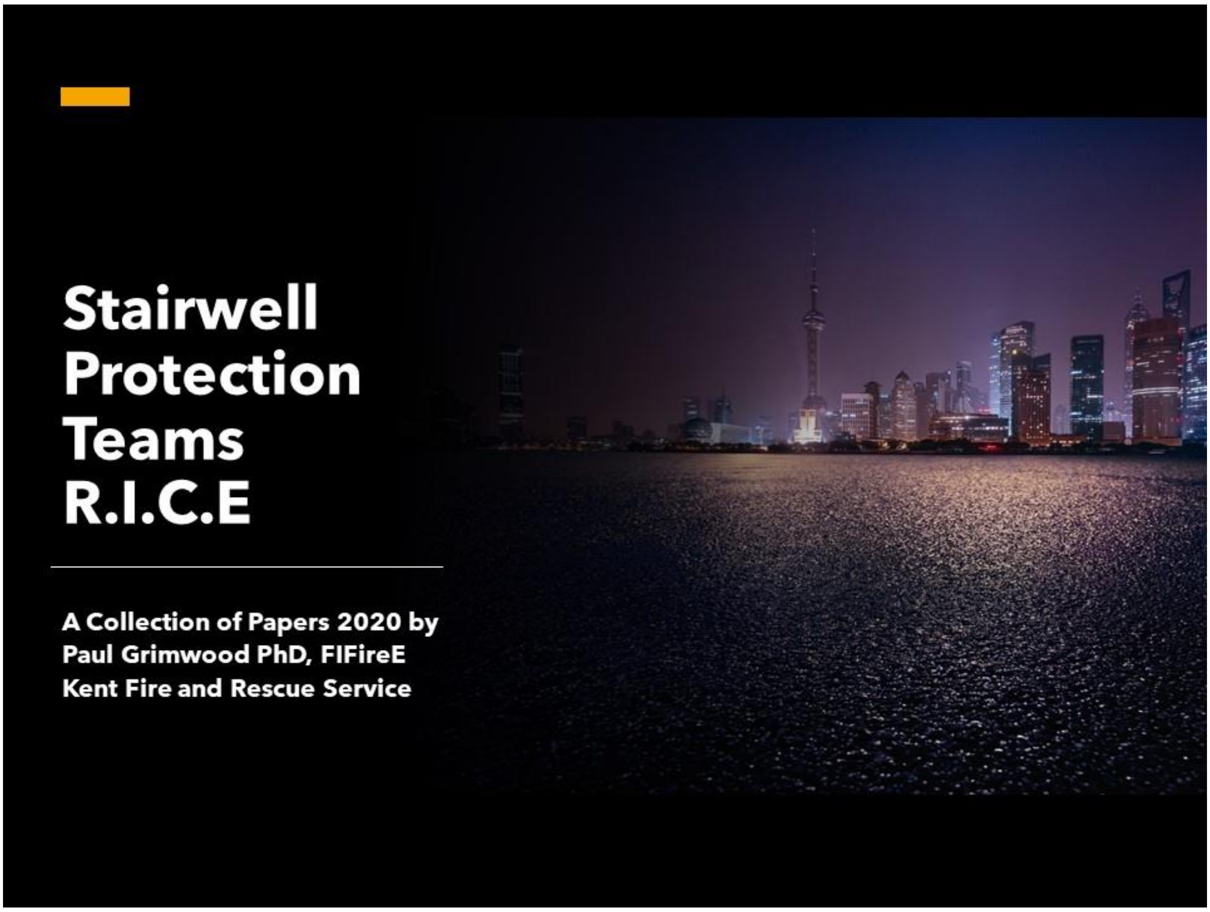

Stairwell Protection Teams in High-rise Fires

A Collection of 2020 Papers by

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We have learned over past decades through multiple tactical omissions by fire services in North America and the UK, where if we fail to deploy search teams of firefighters **as soon as possible into the stairwells** at high-rise fires we may eventually find occupants critically impacted or overcome by smoke. This risk may be even greater in single stair buildings. That is a stark but hard reality.

We know from experience of human behaviour in high-rise fires that uncontrolled self-evacuation will likely occur. This may see many people attempt to leave by the nearest or most obvious stair, whether that is our strategically designated *evacuation* or *firefighting* stair, it makes no difference in their decision making. If firefighters are not able to prevent or mitigate smoke from entering the stairwells as they lay hose-lines through stair doors, holding them open in the process, then expect occupant safety problems above the fire floor.

Stairwell protection is one of the most important strategies of a successful firefighting operation, in an occupied building involved in fire. That's why we design buildings that way, to protect the escape routes using passive and active means such as fire resistance and smoke control systems. The intent is to protect the horizontal and vertical escape channels long enough for persons to evacuate safely and allow firefighters to enter and establish a base from which they can mount an effective fire attack. In a residential building, a care home, a hospital or a phased evacuation office tower, these escape channels must be kept clear of smoke and combustion products for an extended period of time. In an apartment block, the common *'stay put' 'defend in place'* policy means we must still ensure by design that access and escape routes are relatively smoke free for the entire length of time we are firefighting. If they aren't, something has gone wrong with the building, its systems, or our own firefighting actions

The escape and evacuation provisions provided in tall residential or commercial buildings will vary substantially between those where occupants may be asleep and those where occupants work and are awake. The most notable differences will be in the alarm and evacuation provisions and the width of stairs. Although building design guidance has always promoted escape concepts that allow occupants to turn their back on a fire and move towards relative safety, the residential ***stay put*** strategy in apartment blocks has placed greater emphasis for residents to remain in situ, if not personally affected by fire or smoke. However, ever since the 1960s and through to current building design guidance, 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.

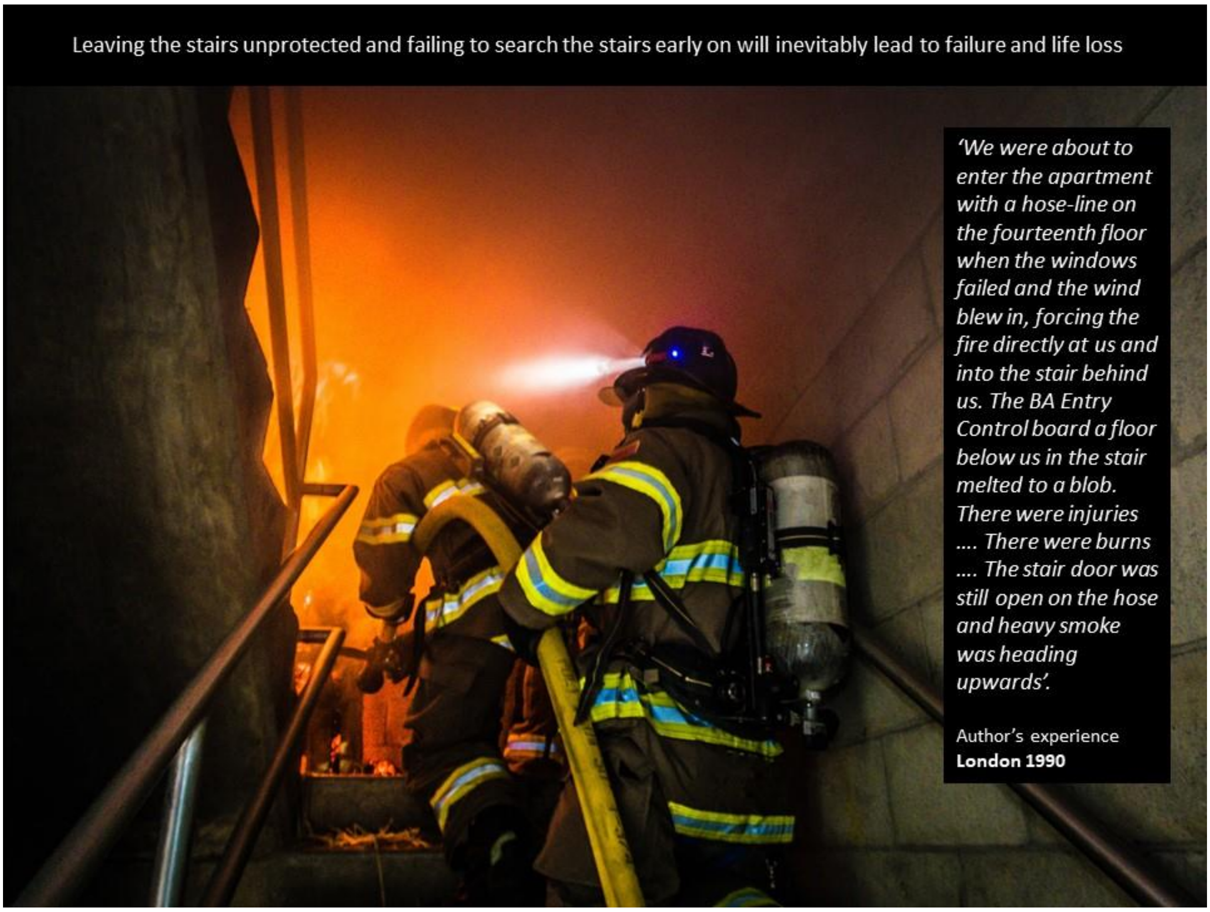
In the UK - s3.3 ADB-1 2019*: (in part) 'Sufficient protection to common means of escape is necessary to allow occupants to escape* ***should they choose to do so*** *or are instructed/aided to by the fire service. A higher standard of protection is therefore needed to ensure common escape routes remain available for a longer period than is provided in other buildings.'*

