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Project Summary

Proceedings: Symposium on Iron and Steel Pollution Abatement Technology for 1981

Franklin A. Ayer

Summaries or abstracts of the speakers' presentations contained in the proceedings of the third EPA-sponsored Symposium on Iron and Steel Pollution Abatement Technology held on October 6-8, 1981, in Chicago, IL, are contained in this report. The symposium provided a forum for the exchange of information on technology problems related to air, water, and solid waste pollution abatement in the iron and steel industry. This symposium brought together international representatives from industry, associations, academic institutions, research organizations, Federal, state, and local government agencies, equipment manufacturers and suppliers, scientists, engineers, and consultants. The program included sessions on Air Pollution Abatement (inhalable particulates, fugitive emission control, coke plant emission control, innovative air pollution technology, and iron- and steelmaking emission control); Solid Waste Pollution Abatement; and Water Pollution Abatement (recycle/reuse of water, coke plant wastewater treatment, and new developments in wastewater treatment). The symposium was attended by 226 participants.

This Project Summary was developed by EPA's Industrial Environmental Research Laboratory, Research Triangle Park, NC, to announce presentations at a symposium that is fully documented in a separate proceedings of the same title (see ordering information at back).

Summaries or abstracts of speakers' remarks follow:

Opening Session

Richard D. Stern, Chairman
Industrial Environmental Research Laboratory U.S. EPA, Research Triangle Park, NC 27711

Stern called the symposium to order, welcomed the participants, and introduced John S. Ruppersberger, General Chairman, U.S. EPA, IERL-RTP.

Symposium Objectives and Announcements

John S. Ruppersberger,
Symposium General Chairman
Industrial Environmental Research Laboratory U.S. EPA, Research Triangle Park, NC 27711

Ruppersberger informed the participants that the objective of the third symposium was to provide a forum for the exchange of information on iron and steel multi-media pollution abatement technology. In addition, he emphasized that the symposium continues as a high-priority activity due primarily to the opportunity it provides for learning and cooperation (encouraged by attendees) in pollution abatement for the iron and steel industry. The results achieved by the interchange of ideas will provide for better solutions to pollution abatement problems, more efficient and cost-effective technology, more productive research and engineering, and improved equipment design and operation. He also emphasized that the program was well balanced—one-fourth of the papers being

presented by EPA ORD and the remainder of the papers presented by industry, foreign governments, academia, EPA program offices, and others.

Keynote Address

Carl J. Schafer, Director, Industrial and Extractive Processes Division
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Schafer reviewed some of the cooperative efforts and the people involved in those projects which began over a decade ago. These projects included the combined treatment of steel mill and municipal wastewater, countercurrent rinsing on the halogen tin plate line which demonstrated the large blowdown reduction and accompanying economic benefits, and several projects to encourage increased process water reuse/recycle. On the air program side, there were the coke oven charging and pushing demonstrations, development and demonstration of improved coke oven door seals, measurement of inhalable particulate emissions, assessment of blast furnace cast house emission control technology, measurement of open source emissions, evaluation of control technologies, and other major programs with AISI, universities, and foreign countries. He stated that renewed emphasis on the handling and disposal of hazardous waste has spurred renewed emphasis on prevention, recovery, and more cost-effective and environmentally sound alternatives to disposal.

Whither Research?

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This paper reviews the WHO, WHAT, WHEN, and WHERE of environmental research in the iron and steel industry and makes projections and suggestions as to future conduct of research in the field. Young reviews what has been covered in past symposia and what is being covered in this one. He looked for trends and made projections as to what should be covered in the future.

He reviewed subject matter from the viewpoint of air, water, and solid waste (multimedia) pollution control; sources of papers (who made the presentations) — EPA, EPA contractors, steel companies, joint research, and others; and his self-defined types of papers (regulatory analyses, technical reviews, quantifications of emissions and effluents, laboratory conceptual studies, pilot studies, demonstrations, environmental assessments, and cost-effectiveness/cost-benefit analyses).

Young covers a whole series of factors which he believes will change the way we look at iron and steel pollution abatement technology in the future. Using the same framework discussed above, he projects where he thinks the program should go and what should be emphasized.

The Unfinished Agenda: An Environmentalist's View of Steel Mill Air Pollution

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The steel industry has made substantial progress in controlling air pollution. Particularly noteworthy are efforts to control coke oven emissions in a comprehensive manner. In addition, several companies are developing noncapture systems to control fugitive emissions from iron-and steel-making facilities.

But the job is not done. Total suspended particulate levels still exceed the primary standards in major steel-making areas of the country by a significant margin. Therefore, additional controls on process sources will be necessary. Attainment of standards will also depend on achieving good work practices. To make sure such practices become part of the daily operating routine, self-monitoring programs should be instituted at steel mills.

Session 1. Air Pollution Abatement

Philip X. Masciantonio, Chairman
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Inhalable Particulate Matter Sampling Program for Iron and Steel: An Overview Progress Report

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EPA's Office of Research and Development has entered into a major program to develop inhalable particulate (IP) matte emission factors (IP is defined as airborn particles of < 15 μm aerodynamic equiva lent diameter). The Industrial Processe Branch of EPA's IERL-RTP is responsib for the ferrous metallurgical industry seg ment of this program. Efforts to date f the iron and steel category are summa rized in this paper. IP requirements ar meshed with those of other EPA samplir programs whenever possible, thus redu ing overall cost to EPA and minimizir inconvenience to the host plants.

