Air Pollution Aspects of Emission Sources:

IRON AND STEEL MILLS

A Bibliography with Abstracts

U. S. ENVIRONMENTAL PROTECTION AGENCY

AIR POLLUTION ASPECTS OF EMISSION SOURCES: IRON AND STEEL MILLS— A BIBLIOGRAPHY WITH ABSTRACTS

Air Pollution Technical Information Center

ENVIRONMENTAL PROTECTION AGENCY
Office of Air Programs
Research Triangle Park, North Carolina
May 1972

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 - Price $1.00

The AP series of reports is issued by the Environmental Protection Agency to report the results of scientific and engineering studies, and information of general interest in the field of air pollution. Information presented in this series includes coverage of intramural activities involving air pollution research and control technology and of cooperative programs and studies conducted in conjunction with state and local agencies, research institutes, and industrial organizations. Copies of AP reports are available free of charge - as supplies permit from the Air Pollution Technical Information Center, Environmental Protection Agency, Research Triangle Park, North Carolina 27711.

Publication Number AP-107

CONTENTS

INTRODUCTION v

ANNOTATED BIBLIOGRAPHY

A. Emission Sources 1

B. Control Methods 12

C. Measurement Methods 50

D. Air Quality Measurements 52

E. Atmospheric Interaction (None)

F. Basic Science and Technology 54

G. Effects - Human Health 56

H. Effects Plants and Livestock (None)

I. Effects - Materials 61

J. Effects Economic 62

K. Standards and Criteria. 65

L. Legal and Administrative 66

M. Social Aspects 67

N. General 68

AUTHOR INDEX 69

SUBJECT INDEX 73

AIR POLLUTION ASPECTS OF EMISSION SOURCES: IRON AND STEEL MILLS— A BIBLIOGRAPHY WITH ABSTRACTS

INTRODUCTION

Iron and steel mills contribute significantly to the overall air pollution level in the United States. To aid efforts to improve air quality, the Air Pollution Technical Information Center (APTIC) of the Office of Air Programs has compiled this bibliography relevant to the problem and its solution.

Approximately 302 abstracts have been selectively screened from the contents of APTIC's information storage and retrieval system to cover the 14 categories set forth in the table of contents. The compilation is intended to be representative of available literature, and no claim is made to all-inclusiveness.

Subject and author indexes refer to the abstracts by category letter and APTIC accession number. Generally, higher accession numbers, representing the latest acquisitions, cover the most recent material.

All documents abstracted herein are currently on file at the Air Pollution Technical Information Center, Office of Air Programs, Environmental Protection Agency, Research Triangle Park, North Carolina 27711. Readers outside the Environmental Protection Agency may seek duplicates of documents directly from libraries, publishers, or authors.

A. EMISSION SOURCES

02146

QUALITY CONTROL OF AIR AND WATER-A CONTINUING U.S.STEEL CONCERN. U.S.STEEL NEWS 31, (7) 8-11, NOV. 1966.

This article summarizes the efforts made by U.S. Steel in the last 15 years to control air and water pollution from their steel plants. The control of air and water quality is vested in a committee which reports directly to top management, the Operations Policy Committee, and is composed of representatives of the engineering and research, law, personnel, and production departments. Electrostatic precipitators and wet scrubber applications are discussed. Processes for controlling air pollution include mechanical (i.e. centrifugal force), electrostatic, washing, vacuum cleaning through filters, and incineration applications.

04000

G. W. Perbix

THERMODYNAMIC EVALUATION OF BASIC OXYGEN FURNACE HOT MODEL STUDIES. J. Metals (Japan) 18, (8) 824-31, July 1966. (Presented at the Annual Meeting, American Inst. of Mining, Metallurgical and Petroleum Engineers, New York City, 1966.)

BOF hot models tests were carried out with a 150 lb metal charge in order to investigate the effects of blowing conditions on refining kinetics, oxygen efficiencies, and thermodynamic aspects of BOF steelmaking. The results from 20 heats are reported covering a range of oxygen flow rates from 4.5-11 scfm or 60-147 scfm per net ton of metallic charge at lance-to-bath distances of 2-6.5 in. The following results were obrained: (1) Decarburization kinetics are strongly affected by lance height and oxygen flow rate. Carbon removal proceeds at the highest rate toward the end of the heat. A decrease in decarburization rate at a carbon level higher than 0.10% C was observed only once for a heat blown under extremely soft conditions; (2) The decarburization reaction is strongly temperature-dependent. Scatter in the results is traced to differences in temperature patterns during the course of the heats; (3) Oxygen efficiencies are evaluated for the decarburization reaction and the total reaction history. These oxygen efficiencies are also controlled by blowing conditions. For hard blows, efficiency values of 100% are reached; and (4) The thermodynamic portion of this investigation is focused on the manganese oxidation and its distribution between metal and slag. The path of the manganese reaction is analyzed for each heat and plotted as a function of temperature for different blowing conditions. Large deviations from equilibrium prevail for the better part of the blowing time. Toward the end of the heat, at carbon levels of 0.10% C, equilibrium is approached in all cases. Attainment of near-equilibrium values at the end of the blowing period means that, for low-carbon steels, manganese yield is controlled mainly by the FeO content of the slag. The FeO content of the finish-slag and, consequently, manganese yield are strongly affected by blowing conditions. (Author summary)

04001

J. G. Harhai and D. A. Dukelow

FACTORS AFFECTING SULFUR REMOVAL IN THE BASIC OXYGEN PROCESS. J. Metals (Japan) 18, (7) 833-5, July 1966.

