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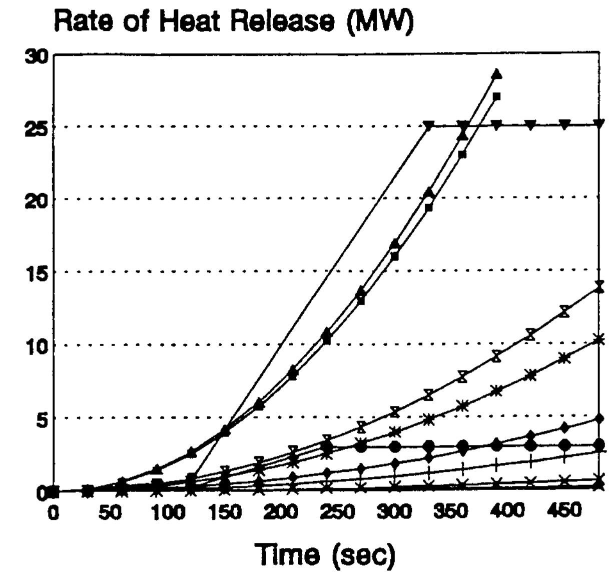
APPENDIX: THE t^2 FIRE AND ITS TENUOUS RELATION TO REALITY

A number of the simpler models in use worldwide prescribe the fire conditions not by computing the actual HRR curve, nor by asking the user to input such a curve. Instead, they claim that all real fires can be closely matched up to one of four idealized fires. These are called 'slow,' 'medium,' 'fast,' and 'ultrafast.' This approach has now been used for so much engineering work that undoubtedly many practitioners feel that it is soundly based in fire physics. Yet, this is far from the actual reality.

The use of the t^2 fires first arose in the early 1970s, when quantitative performance evaluation of fire detectors was first being attempted[29]. It was noted that the HRR from fires could have different rates of rise and this would affect the response of the detector. Thus, a series of different categories of initial rate of fire growth were set up to aid in such detector studies. This was subsequently popularized when it became part of the standard NFPA 72[30]. It is important to note carefully the original application—characterizing the response of fire detectors. A fire detector should alarm very early in the fire, before it is a threat to any occupants. This level will typically be less than 100 kW. For such small fires, declaring that there are only four distinct fire types is not a bad decision. In fact, the designer of a detector would not know what to do with any greater amount of detail about the fire. But, once the detector designer has provided adequate responsivity for such a small fire, his job is finished; larger fires are not a concern to him. Indeed, we may note that a much larger fire will destroy the detector itself!

Such small fires, however, are not the appropriate focus for modeling the general fire hazard in buildings. Even in structures of very low combustibility, occupant goods can provide fires yielding megawatts, not kilowatts. Yet, the detector designer's four



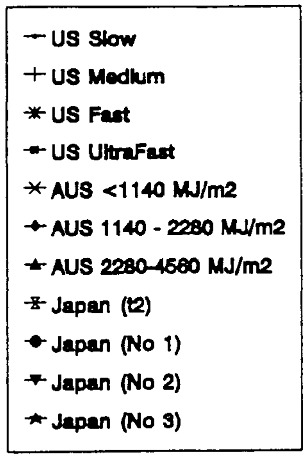


Figure 1. Various t^2 and Similar Simplified Fires, as Suggested by FSE-Based Performance Codes Being Developed in Several Countries; From Reference 1.

schematic fire types have simply been extrapolated to entirely unreasonable sizes. For instance, we find in a recent review paper[31] the suggested fires as proposed for several FSE-based building codes (Figure 1). Note the y-axis of this graph, which goes up to 30 megawatts. In the world's fire literature, there are very few objects over about 3-5 MW whose HRR curves have ever even been described; to extrapolate from the 100 kW regime to 30 MW, however, is a singularly questionable move.

Equally questionable is the suggestion that the designer should match up potential burning objects against some chart which tells him which t^2 curve to select. As an example, upholstered furniture has probably been studied more extensively than have most other combustibles. Thus, if anything, its 'assignment' into one of the four t^2 fire types should be very easy. In Figure 2 are shown examples of three different chairs whose HRR curves have been published, along with the t^2 curves of NFPA 72. The inappropriateness of the attempted use of t^2 fires for fire hazard assessment is graphically made clear in Figure 2. In general, there *is no* available engineering method whereby real burning objects could be equated with such schematic fire curves. Development of such methods has been attempted[32]; however the attempts did not lead to success.

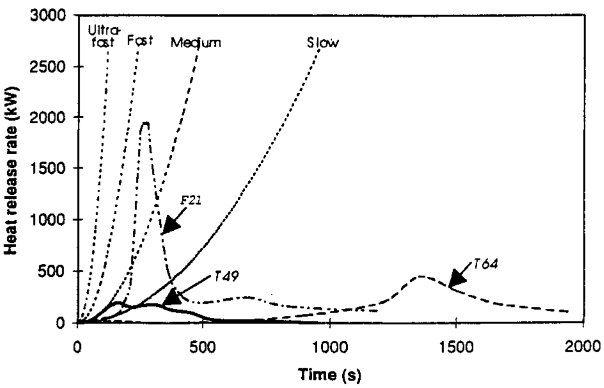


Figure 2. Some HRR Curves For Actual Furniture Items 33, Compared to The t^2 Curves of NFPA 72.

Finally, we wish to point out that the *peak* HRR is often the most significant fire hazard variable of concern[15]. The t^2 curves of NFPA 72 go, in principle, to infinity. In some applications, committees have suggested that such design curves be chopped off at some maximum value. Such a committee action, however, is bereft of burning object physics: it is arbitrary and unrelated to real burning behavior.

To summarize, then, t^2 and similar schematic curves which have been proposed for use as design fire HRR values by various FSE-based building code drafts are not acceptable from an engineering point of view since:

- The shapes of these schematic curves are very different from real fire HRR curves, except when considering a minuscule portion (e.g., 0 to 100 kW).

- No viable scheme exists for matching up real combustibles against specific schematic HRR curves.

- The peak HRR, which is often the most important fire hazard parameter, is completely ignored or treated in an unphysical way in the proposed schematic t^2 fires.

The above considerations do not imply an opposition to the general concept of simplified design fires. If done right, such a concept could provide a useful simplification for the designer, while still retaining real combustion physics. At the present stage, however, the t^2 and similar schematic design fires fall very short of being usable.

There is a final sobering thought in the situation. Many of the current-day building code provisions are intended to control the flammability of building components and finishes. The indiscriminate adoption of t^2 design strategies would naturally lead to the situation where testing of such components becomes viewed as unnecessary. After all, if we know how to categorize fires before testing any of the products in question, what is the point of testing? It does not require much discussion to realize that such a path does not lead to improvements in fire safety for building occupants.