State of Minnesota
Minnesota Department of Health
Environmental Health Division
Indoor Environments and Radiation Section

In the Matter of the Proposed Rules of the Minnesota Department of Health Relating to Enclosed Sports Arenas, *Minnesota Rules*, Chapter 4620. AR # 502

Statement of Need and Reasonableness

August 22, 2012

MINNESOTA DEPARTMENT OF HEALTH

STATEMENT OF NEED AND REASONABLENESS

PROPOSED MINNESOTA RULES, CHAPTER 4620

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I. INTRODUCTION

The Minnesota Department of Health (MDH or the department) regulates the air quality in enclosed sports arenas to protect the public from exposure to harmful levels of combustion byproducts. Indoor ice arenas provide the venue for the ice skating and hockey playing that are essential to Minnesota's culture. Indoor motorsports arenas host events that feature vehicles such as monster trucks or motocross motorcycles. Both types of arenas use equipment that emits carbon monoxide (CO) and nitrogen dioxide (NO_2). These contaminants must be carefully monitored when the general public is present. But due to the differing nature of these activities, each carries its respective considerations for regulation. This Statement of Need and Reasonableness (SONAR) supports MDH's revision of its Permanent Rules Relating to the Control of Air Quality Conditions in Enclosed Sports Arenas (Enclosed Sports Arena Rules or the rules). The revised rules are available at:
http://www.health.state.mn.us/divs/eh/indoorair/arenas/rule/2009revision/index.html

Maintaining ice surfaces for skating entails resurfacing and ice edging, operations that usually employ internal combustion engines. Likewise, the racing, competing, or demonstrating that make up motorsports events by their nature use internal combustion engines. Combustion byproducts are released into the air. The department has regulated air quality in enclosed sports arenas since April 19, 1973, when the Minnesota State Board of Health adopted the MDH Enclosed Sports Arena Rules by resolution, using their authority under Minnesota Statutes, 144.12 (14) (1971) (now codified as Minnesota Statutes, 144.1222, subdivision 3). In 1977, Minnesota's Enclosed Sports Arena Rules were revised primarily to comply with a new rule numbering scheme.

MDH adopted the current Enclosed Sports Arena Rules in 1977 to ensure that enclosed sports arena operators who operate internal combustion engines do so in a manner that protects the health of facility participants and spectators. The rules require that arenas be certified by MDH, maintain acceptable air quality, measure carbon monoxide and nitrogen dioxide concentrations on a regular basis, and take corrective action when contaminant levels exceed established action levels. The current rules, however, do not readily accommodate newer air-monitoring technologies. Thus, these outdated rules confuse the regulated community and are often difficult to enforce.

At one time, there was a general expectation that ice arenas would eventually universally adopt electrically powered ice maintenance equipment and therefore eliminate the need to be regulated. This conversion, however, has been slow in coming due to the high cost and limited availability of such equipment. The majority of ice arenas continue to rely on maintenance equipment powered by internal combustion engines fueled by gasoline or propane. Recent media reports of carbon monoxide and nitrogen dioxide-poisoning episodes occurring at indoor ice arenas elsewhere in the U.S. highlight the continued potential health impact of poor air quality in such settings.

Indoor motorsports facilities and events, while perhaps less common than they once were, continue to operate in Minnesota. When internal combustion-powered engines that propel motorcycles, go-karts, and monster trucks are operated in indoor arenas, significant combustion-byproducts levels can be found. The existing rules only minimally address these types of arenas and events.

The department's objectives for the rules revision are:

- clarifying air monitoring and documentation requirements;
- ensuring that information from current published studies on the health risks of combustion byproducts are incorporated into appropriate action levels;
- separating the rules into distinct sections for ice arenas and motorsports arenas and events;
- prescribing more specific requirements for motorsports events and routine operation of indoor motorsports arenas; and
- recognizing the use of modern air-monitoring technology without requiring a variance or special approval.

In the fall of 2009, the department held a series of meetings around the state to inform the regulated and affected stakeholders of the problems with the existing rule and MDH's intentions to revise the rule. Department staff discussed the rulemaking process, provided information about desired rule changes, and provided an informal opportunity for attendees to provide comment to the rulemaking team. Approximately 75 interested parties attended the meetings which were held in Bemidji, Saint Cloud, Mankato and Saint Paul.

To advise the department on the rule amendments, MDH appointed an advisory committee. This committee considered both ice arena and indoor motorsports rules. For the ice arena rules it met ten times for two and one-half hours each time to develop its recommendations. To consider motorsports issues, it met for one day with meetings in the morning and afternoon. In addition, the department appointed a separate sub-committee that met twice for a total of four and one-half hours to provide advice regarding the contaminant action levels.

The two primary combustion byproducts regulated under the 1977 Enclosed Sports Arena Rules, CO and NO_2, are commonly recognized air pollutants and fall within the U.S. Environmental Protection Agency's (EPA's) National Ambient Air Quality Standards (NAAQS) for outdoor air. Several diverse organizations, agencies, and researchers have enforced or recommended air quality standards, regulations, or guidelines for ice arenas. These are summarized in Appendix A.

Exposure to high levels of CO can be life-threatening, and CO poisoning is the leading cause of death due to poisoning in the United States (ATSDR 2009). Inhaling lower levels of CO can result in headache, nausea, vomiting, dizziness, blurred vision, confusion, chest pain, weakness, and difficulty breathing. People who have heart or lung disease are more vulnerable to the toxic effects of carbon monoxide, as might be pregnant women and fetuses.

Breathing high levels of nitrogen oxides, including NO_2, can cause rapid burning, spasms, and swelling of throat and upper respiratory tract tissues, reduced oxygenation of body tissues, a build-up of fluid in the lungs, and even death. Exposure to NO_2 at lower levels can irritate the eyes, nose, throat, and lungs; causing coughing, shortness of breath, fatigue, and nausea (ATSDR, 2002). Exposure to lower levels of NO_2 can also result in fluid build-up in the lungs one or two days after exposure. Exposure to NO_2 can also lead, in some exposed people, to Reactive Airway Dysfunction Syndrome (RADS), a form of chemical or irritant-induced asthma. RADS can result from a single acute, high-dose exposure. The National Academies of Science has concluded that sufficient evidence exists for an association between exposure to nitrogen dioxide and exacerbation of asthma (IOM 2000).

General Justification for the Regulation of Air Quality in Enclosed Sports Arenas

Indoor Ice Arenas[1]

Air quality in indoor ice arenas affects public health. The popularity of ice skating and ice hockey continues to climb in Minnesota, with new arenas added every year, despite the current economic recession. There are a reported 70,000 regular users and a larger number of occasional users of ice arenas in Minnesota.

In 1966, the first incident of CO poisoning from an ice arena was reported to MDH. The gas emanated from the ice maintenance machines' exhaust. MDH received reports of, but could not confirm, other alleged instances of illness in 1969. MDH tested for CO and NO_2 in 19 arenas with no known history of problems, yet found elevated levels of these pollutants in many of them. In February 1971, the department released a report describing the potential hazards with internal combustion ice maintenance machines, including pollutant measurements (Andersen 1971).

MDH began regulating indoor air quality in enclosed sports arenas in 1973 when it adopted its first Enclosed Sports Arena Rules. At that time, MDH did not inspect routinely, investigating only complaints or reported instances where combustion byproducts exceeded action levels. During the late 1980s, the public or arena operators reported 16 arenas with elevated CO or NO_2 (Oatman and Zetterlund 1990). When 116 participants and attendees were sickened by nitrogen dioxide during and after a hockey game at a Minnesota ice rink in 1987, the severity of this problem garnered new attention. (Hedberg et al 1989).

In addition to these three Minnesota studies, there are at least 32 published studies describing exposure to CO or NO_2 in indoor ice arenas in the U.S. and other countries. Eighteen of these studies reported poisonings. And carbon monoxide or nitrogen dioxide exposure from the ice maintenance equipment was identified as the cause of the skaters and other arena users' poisoning. Other general studies of air testing in ice arenas that had no known history of problems also revealed elevated pollutant levels in some arenas. Exposures to high levels of CO and NO_2 in ice arenas are associated with long-term health effects, according to the scientific literature. Recent studies show poisonings and elevated concentrations have persisted, despite improvements in emission control technologies. There are also numerous media reports of poisoning incidents, including Minnesota media.

Serious incidents in Minnesota and elsewhere, coupled with an increased awareness of the potential hazards, prompted MDH to enforce the Enclosed Sports Arena Rules more rigorously in the mid-2000's. Starting in 2006, the department moved from its customary practice of

[1] For a detailed discussion on indoor air quality in ice arenas, see Appendix B.

inspecting some arenas, responding to public complaints, and reviewing quarterly air quality results that arenas submitted, to routinely inspecting all arenas, educating ice arena operators, and taking enforcement action against arenas that violate the rules. MDH continues this enforcement strategy today.

MDH's enforcement has shown that rule violations continue in some indoor ice arenas, but operators have made significant improvements. From June 2006 to February 2011, MDH inspected all 274 indoor ice arenas at least twice. During this period, the department identified 18 arenas that exceeded the current air quality action levels, which are 30 ppm for carbon monoxide and 0.5 ppm for nitrogen dioxide. Thirty arenas had other major rule violations, such as failing to test air quality weekly. Since 2006, MDH has also received approximately twelve complaints about indoor air quality, and there were three cases of apparent illness, according to information reported by arena operators or first-responders. MDH has issued orders, and has verified improvements in these arenas through follow-up inspections and documentation submitted by the arenas. Arenas can also have minor rule violations.

Compliance rates are improving. During the second round of inspections, the average number of violations per facility was 1.6. The average number of violations dropped to 0.8 during the 3rd round of inspections, which started in February 2011. These statistics demonstrate the effectiveness of MDH's ongoing enforcement.

Indoor Motorsports Arenas[2]

Air quality in indoor motorsport arenas and at special motorsports events also affects public health. The internal combustion engine-powered vehicles operated in Minnesota facilities include midget cars (go-karts), monster trucks, motorcycles, tractors, automobiles, snowmobiles, and remote controlled cars. These vehicles use gasoline, nitromethanol, and nitromethane for fuel. Many engines do not, however, use catalytic converters. The tailpipe can emit significant amounts of pollutants, carbon monoxide in particular. Go-karts, for example, can emit almost five times as much CO as automobiles.[3]

Elevated CO levels have routinely occurred in U.S. and Canadian motorsports arenas. At least ten published studies described exposure to CO or NO_2 in motorsports arenas. These concentrations were measured in a variety of large and small arenas, including monster truck events, motocross facilities, and go-kart facilities. High levels developed despite the buildings' high ventilation rates. Concentrations fluctuated quickly, due to rapid changes in the number of vehicles operating, types of vehicles, lengths of breaks, and ventilation settings. Nitrogen dioxide was also detected, although CO concentrations were much higher relative to their respective levels and posed the greater health concern. Some published studies have documented adverse health effects associated with exposure to carbon monoxide in indoor motorsports arenas. There are also a few media reports of air quality problems in motorsports arenas.

Since 2006 when MDH increased its enforcement, MDH has seen elevated CO in some Minnesota enclosed motorsports arenas during inspections, including readings over 100 ppm,

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[2] For a detailed discussion on indoor air quality in motor sports arenas, see Appendix C.
[3] Jetex Exhaust, Ltd http://www.kartalyst.com/website/kartingemissions.php

which is more than three times the acceptable quality standard of 30 ppm. Heightened awareness from enforcement in the last three years has led to stepped up efforts toward compliance, thus MDH has generally observed lower CO concentrations. Measured NO_2 levels have been relatively lower than CO levels, with only occasional very low level detection. This is because the smaller engines or their tuning leads to a much higher amount of CO emission.

Conditions in Minnesota motorsports arenas have improved in recent years due to education, routine inspections, review of arena's air testing records, and, in some cases, regulatory action. The authors of published studies have noted that inspections and continuous attention were necessary to improve air quality in motorsports arenas. As with ice arenas, voluntary testing and maintenance of air quality would likely not be effective.

The combination of arena proliferation and its accompanying increased public use, scientific advances, and improved technology means that the Minnesota Department of Health must bring its regulations up to date to carry out its public health mission.

II. ALTERNATIVE FORMAT

Upon request, this Statement of Need and Reasonableness can be made available in an alternative format, such as large print, Braille, or cassette tape. To make such a request, please contact:

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III. STATUTORY AUTHORITY

MDH proposes to revise current Minnesota Rules, parts 4620.3900 to 4620.4800 and add Minnesota Rules, parts 4620.5000 to 4620.4620.5950.

Minnesota Department of Health received authority to adopt rules governing "public pools and enclosed sports arenas" in Minnesota Statutes, 144.1222, subdivision 3, which provides that: "[t]he commissioner of health shall be responsible for the adoption of rules and enforcement of applicable laws and rules relating to indoor air quality in the operation and maintenance of enclosed sports arenas."

Additional authority is implicit in Minnesota Statutes, section 144.0751, which applies to "safe drinking water or air quality standards established or revised by the commissioner of health." This statute provides, in part:

(a) Safe drinking water or air quality standards established or revised by the commissioner of health must:
(1) be based on scientifically acceptable, peer-reviewed information; and
(2) include a reasonable margin of safety to adequately protect the health of infants, children, and adults by taking into consideration risks to each of the following health outcomes: reproductive development and function, respiratory function, immunologic suppression or hypersensitization, development of the brain and nervous system, endocrine (hormonal) function, cancer, general infant and child development, and any other important health outcomes identified by the commissioner."

This rule revision meets the department's statutory charge for setting enforcement standards by setting levels of CO and NO_2that require arena evacuation, which it will enforce through proposed actions. MDH's analysis of some of the health effects listed in this statute and the scientific information used to develop the action and evacuation levels are set out in Appendices E and F.

Under these statutory provisions, MDH has the necessary authority to revise the proposed rules and to include both science and policy-based protections for sensitive populations.

IV. REGULATORY ANALYSIS

Minnesota Statutes, section 14.131, sets out seven factors for a regulatory analysis that agencies must include in the SONAR. Paragraphs (1) through (7) below quote these factors and then give the agency's response.

(1) a description of the classes of persons who probably will be affected by the proposed rule, including classes that will bear the costs of the proposed rule and classes that will benefit from the proposed rule

Enclosed sports arenas owners and operators, specifically owners and operators of indoor ice arenas and indoor motorsports arenas and events probably will be affected by or bear the costs of these proposed rule amendments. As of April 2012, Minnesota has 274 indoor ice arenas (i.e., rinks or sheets of ice) located at 198 facilities. Of these arenas, 221 use at least one combustion-powered ice maintenance machine, while the remaining 53 arenas primarily use electric ice maintenance machines. Most facilities are owned by municipalities or nonprofit organizations (such as hockey associations) while some are owned by schools. A few are owned by for-profit organizations. In recent years, MDH has identified ten facilities that have either dedicated indoor motorsports racing or occasional motorsports events. As of March 2012, there are only three dedicated indoor motorsports facilities. In addition, in the last three years, seven other facilities have held indoor motorsports events.

Those who probably benefit from the indoor ice arena rule are the regular users of arenas (hockey players, figure skaters, coaches, officials) and occasional users of arenas (open skate participants and spectators). There are no definitive statistics, but the department estimates there are at least 70,000 regular users of indoor ice arenas and an additional, probably much larger, number of occasional users (see Appendix B for details). Those who probably benefit from the indoor motorsports rules are spectators and the unpaid participants in motorsports racing, all of whom can generally be considered occasional users of motorsports arenas. Arena employees will also benefit from improved indoor air quality.

(2) the probable costs to the agency and to any other agency of the implementation and enforcement of the proposed rule and any anticipated effect on state revenues

There are no additional costs to MDH or to any other agency to implement or enforce the proposed rule revision. MDH has staff in place to enforce the existing rules. Since there are no fee increases for current registrants or service providers, MDH does not anticipate that these proposed rules would affect state revenues.

(3) a determination of whether there are less costly methods or less intrusive methods for achieving the purpose of the proposed rule

There are no less costly methods or less intrusive methods for achieving the purpose of the proposed rules. MDH carefully considered the cost and burden of the proposed rules. MDH held several public meetings and advisory committee meetings to receive advice from affected parties. Three changes to the rule carry potential costs: 1) more frequent air testing; 2) training of arena staff; and 3) lower air quality action levels.

Some arenas will incur a small increased cost of $600 or more for purchasing the testing equipment necessary to conduct the proposed routine air testing. The proposed rule allows for arenas to obtain, without special approval, electronic instruments to monitor air levels of CO and NO_2. The flexible rules permit the owners or operators to use the real-time testing equipment of their choosing, as long as the equipment meets certain technical specifications.

For most arenas the testing frequency will increase from once per week to three times per week. MDH, after consulting its advisory committee, determined that such a testing frequency was necessary, at a minimum, to ensure acceptable air quality in arenas. Some arenas are likely to use electronic instruments rather than single-use disposable devices (the latter usually being less economical when testing more than once a week). The cost of the electronic instruments, for most arenas, will be comparable to or less than the cost of single-use disposable colorimetric tubes. For arenas that are only open a few months per year, there will be a small increased cost due to more frequent testing. MDH cannot identify a less costly alternative without eliminating this provision of the proposed rules.

Another potential expense of the proposed rules is training. Having a trained responsible staff at the arena is essential for protecting public health as well as arena staff. Arena managers can train their own staff, at their building, so the only expected cost would be staff time. Staff are not required or expected to attend formal training courses. The department incorporated this flexibility into the proposed rule, in part, to minimize costs and intrusion. MDH cannot identify a less costly or intrusive alternative without eliminating this provision of the proposed rules.

For some ice arenas that cannot maintain acceptable air quality under the proposed lower air quality limits, there will be costs for reducing engine emissions or increasing ventilation. MDH has considered the economic impact to arenas when establishing the air quality limits. By following a performance-based standard, arenas will have flexibility to identify the least costly method(s) of maintaining acceptable air quality for their facility. MDH cannot identify a less costly or intrusive alternative, short of raising the acceptable air quality standards, which, as discussed in Section I, Introduction, are necessary to protect public health.

(4) a description of any alternative methods for achieving the purpose of the proposed rule that were seriously considered by the agency and the reasons why they were rejected in favor of the proposed rule

Current Enclosed Sports Arena Rules require that arena operators test for both carbon monoxide and nitrogen dioxide. In revising the current rule, MDH staff assessed whether both of these contaminants should continue to be tested, whether one contaminant could act as an "indicator" for both pollutants, and whether significant differences exist between types of engines. In addition, MDH researched whether testing for additional pollutants is warranted.

Under well-maintained and consistent engine operating conditions, there is a slight difference in emissions between propane and gasoline. There are several factors that are more important — especially the fuel-to-oxygen ratio—that dictate the levels of CO and NO_2 emitted from engines. Researchers have concluded that a poorly performing engine, not the fuel type, is the primary factor that affects pollutant levels. When engines have a high fuel-to-oxygen ratio, the rate of carbon monoxide emission increases. When engines have a low fuel-to-oxygen ratio, the rate of nitrous oxides (NOx) increases. Most studies have shown that one or the other pollutant is present in the air, but usually not both. Testing for both pollutants remains necessary for combustion-powered resurfacers, regardless of engine fuel.

Research of combustion byproducts in ice arenas other than CO and NO_2 has been limited. With the exception of one researcher, scientists have focused their attention almost exclusively on CO and NO_2. Reason for regulating other contaminants, such as particulates, is therefore limited. Some resurfacers do appear to emit very small particulate matter. MDH, however, has not identified particulate matter less than 2.5 microns ($PM_{2.5}$) as a problem that could exist in ice arenas, independent of CO or NO_2. Therefore, the department is not proposing to regulate particulate matter or other combustion byproducts.

The department also considered amending the current Enclosed Sports Arena Rule, Minnesota Rules, parts 4620.3900 to 4600.4800 but keeping it as a single rule. Because there are many differences between ice arenas and motorsports arenas, this proved to be too cumbersome. Thus, we are proposing two separate sets of rules, one governing ice arenas and one governing motorsports arenas. Splitting these two components of the current rules will make the requirements easier to find and reduce confusion in the regulated community.

MDH also considered a variety of prescriptive requirements, which we discussed with the advisory committee. These prescriptive requirements included specific routine engine maintenance, routine tailpipe emission testing, emission control technology, specific mechanical ventilation rates, and continuous air monitoring systems. We also considered mandating electric-powered ice maintenance equipment in all arenas. Ultimately, the department, with concurrence from the advisory committee, determined these requirements would: be too costly, be technically unfeasible to implement (in some cases), not eliminate the need for routine air testing; and be unnecessarily rigid if arenas can maintain and document acceptable air quality. The department deemed the proposed performance-based standard to be the most reasonable approach to address the public health need. The need and reasonableness of each rule part are discussed in further detail Section VI, Rule-by-Rule Analysis.

Voluntary programs would likely not sufficiently protect public health. A Canadian study surveyed arena managers, who were not regulated by the provincial government. (Hillman 1984). None of the 65 arenas in this study conducted air or maintenance equipment emission testing. MDH discussed testing with a Canadian provincial manager of inspections, who commented that he doubted more than 20% of rinks in his province had testing equipment.[4] In Finland, a pilot educational campaign to implement resurfacer and ventilation changes in arenas produced mixed results (Pennanen et al. 1998). While the number of Finnish arenas using resurfacers with emission control technology or electric resurfacers increased, more than half the arenas kept their existing equipment and made no changes in building ventilation. In other words, a majority of arenas chose not to implement any of the recommendations.

(5) the probable costs of complying with the proposed rule, including the portion of the total costs that will be borne by identifiable categories of affected parties, such as separate classes of governmental units, businesses, or individuals

There are three changes to the Rules that have potential modest costs: 1) more frequent air testing; 2) training of arena staff; and 3) lower air quality limits. The costs will be borne by arena operators or owners. Cities own and operate most ice arenas in Minnesota. There are also school districts, nonprofit, and for-profit organizations that own or operate arenas.

The cost to purchase electronic equipment that meets the rule requirements is as low as $600, and the equipment might need to be replaced after 5 to 10 years. In addition, there are also approximately 200 dollars' worth of yearly maintenance costs. Using electronic instruments will become more economical to almost all arenas under the proposed rules and are already more economical for most facilities under the current rules. This is because most arenas currently use disposable colorimetric tubes for air testing, which are usually more costly on an annual basis than the electronic alternative. Only those few facilities with, for example, one sheet of ice open three months a year are expected to see an increased cost since they are currently spending only about $200 per year for air testing tubes. Over the course of ten years, assuming equipment are replaced after five years, these arenas might spend about $100 per year more as a consequence of the proposed rules. For most arenas, however, switching to electronic equipment will not increase air testing costs and for some the cost will actually decline.

The proposed rule requires a trained responsible person be present at the arena at all times. This will require arena staff to obtain training, either self-administered or through formal training

[4] Personal correspondence with Mike LeBlanc, Chief Public Health Inspector & Manager, Health Protection Unit, Environmental Health Branch, Manitoba Health

programs, that an organization such as the Minnesota Indoor Arena Managers Association (MIAMA) could sponsor. Arena managers must train their staff specifically for the arenas' features and their staff's level of responsibility. MDH will not require attendance at a formal course, and thus there would be no associated registration fee for coursework. The training requirement will, however, result in a few hours per year of staff time devoted to training. In addition, the requirement to have a trained responsible person on staff might lead arena managers to assign paid staff to work at the arena where previously a volunteer, such as a coach, was in charge of the arena. This is, however, a choice of the arena operator as they could train the volunteers instead. A value for these costs cannot be estimated, but is expected to be minimal.

The proposed rules would require ice arenas to comply with lower acceptable air quality action levels. Because the rules are performance-based and not prescriptive in how acceptable air quality is attained, arena operators or owners can tailor administrative or engineering controls to suit their needs and financial considerations. Ventilation adjustments can be introduced, such as: increasing ventilation use, repairing existing ventilation, or installing new ventilation equipment. Engine changes can be introduced, such as performing more routine preventive maintenance, emission testing of engines, repairing engines, installing updated emission control technology or replacing ice maintenance equipment. By lowering the acceptable air quality action levels, a small number of additional arenas might be out of compliance with the proposed rules. For these few arenas, the cost of making changes to comply with the proposed rules can be as low as a few hundred dollars, for example, if they determine running the ventilation fans more frequently can ensure acceptable air quality. In some cases, arenas might determine an engine tuning can correct the problem, which can cost from a few hundred to about $1,000. In a few cases, arenas might have to complete more costly renovations to engines (such as installing modern emission control technology or new ventilation), although such work typically costs a few thousand dollars. Overall, MDH does not expect costs in excess of $25,000 during the first year.

(6) the probable costs or consequences of not adopting the proposed rule, including those costs or consequences borne by identifiable categories of affected parties, such as separate classes of government units, businesses, or individuals

If the proposed rules are not adopted, the primary consequence is that the health and safety of the public might be jeopardized. The department has determined that the current acceptable air quality limits should be lowered in indoor ice arenas and the current evacuation level should be lowered for both types of arenas to protect public health. In addition, the existing rules require clarification to enable effective enforcement. More frequent testing is needed to ensure acceptable air quality is being maintained under differing operational conditions. Due to these limitations of the current rule, there might be exposures to CO or NO_2 that lead to medical and associated costs, although the costs cannot be quantified.

In addition, the rule changes will simplify or clarify some requirements, such as not requiring special approval to use electronic instruments and delineating specific follow-up measures required when the acceptable air quality limits are exceeded. This should reduce the amount of time arena operators spend on correspondence and consultation with MDH, which likely has some cost savings.

(7) an assessment of any differences between the proposed rule and existing federal regulations and a specific analysis of the need for and reasonableness of each difference.

There are no existing federal regulations protecting the general public in enclosed motorsports arenas or ice arenas. Besides Minnesota, only the States of Rhode Island and Massachusetts regulate air quality in ice arenas. The U.S. EPA, most of Canada's provinces, and a few states have recommended guidelines for ice arenas, but these are not regulatory requirements (see Appendix A for details). A few cities around the country have regulated air quality in motorsports arenas. There are state and federal regulations of workplace health and safety that apply to workers in enclosed sports arenas, but these standards do not apply to the public nor are they sufficiently protective for the general public.

(8) an assessment of the cumulative effect of the rule with other federal and state regulations related to the specific purpose of the rule.

The changes that regulated parties must make under these proposed rules comprise the only regulatory results for them, since as stated in item (7) above, there are no existing other state and federal rules related to the same specific purpose protecting the general public in enclosed motorsports arenas or ice arenas. The U.S. EPA has published guidance for best practices but no regulations. The U.S. Occupational Safety and Health Administration (OSHA) has set CO and NO_2 exposure limits that cover arena workers. Those regulations do not conflict with or overlap these proposed rules, because as also stated in item (7) above, these state and federal regulations of workplace health and safety apply to workers in enclosed sports arenas, but these standards do not apply to the public. Nor are they sufficiently protective for the general public. Further, these proposed rules do not overlap with building codes. There are no building codes specific to enclosed arenas. MDH is not proposing ventilation standards. The rules are purely performance-based. The department will regulate through the air quality standards that arenas must meet and the arenas operators control how they achieve them. For these reasons, as the sole regulatory requirements for the affected parties, the cumulative effect comes only from these standards.

V. ADDITIONAL STATUTORY REQUIREMENTS

A. Performance-Based Rules

Minnesota law (Minnesota Statues, sections 14.002 and 14.131) requires that the SONAR describe how MDH, in developing the rules, considered and implemented performance-based standards that emphasize superior achievement in meeting the department's regulatory objectives and maximum flexibility for the regulated party and MDH in meeting those goals. MDH staff asked its advisory committee and affected and interested stakeholders for input on performance-based standards.

During the internal and advisory committee discussions about the various provisions of the proposed rules, many suggestions for prescriptive rules were presented. Ultimately, all but a very few of these suggestions were dropped as department rule makers applied the standard of performance-based rules, as required. Specific prescriptive rule proposals and considerations are discussed in detail in the rule-by-rule analysis that follows.

B. Additional Notice

In accordance with our OAH-approved additional notice plan under *Minnesota Statutes,* section 14.101 and *Minnesota Rules,* part 1400.2060, subpart 2, item A, MDH did the following:

1. Posted the Request for Comments, proposed rules and information for submitting comments on the Indoor Air Unit's Web page. It also posted notice of the rule changes on the Minnesota Department of Health website with links and highlights from the department's and Environmental Health Division's home pages.

2. In 2009, held four regional public-information meetings at Bemidji, St. Paul, St. Cloud and Mankato on October 27, November 10, November 17 and November 19, 2009 respectively for interested parties about possible rule changes. These meetings allowed the public an opportunity to provide comments and suggestions.

3. Mailed a notice of the public information meetings and that a Request for Comments (RFC) was published in the State Register to the following entities:

    a. Certified enclosed sports arena owner/operators that hold certificates of approval from MDH to operate an enclosed sports arena according to Minnesota Rules, part 4620.4100. The list of Minnesota enclosed sports arena owner/operators is "Appendix H-1"

    b. Businesses that promote and manage regulated indoor motorsports events, including racing and demonstrations of motorcycles, "monster trucks", go-karts, and other vehicles powered by internal combustion engines. Some have previously held events in Minnesota arenas; others were identified in an internet search. A list of indoor motorsports event promoters is "Appendix H-2."

    c. Trade organizations for ice arena managers, which serve as an efficient information conduit from the department to individual arena managers. A list of ice arena manager membership organizations is provided as "Appendix H-3"

    d. Companies that manufacture and or distribute products for maintaining or measuring indoor air quality. These are companies or individuals that MDH does not certify, such as ice resurfacer machine manufacturers and mechanics, ventilation system contractors and manufacturers of air quality measurement equipment. Many are listed as vendors in the Minnesota Ice Arena Manager Association's annual handbook. A list of indirectly regulated entities is provided as "Appendix H-4."

e. Other affected parties. Minnesota hockey and figure skating associations. Members of these organizations skate in Minnesota's ice arenas. A list is provided as "Appendix H-5"

f. Persons on the department's rulemaking mailing list per *Minnesota Statutes,* section 14.14, subdivision 1a. A list of these persons is "Appendix H-6".

The department's website has links to the State Register so the Request for Comments can be viewed electronically. The department has also made the drafts of the proposed rules available on its website. In addition, it will post this Statement of Need and Reasonableness.

The department created a website dedicated to the Enclosed Sports Arena Rules and sent electronic notice to its list of affected and interested parties that the site was available for staying informed of rulemaking developments. The website has separate links for drafts of the ice arena and indoor motorsports rules. It also includes a link for viewers to sign up for automatic electronic notification when the pages are updated. To date, over 300 individuals have signed up for this service. In addition, the website provides directions and electronic links for individuals to submit comments on proposed rule revisions.

MDH will provide all further notices required by statute. The proposed rules and Notice of Intent to Adopt will be sent to everyone who has registered to be on MDH rulemaking mailing list under Minnesota Statutes, section 14.14, subdivision 1a. We will also give notice to the Legislature per Minnesota Statutes, section 14.116. At the time the Notice of Intent to Adopt in the State Register, the department will provide a copy of the Notice to the 200 facilities that house MDH-certified enclosed sports arenas, as well those who have been identified as interested or affected parties in the Additional notice plan. All referenced communication will be made by electronic mail if the department has the recipient's email address, or, otherwise, by US Mail.

The department's plan is designed to provide affected and interested parties with ample opportunity to be informed of the department's rulemaking plans and offer their input, in person and in writing.

C. Consultation with Minnesota Management and Budget on Local Governmental Impact

As required by Minnesota Statutes, section 14.131, the department will consult with the Commissioner of Minnesota Management and Budget (MMB) before publishing of the Notice of Intent to Adopt in the State Register. We will do this by sending to the Commissioner of MMB copies of the documents sent to the Governor's Office for review and approval. The documents will include: The Governor's Office Proposed Rule and SONAR form; draft rules; and draft SONAR.

D. Determination about Rules Requiring Local Implementation

As required by Minnesota Statutes, section 14.128, subdivision 1, the agency has considered whether these proposed rules will require a local government to adopt or amend any ordinance or other regulation to comply. The agency has determined that they do not because the Commissioner has the sole authority to enforce the rules for enclosed sports arenas in Minnesota Statutes, section 144.122, subdivision 3. The Commissioner has not delegated this responsibility to any local public health agencies or any other local units of government. Therefore, local government units need not adopt supporting ordinances.

E. Cost of Complying for Small Business or City

As required by Minnesota Statues, section 14.127, MDH has considered whether the cost of complying with the proposed rules in the first year after the rules take effect will exceed $25,000 for any small business or small city. MDH has determined that it will not, as described in part (5) of the Regulatory Analysis section on page 12 above.

F. List of Witnesses

If these rules require a public hearing, in addition to representatives of the department's rulemaking team, the department anticipates having representatives from the following organizations testify in support of the need for and reasonableness of the rules.

- Minnesota Ice Arena Managers Association (MIAMA)
- Minnesota Medical Association (MMA)
- Minnesota Poison Control Center

RULE-BY-RULE ANALYSIS

The proposed rules will replace the current rules, Minnesota Rules, Chapter 4620, parts 4620.3900 to 4620.4900.

Ice Arena Rules

Proposed Minnesota Rules, Chapter 4620, parts 4620.3900 to 4620.5950 govern indoor ice arenas. The rules clarify air monitoring and documentation requirements, ensure that air quality standards are consistent with current health risk data, and incorporate modern air-monitoring technologies into compliance measures. The revised rule language is intended to provide clarity to the regulated community and close gaps from the previous rule to ensure protection of the public who use these regulated facilities. The rule parts are as follows:

Part 4620.3900	Purpose
Part 4620.3910	Application
Part 4620.3950	Acceptable Air Quality
Part 4620.4000	Definitions
Part 4620.4100	Certificate of Approval
Part 4620.4450	Training
Part 4620.4510	Measurement of Air Quality Conditions
Part 4620.4550	Air Quality Measuring Devices
Part 4620.4600	Failure to Maintain Air Quality
Part 4620.4650	Record Keeping
Part 4620.4700	Other Fuel Burning Equipment
Part 4620.4800	Enforcement
Part 4620.4900	Variance to Rules Relating to Indoor Ice Arenas

4620.3900 PURPOSE

This proposed new rule part states that the department's intent is to ensure that *all* indoor ice arenas maintain acceptable air quality conditions to protect the health of arena occupants, and therefore its regulation is not limited to enclosed sports arenas "in which a resurfacing machine is used."

The department is statutorily "responsible for the adoption of rules and enforcement of applicable laws and rules relating to indoor air quality in the operation and maintenance of enclosed sports arenas." (Minnesota Statutes, 144.1222, subdivision 3). The department's authority is not limited to enclosed sports arenas "in which a resurfacing machine is used." The existing definition of "resurfacing machine" specifies that such equipment be "internal combustion engine-powered." (Minnesota Rules, part 4620.4000, subpart 9) MDH found unacceptable air quality conditions during a compliance inspection when internal combustion engine-powered ice resurfacers had *not* been in use. Ice arenas sometimes use internal combustion-powered ice edgers and other unvented fuel burning equipment such as generators, forklifts, and personnel lifts (also known as "manlifts"), without using internal combustion engine-powered ice resurfacers. Any fuel-burning equipment that releases its emissions into the arena building air space is a source of airborne contaminants, including CO and NO_2. In addition, some arenas that use electric ice resurfacers or edgers have switched to combustion-powered equipment, and thus MDH needs to track and inspect all ice arenas. As such, all indoor ice arenas must be certified to ensure that acceptable air quality conditions are maintained (as per part 4620.4100, subpart 3).

The purpose has also been changed to reflect the split of the current rule into two rules. Ice arenas come first under the new scheme.

4620.3910 APPLICATION

This revised and renumbered part specifies that owners or operators of indoor ice arenas must comply with the rule parts that comprise the regulation. The amendments use the term “owners or operators” in lieu of the existing rule parts term – “owners/operators” because the proposed term is grammatically less cumbersome. The term “indoor ice arena” is defined in proposed Minnesota Rules, part 4620.4000, subpart 7d.

In addition, the department is repealing existing rule language that limits the application of Minnesota Rules, parts 4620.3900 - 4620.4800 to ice arenas using internal combustion engine-powered *ice resurfacers*.

The current rule was limited to arenas in which combustion-powered ice resurfacing machines are used, while the purpose of the proposed rule encompasses all ice arenas, including those arenas that typically use electric-powered resurfacing equipment. This expansion is justified because some of these so-called “all-electric” arenas temporarily use combustion-powered ice resurfacing equipment, permanently switch to combustion-powered ice resurfacing equipment, or conduct renovation or maintenance activities that use combustion-powered engines or equipment. Air quality must be maintained under these circumstances as well, and MDH needs to track, certify, and inspect all ice arenas to monitor these changing circumstances.

When the advisory committee met on August 9, 2010, the rule draft then being discussed proposed that the entire regulation should apply to those indoor ice arenas that used internal combustion engine-powered ice maintenance equipment (resurfacer or edger). But facilities with non-fuel-burning ice maintenance equipment would not be required to comply with training, routine air quality testing, and recordkeeping requirements. Some committee members expressed concern that the ice arenas were being unfairly singled out and proposed that the rules apply to all indoor facilities that could be construed as sports arenas, such as gymnasiums and “sports bubbles”, indoor golf ranges, indoor horse shows, etc. The department’s rulemaking team rejected this proposal on several grounds. There was no consensus among committee members. Expanding the rule to all sports arenas is neither needed nor reasonable because the department has no evidence of CO or NO_2 problems in sports arenas other than ice and motorsports arenas. The original rule specifically targeted ice and motorsports arenas, and the statute was later written in a broad manner to enable the commissioner to regulate as needed. Expanding the rule would burden the department since this would increase the number of regulated parties from about 200 to probably thousands. Further, the rulemaking team determined that writing a rule that instructs all sports arenas on how to test (since there is great variability in engines and equipment used) would be difficult.

Department rule makers accepted an advisory committee proposal to remove proposed language from 4620.3901 that applied parts of the rule to facilities "…in which other combustion-powered engines or fuel-burning devices are used." Ultimately, the department decided to simplify the regulatory scheme to make all rule parts applicable to all indoor ice arenas, with the requirements of compliance detailed in the individual rule parts below.

Finally, the department has proposed repealing language pertaining to indoor motorsports applications from the ice arena provisions and has proposed a parallel set of Minnesota Rules, parts 4620.500 – 4620.5800, to regulate air quality in indoor motorsports arenas. Existing rule language is geared toward indoor ice arena air quality, with the rules for indoor motorsports activities brief and vague. This will be discussed in further detail below in the "application" section of indoor motorsports rules proposed Minnesota Rules, part 4620.5100. The department's rulemaking team and those who commented viewed an original attempt to make one rule fit both applications unfavorably.

4620.3950 ACCEPTABLE AIR QUALITY

This part establishes the baseline requirements for "acceptable air quality" and specifies that the owner or operator is responsible to ensure these standards are met. This rule part replaces existing Minnesota Rules, part 4620.4300, which requires the regulated party to document "that acceptable air quality conditions *can be* maintained." The existing requirement is inadequate because it does not actually require that acceptable air quality conditions *be* maintained. In enforcing the rule, the department has found that the existing rule does not provide the authority to actually require that the operator maintain acceptable air quality conditions, which is, of course, this rule's purpose. Thus, this modification is necessary for the department to protect the public from CO and NO_2 by citing violations. Members of the advisory committee unanimously supported this amendment.

This part also clarifies that the regulated area is the entire facility where an ice sheet is housed. On several occasions during compliance inspections, the department has observed unacceptable air quality conditions in other areas of the arena building that the public occupied besides the ice sheet, such as locker rooms and lobby areas.

Limiting the acceptable air quality conditions to times that the arena is open to the public is reasonable because paid workers or employees are covered under health standards promulgated by the Minnesota Occupational Safety and Health Administration (MN OSHA), including those times when the arena is not open to the general public.

The rulemaking also team considered regulating other air contaminants along with CO and NO_2. Internal combustion engine exhaust is composed of myriad pollutants such as various hydrocarbons, oxides of nitrogen, and particulates. Ultimately, the team decided to retain regulating only CO and NO_2, as surrogate indicators of other products of combustion. In other words, measures that maintain acceptable levels of these contaminants are likely to keep the other exhaust components within acceptable parameters. This is further discussed in the Introduction section and Appendix D.

In the future, emerging pollutants, such as ultra-fine particles, might become a public health issue that can be reasonably regulated. The rule currently lacks provisions to allow MDH to take reasonable measures to regulate these pollutants, if and when sufficient information is available to MDH regarding the health risks, potential health standards, and reasonable mitigation measures. Although MDH considered inserting a "catch all" statement regarding MDH having the authority to regulate hazards that become known in the future, the team ultimately voted against it, as it seemed unnecessary.

Regulated parties are free to and might establish more stringent standards to offer a higher level of protection than the minimum baseline standards required by this rule.

Acceptable air quality is when levels of carbon monoxide and nitrogen dioxide are at or below the concentrations of concern, or action levels. These chemicals are produced and emitted into the air whenever fuel is burned. CO and NO_2 are used as surrogate chemicals for other combustion byproducts because they are easily measured in indoor air using available technology. The acceptable levels of CO and NO_2 have been revised to reflect current knowledge about the health effects from exposure to these air pollutants.

MDH proposes to reduce the current action level of 30 parts per million (ppm) for CO to 20 ppm. An action level reflects a concentration of CO in air that requires the enclosed sports arena operator to take action to reduce exposure. More specifically, this action level for CO is intended to protect arena users by preventing any increase in blood carboxyhemoglobin levels (COHb) from exceeding ~ 2.0%. This action level is designed to protect the most sensitive group identified in the scientific literature, people with documented or latent coronary heart disease from angina or other acute ischemic heart effects. It also provides additional protection to fetuses of pregnant women from hypoxic effects caused by exposure to CO (WHO 2010; ATSDR 2009; Allred et al 1989, 1991). It will also better protect individuals who might be exposed for longer time periods, or who greatly exert themselves physically. This proposed action level better reflects the current state of scientific knowledge about the adverse health effects related to exposure to CO.

MDH proposes to reduce the action level for nitrogen dioxide from 0.5 ppm to 0.3 ppm, again to reflect current scientific knowledge about the health effects from exposure to nitrogen dioxide as well as improvements in the ability to measure nitrogen dioxide in air. It has been shown that some asthmatics might experience enhanced response to allergens at exposures to NO_2 beginning at 0.26 ppm for 15 – 30 minutes, and increased airway reactivity has been found in asthmatics exposed to 0.25 – 0.3 ppm for 30 – 60 minutes (EPA 2008a). When electronic devices are properly maintained, readings for NO_2 are reliable and will fall within the accuracy and precision specifications at levels of greater than or equal to ~ 0.3 ppm.

Further information on the development of these proposed action levels, including the evacuation levels described below in part 4620.4600, can be found in Appendices E & F.

4620.4000 DEFINITIONS

Minnesota Rules, part 4620.4000 defines the terms used throughout parts 4620.3900 -4620.4800. Defining words used in this rule ensures that regulated and affected parties clearly understand the terms used in the requirements. Definitions provide consistency, clarity and understanding when reading and interpreting the proposed rules.

Subpart 1. Scope. The department proposes to repeal the language relating to the “context” of defined words, because the proposed definitions are not dependent upon the context in which they are used in Minnesota Rules, parts 4620.3900 - 4620.4800.

Subpart 1a. Air quality measuring device. Department rule makers proposed that the definition for “air quality measuring device” include both electronic and manual pump and tube devices so that regulated parties that choose to use electronic devices need not obtain special approval from the commissioner, as they must under existing Minnesota Rules, part 4620.4500, subpart 2, item B.

Subpart 2. Applicant. The department proposes to repeal of this definition because the term is not used in proposed parts 4620.3900 to 4620.4800.

Subpart 3a. Arena. The department adds this term because the rule uses it as “shorthand” for the term “indoor ice arena” throughout Minnesota Rules, parts 4620.3900 – 4620.4800.

Subpart 3b. Arena building. The department proposes this definition to provide clarity in determining the boundaries of the regulated facility, and to distinguish between the sheet of ice and other areas associated with ice activities. The arena building encompasses rooms, such as the lobby, locker room, bathrooms, workout rooms, and other rooms used by the public that are directly related to ice activities.

Subpart 4. Certificate. This definition is carried forward from existing part 4620.4000, subpart 4, and is still needed and valid for the proposed rules to specify what this means in the rules’ context.

Subpart 5. Certificate holder. The department proposes repeal of this definition because the term is not used in proposed parts 4620.3900 to 4620.4800.

Subpart 5a. Commissioner. The department proposes to define this term because it will be used throughout the rules to reference the commissioner of health and designated department of health staff, which might not be apparent to the regulated or affected parties.

Subpart 5b. Edging. The department proposes to define this term because it is used in the proposed rules and it might be unfamiliar to some affected parties.

Subpart 6. Enclosed sports arena. This definition is no longer needed here because the department has proposed separate rules to regulate air quality for indoor motorsports arenas. The term is not used in the proposed indoor ice arena rules.

Subpart 7. Ice Arena. This term is no longer used in the proposed regulation, being replaced with the term "indoor ice arena" which is defined in proposed subdivision 7d.

Subpart 7a. Ice edger. This term is used in the proposed rules and might not be familiar to parties affected by the rule. It is not part of the common vernacular.

Subpart 7b. Ice maintenance machine. This term is used in the proposed rules when a provision addresses both ice resurfacers and ice edgers. It is not part of the common vernacular.

Subpart 7c. Ice resurfacer. This term is used to reference a specific type of ice maintenance machine, distinct from the ice edging machine. The existing rule does not make the distinction between ice edgers and ice resurfacers and it has led to confusion regarding the applicability of the rule to ice edgers.

Subpart 7d. Indoor ice arena. This term is used to describe the room that houses the ice sheet. It is necessary to specify how "indoor "is determined in because outdoor ice arenas are not regulated by these rules. This definition is consistent with that of "indoor area" found in Minnesota Statutes, section 144.413, subdivision 1a – the definitions section of the Minnesota Clean Indoor Air Act.

Subpart 7e. Operator. The department proposes to define this term to differentiate between the person who is designated by the owner to run the arena and the owner of the arena. Many, if not most, indoor ice arenas have different operators and owners.

Subpart 7f. Owner. This definition differentiates between the person or entity that owns the indoor ice arena from the person or entity who operates the arena. Many, if not most, indoor ice arenas have different owners and operators.

Subpart 8. Person. This definition is carried forward from existing rule part 4620.4000, subpart 8 to notify the reader that the term encompasses both human beings and other legal entities recognized by law as having rights and duties.

Subpart 8a. Responsible person. The rule uses this term in the rule part regarding training. Informing the regulated and *affected* parties of the expectation that a person who is accountable for air quality conditions be present at the arena at all times that the arena is open to the public is necessary.

Subpart 9. Resurfacing. The department proposes this definition because the term is used throughout the rules and might not be familiar to an affected person reading the rules.

4620.4100 CERTIFICATE OF APPROVAL

MDH proposes several structural changes to improve organization and clarity. To this end, the department is renaming the heading of this part to accurately reflect the subject matter, moving the certificate posting requirements of existing rule part 4620.4100 to a new subpart 5, and moving the conditions of application acceptance to a separate subpart 3.

Subpart 1. Applicability. The department is adding this subpart to clarify to the regulated and affected parties the type of facilities that must be certified by the commissioner. This follows the changes discussed above under "Purpose and Applicability," which describes extending the scope of the rule from ice arenas with combustion-powered resurfacing equipment to all indoor ice arenas.

Repealing the phrase "After July 1, 1973," when describing the applicability of the certification requirements deletes an obsolete and unnecessary reference.

The department proposes to delete the phrase "in which a resurfacing machine is used" from the description of the types of indoor ice arenas that must be certified. The department is statutorily "responsible for the adoption of rules and enforcement of applicable laws and rules relating to indoor air quality in the operation and maintenance of enclosed sports arenas." (Minnesota Statutes, 144.1222, subdivision 3). This authority is not limited to enclosed sports arenas "in which a resurfacing machine is used."