One particular golden fire-ground rule I learned during my time as a New York State firefighter (1976-78) was that the vertical escape routes should be protected at all times by firefighters. This tactical nugget was indoctrinated into me at an early stage of my career and stayed with me throughout my service as a London firefighter. It appears at section 3.3.29 of the FDNY Multiple Dwellings (residential high-rise) SOP:

3.3.29: *"The first line stretched for a fire in a multiple dwelling should be stretched by way of the interior stairs. The primary purpose of this line is to safeguard the stairway so that it can be used by the escaping occupants.* ***The door to the fire apartment must not be opened while people are coming down the stairway from the floors above****. When the safety of the stairway is assured, this first line may be advanced to extinguish the fire".*

There is a clear benefit in an early firefighting action and adequate resources and weight of attack in high-rise fires should be assembled prior to taking any action as required. However, human behaviour research demonstrates that many residents are likely to act on the fire instructional signage in most tall residential buildings that informs them that whilst normally it is safer to remain in their apartment, they can leave the building at any stage if they feel threatened. Therefore firefighters may experience some counter flow of people movements in the stairs as residents descend and firefighters ascend. 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. It is important to ensure the stairwells remain tenable and safe for escaping occupants at all times, and are relatively free of smoke infiltration and trip hazards created by excessive hose and equipment.

Wherever possible, the laying of hose-lines through stair doors should be avoided, unless methods, equipment or building systems are available to prevent or reduce dangerous amounts of smoke from entering the stairwell. In some cases where a building is clearly failing, there may be a need to prioritise evacuation over firefighting. In effect this means that the fire service should make every effort to protect and maintain egress routes, particularly stairwells, as well as safeguarding firefighters working around and above the fire floor. An understanding and awareness of how building stack effect or external wind conditions might affect airflow and smoke movements into stairwells, where doors are held open, is key to maintaining tenable conditions in the stairs.



The fact that variable numbers of occupants may choose to leave the building prior to any Fire Survival Guidance (FSG) calls being made, or local, emergency or mass evacuation becoming necessary due to a failing building, may enhance later strategic actions. Finally, we must take every opportunity to look 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.

Stairway Protection Team Objectives –

- To protect stair doors from smoke infiltration by deploying smoke-blocking door curtains as an additional preventive measure.
- To monitor fire gases accumulating in the stairwells.
- To ensure the stair is kept clear of smoke infiltration and that conditions are clear for self-evacuating occupants who decide they wish to leave the building.
- Where conditions are not safe that occupants are protected in a safe area or are escorted out of the building, possibly whilst wearing smoke hoods.
- To control ventilation in the stair, using portable PPV fans where viable.
- To provide updated information on the status of the stair to the Bridgehead.
- To respond to Fire Survival Guidance (999) calls in their 'five-floor zone' and act according to conditions and assignments.

Where buildings also have extended corridors, the assignment of additional resources may become necessary and the effectiveness and correct operation of smoke control systems are vital.

Reversing a 'stay put' strategy

As buildings are at present in the UK, it is unlikely we can effectively reverse a stay put strategy. However, what we can do is maintain existing vertical escape channels free of smoke to enable those that decide to leave to do so safely, whilst enabling firefighters to reach upper levels in case total evacuation becomes a requirement. The original 'stay put' strategies for 1960s CP3 buildings was to give an option where the residents away from the flat of fire origin are advised to 'stay put', but also leave by the stairs if they felt they wanted to. In fact, that's exactly what the evacuation instructions were for Grenfell Tower.

The fire service has no direct responsibility in the evacuation of fire involved buildings and yet, inevitably they will take responsibility when a building begins to fail by design, or where specific fire behavior surpasses the passive or active design limitations. **There has to be foresight of such failures** and firefighting tactics and command strategies that encompass evacuation need pre-planning, training and equipping for. Smoke control systems and fire resistive measures are provided by codes to 'protect the stair' for escaping occupants above the fire floor in 'stay put' buildings, even during firefighting operations. Therefore, our tactical objectives are surely to maintain any such escape routes at all times as part of any evacuation strategy.

The importance of stairwell protection and reversing a 'stay-put' strategy is nothing new. It was written into national high-rise firefighting guidance in GRA 3.2 and also National Operational Guidance some years ago:

- *Ensure access and egress routes are protected and not compromised by firefighting activity* (**National Operational Guidance**)
- *Incident Commanders should understand when a partial or full evacuation strategy might become necessary in a residential building where a "Stay Put" policy is normally in place* (**GRA 3.2 High-rise Firefighting**)

These two factors formed life critical directives that should serve to determine our tactical approach at every fire in multi-storey residential buildings. However, there are conflicts in both building design and operational guidance that serve to prevent firefighters from effectively achieving this. Residential apartment buildings in the UK were never designed to support the reversal of a ‘stay put’ strategy as there is no designated means of communicating with occupants. In the USA and other countries there are normally two stairs, a specially protected evacuation stair and often voice alarm public address systems that enable the fire service to communicate evacuation instructions, if ever needed.
Placing rising main outlets in the stair and directing firefighters to take hose-lines through fire doors protecting the stair is additionally countering the above guidance and potentially cutting off vertical escape routes.

- Rising fire mains should be a minimum of 150mm in diameter.
- Rising fire mains should have at least two outlets per floor level.
- Rising fire main outlets should be located in a firefighting lobby (as in commercial buildings) or in the accommodation corridor/lobby, sited **immediately adjacent** to the firefighting stair door.

Hazards

- In an operational perspective, the deployment of properly trained and equipped **stairwell protection teams,** patrolling and monitoring stairwells in assigned **five floor zones** above the fire floor is of great benefit. These firefighting teams need to be in position at a very early stage during firefighting from a life safety perspective.

- Unsafe conditions for firefighters not wearing BA may exist or occur in a stairwell, where levels of dangerous fire gases accumulate. This requires that firefighters work with the protection of breathing apparatus under air, which will limit their working duration in a stairwell above the fire floor.

- Where pre-planned, firefighters working with BA whilst not immediately under air should monitor fire gas levels at their locations using a portable gas detector with each stairwell team, ensuring they are always working in ‘safe’ air (Short Term Exposure Limits [STEL] applied).

