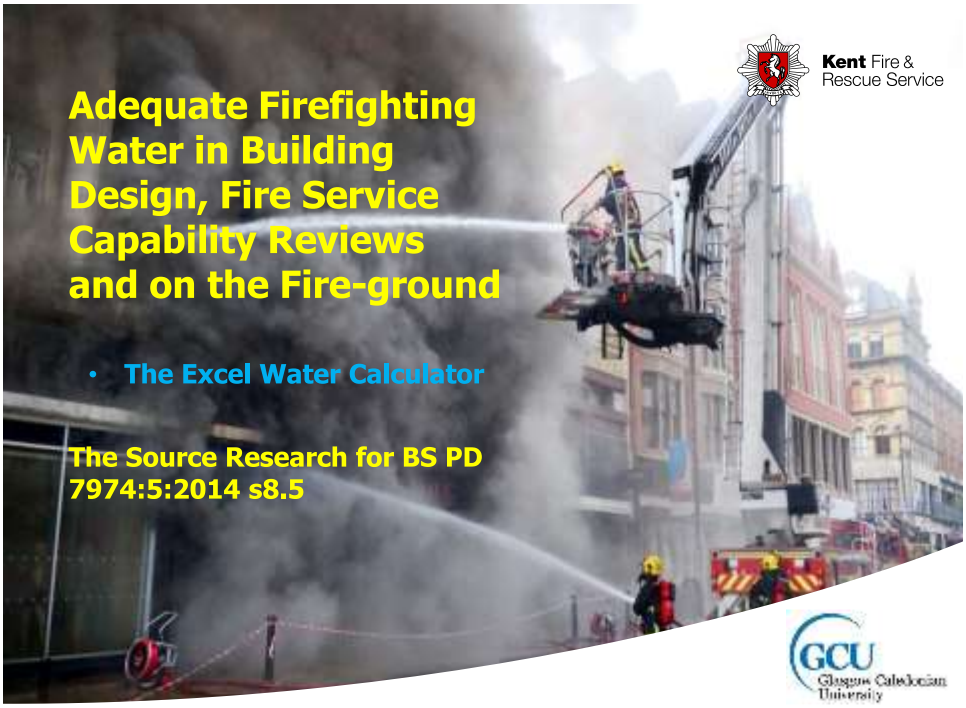
Kent Fire & Rescue Service

Adequate Firefighting Water in Building Design, Fire Service Capability Reviews and on the Fire-ground

- The Excel Water Calculator

The Source Research for BS PD 7974:5:2014 s8.5



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- **How capable are your buildings?**
  - *Compartment size
  - *Fire Resistance
  - *Sprinklers
  - *Stand-pipe rising mains
  - *Storage water
  - *Design fires
- **How capable is your response?**
  - *Staffing & resources
  - *Tactics
- **How capable is your equipment?**
  - *Transport & delivery of water
  - *Flow gradient (200-500-700-1500->2000)
- **How capable is your water plan?**
  - *Hydrant grid
  - *Alternative water supplies
  - *Matched against fire load?

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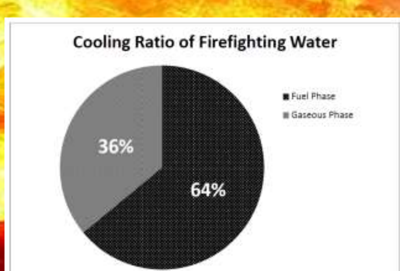
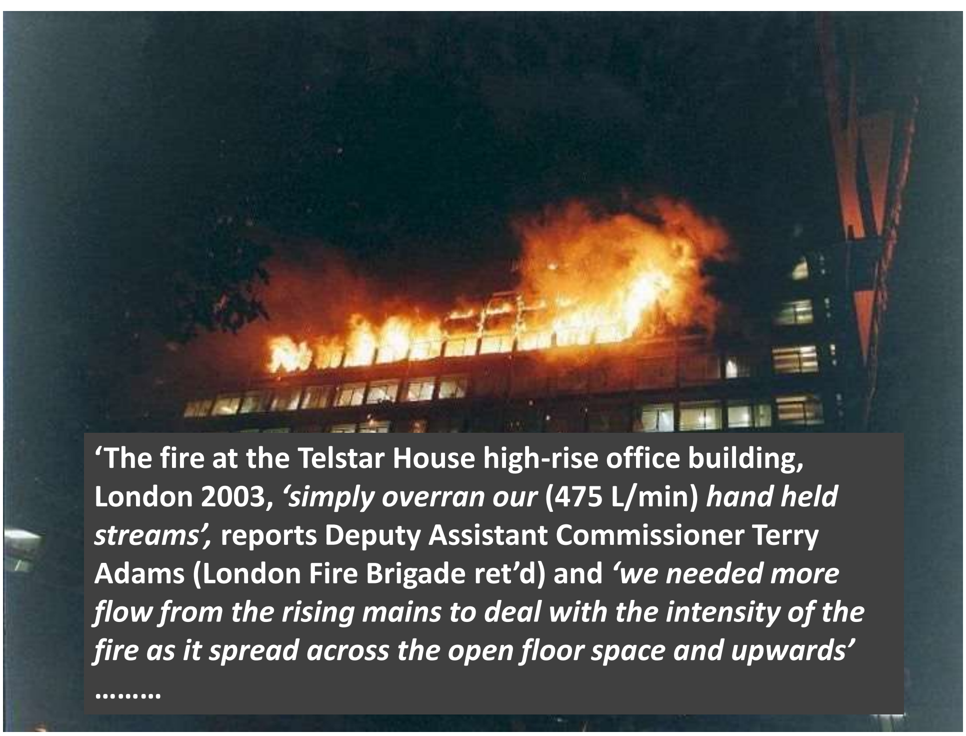
Adequate Water (volume) versus 'velocity and drop size'

- **Stream velocity**
- **Droplet size**
- **Cone volume (Litres/m³)**
- **Application method**
- **Operator skill**




'The fire at the Telstar House high-rise office building, London 2003, *'simply overran our* (475 L/min) *hand held streams',* reports Deputy Assistant Commissioner Terry Adams (London Fire Brigade ret'd) and *'we needed more flow from the rising mains to deal with the intensity of the fire as it spread across the open floor space and upwards'*
………

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'Adequate' Firefighting Water

The definition of 'adequate water' would be the optimum quantity that extinguishes the fire with least punishment to firefighters, least amount of water damage and to the point that building fire damage is seen to reduce.

You could use a very high flow and the fire may be suppressed faster but in some cases not. You could use a low flow but firefighters may suffer longer exposure to heat. Or you could attempt to locate the optimum amount.

Variables that will affect the application volumes and flow-rate will be fire load distribution and density, window or opening sizes, compartment size as well as construction factors. As always there are practical aspects, such as having good access and protection to be able to reach the fire effectively, that also have an impact.

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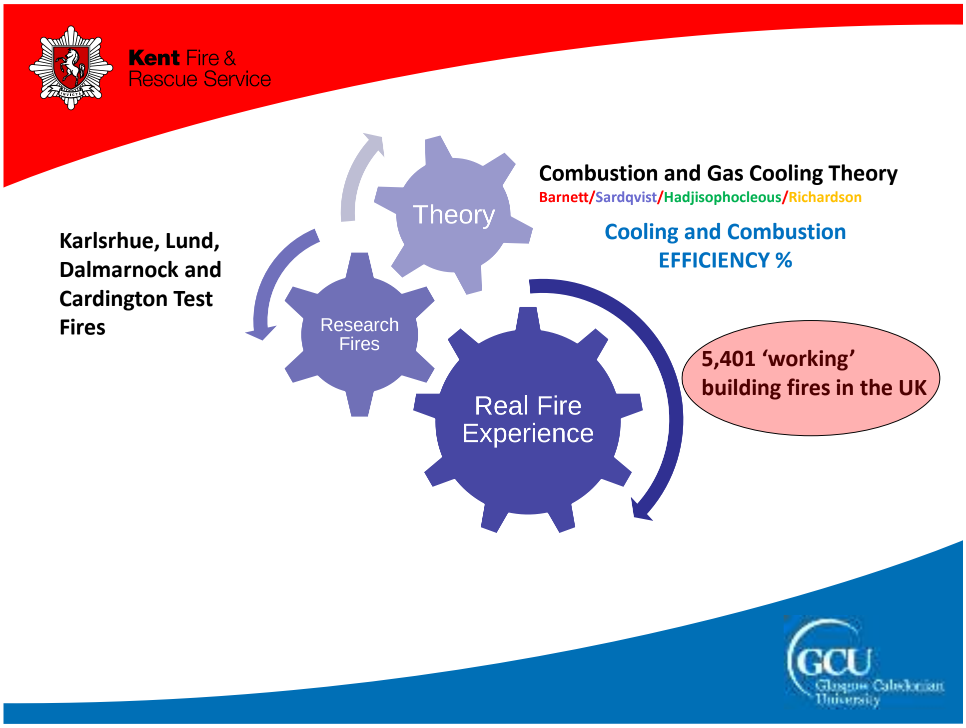
Kent Fire & Rescue Service
Theory
Research Fires
Real Fire Experience
Combustion and Gas Cooling Theory
Barnett/Sardqvist/Hadjisophocleous/Richardson
Cooling and Combustion EFFICIENCY %
Karlsrhue, Lund, Dalmarnock and Cardington Test Fires
5,401 'working' building fires in the UK
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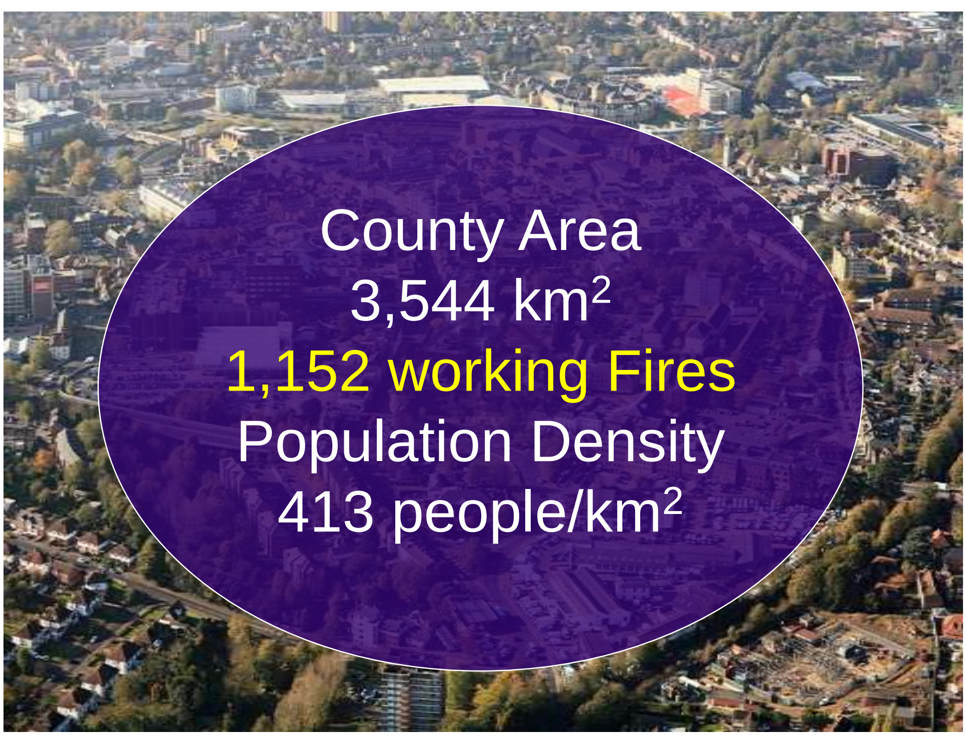
County Area
3,544 km2
1,152 working Fires
Population Density
413 people/km2

