New Source MACT and Residual Risk at an Iron Foundry

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Steven Klafka, P.E., DEE
Wingra Engineering, S.C., 303 South Paterson Street, Madison, WI 53703

ABSTRACT

Expansion of three Wisconsin grey and ductile iron foundries required an air quality construction permit under the Prevention of Significant Deterioration air quality regulations. In addition, state and federal regulations included a determination of Maximum Available Control Technology (MACT) for hazardous air pollutants (HAP) and evaluation of the air quality impacts of residual emissions. Proposed changes to the state air toxics regulations will allow facilities to either control HAP emissions or demonstrate the residual risk does not pose a hazard to human health or the environment. The HAP emissions, new source MACT determinations, estimates of residual risk for these projects are presented.

INTRODUCTION

The expansion of three Wisconsin grey and ductile iron foundries required an air quality construction permit under the Prevention of Significant Deterioration (PSD) regulations of 40 CFR 52.21.[1,2,3,4,5,6] In addition, state and federal requirements included a determination of Maximum Available Control Technology (MACT) for hazardous air pollutants (HAP) and evaluation of the air quality impacts of residual emissions. Issuance of the construction permits required an evaluation of prior MACT determinations and a modeling analysis to verify compliance with applicable air quality standards.

RECENT MACT DETERMINATIONS

Under 1990 Clean Air Act Amendment, USEPA is developing Maximum Available Control Technology or MACT requirements for the emission of HAP. MACT is applied to the 187 HAP identified under Title III of the 1990 Clean Air Act Amendments. These HAP are constituents of the inorganic PM emissions and organic VOC emissions.

The MACT standard for new and existing operations in the foundry industry was proposed by USEPA in December of 2002. After consideration of public comments on the draft regulations, including those from the foundry industry, these requirements are expected to be finalized in 2003.

The MACT regulations proposed by USEPA for iron and steel foundries targeted the control of inorganic HAP (i.e. manganese, cadmium, chromium, and nickel) and organic HAP (i.e. acetophenone, benzene, cumene, dibenzofurans, dioxins, formaldehyde, methanol, naphthalene, phenol, pyrene, toluene, triethylamine, and xylene.)

Until final MACT regulations are promulgated, MACT must be applied on a case-by-case basis to any new major source of HAP. This includes any project which results in the emission of 10 tons per year of any one of the Clean Air Act Amendment HAP, or 25 tons per year of any combination of HAP.

Recent foundry projects that have required case-by-case MACT determinations include the following:

- Expansion of the ThyssenKrupp Waupaca, Inc. Plant 3 in Wisconsin;
- Expansion of the the Grede Foundries, Inc. in Wisconsin;
- Expansion of the ThyssenKrupp Waupaca, Inc. Plant 1 in Wisconsin;
- Construction of the ThyssenKrupp Waupaca, Inc. Plant 6 in Tennessee; and,
- Construction of Phase II of ThyssenKrupp Waupaca, Inc. Plant 5 in Indiana.

A new source MACT determination requires a case-by-case determination of what constitutes a maximum achievable reduction of hazardous air pollutants considering the costs of achieving the emission reduction and any non-air quality health and environmental impacts and energy requirements. MACT may include but is not limited to control equipment, work practice standards, emission standards, process modifications or raw materials substitution and/or reformulation.

The aforementioned projects also required issuance of an air quality construction permit under the PSD regulations for major air pollution sources. As part of the PSD approval process, criteria air pollutants such as PM_{10} and VOC are controlled using Best Available Control Technology or BACT. In general, the BACT determination procedure for criteria air pollutants results in more restrictive control technologies than the MACT procedure. For this reason, the control methods determined to be BACT have been accepted as MACT for HAP.

Table 1 presents a summary of recent new source MACT determinations that have been made in the foundry industry.[7] At this time, no new requirements have been implemented beyond that required as BACT under the PSD regulations. MACT for inorganic HAP contained in the PM_{10} emissions has been use of the same control equipment used for PM_{10} emissions - a fabric filter baghouse system. MACT for organic HAP contained in the VOC emissions has been the same equipment or methods used for VOC. For the cupola, this required use of an incineration system. For the pouring/mold cooling and shakeout operations, no control equipment such as incineration has been required. For the coldbox core making operations, this required a packed bed scrubber system to capture and recover the catalyst such as triethylamine.

