading imposed by the system under test and any subsequent distortions that can occur during the test program. Other structural frames such as timber or concrete can be employed for specific applications.

4.4 Supporting construction

If a part of the full external wall is tested, for instance a cladding system, a supporting construction (representing the wall onto which the tested system is used) is necessary onto which the test specimen can be mounted. See 6.6 for more instructions.

The supporting construction shall be erected onto the structural frame. It shall be made of a masonry, e.g., aerated or light weight concrete blocks or slabs, and it shall be mounted in such way that it is airtight.

Note: It is recommended to fix the supporting construction on the structural frame for safety reasons.

4.5 Combustion chamber

The design and location of the combustion chamber opening in the main face shall be in accordance with the design details specified in Table 1. The distance specified in Table 1 are clear distances, i.e., measured once the chamber preparation is ended with the cladded insulation in place.

Table 1. Specification of combustion chambers.

Parameter	**Value**
Distance of combustion chamber opening from finished corner (mm)*	0
Height of combustion chamber opening (mm)	1000 ± 50
Width of combustion chamber opening (mm)	1000 ± 50
Internal height of the combustion chamber (mm)	1000 ± 50
Internal width of the combustion chamber (mm)	1000 ± 50
Depth of combustion chamber (mm) (inside back wall to front surface)	800 ± 50
Opening for Forced Ventilation	Round of 300 mm in diameter A fan shall be located behind the rear wall of the combustion chamber and blow 400 ± 40 m^3/h fresh air in the combustion chamber
Figure Reference	Figure 2

* To fulfil this requirement for any thickness of the tested façade, it is recommended to design a flexible test rig (see note in 4.2).

The combustion chamber walls and roof shall be made of a non-combustible construction and its inner surfaces shall be cladded with high temperature insulation (ceramic or equivalent).

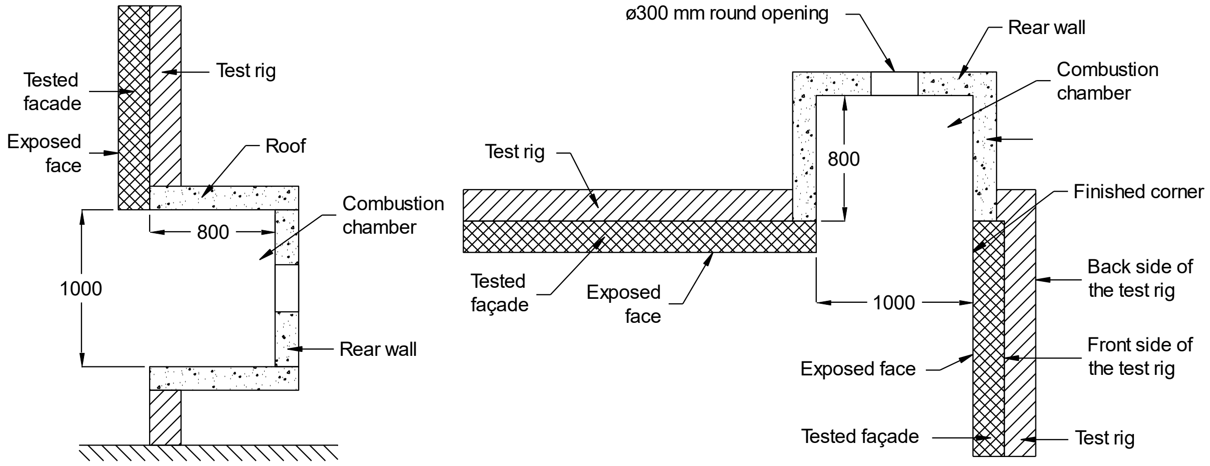


Figure 2. Combustion chamber for the medium fire exposure.

4.6 Fuel source

The fuel source is a wood crib made of spruce placed in the combustion chamber. The wood shall be stored indoor within a heated building until the weight is constant (Defined as when two successive weighings at 24 h intervals differ by less than 0,1% is reached.). The mean density after conditioning shall be 475 ± 25 kg/m³. The mean moisture content of the wood shall be 11 ± 2 % (mass water to mass of dry wood).

The crib is nominally 500 mm × 500 mm in plane.

It shall be constructed from sticks with the dimensions of 40 ± 2 mm x 40 ± 2 mm x 500 ± 5 mm.

The crib shall be constructed in layers, the sticks of the layers have 90° angle from layer to layer, the wood to air ratio is approximately 1:1. The sticks of the layer at the bottom are parallel to the rear wall of the combustion chamber. Each layer consists of 6 sticks which are in line with the outer edge of the crib. See Figure 4a. The number of sticks in the top layer is adjusted in a way that the mass of the crib is 30 ± 1.5 kg.

The wood crib shall be positioned on a meshed platform made of steel sections, in such a way that the base of the crib is at 200 ± 5 mm above the floor of the combustion chamber. The top side of the platform shall be covered by a 40 mm x 40 mm steel mesh to allow for ventilation from the bottom. The front side of the crib shall be located at 100 ± 10 mm behind the front side of the test rig. The distance between the crib and the side walls on both sides shall be the same. See Figure 3b.

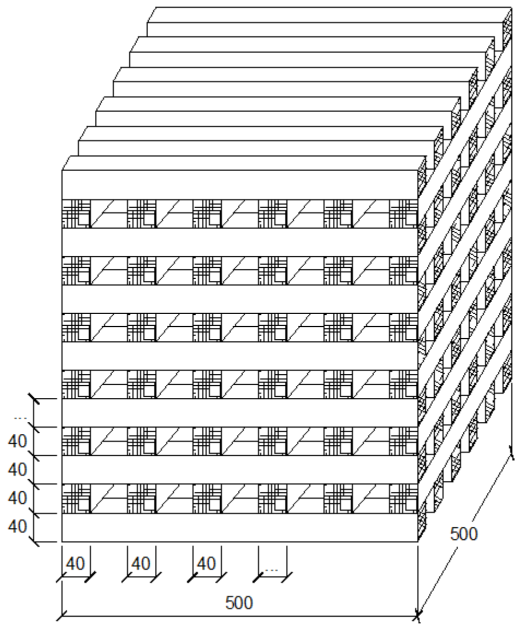


Figure 3a. Geometry of the wood crib for the medium fire exposure.

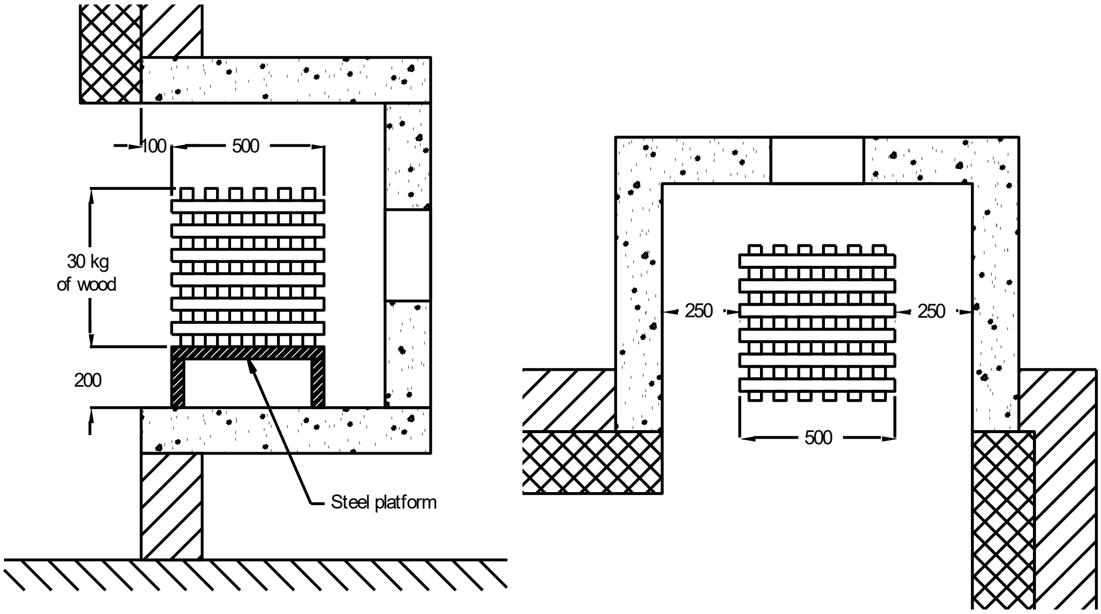


Figure 3b. The nominal position of the wood crib for the medium fire exposure.

4.7 Instrumentation

4.7.1 Thermocouples

The external and internal thermocouples shall have measuring junctions of nickel chromium/nickel aluminium (type K) wire as defined in EN 60584-1 contained within mineral insulation in a heat resisting alloy sheath of nominal diameter range of 1 to 3 mm, the hot junctions being electrically insulated from the sheath.

4.7.2 Data acquisition system

Instruments shall be connected to a data acquisition system capable of recording data at intervals not exceeding 5 s.

4.7.3 Visual equipment

Digital cameras shall be used to provide a continuous visual record of the test. A pixel resolution of 1920x1080 or higher shall be used. The camera shall be able to record at a speed of ≥ 10 Hz.

On the exposed face of the tested façade, at least one camera shall be used to cover the full height and width of the exposed faces (both main face and wing), as well as the full area of the load cell platform. Additional cameras (four cameras in total are generally sufficient) may be needed to ensure good coverage of the whole exposed face and also to cover for possible malfunction of the main camera.

The recorded pictures shall be used to distinguish the parts falling from the façade from those falling from the crib, as well as for the purpose of reporting of observations in the test report.

It is strongly recommended that the timer displaying the test time is visible on the video, and easy to read.

4.7.4 Mass measurement of falling parts

<u>Indoor testing</u>

A weighing load cell platform with an accuracy of ± 50 g shall be used to measure the mass of falling parts during the test. A plate that covers the rectangular area which is defined by the main face and the wing as shown in Figure 7 shall be used on top of the weighing cell platform to collect falling parts during the test. The platform shall be positioned at 100 mm below the bottom of the tested façade and at 50 mm of the supporting construction (see Figure 4). The platform shall under no circumstances enter in contact with any other element. This shall be checked with the greatest care before and during the test. A software shall be used that allows the automatic measurements and recording of the masses. The mass over time shall be documented.

Outdoor testing

No weighting load cell platform shall be used, due to their great sensitivity to wind. Any other equipment can be used provided it has been validated the for purpose of the falling part measurements. Among other, the accuracy of measurement of ± 50 g and the insensitivity to wind shall be demonstrated.

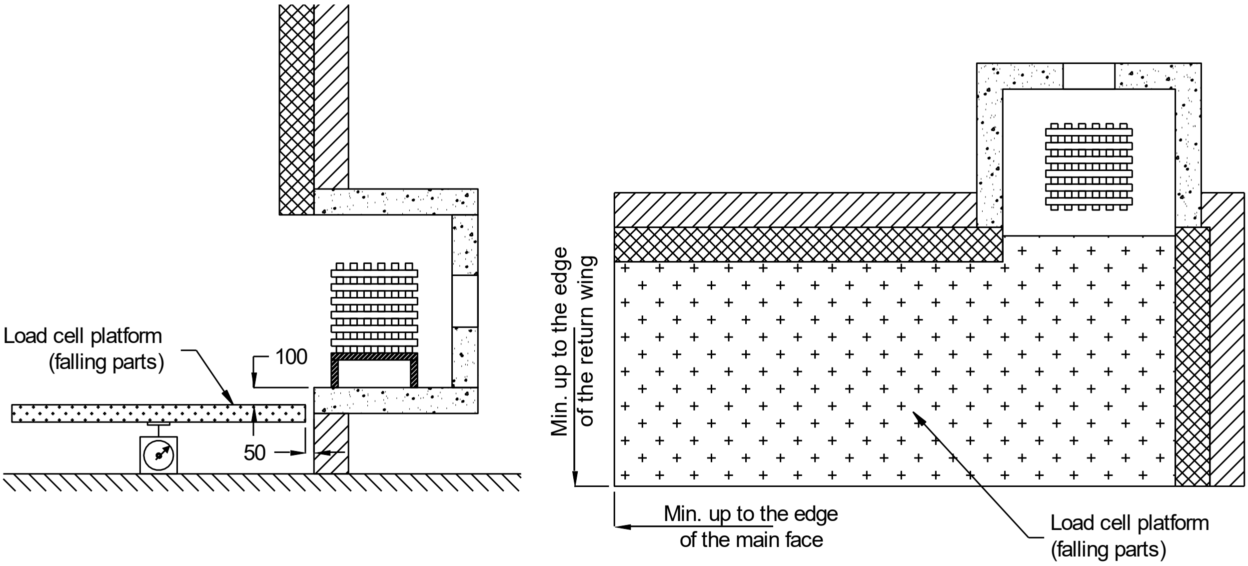


Figure 4. Nominal placement of measurement platform for falling parts.

5 ENVIRONMENTAL CONDITIONS

5.1 Ambient wind speed

The horizontal component of the ambient air speed shall be less than 2 m s^{-1} before the commencement of the test. This shall be demonstrated by measurements from a bidirectional anemometer measuring the horizontal wind speed and its direction with an accuracy of ±0.1 m/s and ±5°. It shall be located at a distance of 2000 mm ± 200 mm horizontally away from the exposed faces (main face as well as return wing, see Figure 5), and at the same height as the upper edge of the combustion chamber. The ambient air speed shall be measured at intervals of 1 minute during 15 minutes before the commencement of the test, and none of these 15 values shall exceed the speed limit above in order to allow starting the test. For indoor testing, these measurements shall be carried out under the same ventilation conditions as the ones used under the test.

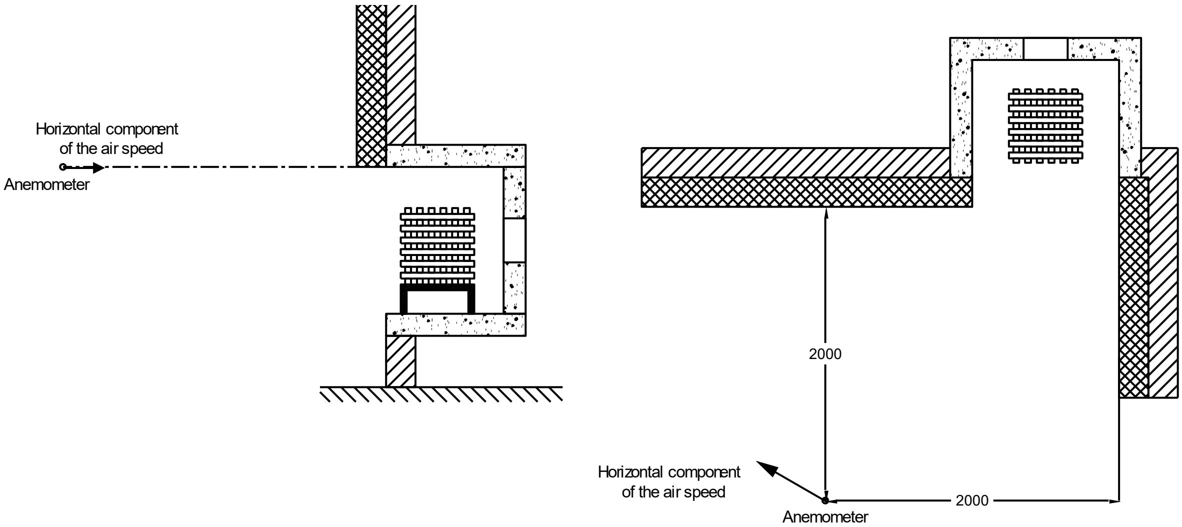


Figure 5. Nominal position of the anemometer and air speed component of interest.

During the test, wind (direction and velocity) shall be measured by means of a weather station (for outdoor test) or other equivalent system for indoor tests located in the vicinity of the test bench. The 2 m/s^{-1} limit applies also during the test.

5.2 Ambient temperature

The ambient temperature prior to testing shall be between +5 °C and +35 °C. This shall be demonstrated by a measurement from the ambient thermometer located at a distance of between 1.8 m and 2.2 m horizontally away from the exposed faces (main face as well as return wing), and between 1.8 m and 2.2 m above the ground. This measurement shall be performed not more than 5 min before the commencement of the test. In case of direct sunshine in the thermometer area, the ambient thermometer shall be shadowed from the sun by a suitable screen.

5.3 Ambient moisture

The ambient relative humidity shall be measured prior to the test the day of the test but also the two nights and two days before the test.

5.3 Outdoor testing

The laboratory shall carry out the tests during conditions meeting the requirements on ambient air velocity and temperature above shall be met. It could be necessary to shield the specimen from the effects of high wind.

5.4 Indoor testing

The requirements on ambient air velocity and temperature above shall be met. Mechanical or natural ventilation above the test rig (exhaust duct) is allowed, as long as the requirement on ambient air velocity is maintained.

6 TEST SPECIMEN

6.1 Size

The exposed face of the test specimen shall extend horizontally from the finished corner of the tested façade, at least 3200 mm on the main face and at least 1500 mm on the wing. The system shall, on both the main face and the wing, extend vertically from the lower part of the of the combustion chamber to a height of at least 4000 mm above the top of the combustion chamber opening. The test specimen shall not obstruct the combustion chamber opening nor the secondary opening, with the exception of the strictly minimum protrusion constituted by the representative edge detailing. See Figure 6.

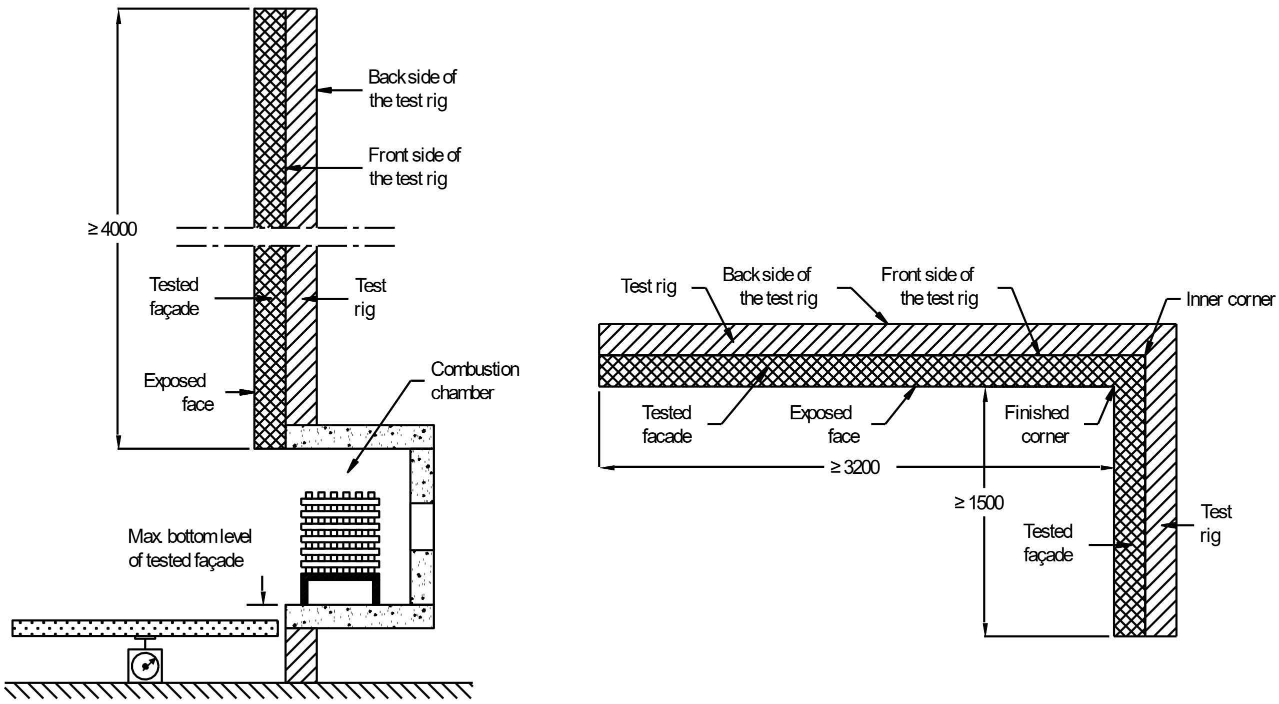


Figure 6. Test specimen and test rig (minimal dimensions).

6.2 Number of specimens to be tested

At least one specimen shall be tested. In the case where the mounting can be made in different ways (e.g., panels mounted vertically or horizontally), or where different details can be used (e.g., different types of fire stops or cavity barriers), or where other features can be done in different ways, then additional test specimens may be required. It is therefore important to use the direct field of application given in Section 12 which shows the possible changes and variations based on one test.

6.3 Design

The test specimen should be designed to obtain the widest applicability of the test results, by considering the product range of the manufacturer and the direct field of application given in Section 12.

The test specimen shall include all relevant components assembled and installed in accordance with the manufacturer's instructions.

The test façade shall include the special detailing around both openings in the façade system as close to end use conditions as possible, i.e., the detailing where features such as opening are to be mounted in practice, see 6.7.

At the boundaries of the tested façade (upper/lower horizontal and left/right vertical extremities), edges detailing and terminations shall be as intended for the end use design and shall be documented. As an example, a ventilated façade should be closed on the vertical sides and open at the upper horizontal edge.

Ventilated systems shall be built with all accessories for the ventilation to function in a real application, such as ducts or channels. The dimensions of cavities and installations shall be the same as in a real application.

All detailing shall be installed as in practice, including any fire stop, compressing seal, finishing mastic, insulating material, filling material, cladding, fastening and thermal breaks.

If in practice *horizontal* joints are incorporated into the outer layer of the façade system (i.e., the first layer on the side of the exposed face), the test specimen shall incorporate such horizontal joints at intervals specified by the manufacturer, with at least one joint placed between the combustion chamber opening and the secondary opening. If there is no joint in the outer layer, then the outermost layer of the façade system incorporating a joint shall be considered. The horizontal joints shall extend on the full width of the main face and the wing. See Figure 7a.

If in practice *vertical* joints are incorporated into the outer layer of the façade system (i.e., the first layer on the side of the exposed face), the test specimen shall incorporate such vertical joints at intervals specified by the manufacturer, with at least one joint on the main face extending upwards within a tolerance of ±250 mm on the centre line of the combustion chamber opening. If there is no joint in the outer layer, then the outermost layer of the façade system incorporating a joint shall be considered. The vertical joints shall extend on the full height of the main face. See Figure 7a.

Any modifications made to accommodate the installation of a test specimen on the test rig shall be such as to have no significant influence on the behaviour of the test specimen and shall be fully described in the test report.

6.4 Construction

The method of construction including the tolerances and the erection shall be representative of the use of the element in practice. The standard of workmanship shall be as normally provided in buildings.

The sponsor shall be responsible for ensuring that the quality of construction of the test specimen is representative of the product in practice.

The laboratory shall monitor the erection of the test specimen in order to be able to include details of the methodology and workmanship in the test report. The installation of the test specimen shall be compared to the design drawings for reporting by the test laboratory. Photographic records shall be used to support this.

6.5 Verification

The sponsor shall provide a description of all construction details, drawings and list of major components and their manufacturer/supplier, as well as an assembly procedure to the test laboratory, prior to the test. This shall be provided sufficiently in advance of the test to enable the laboratory to verify the conformity of the test specimen with the information provided. As far as possible, any area of discrepancy shall be resolved prior to starting the test. In case the construction details cannot be verified, the laboratory shall oversee the fabrication of the test specimen. Where appropriate, the critical material properties shall be determined, e.g., density, moisture content and tolerances.

On occasion, it may not be possible to verify the conformity of all aspects of the construction of the test specimen prior to the test and adequate evidence may not be available after the test. When it is necessary to rely on information provided by the sponsor, this information shall be clearly identified in the test report. The laboratory shall nevertheless ensure that it fully appreciates the design of the test specimen and shall be confident that it is able to accurately record the construction details in the test report.

6.6 Selection of the test rig

Depending on the type of test specimen being evaluated, the tested façade shall be installed either directly on the structural frame or it may be necessary to mount it on a supporting construction.

When in practice the façade system doesn't consist of a full stand-alone external wall but rather of a covering system to be fixed on an existing wall, then the test specimen shall be mounted onto a supporting construction, which one substitutes the existing wall in practice for the purpose of the test. See 4.4 for details.

When in practice the façade system consists of a full stand-alone external wall, then the test specimen shall be mounted directly on the structural frame.

The fixing on the rig shall be as close as possible to the intended practical application and appropriate for the rig i.e., if mounting on aerated concrete suitable anchors should be used.

6.7 Secondary opening

6.7.1 General

The objective of the secondary opening is to simulate the presence –of any kind of feature – such as windows - at levels above the combustion chamber opening. The main face of the test specimen and of the test rig (structural frame/supporting construction) shall incorporate a secondary opening of 1200 mm in width, 1200 mm in height. It shall be located 1000 mm above the top of the combustion chamber and 500 mm from the finished corner. See Figure 8a.

6.7.2 Test rig

Whether the test specimen is mounted directly on the structural frame or on a supporting construction, the backside of the opening shall be covered with a board with a thickness of ≥ 20 mm made of calcium silicate or any other material classified A1 according to EN 13501-1, see Figure 7b.

6.8 Mounting of the test specimen

The test specimen shall be installed on both the main wall and the wing as in practice. Among others, it shall be mounted with access only from areas that are actually accessible in real buildings and be installed as far as possible by the same method and procedures as in practice. It is not allowed to mount the specimen on the main face and the wing separately, and afterwards assemble the main face and the wing, since such mounting would not be possible in any real building.

If the façade system does not provide any protection to openings in practice (see definition in Section 3), then the detailing of the test specimen at openings (combustion chamber opening and secondary opening) shall also remain unprotected. Otherwise, the test specimen shall include the representative protections to openings intended to be used in practice.

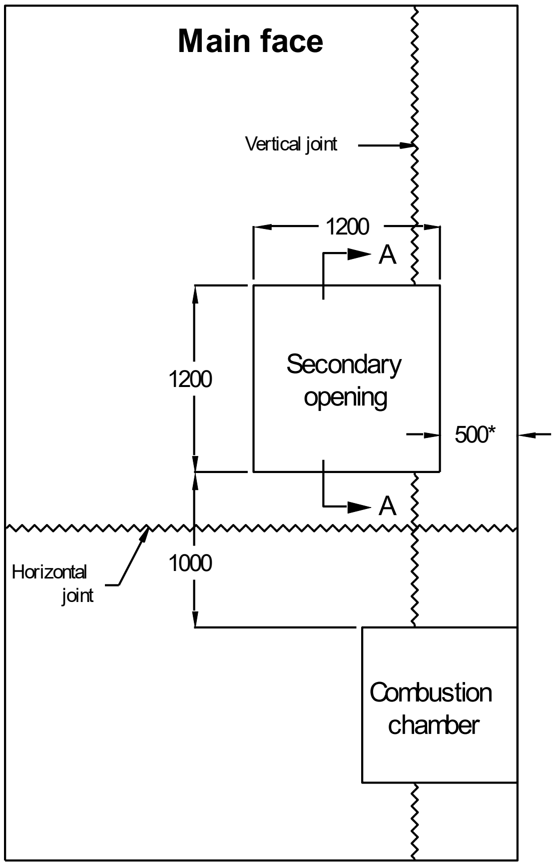


Figure 7a. Main face with secondary opening including the location of vertical and horizontal joints. Distances in the drawing shall be considered with a tolerance of ±50 mm except the vertical distance between corner and secondary opening which is 500 ± 100 mm.

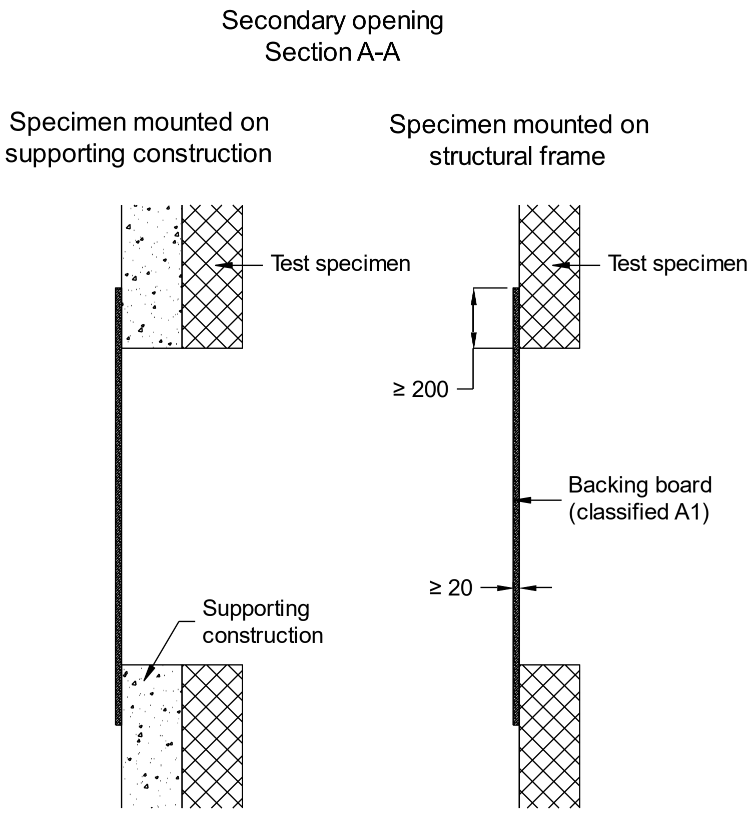


Figure 7b. Cross-section A-A of the secondary opening area

6.9 Edges of openings

The perimeter of the secondary opening and of the combustion chamber shall be closed as similar to the end use as possible. In case end use conditions are not known, a general closing may be used such as thin aluminium or steel plate, that would allow for different details to be fitted at the edge.

This general closing shall only be used where it is obvious that the fire behaviour of the simplified detail will be very similar to that used in practice.

A simplified detail cannot be used, for example:

- for heavy sheet coverings used in the window reveal and soffit (e.g., ceramic tiles, stone tiles)
- where the thermal insulation in the window reveal and soffit or the specific design of the junction prevents the fire from spreading to the rest of the façade (e.g. façade insulation system)

For all junction designs, the width of the fire opening in the horizontal direction shall be maintained at 1000 mm. In the vertical direction, the distance from the combustion chamber floor to the edge shall be kept at 1000 mm including detailing.

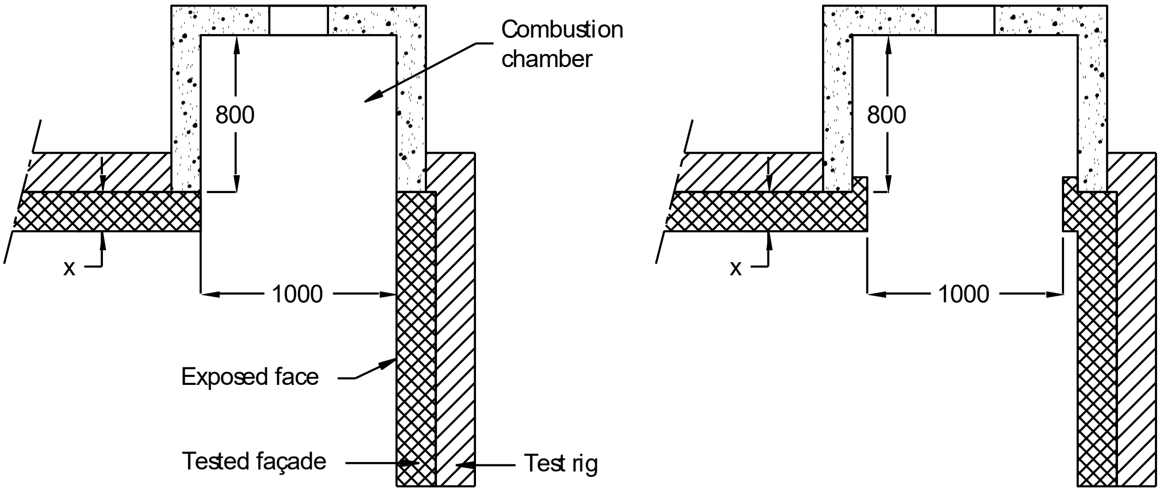


Figure 7c. Horizontal section of the detailing at the edges of openings schematically exemplified. The general closing configuration is shown on the left, the detail as in practice is shown on the right, x refers to the actual thickness of the tested façade.

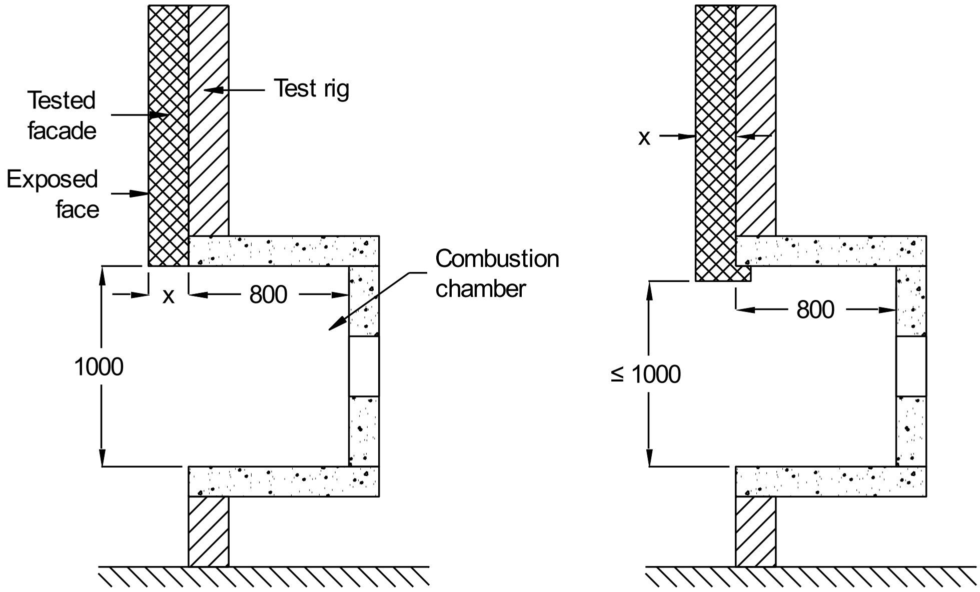


Figure 7d. Vertical section of the detailing at the edges of openings schematically exemplified. The general closing configuration is shown on the left, the detail as in practice is shown on the right, x refers to the actual thickness of the tested façade.

Note 1: The closing of the façade system is closely linked to the Field of Application and need to be developed separately.

7 CONDITIONING OF TEST SPECIMEN

7.1 General

After installation of the test specimen to the test rig, it shall be left for a period of time which is sufficient for all components to cure. If the tested façade system includes hygroscopic materials, it shall be conditioned following the requirements of 7.2, otherwise it shall be conditioned in accordance with the test sponsor's specifications.

The test rig with the mounted test specimen shall be protected from adverse environmental conditions such as water, wind load and ambient temperatures outside the range +5 °C to +35 °C during the mounting, conditioning and test period.

At the time of the test, the strength and the moisture content of the test specimen shall approximate to those expected in normal service.

7.2 Mock-up test specimen for verification of conditioning

When the tested façade system includes hygroscopic materials, in which case the fire performance is affected by the moisture content, the moisture content shall be measured during the conditioning period up to the time of testing by means of a small size mock-up of the façade.

This mock-up shall be prepared during the installation of the façade, using the same materials. This mock-up shall be used to estimate the weight stabilization of the sample and to determine material characteristics (mainly moisture content). It shall be stored together with the façade specimen and in the same ambient conditions.

The mock-up shall have the following dimensions:

- thickness: same thickness than the tested façade system,

- length and height of the front face: at least 200 mm x 200 mm or at least three times the thickness of the tested façade system, whichever is larger.

In order to ensure that the drying is allowed in the same way as for the façade in practice, namely only from the faces exposed to ambient air, all sides of the mock-up shall be covered in plastic except:

- the exposed face in case where the test specimen is mounted onto a supporting construction,

- both exposed and unexposed faces where the test specimen is mounted onto a structural frame.

The whole mock-up shall be weighted daily until the weight change between two measurements, 24 h apart, is less than 0.1 %. In case of materials that need long curing times, the conditioning can be limited to 28 days.

After this conditioning time, the moisture content of each individual hygroscopic material in presence shall be measured on samples taken from the mock-up test specimen. The moisture content of each such sample is determined by weighting the sample before and after drying at 105 °C. For some specific materials, such as gypsum, other drying temperatures may be applied which then shall be clearly stated in the test report.

8 APPLICATION OF INSTRUMENTATION

8.1 Temperature measurements

8.1.1 General

Sheathed thermocouples (external and internal, see below) shall be installed by drilling holes through the test specimen at the locations defined in Sections 8.1.2 and 8.1.3 to enable the thermocouples to be installed from the rear face of the tested façade. This instrumentation from behind shall ensure no interference with the development of the ignition source or with the fire propagation on the tested façade.

Drilling the holes in the tested façade shall be achieved by using equipment suitable for the type of façade system and materials being tested. The diameter of the holes shall be the minimum required to allow the thermocouples to be inserted from the rear to the exposed face of the tested façade, allowing for multiple thermocouples to be located through the full depth of the system, see Figure 10.

Care shall be taken to ensure that damage or displacement of material in each layer is minimized.

Where the external thermocouples pass through the exposed face of the tested façade, the thermocouples shall be allowed to travel freely and shall not be restrained to the test specimen. If any form of closure around the holes is required on the exposed face of the tested façade, this shall be achieved by use of non-combustible cementitious or packing materials.

Optionally, external thermocouples may be installed from the front side of the façade and maintained in place by means of any kind of steel structure (grid, chain, channels, angles, cables...), which avoid drilling into the outer layer of the façade.

One horizontal line (referenced as level 1) and two vertical lines (referenced as columns 1 and 2) are defined for external and internal thermocouples.

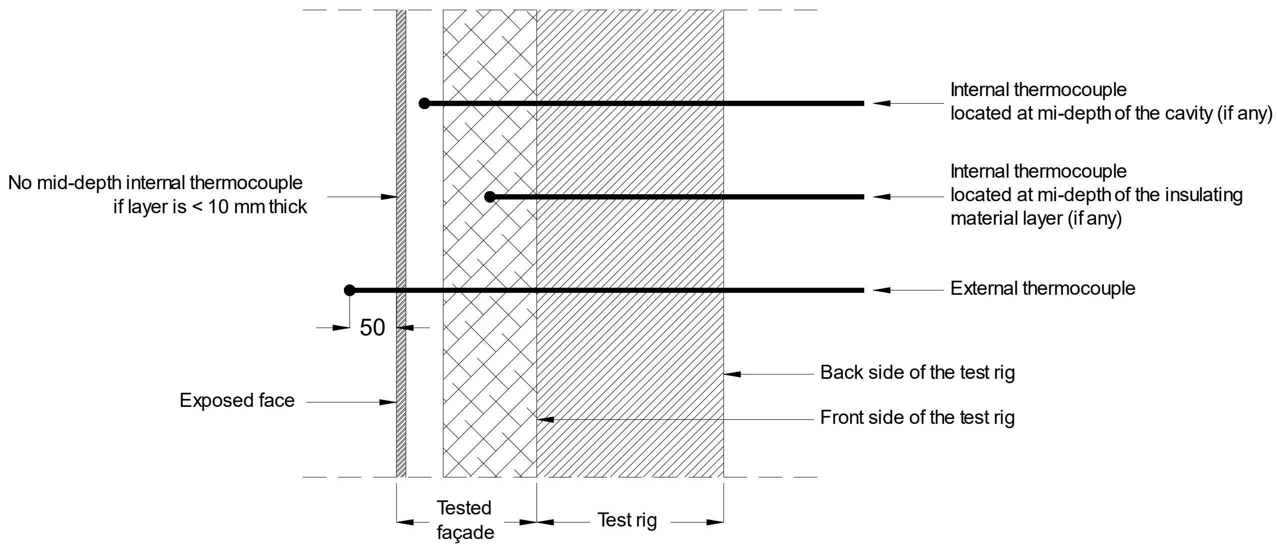


Figure 8 Principle drawing for the internal and external thermocouples for fire spread assessment

8.1.2 External thermocouples

The position of external thermocouples shall be according to Figure 9 within a tolerance of ± 10 mm. Nevertheless, if there are studs, joints, stiffeners, cavity barriers, or other components which interfere at the given position, then the external thermocouple shall be moved toward the combustion chamber to a location not more than 50 mm from the component. Regarding the depth position, the external thermocouples shall be placed with their hot junction positioned 50 ± 5 mm in front of the exposed face of the test specimen.

8.1.3 Internal thermocouples

In each location, internal thermocouples shall be positioned at the mid-depth of each combustible layer (see definition in Section 3) or air cavity that are at least 10 mm deep. In this regard, several consecutive layers of the same material shall be considered as one single layer. Notice that to minimize the impact on measurements on the façade system it is allowed to use the same hole for all thermocouples at the same location.

In each position, the internal thermocouples shall be positioned around - and at a distance of maximum 50 mm from the external thermocouple and moved toward the combustion chamber to a location not more than 50 mm from interfering studs, joints, stiffeners, cavity barriers, or other components.