MDH discussed different types of certificates for those with internal combustion engine-powered ice maintenance equipment (ice resurfacers and edgers) and those with battery-powered ice maintenance equipment. An advisory committee member recommended that MDH add a third certificate category for facilities that primarily use electric ice maintenance equipment, but bring in internal combustion engine-powered equipment from time to time. Advisory committee support for this recommendation was mixed. Subsequently, the committee strongly opposed MDH's two-tiered certificate proposal, with the over-arching complaint being that such a system would be too confusing. The department's resolution is this proposed single certificate category.

Subpart 2. Certificate application. MDH added this subpart in lieu of existing rule part 4620.4200 so that all certificate requirements are in one part, which makes the rule easier to read and understand.

Retaining the language requiring that certificate applications be made on forms prescribed by the commissioner retains an administrative system that has worked well for arena certification since the rule became effective in 1973.

Item A requires ice arenas be certified annually. This is a proposed change from current rule part 4620.4200, item C, which requires arenas to submit new applications when it changes its equipment. Arenas must apply prior to "change of the approved method of maintenance of required air quality conditions or the replacement or modification of the resurfacing machine." MDH inspections show this to be one of the most common violations. Regulated parties have routinely expressed frustration in remembering to recertify when they make the relevant changes. By requiring annual certification, the commissioner will have up-to-date information each year regarding changes to ice maintenance equipment, ventilation, or other arena conditions that directly affect the air quality.

Having regulated parties apply for certificates each year is reasonable since the department is simplifying the recertification process by making it routine. This will minimize confusion while keeping the state's records up to date. It will also minimize the effort and time the regulated party must expend. In addition, a current certificate provides visual evidence at the arena that the regulated party maintains acceptable air quality conditions as a contemporary and ongoing activity. Moreover, the certification process provides an efficient method to collect other information that the department collects through an annual survey, such as hours and days of operation, arena manager information, and type of ice resurfacer and edger. Lastly, the annual certification process will serve to educate arena staff about the new rule as MDH collects information about the arena.

Existing rule part 4620.4200, item B requires the regulated party to submit a certificate application "prior to commencement of operation" of new ice arenas. The department proposes to carry over and modify this requirement in Minnesota Rules, part 4620.4100, item B by requiring that the application be submitted "at least 30 days prior to commencement of operation". This allows the commissioner's designees the necessary time to review and process the application and verify that the regulated party can demonstrate the ability to maintain acceptable air quality conditions, as per the approval criteria the department is proposing in part 4620.4100, subpart 3.

Item C is no longer necessary. This information is proposed to be collected in the annual certification process required under item A of this subpart.

Subpart 3. Certificate issuance. This subpart amends the existing rule language that establishes that MDH issues a certificate if "all conditions specified in Minnesota Rules, parts 4620.3900 to 4620.4800 (the existing enclosed sports arena air quality rules) are met". The commissioner proposes to clarify this phrase to say that the arena has demonstrated compliance with the applicable rules, and specifically, "the ability to maintain acceptable air quality conditions in the arena" This last phrase is taken from and meant to replace existing requirements in part 4620.4300, which the commissioner proposes to repeal, as discussed later. As such, there are no new requirements in this proposed new subpart.

Subpart 4. Certificate expiration and renewal. This subpart is self-explanatory. Item A requires operators to submit data 30 days before their certificate expires. Item B provides for the possibility that the current certificate expires while the certificate renewal is pending. Allowing an arena to continue operations under an expired certificate during the renewal process is reasonable.

Subpart 5. Posting of certificate. This language replaces current language and is needed for clarity. The current rule requires the certificate to be posted in a "conspicuous place". The revised language clarifies that regulated parties must post the certificate so that the public can see it.

Repeal Part 4620.4300 DOCUMENTATION OF AIR QUALITY CONDITIONS

The hearing record for the original rule shows that this part, which was numbered "(c) (3)" at the time, was intended to provide criteria for original certification. The department proposes to require the regulated party to demonstrate its ability to maintain acceptable air quality conditions under newly crafted Minnesota Rules, part 4620.4100, subpart 3. This will put all certification requirements together in one rule part to improve ease of use for the regulated party.

Upon being presented with the department's rationale for repealing this part, the Advisory Committee provided a strongly supported, consensus recommendation in favor of the department's proposal.

Repeal Part 4620.4400 MAINTENANCE OF AIR QUALITY CONDITIONS

Repealing this part eliminates a rule part that doesn't require anything of the regulated party. Rather, the existing part offers guidance or options to the regulated party regarding activities that the party could undertake to maintain acceptable air quality. According to the original rule's hearing transcript, the department witnesses, when questioned if this rule part required the regulated party to install ventilation, stated that the department was putting forth a performance-based rule. Ultimately, the witnesses explained, it doesn't matter *how* acceptable air quality conditions are maintained, so long as they *are* maintained.

In addition, 4620.4400 C., was apparently intended to apply to applicants seeking original certification. The certificate of approval requirements proposed in part 4620.4100more precisely accomplish the objectives currently contained in 4620.4400.

The advisory committee discussed several options for methods that would make the rule more prescriptive for maintaining acceptable air quality conditions. These options included requiring a particular mechanical ventilation rate, emission control equipment for ice maintenance equipment, tail-pipe emission testing, and routine preventive maintenance of engines (i.e., tuning).

During the advisory committee's August 31, 2010 meeting, the committee discussed arena ventilation at length. One committee member suggested that there should be some basic ventilation requirement, noting some small "barn" arenas have no mechanical ventilation. (It should be noted that building codes dictate minimum ventilation requirements, by year of construction.) The argument for specific ventilation requirements is that relying on testing alone could be insufficient; testing can be inaccurate and engines can break down quickly, so having a certain level of ventilation can serve as a back-up system to help maintain air quality. Another committee member suggested that a "safety net" is needed beyond just air testing, adding that building and food codes have prescriptive requirements and so should the arena rule, reiterating the EPA guideline.

The committee strongly opposed a committee member's proposal to require that arenas meet American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) standard 62.1.2007 for ventilation as recommended in the United States Environmental

Protection Agency guidance on indoor ice arena air quality. While the existing rule's use of the term "proper ventilation" is intrinsically vague, there are several problems with mandating an ASHRAE or other ventilation rate. ASHRAE standards do not consider air toxins but are based on occupancy and comfort. Moreover, they change every few years, making compliance difficult for the regulated party and enforcement difficult for the department.

Enforcing a ventilation rate would be difficult for MDH, since measuring ventilation in a particular building is complex and can fluctuate as various factors change, such as outdoor temperature, humidity, and operational variables. Also, operating ventilation continuously or installing new ventilation can be very costly to arenas at a time when budgets are dwindling. An advisory committee member observed that so long as the arena is maintaining proper air quality, as demonstrated by air testing, ventilation methods should not be prescribed. Another member reminded the group that ventilation can break down or not perform as designed. MDH researchers have been unable to identify an acceptable universal standard for ice arena ventilation. While the USEPA can recommend certain ventilation rates, guidelines are not enforceable requirements and do not factor reasonableness. MDH has provided and will continue to provide guidance in its informational fact sheets, presentations and Web page materials to encourage that arenas' efforts to provide certain ventilation without requiring it in rule.

The advisory committee also discussed having prescriptive rules for engine tuning, retrofitting of catalytic converters, and emission testing. One committee member argued that MDH should set a tailpipe emission standard that requires emissions be at the level of a properly tuned resurfacer. In addition, it was proposed that all resurfacer engines be retrofitted with current emission control technologies, such as 3-way catalytic converters with fuel management systems. These viewpoints were countered by another member who expressed that the arena rule should be performance-based and that emission testing would not prevent problems; he argued problems were human error (e.g., not turning ventilation on, not complying with existing rules). One resurfacer repair company representative advised MDH that not all resurfacers could be retrofitted, which other resurfacer repair representatives confirmed. Another committee member expressed concern that requiring these measures might provide a false sense of security about air-quality safety and could possibly result in lax routine testing.

To augment committee knowledge about the subject, the department invited ice maintenance equipment mechanical experts to the September 15, 2011, advisory committee meeting. MDH facilitated a discussion with representatives from Becker Arena Products and R&R Specialties, the authorized Minnesota service companies for Olympia and Zamboni respectively, the predominant ice resurfacer manufacturers. The engine discussion focused on retrofitting with 3-way catalytic converter, tailpipe emission testing, and routine engine tuning (i.e., preventive maintenance).

R&R and Becker representatives agreed that retrofitting resurfacing machines with 3-way catalytic converters is a good way to control pollutants, that the retrofit should include a fuel management system, and that the retrofit typically remained effective for several years before gradual loss of efficiency began to occur. According to the representatives, the typical cost to retrofit is few thousand dollars and maintenance needs are minimal (e.g. a few hundred dollars every few years for oxygen sensors). They added that the check-engine light should turn on if the fuel management system malfunctions and breakdown in the 3-way converter or fuel management system should probably not result in a significant increase in CO (despite rich tuning) and this would be caught by the routine air testing by arena staff and by the check engine light.

Despite the potential reduction in contaminant emissions when engines are equipped with 3-way catalytic converters, the experts noted that ventilation remains critical (i.e.: arenas with 3-way catalytic converters could still have problems if there were not enough ventilation, and air quality in arenas with unequipped engines can be fine with good ventilation). The R & R representative stated that pre-1980 resurfacers probably could not be retrofitted with a 3-way converter, but that a 2-way converter would be economical and might still reduce NO_2 somewhat. R & R explained that if a 3-way converter is mandated, it would be expensive in these oldest resurfacers, and the arena would be better served buying a new resurfacer (>$60,000) or a reconditioned newer resurfacer (currently $20,000 – 30,000).

Regarding routine emission testing, the Becker representative suggested that operators should perform emission testing by hours of resurfacer operation, not by an arbitrary time period. The department's perspective is that determining the number of hours that a resurfacer had been used would be difficult for MDH's enforcement staff, making such a requirement essentially unenforceable. Neither Becker nor the R&R representatives knew of any criteria for a "qualified technician", standardized emission testing methodology, or published emission specifications from Zamboni. One committee member suggested that MDH create emission specifications. To accomplish this, MDH would have to rely on the engine manufacturers' specifications for normal emissions from a properly maintained resurfacer and that the department is unaware of specifications other than for CO emissions for Olympia machines and NOx (not NO_2) emission specs for Olympia machines built since the year 2000. MDH would need emissions specs for Zambonis to consider requiring emission testing. At the time, MDH was unable to obtain emission specs from Zamboni, despite repeated inquiries.

Finally, the subject of engine tuning and routine preventative maintenance was discussed. Neither Becker nor the R&R representatives believed that requiring specific preventive maintenance practices is reasonable, explaining that maintenance is customized to every engine, depending on the technicians' findings, emission testing results, and the fuel being used (source of the fuel). They expressed unwillingness for turning general recommended tuning suggestions from their companies or the manufacturers and into across-the-board requirements for all resurfacers. Given the lack of support for a particular set of preventive maintenance practices, the committee member advocating for annual engine tuning rescinded the proposal, stating that yearly emission testing should accomplish that goal instead.

Following its discussion with the resurfacer representatives, the advisory committee made several recommendations to department rule makers. The advisory committee rejected a recommendation to require annual emission testing. MDH agreed and contends that we should not set an emission standard. A single annual emission test can also provide a false sense of security regarding resurfacer operation at other times of the year. Such testing does not reflect ambient exposure levels. MDH has observed unacceptable air quality in ice arenas that had been doing annual emission testing. Emission testing is merely a tool that would lead to engine tuning, but there is no set of repairs or tuning that could be mandated. The routine ambient air testing that this set of rules requires should also alert arena operators of problems that would lead them to detect engine problems. Finally, MDH would have to rely on resurfacer manufacturers for what their properly operating engines should be emitting. Such reliance is not feasible. MDH has not been able to obtain manufacturer emission specs from Zamboni. MDH has obtained CO emissions specs for Olympias for CO and NOx for some Olympias (not specifically for NO_2). Nonetheless, MDH will recommend emission testing as part of implementation, education, and outreach.

One advisory committee member proposed to require that all internal combustion engine-powered ice resurfacing machines be equipped with three-way catalytic converters to minimize concentrations of CO and NO_2 in the machine's exhaust. Other committee members strongly opposed this proposal on the grounds of excessive cost and unnecessary prescription. MDH agrees that this proposal runs counter to the performance-based standard that is sufficient to meet the public health protection need. MDH has learned, from speakers at the meeting and from other research [*see Appendix B*] that catalytic converters significantly reduce CO and NOx emissions. But on the other hand, such a prescriptive retrofitting requirement might not be reasonable, considering the cost and that most arenas do not have unacceptable air quality. As stated above, the cost can vary from a few thousand dollars to retrofit existing engines, to at least $20,000 - $30,000 for a used resurfacer, to replace older resurfacers that cannot be retrofitted. Therefore, MDH rejected this proposal.

Another prescriptive proposal from a committee member would require a minimum ice resurfacer tail pipe height of 80 inches above the ice. Committee members had varying support and some opposed. MDH maintains a performance-based standard is sufficient to meet the public health protection need. MDH will recommend tail pipe height as part of implementation education and outreach.

Finally, although the advisory committee advocated somewhat for a proposal to ban internal combustion engine-powered ice edgers by 2012, the department rejects this proposal as overly prescriptive. The department contends that it is not needed and unreasonable since arenas can maintain air quality with combustion-powered ice edgers. To justify such a prohibition, MDH would need clear evidence that edgers are a significant and greater public health exposure risk than resurfacers, but there is no such evidence to draw such a conclusion.

4620.4450 TRAINING

The department proposes this new rule part to ensure that a person knowledgeable about the rule and acceptable air quality conditions is present whenever an ice arena is open to the public. The training requirements are stated in subpart 1 and the documentation requirements are in subpart 2.

Incidents of unacceptable air quality can occur any time that arenas operate internal combustion engines or other fuel-burning equipment in indoor settings. MDH has observed poor air quality occurring when the assistant manager was in charge of the arena, on the weekend or in the evening. Requiring that the person in charge of the arena at any given time knows about the need for acceptable air quality, how to test the air, and be able to respond to incidents of poor air quality is reasonable. Because these issues are not common knowledge, requiring operators and owners educate and train arena attendants is necessary and reasonable.

In addition, MDH inspectors have often been unable to complete routine unannounced inspections because the arena staff on duty had no knowledge of the rule, where records were located, and where testing equipment was kept. Requiring a trained responsible person be present will increase enforcement efficiency and effectiveness.

The advisory committee recommended that training follow a model curriculum developed by the department or requiring that training be provided by the department. Although the department notes these concerns, such requirements would be overly prescriptive and burdensome to the regulated party and the department. In keeping with the performance-based standard required for rulemaking, outlining the content requirements of training without specifying who needs to provide the training is appropriate. This approach allows the regulated party the greatest flexibility to comply. The department intends to allow for a wide range of training options, yet make sure that the trainees gain the knowledge needed to monitor and control the hazards inherent to indoor ice arenas.

In addition, the advisory committee raised concerns about the department's expectations and enforcement of the proposed requirement of having to staff the arena with trained attendants. Some committee members suggested having trained staff on call, rather than requiring being physically present in the arena. While the regulated party's concerns are understandable, MDH maintains that the training expectations here are modest given the potential threat to public health and thus offsets the training burden placed on arena managers. The department points out that the individual in charge of the arena at any given time should have a basic understanding of air quality issues and be able to respond immediately to an air quality incident. An on-call person might not respond or be in close enough proximity to arrive at the arena quickly enough when a problem arises. Without a trained person on site, arena staff might not even recognize that there is a problem that necessitates a call to the on-call person. Also, the proposed requirement's goal is that a trained person knows what to do to prevent problems in the first place, such as operating the ventilation system. Enforcing an on-call system would be difficult, since inspectors would have to evaluate whether an individual would be truly available to respond to an incident or concern.

Finally, the advisory committee recommended that the rules' training include MDH expectations of arena staff and responsibilities to the public (such as responding to air quality-related requests). The department has chosen not to propose such a requirement. Such requirements are unneeded and cannot be reasonably defined. Expectations of staff are already outlined in rule and will be described in simpler language in fact sheets. "Responsibilities to the public" is a vague concept and difficult to define, and therefore should not be in rule. MDH will include general guidelines on how to respond to public concerns as part of rule implementation.

A. Training appropriate for trainee's responsibility level.
   To minimize the burden and time commitment upon the regulated party, the department proposes to require that the level of training need only match the trainee's level of

responsibility in operating the arena. If an individual will be alone at the rink and solely responsible for the occupants' well-being, it is both necessary and reasonable that the person be fully educated in maintaining acceptable air quality. Less training is necessary for an individual who works in the arena under supervision. In that scenario, the supervisor could provide basic information to the employee. Similarly, if a staff person's job duties do not involve calibrating the air monitoring instrument, there would be no need for that person to have hands-on training on that topic.

B. Annual training.
The department proposes to require annual education, a strongly supported, consensus recommendation of the advisory committee. The knowledge and skills necessary to maintain acceptable air quality in ice arenas, like any other knowledge or skills, diminish over time, and ventilation, engines, other sources, and testing equipment can change. Operators can perform refresher training in-house at little or no expense of time or money.

C. Topics of inclusion.
The department proposes that operators provide each applicable arena attendant with education that addresses the following topics relevant to maintaining acceptable air quality in indoor ice arenas.

1. Acceptable air quality conditions. Obviously, to maintain acceptable air quality conditions, arena staff need to know the parameters.
2. Arena-specific methods of maintenance. Methods of maintenance of acceptable air quality conditions vary by site (e.g.: ventilation system operation). Arena attendants must be informed of the methods that their particular arena employs to maintain acceptable conditions.
3. Operation and storage of arena's air monitoring equipment. The department has found improper use and maintenance of air monitoring equipment to be relatively common, often resulting in inaccurate air testing.
4. Air sample collection. All arena attendants need to be familiar with the purpose and general techniques of air sample collection. Those individuals directly responsible for air sampling need to know how the instrument operates and the sampling technique used in the arena.
5. Corrective actions. Similar to methods of maintenance, corrective actions to correct incidents of unacceptable air quality conditions vary. Attendants must have information on the various options, with emphasis on those that might have been demonstrated to be particularly effective in past situations.
6. Recordkeeping. In keeping with the department's objective of improving public information regarding air quality in ice arenas, the department proposes that at least one individual at the arena know the recordkeeping requirements of the rules. This provision will also enable inspectors to complete unannounced inspections effectively.

D. Training documentation. For the department to determine if the regulated party is complying with the requirements of this part, the department proposes in subpart 2 that operators be required to keep a record of training. The best practice is for the trainees to sign an acknowledgement that they've received training in the required topics.

Repeal existing rule part 4620.4500 and replacement with identically titled part 4620.4510 MEASUREMENT OF AIR QUALITY CONDITIONS

The Revisor made this editorial correction. The measurement requirements of existing part 4620.4500, subpart 1 are addressed in proposed Minnesota Rules, part 4620.4510, subparts 3 and 4. The air measurement device requirements of existing subpart 2 are addressed in proposed rule part 4620.4550.

4620.4510 MEASUREMENT OF AIR QUALITY CONDITIONS

Subpart 1. Measuring air quality. This rule part designates who is responsible for measuring air quality in ice arenas and under what conditions. This proposed part notifies the regulated party and ice arena users that the arena owner or operator is responsible for measuring air quality conditions and establishing the necessary measurements that must be taken when internal combustion engine-powered ice maintenance equipment is used, which includes resurfacing machines and edgers. These requirements are similar to those of the existing rule, except that the proposed rule adds specific air monitoring requirements after ice edgers are used.

Subpart 2. Persons who can take measurements. This subpart bolsters air quality measurements' accuracy and validity. During compliance inspections, the department has frequently found improper operation, interpretation, and documentation of air testing. In many cases, the individual responsible for performing air monitoring admits that they've never been trained. Safety of the arena occupants requires that someone knowledgeable in air monitoring be present at the arena to take measurements and ensure that indoor ice arena air quality remains acceptable.

Subpart 3. Measurements for ice resurfacing. This proposed rule part is essentially part 4620.4500, subpart 1 of the current rule, with two modifications. Items A through C are existing rule requirements that have been itemized for ease of reading and citation. These items provide consistency for measuring air quality between ice arenas and within each ice arena. Measuring according to these specifications has proven to be most effective in determining exposure to the skaters who are closest to the contaminants, and, due to their exertion, might be most vulnerable to the hazard.

The department proposes to require twice weekly air quality testing following resurfacer use, with at least one testing occurring during weekend operations. This will ensure adequate sample data to evaluate air quality under a variety of conditions. More frequent air testing also addresses the advisory committee concern that air quality problems can go undetected for several days. The department contends that this proposal carries out the advisory committee recommendations to increase the frequency of testing.

One of the most frequent violations to the existing rules is failing to perform air quality testing "at a time of maximum resurfacer use", despite MDH's frequent reminders to the regulated parties and emphasis during compliance inspections. By requiring that at least one of the required air tests is on the weekend, the department plans to ensure that testing is actually being performed under the worst-case scenario involving weekend tournaments and elevated ice use (and subsequent frequency of resurfacing).

When the advisory committee discussed the department's proposed changes to this rule part, MDH had proposed to change testing "at a time" of maximum resurfacer use to "at the time" of maximum resurfacer use. The committee recommended that the department maintain the original language to allow for flexibility and because there might be more than a single time of maximum resurfacer use and the department ultimately agreed.

Another committee member recommended that all arenas be required to continuously monitor air quality conditions via continuous monitoring systems. Most of the advisory committee and the department oppose this recommendation. The department asserts that this testing goes beyond what it has proposed, and is neither needed nor reasonable. Continuous monitoring systems are new technologies and MDH continues to evaluate their accuracy and reliability. Due to their continuous operation and location in the boards where they are bumped and exposed to contaminants (e.g., ice chips), the department is concerned that continuous monitoring systems might not operate properly over time. Also, they cost significantly more than portable equipment. Further, it is uncertain whether existing manufacturers and suppliers of continuous air monitoring systems could meet the installation and service needs of the state's approximately 280 indoor ice arenas. Nonetheless, the department will continue to track the development of continuous monitoring systems..

Subpart 4. Measurement for ice edging. The department has learned of ice edging's potential for to contributing to or causing instances of unacceptable air quality conditions in indoor ice arenas. Although ice edger engines are considered small engines, this equipment also can produce significant carbon monoxide emissions . While ice resurfacing equipment is used more often than ice edging equipment, MDH staff has observed measureable CO levels hours after arenas have used edging equipment. The department has proposed the same testing parameters for testing as those for resurfacing, listed as items A to B so that there is consistency in sampling and sampling protocols. The department's advisory committee provided a consensus recommendation for weekly air monitoring following internal engine-powered ice edging, as well. The department and the majority of the advisory committee, however, rejected a proposal that air monitoring be performed after every use of an internal engine-powered ice edging machine as unneeded and unreasonable. Weekly testing of ice edgers is sufficient to identify air quality problems stemming from this equipment's use.

Subpart 5. Measurement records. This carries over the requirement for the regulated party to submit testing records to the commissioner upon request from existing Minnesota Rules, part 4620.4500, subpart 1. This provision allows the department access to information to determine if the regulated party is complying with the rules. The commissioner's need for the information is obvious and the regulated community has yet to protest this measure as unreasonable.

Subpart 6. Additional measurements. This provision, too, originated in existing Minnesota Rules, part 4620.4500, subpart 1. Although infrequently cited during an inspection, the department must retain the authority to have the regulated party take additional measurements, as needed, for special air quality circumstances.

4620.4550 AIR QUALITY MEASURING DEVICES

Existing Minnesota Rules, part 4620.4500, subpart 2, item A established gas-detector tubes certified by the National Institute of Occupational Safety and Health (NIOSH) as the acceptable method of measuring air quality conditions for rules compliance. Item B of the same existing rule part required that the regulated party obtain the commissioner's permission to use any other air quality measurement method or equipment. The department defines the term "air quality measuring device" in rule part 4620.2000, subpart 1a to include both the gas-detector tubes approved under the existing rules and electronic air monitoring devices now being used with greater frequency.

Existing rule part 4620.4500, subpart 2, item A requires gas-detector tubes certified by the National Institute of Occupational Safety and Health (NIOSH). Because NIOSH no longer certifies gas-detector tubes, the department proposes repealing NIOSH references. In addition, the department proposes to use the term "pump and colorimetric tube" because it more accurately describes the device. Colorimetric gas tubes are sometimes certified by an independent laboratory. However, this is not required for all tubes and these requirements are subject to change over time. Therefore, it is no longer feasible to include tube certification in this rule.

Under existing rule part 4620.4500, subpart 2, item B, the department has been approving the use of portable direct-read electronic gas detection devices on a case-by-case basis. Generally allowing portable direct-read electronic gas detection devices to be used is reasonable because over time this technology has gained wider acceptance and greater capabilities to accurately measure carbon monoxide and nitrogen dioxide. In light of the improvements in electronic air-monitoring technology, the existing approval process has become unnecessarily burdensome and time-consuming for the department and regulated party.

In subpart 1, the department defines the criteria for acceptable air-measuring devices for the regulated party to use for purchasing them. The department provides the appropriate gas detection range and resolution of the acceptable air measuring devices in items A and B of the proposed part. The department accepted the unanimous advisory committee recommendation to move forward without a clause requiring approval of alternative monitoring devices. The net effect of these changes is that arenas will no longer apply for equipment approval outside of the annual certification process and MDH will regulate equipment by annual review.

Because accuracy and reliability of air-monitoring equipment are paramount to understanding air quality conditions in the arena, requiring the regulated party to "demonstrate" that their chosen equipment is accurate and reliable is both necessary and reasonable. The regulated party can ensure accuracy and reliability by conducting performance checks, such as checking the devices to standardized gases, which are widely available at reasonable cost, and calibrating or servicing as needed. MDH inspectors have observed problems with electronic instrumentation during unannounced inspections. It is also possible that new instrumentation will be brought to the market place that could be found to be inadequate. Therefore, this provision will enable MDH to ensure equipment used are in fact appropriate.

The department proposes subpart 2 because a poorly maintained instrument might not accurately and reliably measure the contaminants of concern. Each manufacturer might have different recommendations on how to maintain and calibrate an instrument. Therefore, it is reasonable to require arenas to follow manufacturer's specifications on how to care for the air-monitoring equipment. To evaluate compliance with maintenance and calibration requirements, the department proposes requiring that the regulated party maintain these records.

Several public commenters have suggested that the department require all arenas to install the type of CO detectors found in homes and businesses to continuously monitor for this contaminant. The department discussed this option with its advisory committee and all agreed that installing "plug in" CO monitors outside and away from the ice enclosure would not provide a health-and-safety benefit to arena users. The technology used in these devices is inferior to that in handheld devices. Air quality measurements from a device on a wall some distance from the ice enclosure would be unlikely to approximate the results from the monitoring currently required in rule, especially for the time frame immediately after resurfacing activities and before the air mixes completely throughout the arena room.

An advisory committee member proposed prohibiting using colorimetric tube technology for NO_2 testing. The department rejected this recommendation because it has not found any information from pump and tube manufacturers that suggests they are not specific for use in ice arenas. While colorimetric NO_2 tubes are difficult to read at low levels, at least one tube manufacturer does have a lower limit of NO_2 detection of 0.25 ppm. In addition, the electronic NO_2 instruments have their own problems: they might be more costly; sensors might have a fairly short lifespan (~2 years) and require more maintenance (calibration) to ensure accuracy. A more detailed discussion of air quality measuring devices can be found in Appendix G.

4620.4600 FAILURE TO MAINTAIN AIR QUALITY

Subpart 1. Corrective action necessary. The department proposes to require that operators take corrective measures as soon as they observe unacceptable air quality conditions to prevent the public from being exposed to elevated levels of carbon monoxide or nitrogen dioxide for significant periods. The current rule requires immediate corrective action only after unacceptable air quality conditions are measured over the course of one hour. This allows too much potential for harm in the interim.

The revised language requires that any corrective action include ventilation (item A) and that the arena suspend further use of internal combustion engine-powered equipment, the source of the emissions, until acceptable air quality standards are met (item B). The advisory committee strongly supported requiring arenas to take these specific actions in lieu of the actions being optional measures under the existing rule. Although making such requirements is prescriptive, the department argues that, in this case, the need to take the logical step of clearing the pollutants (increased ventilation) and eliminating the source of contaminated air (cease using the engine) precludes the usual hesitation. The source of pollution, once identified, should be controlled (turned off) until levels are brought down to acceptable levels. This shouldn't stop arena operation. The ice could still be used, although the ice condition of an un-resurfaced sheet might not be ideal.

In addition, the department proposes that this subpart apply to any part of the arena building that the public occupies. The department knows of incidents of unacceptable air quality in locker rooms and arena lobbies. This provision would compel the regulated party to maintain acceptable air qualities in these public-occupied areas as well.

The department proposes subpart 2 to ensure that the arena completes further air monitoring in an orderly fashion after the CO or NO_2 action levels have been exceeded. This ensures that the arena can maintain acceptable air quality and that the corrective actions have effectively reduced contaminants in the arena air. Items A, B and C are intended to ensure that ice resurfacing equipment is properly tuned and that the ventilation equipment is providing enough air changes to prevent carbon monoxide and nitrogen dioxide build-up after multiple resurfacings. Department investigations have found that the existing requirement to perform "subsequent" air monitoring often confused the regulated parties, which meant that they evaluated the effectiveness of corrective measures inconsistently. In fact, the advisory committee recommended prescriptive follow-up air monitoring unanimously.

Subpart 3. Report. Existing rule part 4620.4600, subpart 2, with little change, becomes subpart 3, which the Minnesota Department of Health needs to follow up with arenas that might be experiencing problems in maintaining indoor air quality. One difference between the proposed language and current language is that "working days" have been changed to "business days" for clarity, since working days for arenas are often on the weekend. The only significant change comes from the advisory committee's unanimous recommendation to require reporting of the "possible causes of unacceptable air quality conditions" instead of the existing rule's requiring an explanation of "why the methods of air quality control had failed." The committee felt the proposed language more clearly expressed the department's intention.

Subpart 4. Arena evacuation necessary. Changing the heading from existing subpart 3clarifies this subpart's intent. In addition, the department proposes to replace the existing subpart language. The first sentence was explanatory rather than action-directive. The remaining three sentences vaguely directed the regulated party in its response. Instead, the department proposes to clearly direct the regulated party in determining when to evacuate the arena (item A), how to evacuate the arena (item B), and when and how to re-occupy the arena (item C). Although the department's advisory committee discussed the proposed provisions at length, the committee advocated only one minor linguistic change, which the department incorporated into its draft.

Proposed item A specifically assigns the responsibility for arena evacuation to the owner or operator and describes the specific measured air quality conditions that trigger evacuation. With subitem 1, the department sets a "ceiling" or a not- to-exceed level for the contaminants. To account for brief fluctuations in measured levels and due to the serious nature of an arena evacuation, it is reasonable that only measurements holding above this ceiling level for a brief period of time (five minutes) trigger evacuation. This would allow sufficient time for an arena using pump and gas-detector monitoring equipment to take a confirmatory measurement before evacuating the public.

Similarly, in item A, subitems 2 and 3, the department proposes that the operator evacuate the arena if the CO and NO_2 concentrations reach the specified one-hour and two-hour limits. Having these longer duration evacuation levels is warranted because MDH identified a gap in the existing rule. Under the existing rule, the regulated party can operate indefinitely with unacceptable air quality conditions, so long as the upper limit evacuation level is not exceeded and corrective actions are being taken. In the meantime, the public continues to be exposed to potentially harmful levels of contaminants.

Subitem 1 is needed for when the air concentrations in the arena meet or exceed the air concentrations designated as evacuation levels, which are considered hazardous for health and safety of the people in the arena.

The proposed evacuation level for CO is lowered from 125 ppm to 85 ppm. The 85 ppm evacuation level for CO correlates with a ~ 4% increase in carboxyhemoglobin (COHb) levels that is predicted based on a 1-hour exposure to 85 ppm CO in air (EPA 2008b). This ~4% increase in COHb is intended to protect against potentially severe adverse health effects in sensitive individuals, particularly those with latent or diagnosed coronary heart disease. This will also be protective for the other sensitive groups, namely children and the fetuses of pregnant women. It is also important to have an evacuation level that will allow for people to get out of the arena before people experience psychomotor effects, such as reduced coordination and tracking, or impaired vigilance, generally accepted as occurring at COHb levels ranging from 5-7%.

The proposed evacuation level for NO_2 remains the same as in current rule. In most human clinical studies of healthy individuals, exposures to NO_2 at concentrations less than 4.0 ppm do not cause symptoms or alter pulmonary function. It has been observed, in some healthy individuals, exposures in the range of 1.5 to 2 ppm might increase airway responsiveness; similarly, exposures in the range of 1-2 ppm NO_2 might induce mild airway inflammation (EPA 2008a). In addition, the World Health Organization notes that in humans, the vast majority of lung biochemical studies show effects only after acute or sub-chronic exposure to levels of nitrogen dioxide exceeding 2 ppm (WHO 2005).

Further information on these proposed evacuation levels can be found in Appendices E & F.

Subitem 2 is necessary because the acceptable air quality values are based on 1-hour limits. For CO, toxicity is a function of [concentration x time]. One-hour limits were established as a reasonable time for carrying out air monitoring. This is consistent with the current rule, which has worked well. If a pump and colorimetric tubes are used, then the single reading is interpreted to be representative of a sample taken over the period of one hour. When airborne concentrations of carbon monoxide or nitrogen dioxide continue to increase, the source is not being controlled or ventilation is not proving effective and people must be evacuated to prevent them from getting sick. The department proposes that once concentrations remain elevated for 1 hour above the allowable level, then these levels——*which are twice the concentration* as allowed for the "action level," are enough to trigger an evacuation of the arena.

Subitem 3 is necessary because the values are based on 1-hour limits to allow for a reasonable sampling or monitoring protocol. If the 1-hour concentration of concern remains for a second hour—which is *twice the time* as allowed for the "action level," mitigation is not working and therefore the arena must be evacuated.

Item B provides the regulated party with specific direction if an evacuation is required as discussed under item A. Under the current rule there is no direction provided as to who must decide to evacuate, and no assistance or support provided for the evacuation process.

The department proposes subitem 1 because the evacuation of an arena is a serious activity that might be difficult for one person to orchestrate. Requesting the local fire department's assistance in this evacuation is reasonable because these professionals are trained in getting people out of hazardous situations, they are ready to respond, and they are dressed to call attention to the fact that this is a serious condition. Their attire commands attention. In addition, local fire departments most often have their own equipment capable of measuring carbon monoxide levels. They can also serve as an independent resource to verify the operator's air monitoring results.

Subitem 2 is needed because the department needs to know about the evacuation in a timely manner to ensure that MDH can respond to concerns from the public, as well as ensure that corrective measures are successful and are permanent for protecting the citizens who might use that facility in the future. Because, in almost all instances, the department will be unable to assist in an actual evacuation due to geographical distance, it is reasonable to expect the arena to contact the agency once the evacuation has been completed.

Item C sets criteria for the reoccupation of the arena to ensure that air quality conditions are safe for those that re-enter. In past experiences involving evacuated arenas, regulated parties and emergency responders have expressed confusion about when the arena is considered safe to enter.

The department's primary objective is outlined in subitem 1. Before any reoccupation of the arena, acceptable air quality conditions must be measured. To prevent recurrence of unacceptable air quality conditions, the department proposes requiring corrective measures be taken (sub-item 2). Finally, the department proposes that an independent third party verify that conditions are acceptable and unlikely to recur before re-occupation. (sub-item 3) Third party verification limits the possibility that the regulated party might prematurely reoccupy due to public pressure or perception.

4620.4650 RECORD KEEPING

A frequent problem encountered by department inspectors is unavailability of records to demonstrate compliance. For this reason, the department proposes this new part to require that regulated parties keep compliance documentation together in a single location. The department did not receive any negative comments from the arena managers serving on the advisory committee or the public about this proposal.

Item A, sub-items 1 to 4 provide detail of exactly what records need to be kept in the arena log. It is reasonable to require that training, air monitoring, air monitoring device and corrective action reports all be kept in a log because these records are all pertinent to making sure that the indoor ice arena is operated in a safe manner.

Item B designates where the indoor ice arena log is to be kept and who might view it. It is reasonable for the public to have access to these records because it provides another check and balance in addition to the commissioner's designee who might only get to inspect arenas annually or every other year. The availability of records to the public also provides additional incentive for ice arena operators to maintain complete and current logs.

Finally, the department accepts the premise of its advisory committee's consensus recommendation to establish a retention schedule for required records. The department settled on a three-year schedule, because, at the time of the drafting of these rules, that is the longest gap between inspections under the enforcement programs current protocols. In addition, the advisory committee noted that many already have a three-year retention schedule for certain records. This would improve the likelihood that department inspectors will have all relevant records available to them for the period between compliance inspections without excessive record-keeping demands.

4620.4700 OTHER FUEL-BURNING EQUIPMENT

MDH has rewritten this rule part, which currently governs the department's regulation of indoor motorsports activities to instead regulate the use of other internal combustion engines used in operating and maintaining ice arenas. Proposed rule parts 4620.5000 to 4620.5800 specifically address the unique hazards of indoor motorsports activities, which are discussed in rule-by-rule explanations that follow.

Department rule makers are adding these requirements because indoor ice arena operators occasionally use other fuel-burning equipment in indoor ice arenas that emit CO or NO_2. This other equipment is not considered ice maintenance equipment but has the potential to create or contribute to instances of unacceptable air quality conditions in indoor ice arenas. Examples include unvented, fuel-burning generators, portable heaters, personnel lifts (also known as "manlifts"), and power-washers. By adding additional testing requirements when this equipment is used, the department plans to increase the regulated party's awareness of these potential hazards and thus avert harm to arena users.

At the recommendation of the advisory committee and to meet its reasonableness requirement, the department proposes that these requirements apply only to equipment that is not directly vented to the outdoors. In other words, equipment such as existing furnaces, boilers and water heaters that vent combustion byproducts directly to the outdoors are exempted from this testing requirement. Furthermore, the department proposes to leave the language from the existing rule that make these provisions applicable when the arena is open to the general public. This would allow for normal off-season maintenance and remodeling activities without the burdens of air monitoring and maintenance of acceptable air quality when the public is not present.

Occupational Safety and Health Administration regulations would still be in place to protect the workers under this scenario.

In addition, the department accepted a committee recommendation to withdraw proposed language that would have required the regulated party to notify the department each time this type of equipment was brought into use in an indoor ice arena. The advisory committee argued that this put an unreasonable burden on the regulated party. There might be times MDH staff are unavailable to be notified (e.g., weekends). Thus requiring notification every time an engine or equipment is brought in would be unreasonable.

4620.4800 ENFORCEMENT

The department is not proposing material changes to this part, except to repeal the reference to part 4620.4700. Proposed revised part 4620.4700 does not include content related to certification. The new heading better describes the part's content.

4620.4900 VARIANCE TO RULES RELATING TO INDOOR ICE ARENAS

The department does not propose material change to the existing rule part, except to propose that part 4620.3950 cannot be varied, rather than part 4620.4300. As previously discussed, the department has proposed part 4620.3950 to require the regulated party maintain acceptable air quality at all times when open to the public, rather than the requirement in existing part 4620.4300 to document that acceptable air quality conditions "can be maintained".

Indoor Motorsports Arenas

As previously explained, this separate set of rules, proposed Minnesota Rules, Chapter 4620, parts 4620.5000 – 4620.5950 regulates air quality in enclosed sports arenas where indoor motorsports activities are open to the public. They establish air monitoring and documentation requirements, ensure that air quality standards are consistent with current health risk data, and incorporate modern air-monitoring technologies into compliance measures. This language is intended to provide clarity to the regulated community and close gaps from the previous rule to ensure protection of the public who use these regulated facilities. The following rule parts closely parallel the ice arena air quality regulations in proposed parts 4620.3900 – 4620.4900. As such, the analysis of many parts will be quite similar, if not identical. This repetition will make future references easier. The rule parts are as follows:

Part 4620.5000	Purpose
Part 4620.5100	Application
Part 4620.5200	Acceptable Air Quality
Part 4620.5300	Definitions
Part 4620.5400	Certificate of Approval
Part 4620.5500	Training
Part 4620.5600	Measurement of Air Quality Conditions
Part 4620.5650	Air Quality Measuring Devices
Part 4620.5700	Failure to Maintain Air Quality
Part 4620.5800	Record Keeping
Part 4620.5900	Enforcement
Part 4620.5950	Variance to Rules Relating to Indoor Motorsports Arenas

4620.5000 PURPOSE

This part states the department’s intent to ensure that ice arena operators maintain acceptable air quality conditions in all indoor motorsports arenas to protect the health of arena users and is self-explanatory.

4620.5100 APPLICATION

This part, which specifies that owners or operators of indoor motorsports arenas must comply with the rule parts that comprise the regulation, too, is self-explanatory. The term “indoor motorsports arena” is defined in proposed rule part 4620.5300, subpart 8.

4620.5200 ACCEPTABLE AIR QUALITY

This part establishes the baseline requirements for “acceptable air quality” and specifies that the owner or operator is responsible to ensure these standards are met. Setting minimum requirements to maintain acceptable air in indoor motorsports arena buildings is necessary to protect public health.

The necessity and reasonableness of such a rule is analogous to the discussion above for proposed rule part 4620.3950 regarding indoor ice arenas – specifically the second paragraph of that section.

Clarifying that the regulated area includes all parts of the facility that are open to the public is necessary because on several occasions during compliance inspections, the department has observed unacceptable air quality conditions in other publicly occupied areas of the arena building, such the lobby.

Limiting the acceptable air quality conditions to times that the arena is open to the public is reasonable because paid workers or employees are covered under health standards promulgated by the Minnesota Occupational Safety and Health Administration (MN OSHA), including those times when the arena is not open to the general public.

The rulemaking also team considered regulating other air contaminants along with CO and NO_2. Internal combustion engine exhaust is composed of myriad pollutants such as various hydrocarbons, oxides of nitrogen, and particulates. Ultimately, the team decided to retain regulating only CO and NO_2, as surrogate indicators of other products of combustion. In other words, measures that maintain acceptable levels of these contaminants are likely to keep the other exhaust components within acceptable parameters. This is further discussed in the Introduction section and Appendix D.

In the future, emerging pollutants, such as ultra-fine particles, might become a public health issue that can be reasonably regulated. The rule currently lacks provisions to allow MDH to take reasonable measures to regulate these pollutants, if and when sufficient information is available to MDH regarding the health risks, potential health standards, and reasonable mitigation measures. Although MDH considered inserting a “catch all” statement regarding MDH having the authority to regulate hazards that become known in the future, the team ultimately voted against it, as it seemed unnecessary.

Regulated parties are free to and might establish more stringent standards to offer a higher level of protection than the minimum baseline standards required by this rule.

Acceptable air quality is when levels of carbon monoxide and nitrogen dioxide are at or below the concentrations of concern, or action levels. These chemicals are produced and emitted into the air whenever fuel is burned. CO and NO_2 are used as surrogate chemicals for other combustion byproducts because they are easily measured in indoor air using available technology.

Acceptable air quality values are based on 1-hour limits. For CO, toxicity is a function of [concentration x time]. One-hour limits were established as a reasonable time for carrying out air monitoring, and is also consistent with typical exposures, the minimum amount of time people spend in the arena. This is consistent with the current rule and has worked well.

MDH proposes to retain the current 30 parts per million (ppm) action level for carbon monoxide (CO). An action level reflects a concentration of CO in air that requires the enclosed sports arena operator to take action to reduce exposure. The department decided to retain the current action level in part on a greater awareness of motorsports arena participants and spectators that they will be exposed to combustion byproducts, primarily CO, due to the nature of this activity. Participants typically sign waivers acknowledging that they will be exposed, and signage is typically posted during events notifying spectators that exposure to CO will occur. This awareness provides a greater opportunity for sensitive individuals to avoid or limit exposure than is afforded in an ice arena, where participants or spectators might not be aware that the arena operators have recently used internal combustion powered equipment. In addition, motorsports arena participants generally do not exert themselves physically to the degree that is typical of ice arena users, or for as long a time period. These were key factors in proposing a lower action level for CO in ice arenas.

MDH proposes to reduce the action level for nitrogen dioxide from 0.5 ppm to 0.3 ppm, again to reflect current scientific knowledge about the health effects from exposure to nitrogen dioxide, as well as improvements in the ability to measure nitrogen dioxide in air. It has been shown that some asthmatics might experience enhanced response to allergens at exposures to NO_2 beginning at 0.26 ppm for 15 - 30 minutes. And increased airway reactivity has been found in asthmatics exposed to 0.25 - 0.3 ppm for 30 - 60 minutes (EPA 2008a). When electronic devices are properly maintained, readings for NO_2 are reliable and will fall within the accuracy and precision specifications at levels of greater than or equal to ~ 0.3 ppm.

Further information on the development of these proposed action levels, including the evacuation levels described below in part 4620.4600, can be found in Appendices E & F.

4620.5300 DEFINITIONS

Part 4620.5300 defines the specific terms used throughout parts 4620.5000 to 4620.5950 to ensure that regulated and affected parties clearly understand the requirements. Definitions provide consistency, clarity and understanding when reading and interpreting the proposed rules.

Subpart 1. Scope. This subpart ties the regulated and affected parties to the definitions provided for parts 4620 to 4620.5950.

Subpart 2. Air quality measuring device. Department rule makers proposed that the definition for “air quality measuring device” include both electronic and manual pump and tube devices so that regulated parties that choose to use electronic devices need not obtain special approval from the commissioner, as they must under existing Minnesota Rules, part 4620.4500, subpart 2, item B.

Subpart 3. Arena. The department adds this term because the rule uses it as “shorthand” for the term “indoor motorsports arena” throughout Minnesota Rules, parts 4620.5300 – 4620.5950.

Subpart 4. Arena building. The department defines this term to clarify the boundaries of the regulated facility, and to distinguish between the track area and other areas of the building occupied by the public. The arena building encompasses rooms such as the lobby and restrooms.

Subpart 5. Certificate. The department proposes carrying this definition forward from existing part 4620.4000, subpart 4. It is needed for clarity.

Subpart 6. Commissioner. The department proposes to define this term because it will be used throughout the rules to reference the commissioner of health and designated department of health staffers, which might not be apparent to the regulated or affected parties.

Subpart 7. Event manager. The rule uses this term in the certificate rule part because it might not be familiar to all regulated or affected parties who read the rule. The organization that stages an indoor motorsports event has an important role in maintaining acceptable air quality conditions during the event.

Subpart 8. Indoor motorsports arena. This term is used throughout the rules to describe the room where motorsports vehicles are being operated. Specifying how "indoor" is determined is necessary because outdoor motorsports arenas are not regulated by these rules. This definition is consistent with that of "indoor area" found in Minnesota Statutes, section 144.413, subdivision 1a – the definitions section of the Minnesota Clean Indoor Air Act.

Subpart 9. Motorsports vehicle. This term designates the equipment that produces emissions that are the primary concern of this regulation. The term is not part of the common vernacular.

Subpart 10. Operating hours. MDH proposes to define this term because it is used in proposed part 4620.5600, subpart 3, item B, to describe the time period when arena operators must perform air monitoring.

Subpart 11. Operator. The department proposes to define this term to differentiate between the person or entity designated by the owner to run the arena and the owner of the arena. Indoor sports arenas might have different operators and owners.

Subpart 12. Owner. This definition differentiates between the person or entity that owns the indoor ice arena from the person or entity that operates the arena. Indoor sports arenas might have different owners and operators.

Subpart 13. Person. This definition is carried forward from existing rule part 4620.4000, subpart 8 to notify the reader that the term encompasses both human beings and other legal entities recognized by law as having rights and duties.

Subpart 14. Responsible person. The rule uses this term in the rule part regarding training. Informing the regulated and *affected* parties of the expectation that a person who is accountable for air quality conditions be present at the arena at all times that the arena is open to the public is necessary.

Subpart 15. Special indoor motorsports event. This term differentiates between the use of an indoor arena for a discrete unit of time versus ongoing use of an arena dedicated to motorsports activities. The department has proposed separate certification and air monitoring requirements for the two types of arrangements.

Subpart 16. Spectator. Defining this term informs the regulated party of the specific types of people that they must accounted for in maintaining acceptable air quality in the arena.

Subpart 17. Spectator area. This term defines the areas where the regulated party is responsible for air monitoring in proposed part 4620.5600, subpart 3. The boundaries of this regulated area might not be intuitively apparent to the regulated party.

