High-rise Firefighting in the UK 2020
'Safe Systems of Work'

Senior Fire Safety Engineer Paul Grimwood PhD, FIFireE
Kent Fire and Rescue Service

The Skyline of inner city residential high-rise construction in New York City going higher with limited space at each level

paul.grimwood@kent.fire-uk.org

Having researched high-rise firefighting tactics and tall building designs both as a firefighter and a fire engineer on an international forum for over 45 years, it is my intention to offer this paper as a summary of relevant and timely work. It is certain that existing building design guidance causes misalignment with UK firefighting procedures and vice versa. Should we design according to the optimum procedure or should the procedural approach align with building design?

Following several high-rise fires over the past twenty years in the UK, we are now seeing some further experiential evolution as to how fire services develop their procedural guidance based upon the 'safe systems of work' concept. This paper discusses such evolution, provides some relevant detail and sometimes challenges the reasoning in why we do things a certain way. It must be said that even though a 'one size fits all' approach cannot ever be considered for all service response and resource provisions, national guidance GRA 3.2 has always offered a useful foundation upon which each fire service, metropolitan or rural, can best address their resource deployment capability and weight of attack.

1. Protection of the Stairwell

Although UK building design guidance has always promoted escape provisions that allow occupants or residents to turn their back on a fire and move towards relative safety, the residential ***stay put*** strategy in tall buildings has always placed great emphasis on remaining in situ, if not affected by fire or smoke. However, ever since CP3 building design guidance in the 1960s and through to the current version of Approved Document B (ADB) 2019, there has always been a clause that ensures residents have the *right by design* to leave the building at any stage during a fire, should they so wish. In fact, human behaviour research demonstrates that many are likely to take up this option and enter the stairwells and the fire safety instructional signage of most tall residential buildings informs them to do this if they feel threatened. Should a time come when emergency or mass evacuation becomes necessary within a building, the preservation of those vertical channels will be vital. In single stair buildings this will be life critical.

s.3.3 ADB-1 2019: (in part) *'Sufficient protection to common means of escape is necessary to allow occupants to escape* ***should they choose to do so*** *or are instructed/aided to by the fire service. A higher standard of protection is therefore needed to ensure common escape routes remain available for a longer period than is provided in other buildings.'*

In effect this means that the fire service should make every effort to protect and maintain egress routes, particularly stairwells, as well as safeguarding firefighting access routes. In fact, that basic rule might be said to represent a firefighter's primary tactical objective when working inside a fire building.

Any action that is taken by a fire service that contradicts this design guidance and places self-evacuating residents at risk could be taken as neglectful, as was the case at a 2003 high-rise office fire in Chicago where firefighting actions were seen to cause smoke to infiltrate the evacuation stair and trap a large number of people who were exiting the building. In this case six persons died in the stairwell and were not located by firefighters until after the fire had been extinguished. There have been multiple life losses globally caused in this way as stair doors are repeatedly breached by hose-lines.

Therefore, we must look very closely at how tall residential, mixed use and commercial office buildings are designed if we are to align our operational deployments in the most effective and safest way.

 paul.grimwood@kent.fire-uk.org

2. ‘The Closest [useable] rising main outlet’

The guidance we follow so often has a way of presenting challenging problems without offering any practical solutions, for example GRA 3.2.

- *‘Hose, other equipment and firefighting operations in staircases and other parts of the building may create significant slip and trip hazards for firefighters and those evacuating. This risk will be intensified in buildings which only have one staircase’.*
- *‘Operations may breach firefighting lobbies thereby increasing the risk to occupants and impacting on operations at and beyond the bridgehead’.*
- *‘It will be necessary to run hose lines onto protected routes and stairways and this will allow the products of combustion to spread to unaffected areas of the building’.*

It must be our objective to do all we can to avoid these pitfalls.

The placement of the primary attack hose-line and secondary safety hose-line are guided by National Guidance GRA 3.2

- *‘Hose lines must be laid and charged in an area unaffected by fire or smoke and behind the safety afforded by **a fire-resistant structure or fire resisting door**(s). Hose lines must be fully charged before entering any doorway’.*
- *‘An additional breathing apparatus team with a second jet must protect personnel involved in rescue/firefighting operations as soon as possible’.* (Chief Officer’s Directive from DCLG 2006).
- *Branches should be supplied from the closest rising main outlet to the fire which has not been affected by fire or smoke. This will normally be from the floor below the fire floor or, if unavailable, from the nearest available outlet below that.*

Key words here state *‘hose-lines are laid and charged behind the safety afforded by a <u>fire-resistant structure or fire resisting door</u>(s)’*

However, the following GRA 3.2 guidance is not always necessarily accurate.

