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British Automatic Fire Sprinkler Association

Safer High-rise Living

The Callow Mount Sprinkler Retrofit Project

A Report from the Sprinkler Coordination Group

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British Automatic Fire Sprinkler Association

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The Sprinkler Coordination Group

The SCG is an informal grouping of the UK organisations with an interest in promoting the wider use of sprinklers. It meets as and when this is required and is presently convened by the Secretary General of BAFSA. The Group works by exchanging information and avoiding duplication in respect of research, campaigning and lobbying. It works closely with the Parliamentary All Party Fire and Rescue Group. Its members are:

British Automatic Fire Sprinkler Association
Chief Fire Officers' Association
European Fire Sprinkler Network
FM Global Insurance
*London Fire Brigade**
National Fire Sprinkler Network
Sprinklers Scotland
Zurich Municipal Insurance

*In this document, any references to the Lakanal House fire should not be construed as in any way being the views, opinions or position of the London Fire and Emergency Planning Authority or the London Fire Brigade or its board, commissioners, officers or members.

Other publications from BAFSA

Sprinklers for Safety: uses and benefits of incorporating sprinklers in buildings and structures (a report by Arup Fire)

Sprinklers for Safer Living: the benefits of automatic fire suppression systems in residential care premises (a report by Arup Fire)

Technical Guidance Note No 1: The design and installation of residential and domestic sprinkler systems

Technical Guidance Note No 2: Using sprinkler systems in buildings and structures

Technical Guidance Note No 3: Watermist systems: compliance with current fire safety guidance

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Rapporteur's Statement of Verification

Having initiated the Scottish Historic Buildings Fire Liaison Group and National Fire Database in conjunction with the eight Scottish Fire and Rescue Services, and chaired the highly successful, 22 country strong, European Science Foundation COST Action C17 'Fire Loss to Historic Buildings' project, I was pleased to accept the role of Project Rapporteur for the Sheffield High-rise Pilot Sprinkler Installation Project. In doing so, I was particularly impressed by the intention to be fully transparent during every step of the project throughout its development, its on-site activities, and analysis of results.

The legislative anomalies that exist in the sprinkler protection of existing high-rise buildings have long since been in need of challenge. It is to the credit of all involved in the Sheffield project that this challenge has been taken up in such a successful, collaborative and mutually beneficial manner.

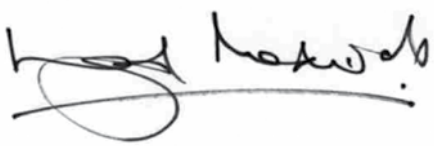
I have been involved in the project at all stages, from inception to completion, and am happy to confirm the validity of its pragmatic approach and relevance of its proven findings. These are far reaching and provide real evidence to confront the hitherto unrealistic and negative positions that have been generally adopted in considering the retrofitting of fire sprinkler protection in existing high-rise properties.

The evidence and conclusions presented in this report are profound in their ability to effect better life safety and the reduction of consequential fire damage, whilst also creating significant cost savings, particularly in these difficult economic times. Supported by unsolicited comments from the Sheffield Callow Mount high-rise occupants, this report should make a positive impact on all those responsible for the future well being of tenants and owners in high-rise properties across the UK.

With the full cooperation of the relevant authorities and, importantly, the tenants occupying the high-rise block, the sprinkler system was designed and installed under independent supervision by a UKAS-accredited certification body.

Overseen as it was by a multidisciplinary Steering Group I can record that every stage of the project was effectively developed, scrutinised and implemented in an exemplary manner. It is also significant that the design and on-site installation was so economically carried out, with all the tenants still in residence, without complaint.

In my professional opinion this was a well conceived and executed project that reaches valid conclusions about the practicability of installing sprinkler suppression systems in unsprinklered high-rise domestic buildings. The results deserve to have a widespread distribution, followed by much practical uptake – particularly in existing high-rise properties that are currently not protected in this way.



Ingval Maxwell OBE DADun RIBA FRIAS CAABC ACA FSAScot
Formerly Director of Technical Conservation, Research and Education, Historic Scotland

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Foreword

When BAFSA was first formed in 1974 its creators wisely decided to make its objectives and purposes as simple as possible:

> *To promote the greater and more efficient use of automatic sprinkler and other systems using water as a means of the control and extinguishment of fires.*

These priorities are unchanged nearly 40 years later, and in a very different world, BAFSA believes that the provision of accurate and independent information is still the best way to promote the wider and more effective use of sprinklers.

Since 2001 we have spent a considerable amount of our resources on promoting research and ensuring that the wider world has easy access to a wide range of publications of which this is the latest.

Even as this is being written, work is being completed on a study re-examining the cost/benefits of domestic sprinkler systems. The study is being undertaken for the Chief Fire Officers' Association by BRE Global and BAFSA is pleased to be a participant and the provider of the majority of the funding for this.

The report you are now reading is the result of BAFSA's largest ever commitment to its primary objectives and has been funded by its members with support from the International Fire Sprinkler Association.

We believe that this report demonstrates beyond all doubt that it is both cost-effective and practical to retrofit automatic fire sprinklers in occupied, high-rise social housing blocks without disturbing residents.

We earnestly hope that the report will receive the widest possible circulation and that its contents will not only inform the ongoing debate about how society can protect its most vulnerable members from the ravages of fire but also will result in the idea that sprinklers in high-rise buildings are not an 'add-on' or luxury but rather the default approach to providing fire safe homes.

BAFSA will continue to follow its founders' wishes and repeats its willingness to collaborate with any group or organisation which shares its ambitions to eliminate the impact of fires on the community and the national economy.

Peter Armstrong
Chairman, BAFSA Council

1. Executive summary

High-rise social housing blocks create a number of specific fire safety and firefighting challenges that may not exist in other properties. The majority of such blocks were built between 1950 and 1970 when the design and fire protection standards of that time were lower than those required by current building regulations. After about 1968, the numbers of such blocks being constructed declined as they fell out of favour with both their intended occupants and local authorities[1].

This report demonstrates that it is both cost-effective and practical to retrofit automatic fire sprinklers in occupied, high-rise social housing blocks of that period, without disturbing residents. The report details how a pilot project, sponsored by the sprinkler industry through the British Automatic Fire Sprinkler Association, was undertaken in September 2011. The project resulted in the retrofitting of a fully comprehensive sprinkler system in a 1960s high-rise residential block, 13 storeys high with 47 flats[2]. Sheffield City Council owns the block, which is operated by Sheffield Homes as sheltered housing.

The report also reviews:

- the identification of risks associated with high-rise social housing blocks;
- the direct and indirect consequences of fire in high-rise residential premises;
- the relevant recommendations in current fire safety legislation and guidance documents;
- research into the use of sprinklers in residential and domestic premises;
- the outcome of the pilot installation of a sprinkler system into a high-rise social housing block.

It acknowledges that:

- high-rise social housing blocks present unique challenges with regard to the protection of residents, and firefighters, from fire;
- where evacuation is required the process takes longer from upper floors, and sprinklers provide significant benefits in addressing this risk;
- where a fire occurs in a high-rise block it can take a significant time before the fire and rescue service can commence firefighting operations, with the potential of greater risk to firefighters. Sprinklers can assist in controlling fire growth while reducing the time between the outbreak of fire and the start of fire suppression activity, and the risk to firefighters.

It summarises the Sheffield pilot project key findings to reveal that:

- the retrofit was completed with little or no disruption to the residents, who remained in their homes throughout the installation programme;
- the owners of the building and residents expressed a high degree of satisfaction with the workmanship and finished product and in not having to leave their homes or pack up their possessions;
- in recording the full and true costs of this project (and other similar exercises) authoritative data is provided for housing authorities, associations and landlords which will allow them to consider the cost-benefit/effectiveness of installing an automatic sprinkler system;
- the approach adopted provides a template for organisations considering the use of sprinklers when developing their fire safety strategy for such buildings as part of a redevelopment or refurbishment programme, or as a result of actions that may be required following a fire risk assessment;
- the sprinkler installation was carried out at a cost of £1,150 per flat. The cost of annual maintenance will be £250 per year if a contract for the whole block is entered into and if access can be guaranteed at the same time (where this is required), at 2011 prices. The combined cost of installation and maintenance provides an annualised cost per flat of £40 over a 30-year time frame.

1 'The period also saw the consolidation and decline of the high-rise era. In 1966, flats of over five storeys accounted for over one-quarter of all new local authority housing. In some places the proportion was far higher; in London, 91 per cent of completions in 1967 were flats and of these two-thirds were in high-rise blocks. However, high-rise construction had not proved to be the promised cheap and popular solution. The coinciding of the physical collapse of Ronan Point with the collapse of sterling in 1967 and the subsequent cut back in the building programme meant that by 1968 the era of high-rise was all but over'. BMA (2003) *Housing and health: building for the future:* http://www.bma.org.uk/images/Housinghealth_tcm41-146809.pdf

2 Two single-bedroom flats have been converted into one two-bedroom unit.

2. Introduction

The fire at Lakanal House, Camberwell, London on 3 July 2009 killed 6 people and injured 20 others. The 12-storey tower block was unsprinklered; after the fire all residents were evacuated and rehoused and the block remains empty.

The current Building Regulations for England and Wales require sprinklers only to be fitted to new domestic high-rise blocks over 30m high. The Scottish Building Standard's Technical Handbook requires sprinklers to be fitted to blocks over 18m high. Significantly, there is currently no legal requirement to fit sprinklers to existing high-rise blocks, and one of the intentions of this report is to draw attention to this omission. It is however worth noting that building regulation in both England and Wales and in Scotland comes into play when major refurbishment work is undertaken and, in theory at least, this should mean that sprinklers should be installed. It's not clear why this was not done, for example, as part of the £3.5m refurbishment project of Lakanal House, Wandsworth, London.

In recent years there have been a number of serious fires in older high-rise blocks that have resulted in occupant and firefighter fatalities. Following a major fire resulting in six deaths in 2009 in a social housing block, Lakanal House[3], questions were asked about the potential benefits of automatic fire sprinklers in protecting residents in such properties. In response, a Department for Communities and Local Government (CLG) report suggested that retrofitting fire sprinklers to such buildings would not be cost-effective or practicable.

The findings of the Sheffield pilot project, as presented in this report, suggest otherwise.

Members of the UK Sprinkler Coordination Group (SCG) had long held the view that retrofitting fire sprinkler systems in existing residential high-rise buildings could indeed be cost-effective. To determine the reality, SCG approached CLG in early 2010 with a proposal for a proper study. Initially, this approach was welcomed and agreement was reached to commission research work, possibly including a pilot retrofit. Unfortunately, after the 2010 election there were no further discussions and CLG cited resource availability as the reason for their withdrawal. CLG were invited to join the Steering Group (see below) set up to manage the project but did not send a representative to any of the meetings

The SCG decided to proceed with the project and at the end of 2010 identified a suitable housing block in Sheffield, South Yorkshire. Delegating the management of the project to BAFSA, the Steering Group devised and completed the design and installation of a retrofit sprinkler system in a 13-storey block at Callow Mount, Sheffield. The aim was to determine the real costs, both financial and societal, of retrofitting an automatic fire sprinkler system into an unprotected, older, high-rise social housing block of earlier design while also determining the problems of doing so and developing guidance which can be used elsewhere.

To oversee and monitor this project a Steering Group was created with representatives from:

- British Automatic Fire Sprinkler Association (BAFSA)
- Chief Fire Officers' Association (CFOA)
- Kier (Sheffield Homes' maintenance contractor)
- Marpal Ltd (construction, design and management (CDM) co-ordinators)
- National Fire Sprinkler Network (NFSN)
- Roy Young Consultancy
- South Yorkshire Fire and Rescue Service
- Sheffield Homes
- Warrington Certification
- Zurich Insurance

3 Note that a Coroner's Inquest is currently (March 2012) still under way in respect of this fire.

The search for a tower block, for use as premises for the Sprinkler Coordination Group's retrofit project, took the SCG to Sheffield Town Hall, for discussions with the City Council. It was agreed among the parties that a candidate tower block could be found among those at Callow Mount, being City Council properties managed by Sheffield Homes. (Photo by permission of Sheffield City Council.)