The problem of unpredictably high sulfur contents in steel and factors affecting sulfur removal at the basic oxygen shop of Pittsburgh Steel Co. have been analyzed. It has been found that heats with high burnt dolomite charges in place of lime show a lower frequency of good desulfurization performance. The index of measurement was the ratio of sulfur content in the steel to that in the charge and is defined as the sulfur removal ratio (SRR). High MgO slags are apparently detrimental to sulfur removal because of the resulting higher slag viscosity and lower desulfurization potential of MgO relative to CaO. In studying the question of blast furnace slag carry-over, a special depth reading device was constructed and used to measure the depth of slag-kish atop the hot metal transfer ladle. The data of 251 heats were investigated by multiple regression analysis on an IBM 1410 computer and the derived model equation, although not reliable enough for a quantitative calculation of SRR, confirmed the significance of blast furnace slag carry-over and the resultant effect on SRR. The model also indicated the relative importance of variables affecting sulfur removal in the basic oxygen process. Based on the findings of this study, the flux charge practice has been altered to permit a lower burnt dolomite charge. In addition, steps have been taken to improve hot metal and slag separation practices at the blast furnace and a facility is being modified to serve as a submarine ladle dekishing and deslagging station. (Author summary)

04345

D. D. Wangerin

WASTE-HEAT BOILERS - PRINCIPLES AND APPLICATIONS. Proc. Am. Power Conf. (Presented at the 26th Annual Meeting, American Power Conference, Chicago, Ill., Apr. 14-16, 1964.) 26, 682-91, Apr. 1964.

The special problems which the waste-heat boiler designer encounters are reviewed. Some of the more recent improvements in the utilization of waste by-products for steam generation are illustrated. The types of waste-heat boilers available are discussed. The discussion is limited to the utilization of the principal waste products available in three major industries - pulp and paper, steel, and petroleum. All of the waste fuels considered have characteristics that require special equipment-design considerations. Waste fuels are extremely poor when compared with the usual prime fuels. Many byproduct fuel or waste gases contain sufficient heat energy to make it economically feasible to generate steam for power and process use. Each waste fuel has a different characteristic, requiring a boiler of special design. But, all have very low heating values when compared with the usual prime fuels. In many cases, multiple-fuel-fired boilers can be designed to dispose of the waste product while minimizing the burning of the prime fuels. So, with cost of prime fuels steadily rising over the years,

waste products are more and more harnessed to provide part of industry's steam demands.

04946

A. F. Snowball

DEVELOPMENT OF AN AIR POLLUTION CONTROL PROGRAM AT COMINCO'S KIMBERLEY OPERATION. J. Air Pollution Control Assoc. 16, (2) 59-62, Feb. 1966.

During the concentration of lead and zinc sulfides from Cominco's Sullivan Mine at Kimberley, British Columbia, there is also produced an iron sulfide concentrate as a byproduct. A portion of these iron concentrates is roasted and the resulting calcine is treated in electric furnaces to produce 300 tons of pig iron per day. The sulfur dioxide produced in the roasting process is used to make sulfuric acid which is employed in the manufacture of ammonium phosphate fertilizers. Problems in the control of air pollution resulting from the iron sintering, iron smelting, and fertilizer operations at Kimberley are discussed, including those arising as a result of almost continuous expansion of these facilities since their establishment 12 years ago. (Author abstract)

05005

R. P. Hangebrauck, D. J. von Lehmden, and J. E. Meeker

SOURCES OF POLYNUCLEAR HYDROCARBONS IN THE ATMOSPHERE. Public Health Service, Cincinnati, Ohio, National Center for Air Pollution Control. (PHS Publ. No. 999-AP-33.) 1967. 48 pp.

Rates of emissions of polynuclear hydrocarbons were measured at several sources considered likely to produce such emissions. The sources included heat generation by combustion of coal, oil, and gas; refuse burning; industrial processes; and motor vehicles. The annual emissions of benzo(a)pyrene in the United States were estimated for each of the sources surveyed, to provide a rough gauge of the importance of each source. Small, inefficient residential coal-fired furnaces appear to be a prime source of polynuclear hydrocarbons; other sources may be of local importance. Production of polynuclear hydrocarbons was generally associated with conditions of incomplete combustion. (Author abstract)

08392

J. D. Clendenin

THE UTILIZATION OF COAL. Am. Chem. Soc., Pittsburg, Pa., Div. Fuel Chem. Preprints, 9(2):222, 1965. (Presented at the 149th National Meeting, American Chemical Society, Division of Fuel Chemistry, Symposium on Fuel and Energy Economics, Detroit, Mich., April 4-9, 1965.)

A brief survey is presented of current and prospective utilization of coals including lignite, (1) in the production of metallurgical, chemical and specialty cokes, (2) as fuel for process steam, space and home heating, locomotives and ship bunkers, (3) In the manufacture of industrial producer gas and gas for chemical synthesis, (4) as fuel in cement and lime kiln firing, (5) at steel and rolling mills and (6) in a variety of specialty and/or non-fuel uses, including industrial carbons, active carbon, fillers, filter aids and media, water treatment, foundry facing, road building, roofing and coating applications, barbecue briquets, fertilizer and soil conditioner, coal-based plastics, etc. Insofar as possible, information is presented on process and product research and other developments that may affect coal utilization, favorably or unfavorably, in the areas cited. Since economics of coal utilization cannot be divorced from economics of coal supply and transportation, these are touched upon briefly. (Author's abstract)

09572

Miller, C. E.

