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Effectiveness of Fire Alarm Signals in Sleeping Older Adults

Adults over the age of 65 have a fire death rate that is twice that of the national average and the U. S. Census Bureau predicts that the older population will double over the next thirty years. How do older adults (65-85 years) respond to emergency signals during sleep? In an effort to find out, Dorothy Bruck and Ian Thomas of Victoria University in Australia began a research project in which the auditory arousal thresholds (AAT) of 45 older adults were compared across four signals; the high pitched T-3 (as in current US smoke alarms), a mixed frequency T-3 (500–2500 Hz), a 500 Hz T-3 and a male voice. In the study, sounds increased progressively in volume until awakening occurred. It was found that the median AAT for the most effective signal, the mixed frequency T-3, was 20 dBA lower than the median AAT of the least effective signal, the current US high frequency smoke alarm signal. This finding is consistent with previous research, where the high pitched signal required a significantly louder volume than alternatives to wake sleepers of different ages, including children. Those aged over 75 years are especially at risk for sleeping through high pitched signals, probably due to the normal age-related decline in the ability to hear high pitched sounds.

The results of this study led to the recommendation, "The high frequency alarm signal currently found in smoke alarms should be replaced by an alternative signal that performs significantly better in awakening most of the adult population, once the nature of the best signal has been determined." More details are available in the journal article, "*Comparison of the effectiveness of Different Fire Notification Signals in Sleeping Older Adults*" by Dorothy Bruck and Ian Thomas, Fire Technology, vol. 44(1), March 2008, or contact: dorothy.bruck@vu.edu.au. Additional research by Dr. Bruck has led NFPA to adopt a mixed frequency T-3, 520 Hz square wave signal for their NFPA 72, 2010 edition, for people with mild to severe hearing loss.

In another research project by the National Fire Protection Research Foundation (NFPRF), researchers wanted to determine how to assess and optimize the

Cont. on page 3.

Building Materials and the Fire Performance of Houses

New building materials and innovative new construction products and systems are being used more and more in housing construction today. It is important to understand what impact these materials and products have on occupant life safety under different fire conditions.

The National Research Council of Canada Institute for Research in Construction (NRC-IRC) was asked to undertake research into fires in single-family houses to determine factors that affect the life safety of occupants. The first phase of the experimental studies focused on basement fires and the floor assembly located over a basement.

A number of engineered floor systems, including wood I-joist, steel C-joist, metal plate and metal web wood truss assemblies, and wood joist assemblies were compared in the full-scale fire experiments. A single layer of oriented strandboard (OSB) was used for the subfloor of all assemblies without additional floor finishing materials on the test floor assemblies. This was considered the code minimum since there are no specific code requirements for floor finishing

Facility used in the NRC-IRC study

Cont. on page 2.

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Building Materials and the Fire Performance of Houses, cont.

materials to be installed atop the OSB subfloor. The National Building Code of Canada (NBCC) has no specific fire resistance requirements for the floor assemblies in single-

family houses, therefore, the floor assemblies used in the experiments were constructed with the structural elements unprotected (unsheathed) on the basement side (this was considered as the code minimum). The fuel package created for use in the Phase 1 full-scale experiments had to be repeatable for fire simulation of a basement living area fire. The fuel package consisted of a mock-up sofa constructed with exposed polyurethane foam and wood cribs. The polyurethane foam was the first to be ignited, it produced a relatively severe, fast-growing fire, sustained by the wood cribs. The primary gas products were toxic carbon monoxide (CO) and asphyxiant carbon dioxide (CO2) in a vitiated oxygen (O2) environment.

Several conclusions were drawn: for open basement doorway -- the estimated time to reach untenable conditions in the tests using engineered floor systems was similar to that in the test using a solid wood joist floor system. The tenability limits were reached before the structural failure of the test floor assemblies. For closed basement doorway -- the closed door in the doorway to the basement reduced the rate of fire growth in the fire room and prevented the combustion products from being transported from the basement to the upper levels. The time available to escape before the beginning of untenable (incapacitation) conditions were roughly doubled and the times to reach structural failure were from 50-60 percent longer than with the open basement doorway scenario. For both scenarios, the times for the unprotected engineered floor assemblies to reach structural failure were 35-60% shorter than for the wood joist assemblies.

