ABI STUDY: POST GRENFELL RESEARCH ON RESIDENTIAL SPRINKLER SYSTEMS

Development of Technical Guidance with a view to increasing performance and reducing the likelihood of escape of water incidences

ABSTRACT

This work was commissioned by ABI on behalf of its membership to promote the procurement philosophy of Dame Judith Hackitt's Review in respect of the provision of Sprinkler Systems for Residential buildings. The work was undertaken by the Fire Protection Association with the support of the Residential Sprinkler Association.

29/09/2018

Executive Summary

This work was commissioned by ABI on behalf of its membership to promote the procurement philosophy of Dame Judith Hackitt's Review in respect of the provision of Sprinkler Systems for Residential buildings. The work was undertaken by the Fire Protection Association with the support of the Residential Sprinkler Association. The UK insurance industry has always supported and invested heavily in the development of sprinkler systems for the protection of the built environment and within their own rule sets for commercial property protection[a] seek to enhance overall system resilience and reduce consequential damage.

Following a number of fires in residential premises involving multiple loss of life it is anticipated that there will be a proliferation of sprinkler system use in the domestic / residential environment; particularly where higher risks exist, such as high-rise buildings. Without changing the life-safety[b] focus of the dominant residential sprinkler standard BS9251, this document seeks to exploit current best industry practice and knowledge to ensure future installed systems resiliently meet their design objective without introducing other insurance challenges which if left unaddressed, have the potential to damage sprinkler system performance and reputation.

Since the sprinkler protection element of any building is only one safety feature component of a building's Fire Safety Plan, guidance is provided to clarify the roles and responsibilities of all participants in the specification, design, and installation process.

The primary areas of reinforcement are:

- Quality – ensuring all persons and products in the sprinkler system supply chain are appropriately qualified / certificated / approved and the installing company has the appropriate third-party accreditation and listing in one of the recognised industry approval schemes for sprinkler contractors to ensure the system functions when required, and does not operate falsely when not, for the life-span of the system.
- Clarity - this document seeks to provide additional guidance to assist the fire engineer address 'Special Circumstances' that may feature in the system design requirement and will demand design adaptations to the sprinkler system to be made.
- Curtailment of Escape of Water (EoW) risks – EoW is the largest category of insurance loss in the domestic / residential environment; greater than fire or security losses combined. The installation of fire sprinkler protection introduces an additional system to domestic water, waste water, and heating systems, and its potential to adversely contribute to EoW loses must be carefully considered at the design stage with a view to:
    - Reducing the likelihood of an EoW event occurring
    - Enabling the rapid management of an EoW event when it does happen

  Particularly in the multi-storey environment, EoW events have the potential to displace many people from their homes for significant periods of time which will act to both defeat the purpose of what a sprinkler system seeks to achieve (preservation of a habitable environment) and cause severe damage to perceptions of sprinkler system benefit.

In common with all suppression guides, this note assumes the degree of fire resisting construction (separation) present in a building is compliant with the requirements of the appropriate Building Regulations.

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[a] LPC Rules for automatic sprinkler installations 2015 incorporating BSEN 12845

[b] Sprinkler systems for life-safety seek to assist occupant evacuation or rescue by preventing or prolonging the time it would take for a compartment on fire to reach flash-over. Property Protection sprinkler systems additionally seek to prevent spread and hold the fire to a size coherent with the determined Business Continuity objectives and manageable by intervention resources such as the Fire and Rescue Services.

This Technical Guidance Note is intended to supplement the contents of BS 9251:2014 but is not a substitute or replacement for that standard.

1 Introduction

Following the Grenfell tragedy, the Fire Protection Association proposed fourteen potential research themes that it considered valid in addressing fire safety and resilience issues within the UK built environment as follows:

- Clarity and interpretation
- Scope
- Engagement
- Competency, Supervision, Control, and Authorisation
- Combustible Materials
- Imperfect World
- Standards
- Detection and Evacuation
- Engineered solutions
- Data
- Awareness
- Impact of other parts of Building Regulations
- Sprinklers
- Consequences of previous BR reviews and legislative changes

These themes were considered by the ABI and RISCAuthority memberships and ABI funding was provided to deliver on three fronts in time to influence the inquiry:

- **Cladding Standards**: The adequacy of the current cladding testing regimes to deliver high levels of fire safety under real world conditions.
- **Detection & Evacuation:** The effectiveness of detection and associated evacuation procedures: furthering the 2014 FPA campaign for high-integrity detection systems in high hazard and commercial applications.
- **Residential Sprinkler Systems**: The standards and relative performance of sprinkler systems specified for residential applications with a view to ensuring quality in operation and function.

A fuller explanation of the research themes is given in Appendix A. This report details the research outputs of Workstream 3: Residential Sprinkler Systems. The resulting Technical Guidance Note is given in full in Appendix B.

2 Background

The UK insurance industry has a long association with Sprinkler Systems and continuously develop system designs for the UK commercial sector via RISCAuthority and the publication of the LPC Rules for automatic sprinkler installations 2015 incorporating BSEN 12845. The LPC Rules are focussed on the protection of business and property and should not be confused with Residential Sprinkler Standards, such as BS 9251, which, by default, have an objective limited to that of life-safety only – assisting the occupants to evacuate to a place of safety, and those responding to carry out their duties. In comparison to the Commercial sprinkler sector, the quality regimes in place to assure performance in respect of the designer, installer, and product approvals are less stringent, and installation standards are relatively loose preferring to default to the seeking of expert guidance for anything but the ordinary. It is essential to understand that system cost is a very dominant driver in the residential sprinkler arena, and there are few opportunities for a study like this to have impact if the advice given adds significantly to the overall cost of installation.

Post Grenfell there is an observed increase in the provisioning of residential sprinkler systems in the high-rise environment which is admirable. To ensure that the full benefit is extracted from these systems the ABI membership asked for guidance that:

- Could improve the likelihood of the system to perform its function – thereby preserving the reputation of sprinkler systems as the most reliable form of protection for the built environment.
- Would reduce the likelihood of escape of water incidences – escape of water is the highest category of insurance loss in the residential sector, and nowhere more so than in the multi-storey environment for obvious reasons.

This work seeks to give additional advice and recommendations in support of BS 9251, the dominant residential sprinkler system design and installation standard at the time of writing. This will be replaced in due course by a CEN standard, but the principles of what it seeks to achieve remains unchanged.

3 Methodology

Analysis of residential sprinkler system procurement showed that there was often a disconnect between the specification of the sprinkler system requirements, and those who ultimately had responsibility for the building's Fire Safety Plan. Often as not the sprinkler system designer / installer was undertaking some of the duties of the fire engineer in respect of i.e. making assumptions about the occupancy of the building and the role system had to play in the overall fire safety management plan of the building. Identification of issues such as this were core to Dame Judith Hackitt's inquiry and so it was necessary for the focus of this guidance to involve both the fire engineer, sprinkler installer, and some other parties besides whose input has the ability to impact upon overall performance, such as the passive protection installers. Without the same quality systems in place that define the commercial sprinkler sector, the provision of quality within the residential sector can stem greatly from the experience and ethics of the company commissioned itself, although that is not to say that schemes do not exist from which competency can be implied.

The TGN seeks to achieve its goals by:

- Confirming roles and responsibilities between the client, main contractor, fire engineer, and fire protection service designers / installers
- Advising the fire engineer of the critical features of a residential sprinkler system, how the design must change to accommodate different design objectives, and inform of known vulnerabilities and issues in their installation.
- Promote at every stage 3rd party approvals for the design and installation of systems, and use of approved products within the system (including passive fire protection)
- Highlighting best-practice design approaches within the multi-storey environment

4 Output

The output of this work is a Technical Guidance Note to accompany BS9251. The document is aimed at both the fire engineer that is using a residential sprinkler system as part of their overall fire safety management plan for the building, and the sprinkler installer.

5 Review

The document has been sent for review to the fire community and as at this date comments received from the insurance sector have been incorporated.

6 Next steps

The document release will be supported by a webinar and the work shall be submitted to the relevant standards bodies for consideration.

APPENDIX A - ABI / FPA Tall Building Fire Safety: Research Themes

This note is a deliverable of the ABI / FPA Workshop 'Building Regulations Industry Asks' held jointly at ABI on 28th June 2017. FPA committed to specifying a series of logical research themes that would address all current and historic insurer concerns in respect of the UK's Building Regulations and the review framework they sit within. The list is not constrained to issues relevant to the Grenfell fire. The purpose of this note is to simply propose themes, providing limited supporting information, so that members of the workshop might add to the document, prioritise their instructions for effort placement, and develop detailed requirements in key areas going forward. Some of the themes might be 'fanciful' in that they would not be open for discussion in any Building Regulations review, but are included for completeness to present a fuller overall picture of insurance challenges in the built environment. The ambition is to have a well-focussed understanding of key insurer research requirements in time for the September GIC meeting accompanied by costed options which will enable insurers to develop well researched cases for change in a format, and with sufficient rigor, to influence those in a position to invoke change. Where prudent, collaboration with likeminded groups in some areas will be encouraged.

The research themes suggested, presented in no specific order, are as follows:

- Clarity and interpretation
- Scope
- Engagement
- Competency, Supervision, Control, and Authorisation
- Combustible Materials
- Imperfect World
- Standards
- Detection and Evacuation
- Engineered solutions
- Data
- Awareness
- Impact of other parts of Building Regulations
- Sprinklers
- Consequences of previous BR reviews and legislative changes

1. Clarity and Interpretation

Issue: Irrespective of the specifics of the Grenfell Tower fire many hundreds of other tower blocks (and other premises, hospitals for example) around the UK have been found to be clad in similar products. Product selection may be made by three specific routes; prescription, full-scale built-up system testing, or desktop study. Whilst the cladding product in question has been described as 'illegal', its use could have been legitimised via the second two of the three routes. If it transpires that the majority use is 'illegal' then consideration must be given to the apparently endemic misinterpretation / ignoring of the Building Regulations and/or Approved Documents (AD's) by

those both designing and approving buildings. If it turns out that their use has been legitimised, then the soundness of the case made, methods used, and persons involved needs scrutiny.

