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ACCOUNTING FOR ARSON IN FIRE SAFETY ENGINEERING

A New Method for Quantifying Fire Growth Rates Using Statistical and Empirical Data

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BACKGROUND

A common approach in fire safety engineering and design of buildings is to determine a design fire where the heat release rate (HRR) is described with an exponential fire growth rate, this in turn forms the basis of the design. The exponential fire growth rate is often referred to as the alfa-t^2 fire curve. In general, this choice of a deterministic fire growth rate for design is thought to represent the worst possible conditions that could "reasonably" occur, often called the worst-credible case. But, there is always the question of how conservative the chosen value actually is. Since the uncertainties, or the risks, are not quantified, the worst-credible case approach presents shortcomings since it does not allow for meaningful comparisons of risks and therefore priorities between mitigating measures are difficult.

A faster fire growth rate can be associated with a shorter available safe egress time (ASET) causing the required safe egress time (RSET) to be longer than ASET, hence endangering people. In addition, a faster fire growth rate could result in less time for the fire service to intervene, which could affect life safety as well as property damage. A faster growing fire than designed for could also result in impairment of fire protection systems, e.g. a sprinkler system might not be able to control a fire that is too large upon activation and a smoke management system might be overwhelmed causing large property damage and a negative effect on life safety. Therefore, it is desirable to find the actual distribution of fire growth rates for different types of buildings, in order to quantify how conservative the chosen fire growth rate actually is.

Most buildings codes have a focus on life safety in case of accidental fires, i.e. fires that starts by accident, or rather; there is no explicit approach to deal with antagonistic threats such as arson. This is of course reasonable if there is no significant difference between the fire growth rate of only accidental fires and all fires (including arson). Arson is a common cause of fires according to statistics from several countries and the extent of arson varies with the type of occupancy. In Sweden, for example, arson accounts for 8% of fires in residential buildings and for more than 40% of fires in school buildings. So, in some buildings it might be important to give special attention to these fires in the design phase.

Table 1. Parameters for lognormal distributions and percentile values

	μ_α (Std. Err.)	σ_α (Std. Err.)	$E(\alpha)$ (kW/s²)	α_{95} (kW/s²)	$\alpha_{99.5}$ (kW/s²)	Percentile for $\alpha = 0.047$ kW/s²
Accidental fires (arson exl.)	-5.09 (0.023)	1.10 (0.016)	0.011	0.038	0.105	97%
All fires (arson incl.)	-4.73	1.25	0.019	0.069	0.219	91%

The aim of this work is to present a method that can be used to obtain distributions of fire growth rates in specific building types.

The method is demonstrated by investigating whether the overall fire growth rate is faster for commercial buildings if arson fires are included than if they are not.

METHOD

Two sources of information have been combined in this work. Firstly, fire statistics is used to find the frequency of fire in different objects, e.g. the first object ignited, for different room types in commercial buildings. Secondly, information on fire growth rates for the different objects is gathered from published free burn fire experiment data in the literature and each object first ignited is assigned a fire growth rate..

The method is applied when studying Swedish commercial buildings to find the distributions for all fires (including arson) and accidental fires (excluding arson). The lognormal distribution fit to the fire growth data was found with the help of Matlab.

RESULTS

The results of the investigation are presented in table 1, figure 1 and 2. The developed method is associated with uncertainties but it is considered to be novel and important for future work on determining fire growth rates in different types of buildings. It is shown that if arson fires are included when determining the distribution a considerably higher fire growth rate is obtained, especially for the tail of the distribution. If the probability for arson fires is considerable, a higher fire growth rate is expected and this might need to be taken into account during design since it affects the overall fire safety level of the building.