PULVERIZED COAL INJECTION INTO BLAST FURNACES. Blast Furnace Steel Plant, 56(3):235-240, March 1958. 5 refs.

The use of pulverized coal injection into blast furnaces is economically attractive. Based on the 1965 blast furnace coke consumption, the use of coal in place of 25 percent of the coke used could produce an annual saving of more than 125 million dollars. Although the capital investment to install a pulverized coal system is substantially greater than for an oil or gas system, the cost reduction from the substitution of coal for oil is about $1.04/Net Ton Hot Metal and for coal in place is about 93 cents NTHM, which makes recovery of the initial investment in two years possible. Improved materials handling, space saving, and improved air pollution control are additional features of coal injection systems.

09686

R. L. Duprey

COMPILATION OF AIR POLLUTANT EMISSION FACTORS. Public Health Service, Durham, N. C., National Center for Air Pollution Control, Publication No. 999-AP-42, 67p., 1968. 126 refs.

Detailed emission factors are given for the following processes and industries: fuel combustion, refuse incineration, chemicals, food and agriculture, metallurgical refining, minerals, petroleum, pulp and paper solvent evaporation and gasoline marketing, and transportation (vehicle emissions).

09737

Ozolins, G. and C. Behmann

AIR POLLUTANT EMISSION INVENTORY OF NORTHWEST INDIANA. (A PRELIM- INARY SURVEY, 1966.) Public Health Service, Durham, N. C., National Center for Air Pollution Control, APTD-68-4, 36p., April 1968.

Sources of air pollutant emissions were surveyed to quantify the total pollution load emitted to the air over the Northwest Indiana communities of East Chicago, Gary, Hammond, and Whiting. The emissions are reported on an annual basis and subdivided into the five major pollutants: particulates, sulfur oxides, nitrogen oxides, hydrocarbons, and carbon monoxide. The four major source catagories that were utilized in reporting emissions from area and point sources are: fuel combustion in stationary sources, fuel combustion in mobile sources, combustion of refuse, and industrial process losses. The results of this survey are reported by city and illustrated on the grid system established by the Northwest Indiana Air Resource Management Program. (Authors' abstract)

10463

Bogdandy, L. von

VAPORIZATION AND REFINING. (PART II-A OF THE KINETICS OF IRON AND STEELMAKING REACTIONS.) Arch. Eisenhuettenw., 32(5):287- 292, May 1961. 87 refs. Translated from German. Henry Brutcher Technical Translations, Altadena, Calif., HB-5334, 17p., 1961. Available from Henry Brutcher Technical Trans- lations, P. O. Box 157, Altadena, Calif.

Iron and steelmaking reaction mechanisms and kinetics are dis- cussed in detail. The formation of droplets and brown fumes are considered in the light of nucleation theory. Elimination of car- bon from pig iron is the most important reaction in steelmaking; the equilibrium between carbon and iron is discussed theoretically, along with the effect of oxygen content on the frequency of CO nucleation from a homogene-

ous iron melt, the wetting relationships in Fe-CO-slag or vessel wall system, and the wetting of refrac- tories by liquid iron. Applications of the theories of fume for- mation and carbon elimination to the open hearth process are discussed.

10466L

Migawi, M., Fikri Abdel'razik, A. F. Vishkarev, and V. I. Yavoiskii

EFFECT OF VARIOUS FACTORS UPON THE QUANTITY OF BROWN FUMES PRODUCED IN OXYGEN STEELMAKING. Izv. Vysshikh Uchebn. Zavedenii Chernaya Met., No. 1: 41-45, Jan. 1964. 3 refs. Translated from Russian. Henry Brutcher Technical Translations, Altadena, Calif., HB-6247, 7p., Jan. 1964. Available from Henry Brutcher Technical Translations, Altadena, Calif.

A laboratory study of the factors effecting the quantity of brown fumes produced in oxygen steelmaking was conducted. For carbon contents up to 0.5% little smoke is produced. Emission gradually increases with carbon concentration up to 2%, where smoke increases sharply probably due to phase changes in the iron at this carbon level. Also considered are the effects of carbon concentration on the rate of oxygen absorption and the quantity of fumes produced when iron is oxidized by Fe2O3 in an inert atmosphere. The effects of temperature, blowing with nitrogen and hydrogen, and total oxygen consumption on fume emission are also examined.

10467L

Harms, F. and W. Riemann

MEASUREMENT OF FUMES AND DUST VOLUMES FROM 70-TON ELECTRIC ARC FURNACES OPERATED PARTIALLY ON OXYGEN. Stahl Eisen, 82(20):1345 1348, 1962. Translated from German.Henry Brutcher Technical Translations, Altadena, Calif., HB-5719, 12 p., 1962. Available fro Henry Brutcher Techni cal Translations, P.O. Box 157, Altadena, Calif., 91001

Measurements of waste gas and the dust content from a 70 m. ton electric arc furnace are reported. The results show that considerably higher contents of carbon monoxide occur in the presence of several percent of oxygen than was previously supposed. The volume and composition of the deposited dust depend to a great extent on the particular stage of the heat and on the type of steel being produced. The impirical basis of 200 Ncu.m of waste gas per m ton of charge, which has hitherto been used for the calculation of waste gas cleaning plants, is confirmed with reasonable certainty b these measurements. (Authors' summary, modified)

10471L

Kahnwald, H. and O. Etterich

DETERMINATION OF THE VOLUME, COMPOSITION, AND TEMPERATURE OF THE WASTE GAS AND THE DUST DURING MELTDOWN AND OXIDATION BY OXYGEN LANCING IN A 15-TON ELECTRIC ARC FURNACE. Stahl Eisen, 83(17):1067-1070, 1963. 5 refs. Translated from German. Henry Brutcher Technical Translations, Altadena, Calif., HB- 6066, 14p., 1963. Available from Henry Brutcher Technical Translations, Altadena, Calif.