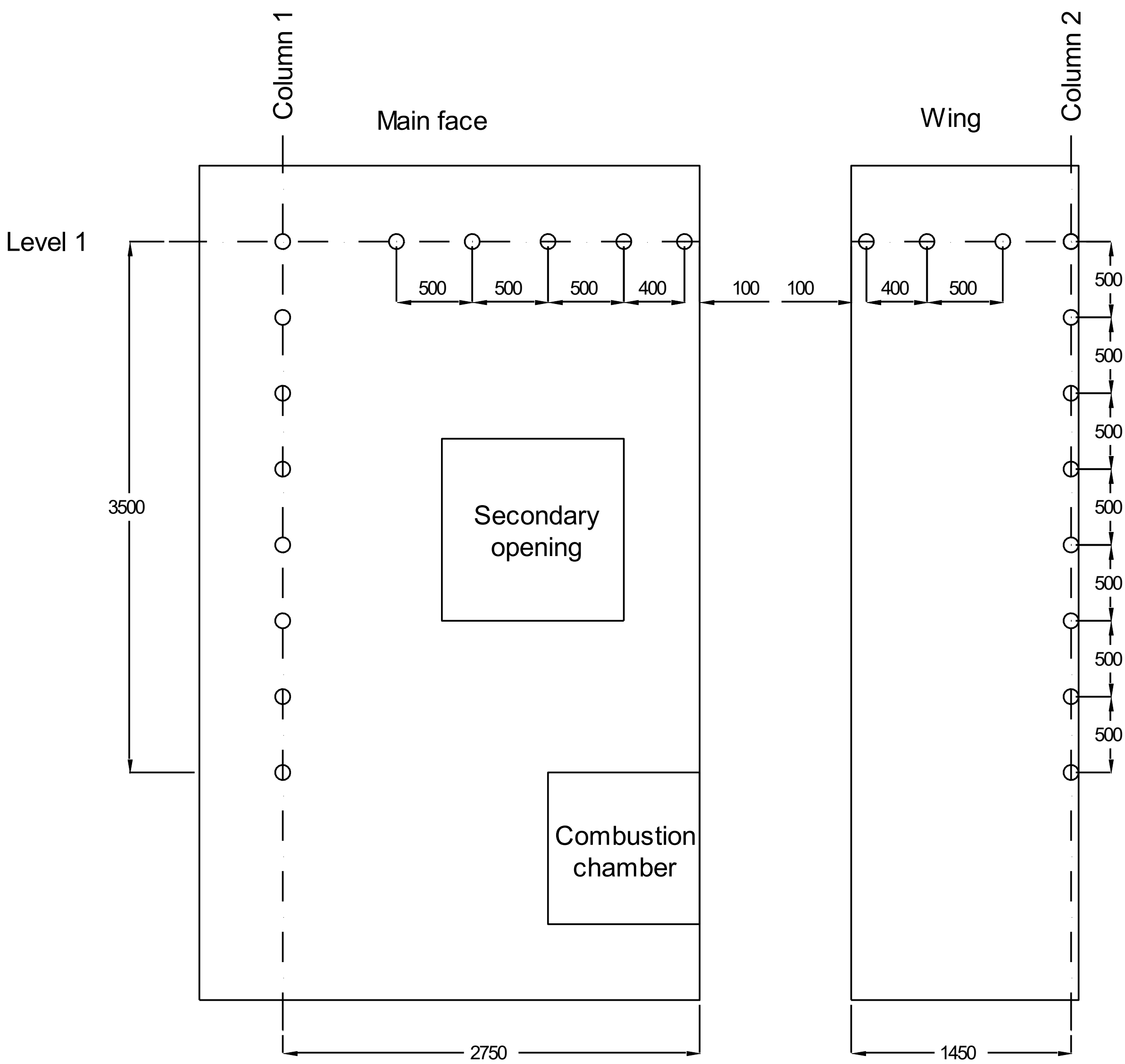


Figure 9. Positions of thermocouples on the exposed face of the tested façade.

8.1.4 Method of installation of the thermocouples

An example of installation is presented here:

- marking of the main thermocouples section at the front face of the specimen
- drilling from the front of the specimen a 10 mm hole crossing the complete façade thickness and the supporting construction if existing
- creation of a bundle with all internal and external thermocouples of the same section with their measuring junction located at the suitable horizontal distance corresponding to the design of the façade system
- insertion of the bundle in a hollow pipe with external diameter smaller than 10 mm
- introduction of the pipe with thermocouple bundle from the rear of the rig
- adjusting the bundle horizontal position by having the measuring junction of the external thermocouple located at 50 mm distance of the exposed face
- fastening of thermocouples cables at the rear face of rig
- removal of the pipe from the front of the rig
- sealing of the space of hole between the thermocouples and the exposed face of the façade
- sealing of the space of hole between the thermocouples and the unexposed face of the façade or back side of the test rig as the case may be

Another example could consist in:

- Installing external thermocouple by means of a grid/mesh made of steel profiles (channels, angles) installed from the top of the rig in front of the exposed face of the façade.
- Installing all internal thermocouples by drilling from the rear face

8.4 Assessment of smouldering (optional)

When the smouldering criterion is required, additional thermocouples in accordance with DIN 4102-20 shall be installed within the façade system.

8.5 Mass of the falling parts

<u>Indoor testing</u>

A load cell platform shall be located in front of the test bench to collect any falling part coming from both the main face and the wing. See Section 4.7.4 and Figure 4 for description.

This platform shall have a surface corresponding to the rectangle created by the main face and the wing.

The platform shall be protected from mechanical shocks and thermal aggression by means of fire boards and high temperature blanket.

The mass shall be recorded during the 60 min of the test. The recordings of the mass over time shall be documented as a mass-time curve. The increment of fallen mass over a period of 10 seconds shall be computed all along the test by subtracting raw mass data in time steps of 10 seconds. The videos shall be used to sort the parts falling from the façade from the parts falling from the crib, only the first case being considered.

In cases where falling parts would eventually fall or bounce of the loadcell platform, their mass shall be weighted or estimated separately and added to the recording after the test.

<u>Outdoor testing</u>

Further investigations needed to allow for outdoor testing.

9 TEST PROCEDURE

9.1 General

The test procedure follows the following steps.

- Document the test set-up.
- Confirm that all measurement devices are functioning.
- Determine the environmental conditions (ambient air speed, precipitation and local temperatures).
- Begin data logging and audio-visual recording equipment.
- Ignite the timber crib following the relevant procedure as defined in 9.3.
- Monitor and record the behaviour of the test specimen during the full 60 minutes test period.
- Continue to record measurements and observations for the full duration of the test.
- Terminate of the test 60 minutes after the starting time.
- Record observations of permanent changes to the test specimen once the test is finished.

9.2 Test time

9.2.1 Starting time vs. ignition time

Regarding the test time, several points in time need to be regarded, especially the ignition time and the starting time as they are not the same. The ignition time is the time when the crib is ignited. The starting time is described in detail in clause 3.

The reference values of the measurements shall be considered the moment when the fire source is ignited (ignition of the strips of soaked fibreboard), see 9.3 for detailed procedure. All measurement devices are started at latest at the ignition time, e.g., the rises of temperature, masses etc. shall be computed from these reference values.

The starting time of the test as defined in Section 3 means the elapsed time shall be measured from this point.

9.2.2 Progress of the test

The test duration shall be 60 minutes for all fire exposure scenarios, extended observation is needed if smouldering shall be assessed.

Table 2. Step-by-step timing of the test

Time (in minute)	**Action**	**Reference Clause**
-10 before ignition	Soak fibreboard ignition strips	9.3
-5 before ignition	Insert fibreboard ignition strip into crib	9.3
ignition time	Ignition of the timber crib	9.3
0	Starting time	3
4 after ignition time	Supply of additional air to the combustion chamber via a fan unit	4.5, table 1
60	End of test*	

* Except if the smouldering shall be assessed. If so, the test duration is extended according to Section 9.5.

9.3 Ignition of the fire source

The crib shall be ignited by using 5 strips of low-density fibreboard, each strip having nominal length corresponding to the depth of the crib + 30 mm. The width of the strip shall be lower than the space between two consecutive wood sticks, e.g., 25 mm. The strips shall be soaked uniformly in Isopropanol (= Isopropyl alcohol) min. 90% concentration for a minimum of 5 minutes. Not more than 5 minutes before ignition, strips of soaked fibreboard shall be inserted into all spaces between the timber sticks in the second layer of the crib allowing approximately 30 mm to project from the front of the crib. Additional 2 strips shall be laid horizontally and perpendicularly across the projected strip ends.

Ignition of the crib is achieved by igniting only additional perpendicular strips across their full length.

9.4 Observations

Video records shall be made during the whole duration of tests.

The camera(s) on the exposed side of the tested façade aims to record the occurrence of any flames, falling parts and other events during the test. It also helps to control the risk of collapse of the test specimen and, more generally, the safety of the test.

A camera at the back face of the tested façade aims to control the behaviour of the test rig.

Details and times of significant events shall be recorded during the test such as the change of flaming conditions and any change in the mechanical behaviour of the cladding system shall be recorded, especially the detachment of any part of the cladding system (whether flaming or otherwise) or any fire penetrations through fire stops incorporated within the cladding system.

Areas shall be expressed in square meters and lengths in meters or millimetres.

Perform all observations in accordance with Section 11.

9.5 End of the fire source

The fire in the combustion chamber is extinguished after 60 minutes after the starting time. Only after these 60 minutes, the fire on the test specimen can be extinguished, except if the smouldering shall be assessed. In such case the specimen shall be kept under observation until all thermocouples show a temperature lower than 50°C with a maximum duration of 6 / 15 hours[1] after ignition.

9.6 Post-test inspection

Observation of permanent changes of the tested system shall be assessed after the end of the test and shall be documented. Examination of the test specimen shall take place within 24 hours after the test, once the specimen has cooled. The examination shall record details of permanent changes, including (but not limited to) spalling, melting, deformation, softening, detachment, charring, discolouration and delamination. The examination shall note size, shape, location and type of permanent changes. Both changes on the surface as well as within any layers or cavities of the system shall be noted. Any collapse or partial collapse of the test specimen shall also be noted.

Areas shall be expressed in square meters and lengths in meters or millimetres.

[1] According to DIN 4102-20 a maximum test duration of 15 hours is given. By many laboratories that is seen to be problematic, especially for large exposure tests regarding acceptable working hours. Therefore, an alternative of 6h hours according to ISO 16733 has been proposed as well.

9.7 Termination of test

The test may be terminated for one or more of the following reasons:

a) flame spread extends beyond the test rig (vertically or horizontally) at any time during the test duration, or if flames pass through the test specimen to the backside of the test rig;

b) there is a risk to the safety of personnel or impending damage to equipment,

c) request of the sponsor,

d) risk of imminent collapse or actual collapse of most of the tested façade,

9.8 Invalidation of the test

The test shall be invalidated when one or more of the following reasons is met during the test (up to its termination at 60 minutes).

9.8.1 Weather conditions

For outdoor tests, the validation of test shall be assessed in case of severe changes of weather conditions during the test. This assessment shall be clearly specified in the test report.

9.8.2 Thermocouple failure

The test shall be invalidated when one or more of the following reasons is met:

- failure of 3 or more thermocouples in the same level and in the same layer on the main wing,
- failure of 2 or more thermocouple in the same level and in the same layer on the return wing,
- failure of 4 or more thermocouples in the same column and in the same layer.

9.8.3 Other reasons to invalidate a test

The test shall be invalidated:

- in case of premature collapsing of the crib, i.e., within 15 min after ignition,
- if the starting time of the test is not achieved, namely if no TC at 3500 mm reaches 80 °C in rise over a 30 second average.

10 PERFORMANCE CRITERIA

The following criteria shall be assessed from the starting time as defined in Section 3.

10.1 Fire spread

This is the time in completed minutes for which the test specimen continues to maintain its ability to limit the propagation of a fire front. The failure of the fire spread performance is deemed to have occurred when one of the criteria below has failed.

10.1.1 Vertical fire spread

The failure of vertical fire spread criterion occurs when any external or internal thermocouple positioned on level 1 exceeds a temperature rise - above its initial temperature - of 500 K on average over the assessment time of 30 seconds during the 60 minutes test period after the start of the test. The time of failure shall be reported as the time at the end of this 30 seconds period i.e., when the observation is finally made.

10.1.2 Horizontal fire spread

The failure of horizontal fire spread criterion occurs when any external or internal thermocouple positioned on the columns 1 and 2 exceeds a temperature rise - above its initial temperature – of 500 K on average over the assessment time of 30 seconds during the 60 minutes test period after the start of the test. The time of failure shall be reported as the time at the end of this 30 seconds period i.e., when the observation is finally made.

10.2 Burning parts

The burning parts can either be in liquid or solid phase.

The failure of burning parts criterion occurs when a falling part burns for 30 s or longer after hitting the ground.

The time of failure shall be reported as the time at the end of this 30 seconds burning period i.e., when the observation is finally made.

10.3 Falling parts

Falling parts include all material falling from the test specimen. They are assessed by measuring the mass of the falling parts during the test time with a load cell platform as well as visual observations.

Limits for the mass of falling parts are given below. The time of failure shall be reported as the time at which the falling part touches the ground i.e., the falling part shall have completely broken off from the façade, without being still hung somewhere.

10.2.1 Falling parts – Level 1

The failure of falling parts (level 1) criterion occurs when the increment of mass of falling parts over a period of 10 seconds exceeds 1 kg.

10.2.32Falling parts – Level 2

The failure of falling parts (level 2) criterion occurs when the increment of mass of falling parts over a period of 10 seconds exceeds 5 kg.

Example:

- A falling part of 2 kg will fail the level 1 criterion but not the level 2

- A falling part of 6 kg will fail both level 1 and level 2 criteria

10.4 Smouldering (optional)

This is the time in completed minutes for which the test specimen continues to maintain its ability to limit the propagation of a combustion without flame and without visible light. The failure of the smouldering performance is deemed to have occurred when one of the criteria below has failed.

10.4.1 Edge damages

The failure of edge damages criterion occurs when the damage of the test assembly by spread of smouldering processes reach the top of the assembly or reach the lateral edges of the test assembly – both shall be assessed after termination of the test.

10.4.2 Maximum temperature

The failure of maximum temperature criterion occurs when a temperature of higher than 50 °C is measured at any of the thermocouples at the end of the 6 / 15 hours[2] period after beginning of the test.

[2] According to DIN 4102-20 a maximum test duration of 15 hours is given. By many laboratories that is seen to be problematic, especially for large exposure tests regarding acceptable working hours. Therefore, an alternative of 6h hours according to ISO 16733 has been proposed as well.

11 TEST REPORT

A test report shall be written describing the execution and the results of the test. The report shall contain the following information and data:

a) Name and address of the test laboratory

b) Date of the test and date of issue of the test report

c) Name and address of the sponsor of the test

d) Applied fire exposure (medium or large) and detailed data describing the wood crib

e) Installation and assembly of the test specimen

- Description of the supporting construction, if used
- Mounting (directly on the structural frame or on a supporting construction)
- The secondary opening

f) Description of the façade system tested including (see Section 6):

- Name and type of the products used, dimensions, form
- Properties of the materials used, nominal and measured values,
- All elements included in the system such as fixing types, specifications, installation density (i.e., number per m^2 and layout patterns of fixings, coverage and type of application of adhesive etc.)
- The position of all components in the system
- Design of construction details such as lintel, joints, edges, openings, expansion joint details, fire stops, cavity and fire barriers

g) Position of the external and internal thermocouples

h) Environmental conditions (see Section 5). For indoor tests: changes of ventilation and incoming air during the test. For outdoor tests: changes of wind speed and direction during the test. Assessment of the validation of results in case of changes of weather during the test for outdoor test or change of ventilation for indoor tests.

i) Visual observations and photographs including the time during the test such as:

- flame spread extends beyond the test rig (vertically or horizontally)
- visual flame spread on the surface of the test specimen, burning through joints or showing flames at the outer edges of the test specimen
- occurrence of burning debris of the test specimen including time and duration of burning
- occurrence, duration and extent of a secondary fire on the floor of the test rig caused by burning debris
- occurrence time, dimensions and amount of falling parts
- changes of the test specimen during the tests like deformations, colourations or delamination's
- visual description of the smoke development

j) Permanent changes to the test specimen (see Section 9.6) once the test is finished, both on the surface and inside the test specimen

k) Graphs of temperatures versus time measured by all individual thermocouples

l) The test results stated in terms of the elapsed time, in completed minutes, between the starting time of the test (as defined in Section 9.2.1) and the time of failure with respect to the relevant performances and criteria (as defined in Section 11), including:

1) the fire spread performance and its vertical fire spread, horizontal fire spread

2) the burning parts performance

3) the falling parts (level 1) performance

4) the falling parts (level 2) performance

5) a table listing the test times at which the falling parts (increment of masses over 10 seconds) exceeded thresholds from 0.5 to 10 kg in steps of 0.5 kg

6) the smouldering performance, if assessed, and its edge damages and maximum temperature criteria

In addition, when the test has been terminated prior to failure under all of the relevant performance criteria:

- the reason for termination shall be reported,
- the performance criteria which didn't fail prior to termination of the test shall be reported in accordance with Section 9.7.

The results shall be presented as follows:

Performance	Criterion	Test result
Fire spread		
	Vertical fire spread	…… minutes
	Horizontal fire spread	…… minutes
Burning parts		
	Burning parts	…… minutes
Falling parts – Level 1		
	Falling parts (level 1)	…… minutes
Falling parts – Level 2		
	Falling parts (level 2)	…… minutes
Smouldering		
	Edge damages	…… minutes / Not assessed
	Maximum temperature	…… minutes / Not assessed

Falling parts	Test time (min)
0.5 kg	
1.0 kg	
1.5 kg	
2.0 kg	
2.5 kg	
3.0 kg	
3.5 kg	
4.0 kg	
4.5 kg	
5.0 kg	
5.5 kg	

6.0 kg	
6.5 kg	
7.0 kg	
7.5 kg	
8.0 kg	
8.5 kg	
9.0 kg	
9.5 kg	
10.0 kg	

m) The date and the main results of the last calibration performed on the test bench according to Annex A

n) A statement of invalidity of the test in case where the test is invalidated for one or more of the reasons given in Section 9.8. This statement shall include the reason(s) invalidating the test and the test time from which the test is invalidated.

o) The field of direct application of the results for the specimen being evaluated, either in the form of the full text from Section 12, or only those clauses which are relevant for the tested specimen. A field of application can only be granted in cases where the tested façade has achieved at least one of the performance criteria. Otherwise, the dedicated section in the report shall mention "Not applicable".

p) The following statements shall be included:

"This report details the method of construction, the test conditions and the results obtained when the specific façade system described herein was tested following the procedure outlined in the assessment method xxxxxx (official reference of the assessment method once published). Any significant deviation with respect to size, constructional details, stresses, edges or end conditions other than those allowed under the field of direct application in the relevant section of the method is not covered by this report.

Because of the nature of fire testing and the consequent difficulty in quantifying the uncertainty of measurement of fire performances, it is not possible to provide a stated degree of accuracy of the result."

a) Signature(s) of the responsible staff(s) of the testing laboratory

- As annexes the following shall be added to the test report:

b) Illustrations / drawings of:

- test assembly
- constructive design of specific details of the test assembly
- position of all thermocouples on the test specimen for measuring the temperatures

c) Photo documentation: description of the test course by significant pictures at special time points

The video of the test shall be archived by the test laboratory.

12 DIRECT FIELD OF APPLICATION

Note: It is currently too early to define a set of direct field of applications (DIAP). Later when more information is available the DIAP can be defined in more detail. The following gives examples on what can be considered in the DIAP. The question on when the full external wall or only a part of the wall, or a cladding system is enough, needs to be tested has not yet been decided. Some kind of definition will be needed, especially for the field of application. Such definition could be that the system shall be mounted on a wall with an outer layer of class A and a protection of K_2 30, or something similar.

The results of the fire test are directly applicable to similar constructions where one or more of the changes listed below are made and the construction continues to comply with the appropriate design code for its stiffness and stability:

a) decrease in distance of fixing centres;

b) increase in the number of horizontal joints, of the type tested, when tested with joints;

c) increase in the number of vertical joints, of the type tested, when tested with joints;

d) the width of an identical construction may be increased if the dimensions of the tested specimen were at least the minimal size specified in Section 6.1 provided joints were tested and provided distance of fixing centres is not increased;

e) the height of the construction may be increased;

f) an insulation of Euroclass A2 can be replaced with an insulation of Euroclass A1 if the thickness and density is the same;

g) an insulation of Euroclass E can be replaced with an insulation of Euroclass B, C or D if the thickness and density is the same;

h) any kind of frame can be fitted around openings (like windows) if the test has been performed without any frame to protect the edge of the façade system at such openings (see Annex B);

i) the width of the construction may be decreased;

j) the height of the construction may be decreased.

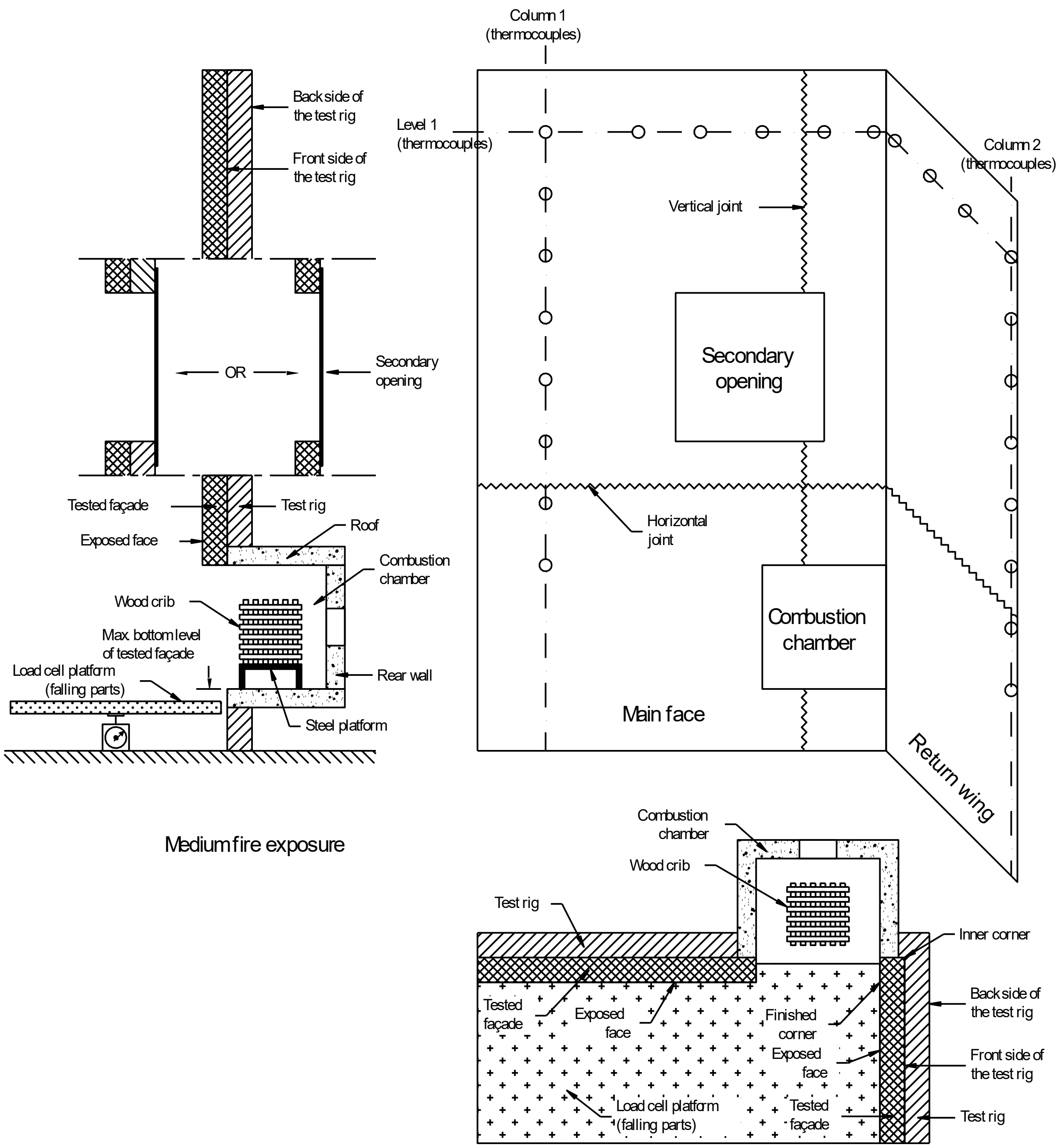


Figure 10. Designation and localisation of the main concepts for the medium fire exposure test.

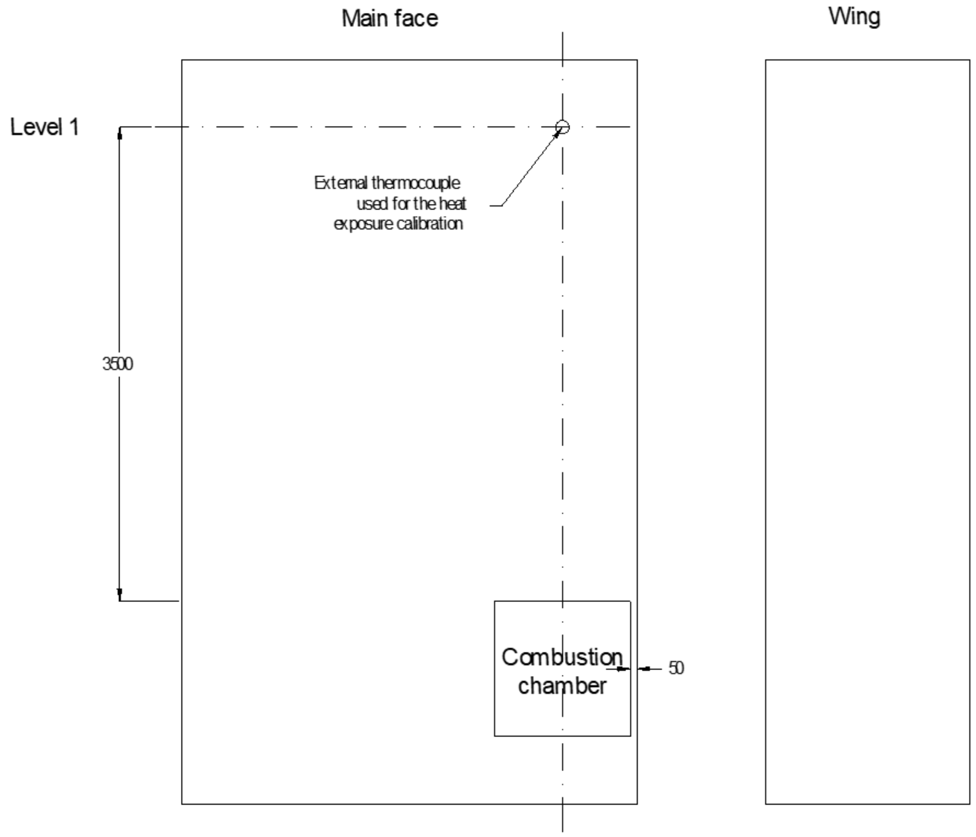
Annex A Calibration of the heat exposure (informative)

A test bench calibration record shall be maintained before putting the test bench into operation and the test bench shall be recalibrated after completion of any repair that could alter the flame distribution, air supply conditions and any other parameters impacting the heat exposure and at least after three years.

The following procedure shall be followed.

1. Prepare the test rig in compliance with this assessment method, with a supporting construction according to Section 4.4. No façade / specimen shall be erected. The inner corner shall be 50 mm away from the combustion chamber opening.

2. Place one external sheathed thermocouple (as in 4.7.1) at level 1 (3500 mm above the top of the combustion chamber), centered at mid-width of the combustion chamber opening. This thermocouple shall be placed with its hot junction positioned 50 ± 5 mm in front of the supporting construction.



3. Prepare the combustion chamber, the fuel source, and perform a test following the test procedure in compliance with this assessment method. For the purpose of this calibration test, the elapsed test time shall be measured starting from the ignition of the crib. Record the environmental conditions during the test.

4. For this only external thermocouple:

   a. compute the temperature development over time from the ignition time of the crib,

   b. compute the average of the temperature development computed in the previous step, i.e. step 4. a., over a 15 minutes period, using a centered first order scheme,

c. only retain the maximum value of the averages computed in the previous step, i.e. step 4. b.

The two following conditions shall be met to validate the heat exposure calibration:

1. the maximum average temperature rise computed in the previous step, i.e. step 4. c., shall be within the range 80...230 °C during the first 30 minutes of the calibration test, AND
2. the maximum average temperature rise computed in the previous step, i.e. step 4. c., shall be reached before the test time 30 minutes.

A calibration report shall be issued, including the analyzes above.

ANNEX B MOUNTING OF TEST SPECIMEN AT OPENINGS (NORMATIVE)

This annex explains how the detailing around openings shall be implemented, namely the combustion chamber opening and the secondary opening.
Different standard configurations are identified below, based on how framed features (like windows or ventilation grid) are mounted in practice. For each standard configuration, when relevant, two testing options are proposed: mounting without any frame or mounting with a frame. When testing without frame, not only the frame should be removed, but also any detailing that implicitly accompanies the frame, i.e., whose presence results from the presence of the frame (e.g., fixings, caulking, sealants, edging profiles…). When testing with a frame, the frame and all its accompanying detailing used to protect the edge of the façade system shall be the same than the one used in practice.

When the practical façade system doesn't correspond to any of the standard configuration below, it shall be tested in the real configuration in which it is intended to be used and shall include the frame used in practice.

When the test setup includes a frame, whether in standard or real configuration, the feature which is normally present in the frame (like glazing or grid) shall not be installed.

> *Note: The figures below illustrate the configurations for secondary opening, which include a backing board classified A1 according to EN 13501-1 (see Section 6.8 and Figure 8.b.). The figures also apply for combustion chamber opening except that no backing board shall be placed.*

Case 1

Building practice

- The feature is mounted within the wall on which the façade system is applied and doesn't flush with the wall on the outside of the building (see Figure B.1), AND
- the façade system extends inside the opening, AND
- the frame is used to protect the edge of the façade system.

Test setup

In this case the test specimen is mounted on a supporting construction (see Section 6.6). The façade system shall extend a minimum of 25 mm into the opening. A frame can be used or not. In the case where no frame is used, there shall be a distance of at least 25 mm from the façade system to the backing board.

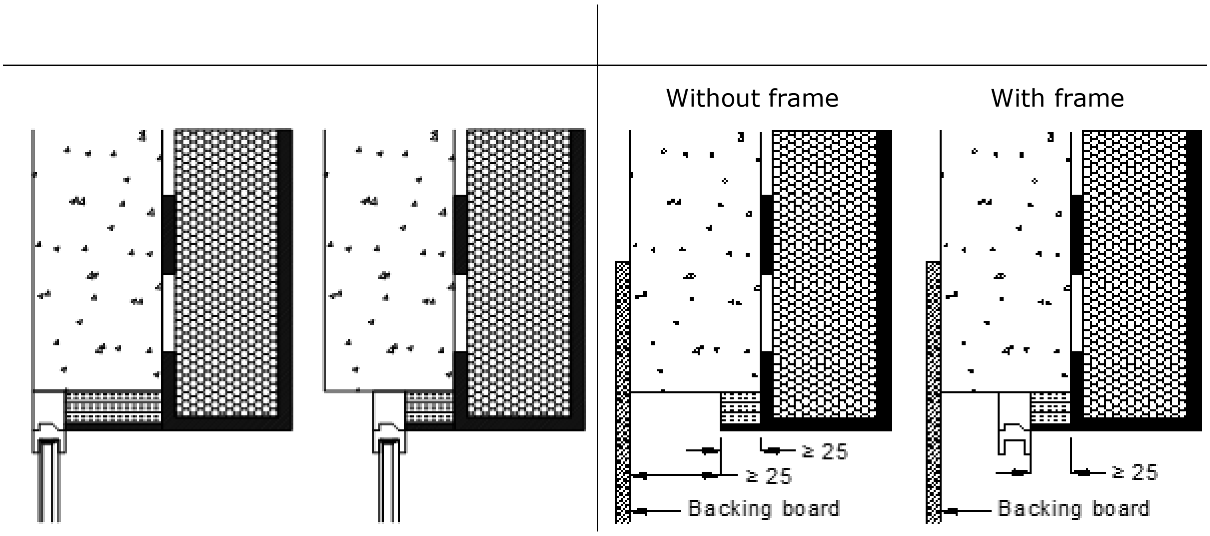


Figure B.1 Case 1

Case 2

Building practice

- The feature is mounted within the wall on which the façade system is applied and doesn't flush with the wall on the outside of the building (see Figure B.2), AND
- the façade system extends inside the opening, AND
- the frame is not used to protect the edge of the façade system.

Test setup

In this case the test specimen is mounted on a supporting construction (see Section 6.6). No frame is used. The façade system shall extend a minimum of 25 mm into the opening, and there shall be a distance of at least 25 mm from the façade system to the backing board.

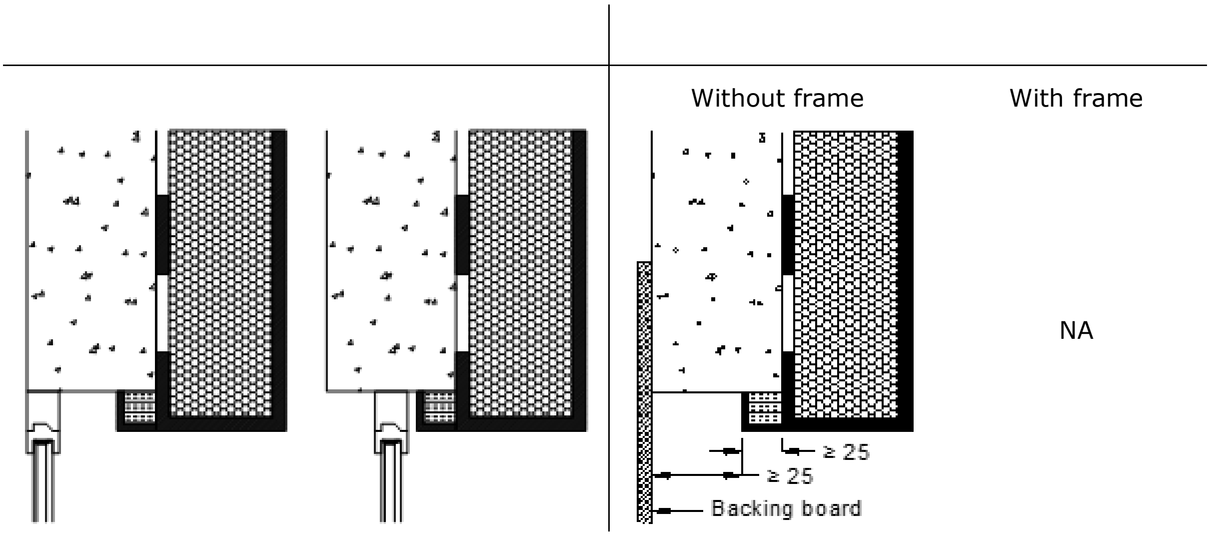


Figure B.2 Case 2

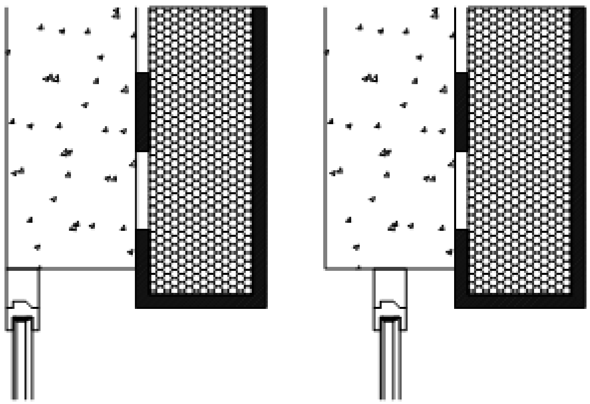
Case 3

<u>Building practice</u>

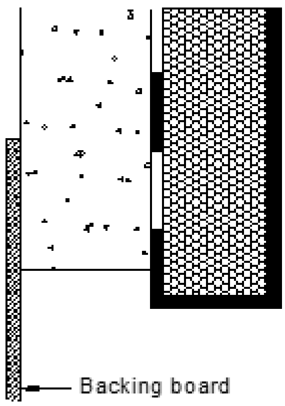
- The feature is mounted within the wall on which the façade system is applied and doesn't flush with the wall on the outside of the building (see Figure B.3), AND
- the façade system does not extend inside the opening (i.e., flush with the wall), and consequently the frame is not used to protect the edge of the façade system.

<u>Test setup</u>

In this case the test specimen is mounted on a supporting construction (see Section 6.6). No frame is used.



Without frame



With frame

NA

Figure B.3 Case 3

Case 4

Building practice

- The feature is mounted flush with the wall on the outside of the building (see Figure B.4), AND
- the façade system does not extend inside the opening (i.e., flush with the wall), AND
- the frame is used to protect the edge of the façade system.

Test setup

In this case the test specimen is mounted on a supporting construction (see Section 6.6). A frame can be used or not.

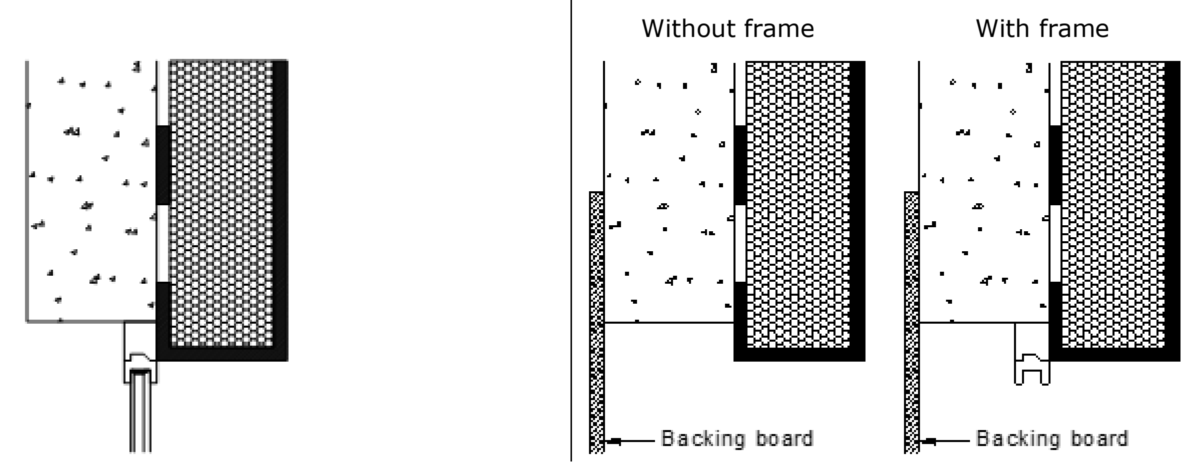


Figure B.4 Case 4

Case 5

Building practice
The feature is mounted inside the thickness of the façade system, which presents a protrusion onto which the feature leans (see Figure B.5). Consequently, the frame is used to protect the edge of the façade system.

Test setup
In this case the test specimen is generally mounted on a structural frame, and sometimes on a supporting construction (see Section 6.6). A frame can be used or not. In the case where no frame is used, there shall be a distance of at least 25 mm from the façade protrusion to the backing board.

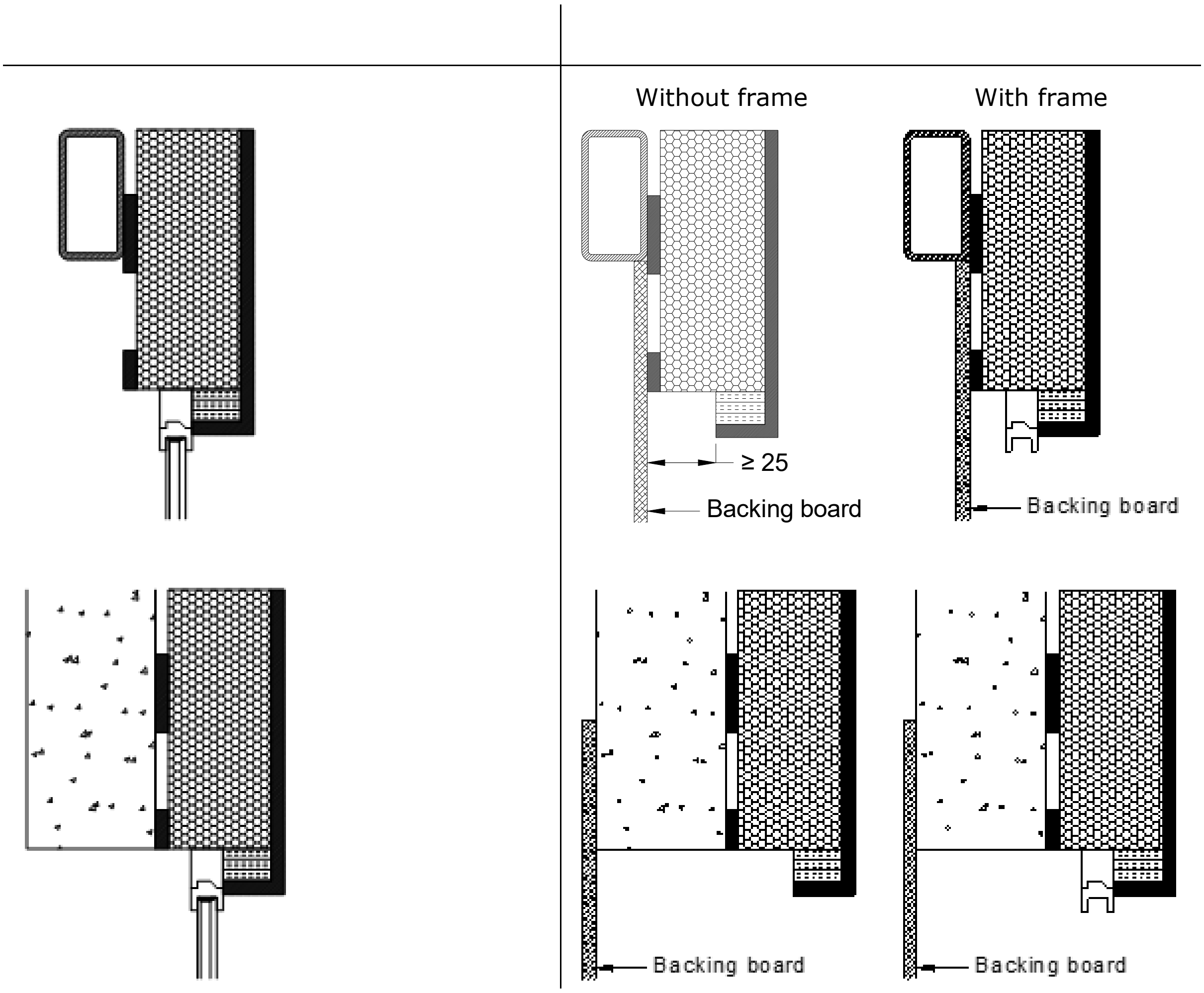


Figure B.5 Case 5

Case 6

Building practice
The feature is mounted inside the thickness of the façade system, which doesn't present any protrusion facing the feature (see Figure B.6). Consequently, the frame is used to protect the edge of the façade system.

Test setup
In this case the test specimen is generally mounted on a structural frame, and sometimes on a supporting construction (see Section 6.6).

