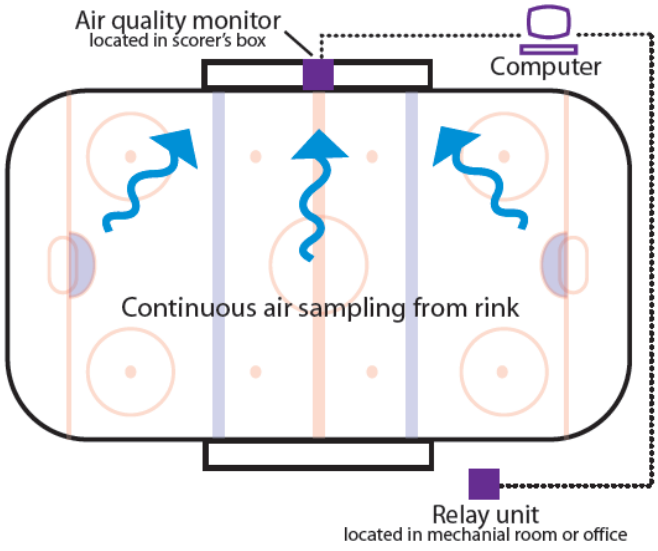
# <u>Case Study</u>: PPM Technology's *Mini IAQ Profile Monitor* system used by ice rinks to monitor levels of harmful gases.

- **Ice rinks and arenas vulnerable to harmful pollutants.**

Indoor Air Quality (IAQ) is a significant concern in ice rinks and arenas; these facilities are especially vulnerable to the affect of an unhealthy indoor environment as fuel-burning equipment such as ice resurfaces are used indoors.

PPM Technology and our partner in the United States, Joel Anderson of *Precision Quality Consulting* have supplied a number of **Mini IAQ Profile Monitor** units to various ice rinks/arenas with the aim of providing a safe environment for users and employees of the rinks. Regulations and guidelines regarding the emission of pollutants in ice rinks/arenas have been introduced at local and state level in many US states and a number of Canadian provinces.

An example of the most stringent standards aim to reduce hydrocarbon emissions by about 71 percent, nitrogen dioxide emissions by about 80 percent, and carbon monoxide emissions by about 57 percent.




PPM Technology's wireless monitoring unit is installed in the ice rinks *'scorer's box'*; the monitor continuously receives air samples from the rink, readings are transmitted in real-time to the rink office computer which stores the readings on easily read graphs.

Multiple alarm levels are available to activate exhaust fans, dehumidification systems, or signal an auto dialer. Energy savings can be achieved by operating the exhaust system more efficiently.

An example of one American health department, which has been pro-active in dealing with issues relating to levels of pollutants in ice rinks, is the Minnesota Department of Health.

- They have inspected 282 arenas since 2006.
- Have found levels above the limits during 12 inspections.
- 3 credible cases of people becoming ill reported to MDH.
- Exceedances involved CO and/or NO2/
- Propane resurfacer used in 13 cases.
- Gas edger used in one case.
- Propane edger possibly used in one case.

The recommended actions by the MDH for levels are indicated in the diagram below, these levels are currently under review; the hope is the new level will help ensure a safer skating environment.

| CO | No Action | Action level | Evacuate |
|---|---|---|---|
| Current | ≤ 30 ppm | 30-125 ppm | >125 ppm |
| Proposed | ≤20 ppm* | 25-85 ppm | >85 ppm** |

*20 ppm based on 2.5% carboxyhemoglobin (COHb)
** 85 ppm based on 4.0% COHb from the AEGL-2

- *The MDH recommend immediate corrective actions if levels fall between 3-125ppm – levels need to be reduced within one hour using ventilation or other methods.*

The recommended actions by the MDH for levels of Nitrogen Dioxide are indicated in the diagram below; these levels are also currently under review, the proposed limits aim to ensure a safer indoor environment.

| $NO_2$ | No Action | Action level | Evacuate |
|---|---|---|---|
| Current | ≤ 0.5 ppm | 0.5-2 ppm | >2 ppm |
| Proposed | ≤ 0.3 ppm* | 0.3-2 ppm | >2 ppm** |

