Fire Load Fixes the Total but Not Whether the Fire Is Hot and Short or Mild and Long; That Is Fixed by the Opening

— doubling the opening multiplies the heat release by **2.000000** and the duration by **0.500000**, while the product stays at **60000** MJ — the separator is whether the pace of the fire is set by the fuel or by the opening — [Paper 729]

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— From thinking to syncing. —

Abstract

Fire load is how many megajoules a room stores. It fixes the total exactly and says nothing about whether the fire is hot and short or mild and long.How far the duration moves at a fixed total is counted.No new theorem or law is claimed. First, the total does not depend on ventilation——600 MJ/m² over 100 m² is 60000 MJ (Section 2). **Second, and this is the core. At the same total the duration spans a factor of four——94.280904 minutes with a 5 m² opening and 23.570226 with 20 m²** (Section 2). **Third, doubling the opening halves the duration exactly——the heat release by 2.000000 and the duration by 0.500000** (Section 3). **Fourth, and the total still does not move——the product is 60000 MJ in both cases, differing by under 10^{-6} MJ** (Section 3). **Fifth, height and area are interchangeable——height enters under a square root, so quadrupling it multiplies the factor by exactly 2.000000, the same as doubling the area** (Section 3). **Sixth, the separator is whether the pace of the fire is set by the fuel or by the opening——the fuel fixes the total and the opening fixes how it is spread** (Section 4). **Keywords**: fire load, ventilation-controlled fire, ventilation factor, duration, total against spread, fuel or opening.

Scope of this paper (scope note): **No new theorem or law is claimed——fire load, ventilation-controlled fires and the ventilation factor $A\sqrt{h}$ are all standard (Kawagoe 1958, Drysdale 1985).No absolute value of the coefficient is claimed——the coefficient in the heat release is representative; only ratios are read.The transition is not located——with a large enough opening the fire becomes fuel-controlled, but that boundary is only stated to exist and is not located.Regulations are not treated——temperature-time curves and fire resistance requirements are not treated.The form of the fuel is not treated——kind, arrangement and surface area are not treated; only the total stored heat is used.Relation to earlier papers**: **Paper 728 showed that most of the smoke is not what burned but air the plume pulled in——there the answer for the volume of smoke lay not with the fuel but with the ceiling height. Here the answer for the duration lies not with the fuel but with the opening. A second instance of the same shape: the answer is not in the fuel.**What is added is **showing the total to be independent of ventilation**, **deriving a fourfold span in duration**, **showing that doubling the opening halves the duration exactly**, **confirming the product to agree to within 10^{-6} MJ**, and **placing the separator on fuel against opening**.

1. Notation and the Question

Setting: **the total combustible heat stored in a room is its fire load. In a ventilation-controlled fire the heat release is proportional to the opening area times the square root of its height.**

$$E = q\,A_f, \qquad \dot{Q} = c\,A\sqrt{h}, \qquad t = \frac{E}{\dot{Q}}$$

q is the fire load density, A_f the floor area, and A and h the area and height of the opening. c is representative and its absolute value is not claimed.

Question: **what does the fire load determine?**

2. At the Same Total, the Duration Moves Fourfold

Computation 2.1: **for a fire load density of 600 MJ/m² over 100 m², a total of 60000 MJ, the heat release and duration were derived for each opening.**

opening	ventilation factor	heat release	duration
5 m², **2** m	**7.071068**	**10606.601718** kW	**94.280904** min
10 m², **2** m	**14.142136**	**21213.203436** kW	**47.140452** min
20 m², **2** m	**28.284271**	**42426.406871** kW	**23.570226** min
10 m², **8** m	**28.284271**	**42426.406871** kW	**23.570226** min

> **Observation 2.2**
>
> **this is the core: the same 60000 MJ becomes 94.280904 minutes or 23.570226.Not one combustible item has been changed——the fire load fixes the total and does not fix how it is spread.**

> **Observation 2.3**
>
> **hotter is shorter and milder is longer.A large opening burns fiercely and briefly; a small one mildly and long——which is the more dangerous depends on what one is trying to protect.**

3. The Total Does Not Move; Only the Spread Does

Computation 3.1: **the heat release, duration and their product were derived on doubling the opening.**

quantity	value
ratio of heat release	**2.000000**
ratio of duration	**0.500000**
product (at **10** m²)	**60000** MJ
product (at **20** m²)	**60000** MJ

Observation 3.2

the product does not move.It is 60000 MJ in both cases, differing by under 10^{-6} MJ——ventilation changes only how the release is divided between rate and time, and does not touch the total released.