4620.5400 CERTIFICATE OF APPROVAL

MDH proposes moving the certificate posting requirements of existing rule part 4620.4700 to this new part to improve readability for the regulated and affected parties. The department's rulemaking advisory committee heard the department's proposal and justification and did not propose alternative language.

Subpart 1. Applicability. The department is proposing to add this subpart to clarify to the regulated and affected parties the type of facilities that must be certified by the commissioner.

MDH proposes to repeal the phrase in the existing rule "After July 1, 1973," when describing the applicability of the certification requirements because it is obsolete and unnecessary.

Subpart 2. Certificate application. The department proposes to keep the language requiring that certificate applications be made on forms prescribed by the commissioner as this requirement has worked well for the certification of arenas since the rule was made effective in 1973.

Item A, as proposed, requires that the commissioner certify indoor motorsports arenas annually. The current rule part is specific to motorsports "events" instead of arenas. This language applies to the few dedicated indoor motorsports facilities where motorsports activities are routinely held, such as an indoor go-kart facility. By requiring annual certification, the commissioner will have updated information each year regarding changes to motorsports vehicles, ventilation or other arena conditions that might directly affect the air quality.

Having regulated parties apply for certificates each year is reasonable since the department is simplifying the recertification process by making it routine. This will minimize confusion while keeping the state's records up to date. It will also minimize the effort and time the regulated party must expend. In addition, a current certificate provides visual evidence at the arena that the regulated party maintains acceptable air quality conditions as a contemporary and ongoing activity. Moreover, the certification process provides an efficient method to collect other information that the department collects through an annual survey, such as hours and days of operation, arena manager information, and type of motorsports vehicles. Lastly, the annual certification process will serve to educate arena staff about the new rule as MDH collects information about the arena.

The department proposes item B to inform the person responsible for a new dedicated indoor motorsports facility of the deadline to submit an application for approval. By requiring that the application is submitted 30 days before the facility being opened to the public, the department is allowed enough time to evaluate the prospective arena's ability to maintain acceptable air quality and perform required air testing. It also allows the department ample time to educate the responsible person in the requirements of the rules.

Item C applies to situations where singular, limited duration, motorsports events are held in enclosed sports arenas that are dedicated to other purposes, such as indoor ice arenas, indoor sports stadiums, etc… As is the case with item A, and for the same reasons, the department proposes to require that applications for certificate be submitted at least 30 days before the event being held.

Subpart 3. Certificate issuance. In item A, the commissioner proposes this subpart, which replicates part 4620.4100, subpart 3. It is a change from existing indoor motorsports arena requirements in part 4620.4700, which establishes that a certificate is issued if "all conditions specified in parts 4620.3900 to 4620.4800 are met." The department proposes to clarify this phrase to say that the arena has demonstrated compliance with the applicable rules, and specifically, "the ability to maintain acceptable air quality conditions in the arena". This last phrase is taken from and meant to replace existing requirements in part 4620.4300, which the commissioner proposes to repeal, as discussed earlier. As such, there are no new requirements in this proposed new subpart.

Item B of this subpart also proposes that the commissioner will issue a certificate for a special motorsports event via the same criteria as item A, but adds, in proposed subitems 1 and 2 that the responsible party submit a plan to monitor and ensure acceptable air quality maintenance that is agreed upon by the event manager and arena operator. The department is proposing this additional requirement due to the unique nature of each indoor motorsports event. The track, number and type of motorsports vehicle, phasing and pacing of the event vary greatly from event to event, as do the venues themselves. The department wants to make sure that the regulated party is considering all of these variables while preparing to maintain a safe environment for participants and spectators at these events.

Subpart 4. Certificate expiration and renewal. This subpart is self-explanatory. Item A requires operators to submit data 30 days before their certificate expires. Item B provides for the possibility that the current certificate expires while the certificate renewal is pending. Allowing an arena to continue operations under an expired certificate during the renewal process is reasonable.

Subpart 5. Posting of certificate. This language replaces current language and is needed for clarity. The current rule requires the certificate to be posted in a "conspicuous place". The revised language clarifies that regulated parties must post the certificate so that the public can see it.

4620.5500 TRAINING

The department proposes this rule part to ensure that a person knowledgeable about the rule and acceptable air quality conditions is present whenever an indoor motorsports arena is open to the public. The training requirements are stated in subpart 1 and the documentation requirements are in subpart 2.

Incidents of unacceptable air quality can occur any time that internal combustion engines or other fuel-burning equipment are operated in indoor settings. Requiring that at any given time the person in charge of the arena knows about the need for acceptable air quality, how to test the air, and be able to respond to incidents of poor air quality is reasonable. Because these issues are not common knowledge, requiring operators and owners educate and train arena attendants is necessary and reasonable.

In addition, MDH inspectors have often been unable to complete routine unannounced inspections because the arena staff on duty had no knowledge of the rule, where records were located, and where testing equipment was kept. Requiring a trained responsible person be present will increase enforcement efficiency and effectiveness.

One committee member noted that he is self-trained on the rule and MDH responded that self-training is acceptable, as long as it is documented and covers the criteria in rule. The same committee member commented that it would be a burden to have to train all his staff on the rule considering the high turnover in staff. To address these types of concerns, MDH is proposing that training should be done to the level of responsibility of the employees to be trained. Furthermore, MDH is not proposing to require that all employees are trained, but, rather that at least one trained employee is present in the arena building at all times that the facility is open to the public.

A. Training appropriate for trainee's responsibility level.

To minimize the burden and time commitment upon the regulated party, the department proposes to require that the level of training need only match the trainee's level of responsibility in operating the arena. If an individual will be alone at the facility and solely responsible for the occupants' well-being, it is both necessary and reasonable that the person be fully educated in maintaining acceptable air quality. Less training is necessary for an individual who works in the arena under supervision. In that scenario, the supervisor could provide basic information to the employee. Similarly, if a staff person's job duties do not involve calibrating the air monitoring instrument, there would be no need for that person to have hands-on training on that topic.

B. Annual training

During the advisory committee discussion on this topic, MDH noted that a yearly refresher training requirement was added to the proposed ice arena rule and should be considered for motorsports arenas. Committee members concurred that this was reasonable. The knowledge and skills necessary to maintain acceptable air quality in motorsports arenas diminish over time, and ventilation, engines, other sources, and testing equipment can change. Operators can perform refresher training in-house at little or no expense of time or money.

C. Topics of inclusion.

The department proposes that operators provide each applicable arena attendant with education that addresses the following topics relevant to maintaining acceptable air quality in indoor motorsports arenas.

1. Acceptable air quality conditions. Obviously, to maintain acceptable air quality conditions, arena staff need to know the parameters.

2. Arena-specific methods of maintenance. Methods of maintenance of acceptable air quality conditions vary by site (e.g.: ventilation system operation). Arena attendants must be informed of the methods that their particular arena employs to maintain acceptable conditions.
3. Operation and storage of arena's air monitoring equipment. The department has found improper use and maintenance of air monitoring equipment to be relatively common, often resulting in inaccurate air testing.
4. Air sample collection. All arena attendants need to be familiar with the purpose and general techniques of air sample collection. Those individuals directly responsible for air sampling need to know how the instrument operates and the sampling technique used in the arena.
5. Corrective actions. Similar to methods of maintenance, corrective actions to correct incidents of unacceptable air quality conditions vary. Attendants must have information on the various options, with emphasis on those that might have been demonstrated to be particularly effective in past situations.
6. Recordkeeping. In keeping with the department's objective of improving public information regarding air quality in indoor motorsports arenas, the department proposes that at least one individual at the arena know the recordkeeping requirements of the rules. This provision will also enable inspectors to complete unannounced inspections effectively.

D. Training documentation. For the department to determine if the regulated party is complying with the requirements of this part, the department proposes in subpart 2 that operators be required to keep a record of training. The best practice is for the trainees to sign an acknowledgement that they've received training in the required topics.

4620.5600 MEASUREMENT OF AIR QUALITY CONDITIONS

Subpart 1. Measuring air quality. This proposed rule part explains who is responsible for measuring air quality in motorsports arenas and that carbon monoxide and nitrogen dioxide are the contaminants of concern. This proposed part notifies the regulated party, indoor motorsports users, and spectators that the arena owner or operator is responsible for measuring air quality conditions and establishing that such measurements are necessary as directed by the commissioner. The proposed language and effect is similar to that found in existing rule part 4620.4700.

Subpart 2. Persons who can take measurements. This subpart bolsters air quality measurements' accuracy and validity. Air monitoring is a skill that needs to be learned. Safety of the arena occupants requires that someone knowledgeable in air monitoring be present at the arena to take measurements and ensure that air quality remains acceptable.

Subpart 3. Measurement requirements.

A. This proposed rule part is essentially a restatement of the last line of existing part 4620.4700 of the current rule, with one alteration. Based on the research and the department's experience, NO_2 levels generally do not exceed acceptable air quality levels due to indoor operation of motorsports vehicles. The emission profile for motorsports vehicles typically skews very strongly toward CO. If CO levels are maintained at acceptable levels, NO_2 is typically not detected in the arena air. Because of this, under the existing rule, the department has generally not required that the regulated party monitor NO_2 concentrations. See Appendix C for details.

However, combustion of certain fuels (for example propane) might result in measureable NO_2 emissions. As such, the department feels it necessary and reasonable to maintain the authority and flexibility to require NO_2 measurements if the situation merits it.

B. Carbon monoxide has been established as the primary contaminant of concern in indoor motorsports arenas and one that is easily measured with available air monitoring equipment at a reasonable cost. In this proposed rule part, the department establishes the schedule by which the regulated parties will be required to monitor for CO.

Because the dynamics of air quality maintenance differs between facilities dedicated to indoor operation of motorsports and indoor motorsports events held in ice arenas or other enclosed sports arenas (special indoor motorsports events), the department is proposing a separate CO monitoring scheme for each application.

(1) Frequency of CO measurements. There are generally fewer variables that affect air quality maintenance in certified arenas. Typically, the types and sizes of vehicles remain fairly consistent with the primary variables being the number of vehicles used on the track and the pacing of their use. This dynamic is best exemplified in indoor go-kart facilities.

At the opposite end of the spectrum is an indoor motocross event held in an arena designed for other sporting activities. During these events, many different engine sizes and even fuel mixtures are used and varying numbers of vehicles operate at different times.

For both certified arenas and special motorsports events, the department proposes to reserve its authority to require additional measurements as it deems necessary to account for any unforeseen realities.

(a) At the time that the rulemaking advisory committee met on this topic, the department's proposed rule language pertaining to certified arenas would require the regulated party to perform air monitoring for CO at all times that motorsports were operated. This proposal met with resistance from an individual representing a certified arena as being overly burdensome and unnecessary. After careful consideration, the department revised its proposal to require periodic testing.

Due to the relative consistency of operation in certified arenas, the department has proposed an air monitoring scheme that is intended to get an accurate picture of air quality conditions in this type of facility by establishing that monitoring take place on two or more days with a minimum sampling period of three hours per week. The department has further proposed that monitoring be performed during heavy use of motorsports to evaluate "worst case scenario." The department does not propose specifying the day(s) of the week to allow the regulated party flexibility in meeting air monitoring obligations. Finally, the department proposes to retain its authority to require additional monitoring (provided in the existing rule) to allow it to address unexpected or special air quality concerns that might arise.

(b) Because of the rapidly changing dynamics that affect air quality and the significantly varying air quality measurements that can occur from one moment to the next, the department is proposing that air monitoring be performed continuously during indoor motorsports events. This proposal is consistent with the testing regime that MDH has been requiring under its existing authority for at least the last five years. Since these are short-term events of limited duration (typically 2 to 4 hours), the department has found little or no resistance from the regulated community to assigning an individual the job of air monitoring for the event.

(2) Location and documentation of measurements. The department proposes different measurement location and documentation requirements based on whether the motorsports vehicle operators are paid performers or members of the general public. The reason for this dichotomy is that the department is charged with protecting public health (general public) while the Department of Labor & Industry is responsible for worker (employee performers) safety and health through MN OSHA. Spectators in motorsports arenas are also under 'MDH's purview, resulting in proposed requirements for testing in the area where spectators assemble.

(a)(i) In arenas where the motorsports operators are not paid performers, MDH proposes requiring that monitoring be performed on the track to gauge vehicle operator exposures. The rule draft at the time of the advisory committee meeting would have required the regulated party to take the measurement at the center of the track. This provision met with advisory committee resistance as being overly rigid and potentially unsafe. As a result, the department revised its proposal and is now proposing the regulated party can monitor at any location on the track, so long as it can be shown to be representative of "average" concentrations.

(a)(ii)The department similarly acquiesced to advisory committee concerns about its original proposal to require that measurements be recorded after every heat or discrete run on the track. The department accepted the committee's argument that documenting testing at least every 15 minutes would be simpler, consistent with requirements for spectator area testing, and similar to the testing regime that MDH has been requiring under the authority to prescribe testing requirements in existing Minnesota Rules, part 4620.4700.

(b)(i)When spectators are present, the department proposes requiring the regulated party to measure air quality conditions in the location of poorest air quality ("worst case scenario"). Because this location will vary by location and event, the department proposes that the regulated party be responsible for its identification.

(b)(ii) Consistent with documentation requirements for the track area, MDH is proposing the measurements be recorded at least every 15 minutes of motorsports activity in the arena. The department feels this measurement frequency will account for temporal variances in measurements and allow the regulated party to conveniently determine one-hour average air concentrations. This documentation regime has been successfully employed by the department under the existing authoring granted to specify measurement documentation granted by existing Minnesota Rules, part 4620.4700.

Subpart 4. Measurement records. The department is proposing carrying over the requirement for the regulated party to submit testing records to the commissioner upon request from existing rule part 4620.4700. This provision allows the department access to information to determine if the regulated party is complying with the rules. The commissioner's need for the information is obvious and the regulated community has yet to protest this measure as unreasonable.

4620.5650 AIR QUALITY MEASURING DEVICES

Existing rule part 4620.4700 references 4620.4500, subpart 2 as the criteria for acceptable air quality measuring devices under the current standard. Existing Minnesota Rules, part 4620.4500, subpart 2, item A established gas-detector tubes certified by the National Institute of Occupational Safety and Health (NIOSH) as the acceptable method of measuring air quality conditions for rules compliance. Item B of the same existing rule part required that the regulated party obtain the commissioner's permission to use any other air quality measurement method or equipment. The department defines the term "air quality measuring device" in rule part 4620.5300, subpart 2 to include both the gas-detector tubes approved under the existing rules and electronic air monitoring devices now being used with greater frequency.

Existing rule part 4620.4500, subpart 2, item A requires gas-detector tubes certified by the National Institute of Occupational Safety and Health (NIOSH). Because NIOSH no longer certifies gas-detector tubes, the department proposes repealing NIOSH references. In addition, the department proposes to use the term "pump and colorimetric tube" because it more accurately describes the device. Colorimetric gas tubes are sometimes certified by an independent laboratory. However, this is not required for all tubes and these requirements are subject to change over time. Therefore, it is no longer feasible to include tube certification in this rule.

Under existing rule part 4620.4500, subpart 2, item B, the department has been approving the use of portable direct-read electronic gas detection devices on a case-by-case basis. Generally allowing portable direct-read electronic gas detection devices to be used is reasonable because over time this technology has gained wider acceptance and greater capabilities to accurately measure carbon monoxide and nitrogen dioxide. In light of the improvements in electronic air-monitoring technology, the existing approval process has become unnecessarily burdensome and time-consuming for the department and regulated party.

In subpart 1, the department defines the criteria for acceptable air-measuring devices for the regulated party to use for purchasing them. The department provides the appropriate gas detection range and resolution of the acceptable air measuring devices in items A and B of the proposed part. The department accepted the unanimous advisory committee recommendation to move forward without a clause requiring approval of alternative monitoring devices. The net effect of these changes is that arenas will no longer apply for equipment approval outside of the annual certification process and MDH will regulate equipment by annual review.

Because accuracy and reliability of air-monitoring equipment are paramount to understanding air quality conditions in the arena, requiring the regulated party to "demonstrate" that their chosen equipment is accurate and reliable is both necessary and reasonable. The regulated party can ensure accuracy and reliability by conducting performance checks, such as checking the devices to standardized gases, which are widely available at reasonable cost, and calibrating or servicing as needed. MDH inspectors have observed problems with electronic instrumentation during unannounced inspections. It is also possible that new instrumentation will be brought to the market place that could be found to be inadequate. Therefore, this provision will enable MDH to ensure equipment used are in fact appropriate.

The department proposes subpart 2 because a poorly maintained instrument might not accurately and reliably measure the contaminants of concern. Each manufacturer might have different recommendations on how to maintain and calibrate an instrument. Therefore, it is reasonable to require arenas to follow manufacturer's specifications on how to care for the air-monitoring equipment. To evaluate compliance with maintenance and calibration requirements, the department proposes requiring that the regulated party maintain these records.

A more detailed discussion of air quality measuring devices can be found in Appendix G.

4620.5700 FAILURE TO MAINTAIN AIR QUALITY

Subpart 1. Corrective action necessary. The department is proposing to require that operators take measures when unacceptable air quality conditions are observed for a sustained period of time (15 minutes) to prevent the public from being exposed to elevated levels of CO or NO_2 for significant periods. The current rule requires immediate corrective action only after unacceptable air quality conditions are measured over the course of one hour. This allows too much potential for harm in the interim. Although members of the advisory committee suggested that corrective action should not be required unless unacceptable air quality conditions are measured for at least 30 minutes, the department rejected this proposal. In the department's experience, allowing unacceptable air quality conditions for more than 15 minutes makes it very difficult for the arena to get back into the acceptable air quality range.

The proposed language requires that any corrective action include ventilation (item A) and that the arena suspend further use of internal combustion engine-powered equipment, the source of the emissions, until acceptable air quality standards are met (item B). Although making such requirements is prescriptive, the department argues that, in this case, the need to take the logical step of clearing the pollutants (increased ventilation) and eliminating the source of contaminated air (cease using the engine) precludes the usual hesitation. If increased ventilation has failed to return acceptable air quality to the arena after a sustained period of one hour, the department must exercise its obligation to protect public health by prohibiting that additional contaminants be added to the indoor air. Doing so will result in the delay of motorsports activities, but no other options exist to reduce the airborne contaminant load. The department maintains that it is being reasonable by allowing the motorsports activities to resume after acceptable air quality conditions are returned and maintained moving forward. In addition, the department proposes that this subpart apply to any part of the arena building that the public occupies. The department knows of incidents of unacceptable air quality in locker rooms and arena lobbies. This provision would compel the regulated party to maintain acceptable air qualities in these public-occupied areas as well.

The department proposes subpart 2 to ensure that the arena completes further air monitoring in an orderly fashion after the CO or NO_2 action levels have been exceeded. This ensures that the arena can maintain acceptable air quality and that the corrective actions have effectively reduced contaminants in the arena air. Department investigations have found that the existing requirement to perform “subsequent” air monitoring often confused the regulated parties, which meant that they evaluated the effectiveness of corrective measures inconsistently.

Subpart 3. Report. Existing rule part 4620.4600, subpart 2, was not referenced in rule part 4620.4700 as applicable to indoor motorsports arenas. However, in this new rule part, the department is proposing that this language (very similar to existing rule part 4620.4600, subpart 2) is needed so that the Minnesota Department of Health can follow up with arenas that might be experiencing problems in maintaining indoor air quality.

Subpart 4. Arena evacuation necessary. The department proposes this subpart in lieu of existing rule part 4620.4600, subpart 3, which was incorporated by reference for indoor motorsports applications in existing part 4620.4700. The first sentence was explanatory rather than action-directive. The remaining three sentences vaguely directed the regulated party in its response. Instead, the department proposes to clearly direct the regulated party in determining when to evacuate the arena (item A), how to evacuate the arena (item B), and when and how to re-occupy the arena (item C).

Proposed item A specifically assigns the responsibility for arena evacuation to the owner or operator and describes the specific measured air quality conditions that trigger evacuation. With subitem 1, the department sets a “ceiling” or a not-to-exceed level for the contaminants. To account for brief fluctuations in measured levels and due to the serious nature of an arena evacuation, it is reasonable that only measurements holding above this ceiling level for a brief period of time (fifteen minutes) trigger evacuation. This would allow sufficient time for an arena using pump and gas-detector monitoring equipment to take a confirmatory measurement before evacuating the public.

Similarly, in item A, subitem 2, the department proposes that the operator evacuate the arena if the CO and NO2 concentrations reach the specified two-hour limit. Having this longer duration evacuation level is warranted because MDH identified a gap in the existing rule. Under the existing rule, the regulated party can operate indefinitely with unacceptable air quality conditions, so long as the upper limit evacuation level is not exceeded and corrective actions are being taken. In the meantime, the public continues to be exposed to potentially harmful levels of contaminants.

Subitem 1 is necessary for when the air concentrations in the arena meet or exceed the air concentrations designated as evacuation levels that are considered hazardous for health and safety of the people in the arena.

The proposed evacuation level for CO is lowered from 125 ppm to 85 ppm. The 85 ppm evacuation level for CO correlates with a ~ 4% increase in carboxyhemoglobin (COHb) levels that is predicted based on a 1-hour exposure to 85 ppm CO in air (EPA 2008b). This ~4% increase in COHb is intended to protect against potentially severe adverse health effects in sensitive individuals, particularly those with latent or diagnosed coronary heart disease. This will also be protective for the other sensitive groups, namely children and the fetuses of pregnant women. It is also important to have an evacuation level that will allow for people to get out of the arena before people experience psychomotor effects, such as reduced coordination and tracking, or impaired vigilance, generally accepted as occurring at COHb levels ranging from 5-7%.

The proposed evacuation level for NO_2 remains the same as in current rule. In most human clinical studies of healthy individuals, exposures to NO_2 at concentrations less than 4.0 ppm do not cause symptoms or alter pulmonary function. It has been observed, in some healthy individuals, exposures in the range of 1.5 to 2 ppm might increase airway responsiveness; similarly, exposures in the range of 1-2 ppm NO_2 might induce mild airway inflammation (EPA 2008a). In addition, the World Health Organization notes that in humans, the vast majority of lung biochemical studies show effects only after acute or sub-chronic exposure to levels of nitrogen dioxide exceeding 2 ppm (WHO 2005). Further information on these proposed evacuation levels can be found in Appendices E & F.

Subitem 2 is necessary because the values are based on 1-hour limits to allow for a reasonable sampling or monitoring protocol. If the elevated 1-hour concentration remains for a second hour—which is twice the time as allowed for the "action level," mitigation is not working and therefore the arena must be evacuated.

Item B provides the regulated party with specific direction if an evacuation is required as discussed under item A. Under the current rule there is no direction provided as to who must decide to evacuate, and no assistance or support provided for the evacuation process.

The department proposes subitem 1 because the evacuation of an arena is a serious activity that might be difficult for one person to orchestrate. Requesting the local fire department's assistance in this evacuation is reasonable because these professionals are trained in getting people out of hazardous situations, they are ready to respond, and they are dressed to call attention to the fact that this is a serious condition. Their attire commands attention. In addition, local fire departments most often have their own equipment capable of measuring carbon monoxide levels. They can also serve as an independent resource to verify the operator's air monitoring results.

Subitem 2 is needed because the department needs to know about the evacuation in a timely manner to ensure that MDH can respond to concerns from the public, as well as ensure that corrective measures are successful and are permanent for protecting the citizens who might use that facility in the future. Because, in almost all instances, the department will be unable to assist in an actual evacuation due to geographical distance, it is reasonable to expect the arena to contact the agency once the evacuation has been completed.

Item C sets criteria for the reoccupation of the arena to ensure that air quality conditions are safe for those that re-enter. In past experiences involving evacuated arenas, regulated parties and emergency responders have expressed confusion about when the arena is considered safe for reentry.

The department's primary objective is outlined in subitem 1. Before any reoccupation of the arena, acceptable air quality conditions must be measured. To prevent recurrence of unacceptable air quality conditions, the department proposes requiring corrective measures be taken. Finally, the department proposes that an independent third party verify that conditions are acceptable and unlikely to recur before re-occupation. Third party verification limits the possibility that the regulated party might prematurely reoccupy due to public pressure or perception.

4620.5800 RECORD KEEPING

A frequent problem encountered by department inspectors is unavailability of records to demonstrate compliance. For this reason, the department proposes this new part to require that regulated parties keep compliance documentation together in a single location. The department did not receive any negative comments from the arena managers serving on the advisory committee or the public about this proposal.

Item A sub-items 1 to 4 provide detail of exactly what records need to be kept in the arena log. It is reasonable to require that training, air monitoring, air monitoring device and corrective action reports all be kept in a log because these records are all pertinent to making sure that the indoor ice arena is operated in a safe manner.

Item B designates where the motorsports arena log is to be kept and who might view it. It is reasonable for the public to have access to these records because it provides another check and balance in addition to the commissioner's designee who might only get to inspect arenas annually or every other year. The availability of records to the public also provides additional incentive for motorsports arena operators to maintain complete and current logs.

Finally, the department accepts the premise of its advisory committee's consensus recommendation to establish a retention schedule for required records. The department settled on a three-year schedule, because, at the time of the drafting of these rules, that is the longest gap between inspections under the enforcement programs current protocols. In addition, the advisory committee noted that many already have a three-year retention schedule for certain records. This would improve the likelihood that department inspectors will have all relevant records available to them for the period between compliance inspections without excessive record-keeping demands.

4620.5900 ENFORCEMENT

The department is proposing to add this part, parallel to proposed part 4620.4800, with changes for respective citations to the indoor motorsports rules (parts 4620.5000 - 4620.5800) MDH feels it important to establish the specific authority to enforce the provisions of the indoor motorsports rules. This provision informs the regulated party of the ultimate consequences of failure to comply with the rules and that the enforcement process will follow the Administrative Procedure Act, as cited in the text. In the event that the department must suspend or revoke its approval for an arena to operate, the department has added proposed language specifying how the arena can have its approval reinstated.

4620.5950 VARIANCE TO RULES RELATING TO INDOOR MOTORSPORTS ARENAS

The department does not propose material change to the existing rule part (4620.4900), except to propose that part 4620.5200 cannot be varied, rather than part 4620.4300. As previously discussed, the department has proposed part 4620.5200 to require the regulated party maintain acceptable air quality at all times when open to the public, rather than the requirement in existing part 4620.4300 to document that acceptable air quality conditions "can be maintained".

CONCLUSION

Based on the foregoing, the proposed rule amendments are both needed and reasonable.

Date: August 29, 2012

Edward P. Ehlinger, MD, MSPH
Commissioner, Minnesota Department of Health

Appendix A. Air Quality Guidelines, Regulations, and Recommendations for Ice Arenas

The following are air quality regulations and guidelines that have been adopted by or recommended by various governmental, non-governmental agencies, and researchers. There are suggested guidelines (i.e., best practices), research-based recommendations, or regulations mandated for ice arenas. All have been developed specifically for the general public whom use ice arenas; not workers in arenas.

Agency	CO ppm	NO2 ppm	Type
State of Minnesota (current)	30 (1 hr)	0.5 (1 hr)	Regulation
State of Massachussetts(9)	30 (single)[1]	0.5 (single)	Regulation
State of Rhode Island(10)	35 (1 hr)[2]	n/a	Regulation
Province of Manitoba(1)	12.5 (1 hr)[3]	0.25 (1 hr)	Guidelines
City of Winnipeg(2)	33 (1hr), 18 (8hr)	n/a	Guidelines
Ontario Recreational Facilities Association(3)	25 (1hr)	3 (1 hr)[4]	Guidelines
Recreational Facilities Association of Nova Scotia(4)	25 (1 hr)	1 (1 hr)	Guidelines
British Columbia Ad Hoc Working Group(5, 6)	11 (single)[5]	0.25 (single)	Guidelines
Province of Saskatchewan(7)	25 (1 hr)	1 (1 hr)	Guidelines?
State of Pennsylvania(8)	20 (1 hr)[6]	0.25 (1 hr)	Guidelines
Brauer & Spengler(11)	35 (1 hr)	0.25 (1 hr)	Recommendations
Lee et al.(12)	20 (1 hr)	0.25 (1 hr)	Recommendations
Levesque et al.(13)	20 (1 ½ hr)	n/a	Recommendations
Pelham et al.(14)	20 (1 hr)	0.2 (1 hr)	Recommendations
Luckhurst & French(15)	25 (1 hr), 12 (8 hr)	n/a	Recommendations

Numbers by author in parentheses is the reference; superscript in chart refers to footnote.

1 **Manitoba Province:** "Air quality guidelines for arena operations in Manitoba." 2009.
2 **Solkoski, G.:** International notes: carbon monoxide levels in indoor tractor-pull events--Manitoba, Canada. *Morbidity Mortality Weekly Report* 39(41): 743-745 (1990).
3 **Ontario Recreation Facilities Association:** "Guidelines for arena indoor air quality." 2009.
4 **Recreational Facilities Association of Nova Scotia:** "Air quality guidelines for arenas in Nova Scotia." 1999.
5 **Ad Hoc Working Group:** "Indoor air quality in ice arenas." 1996.
6 **Brauer, M.:** Recreation buildings. In *Indoor Air Quality Handbook*, pp. 67.61-67.15: McGraw-Hill, 2001.

[1] Require testing 20 minutes after resurfacing. Don't define a time frame for standards. Any single sample must trigger corrective action.
[2] One hour average must trigger corrective action
[3] Any single sample should trigger corrective action.
[4] The ORFA (Ontario) standard refers to "every hour the public is exposed", but their numbers are the same for the public and workers. In fact, they also describe a 15-min STEL of only 3 ppm for workers. ORFA's NO2 guideline is used as an occupational number by the other provinces.
[5] Group consists of researchers, government and the rec. facilities assoc. No time period—"immediately endeavor to bring levels within the target zone."
[6] Any single sample must trigger corrective action.

7 **Saskatchewan Province:** "Saskatchewan arena air quality program: air quality standards." 2000.
8 **Pennsylvania Department of Health:** "Guidelines on ice skating rink resurfacing machine and indoor air quality issues." 2003.
9 "Requirements to maintain air quality in indoor skating rinks," *105 CMR 675.000 Massachussetts sanitary code, chapter XI*. 1997. pp. 3943-3944.3910.
10 "Rules and regulations pertaining to air quality in ice arenas," *Rhode Island R23-1-18-IAQ*. 1990.
11 **Brauer, M., and J.D. Spengler:** Nitrogen dioxide exposures inside ice skating rinks. *American Journal of Public Health* 84(3): 429-433 (1994).
12 **Lee, K., Y. Yanagisawa, J.D. Spengler, and S. Nakai:** Carbon monoxide and nitrogen dioxide exposures in indoor ice skating rinks. *Journal of Sports Science* 12: 279-283 (1994).
13 **Levesque, B., E. DeWailly, R. Lavoie, D. Prud'Homme, and S. Allaire:** Carbon monoxide in indoor ice skating rinks: evaluation of absorption by adult hockey players. *American Journal of Public Health* 80(5): 594-598 (1990).
14 **Pelham, T.W., L.E. Holt, and M.A. Moss:** Exposure to carbon monoxide and nitrogen dioxide in enclosed ice arenas. *Occupational and Environmental Medicine* 59: 224-233 (2002).
15 **Luckhurst, D.G., and W. French:** Carbon monoxide in indoor skating arenas. *Canadian Medical Journal* 121: 1053-1056 (1979).

Appendix B. Indoor Air Quality in Ice Arenas

Arenas and their Ice Maintenance Equipment in Minnesota

The Minnesota Department of Health conducts yearly surveys of indoor ice arena managers using a mailing list collected over many years of enforcement activities. The most recent survey was completed in Fall 2010. Surveys were sent to all known indoor ice facilities. Some if the information from the survey was updated according to inspection findings.

As of May 2011, there were 272 indoor ice arenas (i.e., rinks or sheets of ice) in Minnesota located at 198 facilities (a facility is defined as having a unique street address that houses one or more arena). These data are summarized in Table 1. By comparison, in 2009 there were 266 arenas[1].

Of the 272 arenas, 42 arenas (30 facilities) had all-electric ice maintenance equipment, including the resurfacer and edger. In 2009, there were 24 arenas that were all-electric. The remaining 232 arenas were known or assumed to have at least one combustion resurfacer or edger. Until a facility demontrates that all their resurfacer(s) and edger(s) are electric powered, MDH assumes the arena has at least one combustion-powered resurfacer or edger. Of these 232 arenas, there were 30 arenas which were exclusively using an electric resurfacer and a combustion-powered edger; there were 23 other arenas where either an electric or combustion-powered resurfacer may be used with a combustion-powered edger.

Figure 1. General Indoor Ice Arena Statistics (2011)

Parameter	*2011*	*2009*
Indoor Hockey Facilities in MN	198	194
Arenas (Sheets of Ice) in MN	272	266
Arenas Known or Assumed to have at Least One Combustion-powered Resurfacer or Edger	232	242
Arenas that are All Electric	42	24
Arenas Reporting Electric-Only Resurfacer with Combustion-powered Edger	30	42

A more detailed break-down by fuel-type is shown in Table 2. Data were submitted from 256 of 272 arenas (94%) of MN arena. Propane resurfacing machines and gasoline edgers are the most commonly used equipment.

[1] These numbers are likely a slight underestimate as facilities continue to add sheets and arena managers are known to occasionally fail to report their new arenas.

Figure 2. Percentage of Arenas using Particular Fuel Types [2]

Fuel Type	*Resurfacers*	*Edgers*
Propane	61.1%	17.6%
Gasoline	4.5%	60.0%
Natural Gas	3.1%	2.0%
Diesel	0.4%	0%
Electric	30.4%	20.4%

A majority of arenas in Minnesota continue to use combustion-powered ice maintenance equipment. The use of electric ice maintenance equipment is increasing, but the trend has been gradual.

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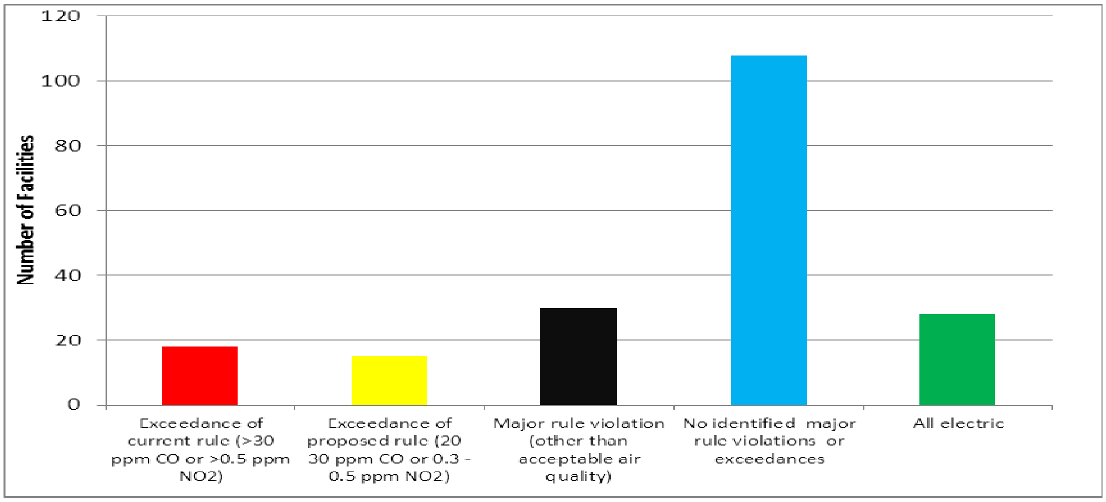
Enforcement Findings in Minnesota: June 2006 – May 2011

MDH staff have routinely inspected all arenas and investigated air quality complaints in specific arenas, under the indoor arena rule enforcement. From June 2006 to June 2011, MDH staff inspected all ice arenas at least twice. MDH staff identified an exceedance[3] at 15 arenas during inspections. In addition, since 2006 MDH has received seven complaints alleging poor air quality conditions at ice rinks, which suggested possible exceedances. Credible information regarding exceedances was collected at three of these arenas. Overall, exceedances were identified in 18 arenas. In addition, there were 15 arenas that would exceed the proposed limits (CO>20 ppm, NO2>0.3 ppm). Moreover, there were 30 arenas that had other major rule violations, such as failing to weekly test air quality. The number of arenas by enforcement status can be found in Figure 3.

Figure 3. Summary of Enforcement Findings

[2] Percentages rather than total numbers are shown since not all facilities responded to the survey. Where facilities listed more than one resurfacer or edger, one type was assigned to each arena.

[3] An exceedance is defined as a carbon monoxide concentration greater than 30 ppm and/or a nitrogen dioxide concentration greater than 0.5 ppm.



Propane resurfacers have been the source of carbon monoxide or nitrogen dioxide in all but two of the exceedance cases where the edger was the suspected source. MDH has not found a single resurfacer emit a significant amount of both CO and NO2; one or the other pollutant was identified. Gasoline and natural gas resurfacers have never been implicated in an exceedance, but these two types of resurfacers constitute less than 8% of all resurfacers in the state.

Inadequate ventilation was a co-factor in most exceedance cases. In most cases, it was clearly identified that fans were simply not turned on or did not function properly. In other cases, fans were operated, but it appeared that the fans provided a low volume of air to the ice level or were not operated as much as usual.

Resurfacer age varied. Most of the resurfacers involved in exceedance were older, from the 1980s or early 1990s; a few cases involved older equipment. However, in some cases the resurfacers were less than 10 years old.

MDH provided orders describing corrective actions to arena managers to address problems. Corrective actions included repairs to the resurfacer(s), repairs to ventilation, and the use or prolonged use of ventilation. These measures were found to reduce concentrations to below the exceedance levels, according to data collected by MDH staff or reported by arena or local fire department staff.

Since 2006, there have also been seven complaints about indoor air quality, and there were three cases were illness seems to have occurred, according to information reported by arena operators or first-responders. MDH has issued orders, and has verified improvements in these arenas through follow-up inspections and documentation submitted by the arenas. Arenas can also have minor rule violations. MDH has found that during the second round of inspections, the average number of violations per facility was 1.6. During the current round 3 inspections that started in February 2011, the average number of violations has dropped to 0.8.

Cases of elevated levels of carbon monoxide and nitrogen dioxide continue to be observed in MN hockey arenas. It is likely that additional exceedances occur beyond the incidents known to MDH. Propane resurfacers can be a significant source of both carbon monoxide and nitrogen dioxide. Facilities with this type of engine should continue to monitor for both pollutants. Gasoline powered edgers can be a significant source of carbon monoxide. There is no clear evidence that edgers cannot be a source of nitrogen dioxide. There is insufficient evidence to conclude that gasoline resurfacers, natural gas resurfacers and propane edgers are won't emit significant levels of either pollutant. While older resurfacers are more likely to emit higher levels, poorly maintained newer resurfacers may also have problems when operated in inadequately ventilated facilities. Repairs to ice maintenance equipment and increased ventilation can be implemented and have been shown to reduce pollutant levels. Corrective orders issued by MDH appear to be effective at addressing problems.

Published Studies

The scientific literature was researched to identify technical studies published in peer-reviewed journals. A large body of scientific research exists in the area of combustion by-product pollutants in indoor ice arenas. The first study was published in Minnesota in 1971 and studies have continued to be published at a continuous rate since then. In most studies, carbon monoxide and/or nitrogen dioxide were sampled. Thirty-five such studies were identified, which are listed in Figure 7 at the end of this Appendix. Three of the published studies evaluated MN arenas. Contaminants other than CO and NO_2 were measured in a few studies, and these are discussed in another report.

Most of the studies were from the USA or Canada, some from Scandinavia, one from Hong Kong, and one large study was an international survey. Comparing studies from around the world to Minnesota is appropriate. The large majority of resurfacers in MN and around the world are Zamboni or Olympia brand, powered by propane or gasoline. Arenas in MN vary in size as do those in other countries. In a study of nine industrialized nations, the average NO_2 level in US arenas was slightly higher than other countries, but this difference was not statistically significant [(1)]. The characteristics of the resurfacers, resurfacing practices, and the sizes of arenas in the USA were similar to other countries.

Seventeen studies were 'poisoning investigations'—illnesses were reported to the local authorities, which triggered an inspection and air testing. Five of these poisoning investigation studies actually described two or more distinct poisoning incidents at different arenas[(2-6)]. The poisoning investigations likely underestimated exposure concentrations because air testing was done several days after the incidents under conditions that may not have accurately simulated conditions during the exposure event[(7, 8)].

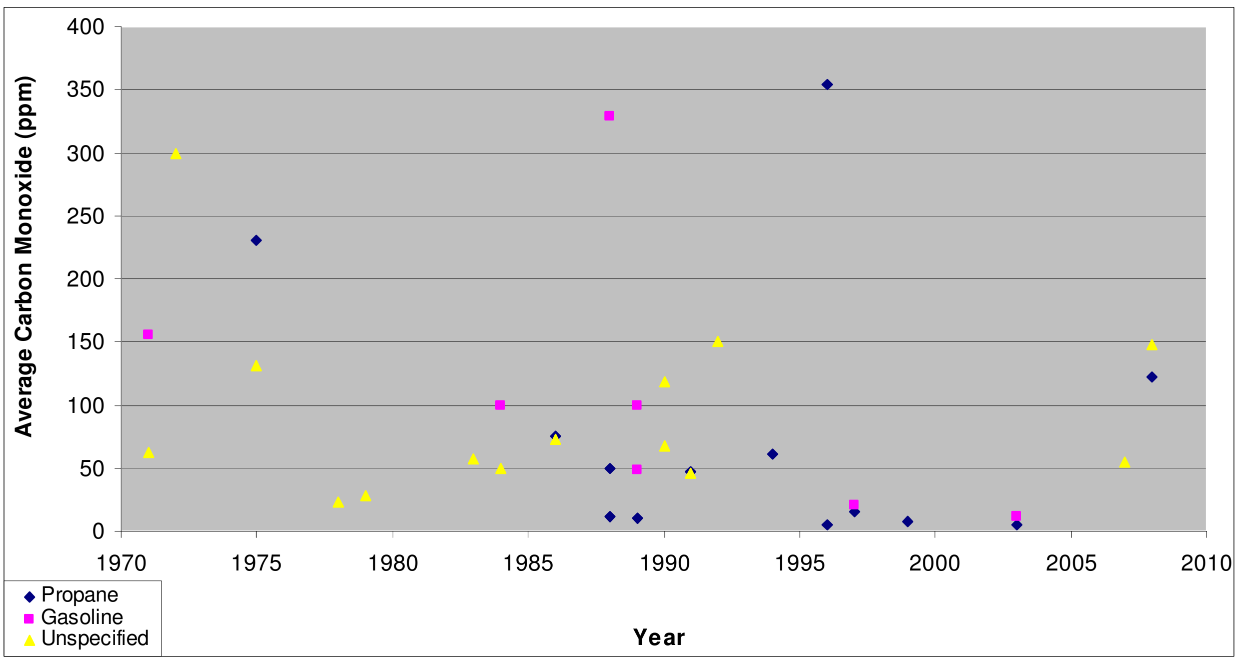
Eighteen studies were 'general studies' that involved arenas that had no known history of problems. A larger number of arenas were sampled in these studies (as many as 332 in one study(1)). Some of these studies assessed CO toxicology and NO_2 health effects.

Concentrations of Carbon Monoxide and Nitrogen Dioxide in Indoor Ice Arenas Associated with Resurfacer Operation

Carbon Monoxide

Twenty-nine studies reported carbon monoxide concentrations associated with resurfacing machines operated in indoor ice arenas. Figure 4 shows the average concentrations reported in these studies; additional details are available in Figure 7. CO levels over 30 ppm were present in all the CO poisoning cases and also found in many of the general studies. There does not appear to be any clear downward trend in reported CO levels over time.

Figure 4. Carbon Monoxide Concentrations in Ice Arenas: Average Levels Reported in the Scientific Literature[4]



[4] Most of the studies reported an average concentration; for those that reported no average, the central point of the reported range is used to represent the central tendency. Each point in the graph represents results from a study, except for three studies where both poisoning and non-poisoning data were provided in a study; these are represented separately in the graph.

Of the 18 poisoning studies, 9 studies implicated CO as the cause, two studies implicated both CO and NO2, and two studies reported separate CO and NO_2 poisoning incidents. The findings in Figure 1 at or above 100 ppm are all from poisoning investigations, with one exception—CO levels between 12 – 250 ppm in a Seattle arena with no known history of problems [9]. The highest result was 500 ppm in a Canadian poisoning incident [4].

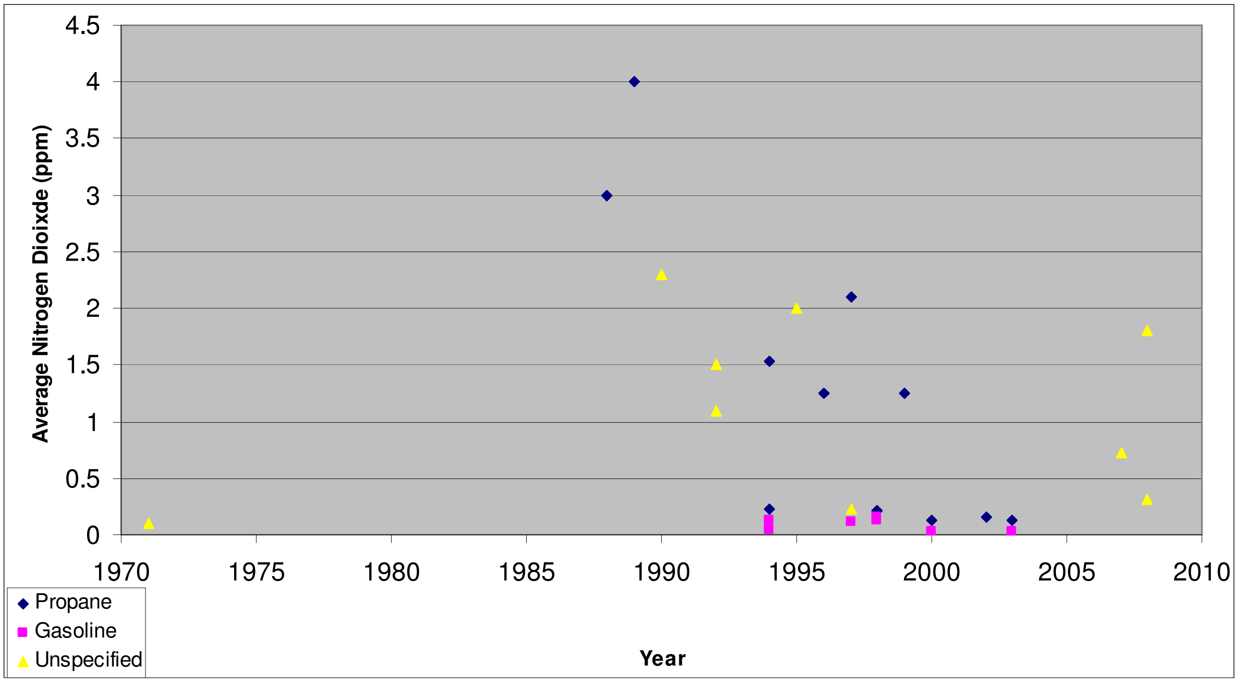
Three of the published studies evaluated MN arenas. Anderson reported a carbon monoxide poisoning incident where individuals developed nausea and headache symptoms [3]; CO levels were 40 – 250 ppm. Anderson also conducted a general survey of 19 arenas with no known problems, and found the average CO level after surfacing was 63 ppm (range: 11 - >200 ppm). Individual resurfacings increased CO level by an average of 34 ppm. In 1990, Oatman and Zetterlund reported details of two cases of high CO in the late 1980s[6]. In one case, CO was 200 ppm; in the other case CO was measured at only 60 ppm and various symptoms consistent with CO poisoning were reported. The third MN study presented a NO_2 poisoning case where CO levels were less than 10 ppm[7].

Nitrogen dioxide

Twenty-four studies reported nitrogen dioxide levels associated with resurfacing machines operated in ice arenas. Figure 5 shows the average concentrations reported in these studies; additional details are available in Appendix A. Nitrogen dioxide received little scrutiny in the 1970s and early 1980s. By the late 1980s, researchers began to assess nitrogen dioxide in ice arenas. NO_2 levels over 0.5 ppm were present in all the NO_2 poisoning cases and also found in some of the general studies. There does not appear to be any clear downward trend in reported NO_2 levels over time.

