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Su, J.; Paterson, B.

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Canada: Setting a town alight – smoke detector research

A recent project saw an entire Canadian town go up in flames and fire researchers were on hand to take full advantage of the smoke, flames and research opportunities, write Joseph Su and Bruce Paterson.

Kemano, British Columbia was a company town built 50 years ago by Alcan Smelters and Chemicals Ltd to support its hydroelectric station. When the station became essentially automated, making the town obsolete, an idea was born. The deserted town was donated to British Columbia's fire services. In addition to becoming a proving ground for firefighting, abandoned houses filled with donated furniture and props made an ideal, full-scale experimental site.

Working with the Underwriters' Laboratories of Canada, researchers in the Fire Risk Management Program of the National Research Council of Canada conducted a series of full-scale home smoke-alarm experiments to study the effects of detector type, number, orientation and location on detector response to various fires in residential settings.

The researchers installed groupings of three types of smoke-alarms: photoelectric, ionization and combination photoelectric-ionization in code required, as well as several other locations in test houses. Two Kemano dwellings served as test sites for the experiments with smoke-alarms installed in the living room, bedrooms, corridor and egress route. One house, 900-square-foot one-storey, was equipped with 35 smoke-alarms (Figures 1-2 show the units installed in the living room and a bedroom). The second house, 1400-square-foot two-storey, was equipped with 20 units. These test houses were unconditioned and initially at the ambient temperatures of the area.

Figure 1. Smoke-alarms installed in a bedroom.

Figure 2. Smoke-alarms installed in the living room.

The researchers recreated fire scenarios that often occur in homes, including both flaming and smouldering fires of wood, paper, polyurethane foam, cotton flannel, upholstered furniture and cooking oil in the bedroom, living room or kitchen. All fires started small and grew slowly to challenge the smoke-alarms .

In the experiments, optical density profiles generally changed more gradually in the areas remote from the fire than in the room of fire origin. The activation optical density for a detector remote from the fire was more reliably determined. The activation optical density was 0.01 to 0.14 m^{-1} for the smoke-alarms in the remote areas. The average of the activation optical density over 13 experiments was 0.065 m^{-1} for the ionization units , 0.043 m^{-1} for the dual units , and 0.046 m^{-1} for the photoelectric units . Observed visibility in the test houses appeared to be sufficient for evacuation purposes in all the experiments.

In general, the results of the experiments backed up expectations regarding the effect of smoke-alarm type on fire detection time. Combination ionization-photoelectric smoke-alarms responded at the same time, or in some instances sooner, in each fire scenario than ionization or photoelectric units alone (ie using combination ionization-photoelectric smoke-alarms can be, in some cases, more effective than using ionization or photoelectric units alone in homes). In addition, smoke-alarms located in every room provided the best early warning of fires. Smoke-alarms of any type outside the room of origin took significantly longer to detect fires if separated from the fire by a closed door.

Part of this experimental study was designed to address the response of smoke-alarms located in the "dead air space" (the triangular area 10 cm from ceiling and wall joints in each direction), where it was assumed difficult for smoke to reach. Several detectors were strategically installed both inside and outside the "dead air spaces" to study smoke-alarm response in these spaces.

Surprisingly, some smoke-alarms installed in the "dead air spaces" were among the first to detect the fires in the experiments. The experiments demonstrated consistently good response of the wall-mounted detectors located in the "dead air spaces". These smoke-alarms responded to the test fires as quickly as and, in approximately half of the cases, even faster than those in the recommended positions (compared with the same type of wall-mounted and central ceiling-mounted detectors). Results were mixed for the ceiling-mounted detectors in the "dead air spaces". However, in approximately two thirds of the cases, these units responded as quickly as, or even faster than, central ceiling-mounted detectors. Further research is needed to determine the effect of room temperature on detector response in the "dead air spaces" as the test house was unconditioned and initially at the ambient temperature of around 12°C in some tests.

This project was part of an ongoing effort in the fire protection community to maximise the benefit of current smoke-alarm technologies to improve residential fire safety. Between 1985 and 1995, Canada's death rate in fires declined by more than 40 per cent. Much of this decline is attributed to the use of residential smoke alarms and the enforcement of the relevant codes and standards.

Joseph Su, National Research Council of Canada, Ottawa, Canada K1A 0R6 Joseph.Su@nrc.gc.ca
Bruce Paterson, Underwriters' Laboratories of Canada, Toronto, Canada M1R 3A9
Bruce.Paterson@ca.ul.com