Observation 3.3

height and area are interchangeable.Height enters under a square root, so quadrupling it multiplies the ventilation factor by exactly 2.000000, the same value as doubling the area——two design quantities merge into one number.

Observation 3.4

so blocking an opening reads two ways.The total is unchanged, so the fire merely lasts longer——one may read it as “the fire was made smaller” or as “the fire was made to last”.

Observation 3.5

this expression has a limit that bites.With a large enough opening the air is sufficient and the fire comes to be set by the fuel——beyond that, more ventilation does not raise the release, and this paper does not locate the boundary.

4. The Separator

Observation 4.1

the separator is whether the pace of the fire is set by the fuel or by the opening.The fuel fixes the total and the opening fixes the spread——counting “how much there is to burn” does not answer “how it will burn”.

Observation 4.2

beside Paper 728.Paper 728 showed that most of the smoke is not what burned but air the plume pulled in——there the answer lay with the ceiling height. Here it lies with the opening. Two instances of the same shape, the answer not being in the fuel.

Observation 4.3

beside Paper 713 as well.Paper 713 showed that a conservation law fixes exactly how many grams are deposited and says nothing about where——there what was left open was the distribution in space. Here it is the distribution in time. The same shape, seen in two places: place and time.

Observation 4.4

what is not said.The absolute coefficient, the location of the transition, regulations and the form of the fuel are not treated——what is shown is that the total and the spread are fixed by different quantities.

5. Roll Call and Closing

1. **total 60000 MJ** (Computation 2.1): **independent of ventilation.**
2. **94.280904 min at 5 m²** (Computation 2.1): **mild and long.**
3. **23.570226 min at 20 m²** (Computation 2.1): **hot and short; the core.**
4. **10606.601718 kW** (Computation 2.1): **the small opening.**
5. **42426.406871 kW** (Computation 2.1): **the large opening.**
6. **release ratio 2.000000** (Computation 3.1): **on doubling.**
7. **duration ratio 0.500000** (Computation 3.1): **exactly half.**
8. **product stays 60000 MJ** (Observation 3.2): **within 10^{-6}.**
9. **height $\times 4$ equals area $\times 2$** (Observation 3.3): **interchangeable.**
10. **fuel or opening** (Observation 4.1): **the separator; Paper 728.**

Closing: **Fire load fixes the total but not whether the fire is hot and short or mild and long; that is fixed by the opening.A fire load density of 600 MJ/m² over 100 m² stores 60000 MJ, and that does not move with ventilation——yet the same 60000 MJ becomes 94.280904 minutes with a 5 m² opening and 23.570226 with 20 m², a fourfold span**

with not one combustible item changed.Doubling the opening multiplies the heat release by 2.000000 and the duration by 0.500000, and the product is 60000 MJ in both cases, differing by under 10^{-6} MJ——ventilation changes only how the release is divided between rate and time, and does not touch the total.Height enters under a square root, so quadrupling it multiplies the ventilation factor by exactly 2.000000, the same as doubling the area——two design quantities merge into one number.So blocking an opening reads two ways: the total is unchanged, so one may say the fire was made smaller or that it was made to last.With a large enough opening the air becomes sufficient and the fire comes to be set by the fuel——this paper does not locate that boundary.The separator is whether the pace of the fire is set by the fuel or by the opening.Placed among the earlier papers——in Paper 728 the answer lay with the ceiling height; here it lies with the opening.To be honest——the absolute coefficient, the transition and the regulations are not treated.

References

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