blackhorse testing lane

Icon

Description automatically generated

04-10-2023

TODAYS\_DATE}}

**Date**

Common Corridor Ventilation - CFD Modelling Report

www.firedynamicsgroup.com

Fire Dynamics Group

test

**Client**

Version History

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Revision | Description | Date | Author | Checked by |
| 00 | First Issue | 04-10-2023 |  |  |
| 01 |  |  |  |  |
| 02 |  |  |  |  |
| 03 |  |  |  |  |

Fire Dynamics

WeWork

71-91 Aldwych

London

WC2B 4HN

UK

|  |
| --- |
| Fire Dynamics Group Ltd  13476929 |

sm@firedynamicsgroup.com

This document is confidential and for the exclusive benefit of the client. It may not be assigned to or relied upon by a third party without the agreement of the client. However, this strategy report may be used by the end user of the building in the development of any fire safety management procedures and plans considered necessary to fulfil their responsibilities under applicable fire safety legislation.

Table of Contents

[Version History 1](#_Toc106722105)

[1. Introduction 4](#_Toc106722106)

[2. CFD Modelling Approach 5](#_Toc106722107)

[2.1. Overview 5](#_Toc106722108)

[2.2. Modelling Software 5](#_Toc106722109)

[3. Relevant Guidance 6](#_Toc106722110)

[3.1. BS 9991 6](#_Toc106722111)

[3.2. Smoke Control Association Guidance (SCA Guide) 6](#_Toc106722112)

[3.3. Roslin Road Design 6](#_Toc106722113)

[4. Mechanical Smoke Ventilation System Design 7](#_Toc106722114)

[5. Acceptance Criteria 8](#_Toc106722115)

[5.1. General 8](#_Toc106722116)

[5.2. CFD validation Study – Acceptance Criteria 8](#_Toc106722117)

[6. CFD Model Properties 9](#_Toc106722120)

[6.1. Fire Scenarios 9](#_Toc106722121)

[6.2. Model Geometry 10](#_Toc106722122)

[6.3. Fire Type 12](#_Toc106722123)

[6.4. Fire Size 13](#_Toc106722124)

[6.5. Material Properties 13](#_Toc106722125)

[6.6. Sprinkler System Properties 14](#_Toc106722126)

[6.7. Ventilation and Make-Up Air 14](#_Toc106722127)

[6.8. Mesh Sizing 14](#_Toc106722128)

[6.9. Measurements 15](#_Toc106722129)

[6.10. Slice Files 15](#_Toc106722130)

[7. Timeline Assumptions 16](#_Toc106722131)

[7.1. Means of Escape (Scenario 1) 16](#_Toc106722132)

[7.2. Fire Service Access Phase (Scenarios 2, 3 and 4) 16](#_Toc106722136)

[7.3. Summary of Timeline 17](#_Toc106722137)

[8. Results and Discussion 18](#_Toc106722138)

[8.1. Overview 18](#_Toc106722139)

[8.2. Fire Scenario 1 – Means of Escape 18](#_Toc106722140)

[8.3. Fire Scenario 2 – Fire Service Access 20](#_Toc106722141)

[8.4. Fire Scenario 3 - Fire Service Access 20](#_Toc106722142)

[8.5. Fire Scenario 4 – Fire Service Access 22](#_Toc106722143)

[9. Discussion 23](#_Toc106722144)

[9.1. Summary of Objectives 23](#_Toc106722145)

[9.2. Fire Scenario 1 – Means of Escape 23](#_Toc106722146)

[9.3. Fire Service Access Phases – Fire Scenarios 2, 3 and 4 23](#_Toc106722147)

[9.4. Conclusion 24](#_Toc106722148)

[9.5. Fire Strategy Design Considerations 24](#_Toc106722149)

[10. References 26](#_Toc106722150)

[Appendix A - Heat Release Rate Graphs 27](#_Toc106722151)

[A.1. Fire Scenario 1 27](#_Toc106722152)

[A.2. Fire Scenario 2 27](#_Toc106722153)

[A.3. Fire Scenario 3 28](#_Toc106722154)

