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Project Summary

Multimedia Environmental Assessment of Electric Submerged Arc Furnaces Producing Ferroalloys

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The report gives results of sampling and analysis at five ferroalloy plants to determine the amounts of particulates and organics generated during manufacture of several products, the effect of furnace type on the amounts generated, and the amounts of these materials escaping to the environment.

Furnace emission reduction systems tested were: baghouses serving open furnaces producing silicon metal (Si), high-carbon ferromanganese (H.C.FeMn), and 50 percent grade ferrosilicon (FeSi); and scrubbers (primary emissions) and baghouses (secondary emissions) serving semi-enclosed furnaces producing H.C.FeMn and 50 percent grade FeSi. All air pollutant sampling was conducted using modified EPA Method 5. Simultaneous samples were obtained before and after the capture device except for the scrubbers, where samples were taken only after the device. For scrubber systems, composite scrubber discharge water samples were also taken simultaneously with the air samples. Samples were also taken of the influent to and effluent from two plant wastewater treatment systems and groundwater samples around the waste disposal area of one plant.

Particulate emissions ranged from 0.078 kg/MW-hr for the open FeMn furnace to 1.22 kg/MW-hr for the Si furnace. More organics were emitted to the atmosphere than particulates. Open furnaces emitted as much as or more organics to the atmosphere than did semi-enclosed furnaces (kg/MW-hr basis). Benzo(a)pyrene (BaP) was detected in the emission to the atmosphere from both semi-enclosed furnaces and from the Si furnace. The BaP content of solids from the pollution reduction equipment of all furnaces, except the open FeSi furnace, exceeded 0.006 μg/g. Wastewater treatment systems were very effective in removing particulates, organics, and BaP. No metals were extractable (EPA/OSW extraction procedure) from any of the solid waste in sufficiently high concentration to classify the waste as hazardous. Groundwater testing at one site showed no leaching of metals or organics.

This Project Summary was developed by EPA's Industrial Environmental 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

Ferroalloys are mixtures of iron and alloying elements which, when added to molten iron, give it the unique character and properties associated with different grades of steel. The ferroalloy used amounts to about 2 percent of the weight of the finished steel. CO-rich gases generated by the smelting reactions contain fume from the high temperature region and also entrain finer material contained in the furnace charge. In open furnaces, which have no top cover, the escaping gases burn on the surface of the

charged material. Typically fumes from these furnaces are collected in hoods above the furnace and the particulate matter removed in a baghouse, but wet scrubbers are used on a few furnaces For covered (semi-enclosed and sealed) furnaces, on which the covers fit tightly over the furnace top and raw materials are added either through annular spaces around the electrodes (semi-enclosed) or through sealed chutes (sealed), little combustion normally occurs under the cover. The space under the cover is evacuated through a scrubber. The cleaned CO-rich gas is then either flared or used as a fuel. Fumes escaping around the electrodes (secondary emissions) are captured by a hood above the furnace and discharged to the atmosphere either directly or after cleaning in a baghouse.

The purpose of this study was to determine the amounts of particulates and organics generated by various ferroalloy furnaces, and the amounts of these materials escaping to the environment. To this end, one furnace at each of five plants was sampled. EPA Methods 1-5 were used for stack sampling wherever possible. The units tested included two covered (semi-enclosed) furnaces (one producing 50 percent FeSi and one producing standard FeMn) and three open furnaces (producing, respectively, Si, standard FeMn, and 50 percent FeSi). (The term "covered furnace" in this report refers to a semi-enclosed furnace, unless otherwise stated.)

Note that, in some cases, test runs were made which do not meet all criteria of EPA Methods 1-5. The project emphasized obtaining the best data possible without expending great sums of money on construction of facilities (e.g., baghouse exhaust stacks) that comply exactly with these criteria.