- Unsafe conditions for occupants may exist or occur in a stairwell, where levels of dangerous fire gases may accumulate or high heat levels may stratify or become localised. This requires firefighters to monitor gas levels or assess heat conditions that may be untenable for occupants to escape through (Acute Exposure Guide Lines [AEGL] applied).

- In such cases that exceed predetermined AEGLs, occupants should be provided with smoke hoods and assisted down, or directed to refuge in tenable areas, until evacuation via the stairwell again becomes safe. In some cases, vulnerable persons may still require the protection of smoke hoods if available, even in tenable atmospheres as recorded.

- Difficulties may be experienced by occupants evacuating down stairwells that are laden with hose and other items of fire service equipment. These potential trip hazards may even slow an emergency or mass evacuation.

Control Measures

- In the UK we have workplace exposure limits (WELs) and short term exposure limits (STELs). A WEL is based on the concentration of a hazardous substance present in the air that people breathe, averaged over a specified reference period, referred to as a ‘time-weighted average’ (TWA). Two periods are used: long-term exposure limit (LTEL) (8 hours) and short-term exposure limit (STEL) (15 minutes). These short term exposure limits will inform firefighters at which gas levels they should go on air if they are deployed whilst not under air.

- There is government guidance that can be referenced from Public Health England for responding to, and dealing with, incidents involving the release of dangerous chemicals and gases. This guidance is presented in the form of Acute Exposure Guideline Levels (AEGLs) for the two most common asphyxiant and toxic fire gases such as Carbon Monoxide and Hydrogen Cyanide. AEGLs represent threshold exposure limits for the general public and are applicable to emergency exposure periods ranging from 10 minutes (min) to 8 hours (h).

- There is a need to search for occupants and protect stairwells from dangerous levels of smoke infiltration and localised heat build-up at the earliest practical stage of operations. This may precede firefighting operations in some circumstances and could be even more important in tall single stair buildings. The use of a stairwell protection plan requires specific assignments to be in place prior to firefighters being deployed above the fire floor, as follows:

    1. An external observer should be assigned to monitor and report both fire behaviour indicators and wind conditions on the involved face of the building.
    2. A dedicated safety officer to be located in safe air at, or on the half landing below the fire floor, to observe smoke infiltration at the stairwell door and to recall stairwell protection teams back to the Bridgehead where necessary.
    3. A dedicated BA Control board serving as a means for monitoring firefighter deployments above the fire floor/s.
    4. A dedicated BA Emergency Team in place at the earliest practical opportunity.
    5. Additional command support located at the Bridgehead to control operations above the fire floor/s.
    6. Pre-determine and justify by procedure, maximum levels above which it is not considered appropriate or safe to deploy firefighters in a fire attack stair.
    7. Pre-determine by procedure, maximum levels above which it is not considered appropriate or safe to deploy firefighters in a protected evacuation stair that is effectively separated by at least two fire-resisting doors (full slab partitions), from the attack stair/s.

8. Utilise Stairwell Protection Teams to provide evacuation support and respond to Fire Survival Guidance calls as needed.

- Every effort or opportunity should be made to keep stairs clear of hose-lines or other fire service equipment that may slow an emergency or mass evacuation.

Strategic Actions

- There should be a pre-planned approach to implement stairwell protection, anticipating that evacuation support may be needed, taking account of the following situations:

    1. Apartments where both stairwell and relevant corridor are both initially smoke free.
    2. Apartments where the stairwell is initially smoke free but the relevant corridor/lobby is smoke contaminated.
    3. Apartments where smoke has contaminated both corridor/lobby and stairwell.
    4. Open-plan commercial office fires.
    5. Wind driven fires in any building.

- Determine the optimum zones (number of floor levels) that each Stair Protection Team will be assigned to cover and brief each team prior to deployment. This should include detail of how the stairwell is primarily searched and protected (e.g. from the top down, or vice versa).

Tactical Actions

- Do not discourage occupants from evacuating in stairwells in tenable conditions and delay laying hose through a stair door until it is confirmed the stair for at least five floors above is clear of occupants.

- Utilise means to monitor and report tenability levels in assigned stairwells.

- Monitor and report conditions in each lobby/corridor off the assigned stairwell.

- Use methods and equipment to protect and/or assist occupants in evacuating via the stairwells and prevent/reduce smoke entering the stairs.

- Locate suitable and tenable refuge for occupants evacuating or entering in untenable environments.

Stairway (and egress) Protection Teams – Gas Monitoring

There is UK government guidance[1] that can be referenced from Public Health England for responding to, and dealing with, incidents involving the release of dangerous chemicals and

[1] https://www.gov.uk/government/publications/carbon-monoxide-properties-incident-management-and-toxicology

gases. This guidance is presented in the form of Acute Exposure Guideline Levels (AEGLs) for the two most common asphyxiant and toxic fire gases such as Carbon Monoxide and Hydrogen Cyanide[2].

AEGLs represent threshold exposure limits for the general public and are applicable to emergency exposure periods ranging from 10 minutes (min) to 8 hours (h).

Three levels—AEGL-1, AEGL-2, and AEGL-3—are developed for each of five exposure periods (10 and 30 min and 1, 4, and 8 h) and are distinguished by varying degrees of severity of toxic effects. The recommended exposure levels are applicable to the general population, including infants and children, and other individuals who may be sensitive or susceptible.

The three AEGLs are defined as follows[3] -

AEGL-1 is the airborne concentration (expressed as parts per million [ppm] or milligrams per cubic meter [mg/m3]) of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic, non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.
AEGL-2 is the airborne concentration (expressed as ppm or mg/m^3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects, or an impaired ability to escape.
AEGL-3 is the airborne concentration (expressed as ppm or mg/m^3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death.

Note: *Although the AEGLs represent threshold levels for the general public, including sensitive subpopulations, it is recognized that certain individuals, subject to idiosyncratic responses, could experience the effects described at concentrations below the corresponding AEGL.*

Stairway Protection Teams – Gas Monitoring

1. Since 1962 it is the case in most tower blocks of flats that a 'stay put' strategy is generally dictated by design, whereby simultaneous evacuation of all residents together is likely to be problematic, due to limited stair escape capacity and building height.

2. Many of the buildings still around today, constructed in the 1960s and 1970s, originally incorporated a **'stay or go'** approach, where '*the possibility that individuals may seek to leave the building cannot be overlooked and provision should therefore be made for the occupant of*

[2] http://cvoed.imss.gob.mx/COED/home/normativos/DPM/archivos/HDRM/health_topics/chemical_safety/a_toxicological_review.pdf

[3] Acute Exposure Guideline Levels for Selected Airborne Chemicals (v8); Committee on Acute Exposure Guideline Levels Committee on Toxicology Board on Environmental Studies and Toxicology; National Academy of Sciences, USA. 2010.

any dwelling to do so by his own unaided efforts, using adequately protected escape routes within the building without outside assistance'.

3. It was never implied that self-evacuating residents should be prevented from leaving the building should they wish to do so and protected stairwells were provided for that purpose. In fact the fire safety instruction signs at Grenfell Tower at the time of the 2017 fire stated that residents were entitled to leave at any point during a fire, using the stair.

4. A conflict arose though when rising fire mains were located through regulation within escape stairs and firefighting actions sometimes caused smoke infiltration into the stair.

5. A review of 113 Grenfell survivors witness statements demonstrated that 38% of residents would ignore any *stay put advice* and evacuate as soon as they became aware of a fire. Also, 34% of residents who gave evidence stated they were unaware of the evacuation policy and would self-evacuate if they felt threatened in any way and were able to do so.

6. It is therefore clear from a human behaviour perspective that the fire service have a responsibility to make all efforts to maintain protected escape routes and stairwells from any infiltration of smoke and combustion products so that self-evacuating residents are able to escape in tenable conditions.