[A.4. Fire Scenario 4 28](#_Toc106722155)

[Appendix B - Sprinkler Activation Calculation Methodology 29](#_Toc106722156)

[Calculation of System Activation Time 29](#_Toc106722157)

[Calculation of Smoke Layer Temperature (Zone Model) 29](#_Toc106722158)

[Calculation of Detector Activation Time 30](#_Toc106722161)

[Calculation of Corresponding Heat Release Rate 31](#_Toc106722162)

[Appendix C - Slice Files 32](#_Toc106722167)

1. Introduction
   * 1. Fire Dynamics has been appointed by test to provide fire engineering advice for the proposed blackhorse testing lane development in london. This report details a CFD modelling study undertaken to justify the provision of extended travel distances within the residential common corridors and show that the proposed mechanical smoke extraction systems provide adequate protection to the stairs during fire fighting operations.
     2. The approach taken follows the methodology described in the Smoke Control Association document “Guidance on Smoke Control to Common Escape Routes in Apartment Buildings (Flats and Maisonettes)”[1] (referred to as the “SCA Guide” throughout). Specifically, the report models fires which represent “reasonable worst case” scenarios (as defined by the SCA Guide) within the residential common corridors to show that should fire occur:

* The common corridors can be cleared within a reasonable period of time following an occupant escaping from the apartment of fire origin.
* The stairs are kept reasonably clear of smoke when occupants are escaping from the building and when the Fire Service are undertaking operations.
* When the system is active, the drop in pressure within the corridor does not prevent occupants from opening the doors to the apartments and stair.
  + 1. The results of the study show that under the proposed design the above objectives are met and, as such, the smoke ventilation design meets the functional requirements of Parts B1 and B5 Building Regulations 2010[2].
    2. The report has been prepared as part of an overall Building Regulations submission and should be read in conjunction with the overall fire strategy report and all other supporting documentation prepared and submitted by other consultants who are acting on behalf of the design team.

1. Overview
   1. Reasons for Modelling / Relevant Design Guidance

The design features residential common corridors which feature single direction travel distances of up to 23m. This exceeds the 15m limit stated in BS 9991[3] in a building where sprinkler protection is provided. As such, a fire engineered solution is required to demonstrate that the proposed design provides an adequate level of safety. Under the methodology described in the SCA Guide, extended single directional travel distances of up to 30m can be considered acceptable if it is demonstrated that the common corridors can be returned to tenable conditions within two minutes of an occupant escaping from the apartment of fire origin (Means of Escape Phase). In addition, the SCA guide requires the system to be designed to ensure that the temperatures within the common corridor are controlled and the stair is kept relatively free of smoke when the Fire Service are fighting the fire (Fire Service Intervention Phase).

* + 1. A CFD modelling study has been undertaken to calculate the required extract rate of this system and demonstrate that these performance objectives are achieved and, as such, the design can be considered to meet the functional requirements of Part B1 and B5 of the Building Regulations 2010.
    2. The approach taken is “deterministic” and “absolute” as per the guidance of BS 7974[4].
  1. Modelling Software Used
     1. The CFD analysis has been carried out using Fire Dynamics Simulator (FDS) Version 6.8.0 [5]. The software is produced by the National Institute of Science and Technology (NIST), it has been extensively validated against both, real and laboratory type fires and is an industry standard.
     2. Information on model assumptions can be found in NIST Special Publication 1080 ‘Fire Dynamics Simulator (Version 6) - Technical Reference Guide[6].
  2. Smoke Control System Design
     1. *User to describe common corridor layouts and system design including the extract rates – this is too complicated to automate.*
     2. In addition, the design of the smoke control system should be in accordance with the recommendations of Clause 14.2.4 of BS 9991 as set out below:
* The mechanical smoke shaft will be closed at the base and smoke will be discharged to the outside via extract fans at roof level. Duty and standby fans will be provided to account for potential fan failure.
* The top of the corridor vents discharging into the shaft should be located as close to the ceiling of the corridor as is practicable and should at least be as high as the top of the door connecting the corridor to the stairwell.
* The corridor vents in the closed position should have a minimum fire and smoke resistance performance of 30 minutes and integrity (leakage) no greater than 360m3/h/m2 when tested in accordance with BS EN 1366-2[7].
* No services other than those relating to the smoke shaft should be contained within the smoke shaft.
* The smoke shafts will be located as indicated on the architectural drawings.
* The design of the system should limit pressure differentials so that door opening forces do not exceed 100N at the door handle when the system is in operation.
* A secondary power supply should be provided to the fans and all actuators and controls.
* A 1.0m2 Automatically Opening Vent (AOV) will be provided at the head of the stair.
* The activation of the mechanical smoke control system and the actuation of the AOV at the head of the stair will be linked to an L5 fire detection system[8] installed in the common corridors and stairs of the development. When smoke is detected in the common corridor or stair:
  + The damper at the head of the smoke shaft will open and the fans contained within will activate.
  + The damper to the mechanical smoke shaft within the corridor on the floor of fire origin will open. Dampers on other floors will remain closed.
  + The AOV at the head of the stair will open.
  1. Modelling Acceptance Criteria
     1. The relevant acceptance criteria for the study, as defined in the SCA Guide, are set out below.

