Provision of water for fire fighting.

In "FRAME" the existing water supplies are evaluated for their use as fire fighting resource in the water supply factor W and the special protection factor S.

The old Gretener method has no provisions for water supplies, probably because good water supplies are available in a country like Switzerland with its mountains and lakes. In a flat country like Belgium, having adequate supplies for fighting is not evident. Public water supplies are designed for drinking water distribution, with smaller piping and lower pressure from water towers and pumping systems. FRAME evaluates the capacity of these systems by the water supply factor S.

To define the value of W, the water quantity available is compared with the total fire load density and the distribution system is checked for its ability to convey the required quantity of water to the fire scene in a 2 hr period. In the special protection factor S, bonus points are awarded for superior water supplies.

Guidelines for water supplies
To check the validity of the FRAME approach, a review was made of the available information on the Internet. Before all, it was found that there are no internationally accepted rules for defining the water supplies required for adequate fire fighting. The main differences are due to the local fire fighting tactics and the available equipment and to the legal obligations imposed on the local governments, the water supply companies and the owners of buildings.

The following documents have been consulted to check the validity of the FRAME approach:

- SFPE (NZ) TECHNICAL PUBLICATION - TP 2007/1 : COMPARISON OF 11 METHODS FOR DETERMINING WATER USED FOR FIRE FIGHTING.
- Fire Fighting Water: A REVIEW OF FIRE FIGHTING WATER REQUIREMENTS, A New Zealand Perspective by S. Davis see: http://www.civil.canterbury.ac.nz/fire/pdfreports/SDavis.pdf
- The Dutch document : REKEN- / BESLISMODEL BEHEERSBAARHEID BRAND (printed version)
- Dutch rules for “bluswatervoorzieningen”. See: http://www.brandweerkennisnet.nl
- German practice : HST Merkblatt Löschwasserversorgung.

New Zealand technical reports.
In the New-Zealand technical report TP 2007/1, Cliff Barnett examines eleven different methods for determining water supply for fire fighting purposes. The methods were:

1. ISO - Insurance Services Office Method
2. ISU - Iowa State University Method
3. IIT - Illinois Institute of Technology Research Method
4. FEDG - New Zealand Fire Engineering Design Guide Method
The report discusses the various methods and concludes that there are many differences. The primary conclusion is that there are large differences between the results for both flow and storage. Methods 1, 3, 5, 9, and 10 were based on empirical data. Only Methods 2, 4, 6 and possibly 11 were based on fire engineering calculations. Some give water flows, while others give storage requirements. Most consider only suppression, while TP2004/1 makes also an allowance for exposure. The methods give only “affordable” flows for fire cells of a limited size, which indicates that they imply in some way a maximum controllable fire size, equal to one fire cell (room) in office and residential buildings.

The “REVIEW OF FIRE FIGHTING WATER REQUIREMENTS, A New Zealand Perspective” by S. Davis, gives an even larger overview of methods. He proposes an alternative method to calculate the flow needs based on a maximum heat output of the fire. His method as well as the more traditional tables have been combined in the New Zealand Publicly Available Specification SNZ PAS 4509:2003 “New Zealand Fire Service Fire Fighting Water Supplies Code of Practice”.

The tables in PAS 4509 give, for seven classes of occupancy, flows from 12.5 to 100 l/sec and storage volumes from 11 to 2160 m³. These volumes are obtained for durations from 30 minutes to 3 hours. The 8th class requires a calculation based on the maximum heat output of the fire, with a correction for human intervention and fire safety features like automatic detection and sprinklers. An extra flow for exposure protection is required. The flow is only 1/10th for sprinklered buildings, but in that case the sprinklers should have their own water supply.

UK Guidance document.
In the UK, the 2nd edition of the “National guidance document on the provision of water for fire fighting” has been issued in May 2002. This second edition of the National document has been produced jointly by representatives of the Water Industry, the Fire Service with the encouragement of the Department for Environment, Food and Rural Affairs, The Welsh Assembly Government and the Department for Transport, Local Government and the Regions.

The document contains a “risk assessment methodology” approach to define the requirements for fire fighting water supplies. Appendix 5 of the document gives various flow requirements from 8 l/sec (28.8 m³/h) for detached housing up to 75 l/sec (270 m³/h) for large industrial estates, while appendix 4 gives several points to be considered when defining the required capacity.

The guideline links the flow requirement to the type of occupancy and the size of the risk to be protected. The occupancy link can be seen as defined by the fire load density and the increased flow requirement can be explained as an added flow for exposure to a minimum flow for suppression.