7. It may be inevitable though, that due to building layout and the effectiveness of compartmentation that some smoke may infiltrate the stairs and other egress routes, despite the efforts of fire service personnel. Therefore to offer additional protection to self-evacuating occupants the monitoring of dangerous fire gas levels by firefighters and the provision of RPE to assist, where available, is being proposed.

8. The asphyxiant gases most relevant to incapacitation and death in fires are carbon monoxide, hydrogen cyanide, carbon dioxide and low levels of oxygen. Asphyxiant gases have little or no immediate effect on exposed subjects, but when a sufficient exposure dose has been inhaled during the course of a fire, then confusion, rapidly followed by incapacitation, occurs with collapse and loss of consciousness. If the subject is not rescued immediately after incapacitation occurs, death is likely within a few minutes.

9. It is therefore the primary objective of stair protection teams to maintain tenable levels in stairwells through monitoring fire gas levels, taking control of ventilation where necessary to reduce gas and combustion products in the stairs, and aid or assist occupants to self-evacuate where they have chosen to do so. It is not the intention to prevent residents from evacuating but rather protect and assist them to do so whilst preventing them from entering areas where tenability may be in question.

10. Every means will be taken using stairway protection concepts to maintain the integrity of the stair and avoid or reduce smoke infiltration. These actions will include requesting proactive relocation of rising main outlets off the stair during building design (TFS); the use of smoke-blocking door curtains; RICE tactical decision tool; deployment of stairway protection teams into five floor zones above the fire floor; taking control of any fixed ventilation system and utilising PPV to pressurise the stairs if needed.

11. Where self-evacuating occupants are in stairwells whilst firefighting operations are underway, it may be prudent to undertake monitoring of the most common asphyxiant fire gas levels in the stair, to;

(a) Identify where tenable conditions exist, where residents may self-evacuate unaided.
(b) Identify at which points it is practicable and useful to utilise RPE (where self-evacuating residents may need to be escorted to safety).
(c) Identify very young, or elderly, or vulnerable and disabled residents, who may require the protection of RPE even at very low levels of gas infiltration in the escape routes.
(d) Identify zones within the stairwells where gas levels exceed pre-determined limits (ppm), beyond which it may be necessary to seek refuge for residents in a safer environment, should an adequate quantity of RPE not be immediately available.

12. There is government guidance[4] that can be referenced from Public Health England for responding to, and dealing with, incidents involving the release of dangerous chemicals and gases. This guidance is presented in the form of Acute Exposure Guideline Levels (AEGLs) for the two most common asphyxiant and toxic fire gases such as Carbon Monoxide and Hydrogen Cyanide[5].

13. AEGLs represent threshold exposure limits for the general public and are applicable to emergency exposure periods ranging from 10 minutes (min) to 8 hours (h). Three levels—AEGL-1, AEGL-2, and AEGL-3—are developed for each of five exposure periods (10 and 30 min and 1, 4, and 8 h) and are distinguished by varying degrees of severity of toxic effects. The recommended exposure levels are applicable to the general population, including infants and children, and other individuals who may be sensitive or susceptible. The three AEGLs are defined as follows:

14. The proposed and most practical level normally considered acceptable for emergency management during evacuation is AEGL-2. As it should not take able-bodied persons longer than 15 to 20 minutes to descend a twenty-storey building from the highest floor level in relatively smoke free conditions, the following AEGLs appear the most appropriate to use -

15. **Carbon Monoxide – AEGL 2 for 30 minutes – maximum 150 ppm**
Hydrogen Cyanide – AEGL 2 for 30 minutes – maximum 10 ppm

16. Therefore the AEGL-2 levels are proposed as a benchmark for determining either the use of Respiratory Protective Equipment (RPE) to aid escape, or the refuge of residents in a safer area, where AEGL-2 is exceeded (should be determined under a DRA at the time). Where individuals are either elderly, disabled, bariatric or very young, a lower level of AEGL might be considered[6].

[4] https://www.gov.uk/government/publications/carbon-monoxide-properties-incident-management-and-toxicology
[5] http://cvoed.imss.gob.mx/COED/home/normativos/DPM/archivos/HDRM/health_topics/chemical_safety/a_toxicological_review.pdf
[6] See Fractional Effective Dose (FED) below (s3)

Acute exposure guideline levels (AEGLs)

	Concentration (ppm)				
	10 min	30 min	60 min	4 hours	8 hours
AEGL-1*	NR	NR	NR	NR	NR
AEGL-2†	420	150	83	33	27
AEGL-3‡	1,700	600	330	150	130

* Level of the chemical in air at or above which the general population could experience notable discomfort

† Level of the chemical in air at or above which there may be irreversible or other serious long-lasting effects or impaired ability to escape

‡ Level of the chemical in air at or above which the general population could experience life-threatening health effects or death

NR Not recommended due to insufficient data

Reference

US Environmental Protection Agency. Acute Exposure Guideline Levels. http://www.epa.gov/oppt/aegl/pubs/chemlist.htm (accessed 11/2015).

1. *Carbon Monoxide (above)*

Acute exposure guideline levels (AEGLs)

	Concentration (ppm)				
	10 min	30 min	60 min	4 hours	8 hours
AEGL-1*	2.5	2.5	2.0	1.3	1.0
AEGL-2†	17	10	7.1	3.5	2.5
AEGL-3‡	27	21	15	8.6	6.6

* Level of the chemical in air at or above which the general population could experience notable discomfort

† Level of the chemical in air at or above which there may be irreversible or other serious long-lasting effects or impaired ability to escape

‡ Level of the chemical in air at or above which the general population could experience life-threatening health effects or death

Reference

US Environmental Protection Agency. Acute Exposure Guideline Levels. http://www.epa.gov/oppt/aegl/pubs/chemlist.htm (accessed 11/2015).

2. *Hydrogen Cyanide (above)*

Fractional Effective Doses (FED)

17. Another method of determining ‘safe’ exposures to fire gases is used in fire safety engineering building design, termed Fractional Effective Doses (FEDs). FEDs are determined for each asphyxiant at each discrete increment of time. Their accumulated sum is then compared with a predetermined total FED value judged to represent an acceptable incidence of incapacitation. Due to variations in susceptibility within the population, the proportion incapacitated follows an approximately normal distribution as a function of exposure dose, with an FED of 1 representing the dose statistically estimated to result in incapacitation of 50% of the exposed population. A tenability limit can then be set for evacuation design purposes, depending on the desired probability of the incidence of incapacitation.

18. While there is no absolute threshold, incapacitation is considered unlikely in even vulnerable individuals at an FED < 0.1. **For practical purposes**, an FED < 0.3 is estimated to represent incapacitation of <1% of the exposed population. If the total accumulated FED value is less than the predetermined maximum FED value (e.g. 0.3), the incidence of safe escape for those exposed (i.e. the probability that all occupants will be able to escape safely) may be considered to be acceptable. Conversely, if the accumulated total FED value is greater than the predetermined target FED, the incidence of safe escape for those exposed is considered to be unacceptable.

19. There is a considerable range of sensitivities to smoke contaminants within the population. It is considered that effects on approximately 99% of the population would be minimal at up to and including 0.3 FED. In order to protect vulnerable sub-populations, particularly in situations where vulnerable subjects are likely to be present (such as health care or residential care premises) then a tenability limit of 0.1 FED is thought to be sufficient to enable safe escape of essentially all occupants. In effect, this would mean total use of smoke hoods and/or PPV combined with Gas monitoring.

20. Since there is some relationship between smoke density and the concentrations of irritant and asphyxiant gases in fires, it is considered that, at the proposed smoke tenability limit of $D \cdot m^{-1}$ = 0.2, the majority of fires would remain tenable with respect to asphyxiant gases for at least 30 min'.