To learn more specifics of these fire experiments and the conclusions, refer to the complete report: *"Fire Performance of Houses. Phase 1. Study of Unprotected Floor Assemblies in Basement Fire Scenarios. Summary Report."* RR-252 by Su, J. Z., Benichou, N., Bwalya, A. C., Lougheed, G. D., Taber, B. C., Leroux, P., Proulx, G., Kashef, A., McCartney, C., Thomas, J. R., December 15, 2008, at http://www.nrc-cnrc.gc.ca/obj/irc/doc/pubs/rr/rr252/rr252.pdf. If additional information is needed, contact Dr. Su at joseph.Su@nrc-cnrc.gc.ca.

Related research addresses that fact that many residential structures are now being built using lightweight construction materials such as composite wood joists or engineered wood truss systems, instead of traditional solid-sawn lumber. These lightweight construction materials have many advantages including lower costs, reduced use of natural resources and, in many cases, improved dimensional stability. There is indication, however, that they do not provide equivalent performance compared to traditional building techniques when subject to the loading imposed by structure fires, and there have been several incidences of progressive structural collapse due to the failure of lightweight assemblies that have resulted in firefighter injuries and fatalities.

A series of real-scale fire tests conducted at the Underwriters' Laboratories (UL) studied the performance of composite wood joists in both sprinklered and unsprinklered conditions. Tests demonstrated residential sprinklers operating at a flow rate of 13 gpm can arrest fire growth rates. Tests without sprinklers had a total failure of the structure in less than 10 minutes from ignition. Given the open doorway to the fire compartment, test results demonstrated that exposed, lightweight composite wood joists are likely to fail 3-5 min. after compartment flashover. The time to collapse in these tests was from 8-12 min. This small time frame may encourage the fire service to have alternate techniques and tactics when fighting fires with lightweight construction. In addition, there was an observable difference between the sprinklered and unsprinklered scenarios. Sprinklers give life safety advantages not only to the dwelling occupants but also the firefighters.

Complete discussion of the fire tests and the results can be found in the report, "*A Technical Analysis: The Performance of Composite Wood Joists Under Realistic Fire Conditions*" by Melissa Avila, Tyco Fire Suppression and Building Products, may be downloaded from: http://www.tyco-fire.com.

The U. S. Department of Homeland Security's Assistance to Firefighter Grant Program has funded a research program and a web-based training course with UL University entitled "*Structural Stability of Engineered Lumber in Fire Conditions*," based on a UL study which compared a variety of flooring assemblies to the Standard ASTM E119 fire test method. The two-hour course is designed for the fire professional to better understand the fire hazards and to assess risk for life safety to the building occupants and firefighters. The course is free. To find out more and register for the class, see the website: http://www.uluniversity.us/catalog/display.resource.aspx?resourceid=187716.

Composite wood joists before (left) and after fire exposure.
Photo credit: Tyco Fire Suppression and Building Products

Effectiveness of Fire Alarm Signals in Sleeping Older Adults, cont.

performance requirements for alarm and signaling systems to meet the needs of adults over the age of 65. The tasks include characterizing the older adult population by risk factors; conducting a risk assessment of older adults to quantify the potential impact of improving the waking effectiveness of smoke alarms in terms of number of potential lives saved; and studying the human behavior aspects of the problem. The conclusions of the study showed that smoke alarms that are improved to wake all sleeping occupants would reduce the estimated risk to older adults by only 27-32 percent. One major reason for the modest risk reduction is that about three-quarters of sleeping older adults that were fatally injured in fires did not have an operable smoke alarm. Therefore, a primary conclusion to improve fire safety is to increase the use and maintenance of smoke alarms per NFPA 72, so that there are alarms on every level, in bedrooms and the alarms are interconnected, enabling the occupants to be notified simultaneously by all alarms, not just the alarm closest to the fire. For more, see "*Reducing Fire Deaths in Older Adults: Optimizing the Smoke Alarm Signal. Research Project. Summary Technical Report,*" by J. A. Geiman and D. T. Gottuk, http://www.nfpa.org/assets/files/PDF/Research/Summary_Technical_Report.pdf, or contact Dan Gottuk, dgottuk@haifire.com.