Also note that the report frequently refers to New Source Performance Standards (NSPS). No furnace in the industry is currently subject to NSPS, and few (if any) of the emissions control facilities were built to meet NSPS. NSPS are used to provide uniform comparisons, rather than using individual state regulations

Conclusions

In this project, environmental data were collected for five furnaces. Each test period lasted less than 5 days. It should be recognized, therefore, that the data are based on a limited test program and represent the performance of individual systems under specific operating conditions. Frequently, especially when comparisons are made, the data are used to represent typical performance of similar furnaces producing similar products. These statements are more properly indicators of trends: undue significance should not be attached to numerical ratios.

An effort has been made to use sufficiently specific language to prevent mistaking data taken before control devices for actual emissions to the environment. The term "generated" refers to materials entering a collection or control device. The term "emitted" refers only to material actually entering the atmosphere.

1. The total amount of particulates generated by the furnaces per MW-hr of furnace power input increases for different alloys in the order FeMn, FeSi, and Si in the approximate ratios of 1:2:9, respectively. Based on the limited test data, there appears to be little significant difference in the particulate generation rates of open and covered furnaces producing similar products.
2. Particulate emissions to the atmosphere from the Si furnace, and the covered furnaces producing FeMn and FeSi exceeded the NSPS. *NSPS do not apply to these furnaces and are used here only as a reference mark for discussion.* The data indicate that similar new furnaces could achieve NSPS compliance with similar well designed and operated control equipment.
3. The test data presented in this report indicate that, in general, the ferroalloy industry does a good job in preventing discharge of generated pollutants into the environment. However, despite efforts by at least one company, further development is needed to find a solution to the rapid failure of the bags in baghouses handling fume from Si metal production. These failures are not only expensive, in both time and money expended, but also result in periods of increased particulate emissions to the atmosphere. This product line is the largest, in terms of installed MW capacity (but not product tonnage), in the industry; baghouses are the common method of fume control
4. Current wording of the NSPS leads to some confusion as to what the applicable reference mark should be for the FeSi furnaces tested. In the NSPS, FeSi is defined as an alloy meeting a certain ASTM designation *and* containing 50 percent or more Si. Silvery iron is likewise defined as an alloy of Fe and Si containing less than 30 percent Si. There is no definition of or reference to a FeSi with Si content between 30 and 50 percent or to products not meeting all aspects of the ASTM designations. For FeSi, the NSPS value is 0.45 kg/MW-hr; for silvery iron, 0.23 kg/MW-hr. The two FeSi furnaces tested in this study were producing 50 percent grade FeSi; however, the actual Si content was low, on the order of 47 percent. This is within the ASTM designation A100-69 grade E (47-51 percent); however, it does not meet either the 50-percent-or-greater or the 30-percent-or-less criterion of the NSPS. Thus, it seemed neither NSPS value was applicable as a reference mark. For this study, it was decided that the lower NSPS value (0.23 kg/MW-hr) would be used as a reference.
5. The amount of organics generated per MW-hr of furnace power increases in the following order of furnace and product types: covered FeMn with substantial undercover combustion, open FeSi, covered FeSi with little undercover combustion, open FeMn, and open Si. The data suggest that organic generation rates are significantly lower in covered furnaces with substantial undercover combustion than covered furnaces in which this does not occur, and may be as low as or lower than organic generation rates of open furnaces producing equivalent products.
6. The data indicate that open furnaces emit as much as or more organics to the atmosphere than do covered furnaces producing equivalent products. A major reason for this is that the scrubbers used on covered furnaces remove a greater percentage of the organics from gas from covered furnaces than baghouses remove from gas from open furnaces. No testing was done to determine if scrubbers would remove a greater percentage of organics from gas from open furnaces than is achievable with baghouses. In general, organic

emissions exceeded inorganic particulate emissions.