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County FRS	Metro FRS
100 L/min	100 L/min
350 L/min	500 L/min
1800 L/min	1800 L/min

- 5,401 building fires 2009-2012
- All fires were active ‘working’ fires
- Fire involvement of 1 to 500m^2
- Flow-rate densities between 5 – 47 L/min/m^2
- >600 (6.5%) fires were >50m^2

- 69 Large fires (1.3%) >500m^2
- Flow densities between 0.4 – 47 L/min/m^2
- Overall Flows between 100 and 6000 L/min

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COUNTY	Group	Incidents	m²	L/min	L/min/m²	L/min/INCIDENT	Average Fire Size m²	ROOM %	FLOOR %	MULTI FLOOR %	H/REELS %	TANK %	AUG %
	Dwellings	319	14112	165990	11.84	520.69	16.82	81.79	16.69	31.57	92.07	-	-
	RES INST	16	882	7000	8.14	438.15	36.7	78.60	8.10	40.63	84.2	-	-
	RES OTHER	33	2288	11200	8.92	332	28.3	38.56	20.8	41.86	81.0	-	-
	ASSEMBLY	72	2626	34700	11.94	498.61	30.88	28.32	18.66	32.88	83.55	-	-
	OFFICES	23	348	6800	15.54	295.65	15.13	68.07	4.35	34.78	61.39	-	-
	SHOPS	107	2447	42950	17.55	401.4	22.86	56.07	17.76	26.17	77.32	-	-
	INDUSTRIAL	25	2194	11850	9.58	601.43	92.68	34.28	8.57	17.34	58.28	-	-
	STORAGE	9	841	3080	6.3	388.8	93.44	11.1	21.2	66.67	89	-	-
	TOTALS	1152	24488	319700	12.06	391.74	26.78	26.46	14.15	31.23	72.98	86.31	13.16

METRO	Group	Incidents	m²	L/min	L/min/m²	L/min/INCIDENT	Average Fire Size m²	ROOM %	FLOOR %	MULTI FLOOR %	H/REELS %	TANK %	AUG %
	Dwellings	3999	68320	960813	13.16	190.34	15.72	87.68	15.75	16.57	84.82	-	-
	RES INST	17	167	3500	18.71	129.62	9.83	74.07	18.52	7.41	92.08	-	-
	RES OTHER	72	907	17800	18.74	138.1	12.59	54.17	11.11	34.72	87.63	-	-
	ASSEMBLY	308	5776	70800	12.22	235.18	18.34	84.67	17.18	20	89.67	-	-
	OFFICES	96	2622	20900	7.96	418.06	38.77	58.59	50.00	33.83	28.78	-	-
	SHOPS	459	13808	181000	18.18	418.33	30.17	84.06	27.35	37.87	84.08	-	-
	INDUSTRIAL	238	14098	141300	9.01	498.27	55.00	48.53	26.39	27.66	59.59	-	-
	STORAGE	98	8534	64080	9.71	674	87.27	42.08	31.93	25.51	45.9	-	-
	TOTALS	5269	80829	1023419	12.38	421.23	38.33	58.14	19.84	23.97	86.46	87.05	12.95

Key:

Group – Purpose Groups according to the UK building regulations
m² - area of fire damaged floor space in square metres
L/min – Litres/minute flow-rate as deployed to achieve control/suppression
Room – percentage of 'working' building fires confined to room of origin
Floor - percentage of 'working' building fires confined to floor of origin
Multi floor - percentage of 'working' building fires spread beyond floor of origin
H/reels – percentage of fires dealt with using 19mm x 19mm rubber tubing first strike fire-fighting hose @ 100 LPM
Tank – percentage of fires suppressed using just the 1800 litres water carried on fire engine to scene of fire
AUG – percentage of fires requiring additional water beyond that carried to scene, augmented from hydrants or other source

Note: [illegible]

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Inadequate firefighting water may lead to an increase in building fire damage

It was noted in the research that the primary flow rates differed between the two fire services (County and Metro) and this was apparent in the amount of building damage suffered.

Metro fire service main jets flowed 150 L/min more than County and they were able to contain fires to the compartment of origin more frequently.

The lower flow-rates further lead to an increase in on-scene staffing and additional resources as required.

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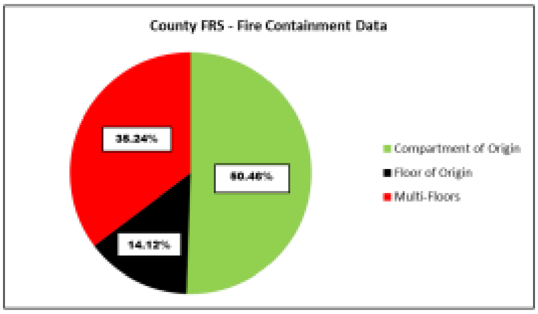
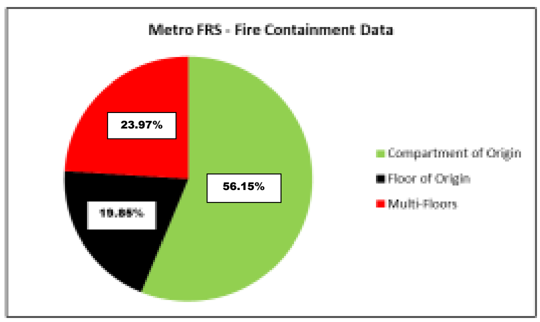


Building Fire Damage as a result of low flow-rate?



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The Design Process

From the research of 5,401 'working' building fires in the UK, the trend line data produced a series of equations that can be used for building design and fire service intervention capability review.

The data showed that less water was used (needed) in residential dwelling fires but far more water was required in industrial (IND) and storage (STO) fires. Office, retail and other occupancies fell between these two trend lines. The midline was validated using work by Stefan Sardqvist (Sweden).

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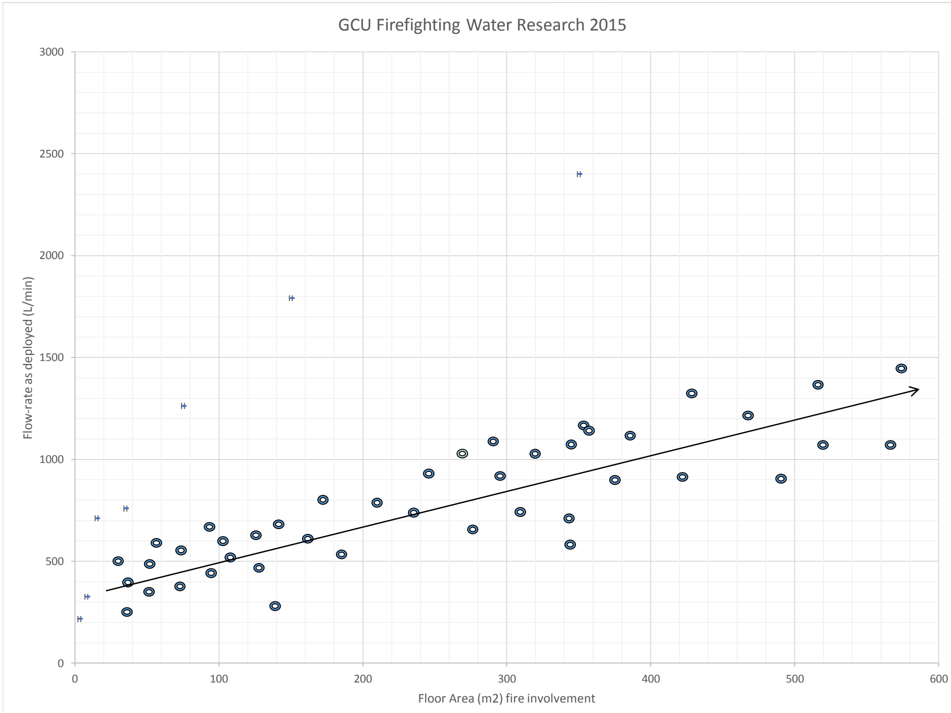
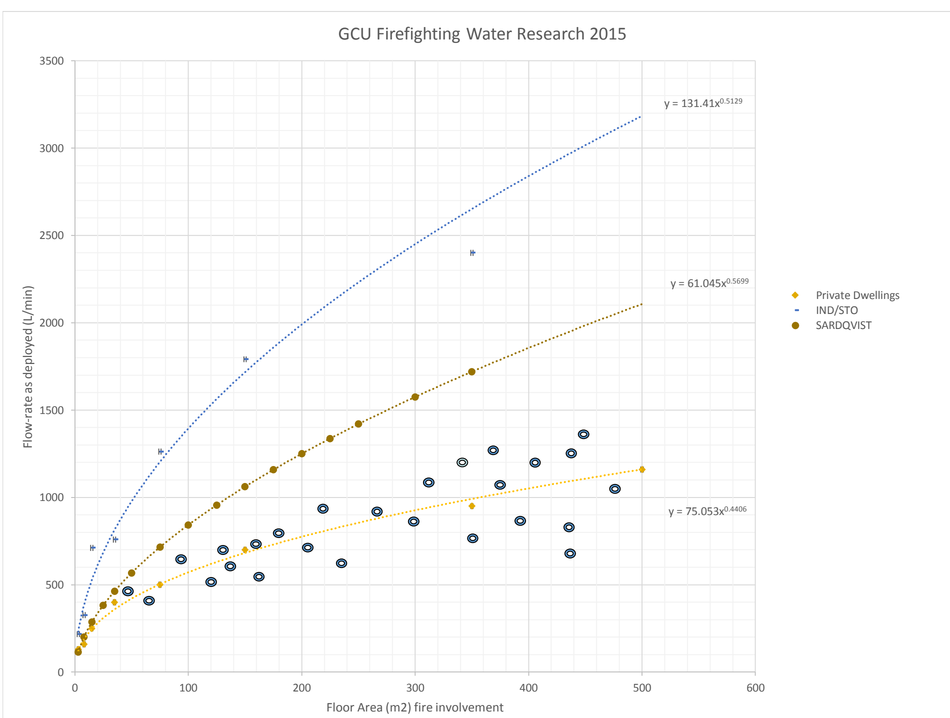
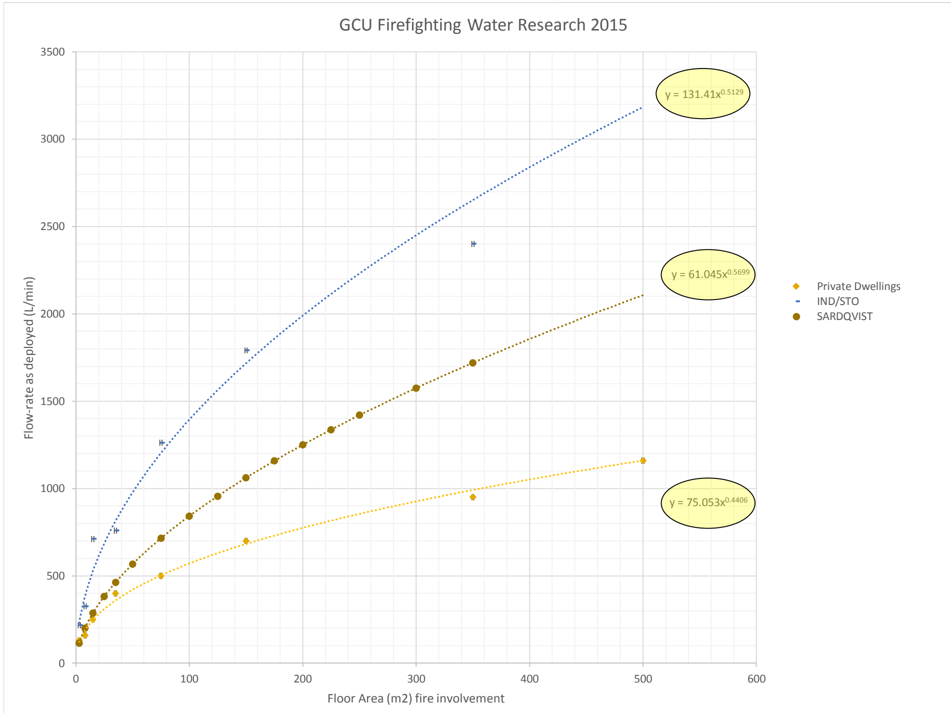