The NFPRF also has published earlier works in this series. To view them, go to: http://www.nfpa.org/displayContent.asp?categoryID=1876.

Studying Exit Path Markings in Evacuation Stairwells

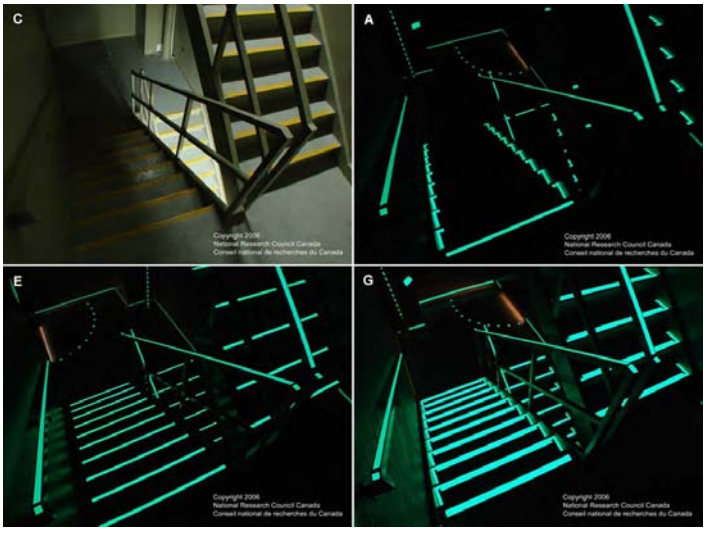
Various installations of photoluminescent material (PLM) as way-guidance systems for use during building evacuations are becoming accepted in North America as a useful and cost-effective safety measure to assist building evacuations. However, such installations may use paint, stripes, and signs in varying quantities and in different locations in the egress route producing quite different results. Except in New York City (Building Code Reference Standard RS 6-1) PLM installation setups are not yet standardized. In addition, response by building occupants to different PLM installation setups has not yet been tested.

To assess the effectiveness these different installations, The National Research Council of Canada and Public Works and Government Services Canada worked together to conduct this research with support from 3 PLM manufacturers: Jalite USA, Jessup Manufacturing Company and Prolink North America. Four windowless stairwells were used in a test building. Three of the four were installed with markings incorporating photoluminescent materials, and the fourth was left as the control stairwell with no photoluminescent marking and lighting reduced to an average level of 37 lux, as if the stairwell was under emergency lighting. Twenty-eight video cameras were used to gather movement time and the behavior of evacuees, and a questionnaire was distributed to evacuees upon exiting the building.

Results from the questionnaire show that overall, 65 to 75% of the respondents felt comfortable going down the stairwells with the photoluminescent markings or the stairwell with reduced lighting. Overall, respondents from the four stairwells studied were positive when asked if the first step to each flight was easy to locate. It was easier, however, for evacuees to identify each step in Stairwells E and G, while it was more difficult to identify each step in Stairwells A and C (see figure on right.) When asked about the ease of locating the last step of each flight, evacuees who used Stairwell A found it particularly difficult to locate the last step of each flight in that stairwell. Stairwell E, with one inch wide marking across each step, received the best appreciation from the respondents. The two stairwells with marking across each step received a better evaluation from respondents than the stairwells with "L" shaped markers or reduced lighting.

The study's findings show that photoluminescent stairwell marking systems appear as a cost-effective addition to, or even a potential replacement for, traditional emergency lighting. Advantages are: no additional consumption of energy, no additional wiring, minimal maintenance, and complete reliability when installed appropriately. Occupant behavior, speed of movement, and subjective appraisal of the material are all in concordance to indicate that photoluminescent markings would be a worthwhile addition improving occupant fire and emergency evacuation safety in office buildings.