Following appropriate agreements among all parties, BAFSA were granted a licence by Sheffield City Council to proceed with the installation. BAFSA appointed Domestic Sprinklers Limited, an experienced, third-party-certificated member-company, to design and install a BS 9251 residential sprinkler system. In order to ensure full transparency of all aspects of the design and installation, Warrington Certification Limited, the principal third-party certification body for residential and domestic sprinkler installation companies, was invited to oversee the design and installation process, assisted by the Roy Young Consultancy and the Chairman of BAFSA.

The installation commenced on 30 August 2011 and was successfully completed on 28 September 2011.

3. Background

3.1 BRE research: cost-effectiveness of residential sprinklers

In 2003 the then Office of the Deputy Prime Minister commissioned the Building Research Establishment (BRE) to carry out a study[4] into the cost-effectiveness of sprinklers in residential premises. The purpose was to ascertain whether or not sprinkler systems could provide, at a reasonable cost, an adequate control of fire to allow escape/rescue.

The BRE study objectives were:

- to analyse statistical information to determine how effective sprinklers had been in reducing life loss and property damage;
- to make a risk-based assessment to determine the potential benefits for the UK housing sector, including houses in multiple occupation (HMOs), flats and maisonettes of varying heights;
- to collect data on the benefit and costs of residential sprinklers;
- to establish benchmark tests for UK conditions to support the further development of DD 251 and DD 252;
- to carry out an experimental programme to examine and quantify the effectiveness in fire suppression of residential sprinklers, including in the room of fire origin.

The BRE research programme studied and assessed the effectiveness of sprinklers in eight simulated domestic dwelling lounge fires and 29 compartment fires, and their ability to control toxicity, temperature and visibility.

The findings, reported on in 2004, indicated that:

- for the majority of fires, a sprinkler installation proved effective, possibly reducing casualties in the room of origin;
- sprinkler systems were not as effective in slowly developing fires or fires where the initial point of ignition was shielded;
- smoke alarms installed in the fire test rooms responded in approximately half the time required by the sprinklers, and well before conditions become untenable;
- a residential sprinkler installation is probably cost-effective for tall blocks of flats (11 or more storeys), residential care premises and children's homes.

Section 3.2 below discusses the cost-benefit analysis in more detail.

Although the intention of the BRE programme was to examine and quantify the effectiveness of residential sprinklers in relation to life safety in the room of fire origin, following the release of the final report considerable attention focussed on the results of the shielded fire tests – in particular on the finding that conditions became unsurvivable in the room of origin for both the sprinklered and unsprinklered fires.

In consequence, it is unfortunate that other more positive results (on the benefits of sprinkler protection outside the room of origin for the shielded fire and in the room of origin for unshielded fires) have sometimes been overlooked and the 2011 Sheffield project sought to redress this inconsistency.

3.2 BRE view of cost-benefits

Section 6 of the BRE 2004 report presented a cost-benefit analysis of the expected impact of residential sprinklers to determine whether or not there was a positive gain in providing them in a range of building types, including care premises.

In doing so, BRE used a statistical value of £1,243,000 for each life saved and £58,300 for each

4 Full details of this study and its key findings can be found in BRE Report Number 204505, *Effectiveness of sprinklers in residential premises.*

injury prevented. These figures were those used by the Department of Transport in its cost-benefit assessments on the investment required to prevent road crash fatalities, and in making Regulatory Impact Assessments for the Department for Communities and Local Government.

Since the risks associated with building safety are very different from those of road safety, the applicability of these figures as the basis of assessment in fire sprinkler considerations is open to debate[5]. Consequently, a number of other cost-benefit studies, founded on a 'willingness to pay' basis, have used a different range of values. Nonetheless, the quoted BRE statistical values offer a reasonable indication of the financial implications involved in such assessments, against which retrofit implementation costs might be compared.

In addition, it is also interesting to reflect upon what issues were, and were not, considered in the BRE study, as indicated in Tables 1 and 2. The additional factors (in Table 2) do not appear to have been taken into account by BRE either because the data was unavailable or was too hard to quantify with any accuracy at the time. Importantly, in assessing the factors that were taken into account, the study concluded that sprinklers would *probably*[6] be cost-effective in tall blocks of flats of 11 storeys or more and possibly in blocks of flats of more than 6 storeys.

Table 1. Factors considered by BRE as part of the cost-benefit analysis of sprinkler installation.

Factors considered	
Costs	*Benefits*
Installation	Lives saved
Water supplies	Injuries prevented
Maintenance and testing	Property loss savings

Table 2. Factors not considered by BRE as part of the cost-benefit analysis of sprinkler installation.

Factors not considered	
Costs	*Benefits*
Accidental water damage	Environmental impact discharge
Arson fires	Insurance premium reductions
	Fire brigade cost savings
	Design/construction trade offs

The BRE study findings were subsequently utilised in part of the Regulatory Impact Assessment in England/Wales and in Scotland in respect of changes to building regulations in both countries. However, the new requirements that were actually implemented in the two different regimes are very different. In England and Wales, a substantial weight of opinion in favour of requiring sprinklers in new residential care premises was ignored and the need for sprinklers in high-rise blocks only came into play in buildings taller than 30m. In Scotland, by contrast, the regulations require residential sprinklers to be installed in all new and refurbished residential care homes and in blocks of flats over 18m high.

3.3 Factors not considered in the BRE study

The decision in the 2006 version of Approved Document B not to include a proposal for sprinklers in high-rise blocks lower than 30m has been frequently questioned by a number of organisations including the Chief Fire Officers' Association, the Fire Brigades Union and the Fire Protection Association as well as all of the fire industry associations.

Therefore, revisiting all the factors that were omitted from the BRE study can allow a better understanding of the costs and benefits that the installation of sprinkler protection can bring.

5 For example, comparable figures used in the US in 2007 are $7.94m and $171,720 (£5.2m and £112,300). Source: NISTIR 7451, S.K.Fuller et al., *Benefit-Cost Analysis of Residential Fire Sprinkler Systems*, September 2007, USA.

6 Author's emphasis.

A view across Callow Mount. One of these 13-storey towers was chosen for the pilot retrofit project, and BAFSA was granted a licence by the City Council to manage the project.

This particular objective of the BAFSA pilot project will permit a definitive assessment to be made of the financial and practical issues in a actual installation.

3.4 Cost: accidental water discharge

As a result of the misrepresentation of the way sprinklers work in numerous films, tv programmes and advertisements there is a popular belief that sprinkler systems can result in excessive water damage as a result of all the heads actuating at the same time[7]. The same series of myths expresses fear that sprinklers, like smoke alarms, will 'false-alarm' as a result of domestic mishaps such as burnt toast. Significant efforts have been made in the fire safety community to correct this misunderstanding. In reality, when activated, only a minimal amount of water is released. While unwanted activation can occasionally be caused by accidental or malicious damage to a sprinkler head, or by a leak from the water supply system, this is no more likely than a leak from any properly installed plumbing system.

Such commonly held misconceptions were, inevitably, encountered in meetings with the Sheffield block's residents during the initial stages of the pilot project. These were addressed by showing them the BAFSA DVD presentation *Sprinklers for Safety*[8].

There is international evidence that the likelihood of a sprinkler head operating accidentally is 1 in 500,000[9]. Accidental operation due to mechanical damage is also statistically low and can be prevented by installing sprinkler head guards or by using concealed heads in those areas where there is a possibility of deliberate attack.

3.5 Benefit: environmental impact reduction

It was also explained to the Sheffield residents that sprinkler systems not only provide benefits in terms of life safety and protection of property, they also reduce the impact a fire has on the environment by limiting the production of carbon dioxide and other products of combustion[10].

Implicit in the environmental benefit of quick and reliable suppression of fires is the prevention of the need to replace and repair buildings, resulting in significant savings in respect of the energy and resources that have to be expended in buildings.

To summarise, these benefits could include any or all of the following:

- extent of post-fire demolition or refurbishment and repair to buildings;
- extent of fire-resisting glazing;
- exposure to harmful materials and substances that can be released in large fires;

7 The ultimate misrepresentation was perhaps an episode of a BBC hospital drama that showed a fire in a storeroom where no sprinkler heads had opened but staff and patients were slipping and sliding in the water from the sprinklers in a neighbouring corridor!

8 Single copies of this can be obtained free of charge from BAFSA: info@bafsa.org.uk.

9 Arup Fire, *Sprinklers for Safety,* 2006.

10 Bureau Veritas report for the Business Sprinkler Alliance: http://www.business-sprinkler-alliance.org/bureau-veritas-report.

- risk of polluting ground, air and water courses;
- costs and impact of treating water used by the fire and rescue service[11];
- removing the need to relocate residents to temporary or permanent accommodation by preventing major destructive fires;
- facilitating the continued use of existing buildings;
- protection of built heritage and heritage contents and fabric.

3.6 Benefit: advantages for fire and rescue services

While the principal benefit to the fire and rescue services must be the significant reductions in the exposure of firefighters to danger, there will also be cost savings:

- lower numbers of false alarms caused by spurious operation of fire detection systems[12];
- a reduced number of fire pumps and special appliances and personnel required at an incident;
- a reduction in the duration of the attendance time;
- experience shows that many fires are extinguished by the time the fire service attends, thus requiring no fire service action other than inspection and assistance with the clean-up.

3.7 Benefit: design and construction trade-offs

The potential for providing alternative solutions through the use of sprinklers is considered to be a key factor in determining whether or not their provision in residential premises is cost-effective.

It is important to recognise that in certain circumstances the presence of a sprinkler system may permit significant cost savings in respect of the provision of other fire protection measures. More information on such 'trade-offs' can be found in section 5.3 below and also in chapter 3 of Arup Fire's report *Sprinklers for Safety* (BAFSA, 2006).

While there may be alternative views on the appropriateness and applicability of trade-offs, there is little doubt that their presence does provide architects and developers with significant design freedoms in respect of compartment size, travel distances and the levels of fire-resistant construction required. One particular set of circumstances where sprinklers can play an important role is where a refurbishment (or even new build) seeks to provide an 'open plan' environment or an 'inner room' situation. Details regarding the value of sprinklers in such circumstances can be found in 5.2 below.

3.8 Benefit: insurance premium savings

It is well known that insurers have such confidence in automatic fire sprinkler systems that, given two very similar premises, one sprinklered and one unsprinklered, the latter will attract higher insurance premiums. The Fire Protection Association, which represents the views of fire insurers, says: 'Insurers will be certain to take a more favourable view of firms whose premises have approved sprinkler systems'[13]. It's also likely that the self-insurance element of a fire insurance policy (the 'policy excess') will be much lower for sprinklered buildings.

3.9 Reappraisal of the BRE research findings

The BRE study concluded that whilst sprinklers were not cost-effective in most residential premises, they were probably cost-effective for tall blocks of flats (11 storeys or more) even without the above factors being taken into account.

In reviewing these additional issues, and supported by the 2011 Sheffield pilot project findings, it is considered that the case for retrofitting automatic fire suppression in existing high-rise properties is now even stronger than that put forward by BRE in 2004.

11 Estimates suggest that intervention by the f&rs could use as much as 20 times the water used by a sprinkler system. Arup Fire (2006), op. cit. suggests 6 - 10 times as much.

12 An alarm can normally only be actuated by a sprinkler system if there is a flow of water through a sprinkler head.

13 Jackson, L., *Guide to Building Fire Protection,* Fire Protection Association, 1997.

4. Current legislation

BAFSA member company Domestic Sprinklers was chosen as the main contractor for the installation.

The BRE research inevitably influenced changes to building standards across the United Kingdom but, as previously noted, not all of the findings appear to have been fully taken into account. The following section reviews the recommendations in current building standards documents for the provision of sprinkler protection in high-rise residential premises in the UK.

