

Case Study

Air Quality Testing in Indoor Ice Arenas

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Episodes of carbon monoxide (CO) or nitrogen dioxide (NO₂) intoxication have been documented in indoor arenas. While a national CO/NO₂ exposure registry does not exist, news reports indicate the lack of installation and/or use of adequate ventilation (HVAC) systems in these locations, coupled with extended exposure during certain high-risk periods (for example, tournaments requiring repetitive ice maintenance), hospitalizes an estimated 250 individuals per year. Also of concern is the role of ultrafine (less than 100 nm) particulate matter (UFP), which is found in the exhaust train of some maintenance equipment.

Aware of these concerns, the NBC television show *Today* commissioned us to produce a study to identify risks and provide public guidance. We chose the Revolution Ice Centre in Pittston, Pa., for our study because it possesses gasoline-, propane- and electrically powered ice surfacing equipment. We interviewed maintenance operators and developed tests for each of these scenarios.

Calibrated test equipment for the referenced toxins was placed in three locations near the ice surface (in player breathing zones) and in the arena stands. We also used handheld equipment to spot-test the surfacing equipment operator's position and other areas of the building. Table 1 shows information about recommended practices for air quality in ice arenas.

Test Results

Within five minutes after initiating testing, levels of CO in the arena reached 20 ppm. Levels elevated to 60–80 ppm within 40 minutes, and the testing was cancelled due to exceedance of the Pennsylvania Department of Health (PA DOH) Public Health Action Guidelines prior to the one-hour timeframe.

Table 1. Guidelines and Standards for Air Quality in Ice Arenas*†

Guideline/Standard	CO	NO ₂
Pennsylvania Department of Health Ice Arena Public Exposure Guidelines	Corrective action: 20 ppm/1 hour Immediate evacuation: 100 ppm	0.25 ppm/1 hour Immediate evacuation: 2 ppm
Rhode Island Health and Safety: Air Quality in Ice Arenas	Corrective action: 35 ppm/1 hour Immediate evacuation: 100 ppm/1 hour or 200 ppm (c)	
Massachusetts State Sanitary Code: CH XI	Corrective action: 30 ppm (c) Notification levels: 60 ppm (c) or 6 consecutive samples exceeding 30 ppm Evacuation level: 125 ppm	Corrective action: 0.5 ppm (c) Notification level: 1 ppm (c) Evacuation level: 2 ppm (c)
Minnesota Enclosed Sports Arena Rule: 144.1222	Corrective action and notification levels: 30 ppm (c) Evacuation level: 125 ppm	Corrective action and notification level: 0.5 ppm (c) Immediate evacuation: 2 ppm (c)
U.S. EPA Ambient Outdoor Air Quality Standards	9 ppm/24 hours	0.1 ppm/1 hour
OSHA Permissible Exposure Limits (Private Sector Employees)	50 ppm/8 hours (40 hour work week)	5 ppm (ceiling concentration—not to be exceeded)
NIOSH Recommended Exposure Limits—(All Employees)	35 ppm/10 hour day (40 hour work week)	1 ppm (30-minute exposure limit)

*No state has recommended exposure limits for UFP; adverse health effects have been observed at levels of 100,000 p/cc. †(c) indicates ceiling concentration.

CO at 20 ppm was recorded in other areas of the building. When the testing was stopped, the site was force-ventilated by positive pressure (PPV). By this time, CO was uniformly distributed through the arena (40–60 ppm); it took approximately two hours to bring levels below the 9 ppm EPA Ambient Air Quality Standard (AAQS), using PPV. One spot reading of 0.2 ppm NO₂ was recorded during the test regimen (ice area). During operations, UFP levels throughout the arena elevated to 300,000 p/cc. These diminished to ~26,000 p/cc after two hours of ventilation.

When the test was repeated with electric resurfacing equipment, no increases in CO (which was <9 ppm at the time) were noted. UFP levels were recorded at ~26,000 p/cc through the test. No NO₂ was recorded.

Recommended Actions

Based on our test results, we recommend ice arenas take the following actions:

- Public health outreach relative to air quality hazards in ice arenas. This is particularly important during hockey or skating tournaments, and should include exposure symptomatology.
- Installation of air monitoring equipment in arenas where fossil-fueled equipment is used and planning for replacement with alternative equipment.
- Corrective action programs when CO, NO₂ or UFP are identified at target levels. ✓

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