A thorough literature review and comp lation of existing data revealed the exi tence of particle size data for several the major iron and steel sources. Hov ever, none of these data was obtaine using current IP measurement techno ogy; most of them do not cover the full size range and, in many cases, there insufficient documentation to complete determine test procedures followed ar to fully define the process operatic during the tests. The current field te program is designed to augment th existing data base by directing resourc toward these sources with the combin tion of high priority and low existing da quality. Both process sources and op sources are included. To date, process tested are basic oxygen furnace (BO charging and tapping, hot metal desulfu ization, blast furnace cast house (bo building evacuation and local control tec nologies), sinter discharge, and BOF ma stack (limited combustion system aft scrubber). Open sources tested are pav and unpaved roads and coal storage p maintenance, all both with and withc controls, and an uncontrolled open are Several additional tests are underway scheduled. All data gathered will be su marized and published in a single rep early next year.

Cost Effectiveness Evaluatio of Road Dust Controls

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Preliminary analysis of control mea ures for fugitive particulate emissi sources in the iron and steel indus indicates that control of open dust sourc has a highly favorable cost effectivene ratio in comparison with control of proce sources of fugitive particulate emissio However, rigorous cost effectivene evaluation must await accurate and we documented information on control p formance and cost. This paper address

he analytical and practical considerations involved in acquiring meaningful cost effectiveness data for the major open dust sources in the iron and steel industry—vehicular traffic on unpaved and paved roads.

Results of extensive performance testing of road dust controls are presented. The control measures tested were watering and chemical treatment of unpaved roads and vacuuming, flushing, and broom sweeping of paved roads. The mean efficiencies of control measures tested, except for vacuum sweeping of paved roads, were found to be independent of particle size. The mean control efficiency of freshly applied Coherex® to unpaved roads was higher than the efficiencies of the other measures tested. An analytical framework for control cost effectiveness analysis is proposed, and control cost data for road dust controls at two steel plants are given.

Blast Furnace Casthouse Control Technology - Fall 1981 Update

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This paper describes blast furnace casthouse information that has become available in the past 6 months. Results of total mass and inhalable particulate testing on the baghouse inlet at Bethlehem Steel's Sparrows Point L furnace are presented. Baghouse outlet test data are also presented for Inland Steel's No. 7 furnace and Wheeling-Pittsburgh's Monessen No. 3 furnace. The status of United States and Canadian casthouse control systems as of September 1981 is provided along with a listing of worldwide controlled casthouses, excluding Japan. Cost data for installed systems are also given.

Coke Quench Tower Emissions and Emissions Control

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Available test data indicate that the mass of particulate emissions from a coke quench tower may be affected by quench water quality (based on dissolved or total solids in the quench water), and the design and location of baffles in the tower. This paper examines the impacts of the water quality and baffle design on quench tower emissions and emissions control. Emissions test data and engineering models are used to estimate the relationship of these parameters to emissions. Six possible control schemes are defined and the impacts of the controls are evaluated.

Current Regulations and Control Performance for Visible Emissions from Wet-Coal Charging, Door Leaks, and Topside Leaks

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The Research Triangle Institute, under contract to the U.S. Environmental Protection Agency (EPA), compiled background information on emissions from wet-coal charging, door leaks, and topside leaks from coke ovens. The study was undertaken as part of EPA's effort to examine the need for coke oven regulations. This paper summarizes a portion of the background information which was compiled. Current regulations from State Implementation Plans, consent decrees, and Occupational Health and Safety Administration (OSHA) requirements are summarized. Emission test results and performance data in terms of visible emission control are presented.

A Review of Shed and Gas Cleaning Systems for Controlling Coke Pushing Emissions from Coke Plants

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The body of information in this paper is directed to coke producers and their management, the environmental control agencies, and labor organizations interested in further protection of their members.

There are a number of different areas of concern in pollution control for coke ovens. We are directing our efforts to properly control all the emissions on the coke side of the oven.

In the United States in the past 7-10 years, there have been a number of concepts used by the steel industry and coke producers to control pushing emissions and door leakage on coke side of ovens. These concepts included various types of quench cars, land-based systems, hooded hot cars, and sheds.

The purpose of this paper is to review the evolution of the shed concept up to the present and the new concepts presently being offered. We will also review and compare the gas cleaning devices used on the early sheds which were either high energy scrubbers or wet electrostatic precipitators versus the baghouse which is today's accepted technology on coke pushing emissions.

Armco's Experience with Application of the Bubble Concept

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Armco's early efforts to demonstrate the advantages of the Bubble Concept led to the implementation of a comprehensive fugitive dust control program at its Middletown Works. The program was fully operational by August 1980 and led to an acceptable alternative control plan approved by U.S. EPA in March 1981. The prototype program has shown that significant improvements in ambient air concentrations of total suspended particulates are possible with a comprehensive fugitive dust control program and that improvements in smaller particle size fractions are realized as well.