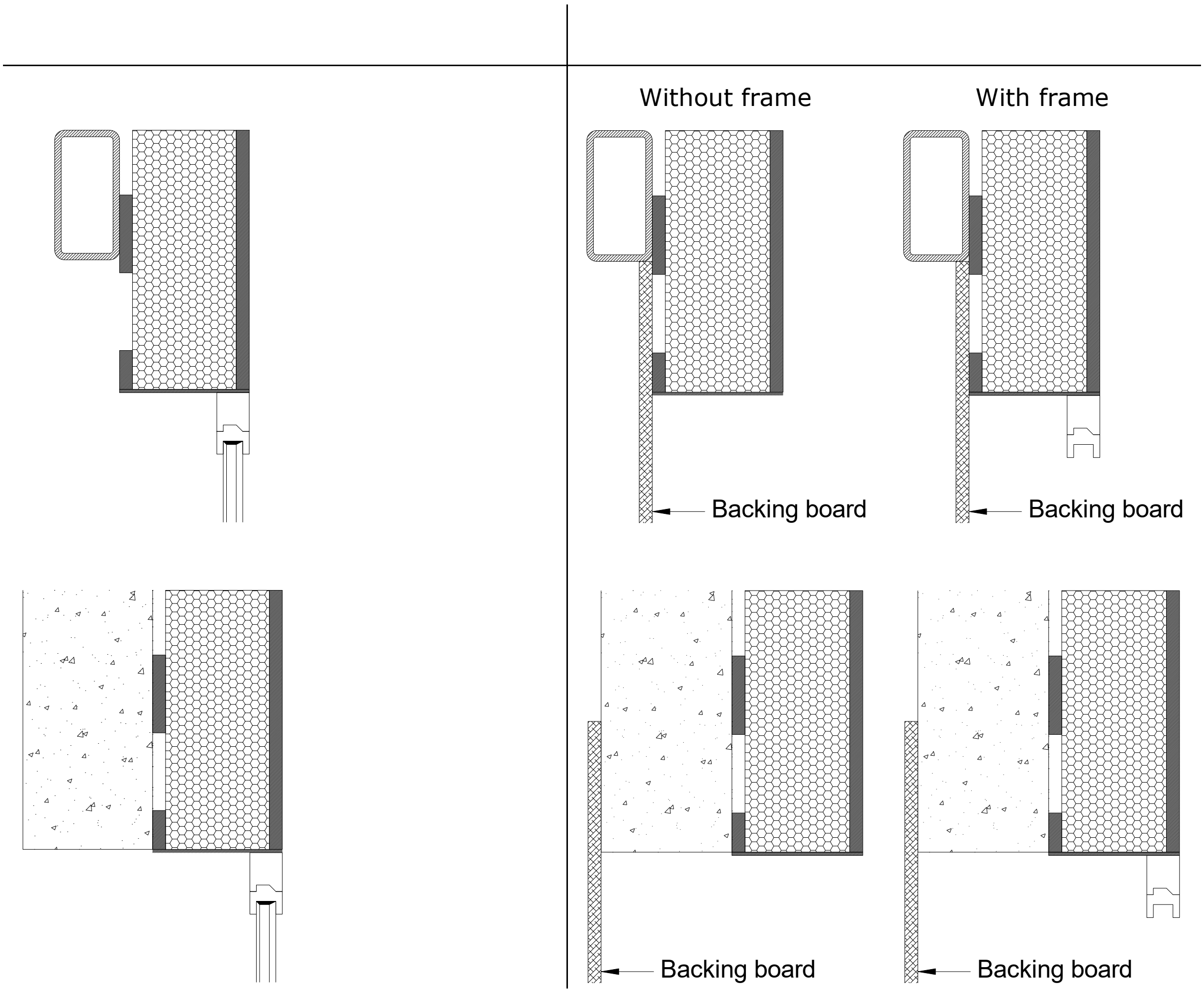


Figure B.6 Case 6

ASSESSMENT OF FIRE PERFORMANCE OF FAÇADES USING LARGE FIRE EXPOSURE

Draft revision 8
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TABLE OF CONTENT

1 SCOPE

This assessment method is applicable for any façade system, like for instance external walls, façade cladding systems vertically fixed to and supported by a structural frame or a supporting construction. The façade is a complete external wall construction of any type (massive wall or curtain walling …etc.) or constitution (masonry, combustible material etc). The method will not address the load-bearing capacity of the tested system, nor inclined façade systems. This method addresses requirements which go beyond the requirements that can be addressed and classified according to EN 13501-1,2, like for instance EN 1364-3 and 4 for fire resistance of curtain walling.

The method includes a secondary opening for assessment of detailing of the façade system around openings to simulate the presence of any kind such features at levels above the fire source, but not any window detailing. Vertical and horizontal fire spread on the surface and within façade systems is assessed. The method also evaluates falling parts (mass of falling parts and risk for fire spread downwards through burning material falling down from the façade) of a façade when exposed to fire. This method cannot directly assess the fire re-entry into the compartments above the combustion chamber, because window detailing is not tested. Vertical fire spread is limited to reduce the risk of fire re-entry into the building, see note below.

Note 1: Generally, a fire re-entry into the building from one storey (origin of the fire) to the next one above via windows cannot be prevented. Limitation of vertical fire spread concentrates usually on the task to prevent further fire spread.

Note 2: Vertical fire spread is assessed only in the upward direction by the present method, not in the downward direction, since the combustion chamber is kept at the base of the test rig. Assessing a downward fire spread would require to raise the combustion chamber at 3 m from the ground for instance.

Examples of typical products and systems covered by this proposal include (but is not limited to):

(1) Exterior Thermal Insulation Composite Systems (EIFS, ETICS or synthetic stucco)

(2) Metal composite material cladding systems (MCM)

(3) High-pressure laminate façade and cladding systems

(4) Structural Insulation Panel Systems (SIPS) and insulated sandwich panel systems

(5) Rain screen cladding or ventilated façades

(6) Weather-resistive barriers (WRB)

(7) Wooden façades

(8) External walls

(9) Curtain walling

This proposal covers the fire performance of the façade system, not its individual insulating components, products or elements.

This proposal defines the procedure using a *large fire exposure* test, representative of a fully developed (post-flashover) fire in a room, vented through an opening such as a window aperture, that exposes the cladding to the effects of external flames, or from an external fire source.

The method includes an optional assessment for the façade to floor junction and for the smouldering. These are features assessed in some Member States and are therefore also included here. However, any eventual classification on the façade to floor junction nor for smouldering is not included.

The direct field of application is limited in the present document, and more information and studies are required to give a wider direct field of application. The extended field of application, i.e., when the results from two or more tests are combined, has not been addressed in this document.

There is no clear definition of a façade system. In some Member States the regulation covers the complete exterior wall, while in other Member States it is the outer skin that needs to be assessed.

Therefore, the European assessment method needs to cover all, and it will be important to have a good description of the field of application together with the test and classification report.

2 Normative references

ISO 13943 Fire safety - Vocabulary

EN 60584-1 Thermocouples – Part 1: EMF specifications and tolerances

EN 1364-3 Fire resistance tests for non-loadbearing elements – Part 3: Curtain walling – Full configuration (complete assembly)

EN 1364-4 Fire resistance tests for non-loadbearing elements – Part 4: Curtain walling – Part configuration

EN 16733 Reaction to fire tests for building products – Determination of a building product’s propensity to undergo continuous smouldering

EN 1363-1 Fire resistance tests – Part 1: General requirements

EN 13238 Reaction to fire tests for building products – Conditioning procedures and general rules for selection of substrates

EN 13501-1 Fire classification of construction products and building elements – Part 1: Classification using data from reaction to fire tests

EN 13501-2 Fire classification of construction products and building elements – part 2: Classification using data from fire resistance tests, excluding ventilation services

3 TERMS, DEFINITIONS, SYMBOLS AND DESIGNATIONS

cavity systems	Systems with a cavity (i.e., a volume containing air). This includes (but is not limited to) what is generally referred to as ventilated façades.
charred material	Material that is judged to have been changed by pyrolysis. The assessment should be motivated by some charring characteristic, including (but not limited to) density changes, fissures, porosity etc.
collapse	Any part of the façade system which becomes detached and/or falls off
combustible (layer)	Material whose Euroclass ranges from B to F or whose reaction to fire performance has not been determined. Materials have to be assessed individually, i.e., a composite material may have a Euroclass A due to a good protection of a backing combustible insulation, and in these cases each material must be assessed individually.
discoloration	Visual change of specimen not caused by burning, charring or melting
discrete area	Portion of the total surface of a building element (e.g., façade, floor…) which may be expected to have different thermal insulation than the other areas in presence in this building element, whether visible or invisible (i.e., hidden inside the building element)
element, component or product	In this context part of the façade system
Euroclass	Reaction to fire class of a material according to EN 13501-1. (e.g., A1, A2, B, C, D, E, F).
exposed face	Finished external face of the tested façade
external cladding system	Complete cladding assembly *Note: This includes sheeting rails, fixings, cavities, insulation and membranes, coatings, flashings or joints*
external wall assembly	Complete system including any sheeting rails, cavities, fire barriers and weathering membranes and/or coatings
façade	A complete external wall construction of any type (massive wall or curtain wall …etc.) or constitution (masonry, combustible material …etc.*).* Since there is no general definition available on the term façade or a façade system, it is used in a very general way in this document. Due to different uses of the term in the Member States, and the present assessment method have to be applicable in all Member States the definition has to cover everything from the outer skin of the building envelope to the full external wall. What to test in accordance with this assessment method is than defined by the regulations and requirements in the individual Member States and the field of application.
façade system	see façade
falling parts	Material (solid or molten) separating from the specimen, burning - with or without a visible flame - or not burning, during a fire or a fire test.
finished corner	90° corner formed between both exposed faces of the tested façade, namely the main face and the return wing
fire barrier	Separating element which inhibits the passage of flame and/or heat and/or effluents for a period of time under specified conditions
fire load	Quantity of heat which could be released by the complete combustion of all the combustible materials in a volume, including the facings of all boundary surfaces *Note 1: Fire load is expressed in joules* *Note 2: Fire load may be based on effective, gross or net heat of combustion (thermal energy produced by combustion of unit mass of a given substance as required by the specifier)*

fire scenario	Detailed description of conditions, including environmental, of one or more stages from before ignition to after completion of combustion in an actual fire at a specific location or in a real-scale simulation
fire stop	Fire safety measure to limit the fire propagation within the system
fire spread	Propagation of a fire front on a material surface or within a material defined by the width or height to which any thermocouple exceeds a temperature rise of 700 K on average over a period of 30 seconds
flashover	Transition to a state of total surface involvement in a ventilated controlled fire within an enclosure
fully developed fire	State of total involvement of combustible materials in a fire
hygroscopic material	A material which is able to absorb significant amount of moisture from the ambient air.
inner corner	90° corner formed between both front sides of the test rig, namely the main face and the return wing
main face	The large vertical surface of the test rig and test specimen in which the combustion chamber is placed.
mass loss rate	Mass of material lost per time unit under specified conditions *Note: It is expressed in kilograms per second*
protection to openings	Any feature provided to accommodate the termination of the façade specifically at the boundaries of openings (combustion chamber opening and secondary opening) and that is deemed to offer to this termination any protection against fire spread. Examples of protection to openings are: window frame, sealant, caulking, profile that encapsulates or screens the termination, window sill etc. covering partially or totally the façade termination
smouldering	Combustion of a material without flame and without visible light, including glowing combustion. *Note: Smouldering is generally evidenced by an increase in temperature and/or by effluent*
starting time	The starting time of the test is determined as the time when 380 K in increase is exceeded over a 30 second average at any thermocouple at 4500 mm from the top of combustion chamber.
structural frame	A stable frame onto which a full external wall, or a supporting construction, can be mounted.
supporting construction	A secondary structure mounted on the structural frame onto which a façade test specimen can be mounted. A supporting construction may be necessary when not the full external wall is tested.
system	see façade
test rig	The total assembly of the structural frame, the eventual supporting construction, and the combustion chamber.
window frame	In the test it is possible to have a protection of edges around openings which would be the case in practice through details from windows.
wing (= return wing)	The smaller vertical part of the test rig and test specimen placed at a 90° angle to the main face.

4 TEST EQUIPMENT

4.1 General

The test equipment consists of the following main components:

(10) Structural frame

(11) Supporting construction in some cases

(12) Combustion chamber and fuel source

(13) Instrumentation

The test rig consists of a structural frame, eventually covered by a supporting construction, composed of a main face and a return wing, fitted with a combustion chamber. The rig utilizes a vertical structural frame, representative of a structural steel framed building and shall be capable of enduring the effects of the test procedure without itself suffering undue damage or distortion, see 4.3 for details.

Note: In the Figures in this document, the hatched areas referenced as "test rig" are simplified representations of the main face and the wing of the test rig which – for convenience – have been schematically reduced to their surrounding rectangular envelope. It should be understood that this schematic representation always includes a structural frame and, depending on the kind of façade being evaluated, may or may not include a supporting construction (see 6.6 for detail).

4.2 Main face and wing

The test rig shall include a main face and a wing, see Figure 1, where the wing is mounted at 90° to the main face. Figure 1 shows the minimum size of test rigs for medium fire exposure and large fire exposure. The front side of the test rig shall extend horizontally from the inner corner of the test rig, over sufficient widths to accommodate the minimal required dimensions of the tested façade (see 6.1), and this as much for the main face as for the return wing. The needed minimal horizontal dimensions of the test rig will consequently depend on the thickness of the tested façade.

Note 1: It is recommended to design a flexible test rig, with main face and return wing widths sufficient to accommodate any façade thickness, and with a return wing that can be shifted to increase/decrease the main face width, or with a larger combustion chamber to be reduced depending on the façade system thickness.

Note 2: The return wing may be accommodated either on the left or on the right of the main face. In the present document, the figures only show the configuration with the return wing located on the right side of the main face.

The front side of the test rig (both main face and wing) shall extend vertically from the base of the test rig to a height of at least 5500 mm, above the top of the combustion chamber opening.

The main face shall include one secondary opening, see Section 6.7 for details.

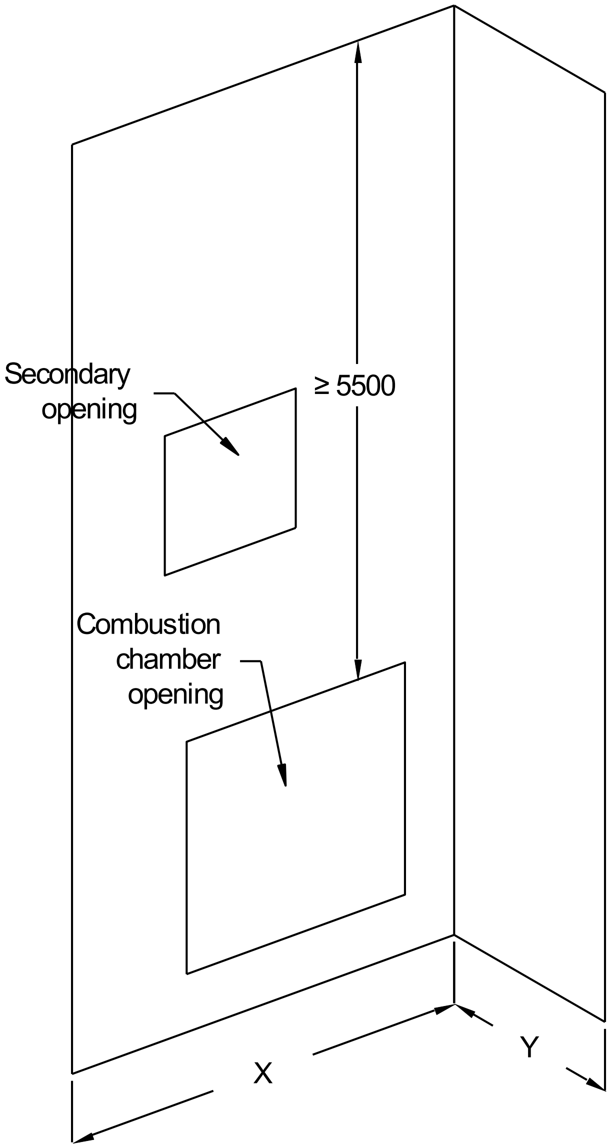


Figure 1. Principle drawing of the test rig. The front side of the test rig is represented here. The widths X (main face) and Y (return wing) are chosen to accommodate the dimensions of the tested façade.

4.3 Structural frame

A structural steel frame shall, if required, be designed and constructed to withstand the expected loading imposed by the system under test and any subsequent distortions that can occur during the test program. Other structural frames such as timber or concrete can be employed for specific applications.

4.4 Supporting construction

If a part of the full external wall is tested, for instance a cladding system, a supporting construction (representing the wall onto which the tested system is used) is necessary onto which the test specimen can be mounted. See 6.6 for more instructions.

The supporting construction shall be erected onto the structural frame. It shall be made of a masonry, e.g., aerated or light weight concrete blocks or slabs, and it shall be mounted in such way that it is airtight.

Note: It is recommended to fix the supporting construction on the structural frame for safety reasons.

4.5 Combustion chamber

The design and location of the combustion chamber opening in the main face shall be in accordance with the design details specified in Table 1. The distance specified in Table 1 are clear distances, i.e., measured once the chamber preparation is ended with the cladded insulation in place.

Table 1. Specification of combustion chambers.

Parameter	**Value**
Distance of combustion chamber opening from finished corner (mm)*	250 ± 100
Height of combustion chamber opening (mm)	1900 ± 50
Width of combustion chamber opening (mm)	2000 ± 50
Internal height of the combustion chamber (mm)	2100 ± 50
Internal width of the combustion chamber (mm)	2400 ± 50
Depth of combustion chamber (mm) (inside back wall to front surface)	1300 ± 50
Figure Reference	Figure 2

* To fulfil this requirement for any thickness of the tested façade, it is recommended to design a flexible test rig (see note in 4.2).

The combustion chamber walls and roof shall be made of a non-combustible construction and its inner surfaces shall be cladded with high temperature insulation (ceramic or equivalent).

However, when assessment of the façade-to-floor junction is performed, the roof of the combustion chamber shall follow the instructions given in Annex C.

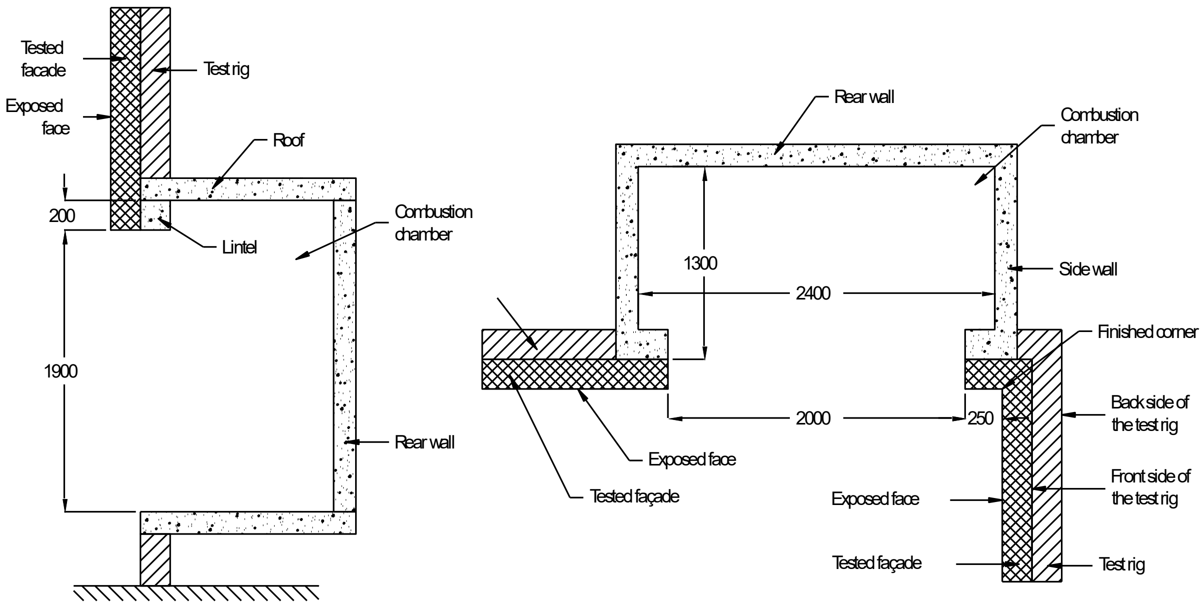


Figure 2. Combustion chamber for the large fire exposure.

4.6 Fuel source

The fuel source is a wood crib made of spruce placed in the combustion chamber. The wood shall be stored indoor within a heated building until the weight is constant (Defined as when two successive weighings at 24 h intervals differ by less than 0,1% is reached.). The mean density after conditioning shall be 500 ± 100 kg/m³. The mean moisture content of the wood shall be 11 ± 2 % (mass water to mass of dry wood).

The crib is nominally 1500 ± 5 mm × 1000 ± 5 mm in plane and 1100 ± 25 mm high.

It shall be constructed from alternating layers of:

- long lengths 1500 ± 5 mm and
- short lengths 1000 ± 5 mm

of softwood sticks with sawn square section 47 ± 3 mm.

The crib shall be constructed in alternate layers of long and short sticks, with the base layer consisting of 10 long sticks of 1500 mm. The next layer shall consist of 15 short sticks evenly distributed to cover an area of 1500 mm × 1000 mm. The sticks of the layers have 90° angle from layer to layer, the wood to air ratio is approximately 1:1. In each layer, sticks are in line with the outer edge of the crib. See Figure 4a. This process is repeated until the total height is 1100 ± 25 mm high and the total weight is 350 ± 20 kg.

The crib shall be positioned on a solid platform made of steel sections, in such a way that the base of the crib is at 300 ± 50 mm above the floor of the combustion chamber. The top side of the platform shall be covered by a solid plate. The back side of the crib shall be located at 100 ± 10 mm from the rear wall of the combustion chamber. The distance between the crib and the side walls on both sides shall be the same. See Figure 3b.

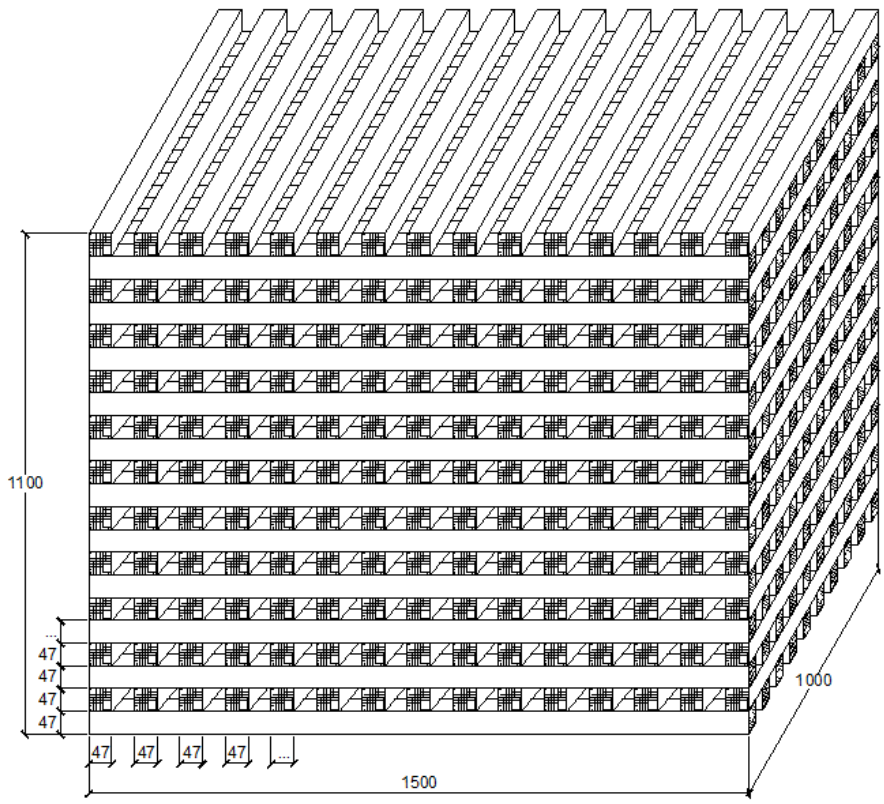


Figure 3a. Geometry of the wood crib for the large fire exposure.

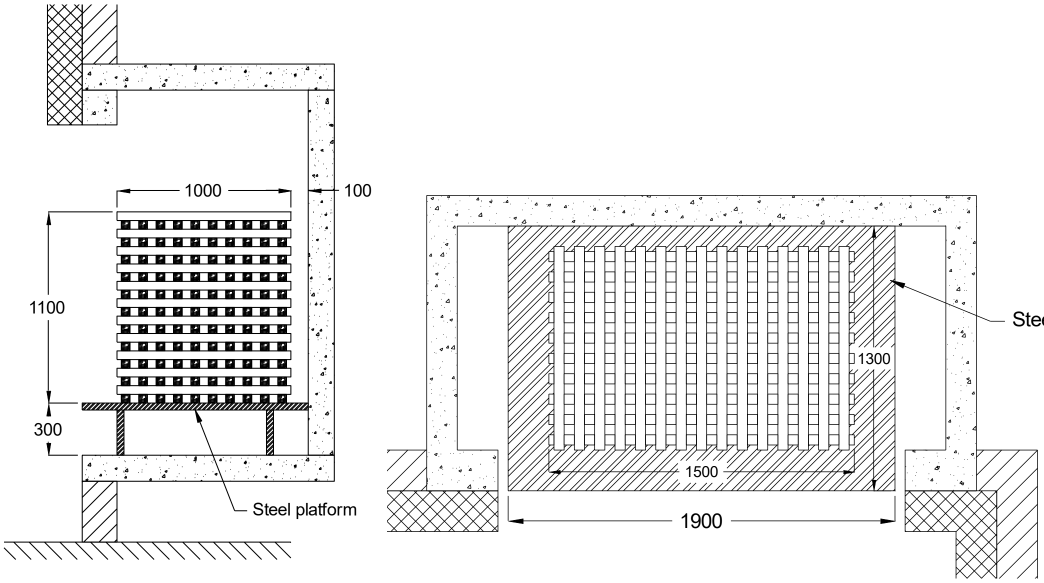


Figure 3b. Nominal position of the wood crib for the large fire exposure.

In order to avoid premature collapse of the crib, the sticks shall be nailed together. It is not necessary to nail all sticks. The minimum nailing shall be done according to the patterns shown in Figure 5, alternating the short sticks layer pattern and the long sticks layer pattern from one layer to the next. Additional nails can be placed at the discretion of the laboratory.

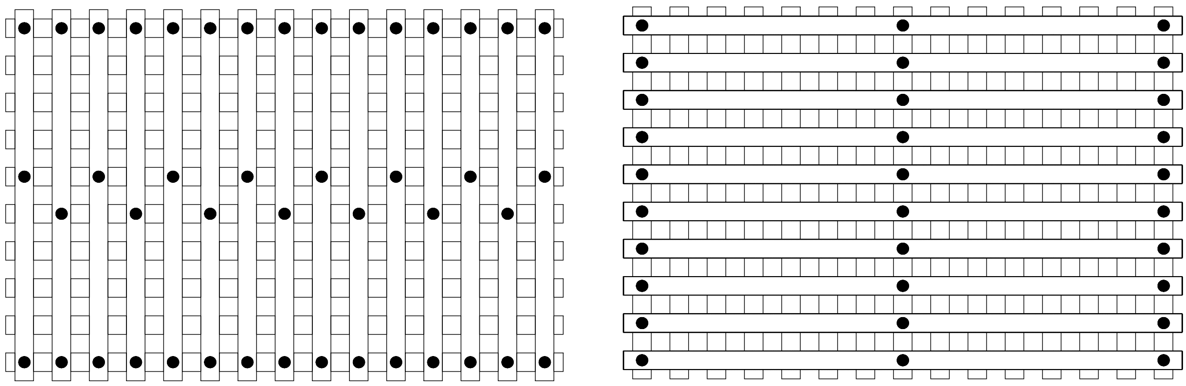


Figure 4. Patterns of stick nailing (short sticks layer on the left, long sticks layer on the right).

4.7 Instrumentation

4.7.1 Thermocouples

The external and internal thermocouples shall have measuring junctions of nickel chromium/nickel aluminium (type K) wire as defined in EN 60584-1 contained within mineral insulation in a heat resisting alloy sheath of nominal diameter range of 1 to 3 mm, the hot junctions being electrically insulated from the sheath.

When including a façade-to-floors junction assessment, thermocouples with copper disc and insulating pad as described in EN 1363-1 shall be used.

4.7.2 Data acquisition system

Instruments shall be connected to a data acquisition system capable of recording data at intervals not exceeding 5 s.

4.7.3 Visual equipment

Digital cameras shall be used to provide a continuous visual record of the test. A pixel resolution of 1920x1080 or higher shall be used. The camera shall be able to record at a speed of ≥ 10 Hz.

On the exposed face of the tested façade, at least one camera shall be used to cover the full height and width of the exposed faces (both main face and wing), as well as the full area of the load cell platform. Additional cameras (four cameras in total are generally sufficient) may be needed to ensure good coverage of the whole exposed face and also to cover for possible malfunction of the main camera.

When also assessing the junction between floor and façade, on the back face of the tested façade, at least one additional camera shall be used at a location allowing capturing the complete width of the façade-to-floor junction.

The recorded pictures shall be used to distinguish the parts falling from the façade from those falling from the crib, as well as for the purpose of reporting of observations in the test report.

It is strongly recommended that the timer displaying the test time is visible on the video, and easy to read.

4.7.4 Mass measurement of falling parts

Indoor testing

A weighing load cell platform with an accuracy of ± 50 g shall be used to measure the mass of falling parts during the test. A plate that covers the rectangular area which is defined by the main face and the wing as shown in Figure 6 shall be used on top of the weighing cell platform to collect falling parts during the test. The platform shall be positioned at 100 mm below the bottom of the tested façade and at 50 mm of the supporting construction (see Figure 5). The platform shall under no circumstances enter in contact with any other element. This shall be checked with the greatest care before and during the test. A software shall be used that allows the automatic mass measurements. The mass over time shall be documented.

Outdoor testing

No weighting load cell platform shall be used, due to their great sensitivity to wind. Any other equipment can be used provided it has been validated the for purpose of the falling part measurements. Among other, the accuracy of measurement of ± 50 g and the insensitivity to wind shall be demonstrated.

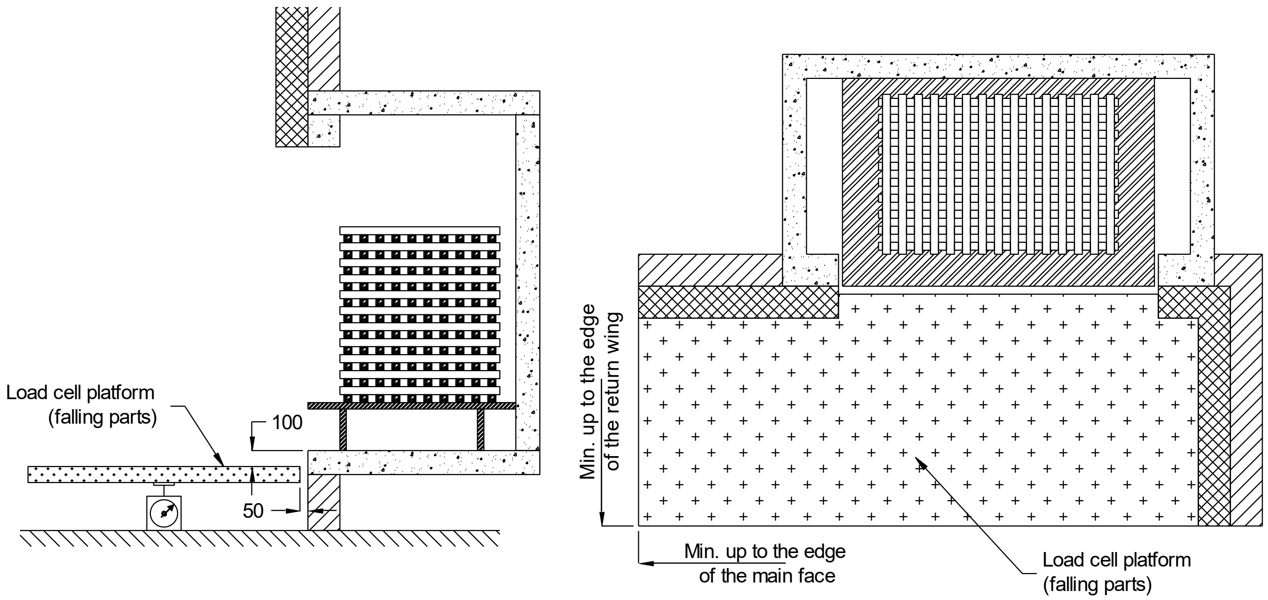


Figure 5. Nominal placement of measurement platform for falling parts.

5 ENVIRONMENTAL CONDITIONS

5.1 Ambient wind speed

The horizontal component of the ambient air speed shall be less than 2 m s^{-1} before the commencement of the test. This shall be demonstrated by measurements from a bidirectional anemometer measuring the horizontal wind speed and its direction with an accuracy of ±0.1 m/s and ±5°. It shall be located at a distance of 2000 m ± 200 mm horizontally away from the exposed faces (main face as well as return wing, see Figure 6), and at the same height as the upper edge of the combustion chamber. The ambient air speed shall be measured at intervals of 1 minute during 15 minutes before the commencement of the test, and none of these 15 values shall exceed the speed limit above in order to allow starting the test. For indoor testing, these measurements shall be carried out under the same ventilation conditions as the ones used under the test.

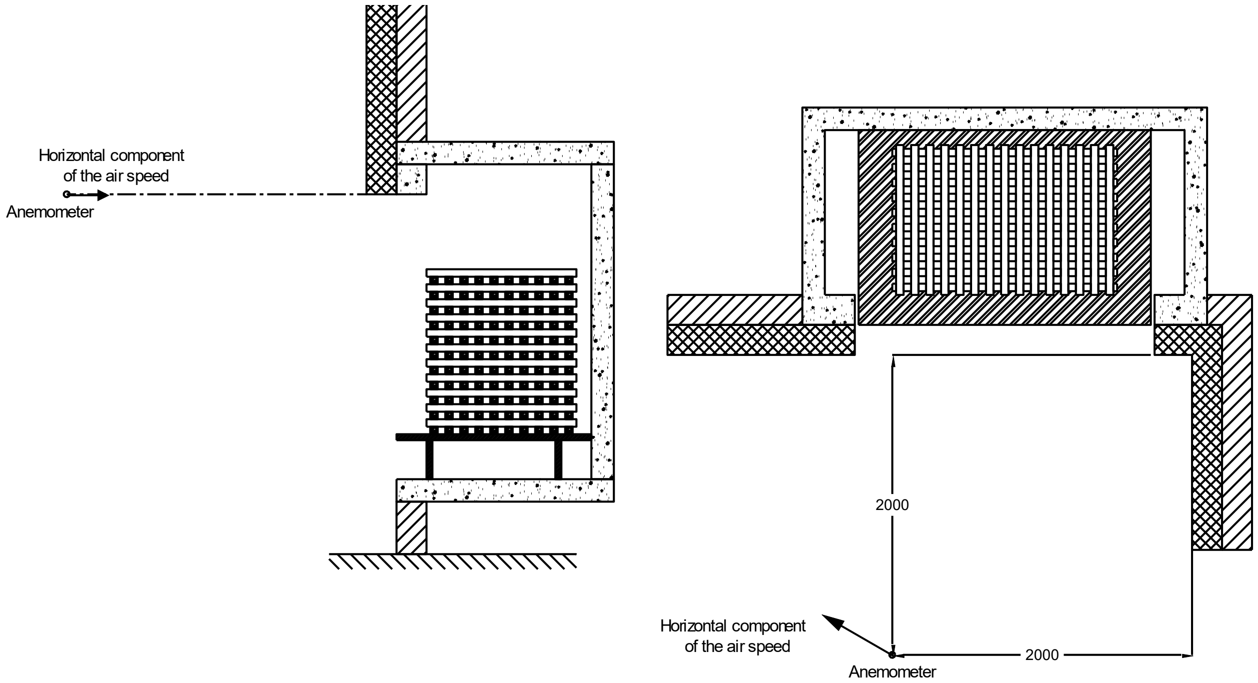


Figure 6. Position of the anemometer and air speed component of interest.

During the test, wind (direction and velocity) shall be measured by means of a weather station (for outdoor test) or other equivalent system for indoor tests located in the vicinity of the test bench. The 2 m/s^{-1} limit applies also during the test.

5.2 Ambient temperature

The ambient temperature prior to testing shall be between +5 °C and +35 °C. This shall be demonstrated by a measurement from the ambient thermometer located at a distance of between 1.8 m and 2.2 m horizontally away from the exposed faces (main face as well as return wing), and between 1.8 m and 2.2 m above the ground. This measurement shall be performed not more than 5 min before the commencement of the test. In case of direct sunshine in the thermometer area, the ambient thermometer shall be shadowed from the sun by a suitable screen.

5.3 Ambient moisture

The ambient relative humidity shall be measured prior to the test the day of the test but also the two nights and two days before the test.

5.4 Outdoor testing

The laboratory shall carry out the tests during conditions meeting the requirements on ambient air velocity and temperature above shall be met. It could be necessary to shield the specimen from the effects of high wind.

5.5 Indoor testing

The requirements on ambient air velocity and temperature above shall be met. Mechanical or natural ventilation above the test rig (exhaust duct) is allowed, as long as the requirement on ambient air velocity is maintained.

6 TEST SPECIMEN

6.1 Size

The exposed face of the test specimen shall extend horizontally from the finished corner of the tested façade, at least 3200 mm on the main face and at least 1500 mm on the wing. The system shall, on both the main face and the wing, extend vertically from the lower part of the combustion chamber (or the floor level) to a height of at least 5500 mm above the top of the combustion chamber opening. The test specimen shall not obstruct the combustion chamber opening nor the secondary opening, with the exception of the strictly minimum protrusion constituted by the representative edge detailing. See Figure 7.

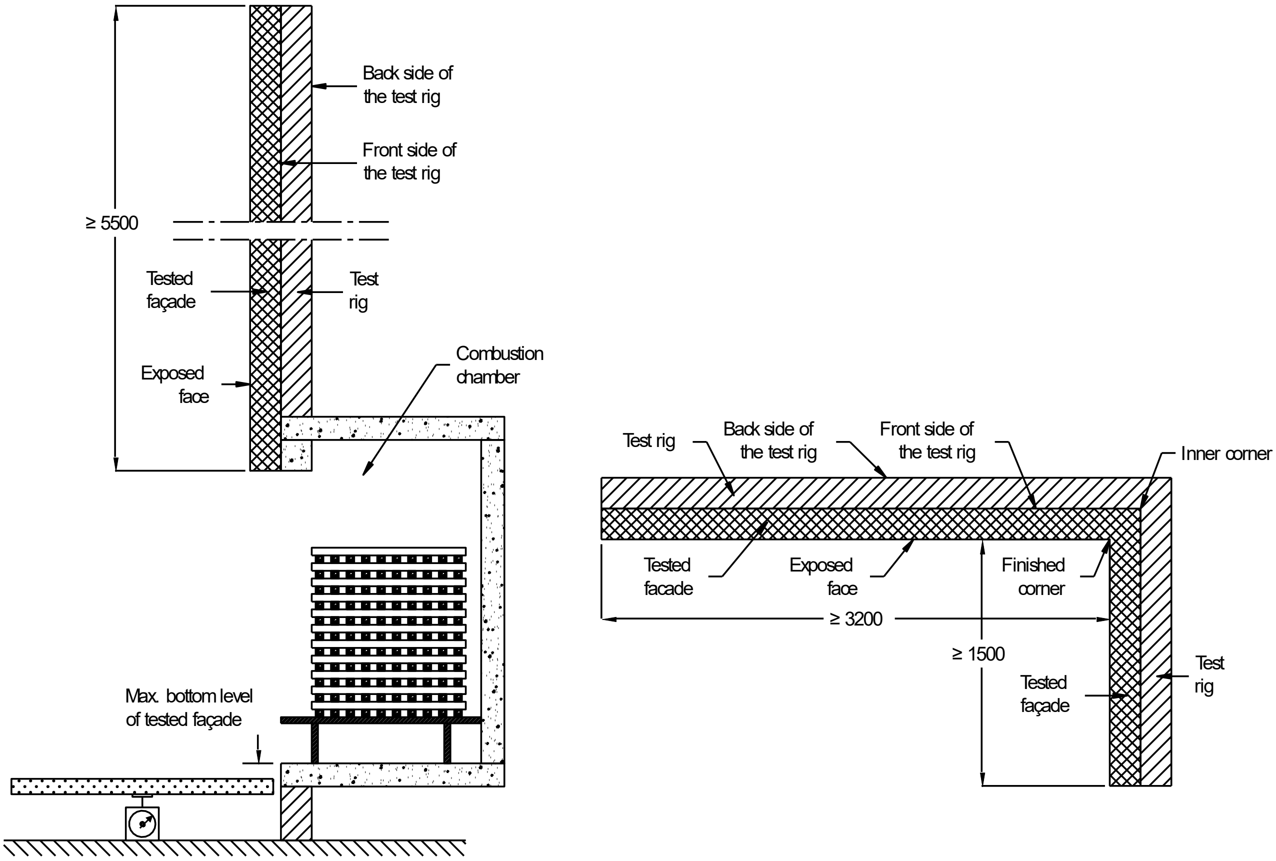


Figure 7. Test specimen and test rig (minimal dimensions).

6.2 Number of specimens to be tested

At least one specimen shall be tested. In the case where the mounting can be made in different ways (e.g., panels mounted vertically or horizontally), or where different details can be used (e.g., different types of fire stops or cavity barriers), or where other features can be done in different ways, then additional test specimens may be required. It is therefore important to use the direct field of application given in Section 12 which shows the possible changes and variations based on one test.

6.3 Design

The test specimen should be designed to obtain the widest applicability of the test results, by considering the product range of the manufacturer and the direct field of application given in Section 12.

The test specimen shall include all relevant components assembled and installed in accordance with the manufacturer's instructions.

The test façade shall include the special detailing around both openings in the façade system as close to end use conditions as possible, i.e. the detailing where features such as opening are to be mounted in practice, see Section 6.7.

At the boundaries of the tested façade (upper/lower horizontal and left/right vertical extremities), edges detailing and terminations shall be as intended for the end use design and shall be documented. As an example, a ventilated façade should be closed on the vertical sides and open at the upper horizontal edge.

Ventilated systems shall be built with all accessories for the ventilation to function in a real application, such as ducts or channels. The dimensions of cavities and installations shall be the same as in a real application.

All detailing shall be installed as in practice, including any fire stop, compressing seal, finishing mastic, insulating material, filling material, cladding, fastening and thermal breaks.

If in practice *horizontal* joints are incorporated into the outer layer of the façade system (i.e., the first layer on the side of the exposed face), the test specimen shall incorporate such horizontal joints at intervals specified by the manufacturer, with at least one joint placed between the combustion chamber opening and the secondary opening. If there is no joint in the outer layer, then the outermost layer of the façade system incorporating a joint shall be considered. The horizontal joints shall extend on the full width of the main face and the wing. See Figure 9a.

If in practice *vertical* joints are incorporated into the outer layer of the façade system (i.e., the first layer on the side of the exposed face), the test specimen shall incorporate such vertical joints at intervals specified by the manufacturer, with at least one joint on the main face extending upwards within a tolerance of ±250 mm on the centre line of the combustion chamber opening. If there is no joint in the outer layer, then the outermost layer of the façade system incorporating a joint shall be considered. The vertical joints shall extend on the full height of the main face. See Figure 9a.