4.1 England and Wales: Building Regulations and official guidance

The minimum requirements for fire safety measures that need to be provided to meet the requirements of the Building Regulations in England and Wales are contained in Part B of Schedule 1 to the Building Regulations. Guidance on technical solutions to implement such measures is given in the two volumes of Approved Document B to the Building Regulations, and Volume 2 (2006, with 2007 amendments) is entitled *Buildings other than dwelling houses;* it deals with the requirements for blocks of flats. Its guidance proposes that new and refurbished multi-storey blocks with a floor more than 30m above ground floor should be fitted with a sprinkler system.

The document further identifies that a sprinkler system should be provided throughout a building, or separated part, and installed in accordance with BS 9251: 2005: *Sprinkler systems for residential and domestic occupancies. Code of practice.* It also advises that the limit in the application of the standard as it applies to buildings above 20m in height can be ignored.

4.2 Scottish Building Standards

Scottish Building Standard 2.15 requires automatic life safety suppression systems in two categories of domestic buildings:

- dwellings which form part of a sheltered housing complex;
- high-rise domestic buildings with a top-most storey of more than 18m, but not more than 60m.

For the high-rise premises, the Standard requires:

> *... every flat . . . maisonette including all ancillary rooms and spaces throughout the building should be provided with a life safety suppression system designed and installed in accordance with BS 9251: 2005. For the purposes of satisfying standard 2.15, a high rise domestic building should be regarded as a 'residential occupancy' as defined in BS 9251: 2005 and the limit on the scope of BS 9251: 2005 to buildings below 20m in height can be ignored.*

4.3 Northern Ireland: Building Regulations

The Building Regulations (Northern Ireland) 2000 require that an automatic sprinkler system complying with the relevant recommendations of BS 5306-2: 1990 should be installed throughout the building where it has a storey more than 30m above ground level (supporting Technical Booklet E, *Fire safety,* 2005).

5. Fire safety guidance for existing buildings

5.1 England and Wales: Regulatory Reform (Fire Safety) Order 2005

The Regulatory Reform (Fire Safety) Order 2005 (the Fire Safety Order or FSO) replaced many earlier items of fire safety legislation, including the Fire Precautions Act 1971. In relation to residential premises the Order places a duty on employers, owners and occupiers to provide a fire safe environment and more specifically to maintain adequate fire safety measures only in relation to the common parts of multi-occupied premises such as high-rise blocks.

In high-rise blocks the responsibility for complying with the Order rests with the 'Responsible Person' defined in the Order, being the dutyholder in respect of fire safety matters in the premises. For high-rise accommodation this would normally be the owner of the premises or the managing agent or, in respect of social housing, the housing association or housing authority or registered social landlord.

5.1.1 Guidance document: sleeping accommodation

The Responsible Person has a duty to carry out a fire risk assessment that must focus on the safety of all 'relevant persons' in the event of a fire. To assist Responsible Persons in meeting their duties under the Order, CLG have published a series of Guides for use in England and Wales. With respect to the management of fire risks relating to premises used as sleeping accommodation, the guidance includes the 2006 document *Fire safety risk assessment: Sleeping accommodation* (the CLG Guidance Document).

The CLG Guidance Document contains a list of premises to which the guide applies. This includes a reference to 'the common areas of flats and maisonettes' and provides guidance on how to prevent fires and ensure people's safety in the event of fire. It also makes reference to other guides and standards that may be applicable to high-rise flats and maisonettes. The document consists of two parts:

- Part 1 explains what a fire risk assessment is, and how it should be conducted;
- Part 2 provides further guidance on fire precautions in premises providing sleeping accommodation.

While the Guidance Document does not require the installation of sprinklers in high-rise flats and maisonettes, it does recognise that there may be some safety and financial benefits in providing such a system, including:

- being regarded as a cost-effective solution for reducing the risks created by a fire;
- reducing the amount of portable firefighting equipment required;
- relaxing restrictions in the design of buildings;
- allowing alternative approaches to satisfying building regulations and other fire safety requirements.

5.2 Guidance on fire safety in purpose-built flats

In August 2011 the Local Government Improvement and Development organisation launched in electronic form a guidance document entitled *Fire safety in purpose-built blocks of flats,* with funding from the Department of Communities and Local Government and Electrical Safety Council. The decision to produce it reportedly aimed to resolve confusion over the scope of the Fire Safety Order and to clarify the view that the application of the Order to blocks of flats had proved problematic, resulting in wide variations in the standard of fire safety. It should be noted that that document was written before the announcement of the success of the Callow Mount

The installation team was equipped with BAFSA-branded t-shirts.

pilot project, so it is hoped that the publishers will arrange to have the guidance revised in the light of its conclusions.

The purpose of the LGID's guidance is to ensure adequate levels of fire safety in existing blocks of flats, regardless of age. It is not prescriptive, providing guidance and recommendations, together with examples of best practice. It also identifies that sprinkler systems:

- are, using appropriate design and installation standards, suitable for use in domestic and residential premises;
- are the default proposal in Approved Document B, volume 2 to the Building Regulations for installation in new blocks of flats over 30m;
- greatly enhance the future fire safety of residents in high-rise blocks, making death unlikely, even in a flat where the fire starts; and that
- when installed can permit design freedom, such as open-plan layouts.

With regard to the use of sprinklers in existing buildings, unfortunately, the LGID guide also promotes views, hopefully now debunked, that retrofitting such systems:

- cannot always be readily applied to existing buildings;
- may not be reasonably practicable.

However, the guide recognises that such supposed difficulties should not preclude the use of sprinklers where there is clear justification and appropriate consideration of the practicalities of their installation and subsequent maintenance. It also acknowledges that they may be used to protect refuse bins and stairways or lobbies where refuse chute hatches open onto protected stairways or lobbies containing more than two flat entrance doors.

Based on the experience of successfully completing the Sheffield pilot project installation, and an associated scheme in Pontypool (see below), evidence of the practicality of installing sprinklers in existing high-rise buildings has now emerged which firmly demonstrates that the less-than-enthusiastic support for sprinklers as expressed in the LGID report may need to be reconsidered.

5.3 BS 9991: 2011

British Standard 9991: 2011, *Code of practice for fire safety in the design, management and use of residential buildings,* offers guidance to those designing or refurbishing buildings and is largely based on fire safety engineering principles. The standard provides a risk-based approach to prescribing fire safety precautions in the design of the following types of buildings:

The chosen block at Callow Mount, 'Handbank', was built in 1962 and had recently undergone refurbishment. It had originally contained 48 one-bedroom flats, two of which were converted into a two-bedroom unit.

- dwellings (single-family dwelling houses, self-contained flats or maisonettes);
- residential accommodation blocks (for example, for students or hospital staff), with individual bedrooms and the provision of kitchen/sanitary facilities constructed within a fire compartment, accommodating not more than six persons;
- sheltered housing and extra care housing.

This standard complements BS 9999: 2008, *Code of practice for fire safety in the design, management and use of buildings.* These standards usefully provide alternatives to the technical solutions proposed in Approved Document B to the Building Regulations. Together BS 9991 and BS 9999 offers a middle ground in terms of flexibility, as they sit between the general approach proposed by Approved Document B (and the Scottish Technical Handbooks) and the fully engineered approach of BS PD 7974: 2001, *Application of fire safety engineering principles in the design of buildings. Code of Practice.* (This potential for greater design freedoms is discussed in more detail in section 7.2 below.)

British Standard 9991 can be used as a tool for assessing existing buildings, although fundamental change in line with the guidelines might well be limited or not practicable. The standard permits variations where additional fire protection measures are provided. Where these additional measures, which include sprinklers, are installed, the the level of risk can be reduced.

For high-rise residential premises blocks a brief summary of the recommendations is provided in 5.3.1.

5.3.1 Use of sprinkler systems in BS 9991

British Standard 9991 proposes variations in other published guidance where sprinkler systems are provided:

- where a flat is fitted with a sprinkler system and an LD1 fire detection system in accordance with BS 5839-6, it may have an open-plan living room with inner rooms leading off it;
- with the exception of sheltered and extra care housing, where a block of flats is fitted with a sprinkler system in every flat, the maximum travel distance for escape in one direction only may be increased from 7.5m to 15m and for escape in more than one direction it may be increased from 30m to 60m;
- where sprinklers are fitted throughout a house or block of flats, the minimum distance between the side of the building and the relevant boundary may be halved and the amount of unprotected area on the façade doubled;
- where fire and rescue service attendance is expected to be less than 10min the distance from a fire pumping appliance to any point within the house or flat can be increased.

British Standard 9991 recognises that the provision of sprinklers is effective in reducing fire severity and permits a reduction of fire resistance of compartment walls and floors as listed in Tables 3 and 4 of the standard. Sprinklers also permit the fire resistance of glazing to be reduced or the use of non-insulated glazing.

In this regard, the findings of the Sheffield pilot project demonstrates how cost-effective the adoption of these variations can be.

6. Sprinkler system Standards and guidance

6.1 BS 9251: 2005

British Standard 9251: 2005, *Sprinkler systems for residential and domestic occupancies* is a Code of Practice providing guidance on the design and installation of fire sprinkler systems in residential and domestic occupancies. Its intention is to offer a more building-specific and cost-effective sprinkler solution for residential premises.

The standard is deemed to be suitable for residential occupancies, including blocks of flats not more than 20m high, with a maximum individual room size of 180m^2. Where buildings in multiple occupation are more than 20m high, special circumstances need to be considered, and the Authority Having Jurisdiction should be consulted before designing a sprinkler system for this type of premises using BS 9251: 2005[14].

6.2 BAFSA Technical Guidance Note No. 1

A revised version of BAFSA's Technical Guidance Note No.1, T*he design and installation of residential and domestic sprinkler systems,* will be published in spring 2012. The TGN is designed to provide clarification to BAFSA members on a number of clauses in the BS document that had given rise to varying interpretation.

The TGN seeks to resolve a number of areas of inconsistency and doubt that remained in the text of BS 9251 after its adoption. Where a sprinkler design or installation deviates from the recommendations of BS 9251 it is BAFSA's view that such deviations must be brought to the attention of the Authority Having Jurisdiction for their approval. BAFSA also suggests that such deviations be put in writing and provided to the owner or occupier of the protected premises. Some of the areas within the BS where clarifications are considered necessary as they relate to high-rise accommodation include:

- Where buildings over 20m high are protected by BS 9251 sprinkler systems then the entire building should be sprinkler protected, and the system be designed to the 'Residential' requirements, with a minimum of 30min duration of water supply.
- Special provision may need to be made to strengthen the level of protection provided.
- In all cases where the building height exceeds that given in BS 9251, a risk assessment should be made of the building for or by the Authority Having Jurisdiction. Appropriate additional specified equipment, such as dual electric pumps fed from independent electrical supplies, should be provided if this is indicated as being necessary in the fire risk assessment.
- Where sprinklers are to be installed in buildings outwith the scope of BS 9251, the sprinkler systems shall be installed to BS EN 12845: 2009, *Fixed firefighting systems. Automatic sprinkler systems. Design, installation and maintenance.*
- BAFSA's TGN No.1 considers that where only one or two flats are sprinklered but not the corridors or common spaces, then the domestic requirements (as opposed to residential requirements) would be appropriate.
- Guidance to the Building Regulations and Scottish Building Standards suggests that only individual flats need protection (that is, that common areas do not need to be protected). However, it is BAFSA's view that experience of deliberately set fires in corridors and stairwells makes provision of protection only to individual flats unwise.
- Common areas should also follow residential requirements.
- Domestic sprinkler systems can protect rooms larger than 40m^2, providing a fire risk assessment to determine fire load and the potential for ignition sources[15] has been carried out.

14 Note that this Standard will be reviewed in 2012.

15 For example, is the occupant of a flat a bedridden smoker?

Should there be an abnormal fire load in such rooms, it is BAFSA's view that the premises should be protected to the 'Residential' recommendations of BS 9251.