An experimental gas evacuation plant was built on to a 15 ton electric arc furnace. This was used for the determination of the composition, volume and temperature of the waste gas and the evolution of dust during melt-down and oxidation with gaseous oxygen. A linear relationship exists between the carbon monoxide evolved and the dust arising per unit time. The dust content of the gas evolved in the furnace accordingly is constant, amounting to 119 g/Ncu.m CO. The experimental results are not generally valid and can only be applied conditionally to other relationships. (Authors' summary, modified)

10474L

Meldau, R.

EVOLUTION OF FUMES FROM STEEL BATHS AT HIGH TEMPERATURES. Stahl Eisen, 80(19):1288-1289, 1960. 11 refs. Translated from German. Henry Brutcher Technical Translations, Altadena, Calif., HB-4938, 9p., 1960. Available from Henry Brutcher Technical Translations, P. Box 157, Alatadena, Calif. 91001

International literature on the causes of fume formation in various steelmaking processes is critically reviewed. Although the theories and mechanisms presented differ, most researchers agree th fume development is somehow connected with carbon elimination. Oxygen- lance temperature is also suggested as a factor in smoke formation. In addition, the effects of CO, bubbles, alloying materials, and impurities on fume production are discussed.

11974

Nikami, K., K. Matsuda, T. Koyano, and T. Yasui

THE WASTE GASES LEAVING THE BASIC OXYGEN LD FURNACE. Tetsu To Hagane, 52(9):1491-1493, 1966. Translated from Japanese. Henry Brutcher, Technical Translations, Altadena, Calif., 8p., 1967.

Basic oxygen furnace gases were examined with a view of utilizing their properties to automate the steelmaking process in the basic LD oxygen furnace. The sampling apparatus consisted of a water- cooled probe fitted with channels for water cooling and gas, and a suction disk with a steam injector. The following properties were determined for the gases emerging from the sampling system: gas temperature at the suction disk outlet, 30-40 C; humidity at the suction disk outlet, 100%; dust content at the suction outlet, 0.2 g/N cu m; and gas temperature at the cooler outlet, 5 C. Hardly any obstruction of the probe tip took place during the blow, indicating that continuous analysis of carbon monoxide and carbon dioxide is possible. When the relationship between the CO and CO2 contents of the gas was investigated, an almost identical pattern was obtained, even when the oxygen lance height and the blowing pressure were changed. After 70% of the blow was completed, the percentages of CO and CO2 became constant. When the steel carbon content decreased below 0.10%, the concentration of CO decreased and that of CO2 increased. Though no direct connection was established between the proportion of CO and CO2 in the furnace gases and the reactions taking place in the furnace, it is believed that the gases provide useful information about blowing processes.

12396

Gedgaudas, Marius J.

THE EMISSION INVENTORY AND ITS APPLICATION IN THE IRON AND STEEL INDUSTRY. Preprint, National Air Pollution Control Administratio Raleigh, N. C., Div. of Abatement, 13p., April 1969.

A summary is presented of emission inventory objectives and procedures; an example is given of emission calculations for a hypothetical steel mill, based on published data. The emission inventory data includes techniques for defining study boundaries, selecting a grid system, defining point and area sources, compiling a questionnaire mailing list, estimating fuel and solid waste balances, using emission factors, presenting data, and using results in a control program. Illustrations are given on

calculations of emissions from the major operations in a steel mill, including coking, blast furnace, sintering, open hearth, and power plant operations. (Author abstract modified)

13261

Voronov, F. D., I. A. Taldykin, B. L. Markov, V. G. Antipin, and V. F. Bogatenkov

DUST FORMATION IN A TWO BATH STEEL FURNACE. (Pyleobrazovaniye v dvukhvannoy staleplavil 'noy pechi). Text in Russian. Izv. Vysshikh Uchebn. Zavedenii Chernaya Met., no. 8:62-64, 1968. 2 refs.

Tests carried out on a 215 ton martensite furnace revealed that tuyere placement plays the greatest role in the production of lignite smoke, a major constituent of exhaust dust. During furnace operation without oxygen scavenging, the dust content of exhaust gases during filling, melting, and melt removal is 2.1, 1.4, and 1.3 g/cu m, respectively. Dust samples in this case contained 70-90% iron oxides, pointing to the metal bath as the main dust source, the presence of other metal oxides indicating slag and refractory materials as additional sources.

14799

Barnea, M.

AIR POLLUTION CAUSED BY IRON AND STEEL MANUFACTURING. (Impurificarea aerului atmosferic produsa de industria siderurgica). Text in Rumanian. Igiena (Bucharest), 16(12): 741-746, 1967. 10 refs.

The industrial complexes of Hunedoara and Resita were studied over a ten-year period by the Bucharest Institute of Health, while the complex of Timisoara was studied by the local board of health. Hunedoara, while producing more tonnage of metal than Resita, has a smaller air pollution problem due to better movement of air. The city of Deva, however, has a lower incidence of respiratory, ophthalmic, and rachitic illnesses. Timisoara has both higher production and greater air pollution, with over 50% of samples collected containing above-normal content of SO2, although not above 0.50 mg/cu m. Pollution particles also filter out 3/4 of the city's solar radiation. Improvement of existing conditions and provision for future industrial expansion depend on improving efficiency of purification systems, whose cost is often prohibitive, and more careful urban planning.

