Benzene Emissions and Exposure - Targeting Sources for the Greatest Benefit

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ABSTRACT

Issuance of recent air quality construction and operation permits for iron foundries in Wisconsin has generated public concern over the air quality impacts of trace benzene emissions. These emissions are a product of incomplete combustion which occurs when molten iron comes in contact with organic binders in the sand core and molds. In Wisconsin, approval of industrial benzene emissions requires control by use of Best Available Control Technology (BACT) and a demonstration that the residual emissions are not injurious to humans or the environment. The results of the BACT determination and of the air quality impact analysis for benzene are presented at a public hearing prior to permit issuance by the state agency. To better inform the general public about foundry benzene emissions, public informational materials were developed by Wisconsin foundries. These compare of foundry benzene emissions with other sources of benzene exposure. Emissions and exposure data were taken from the permit support documents for foundries, USEPA National Air Toxics Assessment and existing literature. Current benzene emission inventories indicate that less than one percent of benzene emissions result from industrial operations. The remainder is generated by area and mobile sources. The predicted health risks due to foundry benzene emissions are much less than background concentrations and other common sources of risk. These comparisons place industrial emissions and impacts in context with other more familiar activities. If they were more widely publicized, members of the general public would be able to make more informed decisions about the risk posed by local industries. These comparisons also suggest that everyone will benefit if the focus of benzene control strategies includes non-industrial as well as industrial sources.

INTRODUCTION

Issuance of recent air quality construction and operation permits for iron foundries in Wisconsin has generated public concern over the air quality impacts of trace benzene emissions. These emissions are a product of incomplete combustion which occurs when molten iron comes in contact with organic binders in the sand core and molds. In Wisconsin, approval of industrial benzene emissions by the Wisconsin Department of Natural Resources (WDNR) requires control by use of Best Available Control Technology (BACT) and a demonstration that the residual emissions are not injurious to humans or the environment.

Under Chapter NR 445, Wisconsin Administrative Code, industrial facilities with benzene emissions exceeding 300 lbs per year are subject to the BACT requirement. Approximately 33 foundries in the state are affected by this rule. Compliance is verified either before issuance of a construction permit for a new or modified operation at the foundry, or during processing of a Title V operation permit for an existing foundry.

The results of the BACT determination and of the air quality impact analysis for benzene are available for review by the public as part of the regulatory agency's technical support documents. The results are also presented at a public hearing organized by the WDNR. The information presented at the public hearings focuses solely on the foundry emissions and the resultant risk to the public. Not unexpectedly, the public reaction is negative.

Newspaper articles on the pending regulatory approval exacerbate this situation with statements such as:

- Environmental research conducted on behalf of [the foundry] estimated the expansion would increase the plant's smokestack emissions of benzene, a recognized carcinogen and reproductive toxicant, by 3.3 tons per year.[1]

- According to a Web site scorecard posted by the Environmental Defense Fund, [the foundry] releases more that 30,000 pounds of benzene into the air annually. The Web site, based on a 1996 survey of toxic industrial releases, ranked [the county] in the top 20 percent of all U.S. counties for reproductive toxicants. Benzene was the major chemical involved.[1]

- EDF's scorecard ranked [the county] 72nd in the nation for benzene emissions; Los Angeles County ranked 71st.[1]

- Are you aware that [the foundry] pumps excessive levels of carcinogenic gases into the air? What is your feeling on this?[2]

The adverse public reaction and comments submitted to the agency must be addressed prior to issuance of a final air quality permit. Despite the negative public reaction, the project is eventually approved, since approval is based on compliance with applicable requirements and not on public opinion.

This is a lose-lose situation for the general public, the regulatory agency, and the foundry. The public loses because people come away with the perception that there is a large source of carcinogens in their community, and that their concerns about the health hazards the foundry poses have no effect on the decision by the regulatory agency to issue an air quality permit. The agency uses valuable staff time responding to similar comments which arise at each hearing and then loses credibility due to its lack of response to the public's concerns. The foundry loses due to project delays and lost economic opportunities, and a negative public image within its community.

REACTING TO PUBLIC CONCERNS

During air quality permit issuance, regulatory staff focus on their responsibilities to review new industrial projects for compliance with applicable air quality regulations. This requires highly technical skills for understanding industrial processes, estimating emissions, evaluating the effectiveness of air pollution control methods, predicting compliance with air quality standards, determining applicable regulations, and drafting enforceable permits and regulatory documents.

Low on the list of priorities for regulatory staff is the development of presentations at public hearings which are understandable by the general public, including the ability to place industrial projects in context of other sources of air pollution emissions and exposure, both regulated and unregulated.