- Bathrooms, shower rooms and toilets less than 5m^2 should be protected by sprinklers but these are not mandatory in cloakrooms and toilets under 2m^2.
- Approved, concealed sprinkler heads may be used for life safety purposes.
- Notwithstanding the requirements of some building control officers and independent inspectors, partial protection of a flat or dwelling is rarely acceptable.

As previously indicated, incorporation of any of the above deviations should be agreed with the Authority Having Jurisdiction and the owner notified in writing.

7. The use of sprinklers in high-rise blocks

7.1 The benefits of sprinkler protection

Sprinklers have been successfully used for the protection of commercial and industrial buildings for over 130 years. But their potential to improve life safety in a wide range of other properties has not always been fully recognised. Specifically, in the case of social housing, care premises, homes in multiple occupation, hostels and similar properties, there are now clear arguments to confirm that sprinkler systems offer the best chance of preventing deaths should a fire occur in such premises.

It is also increasingly being recognised that sprinklers can provide additional levels of safety for firefighters in large complex structures, such as high-rise residential premises. This awareness has led to an increasing use of sprinkler systems in residential and domestic premises, with a legislative requirement for their incorporation in new build premises emerging in many jurisdictions.

In the current volumes of Approved Document B of the Building Regulations (in England and Wales), and in Scotland, the Technical Handbooks of Scottish Building Standards, there is recognition of the value of sprinklers in improving levels of safety for occupants, in addition to preventing the spread of fire.

Despite these changes, there are no requirements to ensure that these valuable safety measures are installed on existing high-rise domestic blocks of flats. However, the experience gained from the Sheffield pilot project can demonstrate that retrofitting a sprinkler system incorporating fast response sprinkler heads provides improved levels of fire safety for occupants and firefighters at a very reasonable cost. Almost equally important is the understanding that such installations can be undertaken in a very short time with little disruption to occupants.

The sprinkler retrofit was planned to protect all the block's flats, lobbies, communal rooms and even the four external bin stores at the bases of the bin chutes (see above). Bin stores are frequently targeted by arsonists.

7.2 Design freedoms

Local authorities usually refurbish their housing stocks every 16 years, and carry out major upgrades every 30 years. One of the most significant but little-known benefits in complying with these requirements is the additional flexibility that the installation of sprinkler systems provides to designers and building owners. In terms of internal layout and means of escape, greater awareness is required that the use of sprinklers can allow such design freedoms, and cost-effective compliances that would not otherwise be possible as part of these refurbishment programmes.

When undertaking such major refurbishment programmes, those responsible may wish to redesign the internal layout to meet modern needs, and the range of design freedoms associated with retrofitting sprinkler protection could be beneficially investigated. Often their integration into a comprehensive retrofit project can compensate for relaxations in other fire protection requirements, including:

- being an alternative to providing secondary means of escape from upper levels of apartments, or dwellings, with a floor greater than 4.5m above ground level;
- relaxation of the requirement for internal fire spread (linings), for example, Class 1 instead of Class 0;
- relaxation of the 7.5m dead-end travel distance limit for apartment buildings;
- relaxation of the 30min fire resistance of walls, floors and doors (providing they are of sound construction);
- relaxation of the requirement for heat detectors in kitchens;
- acceptance for inner rooms to open into an open-plan living space[16];
- relaxation of the need to provide intumescent door seals on those leading to escape routes.

16 *Open plan flat layouts – Assessing life safety in the event of fire,* NHBC Foundation, 2009.

Particular attention was paid to communal areas, including the lobbies.

Due to the significant financial and functional potential of these benefits it could be argued that, in the case of major refurbishments in buildings over 30m high, the requirement for installing sprinklers should be more clearly prescribed in Approved Document B of the Building Regulations for England and Wales. In Scotland this could also be argued for in the case for buildings over 18m high[17].

Note: Proposals for adopting fire sprinklers in lieu of passive fire protection requirements are generally made during the design process. These still require approval by Building Control and/or the Authorities Having Jurisdiction as part of the overall Building Regulations' approval process.

Northampton House, Northampton, is a former office block converted to flats in 2000. Northampton Borough Council Building Control Department and the Fire and Rescue Service agreed to the installation of a sprinkler system because there was a difficulty in complying with the requirement for two firefighting shafts. The main shaft could not be ventilated due to a lack of windows, and the developer considered that the cost of a roof-mounted smoke extract system was too prohibitive since installing this would have led to the loss of one flat per floor.

The solution was to install a residential fire sprinkler system (designed to the US standard, NFPA 13R). The installation has since proved its value following a fire in an occupied flat in July 2007 that was successfully extinguished and, it is believed, saved 3 lives.

Since the introduction in October 2006 of the Regulatory Reform (Fire Safety) Order 2005, owners of high-rise blocks have been required to undertake fire risk assessments of their properties. The outcome of many of these has been to identify and require significant work to upgrade, or maintain, existing fire protection measures, such as compartmental fire resistance, uprating fire doors and fittings, installing fire alarms etc.

However, following a number of well-publicised fires in blocks of flats, reports in the press and on radio and tv have suggested that fire risk assessment in some tower blocks have not identified defects in existing fire safety measures. Article 17 of the Fire Safety Order has also emphasised the need to ensure that all fire safety and protection measures are regularly reviewed and subject to a suitable maintenance regime.

On 25 October 2010 BBC East and West Midlands 'Inside Out' programmes featured fire safety concerns in high-rise flats. Both programmes highlighted failings in the fire-resisting construction and separation in some blocks that would have allowed a fire to spread internally and also to impede means of escape from some flats.

Emerging evidence (including some of those incidents noted elsewhere in this report) supports the view that fire can spread within tower blocks where passive fire protection measures have not actually performed as predicted (either as a result of improper installation or to their having been damaged by the installation of building services). Consequently, in considering the outcome of fire risk assessments, all involved - including building owners, fire risk assessors and the fire and rescue services - need to reappraise the effectiveness of the fire protection measures to ensure they are 'fit for purpose', and assess the full life-costs involved in maintaining them. Any assessment of the cost- effectiveness of these measures should then be compared with the full life-cost of retrofitting sprinkler systems.

Where sprinkler systems can be fitted during routine refurbishment work the gains result in significant economic, social and functional benefits, at minimal additional cost – as well illustrated by the Sheffield pilot project approach which (successfully) took on the additional challenge of installation whilst the residents were still in occupation.

Following a fire risk assessment, proposals for installing sprinklers either as an adjunct or in addition to passive fire protection will still require approval by the Authority Having Jurisdiction. Early consultation in the sprinkler design process will be beneficial.

17 As is well known, in Scotland, extensions to existing residential care homes are deemed to trigger the requirement for the installation of a sprinkler system in both the extension and original portions of the premises.

8. The Sheffield Pilot Project (2011)

8.1 Handbank, Callow Mount, Gleadless, Sheffield

Following an approach through South Yorkshire Fire and Rescue Service, contact was made with Sheffield City Council as owner of the high-rise block, 'Handbank', on the Gleadless Estate. This estate is managed by Sheffield Homes as an 'arm's length organisation'. The block, which fully complied with current fire safety standards, is one of six 13-storey tower blocks built during 1962. It had recently undergone major refurbishment work under the Decent Homes Scheme and was fitted with a fire detection and alarm system. The refurbishment had not, however, included consideration of the value of sprinkler protection.

The block, which originally contained 48 flats, is designated as 'sheltered housing', with warden cover being provided during weekday periods. The ground floor contains offices and communal rooms, with the 46 one-bedroom flats and 1 two-bedroom flat (converted from 2 original single-bedroom flats) on the remaining 12 floors.

After discussion, agreement in principle was reached with Sheffield Homes to offer the block for a pilot project to test the thesis of the Sprinkler Coordination Group (SCG) that retrofitting sprinklers was not as difficult as had been suggested. It was agreed that the 47 residents of the flats would remain in occupation during the installation work. Although this added to the challenges, it was considered by the SCG that if a system could be retrofitted in an occupied block, this would demonstrate once and for all that concerns about the practicability of sprinkler retrofit were unjustified. The SCG considered that there was little doubt about the practicability of retrofitting sprinkler systems as part of a major renovation scheme.

8.2 Contractual arrangements

Since the installation of the pilot project was to be funded wholly by BAFSA[18] to illustrate its effectiveness, the project fell outwith the Sheffield Homes/Sheffield City Council's normal procurement and tendering arrangements. As a result, it was subsequently determined that the most suitable arrangement for it to proceed was for the Council to grant BAFSA a licence to install the system. It has to be said that the pre-contract negotiations took many more weeks that did the actual installation work!

Using a JCT (Joint Contracts Tribunal) *Minor Works Building Contract with Contractor's Design,* BAFSA appointed Domestic Sprinklers Ltd as Main Contractor to design and install the system. Domestic Sprinklers Ltd subcontracted the ancillary boxing-in and decoration work to Kier Construction (the company responsible for maintenance work on other Sheffield City Council properties). The work was notifiable under the Construction Design and Management (CDM) Regulations 2007, and Marpal Ltd were appointed by BAFSA to fulfil the role of CDM Coordinator.

8.3 Design and specification

The system was designed to conform to BS 9251: 2005, *Sprinkler systems for residential and domestic occupancies.* (A detailed specification is included as Appendix A.) In order to ensure that there was full transparency in respect of compliance, the Steering Group decided to invite full oversight of the installer's design by inviting participation from:

- Warrington Certification Limited[19];
- BAFSA Council;
- Zurich Insurance;

all of whom reviewed the design drawings and calculations.

18 At no cost to Sheffield City Council or Sheffield Homes.

19 Warrington Certification Limited is an independent, UKAS-accredited, third-party certification body and is part of Exova Warringtonfire, a leading fire testing, consultancy, research and certification organisation. It provides certification services to clients who specify, manufacture, install, assess or maintain fire protection and security products and systems. Warrington Certification Limited manages the FIRAS voluntary, third-party certification scheme for installation contractors of both passive and active fire protection systems, and accredited by UKAS to EN45011.

It was vital that residents were happy with the proposals to install sprinklers in their homes. Many meetings with residents were held, before and during the project, to ensure that they were kept fully informed and that their concerns were properly considered. Their support was essential.

In addition, Yorkshire Water also reviewed the proposed installation and gave the required Water Regulations Advisory Scheme (WRAS) approval.

The scheme provided for the complete sprinkler protection of all flats, lobbies, communal rooms, and four external bin stores at the bases of the bin chutes.

The four existing internal service water mains serving the flats in each corner of the building provide the water supply for the sprinkler installation. Twin electric pumps supplement the mains supply but, during the course of installation, pressure readings of 1.5bar were recorded on the top floor (without the pumps running) and this was deemed sufficient for the design.

8.4 Consultation with residents

It was recognised during the early stages of planning the project that, to carry out the installation successfully while the block was still occupied, would require the full support and cooperation of the residents. They needed to be informed, at all stages of the work that could affect them, of what was going to happen, when and how.

Following the decision to proceed with the work, residents were invited to an initial meeting with the Project Manager and representatives from Sheffield Homes and South Yorkshire Fire and Rescue Service. This event was used to explain how fire sprinklers worked and it offered them full details of the proposals for the block they lived in. They were also shown the BAFSA DVD *Sprinklers for Safety*. At the end of the meeting, those present gave their unanimous support for the installation.

During the project development stage, regular progress briefings were also held with the residents. Support of the attending Warden, and Sheffield Homes' Tenant Liaison Officers, was crucial in maintaining effective links with them at all times.

In the week prior to work starting a further residents' meeting was held to outline the actual programme and to inform them of the proposed dates for work in each flat. Since Sheffield Homes are required to provide tenants with a minimum of 7 days' written notification of work, formal letters giving them these dates were circulated immediately afterwards. Where

the proposed dates proved inconvenient, individual alternative arrangements were made to reschedule the work.

Further regular meetings were held, as required, with groups of residents and individuals during the work in progress. This ensured that any emerging problems could be minimised and addressed, and good working relationships were maintained throughout as a result.

This inclusive approach contributed significantly to the success of the Sheffield scheme.