17199

Oshio, Toshiki

AIR POLLUTION PROBLEMS IN JAPAN (I). (Wagakuni ni okeru taiki osen to sono mondaiten (I)). Text in Japanese. Kogai to Taisaku (J. Pollution Control), 4(4):197-208, April 15, 1968.

It is known that air pollution grows more serious where various types of industries are concentrated in one area. The coastal industrial area in Japan is typical in this respect: the recent tendency of plants to locate on, or adjacent to the coastline is particularly reflected in locations of petroleum refineries and petrochemical plants associated with iron and steel refineries or with thermal power plants for whom coastal areas provide shipping advantages. The difficulty of shoreline air pollution control lies in the diversity of industries involved. Factors associated with different pollutants generated by individual plants must be investigated to determine the collective effect of combined pollutants. For example, where heavy oil is burned, the determination of the air-pollution load in the immediate area is based on multiple density, which is the product of the total quantity of exhaust gas emission and respective density of each pollutant. In addition, several major types of effects of the concentration of air pollutants after they leave emission sources should be taken into consideration. Dispersion of pollutants depend on the effective emission height of the chimney, efflux velocity, wind speed, and other geographical conditions which complicate the behavior of atmospheric pollutants in coastline areas. The major sources of sulfurous gases are the thermal power plants, iron-steel refineries, petroleum refineries and petro chemical plants, but there are additional pollutants which make the pollution density thicker. Since sulfurous gas alone may be less important in qualitative and quantitative respects, other combustion products, such as metal sulfides or sulfates generated in iron-steel plants, need to be considered in shoreline pollution abatement programs.

17252

Odaira, Toshio, Sadao Imano, Saburo Fukuoka, and Yoshihide Agata

QUALITIES OF THE PARTICLE EMITTED FROM STEEL MANUFACTURING ELECTRIC FURNACE. (Seikoyo denkiro no baien no seijo). Text in Japanese. Kogai to Taisaku (J. Pollution Control), 2(5):26-27, June 15, 1966.

An electromelt furnace was investigated by the Japan Industrial Standard method (Z-8808, K0103). A small bag filter and a cascade impactor were used as the precipitators. A smoke cylinder (2.4 m in diameter) was placed 5 m above the furnace. The mean velocity of exhaust gas was 3.5 m/s; during the oxidizing period, it was 1 m/s and during the reducing period, 2.5 m/s. The amount of gas measured was 40,000 N cu m/hr, and 22,000 N cu m/hr, and showed that the attenuation is more than 90% and 95%, respectively. The quantity of particles 5 m above the furnace were about 4.5 g/N cu m and 1.5 g/N cu m; at the generated point, it was estimated to be about 55 g/N cu m and 50 g/N cu m, respectively when diluted. The distribution of the diameter of the particles gathered by the bag filter, both in the oxidizing and reducing period, indicated that one-half of the particles (by weight) were less than 10 micron in diameter. Particles of the oxidizing period in the cascade impactor were spheres, 0.1-1.0 micron in diameter, which is one-half the diameter of the particles in the reducing period. Plans for smoke installations must be investigated in view of fine particles.

17299

Saruta, Namio, Noburu Ishinishi, Yasushi Kodama, Eizaburo Kunitake, Toshio Baba, and Yoko Katori

AIR POLLUTION CAUSED BY EXHAUSTED GASES FROM MOTOR VEHICLES IN BOTH KITAKYUSHU CITY AND FUKUOKA CITY. (I). (Kogyotoshi to shogyotosh niokeru jidosha haikigasu niyoru taikiosen no hikaku - Kitakyushushi oyobi Fukuokashi niokeru jittai chosa kara (I)). Text in Japanese. Kogai to Taisaku (J. Pollution Control), 4(11): 735-739, Nov. 15, 1968.

Kitakyushu City is one of the most polluted cities in Japan. Compared to the soot and smoke emitted by the iron works in Yahata Ward, air pollution by automotive exhaust gas is small, although the latter is becoming a serious public nuisance during rush hours when traffic comes to a standstill because of the number of vehicles on the highways and the number of traffic intersections At present, air pollution control measures in Kitakyushu are directed mainly against the soot and smoke by factories and center on the Kitakyushu and Omuta industrial belts; automotive exhaust gas is not yet a matter of interest. Over a one year period, air quality measurements were made every other month at two sidewalk points along the highway in Yahata Ward and also at two sidewalk points near an intersection in the commercial city of Fukuoka. Seasonal

changes in air pollution, differences in air pollution due to the social and economic characteristics of the cities, and the relation of air pollution due to factory soot and smoke to that due to automotive exhaust gas are being studied. Conclusions will be given in a forthcoming report.

17471

Knop, Wilhelm

INDUSTIRAL DUSTS AND WASTE GASES. (Industriestauebe und-abgase). Text in German. Wasser Luft Betrieb, 14(2):63-66, Feb. 1970. 22 refs.