**Means of Escape Phase**

* + 1. Under the methodology described in the SCA Guide, extended single directional travel distances can be considered acceptable if it is demonstrated that conditions within the common corridors are returned to tenable levels within two minutes of an occupant escaping from the apartment of fire origin. As per the SCA Guide, “tenable conditions” is taken to be temperatures of less than 60°C and a visibility distance greater than 10m when measured at a 2m head height. These acceptance criteria will be adopted during the means of escape phase.

* + 1. As defined in the SCA Guide, the objective of the system is to keep the stair relatively clear of smoke to provide a place for the Fire Service to retreat to and to allow search and rescue operations from the upper levels to take place.

For the purposes of this assessment, it is proposed that “relatively clear of smoke” is defined by the tenability criteria given in BS 7974: PD6[9] for visibility and temperature for general occupants (10m and 60°C). If these conditions are generally maintained throughout the stair for the duration of the model, then it is our view that the results can be considered acceptable.

* + 1. In addition, Table 5.1 of the SCA Guide states that where a corridor features extended travel distances, temperatures for fire fighters (measured at a 1.5m height) should be limited as follows:
* 2m from the apartment door – <160°C
* 4m from the apartment door - <120°C
* 15m from the apartment door - <100°C

**Pressure in Corridor**

* + 1. Section 5.3 of the SCA Guide states that system should be designed to ensure that the pressure differences between the corridor and adjacent spaces do not cause the force required to open a door to exceed 100N. BS EN 12101-6[10] states that if, at design stage, the force required to overcome the door closer is unknown, a maximum pressure differential of 60Pa may be utilised for design purposes. As such, this requirement is deemed to be met if the maximum pressure differential within the common corridor does not exceed -60Pa.
    2. Pressure differentials have been considered in the means of escape analysis only as in this phase it is likely that occupants will be impacted by corridor pressure profiles. During the fire service access phase, it is assumed that occupants will have already been evacuated or will remain in their apartments.

1. CFD Model Properties

3.1 Fire Scenarios

* + 1. Eight fire scenarios have been considered in this assessment, four Means of Escape scenarios and four Fire Service Access scenarios. Fire scenarios are based on credible worst case apartment locations.
    2. The proposed fire scenarios are summarised in Figure 1 – Figure XX

