Second edition

External fire spread

Building separation and boundary distances

Richard Chitty

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Tel: +44 (0) 333 321 8811
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BR 187

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Contents

Preface to the second edition

The first edition of BR 187 *External fire spread: building separation and boundary distances*[1], published in 1991, was divided into two parts: Part 1: *Methods for determining boundary distance* described the application of several methods of determining boundary distance with a few examples, while Part 2 was a reproduction of Technical paper 5 *Heat radiation from fires and building separation*[2], which gave some of the technical background to the calculation methods. While it was expedient to reuse Technical paper 5 in the first edition, after almost 50 years it is showing its age. Imperial units are used for calculations and some of the graphs justifying assumptions needed to be updated with additional modern data (to confirm that they are still valid). In addition it was not especially clear how the methods used in Part 1 were derived from the theory in Part 2 – this is especially important to those who wish to develop software tools (for example spreadsheets) to perform the calculations. It was also felt that further examples and explanations would be useful to newcomers or those who only occasionally have to calculate boundary distances.

For the reasons stated above, a major revision of BR 187 was needed. The revision allows more recent data to be included to investigate the validity of the assumptions in the methods for current building materials and techniques.

Some people will use this second edition as a reference document, others will use it as a textbook. The working tables A to J (called Table 1 in the first edition) can be found in **Tables for calculations** on pages 46 to 56 – they are easier to locate than in the first edition. They can be copied, annotated and added to other calculation sheets relating to a particular project.

The terminology associated with thermal radiation can be difficult as some words or phrases have a very specific technical meaning, as well as a more general colloquial usage. In this edition we have attempted to be rigorous and the definitions used here are given in the glossary of terms – readers should find this consistent with technical reference books and scientific papers. The definitions in ISO 13943 *Fire safety – Vocabulary*[3] and in BS 7974 *Application of fire safety engineering principles to the design of buildings – Code of practice*[4] do not include many items relevant to radiation.

Who is the guide for?

- Those who know what they are doing and need to solve a boundary distance problem. They may want to go directly to one of the methods as a reference or access the tables for the enclosing rectangles method.
- People who have a tricky problem or are new to the topic (or revisiting it after a long interval) and need to revise how to do things and look at, or work through, some examples.
- Those who want to fully understand the methods and their limitations:
  - because they are studying fire safety science/ engineering
  - they wish to adapt the methods and develop a fire engineering solution to a problem
  - they are developing tools (software, eg spreadsheets) to perform the calculations
  - they have a problem that is not covered by the ‘standard’ methods and need to work around something
  - they wish to use the tools to perform similar radiation calculations
  - they are fire investigators ‘reverse engineering’ the design process.

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BRE would like to acknowledge the authors (R E H Read, M Law and S Melinek) the authors of the first edition of BR 187, which has been used successfully for many years, and is the basis for this second edition.

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- Association of Building Engineers
- Building Control Alliance
- Chartered Institute of Architectural Technologists
- Chief Fire Officers Association
- Chief Fire Officers Association (Scotland)
- Fire Brigades Union
- Institution of Fire Engineers
- Local Authority Building Control
- Royal Incorporation of Architects in Scotland
- Royal Institute of British Architects (RIBA)
- Royal Institute of Chartered Surveyors
- Scottish Association of Building Standards Managers
- Scottish Fire Engineering Network
- The Welsh Government.

National building regulation guidance

Throughout this guide, reference is made to national building regulation guidance. Guidance can be found in the following publications which relate to a specific UK region.

Scotland

The Building (Scottish) Regulations 2013. *Technical handbook – Domestic, and Technical handbook – Non-domestic*. 2013 edition[5].

Northern Ireland

The Building Regulations (Northern Ireland) 2000. *Technical booklet E*. 2012 edition[6].

England

The Building Regulations 2010. Approved Document B *Fire safety*. Volumes 1 and 2. 2006 edition with 2010 and 2013 amendments[7].

Wales

The Building Regulations 2006. Approved Document B *Fire safety*. Volumes 1 and 2. 2006 edition[8].

This guidance is updated from time to time. Readers should ensure that they are using the most current edition and that the guidance is relevant for their region of the UK.