Engineering Study of Roof Mounted Electrostatic Precipitator (REP) for Fugitive Emission Control on Two Basic Oxygen Furnaces of 300 Ton Capacity

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Several alternatives are available for controlling fugitive dust emissions from basic oxygen furnace operations. Local hoods and partial building evacuation are the common means for capturing emissions. An alternative not used in the United States, but successfully used in Japan, is roof-mounted electrostatic precipitators (REPs). This paper presents the results of a study examining the feasibility of REP installation for a BOF shop with two 225 metric ton (280 ton) vessels. The purposes of the study were to determine the applicability of the devices to the BOF fugitive dust sources, examine the changes needed to existing plant facilities to interface the new equipment with the old, estimate the costs for modification of existing plant facilities and the addition of new facilities, and examine the expected performance of the proposed REPs. In performing the study, a preliminary quote for the REP was obtained from Sumitomo Heavy Industries, Ltd., electrical power supply and spray washing system requirements were investigated, structural reinforcement to the existing BOF building was investigated, an estimate of cost to install and to operate the REP was then generated, and, finally, the quantity of fugitive furnace emissions escaping the building with the REPs in place was estimated.

Demonstration of the Use of Charged Fog in Controlling Fugitive Dust from a Coke Screening Operation at a Steel Mill

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TRC-Environmental Consultants, Inc. (TRC) has been contracted by the Industrial Environmental Research Laboratory of the Environmental Protection Agency at Research Triangle Park, North Carolina (EPA/IERL-RTP), to test a commercially available electrostatically charged fogger on several large-scale industrial sources within the iron and steel and sand and gravel industries. This paper discusses tests conducted at a coke screening operation at a steel mill. Tests were run with no fog, uncharged fog, negatively charged fog, and positively charged fog. Data analysis indicates a doubling in total suspended particulate control efficiency when a positively charged fog was used relative to uncharged fog. For the same case, removal efficiency for particles less than 16 μm improved 2.5 times.

Performance of BOF Emission Control Systems

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Many of the recently constructed BOF facilities worldwide have incorporated both primary and secondary emission control systems in initial construction programs. Domestically, as a result of consent decrees and state air regulations, some older plants have retrofitted secondary emission control systems and upgraded their primary emission control systems. The effectiveness of these recent air pollution control systems varies widely. The performance of most primary control systems has been good. The largest variation in performance domestically appears among secondary control systems. This paper discusses the technology in use at some plants, and reports the performance as well. Some data reported in this paper have been obtained in the process of developing background information for New Source Performance Standards for the U.S. EPA.

Investigation of Opacity and Particulate Mass Concentrations from Hot Metal Operations

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The objective of this study was the investigation of possible relationships between plume opacity, mass concentration, and sub-10- μm mass concentration for three hot metal processes. Size distribution data from a blast furnace cast-house, BOF shop, and hot metal desulfu ization were used to compute mass lig extinction coefficients. A wide range materials (iron oxide, carbon, and glas were assumed to model the emission The results suggest that opacity-to-ma concentration should be insensitive composition, and a good correlation mass-to-plume opacity is expected. Tl emissions studied were of similar optic activity as those reported in the literatu in other industries. The results of tl analysis also imply that the sub-10-μ particles should be well correlated to mas

It is recommended that future field tes to measure particle size distribution shou include instrumental measurements opacity. Thus, opacity, mass concentratic and sub-10-μm particle concentrati could be subjected to a correlation an ysis. In addition, the refractive index a particle density of particulate mater should be measured on bulk material aid in explanation of the test results.

Retrofitting Emission Contro on Electric Furnaces at a Ste Mill

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The body of information presented this paper is directed to design engine electric arc furnace owners, and oth who are interested in air pollution emiss control technology. This paper prese the methodology and results of a 2 -y project at the Knoxville Iron Company. extensive field measurement program v conducted to quantify plume generat rates from two 30-ton electric arc furna melting scrap. Plume measurements w made for charging, tapping, and melti Measurements were also made for t dish lancing and billet cutting. M tenance and operational problems of first-generation side draft-hood and t house system were inventoried. Base the source characterization and sys performance, an integrated air pollu control system was designed and instal Installed system capacity was 300,(acfm, utilizing two shaker-type baghou with flow switching and continuous li stone injection. Capital and installa costs are presented by major categor addition, pertinent design parameters system performance data are presen

The Present and the Future for the Industrial Treatment of Fumes in the French Steel Industry

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Over the last few years, the French steel industry has committed large sums and made an uprecedented technological effort to improve the environment around its plants. Thus, during 1976-1980, 880 million francs were spent in antipollution investments in spite of the unfavorable economic situation. Two-thirds of these investments were devoted to the fight against air pollution and, in several cases, new technologies were used.

This report covers the present situation in seven projects: two coking plants (Sollac and Pont-à-Mousson), three oxygen steelmaking shops (Fos, Mondeville, and Neuves-Maisons), and two electric steelmaking shops (Firminy and Les Dunes). For each, the authors analyze the problems to be solved on a technical and regulatory level, the solution applied (especially when technologically unusual), and the results obtained. From the present situation we can anticipate an evolution of pollution standards and of antipollution technology.