Figure 5. Nitrogen Dioxide Concentrations in Ice Arenas: Average Levels Reported in Scientific Literature[5]

5 Most of the studies reported an average concentration; for those that reported no average, the central point of the reported range is used to represent the central tendency. Each point in the graph represents results from a study.



Of the 18 poisoning studies, 5 studies implicated NO_2, 2 studies implicated both CO and NO_2, and 2 studies reported separate CO and NO_2 poisoning incidents. NO2 exceeded 1 ppm in all the NO_2 poisoning cases. The highest reading reported was 40 ppm measured in a MN arena in 1971[6] [(3)]. While many of the general studies had average or most readings under 1 ppm, the range of concentrations was usually broad. Brauer found that 10% of rinks had average NO_2 > 1 ppm[(10)]. Penannen found a one week average level as high as 0.98 ppm[(11)]. Other general studies also reported results that exceeded 1 ppm, ranging over 2 ppm [(12, 13)] and as high as 3.9 ppm[(14)].

NO_2 levels were reported in the three MN studies. Anderson (1971) reported a NO_2 poisoning incident where individuals developed respiratory illness [(3)]; NO_2 levels were 35-40 ppm in this arena. In Anderson's general survey of 19 arenas, NO_2 levels were low with an average concentration of 0.1 ppm (range 0.1 – 0.6 ppm). A significant NO_2 poisoning incident is reported in the other two studies[(6, 7)]. Nitrogen dioxide poisoning was identified among 116 individuals exposed at 2 hockey games. When the air was tested at a later time with arena ventilation on, the NO_2 reached 4 ppm after only 30 minutes of resurfacer operation.

Comparison of Propane vs. Gasoline Resurfacers

MDH Rules require that all arenas with combustion powered resurfacing engines test for both CO and NO_2. But does testing for both pollutants continue to be justified for combustion-

[6] This value is not shown in Figure 2 because all the other arenas tested in that study were less than 1 ppm, so the average for those arenas is shown.

powered resurfacers, regardless of fuel-type? Should different pollutants be tested for propane vs. gasoline resurfacers?

Propane and gasoline resurfacers tend to operate at different combustion temperatures and fuel-to-oxygen ratios , which can lead to differences in combustion by-product emissions [10, 15]. It was first noted by Anderson that: "carbon monoxide emissions from engines generally were lower with LPG [propane]"[3]. Anderson also found that of the five engines with measurable nitrogen dioxide, four were propane engines. Moreover, he found that in a NO_2 poisoning case, conversion from propane to gasoline dropped nitrogen dioxide levels but caused CO to increase. The conclusion drawn from this study was that gasoline produces more CO and propane produces more NO_2. his generalization was reiterated by other researchers in subsequent years[1, 16, 17], and a crude difference can be seen among the studies (see Figure 3). Some went as far as to recommend conversion of gasoline engines to propane, under the belief that propane engines were safer [4, 18].

This dichotomy between gasoline and propane should not be over-stated. Anderson also noted that "the range of CO concentrations found was almost as wide for propane as gasoline" and that "a well-tuned propane engine will produce less carbon monoxide than a gasoline one; however, maintenance of the engine is the key factor in carbon monoxide production from any one engine"[3]. He concluded that a well-tuned propane resurfacer should not exceed 1% CO in its exhaust, while a well-tuned gasoline resurfacer should not exceed 2% CO in its exhaust. MN OSHA standards mandate "the employer shall ensure that powered industrial truck engine exhaust gases do not contain more than one percent carbon monoxide for propane fueled trucks or two percent carbon monoxide for gasoline fueled trucks…"[19]. Quebec regulations require that CO emission rate must not exceed 0.5% for propane resurfacers and 1% for gasoline resurfacers[17], while Ontario's limit is 2% for gasoline and 0.5% for propane[20].

These emission standards indicate that, under well-maintained engine conditions (i.e., 'all things being equal'), there is a difference between propane and gasoline, although not a very large one. There are several other factors--especially the fuel to oxygen ratio--that dictate the levels CO and NO_2 emitted from engines. Researchers have concluded that poorly performing engines, not the fuel type, were the primary factor that affected pollutant levels in all the studies.

The data reported in the studies show that both propane and gasoline resurfacers can emit CO at rates that result in exceedances of the 30 ppm CO benchmark (see Figure 1). In the CO poisoning cases, 5 cases were attributed to propane and 4 cases were attributed to gasoline. In addition, in the general studies, arenas with both propane and gasoline resurfacers had elevated CO. For example, Lee et al. reported CO levels ranging from 4-117 ppm and NO_2 from 0.342 - 2.729 ppm in 6 arenas with propane ice resurfacers[13]. Pennanen et al found CO levels were slightly, but not significantly, higher in gasoline resurfacers compared to propane (21 ppm vs. 11-18 ppm)[14]

Clearly both propane and gasoline resurfacers can emit CO—but do gasoline resurfacers emit significantly less NO_2?

The data reported in the poisoning studies are not clear as to whether arenas with gasoline resurfacers would present a NO_2 health concern. Gasoline resurfacers have not been directly implicated in any of the NO_2 poisoning cases. In the NO_2 poisoning studies, 4 cases were attributed to propane resurfacers, but the resurfacer fuel was not specified in the other 5 cases. NO_2 was never tested in any poisoning case where a gasoline resurfacer was present.

A few of the general studies compared NO_2 in propane and gasoline powered resurfacers, which allows for direct comparisons. Brauer and Spengler found that among 70 arenas in New England, arenas with propane resurfacers had higher NO_2 levels compared to arenas with gasoline resurfacers (0.221 vs. 0.134 ppm), but this difference was not statistically significant. Likewise, Pennanen et al found that among 69 arenas in Finland, the arenas with propane resurfacers had higher NO_2 levels compared to arenas with gasoline resurfacers (0.176 vs. 0.150 ppm), but this difference was also not statistically significant[(11)]. The levels in both propane and gasoline arenas were significantly higher than levels in electric arenas (0.013 ppm). Three other studies also found that arenas with propane resurfacers had slightly higher concentrations of NO_2; however, the differences were not statistically significant[(1, 14, 21)].

On other hand, two studies did find a significant difference. Levy et al. found that, for certain data sub-sets, arenas with propane resurfacers had higher NO_2 levels that were statistically significant, (0.206 vs. 0.132 ppm) [(10)]. Yoon et al also observed that arenas with propane resurfacers had significantly higher NO_2 levels for 3 out of 4 months, with levels 4 to 14 times higher[(22)].

It is noteworthy that Levy et al also found that some gasoline rinks had NO_2 levels between 0.5 and 0.9 ppm[(23)]. In addition, arenas with gasoline resurfacers had significantly higher NO_2 levels compared to electric arenas and the outdoor levels (0.03 ppm). Moreover, in 4 rinks with gasoline resurfacers that switched to electricity, the median NO_2 dropped from 0.124 to 0.035 ppm. Penannen et al. found that the highest weekly average NO_2 concentration in gasoline powered arena was 0.92 ppm, which was only slightly less to the highest weekly average in a propane arena[(11)].

While propane resurfacers have a greater propensity for NO_2 emissions, data indicate that the difference between propane and gasoline is small and usually not statistically significant. Arenas with gasoline-powered resurfacer had significantly higher NO_2 levels compared to electric arenas, and levels exceeded health benchmarks in some cases. These conclusion were also drawn by Pelham in his review of the scientific literature [(17)].

Diesel and natural gas are also fuel sources for combustion powered resurfacers. There is only one known diesel resurfacer and only 10 natural gas resurfacers in MN. Data for natural gas resurfacers are scant. Game found that CO and NO_2 levels associated with one natural gas resurfacer was low [(24)]. Pribyl stated that natural gas is probably similar to propane and associated with higher NO_2, but lower CO compared to gasoline [(16)]. Diesel probably has characteristics similar to gasoline.

Carbon Monoxide or Nitrogen Dioxide as a Marker for Both Pollutants

It is clear from the literature that ice resurfacing machines can emit significant levels of both CO and NO_2. But are these contaminants produced independently? Pelham concluded that "these pollutants (CO and NO_2) are never isolated"—when one is detected, measurable levels of the other contaminant is usually found [17]. Rhode Island's regulation only requires testing for carbon monoxide. If a strong positive correlation exists between CO and NO_2, it would be sufficient to test only one of the two contaminants as a marker for the other.

There does not appear to be a strong positive correlation between the two pollutants. The fuel-to-oxygen ratio is the primary factor that dictates the amount of either pollutant emitted. In virtually all the studies, a malfunctioning resurfacer was identified as the primary cause, with an imbalanced fuel-to-oxygen ratio specifically identified in a few cases [7, 14, 16, 17, 20, 25]. The fuel-to-oxygen ratio depends on the condition of the engine. Unexpected break-downs, inadequate maintenance, or intentional mechanical adjustment of the engine have been found to affect the fuel-to-oxygen ratio.

When engines have a high ratio of fuel to oxygen, the rate of carbon monoxide emission increases. This is because insufficient volume of oxygen (O2) is supplied to the combustion process and, rather than create CO2, the combustion produces CO. Carbon monoxide emission can increase during cold starts and fuel-rich operating such as heavy acceleration[26].

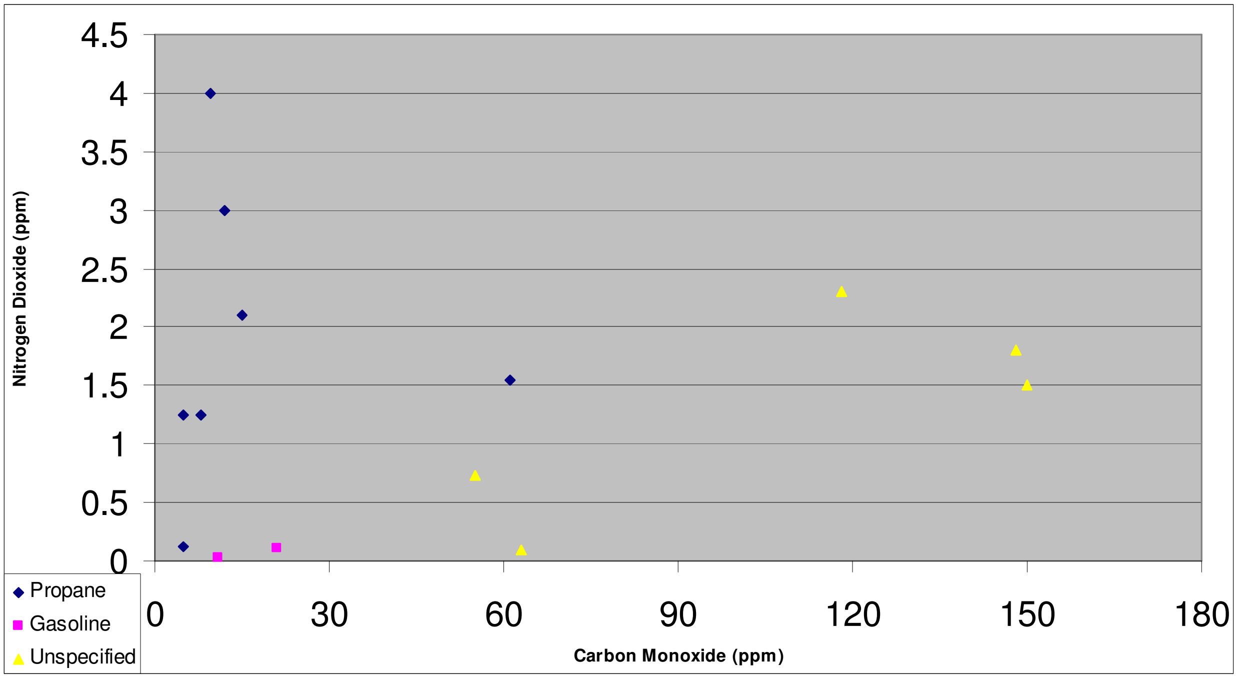
When engines have a low ratio of fuel to oxygen, the quantity of nitrous oxide (NO) increases. The NO is converted to nitrogen dioxide (NO_2) in the ambient air of an arena. In addition, NO_2 can be directly emitted from the tailpipe. NO_2 emissions are increased at higher temperatures, and there are other poorly understood factors[26].

If a strong positive correlation existed between CO and NO_2, high levels of both contaminants would be expected in the studies that measured both chemicals. here is, however, no clear trend of CO levels relative to NO_2 (see Figure 3). Anderson found an inverse correlation between CO and NO_2--higher CO were associated with lower NO_2 levels[3]. Pennanen reported no correlation between CO and NO_2[14].

The lack of correlation between CO and NO2 was also demonstrated in Oatman and Zetterlund's investigation of MN arenas [6]. Prior to 1990, MDH investigated complaints and reported exceedances of its air quality standards. Of the 16 reported exceedances, in 6 cases CO exceeded the 30 ppm standard, in 7 cases NO_2 exceed the 0.5 ppm standard, and in 3 other cases both pollutants exceeded their respective standards.

There is also some evidence regarding the lack of correlation that can be found in the poisoning cases. In 16/18 poisoning studies the authors concluded the poisoning was caused by either CO or NO_2 (not both)[7], and in two studies the authors concluded both pollutants could be the cause of symptoms. In sum, testing for CO or NO2 cannot serve as a surrogate for testing the other pollutant.

Figure 6. Nitrogen Dioxide Concentrations Plotted Against Carbon Monoxide for those Studies that Reported both Pollutants



Health Effects Reported in the Studies

Poisoning incidents

In the 18 poisoning studies where exposure was confirmed, short and long-term health effects associated with CO and NO_2 exposure were reported. In most poisoning cases, some individuals were hospitalized (7, 8, 15, 27-32). Symptoms were more prevalent among those exposed to higher pollutant concentrations (2, 7, 33). The exposure concentrations—usually measured under simulated conditions—can be found in Figures 4, 5, and 7.

[7] In most CO poisoning cases, researchers did not test for NO_2; however, the symptoms and physical signs associated with CO poisoning are distinctly different from NO_2 poisoning and, in some cases, CO poisoning was corroborated with elevated carboxyhemoglobin. Had the NO_2 been measured, it would likely have been low. In the NO_2 poisoning cases, CO was usually tested, and, in most cases, the CO levels were low in these arenas.

Nitrogen dioxide poisoning incidents have been referred to as 'hockey lung', 'Zamboni disease'[31], and 'nitrogen dioxide pneumonitis'[27]. Symptoms included cough, dyspnea (shortness of breath), haemoptysis (coughing up blood), hypoxaemia (reduced oxygen in blood, reduced peak expiratory flow (obstructed airways), and chest pain [2, 7, 27, 32]. Other symptoms have included headache, weakness, and exacerbation of asthma [7].

Symptoms in CO poisoning incidents typically involved headaches, dizziness, tiredness, nausea, and other central nervous system effects [2, 4, 25, 32]. Carboxyhemoglobin was measured in some of these poisoning cases, with levels ranging from 8.6% to 35% in exposed individuals [25, 28-30]. Other subtle effects of CO can occur, such as sensory effects and cardiovascular damage, but there weren't evaluated in the poisoning studies[16, 17, 34, 35].

A few of the poisoning studies assessed long term health effects. Rosenlund and Blum investigated health effects among 55 hockey players exposed to NO_2 levels over 1 ppm[33]. After exposure, 55% reported respiratory symptoms compared to 7% of the unexposed individuals (hockey players at an electric rink). Five years later, the exposed individuals were 2-3 times as likely to have persistent upper respiratory symptoms (nasal blockage, rhinitis) and lower respiratory symptoms (shortness of breath, wheezing, cough) compared to the reference group of unexposed subjects[36]. Asthma diagnosis or use of asthma medications were more common among previously exposed subjects, but the association was weak.

In another long-term study of a CO and NO_2 poisoning incident of 16 hockey players, Kahan et al. reported that 92% had dyspnea (shortness of breath), 75% had chest pains, 33% hemoptysis (coughing up blood) and 8% were hospitalized after the event[15]. Concentrations of NO_2 were 0.35 – 1.1 ppm and CO were 50-60 ppm. Six months after exposure about half the exposed hockey players complained of cough or dyspnea and there was some evidence of increased airway resistance and small airway disease. In other studies, lung function problems were found to continue for several days to several weeks, but eventually returned to normal after 1-2 months, indicating a full recovery is also possible [7, 27].

There have been many cases of CO and NO_2 poisoning incidents in MN and elsewhere. It is likely that CO and NO_2 poisonings incidents are grossly underreported. The symptoms of carbon monoxide and nitrogen dioxide intoxication can go undetected. CO poisoning symptoms are non-specific and similar to other illness (e.g. food poisoning). In some of the CO poisoning cases, food poisoning was investigated initially[20]. NO_2 poisoning can also go unnoticed because the symptoms are usually delayed by several hours or even days[27, 33]. As such, exposures may go unnoticed or unreported[2].

General Studies

Toxicological studies have identified a dose-response relationship between CO exposure in arenas and CO in the lungs (alveoli) and blood (carboxyhemoglobin) of hockey players. Spengler et al. was the first demonstrate that exposure to carbon monoxide in ice arenas following the operation of a combustion resurfacer resulted in increased carboxyhemoglobin[37]. After exposure to 22.5 ppm CO for 90 min, carboxyhemoglobin of hockey players rose to 1.1% - 3.2%. Later, Lee et al reported that every 10 ppm of CO in the arena air corresponded to about 5.3 ppm in the lungs (alveoli) and about 1% carboxyhemoglobin(13). Levesque et al found that players in the arenas with CO >75 ppm had carboxyhemoglobin averages of 8.7%, 10.8%, and 13.2%, with some players as high as 17%(36). Similar relationships between ambient CO after resurfacing, alveolar CO, and carboxyhemoglobin were observed in other studies (35, 38).

Case-control studies of ice arenas have identified increased prevalence of health effects among ice arena users. Lumme et al found that 22% of junior hockey players had current or previous asthma compared to a control group that had a prevalence of 4%(39). In addition, bronchial hyper-responsiveness and white blood cell counts were higher among the hockey players. The researchers attributed the increased prevalence to exercise, cold air and possibly indoor pollutants such as NO, NO_2, and CO, although no air sampling was conducted in this study. Moreover, this study, had a small number of subjects.

In a study of 1,536 Swedish children playing in 9 propane arenas (mean NO_2=0.15 ppm) and 6 electric arenas (mean NO_2=0.005 ppm), the overall prevalence of asthma was 16%, which is higher than the 10.8% rate for all Swedish children. However, there was no significant difference between propane and electric arenas(40). Thunqvist et al. concluded that "children playing in hockey arenas have a high prevalence of asthma, but it appears unlikely that increased exposure to combustion by-products, including nitrogen dioxide, is a major contributor to this excess risk(40)". Exposure to cold air and exercise seem to explain the higher rates of asthma among hockey players. While NO_2 exposures that may occur on a regular basis in many arenas (0.1-0.2 ppm) may not be a significant risk factor for asthma development, they found that these exposures may present a small risk for asthma-type symptoms--the children in arenas with higher levels of NO_2 (5 fold greater) had slightly higher rates of wheezing (21% v 16%) and nasal symptoms (31% v 21%). It should be noted that NO_2 levels were not high in these arenas; long term health effects may be more pronounced in arenas that have higher NO_2.

Voluntary and Regulatory Options

A large number of people use ice arenas in Minnesota; perhaps the highest per capita rate of ice arena use in the USA exists in MN. It has been reported that the average number of ice rink users per day is 352, according to figures reported by New England arena operators(10). This equates to about 500,000 people daily using the 2,000+ indoor ice rinks in the USA and Canada. Since there are at least 272 Minnesota indoor ice rinks situated in 198 facilities, this means about 70,000 – 95,000 Minnesotans use ice rinks daily. This figure may be high, but could be representative of peak season (Oct-Mar). Minnesota Hockey, the governing body of youth and amateur hockey in Minnesota, has estimated at least 72,000 Minnesotans participate in ice hockey, as players, coaches and officials[8]. Air quality in indoor ice arenas has significant public health relevance. These two statistics may not include occasional users of arenas, such as

[8] Mike Snee, President of Minnesota Hockey, email correspondence 3/28/11

spectators and public skate participants. The popularity of ice skating and ice hockey continues in MN, with new arenas added every year, even during the current economic recession.

During the late 1980s, 16 arenas were reported to MDH (by the public or arena operator) that had elevated CO and/or NO_2 notified to MDH[(6)]. At that time, MDH did not do routine inspections and only investigated complaints or reported levels exceeding action levels. The number of arenas that exceeded standards surely was far greater than 16. As a result of these findings, MDH began a more rigorous enforcement program including: 1) routine inspections, 2) responding to public complaints, 3) quarterly review of air quality results, 4) training programs for operators of ice arenas. MDH continues this enforcement strategy today.

Voluntary Programs

Attention to this public health concern is clearly justified. Would voluntary measures be sufficient? Rather than regulate this problem, one option would be to implement a voluntary program that involved education and outreach. Such efforts do occur in many states and countries.

A Canadian survey found a variety of misconceptions existed amongst arena managers [(20)]. None of the 65 arenas in this study conducted air or emission testing voluntarily. A common misconception of the managers was that propane ice resurfacers are relatively safe and obviate the need for exhaust ventilation. Another misconception was that high CO levels were accompanied by an odor, which could serve as a signal that a problem existed and ventilation was needed; in reality, elevated CO can be present in the absence of an odor. These findings cast doubt on the likelihood that a large number of arenas would voluntarily implement proactive measures or appreciate the hazards associated with resurfacers. Arena managers cited CO poisoning at their arena or elsewhere as their introduction to the problem of CO toxicity. A Canadian manager of inspections commented that he doubted more than 20% of rinks in his province had testing equipment[9].

In Finland, an educational campaign to implement resurfacer and ventilation changes in arenas was piloted with mixed results[(2, 41)]. Efforts to increase the number of electric resurfacers and install emission control technology (ECTs; lambda controlled 3 way catalytic converter) had some success: the number of arenas using resurfacers with ECTs or electric resurfacers increased from 17% to 46% over two years. This, however, still left the majority of arenas choosing not to implement the recommendations. The ventilation recommendations were ineffective since the numbers of arenas with inadequate ventilation did not change.

Non-regulatory recommendations are only partially effective. In MDH's experience, many arenas would not monitor or maintain air quality unless it was regulated. It seems a regulatory

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[9] Personal correspondence with Mike LeBlanc, Chief Public Health Inspector & Manager , Health Protection Unit, Environmental Health Branch, Manitoba Health

program is needed to ensure that most arenas will have safe air quality. MDH's existing rule is 'performance-based', meaning acceptable air quality must be maintained, checked through routine testing, without prescribing control measures. A rule does not necessarily have to require air testing and specific control measures could be required in addition or as alternative to testing. Are there other interventions or strategies that could be employed as an alternative or additionally? Mandating electric resurfacers, emission control technologies, and specific ventilation rates are three such options.

Electric Resurfacers

The simplest regulation would be to mandate that all arenas only use electric resurfacers. Studies have shown that air quality in these arenas is significantly cleaner and comparable to outdoor conditions[11, 14, 23, 40, 42]. All the researchers that present mitigation strategies have stated that switching to an electric resurfacer is the best option.

The cost of purchasing an electric resurfacer is significant. A new propane resurfacer can cost ~$60,000 - $70,000 while a comparable electric resurfacer may cost ~$100,000. The cost of resurfacer can be much less when purchased used, but it is not known whether many electric resurfacers are available in the used resurfacer market. In addition, many arena operators have indicated to MDH that they do not like the performance of electric resurfacers and are concerned about the battery charge life, especially on busy days where more than one rink is being used. On the other hand, arena operators with electric resurfacers have shared favorable opinions with MDH, and we have yet to hear of or find an arena that has switched from an electric resurfacer back to a combustion-powered resurfacer.

MDH should encourage the purchase and use of electric resurfacers, but mandating their purchase seems overly burdensome. The use of electric resurfacers does obviate the need for air testing, which can save an arena several hundred dollars a year. In addition, the amount of ventilation could be reduced in all-electric arenas, also saving on energy costs. Moreover, savings may be found in the cost of electricity, which may be cheaper than the cost of propane or gasoline. The purchase and use of electric resurfacers will grow, and the rate of change could be slow or fast depending on the price of electric resurfacers, battery performance improvements and arena operators' opinions. It will, however, take many years or even decades until combustion-powered resurfacers are obsolete.

Ventilation

Requiring specific rates of ventilation is another regulatory method to maintain air quality. Appropriate rates of ventilation in arenas can control pollutant levels by diluting concentrations with "fresh" outdoor air. In most of the poisoning cases, inadequate ventilation was identified as part of the problem. In many cases, the ventilation was not being operated either due to over-sight or intentionally to reduce energy costs. In other cases, the ventilation malfunctioned. n some cases, mechanical ventilation was absent or limited in the arenas.

Several studies have evaluated the role of ventilation. Arenas with inadequate ventilation (no equipment, not used) had slightly higher NO2 levels, but the difference was not statistically significant(11). Levy et al. found that while NO_2 levels in arenas initially went down following ventilation changes and resurfacer tune-ups, NO_2 levels increased in subsequent months, which demonstrated the difficulty in maintaining mechanical interventions(10). After ventilation recommendations were made (i.e., run fans continuously during operating hours), NO_2 levels dropped from 0.443 ppm to 0.093 ppm in Boston area arenas(22). Levels, however, rose in later months to 0.212 ppm and 0.190 ppm, indicating higher ventilation rates cannot necessarily be sustained.

Arena managers seem reluctant to implement ventilation changes. In the Finnish educational campaign, researchers recommended ECT retrofits and increased ventilation. While some arenas installed ECTs, the number of facilities with inadequate ventilation stayed the same(41).

Ventilation rates to control levels of resurfacer air pollutants have been specified in the literature, but recommended rates vary (17). Installation and operation of ventilation to meet these ventilation rates would be costly. It may cost several thousand dollars per year to ventilate an arena at the recommended rates(10). In fact, it may not be possible for some existing facilities to maintain ice conditions during warm periods with very high rates of ventilation. Moreover, the equipment could fail due to inadequate maintenance, resulting in exposure to combustion by-products(43).

Further complicating the matter is the role of air mixing(43). Because of the colder temperatures at ice level and the barriers formed by the boards and plexiglass, outdoor air that is supplied may not mix well with the polluted air at ice level.

It would be difficult for MDH to enforce a ventilation standard. Ventilation rate testing is more complex than CO and NO_2 testing.

Relying on ventilation alone to ensure acceptable air quality does not appear to be the most effective or economical strategy. If specific ventilation rates were mandated, routine testing of air quality would still be needed to ensure air quality is acceptable. Yoon et al concluded that "ventilation may improve air quality but it may not be sufficient in all cases to maintain safe levels", after they observed levels of 0.227 ppm NO_2 (over the WHO standard of 0.2 ppm) despite continuous ventilation(22). Maximal ventilation rates may not be employed on a regular basis and break-downs in ventilation may go unnoticed. In arenas where resurfacers are well-tuned, high rates of ventilation would be an unnecessary cost.

Emission Control Technologies

Requiring installation of emission control technologies (ECT) to existing resurfacer engines is another option. Improvements in clean burning engines(20) and recent regulations from the EPA(44) have resulted in lower emissions from engines. Existing engines can be retrofitted, in some cases. For example, a lambda sensor-controlled fuel supply and a 3-way catalyst reduced

NO_2 concentrations from 0.345 ppm to 0.078 ppm in 11 Finnish arenas [(41)]. The cost of retrofitting the ECTs was estimated at about $5,000; not insignificant, but much less than a new electric resurfacer (~$100,000). In five other arenas that already had ECTs, the NO2 was about 1/5 to ½ of the average levels of all the arenas in the study.

In another study of a resurfacer in British Columbia also observed a similar significant decline by 86.6% in NO_2 and 95% decline in CO after installation of this ECT system [(45)]. Installation of such technology was more widely embraced by arena operators than was continuous use of ventilation or installation of CO alarms[(2)].

Certain ECTs are not effective at reducing both CO and NO_2. Two-way catalytic converters will not reduce NO_2[(45)]. Fuel-oil injection modifications have yielded overall reductions in pollutants (CO, hydrocarbons, particulates) to help meet air quality standards, although specific pollutants such as NOx increased[(46)].

Three-way catalytic converters with lambda fuel management systems seem to be the generally recommended ECT for ice arenas, to limit both CO and NO_2. The Recreational Facilities Association of British Columbia has recommend its installation as "one of the best ways" to reduce CO and NO_2 and they view this as a "proven good solution" [(45)].

The 3-way converter may not be the perfect solution. For some catalytic converters to be effective, an engine warm-up time of several minutes is required in a well-ventilated area or exhausted directly outdoors [(47)], although new resurfacers do not need this warm-up[10]. Arena staff are often rushed and will not take the time to warm the engine. Moreover, it may not be possible to retrofit gasoline engines [(11)] with a 3-way catalytic converter; retrofitting older engines (pre-1980) may not work or burn the motor[11].

In the Finnish study, an educational campaign was piloted with some success [(2, 41)]. Efforts to increase the number of electric resurfacers and install emission control technology (ECTs; lambda controlled 3 way catalytic converter) had some success: the number of arenas using resurfacers with ECTs increased from 6 (8%) to 37 (37%) and the number of electric resurfacers increased from 7 to 9 arenas. NO_2 levels in 11 arenas declined after installing the ECTs, from 0.35 ppm NO2 to 0.078 ppm. It should be noted, however, that in some resurfacers, the NO2 levels remained over 0.1 ppm, because retroffited ECTs cannot be optimally adjusted for each engine and inadequate ventilation continued to exist in some arenas. In addition, in five other arenas that already had the ECTs, the average NO2 level increased over 2 years, from 0.066 ppm to 0.086 ppm, although it is unknown whether ventilation changed.

In one of the poisoning cases investigated by Salonen et al, the resurfacer had the 3-way ECT, but it was malfunctioning[(2)]. Sorensen found that initial repairs to resurfacing equipment failed to

[10] Personal correspondence with John Milton, Chief Administrative Officer, Ontario Recreation Facilities Association
[11] Personal correspondence with Mark Alton, Hawk Performance Specialties

reduce CO levels, requiring additional work [(48)]. Levy et al. found that while NO_2 levels in arenas initially went down following ventilation and tune-ups, NO_2 levels increased in subsequent months [(10)]. The Recreation Facilities Association of Nova Scotia has stated that the "addition of a catalytic converter… is not recommended as the sole method because special procedures must be followed to maintain its effectiveness, and failure may occur without warning"[(47)].

There may be a potential risk of installing 3 way catalytic converters in resurfacers[12]. If the fuel management system stops working, the check engine light should turn on. CO emissions will be higher at this point, and even higher than prior to retrofitting with a 3 way cat converter because the system is tuned to run richer with the 3 way catalytic converter. It may take some time before the arena operator realizes the light is on or can correct the problem. In addition, the check engine light only comes on if fuel management system fails, but if the 3 way catalytic converter fails, there could be high CO with no light on[13]. Also, the light can burn out or wiring cut. Such engine problem may occur every 2 to 3 years, on average, but breakdowns can occur at any time. For these reasons, it is recommended that engines be inspected and emission tested on a regular basis[14].

Installing catalytic converters on edgers is problematic[15]. A 3 way catalytic converter cannot be installed in an edger because this requires a fuel management system. Without a 3 way converter, NO2 cannot be controlled. Installing a 2-way catalytic converter is possible. New edgers aren't equipped with this feature and the cost of retrofitting is significant. Zamboni recommends against installation of a catalytic converter, because this may damage the engine. In addition, the surface of the converter is exposed and can get very hot, presenting a possible burn or fire hazard.

While the cost of an ECT is low compared to a new resurfacer, the price tag may still be a significant cost for some arenas, such as the small youth hockey facilities. It would be difficult to justify such a cost in an arena that has been able to maintain air quality. Levy et al. concluded that for "resurfacers that may not be covered by this technology, or for rinks that cannot afford the cost, concentrations should be monitored periodically to determine whether the resurfacer has been properly maintained, to ensure that ventilation is sufficient, and to maintain an observer effect".

Continuous Monitoring Systems

Another regulatory option would be to require installation of CO and NO_2 alarms in every arena. A few MN arenas have alarms, but these are usually CO alarms situated away from the ice that have no data logging capacity. MDH knows of only two arenas have monitors for both CO and NO_2, and MDH has seen only one prototype that is mounted inside the boards. The cost of

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12 Personal correspondence with Dan Doornink, R&R Specialities
13 Personal correspondence with Mark Alton, Hawk Performance Specialties
14 Personal correspondence with Mark Alton, Hawk Performance Specialties
15 Personal correspondence with Dan Doornink, R&R Specialities and Mark Alton, Hawk Performance Specialties

installing such a continuous monitor could be significant with one estimate at the suburban Twin Cities' arena cited at $6,500. As with all electronic devices, routine maintenance of the alarm would be necessary, but costs are unknown.

For a continuous monitor to be acceptable, the sensors would have to be situated in a location that allows for testing air directly above the ice, to measure concentrations where skaters are exposed. Several studies have noted the pollutant concentrations are higher directly above the ice, because the boards and plexiglass act to trap combustion by-products and also because the colder temperatures over the ice prevent air mixing with reset of the arena [16, 17]. Pennanen et al. found that there can be a 14 C (~25F) temperature differential between between the surface of the ice to 4 meters above the ice[14]. The highest NO_2 levels were measured at 0.5 – 1.0 m above the ice, in the breathing zone of younger children. Two separate studies found similar levels at various locations, at the same height, over the ice[11, 22]. Testing at any location on the ice, in the breathing zone, seems acceptable.

This justifies testing over the ice, at board height, but it may not be difficult to install monitors inside the boards. Such a location may make a continuous monitor vulnerable to intentional and unintentional damage. Foreign materials and moisture (e.g., flying ice shavings) could collect at the inlet port and obstruct air flow to the sensor. Skaters will routinely bang into the boards were the instrument is located. Cold temperatures may also affect the sensors, which could increase the cost of ownership.

MDH is open to allowing continuous monitors, if they meet various criteria, including: initiates corrective action; draws air from above the ice; rugged; moisture resistant; cold temperature tolerant; can report levels to MDH; and can be maintenanced. MDH continues to evaluate field data regarding these parameter from two MN ice arenas. Due to their relatively new application, mandating continuous monitoring systems seems unreasonable.

Conclusions

Carbon monoxide and nitrogen dioxide exposures continue to occur in indoor ice arenas. Health effects among ice arena users have been observed, including acute poisonings. Attention to this public health issue continues to be justified.

While propane and gasoline resurfacer have different emission profiles, the differences are minor. Both types of engines can be a source of CO and NO_2. Both pollutants should be tested for, regardless of fuel types in resurfacers.

There is no clear correlation between levels of CO and NO_2. In some cases, CO was elevated, in other cases NO_2 was elevated, and in some cases both were elevated. Testing for one pollutant would not protect against exposure to the other pollutant.

There are no simple, economical, and universal engineering or administrative controls available to control CO and NO_2 in ice arenas. In a Finnish study, the simple presence of combustion-powered resurfacing and arena volume were the most significant factors that affected air quality while ventilation and the presence of catalytic converters contributed much less to air quality[11]. As a result, many researchers have recommended routine air testing of ice arenas[14, 17, 23, 28]. Air testing is the only method to verify air pollutants are low. Other U.S. states with regulations also require testing without mandating proactive control measures [49, 50].

Regulation is justified; voluntary measures would likely not be implemented in a large number of arenas. Regulation could prescribe engineering and administrative controls, but the costs and other burdens to arenas would be significant. These measures would be excessive in many arenas that are currently able to maintain air quality through methods arena managers have adopted specific to their arena and resurfacer. Requiring testing seems to be a reasonable and relatively low cost method to identify problems, which should lead to arena-specific control measures being implemented.

Figure 7. Average Carbon Monoxide and Nitrogen Dioxide Concentrations

Poisoning Investigations

Author	Year	Location	Carbon Monoxide			Nitrogen Dioxide		
			Propane	Gasoline	Unspecified	Propane	Gasoline	Unspecified
Anderson[(3) c,n]	1971	Minnesota		40 - 250	63*	40		0.1*
Canadian Lab [(4) c]	1972	Canada			100, 500			
Johnson [(9) c]	1975	Seattle	157 - 304		12 – 250*			
Russell [(25) c]	1984	Pennsylvania		100				
Pitkin County [(38) c]	1986	Colorado			55 - 90			
Andre [(5) c]	1988	Canada	0, 60, 100	158, 500				
DeWailly [(51) n]	1988	Canada	12			3		
Hedberg [(7) n]	1989	Minnesota	9.6			4		
Miller [(28) c]	1989	Virginia		100 (48*)				
Oatman [(6) c,n]	1990	Minnesota			35 - 200			0.6 - 4
Paulozzi [(30) c]	1991	Vermont	47					
Smith [(32) c/n]	1992	Wisconsin			150			1.5
Morgan [(31) n]	1995	Canada						0 - 4 ppm
Hampson [(29) c]	1996	Seattle	354					
Karlson-Stiber [(27) n]	1996	Sweden	<9			1.25		
Rosenlund [(33) n]	1999	Sweden	8			1.25		
Kahan [(15) c/n]	2007	Pennsylvania			50 - 60			0.35 - 1.1
Salonen [(2) c]	2008	Finland	122		148			1.8 (0.01 - 0 6*)

General Studies (no known problems)

Author	Year	Location	Carbon Monoxide	Nitrogen Dioxide

			Propane	Gasoline	Unspecified	Propane	Gasoline	Unspecified
Spengler [37]	1978	Boston, MA			22.5			
Davis [52]	1979	Michigan			28			
Kwok [53]	1983	Canada			3 - 110			
Hillman [20]	1984	Canada			49.7			
Sorensen[48]	1986	Massachussetts	50 - 100					
Levesque [34]	1990	Canada			2 - 132			
Levesque [35]	1991	Canada			16.4 - 76.2			
Berglund [12]	1992	Sweden						0.11 - 2.07
Brauer [10]	1994	New England				0.221	0.134	
Lee [13]	1994	Massachussetts	4 - 117			0.34 - 2.73	0.037	
Brauer [1]	1997	Nine countries						0.228
Penanen [14]	1997	Finland	11,18	21		0.31 - 3.9	0.11	
Levy [23]	1998	Boston, USA				0.206	0.132	
Pennanen[11]	1998	Finland				0.21	0.15	
Pennanen[41]	1998	Finland				0.212		
Yoon[22]	2000	Boston, MA				0.125	0.0291	
Thunqvist [40]	2002	Sweden				0.15		
Guo [21]	2003	Hong Kong	5	7,14		0.128	0.033	

If no average is reported, then the range (separated by a hyphen) or individual readings for each arena are shown (indicated by a comma). Direct comparisons between different studies may not be appropriate considering differences between studies (resurfacers' condition/age, ventilation of buildings, sizes of buildings, numbers of resurfacings, testing methods, etc). The likely cause of the poisoning incident is indicated by the superscript by the author name (c=CO; n=NO2; c,n=CO in one case, NO2 in another case; c/n=CO and/or NO2. Asterisk (*) indicates data are from comparison non-problem facilities included in poisoning investigations.

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Appendix C. Indoor Air Quality in Motorsports Arenas

MDH has observed poor indoor air quality in enclosed arenas in which motorsports activities occur. To further explore this issue, MDH researched the literature and our data. A variety of sources were explored:

- Seven studies published in peer reviewed scientific journals.
- Two reports from governmental agencies[1]
- Media reports regarding four distinct events
- Data submitted to and collected by MDH

The factors affecting air quality during these events, the types of contaminants, levels of contaminants, and the public's exposure to contaminants were analyzed and summarized in this report.

Factors Affecting Air Quality

A variety of engines may be operated during in motorsport events. Researchers have assessed pollutants associated with monster-truck(1-3), tractor pull(1, 4), mud racing(1); motocross(3, 5, 6), go kart(7, 8,10), and demolition derby(2) events. These are the types of engines MDH has typically seen in MN motorsports events; in addition, MDH has seen snowmobiles and remote controlled cars used in MN arenas.

Limited information is available about the engines. The engines in one Monster Truck and tractor pull event utilized high octane fuels that had no emission control devices(1). In other Monster Truck events, methanol was cited as the fuel(2, 3), while the motocross bikes used gasoline mixed with engine oil (32:1 ratio)(3). Gasoline was the fuel used by go-karts in one study(8). MDH has also been notified of gasoline, methanol, and nitromethane use in engines; other types of fuels, such as ethanol, have been discussed. The size of engines also contribute to pollutant levels: higher carbon monoxide (CO) levels were observed when larger engines were operated (80 vs. 250 cc motorcycles)(5). Other and new types of fuels may become common place in the future.

Go-go-karts can emit 10.2 grams of CO per km driven compared to 2.2 g/km for an automobile[2]. In addition go-go-karts can emit 1.2 grams of hydrocarbons and NOx per km, while a car emits 0.5 g/km. Engine tuning, and specifically adjusting the carburetor, was found to reduce CO levels significantly, from 6% CO in emissions to 1.45%(2). While engines in go-karts had catalytic converters, CO levels were still elevated (52-130 ppm)(8). Faulty engine modification

[1] There is another governmental report, but is identical to a published study (Morley et al.) and only the published study is cited.
[2] Jetex Exhaust, Ltd http://www.go-kartalyst.com/website/go-kartingemissions.php

of propane go-kart engines was found to lead to elevated carbon monoxide emission and poisoning [(10)].

Potential ventilation rates are often quite high in motorsports arenas, although the rates may not be utilized. In a Quebec arena, the max rate was at 4.6 to 5 air changes per hour[(2, 5)] (ach). In a Cincinnati arena, the ventilation system could deliver 2-3 ach [(3)]. A ventilation rate of 6 ach was reported to MDH for one MN motorsport arena, which was also reported in a California go-kart arena [(8)]. By comparison, the average ice arena is estimated to have about 1.2 ach[(9)].

Ventilation, coupled with modest measures, however, may not be effective at controlling contaminants. The California go-kart facility with 6 ach had CO levels of 52-130 ppm, and the authors concluded source control (number of go-karts, tailpipe emissions, race pacing) where most important to personal exposures to CO; exposure was primarily from driving in a go-kart immediately behind the tailpipe of go-karts[(8)]. The Cincinnati arena with 2-3 ach had 1 hr averages ranging from 42 – 62 ppm in spectator areas; doors were also opened to supplement ventilation[(3)]. Levels were higher (55-80 ppm) when ventilation was operated at a lower rate. The Quebec arena with 5 ach had average levels from 19.1 to 38 ppm with max levels much higher[(5)], and during the later assessment, average levels of 35 to 100 ppm were observed[(2)]. Increased ventilation, fewer races, and pacing failed to control carbon monoxide at a tractor pull event[(4)]. Even with 'maximum ventilation' operating, a 16,000 seating arena had CO levels over 100 ppm[(1)]. MDH has similarly seen some MN arenas struggle to maintain CO levels under 30 ppm.

The number of vehicles operating at a time is a critical factor. Only one vehicle operation at a time, with 3-4 support vehicles, was sufficient to create average CO levels of 79-140 ppm in a large arena[(1)]. Tractor pulls can have as many as 12 vehicles competing at the same time[(4)], while a combination Monster Truck and demolition derby event involving 0 to 6 vehicles at a time had average CO levels from 15 to 100 ppm[(2)]. MDH has also seen events with anywhere from 5 to over 10 vehicles operating at a time. The California go-kart facility had two tracks with up to 20 go-karts total racing at any time[(8)].

Pacing of events also affects levels and exposure. Arena operators have taken breaks to try to control levels, which seem to have limited affect. Levels did not decline after the interval at one event[(1)]. At another event, a 1-hour intermission and seven breaks occurred over a 5 hour event; these breaks seem to have only slowed the increase in CO[(5)]. Participants racing go-karts for a 10 minute, 10 minute and 20 minute period, with two 30 minute breaks had an average carboxyhemoglobin increase of 2.06% from baseline[(7)]. The California go-go-kart facility had breaks of 5 to 30 minutes, but this was not sufficient to maintain acceptable levels of CO[(8)]. MDH has seen some better results with pacing, although it is often logistically challenging or unappealing to event organizers.

In many arenas, extensive control measures are necessary, but may be impractical. In the Quebec arena, efforts did yield significant reductions to average concentrations, from 35 -100 ppm to 15 -25 ppm[(2)]. The control efforts involved: 1) adding non-fuel powered events (remote control cars, mountain bikes) and intermissions that lasted for more than half of the event; 2) careful tuning of engines; and 3) operation of ventilation at maximum setting.

Contaminants Measured

Varying testing schemes have been used by researchers to assess combustion by-products. Readings have been taken at:

- 15 minute intervals;
- 30 minute intervals;
- continuous monitoring at 5 stations;
- continuous monitoring at seven locations;
- a combination of continuous monitoring using 8 personal monitoring and fixed monitoring at 6 stations;
- a combination of personal monitoring and fixed monitoring at 5 stations; and
- a combination of continuous monitoring of a driver and fixed monitoring at and indoor and outdoor location

Carbon Monoxide

CO levels at the Cincinnati monster truck/tractor pull event varied over the course of the events with average levels each night of 79, 106, and 140 ppm[(1)]. Peak levels of 140, 250, and 283 ppm were observed. Interestingly, levels before the events started ranged from 13-23 ppm indicating possible residual levels from the prior evening.

At another Cincinnati Monster Truck and motocross event, 1 hr average levels in seating areas ranged from 42 to 80 ppm[(3)]. "Roamers' with personal monitoring in the spectator area were exposed to 1 hr averages of 38 to 61 ppm, with a peak one minute concentration of 340 ppm.

In a tractor pull event in Winnipeg, CO levels varied from 68 ppm early in the event to 262 ppm 2 ½ hours later[(4)]. The next evening, levels rose from 77.5 ppm to 435.7 ppm, despite control measures. No averages were reported.

In the Quebec arena, levels quickly rose and fell over 5 hours, ranging from virtually 0 ppm to over 200 ppm during motocross competitions [(5)]. The average levels ranged from 19.1 to 38.0 ppm in 5 locations around the facility.

At the same Quebec arena, during a Monster Truck and demolition derby event, average CO levels ranged from 37 to 100 ppm, with many peak readings over 200 ppm[(2)]. One peak reading was 1645 ppm!

At a Michigan motocross arena, CO poisoning of three children prompted testing at a later date[(6)]. A 7-hr TWA was calculated at 19 ppm, but this calculation assumed equal duration of time in various locations of the facility. In addition, it was unknown whether ventilation operation was comparable to the poisoning incident. The owner closed the facility.

At a California go-kart arena, 1 min CO averages of the driver (personal monitor) ranged from 52-130 ppm measurements(8). The 1-hr average concentration exceeded 35 ppm. The track CO levels over 8-hours was 36 ppm.

There are also media reports that have CO incidents in motorsports arenas, but no CO concentrations were listed. Further information on these reports can be found in the "Health Effects" section.

Other Contaminants

The published studies focused on CO, although some testing of other contaminants have been performed. In the first study of the Quebec arena, no nitrogen dioxide (NO_2) was detected(5). The researchers concluded that the calibration of carburetors in the motorcycles favored the formation of CO. They cautioned, however, that "…this does not guarantee that in other motocross competitions there will not be some [NO_2] exposure for workers, participants, or patrons."

Later, NO_2 testing at this arena found NO_2 averages under 0.5 ppm, and maximum readings up to 0.8 ppm; CO levels where much higher, with averages of 37-100 ppm and a maximum reading of 1,645 ppm(2). The researchers attributed the NO_2 to the Monster Trucks (not the demolition derby vehicles). They concluded "[Monster Trucks] are likely to generate NO_2 contamination…these results demonstrate the need for measuring NO_2 emissions during Monster Truck exhibition indoors".

In another study, the researchers observed no respiratory symptoms among go-kart drivers that would suggest nitrogen dioxide intoxication(7). No NO_2 testing was done. Symptoms were consistent with CO intoxication.