2. Scope

Issue: Since the last review of building regulations, construction and refurbishment techniques and the associated materials have changed/altered substantially. The Grenfell Tower fire has also highlighted the social challenges associated with loss of accommodation. Current regulations are focussed only on life-safety with no cognisance of Property Protection objectives. Consideration must now be given to extending the scope of the regulations and associated AD's and associated guidance (HTM's; BB100) to address the changing risk environment and identified emerging trends. Key areas for attention (not limited to):

- To include a 'lowest bar' non-negotiable (prescriptive) property protection element around which the life-safety provision is formed.
- To address fire ingress – an emerging trend that has led to both significant property loss and near-miss life-safety issues.
- To address Arson (both internal and external) as a tangible threat – amendment of many other sections of AD's may contribute also.
- To review suitability, particularly in respect of the provision for some modern building methods of combustible structure and voids

3. Engagement

Issue: Whilst the UK insurance industry is in an admirable position to detect and comment upon emerging trends associated with fire loss our capability to both raise concerns and invoke change are greatly limited by the defences put in place within MHCLG. Our point-of-contact is a single person who seemingly operates outside of any quality assurance scheme. To this end, issues raised generally receive a short email response and we are left unclear as to whether our concerns have been raised with a panel of appropriate experts or get no further than the inbox of the individual. A typical response might read "…there are no plans to change Building Regulations for the foreseeable future". The lack of an established review period is unacceptable. It is interesting to note that the only time we have been granted access to BRAC has been when we have by-passed the MHCLG point of contact using unorthodox means.

4. Competency, Supervision, Control, and Authorisation

Issue: Within the Regulatory Framework the terms of 'Competency' and 'Responsible Person' are extensively used without any associated reference to qualifications or what makes a person 'competent' other than common phraseology in terms of 'training', 'experience' and 'other qualities'. A person's contribution may only be judged to have been 'competent' or 'incompetent' based on the outcome of a fire occurring and/or enforcement activity / prosecution – a reactive approach rather than predictive. Fire, is thankfully a rare event, and as such could mask many 'incompetent' decisions for many years. Should exposure of systemic 'incompetency' be revealed following an event by an individual or organisation, the legacy problems could have substantial life-safety, societal, and property / business loss implications.

It is clear too that a level of construction supervision is inferred that does not actually happen on today's building sites – the Clerk of Works is a historic and much missed role.

5. Combustible Materials

Issue: As defined in the RISCAuthority 'Essential Principles' guide, resilient fire prevention and protection starts with the selection of non-combustible materials. Non-combustible materials are known to be very forgiving of other key fire relevant challenges such as poor-quality workmanship, structural abuse and wear and tear over time. With a remit that extends no further than 'evacuation before collapse' the regulations allow for the deployment of materials that do burn, so long as they do so to a timeframe, or at a location, that will not impair escape. Whilst life-safety has traditionally been achieved using good performing materials, such as bricks and mortar or reinforced concrete, modern methods of construction, in association with the drive for improved energy efficiency, has introduced large quantities of combustible material into the built environment by way of structure, cladding and insulation. The protection of this material very often demands encapsulation by better performing materials (such as plasterboard), to a precision that may be difficult to achieve on-site or whose capability may reduce during the life-span of the building.

6. Imperfect World

Issue: Evidence exists to demonstrate that key failings in the execution of Building Regulations generally pertain to in-exactness in construction (in both 'traditional' building methods and more modern approaches such as modular construction) and inappropriate (deliberate or accidental) adjustment of the materials/specification or the building during construction or occupation. If this is an accepted fact then there should be a duty on Building Regulations and guidance to not support construction method and material combinations that are so susceptible to minor deviation that they can only really be demonstrated to be safe and compliant 'on-plan'. Specific examples might include the fire stopping requirements of light timber frame construction, and cladding systems that encapsulate combustible insulation.

7. Standards

Issue: Seldom is it the case that test standards accurately represent real-life situations with any exactness but this is generally catered for by the application of safety factors inherent in the challenge of the test, or protection additions over and above the 'pass' threshold. For example, gaseous extinguishing systems are tasked with satisfying a series of tests to determine an 'extinguishing concentration' but the end use, or 'design concentration' is the extinguishing concentration uplifted by 30% to account for 'test to end-use' differences. Such a process does not seem to be common place within the product approvals process for building products. Specific to cladding systems, which are tested as 'perfect build' there might well be a need to introduce additional, reasonable-worst-case features known to impact upon performance. Some of these might be legitimate, such as the installation of plastic vents, grills and pipework that are not required to be fire-stopped; or illegitimate, such as imperfect construction or wear-and-tear features. This may also raise questions over the suitability of testing building components in isolation rather than as built up systems.

An additional area for consideration is in the interpretation of standards. A review of rainscreen cavity barrier tests demonstrate that whilst many products 'technically' fail the testing regimes (in the early stages of a fire they allow flames to pass), they can still be promoted as being fit-for-purpose through later desktop evaluation.

8. Detection & Evacuation

Issue: Building Regulations have traditionally been focussed on the requirement of 'evacuation before collapse'. However, for a range of reasons, stay-put evacuation policies are being used which, if not properly justified in terms of the building's compartmentation capability and resilience strategy to fire, could be more harmful than beneficial. A possible driver for the stay-put policy might additionally be the incredibly unreliable performance of automatic fire detection systems.

Automatically generated fire alarm signals are over 95% likely to be false (not stemming from fire or smoke – shower steam etc.) or unwanted (smoke based, but not something requiring an FRS response (burnt toast or smoking)). A stay-put policy might reduce the inconvenience associated with false and unwanted alarms but does not alter the core issue of poor alarm performance. There are few areas of life-safety where there is such tolerance to poor supporting system performance.

9. Engineered Solutions

Issue: The discipline of fire engineering is a vital tool for the creation of modern complex buildings where the prescriptive elements of building regulations, AD's and the like (BB100; HTMs) are considered inadequate for meeting the design objective. However, experience does also show that, given the limited mandated objective of 'evacuation-before-collapse' that this allows for buildings (and their modification) to be 'value-engineered' down to a level that can significantly reduce the overall resilience of the built estate in the pursuit of cost savings. Clarification is required on the extent of the fire engineer's brief, and in particular, their ability to alter the requirement of established standards upon which their designs depend. An example might be where an engineered solution demands reliance upon sprinklers to meet the objective, but the fire-engineer determines that the full demands of the standard are not required; such as water supply duration. Linked in with the Competency Research Stream, questions must be asked of whether anyone is competent enough to have a standards-setting-level of competency in all of the key areas of fire prevention, protection, life-safety, and regulation, to make decisions of this type. The piecemeal use of fire-engineering must also be considered within this research stream. Fire Engineering by definition is meant to be holistic, and all encompassing, however we do see it applied to solve specific, limited scope problems that defeats the holistic ambition and can be the source of inconsistency in the overall design.

10. Data

Issue: All engagement on Building Regulations issues demand evidencing with appropriate data. One of the principle sources of data, the Incident Recording System (IRS), that records details of every FRS response, is kept a closely guarded secret by the Home Office (and MHCLG before them). For insurers to engage adequately there is a need to be able to marry up the information held within the insurers' large loss database with that held within IRS on a case-by-case basis. Extensive research capability pertaining to the analysis of building make-up and loss experience would quickly follow.

11. Awareness

Issue: The limited objective of 'evacuation before collapse' is not well understood by key industry sectors (Business, Public Services providers, homeowners and occupiers). This lack of understanding prevents those in a position to ask for more, from doing so, and leaves key resilience decisions to disengaged 3rd parties (such as the architect, specifier, supplier or contractor) who do not take benefit from improved decision making. This lack of awareness defeats market forces in that different build methods, with differing levels of inherent resilience, are considered equal on all counts. A scoring method for resilience, akin to the BREEAM sustainability scheme, would seem an appropriate method of redressing balance and supporting those who demand higher levels of protection over life-safety.

12. Impact of other parts of Building Regulations

Issue: Competing parts of Building Regulations can work against building fire protection endeavours. Such areas might include the provision of voids in building cladding to prevent moisture issues; these can act as flues in the event of fire if not controlled, and thermal performance demands that might promote poorer fire performing products over better performing ones.

13. Sprinkler Provision

Issue: The United Kingdom has one of the weakest policies in respect of Sprinkler provision in comparison to other European countries. Much like seat-belts and airbags are deemed essential for making cars safe, the provision of sprinkler systems is considered an essential component to ensuring safety in large buildings and some modern methods of construction – particularly in light timber frame buildings in the US where it is the dominant residential construction method.

14. Consequences of previous BR reviews and legislative changes

Issue: Building Regulations, tightened up following the Great Fire of London, have undergone systematic erosion in recent history to bring us to this point in time where the built estate, whilst generally safe, is increasingly fragile to fire. The last mandated requirement for Property Protection, the Local Acts, was removed in April 2015 – it is possible, had they still been in place that they may have influenced the fire requirements of Grenfell Tower's refurbishment.

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TECHNICAL GUIDANCE NOTE: RESIDENTIAL SPRINKLER SYSTEMS TO BS9251

Guidance and recommendations for the implementation of Residential Sprinkler Systems

BRIEF

This work was commissioned by ABI on behalf of its membership to promote the procurement philosophy of Dame Judith Hackitt's Review in respect of the provision of Sprinkler Systems for Residential buildings. The work was undertaken by the Fire Protection Association with the support of the Residential Sprinkler Association.

29/09/2018

Residential Sprinkler Systems: Technical Guidance Note for Fire Engineers (working on behalf of the Client or their Main Contractor) and Sprinkler System Installers using BS 9251:2014

Seeks to:

1. Confirm roles and responsibilities in relation to:
    a. CDM
    b. RRO
    c. How things might be post Hackitt review

2. Extoll the virtues of:
    a. 3rd party certification of designers, installation and product
    b. BS 9251 experience
    c. Using companies that are financially solid

3. Assist those working on behalf of the Client tasked with producing the Fire Safety Plan, to properly specify the requirements of the Sprinkler system for communication to the Sprinkler System Designer / Installer

4. Assist those working on behalf of the Client tasked with producing the Fire Safety Plan, to properly specify the requirements of the Passive making good (if different from the sprinkler installer) so that poor product choice does not damage the system.

5. Encourage the Designer / Installer to produce good systems that are more likely to perform and less likely to leak

6. To provide worked examples for topical multi-storey buildings

FORWARD

This document has been created by the Fire Protection Association at the request of the membership of the Association of British Insurers (ABI). The UK insurance industry has always supported and invested heavily in the development of sprinkler systems for the protection of the built environment and within their own rule sets for commercial property protection[a] seek to enhance overall system resilience and reduce consequential damage.

Following a number of fires in residential premises involving multiple loss of life it is anticipated that there will be a proliferation of sprinkler system use in the domestic / residential environment; particularly where higher risks exist, such as high-rise buildings. Without changing the life-safety[b] focus of the dominant residential sprinkler standard BS9251, this document seeks to exploit current best industry practice and knowledge to ensure future installed systems resiliently meet their design objective without introducing other insurance challenges which if left unaddressed, have the potential to damage sprinkler system performance and reputation.

Since the sprinkler protection element of any building is only one safety feature component of a building's Fire Safety Plan, guidance is provided to clarify the roles and responsibilities of all participants in the specification, design, and installation process.