Figure 1: Proposed Fire Scenarios

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Fire Scenario** | **Assessment Type** | **Reason for Modelling** | **Mechanical Extract (m3/s)** | **Inlet Type** |
| 1 | Means of Escape | ENGINEER TO INPUT | 5.0 | ENGINEER TO CONFIRM: 1.0 m2 AOV |
| 2 | Means of Escape | ENGINEER TO INPUT | 6.0 | ENGINEER TO CONFIRM: 1.0 m2 AOV |
| 3 | Fire Service Access | ENGINEER TO INPUT | 10.0 | ENGINEER TO CONFIRM: 1.0 m2 AOV |
| 4 | Fire Service Access | ENGINEER TO INPUT | 10.0 | ENGINEER TO CONFIRM: 1.0 m2 AOV |
| 5 | Means of Escape | ENGINEER TO INPUT | 6.0 | ENGINEER TO CONFIRM: 1.0 m2 AOV |
| 6 | Fire Service Access | ENGINEER TO INPUT | 10.0 | ENGINEER TO CONFIRM: 1.0 m2 AOV |
| 7 | Means of Escape | ENGINEER TO INPUT | 6.0 | ENGINEER TO CONFIRM: 1.0 m2 AOV |
| 8 | Fire Service Access |  | 6.0 | ENGINEER TO CONFIRM: 1.0 m2 AOV |

Table 1: Fire Scenario Summary

* 1. Model Geometry
     1. The geometry of the building has been recreated by scaling from the architectural GAs provided by the project architects. Screenshots of the CFD models are provided in Figure 2 to Figure 4. The CFD modelling data, which shows the model layout in full, can be provided for review upon request.
     2. Only areas of the building relevant to the analysis have been included in the models, this includes the apartment of fire origin, corridor and full extent of the stair. Note that in the apartment of fire origin it is assumed that all doors to the [protected entrance hall/living area], except to the room of fire origin, are closed, thereby providing a smaller overall volume for the smoke to fill which would result in greater pressure build up in the apartment prior to the door opening.

Figure 2: Model Geometry – Fire Scenario 1

Figure 3: Model Geometry – Fire Scenario 2

Figure 4: Model Geometry – Fire Scenario 4

* 1. Fire Type
     1. It is assumed that the fire load consists of a polyurethane fire which has stoichiometry values as shown in in Table 2. These values have been taken from the SFPE handbook[11]. This is a conservative assumption as in reality the fire load would likely contain textile or cellulosic materials as opposed to being made up entirely of plastic materials. As per Section 13.2 of the SCA Guide on CFD Analysis for Smoke Control Design in Buildings[12],a 10% soot yield and a heat of combustion of 20MJ/kg has been adopted in this analysis.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Carbon Atoms** | **Hydrogen Atoms** | **Oxygen Atoms** | **Nitrogen Atoms** | **Soot Yield (g/g)** | **Heat of Combustion (MJ/kg)** |
| 6.3 | 7.1 | 2.1 | 1.0 | 0.1 | 20 |

Table 2: Combustion Products – Polyurethane Fire

* 1. Fire Size
     1. As per Section C.5 of the SCA CFD guide for suppressed fires with a residential type fire load, a 1MW steady state fire has been adopted for all scenarios. Whilst, during the means of escape phase, it is possible that the fire would still be growing and the 1MW peak would not be reached at the time of escape, for simplicity it is assumed that it has. This is a conservative assumption.
     2. The Heat Release Rate Per Unit Area of the fires (HRRPUA) is 445kW/m2. This is a middling of the 320-570kW/m2 range given in Table A.4 of BS 7974:1[13] for dwellings.
     3. The recorded heat release rates for each model are shown in Appendix A. The models closely follow the programmed fire, there is some fluctuation away from the programmed heat release rates within the models, however this is not considered to have a significant effect on the results obtained.
  2. Material Properties
     1. It is assumed that all surfaces in the models will have the thermal properties of plasterboard which are given in Table 5. This simplification is not considered to have a significant impact on results.

|  |  |
| --- | --- |
| **Element** | **Plasterboard** |
| Density (Kg/m3) | 1440 |
| Specific Heat (kJ/(kg.K)) | 0.84 |
| Conductivity (W/(m.K)) | 0.48 |
| Emissivity | 0.9 |
| Absorption Coefficient (m-1) | 50000 |