While it is the regulatory agency's responsibility to present its findings in an understandable and professional manner, there typically is not adequate time or resources for this to occur. In this case, it is in the best interest of any regulated industry to be pro-active and educate the public so that people might better appreciate their projects and their effects on the community.

FOUNDRY BENZENE EMISSIONS FACT SHEET

To better inform the general public about foundry benzene emissions, an informative fact sheet or brochure was developed for the Wisconsin Cast Metals Association, representing state foundries. This brochure is entitled, "Understanding Benzene Emissions from Wisconsin Iron & Steel Foundries".[3] It presents the following information:

- A comparison of benzene industrial point source emissions with other common area and mobile sources;
- A comparison of typical state foundry emissions with other common sources in the state such as lawnmowers, snowblowers, wood stoves, and local highway traffic;
- The role of risk assessment in estimating the hazards of exposure to low concentrations of carcinogens; and,
- A comparison of carcinogenic risk due to exposure to foundry emissions versus background concentrations of benzene, or other common causes of death or injury such as smoking or driving.

The final brochure is available for distribution to the general public at regulatory public hearings and in response to questions from local residents. From the information compiled in the fact sheet, it becomes clear that foundries play a small role in the overall generation of and exposure to benzene. Current benzene emission inventories suggest that less than one percent of benzene emissions result from industrial operations; the remainder is generated by area and mobile non-industrial sources. Most of these area and mobile sources are operated by the general public, since combustion of any kind, including the burning of natural gas, fuel oil, gasoline or wood, creates benzene as a by-product. It also demonstrates that predicted health risks due to foundry benzene emissions are much less than background concentrations and other common sources of risk.

This comparison places industrial emissions and impacts in context with other, more familiar, activities. If this comparison were provided to the general public, people would be able to make more informed decisions about the risk posed by their local industries. These comparisons also suggest that we will obtain greater benefit if the focus of benzene control strategies include non-industrial as well as industrial sources.

COMPARISON OF BENZENE SOURCES

Table 1 presents estimates of benzene emissions to the outdoors in Wisconsin compiled by the Wisconsin Department of Natural Resources and U.S. Environmental Protection Agency. Calendar year 1996 was used since concurrent industrial and non-industrial databases were available for this year. The benzene emissions data for industrial sources are taken from the annual emissions inventory reports submitted to the WDNR.[4] Industries must report annually if actual benzene emissions exceed 150 lbs per year.

Table 1. Summary of Wisconsin Benzene Emissions During 1996

Category		Emissions (tons per year)	Contribution (%)
Industrial Sources		88	0.8
Non-Industrial Sources	Area	2,003	18.0
	Onroad Mobile	3,650	32.9
	Nonroad Mobile	5,370	48.3
All Sources		11,111	100

Non-industrial emissions were obtained from the National Air Toxics Assessment (NATA) web site hosted by USEPA.[5] These emissions include area and mobile sources. The area source may include emissions from smaller industrial sources. At the NATA web site, USEPA presents its procedures for conducting a National-Scale Air Toxics Assessment for air toxics that present the greatest threat to public health in urban areas. The first step is the compilation of a national emissions inventory for air toxics. A draft of the inventory used for our comparison is available at the web site (www.epa.gov/ttn/uatw/nata).

The NATA web site also estimates total major source emissions of 38 tons per year. These are industrial sources with benzene emissions above the 20,000 lbs per year major source threshold in Title III of the 1990 Clean Air Act Amendments. The WDNR inventory results are presented in Table 1. These are considered more representative of the industrial contribution due to the lower reporting threshold.

Regulated industrial operations are the most tangible category of benzene sources. As shown in Table 1, they contribute less than 1% of the benzene emissions released in Wisconsin. Over 99% of benzene emissions are generated by non-industrial sources. These are categorized 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 or oil, fireplaces and woodstoves, and forest wildfires. Onroad mobile sources include automobiles, trucks and buses. Nonroad mobile sources include airplanes, trains, lawnmowers, snowmobiles, construction and farm machinery.

Comparisons with more common sources is useful to clarify that everyone contributes benzene emissions through their own personal activities. Table 2 presents estimates of benzene emissions from a lawnmower, wood stove, snowmobile, and current automobile traffic with those from Wisconsin foundries.[6,7,8]

Table 2. Common Sources of Benzene Emissions to the Air (lbs per year)

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

The foundry emissions represent the average of 33 foundries identified by the WDNR for regulation. Individual foundry emissions range from 264 to 38,757 lbs per year, and averaged 6,140 lbs per year.

The emission comparison shows that common residential activities such as driving a car, operating a lawn mower or snowmobile, or heating with a wood stove, contribute benzene emissions. Emissions from an industrial facility such as a foundry can be large. However, they are comparable to the combined emissions from smaller sources such as the traffic on a street or stretch of highway.