Modeling of Hood Control of Blast Furnace Casting Emissions

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A laboratory scale model test technique has been developed to simulate the thermal and flow characteristics of blast furnace casting emissions and to evaluate the performance of potential hood collection devices. The test system utilizes fresh water (as the source fluid to model casting emissions) and concentrated sodium chloride solution (to model the denser surrounding environment). Excellent flow visualization is obtained through the generation of light-reflecting hydrogen bubbles in the source fluid stream by electrolysis. Application of the technique to qualitative evaluation of hood performance is illustrated by an example. In addition, use of the technique to generate numerical values of hood collection efficiencies is described.

Session 2. Solid Waste Pollution Abatement

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RCRA Regulatory Changes and the Steel Industry

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The objectives of the Resource Conservation and Recovery Act (RCRA) in the management of solid and hazardous wastes are to promote the protection of human health and the enviroment and to conserve valuable material and energy resources. This paper updates actions being taken by the Environmental Protection Agency (EPA) in fulfilling the objectives of RCRA with respect to hazardous waste management. It discusses: (1) the status of regulations promulgated to manage hazardous wastes, and (2) RCRA activities specifically associated with steel industry hazardous wastes.

Standards were published in May 1980, establishing a foundation for the management of hazardous waste. Additional technical standards necessary to permit treatment, storage, and disposal facilities were published in January and February 1981.

However, some wastes listed as hazardous in May 1980 have subsequently been delisted, and the effective dates of some of the January and February standards have been deferred.

EPA has also been involved in the investigation of means to alleviate the problem of spent pickle liquor generated by the steel industry via increased reuse/recovery. With regard to the latter, EPA has recently promulgated a conditional exemption from RCRA management standards for spent pickle liquor use, and is also currently considering a Section 6002 procurement guideline for the specific use of spent pickle liquor in wastewater treatment as a phosphorous removal agent.

An overview of each of these EPA activities under RCRA is provided in this paper.

Characterization, Recovery, and Recycling of Electric Arc Furnace Dust

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Electric arc furnace dust samples have been obtained from a number of steel companies representing the broad spectrum of steelmaking practice. The samples have been chemically and structurally analyzed in the bulk, and individual particles have been characterized using analytical electron microscopy. (Most particles analyzed were complex iron-rich spinel oxides with varying amounts of other elements in solid solution.) Procedures to extract elements from the dust have been investigated both physically and chemically. Magnetic separation shows some promise for recovering zinc from high-zinc-bearing dust. Other options for resource recovery are discussed including the technologies which exist for processing high grade dust.

Treatment of Carbon Steel Electric Furnace Flue Dust by Sulfation

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The zinc content of electric furnace flue dust can be sulfated by the action of iron sulfate in briquetted samples at 600-650°C. Up to 96% of the contained zinc is converted to water-leachable zinc sulfate under optimum conditions. The other product is a relatively low-zinc iron oxide. A Plackett-Burman statistical design was used to quantify the factors affecting the

sulfation process. The mechanism of the process is explained by the use of thermochemical diagrams for the Fe-Zn-S-O system at different temperatures. The results suggest a process for rendering the electric furnace flue dust suitable for recycling into the steel plant flowsheet. The process may also be effective in detoxifying dust which does not otherwise pass the EP toxicity test.

Panel: Destruction of Hazardous Waste in Iron and Steel Furnaces

Engineering Requirements for Thermal Destruction of Hazardous Waste in High Temperature Industrial Processes

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A number of high temperature industrial processes offer temperature, mixing, and gaseous residence time conditions which may be sufficient to thermally destroy hazardous wastes of various types. Industrial boilers and cement kilns are most often considered for this purpose. Incineration in lime kilns, steelmaking furnaces, and other processes may also be technically feasible and economically attractive. Consideration must be given, however, to the physical form of wastes, firing methods, residue handling, air pollution control, "incinerability" of the waste, and compatibility of the waste material with the industrial process of interest.

Suitability of Open Hearth Furnaces for Destruction of Hazardous Waste

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The high temperatures and retention times achieved in open hearth furnaces suggest their consideration as candidates for destruction of hazardous wastes. Conceptually, liquid wastes could be co-fired with fuel in the burners, and semisolid and solid wastes could be charged into the furnace. A particularly difficult problem in present hazardous waste destruction is the disposal of contaminated drums. Complete cleaning is expensive and time consuming. Destruction of contaminated drums and other solid wastes is an opportunity not offered in many other destruction schemes.

Serious complications coexist with the advantages of this concept. Control of fugitive emissions, explosion hazards, and potential worker exposure are among the problems to be evaluated. It appears unlikely that hazardous waste destruction could be accommodated in an ongoing steelmaking operation. An alternative is the conversion of an abandoned furnace to serve primarily as a destruction operation with the production of low-grade steel as a byproduct. Economics will dictate the ultimate viability of such an approach as site cleanup activities proceed over the next 5 years under EPA's Superfund program.