7. The percentage capture of organics by baghouses seems to decrease with increasing operating temperature of the baghouse. The industry uses several methods (e.g., introduction of dilution air, heat exchangers, water sprays) to reduce gas temperatures to protect baghouse components. Further reductions in gas temperatures would be expensive, possibly impractical for retrofit application, and may still not reduce organics significantly.
8. The average total amount of BaP generated per MW-hr of furnace power increases in the following order of furnace type and product: open FeMn, none detected in any test; open FeSi, detected in two of five tests; covered FeMn (but with substantial undercover combustion), detected in all tests; open Si, detected in four of six tests; and covered FeSi, detected in all tests. Since the data indicate that the tightly covered FeSi furnace generated 4 g/MW-hr, about 180 times as much BaP as did the next highest ranking furnace, it appears that tightly covered furnaces would generate substantially more BaP than other furnace types producing equivalent products.
9. BaP was detected in the emissions to atmosphere from only three of the five furnaces tested: Si metal, detected in one of three tests; covered FeSi, detected in all tests, and covered FeMn, detected in two of five tests. Emission rates decrease in the order given. The mass of BaP emitted was less than 0.01 g/MW-hr and less than 0.25 g/hr for each furnace.
10. The average organic content of solid wastes from the pollution control systems of the covered FeSi and FeMn furnaces was 12 and 14 percent, respectively, significantly greater than found for solids from the open furnaces—0.9 percent from Si metal and less than 0.2 percent for FeSi and FeMn. In addition, BaP comprised about 0.4 percent of the organics found on solids from the covered FeSi furnace, but less than 0.1 percent of the organics on solids from the other four furnaces. Concentration values found were 0.18, 0.78, 9.0, and 480 μg/g for Si metal, open FeMn, covered FeMn, and covered FeSi, respectively. These data suggest that solids from open furnaces are less likely to contain hazardous amounts of organics, including BaP, than are solids from covered furnaces.
11. Wastewater entering the water treatment system at the two plants tested that use covered furnaces contains a wide variety of EPA designated priority pollutants. More compounds and higher concentrations were found at the plant using the tightly covered FeSi furnace. The treated effluent contained low concentrations of all detected priority pollutants, including metals. No carcinogenic polynuclear aromatic hydrocarbons were detected in the effluents. The data indicate that simply removing suspended solids from the untreated water would result in 80-90 percent reduction in discharged organics and 100 percent removal of BaP. These data indicated that the wastewater treatment methods in use are effective in controlling the discharge of waterborne pollutants.
12. Monochlorinated biphenyl was detected at <20 μg/L in the untreated wastewater at the Ashtabula plant (covered FeSi furnace). This compound, as well as several pesticides also found, may have been in the plant intake water from Lake Erie. Several additional polychlorinated biphenyls (PCBs), each at less than 2 μg/L, were detected in the treated discharge. These data suggest the possibility that the plants' use of a state-of-the-art technology (chlorination) for phenol and cyanide destruction results in PCB formation in this water. The analytical technique used, however, leaves some question about the PCB identification.
13. The limited test data suggest that solid wastes removed from the wastewater treatment system and placed in on-site landfills would be about 1×10^{-2} and 8×10^{-5} percent BaP for the Ashtabula and Marietta plants, respectively. Analysis of one pair of up- and down-gradients groundwater samples around the landfill-wastewater pond system at the Ashtabula plant indicates that neither organic matter, including BaP, nor heavy metals leach or percolate into the underground aquifer. These limited data suggest that this method of disposal does not present a clear and present danger to underground aquifers.
14. No metals were leachable, following the EPA/OSW extraction procedure, from any of the solid wastes (including baghouse dusts, scrubber sludges, and wastewater treatment plant sludge) in sufficiently high concentrations to result in classifying the wastes as hazardous. BaP concentration in solid wastes from air pollution systems on all furnaces tested except the open FeSi furnace exceeded 0.006 μg/g. Extraction in acidic solution by the EPA/OSW procedure indicated that BaP does not leach from the solids.

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The complete report, entitled "Multimedia Environmental Assessment of Electric Submerged Arc Furnaces Producing Ferroalloys," (Order No. PB 83-262 063; Cost: $22.00, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
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