Table 5: Material Properties

* 1. Sprinkler System Properties
     1. A domestic sprinkler system throughout the flats which will be designed in accordance with BS 9251[14]. Therefore a sprinkler sub-model has been introduced to all Scenarios. The suppression system does not influence the heat release rate of the fire (which is controlled solely by the RAMP function of FDS). Rather, the spray is included to account for the cooling effect the spray on the temperatures within the fire compartment.
     2. The modelling inputs for this system are provided in Table 5 and are based on the guidance of BS 9251 rather than a specific design for these flats. It is considered that any minor variations in head location etc. in the actual design will not adversely affect the results or conclusions of this study.
     3. The sprinklers have been set to activate at the beginning of each fire service access model (T=0s) given that they would have already activated during the means of escape phase as indicted in Table 4.

|  |  |
| --- | --- |
| **Element** | **Specification** |
| Activation Time | 0s |
| Operating Pressure | 0.5 bar |
| K Factor | 40.0 L/min/(atm)0.5 |

Table 6: Sprinkler System FDS Inputs

* 1. Ventilation and Make-Up Air
     1. Due to the way the combustion model operates in FDS, make-up air is required to provide oxygen to sustain combustion for sufficient fire sizes. For this reason, openings are provided directly to the outside within the apartment in which the fire is modelled.
     2. The SCA Guide Recommends that the size of the low level vent to the outside be provided with dimension 1.25m x 1.25m for a total area of 1.56m2. It should also be noted that the method adopted in BD 2410[15] considered a 0.95m2 ventilation opening to sustain a 1000kW fire.
     3. The openings adopted for each model are located at low level within the apartment and have dimensions (W x H) 1.8m x 0.8m, with a total area of 1.44m2. This is considered to be a more conservative inlet orientation than that prescribed by the SCA Guide as the height of the opening is lower thereby less likely to provide a route for smoke to be ventilated from the apartment.
     4. The low level vent is fully open during the Means of Escape phase and in the Fire Service Access phase, prior to the door to the to the apartment of fire origin being opened. Once the door to the apartment is opened during the Fire Service Access Phase, the vent is blocked off, as make up air to the fire can be provided via the apartment door. This is done to present more realistic air flow conditions, as it is highly unlikely that any of the windows would break in an apartment where sprinkler protection is provided.
  2. Mesh Sizing
     1. The CFD model is divided into a number of small cells (mesh). Given the small and rather complex geometry of the model, a fine and uniform grid of 100mm x 100mm x 100mm has been used in the apartment, corridor and stair section directly adjacent the corridor. The upper and lower portions of the stair were sized with a grid of 200mm x 200mm x 200mm. These values are as per the recommendations of Section 13.2 of the SCA CFD Guide and, as such, it is not considered necessary to conduct sensitivity studies on the mesh size.
  3. Measurements
     1. Point measurements for visibility (m), temperature (°C) and pressure (Pa) have been distributed throughout the corridor/stair in all models at varying heights above floor level. Readings from these measurements are presented in Appendix A.
  4. Slice Files
     1. Several slice files (sections) for smoke visibility (m) and smoke temperature (°C) have been incorporated into the models to allow for visual outputs at head height on the floor of fire origin and throughout the stair. Selected screenshots of these slices can be viewed in Appendix A.

1. Timeline Assumptions
   1. Means of Escape
      1. The model timeline for the means of escape phase is presented in Table 7.

|  |  |  |
| --- | --- | --- |
| **Event** | **Time (s)** | **Discussion** |
| Ignition | 0 | Steady state 1MW fire Initiated |
| Apartment Door Open | 60.0 | This is considered to give a sufficient amount of time to allow conditions of the fire within the apartment to reach a steady state and for a representative amount of smoke to be produced. |
| Stair Door Open | 70.0 | The stair door is programmed to open 10 seconds after the apartment door has opened, to represent the time taken for the occupant to travel to the staircase. Whilst the actual travel time may be slightly greater or less than this, any variations to this figure would not be considered to have a significant impact on the results. |
| Ventilation Activation | Upon Smoke Detector Activation | The mechanical smoke extract system will activate upon smoke detection into the corridor. The AOV at the head of the stair will also open. The fans in the smoke shaft take 10 seconds to reach their maximum extract rate as per Section 13.1 of the SCA CFD Guide. |
| Apartment Door Close | 80.0 | The apartment door will close 20s after it opens, in line with Table 5.3 of the SCA Guide. |
| Stair Door Close | 90.0 | The stair door will close 20s after it opens, in line with Table 5.3 of the SCA Guide. |
| Model Terminated | 300.0 | This is sufficient time to observe the time taken to clear the corridor of smoke. |