* 0.3 ppm based on precision and validity of air monitoring
** 2 ppm based on indicators of early lung damage

- *The MDH recommend immediate corrective action if levels fall between 0.5-2ppm – levels need to be reduced within one hour using ventilation or other methods.*

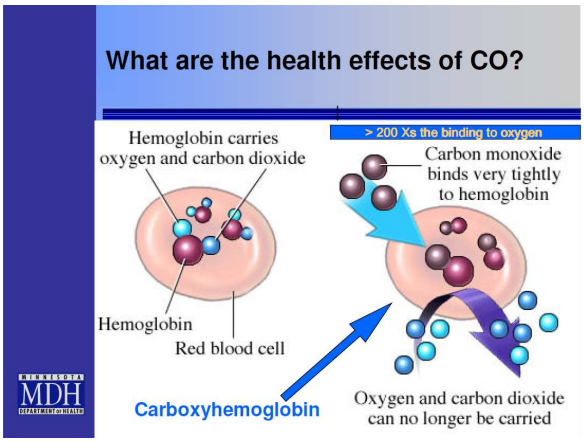
Legislation for maximum levels of exposure to Carbon Monoxide and Nitrogen Dioxide in ice rinks has also been introduced in a number of Canadian provinces. This legislation demands that during every hour that the ice is used by the public, the average carbon monoxide level shall not exceed 25 parts per million (ppm). And the average nitrogen dioxide level must not exceed 3 ppm.

The parameters commonly monitored in ice rinks/arenas are temperature, relative humidity and also carbon monoxide and nitrogen dioxide both these pollutants are released from the ice re-surfacing vehicle; which is a small truck-like vehicle used to clean and smooth the surface of an ice rink. The equipment will typically produce either higher CO or higher NO2 levels but not both at the same time.

Exposure to low levels of carbon monoxide (about 20 ppm) over an extended period (Approximately 8 hours) is reported to result in the absorption of sufficient amounts to cause slight changes in temporal judgment or visual activity. These changes are

slight and unlikely to be noticed by the affected person. Pre-existing respiratory or circulatory ailments in individuals can be aggravated when exposure levels increase above 30 ppm.

As carbon monoxide exposure increases above 50 ppm, headaches are more frequently reported. Depending on levels in excess of 50 ppm, and the duration of exposure, symptoms will progress from headaches and drowsiness to rapid breathing, nausea, and vomiting. At extremely high levels (greater than 800 ppm) there is a risk of death.




**Sources of carbon monoxide at ice rinks/arenas include:**

- Ice resurfacer (gasoline, propane or natural gas).
- Ice edger (gasoline, propane or natural gas).
- Fuel powered floor sweepers.
- Fuel powered lift trucks.
- Gas fired water heaters.
- Special events equipment.
- Vehicles idling in the parking facilities in close proximity to the building.

When diesel engines are used in place of natural gas, propane or gasoline; nitrogen dioxide rather than carbon monoxide tends to be the contaminant of most concern.

Nitrogen Dioxide (N02) is a dark brown or reddish brown toxic gas with a pungent, acrid odour. It is present in vehicle and fueled power equipment as unwanted by-products of firing processes at high temperatures.

It can also be found in emissions from combustion appliances gas stoves, furnaces, diesel generators, etc. Nitrogen Dioxide causes shortness of breath, irritation to the eyes, mucus membrane, lungs and other respiratory organs.

You can detect nitrogen dioxide by odour at 5 ppm or below. At this low level (1 to 5 ppm), slight levels of airway resistance may be noted. At moderate levels of 15 to 25 ppm, it can be irritating to the eyes, nose and throat. At higher levels, above 25 ppm more severe symptoms can develop which include pneumonia or bronchiolitis. At these high concentrations there are usually three stages of response.

In the first stage, coughing and irritation, irregular heart beat; nausea and fatigue may occur but will subside once exposure stops. In the next stage, the person feels fine. The last stage occurs within 6-36 hours when the person may experience symptoms such as rapid breathing, chest pain and flu-like symptoms

Depending on the severity of exposure, symptoms can progress to include inflammation of the lungs (pneumonia) or accumulation of fluid in the lungs (pulmonary edema). Individuals with pre-existing respiratory system disorders, such as asthma, may be more sensitive to the effects of nitrogen dioxide.