8.5 Installation programme

Installation commenced on Tuesday, 30 August 2011 in a vacant flat that was kept reserved for respite use. This allowed the installation team to test, and refine, their approach without impacting on any of the permanent residents. Systems were installed in three additional flats during the first week. At the request of the residents, this included some that were occupied. The subsequent programme was amended in the light of experience gained during that first week, and the entire scheme covering 48 flats (two of the one-bedroom flats were converted into a two-bedroom flat) was completed on Wednesday, 28 September 2011. Table 3 shows how the installation work progressed.

Staffing levels from Domestic Sprinklers was 8 operatives on-site for the entire duration of the installation work, with Kier Construction providing an average of 4 carpenters and 3 painters for 12 days.

Table 3. Sheffield Pilot Installation Programme in 47 flats August – September 2011

Week commencing	Installation undertaken
Tuesday, 30 August	Initial 4 flats, including one that was empty
Monday, 5 September	90% communal areas complete
Monday, 12 September	12 flats, communal areas complete, preparation in lobbies
Monday, 19 September	20 flats. Lobbies completed
Monday, 26 September – Wednesday 28 September	11 flats, boiler room, bin stores. Commissioning and snagging

8.6. Outcomes of the Sheffield Pilot Project

8.6.1 Ease of installation

A primary objective of the Sheffield high-rise sprinkler project was to determine the practicality of installing a complete system without the need for residents to decamp. While this tactic was smoothly realised through the cooperation of all concerned, clearly, if the adopted approach could be fully integrated with other refurbishment work programmes, additional cost and time benefits would be achieved.

The overall time taken for the Sheffield project involving 47 flats and ancillary areas is set out in Table 4. This experience revealed that the installation in each flat could be completed in less than one working day without evacuating its residents. Taking less than four weeks in total to complete the work, the adopted approach ably illustrates how significant improvements in life and building safety can be readily achieved with minimal disruption.

8.6.2 Sheffield Homes/Sheffield City Council

Sheffield Homes and Sheffield City Council place the highest value on providing appropriate levels of fire safety in all their housing and recognise that there can be additional safety issues relating to tower blocks. They were willing participants in this innovative project as they considered it would contribute to developing national thinking on how fire suppression techniques can be applied retrospectively. In addition, the installation of the system helped them develop thinking in using such forward-looking techniques as part of their future Asset Management Business Planning.

Sadly, blocks owned by Sheffield Homes recently experienced three fires in other unprotected tower blocks and, while there were, happily, no injuries, the cost of repair to one property and two communal areas alone cost £16,000.

Sheffield Homes Health and Safety Manager, Gary Lund

'The feedback from the residents has been absolutely remarkable. The time it has taken to do the full installation in all 47 flats has been incredible. There hasn't been any mess, and the workers have been clean and tidy. That's what has really helped, and the way they have worked closely with tenants and Sheffield Homes staff in the block has been exceptional.'

8.6.3 Residents' views

It was evident during the installation work that the essential early consultation meetings with residents ensured they readily understood how and what work would be carried out in their homes. During the actual work some individuals showed an active interest in it and how it was being undertaken, and all commented on the efficiency and cleanliness of the workers.

Resident Pat Morris

'I thought it was going to be a bit disruptive, but it wasn't at all like that. It was very straightforward. They started yesterday afternoon and finished this morning. Straightforward, worked well together and everything. A very good team altogether. I thought they were very good and it's a very neat job to what I thought it might be in the first place.'

Chairman of the Tenants' Association, David Cooke

'I was highly satisfied with the work in my flat. The feedback from residents has been tremendous, everybody is 100% satisfied.

8.6.4 Total installation costs

In scoping the project it was agreed from the outset that the full and true costs of the Sheffield scheme should be recorded and openly reported. In consequence, the costs tabulated below show what the actual cost of a commercial contract between a housing authority or landlord and a sprinkler installation company would be (at August 2011 prices).

Table 4. Summary of total costs (covering 47 flats).

Item	Cost
Materials	£19,055.00
Labour	£26,890.00
Establishment	£9,189.47
Total	**£55,134.47**

Appendix 2 contains an outline of the system specification and a more detailed cost breakdown is provided in Appendix 3.

The labour costs are those of the installation team and sub-contractors. All those involved in the project were trained and registered as competent in the installation of sprinkler systems and materials that were used in the project.

Establishment costs include site survey work, meeting with residents, site supervision, design, administration, training, operating /maintenance manuals, indirect labour costs, overheads and profit.

The actual final cost of the project resulted an average of just under £1,150 (£1,148.63) per flat. This includes the cost of sprinkler installation in utility rooms, common areas and office.

Perhaps the key finding of the project is that the installation cost is less than £1150 per flat. This is significant in that it is significantly less than had been estimated and illustrates how economically such a scheme can be retrofitted in occupied premises without undue disruption.

The cost of comparable installations, in similarly designed high-rise blocks, can be expected to be of the same order. This is supported by evidence from the recent completed installation of a sprinkler system in Pontypool (as described in section 11.3.1 below).

8.6.5 Callow Mount, Sheffield annualised costs

The sprinkler system installed in Callow Mount, Sheffield has a life expectancy of at least 30 years without replacement of major components. Routine checks will be performed by a specially trained member of Sheffield Homes' staff. These will normally be confined to checking water pressures and intervening only if there is a loss of pressure or system actuation.

The installation company has quoted an annual maintenance cost of £250.00 which is based on the presumption that because of the design of the system access to individual flats is rarely going to be required[20]. This quotation has been verified as it seems much lower than the costs quoted in the 2004 BRE study and it appears to be very similar to the costs currently being quoted for similar installations in South Ayrshire and Wales.

Maintenance therefore totals £7,500 over a 30-year period. When added to the installation costs of £55,000 this gives a whole-life cost of £62,000, resulting in an annualised cost of £2,065 per year for the whole block, or just over £40 per flat.

The four internal service mains in the block provided the water for the sprinkler system. Twin electric pumps supplement the service main's supply although, during installation, the mains pressure was tested and the 1.5bar reading at the top floor was in any case judged sufficient for the system.

8.6.6 Effective relationships

The Sheffield project also highlighted the need for and benefits of close cooperation and coordination with residents and property owners and of keeping the tenants involved fully informed. The project steering group was also fundamental in ensuring that all the parties involved were in touch with each other and that matters that required immediate attention received this.

8.6.7 Retrofit during refurbishment

One thing that this project has not determined is the likely cost of fitting sprinklers as part of a major refurbishment. It would appear, intuitively, that there might be additional cost savings in respect of the installation work itself as part of a complete refurbishment programme but this would depend on restrictions on access. Anecdotal reports from sprinkler installers suggest that they incur additional costs on many new-build projects as they are often allowed to work for only a couple of days and then are asked to return at different stages of the project. It's therefore not clear from this project what the reality is and this is something to be determined on another occasion.

One potential saving might well result from the ability to install sprinkler pipes in risers or ducts together with other services. This would obviate the need for most boxing-in.

8.7 Sheffield Pilot Project conclusions

The primary objective of the Callow Mount project was to provide evidence that sprinklers could be practically and economically retrofitted into high-rise tower blocks and to obtain up to date costs to assist the CFOA/BRE review of the earlier 2004 research on the cost/benefits of sprinklers in residential premises.

In addition to enhancing residents' life safety, the project also sought to demonstrate that there were real social, economic and functional benefits to local authorities and housing owners.

The outcome of the Sheffield pilot project has successfully demonstrated that:

- it is possible to retrofit sprinklers into occupied social housing without evacuating residents or

20 Where access is required for all flats in a block and a concierge or porter cannot facilitate this then maintenance costs will be much greater, possibly amounting to £50/flat per year (or more where repeat visits have to be arranged).

causing disruption to their lives whilst work progresses;

- such installations can be successfully undertaken on a 'fast track basis'. The installation time taken equated to approximately one day per flat;
- the £1,150 cost of installation per flat compares very favourably with other fire protection measures that might otherwise be required to provide an acceptable levels of fire safety in older blocks, especially where there is only a single staircase;
- BS 9251 can be successfully used for designing such installations;
- tenants and residents feel safer knowing they are better protected with a sprinkler system in place, as do their families;
- if sprinklers are installed they have the potential to reduce significantly the cost of having to rehouse tenants and minimise the cost of refurbishment work following a fire;
- the true cost of installation, and whole life-costs, can be identified to permit a cost/benefit analysis of sprinkler installations in relation to the potential repair and rehousing costs following a fire;
- the costs of a sprinkler installation incorporated into any major refurbishment project would only constitute a small proportion of the overall cost of the work;
- the full life-costs of a sprinkler system, over the life of the system, should be compared with those of other fire protection measures and the benefits of each approach should be carefully assessed;
- the design and installation procedures adopted here can be adapted for high-rise blocks with different configurations.

9. Fire risks in high-rise blocks

The frequency of fire incidents in high-rise social housing buildings has been acknowledged in both the BRE Research project, and the LGID's *Fire safety in purpose-built blocks of flats* guidance document. Both documents note that the frequency of fires in this type of property is higher than that in single residential dwellings.

In recent years a number of serious incidents in high-rise premises have resulted in fatalities and injury of residents and firefighters.

In the 12 months before the commencement of the Sheffield pilot project installation, the project team recorded 13 fires in comparable properties in the UK. These resulted in 9 fatalities and 12 people, including 5 firefighters, requiring treatment for injuries or smoke inhalation. Many other such fires will also have occurred.

In addition to this loss of life, such fires have impacted upon the daily lives of others and resulted in damage to adjacent dwellings, with all the associated disruption which that entails. Such impacts result in significant unnecessary trauma and stress for the affected occupants, while the local authority suffers the inevitable rehousing and refurbishment costs. Particular problems for the owners and tenants invariably result from water damage (from firefighting activities) caused to accommodation on floors below a fire.

CPVC pipework and related components were the products of choice for the project. Some boxing-in would be necessary for system pipework although, wherever possible, it was hidden within the same concealment as domestic rising mains.

9.1 Number of high-rise blocks

There are over 4,000 high-rise blocks owned, or managed, by local authorities across the United Kingdom. Information provided by the Department for Communities and Local Government list 213,199 individual dwellings in 3,778 high-rise premises in England.

There are 797 such blocks in Scotland and 15 in Northern Ireland but unfortunately comparable figures for Wales were not available at the time of writing.

These tower blocks should have been designed and constructed in accordance with the building regulations of the day and therefore were not fitted with sprinklers. (Exceptions are the blocks in South Ayrshire, Pontypool and Sheffield, as discussed elsewhere in the report.) This situation inevitably poses a significant degree of on-going risk, which, based on the findings and outcomes of the Sheffield pilot project, could be readily eliminated by a commitment to retrofit sprinklers into such properties at an affordable cost per flat. If this work were undertaken as part of the standing commitment on local authorities to upgrade the tower blocks, the associated costs could be even lower.

Against this economic solution, the high cost of dealing with post-fire situations should also be carefully assessed since the associated gains and benefits may be significant.

9.2 Incident frequency in high-rise blocks

The 2004 BRE Report suggested that the frequency of fire per accommodation unit increased with building height, but that the risk of death per fire was not significantly affected by height. UK fire statistics suggest that, in multi-storey buildings, the number of fires per floor was not evenly distributed and that there were more fires at ground floor level. Recent fires, many quoted in this report, appear to call this conclusion into doubt or at least suggest that while the numbers proposed by the statistics may be correct, the more severe incidents which require significant fire service intervention and hence result in media coverage may receive greater attention.

The LGID's document *Fire safety in purpose-built blocks of flats* discusses the relative risk in flats and quotes official sources which say that around 10% of the population[21] live in purpose-built flats. In 2009-10 some 25% of recorded dwelling fires occurred in such properties, and 23% of fire deaths were in this category of dwelling. Such statistics are clearly indicative of the real fire and life safety risks that are involved in unsprinklered premises.

While noting that the number of deaths appears disproportionate to the number of people living in purpose-built blocks of flats, the LGID report dismisses this as 'simply the result of the number of fires occurring in such dwellings most of which occur accidentally[22].' This somewhat surprising conclusion has received little publicity and is, in the opinions of a number of fire safety professionals, not fully explained nor are the implications developed.