Table 7: Timeline of Events for Means of Escape

* 1. Fire Service Access
     1. The model timeline for the Fire Service Access phase is presented in Table 8.

|  |  |  |
| --- | --- | --- |
| **Event** | **Time (s)** | **Discussion** |
| Ignition | 0 | Steady state 1MW fire Initiated |
| Stair Door Open | 0 | The stair door is open for the entirety of the model. It is assumed the Fire Service hoses will hold the door fully open whilst operations commence. |
| Ventilation Activation | 0 | MSVS in the corridor and AOV at the head of the stair are activated from the beginning of the model and will operate at full capacity. This is because it is assumed the system will be switched to Fire Service Access mode and be allowed to run prior to the Fire Service entering the flat. |
| Apartment Door Open | 60.0 | This is considered to give a sufficient amount of time to allow conditions of the fire within the apartment to reach a steady state and for a representative amount of smoke to be produced. Once open, it is assumed the door will remain open for the remainder of the model. |
| Model Terminated | 300.0 | This is considered a reasonable amount of time to determine if smoke enters the stair. |

Table 8: Timeline of Events for Fire Service Access

1. Summary of Results
   1. Overview
      1. The results of the analysis for each scenario are presented in this section and are compared against the relevant tenability criteria.
      2. For further reference, graphs and model screen captures showing the heat release rates, corridor pressures, visibility and temperature throughout the simulations can be viewed in Appendix A. The full modelling data can be provided for review upon request.
   2. Heat Release Rates
      1. As shown in the graphs provided in Appendix A, there is a good correlation between the recorded heat release rate and the programmed heat release rate in all the models.
   3. Means of Escape Assessments
      1. As shown in the detailed results graphs and slices provided in Appendix A, the results of Scenarios [list of numbers of all means of escape assessments] are shown in Table 7 below.

|  |  |  |  |
| --- | --- | --- | --- |
| **Scenario** | **Time Taken to Return Corridor to Tenable Conditions (Failure Criteria = 120 Seconds** | **Maximum Pressure Drop within the Common Corridor (Failure Criteria = -60Pa)** | **Meets Performance Criteria Given in the SCA Guide** |
| 1 | 94.6 | -141.83007kPa | NO!!!! |
| 2 | 41.2 | -71.269389kPa | NO!!!! |
| 3 | 82.0 | -23.747725kPa | Yes |
| 4 | 9.1 | -45.445723kPa | Yes |

Table 7: Overview of Results of Fire Service Access Assessments

* + 1. In all cases, the time taken to clear the corridor and the maximum recorded pressure drop do not exceed the stated failure criteria. As such, the proposed smoke control system meets the relevant performance criteria of the SCA Guide in relation to Means of Escape.
  1. Fire Service Access Assessments
     1. As shown in the detailed results graphs and slices provided in Appendix A, the results of Scenarios [list of numbers of all Fire Service Access assessments] is shown in Table x below. It should be noted that as the corridor arrangement (s) studied in Scenario(s) [insert number(s) of scenarios which do not feature extended travel distances] do(es) not feature extended travel distances, there is no requirement to assess the temperatures within the corridor.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Scenario** | **Maximum Temperature Recorded at a 1.5m Height within the Corridor on the Fire Service Access Path at Varying Distances from the Apartment Door:** | | | **Worst Case Conditions Recorded Within the Stair** | | **Maximum Pressure Drop within the Common Corridor (Failure Criteria =**  **-60Pa)** | **Meets Performance Criteria Given in the SCA Guide** |
| **2m (Failure Criteria = 160°C)** | **4m (Failure Criteria = 120°C)** | **15m (Failure Criteria = 100°C)** | **Visibility (Failure Criteria = 10m)** | **Temperature (Failure Criteria = 60°C)** |
| 1 | 123 | N/A | N/A | 30.0 | 20.3 | -228.0 | Yes |
| 2 | 116 | 32 | N/A | 30.0 | 20.2 | -247.0 | Yes |
| 3 | 116 | 141 | 54 | 30.0 | 20.2 | -207.6 | NO!!!! |
| 4 | 108 | N/A | N/A | 30.0 | 20.1 | -56.3 | Yes |

