United States
Environmental Protection
Agency

Air and Energy Engineering
Research Laboratory
Research Triangle Park, NC 27711

Research and Development

EPA/600/SR-92/058 May 1992

EPA

Project Summary

Controlling Odorous Emissions from Iron Foundries

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The main process sources of odors in an iron foundry are (1) mold and core making, (2) casting, and (3) sand shakeout. The odors are usually caused by chemicals, which may be present as binders and other additives to the molding sand, or as breakdown products when these chemicals are subjected to molten iron as it is poured into molds. There are many binder formulations; typical formulations are based on using some form of an oil, urethane, formaldehyde, phenol, or furan. Common additives include coal, cereals and starches, clays, and refractory minerals such as silica. A great many possible compounds can be formed when these chemicals are exposed to molten iron. Common particulate removal technologies may also reduce odors, although the odors are probably caused by vapor-phase compounds that are not well controlled by cyclones and bag filters. Carbon adsorption may be effective but might also be very expensive. Wet scrubbers with special additives in the water may be more effective but have drawbacks such as generating a waste water treatment requirement and the potential for corrosion. Another technology reportedly used in Europe is biofiltration.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back.

Introduction

The control of industrial odor can be difficult. The choice of a control method depends on many technical and economic considerations. The chemical characteristics of the odorous pollutant, the volume of emissions to be treated, and the manufacturing process are only a few considerations. There are many types of odor control, including masking, various removal techniques, and process modifications. This report describes several removal techniques including wet chemical scrubbing, biofiltration, adsorption, and new emerging techniques. The adaptation of these controls to a particular process can be complicated and requires careful planning.

Many pollutants have low odor thresholds and require the removal of extremely small concentrations from large volumes of air. This is technically difficult and may require huge amounts of energy, capital investment, and large control devices depending on the options selected. Furthermore, odor may not be completely controlled, and some level of odor may persist despite the addition of controls.

Once the decision is made to control odor, the course of action may be determined by the availability of water, energy, and waste water treatment facilities. Most control methods employ water sprays, tanks, and mists to trap water-soluble chemicals and particulate. In the absence of sufficient quantities of water, it may be necessary to consider using other methods such as carbon adsorption or biofiltration.

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Discussion

Sources of Odorous Emissions in Iron Foundries

In an earlier report, the U.S. EPA identified major sources of air toxic pollutant emissions in iron foundries. Of these pollutants, organic compounds are the most odorous, although metals and dust may also be sources of odor. The main sources of organic emissions in iron foundries are mold and core making operations, casting operations, and sand shakeout.

Mold and core making may be subdivided according to resin sand operations, commonly referred to as shell molding, green sand operations, and stack molding. In general, these processes have the greatest potential to release odors because of the relatively high concentrations of organics in the uncontrolled emissions.

Most organic emissions originate from the casting process when molten metal is poured into a mold. During this process, chemical reactions involving various binder ingredients are driven by the intense heat of the molten metal. The resulting gaseous emissions may be the products of numerous reactions of the initial binder ingredients, the products of decomposition, and the reactions among the products of decomposition. In addition, fine particulate matter is released during casting. PM_{10} emission factors range from 2,500 to 4.2×10^6 mg/Mg of metal poured. Foundry dust typically contains inorganic emissions such as nickel, lead, boron, and chromium, depending on the composition of the poured metal and its impurities.

The uncontrolled removal of castings from sand molds during the sand shakeout process releases moisture, dust, resin and binder fumes, and products of thermal decomposition. Information on volatile organic compound (VOC) emission factors is rare, but some information is available for particulate matter that suggests a wide range of PM_{10} emissions from 85×10^3 to 9×10^6 mg/Mg of iron castings.

Most odorous emissions originate from mold and core making operations and from casting operations. These emissions result from the use of chemical binders and resin and sand additives.

Odor Thresholds

The threshold concentration for odor detection and recognition varies from person to person and from compound to compound. Many articles have been written on odor evaluations and threshold values. Odor detection varies depending on the compound being evaluated and on the presence of other compounds that may mask or enhance the odor. Some compounds may be offensive even in low concentrations, especially certain sulfur compounds, while others, such as certain esters, may be less objectionable.

