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Fire Detection and Suppression Studies

By Joseph Su

When the automation of hydroelectric generating facilities meant Alcan Smelters and Chemicals Ltd. no longer needed the town of Kemano, British Columbia, the deserted town was donated to British Columbia's fire services for training and research.

The National Research Council of Canada (NRC), through its Institute for Research in Construction (IRC) Fire Risk Management Program, was invited to conduct a series of full-scale fire experiments at Kemano. This research is part of an ongoing effort in the fire protection community to maximize the benefit of residential fire protection technologies to improve home fire safety. The 40 % decline in Canadian fire fatalities between 1985 and 1995 is mostly attributable to the use of residential smoke alarms and the enforcement of the relevant codes and standards.

To date, the fire research at Kemano has centred on two main areas:

1. Smoke detector response testing, and
2. Evaluation of polyethylene pipe sprinkler systems

The research was conducted by the National Research Council of Canada with the financial support of Underwriters' Laboratories of Canada for the smoke detector research and Wirsbo Canada Ltd. for the sprinkler research.

Three Kemano dwellings served as test sites for the experiments. The test houses were typical wood-frame construction, the internal surfaces were made of typical materials, and typical furniture and furnishings were present. The tests were fire scenarios that often occur in homes, including both flaming and smouldering fires of wood, paper, polyurethane foam, cooking oil, cotton flannel, upholstered furniture, and mattresses with bedding.

Smoke Detector Response Testing

A 900-square-foot one-storey house and a 1400-square-foot two-storey house were used for testing smoke detector response. Multiple detectors were installed in the bedrooms, living room and corridor of the one-storey dwelling. In the two-storey dwelling, groupings of photoelectric, ionization and photoelectric-ionization combined detectors were installed in the living room, staircase landing, three bedrooms and corridor. Detectors were installed in code-required locations and elsewhere to study the effect of type, number, location and orientation on smoke detector response. All windows were closed during each experiment.

The research has generated real-scale experimental data about the impacts of type, number, location and orientation of smoke detectors on occupant warning time. The information obtained from the testing includes optical densities of smoke at various locations, response times of all detectors, temperatures in the fire compartment and egress route, concentrations of carbon monoxide, and video records.

In general, the test results supported previous findings. Ionization-photoelectric combined detectors performed as well as or better in each fire scenario than ionization detectors or photoelectric detectors alone. Smoke detectors located in every room provided the best early warning of fires. Smoke detectors of any type outside the room of origin took significantly longer to detect fires if separated from the fire by a closed door. If the doors were open, they detected the fires at the times reasonably close to (in some cases earlier than) the activation times of the detectors inside the room of fire origin.

Surprisingly, wall-mounted smoke detectors installed in the "dead air space" (the triangular area 10 cm from ceiling and wall joints in each direction) were among the first to detect fires. They responded as fast as or faster (in half the cases) than the similar type detectors installed in the recommended wall and ceiling positions. Because it has been thought this area is not effective for detection, Canadian standards have required that detectors not be installed in this area. This indicates further investigation is required.

Evaluation of Polyethylene Pipe Sprinkler Systems

A wood-framed bi-level house (900 square feet per floor, 1800 square feet total) was used for the evaluation of a cross-linked-polyethylene (PEX-a) pipe sprinkler system. A residential sprinkler system with 11 quick response sprinkler heads (temperature rating of 68.3°C or 155°F) was designed and installed (in accordance with NFPA 13D) in a basement recreation room and throughout the main floor. The system was designed to prevent flashover in the room where fire originated and to allow response time for the fire department.

The sprinkler system was tested four times for two fires originating in a basement recreation room, and one time each for the ground floor bedroom and the living room. Smoke detectors, carbon monoxide detectors and heat detectors were installed in the experimental house. The observations made included temperatures in the fire room and egress route, CO and CO_2 concentrations, activation times of sprinklers and smoke, heat and CO detectors, and video records of smoke movement.

In the recreation room, the plastic pipes and fittings were installed on open wood joists. The system was exposed to temperatures as high as 140°C in two experiments. After exposure to temperatures above their rated temperature of 93°C (200°F) at 552 kPa (80 psi) for 140 seconds, the pipes and fittings were not visibly damaged, and the sprinkler system was successfully actuated and controlled the fire.

In all four recreation room experiments, a single sprinkler head controlled and contained the fire within 1 minute of the sprinkler activation. The sprinkler water spray cooled down the fire compartment and limited the damage to the furniture near the ignition source. The walls, open wood joists or ceiling of the fire rooms had soot deposition but no major damage. For those experiments done with the fire room door closed, the fire did not affect temperature or visibility along the egress route.

The effectiveness of heat and smoke detectors was also investigated in the sprinkler experiments. As expected, the heat detectors, which were rated at 57°C (135°F) and a temperature rise of 8.4°C/min (15°F/min), were always actuated earlier than the sprinkler. Smoke detectors installed on the egress route were actuated before the sprinkler when the fire room was open to the egress

route but after the sprinkler when the fire room door was closed.

The Kemano townsite has provided an excellent opportunity for full-scale fire testing. The valuable information obtained from the testing of detection systems and polyethylene pipe sprinkler systems will contribute to enhanced fire safety and provide a firm basis for further research.

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