Suitability of Blast Furnaces for Destruction of Hazardous Wastes

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The potential for the injection of hazardous wastes in the tuyeres of a blast furnace is discussed in terms of the thermochemical conditions that exist in the raceways and smelting zone of an operating blast furnace. The temperature in the blast furnace tuyere is about 2121°C (3850°F). As the preheated air with additives enters the furnace through the tuyeres, the chemical potential of oxygen rapidly decreases because of the excess supply of hot coke. Hence, the conditions are characterized by high temperature (>2000°C), strong reducing potential ($PO_2 < 10^{-20}$ atm), and moderate pressure (<10 atm). Under such conditions, many hazardous materials may be dissociated into simple molecules. Currently, tars, oils, and pulverized coals are injected into the tuyeres. Hence, a technology for tuyere injection is well developed. During the presentation, the fate of injected hazardous wastes (e.g., PCB) and the potential effects on blast furnace operations are discussed.

Session 3: Water Pollution Abatement

Terry N. Oda, Chairman
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Minimizing Recycled Water Blowdown from Blast Furnace Gas Cleaning Systems

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Retrofit water recycle systems were pu in operation late in 1976 on the ga cleaning systems for two blast furnac complexes at Republic Steel Corporation' Cleveland District steelmaking facility Since the start-up of these systems, ef forts have been made to reduce blowdow by identification and elimination of extra neous water sources. The overall effect o these efforts has caused significan changes in constituent loadings fron these systems to the receiving stream, th Cuyahoga River. Recently, the goal c blowdown reduction has shifted to th elimination of discharge to the river, wit efforts directed toward continued operatio of a very "tight" recycle system. Long term effects are yet to be resolved.

The paper maps the development of blast furnace treatment facility from "onc through" to "recycled" with a low blow down rate. Current work concerning th continuous operation of a tightly close recycle system is presented. This include maintaining hydraulic balance, monitorir water chemistry, and feeding differe treatment chemicals to control potenti problems associated with highly cycle water. It also presents a pictorial displ and schematic representation of the sy tem, and a graphic analysis of key par meters and water quality trends.

Finally, the paper focuses on studi conducted jointly by Republic Steel a U.S. EPA on one of the recycle wat systems. This was accomplished with t use of the U.S. EPA Mobile Wastewa Treatment System during the spring a summer of 1981. Initial work includ testing on a pilot plant scale (5-6 gpm) softening a portion of the recycle strea Secondary work investigated propos BAT/BCT Alternate #4 (Alkaline-Chlo nation) for blowdown treatment from very highly cycled blast furnace recy system.

Minimizing Water Blowdow from Selected Steel Plant Processes

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Objectives of the project were to mi mize the volumes of water blown do from blast furnaces, BOF, continuous c

ters, hot forming mills, sinter plants, electric arc furnaces, and vacuum degassers, and, at the same time: use existing treatment facilities, use no major capital equipment, and have the reduction have no adverse impact on the production facilities.

To meet the project objective, the methodology was to: review existing literature to determine which plants have extensive recirculation systems installed and which plants discharge volumes that are close to BAT volumes (October 1979 proposed guidelines), visit candidate plants; interview personnel; obtain data; perform studies; establish modified operating procedures and/or design system modifications; discuss results with plant operators; and allow plants enough time to make and operate the modified systems to determine if the systems can be operated with reduced blowdown without adverse effects.

Zinc Control in a Blast Furnace Gas Washwater Recirculation System

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In general, it is not possible to operate blast-furnace-gas-washwater circuits at a high degree of recirculation in a steel plant which also recycles a large proportion of zinc-containing scrap and solid wastes. Certain undesirable elements, particularly zinc, are not removed during iron- and steel-making, and will accumulate to dangerous levels under high recycle conditions.

The most serious danger is to blast furnace operations. Zinc threatens these operations by: (a) endangering refractories (which can lead to blowout, collapse, or premature shutdown of the furnace); (b) causing the descending charge to stick (leading to operating irregularities, decreased furnace efficiency, and hazardous slips'); and (c) depositing solids in water recirculating systems (which can block pipes and cause the collapse of cooling towers).

To avoid these problems, all steel companies restrict the amount of zinc in materials fed to blast furnaces. A typical *maximum* permissible level is 0.5 kg/tonne of iron produced—equivalent to about 0.02%of zinc in the raw materials fed to the furnace.

Stelco's Hilton Works in Hamilton, Ontario, recycles solid wastes, including all blast furnace dust from both wet and dry collection systems. Severe operating problems were caused when a recirculation system was commissioned in 1978 for three blast furnaces which had previously operated with a once-through gas-washing and solids-separation system. Subsequently, it was found possible to operate, if blast furnace dusts (up to 40,000 tonne/year) were dumped.

To avoid this problem, a method of generating a zinc-laden blow-down stream has been devised, which enables zinc to be selectively purged from the system. This technique allows the water recirculation system to be operated, while still recycling most of the blast furnace dusts.

Investigation of Reverse Osmosis for the Treatment of Recycled Blast-Furnace Scrubber Water

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Entrained dust in blast-furnace off-gas must be removed before the gas can be used as fuel. Wet scrubbing is the standard method for cleaning blast-furnace gas. Scrubber water, in addition to removing dust, also dissolves contaminants including ammonia, phenol, and cyanide from the blast-furnace gas. The scrubber water is contained in a recycle system and, a sidestream must be discharged to prevent scaling in the recycle system.