Determining Acceptable Levels of Odors

Due to the subjective nature of odors, it is difficult to establish an acceptable level of exposure, especially when many compounds and emission sources are involved. Ideally, the concentration of an odorous compound should be below the odor threshold. While emission controls help reduce the odor, some pollutants such as thiols (mercaptans) require virtual elimination before they are undetectable.

Objective evaluation of an odor should be the first step in controlling it. It is important to know which compound or combinations of compounds is causing the odor. Usually, an independent, third-party assessment of unwanted odor is necessary to form an objective conclusion. Both on-site and community surveys can provide important information for identifying sources of the odor, establishing conditions that elicit complaints in the affected community, and confirming odor levels predicted by source sampling, analysis, and atmospheric dispersion estimation techniques.

Selecting a Control Efficiency

Not all odorous compounds may be sufficiently controlled with the same control device. For example, one compound may require only 99% control efficiency while another may require 99.999% control efficiency to reduce the concentration below its odor threshold value. In this case, two different control devices may be needed to solve the odor problem.

Rather than attempting to reduce all odorous emissions simultaneously, reasonable available control technology should be applied first to reduce total emissions, including particulate matter and organic compounds. In addition, the dispersion and dilution of the emissions should be enhanced to the maximum extent possible. A comprehensive approach to controlling foundry emissions is better than controlling each odorous pollutant individually.

Selecting the Best Control Option

Several methods are available for controlling odor from iron foundries. Aside from reducing overall emissions and good operating practices, emission control technologies that are applicable to iron foundry processes include:

- Fabric filtration
- Adsorption (activated charcoal)
- Wet scrubbers with chemical additives
- Biofiltration
- Photocatalytics and oxidization

There are several basic considerations when selecting one of these control techniques for an iron foundry. The ideal technology would be one that does not require water, energy, or maintenance, costs little, effectively removes many different odorous compounds, and produces no solid or hazardous waste. The ideal technology would also not interfere with existing process operations and conditions.

Fabric filtration is essential to remove sand and other fine particulate matter and should be used first before controlling organic compounds by other means. The control efficiency of various types of wet scrubbers can be enhanced by using various chemical additives. The ideal additive is one that creates harmless waste in small quantities, does not affect process equipment, and does not require special treatment, conditioning, or monitoring.

Selection of a chemical additive requires judgment and knowledge about the chemical reactions with the targeted pollutants. Many companies can recommend and supply chemical additives usually in conjunction with a particular type of scrubber. The particular requirements should be carefully analyzed beforehand, and all aspects of the wet scrubber (including waste disposal, supply requirements, and system operation and maintenance requirements) should be considered.

Incineration, thermal oxidation, and catalytic oxidation are generally not suitable to iron foundries because of the large air flow rates. Odor masking, a technique where a stronger pleasant odor is added to the exhaust stream, generally has not provided consistent and satisfactory results.

Deciding What Is Feasible and Reasonable

Many environmental regulations use the words "feasible" and "reasonable" when describing control requirements. In the case of odor control, specific requirements are often unclear and left to interpretation. Since the ideal control technology does not exist, iron foundry operators wishing to control odorous emissions must accept some level of inconvenience or expense. This report provides basic information that can be used in comparing and selecting a control technology.

Whether a technology is feasible or reasonable depends on the circumstances of the foundry. For example, shortage of wa-

ter would eliminate many of the traditional wet scrubbers described in this report. The need to reduce maintenance costs, for example, might preclude the use of carbon adsorption, while the lack of on-site waste disposal facilities might preclude the use of certain chemical additives in wet scrubbers.

As technology changes, better and proven systems may become available. Currently, atomized mist scrubbers, biofiltration, and photocatalytics offer many advantages over older, traditional systems and should be considered. These new methods have been tried and proven at many different industries here and abroad and can be adapted to the major sources of odor at iron foundries.

☆U.S. GOVERNMENT PRINTING OFFICE: 1992 - 648-080/40253

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The complete report, entitled "Controlling Odorous Emissions from Iron Foundries," (Order No. PB92-166 925/AS; Cost: $17.00, subject to change) will be available only from:

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