In the Cincinnati arena, researchers tested volatile organic compounds and noise levels (3). A variety of VOCs were identified, including methanol, ethanol, acetonitrile, toluene, isooctane, xylene, butane, and pentanes. Other compounds were also detected. No quantitative data were provided, nor was there any assessment of risk associated with these VOCs. The noise levels in the spectator areas were 92-100 dB, with maximum levels exceeding 120 dB. These levels were deemed high enough to warrant recommendation of offering hearing protection devices and conducting public education regarding noise at the event.

The California go-kart study also measured particulate matter less than 2.5 micron size (PM2.5)(8). The maximum 5-minute average PM2.5 ranged from 28-42 ug/m3, and the 8 hr average was 20 ug/m3. These concentrations indicate exposures below the 24-hr USEPA NAAQS of 35 ug/m3.

MDH Data

MDH has collected air quality results from indoor Minnesota motorsports arenas over the past few years. Single readings over 100 ppm have been observed, although levels are generally lower. Many readings are in the 30 – 125 ppm range.

The data present collected at MDH are summarized in Table 1. The data are mostly submissions from the arena operators, with MDH having collected some data during site inspections. Table 1 does not show the number of events for which MDH has data, which can vary from about 10 to 40 per facility. MDH generally has less data for those arenas with fewer exceedance events.

MDH's data indicate that CO levels over 25 ppm are commonly observed, with 8 of 9 facilities reporting at least one reading over 25 ppm. Only Facility 9 has never had a single elevated reading. In addition, Facility 2 is able to control average CO levels, having upgraded ventilation a few years ago. The remaining 7 facilities have and will continue to struggle, to varying degrees, in maintaining acceptable air quality (whether the standard is 25 or 30 ppm), although it should be noted that most of these arenas have made great strides in improving air quality.

MDH has also conducted limited assessment of other contaminants. NO_2 levels have almost always been low, except in one case involving nitromethane-powered remote control cars; NO_2 was 0.4 ppm and CO was 20 ppm. Particulate levels seem to correlate well with CO; in the limited sampling done, where CO was less than 30 ppm, the PM2.5 level was less than the 35 ug/m3 National Ambient Air Quality Standard.

Table 1. Carbon Monoxide Levels in MN Motorsports Arenas:
Number of Events (e.g. days) Reporting Elevated levels

Facility	*>25ppm, single*	*>85ppm, single*	*>25ppm for 1hr*	*>25ppm for 2hr*
1	8	2	2	0
2	6	0	0	0
3	7	2	7	6
4	3	2	2	0
5	17	2	4	0
6	16	3	10	0
7	20	1	20	13
8	25	0	16	4
9	0	0	0	0

The table shows the number of events or racing days during which: 1) a single reading exceeded 25 ppm; 2) a single reading exceeded 85 ppm; 3) all consecutive readings over an hour exceed 25 ppm; and 4) all consecutive readings over 2 hours exceeded 25 ppm. Some arenas have events that last less than 2 hours—these facilities may have exceeded the 2 hr >25 ppm if they continued to operate (e.g., back-to-back events). Moreover, some arenas come close to exceeding the >25 ppm 2hr standard, except one single reading under 25 ppm.

Pollutant Distribution

Levels can vary throughout an arena. Lower CO levels were observed at higher seating[(1)], while in another study, no difference with seat elevation was seen[(5)]. In the Winnipeg arena, the CO levels were uniform across 25 seating locations at varying heights within the arena[(4)]. In the Michigan case, max CO levels ranged from 19 ppm in the mezzanine to 60 ppm in the track[(6)]. In the Quebec arena, average levels were similar in most locations, except one location was significantly different; the authors concluded that "…in a building this size, several sampling stations located at various strategic places throughout the building"[(5)] In a later study of this arena, CO concentration varied two-fold between station 1 and 2, which was attributed to an inversion phenomenon caused by opening doors and uneven mechanical ventilation[(2)].

CO levels fluctuated dramatically in the California go-kart arena, from 52 to 130 ppm[(8)]. The driver levels were 1.4 to 3.0 times the levels by the track, suggesting testing by the track will underestimate actual exposure. These findings indicates the proper testing location should either be someplace inside the track (e.g., center of track) or some other location in the arena representative of exposure. The arena staff will have to identify this location.

Health Effects

In a study of 15 healthy volunteers driving go-karts in a Belgian indoor arena, an increase in carboxyhemoglobin was observed, from an average of 0.49% to 2.06%[(7)]. The participants only drove for 40 minutes, which was divided into three sessions with 30 minute breaks between sessions. The participants also reported various symptoms consistent with carbon monoxide exposure: nausea, headache, altered coordination, and vague abdominal pain. No ambient air concentrations were measured, and no lung symptoms suggestive of NOx exposure were observed. These researchers also noted that the Belgian National Poison Centre had documented six CO incidents in indoor go-karting arenas over 5 years, which involved 86 patients. This study also discussed the affect of CO on coordination, judgment, psychomotor tasks, reaction time, visual acuity, and driving skills. This type of impairment increases the risk of accidents during and after exposure at an arena.

In a Michigan case, three children ages 7 to 10, were diagnosed with nonfatal CO poisoning following seven hours of participating in indoor motocross events[(6)]. Two boys were racing and one was watching. The boys complained of light-headedness and nausea, and one boy vomited. The boys' carboxyhemoglobin, tested at the emergency room, ranged from 9.4% to 13.6%.

The study of the California go-kart facility was prompted by three reports to local health department of cardiovascular events[(8)]. Two drivers experienced cardiac dysrhythmias (one a fatality) and one had a myocardial infarction. The researchers suspected combustion by-products (CO and PM2.5). Elevated levels of CO were measured, and while PM2.5 average levels were below health standards, high PM2.5 spikes were some cause for concern. The researchers noted that other pollutants (ultrafine particulates, NO_2), stress, and noise could have also been implicated in the health effects.

In a British case in 2005, 7 individuals were admitted to a hospital due to carbon monoxide exposure during a birthday party at a go-kart arena(10). The admitted individuals had characteristic CO poisoning symptoms and carboxyhemoglobin levels of 14 – 18% a few hours after leaving the arena. The local health authority surveyed other people present during the party, and found almost all had experienced symptoms consistent with CO poisoning. A local government official later measured a build-up of CO in the arena during the use of recently modified go-karts.

There are also media reports of carbon monoxide poisoning in motorsports arenas. In March of 2009, CO from a motocross event in a Toronto arena led to an evacuation of the arena and the adjacent hotel[3]. In a British arena, 15 people were hospitalized from carbon monoxide poisoning[4]. In another British case, two men collapsed after driving at a go-kart arena and were hospitalized; emergency responders found ‘unsafe levels’ of carbon monoxide at the arena[5]. In a German case, after a company event with several go-go-kart races, a 26-yr-old man returned home complaining of nausea and dizziness, his brother found him unconscious soon afterwards; paramedics called to the scene could not save his life[6]. It should be noted, however, that the media source in the German case is dubious and not known to MDH.

<u>Regulatory Considerations</u>

To the best of our knowledge, MDH is the only governmental agency that has regulations specific to indoor motor sports. There are, however, several governments that have regulated motorsports events through broader public CO standards and event permitting requirements.

- The City of Cincinnati, through its public assembly permitting application, has required that CO levels at indoor motorsports events not exceed a 15 minute time weighted average of 35 ppm and that levels not exceed 200 ppm CO for any two consecutive samples(1). CO measurements are to be made every 5 minutes until the facility has been vacated. f CO concentrations exceed the 35 ppm standard, then readings shall be taken every 2.5 min and mitigation measures shall be implemented until levels drop below 35 ppm. The intent was to protect members of the general public who attend indoor sporting events where internal combustion engines are used(3). Despite these requirements, the standards were frequently exceeded at a Monster Truck/Motocross event.

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[3] City News, Toronto, http://www.citytv.com/toronto/citynews/news/local/article/9695--rogers-centre-nearby-hotel-evacuated-because-of-motocross-fumes
[4] News Shopper, 2007, http://www.newsshopper.co.uk/news/1807545.m5ec/?from=ec&to=1807545&l=carbon_monoxide_poisoning_at_gogo-kart_track
[5] British Broadcasting Corporation, 1999, http://news.bbc.co.uk/2/hi/uk_news/scotland/530616.stm
[6] Toy Town Germany, 2007, http://www.toytowngermany.com/lofi/index.php/t66600.html

- The City of Winnipeg required an arena to implement significant ventilation improvements before further tractor-pull events would be permitted[(4)]. Due to the cost, the arena chose not to hold any more events.
- Quebec has a ceiling limit of 50 ppm for CO and 2 ppm for NO2 at motorsport events; if excesses occurred, the activities are to be interrupted until levels decreased to under 20 or 25 ppm for CO and 0.5 ppm for NO2[(2, 5)]. The standard was enforced by the Quebec Public Health agency, with an employee monitoring motorsports events. The researchers, however, recommended that an average of 30 ppm for a 5 hour event, to avoid COHb of 3% or greater. This TWA was exceeded in most location (over 30 ppm), suggesting the standard was not quite protective enough.

There are also recommended guidelines.

- The Michigan Department of Community health recommended that, if the CO concentration exceeds 27 ppm, motorized activities should be stopped and the facility ventilated[(6)]. They add that: "It may be prudent to evacuate the facility. If so, re-occupancy should occur only when air monitors read 0 ppm."

Belgian researchers suggested implementation of continuous monitoring of CO levels in carting arenas and use of 'adapted ventilation'[(7)]. They concluded, " as these measures cause a substantial financial investment for arenas, they are likely to be applied only if they are legally imposed".

Requiring emission control technologies may be unreasonable considering racing operators are highly resistant. For example, participants have refused to retrofit tractors with pollution-control devices because this would decrease the horsepower of their tractor[(4)]. Nevertheless, there are emission control technologies, such as catalytic converters that could be added, for example, to go-karts. Jetex Exhaust Ltd specializes in a catalytic converter for go-go-karts and their product is named 'go-kartalyst'[7]. Using this device, the CO concentration in the exhaust can be reduced from about 4.5% to 1%, according to the manufacturer[8]. Engine tuning has also been shown to reduce CO emission rates[(2)]

Specific ventilation rates could be proposed, but high rates (up to 5 ach) reported in the literature have not been effective. Extremely high rates of ventilation could be proposed but these may not be necessary if other measures are used (e.g., pacing, emission control technologies, natural ventilation). Mandating a specific mechanical ventilation rate may be unreasonable. In addition, arenas may not operate their system at max ventilation, even when the facility has had a previous history of problems[(3)]. The problem may also be that the ventilation system does not receive the appropriate maintenance that is needed to achieve design specifications. Another drawback of a ventilation standard is that contaminant levels can vary considerably throughout a facility, as a result of poor air mixing, which may result in 'dead air pockets'.

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[7] Jetex Exhaust, Ltd http://www.go-kartalyst.com/
[8] Jetex Exhaust, Ltd http://www.kartalyst.com/website/regulations.php

Conclusions

Every arena and every event may be unique, which makes the application of universal requirements for ventilation, emission control technology and/or engine tuning difficult. It appears a 'performance' standard that requires monitoring of CO and possibly NO_2 is the reasonable approach to regulate combustion by-products in motorsports.

NO_2 is much less likely to be a problem in motorsports events compared to ice arena. In motorsports arenas, where CO is at acceptable levels (e.g., 25 ppm), it is *usually likely* that NO_2 will also be kept at safe levels (e.g., 0.3 ppm). It should also be noted that NO_2 testing is more costly and the testing equipment is less reliable than CO testing equipment. Nevertheless, depending on the type of fuel and engine adjustments, NO_2 could be a problem and MDH has observed this in one instance and the Quebec group of researchers (Leveseque et al.) have recommended NO_2 monitoring[2, 5]. Requiring NO_2 testing should be judged on a case-by-case basis; requiring this testing in all cases seems unreasonable.

Considerable variability can occur in every arena and also between different events. Allowing testing in various locations to calculate an average can allow for 'cherry-picking' locations that help skew the average downward. In addition, such a method does not protect the public situated in area(s) with the highest concentrations. For example, CO exposure of drivers can be 2-3 times higher than levels next to the track. Hence, testing should be done in the worst locations used by the general public, including both the spectator area and within the track area (assuming drivers are unpaid public participants), to account for the variability.

Since events (i.e., exposure durations) typically last from 40 minutes to 5 hours, applying a 1 hour standard seems justified, although ceiling limits seems the more practical approach for the lay person whom is monitoring air quality. MDH has observed considerable confusion and error among arena operators in trying to mentally calculate 1 hr averages after each measurement. Use of a true 1 hr averages, rather than ceilings, could be acceptable if the arena staff are using electronic equipment that continuously calculates 1 hr TWAs; however the arena would likely need at least three devices: 1) fixed at the worst spectator area; 2) fixed at a representative track location (e.g., center); and 3) a roaming device to identify whether other locations should be tested instead. Somehow the arena operator would need to be notified when any one of these devices exceed the action or evacuation level. Since such a strategy is costly and challenging, periodic testing would likely be the simpler approach embraced by most arenas.

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Appendix D. Air Pollutants in Indoor Ice Arenas: Contaminants other than Carbon Monoxide and Nitrogen Dioxide

Research Questions

1. What contaminants other than carbon monoxide and nitrogen dioxide have been identified or measured in ice arenas? What types of health effects have been reported among people exposed to these other contaminants in ice arenas?
2. What levels of particulates have been identified in MN arenas?
3. Should these other contaminants be regulated in ice arenas?

Overview of Published Studies

To answer these questions, the scientific literature was researched to identify technical studies published in peer-reviewed journals. A large body of scientific research exists in the area of combustion by-product pollutants in indoor ice arenas; however, most of the studies evaluated carbon monoxide and/or nitrogen dioxide. Only 5 studies evaluated contaminants other than CO or NO2, compared to 32 studies that evaluated CO or NO2.

Concentrations of Other Contaminants in Indoor Ice Arenas

In his 2002 review of the literature on pollutants in ice arenas, Pelham concluded that "these pollutants [CO and NO2] are never isolated"[(1)]. In addition to CO and NO2, he indicated that refrigerants, sulfur dioxide, aldehydes (acetaldehydes), small particulate matter (PM2.5), and various volatile organic compounds (VOCs--specifically benzene, toluenes) could be found in the air of indoor ice arenas. Pennanen et al. similarly noted that the primary pollutants in engine exhaust are CO, NOx, VOCs and particles [(2)], which could present a health hazard. Neither author, however, presented data for these pollutants in ice arenas.

Particulates

Rundell conducted two studies that examined sub-micron particulate levels in indoor ice arenas[(3, 4)]. In his first study, Rundell measured sub-micron particulate (PM1) levels using a TSI P-Trak device (0.02 to 1 micron), which measure in units of particle count per cubic centimeter (pt/cc). He tested before and after ice resurfacing and edging in 10 rinks[(3)]. CO and NO2 were not sampled.

Rundell found the mean PM1 after resurfacing with a propane or gasoline resurfacer was 104,200 pt/cc compared to a mean outdoor PM1 of 3,800 pt/cc. Gas-powered edging was associated with even higher levels, at about 400,000 pt/cc. No significant difference was found between gas and propane powered resurfacers. Levels before operation of these resurfacers and after operation of electric resurfacers were much lower and similar to outdoor concentrations. The combustion process, not the ice shaving or other engine components, was identified as the source of the PM1.

In his conclusions, Rundell speculated that the high prevalence of exercise-induced bronchospasm among hockey players may be attributable, in part, to particulate exposure from the resurfacing machines, citing studies that link ultrafine particulate exposure to inhalational health effects. He also qualifies this conclusion by indicating that the composition of propane PM1 is poorly understood; studies have generally evaluated health effects associated with diesel and gas PM1, which may not be transferable to most hockey arenas.

Rundell's second study involved a similar sampling scheme to his prior study, but he also evaluated airway dysfunction in 14 hockey players. These subjects first trained in an electric rink and later in a gas or propane rink for 2 years[(4)]. The subjects were compared to a control group of 9 cross-country skiers. The mean PM1 after resurfacing was 120,000 pt/cc., while levels prior to resurfacing, outside and in electric arenas were significantly lower. Carbon monoxide and nitrogen dioxide levels were deemed "acceptable", with no further discussion. The lung function of the 14 hockey players was lower after they trained at arenas with combustion-powered resurfacers, while lung function was stable among the Nordic skiers.

There a few strengths to the second study. An appropriate type of control group was used (Nordic skiers), to limit the confounding affects of exercise and cold air (these may also cause pulmonary health effects). In addition, he evaluated lung function through several measures, before and after exposure to the combustion powered resurfacer.

There are also several weaknesses of this study. The number of subjects was small. No data for CO and NO2 were provided; Rundell simply states that CO and NO2 levels were not unacceptable. It is likely that CO and NO2 levels increased after resurfacing, even if health benchmarks were not exceeded, and thus, these pollutants confounded the effect of PM1. There was no sampling after edging, which can also contribute to CO and NO2 exposure. A large time frame existed between the pre (1997) and post (2001) lung function tests with no lung function data collected in 1998 immediately prior to the transition to combustion powered arenas. While several measures lung function decay was measured, the diagnosis of exercise induced bronchospasm was low (only 4/15 hockey players). Finally, there was no analysis of confounding factors (exposure to pollutants in other environments, pre-existing respiratory conditions, pre-disposing factors).

Rundell concluded that his analysis is "preliminary", which is also reflected in the title which poses the findings as a question: "Pulmonary function decay in women ice hockey players: is there a relationship to ice rink air quality?". Rundell does not present any type of standard or health benchmark for what would be considered safe or recommended in these studies, although he is later quoted in a Canadian news story proposing levels over 60,000 pt/cc are associated with decreased lung capacity[1]. This benchmark was later reiterated in an ESPN story[2]. MDH is not aware of any other accepted, proposed or provisional health standards for sub-micron particle counts.

[1] http://www.cbc.ca/canada/story/2007/03/12/arena-pollution-070312.html
[2] http://sports.espn.go.com/espn/e60/news/story?id=4068448

The more conventional measures of PM2.5 and PM10 particulate matter were assessed in ice arenas in one study. Guo et al. found mean PM2.5 in 3 arenas with gasoline and propane resurfacers were 28-62 ug/m3[(5)]. The mean PM10 were 50 – 79 ug/m3, which was less than the 180 ug/m3 Hong Kong IAQ Objective for Non-industrial Environments. The outdoor levels were also significant of both PM and the authors attributed the indoor PM levels not to the resurfacer, but primarily to outdoor sources.

Volatile Organic Compounds

Total volatile organic compounds (TVOCs) were reported in a Finnish study.[(2)]. Penanen et al measured CO, NO, NO2, and TVOCs in 5 arenas (1 gas, 3 propane, 1 electric). While the -hour CO concentrations were relatively low 1 (17 – 29 ppm), the 1 hour NO2 levels were 0.14 – 3.96 ppm. The 3 hr TVOC was 0.15 – 1.2 mg/m3. The authors did not present any kind of benchmark or standard for TVOCs, nor were health effects measured as part of the study. The authors concluded that the VOC "compounds causing complaints or health effects are not well known, making the interpretation of VOC measurements…difficult".

Similar results were found in a study from Hong Kong[(5)]. Guo et al. found the mean TVOC in 3 arenas with propane and gasoline resurfacers, immediately after resurfacing, was 0.550 – 0.765 mg/m3. Resurfacing was estimated to account for 71% of the TVOCs. They also concluded that it is difficult to interpret TVOCs because compounds causing health effects are not well known.

There are no consensus standards for TVOCs. Differences in sampling methodology and target chemicals make comparisons between studies difficult. Nonetheless, it has been proposed that individuals without asthma, allergy, or chronic bronchitis, but whom suffered from dry mucous membranes (eyes, nose or upper airways) reported experiencing irritation when exposed in laboratory study to total VOC (TVOC) concentrations greater than 5 mg/m3[(6)]. According to the authors, this TVOC exposure concentration was comparable to the average concentrations in new Danish houses and consisted of 22 commonly found chemicals. In a later study, Molhave et al. proposed 25 mg/m3 as a threshold for discomfort and irritation in a large number of people[(7)]. This study has been cited frequently as a TVOC guideline. Hau et al (2000), however, found nasal pungency (i.e. irritation) did not occur at 25 mg/m3,[(8)] which contradicted the Molhave study. Study methodologies may account for different results. While there does not appear to be a clear consensus standard or guideline for irritation of the respiratory system caused by a mixture of VOCs, most researchers have concluded that a negative perception of air quality, odors, and irritation of eyes, nose and throat can occur at levels between 1.7 and 25 mg/m3[(9)]. Hong Kong's Indoor Air Quality Objective for Non-industrial Environments is 3 mg/m3 as an 8-hour TWA[(5)]. These guidelines, however, do not necessarily apply for people with asthma or other respiratory sebsitivity to chemicals (such as formaldehyde and fragrances).

Sulfur Dioxide

Two studies reported sulfur dioxide concentrations in ice arenas following ice resurfacer operation. Guo et al. found low levels of SO2 in 3 arenas with propane and gasoline resurfacers, immediately after resurfacing[(5)]. The levels were under 0.01 ppm, well below the Hong Kong standard of 0.3 ppm. These low levels were attributed to the outdoor sources, not the resurfacers.

In another study, Game et al, found high levels of SO2 in an arena that used a natural gas resurfacer[(10)]. The monthly mean ranged from 0.3 to 4.5 ppm. The SO2 levels were deemed "substantial" since studies cited found levels between 0.25 – 2 ppm correlated with health effects in asthmatics. Game et al concluded that the SO2 and mold, along with cold air and exercise may have contributed to lung the reduced lung function observed in the 16 hockey players during the course of a season.

The generalizability of the Game et al. study is questionable. One arena and only one resurfacer were evaluated, and no exhaust testing or pre-resurfacing sampling was done to verify that the resurfacer was the source. The subject sample size was small (16 hockey players) and there was no control group (e.g., hockey players in an electric arena or cross-country skiers). There was no analysis of confounding factors (exposure to pollutants in other environments, pre-existing respiratory conditions, pre-disposing factors).

The emission of SO2 from a natural gas resurfacer is puzzling and not explained by the researchers. According to the US EPA, emissions of sulfur dioxide and mercury compounds from burning natural gas are negligible[3]. While hydrogen sulfide is a common contaminant in raw natural gas, it must be removed prior to most uses[4]. Sulfur is added as an odorant to natural gas so perhaps this is the cause. According to the 2009 MDH survey, there are only 10 natural gas resurfacers used in MN arenas.

<u>Particulate Levels in MN Arenas</u>

Of the 'other contaminants', particulates appeared to perhaps the most significant hazard. Since there is limited research on particulates in ice arenas, MDH conducted air monitoring at ice arenas during the course of routine compliance inspections. The buildings tested were not problem buildings. MDH tested PM2.5 using a Dust Trak (TSI), PM1 using a P-Trak (TSI), and carbon monoxide and nitrogen dioxide using a VRAE (RAE Systems). Sampling was done in 31 ice arenas, with two arenas tested twice under different conditions. Most of the sampling was done within 1 hr of resurfacing or edging.

In 15 arenas, testing was conducted after a propane resurfacer was operated. In the remaining cases, testing was done after use of a combustion powered ice resurfacer: gas edger (5), combination of gas edger and propane resurfacer (5), propane resurfacer and propane edger (1),

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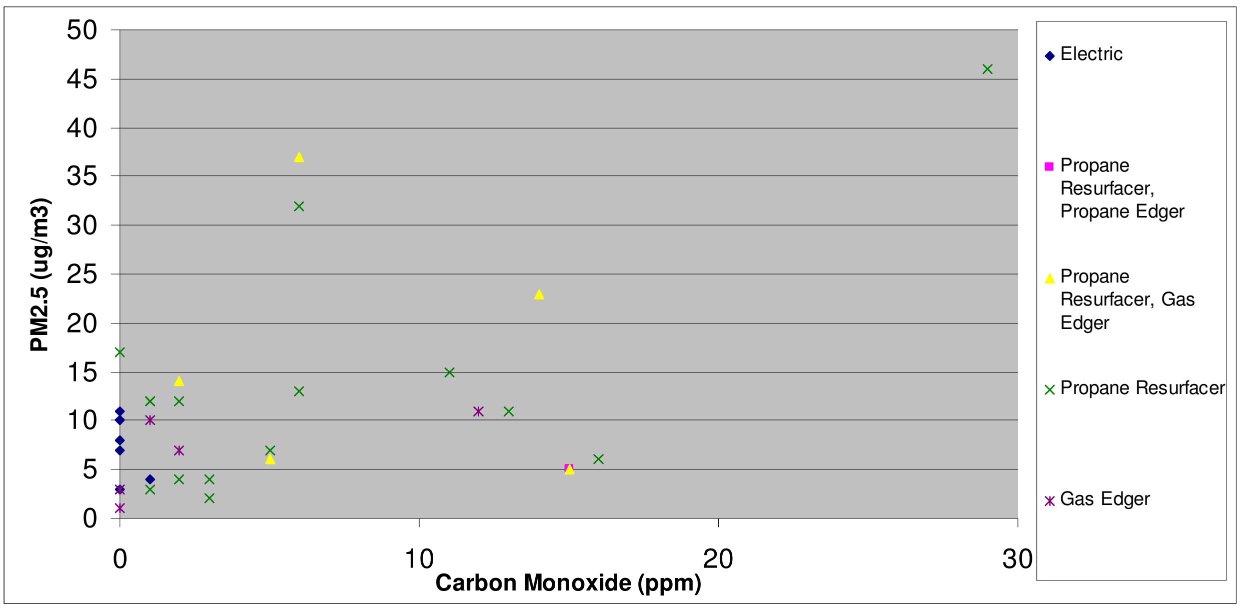
[3] http://www.epa.gov/cleanenergy/energy-and-you/affect/natural-gas.html
[4] http://en.wikipedia.org/wiki/Natural_gas_vehicle

and electric resurfacer (7). The break-down and results by type of resurfacing machine can be found in Appendix A.

PM2.5 levels were generally low and well below the EPA National Ambient Air Quality Standard of 35 ug/m3 (24 hr TWA). The highest reading was 46 ug/m3, measured 5 minutes after resurfacing with a resurfacer that has had a history of emitting high levels of CO. The CO level was 29 ppm in this arena and the NO2 was 0.5 ppm. Presumably the PM2.5 TWA over 24 hours would be much less than 46 ug/m3 and likely less than the 35 ug/m3 EPA standard.

There is a modest positive correlation between carbon monoxide and PM2.5 (all data r=0.50; propane only r=0.64)[5], indicating that elevated levels of PM2.5 can be predicted, to some extent, by elevated carbon monoxide (see Figure 1). In many cases, the indoor and outdoor PM2.5 levels were similar; the medians for indoor and outdoor were both 10 ug/m3. In the 4 arenas that exceeded 20 ug/m3, the indoor levels were 2-6 times higher than outdoors.

Figure 1. PM2.5 Levels in Relation to Carbon Monoxide



PM1 levels varied significantly. While 27 arenas had levels under 50,000 pt/cc, three arenas had levels over 100,000 pt/cc (see Figure 2). The median for all arenas was 13,200 pt/cc with a mean value of 38,327 pt/cc, which reflects the heavy skewing by the three high readings. The outdoor PM1 median was 5,440 pt/cc, indicating that some of the PM1 in the arenas was not from the resurfacer.

[5] The r value measures the strength of an association with a 0 indicating no association and 1 indicating data are in a straight line.

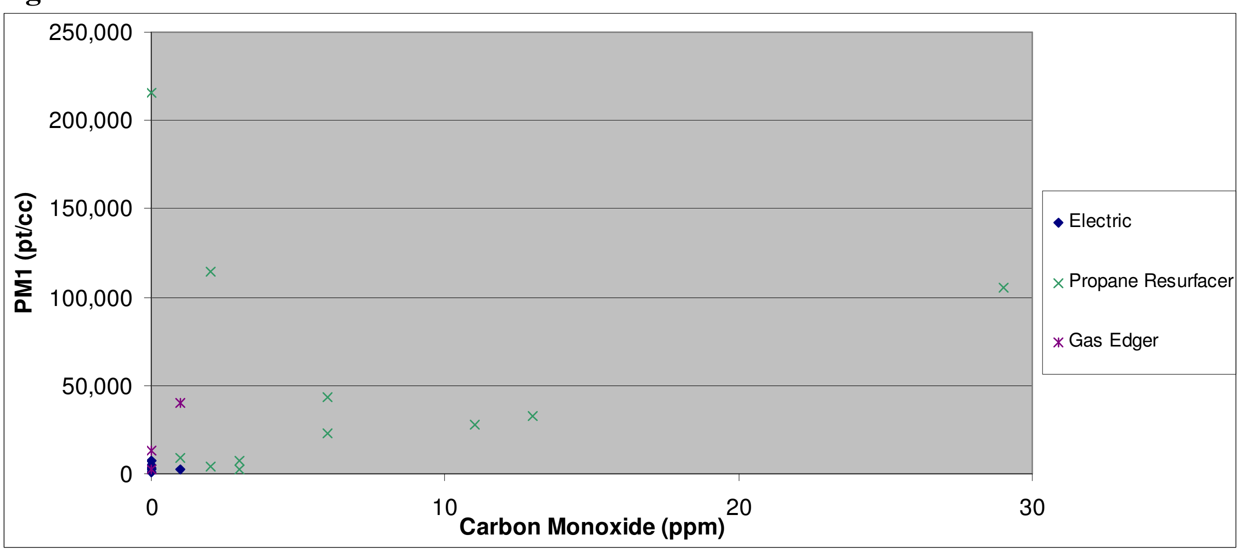
The combustion powered resurfacer appears to be a source of PM1. The propane powered resurfacers had higher PM1 indoors (median=27,600) compared to outdoors (median=4,630). In one arena, PM1 was measured before and after resurfacing with a propane resurfacer, and levels rose from 1,080 to 3,830 pt/cc. These findings are consistent with the Rundell studies and the media reports.

Battery-powered resurfacers do not appear to be a significant source of PM1. Levels in the six arenas tested were less than or comparable to outdoor concentrations. In one arena, PM1 was tested before and after resurfacing and the change in PM1 was minimal (2,530 to 2,940 pt/cc). In this case, the levels may have been lower, but the use of a propane resurfacer in the adjacent rink may have contributed to some PM1. A slightly larger change was observed by a consultant contracted by an arena to test before and after use of an electric resurfacer. Such a small change could be attributed the random variability in readings, better air mixing caused by operating the resurfacer or turning on the ventilation, or from friction or fluids in the electric resurfacer engine.

The correlation between CO and PM1 was not strong (r=0.28). However, the correlation was heavily affected by two high PM1 results with low CO, which may be considered statistical outliers. When these two were removed, the correlation was strong between CO and PM1, with an r=0.90.

With no governmental or non-governmental standard for PM1, it is difficult to interpret results. The large majority 27/30 arenas were below Dr. Rundell's guideline of 60,000 pt/cc. Levels were much less than the average levels cited in his papers. This could, perhaps, be attributed to the quality of the maintenance conducted on resurfacers and the routine use of ventilation during resurfacings in MN.

Figure 2. PM1 Levels in Relation to CO



Regulatory Discussion

The Case for Regulating PM1

A case could be made that sub-micron particulate matter is a significant concern in ice arenas. Even if our knowledge is limited about ultrafine particles, the precautionary principle would dictate that the health authorities should take action on this matter. Attention has been brought to this matter in media reports and two scientific papers, and this issue will likely continue to grow.

While the absence of governmental benchmarks is a challenge, it is likely that a government or environmental health organization will eventually create a standard. Dr. Rundell identified levels exceeding 60,000 pt/cc as a benchmark of health concern. In addition, the Phillips Corporation has stated the following in relation to its Aerasense air monitoring device.

> "Can you give me some reference values of fine particle concentrations?
> There is no standardization on ultra-fine particles at the moment. However, scientific discussions are ongoing on the formation of a standard. Nevertheless, it is possible to give some reference concentrations (Ultra-fine particles are measured in concentrations particles/cm^3)

Clean air in the alps	< 1.000
Clean office air	2.000 – 4.000
Outside Air in urban area	10.000 – 20.000
Polluted outside air (smog)	> 50.000
Cigarette smoke	> 50.000
Workplaces (like welding)	100.000 – 1.000.00

> Note that it is expected that there is no threshold concentration below which there is no negative health effect. Air should be as clean as practically possible. The threshold concentration at which people feel immediate impact is around 50.000 particles/cm^3. Asthmatic people immediately feel the effect of smog."[6]

Dr. Rundell's two studies reported that operation of combustion-powered resurfacers increase PM1 levels substantially. MDH's testing found that 10% of arenas exceeded 100,000 pt/cc. By comparison, the median outdoor level outside the arenas was only 5,020 pt/cc with a maximum of 34,000 pt/cc.

Most of the arenas in MDH's assessment were in the metro area and larger cities; these arenas may have been better maintenanced or newer ice resurfacers that emit less particulates. The three arenas that did have higher levels were small arenas in smaller cities. Levels could be above 100,000 pt/cc in a disproportionate number of smaller arenas in Greater Minnesota due to ther use of older resurfacers, limited maintenance resources, and lower building ventilations rates.

[6] http://aerasense.com/index.php?pageID=5

The correlation between PM1 and CO and NO2 is weak, assuming two of the results were not outliers. This means testing for CO will not regularly predict problems that lead to PM1. In other words, some arenas may have low CO and NO2, but high PM1.

So how could PM1 be regulated? Arena operators do not necessarily need to purchase particle counters. They could utilize an environmental consultant periodically (e.g., yearly) to conduct an assessment; at least one MN arena has done such an assessment. An action level could be set somewhere between 50,000 and 100,000 pt/cc. It would be up to the arena operator to complete the appropriate repairs. The resurfacer service providers would be expected to develop the diagnostic skills and mitigation methods to address the high PM1 emissions. Considering automotive emissions standards exists for particulates, it is plausible to assume mitigation is feasible, although the cost is unknown.

The Case Against Regulating PM1

A case can also be made against regulation of PM1 at this time. The health significance of exposure to PM1 is not well understood. This is a relatively new area of research. Dr. Rundell's studies are limited and preliminary. There are no known governmental or non-governmental standards for PM1 or ultrafine particle matter. Regulating PM1 opens the door to regulate other pollutants, such as total VOCs or specific VOCs (benzene, toluene), sulfur dioxide, and nitric oxide. There are a few studies that have found levels of some of these pollutants were greater indoors compared to outside the arena. As with PM1 counts, there are no consensus standards for TVOCs. Both are actually a measure of a broad range of pollutants, not a measure of a single hazard.

Much of our understanding about PM1 health effects may not directly apply to arenas. Laboratory studies involved lab animals that were exposed particulate matter from gasoline and diesel combustion, not propane derived particulates. In addition, ecological correlations between outdoor PM1 and health primarily reflect gasoline and diesel sources. The large majority of combustion powered resurfacers are fueled by propane, so the direct comparison of most studies may not be inappropriate.

Unlike CO and NO2 which are exclusively combustion by-products, PM can be generated through a wide range of processes, such as chemical reactions. In one arena, PM2.5 levels were found to be quite high, at >200 ug/m3, and about 5 times as great as the next highest arena. There was a strong orange chemical smell in the air; the maintenance staff had just cleaned all the plexiglass around the rink with an 'orange' scented cleaner. When MDH returned two days later to sample under the same conditions, PM2.5 was low, before, during, and after edging. Moreover, other indoor sources may exist, such as cooking or radiant heat. In one arena, it seemed the use of a radiant heater was contributing to PM1 levels in an arena where an edger had last been used 7 hours prior to PM1 testing. In addition, the outdoor environment can be a significant source of particulate matter, especially near busy roads, where vehicles idle by the building, or on days with an outdoor air quality alert. For example, outdoor readings as high as 39 ug/m3 for PM2.5 and 34,000 for PM1 were measured. Because sources other than the edger and resurfacer may exist in ice arenas, testing for particulates can yield a 'false-positive' conclusion, leading to time and money spent addressing a misdiagnosed problem. Application of an absolute numerical standard may be difficult; somehow the indoor measurement would need to be corrected according to the outdoor contribution to indoor PM, but this varies by building, depending on HVAC filtration and structural leakiness. Arena managers should not be expected to develop complex industrial hygiene skills to investigate and weigh the various PM contributions to readings. The only possible solution would be to test before and after resurfacing and then identify the change, but this adds to the workload of the arena manager.

Elevated levels of particulate matter were not a frequent observation in MN arenas. Virtually all the arenas had low PM2.5 levels, and the large majority of arenas had relatively low PM1 levels. For both particulates, levels were mostly similar to or slightly higher than the background outdoor concentrations.

The financial burden of particulate testing is significant. TSI's P-Trak costs $5,190 with annual maintenance costs of at least $395 per year. TSI's Dust Trak costs about half as much. To expect the 200 facilities around the stated to each purchase both or even one of these devices is a considerable burden. MN is only 1 of only 2 states that requires both CO and NO2 testing, which is already present a cost upwards of $3,500 over 10 years per sheet.

While CO and NO2 are not correlated, there appears to be some correlation between CO and PM1/PM2.5. While the correlation is modest, it appears that in many cases testing for CO will also predict PM1 and PM2.5 levels in the air. It seems that well maintained engines will emit lower levels of CO, PM1, and PM2.5. Repairs to correct an elevated CO problem may also correct an elevated PM1 or PM2.5, in some situations.

In other situations, repairing particulate emissions may be challenging. The specific repairs needed to correct high levels of particulate emissions may lbe ess well understood compared to CO and NO2 problems. Companies that service ice resurfacing machines are familiar with CO and NO2 emissions, and they routinely conduct preventive maintenance and service calls to address CO and NO2 emission problems. Repairs that affect the fuel-to-oxygen ratio, catalytic converters, carburetors, oxygen sensors, and other engine components are known CO and NO2 mitigation strategies. While these types of repairs may also affect particulate matter, engine maintenance contractors may struggle to mitigate particulate emissions. In addition, there may be some intrinsic difference between high and low particulate emitting engines, such as the type of engine or whether it was built after federal emissions where enacted. If this latter explanation holds true for some engines, then there may be no simple repairs that could be made.

In his 2002 review paper on this subject, Pelham identified a variety of possible combustion by-product pollutants could be found in arenas. But he also noted that testing for all these contaminants would not be reasonable; a "more practical approach is needed for the financially restrained, community based rink". He recommended testing for CO and NO2, but not other contaminants[7].

Conclusions

Research of combustion by-product contaminants other than CO and NO2 in ice arenas has been limited. With the exception of one author, Dr. Rundell, scientists have focused their attention almost exclusively on CO and NO2. There is ample justification for routine carbon monoxide and nitrogen dioxide monitoring. Justification to regulate other contaminants, such as particulates, is questionable and open to discussion. There are many questions and uncertainties regarding the other contaminants such as PM1. The scientific community's understanding of ultrafine particulates is evolving. Some resurfacers do appear to emit very small particulate matter (less than 1 micron in diameter) and this issue could be regulated at some point in the future. Regulation of PM1 is more challenging than CO and NO2. Difficult questions regarding reasonableness (feasibility, cost) would need to be addressed.

[7] It should be noted, however, that this paper was published in 2002, and 4/5 studies about other contaminants were published since then.

Appendix A.

Gas Edgers

	Indoor				*Outdoor*			
	CO	*NO2*	*PM2.5*	*PM1*	*CO*	*NO2*	*PM2.5*	*PM1*
Median	1	0	7	13200	0	0.1	10	19200
Minimum	0	0	1	2450	0	0	9	4000
Maximum	12	0.1	11	40200	0	0.2	16	34000
Count	5	5	5	3	5	5	5	3

Propane Resurfacer

	Indoor				*Outdoor*			
	CO	*NO2*	*PM2.5*	*PM1*	*CO*	*NO2*	*PM2.5*	*PM1*
Median	3	0.1	12	27600	0	0	5	4630
Minimum	0	0.0	2	2590	0	0.0	1	690
Maximum	29	0.5	46	216000	0	0.1	39	14700
Count	15	13	15	11	14	12	14	11

Propane Resurfacer and Gas Edger

	Indoor				*Outdoor*			
	CO	*NO2*	*PM2.5*	*PM1*	*CO*	*NO2*	*PM2.5*	*PM1*
Median	6	0	14	n/a	0	0.1	10	n/a
Minimum	2	0.0	5	n/a	0	0.0	3	n/a
Maximum	15	0.5	37	n/a	0	0.1	14	n/a
Count	5	5.0	5	n/a	5	5.0	5	n/a

Propane Resurfacer and Propane Edger

	Indoor				*Outdoor*			
	CO	*NO2*	*PM2.5*	*PM1*	*CO*	*NO2*	*PM2.5*	*PM1*
Median	15	0	5	n/a	0	0.2	10	n/a
Minimum	15	0	5	n/a	0	0.2	10	n/a
Maximum	15	0	5	n/a	0	0.2	10	n/a
Count	1	1	1	n/a	1	1.0	1	n/a

Electric

	Indoor				*Outdoor*			
	CO	*NO2*	*PM2.5*	*PM1*	*CO*	*NO2*	*PM2.5*	*PM1*
Median	0	0	8	2940	0	0.1	5	5020
Minimum	0	0	3	1220	0	0.0	3	690
Maximum	1	0	11	7700	0	0.1	15	16400
Count	7	6	7	7	7	6	7	7

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Appendix E: Proposed Action and Evacuation Levels for Carbon Monoxide

Background levels of Carbon Monoxide

Carbon monoxide (CO) is a poisonous gas that consists of one atom of oxygen and one atom of carbon covalently linked with a double bond. It is an odorless, colorless, tasteless gas which is commonly referred to as the "silent killer." A by-product of incomplete combustion, CO is formed whenever any type of organic fuel is burned.

CO is ubiquitous in the environment. The median 1-hour daily maximum concentration across the United States is reported to be 0.7 parts per million in air (ppm) and the mean is 0.9 ppm (EPA 2010). Currently, ambient concentrations of CO in Minnesota are nearly five times lower than the current federal standard (see below; MPCA 2011). Exposure to CO inside automobiles, near busy roadways or rail lines, inside parking garages, and even inside homes can be much higher than ambient outdoor concentrations (ATSDR 2009). The sources of CO in these microenvironments include internal combustion engines, environmental tobacco smoke, gas or wood stoves, and other combustion fuel appliances.

In addition to measurement of CO in air, CO can be measured in the blood as carboxyhemoglobin (COHb). Hemoglobin, the oxygen carrying protein in red blood cells, has a greater affinity (approximately 200 times) for binding with CO than it does for oxygen. Therefore, when CO is present, hemoglobin will bind with CO more readily than with oxygen and form COHb, which is an indicator of CO exposure.

CO is also produced in the body as a normal part of human metabolism. Catabolic processes break down hemoglobin molecules into simpler molecules releasing CO into the body and tissues. According to the National Institute for Occupational Safety and Health (NIOSH), the endogenous production of CO results in a baseline background concentration of between 0.5 and 0.8% COHb in the human body (EPA 2010; WHO 2010; ATSDR 2009). Various references, including a study by Radford and Drizd (1982), estimate that smokers have COHb levels that generally range from 3-8% and can be as high as 10%. People living in homes with gas, coal, wood or kerosene-fired heaters and stoves also typically have higher COHb levels, between 1.8 and 7.5%.

Guidance and Regulatory Levels

Exposure to high levels of CO can be life-threatening, and CO poisoning is the leading cause of death due to poisoning in the United States (ATSDR 2009). Inhaling lower levels of CO can result in headache, nausea, vomiting, dizziness, blurred vision, confusion, chest pain, weakness, and difficulty breathing. People who have heart or lung disease are more vulnerable to the toxic effects of carbon monoxide, as may be pregnant women and fetuses.

Multiple guidance and regulatory levels have been established for CO by various organizations. The criteria used to develop these guidelines and regulatory levels differ depending on the purpose for the guideline or regulation, when it was developed, and the organization that developed it. A table with many of these guidelines is provided in Appendix A of the SONAR. Selected guidelines and regulations most relevant to the Enclosed Sports Arena rule are discussed in more detail below.

U.S. Environmental Protection Agency (USEPA)

National Ambient Air Quality Standard (1 hour): 35 ppm

The U.S. Environmental Protection Agency (EPA) regulates CO as a criteria pollutant under the National Ambient Air Quality Standards (NAAQS). For CO, EPA has an 8-hour standard of 9 ppm in outdoor air. The short-term or one-hour NAAQS for CO is 35 ppm. In September of 2007 the US EPA began the process of reviewing the most current technical data related to regulating CO as a criteria pollutant. Until this current review was initiated, the NAAQS for CO had not been reviewed since June of 2000 [see *Air Quality Criteria Document for Carbon Monoxide* (EPA/600/P-99/001F)]. As part of this most recent review, EPA issued a final Integrated Science Assessment (ISA) for CO in early 2010 (EPA 2010).

The EPA review states that exposure to CO at concentrations relevant to the NAAQS (9 ppm for 8 hours or 35 ppm for 1 hour) have the "potential to increase COHb to levels associated with adverse cardiovascular health effects in some individuals." A substantial portion of Minnesota's population is affected by cardiovascular disease. To put this risk in perspective, in 2010 angina (chest pain or discomfort due to inadequate blood supply to the heart) was reported by 3.6% of Minnesota adults – more than 144,000 people (MDH 2011).

California Air Resources Board (CARB)

Reference Exposure Level (1 hour): 20 ppm

The California Air Resource Board bases their 1-hour Reference Exposure Level (REL) on a 1981 study by Aronow. This study recorded critical effects of aggravation of angina and other cardiovascular diseases for human subjects at a Lowest Observable Adverse Effect Level (LOAEL) of 2% COHb in the blood that correspond to a level of 20 ppm of CO in air when calculated toxicokinetically.

The State of California's current standard for CO is based on maintaining a target COHb increase of no more than 2.5% based on model calculations, including calculations at high altitudes. Other resources cite increases of COHb between 2% and 4% as having adverse affects on individuals with coronary heart disease who are prone to exertional angina.

Additional research on CO poisoning and special sensitivities of children has been done by the State of California's Air Resources Board. Michael Kleinman, Ph.D. has been the researcher instrumental in investigating health effects of CO and has reviewed California's health protective standards and authored the report, "Carbon Monoxide: Evaluation of Current California Air Quality Standards with

Respect to Protection of Children" (Kleinman 2000). California did not find the need revise their REL in response to Dr. Kleinman's report, as the current REL is considered protective for children.

World Health Organization (WHO)

Air Quality Guideline (1 hour): 30 ppm

The World Health Organization (WHO) has issued Air Quality Guidelines that are designed to "offer guidance in reducing adverse health impacts of indoor air pollution based on expert evaluation of current scientific evidence." The WHO guideline cited above is from a recent guidance document on selected pollutants that impact indoor air quality that was published in late 2010 (WHO 2010).

According to WHO (2010), "exposure to carbon monoxide reduces maximum exercise ability in healthy young individuals and reduces the time to angina and, in some cases, the time to ST-segment depression in people with cardiovascular disease, albeit at a concentration that is lower than that needed to reduce exercise ability in healthy individuals."

WHO advises that the following concentrations of CO in air over the specified exposure durations will result in COHb levels at or below 2.0% even when a normal subject engages in light or moderate exercise:

- 86 ppm for 15 minutes
- 26 ppm for 1 hour
- 9 ppm for 8 hours
- 6 ppm for 24 hours

The equivalents provided by WHO demonstrate the interplay between "concentration" and "time" that need to be considered when looking at adverse health effects from CO exposures.

Federal Advisory Committee Acute Exposure Guideline Levels (AEGL)

Acute Exposure Guideline Level 2 (1 hour): 83 ppm
Acute Exposure Guideline Level 2 (4 hours): 33 ppm
Acute Exposure Guideline Level 2 (8 hours): 27 ppm

Another set of health-based reference values to consider are the Acute Exposure Guideline Levels for Hazardous Substances (AEGLs; EPA 2008). These values are derived by a national advisory committee on emergency planning efforts through a cooperative agreement with EPA under the Federal Advisory Committee Act. The charge of the committee is to "identify, review and interpret relevant toxicological and other scientific data and develop AEGLs for high priority, acutely toxic chemicals." AEGLs represent threshold exposure limits for the general public and are applicable to emergency exposure periods ranging from 10 minutes to 8 hours. There are three levels for AEGLs. In the case of CO, only an AEGL-2 has been developed. No advice is offered for a more protective AEGL-1 level.