GCU Firefighting Water Research 2015
Flow-rate as deployed (L/min)
Floor Area (m2) fire involvement
0
500
1000
1500
2000
2500
3000
0
100
200
300
400
500
600


GCU Firefighting Water Research 2015
Flow-rate as deployed (L/min)
Floor Area (m2) fire involvement
y = 131.41x^0.5129
y = 61.045x^0.5699
y = 75.053x^0.4406
Private Dwellings
IND/STO
SARDQVIST


GCU Firefighting Water Research 2015
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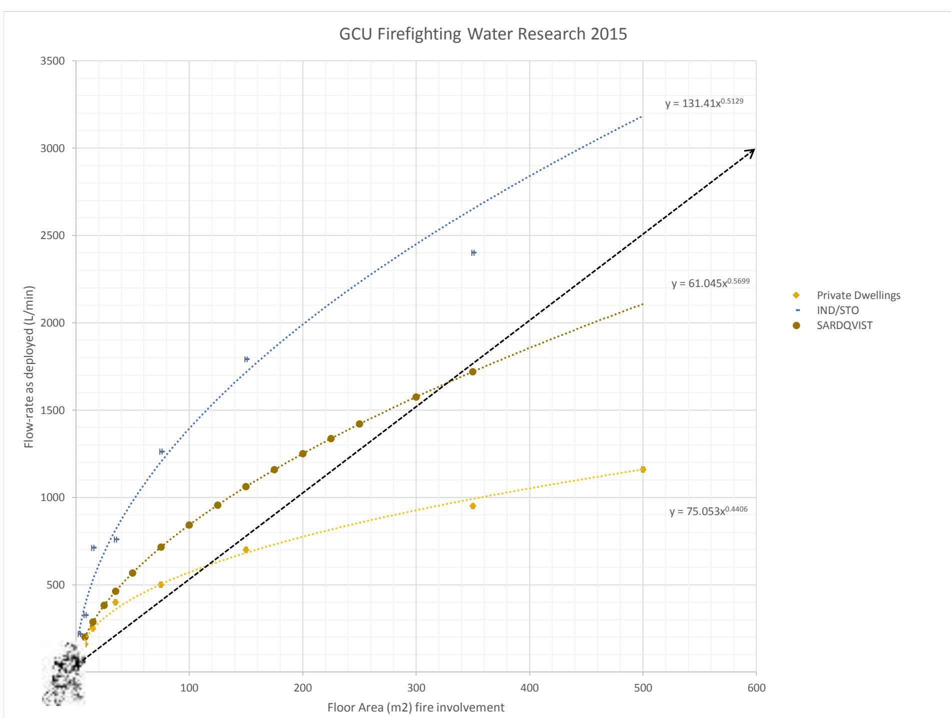
Private Dwellings
IND/STO
SARDQVIST
Flow-rate as deployed (L/min)
Floor Area (m2) fire involvement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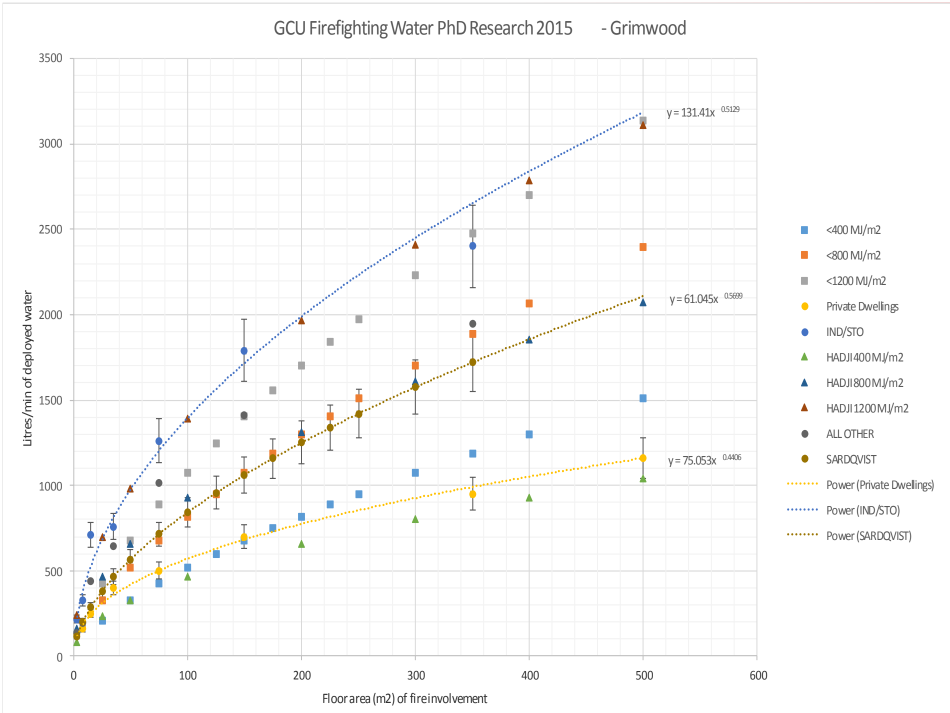
Private Dwellings
IND/STO
SARDQVIST
Flow-rate as deployed (L/min)
Floor Area (m2) fire involvement



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Flow demands in fires <500m²

The building groups listed are as follows:

- **Dwellings** (private houses, apartments and flats)
- **Residential (institutional)** (Hospitals; Homes; schools; prisons)
- **Residential (other)** (Hotels; colleges; hostels; halls of residence)
- **Assembly & Recreation** (Public entertainment; conference; museums, churches; law courts; health centres; day centres; clinics; passenger terminals)
- **Offices**
- **Shop & Commercial** (retail)
- **Industrial** (Factories)
- **Storage and other non-residential** (Storage warehouses and car parks)

L/min/m²

16 to 5

SARD

15 to 9

30 to 5

47 to 7

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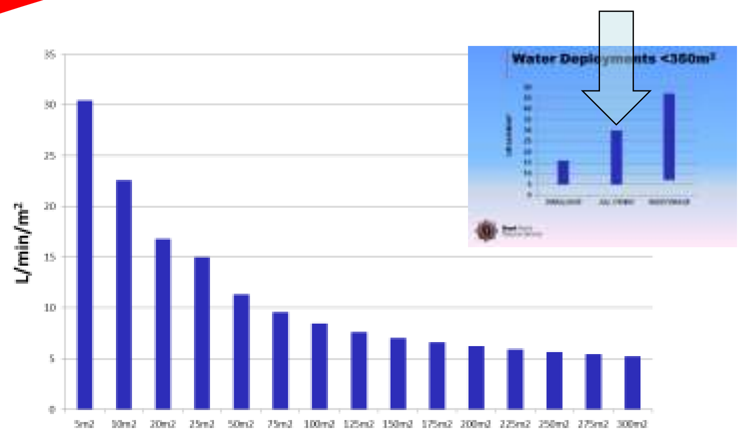
Typical Flow-rate Analysis



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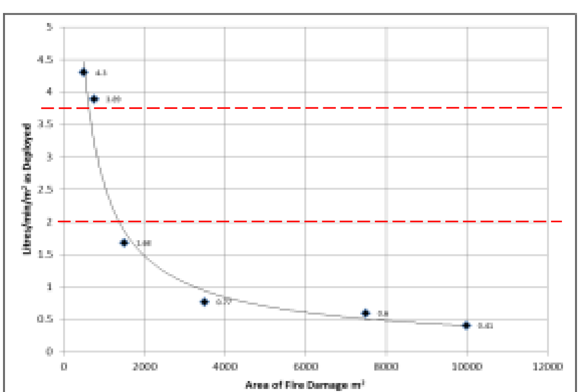
Fires involving >500m of Floor Space

(Travelling Fires)

$641 * A_{fire}(m^2)^{-0.8} = L/min/m^2$



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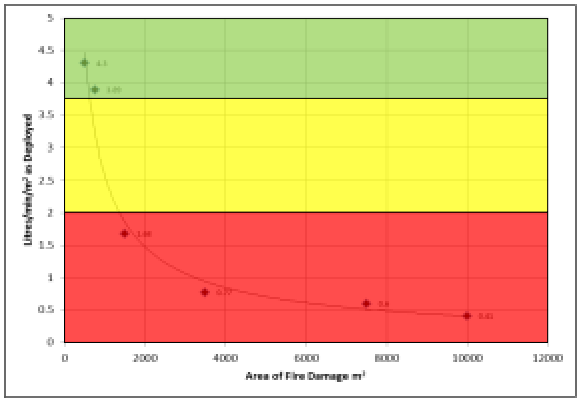
Fires involving >500m of Floor Space
(Travelling Fires)