Suggested smoke tenability limits[7] for buildings with:
– Small enclosures and familiar travel distances: D·m-1 = 0.2 (visibility 5 m)
– Large enclosures and unfamiliar travel distances: D·m-1 = 0.08 (visibility 10 m)

21. Based upon a 0.3 FED tenability limit, two categories are proposed in BS 7974-6 consisting of fires likely to involve fuels containing significant quantities of nitrogen-containing materials in furniture or clothing (>2% nitrogen by mass of fuel, such as fires in residences or retail premises) and fires likely to involve mainly cellulosic or other materials low in nitrogen (<2% by mass of fuel, such as office fires). For both cases, a moderately vitiated combustion condition typical of building fires is assumed. The results are expressed in terms of maximum CO concentrations, assuming the other gases are present at the ratios stated.

Design tenability at 0.3 FED for exposure to concentrations of Carbon Monoxide		
Category	**Maximum asphyxiant concentration as CO 5 minute exposure**	**Maximum asphyxiant concentration as CO 30 minute exposure**
Fuel contains nitrogen (>2% by mass) such as fires in residences or retail premises	800 ppm	125 ppm
Fuel contains nitrogen (<2% by mass) such as office fires	1,200 ppm	275 ppm

Reference: BS 7974-6

[7] BS 7974-6:2019 (updated and in Draft 2018) – The Application of Fire Safety Engineering Principles to Fire safety Design of Buildings - Human factors: Life safety strategies –Occupant evacuation, behaviour and condition

22. If using the **FED** approach described in BS 7974-6, based on fire hazard analysis provided in BS 7899-2:1999 we can see that for a maximum 30 minute exposure, an upper limit of **125 – 275 ppm** should be used. Compare this to the **150 ppm** for a maximum 30 minute exposure under **AEGL-2** (Public Health England).

OPERATIONAL CONCLUSIONS and RECOMMENDATIONS

Of the 31 substances listed within the EU Directive there are two substances that are most commonly involved in FRS operations, they are carbon monoxide (CO) and hydrogen cyanide (HCN).

In the UK we have workplace exposure limits (WELs) and short term exposure limits (STELs). A WEL is based on the concentration of a hazardous substance present in the air that people breathe, averaged over a specified reference period, referred to as a 'time-weighted average' (TWA). Two periods are used: long-term exposure limit (LTEL) (8 hours) and short-term exposure limit (STEL) (15 minutes).

The 2018 changes to Carbon Monoxide and Hydrogen Cyanide are as follows:

Carbon Monoxide

Current LTEL/TWA (8hrs) = 30 ppm	**New LTEL/TWA (8hrs) = 20 ppm**
Current STEL (15mins) = 200 ppm	**New STEL (15mins) = 100 ppm**

Hydrogen Cyanide

Current LTEL/TWA (8hrs) = N/A	**New LTEL/TWA (8hrs) = 0.9 ppm**
Current STEL (15mins) = 10 ppm	**New STEL (15mins) = 4.5 ppm**

For monitoring gas levels on egress routes:

If using the **FED** approach described in BS 7974-6, based on fire hazard analysis provided in BS 7899-2:1999 we can see that for a maximum 30 minute exposure, an upper limit of **125 – 275 ppm** should be used. Compare this to the **150 ppm** for a maximum 30 minute exposure under **AEGL-2** (Public Health England). Above such limits, either RPE should be offered to evacuating occupants or safe refuge areas should be found and advised for use where viable.

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.

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 (now rescinded at 2020)

- *'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.

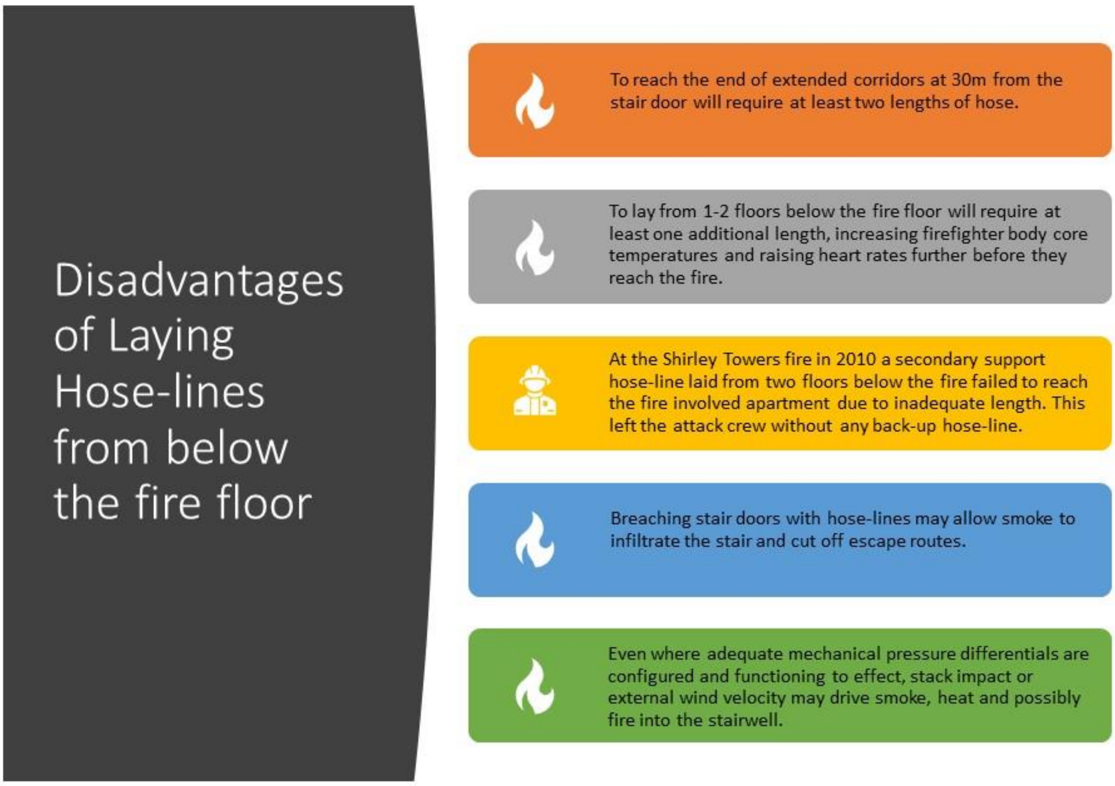
3. 'One Door' or 'Two Door' Protection

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 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.

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 residential buildings. 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 single stair residential buildings but might also feature in multi-stair residential buildings. 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 on upper floors of tall buildings >18 m (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 residential buildings, 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 may 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 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.

