WISCONSIN CAST METALS ASSOCIATION

Understanding Benzene Emissions from Iron & Steel Foundries

INTRODUCTION

The Wisconsin Cast Metals Association (WCMA) represents the majority of the foundries in Wisconsin. This document was developed by WCMA to provide background information on benzene released during the manufacturing of metal castings. Any discharges from foundries, including benzene, are strictly regulated by the U.S. Environmental Protection Agency (USEPA) and the Department of Natural Resources (DNR). However, it is important to recognize that foundries are relatively small contributors of benzene releases to the atmosphere.

BACKGROUND

Few industrial processes actually manufacture benzene. It is typically created as an incidental by-product of a manufacturing or combustion process. For example, foundries do not use benzene as a raw material. However, it is a trace by-product from the combustion which occurs during the casting process when the molten iron contacts the sand mold . In fact, combustion of any kind including the burning of natural gas, fuel oil, gasoline or wood, creates benzene as a by-product.

SOURCES OF BENZENE

USEPA reports that mobile sources such as cars, buses and trucks account for the majority of nationwide emissions. Benzene is a component of gasoline. Cars and gasoline-fueled engines emit small quantities of benzene in unburned fuel. Benzene is also released when it evaporates due to the handling of gasoline such as filling the gas tank of a car.

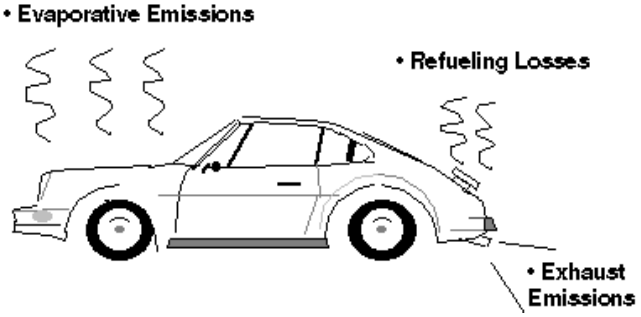


Table 1 presents estimates of benzene emissions to the outdoors in Wisconsin during 1996 as reported by the Wisconsin Department of Natural Resources and the U.S. Environmental Protection Agency.

Table 1
Wisconsin Benzene Emissions

Category	*Emissions (tons per year)*	*Contribution (%)*
Point Sources	88	1
Area Sources	2,003	18
Onroad Mobile Sources	3,650	33
Nonroad Mobile Sources	5,370	48
All Sources	11,111	100

Source: References 1 and 2.

Industrial operations, or point sources, are the most tangible category of benzene sources, but they are by far not the largest. Industrial operations are typically the most regulated and utilize sophisticated methods to reduce emissions. As shown in Table 1, industrial operations contribute less than 1% of the benzene emissions released in Wisconsin.

Over 99% of benzene emissions are generated by non-industrial sources. These are referred to as area and mobile sources. Area sources include a wide variety of common activities including the heating of residential and commercial buildings with natural gas and fuel oil, fireplaces and woodstoves, and wildfires. Onroad mobile sources include automobiles, trucks and buses. Nonroad mobile sources include airplanes, trains, lawnmowers, snowmobiles, construction vehicles, and farm machinery.

Table 2 presents a comparison of emissions from more common sources of benzene such as lawnmowers and current automobile traffic with those from Wisconsin foundries.

Table 2
Common Sources of Benzene Emissions to the Air

Activity	*Benzene Released (lbs per year)*
Average car traveling 15,000 miles	4
Lawn mower	5
Residential wood stove	16
Snowmobile	37
Traffic on a Mile of Main Street in Reedsburg	1,854
Traffic on a Mile of Interstate 43 in Green Bay	3,015
Traffic on a Mile of Highway 51 in Stevens Point	3,406
Traffic on a Mile of Interstates 90/94 in Madison	4,260
Typical Iron Foundry Emissions	6,140
Traffic on a Mile of Interstate 94 in Milwaukee	16,208

Source: References 3, 4 and 5.

WISCONSIN REQUIREMENTS FOR FOUNDRIES

There are no national standards for benzene emissions from foundries. However, in Wisconsin, the DNR has set a low threshold of 300 pounds per year at which industrial sources must evaluate control of their benzene emissions. Benzene emissions from non-industrial sources such as gas stations, vehicles and small engines are not regulated by the DNR. Benzene emissions from each foundry are estimated, and then carefully reviewed and approved by the DNR. The agency must insure the emissions cause no adverse impacts on human health and the environment.

Based on its review of available emission control methods, the DNR has concluded that the control of foundry benzene emissions using air pollution control equipment is economically infeasible. This is due to very low concentrations of benzene in the exhaust gases, high energy and equipment costs, and uncertainty about the effectiveness of available technology.

Benzene can be present in foundry exhaust gases at concentrations of 0.1 to 3 parts per million. These concentrations are up to 10 times lower than the OSHA standards for the workplace. Controlling the benzene would require the use of additional equipment. It would require large amounts of natural gas to heat the air and incinerate the benzene. The burning of natural gas, in and of itself, would generate benzene and other emissions.

As a more cost-effective alternative, DNR requires each foundry to follow a pollution reduction program to research methods for reducing benzene emissions. This program was developed with the state foundry industry. Under this program, each foundry is responsible for researching alternative manufacturing methods and must demonstrate reductions in emissions. Some methods include use of less combustible organic materials in the sand molds or water containing reactants to destroy the benzene or prevent its formation. Foundries must submit periodic reports to the DNR to verify the success of the pollution reduction programs.