The primary areas of reinforcement are:

- Quality – ensuring all persons and products in the sprinkler system supply chain are appropriately qualified / certificated / approved and the installing company has the appropriate third-party accreditation and listing in one of the recognised industry approval schemes for sprinkler contractors to ensure the system functions when required, and does not operate falsely when not, for the life-span of the system.
- Clarity - this document seeks to provide additional guidance to assist the fire engineer address 'Special Circumstances' that may feature in the system design requirement and will demand design adaptations to the sprinkler system to be made.
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Contents

1 Introduction

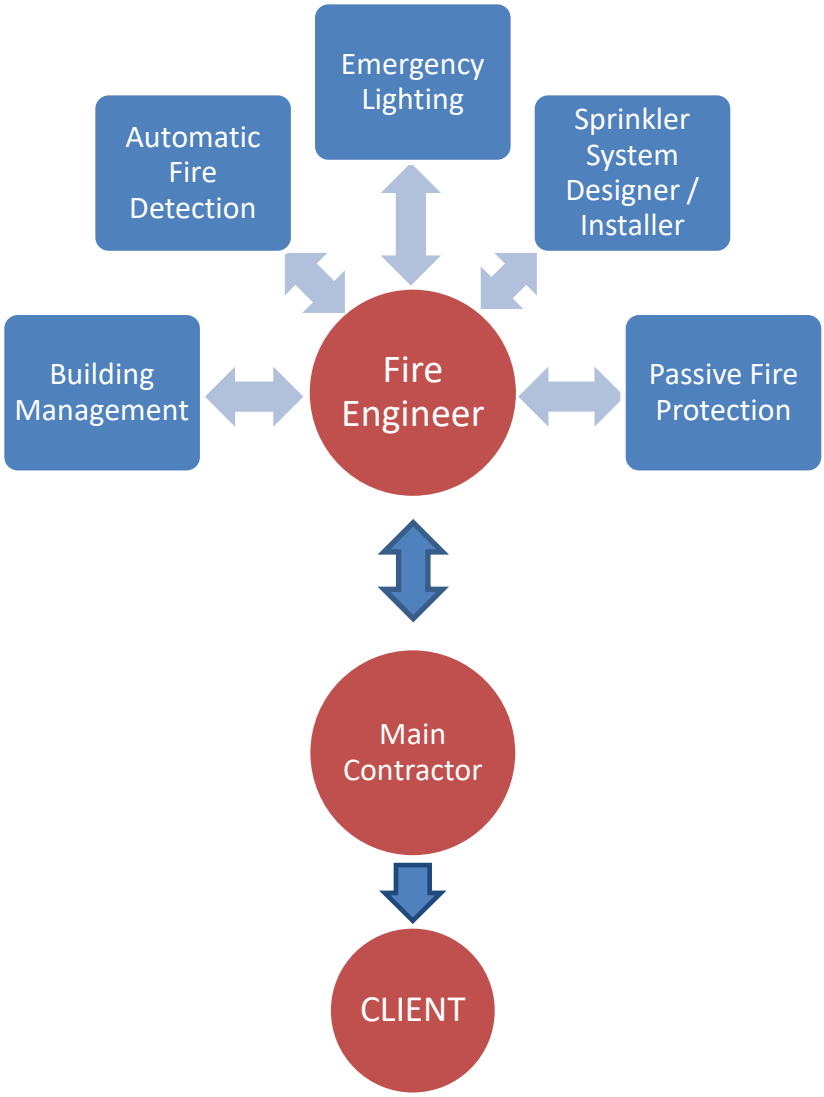
In association with a building's built in passive fire resisting features, Residential Sprinkler Systems have been demonstrated to be very effective at protecting lives from fire, both of the occupants, and those attending. Their use has typically been prevalent where normal safety measures might be considered insufficient to assure the safety of occupants either due to their own special needs, or due to the specific challenges of the building such as its height, layout or remoteness from Fire Service support.

This document seeks to assist the Designer, and their Main Contractor, consider the factors important to the delivery of an effective Residential Sprinkler solution by ensuring roles and responsibilities are understood and appropriate communication is made between the sub-contracted services of:

- Fire Engineering
- Sprinkler System design and installation
- Passive Fire Protection

so that the Fire Strategy Plan for the building is underpinned by demonstrable quality systems that work as a whole for the life of the building.

The sprinkler system design brief must originate from the Client, their Main Contractor, or their appointed Fire Engineer as they are the only participants with the knowledge required of the building and occupancy risks, and the overall Fire Safety Plan and the role that the sprinkler system plays in assuring safety: this responsibility should not be devolved to the Sprinkler Installer.



Specification of the requirements of a residential sprinkler system is not a trivial matter. Although standards provide design solutions for some basic situations, any situation where occupancy, circumstance, or building challenges warrant special consideration, the user is directed to seek the services of a risk expert. Whilst these 'Special Considerations' are referenced in the Sprinkler installation standard, it is the responsibility of the Client, or their appointed representative, to consider these, and communicate the results of their deliberations to the sprinkler designer / installer so that these can be accounted for within the design.

2 Relevant Roles and Responsibilities

This Section describes roles and responsibilities pertinent to the installation of fire safety systems. Although current regulations (CDM 2015) are primarily focussed on the safety of workers during the construction phase, many criteria persist to cover the safety of occupants in the finished building – these are highlighted below.

Following the Grenfell Fire, the Hackitt report recommended a clear model of risk ownership, with responsibilities for the Client, Designer, Contractor and Owner using the CDM Regulations as an exemplar.

2.1 CDM Definitions

2.1.1 'Contractor'

Means any person (including a non-domestic client) who, in the course or furtherance of a business, carries out, manages or controls construction work;

2.1.2 'Managing'

To manage the construction phase, principal contractors must ensure that: '….. those engaged to carry out the work are capable of doing so'

2.1.3 'Appointing workers'

When a contractor employs or appoints an individual to work on a construction site, they should make enquiries to make sure the individual:

a) has the skills, knowledge, training and experience to carry out the work they will be employed to do in a way that secures health and safety for anyone working on the site; or

b) is in the process of obtaining them. Paragraphs 163–173 [ref] give guidance on what a contractor should consider when appointing anyone who has gaps in the skills, knowledge or experience necessary for the work.

Sole reliance should not be placed on industry certification cards or similar being presented to them as evidence that a worker has the right qualities. Nationally recognised qualifications (such as National Vocational Qualifications (NVQs) and Scottish Vocational Qualifications (SVQs)) can provide contractors with assurance that the holder has the skills, knowledge, training and experience to carry out the task(s) for which they are appointed. Contractors should recognise that training on its own is not enough. Newly trained individuals need to be supervised and given the opportunity to gain positive experience of working in a range of conditions.

2.1.4 'Design'

Includes drawings, design details, specifications and bills of quantities (including specification of articles or substances) relating to a structure, and calculations prepared for the purpose of a design.

2.1.5 'Designer'

Means any person (including a client, contractor or other person referred to in these Regulations) who in the course or furtherance of a business—

a) prepares or modifies a design; or

b) arranges for, or instructs, any person under their control to do so,

relating to a structure, or to a product or mechanical or electrical system intended for a particular structure, and a person is deemed to prepare a design where a design is prepared by a person under their control.

Designers include architects, architectural technologists, consulting engineers, quantity surveyors, interior designers, temporary work engineers, chartered surveyors, technicians or anyone who specifies or alters a design. They can include others if they carry out design work, such as principal contractors, and specialist contractors, e.g. an engineering contractor providing design, procurement and construction management services.

The person who selects products for use in construction is a designer and must take account of health and safety issues arising from their use. If a product is purpose-built, the person who prepares the specification is a designer and so are manufacturers, if they develop a detailed design.

2.1.6 'Eliminating, reducing or controlling foreseeable risks through design'

When designing, a designer must consider the risks people may be exposed to through the course of both constructing a building and using it once it is constructed (during maintenance, cleaning or using the building as a workplace once it is built).

2.1.7 'Duty Holders'

CDM duty holders:	Summary of role/main duties
Clients are organisations or individuals for whom a construction project is carried out.	Make suitable arrangements for managing a project. This includes making sure: • other duty holders are appointed; • sufficient time and, • resources are allocated. Make sure: • relevant information is prepared and provided to other duty holders; • the principal designer and principal contractor carry out their duties; • welfare facilities are provided.
Domestic clients are people who have construction work carried out on their own home, or the home of a family member that is not done as part of a business, whether for profit or not.	Domestic clients are in scope of CDM 2015, but their duties as a client are normally transferred to: • the contractor, on a single contractor project; or; • the principal contractor, on a project involving more than one contractor. However, the domestic client can choose to have a written agreement with the principal designer to carry out the client duties.
Designers are those, who as part of a business, prepare or modify designs for a building, product or system relating to construction work.	When preparing or modifying designs, • to eliminate, reduce or control foreseeable risks that may arise during construction; and • the maintenance and use of a building once it is built. Provide information to other members of the project team to help them fulfil their duties.

Principal designers are designers appointed by the client in projects involving more than one contractor. They can be an organisation or an individual with sufficient knowledge, experience and ability to carry out the role.	Plan, manage, monitor and coordinate health and safety in the pre-construction phase of a project. This includes: • identifying, eliminating or controlling foreseeable risks; • ensuring designers carry out their duties. Prepare and provide relevant information to other duty holders. Provide relevant information to the principal contractor to help them plan, manage, monitor and coordinate health and safety in the construction phase.
Principal contractors are contractors appointed by the client to coordinate the construction phase of a project where it involves more than one contractor.	Plan, manage, monitor and coordinate health and safety in the construction phase of a project. This includes: • liaising with the client and principal designer; • preparing the construction phase plan; • organising cooperation between contractors and coordinating their work. Ensure: • suitable site inductions are provided; • reasonable steps are taken to prevent unauthorised access; • workers are consulted and engaged in securing their health and safety; and • welfare facilities are provided.
Contractors are those who do the actual construction work and can be either an individual or a company.	Plan, manage and monitor construction work under their control so that it is carried out without risks to health and safety. For projects involving more than one contractor, coordinate their activities with others in the project team – in particular, comply with directions given to them by the principal designer or principal contractor. For single-contractor projects, prepare a construction phase plan.

2.1.8 'Clients'

Appointing designers and contractors: anyone responsible for appointing designers (including principal designers) or contractors (including principal contractors) to work on a project must ensure that those appointed have the skills, knowledge and experience to carry out the work in a way that secures health and safety.

Contractors appointing anyone for work on a construction site: when contractors appoint anyone to carry out work on a construction site, they must make sure that those they appoint have, or are being supervised by an accreditation body whilst in the process of gaining, the right skills, knowledge, training and experience

Clients could prepare a clear 'client's brief' as a way of setting out the arrangements. The client brief normally:

a) sets out the main function and operational requirements of the finished project;
b) outlines how the project is expected to be managed including its health and safety risks;
c) sets a realistic timeframe and budget; and
d) covers other relevant matters, such as establishing design direction and a single point of contact in the client's organisation.

2.2 Hackitt

Hackitt recommends a clear model of risk ownership, with responsibilities for the Client, Designer, Contractor and Owner using the CDM Regulations as an exemplar.