Any modifications made to accommodate the installation of a test specimen on the test rig shall be such as to have no significant influence on the behaviour of the test specimen and shall be fully described in the test report.

6.4 Construction

The method of construction including the tolerances and the erection shall be representative of the use of the element in practice. The standard of workmanship shall be as normally provided in buildings.

The sponsor shall be responsible for ensuring that the quality of construction of the test specimen is representative of the product in practice.

The laboratory shall monitor the erection of the test specimen in order to be able to include details of the methodology and workmanship in the test report. The installation of the test specimen shall be compared to the design drawings for reporting by the test laboratory. Photographic records shall be used to support this.

6.5 Verification

The sponsor shall provide a description of all construction details, drawings of major components and their manufacturer/supplier, as well as an assembly procedure to the test laboratory, prior to the test. This shall be provided sufficiently in advance of the test to enable the laboratory to verify the conformity of the test specimen with the information provided. As far as possible, any area of discrepancy shall be resolved prior to starting the test. In case the construction details cannot be verified, the laboratory shall oversee the fabrication of the test specimen. Where appropriate, the critical material properties shall be determined, e.g. density, moisture content and tolerances.

On occasion, it may not be possible to verify the conformity of all aspects of the construction of the test specimen prior to the test and adequate evidence may not be available after the test. When it is necessary to rely on information provided by the sponsor, this information shall be clearly identified in the test report. The laboratory shall nevertheless ensure that it fully appreciates the design of the test specimen and shall be confident that it is able to accurately record the construction details in the test report.

6.6 Selection of the test rig

Depending on the type of test specimen being evaluated, the tested façade shall be installed either directly on the structural frame or it may be necessary to mount it on a supporting construction.

When in practice the façade system doesn't consist of a full stand-alone external wall but rather of a covering system to be fixed on an existing wall, then the test specimen shall be mounted onto a supporting construction, which one substitutes the existing wall in practice for the purpose of the test. See 4.4 for details.

When in practice the façade system consists of a full stand-alone external wall, then the test specimen can be mounted directly on the structural frame in 4.3.

The fixing on the rig shall be as close as possible to the intended practical application and appropriate for the rig, i.e. if mounting on aerated concrete suitable anchors should be used.

6.7 Secondary opening

6.7.1 General

The objective of the secondary opening is to simulate the presence of any kind of feature – such as windows - at levels above the combustion chamber opening. The main face of the test specimen and of the test rig (structural frame/supporting construction) shall incorporate a secondary opening of 1200 mm in width and 1200 mm in height. It shall be located 1500 mm above the top of the combustion chamber and 1250 mm from the finished corner. See Figure 9a.

6.7.2 Test rig

Whether the test specimen is mounted directly on the structural frame or on a supporting construction, the backside of the opening shall be covered with a board with a thickness of ≥ 20 mm made of calcium silicate or any other material classified A1 according to EN 13501-1, see Figure 7b.

6.8 Mounting of the test specimen

The test specimen shall be installed on both the main wall and the wing as in practice. Among others, it shall be mounted with access only from areas that are actually accessible in real buildings and be installed as far as possible by the same method and procedures as in practice. It is not allowed to mount the specimen on the main face and the wing separately, and afterwards assemble the main face and the wing, since such mounting would not be possible in any real building.

If the façade system does not provide any protection to openings in practice (see definition in Section 3), then the detailing of the test specimen at openings (combustion chamber opening and secondary opening) shall also remain unprotected. Otherwise, the test specimen shall include the representative protections to openings intended to be used in practice.

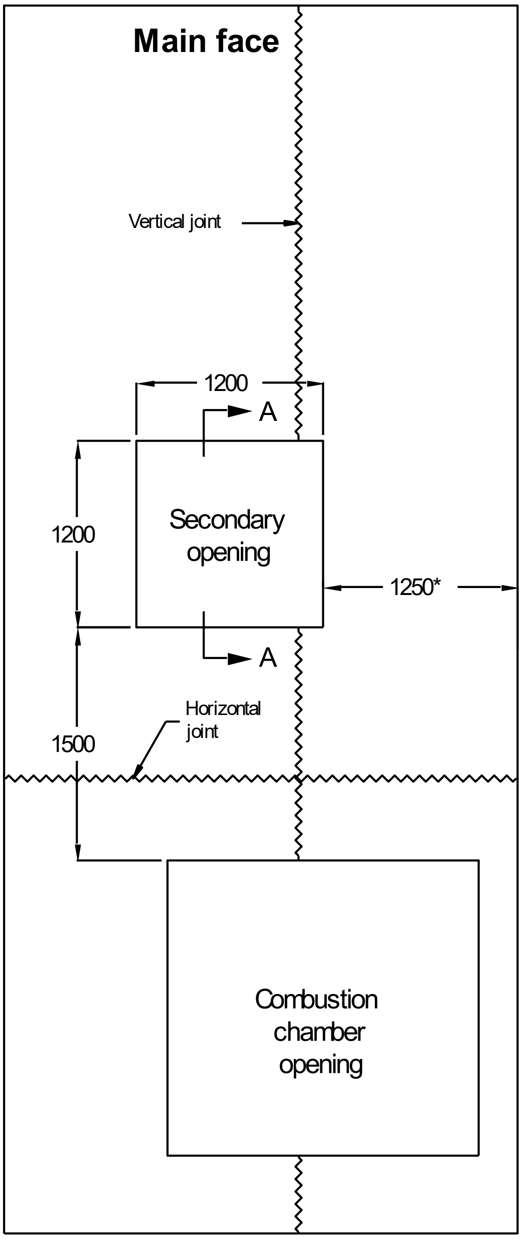


Figure 8a. Main face with secondary opening including the location of vertical and horizontal joints. Distances in the drawing shall be considered with a tolerance of ±50 mm except the vertical distance between corner and secondary opening which is 1250 ± 100 mm.

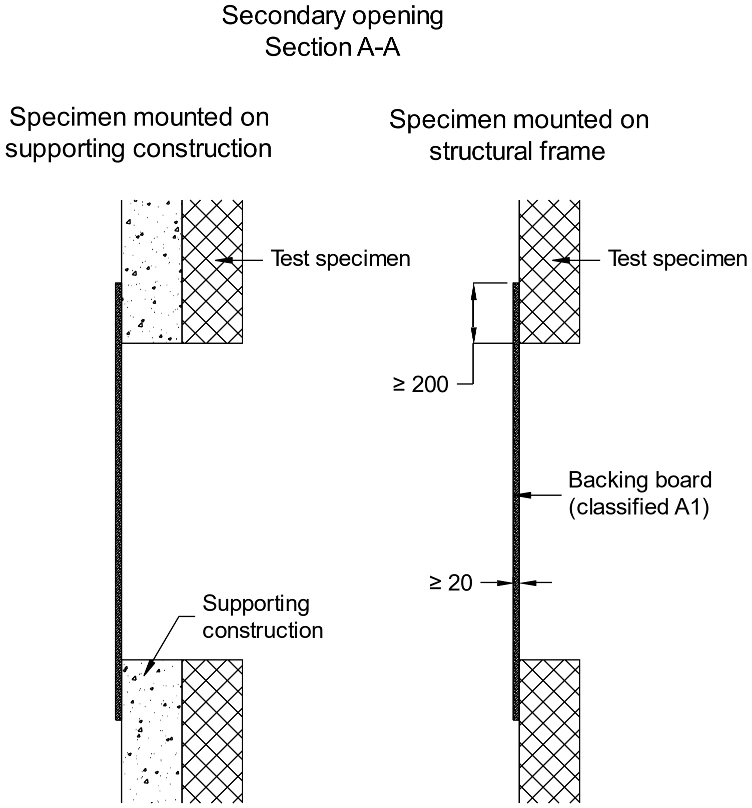


Figure 8b. Cross-section A-A of the secondary opening area

6.9 Edges of openings

The perimeter of the secondary opening and of the combustion chamber shall be closed as similar to the end use as possible. In case end use conditions are not known, a general closing may be used such as thin aluminium or steel plate, that would allow for different details to be fitted at the edge.

This general closing shall only be used where it is obvious that the fire behaviour of the simplified detail will be very similar to that used in practice.

A simplified detail cannot be used, for example:

- for heavy sheet coverings used in the window reveal and soffit (e.g. ceramic tiles, stone tiles),
- where the thermal insulation in the window reveal and soffit or the specific design of the junction prevents the fire from spreading to the rest of the façade (e.g. façade insulation system).

For all junction designs, the width of the fire opening in the horizontal direction shall be maintained at 2000 mm. In the vertical direction, the distance from the combustion chamber floor to the edge shall be kept at 1900 mm including detailing.

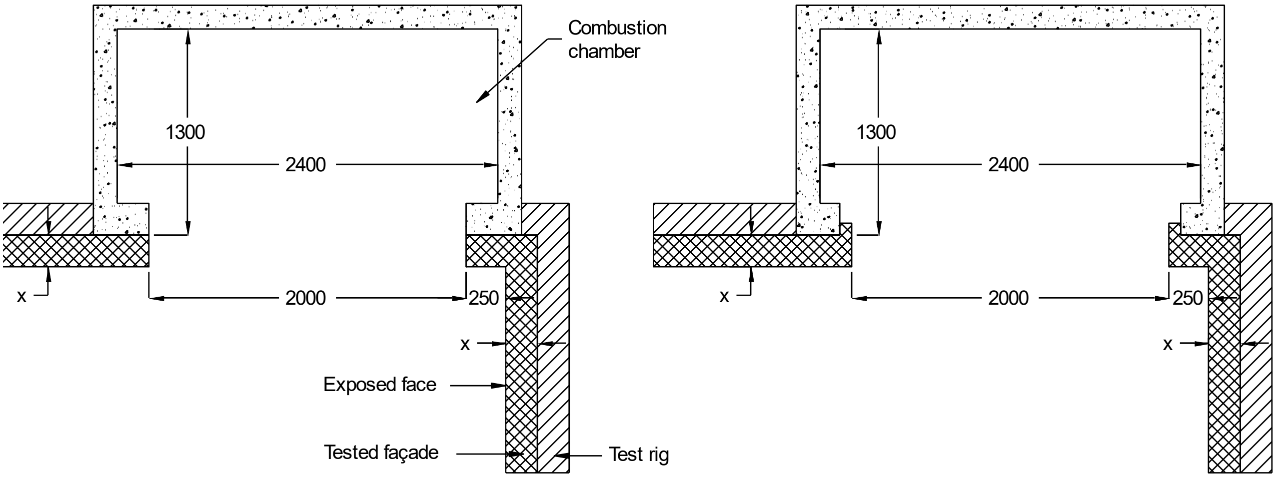


Figure 8c. Horizontal section of the detailing at the edges of openings schematically exemplified. The general closing configuration is shown on the left, the detail as in practice is shown on the right, x refers to the actual thickness of the tested façade.

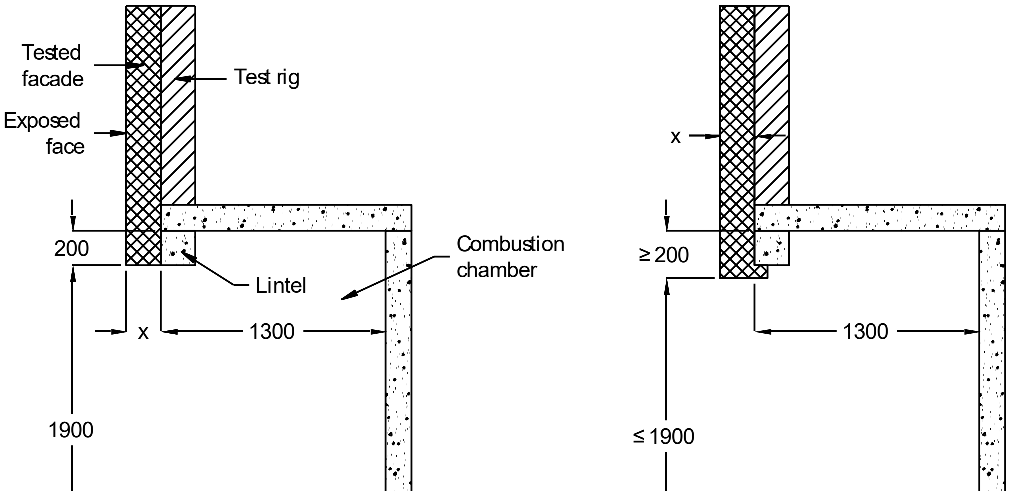


Figure 8d. Vertical section of the detailing at the edges of openings schematically exemplified. The general closing configuration is shown on the left, the detail as in practice is shown on the right, x refers to the actual thickness of the tested façade.

Note 1: The closing of the façade system is closely linked to the Field of Application and need to be developed separately.

6.10 Junction between façade and floor (optional test procedure)

The assessment of the junction between floor and façade as potential weak point may be required in some cases. In order to give the possibility to consider this issue, a specific adaptation can be done in the test. Figure 9 shows how the junction between the façade and the floor can be included in the test.

This optional test procedure is presented in detail in annex D.

> *Note 1: Façade-to-floor junctions don't exist in cases of façades mounted on a supporting construction. Therefore, only the façades mounted directly on a structural frame may be concerned by this optional assessment.*

Note 2: The junction between façade and floor will only be assessed along the width of the combustion chamber, and not along the whole width of the test specimen. See also 10.4.

Note 3: The junction between façade and floor is not covered by the classification system for façades.

In case of assessment of façade-to-floor junction, no lintel (see Section 4.5) shall be installed at the top of the combustion chamber. This removal of the lintel is an exception to the normal procedure and allows to accommodate the junction to be tested as well as any junction detail representative of the end use design.

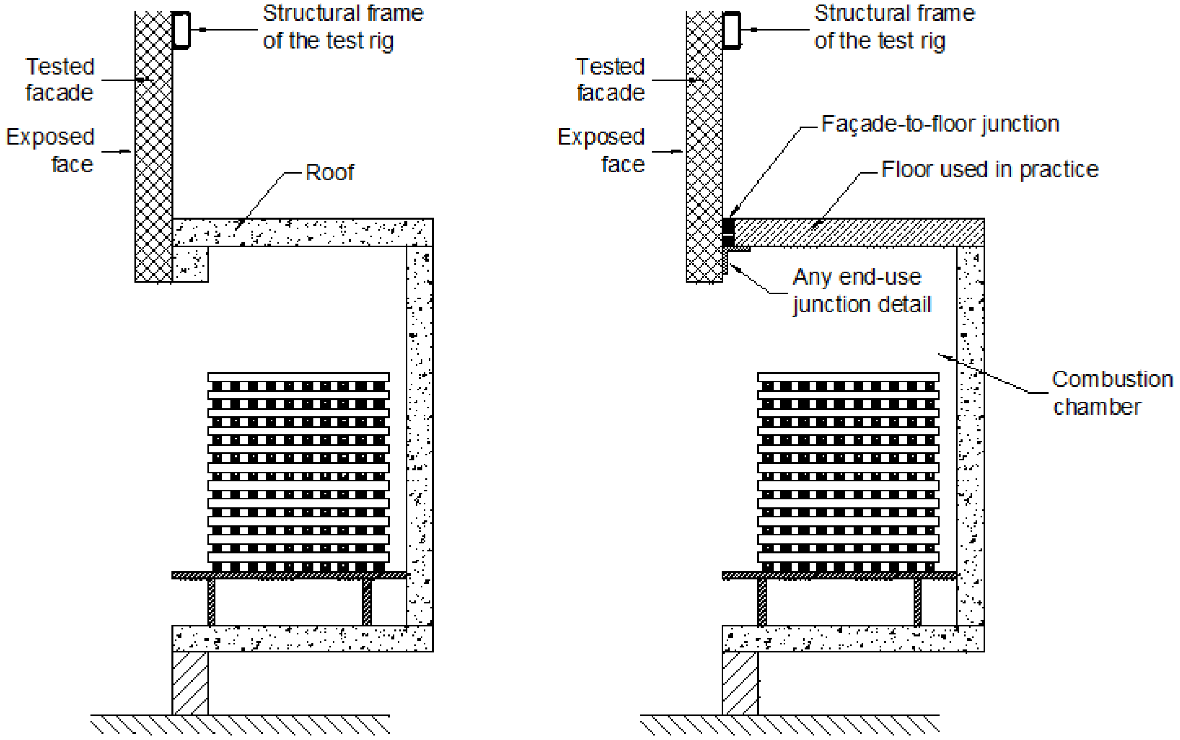


Figure 9. Mounting of façade system and floor at the combustion chamber schematically exemplified. The normal procedure is shown on the left, the adaptation for the evaluation of the façade-to-floor junction is shown on the right.

7 CONDITIONING OF TEST SPECIMEN

7.1 General

After installation of the test specimen to the test rig, it shall be left for a period of time which is sufficient for all components to cure. If the tested façade system includes hygroscopic materials, it shall be conditioned following the requirements of 7.2, otherwise it shall be conditioned in accordance with the test sponsor's specifications.

The test rig with the mounted test specimen shall be protected from adverse environmental conditions such as water, wind load and ambient temperatures outside the range +5 °C to +35 °C during the mounting, conditioning and test period.

At the time of the test, the strength and the moisture content of the test specimen shall approximate to those expected in normal service.

7.2 Mock-up test specimen for verification of condition

It is up to the sponsor to make sure that the specimen is conditioned to a state that represent what could be expected in its practical use. Thus, materials are not allowed to contain more water than in normal use. It is up to the laboratory to verify these conditions, and they shall be included in the test report. Verifications are recommended to use oven drying in 105 °C of excess materials during installation. Should moisture contents be deemed unreasonably high then this shall be stated in the test report. Further verifications at the time of the test could be necessary. If no excess material is available, the laboratory needs to plan with the sponsor in advance how to verify the condition of the specimen.

The same principle applies when testing materials which require time for curing. Their state shall be close to what is expected in its practical use. The sponsor is responsible for delivering representative systems and the laboratory is required to verify that the material meets the representative status described by the sponsor.

When the tested façade system includes hygroscopic materials, in which case the fire performance is affected by the moisture content, the moisture content shall be measured during the conditioning period up to the time of testing by means of a small size mock-up of the façade.

This mock-up shall be prepared during the installation of the façade, using the same materials. This mock-up shall be used to estimate the weight stabilization of the sample and to determine material characteristics (mainly moisture content). It shall be stored together with the façade specimen and in the same ambient conditions.

The mock-up shall have the following dimensions:

- thickness: same thickness than the tested façade system,
- length and height of the front face: at least 200 mm x 200 mm or at least three times the thickness of the tested façade system, whichever is larger.

In order to ensure that the drying is allowed in the same way as for the façade in practice, namely only from the faces exposed to ambient air, all sides of the mock-up shall be covered in plastic except:

- the exposed face in case where the test specimen is mounted onto a supporting construction,
- both exposed and unexposed faces where the test specimen is mounted onto a structural frame.

The whole mock-up shall be weighted daily until the weight change between two measurements, 24 h apart, is less than 0.1 %. In case of materials that need long curing times, the conditioning can be limited to 28 days.

After this conditioning time, the moisture content of each individual hygroscopic material in presence shall be measured on samples taken from the mock-up test specimen. The moisture content of each such sample is determined by weighting the sample before and after drying at 105 °C. For some specific materials, such as gypsum, other drying temperatures may be applied which then shall be clearly stated in the test report.

8 APPLICATION OF INSTRUMENTATION

8.1 Temperature measurements

8.1.1 General

Sheathed thermocouples (external and internal, see below) can be installed by drilling holes through the test specimen at the locations defined in Sections 8.1.2 and 8.1.3 to enable the thermocouples to be installed from the rear face of the tested façade. This instrumentation from behind shall ensure no interference with the development of the ignition source or with the fire propagation on the tested façade.

Drilling the holes in the tested façade shall be achieved by using equipment suitable for the type of façade system and materials being tested. The diameter of the holes shall be the minimum required to allow the thermocouples to be inserted from the rear to the exposed face of the tested façade, allowing for multiple thermocouples to be located through the full depth of the system, see Figure 10.

Care shall be taken to ensure that damage or displacement of material in each layer is minimized.

Where the external thermocouples pass through the exposed face of the tested façade, the thermocouples shall be allowed to travel freely and shall not be restrained to the test specimen. If any form of closure around the holes is required on the exposed face of the tested façade, this shall be achieved by use of non-combustible cementitious or packing materials.

Optionally, external thermocouples may be installed from the front side of the façade and maintained in place by means of any kind of steel structure (grid, chain, channels, angles, cables...), which avoid drilling into the outer layer of the façade.

One horizontal line (referenced as level 1) and two vertical lines (referenced as columns 1 and 2) are defined for external and internal thermocouples.

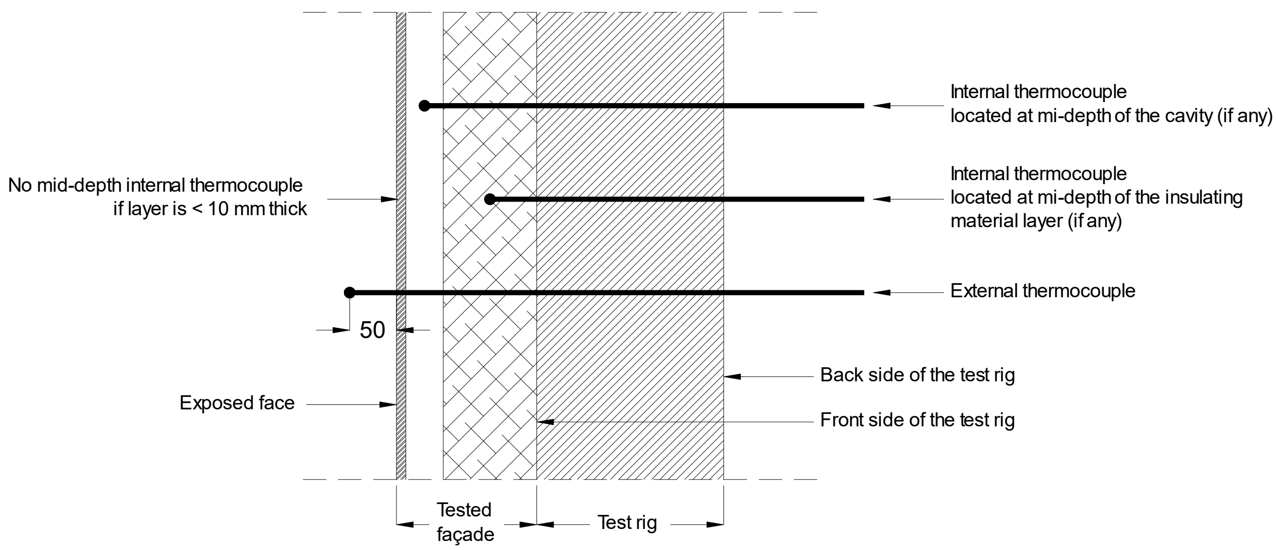


Figure 10. Principle drawing for the internal and external thermocouples for fire spread assessment

8.1.2 External thermocouples

The position of external thermocouples shall be according to Figure 11 within a tolerance of ± 10 mm. Nevertheless, if there are studs, joints, stiffeners, cavity barriers, or other components which interfere at the given position, then the external thermocouple shall be moved toward the combustion chamber to a location not more than 50 mm from the component. Regarding the depth position, the external thermocouples shall be placed with their hot junction positioned 50 ± 5 mm in front of the exposed face of the test specimen.

8.1.3 Internal thermocouples

In each location, internal thermocouples shall be positioned at the mid-depth of each combustible layer (see definition in Section 3) or air cavity that are at least 10 mm deep. In this regard, several consecutive layers of the same material shall be considered as one single layer. Notice that to minimize the impact on measurements on the façade system it is allowed to use the same hole for all thermocouples in each individual layer of the façade system.

In each position, the internal thermocouples shall be positioned around - and at a distance of maximum 50 mm from the external thermocouple and moved toward the combustion chamber to a location not more than 50 mm from interfering studs, joints, stiffeners, cavity barriers, or other components.

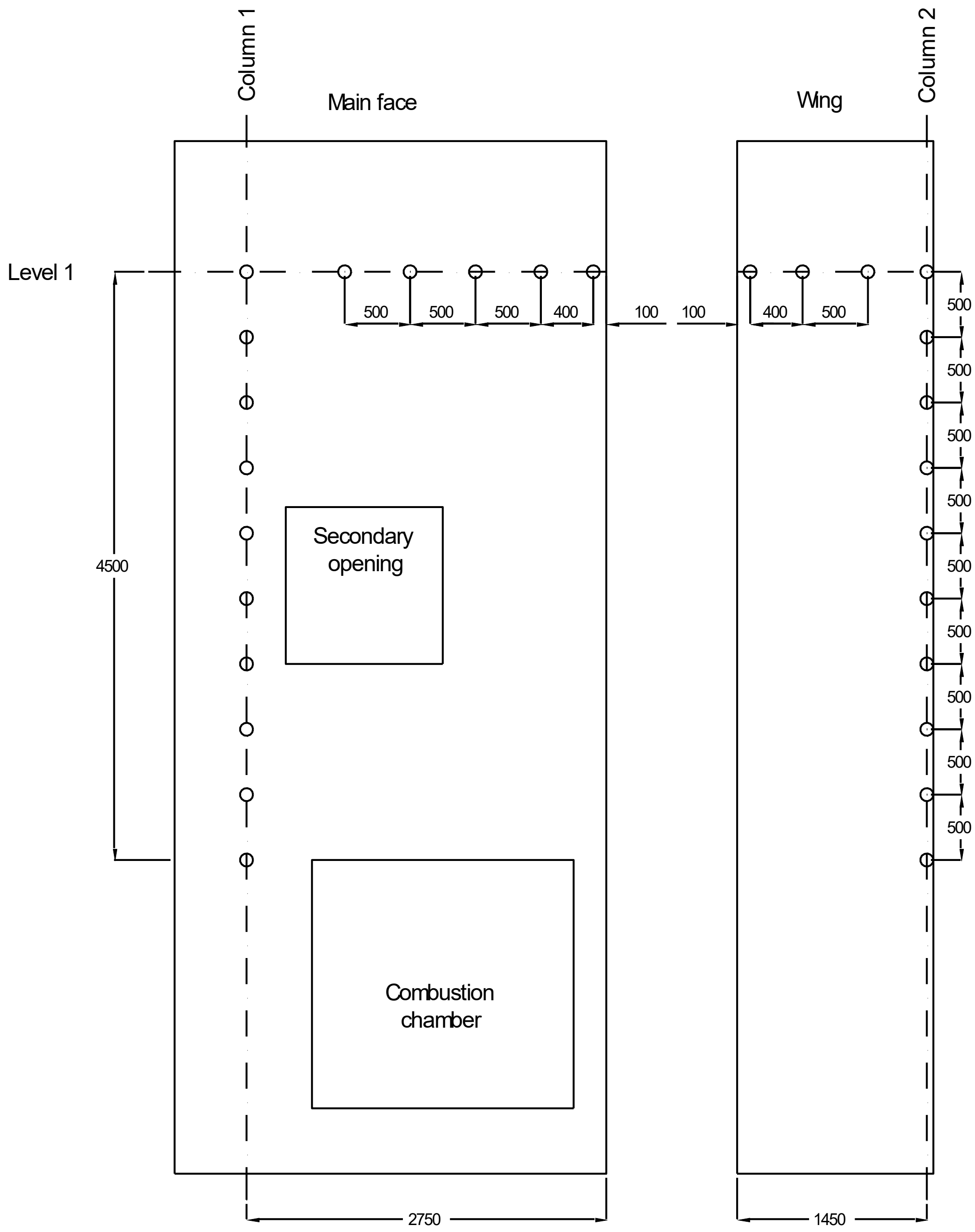


Figure 11 Positions of thermocouples on the exposed face of the tested façade.

8.1.4 Method of installation of the thermocouples

An example of installation is presented here:

- marking of the main thermocouples section at the front face of the specimen.

- drilling from the front of the façade specimen of a 10 mm hole crossing the complete façade thickness and the supporting construction if existing.

- creation of a bundle with all internal and external thermocouples of the same section with their measuring junction located at the suitable horizontal distance corresponding to the design of the façade system.

- insertion of the bundle in a hollow pipe with external diameter smaller than 10 mm.

- introduction of the pipe with thermocouple bundle from the rear of the rig.

- adjusting the bundle horizontal position by having the measuring junction of the external thermocouple located at 50 mm distance of the exposed face.

- fastening of thermocouples cables at the rear face of rig.

- removal of the pipe from the front of the rig.

- sealing of the space of hole between the thermocouples and the exposed face of the façade.

- sealing of the space of hole between the thermocouples and the unexposed face of the façade or back side of the test rig as the case may be.

Another example could consist in:

- Installing external thermocouple by means of a grid/mesh made of steel profiles (channels, angles) installed from the top of the rig in front of the exposed face of the façade.
- Installing all internal thermocouples by drilling from the rear face.

8.3 Measurements on junction between façade and floor (optional)

When assessment of the façade-to-floor junction is performed (see Annex C), copper disc thermocouples and insulating pad, in accordance with EN 1363-1, shall be installed on the visible upper surface of the floor (not inside the floor) as follows:

- in cases of floors which incorporate discrete areas (see definition in Section 3) with depth ≥ 30 mm alongside the unexposed face of the façade (e.g., linear seal) (see Figure 12):
    - four thermocouples shall be located at mid-depth of the discrete area,
    - four thermocouples shall be located on the floor at 15 mm from the discrete area,
- in other cases (see Figure 13):
    - four thermocouples shall be located on the floor at 25 mm from the unexposed face of the tested façade.

When positioning thermocouples near a discontinuity (e.g., a joint between adjacent boards, a joint between one type of construction and another, hotspots…), the centre of the disc shall not be placed closer than 15 mm to the discontinuity.

In all cases, the thermocouples shall be distributed along the width of the junction at equal distances along the internal width of the combustion chamber.

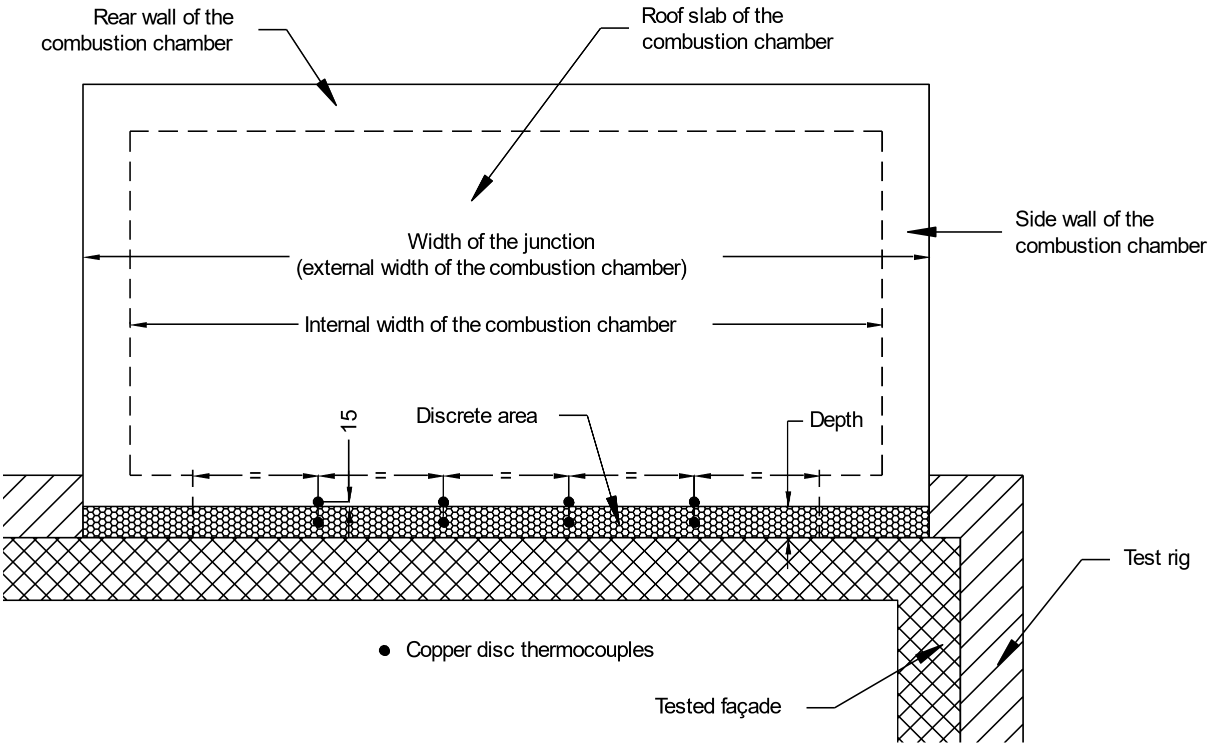


Figure 12. Instrumentation at the junction between façade and floor in presence of a discrete area. The view is from above the floor (the roof of the combustion chamber).

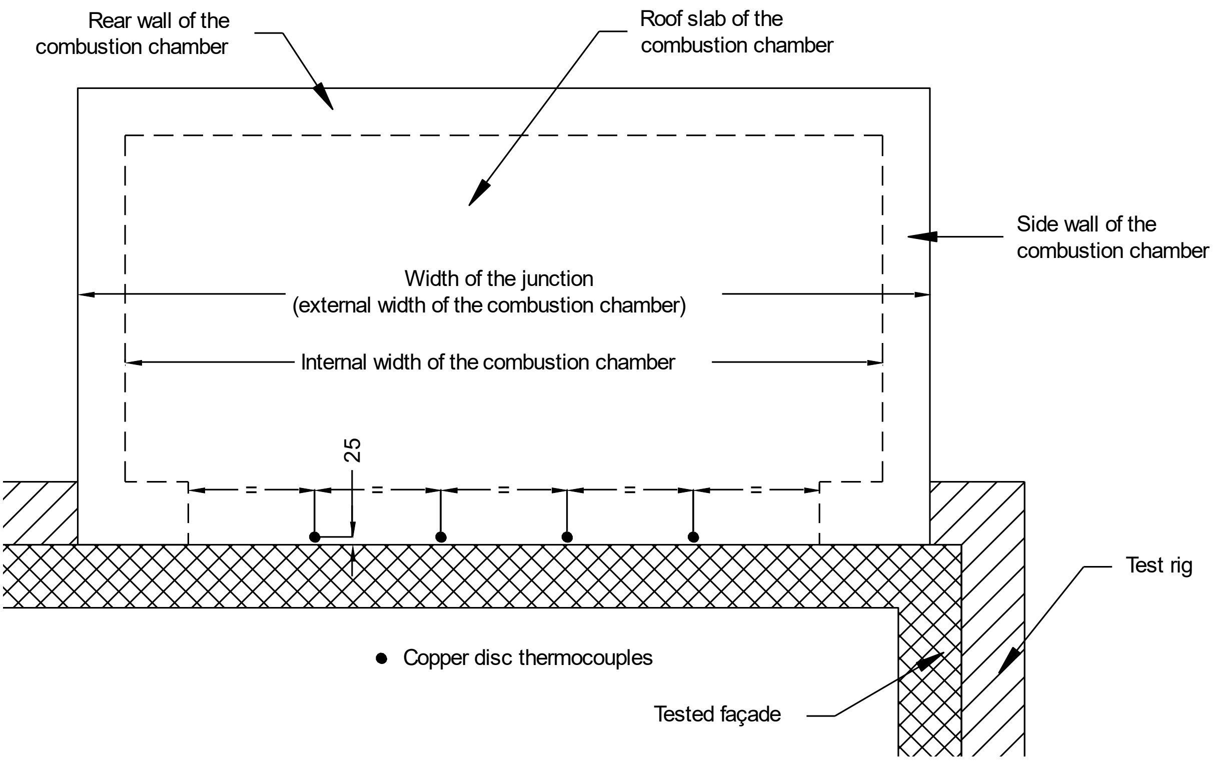


Figure 13. Instrumentation at the junction between façade and floor in absence of any discrete area. The view is from above the floor (the roof of the combustion chamber).

8.4 Assessment of smouldering (optional)

When the smouldering criterion is required, additional thermocouples in accordance with DIN 4102-20 shall be installed within the façade system.

8.5 Mass of the falling parts

Indoor testing

A load cell platform shall be located in front of the test bench to collect any falling part coming from both the main face and the wing. See Section 4.7.4 and Figure 6 for description.

This platform shall have a surface corresponding to the rectangle created by the main face and the wing.

The platform shall be protected from mechanical shocks and thermal aggression by means of fire boards and high temperature blanket.

The mass of the falling parts shall be recorded during the 60 min of the test. The recordings of the mass over time shall be documented as a mass-time curve. The increment of fallen mass over a period of 10 seconds shall be computed all along the test by subtracting raw mass data in time steps of 10 seconds. The videos shall be used to sort the parts falling from the façade from the parts falling from the crib, only the first case being considered.

In cases where falling parts would eventually fall or bounce of the loadcell platform, their mass shall be weighted or estimated separately and added to the recording after the test.

Outdoor testing

Further investigations needed to allow for outdoor testing.

9 TEST PROCEDURE

9.1 General

The test procedure follows the following steps.

- Document the test set-up.
- Confirm that all measurement devices are functioning.
- Determine the environmental conditions (ambient air speed, precipitation and local temperatures).
- Begin data logging and audio-visual recording equipment.
- Ignite the timber crib following the relevant procedure as defined in 10.3.
- Monitor and record the behaviour of the test specimen during the full 60 minutes test period.
- Continue to record measurements and observations for the full duration of the test.
- Terminate of the test 60 minutes after the starting time.
- Record observations of permanent changes to the test specimen once the test is finished.

9.2 Test time

9.2.1 Starting time vs. ignition time

Regarding the test time, several points in time need to be regarded, especially the ignition time and the starting time as they are not the same. The ignition time is the time when the crib is ignited. The starting time is described in detail in clause 3.

The reference values of the measurements shall be considered the moment when the fire source is ignited (ignition of the strips of soaked fibreboard), see 9.3 for detailed procedure. All measurement devices are started at latest at the ignition time, e.g., rises of temperature, masses etc. shall be computed from these reference values.

The starting time of the test as defined in Section 3 means the elapsed time shall be measured from this point.

9.2.2 Progress of the test

The test duration shall be 60 minutes for all fire exposure scenarios, extended observation needed if smouldering shall be assessed.

Table 2. Step-by-step timing of the test

Time (in minute)	**Action**	**Reference Clause**
-10 before ignition	Soak fibreboard ignition strips	9.3
-5 before ignition	Insert fibreboard ignition strip into crib	9.3
Ignition time	Ignition of the timber crib	9.3
0	Starting time	3
60	Termination of test*	No smouldering

* Except if the smouldering shall be assessed. If so, the test duration is extended according to Section 9.5.

9.3 Ignition of the fire source

The crib shall be ignited by using 14 strips of low-density fibreboard, each strip having nominal length corresponding to the depth of the crib + 30 mm. The width of the strip shall be lower than the space between two consecutive wood sticks, e.g., 25 mm. The strips shall be soaked uniformly in Isopropanol (= Isopropyl alcohol) min. 90% concentration for a minimum of 5 minutes. Not more than 5 minutes before ignition, strips of soaked fibreboard shall be inserted into all spaces between the timber sticks in the second layer of the crib allowing approximately 30 mm to project from the front of the crib. Additional 2 strips shall be laid horizontally and perpendicularly across the projected strip ends.

Ignition of the crib is achieved by igniting only additional perpendicular strips across their full length.

9.4 Observations

Video records shall be made during the whole duration of tests.

The cameras on the exposed side of the tested façade aims to record the occurrence of any flames, falling parts and other events during the test. It also helps to control the risk of collapse of the test specimen and, more generally, the safety of the test.

When also assessing the junction between floor and façade, the camera at the back face of the tested façade aims to record the occurrence of any sustained flaming. It also helps to control the behaviour of the test rig.

Details and times of significant events shall be recorded during the test such as the change of flaming conditions and any change in the mechanical behaviour of the cladding system shall be recorded, especially the detachment of any part of the cladding system (whether flaming or otherwise) or any fire penetrations through fire stops incorporated within the cladding system.

Areas shall be expressed in square meters and lengths in meters or millimetres.

Perform all observations in accordance with Section 11.

9.5 End of the fire source

The fire in the combustion chamber is extinguished after the 60 minutes after the starting time. Only after these 60 minutes, the fire on the test specimen can be extinguished, except if the smouldering shall be assessed. In such case the specimen shall be kept under observation until all thermocouples show a temperature lower than 50°C with a maximum duration of 6 / 15 hours[3] after ignition.

9.6 Post-test inspection

Observation of permanent changes of the tested system shall be assessed after the end of the test and shall be documented. Examination of the test specimen shall take place within 24 hours after the test, once the specimen has cooled. The examination shall record details of permanent changes, including (but not limited to) spalling, melting, deformation, softening, detachment, charring, discolouration and delamination. The examination shall note size, shape, location and type of permanent changes. Both changes on the surface as well as within any layers or cavities of the system shall be noted. Any collapse or partial collapse of the test specimen shall also be noted.

[3] According to DIN 4102-20 a maximum test duration of 15 hours is given. By many laboratories that is seen to be problematic, especially for large exposure tests regarding acceptable working hours. Therefore, an alternative of 6h hours according to ISO 16733 has been proposed as well.

Areas shall be expressed in square meters and lengths in meters or millimetres.

9.7 Termination of test

The test may be terminated for one or more of the following reasons:

a) flame spread extends beyond the test rig (vertically or horizontally) at any time during the test duration, or if flames pass through the test specimen to the backside of the test rig;

b) there is a risk to the safety of personnel or impending damage to equipment,

c) request of the sponsor,

d) risk of imminent collapse or actual collapse of most of the tested façade,

When a test has been terminated prior to failure under all of the relevant performance criteria, the reason for termination shall be stated. Regarding the performance criteria which didn't fail prior to termination of the test, the test results shall be given as the time of termination of the test and shall be qualified accordingly.

9.8 Invalidation of the test

The test shall be invalidated when one or more of the following reasons is met during the test (up to its termination at 60 minutes).

9.8.1 Environmental conditions

For outdoor tests, the validation of test shall be assessed in case of severe changes of environmental conditions during the test. This assessment shall be clearly specified in the test report.

9.8.2 Thermocouple failure

The test shall be invalidated when one or more of the following reasons is met:

- failure of 3 or more thermocouples in the same level and in the same layer on the main wall,
- failure of 2 or more thermocouple in the same level and in the same layer on the wing,
- failure of 4 or more thermocouples in the same column and in the same layer.

9.8.3 Other reasons to invalidate a test

The test shall be invalidated:

- in case of premature collapsing of the crib, i.e., within 15 min after the starting time,
- if the starting time of the test is not achieved, namely if no TC at 4500 mm reaches 380 °C in rise over a 30 second average.

