# THE CASE FOR RELATING FLASHOVER TO HEAT RELEASE RATE MEASUREMENTS ON CABIN MATERIALS

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## INTRODUCTION

NPRM 85-10 and 85-10a propose a heat release rate test and criteria for aircraft cabin interior materials that cover large surface areas (sidewalls, ceiling, etc.) (Ref. 1,2). This proposal is a culmination of numerous experimental studies conducted and sponsored by FAA. For example, the criteria for materials acceptability is based on delaying the onset of flashover to provide more time for passenger escape during survivable postcrash cabin fires (Ref. 3). Subsequent to the aforementioned NPRM's, the aviation industry (AIA/ATA) proposed an alternative test standard using the NBS smoke density chamber (Ref. 4). The AIA/ATA proposal contains data showing an inverse relationship between smoke density data and time to flashover. This briefing paper will remove much of the confusion that exists on the relevance of material smoke tests to aircraft cabin flashover and survivability.

### Flashover

The importance of flashover in controlling survivability during an impact-survival postcrash cabin fire was evidenced in early FAA full-scale fire tests in the C-133 test article (Ref. 5). The time of occurrence of flashover, or when rapid and uncontrolled fire growth occurred, dictated when passengers could no longer survive a cabin fire. For the fire scenario studied, the environmental conditions away from the fire origin, including elevated temperature, smoke density, toxic and irritant gas concentrations, and oxygen concentration, were clearly survivable before the onset of flashover. After flashover, these life-threatening conditions, including smoke density, exponentially increased to hazardous levels. Thus, hazardous smoke levels from burning cabin materials are a consequence of flashover.

Also related to NPRM 85-10 and 85-10a were later C-133 full-scale fire tests to determine the potential for improved safety offered by better interior materials. An advanced composite panel was compared to an inservice panel when installed as sidewalls, stowage bins, ceilings and partitions, and subjected to three types of fire scenarios (Ref. 6). The peak heat release rate and total heat release for the advanced panel was approximately 15 times less than the inservice panel. This test series demonstrated that advanced interior panels can provide a significant safety improvement during postcrash and in-flight fires by delaying or preventing the onset of flashover. It is noteworthy that the advanced panel produced a zero smoke reading under the test criteria proposed by AIA/ATA, yet, a flashover occurred when the advanced panel was subjected to an intense postcrash fuel fire. Thus, the absence of smoke under the proposed AIA/ATA test conditions would indicate that flashover should not occur for the advanced panel system; however, this was clearly not the case.

### Heat Release Rate

The relationship of heat release rate to enclosure flashover has been the object of considerable theoretical and experimental evaluation. For flashover to occur, enough thermal energy must accumulate within the enclosure to cause rapid fire involvement of materials which had not been burning prior to flashover. The source of this thermal energy is the rate of heat release of the materials that are burning prior to flashover. For flashover to occur, these burning materials must release enough heat so that significant temperature rise can be sustained in the context of heat losses through ventilation effects and heat transfer to the enclosure structure. The heat accumulation results from heat input from burning materials less heat losses. In effect, this thermal picture of flashover demonstrates material heat release rate as a causal factor in flashover.

One study at the National Bureau of Standards (Reference 7) found that flashover occurs when the heat generation rate is set as follows:

$$Q = 610\ (h_k\ A_w\ A_o \sqrt{H_o}\ )^{1/2}$$

where Q is the heat generation rate in kW, $h_k$ is the wall heat loss coefficient in kW /$m^2$ $^oK$, $A_w$ is the enclosure surface area in $m^2$, $A_o$ is the area of a single doorway in $m^2$, and Ho is the height of the opening in m. Furthermore, in an evaluation of the FAA full-scale flashover tests, the National Bureau of Standards found that flashover occurred when the combined heat release rates of seats and linings reached 1000 kW (reference 8). The FAA position of use of material heat release rate as a basis for flammability testing rests on a far broader base in the fire technology field. The FAA cabin fire safety program resulted in the application of a general finding to the specific cases of aircraft cabin enclosures and the OSU rate of heat release apparatus. In fact, the ATA submitted yet another document to the FAA rules docket (reference 9) that relates time to flashover to heat release rates measured in a different device, the cone calorimeter.

Correlation

The fire technology literature demonstrates a causal relationship between material heat release rate and flashover. Causal relationships are important in a technology as complicated as fire science because a causal relationship affords more confidence in the corresponding correlations developed from testing. For instance, the OSU heat release rate information has been correlated with limited full scale tests in the C-133. Because of the causal relationship between flashover and heat release rate, the correlation can be used with a high degree of confidence for materials that have not been tested in the C-133.

This situation is in contrast to smoke measurements where the ATA/AIA identified a correlation (reference 4) between smoke measurements in the NBS smoke chamber and the limited full-scale C-133 flashover tests. It should be noted that the measurement of smoke in the NBS chamber is made with a light transmissometer and grossly indicates the density of smoke particulates (solids) and aerosols (liquids). In the case of smoke density, the fire technology literature shows no causal relation at all between smoke production tendency and flashover. Thus, the correlation proposed by industry can be considered somewhat fortuitous and potentially very misleading. Because there is no known causal relationship here, it is very likely that full-scale testing of additional materials would identify materials with low smoking tendencies but high flashover propensity. This type situation was documented in the testing that was used to evaluate seat blocking layers. Urethane cushions had high heat release characteristics and led to early flashovers in the C-133 (reference 10). Yet, they demonstrated substantially less smoke production in the NBS smoke chamber than did VONAR. Vonar had lower heat release rate and its use thereof resulted in delay in the onset of flashover.

In summary, the causal relationship between heat release rate and flashover provides confidence for the generalized use of a heat release rate test for material flammability tests. There is no such basis for confidence in the limited correlations between smoke and aircraft cabin flashover.

## REFERENCES


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