The most dangerous and annoying pollutants emitted by various industries are enumerated. Steel mills emit primarily iron oxides and fluorine compounds. Half of the original fluorine input is emitted; the other half goes into the slag. The iron oxide emissions, primarily the small particles below 5 micron, form the brown smoke. The non-ferrous metal fabricating and finishing plants emit metal oxides (cadmium oxide). When inhaled, the latter may be extremely harmful. The TLV (threshold limit value) is 0.1 mg/cu m air. In aluminum production, dust-laden waste gases develop, despite the wet process. The aluminum oxide dust content in the rotary furnace is 300-400 g/standard cu m. In electrolytic reduction of aluminum oxide, cryolite also dissociates. As a consequence, hydrogen fluoride and dusts of fluorine compounds are found in the waste gas. The TLV for fluorides is 2.5 mg/cu m; for hydrogen fluoride, 2 mg/cu m. In lead plants 3 to 3.5 cu m waste gases per kg sinter develop in the sintering and roasting station. They contain 1.5 to 5% by volume SO2 and up to 15 g/cu m dust. The dust contains lead, zinc, sulfur, and small amounts of other elements. Considerable amounts of metal vapors develop. In the fly dust of the shaft furnaces, cadmium oxide or sulfate, arsenic, zinc, and thallium compounds may be found. In copper smelting plants, the waste gases contain fly dust and SO2. In zinc refining, fly dust (0.1 g/standard cu m) and SO2 are emitted to the waste gas. In ferro-alloy production, dusts of various kinds are carried along in the waste gases. The waste gas quantity of a 10 MW furnace amounts to 70,000-250,000 cu m/h; the dust content, to 0.25-2.5 g/cu m.

17516

Watanabe, Goro, Masaharu Murakami, and Keimi Yamawaki

COUNTER-MEASURES TO AIR POLLUTION AND KURE WORKS (CONCERNING MAINLY THE MEASURES TO BE TAKEN AGAINST THE PUBLIC HAZARDS CAUSED BY SO2). Kure-seitetsusho ni okeru taikiosen ni tsuite. Shutoshi SO2 no kogaitaisaku ni tsuite). Text in Japanese. Nissshin Seiko Giho (Nisshin Steel Tech. Rept.), no. 17:33-54, Nov. 1967. 6 refs.

Air pollution becomes a particularly serious problem when many large industrial plants are concentrated in one area. In the case of Kure iron works, there is no real danger of a large-scale air pollution because of the small amounts of waste gas, but localized pollution is a problem, due to the complex topography of the plant site and the closeness of a residential area. After an investigation of air pollution by sulfur dioxide around the Kure works, it became clear that localized pollution involved the down-draught of exhaust fumes and that the phenomenom was caused by the topographical situation. The main source of the exhaust fumes was the sintering plant. A subsequent review of control methods indicated the advantages of a tall chimney for obtaining adequate diffusion, and wind-tunnel tests were conducted to determine the stack height required. A height of 100 m was found to tbe sufficient for normal weather conditions but not for special conditions such as a temperature inversion. Therefore, a stack 120 m high is being built.

20414

Rengstorff, George W. P.

FACTORS CONTROLLING EMISSIONS FROM STEELMAKING PROCESSES. *Open Hearth Proc., vol. 45:204-219, 1962.* 7 refs.

The possibility of modifying the form of iron oxide smoke, so that more effective and/or less expensive smoke-elimination devices could be used is considered. The new experimental data, presented in the form of graphs, were obtained either from a top-blowing process in a bessemer converter, or from a direct study of vaporization of iron oxide. The effect on the formation of iron- oxide smoke of the oxygen jet velocity, the carbon content of the iron, the temperature of the metal, water additions, other hydrogeneous gases, and the slag formation are presented. Hypotheses on the mechanism of iron-oxide smoke formation are discussed. Both industrial practice and laboratory studies lead one to the conclusion that two conditions must exist simultaneously for iron-oxide smoke to form in objectionable quantities: a mechanism for moving Fe or a Fe compound from the bulk of the liquid metal into the gas, either as a metal vapor or as an aerosol; a gaseous medium which is, at least slightly, oxidizing close to the bulk of the liquid metal. A previously suggested mechanism which seems to explain most of the known facts, is the vaporization of metallic Fe from a clean area of the surface of the liquid metal and its reaction with oxygen in the gaseous medium under formation of nonvolatile FeO. The present studies brought out the need for an understanding of the role of the dynamics of flow of both metal and gas in the process of smoke formation.

22000

Sullivan, Ralph J.

PRELIMINARY AIR POLLUTION SURVEY OF IRON AND ITS COMPOUNDS. A LITERATURE REVIEW. Litton Systems, Inc., Silver Spring, Md., Environmental Systems Div., NAPCA Contract PH 22-68-25, Pub. APTD 69-38, 94p., Oct. 1969. 225 refs. CFSTI: PB 188088

The effects, sources, abatement, and methods of analysis for pollution due to iron and its compounds are reviewed, as urban air samples show that the iron content averages 1.6 microgram/cu m, with the iron and steel industry probably the most likely source of emission. Pollution by iron emission can be reduced by use of particulate control equipment, but costs of abatement for basic oxygen furnaces run between 14 to 19% of total industrial plant costs. The impinger, electrostatic precipitator, and filter are commonly used to collect dusts and fumes of iron compounds, while quantitative determinations employ spectroscopy, spectrophotometry, and two spot-test methods. Iron and iron oxide are known to produce a benign siderosis, and iron oxides have been implicated as a vehicle for transporting high concentrations of both carcinogens and sulfur dioxide deep into the lungs, thereby enhancing the activity of these pollutants. Iron oxide also causes damage by staining materials. (Author abstract modified)

22872

Davis (W. E.) and Associates, Leawood, Kans.