The report recommends that government should make the creation, maintenance and handover of relevant information an integral part of the legal responsibilities on Clients, Principal Designers and Principal Contractors undertaking building work on High Rise Residential Building (HRRBs).

It also recommends that government should consider applying the key roles and responsibilities and information product recommendations to other multi-occupancy residential buildings and to institutional residential buildings whilst bearing in mind necessary adjustments to keep the requirements proportionate.

Key roles	**Key responsibilities**
Clients	Make arrangements for managing the building work to deliver core objectives on building safety Establish procurement processes that allow sufficient time, resources and prioritisation to deliver the core objectives; Appoint competent duty holders who'll prioritise building safety and have the required skills, knowledge and experience Establish the necessary information management systems to facilitate successful completion and handover of the work; and Co-sign at completion that the work meets building safety requirements.
Principal Designers	Identify how building safety requirements will be met in the pre-construction phase, controlling foreseeable risks and ensuring that the contractual relationships they enter into are appropriately funded to support core objectives; Ensure that those involved in supporting the Principal Designer have suitable skills, knowledge and experience; Compile Full Plans documentation demonstrating they have considered and managed the key risks to building safety of the proposed construction as far as is reasonably practicable; Ensure that information management systems are properly updated and change control mechanisms are utilised; Co-sign at completion of works that the work meets the Building Regulations requirements.
Principal Contractors	Make suitable arrangements for the planning, management and realisation of the core objectives in the construction phase of a project. This includes ensuring that contractual relationships are appropriately funded to support core objectives. In addition, it includes: • preparing a construction control plan; • organising cooperation between contractors with suitable skills, knowledge and experience and coordinating their work; • updating information management systems and ensuring change control mechanisms are properly utilised; • leading demonstration on completion that the work meets the requirements of the Building Regulations and ensure the handover of the Fire and Emergency File and the digital record to the future building owner.

2.3 General fire safety legislation

- Regulatory Reform (Fire Safety) Order 2005 (applies in England and Wales).
- The Fire (Scotland) Act 2005

- Fire Safety (Scotland) Regulations 2006
- Fire and Rescue Services (Northern Ireland) Order 2006
- Fire Safety Regulations (Northern Ireland) 2010

Although these pieces of legislation were implemented at different times their intent is broadly similar. They replaced older items of legislation and relate to fire safety in non-domestic premises. Hence, in terms of blocks of flats for example, the legislation does not apply to the flats / maisonettes themselves but does apply to the common areas (staircases, corridors and the like) that serve the flats.

They introduce a general duty to ensure, as far as is practicable, the safety of employees; a general duty to ensure the safety of non-employees; to implement general fire precautions to ensure that premises are safe, and a duty to carry out and maintain a suitable and sufficient fire risk assessment.

The legislation applies to all non-domestic premises other than certain premises types such as means of transport whilst in motion, mines and boreholes etc. The main duty holder in terms of ensuring that the requirements of the legislation are met is the 'Responsible Person' or 'Duty Holder'.

The duties on the responsible person are extended to **any person who has, by virtue of any contract or tenancy to any extent, control of the premises to the extent that their obligation extends. This includes fire risk assessors, service providers, installers and maintenance contractors where their activities pertain to fire safety of the premises.**

3 Guidance for the Designer and their appointed representatives

The key roles and functions in the design and installation of a residential sprinkler systems are:

Client's / Designer's / Lead Contractor's appointed Fire Engineer

- Development of the Building's Fire Safety Plan (FSP)
- Specification of the sprinkler system to achieve its role in the FSP

Sprinkler System Design Installing Company

- Design of the system in accordance with the Fire Engineer's requirements and in accordance with the relevant sprinkler standard
- Installation and hand-over of the system with all relevant commissioning test records, demonstrations, documentation and client / user training.
- Where the sprinkler system installer has responsibility for the passive fire protection associated with the compartment breaching required by the sprinkler system to undertake the bulleted functions described below.

Passive Fire Protection company

In addition to their obligations to ensure the fire resistance and fire stopping of the fabric of the building complies fully with the building design requirements and appropriate regulations:

- To make good compartment breaching made during sprinkler system installation (if not done by the sprinkler installing company)
- Ensure all fire stopping products are approved as compatible with sprinkler system pipework materials (selection of incompatible sealing products is known to critically denature some types of plastic pipe used in residential sprinkler systems which can lead to brittle fracture, escape of water, and impairment of the system)
- Ensure all fire stopping products are mechanically compatible with sprinkler system pipework – intumescent devices and products have the potential to crush and close plastic pipe during a fire event thereby potentially disabling parts of the system at their time of requirement

As the only authority with jurisdiction over providers that may otherwise operate quite separately, information is provided to support the Designer and their appointed representatives achieve a coherent solution specific to residential sprinkler system provision. The areas addressed are:

a) Competency (3.1)
b) Subcontractor 'financial wellness' check (3.2)
c) Equipment and product certification (3.3)
d) Management of 'Special Circumstances' (3.4)
e) Known critical issues with the provision of residential sprinkler systems (3.5)

3.1 Competency

3.1.1 Sprinkler system design and installation

Selection of a contractor is the first, and in many ways, the most important step with regards to quality assurance. Whilst not mandatory in the UK, it is highly recommended that a contractor is

sought that is third party accredited (TPA). At the time of writing there are four approval bodies that undertake accreditation of sprinkler installing companies:

- LPCB – Loss Prevention Certification Board LPS 1048 Scheme - www.redbooklive.com
- LPCB – Loss Prevention Certification Board LPS 1301 Scheme - www.redbooklive.com
- FIRAS – Scheme for Residential Sprinkler Systems – www.warringtoncertification.com/firas.html
- IFC – International Fire Consultants - www.ifccertification.com/certification/installer-certification.html

Each of the above TPA schemes covers the requirements for the assessment, approval and regular review of sprinkler system contractors in the UK and Ireland in respect of compliance with relevant 'best practice' industry standards.

Selecting a contractor should not be limited to the contractor being third party accredited alone. Each TPA company registers their contractors at various levels and therefore, it is of paramount importance that the TPA company's website is checked to see if the contractor is accredited to the required level for the project in hand. For example, a contractor may be registered for BS EN 12845 sprinkler system at a level that does not include full hydraulic calculations where all Residential BS9251:2014 systems require full hydraulic calculations. It is important to ensure the contractor selected has Residential and Domestic sprinkler systems as part of the listing scope of their third-party accreditation.

3.1.2 Passive fire protection installation

Product third party accreditation schemes for passive fire protection product installation are run by the following organisations:

- BM TRADA - www.bmtrada.com
- LPCB - www.redbooklive.com/index.jsp
- FM Approvals - www.fmapprovals.com
- IFC Certification Ltd - www.ifccertification.com
- Intertek Testing & Certification Limited - www.intertek.com
- Underwriters Laboratories UK Ltd - www.ul.com
- Warrington Certification Ltd - www.warringtonfire.net

3.1.3 Sprinkler system installation and products – ancillary training

All installers must be specifically trained in the use of the proprietary piping system deployed. The principle current proprietary piping systems used include, but are not limited to:

- CPVC
- Lightweight crimped metal systems

Strict adherence to the manufacturers installation methodologies has been demonstrated to be critical to ensuring the performance of the pipe system as the potential pitfalls are many and often less than obvious. Training courses specific to the system's use in sprinkler systems are provided by the pipe system supplier or manufacturer, and evidence of satisfactory completion of a 'hands-

on' training course for all installing operatives must be sought by the Designer or their appointed representative (e-learning type training in the use of these systems is not considered adequate).

Where the passive fire protection of compartment breaches made during the installation of the sprinkler system is not conducted by the sprinkler system installer, there should be a similar expectation on the passive fire protection company conducting the work to have been appropriately trained in the fire-stopping methods and materials appropriate to the piping system used. Incorrect methods and materials used during fire stopping of sprinkler systems using certain pipe materials are known to extensively damage the pipe network.

3.2 Contractor financial wellness check

In addition to the sprinkler contractor's technical competency to undertake a project, covered in Clause 3.1.1 above, a sprinkler contractor should have the commercial capacity to undertake and complete the project.

Details held at Companies House may help in this contractor selection assessment as the records held will give information on:

- the length of time a contractor has been in business
- the turnover of the company, relative to the value of the contract to be placed.

Additionally, it may be beneficial to seek references for the company's other clients of similar size projects

3.3 Equipment and product certification

3.3.1 Sprinkler system components

The principle components of a residential fire sprinkler system are:

- Sprinkler heads – fire detection and water distribution
- Pipe network – connecting sprinkler head to pump / water source
- Control sets – for testing and isolation of the water supply, alarm connection, and fault monitoring
- Pumps – which may be specific to the sprinkler system or shared with the domestic water supply
- Tanks – which may be specific to the sprinkler system or shared with the domestic water supply
- Isolation valves – which should be monitored to ensure the system is correctly configured for operation
- Non-return valves – which should be installed to be maintainable
- Passive firestopping products – to ensure that the fire resisting capability of the compartment is maintained after sprinkler system installation.

All components should be certified as being fit for purpose for performing their specific roles as part of the sprinkler system. Certification of sprinkler equipment in the UK and internationally include:

- LPCB - https://bregroup.com/products/lpcb/
- FM - https://www.fmapprovals.com/
- UL - https://www.ul.com/
- VdS - http://vds-global.com/en/certifications/lists/vds-approvals/

Where non-certificated equipment is used, the Designer or their appointed representatives, will need to consider carefully the case made for use of the equipment in the context of impact upon the through-life performance of the sprinkler system; its meaning within the constraints of the relevant approved installers scheme, and accept responsibility for these decisions.

3.3.1.1 Sprinkler Heads

In residential areas Residential heads should be used. BS9251 requires the sprinkler heads to conform to BS9252, however, at the time of writing, no sprinklers have been tested against BS9252, and therefore, sprinkler heads listed to UL1626 shall be used.

3.3.1.2 Pipe

There are several pipe systems that can be employed, all of which must be certificated for use as part of a sprinkler system by a recognised UK or international approval body.

3.3.1.3 Control Sets

Currently all Control Sets available for BS9251 systems are not certified, however, the following will suffice to assess the suitability:

- The control set should be arranged similar to BS9251:2014, Figure A.1, items 3,4,5,6 and 7.
- The control set pipe should be fire rated
- Flow switch should be to EN 12259-5, Fixed firefighting systems - Components for sprinkler and water spray systems - Part 5: Water flow detectors

3.3.1.4 Pumps

There are currently three manufacturers that provide pump sets, (which include the Control Set), to BS9251:2014. While the pump sets are not certified, using known manufacturers with long histories of developing fire pumps for Residential & Domestic sprinkler systems ensures the pumps comply with BS9251:2014, Clause 5.9 and that the control systems are to industry standards and best practice. Bespoke or custom-built sprinkler pumps would require careful and detailed assessment and testing to ensure they fully meet the requirements of BS9251:2014, Clause 5.9, including appropriate control systems, before they can be considered acceptable.