10 PERFORMANCE CRITERIA

The assessment of performance criteria is from the starting time defined in Section 3.

10.1 Fire spread

This is the time in completed minutes from the starting time for which the test specimen continues to maintain its ability to limit the propagation of a fire. The failure of the fire spread performance is deemed to have occurred when one of the criteria below has failed.

10.1.1 Vertical fire spread

The failure of vertical fire spread criterion occurs when any external or internal thermocouple positioned on level 1 exceeds a temperature rise - above its initial temperature - of 700 K on average over a period of 30 seconds during the 60 minutes test period after the start of the test. The time of failure shall be reported as the time at the end of this 30 seconds period; i.e. when the observation is finally made.

10.1.2 Horizontal fire spread

The failure of horizontal fire spread criterion occurs when any external or internal thermocouple positioned on the columns 1 and 2 exceeds a temperature rise - above its initial temperature – of 700 K on average over a period of 30 seconds during the 60 minutes test period after the start of the test. The time of failure shall be reported as the time at the end of this 30 seconds period; i.e. when the observation is finally made.

10.2 Burning parts

The burning parts can either be in liquid or solid phase.

The failure of burning parts criterion occurs when a falling part burns for 30 s or longer after hitting the ground.

The time of failure shall be reported as the time at the end of this 30 seconds burning period; i.e. when the observation is finally made.

10.3 Falling parts

Falling parts include all material falling from the test specimen. They are assessed by measuring the mass of the falling parts during the test time with a load cell platform as well as visual observations.

Limits for the mass of falling parts are given below. The time of failure shall be reported as the time at which the falling part touches the ground i.e., the falling part shall have completely broken off from the façade, without being still hung somewhere.

10.2.2 Falling parts – Level 1

The failure of falling parts (level 1) criterion occurs when the increment of mass of the falling parts over a period of 10 seconds exceeds 1 kg.

10.2.23Falling parts – Level 2

The failure of falling parts (level 2) criterion occurs when the increment of mass of the falling parts over a period of 10 seconds exceeds 5 kg.

Example:

- A falling part of 2 kg will fail the level 1 criterion but not the level 2

- A falling part of 6 kg will fail both level 1 and level 2 criteria

10.4 Façade-to-floor junction (optional)

10.3.1 Integrity

This is the time in completed minutes for which the façade-to-floor junction continues to maintain its separating function by preventing the occurrence of flames on the unexposed side of the junction. The failure of the integrity performance is deemed to have occurred when the criterion below has failed.

The failure of the sustained flaming criterion occurs when continuous flaming is observed on the unexposed side of the junction for a period of time greater than 10 s. The time of failure shall be reported as the time at the end of this 10 seconds period i.e., when the observation is finally made.

10.3.2 Insulation

This is the time in completed minutes for which façade-to-floor junction continues to maintain its separating function by restricting the temperature rise below specified levels. The failure of the insulation performance is deemed to have occurred when the criterion below has failed.

The failure of the maximum temperature rise criterion occurs when any thermocouple positioned at the connection between floor and façade (see Figures 14-15) exceeds a temperature rise - above its initial temperature of 180 K.

10.5 Smouldering (optional)

This is the time in completed minutes for which the test specimen continues to maintain its ability to limit the propagation of a combustion without flame and without visible light. The failure of the smouldering performance is deemed to have occurred when one of the criteria below has failed.

10.4.1 Edge damages

The failure of edge damages criterion occurs when the damage of the test assembly by spread of smouldering processes reach the top of the assembly or reach the lateral edges of the test assembly – both shall be assessed after termination of the test.

10.4.2 Maximum temperature

The failure of maximum temperature criterion occurs when a temperature of higher than 50 °C is measured at any of the thermocouples at the end of the 6 / 15 hours[4] period after beginning of the test.

[4] According to DIN 4102-20 a maximum test duration of 15 hours is given. By many laboratories that is seen to be problematic, especially for large exposure tests regarding acceptable working hours. Therefore, an alternative of 6h hours according to ISO 16733 has been proposed as well.

11 TEST REPORT

A test report shall be written describing the execution and the results of the test. The report shall contain the following information and data:

a) Name and address of the test laboratory

b) Date of the test and date of issue of the test report

c) Name and address of the sponsor of the test

d) Applied fire exposure (medium or large) and detailed data describing the wood crib

e) Installation and assembly of the test specimen

- Description of the supporting construction, if used
- Mounting (directly on the structural frame or on a supporting construction)
- The secondary opening

f) Description of the façade system tested including (see Section 6):

- Name and type of the products used, dimensions, form
- Properties of the materials used, nominal and measured values,
- All elements included in the system such as fixing types, specifications, installation density (i.e., number per m2 and layout patterns of fixings, coverage and type of application of adhesive etc.)
- The position of all components in the system
- Design of construction details such as lintel, joints, edges, openings, expansion joint details, fire stops, cavity and fire barriers

g) Position of the external and internal thermocouples

h) Environmental conditions (see Section 5). For indoor tests: changes of ventilation and incoming air during the test. For outdoor tests: changes of wind speed and direction during the test. Assessment of the validation of results in case of changes of weather during the test for outdoor test or change of ventilation for indoor tests.

i) Visual observations and photographs including the time during the test such as:

- flame spread extends beyond the test rig (vertically or horizontally)
- visual flame spread on the surface of the test specimen, burning through joints or showing flames at the outer edges of the test specimen
- occurrence of burning debris of the test specimen including time and duration of burning
- occurrence, duration and extent of a secondary fire on the floor of the test rig caused by burning debris
- occurrence time, dimensions and amount of falling parts
- changes of the test specimen during the tests like deformations, colourations or delamination’s
- visual description of the smoke development

j) Permanent changes to the test specimen (see Section 9.6) once the test is finished, both on the surface and inside the test specimen

k) Graphs of temperatures versus time measured by all individual thermocouples

l) The test results stated in terms of the elapsed time, in completed minutes, between the starting time of the test (as defined in Section 9.2.1) and the time of failure with respect to the relevant performances and criteria (as defined in Section 11), including:

1) the fire spread performance and its vertical fire spread, horizontal fire spread

2) the burning parts performance

3) the falling parts (level 1) performance

4) the falling parts (level 2) performance

5) a table listing the test times at which the falling parts (increment of masses over 10 seconds) exceeded thresholds from 0.5 to 10 kg in steps of 0.5 kg

6) the façade-to-floor junction (integrity) performance, if assessed

7) the façade-to-floor junction (insulation) performance, if assessed

8) the smouldering performance, if assessed, and its edge damages and maximum temperature criteria

In addition, when the test has been terminated prior to failure under all of the relevant performance criteria:

- the reason for termination shall be reported,
- the performance criteria which didn't fail prior to termination of the test shall be reported in accordance with Section 9.7.

The results shall be presented as follows:

Performance	Criterion	Test result
Fire spread		
	Vertical fire spread	…… minutes
	Horizontal fire spread	…… minutes
Burning parts		
	Burning parts	…… minutes
Falling parts – Level 1		
	Falling parts (level 1)	…… minutes
Falling parts – Level 2		
	Falling parts (level 2)	…… minutes
Façade-to-floor junction - Integrity		
	Sustained flaming	…… minutes / Not assessed
Façade-to-floor junction - Insulation		
	Maximum temperature rise	…… minutes / Not assessed
Smouldering		
	Edge damages	…… minutes / Not assessed
	Maximum temperature	…… minutes / Not assessed

Falling parts	Test time (min)
0.5 kg	

1.0 kg	
1.5 kg	
2.0 kg	
2.5 kg	
3.0 kg	
3.5 kg	
4.0 kg	
4.5 kg	
5.0 kg	
5.5 kg	
6.0 kg	
6.5 kg	
7.0 kg	
7.5 kg	
8.0 kg	
8.5 kg	
9.0 kg	
9.5 kg	
10.0 kg	

m) The date and the main results of the last calibration performed on the test bench according to Annex A.

n) A statement of invalidity of the test in case where the test is invalidated for one or more of the reasons given in Section 9.8. This statement shall include the reason(s) invalidating the test and the test time from which the test is invalidated.

o) The field of direct application of the results for the specimen being evaluated, either in the form of the full text from Section 12, or only those clauses which are relevant for the tested specimen. A field of application can only be granted in cases where the tested façade has achieved at least one of the performance criteria. Otherwise, the dedicated section in the report shall mention "Not applicable".

p) The following statements shall be included:

"This report details the method of construction, the test conditions and the results obtained when the specific façade system described herein was tested following the procedure outlined in the assessment method xxxxxx (official reference of the assessment method once published). Any significant deviation with respect to size, constructional details, stresses, edges or end conditions other than those allowed under the field of direct application in the relevant section of the method is not covered by this report.

Because of the nature of fire testing and the consequent difficulty in quantifying the uncertainty of measurement of fire performances, it is not possible to provide a stated degree of accuracy of the result."

a) Signature(s) of the responsible staff(s) of the testing laboratory

As annexes the following shall be added to the test report:

b) Illustrations / drawings of:

- test assembly
- constructive design of specific details of the test assembly
- position of all thermocouples on the test specimen for measuring the temperatures

c) Photo documentation: description of the test course by significant pictures at special time points

The video of the test shall be archived by the test laboratory.

12 DIRECT FIELD OF APPLICATION

Note: It is currently too early to define a set of direct field of applications (DIAP). Later when more information is available the DIAP can be defined in more detail. The following gives examples on what can be considered in the DIAP. The question on when the full external wall or only a part of the wall, or a cladding system is enough, needs to be tested has not yet been decided. Some kind of definition will be needed, especially for the field of application. Such definition could be that the system shall be mounted on a wall with an outer layer of class A and a protection of K_2 30, or something similar.

The results of the fire test are directly applicable to similar constructions where one or more of the changes listed below are made and the construction continues to comply with the appropriate design code for its stiffness and stability:

k) decrease in distance of fixing centres;

l) increase in the number of horizontal joints, of the type tested, when tested with joints;

m) increase in the number of vertical joints, of the type tested, when tested with joints;

n) the width of an identical construction may be increased if the dimensions of the tested specimen were at least the minimal size specified in Section 6.1 provided joints were tested and provided distance of fixing centres is not increased;

o) the height of the construction may be increased;

p) an insulation of Euroclass A2 can be replaced with an insulation of Euroclass A1 if the thickness and density is the same;

q) an insulation of Euroclass E can be replaced with an insulation of Euroclass B, C or D if the thickness and density is the same;

r) any kind of frame can be fitted around openings (like windows) if the test has been performed without any frame to protect the edge of the façade system at such openings (see Annex B);

s) the width of the construction may be decreased;

t) the height of the construction may be decreased.

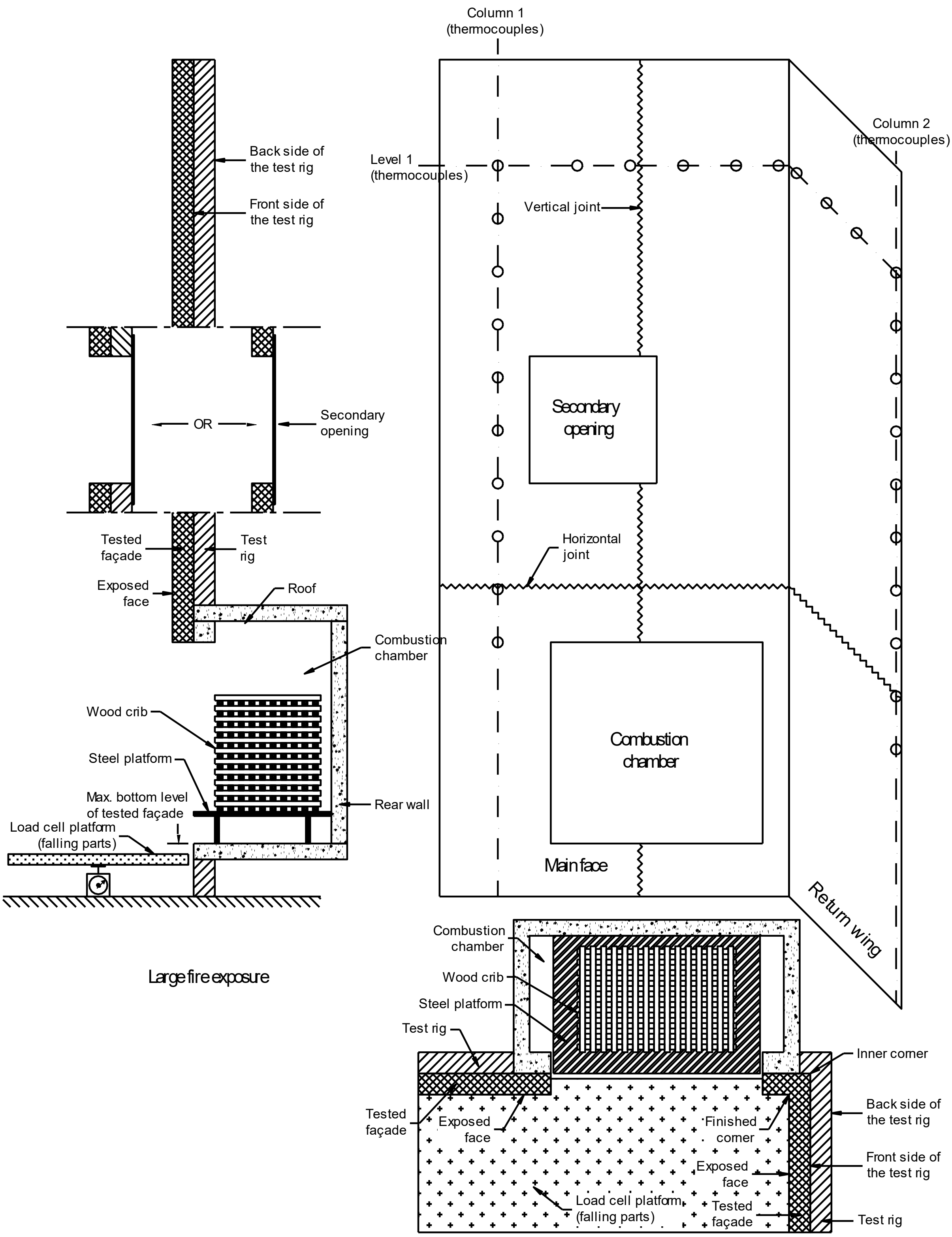


Figure 14. Designation and localisation of the main concepts for the large fire exposure test.

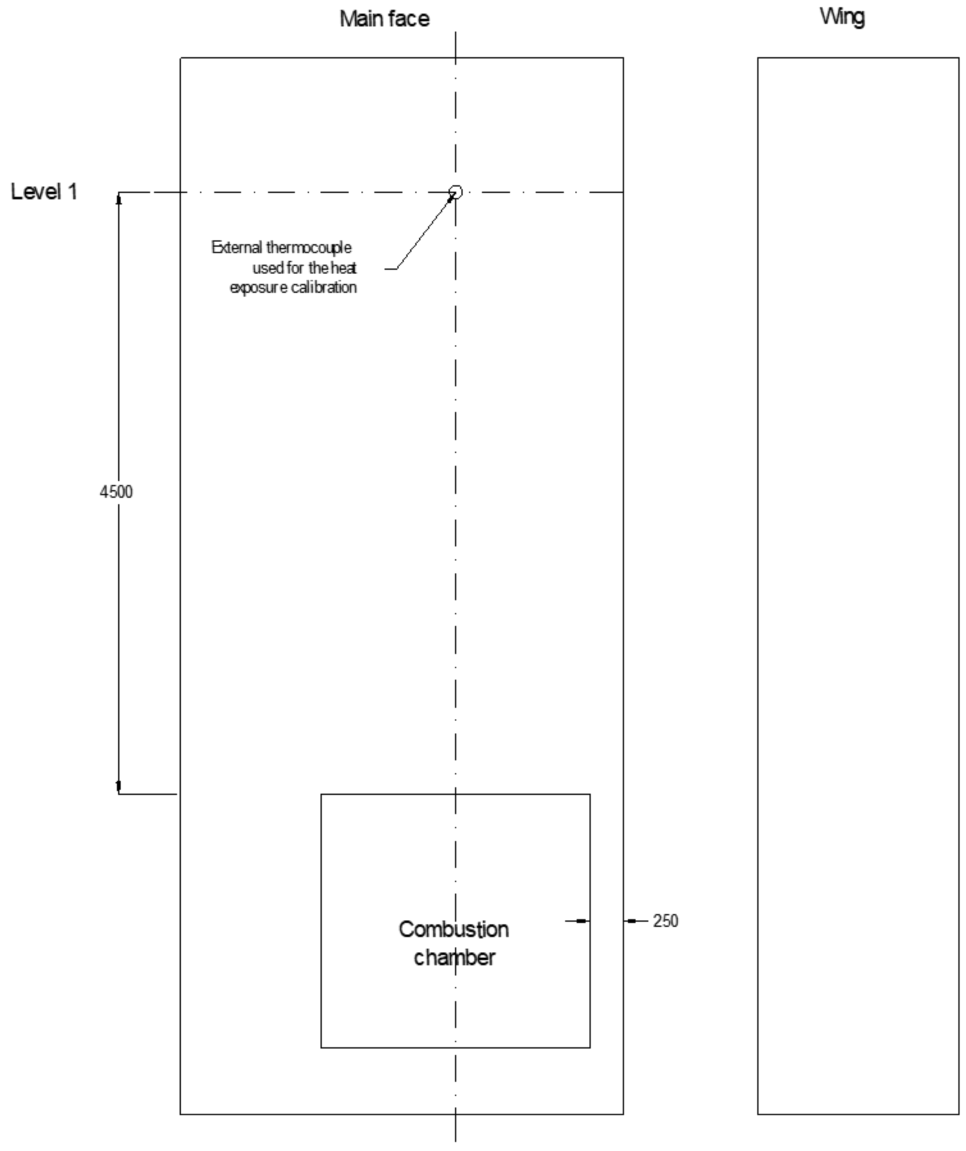
ANNEX A CALIBRATION OF THE HEAT EXPOSURE (INFORMATIVE)

A test bench calibration record shall be maintained before putting the test bench into operation and the test bench shall be recalibrated after completion of any repair that could alter the flame distribution, air supply conditions and any other parameters impacting the heat exposure and at least after three years.

The following procedure shall be followed.

1. Prepare the test rig in compliance with this assessment method, with a supporting construction according to Section 4.4. No façade / specimen shall be erected. The inner corner shall be 250 mm away from the combustion chamber opening.

2. Place one external sheathed thermocouple (as in Section 4.7.1) at level 1 (4500 mm above the top of the combustion chamber), centered at mid-width of the combustion chamber opening. This thermocouple shall be placed with its hot junction positioned 50 ± 5 mm in front of the supporting construction.



3. Prepare the combustion chamber, the fuel source, and perform a test following the test procedure in compliance with this assessment method. For the purpose of this calibration test, the elapsed test time shall be measured from the ignition of the crib. Record the environmental conditions during the test.

4. For this only external thermocouple:

   a. compute the temperature development over time, starting with the ignition of the crib,

   b. compute the average of the temperature development computed in the previous step, i.e. step 4. a., over a 15 minutes period, using a centered first order scheme,

   c. only retain the maximum value of the averages computed in the previous step, i.e. step 4. b.

The two following conditions shall be met to validate the heat exposure calibration:

1. the maximum average temperature increase computed in the previous step, i.e. step 4. c., shall be within the range 380...550 K during the first 30 minutes of the calibration test, AND

2. the maximum average temperature increase computed in the previous step, i.e. step 4. c., shall be reached before the test time 30 minutes.

A calibration report shall be issued, including the analyzes above.

ANNEX B MOUNTING OF TEST SPECIMEN AT OPENINGS (NORMATIVE)

This annex explains how the detailing around openings shall be implemented, namely the combustion chamber opening and the secondary opening.
Different standard configurations are identified below, based on how framed features (like windows or ventilation grid) are mounted in practice. For each standard configuration, when relevant, two testing options are proposed: mounting without any frame or mounting with a frame. When testing without frame, not only the frame should be removed, but also any detailing that implicitly accompanies the frame, i.e., whose presence results from the presence of the frame (e.g., fixings, caulking, sealants, edging profiles…). When testing with a frame, the frame and all its accompanying detailing used to protect the edge of the façade system shall be the same than the one used in practice.

When the practical façade system doesn't correspond to any of the standard configuration below, it shall be tested in the real configuration in which it is intended to be used and shall include the frame used in practice.

When the test setup includes a frame, whether in standard or real configuration, the feature which is normally present in the frame (like glazing or grid) shall not be installed.

> *Note: The figures below illustrate the configurations for secondary opening, which include a backing board classified A1 according to EN 13501-1 (See Section 6.8 and Figure 8b.). The figures also apply for combustion chamber opening except that no backing board shall be placed.*

Case 1

Building practice

- The feature is mounted within the wall on which the façade system is applied and doesn't flush with the wall on the outside of the building (See Figure B1.), AND
- the façade system extends inside the opening, AND
- the frame is used to protect the edge of the façade system.

Test setup

In this case the test specimen is mounted on a supporting construction (see Section 6.6). The façade system shall extend a minimum of 25 mm into the opening. A frame can be used or not. In the case where no frame is used, there shall be a distance of at least 25 mm from the façade system to the backing board.

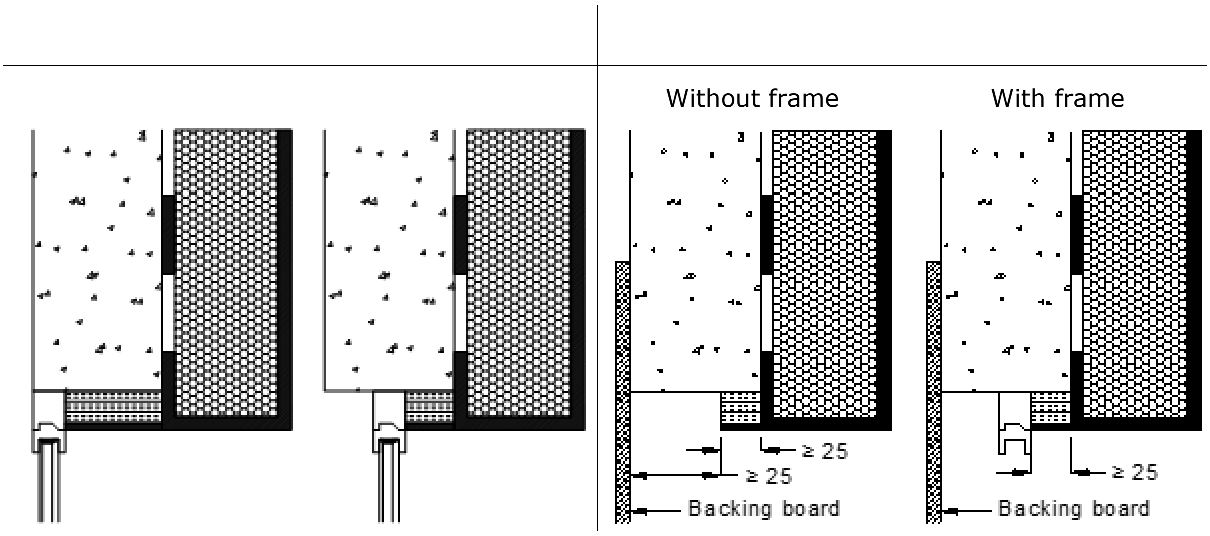


Figure B1. Case 1

Case 2

Building practice

- The feature is mounted within the wall on which the façade system is applied and doesn’t flush with the wall on the outside of the building (See Figure B2.), AND
- the façade system extends inside the opening, AND
- the frame is not used to protect the edge of the façade system.

Test setup

In this case the test specimen is mounted on a supporting construction (see Section 6.6). No frame is used. The façade system shall extend a minimum of 25 mm into the opening, and there shall be a distance of at least 25 mm from the façade system to the backing board.

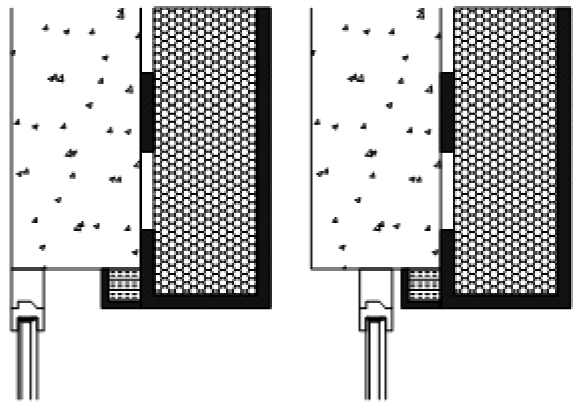
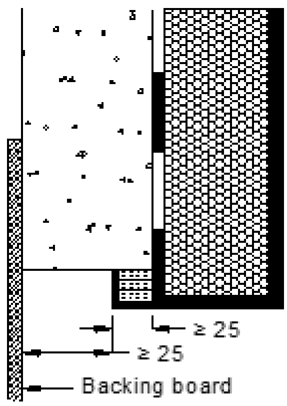
	Without frame	With frame
		NA

Figure B2. Case 2

Case 3

<u>Building practice</u>

- The feature is mounted within the wall on which the façade system is applied and doesn’t flush with the wall on the outside of the building (See Figure B3.), AND
- the façade system does not extend inside the opening (i.e. flush with the wall), and consequently the frame is not used to protect the edge of the façade system.

<u>Test setup</u>

In this case the test specimen is mounted on a supporting construction (see Section 6.6). No frame is used.

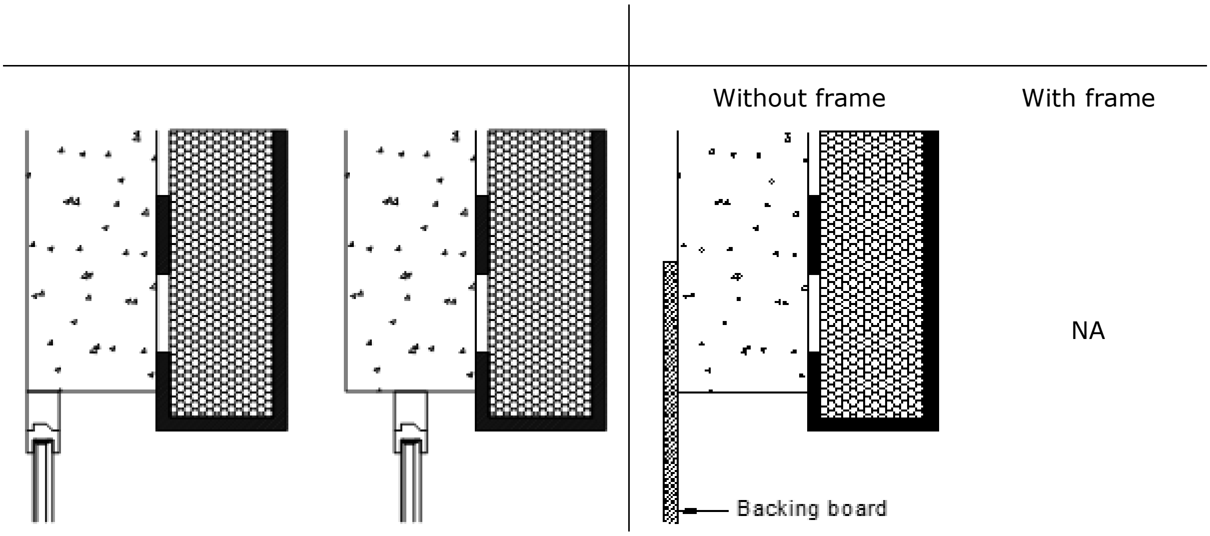


Figure B3. Case 3

Case 4

Building practice

- The feature is mounted flush with the wall on the outside of the building (See Figure B4.), AND
- the façade system does not extend inside the opening (i.e. flush with the wall), AND
- the frame is used to protect the edge of the façade system.

Test setup

In this case the test specimen is mounted on a supporting construction (see Section 6.6). A frame can be used or not.

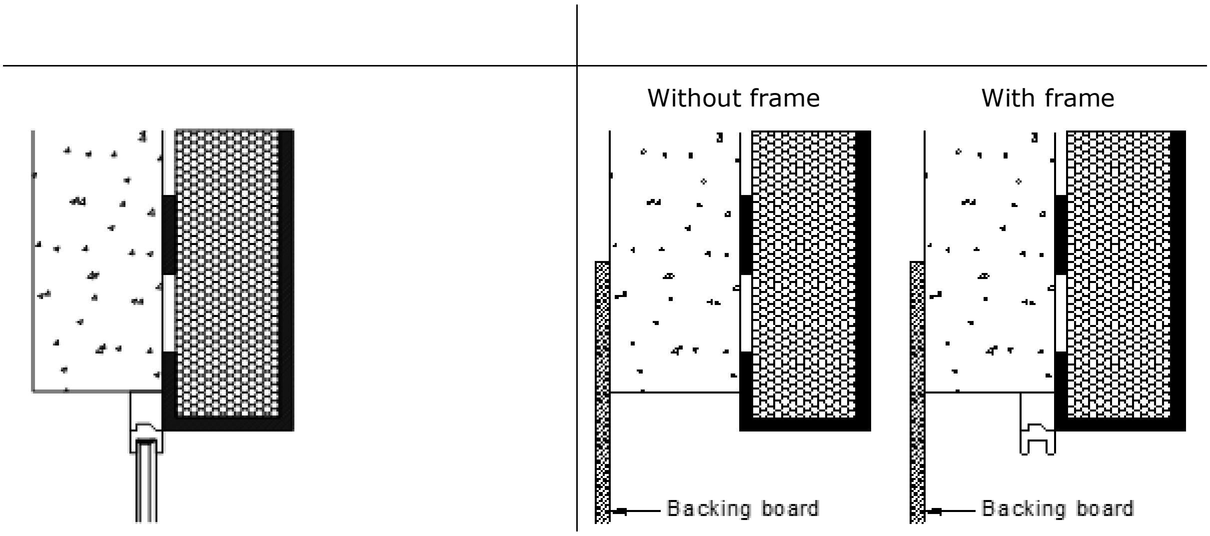


Figure B4. Case 4

Case 5

Building practice
The feature is mounted inside the thickness of the façade system, which presents a protrusion onto which the feature leans (See Figure B5.). Consequently the frame is used to protect the edge of the façade system.

Test setup
In this case the test specimen is generally mounted on a structural frame, and sometimes on a supporting construction (see Section 6.6). A frame can be used or not. In the case where no frame is used, there shall be a distance of at least 25 mm from the façade protrusion to the backing board.

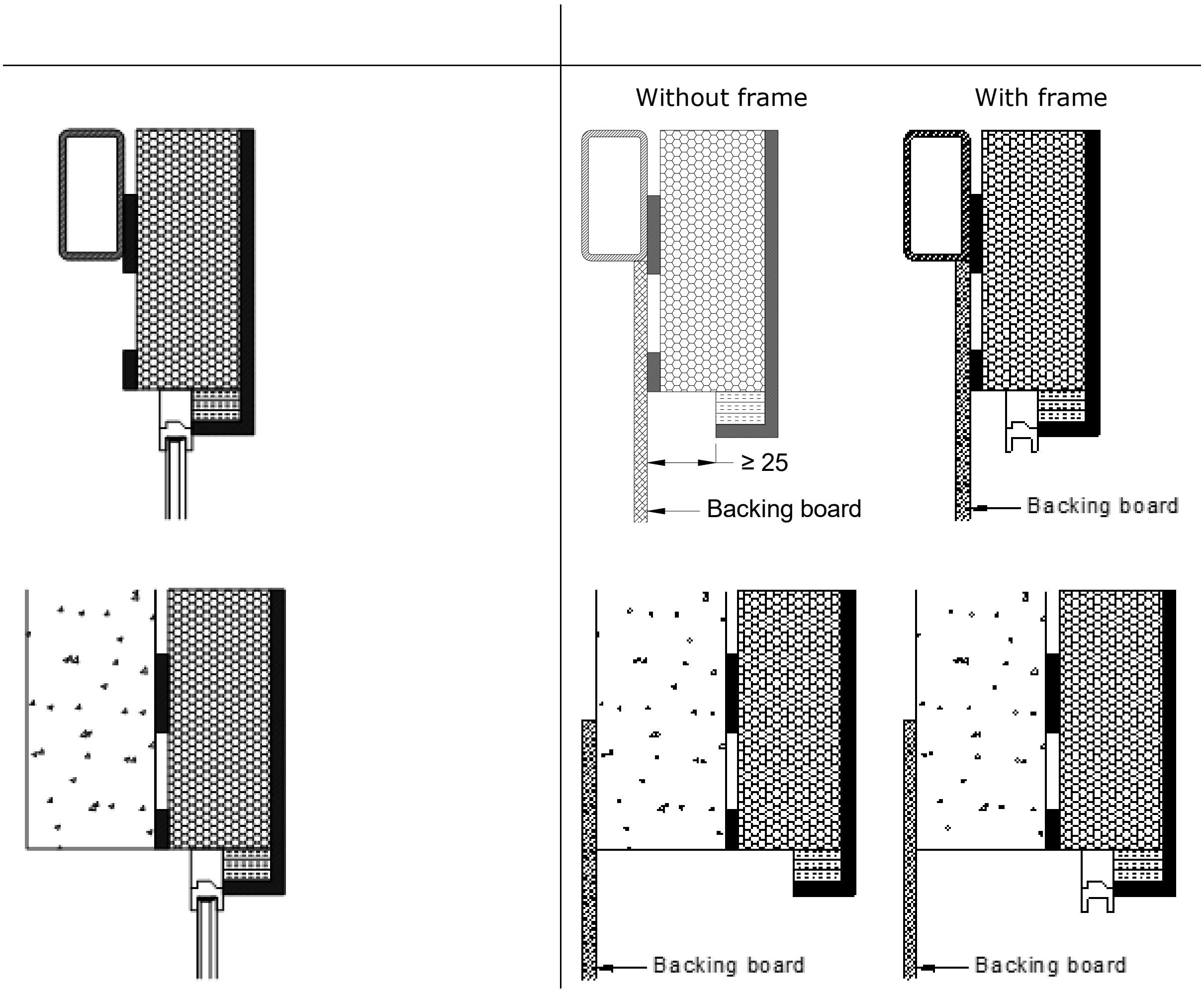


Figure B5. Case 5

Case 6

Building practice
The feature is mounted inside the thickness of the façade system, which doesn't present any protrusion facing the feature (See Figure B6.). Consequently, the frame is used to protect the edge of the façade system.

Test setup
In this case the test specimen is generally mounted on a structural frame, and sometimes on a supporting construction (see Section 6.6).

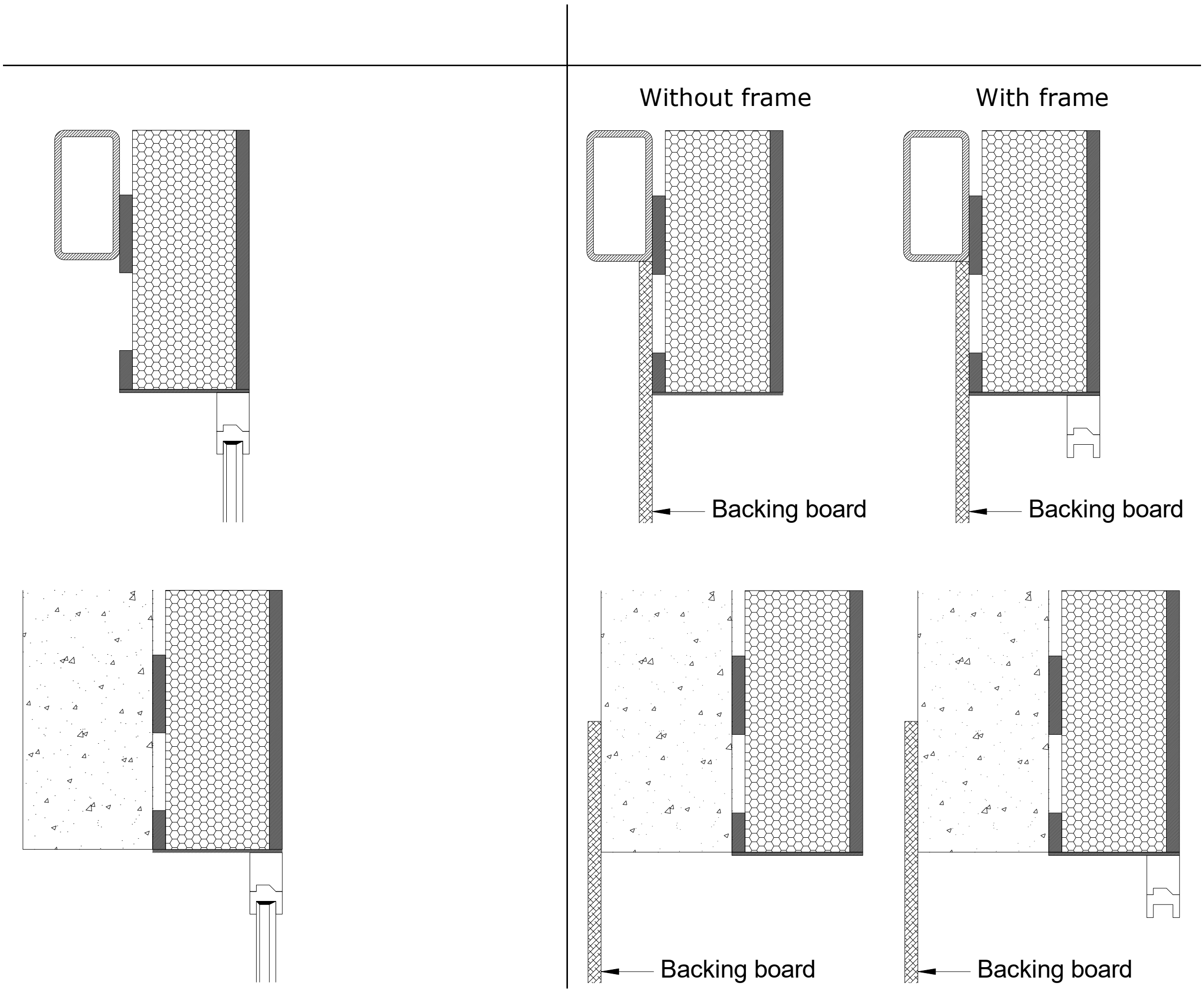


Figure B6. Case 6

ANNEX C FAÇADE-TO-FLOOR JUNCTION (INFORMATIVE)

The assessment of the junction between floor and façade as potential weak point may be required in some cases. It concerns the façade systems installed directly connected to floors of a building.

The objective of this optional test procedure is to ensure that the fire cannot spread from one storey to the next superposed storey through the junction. The way to fulfil this objective is to assess the integrity and the insulation of the junction during the façade test.

The following arrangement shall be implemented to assess this junction during the façade test:

- the roof of the combustion chamber shall be replaced by the representative floor intended to be used in practice (aerated concrete, armoured concrete, timber… including any details like ceilings, seals…) and with the same thickness or smaller (See Figure 14.),

- the tested façade shall be extended down the upper edge of the combustion chamber to allow implementing any junction detail as in practice; anyway, this extension shall not exceed 200 mm (See Figure 14.).

In the neighbouring of the floor, the structural steel frame shall be protected by fire blanket.

Care shall be taken in the possible failure of the junction during the test

Such test configuration allows thus to:

- observe - from behind the test rig - the behaviour of the façade at the junction to check integrity failure,
- add some thermocouples to check any insulation failure.

11. Appendix C – Theoretical Round Robin

The details of the theoretical round robin is presented in REPORT OF THE ROUND-ROBIN NR. TC2 20-1 ON FAÇADES by F. Dumont, L. Boström, J. Anderson and R. Chiva.

12. Appendix D – Laboratory capacities

In the comment handling document, some members of the steering group raised the question of how many laboratories would be able to perform indoor or outdoor façade testing when the assessment method will be released.
To answer this question, the European Group of Organisations for Fire Testing, Inspection and Certification (EGOLF) members have been surveyed. EGOLF has 64 member laboratories for façade testing located in Europe, the 3 non-European ones being in Hong Kong, Israel, and UAE.

12.1.1. Indoor testing on façades

Current situation of the existing facilities

To date, 12 laboratories are equipped with indoor test rig. The façade heights that can be tested ranges from 3 m to 13 m, according to the following frequency distribution:

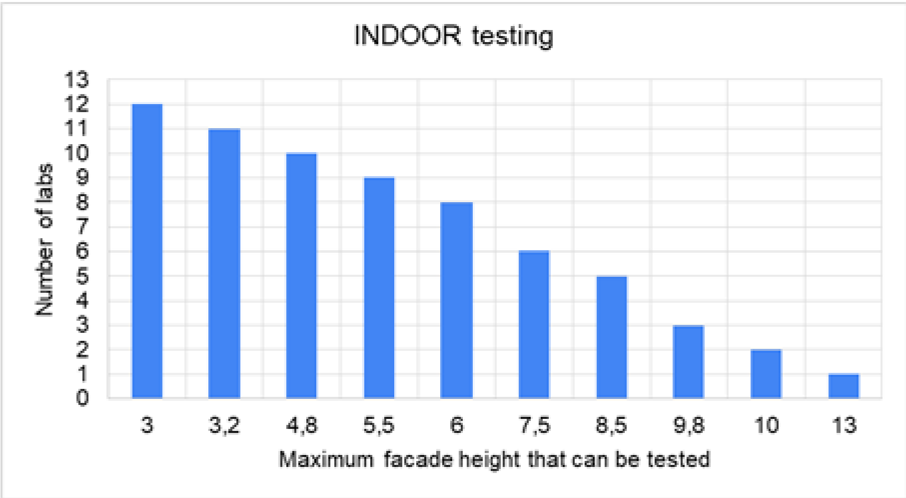


Figure D1. Number of laboratories able to perform tests for different maximum façade heights.

In other words, 12 laboratories are able to test façades up to 3 m high, 6 laboratories are able to test façades up to 7,5 m high, 1 laboratory is able to test façades up to 13 m high.

These 12 laboratories are located in the 11 countries identified in blue on the map below, Figure D2.

Figure D2. Geographical distribution of laboratories able to perform indoor façade testing.

Future intentions

In the case where a new European method would be published in the future (Figure D3.), 19 laboratories would eventually develop facilities to perform indoor tests on façades. Among them, 11 laboratories would plan a maximum testing capacity less than 8 m in height, and 8 laboratories a maximum testing capacity of 8 m in height or more.
These 19 laboratories are located in the 14 countries identified in blue on the map below, as well as in Hong Kong.

Figure D3. Geographical distribution of laboratories with intentions to reach ability of façade testing with at least 8 m height.