$641 * A_{fire}(m^2)^{-0.8} = L/min/m^2$



> **Optimum (Tactical) Flow-rate**

Minimal **Flow-rate**

Critical Flow-rate

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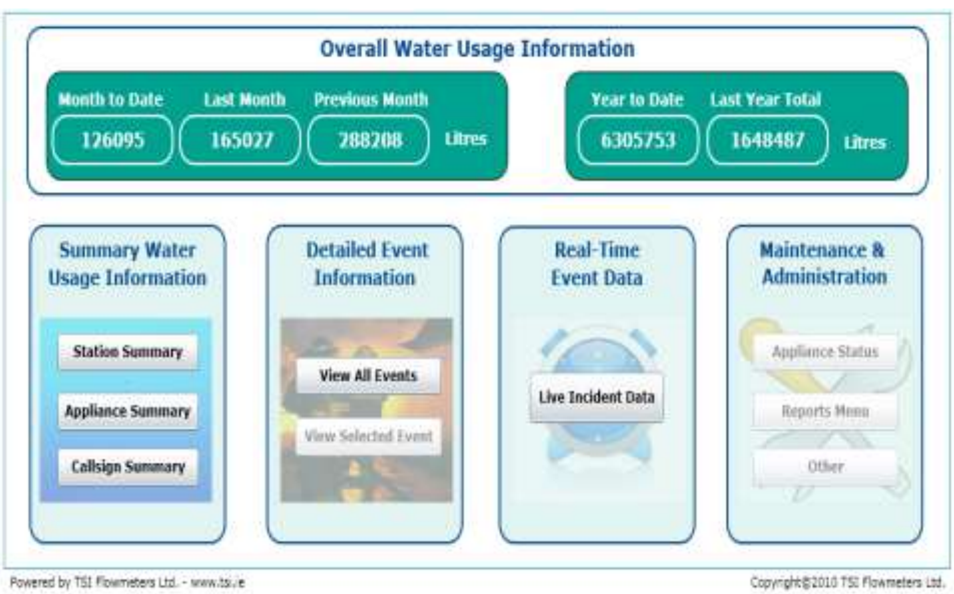

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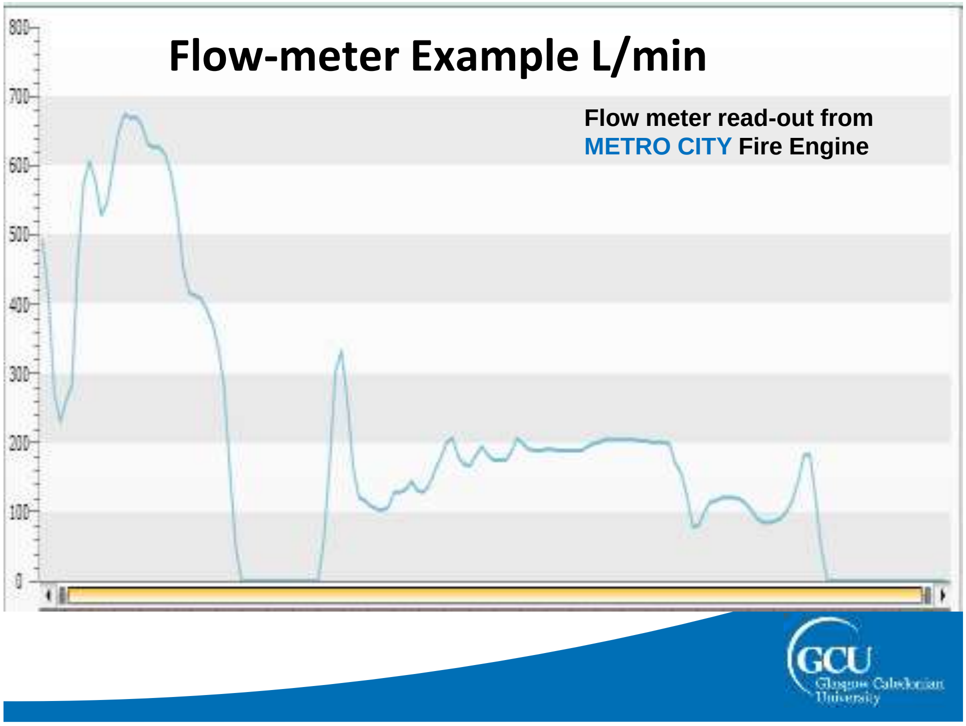

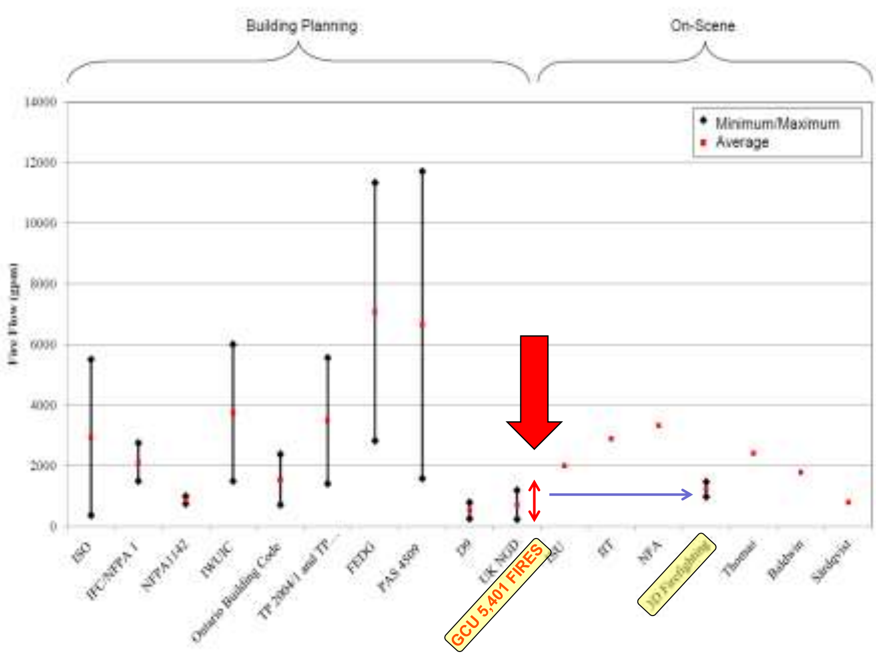

Figure 1 – Maximum and minimum fire flow calculations for a non-sprinklered 10,000 ft² non-residential building.

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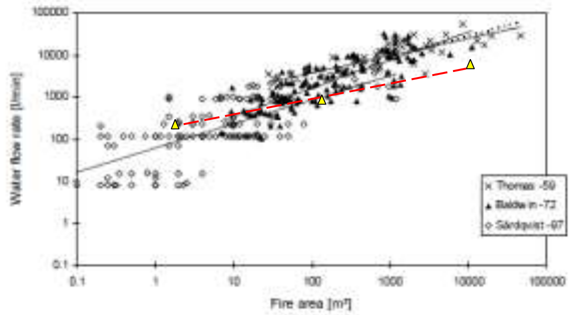
FIRE BRIGADE STUDIES

Statistical studies from fire fighting operations show, although the spread in the material is large, a correlation of roughly $Q = k\ A^{0.5}$ between the water flow rate, Q (l/min) used by the fire brigades and the horizontal fire area, A (m^2), where k is a constant. Three studies are available on the fire brigade use of water, at building fires. They are presented in figure 1.



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BS PD 7974:5:2014 s8.5 Calculator

The requirements for adequate firefighting water provisions to protect buildings can be determined either by codes, standards or by using a bespoke performance based fire engineered strategy.

In this case, s8.5 of BS PD 7974:5:2014 has been used to provide a basis for calculation. This work was based on 5,401 active building fires occurring in two fire authority areas the UK over three years, extinguished using water by firefighters wearing breathing apparatus.

Other data has been incorporated into the calculator from this research to validate and generate a useable tool, enabling fire design engineers, architects and building developers to make potential savings but at the same time, create a safer building.

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BS PD 7974:5:2014 s8.5 Calculator

Firefighting water by design for individual buildings.

Fire Service intervention capability (firefighting water deployments)

On-scene firefighter's 'rule of thumb' guide

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The inputs required are the size of the largest fire-resisting compartment in the building (m^2); the height of the storage (in the majority of buildings this will be taken as 1 metre unless storage height is relevant).

Then select the design methodology (by fire load or floor area). In using floor area you can also utilise the travelling fire calculation for compartments in excess of $500m^2$.

If sprinklers are installed a reduction factor can be applied according to the AHJ's approval.

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The building purpose groups listed are as follows:

- **Dwellings** (private houses, apartments and flats)
- **Residential (institutional)** (Hospitals; Homes; schools; prisons)
- **Residential (other)** (Hotels; colleges; hostels; halls of residence)
- **Assembly & Recreation** (Public entertainment; conference; museums, churches; law courts; health centres; day centres; clinics; passenger terminals)
- **Offices**
- **Shop & Commercial** (retail)
- **Industrial** (Factories)
- **Storage and other non-residential** (Storage warehouses and car parks)

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This section is for the fire service to estimate their capability of dealing with a compartment fire at any point on a timeline, once it has entered a growth phase of fire development.

The t^2 curves are used (fuel controlled fire) for reasonable worst case estimates. Ventilation controlled fire growth may be determined using alternative methods and compared with these outputs.

Enter the time from 'first call' that the fire service estimate water could be applied to a fire. In some cases there will be a 'preparation to deploy' time following the time of arrival.

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The GCU/KFRS research formed National Operational Guidance (2014) for the FRS in relation to firefighting water estimations (rule of thumb).

The on-scene firefighting 'rule of thumb' is a tactical tool for guidance only and cannot be considered as entirely accurate in every fire situation.

The on-scene firefighting 'rule of thumb' estimates are exactly that, based on simple calculations that can be used by firefighters at fire scenes to estimate the quantity of water needed to control or extinguish a fire.

For Industrial building fires **'Area x 10'** can be used. For all other building fires **'Area x 5 can** be applied.

So if 20% of a 1,000m^2 open plan office floor is involved in fire at the time of deployment (water being applied from the interior, or effectively from the exterior) – **200m^2 x 5 = 1,000 L/min**

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The GCU/KFRS research formed National Operational Guidance (2014) for the FRS in relation to firefighting water estimations (rule of thumb).

The on-scene firefighting 'rule of thumb' is a tactical tool for guidance only and cannot be considered as entirely accurate in every fire situation. **(Note the following slide for optimum use) Beyond 500 m2 for Area x 5; and 200m2 for Area x 10 fires the flow estimate becomes less appropriate.**

If it was 20% of a 1,000m^2 warehouse involved in fire at the time of deployment (water being applied from the interior, or effectively from the exterior) – **200m^2 x 10 = 2,000 L/min** is needed as minimum.

Applying water onto a fire effectively requires good access to the burning materials (fire base); optimum hose-line placement according to the direction of the fire's 'flow-path'; and adequate water in meeting the heat release rate.

The capability section can be used to see how flow-rate is affected by more rapid fire spread.