Table 1. Recent New Source MACT Determinations for Iron Foundry Operations

Foundry Operation	*HAP*	*MACT*
Cupola	Sb, As, Be, Cd, Cr, Co, Mn, Ni, Se	Baghouse
	Benzene, Formaldehyde, 2378-TCDD	Incinerator Reagent Injection Baghouse
Pouring/Mold Cooling	Sb, As, Be, Cd, Cr, Co, Mn, Ni, Se	Baghouse
	Acrolein, Benzene, Cumene, Naphthalene, Formaldehyde, Phenol, Toluene, Xylene, Ethylbenzene	None
Shakeout	Sb, As, Be, Cd, Cr, Co, Mn, Ni, Se	Baghouse
	Acrolein, Benzene, Cumene, Naphthalene, Formaldehyde, Phenol, Toluene, Xylene, Ethylbenzene	None
Sand Handling	Sb, As, Be, Cd, Cr, Co, Mn, Ni, Se	Baghouse
Sand Cooling	Sb, As, Be, Cd, Cr, Co, Mn, Ni, Se	Baghouse
	Acrolein, Benzene, Formaldehyde, Methylene bisphenyl diisocyanate	None
Casting Handling	Sb, As, Be, Cd, Cr, Co, Mn, Ni, Se	Baghouse
Coldbox Core Making	Cumene, Naphthalene, Phenol, Triethylamine, Xylene	TEA Packed Bed Scrubber
Warmbox Core Making	None	Not Applicable

RECENT FOUNDRY PROJECT HAP EMISSIONS

In Wisconsin, over 500 hazardous air pollutants are currently regulated under Chapter NR 445, Wis. Adm. Code. Proposed changes to these rules will expand the number of pollutants to over 700. For the three recent foundry projects, inorganic HAP evaluated included arsenic, beryllium, cadmium, nickel, antimony, chromium, copper and manganese. Organic HAP included benzene, formaldehyde, acrolein and methylene bisphenyl diisocyanate (MDI).

Under NR 445, each HAP has a threshold at which emissions are considered significant and further analysis is required. The thresholds were based on conservative dispersion modeling analyses for stacks equal to or taller than 25 feet in height to assure compliance with acceptable air quality concentrations (AAC). Generally, the 24-hour average AAC is based on 2.4% of the American Conference of Governmental Industrial Hygienists threshold level value (TLV). For substances with TLV-ceiling levels, the 1-hour average AAC is based on 10% of the TLV-Ceiling. Maximum predicted off-property concentrations may never exceed the applicable AAC. For carcinogens, the thresholds were established at emission rates not expected to generate significant risk.

For three recent iron foundry projects, emissions are regulated HAP emissions were estimated and compared to applicable NR 445 thresholds. Only emissions of acrolein, phenol, MDI, benzene and formaldehyde exceeded the thresholds at which further analysis was required. All other HAP emissions were well below the threshold at which air quality impacts would require further analysis.

EVALUATION OF SHORT-TERM RESIDUAL RISK

For acrolein, phenol and MDI, a modeling analysis was required to verify compliance with the AAC for short-term concentrations. This analysis was based on the following parameters:

- Use of the ISC3 dispersion model;
- Five years of meteorological data;
- Maximum approved emissions from all foundry operations; and,

- Prediction of maximum 1-hour and 24-hour average off-site concentrations.

The maximum predicted off-site concentrations ranged from 0.4 to 2% of the applicable AAC. For this reason, it was concluded that these HAP emissions would result in insignificant impacts on air quality.

For most HAP, these three projects suggest that use of BACT for the control of emissions (i.e. baghouse fabric filters) and adequate dispersion will result in off-site impacts which are well within health-based air quality standards.

Based on the use of baghouse control equipment for PM_{10}, all inorganic HAP were less than their respective new source MACT thresholds of 10 and 25 TPY. Besides benzene, all other organic HAP were less than the new source MACT thresholds.