paul.grimwood@kent.fire-uk.org

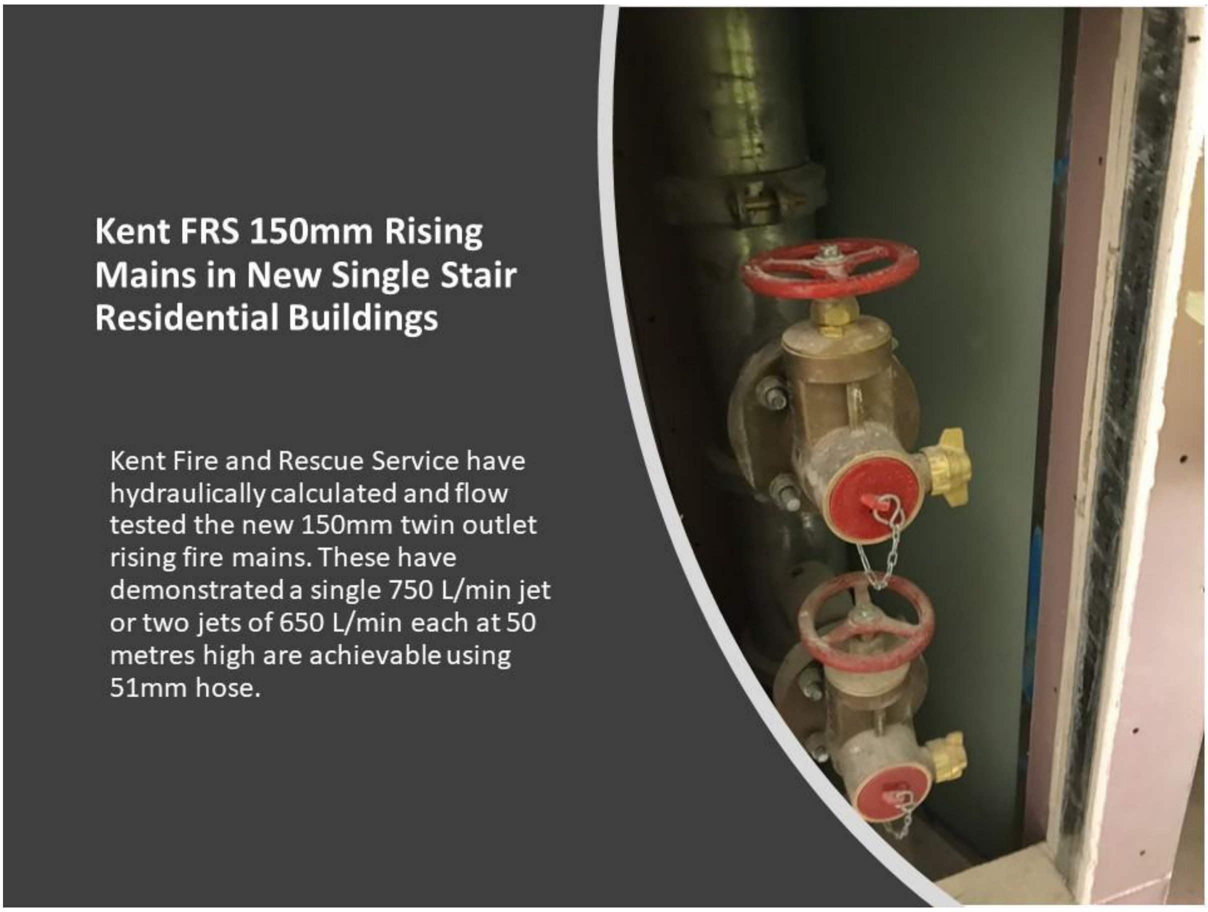
- Effective functioning of an operational stair protection strategy requires a well-documented SOP; effective training; the use of safety officers both externally and in the stairwell/s; specific directives on stair gas monitoring; specific guidance for the use of Breathing Apparatus; and clear directives 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.

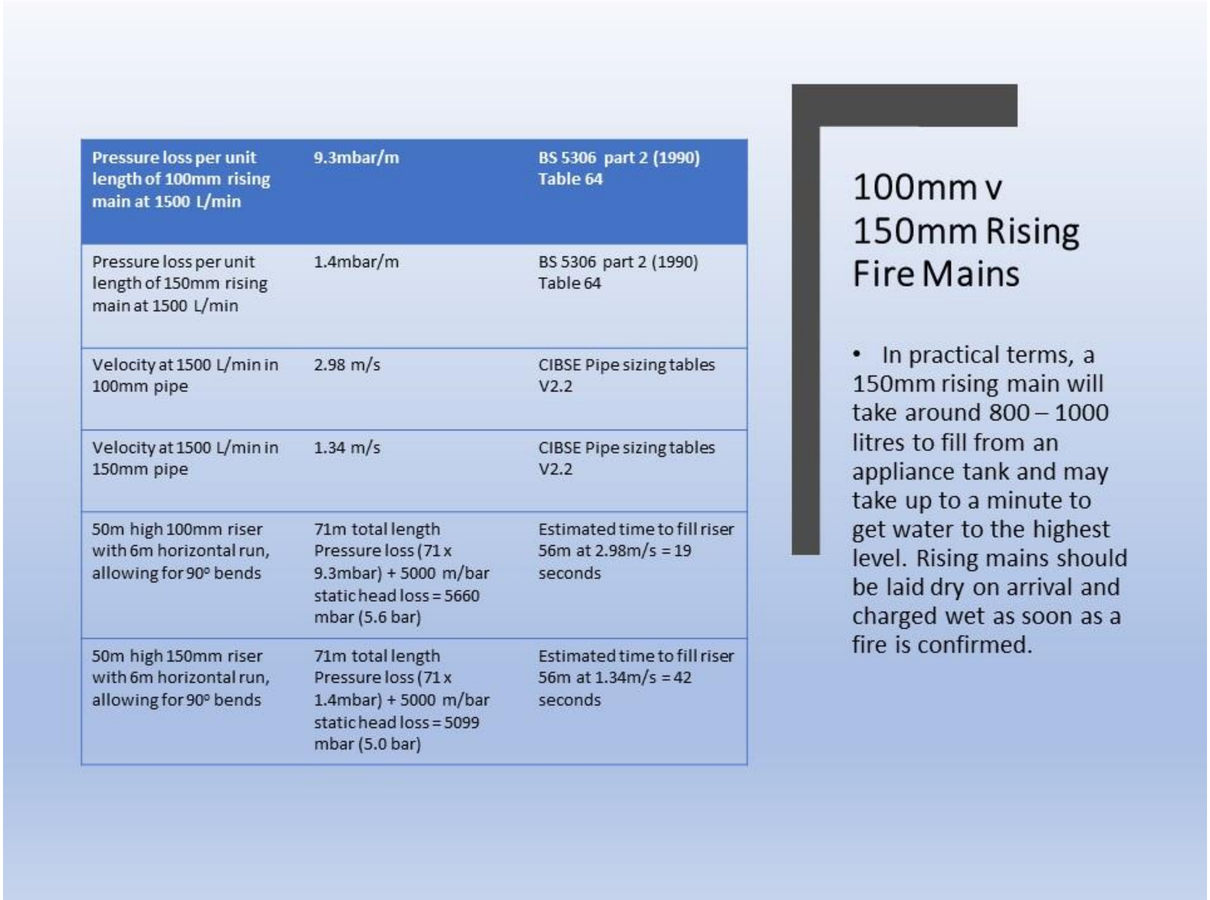


High-rise Firefighting Tactics – RICE and the 150mm Rising Main

In May/June 2020 the revised BS PD 7974-5 (**Application of fire safety engineering principles to the design of buildings** Part 5: Fire and rescue service intervention) will again provide an option for the UK Fire and Rescue Service (FRS) to require 150mm rising fire mains, with optional twin controlled outlets at every floor level, in fire engineered buildings (*including flats with* ***extended corridors protected by mechanical ventilation***). This is something that must first be agreed by the local FRS fire safety department at the QDR stage. This option has in fact existed ever since BS 5306:1976 first proposed twin outlet 150mm rising mains but it has rarely been a provision requested by the FRS.

However in 2006, following several serious high-rise fires in the UK, DCLG Fire Service Circular 32/2006 informed all fire services that they should adopt fire-fighting techniques at all high-rise incidents that provide for an **additional covering jet** to protect fire-fighting personnel actively involved in firefighting or rescue operations. It stated that this second jet should come from the Bridgehead, two floors below the fire. Since then the ‘second jet’ has repeatedly been responsible for allowing smoke to enter the stairs to further compromise the escape stairs. In single stair buildings this has proved life critical.

In 2014, as members of the review committee, Kent Fire and Rescue Service developed the design guidance within the revised BS PD 7974:5 that would enable the 150mm main with double outlets at each level to again *be requested during the design stages of fire* *engineered buildings*. In 2020 this may now be a requirement in specific buildings if the FRS choose to utilise the design option.