The AEGL-2 levels consider both time and concentration factors that contribute to a 4% increase in COHb levels in the exposed population. For a 1-hour exposure, the corresponding AEGL-2 is 83 ppm. The AEGL-2 is defined as "the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects, or an impaired ability to escape."

The AEGL-2 considers a 4% COHb to be a No Observed Effect Level (NOEL) and a range of 6 - 9% COHb is provided as a Lowest Observable Effect Level (LOEL) for individuals with coronary artery disease. In comparison, the AEGL document lists a child LOEL as 10 - 15% COHb with a note that acute signs of CO poisoning, including headache, vomiting, nausea, have been seen in children with COHb levels as low as 7%. These adverse effects occur at significantly lower levels than the LOEL for pregnant women listed as 22 - 25% COHb.

The AEGL-2 document for CO was finalized in July of 2008 (EPA 2008). It is available online at: http://www.epa.gov/oppt/aegl/pubs/results50.htm . The AEGL-2 was the primary basis for determining an evacuation level for CO.

Work-Related Standards

MN OSHA Permissible Exposure Limit (8 hours): 35 ppm
US OSHA Permissible Exposure Limit (8 hours): 50 ppm
MN OSHA & NIOSH Ceiling Limit (not to be exceeded): 200 ppm

NIOSH has issued a variety of guidance and warning statements on CO. NIOSH is the research arm of the Occupational Safety and Health Administration (OSHA), which regulates worker safety. Work place standards for CO are not consistent from country to country and some groups recommend much more conservative or health protective numbers than NIOSH offers.

ATSDR's Toxicological Profile for CO summarized current occupational standards and guidelines for CO (ATSDR 2009). US OSHA's current standard for an 8-hour work place exposure is 50 ppm, while MN OSHA's standard is 35 ppm. NIOSH has a time-weighted average (ten hour exposure) recommended exposure limit of 35 ppm for CO, as well as a ceiling limit (5 minute excursion) of 200 ppm. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends a Threshold Limit Value (TLV) of 25 ppm for CO. TLVs are calculated based on a time-weighted average like NIOSH values.

Health Effects of CO Exposure

Information about the toxicity and health effects of CO exposure to humans is extensive and continues to grow. The current focal areas of study are related to exposure, metabolism and excretion of CO via the multiple physiological pathways involved in CO toxicity. While not all of these pathways have been completely elucidated, understanding of the hazards associated with exposure to CO, particularly at low concentrations, continues to develop. While knowledge continues to expand, there is certainly more than enough data to derive a reasonable action level for CO for Enclosed Sports Arenas.

As a final note before discussion of physiology used in consideration to develop action and evacuation levels, it is important to review the epidemiologic criteria for causation. First of all, CO studies exhibit good *strength of association* with a *dose-response relationship*. *Consistency* is noted in so far as effects are observed by different study methods in different labs with different populations under direction of different researchers. Conditions of *temporality* (exposure prior to adverse health effects), *specificity* (CO tested alone without other combustion products), and *biologic plausibility* (being able to explain biologically how CO has an effect on the human body) have all been met. While scientists continue to study alternative pathways in CO poisoning, the debate that continues to persist is generally about the protective factors and treatment protocols to obtain the best possible health outcomes after CO poisoning rather than whether or not CO causes adverse health effects.

In simplest terms, CO interferes with the use of oxygen in the human body. When CO enters the human body through respiration, it competes with molecules of oxygen for binding to the oxygen carrying portion of the hemoglobin (Hb) molecules within the red blood cells. CO binds with an affinity of approximately 200 times that of oxygen, thereby forming COHb which inhibits the transport and delivery of oxygen to tissues throughout the body (ATSDR 2009).

More specifically, the COHb molecule reduces the amount of oxygen available to be carried to primary tissues that need oxygen to function properly and carry out important metabolic processes. The heart and the nervous system are two sites that are affected early on by the resulting reduction in oxygen. Delayed neurological effects may develop over days or weeks that follow the initial acute CO poisoning.

CO can interrupt oxygen delivery to the mitochondria or "power houses" of cells by combining with two different transport proteins, hemoglobin (Hb) and myoglobin (Mb), at two different sites. In the intravascular compartment CO reduces the oxygen carrying capacity of the blood and the oxygen delivery by formation of carboxyhemoglobin (COHb), and by combining with myoglobin (Mb) to form carboxymyoglobin (MbCO). COHb reduces the oxygen carrying capacity of the blood while MbCO reduces the intracellular transport of oxygen to the mitochondria. Besides binding to intracellular protein such as myoglobin, CO can also bind to guanylate cyclase, and cytochrome oxidase in the mitochondria. Other sites within the cell to which CO binds include cytochrome C oxidase, cytochrome P450 enzymes and tryptophan oxygenase (ATSDR 2009).

Carbon monoxide also affects the nervous system by modifying electron transport in nerve cells which ultimately may result in interference with neurotransmission. CO can also cause endothelial cells and platelets to release nitric oxide. These oxidants add to the neurological effects from CO poisoning by resulting in endothelial and leukocyte injury which contributes to lipid peroxidation and degradation of unsaturated fatty acids. These effects are currently being further investigated.

Current data indicate that neurological effects may occur when COHb levels exceed 10%; neurological effects have not been shown to occur at COHb levels below 5% (EPA 2010). The US EPA in their last revision of the NAAQS for CO in 1979 concluded that it is unlikely that significant and repeatable neurobehavioral effects occur at COHb concentration below 5%. Decrements in vigilance, visual perception, manual dexterity, and performance of complex sensorimotor tasks have been observed at, and above 5% COHb. Similar studies have not demonstrated consistent results, however (WHO 2010).

EPA, in its final ISA (EPA 2010) provided no new health-based values for CO. It does contain useful information and data, and the following are important points from this document:

- The well-established Coburn-Forster-Kane (CFK) model (Coburn et al. 1965) can be updated with models that include myoglobin and extravascular storage compartments (a multi-compartment model including the lungs, muscle tissue, non-muscle tissue, arterial and mixed venous compartments). Only the CFK model is provided;

- Coronary artery disease (CAD) is the most important susceptibility characteristic for increased risk due to CO exposure. Individuals with heart disease may be at a greater risk from CO exposure since they may already have compromised oxygen delivery. The incidence of CAD increases with age. Age also contributes to increased susceptibility in older adults who eliminate CO more slowly as compared to younger persons.

- Decreases in the time-to-onset of exercise-induced angina and heart rhythm changes following CO exposures resulting in COHb levels of 3 - 6% with one multicenter study reporting similar effects at COHb levels as low as 2.4%. It was deduced that the most sensitive individuals may respond to levels of COHb *lower than 2.4%* (emphasis added).

- Infants may have heightened susceptibilities to CO at critical phases of development and due to differences between fetal and maternal CO pharmacokinetics.

- The COHb elimination rate decreases with physical activity. Healthy subjects exposed to CO with resulting COHb levels of approximately 4 - 5% observed a significant detriment to exercise duration and maximal effort capability.

- A significant increase in number of ventricular arrhythmias during exercise was observed relative to room air among individuals with CAD following a 1-hour exposure to 200 ppm CO (targeted COHb of 6%), but not following a 1-hour exposure to 100 ppm CO (targeted COHb of 4%). It is noted that although the subjects evaluated in the studies described in Sheps et al. (1990) are not necessarily representative of the most sensitive population, the level of disease in these individuals was relatively severe, with the majority either having a history of myocardial infarction or having ≥ 70% occlusion of one or more of the coronary arteries.

- CO was demonstrated to decrease the post-exposure duration of exercise by approximately 10%. Adir et al. (1999) reported significant CO-induced decreases in metabolic equivalent units-- decreases in exercise duration and maximal aerobic capacity were observed among healthy adults at COHb levels ≥3%.

- Kizakevich et al. (2000) found statistically significant increases in heart rate occurring at COHb levels ≥5%, and statistically significant increases in cardiac output and cardiac contractility observed at COHb levels ≥10%.

<u>Sensitive Populations</u>

Early investigations directly studied the effects of CO on sensitive populations. The following section provides information about groups of people who may be more sensitive to exposure to CO.

Cardiovascular Disease (CVD)/Coronary Heart Disease (CHD)

People with coronary heart disease (CHD) or coronary artery disease (CAD) are the groups that appears to be the most sensitive to the effects of CO exposure. There are many references that conclude that this population is even more sensitive than other sensitive populations such as healthy children or the fetuses of pregnant women (e.g. WHO 2010).

The population with CVD/CHD includes a sizeable portion of the population of the United States. According to the EPA NAAQS draft report for CO, "an estimated 81 million American adults (1 in 3) have one or more type of cardiovascular disease (CVD), with an estimated 47% of those being 60 or more years of age. For the major diseases within the category of total CVD, about 73 million Americans have high blood pressure, 16 million have CHD, 5 million have heart failure, 5 million have stroke, and the estimated prevalence of congenital cardiovascular defects is estimated to be between 650,000 to 1.3 million." According to 2010 data for Minnesota (MDH 2011), approximately 135,000 Minnesotans have had a heart attack during their lifetime, and 144,000 people reported having angina. In addition, heart disease caused 19% of all deaths in Minnesota from 2005-2009, and in 2009 there were over 50,000 acute heart disease hospitalizations (MDH 2011).

CO exposure and the subsequent increase in COHb force the heart to increase its pumping rate and its output to meet the normal oxygen demands of the body. Oxygen supply to the peripheral tissues in response to higher demand (e.g. as a result of exertion) is normally accomplished by increased blood flow and increased oxygen extraction by the tissues. An increase in cardiac rate and output as a general response to peripheral tissue oxygen demand, exacerbated by exposure to CO, can potentially lead to myocardial infarction (heart attack).

It is recognized that CO exposures can have serious, long lasting effects on the heart. In a 2005 study published by Satran et al., it was found that 37% of patients who had been diagnosed with CO poisoning experienced myocardial injury and cardiovascular sequelae after the initial poisoning. A follow-up prospective cohort study on patients treated with hyperbaric oxygen at Hennepin County Medical Center, found that among the 85 patients who experienced myocardial injury from CO poisoning, 38% eventually died as compared with 15% of the 145 patients who did not sustain myocardial injury (Henry et al. 2006). These studies demonstrate that CO can have deleterious effects on the heart in individuals who have experienced moderate to severe CO poisoning, although it is unclear if people with milder cases of CO poisoning have similar increases in mortality.

According to Health Canada (1994), individuals with heart disease, including stable exercise-induced angina pectoris, coronary artery disease, and ischemic heart disease, represent the population at greatest risk from exposure to ambient CO levels.[1] Adverse health end points for this most sensitive population of individuals with coronary heart disease identified in multiple studies are: 1) a reduction in time until the onset of angina; 2) an increased risk of cardiac arrhythmia; and 3) a significant change in electrocardiogram readings (ST segment depression).

Some of the initial studies looking at the health effects on people with CVD/CHD were completed by Aronow et al. (1981). Fifteen patients who had been diagnosed with angina pectoris experienced

[1] Angina pectoris is a symptom of coronary heart disease. Angina can be classified broadly as stable or unstable, depending on its severity and pattern of occurrence. Stable angina is typically provoked by exercise, stress or extremes of temperature and is relieved by either rest or drugs or both. If left untreated, unstable angina may result in a heart attack and irreversible heart damage.

reduced time to onset of exercise-induced chest pain at COHb levels of 2%; however, the study was not performed under double-blinded conditions. Similar results have been found in other studies with target COHb levels between 2 and 5% (Allred et al. 1989; 1991).

The proposed action level of 20 ppm for one hour will protect against levels of CO in the air that would cause an approximate 2% increase in COHb, thereby protecting people with CHD (WHO 2010).

Pregnant women and their fetuses

In pregnant women, the mother who has been exposed to CO may remain symptom free, yet the fetus may be affected. Therefore, the fetuses of pregnant women, especially those moms who are exercising heavily, may be more vulnerable to the effects of CO. Another consideration is that the excretion rates for fetuses may be much longer and thereby expose the fetus to CO for longer periods of time. In its AEGL technical document (EPA 2008), EPA states that the time required for elimination of half of the CO gas from the human body, or the half-life of CO, is three to five hours. A fetus would have a much longer exposure to the same amount of carbon monoxide because fetal blood has a higher affinity for and slower elimination of CO. For the mother, elimination of CO after poisoning takes roughly twice as long in pregnant women as compared with non-pregnant women.

According to the EPA AEGL support document, pregnant women should not be exposed to CO concentrations that would increase their COHb levels higher than 14-17%. These COHb levels may be lethal to the unborn fetus. Newer data indicate that subtle effects, such as lowered birth weights, may be caused by low level exposures to CO during pregnancy, however, more data is needed to determine the concentration or effect level.

Children

For non-lethal effects, after the population of persons with cardiovascular disease, children may constitute the next most susceptible subpopulation. In children CO poisoning can cause episodes of syncope (fainting) and other neurological effects (EPA 2008).

COHb levels of 5 - 5.6% in newborns and young children are considered protective against acute neurotoxic effects (Klasner et al. 1998; Crocker and Walker 1985) and the EPA AEGL support documents suggests a lowest observed effect level (LOEL) of 10 - 15% COHb in children.

Conclusions/ Recommendation

Action level of 20 ppm

For ice skating facilities, MDH proposes to reduce the current 30 ppm action level for carbon monoxide (CO) to 20 ppm. An action level is set to reflect a concentration of CO in air that will require the enclosed sports arena operator to take action to reduce exposure. More specifically, this action level for CO is intended to protect arena users, ensuring that carboxyhemoglobin levels (COHb) do not exceed an increase of approximately 2%. This level is being reduced to protect people with documented or latent coronary heart disease from acute cardiac effects, and will also protect fetuses of pregnant women from hypoxic effects caused by exposure to CO. This new action level better reflects the current state of knowledge about the adverse health effects due to exposure to CO.

Multiple studies with different experimental designs have yielded surprisingly similar results, providing great credibility for the use of a sensitive endpoint ranging from a 2 - 4% increase in COHb. At mean post-exposure levels of COHb ranging from 2 - 4%, the studies suggest there is a significant shortening in the time to onset of angina (Townsend and Maynard 2002). For people with ischemic heart disease, COHb ranging from 2 - 4% can result in impaired myocardial contractility, irregular heart rate and rhythm, and angina pectoris (chest pain). The evidence suggests this to be an appropriate target for an action level for CO designed to reduce CO exposure in this environment, with its unique combination of exposure duration, intensity, (due to the exertion of active participants), and the potential for participants to be unaware they are being exposed to CO.

Evacuation level of 85 ppm

A CO concentration capable of producing an approximately 4% increase in COHb is a reasonable basis for an evacuation level for CO. As such, MDH is proposing to reduce the evacuation level from 125 ppm to 85 ppm measured on a 1-hour basis. This evacuation level would provide a level of protection for people with coronary heart disease from an increase in COHb above 4% and would provide time for arena users to safely exit the arena. The evacuation level is being reduced to protect people with documented or latent coronary heart disease from acute cardiac effects, and to protect fetuses of pregnant women from hypoxic effects caused by exposure to CO. This new evacuation level better reflects the current state of knowledge about the potential adverse health effects due to exposure to CO.

The 85 ppm evacuation level is derived from the final AEGL document for CO issued in July 2008 under the Federal Advisory Committee Act (FACA) and published on the US EPA website. MDH has taken the 83 ppm AEGL-2 over one hour and rounded it to 85 ppm for ease of use. The AEGL 2 is defined as the airborne concentration (expressed as ppm or mg/m^3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects, or an *impaired ability to escape*. In this case, the AEGL-2 is based on COHb target level of 4%.

Maintaining air concentrations to ensure that COHb levels do not exceed 4% will protect against psychomotor effects such as reduced coordination, tracking, and impaired vigilance that generally has been accepted as occurring at COHb levels ranging from 5 - 7%. This is important as it has been shown that tracking performance was significantly impaired if the subjects engaged in heavy exercise (Bunnell and Horvath 1988). These psychomotor skills are important for performing skills needed to safely evacuate an arena facility and a compromise of these skills could lead to injury.

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Appendix F: Action Levels for Nitrogen Dioxide (NO_2)

Background Levels of NO_2

Nitrogen dioxide (NO_2) is a poisonous gas consisting of one atom atom of nitrogen and two atoms of oxygen, Our atmosphere contains a variety of oxides of nitrogen (NO_x), which includes NO_2. Sources of NO_2 include high temperature combustion processes such as motor vehicle engines and power plants. It can also be the product of atmospheric processes where nitrogen oxides react with ozone to create NO_2. Indoor concentrations are usually caused by indoor sources such as gas appliances, engines, and equipment, especially those that are not directly vented to the outdoor air.

According to the Minnesota Pollution Control Agency, annual average outdoor NO_2 concentrations have been declining in recent years, from approximately 0.012 ppm to 0.009 ppm (MPCA 2011). These concentrations, however, are not from near roadways, and the US Environmental Protection Agency (USEPA) has changed monitoring to include areas that are likely to have higher readings. The USEPA has reported concentrations can be 30-100% higher within 50 meters of heavy traffic or freeways (MPCA 2011). Low income persons may be disproportionately exposed to NO_2 because they live near these roadways.

Average levels of NO_2 in homes without combustion appliances are about half that of outdoors. However, homes with fuel burning equipment such as gas stoves and unflued heaters often have indoor levels that exceed outdoor concentrations (Heinrich 2011). The maximum indoor concentrations of NO_2 measured in homes with gas appliances ranged from 0.1 to 1.3 ppm. Personal monitoring of 65 Detroit volunteers found an average NO_2 exposure of 0.028 ppm (Williams 2011).

Guidance and Regulatory Levels

The adverse health effects from NO_2 include irritation affecting the mucosa of the eyes, nose, throat and respiratory tract (USEPA 2010). In addition, high exposures may result in pulmonary edema and diffuse lung injury. Lower levels can result in increased bronchial reactivity, especially in asthmatics. Exposure to NO_2 can also increase the risk of respiratory infection, particularly in young children. Current scientific evidence links short-term NO_2 exposures, ranging from 30 minutes to 24 hours, with an array of adverse respiratory effects including increased asthma symptoms, worsened control of asthma, and an increase in respiratory illnesses and symptoms. The following paragraphs outline a variety of guidance and regulatory levels found for NO_2.

U.S. Environmental Protection Agency (USEPA)

National Ambient Air Quality Standard (1 hour): 0.1 ppm

The USEPA recently reviewed and updated its outdoor standard for NO_2. On February 9, 2010, EPA published a primary National Ambient Air Quality Standards (NAAQS) for nitrogen dioxide (NO_2) of 0.1 ppm for 1 hour (USEPA 2010). Previously, the NAAQS for NO_2 was an annual arithmetic mean of 0.053 parts per million (ppm) or 0.1 micrograms per cubic meter (mg/m^3). This NAAQS remained unchanged since its inception in 1971, even though reviews were completed in 1985 and again in 1996.

The USEPA proposed a new 1-hour standard for NO_2 ranging from 0.08-0.1 ppm, in addition to the annual mean standard. They solicited comment on alternative levels for a 1-hour standard over a range of values ranging from 0.065-0.150 ppm. In 2010, EPA adopted 0.1 ppm as a new standard. The lower standard has been criticized by scientists with ties to industry (Goodman 2009, Hesterberg 2009). These authors argue that 1 hour exposures under 0.2 ppm are not a significant risk, and that the standard should be established between 0.2 and 0.6 ppm.

It is important to note that the new EPA standard is based on the 3-year average of the 98th percentile of the yearly distribution of 1-hour daily maximum concentrations. In other words, if the average of the highest 2% of the daily 1-hour averages exceeds 0.1 ppm over three years, then corrective action is warranted. By comparison, MDH's enclosed arena rule is an action level, meaning a single measured exceedance in areas would immediately warrant corrective measures.

California Air Resources Board (CARB)

Reference Exposure Level (1 hour): 0.18 ppm

Recent EPA actions follow revisions to the NO_2 standard made by the State of California (Cal EPA 2007). In February 2007, the California Air Resources Board (CARB), as part of the California Environmental Protection Agency, reduced California's 1-hour standard for NO_2 from 0.25 ppm down to 0.18 ppm to protect asthmatics, infants and children. In a press release, CARB cited two reasons for needing a lower 1-hour standard: 1) higher concentrations of NO_2 occur near roadways compared to ambient background levels and raise health concerns (traffic levels are increasing); and 2) health concerns regarding exposure in indoor environments, where the average person spends most of their time, have increased.

A review of environmental and health studies was completed by the Air Resource Board (CARB) as part of their standard revision process. (Cal EPA 2007). This report provides support for efforts to revise California's outdoor air standard (the California equivalent of the National Ambient Air Quality Standards or NAAQS for criteria pollutants). The newer 1-hour standard is intended to protect populations who may be more sensitive to the effects of nitrogen dioxide exposure--people with asthma, children and the elderly.

MDH Health Risk Assessment Unit (HRA)

Acute Health Based Value (1 hour): 0.25 ppm

In July of 2004, MDH's Health Risk Assessment Unit concluded that the California EPA 1 hour standard for NO_2 at that time--0.47 mg/m^3 or 0.25 ppm--was "adequately protective of public health and is well supported by clinical studies showing increased airway responsiveness in sensitive populations (e.g., asthmatics)" (MDH 2004). In healthy populations, the effects occur at much higher levels—in the single parts per million range (1.5 ppm). HRA stated that "While these studies show a range of responsiveness following NO_2 exposures, they indicate that mild adverse effects occur in sensitive populations at concentrations near the [California Reference Exposure Level] CA REL. The CA REL incorporates an uncertainty factor of 1, and therefore, does not provide additional buffer between the value and the concentration at which effects have been observed in sensitive populations."

World Health Organization (WHO)

Air Quality Guideline (1 hour): 0.106 ppm

The World Health Organization (WHO) has developed general and indoor air quality guidelines, including NO_2 (WHO 2005). The WHO has indicated that the lowest observable acute effect level of NO_2 was near 0.2-0.3 ppm based on clinical studies showing increased airway responsiveness in asthmatics. The WHO proposed a 50% margin of safety because of additional evidence of possible effects below 0.2 ppm. In 2005, they published a 1-hour mean air quality guideline value of 0.2 mg/m^3 (0.106 ppm). In 2010, WHO reaffirmed this as their recommended value for indoor air (WHO 2010).

Federal Advisory Committee Acute Exposure Guideline Levels (AEGL)

Acute Exposure Guideline Level 1 (10 min., 30 min., 1 hour, 4 hours and 8-hours) : 0.5 ppm

Another recent review of nitrogen dioxide toxicity, published by the US EPA, are the Acute Emergency Guideline Levels (AEGLs) (USEPA 2008). The interim AEGL for NO_2 was published in December of 2008. The AEGL-1 is defined as "the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic, non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure. It is recognized that individuals, subject to unique or idiosyncratic responses, could experience the effects described at concentrations below the corresponding AEGL". The interim AEGL-1 for NO_2 is 0.5 ppm for all the following exposure durations: 10 min., 30 min., 1 hour, 4 hours and 8 hours. The varying time frames reflect their finding one concentration is protective over a variety of exposure durations ranging from 10 minutes through 8 hours because either short or longer exposure can cause the same health effects. The health endpoint provided is "slight burning of the eyes, slight headache, chest tightness or labored breathing with exercise in 7/13 asthmatics". However, in their summary, the committee states that "some asthmatics exposed to 0.3-0.5 ppm NO_2 may respond with either subjective symptoms or slight changes in pulmonary function."

Work-Related Standards

MN OSHA & NIOSH Short Term Exposure Limit (15 minute): 1 ppm
US OSHA Ceiling Limit (not to be exceeded): 5 ppm

The National Institute for Occupational Safety and Health (NIOSH), the research arm for the Federal Occupational Safety and Health Administration (US OSHA) has a 1 ppm short term exposure limit (STEL) for worker exposure to nitrogen dioxide. The Minnesota Occupational Safety and Health Administration (MN OSHA) has also adopted this standard (MNOSHA 2011). This is a worker standard to protect healthy individuals from adverse health effects. Work place standards are generally much higher (i.e. less protective) than standards generated for the general, more susceptible, populations.

US OSHA issued a final rule in 1989 (54 FR 2332) that lowered its existing standards. On July 10, 1992, the Eleventh Circuit Court of Appeals overturned the rule because: 1) US OSHA had failed to establish that the existing standard presented significant risk and that the proposed standards eliminated or substantially lessened the risk; and 2) US OSHA did not establish the economic and technical feasibility of the proposed standard.. As a result, US OSHA has maintained a higher 5 ppm Ceiling Limit for NO_2 (US OSHA 2011). MN OSHA and NIOSH have held to the STEL of 1 ppm for NO_2

Health Effects of NO_2 Exposure

Nitrogen dioxide is an irritant to the mucous membranes and may cause coughing and dyspnea (shortness of breath) during exposure (USEPA 2008). Symptoms of short term, low level exposures may persist for several hours before subsiding. With severe exposures, pulmonary edema (swelling) ensues with signs of chest pain, cough, dyspnea, cyanosis (blue coloration due to low oxygen) and moist rales (a sound heard over fluid in the bronchial tubes) (NIOSH 1976). Permanent lung damage can result. Death from NO_2 inhalation is caused by bronchospasm and pulmonary edema in association with hypoxemia (insufficient oxygenation of blood) and respiratory acidosis, metabolic acidosis, shift of the oxyhemoglobin dissociation, and arterial hypotension. NO_2 intoxication is characterized by a period of apparent recovery followed by late-onset bronchiolar injury that manifests as bronchiolitis fibrosa (scar tissue). In addition, experiments with laboratory animals indicate that exposure to NO_2 increases susceptibility to infection due, in part, to alterations in host pulmonary defense mechanisms. This latter effect has been further elucidated (supported with studies) in more recent years (Cal EPA 2007).

In contrast to healthy subjects who generally experience no effects to NO_2 concentrations below 1 ppm, asthmatics have been identified as a potentially susceptible population. It is important to protect for effects of this sensitive population because the population is so large. According to CDC's National Center for Health Statistics, the number of non-institutionalized adults who currently have asthma is 16.2 million, while the number of children who currently have asthma is estimated at 6.7 million. In Minnesota, MDH's Asthma Program reported that an estimated 429,000 Minnesota adults have a history of asthma and an estimated 303,000 Minnesota adults currently have asthma (MDH 2008). For Minnesota's children, an estimated 116,000 have lifetime asthma and 85,000 (7.0%) currently have asthma. This accounts for 9.5% of children reporting to have ever been diagnosed with asthma, which is very similar to national statistics. With nearly 1 out of 10 children at risk in enclosed sports arenas, exposure to combustion by-products in these environments is a significant public health issue.

Older evidence indicates that some asthmatics exposed to 0.3-0.5 ppm NO_2 may respond with either subjective symptoms or slight changes in pulmonary function of no clinical significance. Health effects for asthmatics, however, have been inconsistent and it has been found that some asthmatics did not respond to NO_2 at concentrations between 0.5 and 4 ppm. It should be noted that only some asthmatics are sensitive to irritants such as nitrogen dioxide. Since studies usually involve small numbers of subjects, the differences in study results may be attributed to differences in sensitivity.

More recent evidence, as outlined in the Cal EPA report, indicates that asthmatics appear to be especially sensitive to NO_2 (Cal EPA 2007). It has been shown that NO_2 exposure increases allergen responsiveness with effects observed at short term exposure durations near the ambient air quality standard (i.e., 0.2-0.3 ppm for 30 minutes to 2 hours). Most studies cited by CAL suggest effects occur at these low exposure levels to allergens: 0.2 ppm for 2 hr.; 0.25 ppm for 30 min; 0.27 ppm for 30 min.; 0.3 ppm for 30 min; and no effect at 0.25 ppm for 30 min. In addition, NO_2 may impact lung development and function. Subjects with chronic obstructive pulmonary/lung disease (COPD) experienced decreased lung function at 0.3 ppm.

The California EPA lowered their short-term 1-hour value for NO_2 because of: 1) enhanced inflammatory response in asthmatics after 3 exposures to 0.26 ppm NO_2 from 15-30 min., followed by an exposure to an airborne allergen; 2) increased airway reactivity in asthmatic individuals following exposures to 0.2- 0.3 ppm NO_2 for 30 min. to 2 hours; and 3) evidence from time-series epidemiological studies based on 24-hour average NO_2 concentrations. US EPA has followed suit and recently enacted an even lower 1-hour standard for NO_2 of 0.1 ppm.

The results of the epidemiological studies are consistent with the health effects of NO_2 tested on volunteer human subject and animals. Time-series studies have shown a relationship between NO_2 exposure and increased asthma symptoms and medication use, hospital admissions and emergency room visits for asthma. More recent studies suggest NO_2 could be linked to congential abnormalities (Vrijheid 2011) and cardiovascular function (Williams 2011), although these findings are not as robust as the respiratory health effects.

Most of these epidemiological studies, however, have trouble in determining the actual exposure concentrations since measurements are typically from community monitors and not personal or in-home measurements. In addition, there are confounding variables such as co-pollutants (e.g., particulate matter, sulfur oxide, ozone) as well as seasonal allergens and temperature that may also play a role in how asthmatics react to chemicals in the air (Heinrich 2011).

Separating out the effect of NO_2 exposures from the other pollutants (combustion by-products, allergens) is difficult. However, these other pollutants are also found in the micro-environment of an arena where combustion engines or equipment are operated. Real world exposures consist of complex mixtures of air pollutants, some of which correlate closely with NO_2. It is difficult to separate out the effects of NO_2 and other pollutants, but it appears that by keeping NO_2 levels low, other pollutants, such as particulate matter (but not carbon monoxide) will also be maintained at a reasonable level or concentration (see also Appendices A&D).

Although substantial inter-individual variability of response exists to $NO_{2,}$ asthmatics are a very large population who need protection in indoor arena environments. Children may also be at greater risk than adults because they breathe more air, they may still have developing lungs, and children with asthma have higher degree of airway responsiveness than adult asthmatics. In addition, child skaters are closer to the ice and are usually exercising heavily (Heinrich 2011). As a result, they may be exposed to higher concentrations of nitrogen dioxide compared to adults and spectators. Studies conducted of ice arenas have shown adverse health effects associated with NO_2 (see Appendix B). Lowering the NO_2 action level from 0.5 to 0.3 ppm should provide more protection for children, asthmatics, and the very old, all of whom may be potentially susceptible

The proposed action level for NO_2 is 0.3 ppm. The studies summarized above have shown that, sensitive people may experience adverse health effects from exposures at or near this action level. There are no protective factors built into this value other than it is some sensitive individuals who may experience health effects at this level of exposure. The health effects from NO_2 is are associated with 'spikes' (i.e., the peak levels). This differs from chemicals such as carbon monoxide that build up in the body over time.

The proposed action level for NO_2 is being reduced to protect people with asthma from increased airway resistance and increased airway reactivity. Asthmatics are the group who may be most susceptible to NO_2 exposures because of airway hyper-responsiveness to irritants. This new action level better reflects the current state of knowledge about the adverse health effects due to exposure to nitrogen dioxide, particularly issues related to airway responsiveness in asthmatics exposed to NO_2 in combination with other irritants and allergens. The new action level is also based upon the ability to perform adequate air monitoring for $NO_{2,}$ as discussed in the next section. Current real-time air monitoring instruments cannot reliably or accurately measure NO_2 at concentrations below 0.3 ppm. It is therefore important to realize that health effects may occur at levels below this value; however, these effects are expected to be mild and reversible. MDH is not proposing to change the evacuation level for NO_2.

Monitoring Considerations

Air monitoring equipment and protocols exist for most airborne contaminants that allow measurement of chemicals or chemical compounds at levels lower than the targeted health protective value. These methods provide industrial hygienists and other health professionals a way to protect the health of workers and others who may enter contaminated environments. NO_2 testing is problematic because the levels of health concern approach the lower limits of real-time testing equipment that are reasonably priced.

MDH researched the instrumentation and solicited information from all known manufacturers of such instrumentation. There are two general types of portable air monitoring instruments: 1) tubes that use a colorimetric reaction; and 2) electronic sensor instruments that display a digital readout. MDH discussed the limits of accurate detection with manufacturer technical staff, which are summarized here. Air monitoring instruments are further discussed in Appendix G.

The standard testing range for colorimetric tubes extends down to 0.5 ppm; however, this testing range can be extended to 0.25 ppm with the most commonly used instrument (Drager). It nonetheless difficult to visually 'read' the extent of color development at these very low levels.

MDH expects electronic instruments to become the predominant method used in ice arenas, due the increased testing frequency proposed in this rule, the difficulty of reading tubes at low levels, and declining costs of electronic instruments. The manufacturers' representatives stated that the measuring ranges of the electronic devices extend to 0.1 ppm for NO_2 and 1 ppm for CO. However, they added that readings at low levels can be highly inaccurate. At least three companies (Drager, Honeywell, and Gray Wolf) manufacturer representatives stated that readings around 0.1-0.2 NO2 and 1-2 ppm CO can be inaccurate due to 'noise' or 'dead-banding'. In some cases, the instrument may actually display a negative reading when concentrations are in these low ranges. MDH has also noticed this problem with the devices it owns. Staff have observed NO_2 levels routinely displayed from 0.0 to 0.2 ppm in environments where no NO_2 would be expected and other instrumentation showed 0 reading; this continued even after calibration with 0 ppm gas. Maintenance and calibration of the instrumentation does not necessarily result in highly accurate readings. These electronic instrumentation are calibrated with 5.0 ppm gas, which is much higher than the levels of interest. Without calibration gas in the 0.1 to 1 ppm range, it is never possible for an end-user or repair technician to truly verify readings readings are accurate at or near the action level. The gas itself can have up to a 10% variability and the sensor readings can drift between calibration. Despite all these concerns, according to the manufacturer representatives, once readings hit 0.3 ppm for NO_2 or 3 ppm for CO, the readings are reliable and will fall within the accuracy and precision specifications, *if* the device is maintained properly.

The equipment used to test lower levels, such as those used for compliance with the US EPA outdoor air regulation, are far more costly, not portable (these are area monitors fixed at one location), and difficult to use. While there are more affordable portable testing methods used by scientists that can accurately detect levels in the 0.1 – 0.3 ppm range, these devices are also more complex to employ and require laboratory analysis of collected air samples, and, as such, are not viable for the real-time testing and corrective action needs of sports arenas.

With these practical considerations in mind, MDH proposes to require air monitoring resolution the tenth-of-a-part-per-million range and to set the action level for NO_2 at 0.3 ppm, where detection is reasonable with available monitoring equipment, including some tube technologies. Because there are no protective factors built into the NO_2 action level, MDH will need to rely on educating rink managers to convey the seriousness of operating ice rinks at levels above 0.3 ppm for NO_2.

Conclusion and Recommendations

Action level of 0.3 ppm

The Minnesota Department of Health proposes to reduce the current 0.5 ppm action level for nitrogen dioxide (NO_2) to 0.3 ppm. MDH is not proposing to change the evacuation level for NO_2. The new action level better reflects the current state of knowledge about the adverse health effects due to exposure to nitrogen dioxide. An action level is set to reflect a concentration of NO_2 in air that will require the enclosed sports arena operator to take action to reduce exposure.

The reduction of the action level from 0.5 to 0.3 ppm is justified from recent studies that found some asthmatics responds to allergen at 0.26 ppm for 15-30 minutes. In addition, increased airway reactivity has also been found in asthmatics exposed to 0.25 – 0.3 ppm for 30-60 minutes. Additional protective factors have not been incorporated into this value, therefore, it is important to realize that health effects may occur at levels at or below this value. However, these effects are expected to be mild and reversible.

The action level has been established with consideration of air monitoring instruments' ability to reliably measure NO_2 air concentrations in arenas and take immediate corrective measures. For electronic devices that are properly maintained, readings for NO_2 are reliable and will fall within the accuracy and precision specifications at levels of greater than or equal to 0.3 ppm NO_2. There are manual pump methods also available to measure concentrations of NO_2 in the air down to 0.3 ppm.

The proposed testing requirements ensure that areas with the highest possible levels are being tested. NO_2 would be expected to remain at higher levels at or near the ice where the air is typically coldest and also where children may be skating and heavily exercising. NO_2 is a good surrogate for many other combustion by-product pollutants marker of traffic among the criteria pollutants. Within the micro-environment of an arena, control of NO_2 emissions may positively control particulate and some other emissions from the use of fuel-burning ice resurfacing machines in arenas.

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Appendix G. CO and NO2 Air Monitoring Instruments

Introduction

MDH researched the technical specifications and other aspects of portable air monitoring instruments. The purpose of this research was to inform the rule-making process, as well as to help with outreach, education, and inspection activities. This report summarize the findings regarding technical specifications (testing range, accuracy, independent standards, etc), maintenance specifications, other issues associated with operating and owning the devices, and the costs of ownership. The applicability of these details to regulations is also discussed.

MDH staff (Dan Tranter) contacted 9 manufacturer or distributors of air monitoring devices, and requested a referral to the specialist at the company who could answer technical questions. The companies contacted are listed in Attachment A. This is not a complete list of companies that manufacture or distribute air monitoring instruments, but rather a list of those companies that MDH knows have sold testing devices to MN arenas over the years. No endorsement of these companies is implied.

All the companies contacted provided a referral to their staff person considered the technical expert for the instrument(s) (the company "rep"). MDH sent a list of questions to each rep. Six of these reps responded. MDH then called each rep to review, confirm and clarify information provided. **Information provided in this report is not necessarily a complete or accurate depiction of the nature of air testing devices, considering much of the data was obtained from company reps with no independent or objective confirmation.**

There are two general types of portable air monitoring instruments: 1) tubes that use a colorimetric reaction; and 2) electronic sensor instruments that display a digital readout. The devices within each of these categories are similar, but there are differences between the two categories. Within the electronic category there are also portable and continuous monitoring systems in a fixed location. This report focuses on portable instrumentation. Some limited discussion on continuous monitoring systems can be at the end of the report.

Measurement Specifications

Pumps with Colorimetric Tubes

The testing tubes are used by manually pumping a specific amount of air through the chemical matrix inside the tube. If the target chemical (CO or NO2) is present, it reacts with reagents in the matrix to produce a different color (e.g., brown, grayish blue, etc.), which is then read along a graduated scale of the glass tube. The four types of tubes generally had similar technical specifications, even though the reagent involved in the reactions generally differ by tube. Measurement specifications are listed in Attachment B.

According to the reps, most of the devices have 'minimum detection limits' of 0.1 for NO_2 and 1 or 2 ppm for CO. However, since the testing ranges begin at 0.5 for NO_2 and 5 to 10 ppm for CO, the accurate minimum detection limit should be considered the lower end of the ranges. Drager allows for a reduction of the NO_2 testing range down to 0.25 ppm by doubling the number of pump stokes, and Nextteq offers a tube that has a 0.1 – 1.0 ppm NO_2 range.

The standard operating conditions of the tubes generally specify a temperature above freezing and up to 122 F (0 – 40 C). Three of the companies indicated that the accuracy within the temperature and measuring range is +/- 25%, and the precisions range from +/- 5 - 25%. Two of the company reps speculated that the device accuracy and precision should be similar at levels below the testing range, although it is likely that user error would significantly detract from the accuracy of the readings.

Different positions were presented on the topic of using the tubes at sub-freezing temperatures.

- The Nextteq rep (distributor of Gastec products) stated that tube type devices were not meant to be used at below freezing temperatures. The chemical reaction will not occur properly at sub-freezing temperatures, which affects the accuracy of the measurement, probably underestimating concentrations. Even if the tubes are stored at room temperature, the temperature of the tube matrix drops almost instantaneously when air is pulled through the tube. The only way to take an accurate reading of sub-freezing air is to collect a sample of air and warm it to room temperature and then measure CO and NO_2.
- The Sensidyne rep (distributor of Kitagawa products) was equivocal on the subject. He indicated that many use the tubes below freezing. Some people warm the tube by holding a bare hand around it. A correction factor must be applied to the CO tubes as temperature declines, but the manufacturer doesn't provide correction factors outside of the specified range. When the matter was discussed verbally, the rep indicated that the device probably shouldn't use below freezing; moisture needed for the reaction can freeze and the low temperature can slow the chemical reaction.
- The MSA rep indicated testing at below freezing could be acceptable, if the end-user first verified it works. The rep stated that: "heat and cold extremes do directly and adversely affect the chemical reactions talking place and thus limit range of use. This range is set by our chemists and allows an end-user a practical range that the product can be used in. Devices like tube warmers could be used, but the end-user would need to establish their own methods by testing such devices with known concentrations of the gas in question (in a controlled environment)." It is interesting that even though MSA and Draeger tubes are deemed inter-changeable by MSA, their perspective on this topic differs from Draeger.
- The Draeger rep was unequivocal in stating that the tubes can be used below freezing. He stated that as long as the tube starts at a warmer temperature it can be used. The heat from a hand holding the tube or using a special tube warmer available from Draeger prevents temperature loss in the tube and allows for an accurate measurement. When discussed verbally, he indicated with great confidence that the tubes can be used down to -4F, if held in a hand or special tube warmer is used. In fact, Draeger has two fact sheets on the topic of

using their tubes at sub-freezing temperatures. Draeger has stated that they have tested the temperatures inside their tubes and found temperatures will maintain temperature (when beginning at an adequate warmer temperature) when the tube is held in the hand. The rep attributes this to the 7 mm diameter Draeger Tubes, which contain much more volume and subsequent internal material than most other manufacturers' 5 mm diameter tubes.

While the lower end of the testing range for the CO tubes extends to down to 10 ppm or less important differences exist between manufacturers regarding the NO2 tubes' testing ranges.

- Nextteq has a variety of tubes that can test CO and NO2, and the lowest real-time testing option covers 0.5 – 30 ppm. In addition, they have passive tubes that can be left out for 1-24 hours to obtain a reading in the lower range. However, these tubes would not appropriate in an arena where instantaneous measurements are necessary. Moreover, these tubes need to be stored in a refrigerator, unlike the other tubes, which can be stored at room temperature.
- Sensidyne has a tube that covers 0.1 – 1.0 ppm NO2. These could be used in arenas for day-to-day use, but arenas would also need to purchase the 0.5 – 30 NO2 ppm tube for evacuation levels (2 ppm). The CO tubes require a temperature correction at low temperatures: for example at freezing, a 25 ppm reading on the tube must be corrected down to 20 ppm.
- Draeger tubes measuring ranges can be extended downward by extending the number of pump strokes. The standard specification for the NO2 tube used in arenas is to take 5 pump strokes, which provides a measuring range of 0.5 – 30 ppm. Ten strokes can be taken, lowering the measuring range to 0.25 – 1.0 ppm. The reading shown on the tube must be divided by 2 to obtain the actual air concentration. Moreover, when using the 10-stroke method there is an upper limit of 1 ppm (2 ppm on the tube scale) and cannot be used for higher levels. Testing ranges can be increased even further by increasing the number of pump strokes, which can also be done for the CO tubes.
- MSA does not recommend lowering the testing range. The MSA rep stated that the "measuring range is limited to 5 pump strokes, which corresponds to a 0.5 - 50 ppm range. It would not be recommended to double the number of pumps, as the accuracy of this particular tube (and many tubes on the market) is only +/- 25% within the defined range/parameters. Outside our parameters, this accuracy decreases and likely does so exponentially."

It is surprising that Draeger and MSA have different views considering the tube diameters and chemical regents are the same[1]. Draeger and MSA pumps and tubes have been studied and found to be inter-changeable[2].

Electronic Devices

There are many electronic devices on the market. Many companies use sensor chips manufactured by one of two companies (City Technologies or Alpha Sense), while at least one company (Draeger) manufactures its own sensors.

[1] CO tube reagents the same, unclear if NO2 tube reagents are the same
[2] Study by Dr. Stefan Zloczysti "Inter-changeability of Detector Tubes and Pumps" published in newsletter *Innovation in Industrial and Environmental Hygiene.* Not inter-changeable for Draeger's mini-tubes.

The manufacturers stated measuring ranges of the electronic devices extend to lower concentrations (0.1 for NO2, 1 for CO). However, readings at low levels can be highly inaccurate. At least three companies (Drager, Honeywell, and Gray Wolf) have noted that readings around 0.1-0.2 NO2 and 1-2 ppm CO can be inaccurate due to 'noise' or 'dead-banding'. In some cases, the instrument may actually display a negative reading when concentrations are in these low ranges. MDH has also noticed this with devices it owns (Gray Wolf, VRAE)--NO2 levels are routinely displayed from 0.0 to 0.2 ppm in environments where no NO2 would be expected, and this continued even after calibration with '0-air' gas. According to the reps, once readings hit 0.3 for NO2 or 3 ppm for CO, the readings are reliable and will fall within the accuracy and precision specifications, *if* the device is maintained properly.

The accuracy and precision of the electronic devices were superior to the pump and tubes. For most devices, accuracy ranged from 2% to 15%, while precision ranged from 2 to 10%. Many of the companies have specification terms of linearity and repeatability. These were roughly interpreted as equivalent to accuracy and precision respectively. No difference was noted between pump devices and diffusion devices (i.e., passive). The Gray Wolf rep provided accuracy and precision values for the lower end (0-2 ppm NO2) of the testing range in ppm units: +/- 0.25 ppm for NO2 and +/- 5ppm for CO at room temperature. Although the other companies presented a single fixed accuracy as a percentage across the entire range, it may be that other devices have similar absolute inaccuracies at the lower end of the range, which are actually higher as percentages. For example, TSI has noted for its CO devices an error of either 3 ppm or 3%, whichever is greater.

It should be noted that sensor drift can also be a problem that affects accuracy. Gray Wolf indicated that the NO2 sensor can drift 4% per month, while CO can drift 3% per year. Whether this can be generalized to other sensors is unknown. Routine bump testing followed by calibration, where needed, is critical to control this drift and the ensure accuracy of measurements.

The electronic devices are generally specified to perform below freezing temperatures. The sensors should perform within the specified accuracy and precision down to at least -4 F, in some cases down to -22 F. It is, however, noteworthy that one company (Gray Wolf) volunteered data that showed when below freezing, NO2 sensor inaccuracy can double from +/- 0.25 to +/- 0.5 ppm and CO sensor inaccuracy increase from +/- 5 to +/- 8ppm. Gray Wolf's sensors are manufactured by Alpha Sense. Whether this increased error at low temperature can be generalized to other instruments that utilize Alpha Sense sensors or devices utilizing City Technologies sensors is unknown, although it does cast doubt on the veracity of low temperature accuracy and precision claims made by all manufacturers.

Third-Party Certification of Measurement Technologies

Pump and Tube

The only independent standard found for the tube devices is from the Safety Equipment Institute (SEI), a third-party organization that assesses the accuracy of tubes submitted by manufacturers. The tubes from Kitagawa, Draeger, and Gastec, listed in Attachment B, are SEI certified (ANSI/ISEA 102-1990), while MSA's tubes are not certified. Manufacturers do not certify all their tubes; generally, one tube per contaminant is certified. In addition, the relevance of the SEI certification to NO2 testing is questionable. The SEI certifies tubes at concentrations ranging from 0.5 to 5 times the AGIH TLV; for CO this is 12.5 – 125ppm and for NO2 this is 1.5 – 15 ppm. As such, the lower NO2 levels are not covered by SEI.

Electronic Devices

A wide variety of certification is included with the literature of electronic devices, such as Canadian Standards Association (CSA), Underwriters Laboratory (UL), IP, ATEX, IECEx, and ISO. According to the Honeywell/BW Tech rep, the UL standard is an "intrinsic safety standard" dealing with combustibility associated with the electrical system of the device. ATEX and IECEx are also for intrinsic safety standard, recognized in Europe and South America. The IP standard addresses water-proofing. ISO standards relate to general manufacturing QA/QC: 'quality management systems' and 'environmental management systems'.

The CSA standard is similar to the UL standard, but also specifies sensor performance (accuracy and precision). However, two of the Honeywell/BW Tech devices are not certified by CSA because these devices are not marketed in Canada. These two devices are considered comparable to their other devices, and the company rep noted that they would probably qualify for CSA certification if submitted. The costs of certification are significant, involving auditing, which discourages certification unless necessary for sale in a certain country or region.