CONTROL OF BENZENE EMISSIONS

Under Wisconsin hazardous air pollutant rules, Chapter NR 445, Wis. Adm. Code, any industrial facility which emits more than 300 lbs per year of benzene is required to control its emissions to the Lowest Achievable Emission Rate (LAER). The emissions from approximately 32 iron foundries in the state are subject to this requirement. At foundries, the pouring, mold cooling and shakeout operations account for the majority of these emissions. Smaller amounts are released from the handling of hot mold sand and combustion in the cupola and natural gas-fired ovens. Due to the relatively low threshold for regulation, the emission of benzene has received extensive evaluation.

Benzene has been identified as a trace constituent in the VOC emissions from these operations. In 1999, the Wisconsin Department of Natural Resources negotiated with the Wisconsin Cast Metals Association to determine how this rule will be applied to benzene emissions from state foundries.[2,7] It was concluded that use of add-on control equipment such as incineration or biofiltration was LAER.

Foundries can qualify for a variance from the LAER requirement if they comply with the following requirements:

- Demonstrate that LAER is economically infeasible due to high cost effectiveness;
- Implement a pollution prevention strategy;
- Verify emissions do not pose excessive risk to the general public; and,
- Allow public review of the variance during a comment period and public hearing.

For all construction and operation air quality permits issued in Wisconsin, use of LAER has always been demonstrated to be economically infeasible. This typically has been based on order-of-magnitude cost estimates conducted for VOC emissions from the same operations. In lieu of add-on emission controls, foundries are implementing pollution prevention.

The pollution prevention strategy under NR 445 requires foundries to investigate methods for reducing benzene emissions from the pouring, mold cooling and shakeout operations. Some methods already implemented include reductions in the combustible materials in the sand system and the preparation of mold sand using oxygenated water.

Under proposed revisions to the state NR 445 HAP regulations will increase the 300 lbs per year threshold at which benzene emissions are regulated. It will allow facilities to opt out of the control requirement by demonstrating the residual risk does not pose a hazard to human health or the environment.

Besides the 300 lbs per year threshold for regulation under NR 445, new source MACT is also required if benzene emissions exceed the MACT thresholds of 10 TPY. For one of the three recent foundry projects, annual emissions exceeded the 10 TPY threshold for new source MACT.[3,4] In this case, the use of add-on control equipment such as incineration or bio-filtration was concluded to be infeasible. The pollution prevention strategies required under the NR 445 HAP regulations were concluded to represent MACT.

RESIDUAL RISK FROM BENZENE EMISSIONS

Approval of the construction permits required an evaluation of residual risk by benzene emissions from all foundry operations. The risk analysis was based on the following key parameters:

- Use of the ISC3 dispersion model;
- Five years of meteorological data;
- Maximum approved emissions from all foundry operations;
- Prediction of maximum annual average off-site concentrations; and,
- Application of the USEPA unit risk factor of 7.8×10^{-6} $[ug/m^3]^{-1}$.

Table 2 presents the results of the risk assessment conducted for each of the three foundries.[1,2,3,4,5,6] In each case, the maximum predicted risk based on full capacity operation was less than 10 in one million. This level of risk has been considered acceptable for issuance of construction permits in Wisconsin.

Table 2. Evaluation of Residual Benzene Risk

Facility	*Pouring/MC Shakeout Emission Factor (lbs/ton)*	*Total Foundry Emissions (lbs/hour)*	*Average Stack Height (feet)*	*Maximum Annual Concentration ($\mu g/m^3$)*	*Maximum Risk (1×10^{-6})*
Foundry A	0.089	7.5	110	0.71	5.5
Foundry B	0.059	5.4	110	0.21	1.6
Foundry C	0.049	10.6	100	0.90	7.0

In each case, the predicted risk was less than 10×10^{-6}. This is the level typically considered insignificant and acceptable for this type of analysis. These analyses demonstrate that after the application of control requirements under state NR 445 and federal MACT regulations, the residual risk of benzene emissions was found to be insignificant. The results of these three modeling and risk assessment analyses are consistent with prior foundry evaluations.[8]

Key factors which influence the residual risk are the emission rate and stack parameters. The downwind concentrations predicted by the ISC3 dispersion model are linear with the emission rates. If rates double, predicted concentrations will also double.

These three foundry projects were also subject to the PSD air quality regulations. Air quality impacts of criteria pollutants such as TSP and PM10 were stringently limited by the Class II area increments. Adequate control of the emissions and sufficient stack height were essential to comply with the increments. The same improvements in dispersion were reflected in evaluation of residual risk from benzene emissions.