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3 MW


5 MW


15 MW


20 MW

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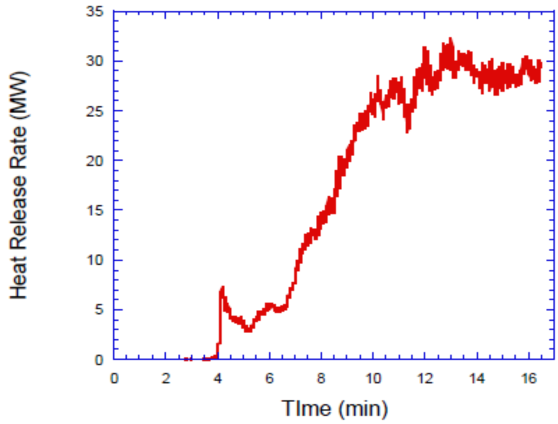

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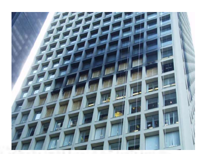

FIRE ENGINEERING GUIDE TO ADEQUATE FIREFIGHTING WATER

(150mm rising mains in commercial buildings and 100mm in residential provide the best design solutions but no single rising fire main as a standalone should flow less than 1,000 L/min)

Size of largest compartment (m²)	244	
Height of storage (default 1 metre)	1 metre	
Design calculation by:	Occupancy and Floor Area (m2)	Firefighting Water Requirement (L/min): 1,400
Occupancy calculation by Floor Area (m²)	Offices	
Reduction in firefighting water for sprinklers		

FIRE SERVICE INTERVENTION CAPABILITY

Fire Growth (t²)	Fast	
Fire Service water applied to fire from time of call (seconds)	1,200	Size of fire at Fire Service primary attack (MW): 67.54
		Water flow required at Fire Service Primary attack (L/min): 1,550

ON-SCENE FIREFIGHTING "RULE OF THUMB" ESTIMATE

Estimated size of Fire (m²)	250	
Building type (purpose group)	All other buildings	Water flow required (L/min): 1,250

BS PD 7974/5/2014 Section 8.5

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FIRE ENGINEERING GUIDE TO ADEQUATE FIREFIGHTING WATER

(150mm rising mains in commercial buildings and 100mm in residential provide the best design solutions but no single rising fire main as a standalone should flow less than 1,000 L/min)

Size of largest compartment (m^2)	244
Height of storage (default 1 metre)	1 metre
Design calculation by:	Fire Load Density
Fire Load Density value (MJ/m^2)	570
Reduction in firefighting water for sprinklers	

Firefighting Water Requirement (L/min): 1,184

FIRE SERVICE INTERVENTION CAPABILITY

Fire Growth (t^2)	Fast
Fire Service water applied to fire from time of call (seconds)	1,200

Size of fire at Fire Service primary attack (MW): 67.54

Water flow required at Fire Service Primary attack (L/min): 1,590

ON-SCENE FIREFIGHTING "RULE OF THUMB" ESTIMATE

Estimated size of Fire (m^2)	250
Building type (purpose group)	All other buildings

Water flow required (L/min): 1,250

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Interstate Bank Office Tower Fire 1988

The fire at the Interstate Bank office tower in Los Angeles 1988 spread through five floors before being brought under control four hours later. The fire started in an office area on floor 12 of the 62 storey office tower at 2225 hours. An automatic sprinkler system, although installed, had been shut down awaiting works. The office space surrounding the core measured 188 metres with a 7.5 metres span, totalling 1,410 square metres.

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Interstate Bank Office Tower Fire 1988

At the Interstate Bank, Los Angeles firefighters were unable to deploy adequate water until 34 minutes into the fire due to a delay in calling the fire department and ineffective fire pump settings serving the wet rising fire mains (standpipes). At this point two thirds of the 12th floor was fully involved in fire although on a zonal basis, part of the floor space would be in decay. Even so, as the firefighters reached the 12th level at 21 minutes into the fires 'fast' growth rate, any attempt at intervention would have been unlikely to succeed as the fire had already spread to a quarter of the floor plate with an estimated heat release of 86 MW.

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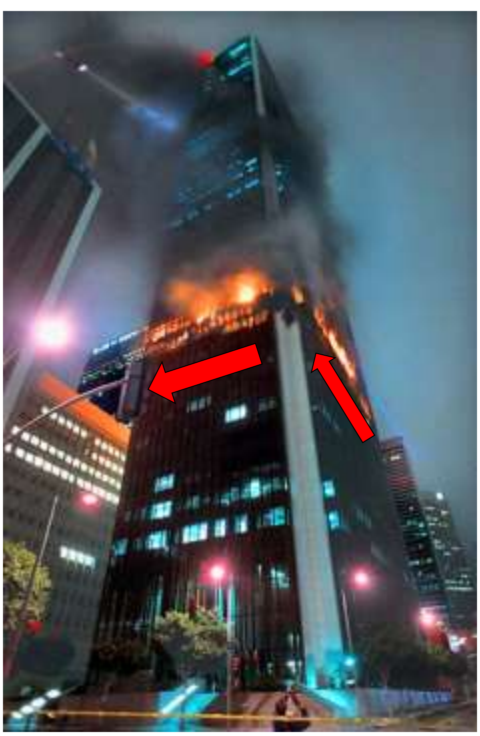

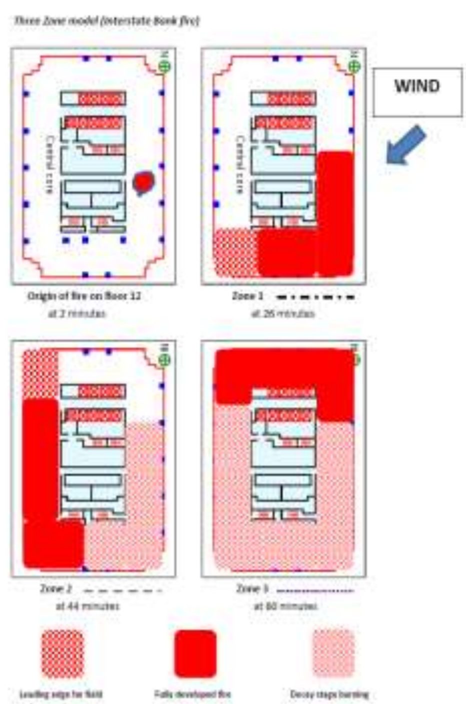

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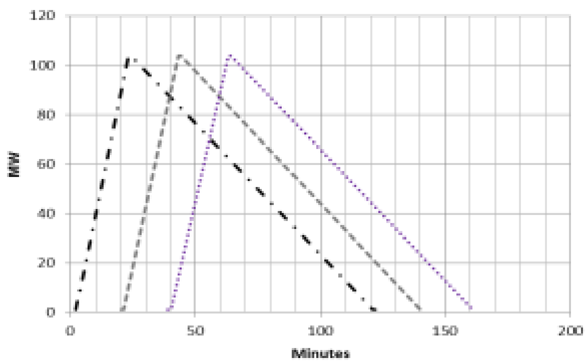
Interstate 3-Zone Travelling Fire



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FIRE ENGINEERING GUIDE TO ADEQUATE FIREFIGHTING WATER

(150mm rising mains in commercial buildings and 100mm in residential provide the best design solutions but no single rising fire main as a standalone should flow less than 1,000 L/min)

Size of largest compartment (m^2)	1,410	
Height of storage (default 1 metre)	1 metre	
Design calculation by:	Occupancy and Floor Area (m2)	Firefighting Water Requirement (L/min): 3,885
Occupancy calculation by Floor Area (m^2)	Offices	
Travelling fire (<4 m ceiling) (>500 m^2)	No	
Reduction in firefighting water for sprinklers		

FIRE SERVICE INTERVENTION CAPABILITY

Fire Growth (t^2)	Fast	
Fire Service water applied to fire from time of call (seconds)	840	Size of fire at Fire Service primary attack (MW): 33.09
		Water flow required at Fire Service Primary attack (L/min): 764

ON-SCENE FIREFIGHTING "RULE OF THUMB" ESTIMATE

Estimated size of Fire (m^2)	150	
Building type (purpose group)	All other buildings	Water flow required (L/min): 750

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Travelling Fire Spread Rates m^2/min

High-rise office Building Fire	Initial fire floor area (m^2)	Fire Spread (m^2/min)	t-squared fire growth rate
Interstate Bank, Los Angeles 1988	1,400 m^2 Open-plan offices	22.2	Fast
CCAB Building Chicago 2003	240 m^2 Open-plan offices	20.0	Fast
Windsor Tower Madrid 2005	900 m^2 Cellular offices	7-15	Medium

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Sprinkler Controlled Fire

Several options open to compensating for sprinkler controlled fire.

PD 7974-5 offers no recommendations here.

Global code reductions range from 20 - 50 percent.

NFPA 14 reduces water requirement in rising fire mains by 20 percent for sprinklered buildings.

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The applied reduction in estimated firefighting flow-rate that qualifies where sprinklers are installed is very subjective and is for AHJ approval.

The scoring method (right) can be used for guidance as an effective way of achieving a safer overall design.

BS PD 7974-5 Firefighting Water Calculator (s8.5)

Guidance: When considering the percentage of sprinkler reduction most suited to the risk, the AHJ should take into account the following issues and a total of:

- 11-12 pts should achieve 40%;
- 7 - 10pts achieving 30%;
- 1 – 6 achieving 20% reductions in riser flow.

POINTS

1. "Beyond code" sprinkler system provisions. 1
2. The potential for zoned maintenance with additional fire watch during system down-times 1
3. Level One Management 1
4. Concrete or Steel structure 2
5. Detailed analysis shows firefighters may intervene effectively in advance of a non-sprinkler controlled growing fire 2
6. Simultaneous or well-phased evacuation strategy. 1
7. The potential for fire spreading to upper levels is effectively countered by design 2
8. The level of cellular partitioning that may slow fire growth 2

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The 'Shard' London

3,000 m2 floor space including 'Back-pack'

61 x $3000^{0.57}$

= 5,852 L/min

With 30% sprinkler reduction

= 4,096 L/min

*BS PD 7974/5 Solution: **Dual 150mm rising mains in the main tower, reducing to one as the floor area reduces in area at height, will flow 4,000 L/min and supply the building's backpack with effective firefighting water as well.***

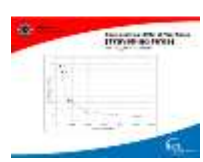
As a travelling fire - calculator input @ 500 m2 zonal fire

500 m2 @ 4.2 L/min/m2

2500 m2 @ 1.3 L/min/m2

= 2107 + 3060

= 5,172 L/min



With 30% sprinkler reduction

= 4,000 L/min (rounded from 3,621)

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The 'Walkie Talkie' London

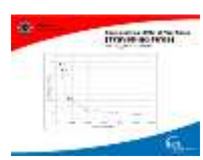
2,400 m2 floor space at largest floor

$61 \times 2400^{0.57}$
= **5,153 L/min**

With 30% sprinkler reduction
= 3,607 L/min

BS PD 7974/5 Solution:* *A single dual-outlet 150mm riser to all floors flowing 2,500 L/min, with a secondary gravity-fed riser supplied internally at an additional 1,000 L/min on upper levels as the floor area increases. This system would be adequate and create savings for the developer in this ground-breaking structural design.