Table 7: Overview of Results of Means of Escape Assessments

* + 1. In all cases, the results show:
* That temperatures at a 1.5m height within the corridor are lower than the limits stated in Table 5.1 of the SCA Guide (where applicable):
* That the stair is kept “relatively clear of smoke” (as defined in Section $$$); and
* The recorded pressure drops within the corridors do not exceed the -60Pa failure criteria detailed in Section $$$.
  + 1. As such, the proposed smoke control system meets the relevant performance criteria of the SCA Guide in relation to Fire Service Access.

1. Conclusion
   * 1. A deterministic and absolute fire engineering assessment has been undertaken (as per the guidance of BS 7974) to demonstrate that the proposed smoke control system for the building provides an acceptable level of performance, as defined by the criteria in the SCA Guide. The results show:

* Where the common corridor features extended travel distances, the system is capable of returning the corridors to tenable conditions within two minutes following the escape of the occupants in the flat of fire origin.
* Where the common corridor features extended travel distances, the system is capable of maintaining suitable temperatures within the corridors to allow the Fire Service to approach the fire.
* The stairs are kept relatively clear of smoke when occupants are escaping from the building and when the Fire Service are undertaking operations.
* When the system is active, the drop in pressure within the corridor does not prevent occupants from opening the doors to the apartments and stair.
  + 1. As the scenarios chosen represent a “reasonable worst case” test of the systems performance, it is reasonable to assume that should a fire be simulated in any other apartment within the building, positive results would also be achieved.
    2. Given this, it is our view that the proposed arrangement meets the relevant performance objectives of the SCA Guide and, as such, as such, the smoke ventilation design meets the functional requirements of Parts B1 and B5 Building Regulations 2010.

1. References
2. **Smoke Control Association:**  Guidance on Smoke Control to Common Escape Routes in Apartment Buildings (Flats and Maisonettes). Revision 3, January 2020.
3. **Building Regulations 2010.** - Statutory Instrument 2000. HMSO, 2010
4. **BS 9991: 2015.** Fire Safety in the design, management and use of residential buildings. Code of Practice.
5. **BS 7974: 2019.** Application of fire safety engineering principles to the design of buildings – Code of practice.
6. **FDS Version 6.8.0** NIST.
7. **NIST Special Publication 1018-1.** Sixth Edition. Fire Dynamics Simulator. Technical Reference Guide. 18/11/2015.
8. **BS EN 1366-2. 2015.** Fire Resistance Tests for Service Installations Part 2: Fire Dampers.
9. **BS 5839-1:2017** - fire detection and fire alarm systems for buildings - Code of practice for the design, installation, commissioning and maintenance of systems in non-domestic premises.
10. **PD 7974-6:2019** - Application of fire safety engineering principles to the design of buildings - Human factors. Life safety strategies. Occupant evacuation, behaviour and condition (Sub-system 6).
11. **BS EN 12101-6 : 2005** Smoke and heat control systems. Specification for pressure differential systems – Kits.
12. **SFPE Handbook of Fire Protection Engineering.** 2016. Fifth Edition.
13. **Smoke Control Association.** CFD Analysis for Smoke Control Design in Buildings. Edition 1, January 2021.
14. **PD 7974-1:2019** - Application of fire safety engineering principles to the design of buildings - Initiation and development of fire within the enclosure of origin (Sub-system 1).
15. **BS 9251:2021** - fire sprinkler systems for domestic and residential occupancies. Code of practice.
16. **BRE BD 2410: 2005** - Smoke Ventilation of Common Access Areas of Flats and Maisonettes.