21 *English Housing Survey 2009-10,* Department of Communities and Local Government, 2011.

22 The latest statistics issued by DCLG, *Fire Statistics, Great Britain 2010-2011* show that there were a total of 44,700 fires in dwellings of which 6,200 were deliberate.

10. Consequences of a high-rise fire for the authorities

10.1 Emergency services

The high population levels of many high-rise blocks of flats requires the emergency services to prepare more complex plans that mobilise a larger number of personnel and equipment than for low-rise domestic premises. Inevitably, this significantly increases the operational costs per attended incident.

10.2 Implications for the fire and rescue services

In recent years there have been a number of incidents in high-rise blocks that have resulted in fatalities and serious injury of firefighters, with all the knock-on operational financial implications that this entails, in addition to family trauma. In 2008, revised guidance was issued by the Communities and Local Government Department and Scottish Government, *Generic Risk Assessment 3.2 – High Risk Firefighting Version 2,* to help ensure that fire and rescue services plan and prepare for such incidents more effectively. Updating previously published guidance from 2006, this emphasised that, by their very nature, fires in high-rise blocks pose potentially more significant and serious risks. It also recognised that high-rise fires can be more physically demanding and resource-intensive for operational personnel compared to incidents in low-rise premises.

When compared to the dates when these blocks were constructed, the weight of fire service resources demanded by each incident has increased over time. This is due to the years of experience gained at such incidents, the loss of firefighters over the years and the more safety-critical approaches being employed by (or, some might say, being imposed on) the fire and rescue service. Given cuts in resources and a move to Integrated Risk Management Planning it's probable that questions need to be asked as to how high-rise fires will be tackled in the future and what the likely outcome will be for the residents of such blocks.

The guidance quoted acknowledges that fire service ladders, and high-reach access equipment, can only, with rare exception[23], access the lower levels of a high-rise block, thereby putting residences above this at greater risk. Operational tactics are therefore based on establishing a 'bridgehead' two floors below where the fire is, and requires all equipment and personnel to be transported there. Where firefighting lifts are available they can be used, but if lifts are unavailable the alternative use of stairs adds to the logistical difficulties. Should the bridgehead be at a high level it may be necessary to establish one or more staging areas between it and the ground floor.

Establishing a bridgehead significantly increases the time before firefighting operations begin. This delay means that the fire can develop and spread much farther than an equivalent incident in low-

Hertfordshire Fire and Rescue Service have undertaken a series of exercises designed to test and practise their procedures for dealing with fires in high-rise housing blocks. As a result, they have determined that it takes 20min from arrival at the incident to establish a bridgehead with the resources required to deal safely with a fire on the upper floors. Compared to a fire in a low-rise block, this time delay before firefighting can commence, clearly encourages significant fire growth, increases the risks involved for firefighters and residents, and leads to greater damage being caused, with consequential increased remedial and rehousing costs.

Photo by kind permission of Hertfordshire Fire and Rescue Service

23 Some fire and rescue services are equipped with appliances which can provide access to 30m but these are rare.

The installation work involved associated carpentry and subsequent redecoration, all carried out with consideration and care in residents' homes.

rise premises. This delay can also increase the potential for a flashover or backdraught that can, in turn, be exacerbated by high-level wind and weather conditions, and internal ventilation systems.

However, the installation of an effective sprinkler system can go a long way to ameliorating such challenges. An acute awareness of such operational difficulties took place in a 2005 fire in Stevenage, which resulted in the loss of two firefighters, and was one of the factors which motivated BAFSA to pursue the Sheffield pilot project.

The CLG 2008 guidance also highlights the need to consider the following:

- While modern high-rise premises are generally constructed of fire-resisting materials, the possibility of internal and external fire spread to other parts of the building must be taken into account. Stairways, enclosures and other flats may have been affected due to damaged smoke stop-doors, door-closers, fire-resisting glazing, or breaches to fire compartmentation. The incidents in Glasgow, Kingston upon Thames and Norwich detailed in section 10.5 of this report illustrate how a serious fire can develop in a high-rise block if the passive fire protection measures are breached.
- The case for exploring worst-case scenarios, such as wet riser pump or communications failures, defective riser installations, or fire service personnel trapped in a lift.

One might add to this:

- The need to consider the risk of a fire spreading both downwards and upwards at the same time and the effect on fire spread and smoke generation from materials installed as part of any refurbishment project.

Any or all of these matters could increase the time taken to commence firefighting, with an increased risk of greater post-fire damage being created as a result, along with the increased risk to occupants and firefighters.

10.3 Implications for the ambulance and police services

The potential for numbers of residents requiring medical attention, and/or police assistance, means that an incident in a high-rise block will have much more impact and create a greater demand for resources on the other 'blue light' services than an equivalent low-rise incident. The possibility of fire and rescue service personnel also requiring medical assistance is increased, together with the need for enhanced security, crowd control, investigation and sadly, coroners' support, all of which entail additional operational costs associated with the incident.

10.4 Implications for local authorities and housing associations

10.4.1 Emergency responses

Local authorities are required to have predetermined, tested plans in place to support the emergency services in the event of incidents such as a major fire in a high-rise block. These include the provision of technical support from maintenance engineers, health and safety advisors, and tenant liaison staff, with their associated costs.

But it is highly likely that a significant number of residents could require evacuation from a tower block during an incident. Depending upon the fire severity, and duration of firefighting operations, short-term temporary shelter is likely to be required in local premises such as community halls and schools. Attendance by social service staff, and voluntary groups, would

also be required to ensure the welfare of evacuees. This too can add significantly to the financial consequences of an incident.

10.4.2 Temporary accommodation and rehousing

In the event that parts of the premises, or the whole block, cannot be occupied following a fire, the local authority will have to provide short-to-medium-term temporary accommodation for residents in local hostels, hotels or other commercial premises. In larger tower block incidents this could conceivably be for over 100 people. Consequently, there can be significant additional costs involved in doing so.

Where extensive refurbishment or repair is required a more permanent and expensive approach to rehousing might also be required. In the case of Lakanal House, the block has remained empty and in its fire-damaged state since July 2009 and it is possible that it will never be re-occupied.

Section 10.5, Case Studies, provides examples of costs experienced by housing authorities following recent fires in high-rise blocks.

10.4.3 Repair costs

While in some cases the effects of a fire may be localised and only necessitate repairs to individual flats, in many of the incidents listed in Appendix 1, fires affected other dwellings and communal areas. This will have had a significant additional impact on rebuilding costs and the time taken to restore premises, while also prolonging the need for (and costs of) temporary accommodation.

10.4.4 Consequences and effects on occupants

A fire has a serious impact on any occupant, particularly so when it occurs in a domestic property. Apart from the obvious risk of personal injury or death it seriously disrupts individual and family life thereafter. It can also create damage to, or the complete loss of, personal property and possessions, some of which are likely to be irreplaceable family memories and treasures. The psychological consequence of this degree of loss is often significantly underestimated. Such trauma can render an individual unable to function normally and may, for example, make it impossible for someone to live above the ground floor or use elevators.

10.4.5 Social costs

A serious fire in a high-rise community can also be detrimental to the wellbeing of all those in the immediate area, and raise wider concerns amongst residents, and those who live in other tower blocks in the neighbourhood. This is particularly noticeable among residents of blocks where fire or smoke spreads to other flats.

Following four fires in a block in Manchester in June and July 2005 a resident who lived on the fifth floor of a block with her 11-month-old daughter, said: 'I'm so scared. I lie awake at night waiting for it to happen again. It is happening right outside my front door, which is my only way out'. She added: 'Smoke has been filling the bedroom and ash has landed on my baby's cot. Now, I've sent my daughter to live with her grandmother'.

A BBC report on 21 July 2009 stated that 'since the fire in Lakanal, residents elsewhere in the borough have became increasingly agitated by what they perceive to be Southwark Council's complacent attitude towards the risk of fire. Southwark is the largest social landlord in London and therefore has a particular challenge on its hands'.

10.5 Case studies

10.5.1 Waddell Court, Glasgow – 0256hr, 16 December 2011

In the period between 2007 and 2009 Glasgow Housing Association undertook a major refurbishment of four multi-storey blocks and maisonettes in Waddell Court and Commercial Court. The programme included fitting new kitchens and bathrooms, central heating and rewiring. Improved security measures, such as new balconies and common entrances were also part of the refurbishment programme, along with insulation and external cladding. Although the cost of this 'mini regeneration' project was in the region of £16.5 million, a sprinkler system was not included in the retrofit work.

There was a fire at Waddell Court, Glasgow, December 2011 (photo courtesy of Glasgow Housing Association/Strathclyde Fire and Rescue Service).

At 0256hr on 16 December 2011 a fire occurred on the fifth floor of a block in Waddell Court. Tragically, one male resident died and two others needed hospital treatment. In the immediate aftermath only 18 of the 77 residents were able to return to their home.

While some of those that were rehoused were able to return within a few weeks of the fire, 10 tenants were in temporary housing for 10 weeks, 6 for 6 months, and the remaining 3 for 11 months.

Excluding the degree of tenants' personal property losses (which are often uninsured), Glasgow Housing Association report the total cost of the fire, rehousing, repair and refurbishment work, loss of rent and other costs to be £2.6 million. This unplanned expenditure will have to be found from within existing budgets. Such a sum could have paid for the installation of sprinkler systems in over 2,500 flats (based on the Sheffield pilot project outcome costs).

In addition, the inclusion of sprinklers in the original refurbishment programme would have only increased the total cost by approximately 2 % per block (£80k) but the subsequent fire aftermath cost 30 times that amount.

10.5.2 Madingley, Cambridge Estate, Kingston upon Thames – 1645hr, 12 July 2010

In the Madingley block of 60 flats, housing up to 150 people, a deliberately started fire in a 12th floor flat spread to the upper floors and roof. Residents were initially evacuated to the nearby Piper Community Centre, subsequently being transferred to temporary accommodation, or having to spend the night with relations. Four nearby blocks, that house some 250 people, were also evacuated for safety reasons.

The Madingley block required extensive refurbishment, and the residents could not return until late April 2011, some 9 months after the incident. In the interim, local newspapers reported that some residents were traumatised by the memory of the fire, and had reported health problems. On 31 March 2011 the Surrey Comet also reported that looters had stolen personal belongings left behind by residents.

Despite an application made under the Freedom of Information Act, the owners, Kingston upon Thames Council, have not provided the author with data on the actual losses and costs resulting from this fire. The Council's Statement of Accounts for 2010/11 indicates that, 'as the property is covered by the Council's insurance arrangements, additional costs are estimated to be about £20,000'. (It is believed that the Council carry an excess of £100,000 on their insurance policy.)

10.5.3 Markham Tower, Bowers Avenue, Mile Cross, Norwich – 1120hr, 26 September 2011

The fire started in an 8th floor flat of the 10-storey Markham Tower block when a resident was absent. It filled the upper levels of the block with smoke and, according to the fire and rescue service, this had started to affect the floor above before being extinguished. All the residents were able to self-evacuate safely, without injury.

The flats were fitted with battery-operated smoke detectors and the block had an up-to-date fire risk assessment, but was not fitted with a sprinkler system.

Norwich City Council, the owner, reported that one flat was badly fire damaged, and at least 10 others were water damaged. Due to the amount of water required to put out the fire, EDF Energy had to cut off the electricity supply to the whole building. The council is investigating if heating pipes, burst by the fire, may have contributed to this extensive water damage.

Of the 44 flats in the block, 19 households were the most severely affected and were moved into temporary accommodation, whilst others stayed with friends or relations.

Norwich City Council estimate that rehousing and refurbishment costs are in the region of

£230,000 at the time of publication but, three months after the fire, 11 occupants were still in temporary accommodation, so it is likely that the final total be significantly higher.

The affected flats were still awaiting repair (in January 2012), and will remain so for the foreseeable future, but until they are brought back into use the cumulative loss of rental income is put at £3,200 per month.