As a travelling fire - calculator input @ 500 m2 zonal fire
500 m2 @ 4.2 L/min/m2
1900 m2 @ 1.5 L/min/m2
= 2107 + 2901
= **5,009 L/min**



With 30% sprinkler reduction
= 3,500 L/min (rounded from 3,506)

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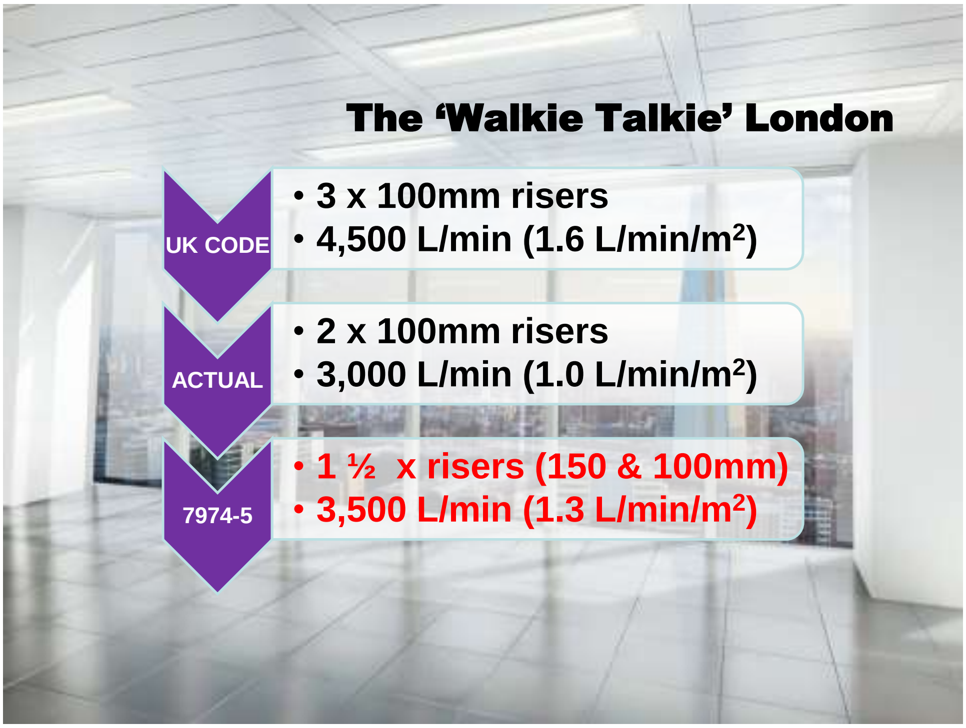
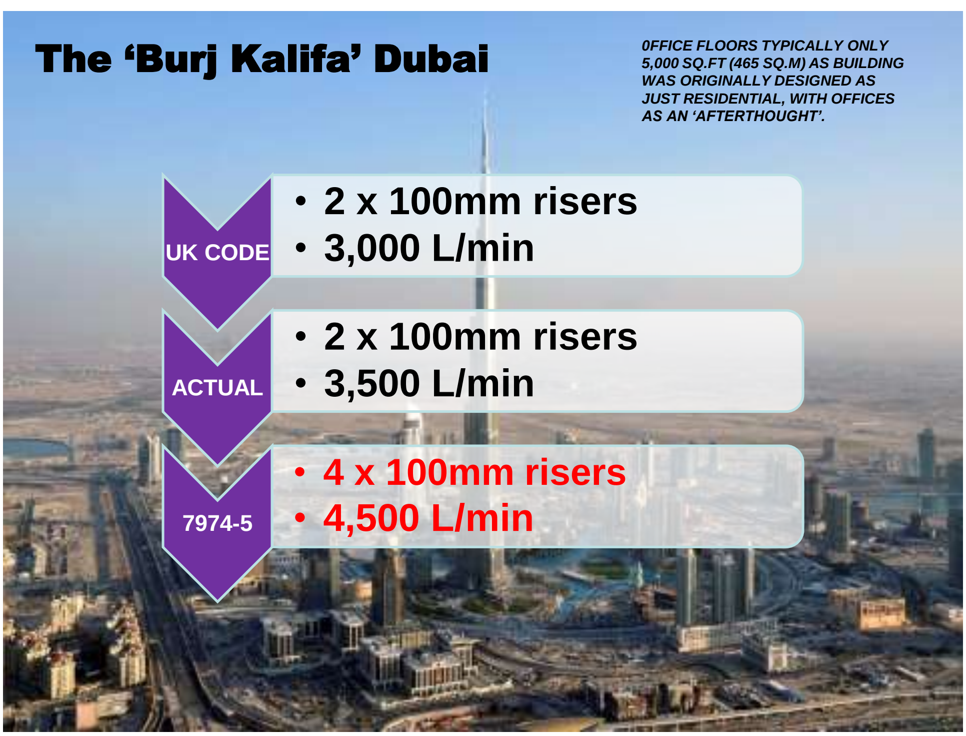

The 'Walkie Talkie' London
UK CODE
• 3 x 100mm risers
• 4,500 L/min (1.6 L/min/m2)
ACTUAL
• 2 x 100mm risers
• 3,000 L/min (1.0 L/min/m2)
7974-5
• 1 ½ x risers (150 & 100mm)
• 3,500 L/min (1.3 L/min/m2)


The 'Burj Kalifa' Dubai
0FFICE FLOORS TYPICALLY ONLY 5,000 SQ.FT (465 SQ.M) AS BUILDING WAS ORIGINALLY DESIGNED AS JUST RESIDENTIAL, WITH OFFICES AS AN 'AFTERTHOUGHT'.
UK CODE
• 2 x 100mm risers
• 3,000 L/min
ACTUAL
• 2 x 100mm risers
• 3,500 L/min
7974-5
• 4 x 100mm risers
• 4,500 L/min

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Horizontal Fire Loads

When assessing horizontal fire loads, from a firefighting water requirement, three types of formulae can be used. One based on floor area (m^2), one based on PHRR (MW) and the other based on fire load density (MJ/m^2). A growth curve is useful to estimate where the fire will be at the time the fire service are able to apply water.

In general, there is a 50/50 chance of effective fire service intervention at the point a fire involves $100m^2$ in a large compartment. As the fire reaches 20-30 MW it may likely be beyond the control of a single hand held firefighting jet.

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Vertical Fire Loads

When assessing vertical fire loads, from a firefighting water requirement, it is important to address the height of the stacked storage in the calculation process. A growth curve is required to estimate where the fire will be at the time the fire service are able to apply water.

As the fire reaches 20-30 MW it will likely be beyond the control of a single hand held firefighting jet.

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Firefighting Water in Design & Practice

This methodology may also be used to optimize fire service intervention, firefighting tactics and response and deployment strategies.

A capability review can be undertaken of individual appliances, stations or cluster groups to quantify the amount of water that can be deployed against the fire load presented, according to each risk. Using a time-lined approach based on reasonable 'worst case' fire growth parameters, the effectiveness of interventions can be effectively quantified.

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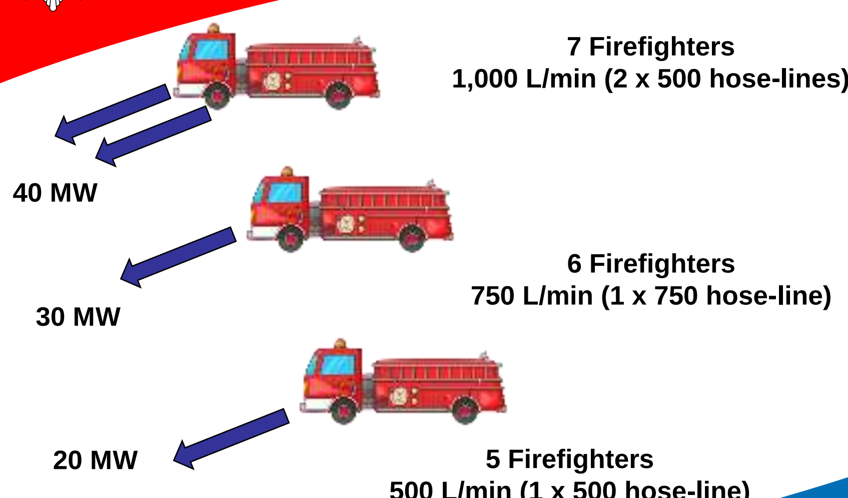

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3 Firefighters
200 L/min (1 x 200 HP hose-line)

Firefighters	Flow-rate	Fire Size m^2	Fire Size Q_{max}
7	2 x 500	200	40 MW
6	1 x 750	150	30 MW
5	1 x 500	100	20 MW
3	1 x 200	20	5 MW

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Fire Service capability

By estimating the fire intensity at the time it will take to deploy water onto a fire, it can be determined if the amount of water available at the nozzle is likely to deal with the level of fire growth.

For fuel controlled fires in large compartments a t^2 fire growth curve can be used and the 0.385 L/s/MW Q_{max} will demonstrate the fire service capability at any particular point on the curve.

0.385 X MW Q_{max} = Needed Flow-rate (L/s)

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t^2 Growth Fire – Fire Service Intervention

t^2	Water on Fire	Water on Fire	PHRR of Fire (Q_{max})	Needed Flow
M	1200 secs	20 mins	17 MW	393 L/min
M	1800 secs	30 mins	38 MW	877 L/min
F	1200 secs	20 mins	68 MW	1,560 L/min
F	1800 secs	30 mins	>100 MW	N/A

Firefighting Flow = 0.385 x MW Q_{max} = L/s

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> 1,200 L/min


Variable fire load 500 MJ/m2


Add permanent (structural) fire
load>250% MJ/m2


2,446 MJ/m^2


Clearance
NFL Jerseys
60 - 80% Off
2,400 MJ/m^2


4,900 MJ/m²


TheWorks.co.uk
READ ALL ABOUT IT!
BIGGEST BOOK DISCOUNTS IN TOWN!
80% OFF
TheWorks.co.uk
Kids Favourites
75% OFF
WE ♥ BOOKS
£9.99
5,305 MJ/m²
Alamy EFE4X5


10,610 MJ/m2


10,610 MJ/m2

Occupancy	Fire Load Density	House fire x ?	Primary Flow- rate
House or Apartment	500 MJ/m^2	x 1	350-500 L/min Or > 200 L/min HP
Toy store	2400 MJ/m^2	x 5	850-1250 L/min
Sports clothing	2400 MJ/m^2	x 5	850-1250 L/min
Shoe store	4900 MJ/m^2	x 10	> 1200 L/min
Modern bookshop	5300 MJ/m^2	x 10	> 1200 L/min
Old style bookshop	10600 MJ/m^2	x 20	> 1500-2000 L/min

Table 16. Details of Phase I and II fuel packages, fire load densities, and combustible materials