The objective of this research was to evaluate reverse osmosis (RO) as a candidate technique to minimize the quantity of wastewater discharged from the gas-scrubber recycle system. The RO permeate would be recovered as make-up water for the recycle system. The concentrate stream would be discharged for further treatment or possible evaporation via slag quench. Samples of blast-furnace recycle water were obtained locally, and tests were conducted with a spiral-wound cellulose acetate RO module at a pH of about 5. Operating pressures investigated were 350 - 450 psig, and feed operating temperatures were 74 - 86°F. Permeate flux rates (gpd/ft^2) were measured as a function of water-volume recovery level. Recovery levels were 10-80% plus.

Low membrane rejections were obtained for phenol, free cyanide, thiocyanate, and sulfide, indicating that these substances would be returned via the permeate to the recycle loop. Consequently, significant reductions in the discharge loadings of these materials could be achieved in the concentrate stream. These substances may not be conserved in the recycle system and, therefore, may not increase in concentration in the system. Aqueous discharge reductions of 70 - 80% appear possible.

Evaluation procedures for the RO system are discussed, applicability advantages and disadvantages are reviewed, and conceptual flow diagrams showing further treatment and disposal options for the reject stream are presented.

Review of Water Usage in the Iron and Steel Industry: Blast Furnace and Hot Forming Subcategories

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This paper gives results of a study of water usage and recirculation techniques in the iron and steel industry blast furnace and hot forming subcategories. The project was conducted for U.S. EPA's Industrial Environmental Research Laboratory, Research Triangle Park, NC. Initially, a list of zero- and low- discharge plants in the subject subcategories was developed from information provided in the "Draft Development Document for Proposed Effluent Limitations Guidelines for the Steel Industry." U.S. EPA wishes to verify the water application and discharge rates presented in the Development Document and update this information if necessary. The work also included a determination of specific process water quality requirements in blast furnace and hot forming operations, and identification of factors which limit process water recyclability, a survey of techniques used to implement zero- or low-discharge systems, and a study of the feasibility of implementing these techniques at existing plants. The study included: telephone and written communications with plant personnel, American Iron and Steel Institute representatives, EPA Regional and Effluent Guidelines staff members, and equipment manufacturers; a review of technical literature; and plant visits.

Control of Scale Formation in Steel Plant Water Recycle Systems

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Several options for scale formation control are discussed with particular reference to the recycling of scrubber water for blast furnace top gas. Experiments on carbonate scale formation are described and several important operating variables are discussed. Several types of sensors that might be used to aid in the avoidance of scaling are reviewed.

Reduction of Wastes Discharged from Steel Mills in Metropolitan Chicago through Local Ordinance Enforcement

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The Metropolitan Sanitary District of Greater Chicago (District) is a municipal corporation authorized under Illinois law to maintain and operate facilities for collecting and treating waterborne wastes in an 886 mi^2 area in northeastern Illinois. The District also enforces its Sewage and Waste Control Ordinance in an industrial community with in excess of 6,000 wet industries that discharge into sewers, inland waterways, and Lake Michigan.

Metropolitan Chicago contains the nation's largest industrial concentration. Included in the District's jurisdiction are five major steel-making facilities, all within 10 miles of the Calumet River. The facilities have a combined total production capacity of 7.8 million tons of steel per year. One of the District's major water pollution enforcement activities involves the five steel mills and began in 1969. Then, the five mills discharged 546 mgd of wastes into the Calumet River and Lake Michigan from 45 separate outfalls.

Enforcement action against the five plants was initiated after a comprehensive sampling effort. The laboratory analyses indicated that the discharges from the plants violated the District's ordinance limits, which incorporated State of Illinois waterway effluent standards. Following attempts at administrative conciliation and show-cause action, the District entered into protracted litigation against the five corporations owning and operating the plants.

Results of this local enforcement action were complete elimination of all process water discharged to the Calument River and Lake Michigan, and installation of process water treatment and recycling with residual blowdown to the District's sewer system. The only remaining discharges to the lake or river are non-contact cooling water.

A Mass Balance Model for Rinsewater in a Continuous Strip Halogen Electrolytic Tinning Operation for Use in Evaluating Wastewater Treatment and Recovery Alternatives

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The operation and rinsewater application of J&L's electrolytic tinning operation at Aliquippa are studied to specify a plating chemical recovery technology for wastewaters. The existing treatment method for wastewaters, hydroxide precipitation, is adequate to meet discharge limits, but economics favor a change that uses a form of recovery.

A mathematical mass balance model is developed to predict rinsewater concentration changes as flowrates are varied. The relationships described by the model are tested, and it is shown that the model for tin is followed within a narrow margin of error. The significance of this is that wastewater flow (and mass rate of tin in the wastewater) can be measurably reduced with no apparent product defects.

The model is refined to reflect the installation of rinsewater controls that optimize rinsewater use, and various recovery techniques are applied to this refined model. A comparison of these recovery methods indicates that several alternatives can recover plating chemicals successfully and have capital recovery periods of less than 1 year. In summary, the importance of modeling in this type of application is paramount to successful recovery.