In August 2011 a fire occurred in another Callow Mount block, not the one in which sprinklers were being installed.

10.5.4 Callow Drive, Gleadless Estate, Sheffield – 2215hr, 2 August 2011

On 2 August 2011 a fire occurred in a 12th floor flat of an adjacent block to that in which the pilot project sprinkler scheme was being installed. The fire did extensive damage resulting in an estimated repair and refurbishment cost in the region of £10,000. The damaged flat was still awaiting repair in December 2011, with an additional loss of £900 rental income to that date.

10.6 Other sprinkler retrofit projects

10.6.1 South Ayrshire Council

In 2002/3 South Ayrshire Council in Scotland retrofitted its three tower blocks with sprinklers as part of a major refurbishment programme. Since then two serious fires have occurred. On both occasions the sprinklers acted effectively, the occupants were uninjured and there was minimal fire damage. The equally limited water damage was dealt with by the fire and rescue service in about 20min.

Residents were not required to leave their premises and the only refurbishment work required, at minimal consequential cost, was the redecoration of the rooms in which the fires occurred.

A fire in the kitchen of a sprinklered flat in South Ayrshire was extinguished by a sprinkler.

10.6.2 The Bron Arfon Housing Association

Bron Afon Housing Association in South Wales has an ongoing refurbishment programme for its residential stock. One of the blocks, Fairview Court, had many problems with false fire alarms being generated by smoke detectors that, in turn, created unnecessary call-outs of the local fire service. A desire to make the building safer for its tenants (and recognising some high profile fires in similar types of accommodation in the UK) caused the Association to investigate installing sprinklers, which they also realised would provide a much safer environment, and solve the false alarms problem.

The installation contract commenced during the summer of 2011 and sprinkler systems have been installed in 70 apartments, all communal areas, corridors, bin stores, cycle store, and a newly created rooftop 'pavilion' for the use of residents. The system is fully compliant with BS 9251.

As with the Callow Mount installation in Sheffield, individual flats and common areas can be isolated for maintenance while all remaining areas remain 'live'. Flow switches, installed at each level, are linked into the main fire alarm panel to indicate where the system has been activated.

The water supply consists of a full capacity tank (hydraulically calculated to provide 30min supply to 4 heads operating) and two electric fire pumps. Additional backup is provided through a fire service inlet breeching valve that would allow water to be pumped directly into the system pipework. A test arrangement was also installed, along with a flow measurement meter. Water used during testing is returned to the storage tank to prevent wastage.

In line with the data derived from the Sheffield pilot project, the average installation cost per flat was also in the region of £1,150. This included the costs involved in protecting common areas and additional costs relating to the water supply connection.

11. General lessons learned and other considerations

In addition to lessons learned regarding the design and installation, a number of other factors were experienced during the Sheffield pilot project that will help ensure the successful retrofitting of a sprinkler system in other occupied high-rise blocks across the UK.

11.1 Contractual and legislative considerations

Although the Callow Mount scheme was unusual in that it was completed outwith conventional procurement and contractual arrangements, much was gained as a result. In particular, the approach emphasised the need to specify clearly the design requirements and determine, at an early stage, well-defined and unambiguous expectations that would be required from all parties in agreeing the way forward.

It also goes without saying that it will be necessary for future projects to ensure that they comply with all legislative requirements including:

- Building Regulations or Standards
- Construction Design and Management Regulations
- Water Regulations Advisory Scheme approval
- Regulatory Reform (Fire Safety) Order 2005 or its equivalent in Scotland and Northern Ireland.

That being the case, an early involvement with the Authorities Having Jurisdiction will also assist in ensuring compliance, since this can reduce the potential for delays, and for any additional costs that could result from difficulties emerging at a later stage of work.

11.2 Authorities Having Jurisdiction

In addition to any formal arrangements relating to legislative requirements, the involvement of the fire and rescue service and other organisations such as the owner's insurers can also assist in progressing the project and making informed decisions. If it is felt that some form of advantageous insurance premium would be looked for it is essential that the insurers be asked to review and approve the design of the sprinkler system.

11.3 Other factors

There are a number of related factors that can have an impact on the practicality and cost of retrofitting a sprinkler system in a high-rise block. Early recognition that some or all of these aspects exist will allow them to be accounted for in the project design and contract. The sections below cover the most common variables that were encountered in Sheffield but they are not exhaustive.

11.3.1 Water supplies

A major factor is the provision of a water supply that meets the performance requirements of the sprinkler system and building standards. In the Callow Mount block, the existing water supply was found satisfactory and this allowed the system to be directly connected to the domestic rising mains. This may not be the case in other projects and additional equipment, such as pumps and tanks, may be required.

For example, the installation carried out in the Pontypool high-rise block required the provision of a tanked 30min of water supply for the system, and two electric pumps. The additional cost of this was approximately £10,000.

The cost associated with additional equipment can vary depending upon circumstances. Consequently it is important to conduct a detailed survey of existing water supplies early in the project so that appropriate solutions, and associated costs, can be identified and included.

Where it is not possible to use the internal domestic mains, it may be necessary to include a dedicated sprinkler service main in the design. This will add to the installation cost and time taken to install it.

Note that most high-rise blocks will be fitted with dry (or on occasion, wet) risers that are intended for use by the fire and rescue service as proposed in paragraph 15.1 of Part 5 of Approved Document B (and its equivalents). It would not normally be considered appropriate to consider utilising these for sprinkler protection but the presence of a sprinklered building may permit the Authority Having Jurisdiction to judge whether the presence of sprinklers might allow reconsideration of the need for the risers or the risers to be used as a conduit for water supply for the sprinklers

11.3.2 Construction issues

The retrofitting of a sprinkler system into an existing high-rise building will also be influenced by the original design, construction method and materials used. While many tower blocks share the same Callow Mount layout (with two independent staircases on opposite sides of a central service core containing lifts), variations on that design do exist.

11.3.2.1 Staircase design

A common format is the 'scissor block' design. This has a number of variations but, typically, it has two storey flats, or maisonettes, laid out so that a common corridor leading to a shared stairwell serves the lower-storey. An internal staircase accesses the upper-storey. This staircase spans from side to side of the building, passing over the common corridor. In taller buildings this pattern is repeated.

The staircases in the Lakanal House incident were of this design, a concern being where the staircase passes over the corridor, as it cuts through the enclosure to the common corridor. If there was to be a breach in the fire-resisting construction above that ceiling, it would permit a fire to spread from a flat into the ceiling void via the staircase.

11.3.2.2 Floor and ceiling construction

Where the floor and ceiling construction is of solid concrete, the sprinkler system pipework will have to be surface mounted. This was overcome at Callow Mount by using sidewall sprinkler heads, with boxed-in pipework to minimise any visual impact.

If the ceiling construction incorporates a void where the pipework can be installed, this can eliminate the need for surface mounting and boxing in by allowing the use of pendant sprinkler heads. This approach is likely to require the removal and replacement of some ceiling materials, and is unlikely to be appropriate if the work is to be undertaken while the flats are occupied. However, if the installation can be incorporated as part of a major refurbishment or conversion, it can be both practical and cost-effective while producing a more visually pleasing result. Of course, if sprinklers are to be installed as part of a major refurbishment, it's likely that most of the pipework can be incorporated with plumbing and other systems at no extra cost.

11.3.2.3 Asbestos

The use of asbestos in building construction was banned from the mid 1980s, although some asbestos-based materials were still in use until 1999. Alarmingly, it is estimated that at least 50% of all asbestos previously used in buildings' construction across the UK is still there, so recognising this as a possible concern is essential.

Building owners are required to carry out a survey and record on drawings where asbestos is present, or believed to be present, its form and condition (the 'Asbestos Register'). There is a legal duty on owners to provide this information to anyone working on their building.

However, not all forms of asbestos present the same levels of health risk and, in most cases, there is no need to have it removed. It should be recognised that if disturbed or damaged by maintenance work, or accident, certain types of asbestos can carry significant health risks and should be dealt

with by a licensed contractor according to the Control of Asbestos Regulations 2006.

To ensure compliance with the Construction Design and Management Regulations, sprinkler contractors are required to take this risk into account when planning work programmes.

11.3.3 Leasehold properties

While most residents of UK high-rise blocks are tenants paying rent to a local authority or housing association, some blocks could contain leaseholders who own their own home and pay a service charge for servicing and cleaning of common areas, maintenance and repair. Where a refurbishment project is being undertaken, the cost of that work may fall outwith any maintenance and servicing agreements. In such circumstances a leaseholder would have to give his or her specific agreement to the work being carried out, and be prepared to pay their share of the installation costs.

If a leaseholder is unwilling to permit access or pay for the installation of sprinklers in his or her property, then the building's system will not comply with BS 9251. Despite this, provided most flats are protected, their occupants will enjoy enhanced levels of fire safety protection and minimise the potential of fire spreading from an unprotected (leasehold) property should an incident occur there.

Ideally, all parties involved should be encouraged to participate in the 'omnibus' scheme.

12. Findings and recommendations from the project

12.1 Findings

The findings of the Sheffield pilot project provide evidence of the practicality and cost-effectiveness of installing sprinklers in older high-rise blocks. In addition, the project has created a template and methodology for the design of sprinkler systems in other un-protected high-rise blocks elsewhere in the country. Particularly, the pilot project has illustrated that:

- it is possible to retrofit sprinklers into occupied, high-rise, social housing without evacuating residents;
- such installations can be undertaken on a fast track basis;
- the installation cost of £1,150 per flat compares favourably with other fire protection measures;
- BS 9251 can be successfully used for designing such installations;
- tenants, residents and their families feel safer knowing they are better protected with a sprinkler system in place;
- the potential trauma and disruption to individuals and communities following a fire would be reduced;
- sprinklers have the potential to reduce significantly the cost of rehousing tenants and any necessary major refurbishment work following a fire;
- the true installation and whole life-costs can permit a cost-benefit analysis of sprinkler installations in relation to potential repair and rehousing costs following a fire;
- retrofitting sprinklers as part of a major refurbishment project would incur only a small proportion of the overall costs;
- the full life-costs of a sprinkler system should be compared with other upgrading fire protection measures so that the benefits of each can be carefully weighed up;
- the retrofit design and installation can be adapted for high-rise blocks with different layouts;
- the outcome of the report could be used to review the findings of the BRE report from 2004 to reflect the cost-effectiveness in existing high-rise blocks.

12.2 Recommendations

12.2.1 One factor which is not clear is the extent to which a refurbishment of an existing high-rise block may be undertaken without bringing into play the latest requirements under the Building Regulations. Given the extent of the work involved in some of these projects where expenditure of up to £5m is not unusual, it might be appropriate to ask why the 'Material Alteration' guidance in paragraph 0.20 of Approved Document B, 2006, seems rarely to be invoked. We recommend that the DCLG Building Regulations division provide guidance on this matter and also that the Scottish and Northern Ireland authorities look at this point.

12.2.2 These findings will permit national government, local housing authorities and private sector housing associations to reconsider realistically the use of sprinklers as part of a comprehensive fire safety strategy for existing unprotected high-rise blocks across the UK.

12.2.3 We suggest that existing guidance documents and approved codes of practice should be updated to reflect the findings of the pilot project.

The retrofit work began on 30 August 2011 and was completed on 28 September 2011. Residents, contractors and members of the Sprinkler Coordination Group attended a reception to celebrate the successful conclusion of the project.

12.2.4 In consequence of the success of the Sheffield pilot project findings, BAFSA and the SCG recommend that the retrofit installation of sprinkler systems should be positively considered by all authorities when reviewing or planning:

- major refurbishment programmes;
- development of fire safety policies;
- fire risk assessments;
- cost-effectiveness of other fire safety measures;
- measures to compensate for deficiencies or defects in fire safety provision or non-compliances with current fire safety standards.