<u>Maintenance and Cost Considerations</u>

Pumps with Colorimetric Tubes

The pumps and tubes require minimal maintenance and repair. Pumps typically have an extended warranty and are expected to last many years and well beyond ten years under normal use. The tubes have a 1 – 2 year shelf life; expired tubes are inaccurate and should not be used. Periodic leak testing is recommended, at least monthly, although prior to each use was also recommended (by Sensidyne). Yearly maintenance of pumps is not specified, although minor repairs (e.g., air leaks) may be needed over the course of a few years. A leaky pump may not draw the proper amount of air, usually resulting in an under-estimation of concentrations. These can be repaired by the end-user or the distributor for a nominal cost. The pumps are relatively inexpensive to purchase, at $168 - $409. The bulk of the cost over time is the tubes ($61 – 78 for a box of 10 tubes).

Electronic Devices

Maintenance of the electronic devices is a critical factor in ensuring accurate readings. The maintenance specifications for the electronic devices vary considerably by company. Some manufacturers recommend bump testing prior to each use and then calibrating as needed. Some manufacturers recommend routine calibration and possibly other maintenance (e.g., cleaning) from every year to every three months), even where routine bump testing reveals no problems. Honeywell's rep. indicated that "most calibration intervals are 180 days providing the monitor is bump tested per OSHA recommendation".

According to OSHA:

> "A bump test or full calibration of direct-reading portable gas monitors should be made before each day's use in accordance with manufacturer's instructions, using an appropriate test gas." If the instrument fails a bump test, it must be adjusted through a full calibration before it is used…
> According to the ISEA, less frequent verification may be appropriate if the following criteria are met:
> - During a period of initial use of at least 10 days in the intended atmosphere, calibration is verified daily to ensure there is nothing in the atmosphere to poison the sensor(s). The period of initial use must be of sufficient duration to ensure that the sensors are exposed to all conditions that might adversely affect the sensors.
> - If the tests demonstrate that no adjustments are necessary, the interval between checks may be lengthened, but it should not exceed 30 days.
> - When calibrating an instrument, always follow the instrument user's manual for the manufacturer's recommended calibration frequency and procedure….
>
> For verification of accuracy, calibration gas should always be certified by and traceable to the National Institute of Standards and Technology (NIST). [3]

Another critical maintenance function is sensor replacement. Where readings quickly drift after calibration or where results are highly unusual, sensor replacement is likely needed. Sensors need to be replaced when they die. The life expectancy is 2-4 years for the CO sensors and 1-2 years for the NO2 sensor. The instruments themselves last at least 5-10 years, and may last longer, especially under the infrequent use conditions expected in arenas.

The calibration and sensor replacement can be done by the end-user or the manufacturer. In some cases the manufacturer requires or recommends that the manufacturers performs the calibration and other repair services. In other cases, the manufacturer recommends that the end-user complete all calibration and sensor replacements. Many devices will likely need to be submitted to manufacturer at some point; either routinely or where major disrepair occurs that can't be handled by end-user. This means there will be periods when the device is unavailable for testing.

Due to all the variables in purchasing, maintenance, and lifespan, the cost of ownership ranges considerably (see Attachment C). The lower end represents the best case scenario, with sensors, the instrument, and calibration gas lasting as long as could be expected, while the upper end represents the worst case scenario regarding longevity. The cost of owning an electronic device

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[3] "Verification Of Calibration for Direct-Reading Portable Gas Monitors",
Safety and Health Information Bulletins SHIB 05-04-2004. http://www.osha.gov/dts/shib/shib050404.html".

is about comparable to the pump and tube option for those arenas with 1 sheet open year-round. Facilities with more sheets would save money in the long run by using an electronic device.

Other User Considerations

Pumps with Colorimetric Tubes

There are some user problems involved with the colorimetric tubes. These various user problems can results in a significant underestimation of actual air concentrations.

First, the tubes can be difficult to read, especially at the lower end of the tube. The color development often produces a dark zone followed by a light zone that gradually tapers. The user may read the staining at the end of dark zone, which is incorrect. Generally the tube is supposed to be read at the end of the stain (lightest point), but when there is channeling (color change at a diagonal), then it should be read at the halfway of channel. These ‘eye-balling’ issues can result in user error that significantly adds to the error of the measurement, beyond the specified device inaccuracies shown in Attachment B.

In addition, the tubes can be used improperly. In a few instances, MDH has observed insufficient or incomplete pump strokes employed by the user. This will result in a lower air volume and under-estimation of actual concentrations. Also, MDH has seen tubes inserted in the wrong direction or without breaking the tip(s) off.

Finally, expired tubes are a common problem found during MDH inspections in arenas. This can either indicate no testing is being done, or that testing is done with expired tubes. According to the Sensidyne Rep, how old tubes affect accuracy and precision is unknown. Recently expired tubes will continue to show color change, but the results start to become inaccurate. The staining may be faint and longer, which can make it hard to read or look higher than actual; alternatively, expired tubes underestimate levels, if oxidation reaction is involved in the chemical reaction. Eventually, expired tubes will not change any color.

Electronic Devices

There are also a number of user concerns associated with the electronic devices. The user problems can lead to minor under-or over- estimation, or possibly complete equipment malfunction. MDH has found during inspections that maintenance of devices is often neglected, and, in some cases, the device did not function.

First, the devices need to be impeccably maintained. One company (Gray Wolf) volunteered that their NO2 sensors will drift up to 4% per month. This means that over 6 months, if no calibration is done, the measurement can drift by as much as 26%. By comparison, the CO sensor drifts only 3% *per year*. Despite this significant drift problem, Gray Wolf recommends calibration every 6 months; end-users can calibrate monthly but this is considered optional. Since many companies use similar sensors, this problem may exist with other instruments. Also, the calibration gas can have a short shelf-life (6-12 months for NO2), requiring continuous replacement

In addition, proper calibration requires some aptitude in being able to follow instructions, which are not always simple to follow. The instruction manuals of some devices can be confusing. Having the vendor write a simple set of instructions may be helpful.

Moreover, if the calibration does not hold, it is likely that the sensor needs replacement; however, an arena manager may not notice this need for sensor replacement. To recognize the need for sensor replacement, the user would either: 1) need to observe a very unusual or unstable reading; or 2) conduct frequent bump testing, followed by calibration, and then another bump test shortly after calibration showing reading does not hold.

Furthermore, unusual readings may be observed at low levels. Readings under 0.3 ppm NO2 or 3 ppm CO can be 'noise' or 'dead-banding' and could be a false-positive. Readings may actually be displayed as a negative reading (-0.1,-0.2). At least one device has a much more significant inaccuracy of +/- 0.5 ppm for NO2 in the low range at low temperatures, which can also confuse the user. This can lead the arena manager to question the reliability of the device and lead to unnecessary sensor replacement. Ultimately, these unusual readings may undermine the credibility of the testing program and possibly the air quality regulations.

Finally, portable electronic instruments require batteries. If the batteries are dead (or out of charge) and replacement(s) is not available (or charging takes time), then an arena would not be able to immediately respond to an air quality concern. Likewise, an arena would fail to complete follow-up testing after an air quality exceedance if the instrument does not operate. Not being able to test could apply in an arena that runs out of tubes, although it may be more intuitively easy to know how many tubes you have than how much battery life exists.

Continuous Monitoring Systems

Electronic devices that are fixed to a specific location and continuously measure air quality are another testing option. These 'continuous monitoring systems' (CMS) would seem to be the best option, at first glance, for testing air quality in a building.

A few MN arenas have alarms, but these are usually CO alarms situated away from the ice that have no data logging capacity. As such, these systems do not comply with the current rule. These arenas must conduct testing that meets rule requirements. MDH has conditionally approved CMS in two ice arenas with two other arenas being currently evaluated (as of 12/12/11). MDH has no information about such systems in other states or countries on which to draw conclusions.

The following are clear advantages of CMS over portable testing equipment.

- CMS would clearly address concerns associated with the representativeness of periodic grab sampling. Testing would occur all the time and provide a more accurate understanding of air quality. The highest levels would be apparent from the testing data, and arena staff would not need to determine the time of maximum resufacer use (ie worst case levels).
- The instrumentation should be able to calculate one-hour averages, rather than rely on a single reading as representative of a one-hour average.
- It would very difficult for arena staff to falsify testing. Testing conducted periodically by staff and noted on logs cannot be verified by MDH and we rely on the honesty of the staff.
- A CMS with automated increases in ventilation or an alarm will ensure corrective action can be taken at any time, including when new or inexperienced staff are managing the arena.

For the above reason, it seems like the logical testing method for arenas, especially for motor sports arenas where CO and NO2 levels fluctuate wildly, is the CMS. There are, however, a number of concerns.

- Since the sensor chips are presumably the same as those found in the portable electronic devices, concerns about maintenance, calibration, and sensor replacement equally apply to CMS.
- Until detachable technologies emerge, the CMS is assumed to be fixed in one location (or possibly multiple sensors in different areas). This means arena staff would not be able to test other areas to verify air quality is acceptable throughout the arena. In a scenario where poor air quality is suspected in a locker room next to the resurfacer room, or some public area where a combustion device is used, arena staff would not be able to test the air, unless they had a portable instrument or a CMS sensor in each room.
- Since the CMS operates all the time, the longevity of sensors and other equipment components may be less than a device operated intermittently. MDH has observed one such CMS sensor malfunction and have to be replaced after only a few months of operation.
- There are concerns about the deployment of the CMS (in the boards, drawing air from the ice); the instrumentation would need to tolerate low temperatures, skaters banging into the boards, moisture (e.g., ice chips), and possible tampering by skaters. Several studies have noted the pollutant concentrations are higher directly above the ice, because the boards and plexiglass act to trap combustion by-products and also because the colder temperatures over the ice prevent air mixing with reset of the arena [17, 18]. Pennanen et al. found that there can be a 14 C (~25F) temperature differential between between the surface of the ice to 4 meters above the ice[14]. The highest NO_2 levels were measured at 0.5 – 1.0 m above the ice, in the breathing zone of younger children. This justifies testing over the ice, at board height. The continuous monitors MDH has seen have been recessed into the boards or the sensors are situated in another area to which air is pumped. There

are questions as to whether these CMS are only measuring air from above the ice, or whether air may be mixing in from other parts of the arena. In only one case (out of four) has MDH been able to verify air is flowing into the CMS from directly from above the ice.

- Arena staff would need to check the readings periodically to ensure acceptable air quality and demonstrate this to MDH; alternatively, there would need to be some alarm or other automated mechanism to institute corrective action where air quality is unacceptable. Automation (fans turning on, alarms), however, can fail. The power source needs to be constant, meaning features would need to be in place to ensure the instrument is not unplugged. Testing with a portable device forces the human element into the testing program and ensures corrective action decision-making.
- The cost of CMS are considerably higher starting at $5,000 for installation with additional maintenance costs. In facilities with more than one sheet of ice, the cost would be higher.
- The increased sophistication of the technology and reliance on computers to manage and store data may present challenges (e.g., computer crashes, malware, new software updates, etc). MDH has observed data lost for several weeks in one CMS. Also, power has been lost to one of these CMS for several weeks.
- There are only two small companies in MN, at this time, which have demonstrated an ability to install a CMS compliant with MDH requirements. It is questionable these two companies can meet and sustain the installation and maintenance demand from 280+ ice arenas across the entire state for years to come.

Conclusions

MDH has concerns about the reliability and practicality of Continuous Monitoring Systems. This technology has many 'unknowns'. As we learn more about the 'prototypes' installed in MN arenas, we may find that the above concerns are unfounded or eventually are resolved. Until that time, mandating continuous monitoring systems is not reasonable. In the meantime, MDH is open to allowing continuous monitors, if they meet various criteria: initiates corrective action; draws air from above the ice; rugged; moisture resistant; cold temperature tolerant; can report levels to MDH; and can be maintenanced.

The pump with tubes and electronic devices have various strengths and weaknesses. The strengths of each type of device are summarized in Table 1. There is no clear advantage for one device or the other. The most significant limitations of the pump with tube devices are their measuring range, questionable operation at sub-freezing temperatures, and user error associated with eye-balling the levels. The most significant limitations of the electronic devices are the necessary routine maintenance, possible inoperation if not maintenanced, and occasional need to send away for maintenance and repair. There were no universal third-party standards identified that could be reasonably used to disqualify specific devices from use in arenas. Similarly, there were no significant differences between pump and diffusion type devices identified that could be reasonably used to disqualify specific devices.

If the NO2 standard is reduced from 0.5 ppm, certain pump and tube devices (Nextteq and Sensidyne) would not be provide the necessary testing range. In addition, these tubes seem to not be appropriate for sub-freezing temperature applications, as are the MSA tubes. It seems only the Drager pump and tubes would be appropriate for use at the lower action level and at sub-freezing temperatures. It does not, however, seem appropriate to 'ban' certain devices based on information provided by individual manufacturer representatives. The rule can specify general language about being able to measure down to the action level at sub-freezing temperatures.

In addition, if the action level is lowered from 0.5 ppm, NO2 will routinely be over- or under-estimated in arenas due to the difficulties of accurately measuring low levels. This will lead to corrective actions being taken unnecessarily, or the reverse, where actions should have been taken but this did not occur. Moreover, there may be a few instances where the arena simply cannot meet the new action level standard, which could require major ventilation renovations or engine repairs, or even possibly the purchase of a new resurfacer.

Table 1. Advantages of Portable Air Monitoring Instruments

Pump and Tube	Electronic Device
• Poorly maintenanced pump with tube probably more accurate than poorly maintenanced electronic device. • Requires less and simpler maintenance: just leak testing • User can do the basic maintenance in most cases (leak testing), meaning device rarely submitted for repair. • Easier to tell if the device is working properly—leak test, tubes not expired, and that's it • Will almost always function • Probably never sent away (electronic devices may need to be sent in for maintenance, repair, etc) • Familiar to arena managers • Cheaper up-front cost • Cheaper for single rink arenas open less than year-round	• Most have greater accuracy and precision when properly maintenanced • Function to below freezing temperatures (to at least -4 F); no special instructions for cold temperature operation. • All report down to lower concentrations NO2:0.3+ ppm; CO: 3+ ppm • Simple digital numerical read-out, less likely to under-estimate readings due to eyeballing, expired tubes, too few pump strokes, pump leaks, etc • Simpler operation, just turn it on and read the level—proper pump strokes, expired tubes, pump leaks, insertion of tubes not an issue. • Cost over time (10 years) will be comparable or less for arenas open year-round or with more than one rink.

Attachment A. Companies Solicited and Contact Persons

Company	Contact	Address	Phone	Email	Other
Drager	Craig Rogers Industry Market Manager Detector Tubes & CMS	Draeger Safety Inc., 101 Technology Drive Pittsburgh, PA 15275	Office: 412-788-5611 Cell: 412-298-9091	craig.rogers@draeger.com	www.draeger.com Fax +1 412 787 2207
Nexteq	Jeffrey S. Duffy PhD, DABT, CIH V.P. Technical Business Development	NEXTTEQ, LLC 8406 Benjamin Rd., Suite J, Tampa, FL 33634	Cell: 813-505-4247 Office: 1-813-249-5888 x26 Toll-free: 1-877-312-2333	jeff_D1@nextteq.com	Fax: 1-813-249-0188 Toll-free Fax: 1-877-312-2444 x26
Sensidyne	Ron Roberson Corporate Industrial Hygienist & Product Manager Air Sampling Products	Sensidyne, LP. 16333 Bay Vista Drive, Clearwater, FL 33760	1-800-451-9444, ext 684 727-530-3602, ext 684	rroberson@sensidyne.com	Fax 727-539-0550 ww.sensidyne.com
MSA	Scott Johns MSA Industrial Sales Manager	4633 Stonecliffe Dr, Eagan, MN 55122	Cell: 651-260-3166 800-759-6423 x5020	scott.johns@msanet.com	Fax: 651-688-0296
GrayWolf	Laura D. Greene	GrayWolf Sensing Solutions International Place, 6 Research Drive, Shelton, CT 06484	Tel: 203-402-0477 ext. 203	LauraG@wolfsense.com	Fax: (203) 402-0478 www.wolfsense.com
Honeywell Analytics (BWTech & Micro-max)	Andrew Saunders Applications and Training Specialist, Honeywell Portable Gas Detection	Honeywell Analytics. 405 Barclay Boulevard, Lincolnshire, IL 60069	Phone: 954-695-1855	andrew.saunders@honeywell.com	
Industrial Scientific (iTX)[4]	Dave Wagner Director of Product Knowledge	Industrial Scientific Corporation 1001 Oakdale Road, Oakdale, PA 15071	Phone: 1-800-338-3287 (x1917) Direct: +1 412-788-0400 (x1917)	engdw@indsci.com	Fax: +1 412-788-8353 Web: www.indsci.com
TSI[4]	Larry Lemanski, North American Service Operations Manager	TSI Inc, 500 Cardigan Road, Shoreview, MN 55126	Wk: 651-490-2809, Cell: 651-315-2941	larry.lemanski@tsi.com	
RAE Systems (QRAE, VRAE) [4]	Randy Fuson	RAE Systems 775 North First Street, San Jose, CA 95134 USA	Cell: 225 892-1722	rfuson@raesystems.com	

[4] Did not respond to MDH request for information about their air monitoring devices

Attachment B: Measurement Specifications

Device	Manufacturer (Distributor)	NO2 measuring range[5]	CO measuring range	Temperature (F)	Accuracy in range	Precision in s range	Accuracy and precision below range	Accuracy and precision below freezing temperatures	Comments
Accuro Pump with CO Tube CH 25601 & NO2 Tube CH 30001	Draeger	0.5 - 25 0.25 – 1	5 - 150 0.5 – 15	32 – 104	Not provided	10-15%	Same for NO2; not stated for 0.5 ppm CO.	Can be used below freezing, down to 4F, at same accuracy/precision, if tubes are warm; with tube warmer or held in hand	Twice the number of pump strokes will halve the measurement range
GV-100X Pump with NO2 Tube 9L & CO Tube 1La	Gastec (Nextteq)	0.5 -30	8 - 1000	32 – 104	25%	10%	Unknown --below specification	Unknown, below specification. Should not be used under freezing.	Other pumps available
AP-20 Pump with CO Tube 106S & NO2 Tube 117SB	Kitagawa (Sensidyne)	0.5 – 30	10 - 250	32 – 104	25%	CO= 5 - 10% NO2=10 %	None stated, but should be the same	None stated. Use under freezing temps is questionable	Another NO2 tube is available (0.1 – 1.0 ppm)
Kwik-Draw Pump (487500) with CO Tube CO-5 (803943) & NO2 Tube NO2-0.5 (487341)	MSA	0.5-50	5-100	CO: 32 – 104 NO2: 41 - 95	25%	NO2= 15% CO= 25%	No data	No data. Out of range. Arena needs to study to determine it works.	Interchangeable with Drager tubes

[5] Where the dead-banding or noise phenomenon was volunteered, the lower end of the testing range was adjusted upward, typically from 0.1 ppm to 0.3 ppm. For the one company that did not comment on this issue, the min detection limit specified by the company of 0.1 ppm for NO2 is shown. It is reasonable, however, to presume that this error at very low levels is common to all NO2 devices.

Device	Manufacturer (Distributor)	NO2 measuring range[5]	CO measuring range	Temperature (F)	Accuracy in range	Precision in s range	Accuracy and precision below range	Accuracy and precision below freezing temperatures	Comments
Chemical Specific Chip	Draeger	0.5 - 25	5 - 150	32 – 104	Not provided	NO2 - 8% CO - 10%	NA	Can be used below freezing at same std dev , if tubes are warm (room temp), for ~25 minutes.	Digital reader of colorimetric tubes
X-am (electronic sensor)	Draeger	0.3 – 50	6 – 2000	-4 - 122	Not provided	2%	NA	NA Same down to -4F	Readings below 6 ppm CO and 0.3 ppm NO2 could be noise. Draeger makes its own sensors, differ from other sensors (e.g., City, Alpha Sense). Diffusion or pump available
Drager Pac 7000 Single Gas Monitors	Draeger	0.3 – 50	6 – 2000	-20 - 120	Not provided	2%	NA	NA Same down to -20F	Two devices. Intended for personal monitoring. Diffusion. Levels under 0.3 may be 'noise'
AlTair Pro Single Gas Monitors NO2 (10076731) CO (10092522 or 10074135)	MSA	0.1 – 20	1 – 500	-4 - 122	10% above freezing	10%	NA	20% below freezing	For personal monitoring. Diffusion. Altair CO p/n 10092522 is disposable (~2 yrs lifespan)

Device	**Manufacturer (Distributor)**	**NO2 measuring range**[5]	**CO measuring range**	**Temperature (F)**	**Accuracy in range**	**Precision in s range**	**Accuracy and precision below range**	**Accuracy and precision below freezing temperatures**	**Comments**
TG-501 Probe with C-AFO and NO2-A1 Sensors	GrayWolf Sensing Solutions	0.3-30.0	3 – 750.0	NO2: -4 – 122 CO: -22 - 122	NO2: +/- 0.25 ppm CO:+/- 5ppm	Not provided	NA	Below freezing accuracy: NO2: +/- 0.5 ppm; CO:+/- 8ppm, if calibrated every 3 months	Diffusion. NO2 sensor can drift 4%/month, CO can drift 3%/yr.
MicroMAX Pro	Honeywell Analytics	0.3-99.9	3-999	-4 - 122	4 - 12	2%	NA	NA	Levels under 0.3 ppm NO2 and 3 ppm CO can be ‘dead-banding’ (ie’noise’)
Gas Alert Micro 5	BW Technologies by Honeywell	0.3-99.9	3-999	-4F - 122F	4	2%	NA	NA	Also available with a PID sensor, which is not applicable for CO or NO2. Levels under 0.3 ppm NO2 and 3 ppm CO can be ‘dead-banding’ (ie’noise’)
Gas Alert Extreme Single Gas	BW Technologies by Honeywell	0.3-20	3-999	CO: -22 - 122 NO2: -4 - 122	4	2%	NA	NA	Levels under 0.3 ppm NO2 and 3 ppm CO can be ‘dead-banding’ (ie’noise’)
Impact Pro	Honeywell Analytics	3-10	3-500	-4 - 131	4	2%	NA	NA	Levels under 0.3 ppm NO2 and 3 ppm CO can be ‘dead-banding’ (ie’noise’)

Device	Manufacturer (Distributor)	NO2 measuring range[5]	CO measuring range	Temperature (F)	Accuracy in range	Precision in s range	Accuracy and precision below range	Accuracy and precision below freezing temperatures	Comments
E3Point Toxic and Combustible Gas Detector Stand Alone Platform	Honeywell Analytics	0.3-10	3-250	NO2: -22 - 122 CO: -4 - 122	3% @ 25C	2%	NA	NA	Wall mounted system, would need to meet variance specifications. Levels under 0.3 ppm NO2 and 3 ppm CO can be 'dead-banding' (ie'noise')

Attachment C. Maintenance Specifications

Device	Manufacturer (Distributor)	Calibration	Maintenance	Life Expectancy	Cost over 10 years [6]
Accuro Pump with CO Tube CH 25601 & NO2 Tube CH 30001	Draeger	Leak test monthly	None, repair as needed	Pump: 5-year warranty, expect 10+ years. Tubes: 2 yr shelf life	$3,716
GV-100X Pump with NO2 Tube 9L & CO Tube 1La	Gastec (Nextteq)	None specified, periodic leak test	None, may need simple repairs every 3 years	Pump: unknown Tubes: 2 yr shelf life	$3,696
AP-20 Pump with CO Tube 106S & NO2 Tube 117SB	Kitagawa (Sensidyne)	None specified	Optional lube and volume check, shipping cost only	Pump: lifetime warranty Tubes: 1 yr shelf life	$3,728
Kwik-Draw Pump (487500) with CO Tube CO-5 (803943) & NO2 Tube NO2-0.5 (487341)	MSA	Leak test monthly	None	Pump: indefinite Tubes: 2 year shelf life	$4,322
Chemical Specific Chip, (digital reader of colorimetric reaction)	Draeger	None specified	Yearly manufacturer maintenance calibration required	Pump: 5-8 yrs Tube chips: 2 yr shelf life	$6,653 – 8,074[7]
X-am (electronic sensor)	Draeger	Calibration by Drager or End-user: 2-4x/yr for NO2, 1-2x/yr for CO	Sensor replacement Sensor replacement as needed	Instrument: 5-8 yrs CO sensor: 3-4 yrs NO2 Sensor: 1-2 yrs	$5,319 – 10,281
Pac 7000 Single Gas Monitors	Draeger	Calibration by Draeger or End-user: 2-4x/yr for NO2, 1-2x/yr for CO	Sensor replacement as needed	Instrument: 5-8 yrs CO sensor: 3-4 yrs NO2 Sensor: 1-2 yrs	$4,660 – 8,638
AlTair Pro Single Gas Monitors NO2 (10076731) CO (10092522 or 10074135)	MSA	Bump test before each use, calibrate as needed	Sensor replacement as needed, can be done by end-user	CO Device: 2 year or indefinite, NO2 monitor indefinite, Sensors 2 yr	$6,828 – 7,073

[6] Cost over 10 years per sheet operating 6 months per year. Costs include instrument/tube purchases and maintenance costs, if applicable. To estimate cost for two sheets or 1 sheet open year round, the tube costs would be multiplied by 2.

[7] Cost of ownership for low end estimate: required maintenance, sensors and instrument last to upper end of longevity). Cost of ownership for high end estimate: recommended maintenance schedule, low end of longevity, optional pump.

Device	**Manufacturer (Distributor)**	**Calibration**	**Maintenance**	**Life Expectancy**	**Cost over 10 years** [6]
TG-501 Probe with C-AFO and NO2-A1 Sensors	GrayWolf Sensing Solutions	Calibration by company or end-user: 2x/yr for NO2, 1x/yr for CO	Sensor replacement as needed, recommend company's maintenance program, but can be done by end-user	Sensors last 2 yrs	\$8,700 – 9,250
MicroMAX Pro	Honeywell Analytics	Bump test before each use. Calibration: 4x /yr by end-user	End-user can replace sensors as needed.	CO Sensor lasts 3-4 yrs, NO2 sensor lasts 2-3 yrs, Instrument last 5-10 yrs	\$6,885 – 9,775
Gas Alert Micro 5	BW Technologies by Honeywell	Bump test before each use. Calibration: 2x /yr by end-user		CO Sensor lasts 3-4 yrs, NO2 sensor lasts 2-3 yrs, Instrument last 5-10 yrs	\$4,460 – 6,875
Gas Alert Extreme Single Gas	BW Technologies by Honeywell			CO Sensor lasts 3-4 yrs, NO2 sensor lasts 2-3 yrs, Instrument last 5-10 yrs	\$4,115 – 5,955
Impact Pro	Honeywell Analytics			CO Sensor lasts 3-4 yrs, NO2 sensor lasts 2-3 yrs, Instrument last 5-10 yrs	\$4,665 – 6,875
E3Point Toxic and Combustible Gas Detector Stand Alone Platform	Honeywell Analytics			CO Sensor lasts 3-4 yrs, NO2 sensor lasts 2-3 yrs, Instrument last 5-10 yrs	\$4,285 – 5,975

Appendix H-1

[MDH regulated enclosed sports arenas]

	A	D	E	F	I	J
1	Facility Name	Mailing Address	Mailing City	Mailing Zip	Adm FName	Adm LName
2	City Arena - Blue	221 E Clark St	Albert Lea	56007	Robert	Furland
3	City Arena - Red	221 E Clark St	Albert Lea	56007	Robert	Furland
4	STMA Arena	PO Box 193	Albertville	55301	Grant	Fitch
5	Runestone Community Center - East Rink 1	704 Broadway	Alexandria	56308	Vincent	Hennen
6	Runestone Community Center - West Rink 2	704 Broadway	Alexandria	56308	Vincent	Hennen
7	Andover Community Center	15200 Hanson Blvd NW	Andover	55304	Erick	Sutherland
8	Anoka Ice Arena Association - Rink 1	4111 - 7th Ave N	Anoka	55303	Bill	Ruckel
9	Anoka Ice Arena Association - Rink 2	4111 - 7th Ave N	Anoka	55303	Bill	Ruckel
10	Packer Arena	121 - 4th Ave NE	Austin	55912	Kim	Underwood
11	Riverside Arena	121 - 4th Ave NE	Austin	55912	Kim	Underwood
12	Babbitt Ice Arena	32 S Dr	Babbitt	55706	Bo	Castellano
13	Bagley Youth Hockey Arena	PO Box 54	Bagley	56621	Lynn	Anderson
14	Baudette Area Arena Association	PO Box 802	Baudette	56623	Daniel	Carlson
15	Baudette Area Arena Association - Rink 2	PO Box 802	Baudette	56623	Daniel	Carlson
16	Bemidji Community Arena	PO Box 1901	Bemidji	56619	Jerry	Colley
17	John Glass Field House	1500 Birchmont Dr	Bemidji	56601	Vance	Balstad
18	Neilson-Reise Arena	317 - 4th St NW	Bemidji	56601	Keith	Huerd
19	Nymore Arena	3300 Gillett Dr NW	Bemidji	56601	Steve	Humeniuk
20	Benson Ice Arena	2200 Targes Ave	Benson	56215	Wayne	Krutson
21	Schwan's Super Rink - Arena 1	1700 - 105th Ave NE	Blaine	55449	Brandon	Radeke
22	Schwan's Super Rink - Arena 2	1700 - 105th Ave NE	Blaine	55449	Brandon	Radeke
23	Schwan's Super Rink - Arena 3	1700 - 105th Ave NE	Blaine	55449	Brandon	Radeke
24	Schwan's Super Rink - Arena 4	1700 - 105th Ave NE	Blaine	55449	Brandon	Radeke
25	Schwan's Super Rink - Arena 5	1700 - 105th Ave NE	Blaine	55449	Brandon	Radeke
26	Schwan's Super Rink - Arena 6	1700 - 105th Ave NE	Blaine	55449	Brandon	Radeke
27	Schwan's Super Rink - Arena 7	1700 - 105th Ave NE	Blaine	55449	Brandon	Radeke
28	Schwan's Super Rink - Arena 8	1700 - 105th Ave NE	Blaine	55449	Brandon	Radeke
29	Bloomington Ice Garden 1	3600 W 98th St	Bloomington	55431	Andy	Baltgalius
30	Bloomington Ice Garden 2	3600 W 98th St	Bloomington	55431	Andy	Baltgalius
31	Bloomington Ice Garden 3	3600 W 98th St	Bloomington	55431	Andy	Baltgalius
32	Brainerd Area Civic Center	1619 Washington St NE	Brainerd	56401	Wayne	Mooney
33	Gold Medal Arena	1619 Washington St NE	Brainerd	56401	Wayne	Mooney
34	Breezy Point Ice Arena	9252 Breezy Point Dr	Breezy Point	56472	Joe	Bergquist
35	Brooklyn Park Community Activity Center - Rink 1	5600 - 85th Ave N	Brooklyn Park	55443	Mark	Palm
36	Brooklyn Park Community Activity Center - Rink 2	5600 - 85th Ave N	Brooklyn Park	55443	Mark	Palm
37	MotoCity Raceway & Recreation	30589- 416th St	Browerville	56438-	Dale	Kadlec
38	Buffalo Civic Center - Rink 1	212 Central Ave	Buffalo	55313	Lee	Ryan
39	Buffalo Civic Center - Rink 2	212 Central Ave	Buffalo	55313	Lee	Ryan
40	Burnsville Ice Center - Rink 1	251 Civic Center Pkwy	Burnsville	55337	Dean	Mulso
41	Burnsville Ice Center - Rink 2	251 Civic Center Pkwy	Burnsville	55337	Dean	Mulso
42	ProKart Indoors	12500 Chowen Ave S	Burnsville	55337	Jason	Garcia
43	Carlton Hockey Shelter	PO Box 344	Carlton	55718	Annette	Kiehn
44	Chaska Community Center - Rink 1	1661 Parkridge Dr	Chaska	55318	Jason	Kirsch
45	Chaska Community Center - Rink 2	1661 Parkridge Dr	Chaska	55318	Jason	Kirsch
46	Centennial Sports Arena	4707 North Rd	Circle Pines	55014	Mike	Koller
47	Cloquet Recreation Center	1102 Olympic Dr	Cloquet	55720	Shari	Olson
48	Pine Valley Ice Arena	1102 Olympic Dr	Cloquet	55720	Shari	Olson
49	Hodgins Berardo Arena	PO Box 519	Coleraine	55722	Patrick	Guyer
50	Cottage Grove Ice Arena - Rink 1 (North)	8020 - 80th St S	Cottage Grove	55016	Zac	Dockter
51	Cottage Grove Ice Arena - Rink 2 (South)	8020 - 80th St S	Cottage Grove	55016	Zac	Dockter
52	Cottage Grove Ice Arena - Rink 3 (West)	8020 - 80th St S	Cottage Grove	55016	Zac	Dockter
53	Crookston Civic Arena - New	124 N Broadway	Crookston	56716	Scott	Riopelle
54	Crookston Civic Arena - Old	124 N Broadway	Crookston	56716	Scott	Riopelle
55	Hallett Community Center	470 - 8th St NE	Crosby	56441	Maurice	Slepica
56	Heartland Sports Complex	24921 Arena Dr	Deerwood	56444	Steve	Jensen
57	Delano Area Sports Arena	PO Box 162	Delano	55328	Justin	Porter
58	Kent Freeman Sport Arena - 1	508 E Front St	Detroit Lakes	56501	Tom	Gulon
59	Kent Freeman Sport Arena - 2	508 E Front St	Detroit Lakes	56501	Tom	Gulon
60	DECC - Arena	350 Harbor Dr	Duluth	55802	Walt	Bruley
61	DECC - South Pioneer Hall	350 Harbor Dr	Duluth	55802	Walt	Bruley
62	Duluth Heritage Sports Center	120 S 30th Ave W	Duluth	55806	Brad	Onofreychuk
63	Duluth Heritage Sports Center - Pavillion Arena	120 S 30th Ave W	Duluth	55806	Gordon	Atol
64	Fryberger Arena	3211 Allendale Ave	Duluth	55803	Gordon	Atol
65	Mars Lakeview Arena	PO Box 161001	Duluth	55816	Brendan	Flaherty
66	U of M Duluth	1216 Ordean Ct	Duluth	55812	Chris	Stevens
67	Eagan Civic Arena - East Rink 2	3830 Pilot Knob Rd	Eagan	55122	Mark	Vaughan
68	Eagan Civic Arena - West Rink 1	3830 Pilot Knob Rd	Eagan	55122	Mark	Vaughan
69	East Bethel Ice Arena	2241 - 221st Ave NE	East Bethel	55011	Matthew	Hanchulak
70	Blue Line Arena	PO Box 125	East Grand Forks	56721	Dave	Aaker
71	East Grand Forks Civic Center	PO Box 321	East Grand Forks	56721	Brian	Larson
72	VFW Memorial Youth Center	PO Box 321	East Grand Forks	56721	Garry	Hadden
73	Eden Prairie Community Center - Rink 1	16700 Valley View Dr	Eden Prairie	55346	Wendy	Sevenich
74	Eden Prairie Community Center - Rink 2	16700 Valley View Dr	Eden Prairie	55346	Wendy	Sevenich
75	Eden Prairie Community Center - Rink 3	16700 Valley View Dr	Eden Prairie	55346	Wendy	Sevenich
76	Velocity Arena formerly North Star Ponds	7901 Fuller Rd	Eden Prairie	55344	Joel	Klute
77	Braemar Arena - East	7501 Ikola Way	Edina	55439	Larry	Thayer
78	Braemar Arena - South	7501 Ikola Way	Edina	55439	Larry	Thayer

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79	Braemar Arena - West	7501 Ikola Way	Edina	55439	Larry	Thayer
80	Minnesota Made Ice Center	7300 Bush Lake Rd	Edina	55439	Bob	Capra
81	Elk River Arena 1 - Olympic	PO Box 193	Elk River	55330	Richard	Czech
82	Elk River Arena 2 - Barn	PO Box 193	Elk River	55330	Richard	Czech
83	Ely Ice Arena	600 Harvey St E	Ely	55731	Jerry	High
84	Eveith Hippodrome	413 Pierce St	Eveith	55734	Mike	Newman
85	Martin County Arena	PO Box 311	Fairmont	56031	Rick	Oskerson
86	Faribault Ice Arena	PO Box 771	Faribault	55021	Rick	Christanson
87	Shattuck St. Mary's Arena - New	PO Box 218	Faribault	55021	Jack	Schwietzer
88	Shattuck-St. Mary's Arena - Old	PO Box 218	Faribault	55021	Jack	Schwietzer
89	Schmitz - Maki Arena	114 Spruce St W	Farmington	55024	Jeremy	Pire
90	Fergus Falls Community Ice Arena	205 S Peck St	Fergus Falls	56537	David	Umlauf
91	Fergus Falls Community Ice Arena - VFW Memorial Youth	205 S Peck St	Fergus Falls	56537	David	Umlauf
92	Forest Lake Athletic Association Sports Center Rink 1	PO Box 21	Forest Lake	55025	Kirby	Sell
93	Forest Lake Athletic Association Sports Center Rink 2	PO Box 21	Forest Lake	55025	Kirby	Sell
94	Gilbert Arena (David Skenzich Arena)	PO Box 548	Gilbert	55741	Kevin	Klander
95	Breck School Anderson Ice Arena	4210 Olson Memorial Hwy	Golden Valley	55422	Steve	Langer
96	IRA Civic Center - Rink East	420 N Pokegama Ave	Grand Rapids	55744	Dale	Anderson
97	IRA Civic Center - Rink West	420 N Pokegama Ave	Grand Rapids	55744	Dale	Anderson
98	Brian Olson Memorial Arena	PO Box 11	Grygla	56727	Carter	Torgerson
99	Hastings Civic Arena - East	101 E 4th St	Hastings	55033	James	McGree
100	Hastings Civic Arena - West	101 E 4th St	Hastings	55033	James	McGree
101	Hallock Ice Arena	PO Box 656	Hallock	56728	David	Bergh
102	Hermantown Arena	4309 Ugstad Rd	Hermantown	55811	Lisa	Paczynski
103	Hibbing Fairgrounds Arena	PO Box 193	Hibbing	55746	Ken	White
104	Hibbing Memorial Building - Rink 1	400 - 23rd St E	Hibbing	55746	Stan	Fink
105	Hibbing Memorial Building - Rink 2	400 - 23rd St E	Hibbing	55746	Stan	Fink
106	The Blake School Ice Arena	110 Blake Rd S	Hopkins	55343	Thomas	Donahue
107	Hopkins Pavilion	11000 Excelsior Blvd	Hopkins	55343	Don	Olson
108	Hoyt Lakes Arena	206 Kennedy Memorial Dr	Hoyt Lakes	55750	S. Tom	Ferris
109	Burich Arena - East Rink	950 Harrington St	Hutchinson	55350	Marvin	Haugen
110	Burich Arena - West Rink	950 Harrington St	Hutchinson	55350	Marvin	Haugen
111	Bronco Arena	1515 - 11th St	International Falls	56649	Jeff	Veeder
112	Kerry Park Arena	615 - 13th St	International Falls	56649	Bill	Mason
113	Inver Grove Heights Veterans Memorial Arena East	8055 Barbara Ave	Inver Grove Heights	55077	Michael	Sheggeby
114	Inver Grove Heights Veterans Memorial Arena West	8055 Barbara Ave	Inver Grove Heights	55077	Michael	Sheggeby
115	Dodge County Four Seasons Arena	100 - 11th St NE	Kasson	55944	Stephen	Howarth
116	La Crescent Community Arena	520 - 14th St S	La Crescent	55947	Steven	Thompson
117	St. Mary's Point Arena	16411 Division St	Lakeland	55043	Michael	Thron
118	Hockey Development Center	PO Box 1042	Lakeville	55044	Mark	Olsen
119	Lakeville Ames Arena - Rink 1	20195 Holyoke Ave	Lakeville	55044	Shayne	Ratcliff
120	Lakeville Ames Arena - Rink 2	20195 Holyoke Ave	Lakeville	55044	Shayne	Ratcliff
121	LeSueur Community Center	PO Box 176	Le Sueur	56058	Layne	Wilbright
122	Chisago Lakes Arena	PO Box 472	Lindstrom	55045	Chris	Sletton
123	Litchfield Civic Arena	900 N Gilman Ave	Litchfield	55355	Steve	Olson
124	Exchange Arena	PO Box 281	Little Falls	56345	Mike	Corrow
125	Orono Ice Arena	1025 N Old Crystal Bay Rd	Long Lake	55356	Steve	Krampf
126	Todd County Expo Arena	PO Box 103	Long Prairie	56347	Cliff	Cline
127	Blue Mound Ice Arena	601 Hatting St	Luverne	56156	David	Van Batavia
128	All Seasons Arena - Rink 1	1251 Monks Ave	Mankato	56001	Paul	Ostoff
129	All Seasons Arena - Rink 2	1251 Monks Ave	Mankato	56001	Paul	Ostoff
130	Alltel Center	1 Civic Center Plaza	Mankato	56001	Stephen	Conover
131	Maple Grove Community Center - Ice Arena	12951 Weaver Lake Rd	Maple Grove	55369	Frank	Weber
132	Maple Grove Community Center - Ice Arena (West Rink)	12951 Weaver Lake Rd	Maple Grove	55369	Frank	Weber
133	ProKart Indoors	11700 Troy Ln	Maple Grove	55369	Jeff	Ophoven
134	Aldrich Arena	1850 White Bear Ave	Maplewood	55109	Garry	Palfe
135	Schwan's Ice Arena (Lyons)	PO Box 173	Marshall	56258	Cody	Mellenthin
136	Saint Thomas Ice Arena	950 Mendota Heights Rd	Mendota Heights	55120	Jon	Balvance
137	Augsburg Ice Arena - Rink 1	2211 Riverside Ave, #141	Minneapolis	55454	Dave	St. Aubin
138	Augsburg Ice Arena - Rink 2	2211 Riverside Ave, #141	Minneapolis	55454	Dave	St. Aubin
139	Northeast Arena	1306 Central Ave NE	Minneapolis	55418	Reggie	Krakowski
140	Mariucci Arena	1901 - 4th St SE	Minneapolis	55455	Craig	Flor
141	Minnehaha Academy Ice Arena	4200 West River Pkwy	Minneapolis	55406	Bruce	Peterson
142	Parade Ice Garden - North	600 Kenwood Pkwy	Minneapolis	55403	Reggie	Krakowski
143	Parade Ice Garden - South	600 Kenwood Pkwy	Minneapolis	55403	Reggie	Krakowski
144	Parade Ice Gardens - Studio	600 Kenwood Pkwy	Minneapolis	55403	Reggie	Krakowski
145	Ridder Arena	1901 - 4th St SE	Minneapolis	55455	Craig	Flor
146	Target Center	600 First Ave N	Minneapolis	55403	Tom	Reller
147	The Depot	225 - 3rd Ave S	Minneapolis	55401	Lisa	Sorlak
148	Victory Memorial Ice Arena	1900 - 42nd Ave N	Minneapolis	55412	Chad	Stanler
149	Minnetonka Ice Arena - Rink A	3401 Williston Rd	Minnetonka	55343	John	Heckmann
150	Minnetonka Ice Arena - Rink B	3401 Williston Rd	Minnetonka	55343	John	Heckmann
151	Pagel Activity Center	18313 Highway 7	Minnetonka	55345	Greg	Clough
152	Moose Sherritt Ice Arena	800 E Broadway	Monticello	55362	Scott	Fredrickson
153	Moorhead Sports Center - North	324 - 24th St S	Moorhead	56560	Barry	Warren
154	Moorhead Sports Center - South	324 - 24th St S	Moorhead	56560	Barry	Warren
155	Moorhead Youth Hockey Arena - North	707 SE Main Ave	Moorhead	56560	Dennis	Bushy
156	Moorhead Youth Hockey Arena - South	707 SE Main Ave	Moorhead	56560	Dennis	Bushy

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157	Moose Lake Riverside Arena	PO Box 104	Moose Lake	55767	Jim	Fundine
158	Lee Community Center	PO Box 303	Morris	56267	Ron	Staples
159	Nashwauk Recreation Center	301 Central Ave	Nashwauk	55769	Tom	Martire
160	New Hope Ice Arena - North	4401 Xylon Ave N	New Hope	55428	James	Corbett
161	New Hope Ice Arena - South	4401 Xylon Ave N	New Hope	55428	James	Corbett
162	New Prague Area Community Center	100 - 12th St NW	New Prague	56071	Connie	Bartelt
163	City of New Ulm Civic Center - North Rink	122 S Garden	New Ulm	56073	Doug	Teneyck
164	City of New Ulm Civic Center - South Rink	122 S Garden	New Ulm	56073	Doug	Teneyck
165	Polar Arena	2444 - 11th Ave E	North St. Paul	55109	Brad	Martinson
166	City of Northfield Ice Arena	1280 Bollenbacher Dr	Northfield	55057	Jason	Eisold
167	Tartan Arena - Main	740 Greenway Ave N	Oakdale	55128	Brad	Martinson
168	Tartan Dome - Bubble Arena	740 Greenway Ave N	Oakdale	55128	Brad	Martinson
169	Osseo Ice Arena - East Rink 2	11200 - 93rd Ave N	Osseo	55369	Richard	Gladen
170	Osseo Ice Arena - West Rink 1	11200 - 93rd Ave N	Osseo	55369	Richard	Gladen
171	Four Seasons Arena - East Old	PO Box 57	Owatonna	55060	Steve	Schroht
172	Four Seasons Arena - West New	PO Box 57	Owatonna	55060	Steve	Schroht
173	Park Rapids Comm Ctr - Ted O Johnson	PO Box 508	Park Rapids	56470	Art	Symantz
174	Koronis Civic Arena Paynesville	PO Box 82	Paynesville	56362	Trevor	Thompson
175	Pine City Civic Center	PO Box 203	Pine City	55063	Rick	Engelstad
176	Wayzata Ice Arena	305 Vicksburg Ln	Plymouth	55447	Jim	Leuer
177	So St. Louis County Arena (PROCTOR)	PO Box 1025	Proctor	55810	Brian	Isaacson
178	Cardin Hunt Arena	219 Bridge St	Red Lake Falls	56750	Jeffrey	Kalbakdalen
179	Bergwall Arena	370 Guernsey Ln	Red Wing	55066	Todd	Lillico
180	Prairie Island Arena	370 Guernsey Ln	Red Wing	55066	Todd	Lillico
181	Redwood Area Civic Center	901 Cook St	Redwood Falls	56283	Jackie	Edwards
182	Richfield Ice Arena - Rink 1	636 E 66th St	Richfield	55423	Brandon	Klement
183	Richfield Ice Arena - Rink 2	636 E 66th St	Richfield	55423	Brandon	Klement
184	River Lakes Civic Arena	PO Box 555	Richmond	56368	Kevin	Mooney
185	Graham Arena - East	201 SE 4th St	Rochester	55904	Bob	Montrose
186	Graham Arena - North	201 SE 4th St	Rochester	55904	Bob	Montrose
187	Graham Arena - South	201 SE 4th St	Rochester	55904	Bob	Montrose
188	Graham Arena - West	201 SE 4th St	Rochester	55904	Bob	Montrose
189	Rochester Recreation Center - North	21 Elton Hills Dr NE	Rochester	55901	Ed	Staiert
190	Rochester Recreation Center - South	21 Elton Hills Dr NE	Rochester	55901	Ed	Staiert
191	Caia Youth Arena - North Arena	1198 Center St W	Roseau	56751	Chad	Johnson
192	Roseau Memorial Arena	1198 Center St W	Roseau	56751	Chad	Johnson
193	Rosemount Community Center	13885 S Robert Tr	Rosemount	55068	Paul	Haglund
194	Bernicks Pepsi Arena	1109 - 1st St S	Sartell	56377	Jon	Erickson
195	Sauk Center Civic Arena	320 Oak St	Sauk Centre	56378	Butch	Wessel
196	Sports Arena East	PO Box 71	Sauk Rapids	56379	Todd	Gunderson
197	Shakopee Ice Arena	1255 Fuller St S	Shakopee	55379	Joshua	Barrick
198	Shoreview Ice Arena	2015 Van Dyke St N	Maplewood	55109	Tom	Moriarty
199	Rukavina Arena	7 Davis Dr	Silver Bay	55614	Michael	Guzzo
200	Sleepy Eye Arena	PO Box 466	Sleepy Eye	56085	Matt	Dockter
201	Wakota Civic Arena - 1	141 E 6th St	South St. Paul	55075	Rick	Rakness
202	Wakota Civic Arena - 2	141 E 6th St	South St. Paul	55075	Rick	Rakness
203	National Hockey Center - Main	720 - 4th Ave S	St. Cloud	56301	Joseph	Meierhofer
204	National Hockey Center - Practice	720 - 4th Ave S	St. Cloud	56301	Joseph	Meierhofer
205	St. Louis Park Recreation Center - East Rink	3700 Monterey Dr	St. Louis Park	55416	Craig	Panning
206	St. Louis Park Recreation Center - West Rink	3700 Monterey Dr	St. Louis Park	55416	Craig	Panning
207	Biff Adams Arena	2015 Van Dyke St N	Maplewood	55109	Tom	Moriarty
208	Drake Arena	1712 Randolph Ave	St. Paul	55105	Eric	Edhlund
209	Gustafson-Phalen Ice Arena	2015 Van Dyke St N	Maplewood	55109	Tom	Moriarty
210	Harding Arena	2015 Van Dyke St N	Maplewood	55109	Tom	Moriarty
211	Highland Arena North	2015 Van Dyke St N	Maplewood	55109	John	Luistad
212	Highland Arena South	2015 Van Dyke St N	Maplewood	55109	John	Luistad
213	Ken Yackel - West Side Arena	2015 Van Dyke St N	Maplewood	55019	Tom	Moriarty
214	Oscar Johnson Arena	2015 Van Dyke St N	Maplewood	55109	Tom	Moriarty
215	Pleasant Arena	2015 Van Dyke St N	Maplewood	55109	Tom	Moriarty
216	Lee & Rose Warner Coliseum	1265 Snelling Ave	St. Paul	55108	Pat	Hunsinger
217	Xcel Energy Center	175 W Kellogg Blvd, Suite 501	St. Paul	55102	Travis	Larson
218	St. Croix Valley Rec Center - Lily Lake Ice Arena	1675 Market Dr	Stillwater	55082	Doug	Brady
219	St. Croix Valley Rec Center - Field House Arena	1675 Market Dr	Stillwater	55082	Doug	Brady
220	St. Croix Valley Rec Center - North Arena	1675 Market Dr	Stillwater	55082	Doug	Brady
221	St. Croix Valley Rec Center - South Arena	1675 Market Dr	Stillwater	55082	Doug	Brady
222	Huck Olson Memorial Civic Center	PO Box 528	Thief River Falls	56701	Curtice	Howe
223	Ralph Engelstad Arena	PO Box 528	Thief River Falls	56701	Curtice	Howe
224	Thief River Falls - Old Arena	PO Box 6	Thief River Falls	56701	Kevin	Sanders
225	Lake County Arena	301 - 8th Ave	Two Harbors	55616	Jesse	Lundgren
226	Victoria Field House - Rink 1	8475 Kochia Ln	Victoria	55386	Corey	Martin
227	Victoria Field House - Rink 2	8475 Kochia Ln	Victoria	55386	Corey	Martin
228	Miners Memorial - Back Rink	821 - 9th Ave S	Virginia	55792	John	Bachman
229	Miners Memorial - Main Rink	821 - 9th Ave S	Virginia	55792	John	Bachman
230	Wadena Community Center	700 Community Center Dr	Wadena	56482	Donavon	Luhning
231	Walker Area Community Center	PO Box 327	Walker	56484	Gretchen	Gribbin
232	Gardens Arena	PO Box 9	Warroad	56763	Jude	Boulianne
233	Olympic Arena	PO Box 9	Warroad	56763	Jude	Boulianne
234	Waseca Community Arena	PO Box 103	Waseca	56093	Kyle	Collins