Foundries in Wisconsin must obtain an air quality permit from the DNR. These permits will contain limitations on benzene emissions and additional requirements for monitoring, testing, and reducing these emissions. Prior to issuance of the permit, the DNR provides opportunities for the general public to review a draft permit and its supporting analysis. Comments on the draft permit and benzene control requirements can be submitted to the DNR during a 30-day comment period and a public hearing.

WCMA PARTICIPATION IN POLLUTION REDUCTION

The Wisconsin Cast Metals Association and its member foundries have been active participants in the development of the Wisconsin benzene reduction program for foundries. They

have sponsored numerous tests to measure benzene emissions, and many WCMA foundries have already implemented benzene reduction methods.

EFFECTS OF BENZENE EXPOSURE

The health effects of pollutants in the air depend on their concentration and an individual's length of exposure. High concentrations or acute exposure may be immediately noticeable. Low concentrations over extended periods of time, or chronic exposure, may require years for the effects to become apparent. The concentrations of benzene in the outdoor air are far below the level where effects are noticeable. The level at which severe toxic effects due to benzene exposure occur is approximately 3 million times greater than a typical rural background concentration, and 9 million times greater than the maximum concentration generated at the property boundary by operations at a typical iron foundry.

Some air pollutants, such as benzene, have been proven to cause cancer in humans. This conclusion is either based on exposure to high concentrations that have occurred to people in their workplace, or based on laboratory experiments in which animals receive very high doses. People are rarely exposed to the high concentrations which occurred in the workplace or

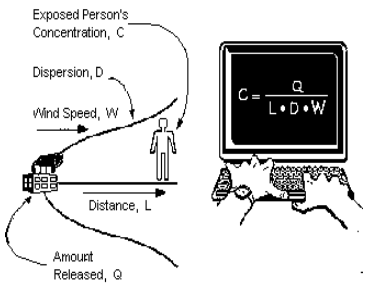
were used in the laboratory experiments. Low level exposures may still pose health risks, so efforts are taken to reduce emissions of these pollutants.

It is important to note that emissions and exposure are not the same. The concentration of benzene released while filling a gas tank or operating a lawn mower may result in a higher exposure than the emissions released by the tall stacks used by industries.

For a typical foundry, the downwind benzene concentrations are well below the concentrations due to common activities such as filling a gasoline tank or traveling in a car.

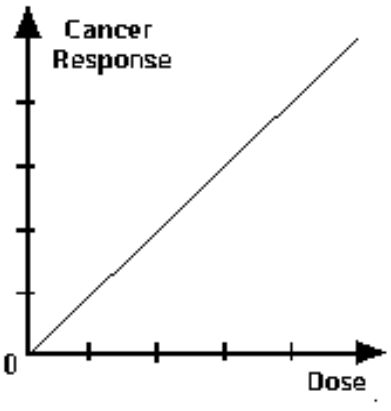
USE OF RISK ASSESSMENT

To evaluate foundry benzene emissions, the DNR must rely on the use of computer modeling to simulate worst-case weather conditions and estimate concentrations at various locations. This is a more practical and conservative approach than placing monitors all around the foundry to measure actual concentrations.



During its review of foundry benzene emissions, the DNR must verify that foundry benzene emissions will not harm the environment or people living near the foundry. For this purpose, the DNR conducts a risk assessment, a common tool for evaluating the hazards posed by low level exposure to environmental pollutants. The risk assessment will estimate the possibility that the emission will cause any harm.

The DNR risk assessment conservatively assumes that an individual is present at the location of maximum concentration near the plant and will be exposed to this concentration for a 70-year lifetime. To assess the risk posed to this individual, the predicted concentration is converted to risk using a unit risk value. Toxicologists and epidemiologists use information on the effects of a pollutant to establish a relationship between exposure and risk and develop the unit risk value. This information is typically obtained from epidemiological studies of human exposure and laboratory animal tests, both based on high levels of exposure. Mathematical models are used to conservatively estimate the hazards found during these studies to those that might be expected at low levels of exposure. The end result is a unit risk value which can be used to estimate the relative risk of harm posed by a low level of exposure. In the case of benzene, the risk of contracting cancer from the exposure is estimated.



A risk of zero indicates that no harm will occur. A risk of one concludes that harm will occur. The risk assessment must conclude that insignificant risk will result due to the foundry emissions. A predicted risk of less than 10 in a million or 0.00001 represents nearly zero risk and is typically considered insignificant by regulatory agencies.

Table 3 presents the predicted risk due to benzene emissions from a typical foundry at various distances from the plant. These theoretical risks of developing cancer are compared to other risks of death in the Wisconsin due to such causes as smoking, driving or being struck by lightning. The risk or probability of harm due to the emissions from a foundry is well below that for more common activities, and even the risk due to urban and rural background concentrations of benzene.

Table 3
Risk Comparison

Cause of Death or Illness	*Certainty of Harm (Frequency in Million)*
Smoking	210,000
Motor vehicles accidents	9,430
All home accidents	7,700
Passive smoking	7,000
Firearms	1,520
Average diagnostic medical xrays	1,400
Drowning	890
Aircraft accidents	290
Electrocution	150
Excessive cold	130
Accidental falls	40
Lightning	35
Urban benzene concentration	16
Rural benzene concentration	12
Iron foundry benzene concentration at the facility property line.	4
½ mile from an iron foundry	0.5
1 mile from an iron foundry	0.3

Source: References 7, 8 and 9.

CONCLUSIONS

The DNR has concluded that the risk posed by the benzene from foundries is small and insignificant, and these emissions are unlikely to cause harm to individuals or the environment. Continued efforts by Wisconsin Cast Metals Association and Wisconsin foundries to identify lower polluting manufacturing methods will further reduce benzene emissions and impacts.

REFERENCES

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10. Graphics courtesy of the USEPA.

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