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Properly designed experiments are still needed in order to understand low-temperature, long-term ignitions of wood

by

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In a recent paper in the FIRE & ARSON INVESTIGATOR, Cuzzillo et al.[1] claim:

(1) That they conducted tests which "properly simulated accidental exposures" leading to low-temperature, long-term ignitions of wood;
(2) That these tests "disproved the old, wrong hypothesis of chemical 'pyrophoric carbon' with tests that showed the opposite is true"; and
(3) That "Babrauskas…cling[s] stubbornly to the old false theory."

None of these statements are correct, based on the research published by Cuzzillo[2] and on my previous paper[3]. Considering each of these claims in turn, it is questionable whether many IAAI members will be reading in detail through all of the 182 pages of Cuzzillo's thesis. Thus, Table 1 summarizes the tests that Cuzzillo described in his thesis and compares them to "properly simulated accidental exposures." There is a discussion in my previous paper concerning how each of these factors is characteristic of the typical fire incidents that involve low-temperature, long-term ignition of wood. It can readily be seen from the Table that Cuzzillo's experiments were not so designed as to simulate these real-life factors.

Table 1 Comparison of actual fire incident conditions to Cuzzillo's experiments

Factor	Fire incidents leading to low-temperature, long-term ignition of wood	Experiments conducted by Cuzzillo	Is the real-life factor reproduced in the experiments?
Time duration	Typically 3 months to 15 years	Most tests: only a few hours; longest test: 9.2 days	no
Material ignited	Beams, joists, floor boards	Most tests used wood chips, not whole wood; only a few tests run on blocks of solid wood	no
Heating applied to material	On one face only, by means of a steam pipe, metal base of heater, etc. Remaining faces are unheated.	Specimens inserted bodily into oven, all faces being heated equally	no
Nature of heated surface	A metal surface (impervious to oxygen) heats the wood	All surfaces open to oven air, although in a few experiments some surfaces were covered with ceramic fiber insulation or silicone sealant	no
Temperature cycling	Usually the steam pipe, heater, etc. operates in a cyclic manner	Steady exposure at a fixed temperature	no

There is no doubt that Cuzzillo conducted an extensive series of tests and made a contribution to understanding the ignition of wood chips. But the tests were not in any sense a realistic reconstruction of

the situation in actual fire incidents where a solid-wood member ignites due to heating from a metal pipe, a metal baseplate of a heater, etc. Consequently, unlike the authors' claim, their work is not capable of finalizing the scientific understanding of the subject.

Considering their second claim, Cuzzillo conducted no tests where the actual details of cracking were examined, and made no measurements of the chemical reactivity of the surfaces that become exposed once a crack occurs. Thus, to claim that the authors have learned any chemical details about the nature of the char as it ages over the course of months or years is inappropriate and unsupported. In fact, in Cuzzillo's entire thesis, there are no chemistry experiments of any kind that are reported! The *only* measurements that he reported making are simple temperature readings in a sample placed in an oven. If chemical reactions are to actually be studied, instrumental techniques must be used which can identify and quantify the chemical species involved. Even measurement of the density of the wood chips tested, which only requires a laboratory balance and which is an important problem variable, was not made.

Considering their third claim, it is best to simply repeat the statement from my original paper:
"Thus, it is entirely likely that Prof. Shafizadeh was right in hypothesizing that long-term ignitions are a 2-step process:
(1) a reactive char gets formed under restricted-oxygen conditions.
(2) the reactive char then ignites. This may occur when further shrinkage takes place and oxygen enters newly-formed cracks."
There is absolutely nothing in the work of Cuzzillo that disproves either of these statements. Nor was any claim made in my paper that this hypothesis has been proven. It is a reasonable hypothesis to investigate, but in the present context of ignition of structural wood members, it has neither been proven nor disproven—specifically focused research still needs to be done.

So what exactly did Cuzzillo's thesis prove? In this paper, he claims that "the physical enhancement of oxygen diffusion due to crack formation is the main discovery of Cuzzillo." That charring and cracking produce a more porous material is inarguable—quite clearly fire investigators knew this even before any new research. But it must be noted that nowhere in his research did Cuzzillo even use as simple a chemistry instrument as an oxygen analyzer, in order that oxygen concentrations be measured. He simply *deduced* that porous material is more permeable to oxygen. His "discovery" of this obvious truth does not advance the understanding of low-temperature, long-term ignitions of wood and does not help the fire investigator to explain real-life ignitions.

In another recent paper[4], Cuzzillo and Pagni wrote: "**Q.** Is there such a thing as pyrophoric carbon? **A.** No. Pyrophoric carbon is a mythical material that, according to legend and some fire investigators, can burst into flame without warning at temperatures as low as a hot summer's day." This is a trivializing dismissal of a subject which is by no means trivial. It is certainly true that solid wood members will not ignite when placed into an atmosphere where the temperature is only equal to that of a hot summer day. And, despite Cuzzillo's attempt to set up a straw man, there do not appear to be any publications by fire investigators where such a claim would have been made. But as Cuzzillo and Pagni well know, the term "pyrophoric carbon" was first applied to haystack fires. Haystacks are well documented in the scientific literature to ignite due to self-heating on a hot summer's day[5,6]. As I have stated in my original paper, the term "pyrophoric" is defined by the U.S. Dept. of Transportation to means a very specific thing, and applying it to other situations is a poor choice of terminology. Consequently, in the paper I argued *against*, not in favor of using this term. "Pyrolyzed carbonaceous material" would be a more correct term. But excessive criticism of fire investigators who use a scientific term incorrectly is perhaps unnecessary.

Summary

(1) As discussed in my previous paper, already in 1984 Bowes reported a study on the low-temperature ignition of wood during *short-term* (days, not months) heating. Based on laboratory

tests and theoretical analysis, he concluded that a steam pipe or similar device must show a temperature of approximately 200ºC for ignition to occur. The results in Cuzzillo's study are in broad agreement with this finding.

(2) The fire investigation problem that is of more importance is one where long-term (months to years) heating takes place since case incidents indicate that temperatures much less than 200ºC are sufficient for ignition under such conditions. Neither Bowes, nor Cuzzillo, nor any other researcher has conducted laboratory research on this topic. It is evident that some additional physicochemical phenomena have to be involved in this problem, but, in the absence of proper research, what these phenomena may be can only be hypothesized at this time.

(3) Despite his claim that he has "solved" the problem, Cuzzillo's work cannot lead to any valid conclusions on long-term heating because he did not conduct any long-term heating studies. Specifically, his work does not contain anything that can predict (a) whether a piece of wood heated by a steam pipe or other hot metal surface will ignite during long-term heating, and (b) if it is predicted to ignite, how long will it take before ignition occurs. To a fire investigator, these two are the questions of topmost importance, and if they are not answered it should be quite evident that more research is needed.

References

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