3.3.1.5 Tanks

The sprinkler water storage tank should have a low water level alarm system to alert the system owner / user if the volume of stored water drops below the capacity required to meet the requirements of BS9251:2014. Consideration should also be given to the installation of a high level water alarm system to mitigate against escape of water incidents. The alarm(s) should report both locally and to the remote monitoring centre.

3.3.1.6 Isolation Valves

Although not a specific requirement under BS9251:2014, it is highly recommended that any valve that has the capability to stop water flow into the sprinkler system should be electrically monitored to ensure these valves are not maliciously or accidentally left closed. There are several manufacturers who provide such monitoring devices which can be installed onto the control set or pump stop valves to help ensure the sprinkler system is always fully operational. Closed valve alarm signals should report both locally and to the remote monitoring centre.

3.3.2 Passive fire protection products

Product third party accreditation schemes for passive fire protection product installation are run by the following organisations:

- BM TRADA - www.bmtrada.com

- LPCB - www.redbooklive.com/index.jsp
- FM Approvals - www.fmapprovals.com
- IFC Certification Ltd - www.ifccertification.com
- Intertek Testing & Certification Limited - www.intertek.com
- Underwriters Laboratories UK Ltd - www.ul.com
- Warrington Certification Ltd - www.warringtonfire.net

3.4 Special Circumstances

BS9251 has an extensive list of circumstances that it does not de facto cover. Addressing these circumstances might require changes to the BS9251 sprinkler system design, selection of an alternative sprinkler standard, and / or changes in association with other protection systems and forms of risk management. The Client and / or their appointed representatives will be required to consider which of these circumstances apply to their application in order to provide an appropriate design brief for the sprinkler installer to design to so that it may fulfil its part of the overall Fire Safety Plan for the building.

3.4.1 Occupancy type not listed in Standard or out of scope

BS9251 and the associated test regimes that the performance of approved products rely on are based around some assumptions as to the size, complexity, occupancy and fuel loading of the space the system will be installed within. Where there might be concern that the residential application under consideration is out of scope for a BS9251 system, other sprinkler standards should be considered.

In many residential buildings protected with BS9251 systems there exist other non-residential areas that might benefit from extension of the sprinkler system into them. Such areas might include the foyer at the entrance to a block of flats, small bin stores, cycle stores, and wheel chair recharging areas. In such cases the BS 9251 system should only be extended into these areas after the Client or their appointed Fire Engineer has assessed the risk including the reasoning behind the extension of the BS9251 system into these areas. Where the BS9251 system is extended to protect these non-residential areas, completion documentation for the sprinkler system should clearly list:

- details of the reasoning behind adopting BS9251 standards for these areas and,
- limitations on the permitted fire loading in these areas to ensure the future use of these areas does not increase the fire load beyond that which is considered at design stage.

At all times it should be taken into account that a BS9251 system can never be a replacement for a BS EN 12845 system.

3.4.2 Mixed Occupancy (Commercial / Residential)

Whilst many purpose-built residential blocks contain just flats, a number of blocks are deemed to be 'mixed use'. The most common configuration is residential units housed above retail space, but also restaurants, shops and offices are commonplace. Typically, the commercial space has different entrances and exits, however, they remain part of the building and must therefore be considered from a fire safety point of view.

The provision of sprinkler protection to the residential and commercial sections of the buildings may be to achieve different goals and their designs will generally reference difference standards. Residential sprinkler system provision can often benefit from the high-integrity water and power supplies associated with commercial installations.

In deciding which standard best applies to any mixed occupancy arrangement the Fire Engineer should consider the split between usage in consultation with the building's insurer. A residential building with one or two small occupancies below may consider (subject to the Fire Engineer's FSP) BS9251 to be appropriate. Residential premises over a shopping centre might demand the

use of an alternative commercial sprinkler standard such as LPC Rules for automatic sprinkler installations 2015 incorporating BSEN 12845.

3.4.3 High-rise buildings

Most published national and international standards recognise that a perceived risk threshold is exceeded when residential buildings are over approximately 18m in height. Whilst this threshold is somewhat arbitrary and probably based upon the height of prevalent Fire and Rescue Service ladder equipment, the need for dry risers, and other additional fire service support features, it is widely accepted that in buildings above this height it is appropriate to apply somewhat more robust levels of sprinkler protection.

Another key threshold for consideration is the stated limit ~~of~~ in BS 9251 of 45m which represents approximately the maximum height that fire appliances can pump water to – necessitating the requirement for the provision of wet risers (50m), and the height above which system standing pressures may challenge sprinkler function – an issue not specifically addressed within BS 9251 design.

Failure of a sprinklers system to perform in a multi-storey environment has the potential to result in life-critical events and as such it is usual to augment the design by the inclusion of safety-factors to water delivery and equipment resilience features.

The consideration of height also brings into play consideration of other factors including:

- Number of stairwells in the building for evacuation / firefighter access
- Whether there is a need to protect common areas (corridors and communal parts)
- Total floor areas
- Fire service response times to the most onerous location
- The overall capability of the building to resist fire spread and the protection objective i.e. Consideration must be given to where the place of safety is considered to be, and the role the sprinkler system must play in assisting occupants to reach that point. For example:
    - In a building with good fire compartmentation, multiple stairwells and sterile common areas, the place of (relative) safety might be the threshold between the flat and the corridor or stairwell. The role of the sprinkler system may therefore solely be to assist the occupant egress to the corridor or stairwell and the inherent fire resisting capability, good access, short travel distances, and building management, combined, will assure their safety from the place of relative safety to the place of ultimate safety – usually the building's exit.
    - In buildings where the fire compartmentation cannot be assured, escape routes are limited, and/or significant fuel loads exist in the escape routes and common areas, the only place of safety for design purposes will be outside of the building. The role of the sprinkler system in these circumstances will be to assist the occupant escape to the point of egress from the building, not just the flat.

  (in deciding which of the above strategies can be adopted the 'Designer' needs to consider possible future changes / increases in fuel loads in the sterile common areas which can occur in the life span of the building and document any limitations in this regard for the ongoing building management controls)

3.4.4 Building of combustible structure, insulation, or cladding

In pursuit of improved thermal performance and sustainability credentials, many modern (and refurbishment) building methods use large quantities of renewable and insulating materials. In some cases, these buildings may have a higher total combustible material composition than more traditional building methods. Whilst these building methods, such as light timber framing, provide equivalent life-safety performance to any other building method it is generally accepted that more

material damage may result in any given fire event and that fire ingress from outside (through air-bricks, vents, or on cladding) can present an additional challenge to their protection. Occupant safety is generally assured by the protection of lower performing materials behind better performing ones, such as plasterboard lining. The following factors are considered important to the design of a sprinkler system where the structure of the building itself may contribute to the fire scenario:

- Preservation and assurance of the fire compartment integrity following penetration by sprinkler system installation and for the life-span of the building
- Ability of the building to resist fire getting in to combustible voids (a non-protected space where sprinkler systems will exert little influence)
- Possibility of the potential for near simultaneous multiple seats of fire following external fire spread over cladding and ingress through ducts and vents. The initial fire may be internal, accessing combustible voids or cladding via weak points such as windows or vents, or be from an external source, such as a bin or car fire (may require associated measures such as a recommendation for i.e. fire stopped vents in kitchens and bathrooms etc.).

Where building methods / materials are likely to contribute to the fire scenario, sprinkler systems designed to BS9251:2014 may not be appropriate and systems designed to BS EN 12845 may be more suitable to combat the potential increased fire challenge.

3.4.5 Property protection requirement

The high societal impact, material, and consequential losses associated with the provision of alternative accommodation following fire in the housing, and care sectors has raised the profile of property protection as a requirement for many specifiers in addition to the v mandated life-safety objectives. PD 7974-8:2012 '*Application of fire safety engineering principles to the design of buildings. Property protection, business and mission continuity, and resilience*' describes a methodology for determining, and designing to goals other than just the life-safety provision of 'evacuation before collapse'. A typical remit for student accommodation might be to ensure '*fire spread is limited to displace no more than 5% of the accommodation's population in any given fire scenario; that the fire is extinguished; and that the lost housing capacity is reinstated to 100% within 4 weeks of the even occurring*'. Working to these goals allows the fire engineer to incorporate both active and passive fire protection measures within a coherent framework to meet the requirement.

Property and business / service provision protection demands 'resilient' systems to ensure the objective is robustly met. In respect of sprinkler fire protection, it is not uncommon to see:

- longer durations of compartmentation specified
- duplication of key elements of active systems such as water supplies and pumps
- the application of additional safety factors to account for uncontrollable elements
- consideration of the unexpected such as fire ingress, arson, vandalism
- consideration of system 'down-time' during i.e. maintenance, water system failure, and how these might be ameliorated within the system design
- fire management systems with reduced dependency upon the 'human element'

Sprinkler systems designed for the protection of the commercial estate, as specified in LPC Rules for Automatic Sprinkler Installations incorporating BS EN 12845, have been developed over many years to offer the highest levels of performance reliability available today. Incorporating many design features to ensure their perpetual viability, this standard's use is strongly recommended where property protection objectives are sought.

3.4.6 System installed to provide compensatory features

The use of sprinkler systems to compensate for parts of the building being unable to meet elements of regulation needs careful consideration. It is not uncommon for the sprinkler system (an

'active' system) to compensate for an unorthodox building layout, or shortcomings in the fire resisting (passive) capability of the building. Passive protection is noted for its resilience in operation under fire in that no action, aside from its presence, is required to ensure it fulfils its roles – it is in an 'always-ready' state. Active systems on the other hand are very much more complicated and generally a chain of events must take place in the correct order for them to perform properly – for various reasons, controlled and otherwise, such systems may be off-line for periods of time and it is essential to consider whether the potential to risks to occupants at these times is acceptable.

3.4.7 Dwelling with high fire load

The fire loading of a space protected by sprinklers influences the rate at which the fire will take off, the complexity of fire geometry that must be tackled, potential for spread, and ultimately the size it may reach / must be limited to.

The determination of water supply requirements for residential sprinkler systems are made by testing in scenarios that use only small and uncomplicated fuel loads and different approaches have produced the differences observed in the Standards. In general terms, higher and more complex the fuel loads demand the delivery of more water, more quickly, through more heads, for a longer period of time.

As part of the review to establish whether Special Circumstances apply in respect of fuel loading there is a need for the Client or their appointed representative to fully understand the context of how the water application rates in each of the domestic and residential sprinkler standards have been determined through testing, and consider how well this matches the anticipated protected environment. Expert help should be sought in association with AHJ input where concerns exist which could warrant changes to the sprinkler system or reinforcement of other protection and management systems.