12.1.2. Outdoor testing on façades

Current situation of the existing facilities

To date, 7 laboratories are equipped with outdoor test rig. The façade heights that can be tested ranges from 2,4 m to 20 m, according to the following frequency distribution:

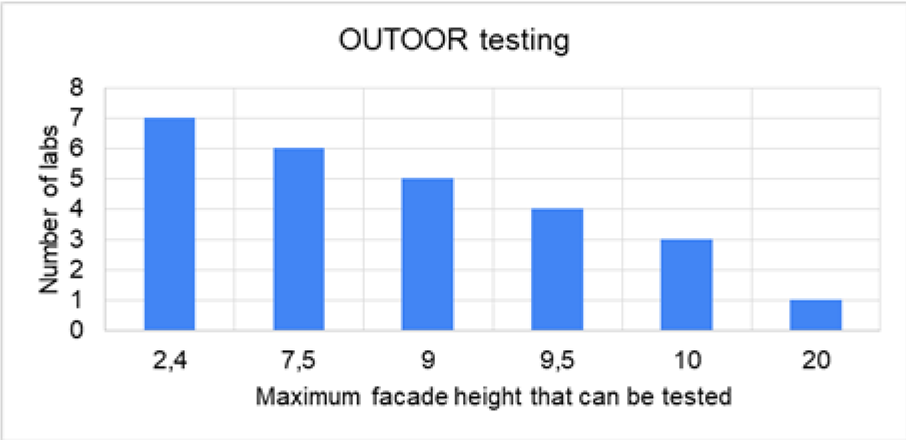


Figure D4. Number of laboratories able to perform outdoor testing.

In other words, 7 laboratories are able to test façades up to 2,4 m high, 5 laboratories are able to test façades up to 9 m high, 1 laboratory is able to test façades up to 20 m high.
These 7 laboratories, see Figure D5, are located in the 6 countries identified in blue on the map below, as well as in Hong Kong.

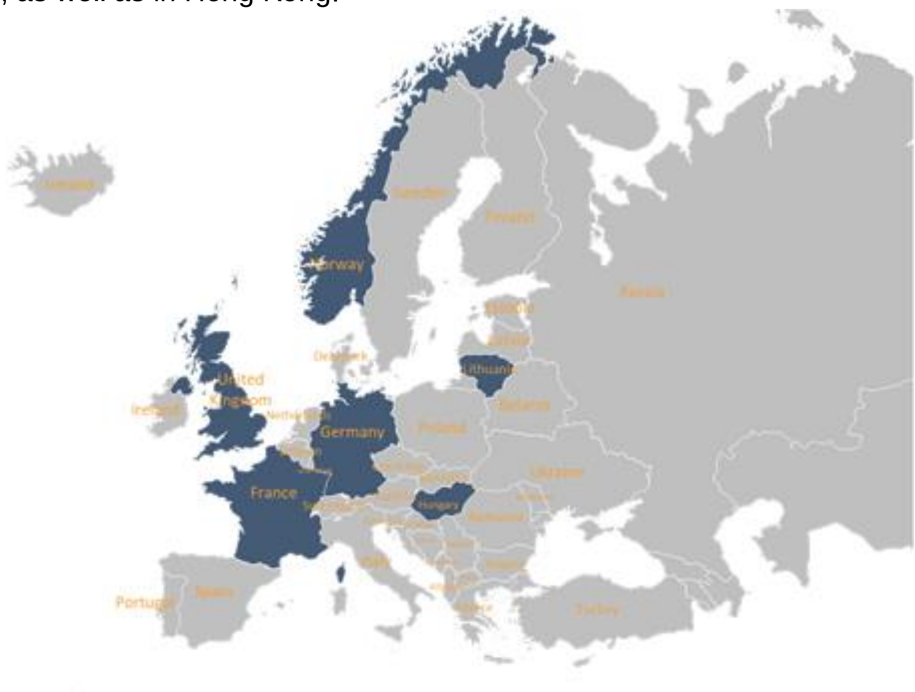


Figure D5. Geographical distribution of laboratories able to perform outdoor testing.

Future intentions

In the case where a new European method would be published in the future, 12 laboratories would eventually develop facilities to perform outdoor tests on façades. Among them, 3 laboratories would plan a maximum testing capacity less than 8 m in height, and 9 laboratories a maximum testing capacity of 8 m in height or more.

These 12 laboratories are located in the 9 countries identified in blue on the map below, Figure D6, as well as in Hong Kong.

Figure D6. Geographical distribution of laboratories with future intentions to perform outdoor façade testing.

13. Appendix E – Falling parts, questionnaire summary

Stakeholders were asked to fill out a questionnaire regarding the future measurement and assessment of falling parts. This questionnaire contained six questions covering a wide range of topics about falling parts as weight, area and burning/non-burning of the parts as well as past experiences with falling parts and requirements. In the analysis of the results from the first questionnaire indicated the need for a second Questionnaire, where more details could be provided. In the second questionnaire the project team got 12 answers from the Stakeholder group about the further development to assess falling parts in the European assessment method. Seven countries sent an answer as well as five associations. Further exploration on the specifics of the falling parts was indicated from the answers and specific discussions. The questionnaire was used to determine the appropriate criteria for falling parts to be used in the Round Robin.

Basis of the questions was the draft proposal in its then current status in Section 11.2 which is given here for completeness:

"11.2 Falling parts
Falling parts include all solid or liquid material falling from the test specimen.
The registered time is the time in completed minutes for which any parts falling from the test specimen do not constitute a risk for the evacuation, the rescue personnel nor the fire brigade, or for fire spread downwards. The failure of the falling parts performance is deemed to have occurred when one of the criteria below has failed.

11.2.1 Mass
The failure of mass criterion occurs when:
- any individual falling part exceeds 1 kg in mass, or
- the cumulated falling parts since the commencement of the test exceeds 20 kg in mass.
The time of failure shall be reported as the time at which the falling part touch the ground; i.e. the falling part shall have completely broken off from the façade, without being still hung somewhere.
The mass criterion is assessed by a load cell platform (still to be described in Annex A).

11.2.2 Sustained flaming
The failure of sustained flaming criterion occurs when any burning material on the ground produces a continuous flaming during a period of time greater than 10 s.
The time of failure shall be reported as the time at the end of this 10 seconds burning period; i.e. when the observation is finally made.
The sustained flaming criterion is assessed by visual observations, possibly supported by video recording."

The Questionnaire contained the following six questions:

Table E1.
Questions and answers about falling parts

Question 1
What should be the levels to be used in the method? • Any individual falling part exceeds 1 kg in mass. Should this be 1kg or 3kg? • The failure of sustained flaming criterion occurs when any burning material on the ground produces a continuous flaming during a period of time greater than 10 s or 30 s?
Answers:

For the first questions about the weight of falling parts that should be assessed, half of the answers stated that they think that no quantitative criteria are possible because of lack of research at present time. The other half of the answers was divided between 1 and 5 kg and most of the answers recognised the need of several steps, i.e. 1 and 5 kg.
Several answers regarded the total weight of the falling parts as necessary to assess as it would give an indication of the mechanical stability of the façade.
Note: the weight of the falling part is assessed if the part is not burning.

If the part is assessed as burning falling part the test is failed.
With regard to the note it was important to clarify when a part is considered as burning part. On the one hand, a tiny part could probably be ignored even if sustained flaming occurs. On the other hand a bigger part only burning for a very short time wouldn't need to be counted as burning probably as well. Regarding this topic the Questionnaire asked for recommendations about the time after which a part is considered as burning, the result was that most answers recommended 30 s as sufficient time for sustained flaming of a falling part.

Two countries recommend assessing the area of falling parts as well, Austria and Sweden as they currently have regulations for the maximum allowed areas of falling parts: 0,4 m² (Austria) and 0,1 m² (Sweden). This has to be discussed further after the Round Robin exercise.

Question 2

If scientific evidence is present suggesting other limits or the possibility of easy assessment of the size, different masses or methods to assess falling parts can be provided. Furthermore, if by providing good evidence for a different position regarding the number of classes a different classification system for falling debris may be suggested.

Answers:
For the 2. Question answers as they were received from the stakeholders are given below as they show a wide range of approaches and answers didn't form a uniform picture.

Answer1: There are no regulatory requirements in Germany regarding the limitation of the mass of non-burning falling parts of external wall cladding. However, es explained to no. 1.), a possible limit could be “lower or equal to 5 kg for any individual falling part”.
On the other side, there is an expectation (especially from German fire brigades) that mechanical collapsing of a tested façade is limited to that area of the façade being directly exposed by the flames of the primary fire source (cf. answer to question no. 3b). But the assessment of the size of this area is always a case-by-case evaluation. No specific criteria can be given for that.

Answer 2: The time of given “part falling off”. In general, in case of fire, after the time required for the rescue teams to arrive (secure the area, navigate the evacuation), the threat is relatively less serious. The 5 kg criteria make sense because it is connected to how fire fighter helmet is designed and how it is tested for impact of falling part.

Answer 3: The area of single “part falling off”. Falling parts of relatively small masses may fly tens of meters away from façade when they area is big enough. We propose 0,25 m2 as a limit.

Answer 4: A proposal could be to calculate the energy of the impact (force) of the falling parts when touching the cell platform as this could provide additional information, like for example the height of the falling parts.

Question 3

In case the regulations or standards contain clauses related to falling parts or debris resulting from buildings on fire, could you please provide a detailed description of the motivation (why) to have such clauses?

1. Could you please provide details as to from which time during the fire development and until which time these clauses apply?
2. In the case there are specific restrictions as regards weight or sizes, could you provide the background of (and possibly even the research behind) these criteria?
3. In the case there are specific restrictions as regards melted and/or flaming parts and droplets, could you provide the background of (and possibly even the research behind) these criteria?
4. In the case there are specific criteria as regards the (non) tolerated distance or area from the façade, could you provide the background of (and possibly even the research behind) these criteria?

5. In the case this is considered relevant by you, and not yet provided in the answers above, could you indicate if and how the importance or relevance of the criteria are ranked?

If scientific evidence is present suggesting other limits or the possibility of easy assessment of the size, different masses or methods to assess falling parts can be provided. Furthermore, if by providing good evidence for a different position regarding the number of classes a different classification system for falling debris may be suggested.

For Question 3. Answers as they were received from the stakeholders are given below as they show a wide range of approaches and answers didn't form a uniform picture.
a.
Answer 1: Safety objective of the national test method is to consider the second floor above the floor where the fire occurs primarily. The time scale is based on the experimental results (Kothoff at all, MATEC Web of Conferences 9, 02010 (2013, DOI: 10.1051/matecconf/20130902010) which can be summarized such, that the vertical fire spread from floor to floor takes place every 10 to 15 minutes, even in a fully non-combustible façade-environment.
Falling parts are therefore detected during the entire test duration of 30 min.

Answer 2: From flashover through a window until the fire load in the test is finished. In a real fire about the same time evacuation is possible and until the fire brigade can apply water from the outside, about the first 30 minutes of the fire.

Answer 3: Large enough to allow some minor parts of rendering etc. to fall off due to spalling, but not as big as they become a major threat to people's safety.

b.
Answer 1: No specific regulation on façades and burning droplets, but some general rules apply to the entire building. The background for these are from the principals in the ID II document and the annex to CPR/CPD "The generation and spread of fire and smoke within the works are limited". This is the same basis as the burning droplets in the Euroclass system and SBI method.

c.
Answer 1: Regulations are never ranked against each over. All relevant rules must be fulfilled in order to follow the entire building code.

Answer 2: In the Netherlands Euroclass B (and in the future some A2) without droplets subclass

d.
Answer 1: These parts are not allowed according to the Austrian test standard in order to avoid a possible fire propagation caused by the flaming parts onto combustible substances on the floor area (such as bushes, …).
e.
Answer 1: In Polish national regulations we have the following requirement: Elements of façade claddings should be fixed to the building in a manner preventing their falling out during a fire in a time shorter than resulting from the required fire resistance rating for an external wall, (…) correspondingly to the fire resistance rating of the building to which they are mounted.
This provision, in unchanged form, is existing in Poland since 2002.
We believe the existence of "falling parts" criteria is necessary to have a practical tool to check if the basic provisions for buildings (CPR 305/2011: ANNEX I / BASIC REQUIREMENTS FOR CONSTRUCTION WORKS / 2. Safety in case of fire /façade the spread of fire to neighbouring construction works is limited; (d) occupants can leave the construction works or be rescued by other means and the safety of rescue teams is taken into consideration.) are met.

Answer 2: There is a demand in Finland's fire regulations (848/2017), that falling of large parts of façade wall must be prevented in case of fire.

Answer 3: From our point of view, only the large-scale failure and falling off of the façade must be reliably prevented. This can be derived very well from qualitative statements and images in the test report.

Conclusions below were drawn from the specific answer above for 2. and 3. questions:

Several countries acknowledge the danger from falling parts to people, fire fighters and that they can cause spread of fire.

It is agreed that spread of fire should not be allowed.
Total instability of the façade is acknowledged as a problem that needs prevention as well.
Several countries have regulations to prevent falling parts that can harm people.

Note: Measurement of area of falling parts is seen as a challenge by the project team as parts can break when they fell and are generally not easy to be assessed during the test. This is even more complicated for the recommended measuring of impact of the falling part. It is not clear how that could be practicably done.

Question 4

Are there any specific fire incidents that have led to the adoption of such clauses? If so, could you please provide some details and references to these events?

Answer 1: Balconies and loggias can favour the action of rescuing people, L or T-shaped buildings increase the risk of fire propagation.
Although very limited number of events were mentioned, several countries acknowledge that falling parts are included in their building regulations, often qualitative.

Question 5

Falling parts and debris may also result from other than fire incidents (e.g. gas-explosion, wind gusts, deterioration of fixings, accidental damage due to cleaning, etc.), in which case occupants and by-passers are likely to be even less-prepared. In how far should fire regulations and standards be more or less strict compared to other incidents?

Most countries think the safety level should be the same in fire and other incidents regarding falling parts.

Question 6

Besides fire testing on and classification or certification of façade assemblies and products, there are potentially also other ways to mitigate the risk of falling parts and debris as a result of a building fire. E.g. rules of engagement and protection equipment of the fire brigade and covered in- and/or egress paths of occupants. In how far is your regulation allowing for such approaches?

Several countries answer that mitigation of risk through other measures may be allowed under certain circumstances, several mention that the regulation of building safety should not regulate how a possible fire fighters intervention have to be designed.

14. Appendix F – Results from wood crib tests

In this appendix the details of the wood crib tests are presented. In Tables F1 and F2 are the variations in the wood crib displayed.

Table F1.

Test programme for large wood crib tests.

Reference	Species	Surface	Density	Moisture	Section	Floor	Chamber
L0	Pine	Sawn	Average	Average	50x50	Grated	Large
L1	Spruce	Planed	Average	Average	47x47	Solid	Large
L2	Spruce	Planed	Low	Average	47x47	Grated	Large
L3	Spruce	Planed	High	Average	47x47	Grated	Large
L4	Pine	Planed	Average	Average	47x47	Grated	Large
L5	Spruce	Planed	Low	Low	47x47	Grated	Large
L6	Spruce	Planed	Low	High	47x47	Grated	Large
L7	Spruce	Planed	Low	Average	47x47	Solid	Large
L8	Pine	Sawn	Average	Average	50x50	Solid	Standard

For all tests, stick sizes averages at 1504 mm and 1034 for long and short sticks, respectively.

Table F2.

Test programme for medium wood crib tests.

Reference	Species	Surface	Density	Moisture	Section	Floor	Chamber
M0	Spruce	Sawn	Low	Average	47x47	Grated	Standard
M1	Spruce	Planed	High	Average	47x47	Grated	Standard
M2	Spruce	Planed	Low	Average	47x47	Grated	Standard
M3	Spruce	Sawn	Low	Average	47x47	Grated	Standard

14.1. Effect of wood species

Two different wood species have been examined, spruce (Picea abies) and pine (Pinus sylvestris). The aim was to evaluate the differences in burning characteristics between the two wood species when used in façade tests, and also to see whether it is possible to harmonize the medium and large heat exposure tests and use the same wood species for both.

14.2. Heat Release Rate comparison

The comparison has only been done with the large wood cribs, i.e., the large heat exposure set-up. Three tests were performed with pine and six tests with spruce that show results when the crib is placed on a solid floor in the combustion chamber see Figure F1 when the crib is placed on a grated floor. The results show that pine gives both higher Heat Release Rate (HRR) and higher heat exposure on the façade surface compared to wood cribs of spruce, while also leading to an earlier collapsing of the crib associated with a premature decrease phase of the combustion. In BS 8414 pine is defined as the main wood species to be used.

Although, in earlier versions of BS 8414 it was also defined that alternative fire sources could be used when it could be shown that certain characteristics were fulfilled.

It is proposed to use spruce as a fuel source even though it is less severe compared to pine. The reasons for this choice are that the heat exposure will be high enough (c.f. BS 8414 criterion of HRR = 3 ± 0.5 MW, obtained for spruce but exceeded by pine) and it harmonizes the fuel to be used in both medium and large heat exposure tests.

Furthermore, BS 8414 states that the total heat release during the test, i.e., for 30 minutes, shall be 5 GJ. This is obtained with spruce while pine shows values of 6 GJ and higher.

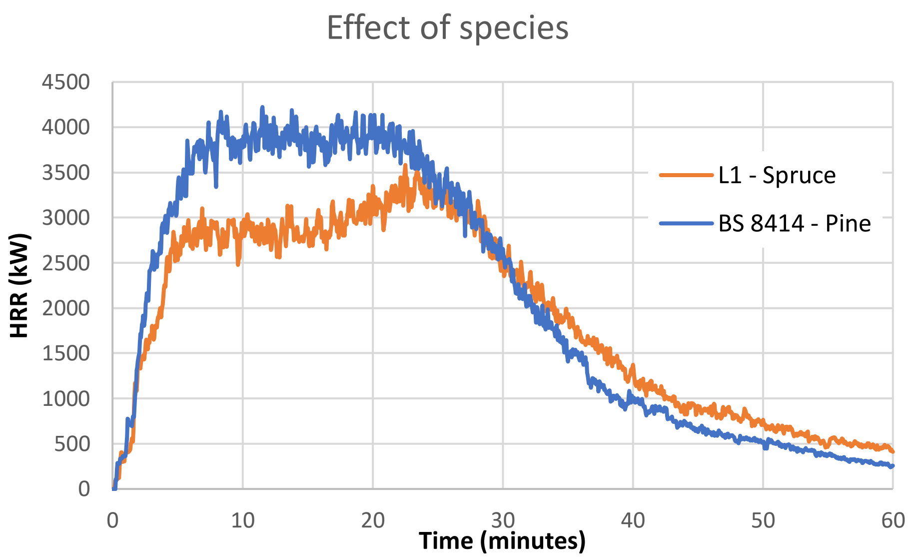


Figure F1. Heat release rate measured in test L1 and extra test with BS 8414. Both with crib placed on a solid floor, and with similar density of the wood.

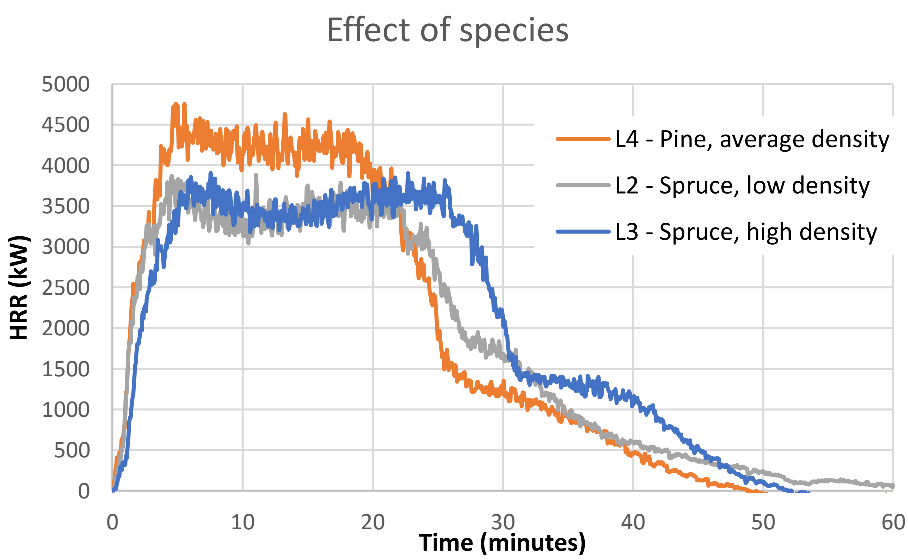


Figure F2. Heat release rate measured in tests L2, L3 and L4. Test L4 was pine with average density, L2 was spruce with low density and L3 was spruce with high density.

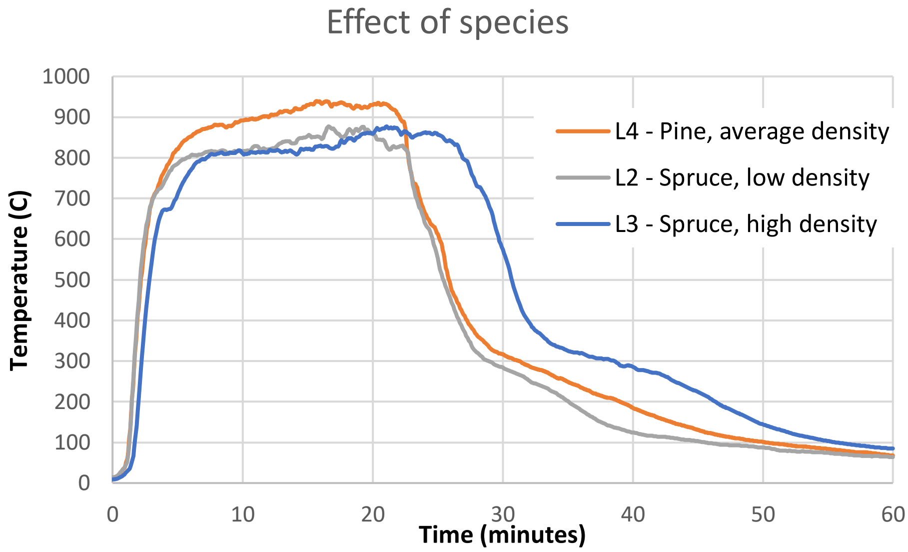


Figure F3. Temperature measured with plate thermometer 1 m above the upper edge of the combustion chamber in tests L2, L3 and L4. Test L4 was pine with average density, L2 was spruce with low density and L3 was spruce with high density.

HRR and MLR: comparison and accuracy

Considering HRR (Heat Release Rate) and MLR (Mass loss rate) and giving an arbitrary coefficient for the HoC (Heat of combustion) to pine (e.g 17.9 kJ/g) and to spruce (16.4 kJ/g). We can plot and compare ratios corresponding to efficiency of combustion which can be calculated as:

$$Eff = HRR/ (MLR*HoC)$$

We obtain the following results:

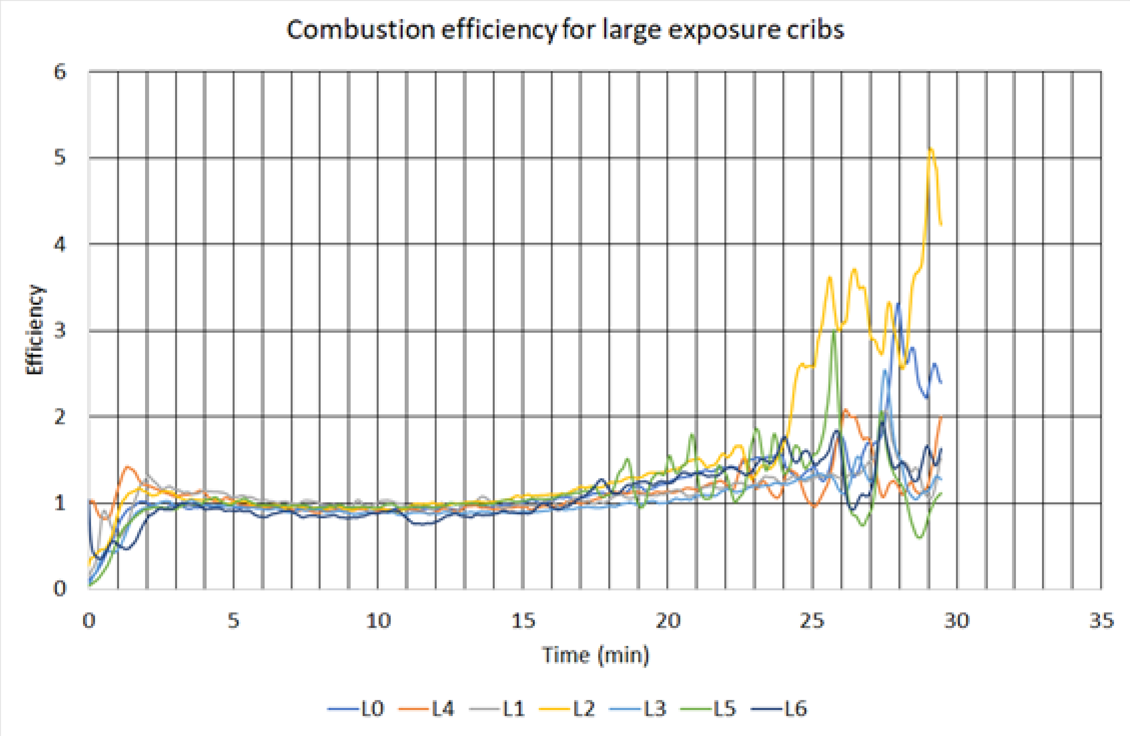


Figure F4. Comparison of efficiencies for large cribs

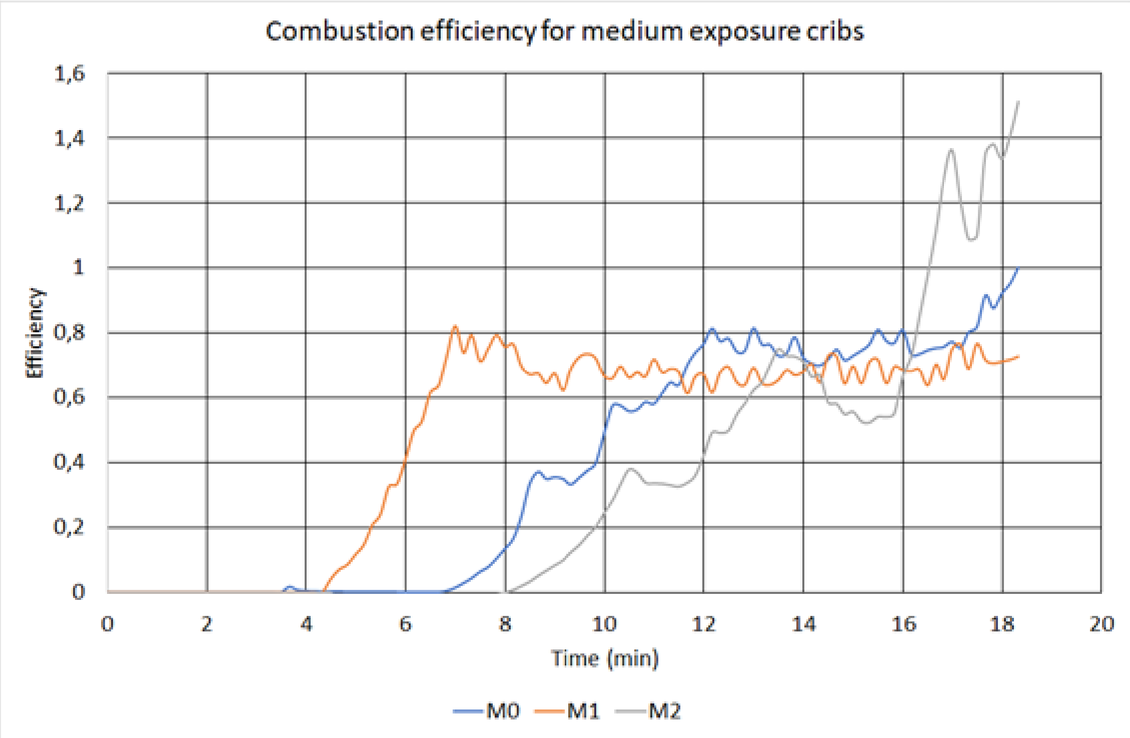


Figure F5. Comparison of efficiencies for medium exposure cribs

These graphs show a good correlation between the MLR and the HRR during the plateau phase. The difference of efficiency between the large exposure and medium exposure is explained by the ventilation conditions which are clearly more favourable for the large cribs.

Regarding the HRR values and MLR values, considering the different accuracy of each measurement involved in their calculation, an accuracy about 10 % for each can be considered.
Furthermore, before each medium crib test was performed a calibration of the HRR measurement is performed by a propane burner.
After the large crib test serie was performed two calibrations of the HRR by heptan pool fire pans was done:

- Test A: Fuel tray overall dimension: 700 mm diameter, 200 mm high / Heat Release Rate expected from the Alpert – Heskestad equations: 931 KW

Figure F6. View of the hood calibration with one heptane pan

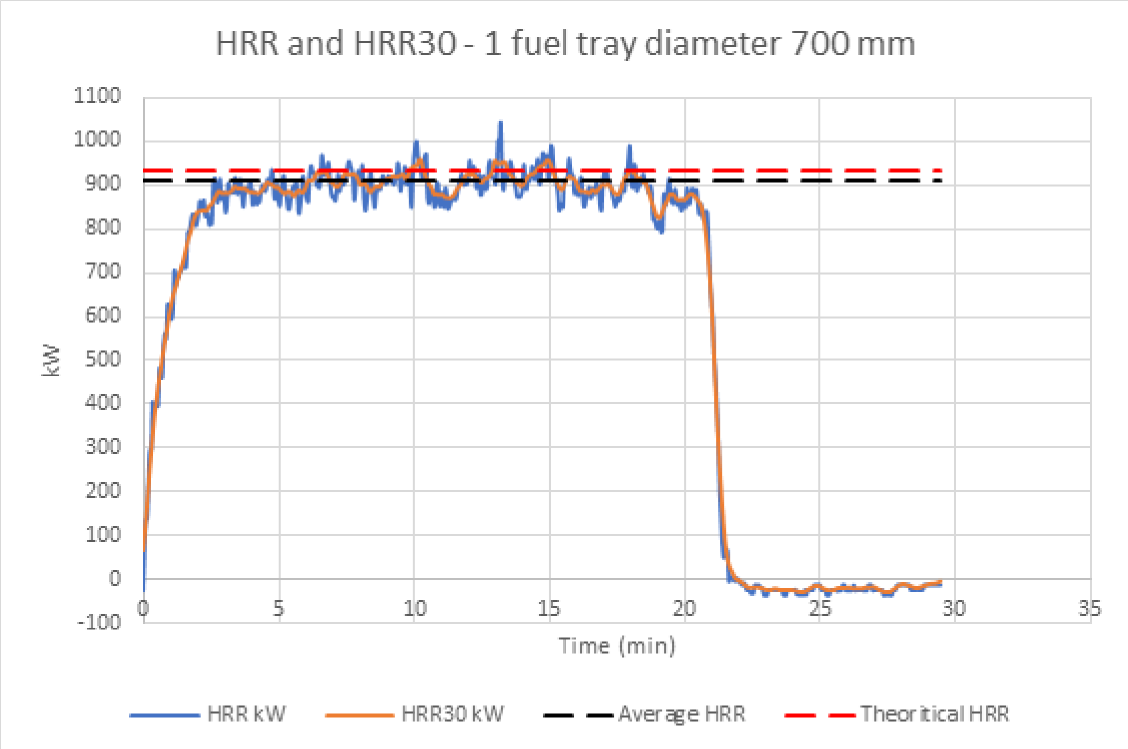


Figure F7. Comparison between measured and theoretical HRR.

Test B: 3 Fuel tray overall dimension: 700 mm diameter, 200 mm high / Heat Release Rate expected from the Alpert – Heskestad equations: 2 793 KW

Figure F8. View of the hood calibration with 3 heptane pans

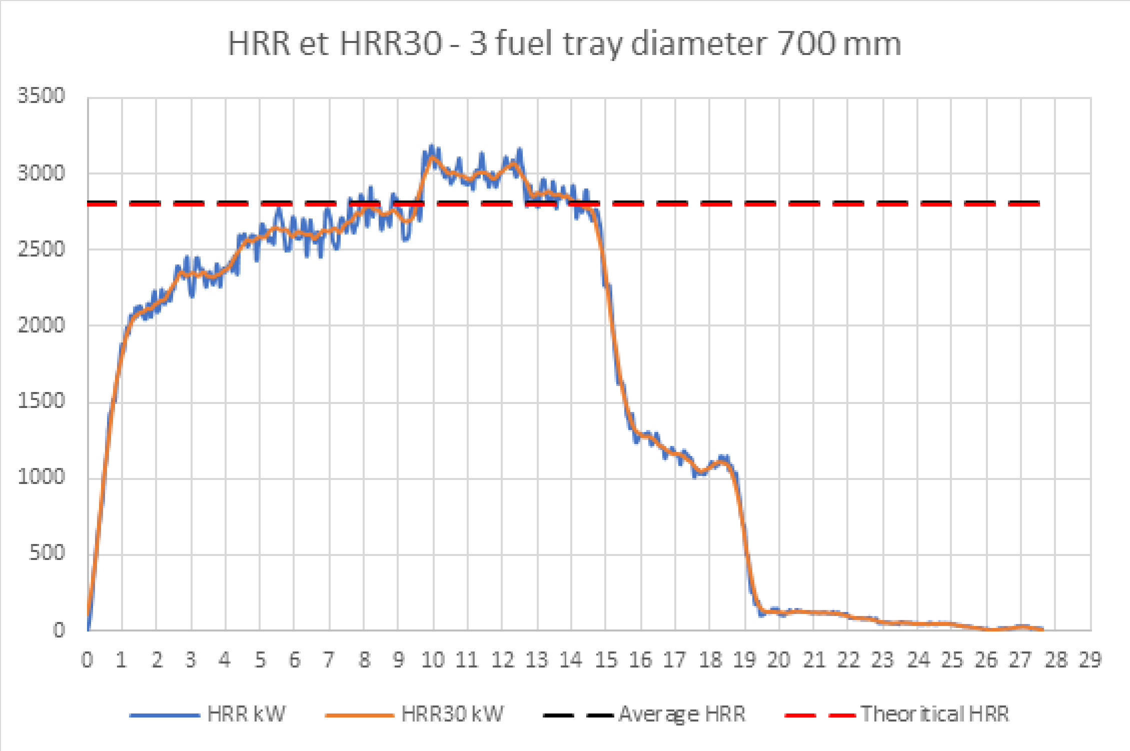


Figure F9. Comparison between measured and theoretical HRR

14.3. Heat flux estimations

In a previous version of BS 8414 (2005), a section was included with information on heat flux 1 m above the upper edge of the combustion chamber when alternative fuels were to be used. Heat flux to Gardon gauges 1 m above the upper edge of the opening in the combustion chamber should be between 45 and 90 kW/m^2 for a duration of 20 minutes. Also, this requirement is fulfilled with spruce, and the pine cribs show heat flux above the tolerances.

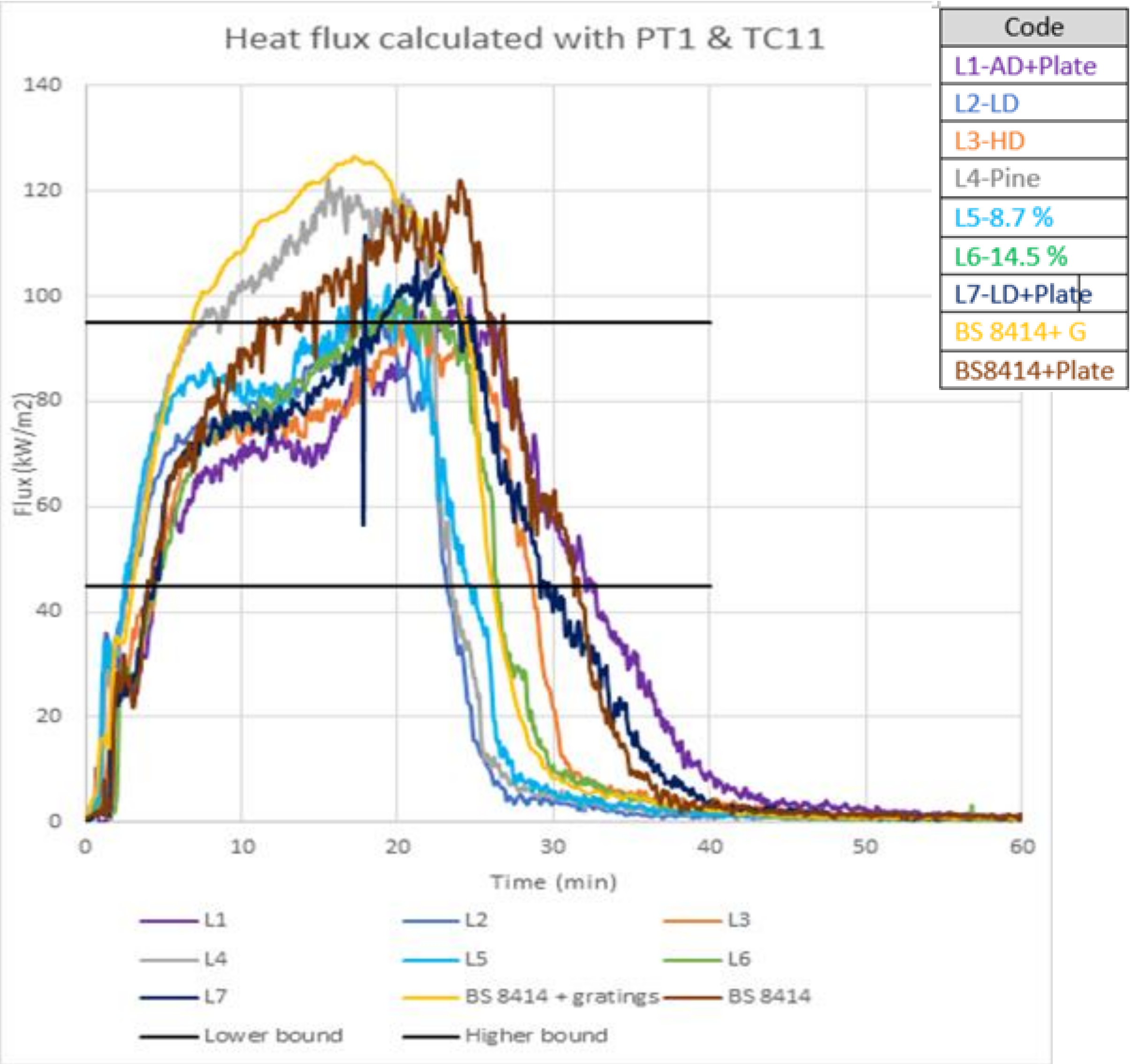


Figure F10: Heat fluxes calculated with temperatures measured by plate thermometer and thermocouples measuring the gas temperatures located 1 m above the upper edge of the combustion chamber and compared together and with the heat fluxes information specified in BS 8414-1:2005

14.4. Effect of moisture content

The tests show that moisture content has an effect on the dynamics of the fire, see Figure F11. Increased moisture delays the onset of the HRR and temperature increase with a subsequently prolonged plateau. The results also indicate a marginally lower heat release rate for the crib with high moisture content. It is therefore proposed to have a good control of the moisture content of the wood to be used in the test. A conditioning of the timber in 23 °C and RH 50 % is proposed to reach a moisture content of 11 ± 2 % (weight of water / weight of the dried wood).

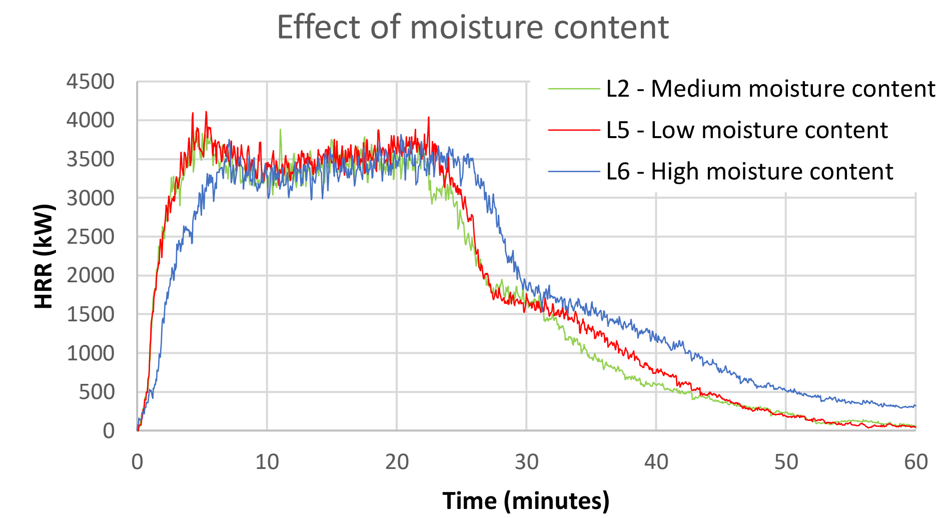


Figure F11. Heat release rate measured with cribs L2, L5 and L6. The average moisture content of cribs L2, L5 and L6 was 10.0, 8.7 and 14.5 %, respectively.

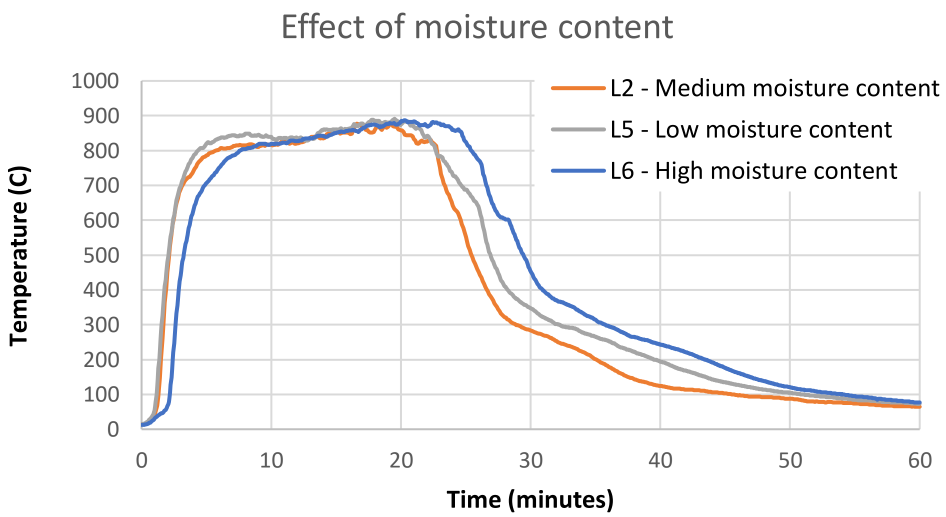


Figure F12. Temperatures measured with plate thermometer placed 1 m above the upper edge of the combustion chamber. The average moisture content of cribs L2, L5 and L6 was 10.0, 8.7 and 14.5 %, respectively.