Investigation of the Solid/Liquid Phase Separation of Preheated and Pipeline Charged Coke Battery Charging Liquor

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Inland's preheat and pipeline charged "C" Battery was built with a solid/liquid phase separation system containing a series of tanks to separate the coal fines collected during the charging process from the charging liquor. This phase separation system did not remove enough coal fines to prevent plugging of the charging liquor spray nozzles and a buildup of material in the charging main when the liquor was recycled. Consequently, several phase separation methods were investigated on the laboratory, pilot plant, and plant scales to establish their ability to decrease the solids content of the "C" Battery charging liquor to a concentration suitable for recycling. These methods were: gravity settling, horizontal belt filtration with and without precoat, hydrocyclone separation, spiral rake classification, conventional flotation, and dissolved air flotation.

All of the phase separation methods separated coal fines to some degree, but three methods (i.e., gravity settling, dissolved air flotation, and horizontal belt filtration with precoat) gave the best results. Gravity settling is easy to operate, but requires a large amount of land area for installation of a pit and the use of chemical additives to accelerate the settling of fines. Dissolved air flotation requires chemical additives and a liquor with a high solids content for best operation. In view of the variable solids and tar concentrations in the charging liquor, the gravity settling method was selected and settling pits were installed to separate coal fines from charging liquor at Inland's "C" and No. 11 preheated and pipeline charged coke batteries.

Assessment of the Biological Treatment of Coke-Plant Wastewaters with Addition of Powdered Activated Carbon (PAC)

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The U.S. Steel Corporation, in cooperation with the U.S. EPA, has conducted an extensive experimental biological-treatment program to develop data relative to Best Available Technology Economically Achievable (BATEA) for coke-plant wastewaters. This program included testing at both bench-and pilot-scale levels. One feature of this program was an assessment of the benefits of adding powdered activated carbon (PAC) to the biological reactor. In bench-scale reactors, gross removal efficiencies (measured by chemical oxygen demand (COD) and total organic carbon (TOC)) were determined with and without PAC. Comparisons were based on the effects of solids-retention time and on PAC-dose levels. A dual-train pilot-scale study was made at optimum conditions established during the bench-scale research to confirm the bench-scale comparisons. Results indicate that PAC does not significantly enhance effluent quality, compared with the effluent quality of a biological reactor operated at optimum conditions. Also, PAC-supplemented biological reactors treating coke-plant wastewater may undergo desorption of a substrate toxic to the thiocyanate-degrading organisms.

Biological Treatment of By-Product Coke Plant Wastewater for the Control of BAT Parameters

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This paper gives results of an evaluation of the activated sludge process for the treatment of coke plant wastewaters (CPW) to meet compliance with BAT limitations for conventional/nonconventional parameters. The evaluation entailed the operation of batch and continuous flow laboratory scale reactors, and a 50 gpd pilot plant.

The study produced understanding of (a) the sequence in which the different components in CPW are removed, (b) the order of the degradation reaction associated with each component, (c) the potential inhibitory effects of different CPW components on the different degradation reactions, and (d) kinetic expressions associated with treatment rates and sludge production which could be used to design the biological treatment system.

Two-Stage Biological Fluidized-Bed Treatment of Coke Plant Wastewater for Nitrogen Control

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The feasibility of the biological fluidized-bed process has been demonstrated for both carbon and nitrogen removal from municipal and concentrated wastewaters. The process can provide significant advantages over conventional suspended growth activated sludge systems owing to the high biomass concentrations that can be maintained in the reactors. The technical and economic feasibility of treating coke-plant wastewater in a two-stage fluidized-bed system, operated in the predenitrification/nitrification mode, is being evaluated at pilot scale at the Wastewater Technology Centre, Burlington, Ontario. This paper reports on the experiences of operating this process configuration.

The pilot plant consists of a 150 mm diameter anoxic denitrification fluidized-bed reactor, coupled to a 290 mm diameter oxygenic nitrification fluidized-bed reactor. Biomass is retained as a fixed film on a support medium of 0.48 mm diameter quartzite sand. Bed reaction volumes are 58.5 and 210 litres, respectively. Pure oxygen is supplied to the nitrification reactor through a proprietary oxygen transfer device provided by Dorr-Oliver Inc. Raw feed consists of limed ammonia still effluent and light oil interceptor sump wastewater from Dominion Foundries and Steel Ltd. (DOFASCO) in Hamilton, Ontario.

At anoxic and aerobic hydraulic retention times (HRTs) of 0.13-0.4 and 1.13 - 1.9 days, respectively, complete nitrogen control and high levels of contaminant removal were effected in undiluted wastewater. Very high recycle ratios for both reactors were required to maintain adequate flux rates to fluidize the sand support medium. Operational problems associated with the accumulation of inorganic (calcium phosphate) and organic residues in the biomass films have been overcome successfully. High effluent suspended solids have prevented strict solids retention time control. Steady-state experiments are continuing to define the minimum system HRT required to achieve consistent nitrogen control.

Based on these results a comparison is made with the results obtained with a suspended growth predenitrification/nitrification system that was evaluated in an earlier phase of this work.