NATIONAL INVENTORY OF SOURCES AND EMISSIONS. CADMIUM, NICKEL AND ASBESTOS. 1968. SECTION I. CADMIUM. NAPCA Contract CPA 22-69- NAPCA-APTD-68, 44p., Feb. 1970. 12 refs. CFSTI: PB 192250

The flow of cadmium, which is essentially a by-product of zinc smelting, is traced and charted for the year 1968 in the U. S. in mining and processing, imports and exports, and reprocessing (e.g., electroplating, pigments, plastics, alloys,

and batteries). The apparent comsumption was 13.3 million lbs, and domestic production 10.6 million lbs. Only a small amount was recovered from scrap. Atmospheric emissions, emission factors, and brief process descriptions are given for areas closely related to existing or potential atmospheric losses of the pollutant. Emissions to the atmosphere during the year totaled 4.6 million lbs. Emissions from the metallurgical processing plants of the primary producers of cadmium, zinc, lead, and copper were more than 2 million lbs, and those from melting operations in the iron and steel industry were about the same. Emission estimates for mining, metallurgical processing, and reprocessing operations are based on data from production companies that represent about 40% of total production and from reprocessing companies handling about 45% of cadmium used in consumer products, and are considered reasonly accurate. Emission control equipment is in use at all the production facilities that were visited; such control is part of the process system for zinc recovery and is not specifically for control of atmospheric cadmium emissions. Further effort is recommended to confirm the accuracy of emissions from scrap containing cadmium. (Author summary modified)

23458

Neuhof, Gerd

ON THE FORMATION OF BROWN SMOKE IN THE PROCESS OF STEEL PRODUCTION WITH OXYGEN. (Die Entstehung von braunem Rauch bei den Stahlherstellungsverfahren mit Sauerstoff). Text in German. Neue Huette, 10(7):391-395, July 1965. 35 refs.

The problems connected with the formation of 'brown smoke' in steel melting using gaseous oxygen are discussed. The origin of formation of the brown smoke of aerosol character is not fully understood. The various hypotheses and literature data on the subject are surveyed. Most often, the formation of the brown smoke is related to direct or indirect iron vaporization. Properties of the smoke are discussed as well as the factors effecting its formation; the latter includes both gas blowing conditions and composition of the iron bath. The modified method for limiting brown smoke emission by either dedusting the exhaust gases or by reducing its formation as used in various countries are surveyed.

23977

Rump, Georg and Alfred Kunst

WASTE HEAT BOILER IN CONVERTER PLANTS. (Abhitzekessel in Konverteranlagen). Text in German. Tech. Ueberwach. (Duesseldorf), 9(11):361-364, Nov. 1968.

Waste gases emanating from steel converters which have a temperature of 1700 C must be cooled before dust can be removed from them. The construction of waste heat boilers which serve this purpose, waste heat utilization, dust removal, the calculation of heat supply and of steaming capacity and safety and measuring devices are described. Heat is supplied to converter waste heat boilers only during the air blast periods; they thus operate under different conditions than normally fired steam boilers. Safety valves must be calculated for maximum steam pressures generated under the most unfavorable conditions. The boiler drum must be calculated for all water volume fluctuations from beginning to end of air blasting. All safety devices must be calculated to handle maximum steam pressures, maximum carbon burning velocity, the shortest possible blast time, and the shortest possible charge time.

24928

Colclough, T. P.

SULFUR IN IRON- AND STEELMAKING. In: Problems and Control of Air Pollution. F. S. Mallette (ed.), New York, Reinhold, 1955, Chapt. 18, p. 202-214.

One of the essential features of the manufacture of iron and steel is that, no matter what the sulfur content of the raw materials use may be, the sulfur content of the finished iron or steel product shall not exceed 0.05%. In the manufacture of the coke used, some 60% of the sulfur in the raw coal is retained in the coke; 40% is found in the tar and coke-oven gas. This sulfur is removed when the gas is used for public utility purposes and can, under certain conditions, be removed economically when the gas is used for steelmaking or other industrial processes. Some 14% of the total sulfur in the coal is contained in the stack gas from the ovens where unpurified gas is used for underfiring. In the smelting of pig iron, the whole of the sulfur present in the coke, ore, and other raw materials, is absorbed in the blast furnace slag with the exception of a small percentage of the iron itself. No sulfur-bearing gases are formed. In the steelmaking operation, the sulfur removed from the metal is retained in the furnace slag. Chimney gases from the furnaces carry away all the sulfur dioxide formed by the combustion of the sulfur, in the fuel. The same conditions apply to the rolling and forging operations. Viewed broadly, the iron and steel industry presents no unique problem with regard to pollution of the atmosphere by sulfur. The only source of sulfur emissions is the combustion of fuel, and the elimination of this pollution is shared in common with all fuel users. Solutions to the problem are a reduction of the sulfur content of the fuel supplied and/or the removal of the sulfur- bearing constituents of the stack gases. (Author summary modified)

26166

Shaffer, N. R. and M. A. Brower

AIR POLLUTION: FURNACE TYPES AND SIZES DICTATE MOST EFFECTIVE CONTROLS. PART I. Iron Age, 175(17):100-102, April 28, 1955. PART II. Ibid, 175(18):110-112, May 5, 1955. PART III, Ibid, 175(19):100-102, May 12, 1955.