14.5. Effect of density and specific surface of the crib

The density and specific surface of the wood crib has a significant effect on the burning characteristics.

Tests with identical mass of the crib but different density of the wood showed that the HRR and temperatures are lower when using wood with higher density, see Figures F13 an F14 It is not possible to say whether the effect is due to the density per se or the fact that the specific surface of the wood crib decreases for higher density. It is proposed to have stricter requirements on the density tolerances for the wood in the crib for medium heat exposure.

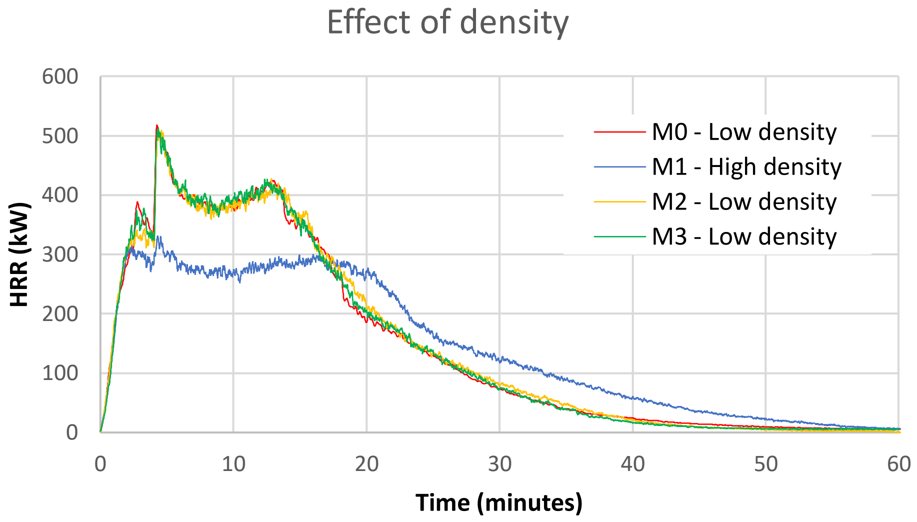


Figure F13. Heat release rate measured with cribs M0 to M3, medium heat exposure. Crib M1 had a high density, while the other cribs had a low density.

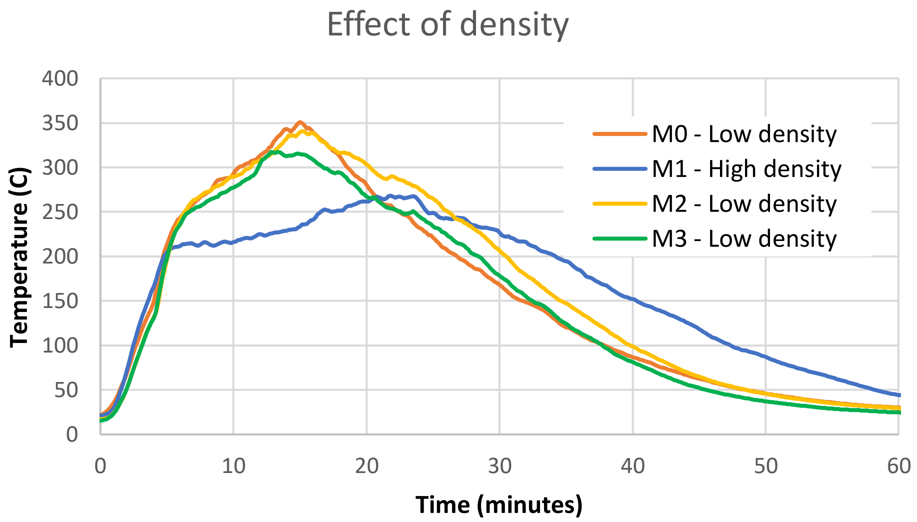


Figure F14. Temperature measured with plate thermometers 1 m above the upper edge of the combustion chamber with cribs M0 to M3, medium heat exposure. Crib M1 had a high density, while the other cribs had a low density.

In the tests made with the large heat exposure, the effect of the density was not so pronounced. Although, it is shown that with a higher density a similar effect is found as for wood with high moisture content, see Figures F11 and F12. The gradients of HRR and temperatures are lower in the beginning of the test, and the fire has a longer duration. A possible solution is to employ a differentiated start time, as is used at present in BS 8414, and accept wider tolerances on the density. The reason for this proposal is that the amount of wood needed in the large heat exposure test is much larger, and it would be very laborious and costly to have very strict tolerances on the density.

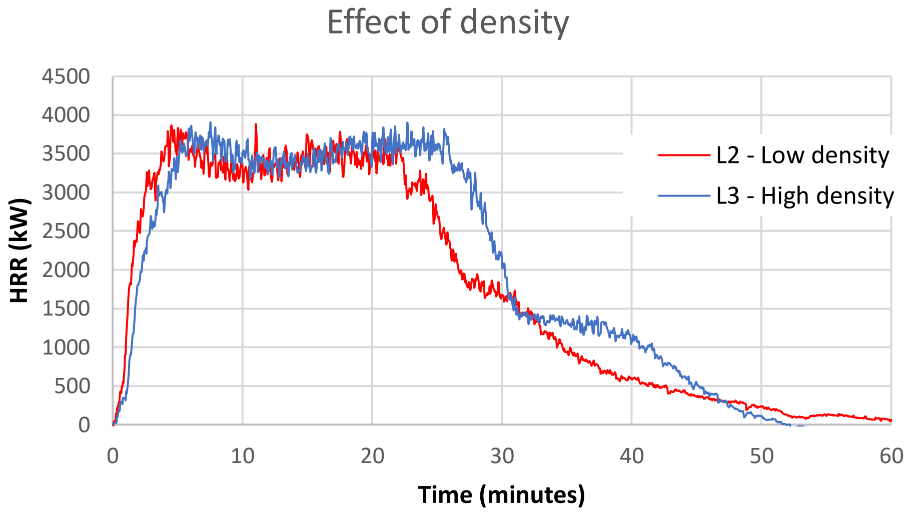


Figure F15. Heat release rate measured with cribs L2 and L3. The average densities of L2 and L3 were 301 and 400 kg/m^3, respectively.

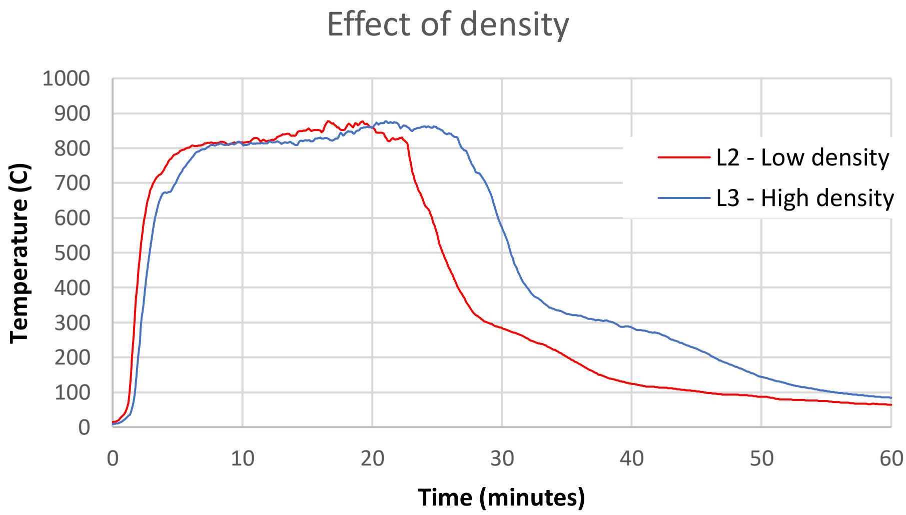


Figure F16. Temperature measured with plate thermometer 1 m above the upper edge of the combustion chamber. The average densities of L2 and L3 were 301 and 400 kg/m^3, respectively.

It is further proposed to have a defined weight of the crib, as it presently is defined in DIN 4102-20. This is different for the large crib where BS 8414 defines the number of sticks to be used. Defining the weight of the crib will ensure that the same amount of fuel is used.

14.6. Effect of surface finish

Planed and sawn surfaces were examined, both with the medium and large wood cribs. The test results did not show any difference on the measured temperatures and HRR, see Figure F17 and 18 for tests with medium cribs and Figure F19 and F20 for tests with large cribs. It is therefore proposed that both planed and sawn surface can be used in the large wood cribs. However, due to narrower tolerances on the cross-sectional dimensions it was deemed necessary to keep the planed sticks for the medium wood crib.

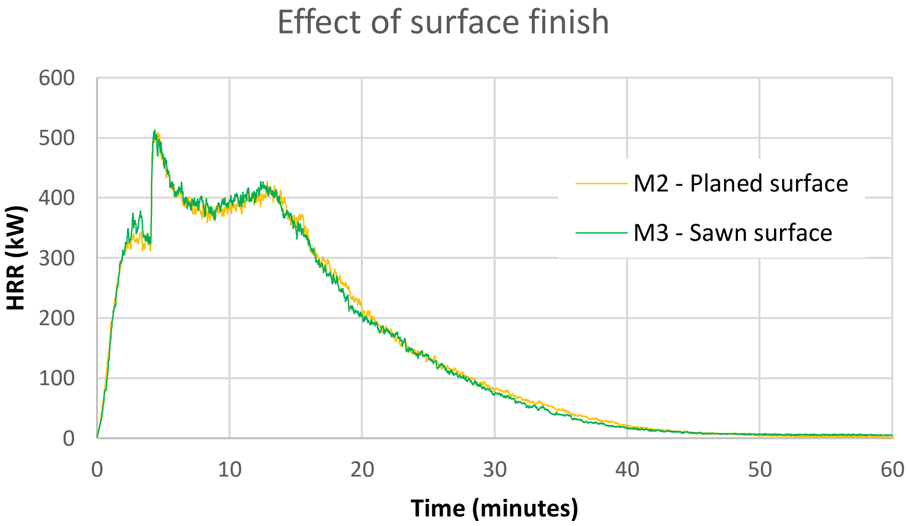


Figure F17. Heat release rate obtained with cribs M2 and M3.

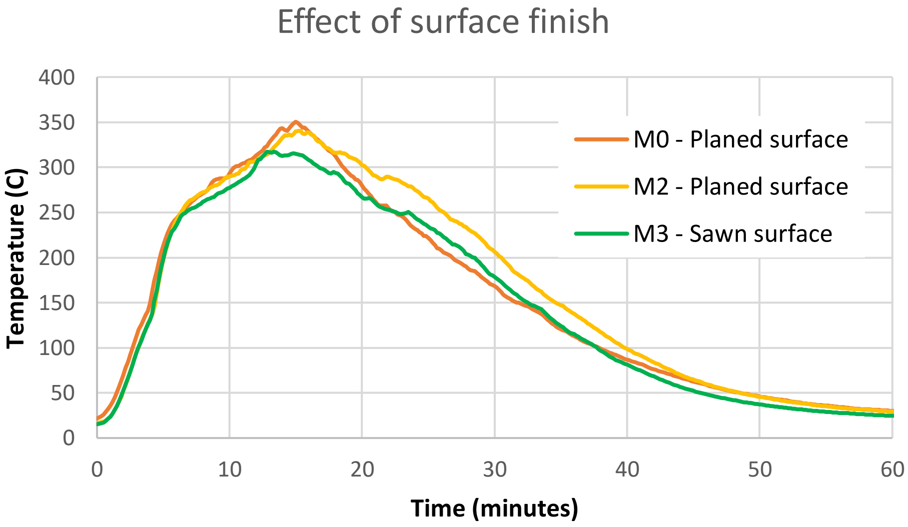


Figure F18. Temperatures measured with plate thermometer 1 m above the upper edge of the combustion chamber with cribs M0, M2 and M3.

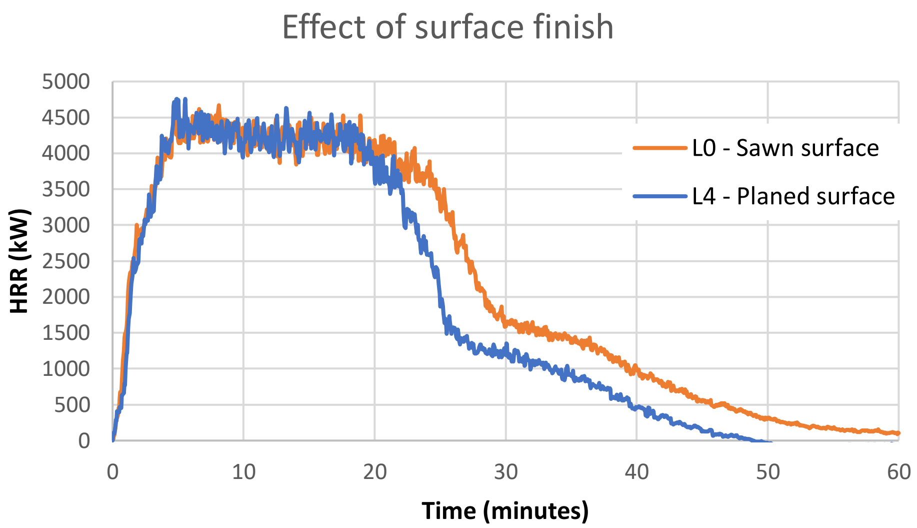


Figure F19. Heat release rate obtained with pine cribs L0 (ρ=490 km/m^3, MC=11.5 %) and L4 (ρ=485 km/m^3, MC=11.7 %).

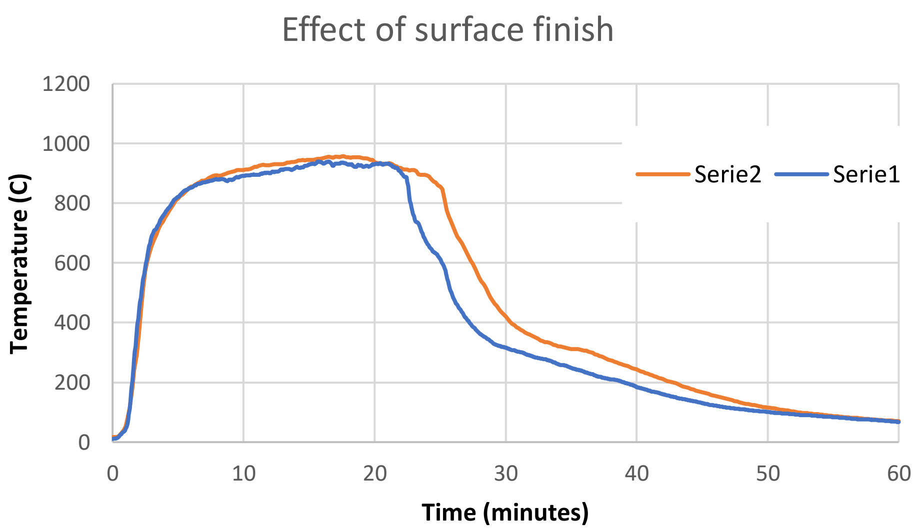


Figure F20. Temperatures measured with plate thermometer 1 m above the upper edge of the combustion chamber with cribs L0 (series 2 in the graph) and L4 (series 1 in the graph).

14.7. Effect of platform for the wood crib

There is a difference between DIN 4102-20 and BS 8414 regarding the platform on which the wood crib is placed. In DIN 4102-20 a grated floor of the platform is used, i.e., the crib is placed on a floor enabling ventilation from below. In BS 8414 the crib is placed on a solid floor, i.e., no ventilation is enabled from below.

Tests were performed both with a solid floor and with a grated platform in some of the large wood crib tests, see Figures F21 and F22. Two effects could be noted:

- There was a significant difference in the measured temperatures and HRR, where the grated floor exhibits higher temperatures and HRR.

- The wood crib kept its stability for a longer time before starting to collapse when the solid floor was used.

The proposal is to use a solid floor on the platform for the large wood cribs. The temperatures and HRR are lower compared to a grated floor, but they are still severe enough and in accordance with BS 8414. Furthermore, it is of great importance that the wood crib keeps its stability throughout the test, and with a solid floor, the time of stability is significantly longer.

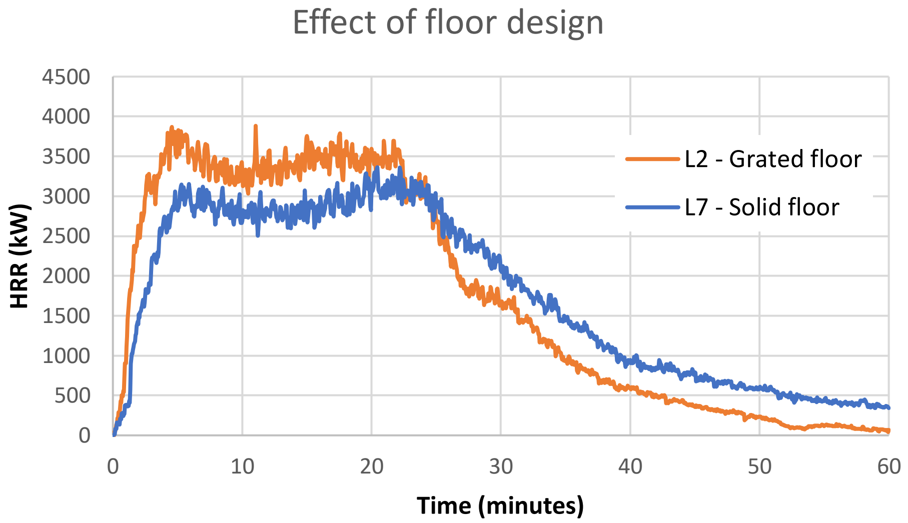


Figure F21. Heat release rate obtained in tests L2 (ρ=411 km/m³, MC=10.0 %) and L7 (ρ=447 km/m³, MC=10.0 %).

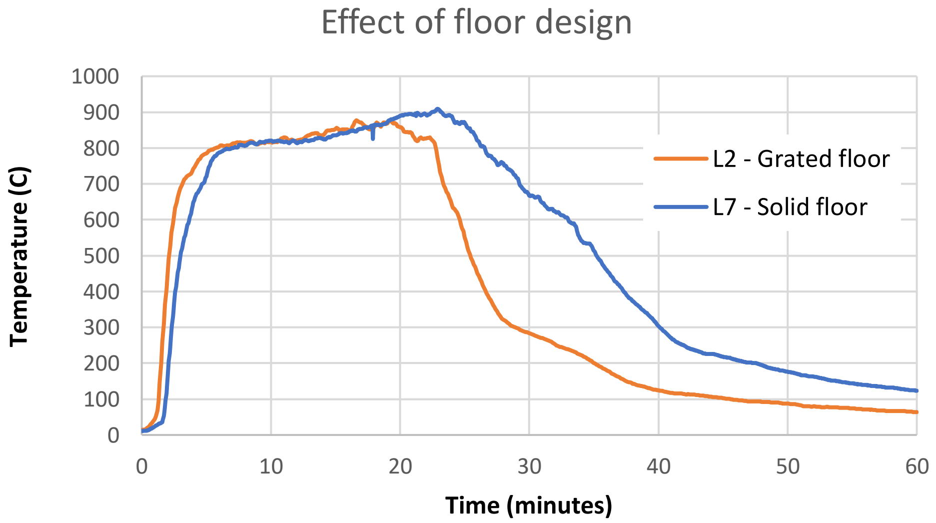


Figure F22. Temperature measured with plate thermometer 1 m above the upper edge of the combustion chamber in tests L2 (ρ=411 km/m³, MC=10.0 %) and L7 (ρ=447 km/m³, MC=10.0 %).

14.8. Joining of sticks

Test results show a significant effect of HRR and temperatures when the crib collapses. It is thus of great importance that the crib keeps its stability throughout the test time. The proposal is therefore to nail the sticks together. It is judged that it is not necessary to nail all sticks, but rather to nail sticks together two layers by two layers. The final crib is then built by stacking these elements on top of each other, each element consisting of two layers of nailed sticks. No nailing is needed between the elements.

There is no nailing needed in medium scale fire and the nailing pattern in large scale fire is displayed in Figure F23.

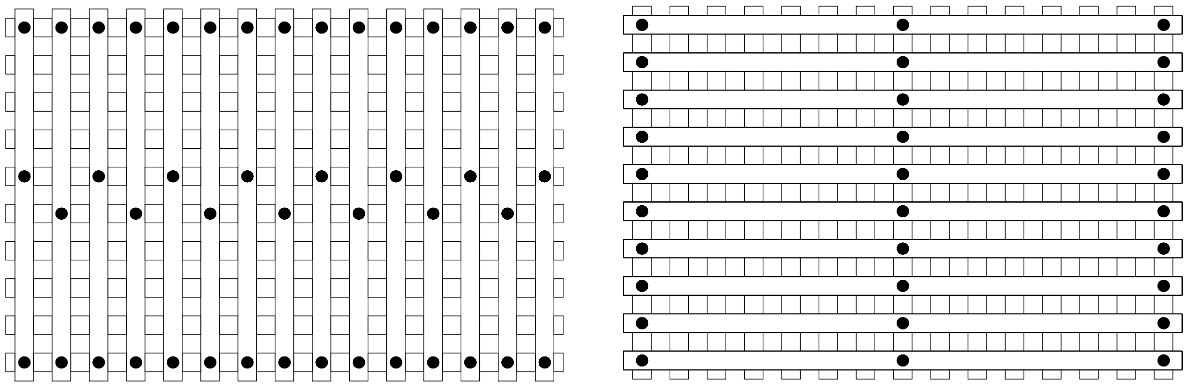


Figure F23. Patterns of stick nailing (short sticks layer on the left, long sticks layer on the right).

14.9. Geometry of crib and sticks

The tests L4 and L0 (BS 8414-grating) are made with cribs with cross sectional dimensions 47 x 47 mm^2 and 50 x 50 mm^2 respectively. There is also a small difference in average density (L4, ρ = 355 kg/m^3 and L0, ρ = 368 kg/m^3). The only notable difference in the measured characteristics is that the stability of the crib with a larger cross section is longer and thus the burning continues at the high level for a longer period, see Figures F24 and F25.

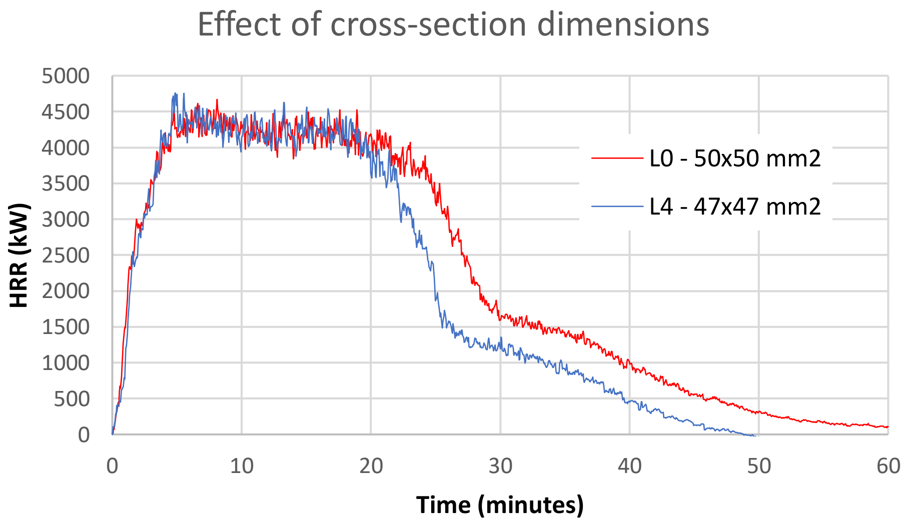


Figure F24. Heat release rate obtained in tests L0 and L4.

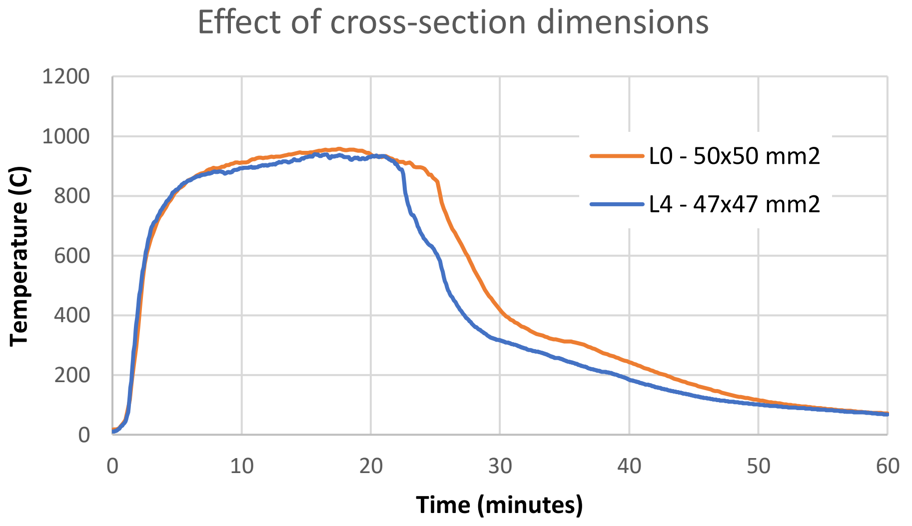


Figure F25. Temperatures measured with plate thermometer 1 m above the upper edge of the combustion chamber in tests L0 and L4.

The proposal on cross sectional dimensions will differ between the medium and the large wood crib. The medium wood crib is likely to be more sensitive to changes in the fuel source, and therefore it is proposed to have narrower tolerances on the cross-sectional dimensions. Furthermore, the wood sticks to be used in the medium crib shall be planned, and thus it is easier to be within narrower tolerances. For the large crib, a large quantity of wood is needed. It shall thus be possible to get access to suitable timber locally. Since the generally used cross-sectional dimensions are different between EU member states it is proposed to accept a wider span of nominal cross-sectional dimensions.

The length of the sticks are proposed to be kept as prescribed in DIN 4102-20 and BS 8414, i.e., 500 mm for the medium heat exposure tests, and 1000 mm for the short sticks and 1500 mm for the long sticks in the large heat exposure tests.

15. Appendix G – Numerical investigations of combustion chamber geometry

The purpose and aim of the numerical investigation, using Fire Dynamics Simulator (FDS) 6.6.0 were to determine, if possible, differences between the regular and the modified combustion chamber. Two simulations were performed, one with a regular combustion chamber (called simulation 1) and one with a slightly larger combustion chamber (called simulation 2). There might be differences in the dynamics due to the difference in volume. The results were evaluated by computing the heat release rates and temperature measurements in front of the chamber as well as heat flux to the façade.

One important aspect in defining simulations is resolving the conflict between their overall accuracy and the computational time required. The simulation must have a sufficiently resolved mesh to provide accuracy, while the finer the mesh size, the more processing time is required. To help resolve this, a mesh resolution study was performed using 20 cm, 10 cm and 5 cm cubic grids for the three different HRRs. A general recommendation for the mesh size relevant for buoyant plumes is to compute the ratio characteristic fire diameter (D*) and the nominal grid size (dx), where the recommended range is $10 < D^*/dx < 20$. For SP Fire 105 HRR at maximum intensity, the ratio characteristic has previously been found to be 6.6, 13.3 and 26.6 for the 20 cm, 10 cm and 5 cm grid, respectively. This means that the 10 cm grid gives a sufficiently good resolution considering $10 < D^*/dx < 20$, and for BS 8414 with a higher HRR the resolution works even better. However previous comparisons with experimental data indicates that simulations using the 5 cm grid performs better.

The geometry of the combustion chamber is presented in Figure G1. The façade is similar to the BS 8414-1:2015 which consists of a main test wall at least 2.6 m wide and 6.0 m high above the fire compartment and a return wall of a minimum width of 1.5 m and the same height as the main wall. The HRR as obtained from previous measurements was assumed to be released from an object with the same physical dimensions as the wood crib. To avoid different dynamics in the simulations the fire source was modelled with an HRR per unit area, thus releasing a certain amount of fuel per unit area. The size of the fire source was 1.5 m x 1.0 m x 1.0 m (width x length x height) placed 0.5 m from the ground. The fuel was specified in accordance with the draft assessment method.

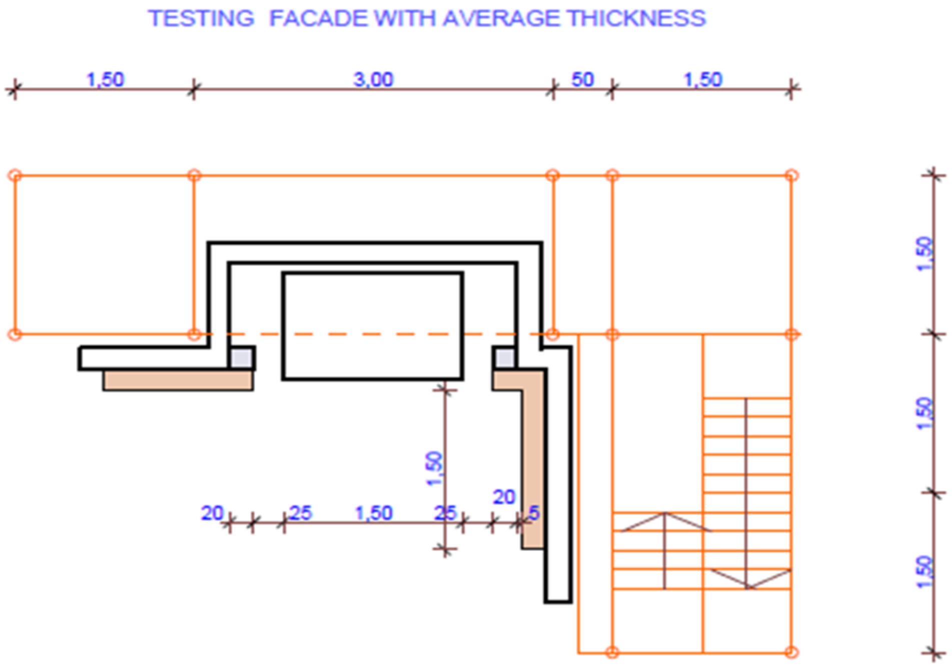


Figure G1. The modified combustion chamber.

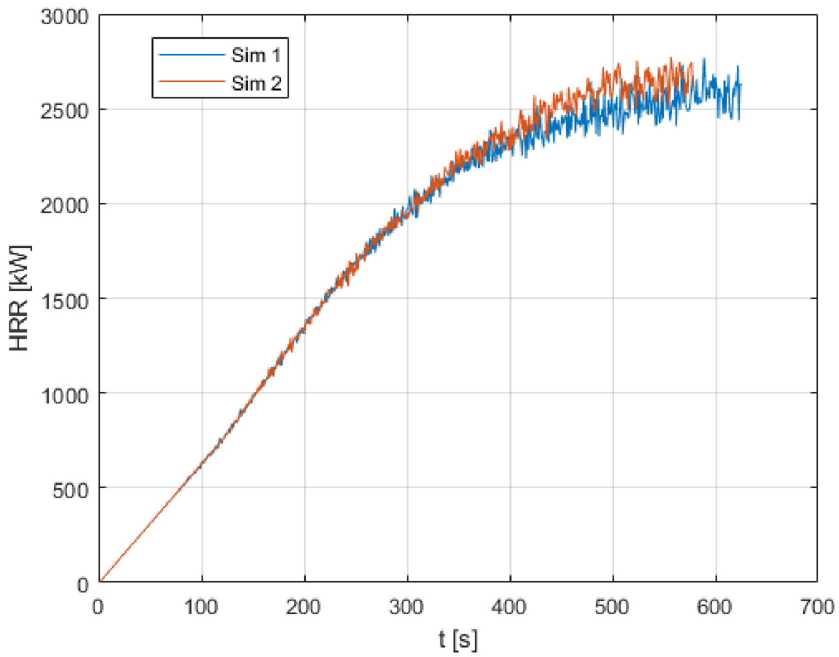


Figure G2. The difference in HRR [kW] between the regular and modified combustion chamber.

In Figure G2, a comparison of sim 1 (original combustion chamber) and sim 2 (modified combustion chamber) where it is found that the HRRs are comparable with a slight increase due to larger volume of the modified chamber in sim 2. Here it is assumed that both cribs had the same mass loss rate and the differences were due to available oxygen concentrations.

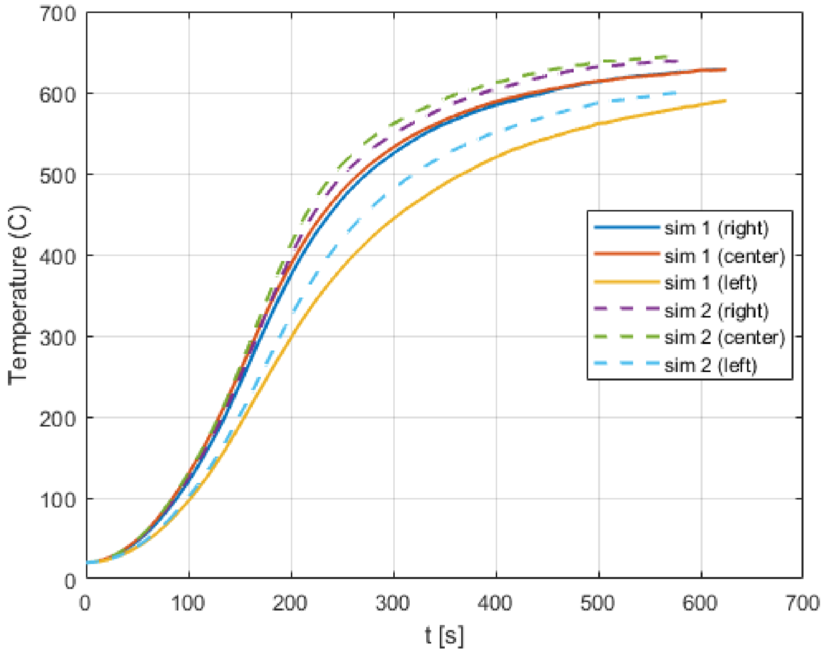


Figure G3. The PT temperatures [°C] measured 0.5 m from the fire source at 1.5 m from the ground.

In order to characterize the crib, three plate thermometers (PTs) were placed symmetrically outside the chamber 0.5 m from the façade surface and 1.5 m above ground, see Figure G3. Here these are used to characterise the difference in where the combustion takes place. It is indicated that higher temperatures are found outside in sim 2 (original combustion chamber) most probably due to a slight difference in the dynamics where more of the combustible gases burn just outside the chamber.

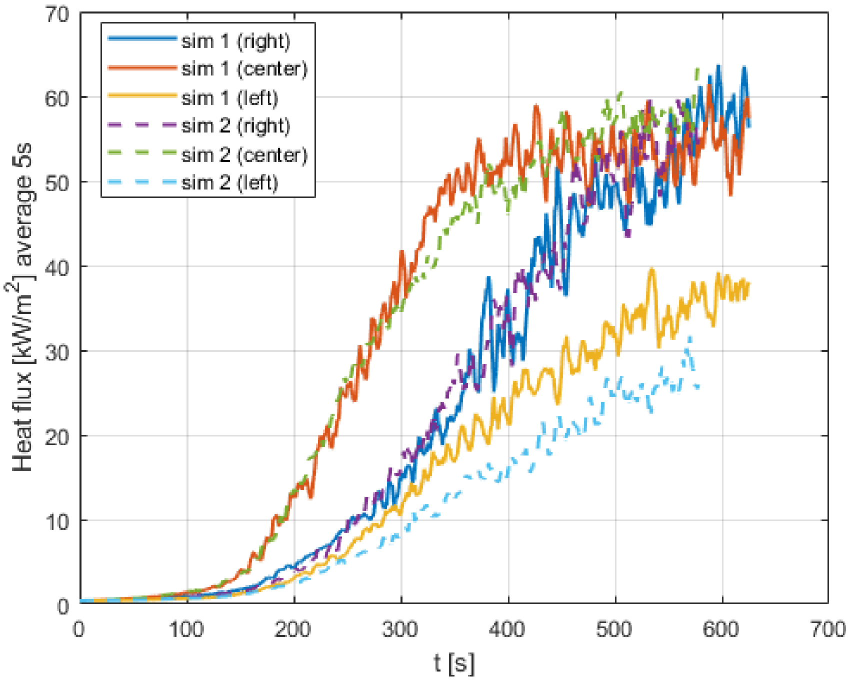


Figure G4. Heat flux [kW/m2] 2.9 m above ground averaged over 5 s to the façade.

Three Schmidt-Boelter heat flux meters (here averaged over 5 s) were inserted in the model, and placed 2.9 m above ground at three locations. One is centred relative to the combustion chamber and the two others in line with the edges of the combustion chamber on each side. It is found that the heat flux is at similar levels at the centre and close to the corner however, slightly lowered at the edge of the main face in the modified case, Figure G4.

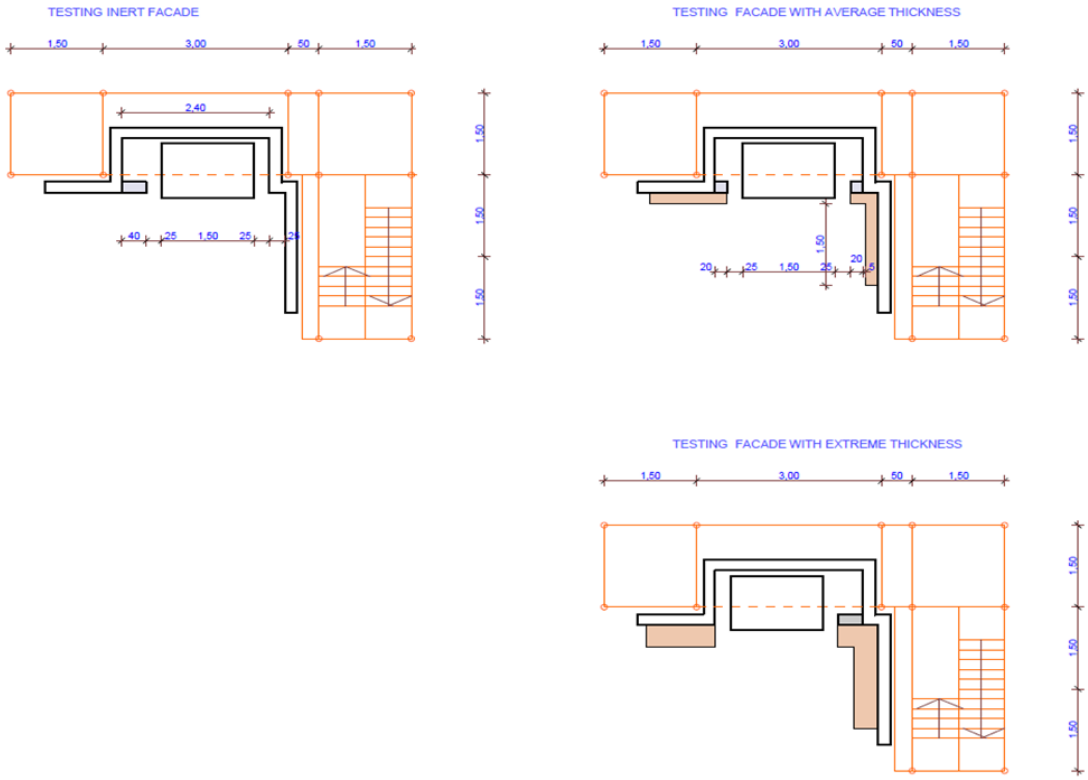


Figure G5. Comparison of different thicknesses of the façade specimen, the first case called inert is 0 mm, the average is 100 mm and the extreme is 300 mm.

Another important factor is the thickness of the façade specimen as has been indicated in earlier experiments and numerical modelling.

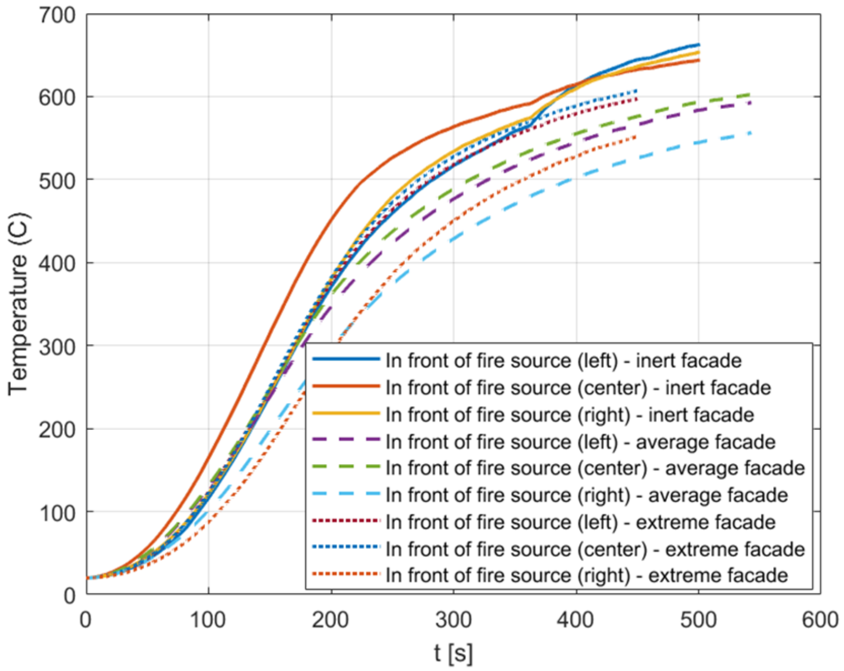


Figure G6. The PT temperatures [°C] measured 0.5 m from the fire source at 1.5 m from the ground for the three cases illustrated in Figure G5 of inert façade, average façade (100 mm) and the extreme façade (300 mm). The results are presented in the order right, center and left of the combustion chamber.

In Figure G6 the PT temperatures in front of the combustion chamber measured 0.5 m from the fire source at 1.5 m from the ground are displayed for the different façade thicknesses. The specimen thickness influences the fire plume and thicker specimen may yield a slightly larger outward momentum of the plume. There are some differences on the order of 100 °C from minimum to maximum temperatures after 600 s.