There have been a number cases where elevated levels of Nitrogen Dioxide in ice arenas have led to symptoms such as serious breathing problems, chest pain, nose bleeds, eye irritation and vomiting blood. On January 8, 2009, twenty-two individuals

fell ill due to exposure to nitrogen dioxide in an Oldsmar, Florida ice skating rink while at hockey practice. Eighteen players along with three adult coaches developed symptoms including many were taken to doctors by parents, some to ER's and two were hospitalised. One coach reported to news media he thought he was having a heart-attack.

Other severe symptoms can also develop which can include pneumonia or bronchitis. At high concentrations there are usually three stages of response. In the first stage, coughing and irritation, irregular heart beat; nausea and fatigue may occur but will subside once exposure stops. In the next stage, the person feels fine. The last stage occurs within 6-36 hours when the person may experience symptoms such as rapid breathing, chest pain and flu-like symptoms.

PPM Technology's IAQ Monitor has been supplied to a number of ice rinks concerned with these issues, they have predominately been in the United States.


In many ice rinks testing for Carbon Monoxide and Nitrogen Dioxide only takes place on a once a week basis, this monitoring method is unreliable as the levels of pollutants are subject to hourly, daily, and seasonal fluctuations, and of course the pollutant levels will very greatly depending on how recently the ice-resurface vehicle has been in use.

The Wireless IAQ Monitor eliminates the problems associated with single-point measurement, samples are taken continuously, this allows the user to identify any patterns and investigate IAQ complaints. If a dangerous level of a pollutant is detected the software will trigger alarms, which if necessary allows the building to be evacuated immediately before the pollutants have an affect on the occupants health.

The alarm can also be used to give a warning that the gas concentration level has reached a non-critical but concerning level. It can then trigger the air-conditioning system in response before the gas reaches a critical level.

**Applications and Functions of the IAQ Profile Monitor system;**

- IAQ complaint investigation and analysis,
- HVAC system performance analysis.
- Health and comfort assessment.
- Labour saving and cost-effectiveness.
- Energy efficiency.
- Ensuring safety of building occupants.
- To comply with national and regional safety regulations and laws.

A wireless gas detection system has many advantages over conventional detection techniques. First, there is the reduced installation costs—a wireless system means there is no need for expensive cables and underground cable conduits. The entire system can be configured and operational in less than a day.

A wireless IAQ sensor network also has the ability for detailed monitoring in inaccessible locations where a wired infrastructure is not viable or possible. A

building-wide network of monitoring units can be achieved—this means a more detailed representation of indoor air quality in general.

The IAQ Profile Monitor uses the low-power, high-performance Zigbee wireless mesh network to communicate. A large number of units can be linked using this mesh networking; the system can show precise changes in concentration of the selected parameters in various locations over time.

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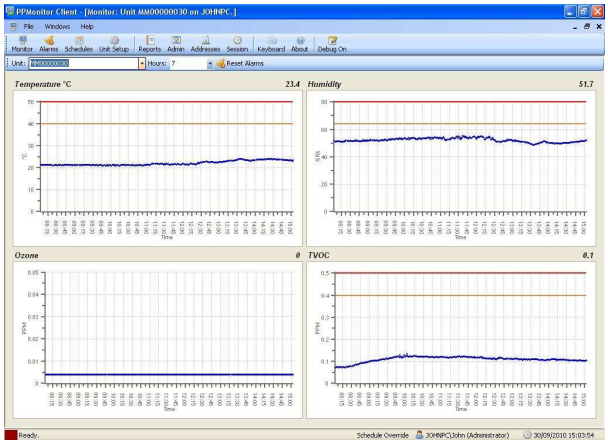


The collected data is presented on the controller PC in real-time. The graphical display enables the user to identify trends and patterns in the sampling; simple user interfaces enable easy use and operation of the software. The user can monitor and control each individual unit and sensor using the software. It is possible to create monitoring schedules using the software, which is ideal if monitoring only needs to take place for a set period of time (*e.g.* during rink opening hours only).

The system is able to collect a complete and accurate record of IAQ, presenting the data necessary for effective air quality management within the ice rink environment.