occupied spaces. Reviewing dated indoor air quality reports, testing, adjusting, and balancing reports, and lighting surveys is generally not acceptable.

In addition to randomly sampling the occupied spaces in the building, the PE should also make every effort to perform a walk-through inspection of occupied areas with observed signs of occupant discomfort related to the thermal conditions, such as:

- Oscillating table fans, window fans, or personal fans
- Personal space heaters
- Open windows
- Window or through-the-wall air conditioners
- Covered or modified supply air diffusers

Note: It is the responsibility of PEs to decide, in their professional opinions, whether the building meets the letter and spirit of the standard concerning all the data collected and observations made.

Illumination Levels

The PE shall measure the illumination levels in a random sampling of spaces, both occupied and unoccupied (e.g., office space) and generally unoccupied (e.g., parking facilities and service spaces). Per the Illuminance Selection Procedure in the *IESNA Lighting Handbook*, the minimum acceptable horizontal, maintained illumination levels are provided in Table 5 on page 11.

Case Study

[In each issue, **IEQS** *presents a case study on an indoor air investigation in a particular building. The information in the cases comes from various sources, including published material, reports in the public record, and, in some cases, reports supplied by the consultants involved in the case.* **IEQS** *presents a variety of approaches to investigation and mitigation implemented by consultants with a broad range of experience, philosophies, and expertise. Inclusion of a particular case study in the newsletter does not imply* **IEQS***'s endorsement of the investigative procedures, analysis, or mitigation techniques employed in the case.* **IEQS** *invites readers to submit comments, suggestions, and questions concerning the case. At the discretion of the editors, correspondence may be presented in a future issue.]*

Family's CO Poisoning Results from an Unusual Source

Usually, we connect carbon monoxide (CO) poisoning to such common sources as vehicle exhaust, appliance spillage, and misuse of combustion appliances indoors. However, public health authorities in Quebec, Canada, recently reported a case of CO poisoning that resulted from an underground source, caused by nearby blasting at a sewer construction site.

Pierre Auger of the Quebec Environmental Health Service and colleagues reported the case in the July 1999 issue of *Environmental Health Perspectives* (vol. 107, no. 7, pp. 603-605).

The case involves a private home where the occupants — a 33-year-old male and a 29-year-old female — began experiencing symptoms consistent with CO poisoning. Originally thinking they were suffering from food poisoning, the couple suffered with the symptoms for a day before being taken to a hospital emergency room by a relative.

Laboratory tests revealed that the male had a carboxyhemoglobin (COHb) level of 29.6% and the female had a COHb level of 24.7%. Because the male had experienced periodic loss of consciousness, doctors placed both in a hyperbaric chamber. Three weeks later, both were asymptomatic upon examination.

Investigation

The house in question was a bungalow — 8.6 meters (m) by 9.8 m — that had an unfinished basement. There was no attached garage or other obvious source of CO infiltration. However, the occupants told investigators that on the three days before the onset of symptoms, workers at a nearby sewer construction site had been using explosives. The last explosives detonated at about 5 pm on the day before the symptoms began. The female resident of the home told authorities that during the final explosion, she heard a cracking sound coming from the foundation.

An initial investigation indicated CO concentrations in the house ranging as high as 500 parts per million (ppm). The highest reading occurred in a floor drain in the basement, while the reading at the southeast corner of the basement, closest to the blasting site, showed a concentration of 367 ppm. A basement window well on the opposite corner of the house had a CO concentration of 250 ppm.

Following the initial measurements, investigators opened the windows of the house. They also dug a trench along the east side of the house and recorded CO concentrations up to 700 ppm in the trench.

Following this, they dug a trench on the west side of the house and installed pipes fitted with mechanical ventilation under the foundation. The CO levels began dropping and the decrease continued for several days until measurements showed no CO contamination. The investigators then continued monitoring for several days without detecting any gas.

Conclusions

The investigators determined from the COHb levels and the CO in the ambient air that the occupants had been exposed to about 500 ppm of CO for up to 16 hours. The investigators were also certain that the gas had entered the house from the southeast corner, but had several hypotheses to explain the occurrence.

The first hypothesis was that the CO came from petroleum waste combustion, but investigators rejected this based on soil analysis. They also rejected a theory of a natural methane pocket from the explosives. Sampling results had shown that methane levels in the house were too low for this hypothesis to hold.

They then focused on the possibility that the CO originated solely from the explosives. Workers had used two products in the construction work. The first was a mixture of ammonium nitrate, sodium nitrate, and fuel oil. The second was a mixture of ethylene dinitrate and glycol/nitroglycerine. Both of these mixtures generate large amounts of CO.

However, the investigators also considered the possibility that other factors increased the amount of CO produced. They determined that the contractor, being behind schedule, had set the explosives under a thick layer of overburden. The investigators theorized that this produced an oxygen deficiency and increased CO concentrations. They also noted that the rock in which the blasting occurred was a limestone that was high in carbonates. This, with intense heat, could generate CO.

As a result, the investigators concluded that the last explosion near the house modified the rock structure under the house and caused a large proportion of the gas to accumulate under the southeast corner. A hidden crack in the foundation wall may have allowed the gas to enter the dwelling.

Update

The report noted in an epilogue that the authors subsequently became aware of a similar situation that occurred in another town in Quebec. However, this case involved six houses, in which CO concentrations ranged from 125 to 600 ppm. Out of 16 occupants, 6 were affected with COHb concentrations ranging from 2% to 24%. Three occupants required treatment in a hyperbaric chamber.

In that case, investigators could find no causes for the CO buildup in the houses other than nearby blasting in a local sewer project. After authorities dug trenches to ventilate the underground area, the CO concentrations in the houses decreased below measurable concentrations. After blasting operations resumed, five houses remained normal, while the concentrations in the sixth house increased. Subsequent measurements found concentrations in a nearby manhole as high as 1,100 ppm. Workers then constructed ventilations shafts under the affected house and used mechanical ventilation to remove residual CO.

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