Trace Metal Removal from Steel Plant Wastewaters Using Lime and Ferrate

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The potential of ferrate for disinfection and chemical oxidation in potable water production and domestic wastewater treatment has been recently identified. This paper is primarily aimed at evaluating the mechanism and effectiveness of ferrate for trace metal and suspended material removal for iron- and steel-making wastewater application. A combined experimental and theoretical approach was used.

Conclusions of this work are:

1. Ferrate has promise for solids and metal removal in steel plant wastewaters.
2. Lime pretreatment is effective to reduce ferrate doses, but postfiltration may be required.
3. Complex dependence on solution chemistry is observed for lime-plus-ferrate or ferrate-only treatment.
4. Comparison of ferrate and ferric shows varying optimal dependency on the metal ion to be removed.
5. Preliminary theoretical computations show considerable difference from experiment, except for Pb removal.

6. Removal of metals in actual wastewaters was high at low dose when provision for added settling is included.
7. Conjunctive oxidation benefits of ferrate should be explored for priority pollutant removal in steel plant wastewaters.

Pilot Evaluation of Alkaline Chlorination Alternatives for Blast Furnace Blowdown Treatment

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To continue discharge of blowdown from blast furnace recycle systems in upcoming years, blowdown water quality will be required to meet the Best Available Technology (BAT) effluent limitations. Pilot plant investigations employing three alternative alkaline chlorination process schemes were conducted to evaluate their effectiveness in treating blast furnace blowdown. The process schemes were single-stage alkaline chlorination, two-stage alkaline chlorination, and air stripping followed by two-stage alkaline chlorination. All three processes were effective in removing ammonia and cyanide, although with varying degrees of success in meeting the presently proposed BAT effluent limitations for the iron-making subcategory of the iron and steel industry. Single-stage alkaline chlorination very effectively removed cyanides but did not provide favorable conditions for complete oxidation of cyanates and ammonia. Two-stage alkaline chlorination provided favorable conditions for oxidation of cyanides, cyanates, and ammonia but required a more complex control system. The air stripping/alkaline chlorination process reduced chlorine requirements by stripping ammonia, while still providing favorable conditions for complete oxidation of cyanide and additional ammonia removal. A comparison of estimated capital and operating costs for each of the alternative schemes is presented.

Abstracts of papers not presented at the symposium but which are published in the proceedings follow:

Application of Second Generation Chemical Solidification/Fixation Processes to Iron and Steel Hazardous Waste Problems

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The iron and steel industries produce various waste sludges and other liquid, semiliquid, and solid wastes which contain toxic metals and other hazardous constituents. Since 1970, several chemical solidification/fixation processes have been tested successfully for some of these waste streams but, primarily due to economics, have not been extensively used. The advent of RCRA has altered this situation, and it is expected that solidification techniques will become important in the near future. In the meantime solidification/fixation technology has progressed from the few, early, broad-spectrum processes to engineered systems which can be most efficiently applied to specific waste streams. This paper will discuss the basic chemical systems in use, their properties and limitations, and the delivery systems for applying them on a commercial basis. The design parameters which must be considered in choosing a solidification technology will also be described. In addition to process and system parameters, the interaction of the treated waste with the environment—in this case, the land disposal site—must be assessed. The paper discusses final disposal practices as they affect, and are affected by, RCRA regulations and the test methods used to determine if a treated waste is hazardous. Current economics of various processes on typical waste streams are compared with other alternatives for hazardous waste disposal.

Optimizing Existing Wastewater Treatment Facilities in Preparation of Meeting BAT/BCT Regulations in the Iron and Steel Industy

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This paper discusses the impact of the BAT/BCT regulations on existing central treatment facilities. To prepare for these new regulations, it will be necessary to review the origin of the waste sources and install pretreatment facilities or internal recycle loops to minimize the cost of end-of-the-pipe treatment schemes. The three examples reviewed in this paper are for a hot mill, a cold mill, and a by-product area.

Development of a Deoiling Process for Recycling Millscale

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The paper presents the practical approach to the recovery, processing, and recycling large tonnages of oily millscale. This paper describes the basic design and operating principles of a combustion technique for deoiling and beneficiating millscale resulting in a feed material of consistent quality for sinter plant and blast furnace. Millscale composition, particle size distribution, and chemical analysis are discussed with emphasis on proper preparation for economical recycling. Also covered are environmental and raw material implications in the present and future.

Recycling of Tar Decanter Sludge

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Tar is a saleable by-product of coke making. The tar is driven off from the coal in the coke ovens. It is collected, condensed, and separated from the water phase in tar decanters. In the processing some of the tar becomes contaminated with solids (primarily coke fines) and is unsuitable for sale.

Many different options were examined to most efficiently dispose of these wastes. The use of tar sludge as a roofing material and in asphalt mixing was studied. Experiments are being conducted to recycle the waste oil to the rolling mills. This paper covers the most promising method of disposal—recycling the oils and tars to either the blast furnace or coke ovens. Bench scale mixes and pilot testing are covered.

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***John S. Ruppersberger** is the EPA Project Officer (see below).*

The complete report, entitled "Proceedings: Symposium on Iron and Steel Pollution Abatement Technology for 1981," (Order No. PB 83-164 038; Cost: $40.00, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650

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