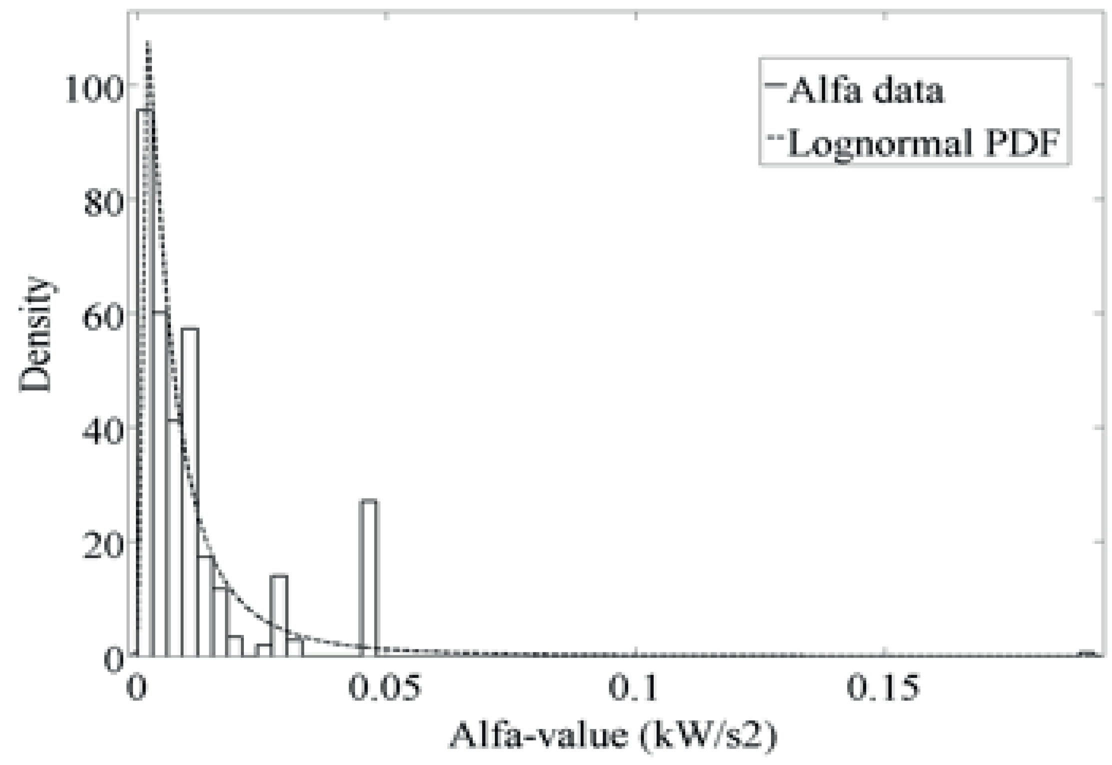

Figure 1: Histogram and PDF for estimated lognormal distribution for accidental fires (arson excluded).

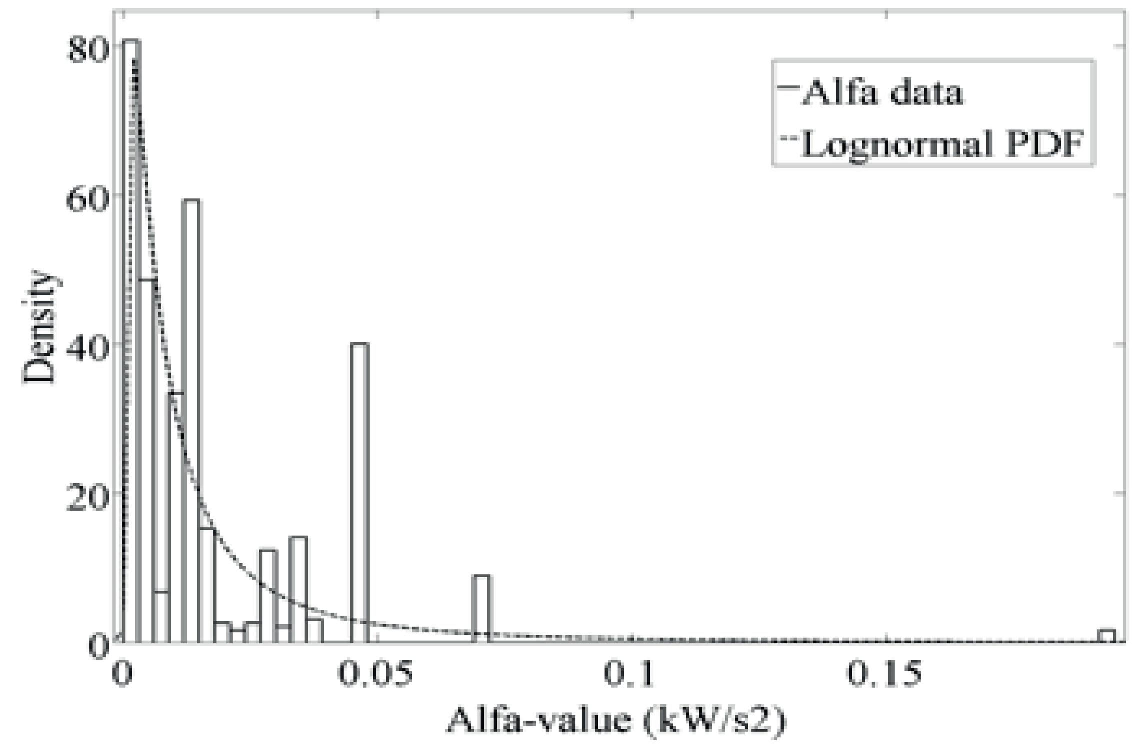

Figure 2: Histogram and PDF for estimated lognormal distribution for all fires (arson inculded).

Shopping centres usually hold a large amount of people and the potential consequences of a fire can be large. Therefore, it is of great importance to use an appropriate fire growth rate in the fire safety design of these buildings.

Swedish school buildings have a high frequency of arson. In the case shown in the picture, a deliberately lit fire caused a total destruction of an elementary school. (Photo: Stefan Svensson)

Flammable liquids can be used as propellants in deliberately lit fires. The figure shows the debris from a Molotov cocktail. (Photo: RIB Database, The Swedish Contingency Agency)