‘‘and should be supplied from the closest rising main outlet to the fire which has not been affected by fire or smoke. This will <u>normally</u> be from the floor below the fire floor or, if unavailable, from the nearest available outlet below that’.

Will the ‘*closest rising main outlet to the fire which has not been affected by fire or smoke’* always be below the fire floor? In fact, the ‘closest not affected by fire or smoke’ that fits this definition will normally be on the fire floor itself.

3. ‘One Door’ or ‘Two Door’ Protection

Firstly and most importantly, I am not aware of **ANY** fire anywhere, where firefighters have died or been injured where the **number of doors** (or floors) between them charging a hose-line and leaving the stair or entering a fire compartment had any impact. There have been fires where external wind or other foreseeable events caused life loss. There have been fires where firefighters have been caught in common areas by unforeseeable extreme fire events. There have also been fires where firefighters exposed themselves to unnecessary risk in smoke-logged corridors without the protection of a charge hose-line However, it is not the number of doors between them and the fire

paul.grimwood@kent.fire-uk.org

that has been the determining factor for once they have begun their advance towards the fire, it is only careful pragmatic and ongoing risk assessment that may reduce any likelihood of exposure to risk. Taking lines from below the fire floor creates additional physiological stress on firefighters, increasing body core temperatures even prior to entering a heated environment. It is also more demanding on resources for effective hose management.

What is apparent though is that there seems some clear links back to traditional firefighting tactics in tenements and older six or seven storey buildings. It was the case in the 1960s -70s that much of the firefighting was undertaken by laying hose-lines externally by hauling aloft, or up escape ladders to the floor below the fire, from where an unprotected stair was entered to access the fire above.

Many high-rise firefighting procedures also adopt an approach that suggests there must be either **one door** or **two door** protection provided between the rising fire main outlet and the fire compartment. Now this brings up a range of issues. It used to be that flats had inner halls between the flat door and the rooms therein. This was taken as ‘two door protection’ when CP3 placed riser outlets within the lobby/corridor. In some instances, firefighting lobbies were placed between the stair and the common lobby/corridor in residential buildings under CP3 design codes and up to three door protection could exist between the firefighting lobby and the fire. However, it remains an important issue for some fire services who choose to operate and charge hose-lines where at least two doors (stair and flat) exist between the charging of the hose-line and the fire. This means under current designs the rising fire main should be in the stair.

However, in a commercial office building the design guidance places the rising main outlets within a firefighting lobby and in facing a vast open-plan office floor demonstrating high fire loading, there is generally only **one door protection**.

For those fire services who have opted in their procedural approach to ensure the stairwell in residential buildings always remains relatively smoke free, they are often relying on the 30 minute door of an apartment/flat as opposed to a 60 minute door into a firefighting shaft. In doing so they are also choosing to place rising main outlets within the common area lobbies or corridors by design, in adopting fire engineering design guidance from BS PD 7974-5. It is a ‘trade-off’ in risk benefit and relied heavily on pragmatic risk assessment by firefighters operating at the fire floor. They must ensure that the lobby/corridor is safe to enter to set-up a charged hose-line. They are operating within the guidance that recommends ***‘hose-lines are laid and charged behind the safety afforded by a fire-resistant structure or fire resisting door(s)’***

The return to provision of firefighting lobbies in residential buildings is something that should be seriously considered for inclusion in future design guidance to reduce risk to firefighters and ensure stairs are well protected during the firefighting intervention phase.

4. Anticipating Compartment Fire Load and Required Flowrate

One thing that is key to dealing with variations in fire load and compartment size is first to **recognise these variations**. Why would we need more water to extinguish a fire in an open-plan commercial office building compared to an open-plan flat or apartment? We need to be prepared, equipped and trained to deliver greater quantities of firefighting water from the primary deployed jet against higher fire loads, such as open-plan offices, storage warehouse with stacked loads and large non-sprinklered retail premises. This may mean solid bore nozzles where the need for water-spray is secondary to delivering a solid core stream directly on to the burning fire load.

paul.grimwood@kent.fire-uk.org

A flat fire has the potential to present a post-flashover fire load of anywhere between 3-15 MW. A 70 m^2 five roomed flat has been known to spread from one room to involve the entire flat within less than sixty seconds. That's a maximum fire spread rate of 70 m^2/min but it is generally contained to one flat as a fire resisting box. An open office floor of 1,500 m^2 may demonstrate a *travelling fire spread rate* of around 30 m^2/min but the growth continues to involve the space until extinguished or suppressed. In real terms this means an office fire could reach 80 MW within around 12 minutes of entering a growth phase. That fire is now beyond the control of one firefighting jet but if a larger 750 L/min jet, the fire development may have been stopped.