12.2.5 It is also contended that the outcomes of the Sheffield pilot project, and the findings of this report, provide realistic evidence for housing authorities, housing associations and fire and rescue services to consider seriously the potential use of retrofitted sprinkler installations in existing unprotected high-rise blocks of flats to:

- enhance the safety of resident and occupants of high-rise blocks;
- reduce the risks to life and injury of firefighters working in high-rise blocks;
- reduce the personal trauma and social impact of fire on individuals and neighbourhoods;
- reduce the costs and impact of a fire on hard-pressed local authorities and other property owners;
- reduce the financial consequences and other burdens of fire;
- reduce the demands on fire and rescue, police and ambulance/health services in responding to the events and aftermaths of major fires in high-rise accommodation.

References

England and Wales

The Regulatory Reform (Fire Safety) Order 2005, Statutory Instrument 2005, No. 1541, HMSO.

Fire Precautions Act 1971, HMSO, 1971.

The Building Regulations, 2000. Approved Document B, *Fire Safety,* volume 2, *Buildings other than dwelling houses,* Department for Communities and Local Government, 2006.

Fire Safety Risk Assessment: Sleeping Accommodation, Department for Communities and Local Government, 2006.

Fire Statistics, Great Britain, 2010-2011, Department for Communities and Local Government, 2011.

CLG Fire Service Circular 54/2008, *Generic Risk Assessment 3.2, High Rise Firefighting,* version 2, Department for Communities and Local Government, 2008.

Scotland

The Building (Scotland) Regulations 2004. Technical Handbooks for domestic and non-domestic buildings, 2009.

Scottish Fire Service Circular 18/2008, *Generic Risk Assessment 3.2, High Rise Firefighting,* version 2, Scottish Government, 2008.

Northern Ireland

The Building Regulations (Northern Ireland). 2000.

Northern Ireland Technical Booklet E, *Fire safety,* NI Department for Finance and Personnel, 2005.

British Standards

BS 7974: 2001, *Application of fire safety engineering principles in the design of buildings. Code of Practice,* BSI.

BS 9251: 2005, *Sprinkler systems for residential and domestic occupancies. Code of Practice,* BSI.

BS 9991: 2011, *Fire safety in the design, management and use of residential buildings. Code of Practice,* BSI.

BS 9999: 2008, *Code of practice for fire safety in the design, management and use of buildings,* BSI.

BS EN 12845: 2009, *Fixed firefighting systems. Automatic sprinkler systems. Design, installation and maintenance,* BSI.

News/local reports

BBC News, 21 July 2009, http://news.bbc.co.uk/local/london/low/people_and_places/newsid_8161000/8161035.stm

Kingston upon Thames tower block fire, report in Surrey Comet, 31 March 2011.

Kingston upon Thames Council: Statement of Accounts 2010/11.

Stockport Express, 13 July 2005. http://menmedia.co.uk/stockportexpress/news/s/501783

BAFSA publications

Sprinklers for Safety: uses and benefits of incorporating sprinklers in buildings and structures, a report by Arup Fire, BAFSA, 2006.

Sprinklers for Safer Living: the benefits of automatic fire suppression systems in residential care premises, a report by Arup Fire, BAFSA, 2010.

Sprinklers for Safety, informational DVD, BAFSA, revised version 2010.

Sprinklers for Safer Living, informational DVD, BAFSA, 2009.

Technical Guidance Note No 1: *The design and installation of residential and domestic sprinkler systems,* 3rd edition, BAFSA, 2012.

Other publications

Fire safety in purpose-built blocks of flats, organisation for Local Government Improvement and Development, 2011.

Fuller, S.K. et al, *Benefit-Cost Analysis of Residential Fire Sprinkler Systems,* NISTIR 7451, USA, Sept. 2007.

Jackson, L., *Guide to Building Fire Protection,* Fire Protection Association, 1997.

Open-plan flat layouts – Assessing life safety in the event of fire, NHBC Foundation, 2009.

Williams, C., *Effectiveness of sprinklers in residential premises,* BRE Report Number 204505, BRE 2006.

Appendix 1: Major high-rise incidents noted during the course of the pilot project, November 2010 – November 2011

Over the 12 months that the Sheffield scheme was running there were many fires in tower blocks and some 13 fire incidents, in unsprinklered high-rise premises, were brought to the project team's attention. These occurred mainly in the early morning or evening, and some 357 individuals were affected, of whom nine died. The aggregated cost of these incidents may well have amounted to more than £17 million (taking the 2003 figures BRE used as statistical values for each life saved of £1,243,000, and £58,300 for each prevented injury).

Set against the outturn installation cost per flat of the Sheffield pilot project, such an imbalance genuinely raises the need for the retrofitting of sprinkler systems in older high-rise properties to be seriously reconsidered by all authorities who, in the interim, continue to carry such risks, consequential incident costs and significant degrees of loss.

Time/Date	Location	Building height	Floor of origin	Rescues/ Injuries/Fatalities
30 November 2010 – 1825hr	Marie Curie House, Southwark	14 floors	13th floor	60 people self evacuated. This block is adjacent to Lakanal House.
20 December 2010 – 1450hr	Omega Way, Somers Town, Portsmouth	8 floors	5th floor	One male fatality, other residents evacuated to local community centre by police
19 January 2011 – 0540hr	Adamson Court, Lochee, Dundee	15 floors	14th floor	One 86 year old male fatality. One other person was treated for smoke inhalation. Firefighters were forced to evacuate 12 people from six nearby flats because of the ferocity of the blaze, which spread to the flat above and caused considerable damage to the close.
29 January 2011 – 2340hr	Acre Road, Maryhill, Glasgow	8 floors	5th floor	Elderly couple and adult son died
4 February 2011 – 1443hr	Marine Tower, Abinger Close, Deptford	16 floors	16th floor	Two female residents died, paramedics treated 4 other residents, one of whom was taken to hospital. London Fire Brigade reported that 6 people were rescued and 35 had been moved out.
10 February 2011 – 0654hr	Overtoun Court, Swinton Street, Clydebank	14 floor	4th floor	1 male fatality
14 July 2011 – 1620hr	Tinwald Path, Cardonald, Glasgow	7 floors	5th floor	1 female fatality, 2 others taken to hospital. Reports of residents trapped on top floor being affected by smoke
15 July 2011- 0300hr	Salamanca Place Lambeth	17 floors	4th floor	Firefighters rescued nine persons externally. Ten more residents led to safety down internal staircases. Five firefighters treated for smoke inhalation after becoming trapped in a lift. Evacuated residents relocated in temporary accommodation.

Time/Date	Location	Building height	Floor of origin	Rescues/ Injuries/Fatalities
2 August 2011 – 2215hr	Parkfield, Callow Mount,Sheffield	13 floors	12th floor	Adjacent to pilot project installation Estimate of damage: £10k
12 August 2011 – 0030hr	Andrew Reed House, Linstead Way, Wandsworth	15 floors	9th floor	One person taken to hospital with life threatening injuries. Fire crews rescued five people using the stairs and four people from the 10th floor via a turntable ladder within minutes of arriving. A further 150 people left the 15 storey block.
13 September 2011 –1340hr	Clem Attlee Estate, Fulham	17 floors	6th floor	25 residents evacuated to community centre
18 September 2011 – 0800hr	Cambria House, Larner Road, Erith	14 floors	14th floor	Nine people rescued
26 September 2011 -1100hr	Markham Tower, Bowers Avenue, Norwich	10 floors	8th floor	Residents from all 44 flats and moved into temporary accommodation

Appendix 2: Specification of system

The specification was as follows:

Pipework

The pipework beyond installation control valves to be sized from 32mm to 50mm according to the requirements of the system. The pipework will be in CPVC to BS 7291-4.

The pipework routes to be in full compliance with Building Regulations, with the final locations being determined on site prior to commencement of works.

The use of CPVC as the preferred material eliminates any hot work and thus complies with all current health and safety regulations. It also minimises the friction losses thus making a mains installation more achievable.

Sprinklers

Viking VK457 concealed sprinklers with a flush fitting to the ceiling line to be used on all flat ceilings. They will be fitted with a cover finished in white in accordance with BS EN 12259-1 and shall not be decorated. Viking VK480 concealed sidewall sprinklers will be used where boxing is being provided and within all flats.

Temperature rating of each head is 74°C. The final position of the heads will be agreed on site.

The four bin stores will be protected by a Reliable sidewall dry sprinkler head.

Flow Switch

A flow switch will be incorporated in the sprinkler valve set located on each supply branch. This will allow Sheffield Homes to incorporate individual monitoring of the units at a later date, if so required.

Installation Equipment

- Sprinkler valve set incorporating system flow switch;
- all necessary sprinklers heads, pipe, fittings and brackets;
- FIRAS Certificate of Compliance and logbook.

Appendix 3: Breakdown of costs

Breakdown of costs - Flats		
	Individual flat	**Total for all flats**
Components	£306.00	£14688.00
Labour	£450.00	£21600.00
Establishment	£149.32	£7167.36
Total	**£905.32**	**£43455.36**

Breakdown of costs - Lobbies		
	Individual lobby	**Total for all lobbies**
Components	£188.61	£2263.32
Labour	£270.00	£3240.00
Establishment	£99.59	£1195.08
Total	**£558.20**	**£6698.40**

Breakdown of costs – Ground floor		
		Total for ground floor
Components		£2103.68
Labour		£2050.00
Establishment		£827.03
Total		**£4980.71**

Appendix 4: The Callow Mount project

Project funded and directed by: the British Automatic Fire Sprinkler Association for the Sprinkler Coordination Group

Project manager: Steve Seaber OBE, DMS, FIFireE

Installation designed and installed: by Domestic Sprinklers Ltd

The International Fire Sprinkler Association provided major funding for project documentation and publicity

Funding for the project was provided by the following BAFSA member companies:
API Vipond Fire Protection
Armstrong Priestley
Automatic Fire Control
Compco Fire Systems
Fire Defence
Galglass
Grundfos Pumps
Hall & Kay Fire Engineering
Hall Fire Protection
Lubrizol Advanced Materials Europe
Nationwide Sprinklers
Reliable Fire Sprinkler (UK)
SPP Pumps
TATA Steel UK Ltd
Thameside Fire Protection Co
Tubetrade
Tyco Fire and Integrated Solutions
UK Firewatch
Victaulic
Viking Fire Protection

The project was also provided with valuable support by:
Applications Engineering
Callow Mount Tenants' Association
Chief Fire Officers' Association
Kier
Marpal Ltd
Sheffield City Council
Sheffield Homes
South Yorkshire Fire & Rescue Service
Warrington Exova
Zurich Municipal Insurance

Safer High-rise Living

The Callow Mount Sprinkler Retrofit Project

A Report from the Sprinkler Coordination Group

This report demonstrates that it is cost-effective and practical to retrofit automatic fire sprinklers in existing high-rise tower blocks, in particular in those constructed between 1950 and 1970. It describes how a pilot project, sponsored by the sprinkler industry and overseen by the British Automatic Fire Sprinkler Association, resulted in the successful installation of sprinklers in a 13 storey, 1960s tower block in Sheffield.

The report reviews:

- the identification of risks associated with high-rise social housing blocks;
- the direct and indirect consequences of fire in high-rise residential premises;
- the relevant recommendations in current fire safety legislation and guidance documents;
- research into the use of sprinklers in residential and domestic premises;
- the outcome of the pilot installation of a sprinkler system into a high-rise social housing block.

It summarises the key findings of the Sheffield pilot:

- the retrofit was completed with little or no disruption to the residents, who remained in their homes throughout the installation programme;
- the owners of the building and residents expressed a high degree of satisfaction with the outcome;
- authoritative financial data is provided for housing authorities, associations and landlords in evaluating the cost-benefit/effectiveness of installing an automatic sprinkler system;
- the approach adopted provides a template for organisations contemplating a similar exercise in fire safety improvements;
- the sprinkler installation was carried out at a cost of £1,150 per one-bedroom flat, with a modest, future annual maintenance charge.

This ground-breaking project makes essential reading for those with responsibility for fire safety in high-rise social housing blocks.

Price: £25 UK postage free

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