Pressure loss per unit length of 100mm rising main at 1500 L/min	**9.3mbar/m**	**BS 5306 part 2 (1990) Table 64**
Pressure loss per unit length of 150mm rising main at 1500 L/min	1.4mbar/m	BS 5306 part 2 (1990) Table 64
Velocity at 1500 L/min in 100mm pipe	2.98 m/s	CIBSE Pipe sizing tables V2.2
Velocity at 1500 L/min in 150mm pipe	1.34 m/s	CIBSE Pipe sizing tables V2.2
50m high 100mm riser with 6m horizontal run, allowing for 90º bends	71m total length Pressure loss (71 x 9.3mbar) + 5000 m/bar static head loss = 5660 mbar (5.6 bar)	Estimated time to fill riser 56m at 2.98m/s = 19 seconds
50m high 150mm riser with 6m horizontal run, allowing for 90º bends	71m total length Pressure loss (71 x 1.4mbar) + 5000 m/bar static head loss = 5099 mbar (5.0 bar)	Estimated time to fill riser 56m at 1.34m/s = 42 seconds

Firefighting Tactics

At the same time Kent FRS were developing national fire engineering design guidance, their firefighting tactics and primary command procedures were being further developed to enhance their tactical approaches and protect the vertical escape channels more effectively, whilst still meeting the requirement to provide a second (covering) jet at the fire floor. At the very core of their tactical approach was the analytical command tool **R.I.C.E** where the **overriding objective** was to establish, protect and maintain a means of escape and firefighting access using the stairs.

As an analytical command mnemonic, RICE has dramatically increased decision making and situational awareness in KFRS since it's introduction in 2010.

The primary commander on scene undertook the usual information gathering to increase situational awareness and assist plan formulation. This is all very dynamic and generally occurs in very short time-frames. Quite often, key decisions are made within less than a minute. The **RICE** command mnemonic allows four options that are targeted in meeting all generic internal approaches –

R – Rescue
I – Intervention
C – Containment
E – Evacuation

The tactical approach follows the KFRS **RICE** guidance –

- **RESCUE** – If there is clear reliable and confirmed information that assure either a person or persons are trapped inside a flat, or an immediate firefighting intervention may save further lives and/or prevent a worsening fire situation from getting out of control, an immediate attack may be made using one hose-line (jet), prior to a cover line being in place. This single line entry is primarily at the discretion of the Incident Commander.

In such situations, the corridor/lobby has now become the fire compartment and any cover line subsequently laid should come from the floor below and only be laid as far as the stair door to avoid unnecessary amounts of smoke leaking into the stairwell. This can be advanced into the accommodation to assist as needed but must be carefully coordinated with stair protection strategies, knowing that firefighters and occupants may still be in the stair.

Prior to advancing a hose-line through a stair door, the ICs permission should first be obtained, and a check should be made for persons in the stair, particularly above the fire floor.

- **INTERVENTION –**

Without the above 'triggers' determining the need for rapid deployment, a firefighting intervention requires both attack and cover (safety) hose-lines in place before compartment (flat) entry should occur. Both lines are laid from the fire floor and within the accommodation corridor/lobby to protect the stair from smoke infiltration. If twin outlets are provided from a 150mm main that alleviates having to bring the dividing breeching. If the outlet is in the stair the provision of a portable smoke blocking curtain at the stair door is necessary, providing it does not hinder any automated mechanical ventilation air supply from the stair.

- **CONTAINMENT –**

There are situations where the fire must be contained or isolated, slowing or preventing its spread rate. It is critical that an external observer is located within sight of the involved building face to report on wind speed/direction, window opening status, fire behaviour indicators and any apparent post flashover conditions to the Incident/Bridgehead Commander and interior firefighting teams. If a wind is heading directly into a window (noted by pulsing flames or smoke emissions at the opening) then it may be more appropriate and safer to delay any firefighting intervention, to enable local evacuation of any primary risk zone to be prioritised. Depending on the strength of the wind, it may be a situation to utilise 'floor below' high-rise nozzles or even allow the fire's fuel-load to burn down before entering to extinguish.

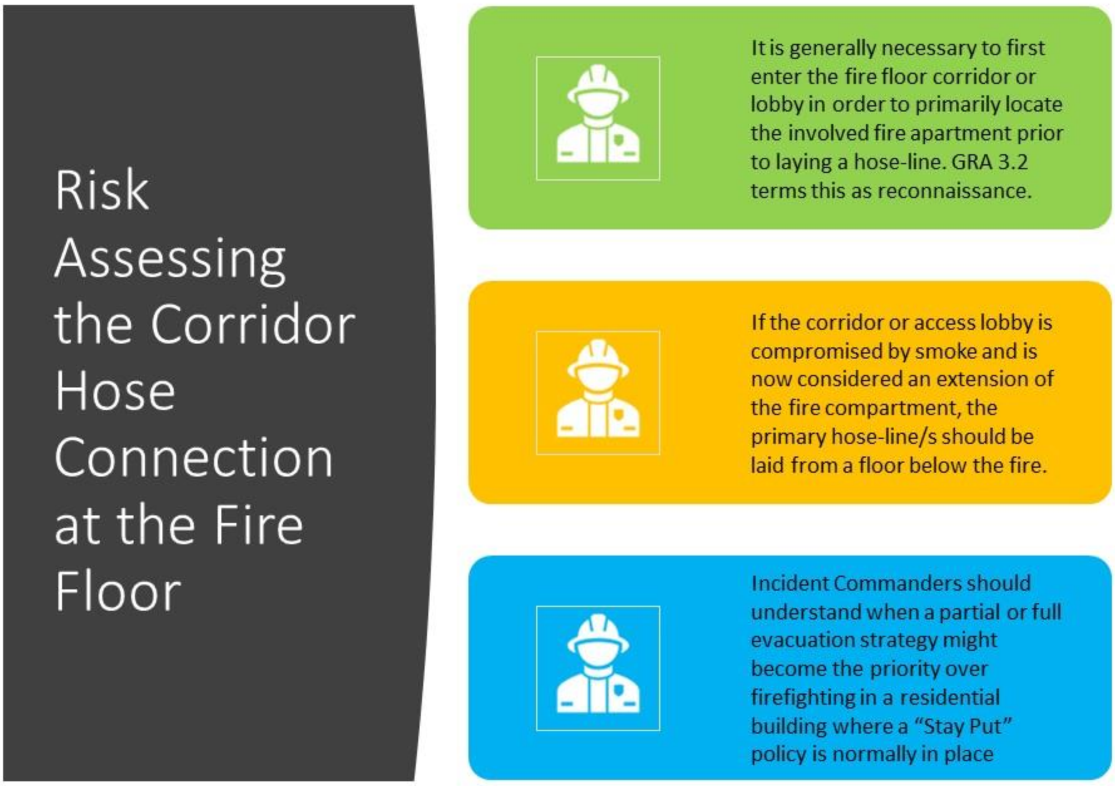
- **EVACUATION –**

In situations where wind is heading into the fire, or a façade fire has spread **beyond three floors (or into the roof void, particularly of a lightweight metal or timber-framed building)**, total building evacuation may precede any internal firefighting intervention. At the same time, external firefighting may be a viable option to control or slow fire spread whilst evacuation is occurring.

