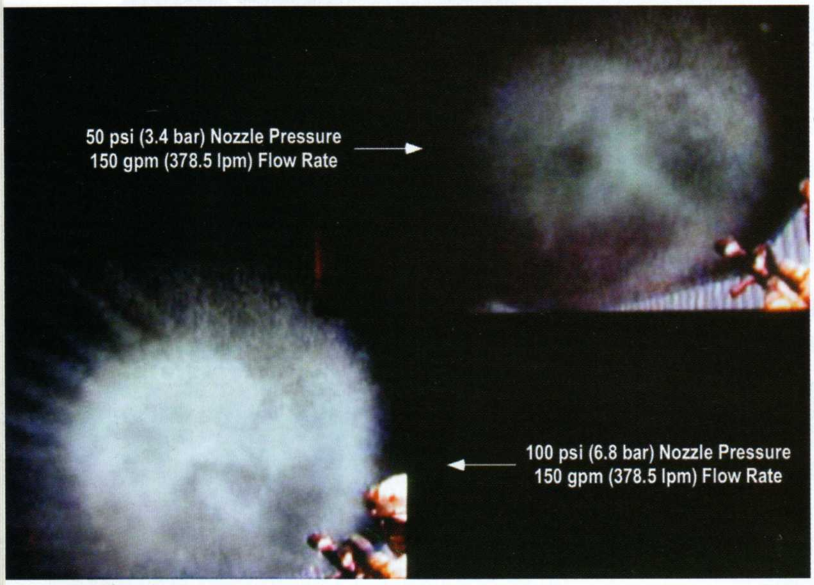
Changing tactics

Paul Grimwood proposes a minimum tactical flow rate to aid firefighters in controlling structural fires

FIRE SERVICE equipment and tactics have changed immensely over the last decade. As a result, there are concerns that rising mains in tall buildings throughout the UK, Europe and parts of Asia are incapable of dealing with serious fires, particularly on the upper floors of open plan high-rise commercial office structures. Research carried out in 1991[1] found that the equipment provided for firefighters to deal with such situations did not complement the fire protection systems installed. And, more recently, research into high-rise firefighting, carried out by the Building Disaster Assessment Group (BDAG) (see *FP&FEJ*, February 2004, p.42), has investigated rising main capability; fire service equipment, hose lines, branches and nozzles; firefighting techniques; and tactical approaches to firefighting in high-rise structures.

Rising main capability

To assess the demands of high-rise commercial fires, one needs to look at past conflagrations. In 1991, research found that it was not only pressure that was a problem in fixed installation rising mains but also flow. The research covered six major high-rise office fires in the USA and the UK, in which flow demands had demonstrated a flow requirement of 0.5 litres/minute of water per m^3 of fire involvement to suppress the fires. In all instances, the fires were extinguished during the decay phase of fire development; that is after the fire had consumed most of the available fuel on the fire floors.



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This is important since it suggests that 100mm, or even 150mm rising mains, may not be sufficient to provide the quantities of water needed to suppress fires in their growth stages of development, unless there are several installations throughout the structure.

This scenario of a high-rise office fire raging out of control, many floors above ground level, became reality in London in 2003. Telstar House is a 13-storey steel-framed concrete office building, with a floor area of 90m x 15m, which was built in the late 1960s. A fire in the building spread across four floors (the 7th to the 10th levels), consuming all the available fuel. It spread through 5,000m^2 of open plan floor space, before being stopped at the 11th level. The rising mains in this situation were incapable of meeting the necessary flow demands to effectively mount an interior fire attack. Control was achieved through a combination of interior and exterior fire streams. This incident raises questions about what would have happened if a similar situation occurred at a higher level. If the fire had involved floors 16 to 20 of a taller building, would the fire service have been able to bring it under control in a safe timeframe?

Of course, in such applications, sprinklers can serve to enhance fire control measures greatly. However, they will not be able to deal with fast spreading fires that may result from terrorist activity. Only systematic operational procedures and adequate firefighting installations will enable firefighters to do their job safely and effectively with the necessary speed. BDAG is right to point out the existing conflicts between rising main outlet pressures, current fire brigade hose lines and nozzles, and modern firefighting tactics. But the flow demands are also of great importance and should not be overlooked.

Fire service equipment

In 1990, the standard firefighting attack hose lines delivered anything from 100 litres/minute (19mm) and 200 to 450 litres/minute (45mm) to 700 litres/minute (70mm), at pump pressures of 3 to 5 bars. Since then, the technology has advanced and modern nozzles are generally set to deliver a predetermined flow at nozzle pressures of 3, 5, 6 or 7 bars. However, in Europe, fire services rarely manage to achieve the higher pressures needed to flow the 6 and 7 bar versions. This is particularly true in the case of a 45mm attack hose line, where friction losses are excessive. In 1991, the author recommended a change to 52mm attack lines, since these were both hydraulically and tactically the optimum size for an interior attack hose line. This will achieve the flows needed by modern nozzles and the manual handling of this size hose line still allows it be advanced easily by crews of two firefighters.

The nozzle research undertaken by BDAG did not take into account the wide range of factory settings that are available from modern nozzles. It is possible to deliver a high flow capability jet, as well as an effective gas-cooling spray pattern, from nozzles that are pre-set to deliver flows at lower nozzle pressures. There are combination (jet/spray) nozzles that can perform effectively at low nozzle pressures of around 3 bars. These have not been subjected to tests or stakeholder reviews as part of the BDAG research.

Firefighting techniques

The techniques and methods used by firefighters to tackle compartment fires have also advanced dramatically over the past decade. A 'compartment' or 'enclosure' fire involves a room, or space, within the confines of a structure. A fire involving two or several rooms/spaces is said to be a 'multi-compartment/enclosure' fire. A fire that has developed beyond the definitions of 'compartmental', once elements of the structure have been breached and become involved in the fire, is said to be 'structural'.