COMPARISON OF AMBIENT CONCENTRATIONS

When comparing industrial and non-industrial sources of benzene, it is important to note that emissions and exposures are not the same. Benzene released while filling a gas tank or operating a lawn mower may result in a higher exposure than the emissions dispersed by the tall stacks used by industries.

Table 3 presents both measured and predicted outdoor benzene concentrations in urban and rural areas. The measured concentrations are taken from an ambient monitoring networks in the U.S.[9] The predicted concentrations are based on the use of dispersion modeling. As part of the National Air Toxics Assessment, USEPA presents preliminary modeled concentrations of air toxics for urban and rural areas of each state in the U.S.[5] In the future, it plans to estimate population exposures and characterize the potential public health risk. The goal of the national-scale assessment is to identify those air toxics which are likely to present the greatest risk to the largest number of people in the largest number of areas. The results will be used to identify areas of the country and pollutants where additional investigation is needed. Table 3 presents the preliminary modeling results for Wisconsin. Typical foundry impacts are the results of a modeling analysis using the Industrial Source Complex Version 3 dispersion model and local meteorological data. This foundry analysis was conducted to evaluate risks from the emissions approved by a recent Title V operation permit in Wisconsin.[10]

Table 3. Modeled and Measured Annual Average Benzene Concentrations (ug/m^3)

Estimate Basis	Source Type	Urban Areas	Rural Areas
USEPA Average Modeled Concentration for All Sources	Major	0.0021	0.00145
	Area	0.207	0.121
	Onroad Mobile	0.547	0.0981
	Nonroad Mobile	0.287	0.122
	Background	0.48	0.48
	Total	1.52	0.83
U.S. Ambient Measurements in 1996		2.08	1.60
Modeled Foundry at Property Boundary		0.5	
Modeled Foundry at 1 mile distance		0.04	

Table 3 shows monitored background levels are higher than those predicted for a single industrial plant such as a foundry. The distribution of ambient concentrations is shown by the USEPA modeling of major, area and mobile sources, where onroad and nonroad mobile sources are the greatest contributors to outdoor exposure. Major sources include those with benzene emissions above 20,000 lbs per year. The area sources results may include industrial sources with emissions less than the major source level. These monitored and predicted concentrations suggest there are significant contributors to outdoor exposure to benzene besides industrial sources.

The significance of non-industrial benzene sources is also shown by studies measuring the actual exposure of individuals to benzene. These studies find that personal and indoor exposure from smoking, driving, attached garages, and transferring gasoline exceeds that from outdoor sources.[11,12]

COMPARISON OF RISK OF DEATH OR INJURY

To evaluate foundry benzene emissions, regulatory agencies 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 around the foundry to measure actual concentrations.

During its review of foundry benzene emissions, the WDNR must conclude that foundry benzene emissions will not harm the environment or people living near the foundry. The WDNR uses risk assessment, a common tool for evaluating the hazards posed by low level exposure to environmental pollutants.

The regulatory 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 correlate 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 4 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 such as smoking, driving or lightning.[11,12,13,14] Actual death statistics are shown for smoking through lightning. The remaining risks are estimated based on measured and predicted benzene concentrations and the current unit risk factor of 7.8×10^{-6} $[ug/m3]^{-1}$. The comparison in Table 4 suggests that the risk or probability of harm due to the emissions from a foundry is well below that for common activities or other more common sources of benzene.

CONCLUSIONS

To better inform the general public about foundry benzene emissions, an informative fact sheet or brochure was developed for the Wisconsin Cast Metals Association, representing state foundries. This brochure is entitled, “Understanding Benzene Emissions from Wisconsin Iron and Steel

Foundries". The final brochure is available for distribution to the general public at regulatory public hearings and in response to questions from local residents. The information compiled for the fact sheet suggests that foundries play a small role in the overall generation of and exposure to benzene. This comparison places industrial emissions and impacts in context with other more familiar activities. If this comparison were provided to the general public, people would be able to make more informed decisions about the risk posed by their local industries. These comparisons also suggest that everyone will benefit if the focus of benzene control strategies includes non-industrial as well as industrial sources.

Table 4. Risk Comparison (Frequency in Million)

Cause of Death or Illness	Risk of Harm
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
Benzene exposure while driving an automobile 1 hour each day	16
Rural benzene concentration	12
Iron foundry benzene concentration at the facility property line.	4
Benzene exposure while filling an automobile gasoline tank	2
½ mile from an iron foundry	0.5
1 mile from an iron foundry	0.3

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KEY WORDS

benzene, foundries, industrial sources, point sources, area sources, mobile sources, risk, emissions