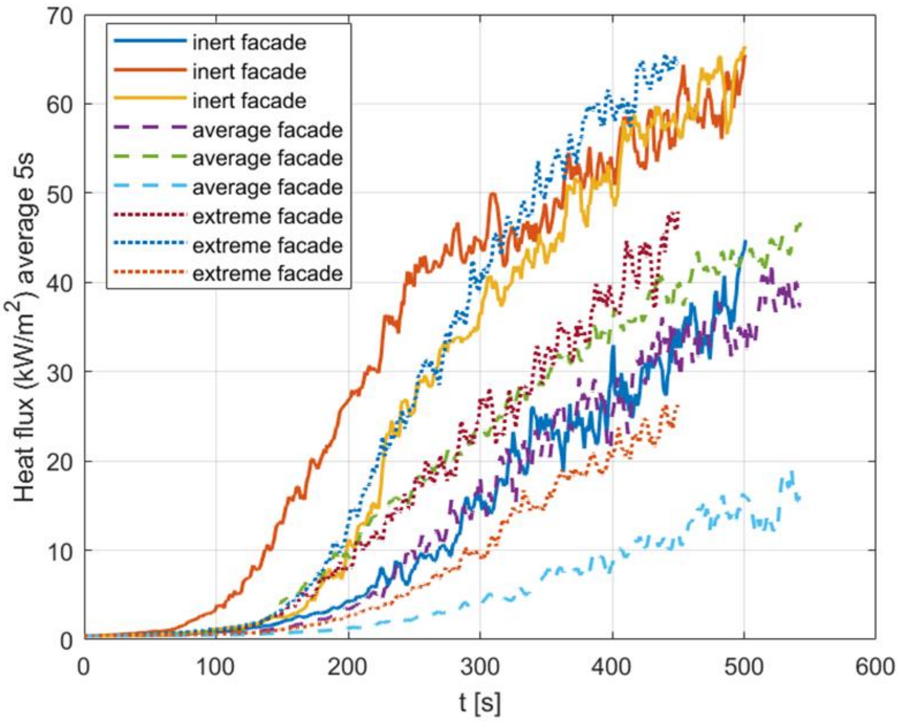


Figure G7. A comparison of the heat flux 2.9 m above ground for the three cases illustrated in Figure 22 of inert façade, average façade (100 mm) and the extreme façade (300 mm). The results are presented in the order right, center and left of the combustion chamber.

The heat flux as measured by Schmidt-Boelter gauges in the model, Figure G7, are placed similarly to those in Figure G4. Significant differences on the thermal impact on the façade for different specimens are found.

When comparing the width extension of the combustion chamber, simulations indicate a small difference in HRR, where some differences in the PT (0.5 m away directed towards the fire) temperatures in front of the combustion chamber are found, whereas good agreement in heat fluxes at 2.9 m above ground is found. Thus, it is indicated that this change may have a limited effect on outcomes from testing. The important limitations of this study are that the wood crib is not self-consistently modelled. Thus, the pyrolysis process may change due to the increase in volume due to different re-radiation conditions and oxygen concentrations are found.

Note that the simulations are only performed until maximum intensity is reached since it is expected that the main differences between the cases are found in the early phase of the fire rather than for the maximum intensity plateau.

In comparing the effect of the façade specimen thickness, large differences in temperatures in front of the combustion chamber are found, which has been seen before in both experiments and numerical work. Moreover, there are significant differences in the heat fluxes around 2.9 m above ground. However, one issue is that if the test has to compensate for changes in specimen thickness i.e. keeping the distance from the edge of the wood crib to the finished façade is kept constant, then a change of wood crib placement is needed. This is, however, not easily done with simulations due to possible differences in the mass loss rates with different placements.

The proposal on geometry of the combustion chamber is for the medium heat exposure test to maintain the definition as it is in DIN 4102-20, and for the large heat exposure test to make an enlargement. There are two main advantages by extending the size of the combustion chamber for the large heat exposure test:

- Firstly, by extending the width of the combustion chamber, it is possible to have the same test rig configuration for all façade thicknesses (limited in this proposal to façades up to 400 mm thick). This will simplify the work needed during the mounting and preparation of the test specimen. The calculations show only a small effect due to this change.
- Secondly, with the extended depth of the combustion chamber, the wood crib can be moved into the chamber with two benefits: firstly it limits the risk that falling parts from the tested specimen may hit and thus affect, possibly destroy, the wood crib during the test, and secondly it allows extending a bit the solid floor of the platform in order to collect the charred sticks falling from the crib, which biases the weight measurement of falling parts. The calculations show that the thickness of test specimens affects the temperatures and heat flux. It is reasonable to assume that extending the depth of the combustion chamber and moving the wood crib further in would lead to a lower heat exposure to the test specimen. Although, the tests performed with wood cribs show that the heat exposure obtained is high, and it will still be a relevant heat exposure even if it is reduced to some degree.

16. Appendix H – Parametric studies on the medium exposure with façade

Parametric tests were performed for the medium fire exposure. All the tests are detailed in the test report “BRE Global Client Report, Characterisation of medium fire exposure fuel source” (BRE, 2022) which is also available on the project website under “Medium scale testing including secondary opening”.

The tests were performed indoors in a controlled environment. The air velocity was checked 5 minutes prior to ignition with the extraction system running and the values measured were below 0.1 m/s. The ambient temperatures before the tests were in the range of +10°C to +30°C.

The experimental programme for the medium fire exposure consisted of ten tests and aimed to explore reproducibility (Test series D), the influence of air flow into the combustion chamber (test series E-F) and the position of the secondary opening for a combustible material (Test series K). An overview of the tests is shown in Table H1 below.

Table H1.

Proposed experimental programme and the associated parameters.

Test ref.	Average wood density of the crib (kg/m^3)	Average moisture content (%)	Total mass of wood crib (kg)	Air flow (m^3/h)	Uplift (m)	Secondary opening location	Test specimen
D1	497	11.6	29.6	400	0.5	Eccentrically (50 mm deep)	Inert
D2	504	12.5	32.9	400	0.5	Eccentrically (50 mm deep)	Inert
D3	499	11.8	32.5	400	0.5	Eccentrically (50 mm deep)	Inert
E1	504	11.9	32.0	360	0.5	Eccentrically (50 mm deep)	Inert
E2	506	12.8	30.4	440	0.5	Eccentrically (50 mm deep)	Inert
F1	505	13.6	31.1	420	0.5	Eccentrically (50 mm deep)	Inert
F2	495	13.2	30.9	380	0.5	Eccentrically (50 mm deep)	Inert
K1	476	10.8	29.0	400	0.5	Without	PIR
K2	463	10.8	29.5	400	0.5	Symmetrically	PIR
K3	458	10.1	29.9	400	0.5	Eccentrically	PIR

As for the large exposure tests, the investigation regarding position of the secondary opening (series K) used a homogeneous combustible material (PIR) outside the regular use of this product. The PIR alone does not represent a façade system. It was only chosen for simplification of the test set-up. However, it should be possible to assess fire spread regarding the secondary opening with this set-up. The secondary opening is 1200 by 1200 mm with its centre placed 2100 mm above the combustion chamber top 500 mm from the façade corner.

Examples of the temperatures measured on the façade are the PT measurements at 2 m above the combustion chamber for series D (repeatability) and E-F (air flow variations), see Figure H1.

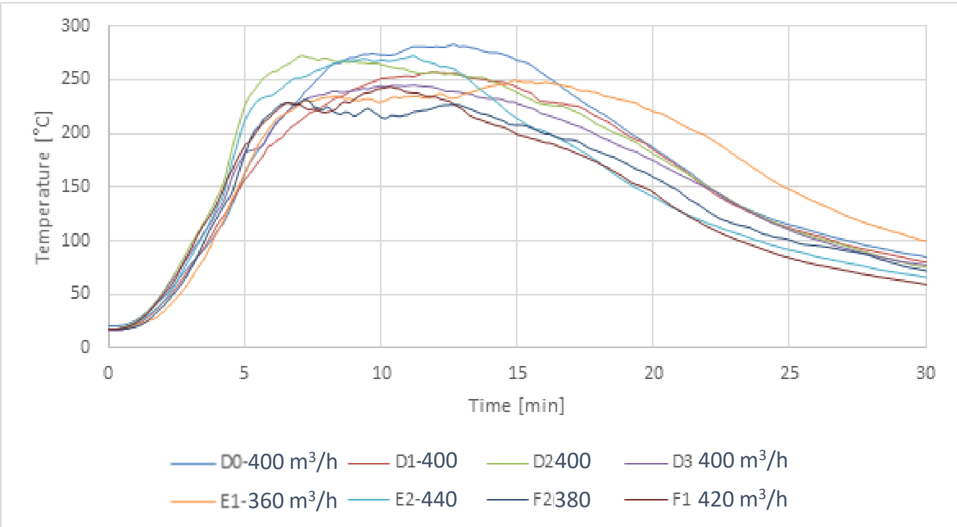


Figure H1. Plate thermometer (PT) measurements at 2.0 m above the combustion chamber. The numbers after the labels refer to the airflow into the combustion chamber during the tests.

The repeatability tests, all using 400 m^3/h for the airflow into the combustion chamber, are summarised in Figure H2 where the total spread in average TC- and PT-temperatures (during the peak burning rate between 5 - 15 minutes) is about 100 °C just above the combustion chamber, but less than 50 °C for heights >1 m from the opening.

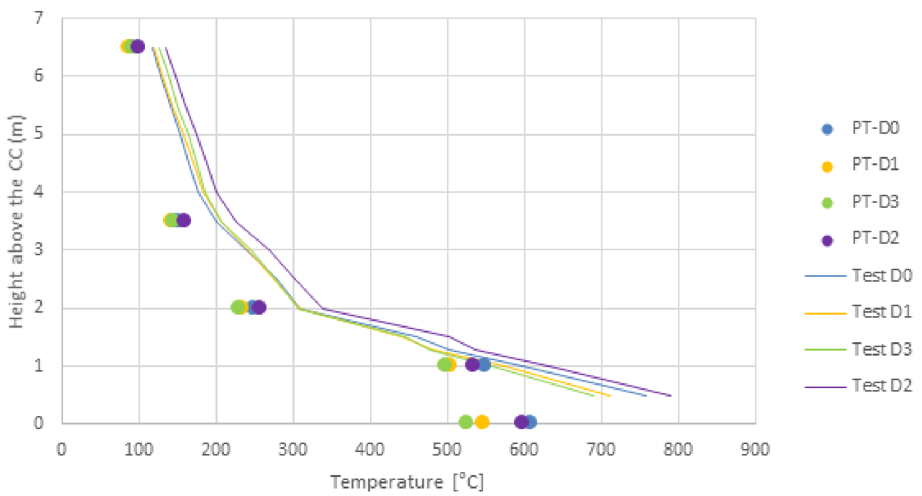


Figure H2. Temperature distribution on the central axis above the combustion chamber (CC) for test series D (repeatability, 400 m^3/h air into the CC). Lines and symbols represent TC- and PT measurements, respectively.

The variations on the façade surface temperatures when varying the airflow into the combustion chamber are summarized in report; Medium exposure testing including secondary opening – Report number P117805-1000 Issue: 1.

No large variations can be noted for the 10 minutes average temperatures, 440 m^3/h yields the highest temperatures and the tests with lower values (360 – 420 m^3/h) are more or less identical Figure H3. The largest effect of changing the airflow is closest to the combustion chamber and that the maximum values increase with increasing airflow, but the duration of the high temperature period is simultaneously reduced, Figure H3.

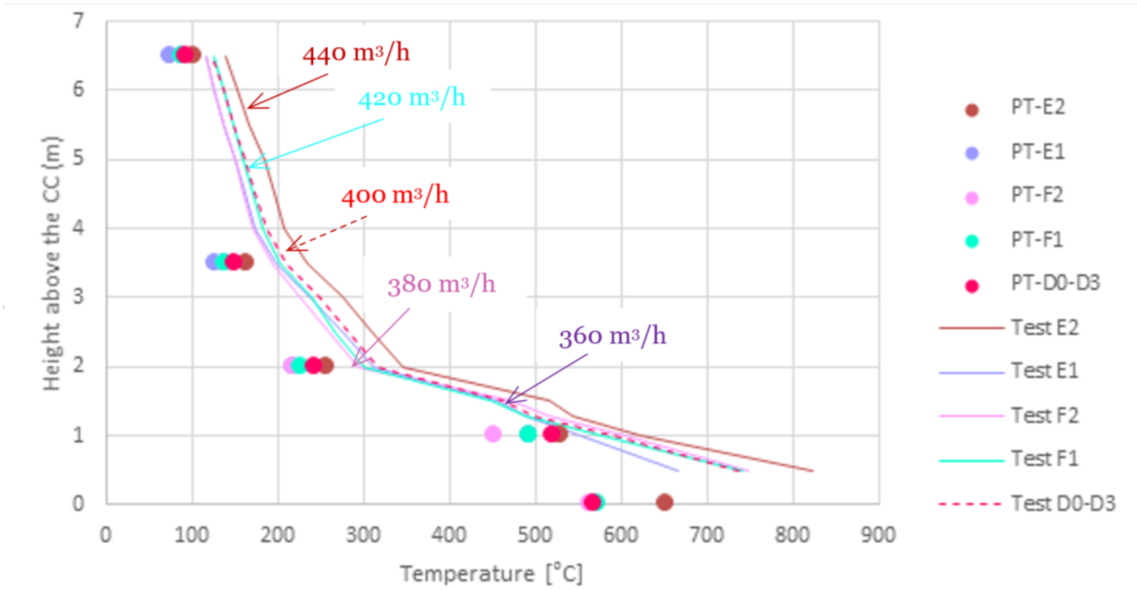


Figure H3. Temperature distribution on the central axis above the combustion chamber (CC) for varying airflow (test series E-F an average of series D). Lines and symbols represent TC- and PT measurements, respectively.

The three tests in the K-series investigating the position of a secondary opening had a large impact on the resulting temperatures. A 100 mm thick homogeneous combustible PIR-material was used and tests without opening (K1) as well as with an opening placed symmetrically (K2) or eccentrically (K3). Snapshots at 5 and 10 minutes after the ignition show that the impact on the façade material is highly similar for the three tests, Figure H4.

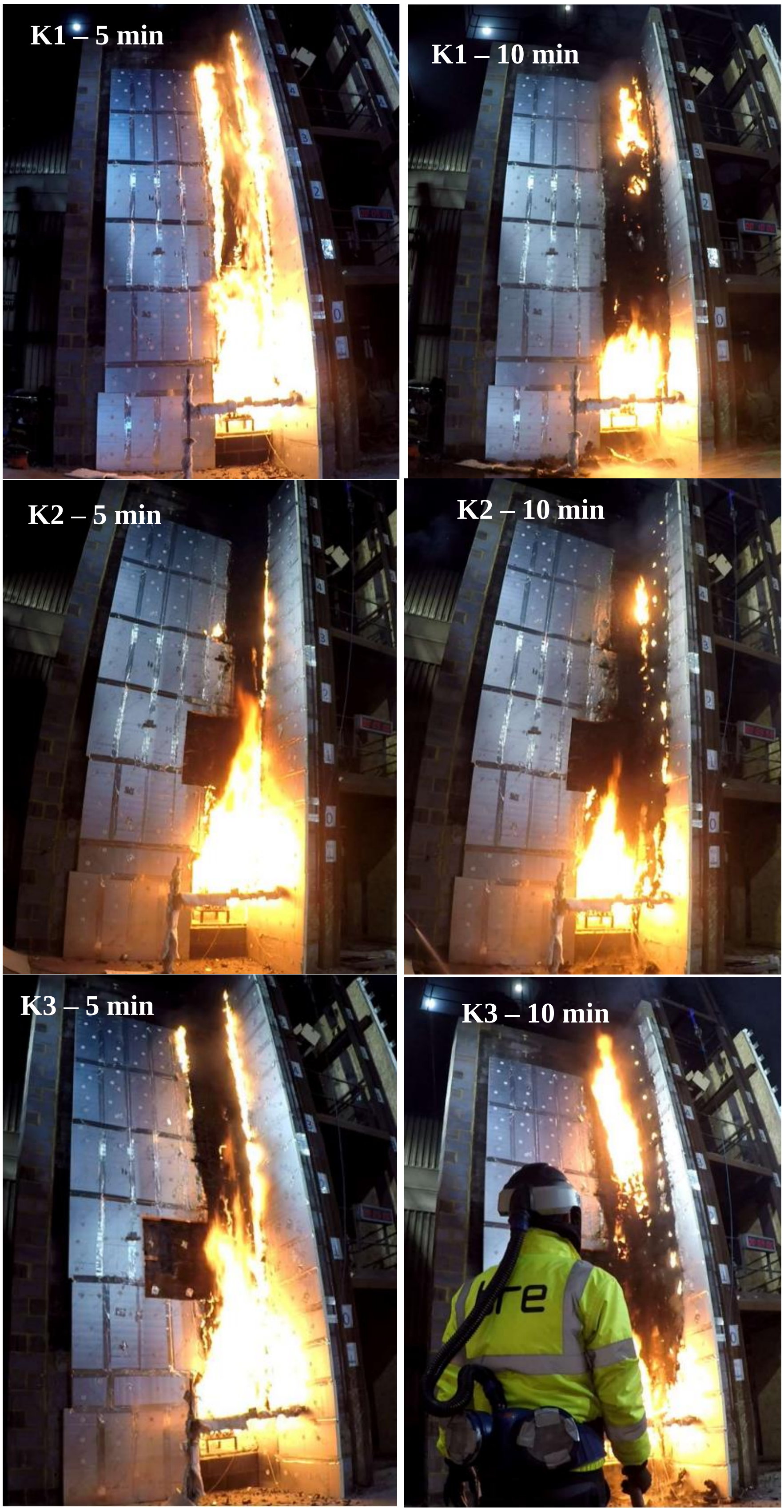


Figure H4. Photos at 5 and 10 minutes after ignition for the three different tests in the K-series.

Average temperatures during the tests are shown along the height of the façade below in Figure H5. Again, no large differences can be found between the three cases and we conclude that the void of combustible material is not something that impedes the spread of fire and if used, the eccentric (asymmetrical in relation to the combustion chamber) placement is preferrable in order to assess simultaneously the effect of a continuous façade and of an opening above the combustion chamber.

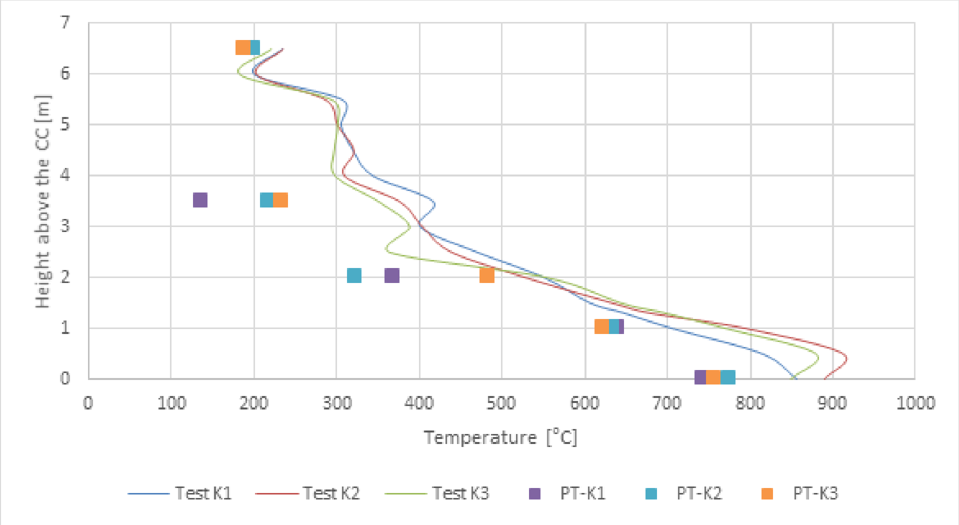


Figure H5. Temperature distribution on the central axis above the combustion chamber for test series K. K1-without opening, K2-Symmetric opening, K3-Eccentric opening.

17. Appendix I – Classification

A proposed system for classification.

Date: 2024-05

Draft document for possible use in European classification system EN 13501

Fire classification of construction products and building elements — Part X: Classification using data from fire tests on façade

Klassifizierung von* Bauprodukten *und Bauarten zu ihrem Brandverhalten — Teil X: Klassifizierung mit den Ergebnissen aus den Prüfungen zum Brandverhalten von Außenwandbekleidungen

Classement au feu des produits et éléments de construction — Partie X: Classement à partir des données d'essais de façades

ICS:

Descriptors:

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Foreword

The classification using fire tests on façades which was developed in the European project *Finalisation of the European approach to assess the fire performance of façades* and was financed by the European Commission – DG GROW under the number: SI2.825082 shall be used in the European classification system, for building products, e.g. a new part of the EN 13501 *Fire classification of construction products and building elements* system.

Introduction

This classification system is based on the assessment methods (for both medium- and large-scale exposure) which are applicable for any façade system, like for instance external walls, façade cladding systems vertically fixed to and supported by a structural frame or a supporting construction. However, the method will not address the load-bearing capacity of the tested system, nor inclined façade systems.

The assessment method addresses requirements which go beyond the requirements that can be addressed and classified according to EN 13501-1,2. The assessment method includes assessment of detailing of the façade system around openings, but not any window detailing. Vertical and horizontal fire spread on the surface and within façade systems is assessed. The method also evaluates falling parts (size of falling parts and risk for fire spread downwards through burning material falling down from the façade) of a façade when exposed to fire.

The Assessment methods which is basis for classification includes two fire load scenarios:

- a medium fire exposure test
- a large fire exposure test

The large fire exposure scenario is representative of a fully developed (post-flashover) fire in a room, vented through an opening such as a window aperture, that exposes the façade to the effects of external flames, or from an external fire source.

The medium fire exposure scenario is also based on a flashover scenario, but the method has been down-scaled. The method has thus virtually removed one storey from the test set-up, and only focus on the façade part located two storeys above the fire room, i.e., the top of the flames. The project report BI5-8001 96-18 (Kotthoff) states in section 8.3.5.4 (translated): “The thermal impact of a 25 kg wood crib is of course not comparable to a fire in a fully furnished room. At the area where the flames emerge the opening and directly above the lintel the exposure is similar to the exposure of a room fire”.

1. Scope

This document provides the fire performance classification procedure for façades.

2. Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

XXXX: Assessment method medium fire exposure

YYYY: Assessment method large fire exposure

3. Terms, definitions and symbols

3.1. Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

• IEC Electropedia: available at http://www.electropedia.org/

• ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1
combustion
exothermic reaction of a substance with an oxidizing agent

Note 1 to entry: Combustion generally emits effluent accompanied by flames and/or visible light.

[SOURCE: EN ISO 13943:2017, 3.55]

3.1.2
direct field of application
outcome of a process (involving the application of defined rules) whereby a test result is deemed to be equally valid for variations in one or more of the product properties and/or intended end use applications

3.1.3
element, component or product
in this context part of the façade system

3.1.4
end use application
real application of a product, in relation to all aspects that influence the behaviour of that product under different fire situations

3.1.5
Euroclass
reaction to fire class of a material according to EN 13501-1 (e.g., A1, A2, B, C, D, E, F)

3.1.6
extended field of application
outcome of a process (involving the application of defined rules that may incorporate calculation procedures) that predicts, for a variation of a product property and/or its intended end use application(s), a test result on the basis of one or more test results to the same test standard

3.1.7
extended application result
predicted result for performance parameter obtained following the process of extended field of application

3.1.8
extended application report
document reporting extended application results, including all details of the process leading to those results, prepared in accordance with EN 15725

3.1.9
façade
a complete external wall construction of any type (massive wall or curtain wall ...etc.) or constitution (masonry, combustible material ...etc.*).* Since there is no general definition available on the term façade or a façade system, it is used in a very general way in this document. Due to different uses of the term in the Member States, and the present assessment method have to be applicable in all Member States the definition has to cover everything from the outer skin of the building envelope to the full external wall. What to test in accordance with this assessment method is than defined by the regulations and requirements in the individual Member States and the field of application

3.1.10
Façade system
see façade

3.1.11
falling parts
material (solid or molten) separating from the specimen, burning - with or without a visible flame - or not burning, during a fire or a fire test

3.1.12
fire barrier
separating element which inhibits the passage of flame and/or heat and/or effluents for a period of time under specified conditions

3.1.13
fire load
quantity of heat which could be released by the complete combustion of all the combustible materials in a volume, including the facings of all bounding surfaces

Note 1: Fire load is expressed in joules.

Note 2: Fire load may be based on effective, gross or net heat of combustion (thermal energy produced by combustion of unit mass of a given substance as required by the specifier).

3.1.14
fire performance
response of a material, product or assembly in a fire.

[SOURCE: EN ISO 13943:2017, 3.137] 3.1.26

3.1.15
fire scenario
detailed description of conditions, including environmental, of one or more stages from before ignition to after completion of combustion in an actual fire at a specific location or in a real-scale simulation

[SOURCE: EN ISO 13943:2017, 3.152]

3.1.16
fire situation
stage in the development of a fire, characterised by the nature, severity and size of the thermal attack on the products involved.

3.1.17
fire spread
propagation of a fire front on a material surface or within a material defined by the width or height to which any thermocouple exceeds a temperature rise of 500 K or 700 K (depending on fire exposure) on average over a period of 30 seconds during the test

3.1.18
flashover
transition to a state of total surface involvement in a ventilated controlled fire within an enclosure

[SOURCE: EN ISO 13943:2017, 3.184]

3.1.19
burning droplets/particles
material separating from the specimen during the fire test and continuing to flame for a minimum period as described by the test method.

3.1.20
level of exposure
intensity, duration and extent of the thermal attack on a product

3.1.21
product
material, element or component about which information is required.

3.1.22
protection to openings
any feature provided to accommodate the termination of the façade specifically at the boundaries of openings (combustion chamber opening and secondary opening) and that is deemed to offer to this termination any protection against fire spread. Examples of protection to openings are: window frame, sealant, caulking, profile that encapsulates or screens the termination, window sill… covering partially or totally the façade termination

3.1.23
reaction to fire
response of a product in contributing by its own decomposition to a fire to which it is exposed, under specified conditions.

3.1.24
reference scenario
hazard situation used as a reference for a given test method or classification system.

3.1.25
smouldering
combustion of a material without flame and without visible light, including glowing combustion

the time in completed minutes for which the test specimen continues to maintain its ability to limit the propagation of a combustion without flame and without visible light. The failure of the smouldering performance is deemed to have occurred when one of the criteria below has failed

Edge damages
the failure of edge damages criterion occurs when the damage of the test assembly by spread of smouldering processes reach the top of the assembly or reach the lateral edges of the test assembly – both shall be assessed after termination of the test

Maximum temperature
the failure of maximum temperature criterion occurs when a temperature of higher than 50 °C is measured at any of the thermocouples at the end of the 6 / 15 hours[5] period after beginning of the test

3.1.26
Starting time
for the large fire exposure tests, the starting time of the test is determined as the time when 380 K increase is exceeded in a 30 second average at any thermocouple located at vertical distance of 4500 mm from the combustion chamber

for the medium fire exposure tests, the starting time of the test is determined as the time when 80 K increase is exceeded in a 30 second average at any thermocouple located at vertical distance of 3500 mm from the combustion chamber

3.1.27
structural frame
a stable frame onto which a full external wall, or a supporting construction, can be mounted

3.1.28
supporting construction
a secondary structure mounted on the structural frame onto which a façade test specimen can be mounted. A supporting construction may be necessary when not the full external wall is tested

3.1.29
system
see façade

3.1.30
test rig
the total assembly of the structural frame, the eventual supporting construction, and the combustion chamber

3.1.31
window frame
in the test it is possible to have a protection of edges around openings which would be the case in practice through details from windows

[5] According to DIN 4102-20 a maximum test duration of 15 hours is given. By many laboratories that is seen to be problematic, especially for large exposure tests regarding acceptable working hours. Therefore, an alternative of 6h hours according to ISO 16733 has been proposed as well.

3.2.Symbols and abbreviations

The symbols and notations correspond to those given in the appropriate test method.

ΔT	temperature rise [K]
Δt	duration [s]
m	mass (kg)

4. FIRE SCENARIOS

4.1.General

Fire performance shall be assessed using the thermal attack given in 4.2 or 4.3 as appropriate. The levels of thermal action given in 4.2 and 4.3 reflect different fire scenarios and the test methods which prescribe their translation into practical tests give tolerances for their application.

4.2.Medium fire exposure test

This method defines the procedure using a medium fire exposure test, based on a flashover scenario in which the primary fire source has been down-scaled. The method has thus virtually removed one storey from the test set-up, and only focus on the façade part located two storeys above the fire room, i.e., the top of the flames.

The test allows the determination of the fire spread and level of falling and burning parts.

4.3.Large fire exposure test

This method defines the procedure using a large fire exposure test, representative of a fully developed (post-flashover) fire in a room, vented through an opening such as a window aperture, that exposes the cladding to the effects of external flames, or from an external fire source.

The test allows the determination of the fire spread and level of falling and burning parts.

5. FIRE PERFORMANCE CHARACTERISTICS

5.1.Classes MS

A product to be assessed for MS classes shall be tested in accordance with the medium exposure assessment method.

Limited fire spread MS is the ability of a facade to limit the propagation of a fire horizontally and vertically at the surface of the façade but also internally. The assessment of MS is made on the basis of temperature measured by internal and external thermocouples.

5.2.Classes LS

A product to be assessed for LS classes shall be tested in accordance with the large exposure assessment method.

Limited fire spread LS is the ability of a facade to limit the propagation of a fire horizontally and vertically at the surface of the façade but also internally. The assessment of LS is made on the basis of temperature measured by internal and external thermocouples.

5.3. Additional classifications F1, F2 for falling parts

Classifications F1 and F2 are deduced from observations and measurement of mass of falling parts during the test as specified in both large and medium exposure assessment methods.

5.4. Additional classification “nb” for burning parts

Classification nb (no burning parts) is deduced from observations of burning parts during the test as specified in both large and medium exposure assessment methods.

5.5. Optional performance regarding the smouldering

Both large and medium exposure assessment methods specify as an option the possibility to assess the smouldering behaviour of the façade.

The assessment of smouldering is made on the basis of temperature measured by dedicated thermocouples and on the basis of façade edges damages evaluation.

Setting a suitable testing time to assess smouldering is a challenge as smouldering is a slow process. Therefore, DIN 4102-20 gives a maximum test time of 15 hours. Regarding regulations for acceptable working hours this is a huge challenge in practice. To reflect that in ISO 16733 a test time of 6 hours is given. For the large fire exposure tests to meet workable conditions and safety requirements 6 hours are the maximum possible testing time.

This performance does not lead to any classification.

5.6. Optional performance regarding the junction between the façade and a floor

The large exposure assessment method specifies as option the possibility to assess integrity and the insulation performances of the façade-to-floor junction.

This performance does not lead to any classification.

6. Declaration of fire performance

6.1. Classification periods

All classification periods against any of the characteristics in accordance with Section 5 shall be declared in minutes, using one of the periods (tt): 15, 20, 30, 45, or 60.

6.2. Designatory letters

The classification of facades shall be made with the designatory letters shown in Section 5.

6.3. Declaration of classification

Combinations of these designatory letters, as appropriate, shall be used as part of the declaration of performance. They shall be supplemented by the time, in elapsed completed minutes of the nearest lower class during which the functional requirements are satisfied considered from the starting time defined in the test methods.

In general, the classes shall be expressed as follows:

MS *tt*:	*tt* being the classification period during which the façade limited the fire spread in the **medium** fire exposure test.
LS *tt*:	*tt* being the classification period during which the façade limited fire spread during **large** exposure is satisfied.
F1 *tt*:	*tt* being the classification period during which the criterion falling parts 1 is satisfied.
F2 *tt*:	*tt* being the classification period during which the criterion falling parts 2 is satisfied.
nb *tt*:	*tt* being the classification period during which the criterion burning parts is satisfied.

6.4. Presentation of classification

The combination of classes and times for main classes LS/MS and for additional classes F1, F2 and nb shall be deduced from test results and/or extended application results. Only those combinations of classes and times as specified in the following clauses of this document shall be used for the facades. The designatory letters for the expansion of performance parameters shall be added as far as relevant and as far as the conditions are satisfied. The classification(s) shall be awarded after verification that specific additional requirements for certain elements of building construction are satisfied.

The classification shall be presented according to the following template:

LS/MS	tt1	F1	tt2	F2	tt3	nb	tt4

Where necessary:

tt2 ≤ tt3

The following main classes for façades are covered:

MS	15	20	30	45	60
LS	15	20	30	45	60

Examples of classification with and without additional classes:

LS/MS	tt1	F1	tt2	F2	tt3	nb	tt4

MS	15	F1	20	-	-	nb	30
LS	30	-	-	F2	60		
MS	15	F1	20	F2	30	nb	45

6.5. Declaration of fire classes in product specifications

Product specifications including descriptive product requirements and claiming a given fire classification in accordance with this document shall justify their classification by fire testing. This establishes the performance at an adequate level of confidence, taking into account the possible variations of the components and the production techniques.

The product specification shall therefore include the necessary means for control of the relevant properties.

7. CLASSIFICATION PROCEDURE

7.1. General

7.1.1. Procedure

a) The envisaged range of products and end use applications to be covered by the classification shall be proposed by the sponsor and includes aspects such as:

- Dimensions of the element: including span, height, width;
- Boundary conditions;
- Exposure conditions;
- Variation of constructional details;
- The envisaged class(es): i.e. combinations of performance criteria and time(s).

b) Taking into account the direct field of application of test results as specified in the relevant test method and/or the extended application results, the number of tests, standard exposures, and the specimen to be tested shall be deduced.

c) Standard fire tests shall be carried out and for each test the times shall be determined, in elapsed minutes, for which the test specimen continues to satisfy the different aspects of the performance criteria:

Criterion/assessment	Aspects
LS/ MS : fire spread	Maximum temperature rise
F1, F2 : falling part	Mass in excess of given values
nb : burning part	Sustained burning
Smouldering	Edges damages

	Limiting temperature
Façade-floor junction Integrity	 Sustained flaming on the unexposed side
Insulation	Maximum temperature rise

d) For any of the tests and criteria, the obtained times in minutes shall be rounded down to the nearest lower value included in the following series: 15, 20, 30, 45, 60.

e) If more than one test has to be carried out because of the envisaged field of application, the lowest result shall determine the classification for the entire field of application. As the classification is linked to the field of application, results of individual tests may lead to higher ranking for a limited field of application.

f) A classification report shall be produced.

7.1.2. *General rules for deducing the number of fire tests*

No test shall be duplicated for aspects of repeatability, and a single test, unless required otherwise by this document, allows the classification of all components in the field of direct application.

If, however, a wider field of application is envisaged, all relevant aspects may not be covered by a single test and additional tests are then required. Also, the influence of different boundary conditions may require evaluation of additional test specimens.

The number of tests required may further depend on:

— required classifications;

— combination of performance criteria envisaged;

— need to apply more than one thermal attack.

Products/elements are supplied in a wide variety of sizes, shapes and materials including finishes to satisfy the requirements of the market. It is impractical to test every variation of shape, size or material for each product.

The extent to which a tested product/element may or may not be changed under the field of direct application is given in rules which limit the permitted variation away from the test specimen without further evaluation or calculation. The field of direct application clause in each specific test method relates to the common forms of construction for which experience of testing has provided the knowledge that such variations can be safely accepted.

The extent to which a tested product or element may be changed under the field of extended application is given in rules in the relevant extended application standards.

— Dimensions:

The test specimen shall normally be full size. When the specimen cannot be tested full size,

— Variation of constructional details:

For the application of test results for constructional details other than those tested, see the field of direct application clause within the appropriate test standard and the field of extended application in the appropriate extended application standard.

Different variations of constructional details shall not be included in a single test specimen, unless it can be shown that they will not interfere with the performance of each other.

Rules for direct and extended application of test results may influence the choice of the specific specimen preparation and/or details of test arrangements, so as to cover an envisaged field of application of test results.

7.1.3. Field of application

Field of application can be defined using test reports and other relevant data, in accordance with the procedures specified in EN 15725, which e.g., describes the role of extended application in the classification process.

7.2. Classification criteria for façades

7.2.1. General

Performance levels for each specific parameter are determined from the respective test method:

XXXX: Assessment method medium fire exposure

YYYY: Assessment method large fire exposure

For all performance criteria, the performance duration is calculated from the starting time unit until the failure time.

To determine, the classification period, the performance duration shall always be rounded down to the nearest lower class

7.2.2. Classes MS – medium fire exposure

The specimen shall limit the propagation of a fire front, when exposed to a **medium fire exposure**, according to the following fire spread criteria:

- The failure of **vertical fire spread** criterion occurs when any external or internal thermocouple positioned on level 1 exceeds a temperature increase - above its initial temperature - of 500 K on average over the assessment period of 30 seconds.

- The failure of **horizontal fire spread** criterion occurs when any external or internal thermocouple positioned on the columns 1 and 2 exceeds a temperature increase - above its initial temperature – of 500 K on average over the assessment period of 30 seconds.

The time declared shall be that for the characteristic having the shortest time, i.e. from starting time until failure time.

7.2.3. Classes LS – large fire exposure

The specimen shall limit the propagation of a fire front, when exposed to a **large fire exposure**, according to the following fire spread performances:

- The failure of **vertical fire spread** criterion occurs when any external or internal thermocouple positioned on level 1 exceeds a temperature increase - above its initial temperature - of 700 K on average over the assessment period of 30 seconds.

- The failure of **horizontal fire spread** criterion occurs when any external or internal thermocouple positioned on the columns 1 and 2 exceeds a temperature increase - above its initial temperature – of 700 K on average over the assessment period of 30 seconds.

The time declared shall be that for the characteristic having the shortest time, i.e. from starting time until failure time.

7.2.4. Additional class F1 for falling parts

This is applicable for both large and medium fire exposure assessment methods.

The product shall satisfy the following criterion:

The failure of falling parts (F1) criterion occurs when the increment of mass of falling parts over a period of 10 seconds exceeds 1 kg from the starting time until the failure time.

7.2.5. Additional class F2 for falling parts

This is applicable for both large and medium fire exposure assessment methods.

The product shall satisfy the following criterion:

The failure of falling parts (F2) criterion occurs when the increment of mass of falling parts over a period of 10 seconds exceeds 5 kg from the starting time until the failure time.

7.2.6. Additional classification nb for burning parts

This is applicable for both large and medium fire exposure assessment methods.

The product shall satisfy the following criterion:

The failure of **burning parts** criterion occurs when a falling part burns for 30 s or longer after hitting the ground from the starting time until the failure time.

For memory, the “nb” performance is calculated as the period from the starting time until the failure, i.e. end of 30 s period.

7.2.7. *Optional assessment: smouldering*

This is applicable for both large and medium fire exposure assessment methods.

The product shall satisfy all of the following criteria:

- The failure of edge damages criterion occurs when the damage of the test assembly by spread of smouldering processes reach the top of the assembly or reach the lateral edges of the test assembly – both shall be assessed after termination of the test.

- The failure of maximum temperature criterion occurs when a temperature of higher than 50 °C is measured at any of the thermocouples at the end of the 6 hours period after beginning of the test.

This assessment does not lead to any classification.

7.2.8. *Optional assessment: façade-to-floor junction*

This is only applicable for large fire exposure assessment method.

The product shall satisfy all of the following criteria:

- The failure of Integrity of the junction, i.e. failure of the sustained flaming criterion, occurs when continuous flaming is observed on the unexposed side of the junction for a period of time greater than 10 s. The time of failure shall be reported as the time at the end of this 10 seconds period i.e., when the observation is finally made.
- The failure of Insulation of the junction, i.e. failure of the maximum temperature rise criterion, occurs when any thermocouple positioned at the connection between floor and façade (see assessment method XXX) exceeds a temperature increase above its initial temperature of 180 K.

This assessment does not lead to any classification.

7.2.9. *Summary*

The classes with their corresponding fire performance are given in Table 1.

Table 1 — Classes of fire performance for façades

Class	Test method(s)	Classification criteria	Additional classification
LS	Large fire exposure assessment method	$\Delta T \leq 700$ °C on average over the assessment period Δt of 30s at level 1; $\Delta T \leq 700$ °C on average over the assessment period Δt of 30 s at columns 1 and 2;	Falling parts [a] Burning parts [b]
MS	Medium fire exposure assessment method	$\Delta T \leq 500$ °C on average over the assessment period Δt of 30s at level 1; $\Delta T \leq 500$ °C on average over the assessment period Δt of 30 s at columns 1 and 2;	Falling parts [a] - Burning parts [b]

a

F1 = No falling parts mass increment during 10 s > 1kg ;
F2 = No falling parts mass increment during 10 s > 5kg ;

b

nb = No burning parts with burning duration > 30 s ;

For particular elements and/or exposure other assessment may be performed:

- Occurrence of smouldering,

- Integrity and thermal insulation at the facade-floor junction.

7.2.10. Classes

The following classes (Table 2 and Table 3) are specified:

Table 2: main classes for facades

MS	15	20	30	45	60
LS	15	20	30	45	60

Table 3: Examples of classification with and without additional classes:

LS/MS	tt1	F1	tt2	F2	tt3	nb	tt4
MS	15	F1	20	-	-	nb	30
LS	30	-	-	F2	60		
MS	15	F1	20	F2	30	nb	45

8. CLASSIFICATION REPORT

8.1.General

The aim of the classification report is to provide a harmonised way of presenting the classification of a product, based on results obtained during tests in accordance with the fire test methods, or based on the outcome of an extended application process.

A classification report is expected to detail the basis and the results of the classification process.

8.2.Content and format

The classification report shall have the following content and format:

a) identification number and date of the classification report;

b) identification of the owner of the classification report;

c) identification of the organisation issuing the classification report;

d) details of the nature and use of the product under classification, including its commercial name(s);

e) detailed description of the product.

Either reference is made to a detailed description of the product as available in one of the test reports or in the extended application report(s) in support of this classification, or a detailed description is reproduced in this classification report. The detailed description shall include a full description, identification of all relevant components and the method of assembly etc. The fire exposure used in the test, i.e. MS or LS shall be given. If generic products are used a general description is sufficient. If special products are used, however, e.g., fire retardant glues, all commercial references shall be given.

It shall also include relevant product specifications applicable to the whole or parts of the classified product.

f) test(s) carried out;

1) each test report or extended application report used in support of this classification is identified by:

   i) the name of the laboratory carrying out the tests or preparing the extended application report;

   ii) the name of the sponsor;

   iii) the test report and/or extended application report identification number;

2) identification of the tests and/or extended application reports carried out in accordance with the standard and the envisaged field of application;

3) summary of test results for each specimen tested and or extended application results;

g) classification and field of application;

   1) reference to this current classification procedure;

   2) conclusion: classification of the facade;

   3) assessment of optional performance according to 7.2.7 and/or 7.2.8,

   4) detailed description of the field of application, i.e. the end use conditions of this classification report;

h) additional statements;

The classification report shall include:

1) any restrictions on the duration of the validity of this classification report;

2) the warning 'This document does not represent type approval or certification of the product';

i) name and signature of the person(s) responsible for the classification report.

Bibliography

[1] EN ISO 13943: Fire safety — Vocabulary

[2] EN 15725 : Extended application on the fire performance of construction products and building elements: Principle of EXAP standards and EXAP reports

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