			Combustible materials										
			Textiles		Plastics		Wood/paper		Rubber/ leather		Food products		
Test Title	ID	FLD (MJ/m^2)	% of fire load[1]	Mass (kg)	% of fire load[1]	Mass (kg)	% of fire load[1]	Mass (kg)	% of fire load[1]	Mass (kg)	% of fire load[1]	Mass (kg)	Total mass[2] (kg)
Computer store	CMP-I	812	3.08	1.35	50.6	9.44	46.3	20.90	0.00	0.00	0.00	0.00	31.69
	CMP-II	1624	3.08	2.70	50.6	18.88	46.3	41.80	0.00	0.00	0.00	0.00	63.38
Storage area	SA-I	2320	5.60	6.85	31.1	16.59	49.1	64.16	8.50	5.329	5.70	9.227	102.1
	SA-II	4640	5.60	13.70	31.1	33.18	49.1	128.3	8.50	10.66	5.70	18.45	204.3
Clothing store	CLS-I	661	55.0	19.65	6.00	0.912	37.0	13.59	2.00	0.497	0.00	0.00	34.65
Clothing store	CLW-I	661	23.0	8.218	1.00	0.152	76.0	27.91	0.00	0.00	0.00	0.00	36.28
Clothing store	CLC-I	661	86.0	30.73	2.00	0.304	12.0	4.407	0.00	0.00	0.00	0.00	35.44
	CLC-II	1322	86.0	61.46	2.00	0.608	12.0	8.814	0.00	0.00	0.00	0.00	70.88
Toy store	TOY-I	1223	6.59	4.360	18.6	5.245	74.8	50.81	0.00	0.00	0.00	0.00	60.42
	TOY-II	2446	6.59	8.720	18.6	10.49	74.8	101.6	0.00	0.00	0.00	0.00	120.8
Shoe storage	SHO-I	4900	1.00	2.649	0.00	0.00	34.0	92.56	65.0	119.6	0.00	0.00	214.8
	SHO-II[3]	4900	1.00	2.649	0.00	0.00	34.0	92.56	65.0	119.6	0.00	0.00	214.8
Bookstore	BK-I	5305	0.40	1.147	0.00	0.00	99.6	301.8	0.00	0.00	0.00	0.00	302.9
	BK-II	10610	0.40	2.294	0.00	0.00	99.6	603.6	0.00	0.00	0.00	0.00	605.8
Fast food outlet	FF-I	881	0.30	0.142	19.3	3.907	38.9	19.05	0.00	0.00	41.5	8.708	31.81
	FF-II	1762	0.30	0.284	19.3	7.814	38.9	38.10	0.00	0.0	41.5	17.42	63.61

[1] % of fire load (MJ) to the total fire load of the represented package.

[2] total masses of combustible materials only, non-combustibles are not included.

[3] same 1 m^2 fuel package tested in SHO-I (performed in the post-flashover facility).

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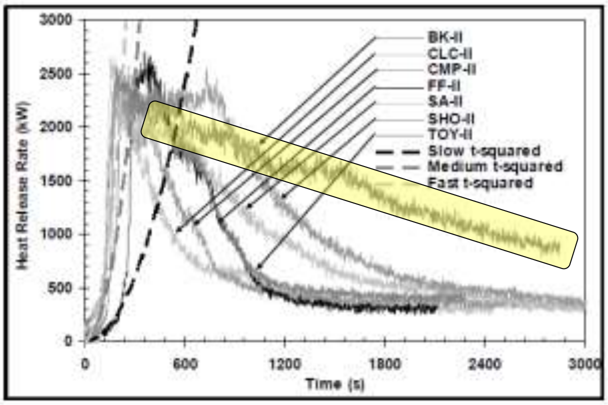

Fig. 3. Heat release rates of experiments

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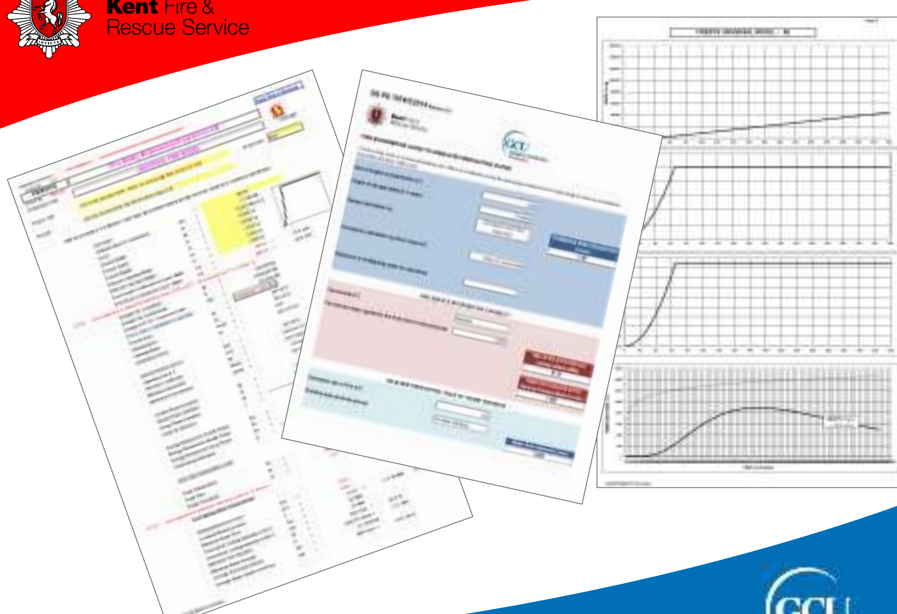

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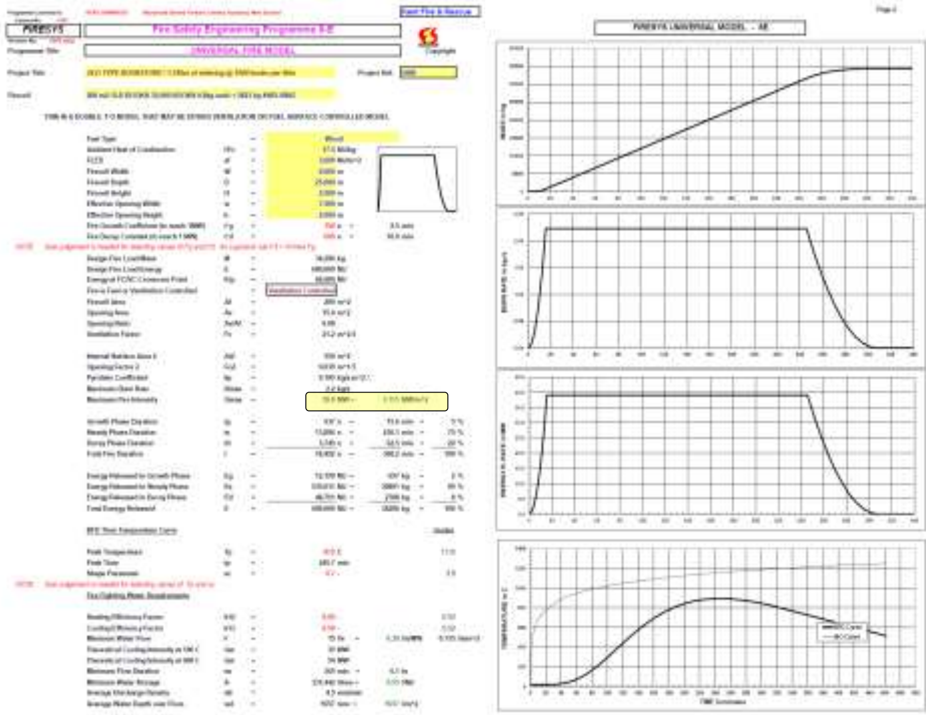

BS PD 7974/5/2014 Section 8.5

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FIRE ENGINEERING GUIDE TO ADEQUATE FIREFIGHTING WATER

(150mm rising mains in commercial buildings and 100mm in residential provide the best design solutions but no single rising fire main as a standalone should flow less than 1,500 L/min)

Size of largest compartment (m^2)	240	
Height of storage (default 1 metre)	2 metres	
Design calculation by:	Occupancy and Floor Area (m2)	**Firefighting Water Requirement (L/min):** 1,387
Occupancy calculation by Floor Area (m^2)	Shop & Commercial	
Reduction in firefighting water for sprinklers		

FIRE SERVICE INTERVENTION CAPABILITY

Fire Growth (t^2):	Medium	
Fire Service water applied to fire from time of call (seconds)	2,400	**Size of fire at Fire Service primary attack (MW):** 67.51
		Water flow required at Fire Service Primary attack (L/min): 1,688

ON-SCENE FIREFIGHTING "RULE OF THUMB" ESTIMATE

Estimated size of Fire (m^2)	200	
Building type (purpose group)	All other buildings	**Water flow required (L/min):** 1,200

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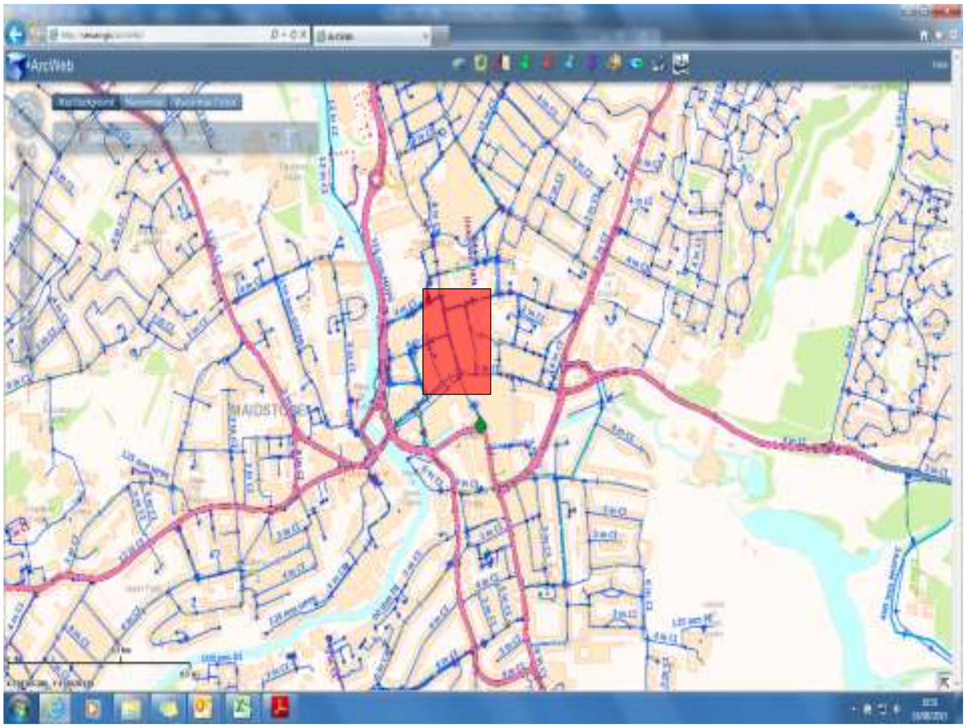
MARKS &
SPENCER
hotter