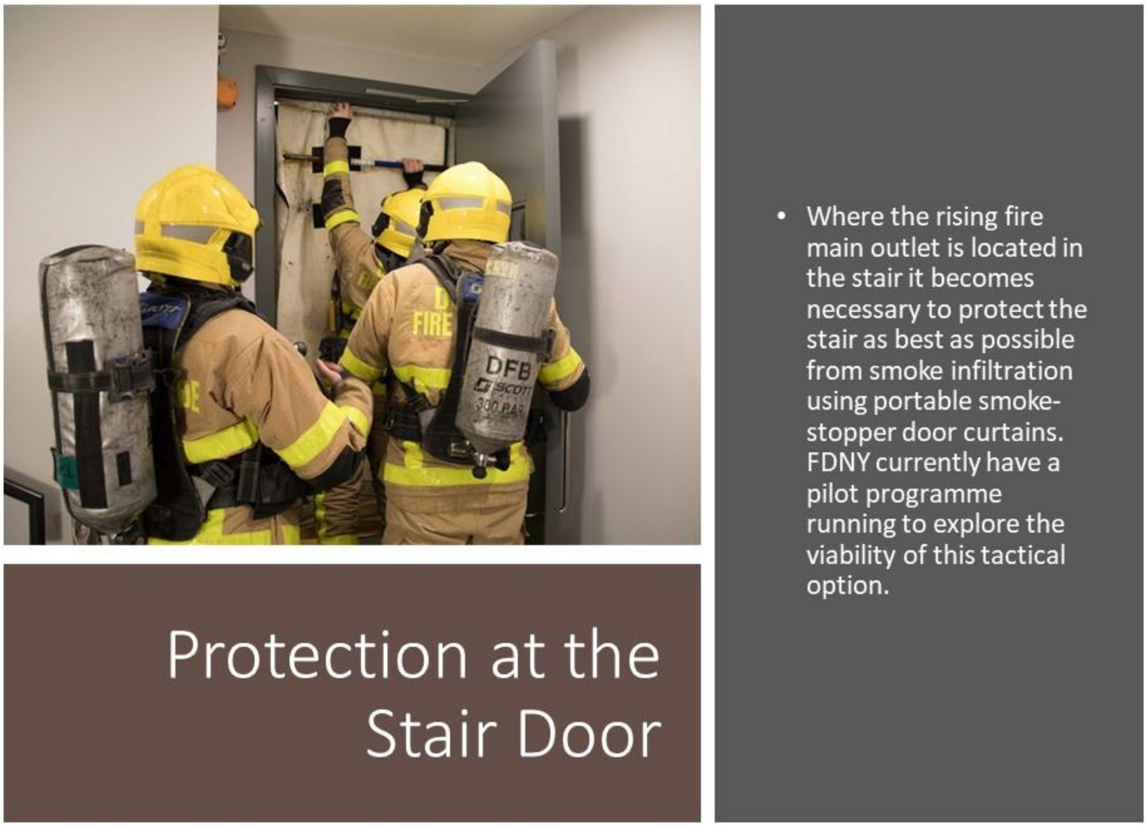
Risk Assess the Corridor/Lobby –

Firstly and most importantly, in 45 years of firefighting research 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 negative 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 charged hose-line However, it is not the number of doors between them and the fire 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. Today we have fully protected (two hours) Firefighting Shafts and it may be life critical that this level of protection is maintained throughout firefighting operations.

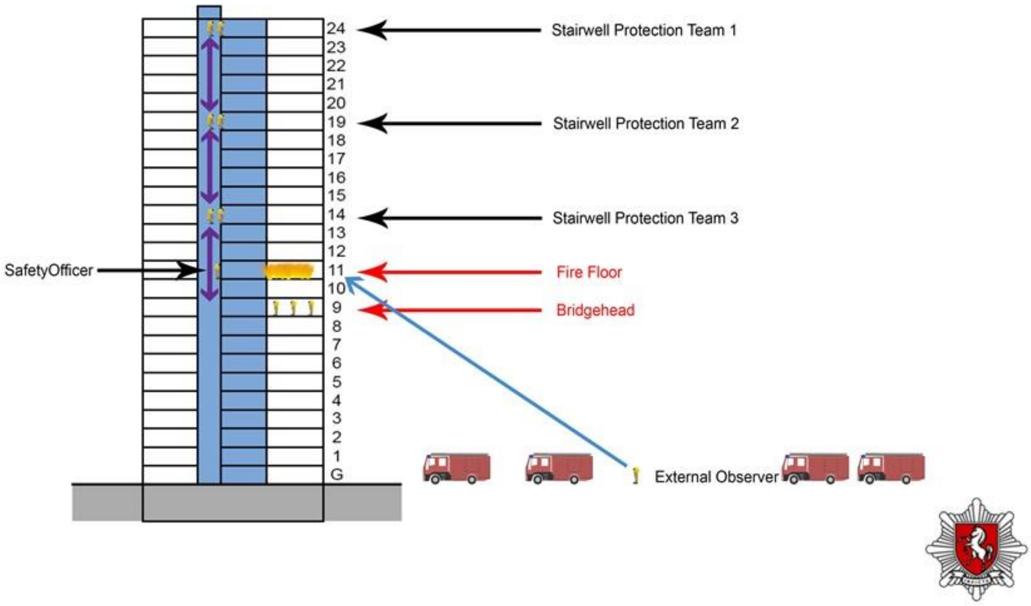


‘Your primary mission as a firefighter is to locate and secure, or to establish and maintain, a means of egress from the building ….’

“I was a firefighter and an officer with nearly 20 years of experience in the country’s second largest fire department when I first heard those words and remember thinking to myself (yet again) ... How could I have lived so long and remained so dumb? It was an epiphany for me. I immediately recalled a dozen incidents where things would have gone better if I had just used that basic mission statement to guide my decisions”.

Chief Pete Van Dorpe
Chicago Fire Department

Kent FRS Stairwell Protection Strategy



Acute exposure guideline levels (AEGLs)

	Concentration (ppm)				
	10 min	30 min	60 min	4 hours	8 hours
AEGL-1*	NR	NR	NR	NR	NR
AEGL-2†	420	150	83	33	27
AEGL-3‡	1,700	600	330	150	130

Carbon Monoxide

Acute exposure guideline levels (AEGLs)

	Concentration (ppm)				
	10 min	30 min	60 min	4 hours	8 hours
AEGL-1*	2.5	2.5	2.0	1.3	1.0
AEGL-2†	17	10	7.1	3.5	2.5
AEGL-3‡	27	21	15	8.6	6.6

Hydrogen Cyanide

“Battalion Chief Glenn Dinger of the Los Angeles Fire Department felt strongly that any pre-plan should account for a team of firefighters to be dispatched into the [high-rise protected] stairs above the fire floor on the initial response, but it was surprising to find that few fire departments actually do this [1990].

However, FDNY do deploy a two-man scout and search team above the fire floor on arrival. They will search stairs, lifts shafts and report smoke conditions in egress routes. The FDNY stair protection procedure is coordinated by a designated Search and Rescue Commander”

Paul Grimwood
Fog Attack 1992 p276

“In situations where single exit stairs may become compromised by smoke as firefighters open up the fire compartment, the evacuation of the entire building above the fire floor, and possibly below it, may need to be prioritized”.

Paul Grimwood
hemmingfire.com 2011

"A prompt fire suppression action may save lives. However stair-shaft integrity should be maintained as far as possible. Whilst it is recognised that building design may, in some situations, place the rising main outlets in the stair-shaft, every effort should be made to keep the stair doors closed as much as possible.

Prior to opening a door into the stairs from the fire floor, a check should be made for occupants in the stair for at least five floors above the fire. Any stair-shaft contaminated by smoke should be prioritised for secondary search undertaken by the second arriving response firefighters".

Paul Grimwood
EuroFirefighter 2008 p331

“The two 100mm rising mains were unable to provide adequate amounts of firefighting water to upper levels to deal with the amount of fire. Rising fire mains should be at least 150mm diameter with dividing connections to allow two hose-lines at each floor level”
Paul Grimwood
Fog Attack p269 –Churchill Plaza Fire, UK

More Information - https://img1.wsimg.com/blobby/go/877d587b-6900-4f7f-b145-e75cc02aff97/downloads/HIGH-RISE%20FIREFIGHTING%202020.pdf?ver=1585139990062
LARGE FILE DOWNLOAD - https://img1.wsimg.com/blobby/go/877d587b-6900-4f7f-b145-e75cc02aff97/downloads/Report%20from%20New%20York%202019.pdf?ver=1585146377236