

The Effectiveness of Sprinklers in Residential Premises

BRE report number 204505

Table of Contents

Executive Summary

Section 1: Summary report

Section 2: Description of the project

2.1	Steering Group	2
2.2	Pilot Study	2
2.3	Benchmark tests	3
2.4	Experimental programme	3
2.4.1	House fires	4
2.4.2	Compartment fires	4
2.5	Cost benefit analysis	5
2.6	Dissemination	6
2.7	Acknowledgements	6
2.8	References	7
	Appendix 2A - Steering Group members	8

Section 3: Pilot Study

3.1	Introduction	1
3.2	Categories of domestic and residential accommodation	2
3.3	The risks from fire in the absence of sprinklers	3
3.3.1	UK Fire statistics database and FDR1 codes	3
3.3.2	Different measures of risk	4
3.3.3	Results	5
3.4	Effect of building height	6
3.5	Direct estimate of sprinkler effectiveness in the UK	7
3.6	Indirect estimate of sprinkler effectiveness	8
3.6.1	Risk as a function of ultimate fire size	8
3.6.2	Benefits of constraining the fire size	10
3.6.3	Estimates of sprinkler benefits	12
3.7	Experience of residential sprinklers in other countries	14
3.7.1	Factors considered in cost benefit analysis	14
3.7.2	Fire risks	17
3.7.3	Estimates of sprinkler effectiveness	18
3.7.4	Costs	26
3.7.5	Monetary benefits	28
3.7.6	Results	28
3.8	Codes and Standards	31
3.8.1	Review of DD 251 and DD 252	31
3.8.2	Developments in New Zealand codes, standards and legislation	33
3.8.3	USA codes, standards and legislation	35
3.9	Conclusions of Pilot Study	35
3.10	References	37
	Appendix 3A – UK statistics data	40
	Appendix 3B – Effect of building height	43
	Appendix 3C – Risks as a function of ultimate fire size, and indirect estimates of sprinkler efficiency	45

Section 4: Benchmark tests

4	Benchmark tests	1
4.1	Introduction	1

4.2	Previous work	1
4.3	Selection and examination of residential sprinkler heads	2
4.3.1	Water distribution tests	2
4.4	Selection of fuel package	7
4.4.1	Conditioning	8
4.5	Apparatus	9
4.5.1	The experimental facility	9
4.5.2	Sprinkler system	9
4.5.3	Fuel package and layout	10
4.6	Instrumentation	14
4.6.1	Temperatures	14
4.6.2	Sprinkler water flow rate	16
4.6.3	Humidity measurement	16
4.6.4	Data recording	16
4.6.5	Visual, video and photographic records	16
4.6.6	Additional measurements	16
4.7	Experimental method	16
4.7.1	Parameters of interest	16
4.7.2	The series of test fires	17
4.7.3	Parameter variation	18
4.7.4	Sprinkler type and model	19
4.7.5	Sprinkler spacing and coverage	19
4.7.6	Sprinkler water flow rate	19
4.7.7	The fuel package arrangement and position of fuel relative to sprinkler spray	19
4.7.8	Presence of a lintel in doorways of the experimental facility	19
4.7.9	Thermal response characteristics of sprinkler	19
4.8	Acceptance criteria	23
4.9	Experimental procedure for each fire test	23
4.10	Results of Benchmark tests	24
4.11	Discussion	26
4.11.1	Unsprinklered fires to characterise fuel package	26
4.11.2	Sprinkler model	26
4.11.3	Sprinkler water flow rate	28
4.11.4	Location of fuel package	29
4.11.5	Effect of lintels in the doorways	29
4.12	Recommended changes and additions to DD 252	30
4.13	Summary and general conclusions of Benchmark tests	31
4.14	References for Benchmark tests	32
	Appendix 4A – Water distribution arrangements	34
	Appendix 4B – Water distribution measurements	36
	Appendix 4C – Selected photographs of tests	46
	Appendix 4D – Specifications for materials	51
	Appendix 4E – Graphs of temperature versus time for Benchmark tests	54
	Appendix 4F – Selected heat release graphs for the unsprinklered calorimetry fires for the Benchmark tests	123

Section 5: Experimental programme

5.1	Introduction	1
5.2	Acceptance criteria	1
5.2.1	Toxicity effect	1
5.2.2	Temperature effects	2
5.2.3	Visibility	2
5.3	House fires	2
5.3.1	Introduction	2
5.3.2	The experimental facility	2
5.3.3	The sprinkler system	5
5.3.4	The fuel arrangement	5
5.3.5	Fire detection	8
5.3.6	Instrumentation	8
5.3.7	Experimental method	11
5.3.8	Results of the House fires	14
5.3.9	Summary and conclusions of house fires	16
5.4	Compartment fires	17

5.4.1	Introduction	17
5.4.2	The experimental facility	17
5.4.3	The sprinkler system	20
5.4.4	Instrumentation	20
5.4.5	The fuel arrangement	22
5.4.6	The large fire compartment	33
5.4.7	Experimental method	35
5.6	References	56

Appendix 5A – House fires test data

Appendix 5B – House fires photographs

Appendix 5C – House fires optical density, visibility and fractional effective dose

Appendix 5D – House fires summary of temperatures and fractional effective dose

Appendix 5E – Compartment fires photographs

Appendix 5F – Compartment fires temperatures, gas concentrations, optical transmittance, smoke alarm activations and water flow rate

Appendix 5G – Compartment fires fractional effective dose, optical density, visibility and temperatures

Appendix 5H – Compartment fires summary of temperatures and fractional effective dose

Appendix 5I – Calorimetry fires heat release rate versus time

Section 6: Cost benefit analysis

6.1	Introduction	1
6.2	Outline cost benefit calculation	2
6.3	Residential classification	3
6.4	Effectiveness of residential sprinklers	3
6.5	The components of the cost benefit calculation	4
6.5.1	Installation costs	4
6.5.2	Water supply costs	5
6.5.3	Capital recovery factor	6
6.5.4	Annual inspection and maintenance charges	7
6.5.5	Risks of death, injury and fires, in the absence of sprinklers	7
6.5.6	The value of each death prevented	8
6.5.7	The value of each injury prevented	8
6.5.8	The average value of property damage in unsprinklered domestic fires	9
6.5.9	Additional factors (not included in the analysis)	9
6.6	Uncertainty analysis	9
6.7	Confidence levels	11
6.8	Results of cost benefit calculations	12
6.9	Cost benefit calculations for 'high-risk' dwellings	13
6.10	Summary and conclusions of the cost benefit analysis	17
6.11	References	19
	Appendix 6A – details of cost-benefit calculations	21
	Appendix 6B – details of cost benefit calculations for HMO's	28
	Appendix 6C – details of cost benefit calculations for buildings of different heights	36

Section 7: Other considerations and recommendations for further work

7	Other considerations, and Recommendations for further work	1
7.1	Concealed and recessed pattern residential sprinklers	1
7.2	Alternative fire suppression systems	1
7.3	Residential sprinklers as compensatory features	2
7.4	Water supplies initiatives	2
7.5	Targeting and assessment of "high risk" properties on a case-by-case basis	3
7.6	Summary of recommendations for further work	3