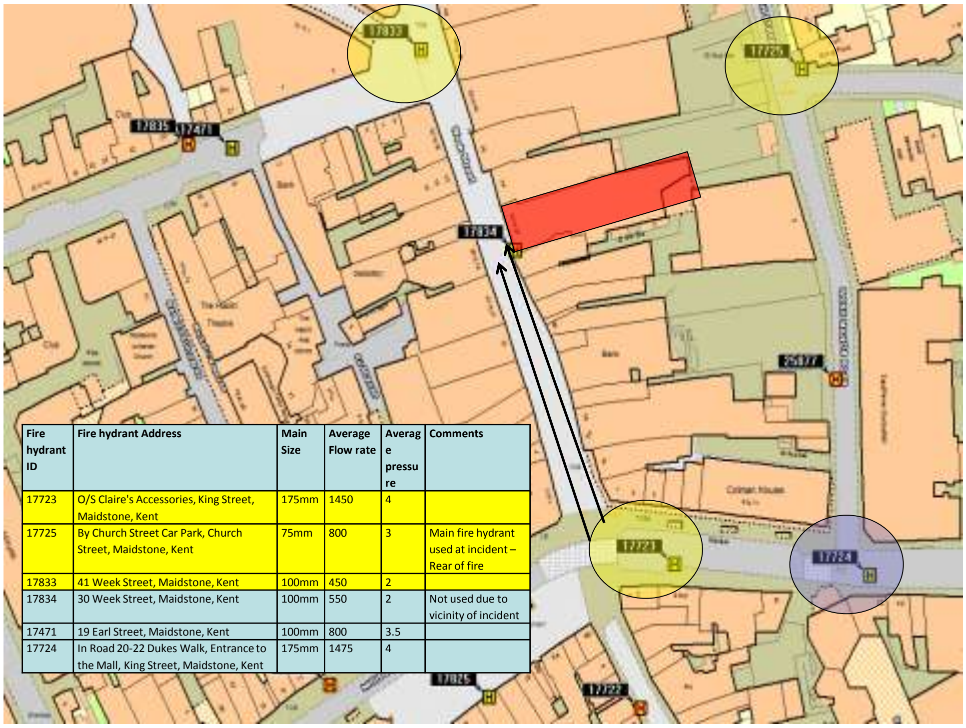

Thomson
The Works
MUST


32 Week Street, Maidstone, United Kingd
The Works
Britain's Leading Discount Book Store
Chubb


GAME


ArcWeb
MAIDSTONE


17833
17835
17471
17725
17834
25877
Colman House
17713
17723
17724
17714
17825
17722



Fire hydrant ID	Fire hydrant Address	Main Size	Average Flow rate	Average pressure	Comments
17723	O/S Claire's Accessories, King Street, Maidstone, Kent	175mm	1450	4	
17725	By Church Street Car Park, Church Street, Maidstone, Kent	75mm	800	3	Main fire hydrant used at incident – Rear of fire
17833	41 Week Street, Maidstone, Kent	100mm	450	2	
17834	30 Week Street, Maidstone, Kent	100mm	550	2	Not used due to vicinity of incident
17471	19 Earl Street, Maidstone, Kent	100mm	800	3.5	
17724	In Road 20-22 Dukes Walk, Entrance to the Mall, King Street, Maidstone, Kent	175mm	1475	4	

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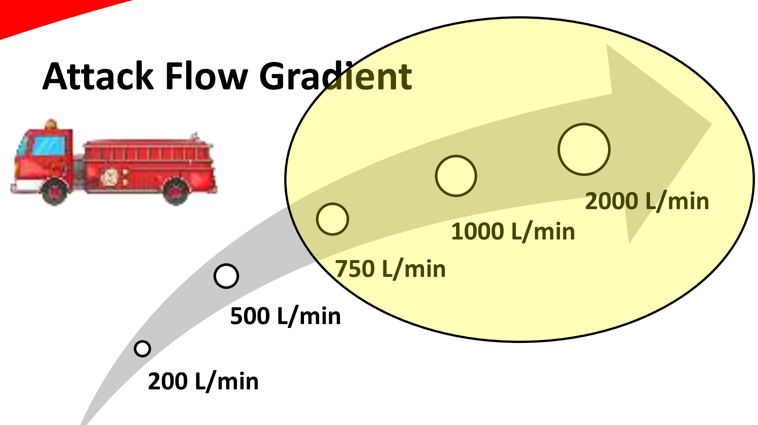
Attack Flow Gradient



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Sudbury Town Centre, Suffolk 6
weeks after the Week Street fire


© Twitter / @MikeOnslow

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Modern Firefighting Methods

At a time when the fire service is looking to further optimize their intervention techniques and methods of dealing with confined fires, using various water-fog applicators and fog insertion tools, the concept of 'adequate water' may see some reductions over time.

However, a developing high energy fire can only be tackled in one way and that is to provide the punch of high-flow water through hand held jets or portable attack monitors/appliance deck guns.

Active fire suppression and effective compartmentation through design is the future!

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Getting adequate water onto a building fire means overcoming the fire's intensity, it's power and it's release of energy. If the flow-rate from the outset of operations is inadequate in meeting this energy release, the fire will continue to spread until it runs out of fuel.

What does this mean? It means that unless your applied flow-rate (L/min) exceeds the fire's energy release (MW) the building damage will increase, as will the need for additional staffing and resources as the fire spreads to involve other areas or adjacent buildings.

Paul Grimwood

Adequate Water (L/min) versus 'MW'

paul.grimwood@kent.fire-uk.org

Kent Fire & Rescue Service

The efficiency of Firefighting Water

The application of firefighting water is never 100% efficient. If using water-fog the efficiency will be far greater than when using a solid stream smooth bore attack.

However, research has demonstrated that around 45-50% of applied water will ‘run off’ in a firefighting attack against intense compartment fires and that a combination of both fog and solid streams are needed to achieve control and extinguishment.

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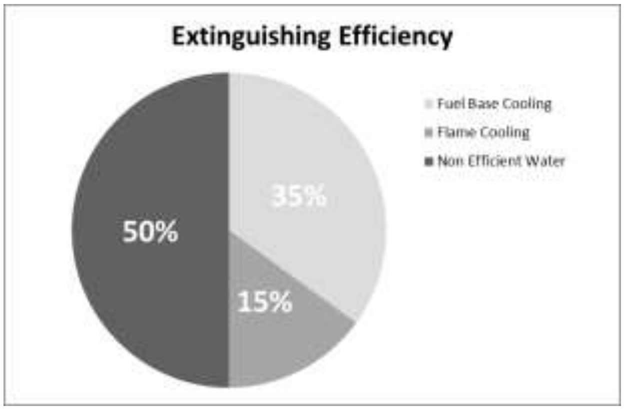
Efficiency of Firefighting Water

Rasbash/Barnett Theories



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The Cooling Ratios of Firefighting Water

The research undertaken in Germany by Karlsruhe University in 1984 compared computer analysis against empirical data from full-scale fires to determine the ratios of firefighting water applied into the reaction zone (gas-phase) and onto the fuel base, in order to achieve the most effective suppression.

The ratios in both cases, determined by computer analysis and real fires in small rooms and larger commercial compartments, were ………

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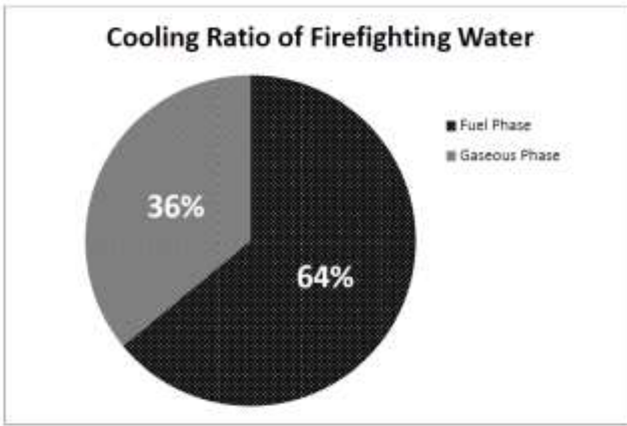
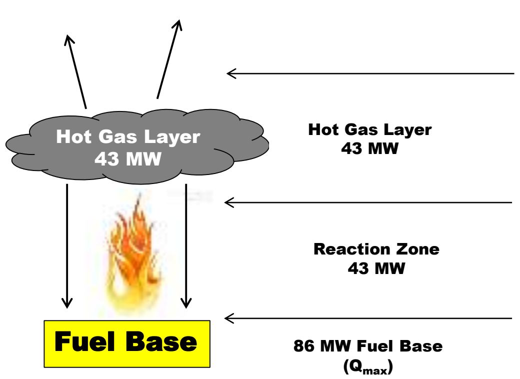
Karlsruhe University Research 1984



4-Zone Travelling Fire
Interstate Bank LA 1988



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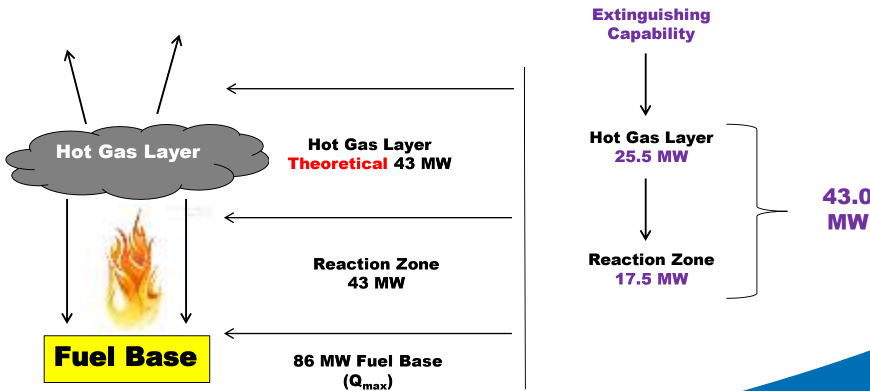
4-Zone Travelling Fire Interstate Bank LA 1988



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4-Zone Travelling Fire Interstate Bank LA 1988

RASBASH

KARLSRHUE

0.36 x 3.6 x (1/0.3) x 32.8 x 0.18%	=	25.48 MW
0.64 x 2.6 x 32.8 x 0.32%	=	17.46 MW
Total	**=**	**43.0 MW**
Q_s = 43 MW / 0.5 k_F ← BARNETT	=	**86 MW** per 32.8 L/s
86 MW / 32.8 L/s = 2.62 MW/L/s	=	**86 MW Q_{max}**
32.8/ 86	=	**0.38 L/s/MW Q_{max}**

BARNETT @ 50% EFFICIENT

Note: *k_F is the assumed combustion efficiency of the fire (taken as 50%)*
Q_s is the heat absorption of firefighting water per L/s

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Heat Absorption of Firefighting Water (1L/s)

0.36 x 3.6 x (1/0.3) x 1 x 0.18%	=	0.78 MW
0.64 x 2.6 x 1 x 0.32%	=	0.53 MW
Total	**=**	**1.31 MW**
Q_s = 1.31 MW / 0.5 k_F	=	2.6 MW per L/s
1/ 2.62	=	**0.38 l/s/MW**

Note: *k_F is the assumed combustion efficiency of the fire (taken as 50%)*
Q_s is the heat absorption of firefighting water per L/s

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