3.4.8 Incompatible fire service response with water supply duration

Sprinkler systems in residential applications are designed to limit the impact of the fire to assist rescue efforts and occupant evacuation. The duration for which the system must operate needs to be considered in association with the likely arrival time of a fire and rescue service response to the point of fire. Factors important in the determination of this time include:

- Knowledge of how the local FRS responds to automatically generated fire alarms (in an effort to deal with the overwhelming number of false and unwanted alarms, some FRS impose a range of methods for clarifying the validity of the call. All of these call-challenging activities either result in a delay in the provision of response or may provide a reduced resource until need is fully established. Policies vary between Fire Services for different occupancy types and time of day.
- Knowledge of how the first responding fire stations are crewed. Whilst whole time stations can deliver a crew quickly upon confirmation of a confirmed fire, retained type crewing systems may demand additional time to assemble the crew before deployment. Crewing methods may change throughout the day for any given fire station.
- Knowledge of where local fire stations are, road network and local traffic conditions that might impact on transit times.
- An understanding of the preparatory procedures adopted for fighting fires in the building under consideration. Multi-storey buildings are a challenge for firefighting and the preparation required to ensure firefighter safety can take some time.

Advice should be sought from the local Fire Service on likely attendance times to establish that the design duration of the sprinkler system is appropriate to meeting the design objective and assisting firefighting for consideration by AHJs in association with relevant experts. It should not be assumed the water supply durations given in BS 9251:2014 are appropriate in this respect.

3.4.9 Building with atrium

The presence of an atrium in a building can provide a route by which fire and smoke may spread through the building with greater ease than in an equivalent non-atrium building. The quantity of smoke produced by a fire is a function of both the energy possessed by the fire and the height through which the rising fire plume can rise. An atrium, resulting as it does from the absence of one or more floors, provides for an unusually high fire plume and, consequently, an increased volume of smoke and fire effluent. Because of this open spatial planning, the fire effluent can spread through the building and may cause damage and risk to occupants that is out of all proportion with the actual size of the original fire.

It is obvious that the unhindered spread of smoke from floor to floor will greatly increase the numbers of occupants that may be put at risk during the initial stages of the fire. The time available for the occupants to escape from the floors affected will be significantly reduced and also the conditions with which the fire crews will be presented on their arrival will be considerably worsened.

Guidance on the atria solutions may be found in BS 5588 '*Fire precautions in the design, construction and use of buildings, part 7: Code of practice for the incorporation of atria in buildings*'

The guidance provides for decision trees and associated tables related to the main technical issues that need to be resolved in order to arrive at an appropriate level of fire life safety. These are:

- the evacuation procedure
- the fire detection and alarm system
- the degree of separation between the atrium and associated accommodation
- the type of smoke management system to be provided
- the use of the base of the atrium
- the provision of an automatic fire suppression system.

3.4.10 Building housing vulnerable people

The risk of harm from fire is substantially increased by ill-health, disability and addiction. In buildings housing vulnerable people, it is common-place to enhance fire-fighting provisions to allow them greater time to affect an escape and increase the time available for others to provide assistance to escape. In respect of sprinkler systems this might typically be characterised by an increase in the duration of operation of the system to the periods listed in BS9251:2014.

3.4.11 Building with fire engineered design solution

Recommendations where sprinkler systems have been installed in support of a fire-engineered solution are as stated for compensatory features. It is additionally recommended that:

- The fire engineering solution considers the fire safety policy of the whole-building and the supporting management processes associated with it, avoiding piecemeal design to cover areas of non-compliance.
- where sprinklers standards are used as part of the overall design, that they are used in full and not themselves 'engineered' to a lower specification (reduction of water supplies, areas of protection etc.)

3.4.12 Building providing secure accommodation

Detention and correctional facilities pose unique fire protection design and installation challenges. This type of building includes any facility where people are restrained by locks they do not control such as prisons, some mental health facilities and juvenile detention facilities. The fire protection design for these buildings is particularly difficult because many of the fire initiations will be

deliberate. Additional concerns exist because of the potential for vandalism to the fire protection equipment and role components may play in supporting self-inflicted injuries.

3.5 Critical issues that can impact performance of residential sprinkler systems

Protecting the occupants of a building demands the client or their appointed representative puts in place a suite of measures that together ensure all legislative life-safety requirements are met in addition to any other desired safety features, for the lifetime of the building.

For this to occur there needs to be a high level of competency:

- in the initial hazard evaluation by the fire engineer
- in the 'total design' of the overall safety solution
- in the design of the individual components supporting the total design (i.e. sprinkler systems, passive systems)
- in the installation of the individual components supporting the total design (i.e. sprinkler systems, passive system)
- in the through life, control, maintenance, and upkeep of each of the individual components supporting the total design
- in the through life management of the overall solution in respect of relevant changes to i.e. occupancy, legislation, and building changes.

Specific to sprinkler systems, where the correct competencies have not been employed the following problems have been experienced:

- systems installed that cannot support properly of overall safety solution design
- systems that fail to deliver the correct quantities of water to the protected spaces
- systems relying on equipment that may fail, or never work in the first place
- failure of piping systems due to incompatible fire stopping materials being used
- failure of piping systems due to poor construction practices
- failure of the system to supply water due to incorrect configuration of isolation valves
- failure to identify system problems due to poor and infrequent testing and inspection regimes
- failure to correct identified faults on a timescale befitting of a life-safety system

4 Guidance for Residential Sprinkler System designers

4.1 Valves

In complex and multi-storey building all valves that have the potential to isolate the delivery of water to any sprinkler head shall be monitored and shall report both locally and to the Alarm Receiving Centre.

4.2 Pumps

BS9251:2014 allows for the use of combined domestic and fire water pumps. This was included in BS9251 for the following reasons:

- The water flow rate for a BS9251 sprinkler system is normally lower than the domestic pump
- The domestic pump systems used in large and higher rise residential buildings are usually of high-quality owing to the high-availability demands, and constantly monitored by the 24 hour occupancy.
- Should the domestic pump fail remedial works will be undertaken immediately to ensure the minimum interruption period to the domestic water supply to each accommodation.
- In all but Category 1 systems of BS9251, all domestic pumps will be configured to have at least duplicate pumps (providing a duty and standby capability), thus the sprinkler system will benefit from this duty and standby pumping facility.

However, it is of paramount importance that on commissioning a system utilising a domestic pump set that a check is made to ensure that the pump sets are not shut down on a fire alarm signal via the building management system (BMS).

Determining the suitability of a domestic pump to also provide the water supplies to a sprinkler system is defined in BS9251, however, the following criteria are to be considered:

- Establish the flow rate required for the sprinkler system
- Establish the peak flow rate required for the domestic usage, (peak flow rate to be considered does not need to be the maximum flow rate which may occur for a few seconds, but the highest flow rate the domestic system provides over the run time of the sprinkler system, (i.e. 10 minutes for a category 1 system and 30 minutes for a category 2 and 3 system)
- Add the flow rate required for the sprinkler system to this highest flow rate the domestic systems is required to provide to establish the combined flow rate required to satisfy both systems.
- Ensure the domestic pump set is capable of providing this combined flow rate

Should the pump set not be capable of providing the combined flow rate then:

- Use a dedicated sprinkler pump with a suitable flow rate capability to supply the sprinkler system.
- Up rate the domestic pump set performance to meet the combined sprinkler and domestic flow rate, or
- Use a priority demand valve.

(***Priority Demand Valve:*** *A priority demand valve is a valve that when closed isolates the domestic draw and thereby exclusively assigns the domestic pump set to the provision of sprinkler water. The demand valve should be considered as a safety critical component and therefore it should be powered open and closes on loss of power. The demand valve is operated via the sprinkler flow*

switch; thus, when water flows into the sprinkler system the sprinkler flow switch will close the demand valve by removing the power supply to the demand valves coil.)

4.3 Tanks

Sizing of the combined domestic and sprinkler tank is more complex although well described in BS9251. The following process should be adopted:

4.3.1 Without Demand Valve

- Multiply the sprinkler demand by the run time of the sprinkler system as per the category of the system listed in Table 2 of BS9251. For example, a sprinkler demand of 150l/m for a category 2 system must be available for a minimum of 30 minutes, thus the sprinkler requirement is 4,500 litres
- Mechanical engineers should calculate the domestic draw over the busiest 30 minutes of the day, say 10,000 litres over 30 minutes
- Add the sprinkler requirement to the domestic requirement, in this case 14,500 litres.
- Assess the infill flow rate and calculate 80% of that infill. Therefore, if the infill rate is 4l/s then over the 30 minute run time, the amount of infill over the 30 minute run time would be; 4 X 60 X 30 X 0.8 = 4824 litres.
- Actual stored water required = 14,500 – 4824 = 9676 litres.
- The amount of infill that can make up the reduced capacity of water shall not be greater than 40%. Therefore, if the total effective capacity required is 10,000 litres, then 4,000 litres can be supplied via the infill as long as only 80% of the infill performance is used for calculation purposes.

4.3.2 With Demand Valve

When a demand valve is fitted to stop the flow of water for domestic appliances, the water tank only needs to have a sufficient quantity of water to run the sprinkler system for the required time.

4.4 Power supplies

Power supplies to all critical components of the sprinkler system must be separated from normal domestic use supplies and not be isolated as part of Fire and Rescue Service Response procedures.

Where concerns about power supply resilience are raised an alternative supply should be installed or battery back-up considered to provide fail-over cover.

4.5 Alarm interfaces

Alarm interfaces are used to monitor the state of flow switches, either open of closed, along with interfaces that monitor the position of isolation valves and other safety critical systems such as the power supply present and low-level tank switches. While there are bespoke sprinkler panels for the monitoring of plant rooms for Wet Risers and sprinkler systems to BS EN 12845, it is normal practice that BS 9251 sprinkler systems are monitored via the building's fire alarm by way of addressable switch monitors. Such devices can be installed to monitor flow switches that represent a sprinkler activation, thus a fire signal, as well as monitoring of isolations valves and other monitored items.

4.6 Building Management System Interfaces

Building Management Systems, BMS, can be used to monitor sprinkler systems instead of the building fire alarm. A BMS should only be used if the BMS system has a connection to a permanently manned location. Any connection between the BMS and a fire alarm system must NOT include a shutdown of the cold water boosted pump sets as this would stop the flow of water

into the sprinkler system. Many of the cold-water booster sets now have a connection that when signalled will put the cold water pump sets into fire mode and thus the configuration of the pumps can be changed from duty, assist standby to duty, duty, assist for example. For future proving, it is also important to have a plaque mounted directly to or beside the cold-water booster set to state, “This pump set also powers the sprinkler system. DO NOT make changes to the software within the pumps sets without consulting the sprinkler contractor or servicing team”

5 Additional Controls for the limitation and avoidance of water damage

Escape of water from the sprinkler system can happen both intentionally and unintentionally and at different times in the system's lifetime. Measures are required to:

- Reduce the likelihood of an un-intentioned release of water
- Contain quickly un-intentioned releases

The following quality measures have already been discussed in Section 3 which should ensure the reduced likelihood of un-intentioned water release through installer and product accreditation:

- Installer accreditation (3.1.1)
- Additional training on specific product usage (3.1.3)
- Equipment certification (3.3.1)

Additional considerations are made in the sections below.