The entire report, "*Evaluation of the Effectiveness of Different Photoluminescent Stairwell Installations for the Evacuation of Office Building Occupants*" by Proulx, G. Bénichou, N. Hum, J.K. Restivo, K.N. is available at http://www.nrc-cnrc.gc.ca/obj/irc/doc/pubs/rr/rr232/rr232.pdf.



Images of the four stairwells used in the study. Photo credit: National Research Council

Kelvin Cochran Named as New Administrator of U.S. Fire Administration

Kelvin J. Cochran was publicly sworn as the U.S. Fire Administrator at Fire-Rescue International Conference in Dallas, Texas on August 27th, 2009. With over twenty-eight years in the fire service, Chief Cochran's experience in fire fighting, emergency medical services, hazardous materials, public education, and fire prevention provides a strong foundation for a successful term as the administrator for the USFA. Previously serving Shreveport, LA as a Firefighter, the Assistant Chief Training Officer, Cochran completed his career there as the city's Fire Chief. He also became the President of the Metropolitan Fire Chiefs Association, the 1st Vice President of the International Association of Fire Chiefs (IAFC), and Vice Chairman of Volunteers of America (VOA). Most recently, Cochran served as Fire Chief for the City of Atlanta Fire Rescue Department; where he oversaw thirty-five stations and coordinated homeland security and emergency preparedness initiatives. As the U.S. Fire Administrator, Cochran's main mission is to oversee, coordinate, and direct a national movement in improving life safety, property conservation, and incident stabilization. He will have a direct role in the supervision of fire prevention and safety programs, along with establishing and maintaining development opportunities for emergency responders at all levels.

Kelvin J. Cochran

Photo credit: U. S. Fire Administration

Fire Retardants and their Potential Impact on Fire Fighter Health

On September 30, 2009, more than 60 people participated in a one-day meeting on "Fire Retardants and their Potential Impact on Fire Fighter Health" which was held was held at the National Institute of Standards and Technology (NIST), Gaithersburg, MD. This meeting was the result of a request from the International Association of Fire Fighters (IAFF) and the National Association of State Fire Marshals (NASFM) to have NIST serve as the organizer for a forum to discuss the following questions: What are fire retardants and why are they used? What is the fate of the fire retardants and their combustion products in the environment? Are there increased or decreased health risks to fire fighters created by fire retardants?

Technical experts from the government and private sector representing the fire services, health sciences, fire science, environmental sciences, and product manufacturers from around the world were invited to participate. Presentations were given on the role of NIOSH, environmental regulations, the impact and effect of flame retardants and the toxicity hazards for fire fighters.

After all of the invited presentations had been made the speakers and attendees were invited to suggest gaps in our knowledge and the research needed to support a scientific basis for answering the initial question: Are there increased or decreased health risks to fire fighters created by fire retardants? The discussion expanded to encompass the research needed to fill in knowledge gaps required to answer broader but related questions concerning the combined societal goals of health and safety for the public, fire fighters, and the environment.

A list of these knowledge gaps, as well as the attendees list and presentations, are available on the meeting's website: http://www.bfrl.nist.gov/info/conf/fireretardants/. For additional information about the meeting, contact William Grosshandler, william.grosshandler@nist.gov.

Contact Information:

National Institute of Standards and Technology
100 Bureau Drive, MS 8660
Gaithersburg, MD 20899

Dan Madrzykowski
Email: editor@fire.gov
Phone: 301-975-6677
Fax: 301-975-4052

Department of Homeland Security
FEMA, U.S. Fire Administration
16825 S. Seton Avenue
Emmitsburg, MD 21727

Meredith L. Lawler
E-mail: meredith.lawler@dhs.gov
Phone: 301-447-1421
Fax: 301-447-1049

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Editor: Dan Madrzykowski
Associate Editor: Nora Jason
Issue Administrator: Kellie Beall