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235	West St. Paul Arena	60 W Emerson Ave	West St. Paul	55118	David	Malay
236	Hippodrome Ice Arena	4855 Bloom Ave	White Bear Lake	55110	Jon	Anderson
237	White Bear Arena	2015 Van Dyke St N	Maplewood	55109	Tom	Moriarty
238	White Bear Lake Sports Center	1328 Highway 96	White Bear Lake	55110	Bruce	Baies
239	Williams Ice Arena	605 Park Ave NW	Williams	56686	Alvina	Lundsten
240	Willmar Civic Center (Blue Line Rink)	2707 Arena Dr	Willmar	56201	Kevin	Madsen
241	Willmar Civic Center (Cardinal Rink)	2707 Arena Dr	Willmar	56201	Kevin	Madsen
242	Windom City Arena	PO Box 38	Windom	56101	Al	Baloun
243	Bud King Ice Arena	PO Box 563	Winona	55987	Jim	Martin
244	St. Mary's University Ice Arena	700 Terrace Heights	Winona	55987	J	Reska
245	Worthington Ice Arena	1600 Stower Dr	Worthington	56187	Ben	DeVries
246						
247	All Electric Equipment					
248	Apple Valley Sports Arena	7100 W 147th St	Apple Valley	55124	Gary	Pietig
249	Hayes Park Arena	7100 W 147th St	Apple Valley	55124	Gary	Pietig
250	Fogerty Arena	9250 Lincoln St NE	Blaine	55434	Mark	Clasen
251	Champlin Ice Forum	12165 Ensign Ave	Champlin	55316	Nick	Powell
252	Chisholm Sports Arena	600 - 1st St NW	Chisholm	55719	Jamie	Junezich
253	Cook Memorial Arena	11091 Mississippi Blvd NW	Coon Rapids	55303	Craig	Scott
254	Isanti County Area - David C. Johnson Civic Arena	PO Box 214	Isanti	55040	David	Englund
255	Lakeville Hasse Arena	20195 Holyoke Ave	Lakeville	55044	Shayne	Ratcliff
256	David M. Thaler Sports Center	5909 Sunnyfield Rd E	Minnetrista	55364	Bruce	Sohns
257	Mora Civic Center	PO Box 41	Mora	55051	Robin	Nordin
258	Harold J. Pond Sports Center	2121 Commerce Blvd	Mound	55364	Bruce	Sohns
259	Plymouth Ice Center 1	3650 Plymouth Blvd	Plymouth	55446	Bill	Abel
260	Plymouth Ice Center 2	3650 Plymouth Blvd	Plymouth	55446	Bill	Abel
261	Plymouth Ice Center 3	3650 Plymouth Blvd	Plymouth	55446	Bill	Abel
262	Princeton Youth Hockey Arena	511 Ice Arena Dr	Princeton	55371	Thomas	Droogsma
263	Rogers Activity Center	22350 S Diamond Lake Rd	Rogers	55374	Mike	Bauer
264	Rams Sports Center	509 - 3rd St NE	Roseau	56751	Jerome	Ziska
265	Roseville Skating Center	2661 Civic Center Dr	Roseville	55113	Brad	Tullberg
266	Municipal Athletic Complex - Torrey Arena	5001 - 8th St N	St. Cloud	56303	Todd	Bissett
267	Municipal Athletic Complex- Ritsche Arena	5001 - 8th St N	St. Cloud	56303	Todd	Bissett
268	Don Roberts Ice Arena	800 W College Ave	St. Peter	56082	Brett	Peterson
269	Bielenberg Sports Center	4125 Tower Rd	Woodbury	55125	Dave	Black
270	Bielenberg Sports Center - Rink 2	4125 Tower Rd	Woodbury	55125	Dave	Black

Appendix H-2

[Companies that promote and manage indoor motorsports events]

Indoor Motorsports Promoters

Motokazie.com
Attn: Lee Theis
PO Box 56
Jordan, MN 55353

Feld Motorsports, Inc.
Attn: Peggy Ann Wales
4255 Meridian Parkway
Aurora, IL 60504

Jon Carlson
2835 7th Street West
Apartment 204
West Fargo, ND 58078

AMP Live Events
Attn: Scott Hart, President/CEO
15849 N. 77th Street
Scottsdale, AZ 85260

Mike Kidd Entertainment
Attn: Mike Kidd
1413 Southeast Parkway
Arlington, TX 76018

Appendix H-3

[Membership organizations for ice arena managers]

Organizations for Ice Arena Managers:

Minnesota Ice Arena Managers Association (M.I.A.M.A.)
8388 81st Street Lane South, Cottage Grove, MN 55016

Ice Skating Institute
17120 Dallas Parkway, Suite 140
Dallas, TX 75248

Minnesota Recreation and Parks Association
200 Charles Street NE
Fridley, MN 55432

Serving the American Rinks (STAR)
1775 Bob Johnson Drive
Colorado Springs, CO 80906

Appendix H-4

[Companies that manufacture and or distribute products related to the maintenance or measurement of indoor air quality in enclosed sports arenas]

Ice Arena Ventilation:

AIRCORPS MECHANICAL
3700 Annapolis Lane North
Suite 175
Plymouth, MN 55447

BONESTROO
2335 West Highway 36
Roseville MN 55113

BRR TECHNOLOGIES LLC
4915 Arendell Street
Suite 313
Morehead City, NC 28557

CENTER FOR ENERGY AND ENVIRONMENT
Russ Landry, PE
212 3rd Avenue North
Suite 560
Minneapolis, MN 55401-1459

MIDWEST MECHANICAL SOLUTIONS
5831 Cedar Lake Road
Minneapolis, MN 55416

SCHWAB VOLLHABER LUBRATT
4600 Churchill Street
Shoreview MN 55126

TOTAL ENERGY CONCEPTS, INC.
P.O. Box 663
Detroit Lakes, MN 56502-0663

Resurfacer Sales & Service:

Hawk Performance Specialties
PO Box 157
121 Division Street, Woodville, WI 54028

Engineered Ice Systems
2610 Yh Hanson Ave
Albert Lea, MN 56007

Becker Arena Products
6611 Highway 13 West
Savage, MN 55378-1100

R & R SPECIALITIES INC
484 Highway 35/64
Somerset WI 54025

Resurfacer Manufacturers:

ZAMBONI INC
15714 Colorado Avenue
Paramount CA 90723

Resurfice, Inc. (Olympia)
25 Oriole Parkway East
PO Box 361
Elmira, Ontario N3B3A9

Air Monitoring Instruments:

Company	Contact	Address	Phone	Email	Other
Drager	Craig Rogers Industry Market Manager Detector Tubes & CMS	Draeger Safety Inc., 101 Technology Drive Pittsburgh, PA 15275	Office: 412 788 5611 Cell: 412 298 9091	craig.rogers@draeger.com	www.draeger.com Fax +1 412 787 2207
Nexteq	Jeffrey S. Duffy PhD, DABT, CIH V.P. Technical Business Development	NEXTTEQ, LLC 8406 Benjamin Rd., Suite J, Tampa, FL 33634	Cell: 813-505-4247 Office: 1-813-249-5888 x26 Toll-free: 1-877-312-2333	jeff_D1@nextteq.com	Fax: 1-813-249-0188 Toll-free Fax: 1-877-312-2444 x26
Sensidyne	Ron Roberson Corporate Industrial Hygienist & Product Manager Air Sampling Products	Sensidyne, LP. 16333 Bay Vista Drive, Clearwater, FL 33760	1-800-451-9444 , ext 684 727-530-3602, ext 684	rroberson@sensidyne.com	Fax 727-539-0550 ww.sensidyne.com
MSA	Scott Johns MSA Industrial Sales Manager	4633 Stonecliffe Dr, Eagan, MN 55122	Cell: 651-260-3166 VM 800-759-6423 x5020	scott.johns@msanet.com	Fax: 651-688-0296
GrayWolf	Laura D. Greene	GrayWolf Sensing Solutions International Place, 6 Research Drive, Shelton, CT 06484	Tel: (203) 402-0477 ext. 203	LauraG@wolfsense.com	Fax: (203) 402-0478 www.wolfsense.com

Company	Contact	Address	Phone	Email	Other
Honeywell Analytics (BWTech & Micromax)	Andrew Saunders Applications and Training Specialist, Honeywell Portable Gas Detection	Honeywell Analytics, Inc. 405 Barclay Boulevard, Lincolnshire, IL 60069 USA	Phone: 954-695-1855	andrew.saunders@honeywell.com	
Industrial Scientific (iTX)[1]	Dave Wagner Director of Product Knowledge	Industrial Scientific Corporation 1001 Oakdale Road, Oakdale, PA 15071	Phone: 1-800-338-3287 (x1917) Direct: +1 412-788-0400 (x1917)	engdw@indsci.com	Fax: +1 412-788-8353 Web: http://www.indsci.com
TSI[4]	Larry Lemanski, North American Service Operations Manager	TSI Inc, 500 Cardigan Road, Shoreview, MN 55126	Wk: 651-490-2809, Cell: 651-315-2941	larry.lemanski@tsi.com	
RAE Systems (QRAE, VRAE)[4]	Randy Fuson	RAE Systems 775 North First Street, San Jose, CA 95134 USA	Cell: 225 892-1722	rfuson@raesystems.com	

Appendix H-5

[Minnesota hockey and figure skating associations]

Hockey Associations (*attached list from Minnesota Hockey)*

Minnesota Hockey
317 Washington Street
St. Paul, MN 55102

Adult Hockey Association
AHA Hockey, Inc.
PO Box 390215
Edina, MN 55439-0215

Women's Hockey Association of Minnesota
3855 10th Avenue S.
Minneapolis, MN 55407

Professional Skaters Association
3006 Allegro Parkway SW
Rochester, MN 55902

Minnesota Wild Adult Hockey League
c/o Jim Greeley, Director
1700 105th Ave NE
Blaine, MN 55449
ph: 763.717.3234
fx: 763.785.5650

Metro Hockey League
Tom Slaird, Chairman
3800 Washburn Av S
Minneapolis, MN 55410
612-929-0133 (H)
612-750-3300 (cell)
slaird@bitstream.net

HOCKEY MOMS INC.
PO Box 25977
Woodbury, MN 55125-0977
Dinomights
3400 Park Avenue South
Minneapolis, MN 55407

Mounds View Youth Hockey Association
P.O. Box 120705
New Brighton, MN 55112

Eagan Hockey Association
P.O. Box 21214
Eagan MN 55121-0481

Farmington Youth Hockey Association
PO Box 223
Farmington, MN 55024

Bloomington Jefferson Hockey Booster Club
Bloomington Ice Gardens
3600 W 98th Street
Bloomington, MN 55431

Rochester Youth Hockey Association
1515 Aune Dr SE
Rochester, MN 55904

Mora Mustang Hockey
Mora Civic Center, 701 South Union Street
Mora, MN 55051

Becker/Big Lake Youth Hockey Association
PO Box 294
Becker, MN 55309-0294

St. Francis Youth Hockey Association
East Bethel Ice Arena
20675 Highway 65 NE, East Bethel, Minnesota 55011

Roseau Youth Hockey Association
1198 Center St W
Roseau, MN 56751

Figure Skating Clubs *(attached list from US Figure Skating)*

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CHICAGO 2016

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	Name	Mailing Address	Miles
1	Albert Lea FSC	Albert Lea FSC PO Box 368 Albert Lea, Minnesota 56007 507.377.2864 eMail Section: Midwestern Region: Upper Great Lakes	N / A
2	Alexandria FSC	Alexandria FSC % Jeff Hess PO Box 471 Alexandria, Minnesota 56308 320.762.1311 Section: Midwestern Region: Upper Great Lakes	N / A
3	Babbitt FSC	Babbitt FSC % Nancy Orcutt 33 Balsam Circle Babbitt, Minnesota 55706 218-827-2230 eMail Section: Midwestern Region: Upper Great Lakes	N / A
4	Bemidji FSC, Inc.	Bemidji FSC, Inc. PO Box 24 Bemidji, Minnesota 56619 218-243-3238 eMail Section: Midwestern Region: Upper Great Lakes	N / A
5	FSC of Bloomington	FSC of Bloomington % Paul Rothweiler PO Box 201632 Bloomington, Minnesota 55420 612-718-3238 Section: Midwestern Region: Upper Great Lakes	N / A
6	Braemar-City of Lakes FSC	Braemar-City of Lakes FSC PO Box 390301 Edina, Minnesota 55439-0301 952-941-2082 eMail Section: Midwestern Region: Upper Great Lakes	N / A
7	Brooklyn Park FSC	Brooklyn Park FSC % Mike Itzin 5600 85th Avenue N Brooklyn Park, Minnesota 55443 763-493-8333 eMail Section: Midwestern Region: Upper Great Lakes	N / A
8	Burnsville-MN Valley FSC	Burnsville-MN Valley FSC PO Box 994 Burnsville, Minnesota 55337 eMail Section: Midwestern Region: Upper Great Lakes	N / A
9	Chaska FSC	Chaska FSC % Barbara Houts Swanson 2269 Manuela Circle Chaska, Minnesota 55318 952-368-0540 Section: Midwestern Region: Upper Great Lakes	N / A

		218-681-7432 eMail Section: Midwestern Region: Upper Great Lakes	
24	Mankato FSC	Mankato FSC PO Box 4312 Mankato, Minnesota 56001 Section: Midwestern Region: Upper Great Lakes	N / A
25	Maplewood FSC	Maplewood FSC % Jamie Drury 3000 Carey Heights Drive Maplewood, Minnesota 55109 651.261.5743 eMail Section: Midwestern Region: Upper Great Lakes	N / A
26	FSC of Minneapolis	FSC of Minneapolis 5115 Excelsior Blvd #244 Minneapolis, Minnesota 55416 612-545-1614 Section: Midwestern Region: Upper Great Lakes	N / A
27	New Prague FSC	New Prague FSC % New Prague Area Community Center 100 12th Street NW New Prague, Minnesota 56071 952-758-7825 Section: Midwestern Region: Upper Great Lakes	N / A
28	New Ulm FSC	New Ulm FSC PO Box 2 New Ulm, Minnesota 56073 Section: Midwestern Region: Upper Great Lakes	N / A
29	Northern Blades NSC FSC	Northern Blades NSC FSC % Lorrie Murdy 12130 Dunkirk Street NE Blaine, Minnesota 55449 763-780-8782 eMail Section: Midwestern Region: Upper Great Lakes	N / A
30	Northern Lights FSC	Northern Lights FSC PO Box 132 East Grand Forks, Minnesota 56721 Section: Midwestern Region: Upper Great Lakes	N / A
31	Owatonna FSC	Owatonna FSC % Michelle Redman PO Box 733 Owatonna, Minnesota 55060 507-451-2704 eMail Section: Midwestern Region: Upper Great Lakes	N / A
32	Park Rapids FSC	Park Rapids FSC PO Box 401 Park Rapids, Minnesota 56470 218-732-0197 Section: Midwestern Region: Upper Great Lakes	N / A
33	Red Wing FSC	Red Wing FSC % Becky Mitchener 1028 Aspen Avenue Red Wing, Minnesota 55066 651-388-9391 Section: Midwestern Region: Upper Great Lakes	N / A
34	Riverside FSC	Riverside FSC PO Box 354 Austin, Minnesota 55912 Section: Midwestern Region: Upper Great Lakes	N / A
35	Rochester FSC	Rochester FSC Rochester-Olmsted Rec Center Rochester, Minnesota 55901 507-288-7536 eMail Section: Midwestern Region: Upper Great Lakes	N / A
36	Roseville FSC	Roseville FSC PO Box 131042 Roseville, Minnesota 55113 Section: Midwestern Region: Upper Great Lakes	N / A

		Region: Upper Great Lakes	
51	Plymouth Panda's FSC	Plymouth Panda's FSC % Plymouth Pandas 3500 Vicksburg Lane Plymouth, Minnesota 55447 Section: Midwestern Region: Upper Great Lakes	N / A
52	University Of Minnesota	University Of Minnesota % Kristina Lambert 5223 Lexington Pl. NW Rochester, Minnesota 55901 651-271-1872 Section: Midwestern Region: Upper Great Lakes	N / A
53	Breezy Point FSC	Breezy Point FSC % Linda Kieffer 73070 Co. Rd. 11 Breezy Point, Minnesota 56472 Section: Midwestern Region: Upper Great Lakes	N / A
54	Shattuck - St. Mary's	Shattuck - St. Mary's 1000 Shumway Ave Faribault, Minnesota 55021 507-333-1618	N / A

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Minnesota Hockey

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Minnesota Hockey

District 1

Minnesota Hockey District 1

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Como Area Hockey Association

Mailing Address: P.O. Box 17098 St. Paul, MN55117

Arena Address: 743 Western Avenue No. St. Paul, MN55103

Dino Mights Hockey

Edgcumbe Hockey

Mailing Address: 1866 Yorkshire Ave St. Paul, MN55116

City of Lakes

Highland/Central Hockey Assoc.

Mailing Address: P.O. Box 16382 St. Paul, MN55116

Arena Address: 800 South Snelling Avenue St. Paul, MN55116

Irondale Youth Hockey Association

Mailing Address: PO Box 120114 New Brighton, MN55112

Johnson Hockey Association

Mailing Address: 902 E. Hyacinth Ave St. Paul, MN55106

Arena Address: 1320 Walsh Avenue St. Paul, MN55106

Richfield

Mailing Address: P.O. Box 23033 Richfield, MN55423

Arena Address: 636 E. 66th St Richfield, MN55423

Minneapolis Youth Hockey

Mailing Address: 3011 East Lake Street Minneapolis, MN

Arena Address: 600 Kenwood Parkway Minneapolis, MN

Washburn

Mailing Address: P.O. Box 19356 Minneapolis, Minnesota55419

District 1 Calendar

Thu 7/30	Fri 7/31	Sat 8/1	Sun 8/2	Mon 8/3
no events	no events	no events	no events	no events

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Minnesota Hockey

District 2

Minnesota Hockey District 2

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Forest Lake Hockey Association

Mailing Address: PO Box 401 Forest Lake, MN55025

Arena Address: 832 4th Street Forest Lake, MN55025

Mahtomedi Youth Hockey

Mailing Address: PO Box 604 Willemie, MN55090

Arena Address: 1675 Market drive Stillwater, MN55082

Mounds View Youth Hockey

North St. Paul

Mailing Address: P.O. Box 9004 N. St. Paul, Minnesota55109

Arena Address: 2416 11th Ave. N. St. Paul, Minnesota55109

Roseville Area Youth Hockey

Mailing Address: 1847 Arona Street Falcon Heights, MN55113

Arena Address: 2661 Civic Center Dr. Roseville, MN55113

Stillwater Area Hockey Association

Mailing Address: PO Box 293 Stillwater, MN55082

Arena Address: 1675 Market Drive Stillwater, MN55082

Tartan Area

Mailing Address: 740 Greenway Ave, North Oakdale, MN

Arena Address: 740 Greenway Ave, N Oakdale, MN651.714.9251

White Bear Lake

Mailing Address: PO Box 10585 White Bear Lake, MN55110

Arena Address: 1328 Hwy 96 White Bear Lake, MN

District 2 Calendar

Thu 7/30	Fri 7/31	Sat 8/1	Sun 8/2	Mon 8/3
no events	no events	no events	no events	no events

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Minnesota Hockey

District 3

Minnesota Hockey District 3

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Armstrong/Cooper Youth Hockey

Mailing Address: 4949 Louisiana Avenue North New Hope, MN

Arena Address: 4949 Louisiana Avenue North New Hope, MN55428

Blake Youth Hockey Association

Mailing Address: 110 Blake Road South Hopkins, MN55343

Arena Address: 110 Blake Road South Hopkins, MN55343

Hopkins Youth Hockey Association

Mailing Address: PO Box 117 Hopkins, MN55343

Arena Address: 11000 Excelsior Blvd. Hopkins, MN55343

North Metro Youth Hockey

Mailing Address: 5600 85th Ave., N. Brooklyn Park, MN55443

Arena Address: 5600 85th Ave., N. Brooklyn Park, MN55443

Orono Youth Hockey

Mailing Address: Orono, MN55356

Arena Address: 1025 Old Crystal Bay North Long Lake, MN55356

Osseo/Maple Grove Hockey Associatio

Mailing Address: P.O. Box 434 Osseo, MN55369

Arena Address: 10390 CR-81 / 12591 Weaver Lake Rd Osseo/Maple Grove, MN55369

St. Louis Park Hockey Association

Mailing Address: 4373 Thielen Avenue Edina, MN55436

Arena Address: 3700 Monterey Dr St. Loius Park, MN55416

Wayzata

Mailing Address: 4300 Niagra Lane, N. Wayzata, MN55446

Arena Address: 3650 Plymouth Blvd. Plymouth, MN

District 3 Calendar

Thu 7/30	Fri 7/31	Sat 8/1	Sun 8/2	Mon 8/3
no events	no events	no events	no events	no events

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Minnesota Hockey

District 4

Minnesota Hockey District 4

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Albert Lea Hockey Association

Mailing Address: P.O. Box 662 Albert Lea, Minnesota56007

Arena Address: Lake Chapeau Drive Albert Lea, Minnesota56007

Austin Youth Hockey

Mailing Address: PO Box 111 Austin, MN55912

Arena Address: 121 4th Ave, NE Austin, MN55912

Fairmont Youth Hockey Association

Mailing Address: PO Box 311 Fairmont, MN56031

Arena Address: Martin County Fairgrounds- Co. Rd 39 Fairmont, MN

Faribault Hockey Association

Mailing Address: PO Box 233 Faribault, MN55021

Arena Address: Faribault Hockey Arenas Faribault, MN55021

Luverne Hockey Association

Mailing Address: PO Box 622 Luverne, MN56156

Arena Address: 601 West Hating Luverne, MN56156

Mankato Area Hockey Association

Mailing Address: PO Box 1262 Mankato, MN56002

Arena Address: 301 Monks Ave Mankato, MN56002

Marshall Amateur Hockey Association

Mailing Address: PO Box 173 Marshall, MN56258

Arena Address: Fairgrounds Road Marshall, MN56258

Montgomery-Lonsdale Youth Hockey

Mailing Address: PO Box 63 Montgomery, MN56069

New Prague Area Hockey Association

Mailing Address: PO Box 131 New Prague, MN56071

Arena Address: 100 12 Street NW New Prague, MN56071

New Ulm Hockey Association

Mailing Address: PO Box 14 New Ulm, MN56073

Arena Address: 1212 N. Franklin St. New Ulm, MN56073

Owatonna Youth Hockey Association

Mailing Address: P.O. Box 76 Owatonna, MN55060

Arena Address: 1514 Elm Street Owatonna, MN55060

Redwood Area Hockey

Mailing Address: PO Box 204 Redwood Falls, MN56283

Arena Address: 901 East Cook St Redwood Falls, MN56283

Sleepy Eye Hockey Association

Mailing Address: PO Box 554 Sleepy Eye, MN56085

Arena Address: 620 Southdale Street, SW Sleepy Eye, MN56085

St. Peter Hockey Association

Mailing Address: PO Box 157 St. Peter, MN56082

Arena Address: 821 Ferry Street LeSueur, MN56058

Waseca Hockey Association

Mailing Address: P.O. Box 133 Waseca, MN56093

Windom Area Youth Hockey Association

Mailing Address: P.O. Box 41 Windom, MN56101

Arena Address: 1480 8th Avenue Windom, MN56101

Worthington

Mailing Address: PO Box 123 Worthington, MN56187

District 4 Calendar

Thu 7/30	Fri 7/31	Sat 8/1	Sun 8/2	Mon 8/3
no events	no events	no events	no events	no events

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Minnesota Hockey

District 5

Minnesota Hockey District 5

Click here to visit the District 5 Website

Buffalo Youth Hockey Association

Mailing Address: PO Box 184 Buffalo, MN55313

Arena Address: 1306 County Road 134 Buffalo, MN55313

Crow River

Mailing Address: PO Box 62 Delano, MN55328

Arena Address: 654 Tiger Drive Delano, MN55328

Hutchinson Hockey Association

Mailing Address: P.O. Box 594 Hutchinson, Minnesota55350

Arena Address: 950 Harrington Street SW Hutchinson, Minnesota55350

Litchfield/Dassel/Cokato

Mailing Address: 512 South Swift Litchfield, MN55355

Arena Address: 900 N. Gilman Ave. Litchfield, MN55355

Mound/Westonka

Mailing Address: PO Box 266 Mound, MN55364

Arena Address: 5909 Sunnyfield Road Minnestrista, MN55364

River Lakes Hockey Inc.

Mailing Address: PO Box 82 Paynesville, MN56362

Arena Address: 319 Central Ave., S. Richmond, MN56368

River Lakes Hockey Inc.

Mailing Address: P.O. Box 82 Paynesville, Minnesota56362

Arena Address: 28780 Koronis Dr. Paynesville, Minnesota56362

Sartell Youth Hockey

Mailing Address: 1109 1st Street, S Sartell, MN56377

Arena Address: 1109 1st Street, S. Sartell, MN56377

St. Michael/Albertville

Mailing Address: PO Box 134 St. Michael, MN55376

Arena Address: 5898 Lachman Avenue Albertville, MN55301

STARS Youth Hockey (MAML)

Mailing Address: P.O. Box 584 Monticello, MN55362

Arena Address: 800 East Broadway Monticello, MN55362

Willmar Hockey Association

Mailing Address: PO Box 445 Willmar, MN56201

Arena Address: 2707 Arena Drive NE Willmar, MN56201

District 5 Calendar

Thu 7/30	Fri 7/31	Sat 8/1	Sun 8/2	Mon 8/3
no events	no events	no events	no events	no events

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Minnesota Hockey

District 6

Minnesota Hockey District 6

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Apple Valley

Mailing Address: P.O. Box 240504, Apple Valley MN 55124

Bloomington Jefferson

Bloomington Kennedy

Mailing Address: PO Box 20351 Bloomington, MN55420

Arena Address: 3600 W 98th Street Bloomington, MN55431

Burnsville Hockey Club

Mailing Address: 251 Civic Center Parkway Burnsville, MN55337

Arena Address: 251 Civic Center Parkway Burnsville, MN55337

Chaska

Mailing Address: P.O. Box 1006 Chaska, MN

Eastview Hockey Association

Mailing Address: P.O. Box 240682 Apple Valley, MN55124

Eden Prairie Hockey Association

Mailing Address: 200 Valley View Road Eden Prairie, MN55347

Arena Address: 200 Valley View Road Eden Prairie, MN55347

Edina

Mailing Address: 4801 W. 50th Street Edina, MN55424

Arena Address: 7501 Ikola Way Edina, MN55439

Minnetonka Youth Hockey

Mailing Address: 18313 Hwy 7 Minnetonka, MN55345

Arena Address: 18313 Hwy 7 Minnetonka, MN55345

Prior Lake-Savage Hockey Association

Mailing Address: PO Box 92 Prior Lake, MN55372

Arena Address: 2100 Trail of Dreams Prior Lake, MN55372

Shakopee

Mailing Address: 1255 s. Fuller Street Shakopee, MN55379

Arena Address: 1255 S. Fuller Street Shakopee, MN55379

Waconia Hockey Association

Mailing Address: P.O. Box 521 Waconia, Minnesota55387

Arena Address: 8475 Kochia Lane Victoria, Minnesota

District 6 Calendar

Thu 7/30	Fri 7/31	Sat 8/1	Sun 8/2	Mon 8/3
no events	no events	no events	no events	no events

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Minnesota Hockey

District 8

Minnesota Hockey District 8

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Cottage Grove

Mailing Address: PO Box 337/7282 E. Pt. Douglas Road Cottage Grove, MN55016

Arena Address: 8020 80th Street South Cottage Grove, MN55016

Dodge County Youth Hockey

Mailing Address: PO Box 363 Kasson, MN55944

Arena Address: 100 11th Street NE Kasson, MN55944

Eagan Hockey Association

Farmington Youth Hockey

Hastings Hockey Association

Mailing Address: 2801 Redwing Blvd Hastings, MN55033

Arena Address: 2801 Redwing Blvd. Hastings, MN55033

Inver Grove Heights

Mailing Address: 4020 75th Street East Inver Grove Heights, MN55076

Arena Address: 8055 Barbara Avenue Inver Grove Heights, MN55077

La Crescent Youth Hockey Lancer

Mailing Address: P.O. Box 172 La Crescent, Minnesota55947

Arena Address: 520 S. 14th Street La Crescent, Minnesota55947

Lakeville Hockey Association

Mailing Address: P.O. Box 135 Lakeville, MN55044

Arena Address: 19900 Ipaja Avenue Lakeville, MN55044

Northfield Hockey Association

Mailing Address: PO Box 111 Northfield, MN55057

Arena Address: 1280 Bollenbacher Drive Northfield , MN55057

Red Wing Amateur Hockey Association

Mailing Address: PO Box 2006 Red Wing, MN55066

Arena Address: 307 Guernsey Lane Red Wing, MN55066

Rochester

Rosemount Area Hockey Association (RAHA)

Mailing Address: PO Box 225 Rosemount, MN55068

Arena Address: 13885 S. Robert Trail Rosemount, MN55068

South St. Paul Youth Hockey

Mailing Address: 141 East 6th St, Suite #1 South St. Paul, MN55075

Arena Address: 141 East 6th Street South St. Paul, MN55075

West St. Paul Youth Amateur Association

Mailing Address: P.O. Box 18097 West St Paul, MN55118-0097

Arena Address: 60 West Emerson(behind Menards off Robert St) West St. Paul, MN55118

Winona Area Hockey

Mailing Address: 670 E. Front Street Winona, MN55987

Arena Address: 670 E. Front Street Winona, MN55987

Woodbury Area Hockey Club

Mailing Address: PO Box 25222 Woodbury, MN55125

Arena Address: 4125 Tower Drive Woodbury, MN55129

District 8 Calendar

Thu 7/30	Fri 7/31	Sat 8/1	Sun 8/2	Mon 8/3
no events	no events	no events	no events	no events

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Minnesota Hockey

District 10

Minnesota Hockey District 10

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Andover Youth Hockey Association

Mailing Address: 2339 Station Parkway Andover, MN55304

Arena Address: 15200 Hanson Blvd. Andover , MN55304

Anoka Area Hockey Association

Mailing Address: PO Box 112 Anoka, MN55303

Arena Address: 4111 7th Ave, N Anoka, MN55303

Becker/Big Lake Youth Hockey

Blaine

Mailing Address: 9250 Lincoln St. NE Blaine, MN55434

Cambridge/Isanti Hockey Association

Mailing Address: 2265 E. Rum River Drive So. Cambridge, MN55008

Arena Address: 600 South 1st Avenue Isanti, MN55040

Centennial Youth Hockey Association

Mailing Address: P.O. Box 356 Circle Pines, MN55014

Arena Address: 4707 North Road Circle Pines, MN55014

Champlin-Park

Mailing Address: P.O. Box 152 Champlin, MN55316

Arena Address: 12165 Ensign Avenue Champlin, MN55316

Chisago Lakes Hockey Association

Mailing Address: P.O. Box 275 Lindstrom, MN55045

Arena Address: 12970 292 Street Lindstrom, MN55045

Coon Rapids Youth Hockey Association

Mailing Address: 11091 Mississippi Blvd. Coon Rapids, MN55433

Arena Address: 11091 Mississippi Blvd. Coon Rapids, MN55433

Elk River

Mailing Address: PO Box 193 Elk River, MN55330

Hinckley Area Hockey Association - Mites Only

Mailing Address: 35330 Southfork Road
Hinckley, MN

Arena Address: 311 2nd Street Southeast
Hinckley, MN55037

Mora

North Branch Youth Hockey

Mailing Address: P.O. Box 541 North Branch, MN55056

Pine City Youth Hockey Association

Mailing Address: PO Box 25 Pine City, MN55063

Arena Address: 1225 Main Street South Pine City, MN55063

Princeton Youth Hockey Association

Mailing Address: 511 Ice Arena Drive Princeton, MN55371

Arena Address: 511 Ice Arena Drive Princeton, MN55371

Rogers Youth Hockey Association

Mailing Address: P.O. Box 35 Rogers, MN55374

Sauk Rapids

Mailing Address: PO Box 244 Sauk Rapids, MN56379

Arena Address: 1410-3rd Ave, S Sauk Rapids, MN56379

Spring Lake Park

Mailing Address: PO Box 49802 Blaine, MN55449

St. Cloud Youth Hockey Association

Mailing Address: P.O Box 1005 St. Cloud, MN56302

Arena Address: 5001 8th Street, N/4th Ave. and 13th St. S. St. Cloud, MN56303

St. Francis Youth Hockey Association

District 10 Calendar

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Recent District 10 News

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Minnesota Hockey

District 11

Minnesota Hockey District 11

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Carlton

Mailing Address: PO Box 344
Carlton, Mn55718

Arena Address: 1568 Hwy 210
Carlton, Mn55718

Cloquet Amateur Hockey Association

Mailing Address: 1102 Olympic Dr Cloquet, MN55720

Arena Address: 1102 Olympic Drive Cloquet, MN55720

Cook County Amatuer Hockey Association

Mailing Address: c/o Tim Miller P.O. Box 327
Grand Marais, MN55604

Arena Address: Outdoor Facility,5th Street
Grand Marais, MN

Duluth Amateur Hockey Association

Mailing Address: 120 South 30th Avenue W. Duluth, MN55806

Arena Address: Isanti & Allendale Avenue Duluth, MN55803

Esko

Mailing Address: P.O. Box 381
Esko, MN55733

Arena Address: 62 Canosia Rd
Esko, Mn55733

Hermantown

Mailing Address: 4309 Ugstad Road Hermantown, MN55811

Arena Address: 4309 Ugstad Rd Hermantown, MN55811

Moose Lake Area Hockey Association

Mailing Address: PO Box 104 Moose Lake, MN55767

Arena Address: 2 Earl Ellens Driver Moose Lake, MN55767

Proctor Amateur Hockey Association

Mailing Address: PO Box 1025 Proctor, MN55810

Arena Address: 800 N. Boundary Ave. Proctor, MN55810

Silver Bay Blue Line Club

Mailing Address: PO Box 147 Silver Bay, MN55614

Arena Address: 129 Outer Drive Silver Bay, MN55614

Twig Amateur Hockey Association

Mailing Address: PO Box 1081 Saginaw, MN55791

Two Harbors Youth Hockey Association

Mailing Address: 301 8th Avenue Two Harbors, MN55616

Arena Address: 301 8th Avenue Two Harbors, MN55616

District 11 Calendar

Thu 7/30	Fri 7/31	Sat 8/1	Sun 8/2	Mon 8/3
no events	no events	no events	no events	no events

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Recent District 11 News

USA Hockey Tape to Tape Electronic Newsletter

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Minnesota Hockey

District 12

Minnesota Hockey District 12

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Ely Blue Line Club

Mailing Address: PO Box 516 Ely, MN55731

Arena Address: 4th Ave & Harvey Street Ely, MN55731

Eveleth Recreation Commission

Mailing Address: P.O. Box 536 Eveleth, Minnesota55734

Arena Address: 501 Douglas Avenue Eveleth, Minnesota55734

Grand Rapids Amatuer Hockey Association

Arena Address: 1401 NW 3rd Ave Grand Rapids, MN55744

Greenway

Mailing Address: PO Box 542 Coleraine, MN55722

Arena Address: 200 Curley Avenue Coleraine, MN55722

Hibbing Youth Hockey Association

Mailing Address: PO Box 193 Hibbing, MN55746

Arena Address: Hibbing Community College Hibbing, MN

International Falls

Mailing Address: 615 13th Street International Falls, MN56649

Arena Address: 1515 11th Street International Falls, MN56649

Mesabi East Youth Hockey Association

Mailing Address: PO Box 214 Hoyt Lakes, MN55750

Arena Address: Hoyt Lakes, MN55750

Virginia Amatuer Hockey Association

Mailing Address: PO Box 511 Virginia, MN55792

Arena Address: 9th Avenue South & 6th Street Virginia, MN

District 12 Calendar

Thu 7/30	Fri 7/31	Sat 8/1	Sun 8/2	Mon 8/3
no events	no events	no events	no events	no events

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Recent District 12 News

Minnesota Hockey

District 15

Minnesota Hockey District 15

Click here to visit the District 15 Website

Alexandria Area Hockey Association

Mailing Address: P.O. Box 592 Alexandria, MN56308

Arena Address: 802 3rd Ave w Alexandria, MN56308

Benson Hockey Association

Mailing Address: PO Box 216 Benson, MN56215

Arena Address: 2200 Tatge Ave Benson, MN56215

Brainerd Amatuer Hockey Association

Mailing Address: PO Box 38 Brainerd, MN56401

Arena Address: 502 Jackson St. Brainerd, MN56401

Crosby/Ironton/Aitkin

Mailing Address: PO Box 222 Crosby, MN56441

Arena Address: 470 8th Street NE Crosby, MN56441

Detroit Lakes Youth Hockey Association

Mailing Address: P.O. Box 393 Detroit Lakes, MN56501

Arena Address: 1300 Rossman Ave Detroit Lakes, MN56501

Fergus Falls Hockey Association

Mailing Address: P.O. Box 691 Fergus Falls, MN56537-0691

Arena Address: 1812 Pebble Lake Road Fergus Falls, MN

Leech Lake Area Youth Hockey

Mailing Address: 6166 Morriss Point Road Walker, MN56484

Little Falls Youth Hockey

Mailing Address: P.O. Box 91 Little Falls, Minnesota56345

Arena Address: 1001 5th Avenue Southeast Little Falls, MN56345

Long Prairie Hockey Association

Mailing Address: PO Box 103 Long Prairie, MN56347

Arena Address: Todd County Fairgrounds

Moorhead Youth Hockey Association

Mailing Address: 707 SE Main Ave. Moorhead, MN56560

Arena Address: 707 SE Main Ave. Moorhead, MN56560

Morris Hockey Association

Mailing Address: PO Box 303 Morris, MN56267

Arena Address: 102 County Road 22 Morris, MN56267

Park Rapids Amatuer Hockey Association

Mailing Address: PO Box 508 Park Rapids, MN56470

Arena Address: 204 Helten Ave N Park Rapids, MN56470

Pequot Lakes Youth Hockey

Mailing Address: PO Box 184 Pequot Lakes, MN56472

Arena Address: 7370 County Road 11 Breezy Point, MN56472

Sauk Centre Youth Hockey Association

Mailing Address: P.O. Box 14

Arena Address: 818 Centre Street Sauk Centre, MN56378

Wadena

Mailing Address: PO Box 522 Wadena, MN56482

Arena Address: 700 Community Center Dr Wadena, MN56482

District 15 Calendar

Thu 7/30	Fri 7/31	Sat 8/1	Sun 8/2	Mon 8/3
no events	no events	no events	no events	no events

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Recent District 15 News

USA Hockey Tape to Tape Electronic Newsletter

06/27/09

By USA Hockey

Tape to Tape is an electronic newsletter created as a means of direct communication between USA Hockey and hockey adminnistrators around the country. We encourage you to distribute this newsletter to as many people in your association as possible. If you do not receive this newsletter directly from USA Hockey and would like to: please click Here: www.usahockey.com//Template_Usahockey.aspx

Tag(s): MN Hockey News District 1 District 2 District 3 District 4 District 5 District 6 District 8 District 10 District 11 District 12 District 15 District 16

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Minnesota Hockey

District 16

Minnesota Hockey District 16

Click here to visit the District 16 Website

Bagley Youth Hockey Association

Mailing Address: PO Box 54
Bagley, MN56542

Arena Address: Clearwater County Fairgrounds, MN

Bemidji

Mailing Address: P.O. Box 1141 Bemidji, MN56619-1141

Crookston Youth Hockey

Mailing Address: 124 North Broadway Crookston, MN56716

Arena Address: 220 E. Robert St Crookston, MN56716

East Grand Forks Blue Line Club

Mailing Address: PO Box 125 East Grand Forks, MN56721

Hallock Youth Hockey Association

Mailing Address: P.O. Box 551
Hallock, MN56728

Arena Address: 163 3rd Street
Hallock, MN56728

Lake of the Woods Youth Hockey Association

Mailing Address: PO Box 984 Baudette, MN56623

Arena Address: 5th Street, SW Baudette, MN56623

Red Lake Falls Blue Line Club

Mailing Address: P.O. Box 312 Red Lake Falls, MN56750

Arena Address: Red Lake Falls, MN

Roseau Youth Hockey

Thief River Falls

Mailing Address: PO Box 6 Thief River Falls, MN56701

Arena Address: 525 Brooks Avenue No. Thief River Falls, MN56701

Warroad Youth Hockey Association

Mailing Address: P.O. Box 9 Warroad, MN56763

Arena Address: P.O. Box 9;707 Elk Street Warroad, MN56763

District 16 Calendar

Appendix H-6

[MDH rulemaking notification list]

JOHN HENRICH
BERGERSON-CASWELL, INC.
5115 INDUSTRIAL STREET
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MICHAEL J AHERN
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MINNEAPOLIS, MN 55402-1498

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BONNIE BRUESHOFF
DAKOTA CTY PUBLIC HEALTH
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WEST ST. PAUL MN 55118

TWILA BRASE, CCHC
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ST PAUL MN 55104

VICKI KUNERTH
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QUALITY IMPROVEMENT
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STEFFL DRILLING & PUMP
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WILLMAR MN 56201-9183

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WOODBURY MN 55125

ROSS MILBERGER
PINE RIDGE HOMES, INC.
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CLOQUET MN 55720

RONALD TORGERSON
TORGERSON WELL CO., INC.
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ROCKFORD MN 55373

LARRY R. ZOBEL, MD MPH
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COLLEEN WIECK
MN GOV'S COUNCIL ON DEV. DIS.
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ST. PAUL MN 55155

ANDREA RAU
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MINNEAPOLIS MN 55409

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MICHAEL NASH
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3M COMPANY
P.O. BOX 33428
ST PAUL MN 55133

Olson, John.D (MDH)

From: Pizzuti, Sandy (MDH)
Sent: Wednesday, August 22, 2012 10:34 AM
To: Olson, John.D (MDH)
Subject: RE: Department Mailing List
Attachments: 2012 6-1-12 updated - Rulemaking emails.docx; 2012 6-1-12 updated (w-o) - Rulemaking Labels.doc

Per your request.

Sandy Pizzuti
Minnesota Department of Health
Commissioner's Office
625 Robert St. N.
St Paul, MN 55155-2538
Phone: 651-201-5804
Fax: 651-201-4986
sandy.pizzuti@state.mn.us

From: Olson, John.D (MDH)
Sent: Wednesday, August 22, 2012 10:16 AM
To: Pizzuti, Sandy (MDH)
Subject: Department Mailing List

Hi Sandy,

Please send me the current MDH Rulemaking notification list.

Thank you,

John Olson
Enforcement Coordinator
Indoor Air Unit
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BIBLIOGRAPHY

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Allred, E.N, Bleecker, E.R., Chaitman, B.R., Dahms, T.E., Gottlieb, S.O., Hackney, J.D.,Pagano, M., Selvester, R.H., Walden, S.M., and Warren, J. 1991. *Effects of carbon monoxide on myocardial ischemia*. Environmental Health Perspectives 91. 89-132.

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Hedberg, K. C.W. Hedberg, C. Iber, K.E. White, M.T. Osterholm, D.B.W. Jones, J.R. Flink, and K.L. MacDonald. 1989. *An outbreak of nitrogen dioxide-induced respiratory illness among ice hockey players.* Journal of American Medical Association 262(21). 3014-3017.

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4620.5900 ENFORCEMENT

The department is proposing to add this part, parallel to proposed part 4620.4800, with changes for respective citations to the indoor motorsports rules (parts 4620.5000 - 4620.5800) MDH feels it important to establish the specific authority to enforce the provisions of the indoor motorsports rules. This provision informs the regulated party of the ultimate consequences of failure to comply with the rules and that the enforcement process will follow the Administrative Procedure Act, as cited in the text. In the event that the department must suspend or revoke its approval for an arena to operate, the department has added proposed language specifying how the arena can have its approval reinstated.

4620.5950 VARIANCE TO RULES RELATING TO INDOOR MOTORSPORTS ARENAS

The department does not propose material change to the existing rule part (4620.4900), except to propose that part 4620.5200 cannot be varied, rather than part 4620.4300. As previously discussed, the department has proposed part 4620.5200 to require the regulated party maintain acceptable air quality at all times when open to the public, rather than the requirement in existing part 4620.4300 to document that acceptable air quality conditions "can be maintained".

CONCLUSION

Based on the foregoing, the proposed rule amendments are both needed and reasonable.

8/29/12
Date

Edward P. Ehlinger, MD, MSPH, Commissioner
Minnesota Department of Health