GRA 3.2 offers guidance here.

'The diameter of hose lines and branches specified in standard operating procedures should take into account:

- *the weight of attack required for different building types*
- *the available water pressure and flow rates from fixed installations.*

Larger diameter hose lines and branches able to make the best use of the available water supply are necessary for buildings with an open plan design and/or high fire load'.

*'The Incident Commander must consider the premises layout, as well as the **fire loading**, when making decisions regarding the size and length of hose lines (**weight of attack**) to be used'.*

5. Dry-riser Charging Pressures 10 or 12 bar

Traditionally, dry rising fire mains designed to be charged to an operating pressure of 10 bar. However, since 2015 all dry risers should meet the new requirement allowing an increase in operating pressure to **12 bar**. In effect, this may increase flowrate at the highest floor served by more than 200 L/min. As rising fire mains are designed to withstand a pressure of one and a half times their maximum operating pressure, it should therefore be considered reasonable to operate at 12 bars in all situations, where necessary.

6. 150mm Rising Mains with Twin Outlets at Each Floor

The provision of 150 mm rising fire mains enables two hand-controlled outlets to be provided at each level. Since 2006 there has been an operational requirement to provide a safety hose-line to protect the primary attack hose-line as soon as possible, or even prior to compartment entry in some situations. The 150 mm main was originally part of the BS 5306 (1976) series of codes and the option to provide these as compliant with regulatory guidance now is detailed in BS PD 7974-5:2014.

In buildings subject to fire engineered design solutions that are outside normal ADB; 9999 or 9991 guidance, or commercial buildings with open-plan floor spaces, we can place greater emphasis on the provision of 150 mm rising fire mains with double hand controlled outlets at each level. In some residential buildings we can also ask for these to be located away from the stair, preferably within a firefighting lobby or if not, a protected lobby/corridor.

If, for example, a residential building has a mechanical smoke ventilation system to protect an extended dead-end corridor that is not protected by sprinklers, or is in excess of 15 m to the stair door from the furthest flat entrance (even with sprinklers), we take this as a fire engineered solution that requires CFD in support. In such cases we can stipulate that as a fire engineered building (even in part), it makes the BS 7974 standard applicable.

The BS PD 7974-5 wording in place in the 2014 version is as follows –

8.5.4 *Where fire service intervention is to be considered as part of the engineering strategy for a building, the effectiveness of such an intervention may be improved in some cases by the provision of 150 mm internal fire mains with twin outlets at every floor as opposed to single outlet 100 mm mains. The reason for this is because any increase in calculated fire-fighting water demands may be more readily available for deployment per m2 of open-plan floor space. The additional provision of protected lobbies allows stairs to remain smoke free for longer and enable fire-fighters to deploy two hose-lines at the fire floor and intervene far more quickly and effectively. In open-plan floor space, time to deployment may be critical.*

The wording in place on revised guidance, as published from May/June 2020 is as follows

7.8.2 *In some cases, the fire service might demonstrate a preference for specific facilities, such as rising fire mains, to be located away from the stair in <u>residential buildings</u>. In such circumstances, a preferred location might be within a ventilated protected lobby/corridor. According to an on-scene risk assessment, this could enable firefighters to lay initial attack hose-lines from the fire floor itself, reducing the likelihood of smoke infiltrating into the firefighting stairwell. This preference is particularly important in <u>single stair residential buildings</u> but might also feature in <u>multi-stair residential buildings</u>. However, any such deviation in this respect, where firefighting main design is not specifically in accordance with typically prescribed regulatory guidance or standards, should take place at the QDR stage and local fire service agreement is essential.*

Such enhancements might serve to assist firefighting <u>on upper floors of tall buildings >18 m</u> (only when agreed by the fire service at the QDR) and may include:

- *a) 150 mm rising mains, enabling four inlets at the access level to deliver greater quantities of water from to the fire floors and allowing additional pumps to augment the supply using an alternative second hydrant where needed.*
- *b) two separate flow-controlled outlets at each floor level, allowing two hose-lines to be taken from each rising main.*
- *c) the locating of rising main outlets away from the stair, into protected corridors or firefighting lobbies in <u>residential buildings</u>, enabling firefighters to prevent or reduce smoke infiltrating into protected escape routes and firefighting stairs.*
- *d) in such situations, riser outlet valves should be located immediately adjacent to the firefighting stair door, but never further than 1 m from the door. They should be contained within a box in accordance with BS 5041, also being large enough to house twin controlled outlets, if installed; the marking of charging pressures on/at the inlet to the rising main, to assist firefighters to determine the maximum charging pressure of any particular dry riser (currently 12 bar); and*
- *e) the marking of individual stairwell and floor numbers on landings, to link up with multiple banks of rising main inlets that might exist in large complexes, to assist the fire service in wayfinding and charging the correct main.*

