Impact of Glazing on Growing Compartment Fires

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ABSTRACT

As we understand it, the purpose of this conference is to address BFRL/NIST's goal of reducing residential life loss due to fire. Materials are sought that will slow or prevent flashover. Since flashover fires are the killers, the use of such materials will reduce life loss. That make's sense.

But we would like you to think outside that box in two ways, one primary and one secondary. Take the secondary first: Pre-flashover fires also kill. Our conference chair, Dr. William Pitts, published a landmark summary of CO generation in compartment fires in the 5th IAFSS Symposium on Fire Safety Science. He identified an incredibly efficient CO generation mechanism as the vitiated, high temperature combustion of wood where nearly all the pyrolysed carbon emerges as CO.[1] The practical consequence of this is that relatively small fires in small enclosed spaces, such as kitchen cabinets, or in wood filled plena, such as basement ceilings, become killers long before flashover occurs.[2] Another case where small fires are deadly, especially to children, are unventilated enclosures, usually second floor bedrooms. These cases are particularly well described by the salt water modeling methods utilized here at NIST, since this is essentially a filling problem.[3] The solution to both of these significant life safety problems is better, faster detection. Among your research priorities please include improved residential CO and smoke detection systems. Economics of scale should allow residential owners to afford reliable, technically sophisticated detectors.

The primary way we'd like you to think outside the materials box, is in studying the effect of compartment ventilation, particularly by window breaking, on growth to flashover. The glass temperature rise required to break window glass is ~100°C.[4] The gas temperature rise required to produce flashover is ~500°C.[5] So in most fires window breaking occurs before flashover. Examples will be presented, both computational and experimental, of the critical effects of window breaking ventilation on fire growth to flashover.

The well understood mechanism leading to the first crack in window glass during a compartment fire will be described.[4] Comparison with glass breaking experiments will be presented for single pane windows. Heating mechanisms and calculated glass breaking times for double pane windows along with applications to fire hardening residential structures exposed to urban-wildland interface fires will be discussed.[6] The interaction of radiation with multipane window glass will be examined in detail.

One critical problem remains unsolved: When does the window pane fall out? Experiments in an ISO compartment at the FireSERT Centre of the University of Ulster suggest that the glass remains in place until a crack is initiated on each of the four window edges.[7] Bifurcating cracks then propagate and join, isolating a large portion of the pane from its support. That portion then falls out. Research support is needed to convert the current validated window breaking computational model[8] into window fall-out computational models. Predicting the time of glazing fall-out, when part of the wall becomes a new vent, is essential to proper field modeling of compartment fires.[9] In addition, the understanding of glazing fall-out may facilitate the development of fall-out proof windows.

REFERENCES

1. Pitts, W.M., "An Algorithm for Estimating Carbon Monoxide Formation in Enclosure Fires," Fire Safety Science—Proceedings of the Fifth International Symposium , pp 535-546, IAFSS, 1997.

2. Packham, S. H., "Toxicity in the Philadelphia Zoo Fire," BETR Sciences Inc., Salt Lake City, UT, 1996.

3. Steckler, K.D., Baum, H.R., and Quintiere, J.G., "Salt Water Modeling of Fire Induced Flows in Multi-compartment Enclosures," Twenty-first International Symposium on Combustion, pp 143-149, The Combustion Institute, 1986.

4. Pagni, P.J. and Joshi, A.A., "Glass Breakage in Fires," *Fire Safety Science—Proceedings of the Third International Symposium*, eds.G. Cox and B. Langford, pp. 791-802, Elsevier, London, U.K. 1991.

5. Quintiere, J.G., "Principles of Fire Behavior," Delmar Publishing, Albany, NY, 1997.

6. Cuzzillo, B.R. and Pagni, P.J., "Thermal Breakage of Double-Pane Glazing by Fire," Journal of Fire Protection Engineering, **9**(1), pp 1-11, 1998.

7. Hassani, S.K.S., Shields, T.J. and Silcock, G.W., "An Experimental Investigation into the Behavior of Glazing in Enclosure Fire," *Journal of Applied Fire Science*, **4**, 303-323, 1995.

8. Joshi, A.A. and Pagni, P.J., *Users' Guide to BREAK1, The Berkeley Algorithm for Breaking Window Glass in a Compartment Fire*, National Institute of Standards and Technology Report No. NIST-GCR-91-596, Gaithersburg, MD, 1991.

9.McGrattan, K.B., "Modeling Fire Growth and Spread in Houses," this workshop, 2002.