The Dutch approach.
The Dutch rules for fire water supplies are somehow different. They foresee primary, secondary and tertiary water supplies. The primary water supply, which is usually the drinking water system, should be capable of supplying 30 m$^3$/h in residential areas and 60 m$^3$/h for non-residential risks. The secondary water supply should be capable of supplying 90 m$^3$/h during 4 hours, available within 15 minutes after the arrival of the fire brigade and at a distance less than 320 m from the fire scene. The tertiary water supply shall be at a distance of less than 1000 m (or 2500 m) and have a capacity of 240 m$^3$/h for an unlimited time. It is clear that the Dutch system relies on the availability of open water in that country, taking into account that the potable water system is only capable of supplying water for the use by one or two fire trucks.

For industrial occupancies, the booklet "REKEN- / BESLISMODEL BEHEERSBAARHEID BRAND" defines the required flow for extinguishment by a formula \( Q = 450 . F . R . \) using the heat release of a fire linked to the fire load density and a second formula that defines the flow required for cooling exposed building facades.

The flow for extinguishment is in l/min, 450 is a conversion factor that corresponds with a heat release of 19 MJ per kg wood, F is an efficiency factor (between 0.15 and 0.6) and R is the "heat" release rate in kg burnt wood per second. With the fire load density (L) is expressed in kg wood per m$^2$, the heat release rate is maximum \( L / 2400 \) kg/sec. The flow for cooling is estimated to be about 2 l/m$^2$ of area to be cooled (depending on the distance between buildings).

The French "Guide pratique".
The French document gives flow requirements from 60 m$^3$/h for small residential buildings up to 240 m$^3$/h for very large office buildings. For other types of building there a calculation guidelines considering three hazard classes for the occupancy, the compartment size (floor area), the storage height, the structural fire resistance, the presence of sprinklers (50 %) and the first intervention organisation. The basic requirement is 60 m$^3$/h per 1000 m$^2$ floor area up to 3000 m$^2$, and above that an additional 30 m$^3$/h per 1000 m$^2$. The water supply must be capable of delivering this flow for 2 hours. In a way, the French documents combines also flow for extinguishment with a flow for cooling. Their hazard classification is like for the UK document an indirect link to the fire load density.

The German way.
In Germany, the local government has a duty to provide adequate water supplies to fight "standard" fires. The quantities and flows are defined in Arbeitsblatt W 405, a document issued by the DVGW, the German water- and gasworks association. The flows vary between 96 m$^3$/h and 192 m$^3$/h and are clearly meant to provide adequate water supply for standard fire fighting operations. The Muster-Industriebaurichtlinie gives similar flows for 1 hr to 2 hr durations for fire fighting operations in industrial premises. For industrial risks, the German insurers have issued Merkblatt 2034 "Bewertung nichtöffenlicher Feuerwehren. In this document a link is made to the size of the private fire brigade and the water supplies they are supposed to use. The combination of both is linked to a rebate system for insurance premiums.

Comparison.
Comparing the requirements formulated in these various documents, they converge toward a 60 m$^3$/h flow to suppress a 25 MW fire. This corresponds with a 100 m$^2$ fire with a 250 kW/m$^2$ heat release typical for office occupancies. For occupancies where more severe fires can be expected the flows are increased and an additional flow is required to protect
adjacent fire cells or building from exposure and the storage volume is linked to an estimated duration between 30 minutes and 3 hours.

**FRAME - approach**

FRAME uses a basic relationship between the fire load density and the required quantity of water for fire fighting, i.e. The quantity in $m^3$ is $1/4$th of the fire load density in $MJ/m^2$. This approach is based on a 260 $m^2$ maximum fire area and 40% efficiency for the heat absorption by the extinguishing water. The rules add an additional flow for exposure protection, linked to the size of the compartment, which FRAME does not. It would be possible in FRAME too, by using the length and width of the compartment in addition to the fire load density. This can give only minor differences in the final property risk assessment, as the weight of the water storage capacity in the calculation varies between 1 and 0.81.

As the rules define flows, they automatically imply requirements for the distribution network. In FRAME the distribution network is evaluated for its capacity to convey the required quantity of water on the fire scene in less than 2 hours, which is comparable with the duration requirements in most of the mentioned rules. The rules are less explicit in their pressure requirements. Partially this is because the fire brigade overcomes most pressure problems with their pumpers, but also because the water companies prefer not to guarantee a minimum pressure on their network. In FRAME the available static pressure is compared with the height of the building to evaluate its effectiveness for fire fighting. The rules also specify that the nearest hydrant must be at a short distance from the building, and give specifications for the type and number of hydrants to be installed. In FRAME the availability of hydrants is judged in comparison with the perimeter of the compartment: the larger the compartment, the more hydrants are needed, as indicated in the rules.

**Summary.**
The water supply factor $S$ of FRAME considers basically the same aspects of the water provisions as most official rules and guidelines. The basic difference between FRAME and most of the mentioned methods is that the FRAME estimate is based on a larger fire area. This compensates in a way the lack of a flow requirement for exposure protection, linked to the compartment area. FRAME does not lower the water supply requirements when the fire safety features are improved as in the above mentioned methods, which is a conservative approach, and justified because these safety features are evaluated separately.

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