Glossary of terms and symbols

Term	Definition	Notes
ASET	Available safe egress time	Time taken for hazardous conditions to occur in a building
RSET	Required safe egress time	Time taken to evacuate a building
Boundary distance	Distance from a building elevation to the boundary	See Figure 1
Fire compartment	A space in a building bound by fire-resisting barriers	See national building regulation guidance on page vii
Separation distance	Distance from a building elevation to an adjacent building	See Figure 1
Unprotected area	Area of a building elevation considered for calculating boundary distance	See national building regulation guidance on page vii
View factor	Fraction of the field of view occupied by the radiating surface (see Appendix A)	Also called configuration factor

Symbol	Description	Units
A	Unprotected area	m^2
H	Height of an opening or radiating surface	m
I	Radiation intensity	kW/m^2
T	Absolute temperature	K
S	Separation distance	m
W	Width of an opening or radiating surface	m
h	Heat transfer coefficient	$kW/m^2/K$
k	Thermal conductivity	kW/m/K
x	Distance into a solid	m
σ	Stefan Boltzmann constant	5.67×10^{-11} $kW/m^2/K^4$
ε	Emissivity	–
ϕ	View factor (also configuration factor)	–

Executive summary

Following a large fire in London an ordinance was issued by King John in 1212[9] requiring new or restored roofs to be made tiled, shingled, boarded or covered with lead and not covered with reeds or rush. The Great Fire of London in 1666 resulted in a number of regulations to classify buildings based on their construction and to control the width of streets each class of building could be built on.

The experience gained from large fires in cities during World War II led to systematic investigation of fire damage and detailed research into how fires could develop in one building and cause ignition of an adjacent one. By the early 1960s The Building Standards (Scotland) Regulations[10], and shortly afterwards The Building (First Amendment) Regulations for England and Wales[11], included methods for calculating the spacing between buildings and requirements to control the use of combustible materials on the external surfaces of a building. This was probably the first practical application of what is now referred to as fire safety engineering.

In 1991 BRE published BR 187 *External fire spread: building separation and boundary distances*[1]. BR 187 described a number of methods for calculating building separation distances that were previously described in the Building Regulations (up to 1976)[12, 13], and in Approved Document B *Fire safety* (1985 edition)[14]. In addition, BR 187 included a reproduction of a technical report that described the underlying principles of the calculation methods. Referencing BR 187 in Approved Document B *Fire safety* (1992 edition)[15] allowed Approved Document B to be simplified.

BR 187 continues to be referenced in the various national building regulation guidance publications used in the UK.

Since 1991 the way people expect to perform calculations has changed. In the first edition of BR 187, the calculations relied on the use of tables or graphs and one of the methods (notional aggregate area) involved constructing a 'protractor' that could be used on scale (paper) drawings to estimate if a boundary was located within the required limits. Now computer software is used by most people to perform these calculations.

There have also been changes to the style of buildings. In Part 2 of BR 187 (reproduced from Technical paper 5 *Heat radiation from fires and building separation*[2]) it is mentioned that there was 'a trend towards designing buildings with larger windows and combustible cladding'. Now smaller windows are more desirable (to conserve energy) and the external surface of a building may include a complex cladding system (for thermal and sound insulation, weather protection, decorative effects or even energy generation) which may, or may not, be combustible.

These and other issues do not change the underlying technical content of BR 187 but do change the emphasis and create a need to go back to basics for some problems.

While it was prudent in 1991 to write the original version of BR 187 in two parts (including Technical paper 5 *Heat radiation from fires and building separation* in Part 2[2]) to provide the technical background, Part 2 after almost 50 years is now dated. Calculations used Imperial units and some of the graphs justifying assumptions used data from experiments conducted between 1955 and 1960. A major revision of BR 187 has allowed more recent data to be included to investigate the validity of the assumptions in the methods for current building materials and techniques.

The objectives of this revision of BR 187 have been to:

- merge the two parts into a single narrative
- improve the presentation of the methods with further examples
- clarify and update (converting to SI units) the theoretical background
- present detailed analysis to the methods so that users can create their own fire engineering software
- include more recent experimental data to confirm the assumptions used in the methods are valid for modern buildings
- provide the background of methods 1 and 2 used in national building regulation guidance.

The methods outlined in the first edition in 1991 are included in this second edition, together with graphs and formulae to calculate view factors. The experimental determination of a view factor using a photo-cell is not discussed.

In addition the sections on several topics, such as flame projection from windows, have been expanded.

This second edition draws on some concepts and definitions from national building regulation guidance notably the meanings of:

- purpose groups/building use
- boundaries
- external wall
- notional boundary
- relevant boundary
- unprotected areas.

Readers should refer to the relevant national building regulation guidance publications for these definitions.

Introduction

Most accidental fires start as small fires which initially present a very small hazard to adjacent buildings. However, as a fire grows, windows in the burning building will break and other openings in the external envelope may develop; this provides the potential for fire to spread to adjacent buildings by contact with flames and hot gases from the openings, thermal radiation or by burning brands (burning debris from the fire) drifting in the wind.