1. Results Graphs and Model Screen Captures
   1. Scenario 1 – Means of Escape

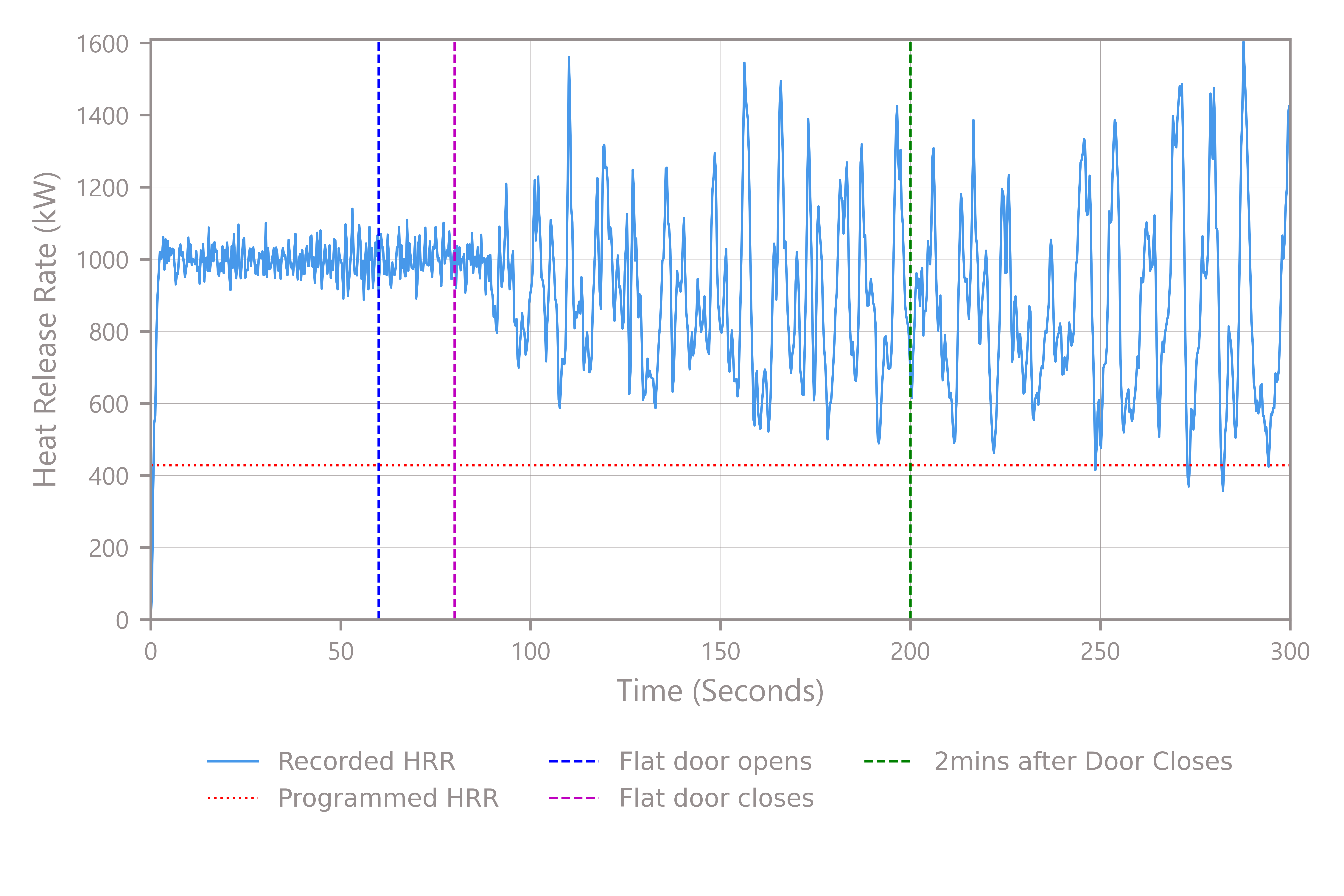


Figure 5: Scenario 1 – Programmed and Recorded Heat Release Rate