5.1 Maintenance

It is vital that any installed system is accompanied by a maintenance and servicing regime provided by an accredited company. Servicing should be conducted at least annually and be accompanied by a comprehensive test regime that demonstrates correct system performance behaviour of every element of the system and leaves it in a fully operational state. The key tests considered to be a minimum (as defined in BS9251) are as follows:

- The system should be inspected to determine whether all components are functioning as designed
- The system should be inspected for leaks
- The system should be inspected to determine whether any or all modifications have been carried out in accordance with BS9251
- Where there has been material alteration to the building, an increase in fire loading or a change to include vulnerable occupants, an assessment should be made as to whether the category of system is still appropriate[c].
- The sprinklers and cover plates should be inspected to determine whether they have been tampered with or whether their spray pattern has been impeded.
- Valves should be exercised to ensure free movement and any locking mechanism should be checked and reinstated.
- The test valve should be operated to determine whether the system's design flow rate and pressure, as hydraulically calculated is achieved.
- Alarms should be tested to determine whether they function as designed[d].
- Backflow prevention devices should be maintained in accordance with the manufacturer's recommendations or BS EN 806-5.
- Any remote monitoring arrangements should be tested to determine whether they are being transmitted and received correctly.
- Where trace heating is installed, its operation should be checked.

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[c] Correct protocol would require this assessment to be made by the Client or their Representative (Fire Engineer), and not the sprinkler system installer / engineer.

[d] To include all flow switches, valve monitoring, power monitoring, and tank level alarms.

- Correct and verified fire stopping around sprinkler pipework has been employed

5.2 System pressure testing

Common to some of the piping systems used in residential sprinkler systems is their ability to attain a level of rigidity and water sealing at the time of pre-assembly, before the joint has been made sound by gluing (i.e. CPVC), or crimping (Crimp light metal system). Whilst specific training in the use of these systems provides recording and marking methods to avoid this occurring, it has been noted in some cases that unmade joints can hold even at the 5 bar test pressure. It is recommended that the sprinkler system pipe network is pressure tested with water to a minimum of 8 Bar or 1.5 times working pressure, whichever is the higher figure, to confirm all joints are satisfactorily made and no leaks exist within the system before pipe work is covered with wall and ceiling lining finishes.

Only when all pipe work is completed, or a section of the building has been completed, should the sprinkler engineer then revisit each joint and sign the joint with initials to indicate he/she has carried out a pressure test to ensure the joint was glued / crimped correctly. This process has been demonstrated to be effective at reducing water losses associated with incorrect pipe network manufacture.

5.3 Material compatibility check

There have been reports from the USA that certain plasticisers can degrade CPVC pipe. Most of these plasticisers are not allowed in Europe. However, there are Fire Mastics available in the UK that can degrade CPVC but these are easily avoided if the guidance provided through the CPVC specific training is followed. Manufacturers have compatibility lists of products such as Fire Mastic that is suitable for use with CPVC and many Mastic manufacturers carry out their own testing for use with CPVC. It is highly recommended that only third-party accredited fire stopping companies should be used to install the fire seals around CPVC pipes as accredited companies should be up to date with compounds that can cause problems to CPVC. But in any case, paperwork should be supplied proving that any fire mastic to be used has been tested for use with CPVC by either the manufacturer of the mastic or by the manufacturer of the CPVC pipe.

5.4 Monitoring systems

The sprinkler system should be monitored at all times both locally and or remotely (where not full-time staffed) to provide awareness of:

- Its operational health (all monitored alarm valves open)
- Its operation in the event of fire
- Its operation in the event of accidental water release
- Insufficient water supply (tank level) to meet the design requirement
- Power supply failure to systems should be monitored when a dedicated sprinkler pump is used.

Integration with the fire alarm panel should enable rapid identification of:

- System activation
- The location of the water release via the flow switches
- The location of system impairment by closed monitored valves

5.5 Isolation valve location and accessibility

The safest reduction of water damage in the event of accidental release demands that those attending, who may be unfamiliar with the building, are able to quickly locate where the release is, and identify and find where the relevant isolation valve is that will impair the least amount of system protection. This should be ensured by:

- At the entrance to the building, or at the fire alarm / sprinkler alarm panel when in the main entrance area, there MUST be a plaque that clearly indicates where the isolation valves are located within the building.
- The alarm panel electronic labelling of flow switch referencing should be recognisable in association with the isolation valve location plaque
- At each floor / location suitable signage should clearly show where the sprinkler system isolation valve is housed

5.6 Building manager training

The building manager requires good knowledge of the sprinkler system and its operation. In the event of a fire, control of the system should be left as a responsibility of the Fire and Rescue Services. In all other situations the Building Manager should receive appropriate training in the system to include:

- The role of the sprinkler system in supporting the overall Fire Safety Plan
- Ability to advise / train occupants
- How the system operates and where all key components are located
- How the system is integrated with the alarm panel
- Fault identification and meaning
- Maintenance requirements
- Alternative safety procedures for the building and its occupant to cover periods when the sprinkler system is disabled for any reason (power outage, insufficient water, maintenance, isolated etc.)
- Who to notify when:
    - There is a fire
    - Any part of the system shows fault
    - Any part of the system is disabled
- How to isolate parts of the system when an un-intentioned release of water has occurred

5.7 Occupier training

Occupiers may or may not have direct access to the system's isolation valve depending upon the Category and type of system installed. Where the occupier does have access, full training must be given in the isolation and system resetting process. Where they do not have access, they must be provided with an emergency contact number of the Building Manager or Sprinkler Engineer.

Within the protected space, the occupants must be given training to ensure:

- They understand the life-safety benefit of the system and its importance to their protection
- They understand where the key components are, how they are routed, and what they do
- Sprinkler heads are not tampered with or used for support / hanging
- Structural modifications do not impact upon the pipe network routing or sprinkler head locations

- Operations within protected space are not moved in such a way to expose the heads to high temperatures
- Structural modification does not impair water distribution around the protected space

Policies will need to be put in place to ensure that responsibilities for training are clearly understood and that the training requirement propagates through all potential occupation / letting / sub-letting / ownership configurations.

5.8 Access to information and instructions

In complex buildings it is recommended that provision of an information storage box at the point of building entry will assist Fire Services and others gain a rapid understanding of the sprinkler system layout and location of all key components. The documentation provided should include location of Isolation Valves on block-plans.

5.9 Provision of labelling and instructions

All key components of the sprinkler system should be appropriately labelled to assist with maintenance and use.

6 Guidance for system owners

System owners must:

- Have available a copy of the building's Fire Safety Plan
- Understand the role the sprinkler system plays in supporting the building's Fire Safety Plan
- Have procedures in place to assure the continued provision of safety for instances when the system is not available in part or in whole which may include notification of the fire and rescue services and the building's insurer
- Have a means of communicating system function to residents and what the alternative measures involve during times of non-availability
- Provide appropriate training for:
    - The Building Manager
    - Occupants
- Have in place an assured servicing and maintenance regime
- Communicate key contact details for the management of:
    - Fire
    - Sprinkler system faults
    - Sprinkler system inadvertent operation or leak
    - Water supply fault
- Maintain all documentation pertaining to the system design and through-life upkeep.

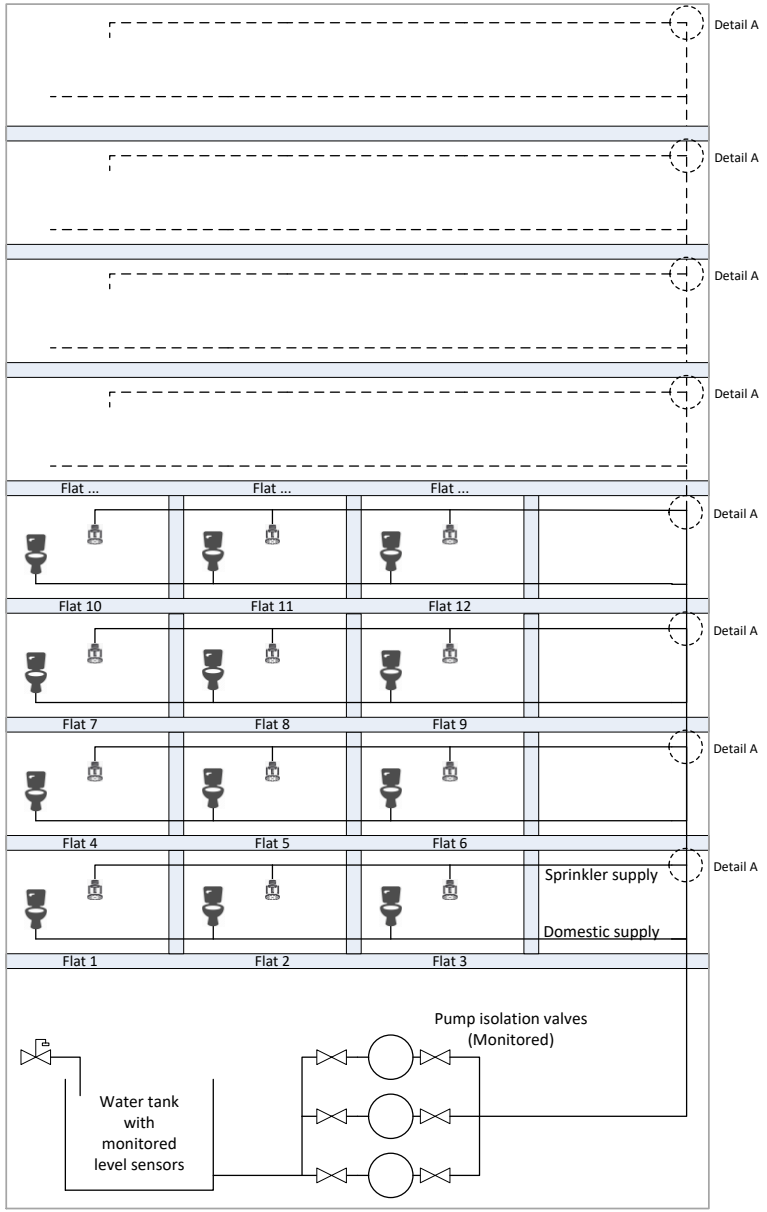
7 Case studies of multi-storey residential sprinkler systems with combined domestic / sprinkler water supply

Case study installations are provided for multi-storey systems with combined domestic / sprinkler water supplies that:

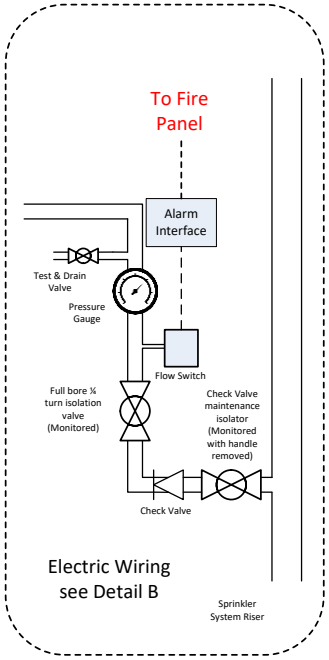
- Do not require a demand valve – where the pumping capacity is sufficient to provide for simultaneous domestic and sprinkler provision
- Do require a demand valve – where domestic water usage must be isolated for the assurance of sufficient water provision to the sprinkler system

Combined Water Supply System without Demand Valve

(used when tank and pumps are suitable to run both the domestic supply and sprinklers simultaneously)



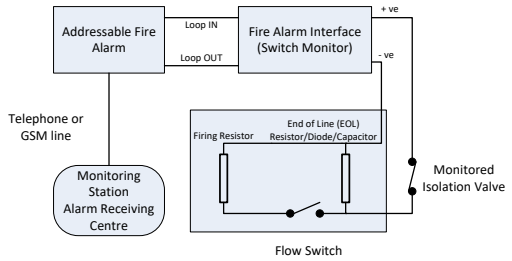
Domestic
Pump Set



Sprinkler System
Connection Detail A

ALARM VALVE ELECTRICAL OPERATION:

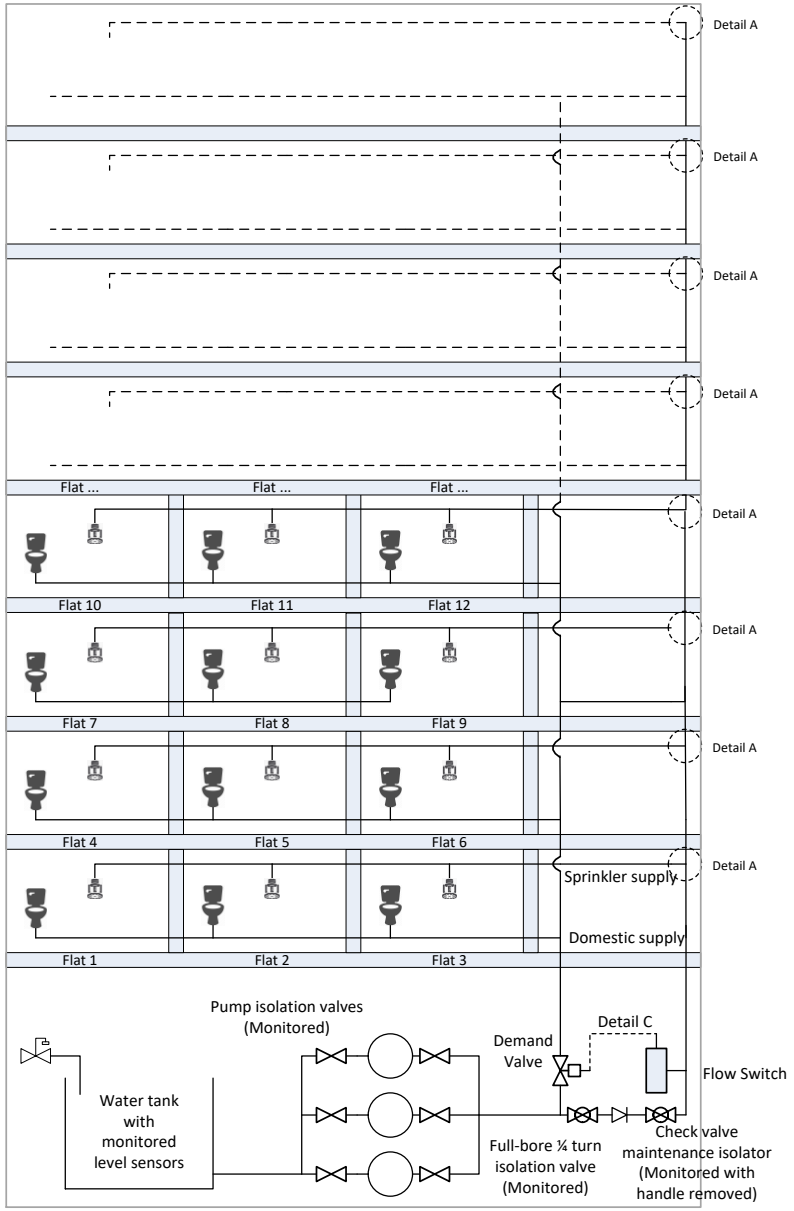
- QUIET State
  a. Isolation Valve contact closed thus EOL in circuit – Panel Quiet
  b. Flow Switch Open thus Fire Resistor not in circuit – Panel Quiet
- Isolation Valve Closed
  a. EOL not in circuit
  b. Fire panel at FAULT stating “Sprinkler Fault Level 4”
- Fire
  a. Flow Switch Closes
  b. Firing Resistor in circuit
  c. Fire panel at FIRE



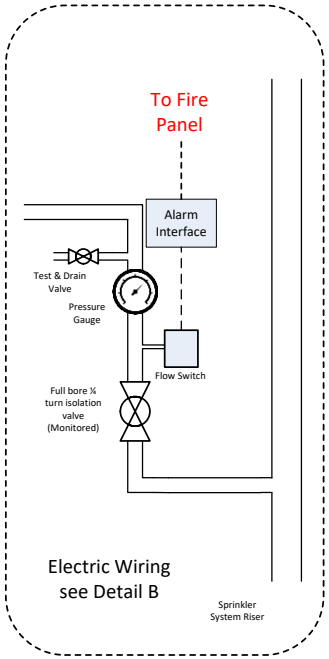
ALARM VALVE WIRING - Detail B

Combined Water Supply System with Demand Valve

(used when tank and pumps are unable to run both the domestic supply and sprinklers simultaneously)



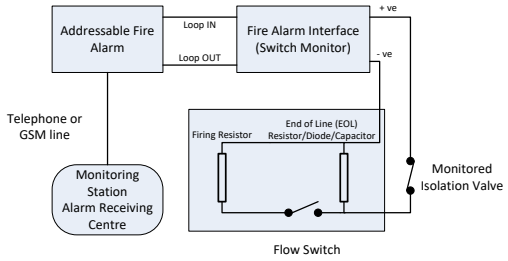
Domestic
Pump Set



Sprinkler System
Connection Detail A

ALARM VALVE ELECTRICAL OPERATION:

- QUIET State
  a. Isolation Valve contact closed thus EOL in circuit – Panel Quiet
  b. Flow Switch Open thus Fire Resistor not in circuit – Panel Quiet
- Isolation Valve Closed
  a. EOL not in circuit
  b. Fire panel at FAULT stating “Sprinkler Fault Level 4”
- Fire
  a. Flow Switch Closes
  b. Firing Resistor in circuit
  c. Fire panel at FIRE

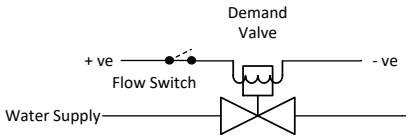


ALARM VALVE WIRING - Detail B

DEMAND VALVE ELECTRICAL OPERATION:

- Flow switch contact NORMALLY CLOSED thus Demand Valve held OPEN
- On sprinkler activation flow switch contacts OPEN
- Demand Valve CLOSES
- All of the water supply now serves sprinkler system only

DEMAND VALVE WIRING - Detail C:



8 Checklist

8.1 Special Circumstances

Residential Sprinkler System Design Checklist – Special Circumstances

1. Have the relevant AHJ's to this undertaking been established (BC / FRS / Insurer etc.)? ☐
2. Has the Fire Safety Plan, and requirements of the Sprinkler System, been communicated to the Sprinkler Installer by the Client or their appointed Fire Engineer? ☐
3. Has the local FRS Automatic Fire Alarm response policy been established and considered in the context of FRS attendance time and sprinkler system water supply duration? ☐
4. Has the building's construction been determined and an assessment made of its ability to meet all legislative fire safety requirements? ☐
5. If any shortcomings were identified in 4., what were they?

6. What 'Special Circumstances' (see 3.4) are applicable to the proposed installation that have influenced the design?

(a)	Occupancy type not listed in Table 1 / or out of scope	☐
(b)	High-rise building	☐
(c)	Building of combustible structure, insulation, or cladding	☐
(d)	Property protection requirement	☐
(e)	System installed to provide compensatory features	☐
(f)	Dwelling with high fire load	☐
(g)	Incompatible fire service response with water supply duration	☐
(h)	Building with atrium	☐
(i)	Building with adjacent un-sprinklered areas	☐
(j)	Building housing vulnerable people	☐
(k)	Building with fire engineered design solution	☐
(l)	Mixed use building (commercial and residential units)	☐
(m)	Building providing secure accommodation	☐
(n)	Resilience features	☐
(p)	Other (please specify)	☐

7. Are all providers in the sprinkler system supply chain 3rd party accredited (Sprinkler Installer / Passive Fire Protection)? ☐
8. Is all equipment certificated? ☐
9. Have measures to curtail Escape of Water issues been considered – see EoW checklist? ☐
10. Where the water supply is direct from a town mains connection has the ability to deliver the maximum flow at the design pressure been established for a 24 period? Has this also been considered in the context of simultaneous peak domestic demand and FRS usage? ☐
11. Has the potential for system abuse and vandalism been considered? ☐

8.2 Water damage mitigation

Residential Sprinkler System Design Checklist – Water damage mitigation

1. Are all providers in the sprinkler system supply chain 3rd party accredited? ☐
2. Is all equipment certificated? ☐
3. Is the sprinkler installer specifically trained in the use of the pipe system technology deployed? ☐
4. Is the Passive Installer aware of potential material compatibility issues with CPVC pipe? ☐
5. Has the sprinkler system been pressure tested with water at 8 Bar or 1.5 times working pressure (whichever is the higher)? ☐
6. Is there an appropriate servicing agreement in place for the sprinkler system? ☐
7. Are all valves that could stop the flow of water to any part of the system monitored? ☐
8. Are all flow switches monitored and linked to the alarm panel? ☐
9. Can the location of water discharge be readily understood from the details on the alarm panel? ☐
10. Without prior knowledge, is the information available at the building's entrance and on the alarm panel enough to readily know where to locate the appropriate isolation valve? ☐
11. Is the signage clear showing where all isolation valves are? ☐
12. Has training been given to the building manager about the operation and location of key equipment for the sprinkler system? ☐
13. Has sufficient training been given to occupants on the function of the system and factors that may impair its performance or lead to unwanted discharge? ☐