Buildings are not normally close enough together for fire to spread by direct contact from flames, although a fire could propagate across combustible materials between buildings such as stored materials, wooden sheds, fences, garden debris, rubbish and even cars or caravans parked between buildings. These factors are beyond the scope of building separation and boundary distances and are more relevant to the use of the building which, in England and Wales, is controlled by the Regulatory Reform (Fire Safety) Order 2005[16] and in Scotland under Part 3 of the Fire Safety (Scotland) Amendment Regulations 2006, as amended in 2010[17].

The presence of fire brands from a burning building will be dependent on the materials that are burning. They are, by their nature, small and have the potential to travel a significant distance, maybe several hundred metres. This is an important mechanism of fire spread in wildfires and needs to be considered when, for example selecting roof materials for a building located in woodland. Burning debris from a fire at high level in a tall building also has the potential to spread fire to lower parts of the building if the material falls onto balconies or is blown into a room through open windows. Burning debris may also ignite items such as vehicles at ground level. The main concern here is that a brand could provide a pilot ignition source for materials on an adjacent building that has been heated by thermal radiation from the fire.

If a fire is allowed to develop, as windows in the compartment break, more air can enter the compartment allowing the fire to grow until it is limited either by the amount of fuel, availability of air or the extent of the compartment. Thermal radiation from the external openings in the burning compartment, and from flames leaving the compartment, will then heat surfaces on adjacent buildings. This has the potential, especially if burning brands are present, to ignite the surface(s) of an adjacent building. If left unchecked the fire could then propagate from building to building and develop into a large urban fire. These have occurred many times in history either as the result of accidental fires, for example in London, UK in 1666[9], Oaklands, USA, 1993[18], during warfare in German and Japanese cities during WWII[19] or as a consequence of natural disasters such as volcanoes in Montserrat, The Caribbean, 1997[20], and earthquakes in Kobe, Japan, 1995[21].

It has been known for a long time that fire spread due to thermal radiation can be controlled by adjusting the size of buildings and openings, and the distance between buildings. For example, the Building Act of 1667[22] following the Great Fire of London had requirements relating the height of buildings to the width of streets and for the use of non-combustible materials. The scientific basis of this approach was explored through the 1950s following post-war building studies and resulted in calculation methods which were first made a requirement in the Building Standards (Scotland) Regulations 1963[10] and was shortly followed by similar requirements being introduced in legislation for England and Wales[11]. Technical paper 5 *Heat radiation from fires and building separation*[2] summarised the background to these calculations.

This guide will allow the reader to trace the development of boundary distance requirements in the building regulations since World War II which is of practical relevance today. Existing buildings will have been built to the building regulations and requirements of the time of their construction. The redevelopment of a site or refurbishment of an existing building will need to consider, and may be constrained, by the location of previous and surrounding buildings.

A glossary of terms and symbols is provided on page viii.

It should be noted that ISO 13943:2000 *Fire safety – Vocabulary*[3] and definitions sections of BS 7974 *Application of fire safety engineering to the design of buildings – Code of practice*[4] contain very few terms relating to heat transfer by thermal radiation that could be used here as definitive definitions.

To be consistent with the national building regulation guidance the term 'radiation intensity' is used here to mean the amount of energy per unit time per unit area or radiant power per unit area. Values of radiation intensity are usually given in units of kiloWatts per square metre (kW/m^2). Care needs to be taken with the terminology as scientific textbooks on heat transfer and illumination use very similar terms (such as radiant intensity, $W\ sr^1$, for power per solid angle) for other quantities.

The terms 'heat flux' or 'heat flux density' are often used to refer to radiation intensity.

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External fire spread (second edition)

Most accidental fires start as small fires which initially present a very small hazard to adjacent buildings. While the risk of fire spread between buildings cannot be eliminated completely, the aim of calculating building separation distances is to ensure that ignition of a building adjacent to a fire is sufficiently delayed to allow the Fire and Rescue Service to arrive on site and take preventative action.

This new edition of BR 187 describes different methods for calculating adequate space separation between buildings and has been prepared in support of national building regulations. Several sections, including flame projection from windows, have been expanded.

Specifically this new edition:

- merges the two parts into a single narrative
- improves the presentation of the methods with further examples
- clarifies and updates (converting to SI units) the theoretical background
- presents detailed analysis of the methods so that users can create their own fire engineering software
- includes more recent experimental data to confirm that the assumptions used in the methods are valid for modern buildings
- provides the background to methods 1 and 2 used in national building regulation guidance.

Table 1 (as referenced in the first edition of BR 187) has been split into 10 pages and renamed Tables A to J – enclosing rectangle heights are now on separate pages. This will allow you to copy, annotate and add the tables to other calculation sheets relating to your projects.

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