7. Critical Considerations

- ❖ External observers form a critical part of any safe system of work at a high-rise fire.
- ❖ Firefighters taking hose-lines through stair doors should check at least five floors of the stairwell above this point for self-evacuating occupants, prior to doing so.
- ❖ Ongoing operations should consider early assignment of teams of firefighters (Stairwell Protection Teams) to patrol, search and monitor stairwells for occupants moving into clear or untenable conditions.
- ❖ Every possibility should be considered in protecting stairwells from smoke infiltration, to include means of attacking from the fire floor within the common spaces using dividing breechings; using smoke blocking curtains; and controlling ventilation in the stair.
- ❖ External wind velocity and direction may cause the Incident Commander to delay or prevent entry into a fire compartment until local evacuation and adequate control measures have been actioned. In cases of strong winds heading into or onto the fire face of the building, consideration my be needed in allowing the fire-load the burn down prior to compartment entry.
- ❖ External firefighting may need to be considered where viable.
- ❖ Particularly on cold nights, **stack effect** can cause hazardous conditions where a fire exists on lower floors of a tall building where post-flashover conditions may act as if an external wind is forcing combustion products towards the stairwell.
- ❖ Adequate firefighting water should be provided at the fire floor. This may require local hydrants to be checked for approximate flow rate as part of building consultations and information provided on MDTs.
- ❖ Rising fire mains were originally designed on live fire research undertaken by the UK Fire Research Station (1960s) to flow 100 GPM (455 L/min) from the first jet at the highest floor (60m or 200ft) using 70mm attack hose-lines and a 20mm branch. Since then our fire loading and window openings have increased, so to drop below the 455 L/min flow provision is in error.
- ❖ Research has also shown that low flow 'pulsing' fog patterns should be used for flashover prevention and not for fire suppression. It may therefore be necessary to look closely at your flow rates available at the end of a 30 and 60m run of hose at 50 metres.
- ❖ Using 22mm smooth bore branches on 51mm hose, Kent Fire and Rescue Service recently flow tested two 650 L/min jets from a 150mm dry riser both at 50 metres height (12 bar riser).
- ❖ Using an evacuation alert system, residents can be directed to evacuate via alarms sounded in each flat. Such use by firefighters gives warning to building residents that a stay-put

paul.grimwood@kent.fire-uk.org

strategy is now being changed to an emergency evacuation (BS 8629). However, there are clear disadvantages when using such systems.

a) If there are two stairs it is impossible to direct residents towards the evacuation stair and away from the firefighting stair.
b) If there is only one stair it is important to know that conditions in the stair are tenable before instructing people to enter and evacuate by this route.

- It is considered far safer and more effective to promote the use of fire service controlled communication PA systems to each flat, where residents are assured either to remain in situ; leave by the assigned evacuation stair if they wish to do so; avoid using the assigned fire attack stair; or evacuate urgently using all available safe stairs.

- Effective functioning of an operational stair protection strategy requires a well-documented SOP; effective training; the use of safety officers both externally and in the stairwell/s; specific directives on stair gas monitoring; specific guidance for the use of Breathing Apparatus; and clear directives of what should happen in the case of communication breakdowns between the BA control operative and the Stair Protection Teams.

- Note: Subsequent mass or emergency evacuations become easier where escape stairwells are maintained in tenable conditions from the beginning.

- **CRITICAL:** Extended corridors (to 30 metres or more) may become the most dangerous environment for firefighters, particularly in wind driven or extreme fire behaviour conditions. Specific procedures should be written/incorporated into existing procedures to account for additional control measures, such as:

  a) No entry until burn-out has occurred
  b) Entry after a 'safe refuge' space has been created in an adjacent flat
  c) Entry with one hose-line to save life
  d) Entry with two hose-lines (one in safety) to save property
  e) Firefighters located at the stair door with third line to act in case needed

- Firefighters assigned to Stair Protection should be spaced at five floor intervals (depending on resource availability), equipped and trained to monitor stairwell fire gas levels and able to determine tenability levels where residents are either safely refuged, are safe to evacuate unaided, or are assisted out whilst wearing smoke hoods smoke hoods.

Stair Protection Teams
Kent Fire and Rescue Service

 paul.grimwood@kent.fire-uk.org