Dispersion of residual air pollutants will improve with the following changes to stack parameters:

- Increased stack height;
- Increased stack velocity or flow rate;
- Increased exit temperature; and,
- Decreased stack diameter.

Use of roof vents to exhaust foundry operations will decrease dispersion and result in higher off-site concentrations and residual risk. Similarly, short stacks will be influenced by aerodynamic downwash created by facility buildings. Sufficient stack height, typically 2.5 times the highest building, is required to eliminate building effects and significantly lower off-site concentrations.

For these reasons, a foundry which has not undergone approval under the PSD regulations may not be equipped to provide adequate dispersion of its emissions, even after use of air pollution controls. Each foundry requires its own evaluation to verify acceptable residual risk.

CONCLUSIONS

The expansion of three Wisconsin grey and ductile iron foundries required air quality construction permits under the Prevention of Significant Deterioration (PSD) regulations of 40 CFR 52.21. In addition, state and federal requirements included a determination of Maximum Available Control Technology (MACT) for hazardous air pollutants (HAP) and evaluation of the air quality impacts of residual emissions. The MACT analysis was consistent with prior air quality permits. Based on the use of baghouse control equipment for PM_{10}, all inorganic HAP were less than their respective new source MACT thresholds of 10 and 25 TPY. Besides benzene, all other organic HAP were less than the new source MACT thresholds. The new source MACT determination for benzene required a pollution prevention program and rejected the use of add-on control requirement. Residual risk at each of the foundries was estimated to be less than 10 in one million, considered acceptable, and allowed issuance of the construction permits.

REFERENCES

1. Wingra Engineering, S.C., *Prevention of Significant Deterioration NR 406 Construction Permit Application for the Line 4 Shakeout Modification Project at Waupaca Foundry, Inc. Plant 1 in Waupaca, Wisconsin,* December 19, 2001.

2. Wisconsin Department of Natural Resources, *Analysis and Preliminary Determination for the Construction and Operation Permits for the Line 4, Pouring/mold Cooling Modification Project for Waupaca Foundry Inc., Plant #1 to Be Located at 406 North Division Street Waupaca, Waupaca County, Wisconsin, Permit # 01-RV-162,* June 2002.

3. Wingra Engineering, S.C., *Prevention of Significant Deterioration NR 406 Construction Permit Application for Disa 2071/2072 Modification Project at Grede Foundries, Inc. in Reedsburg, Wisconsin*, August 14, 2002.

4. Wisconsin Department of Natural Resources, *Analysis and Preliminary Determination for the Construction and Operation Permits for the Disa 2071/2072 Modification Project for Grede Foundries Inc. to Be Located at 700 Ash Street Reedsburg, Sauk County, Wisconsin, Permit # 02-RV-116*, October 19, 2002.

5. Wingra Engineering, S.C., *Prevention of Significant Deterioration NR 406 Construction Permit Application for Foundry Efficiency Project at Waupaca Foundry, Inc. Plant 3 in Waupaca, Wisconsin,* September 7, 2002.

6. Wisconsin Department of Natural Resources, *Analysis and Preliminary Determination for the Construction and Operation Permits for the Modification of Existing Sand Handling Equipment and Expansion of Existing Sand Handling Ventilation System at Thyssen Krupp Waupaca Incorporated (Waupaca Foundry Inc.) Plant 2/3 to Be Located at Tower Road , Waupaca, Waupaca County, Wisconsin, Permit # 02-RV-130,* November 29, 2002.

7. S. Klafka, K. Jacobsen, *Recent New Source MACT Determinations and Air Quality Compliance Experience in the Iron Foundry Industry*, Presented at the Annual Meeting of the Air & Waste Management Association, Orlando, Florida, 2001.

8. S. Klafka, K. Jacobsen, *Benzene Emissions and Exposure - Targeting Sources for the Greatest Benefit*, Presented at the Annual Meeting of the Air & Waste Management Association, Orlando, Florida, June 2001.

KEY WORDS

foundry, iron, Best Available Control Technology, BACT, Maximum Available Control Technology, MACT, Prevention of Significant Deterioration, PSD, New Source Review, NSR, construction permit, operation permit.