There are two basic types of combustion that the firefighter may face in a compartment/structure fire: a fuel phase, two-dimensional fuel bed or surface fire (m^2)); or a three-dimensional gaseous phase fire (m^3).

There are three methods of fire suppression using water:

- **direct attack:** the traditional approach, used to deal with the majority of fires. It relies on a stream of water to cool the fuel surfaces involved in fire when applied directly onto them
- **indirect attack:** applies water fog onto super-heated surfaces in the fire compartment to create a mass of steam that displaces the oxygen to smother the fire. This approach, based upon the principles of Lloyd Layman and commonly known as the Iowa or Royer/Nelson method, is normally applied from an exterior position. In certain situations, and when applied under strict protocols, this method is extremely effective and may deal with combustion in both the fuel and gaseous phases
- **three-dimensional (3D) offensive water fog:** a method introduced by Swedish firefighters during the early 1980s using controlled nozzle 'pulsing' actions or brief 'bursts' of water fog to counter combustion in the gaseous phase (offensively). This approach may also be used (defensively) to prevent/mitigate the effects of flashovers, backdrafts, or other ignitions of the fire gases. The term 3D refers to the volumetric mechanisms of combustion in the gaseous phase. Associated water applications are normally calculated in cubic dimensions (litres/minute/m^3)

No single method of suppression is able to deal with combustion existing both in the fuel and gaseous phases of fire development, with optimum effects. An 'ideal' attack on a compartment fire may alternate between a 3D offensive application of water fog to tackle the gaseous combustion and a direct straight stream attack to deal with the fuel phase fire. The use of indirect fog attack should also be considered under certain conditions.

Improving flow rates

The author has campaigned for years to improve flow rates in the UK, which were becoming dangerously low as compartment fire behaviour training (CFBT) instructors became highly influenced by fighting hundreds of training fires during the gaseous phase of 'container' burns. This experience in a 'controlled' environment resulted in a team of instructors working with a nozzle manufacturer to produce a nozzle offering flow rates of 40 and 90 litres/minute. Such flows are ideally suited to the restricted amounts of gaseous phase combustion that may be regularly encountered inside CFBT flashover simulators, but are far from capable of dealing with 'real world' compartment fires that are progressing towards and beyond flashover.

This nozzle has set a worrying standard for 19mm initial attack high pressure booster lines and, by 2003, was being used on real structure fires, where reports of difficulties in fire suppression efforts are becoming commonplace.

When Rosander and Giselsson originally reported on the Swedish 3D offensive concepts, they recommended a minimum flow rate of 100 litres/minute for gaseous phase cooling applications in real fires. The author suggests that a vast amount of his own empirical data, recorded during hundreds of training fires when dealing with combustion in the gaseous phase, can also be used to produce a tactical flow rate for attacking compartment fires in 3D terms. This ideal (tactical) rate of flow would be about 8 litres/minute/m^2, based upon compartments with 2.5m ceilings. When scaled up to a 70m^2 compartment, the needed fire flow for dealing with fire in the gaseous phase would be 560 litres/minute. The author's tactical flow rate proposes an ideal baseline flow for interior fire attack, based upon all available research to date. This takes into account 3D water fog applications, as well as direct straight stream applications.

Tactical flow rates and baseline flows

Research conducted by Lund University, Sweden demonstrated that flow rates of 112 litres/minute were unable to control developing compartment fires in a 100m^2 compartment within the six-minute control criteria and that any such control achieved after this time would have been during the decay phase of the fire's progression. The same research demonstrated a flow rate of 226 litres/minute and was able to achieve extinction during the growth phase of the fire's development. Much empirical data from different sources suggests that the vast majority of working structural fires are smaller than 100m^2 and are suppressed with a flow rate below 600 litres/minute. The author's research in 1990 suggested flow rates between 200 and 400 litres/minute were generally successful in suppressing developing compartment fires up to 100m^2 and Stolp suggests 200 litres/minute will suffice.

The author proposes a minimum tactical flow rate of 400 litres/minute/100m^2 of compartmental fire involvement (area x 4) for direct attack, and this includes a margin for error. If the fire has spread to a stage where it involves actual structural members, the baseline flow rate should be increased by at least 50% (600 litres/minute/100m^2). In terms of tackling compartment fires in the gaseous phase, it should be mentioned that, in the author's experience, the strategy of 3D water fog attack is limited to a maximum compartment size of 70m^2.

There have been several international research studies into the ideal minimum base line flow for a primary attack hose line, and these have been fairly consistent in their approval for the 45mm (more recently the 52mm) line, flowing 470 to 560 litres/minute. This research takes into account issues such as optimal flow rate; manoeuvrability and manual handling; nozzle reaction; stowage; and tactical deployment issues. Both the 470 litres/minute (125g/minute) and 560 litres/minute (150g/minute) hose lines are fast becoming established as the ideal attack tools for a primary offensive advancement by two firefighters into most compartment/structural fires where the fire area is contained within 100m^2.

In situations where a defensive mode of attack is necessary, or where any particular fire front is rapidly escalating through, for example, the effects of heavy fire loading, extensive structural fire involvement, or wind gusts, then larger lines and higher flows may be necessary. However, flows of up to 945 litres/minute from a 45mm hose line are generally perfectly manageable by a team of two firefighters in a defensive or offensive 'holding position' (ie the nozzle reaction would be too powerful to advance such a line while flowing), although such flows will require extremely high pressures at the pump for hose runs in excess of 50m, due to increased friction losses ❑

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