Atmospheric emissions from steel furnaces, iron foundries, and nonferrous smelters in Los Angeles County are regulated by two rules. One limits the opacity of an emission by making illegal opactiities of 40% or more for a period in excess of three min in any hour. The second rule regulates emissions by pounds per hr, depending on the weight of material charged. The baghouse has proved to be the most efficient control device for these emissions. Collection efficiencies are 99% for dust and fume from steel furnaces and 96-99% for dust and fumes from gray iron cupolas. Brass, aluminum, and lead smelters employing baghouses in combination with cooling chambers or cyclone separators are able to reduce furnace emissions to one lb or less per hr. Next in order of effectiveness are electrical precipitators, which have an efficiency of 97.5% for emissions from electrical steel furnaces, 96.5% on openhearth furnaces, and 96% on gray iron cupola gases. Water scrubbers have failed to meet control regulations for electric furnaces and gray iron cupolas.

26321

Masek, Vaclav

DUST IN ATMOSPHERE OF METALLURGICAL PLANTS. (Prach v ovzdusi hutniho podniku). Text in Czech. Hutnicke Listy (Prague), 25(11):766-772, 1970. 21 refs.

The concentration, dispersion, and physical appearance of dust fall and suspended dust was studied in the new Klement Gottwald steel plant at Ostrava, an important steel center in northern Moravia. In addition to these properties, analysis was made to determine specific surface, content of soot and polycyclic substances, some important inorganic substances such as silicon dioxide, calcium, magnesium, aluminum, iron oxide and manganese, and their sorption properties, concerning all of which there is a scarcity of reliable data. On the basis of findings, it should be possible to establish priorities for the removal of dust not only on the basis of quantity but also with reference to the type of particulate pollution that is most harmful to human beings. The data provides not only a more accurate knowledge of the actual composition of such dust but data that will be of aid in designing improved dust removal equipment.

26929

Wedin, Bertil

FIGHTING AIR CONTAMINATION--CLEANER AIR AN URGENT NECESSITY. Svenska Flaktfabriken Rev., vol. 6-7:201-207, 1963-1964.

Natural and man-made pollution, dispersal and concentration, and pollution control are discussed. Oil refineries, steelworks, foundries, cement works, plastic and fertilizer factories, and power stations are typical generators of pollutants in larger or smaller emissions. Sulfur-containing oils and benzopyrenes have received too little attention in Sweden. While the threat represented by deep valleys of Scandinavia has been clearly demonstrated in many instances, Sweden's forests probably play an important role as pollution control agents, since both deciduous and coniferous trees can absorb considerable quantities of airborne contaminants. While some pollutants display synergistic characteristics causing greater injury together than could the individual pollutants alone, there is evidence that certain airborne substances can reduce the injurious effects of other contaminants.

27501

Vandergrift, A. Eugene, Larry J. Shannon, Eugene E. Sallee, Paul G. Gorman, and William R. Park

PARTICULATE AIR POLLUTION IN THE UNITED STATES. Preprint, Air Pollution Control Assoc., Pittsburgh, Pa., 30p., 1970. 2 refs. (Presented at the Air Pollution Control Association, Annual Meeting 63rd, St. Louis, Mo., June 14-18, 1970, Paper 70-148.)

The identity, characterization, and quantity of the national particulate air pollution problem from stationary sources were determined. Particulate emissions from stationary sources were obtained from data on emission factors, grain loadings, and materia balances. The principal method used for establishing the tonnage emitted by an industry utilized uncontrolled emission factors. Total tonnage emitted was calculated from an emission factor for the uncontrolled source, the total tonnage processed per year by the industry, the efficiency of control equipment used, and the percentage of production capacity equipped with control devices. Particulate emission totaled approximately 21 times 10 to the 6th power tons per year. Major stationary sources included electric power generation plants, the forest products industry, agriculture and related operations, the crushed stone industry, the cement industry, and the iron and steel industry. Estimates of the total quantity of particulate pollutants were made up to the year 2000 by taking into account changes in production capacity, improvements in control devices, and legislative or regulatory action to enforce installation of control equipment. Forecasts indicated that particulate emissions can be reduced from 21 times 10 to the 6th power tons per year to 13 times 10 to the 6th power tons per year by 1980 through the installation of currently available control devices on all sources. (Author abstract modified)

27790

Osaka Municipal Office (Japan)

OUTLINE OF EMERGENCY MEASURES TAKEN FOR AIR POLLUTION IN NISHIYODOGAWA WARD. (Nishiyodogawa-ku taiki osen kinkyu taisaku taiko). Text in Japanese. 13p, June 1970.

Nishiyodogawa Ward is in the northwestern part of Osaka and borders on the industrial area of Amagasaki City. The area itself has been industrialized for a long time. Of the 794 enterprises, 60% are small, but in the coastal area, there are such big enterprises as iron and steel, chemicals, and so forth. About 140,000 kl of heavy oil is consumed in this area, 53.8% of it by the iron and steel industry, and 13.4% by the chemical industry. Throughout the year, northeast and westerly winds prevail, but especially the western wind in winter. Therefore, Amagasaki City contributes to air pollution. The area was designated as 'Air Pollution Special Area' in Dec. 1965. From 1966, exact surveys were carried out, to find the causal relationship between pollution sources and environmental concentration. It became imperative to decrease sulfur oxides concentrations and improve environmental conditions. The annual average of sulfur oxides in 1969 was 0.083 ppm, a much larger figure than 0.064 ppm, the average for Osaka City, and one failing to conform to the environmental standards in every respect. Dust concentration was average 0.197 mg/cu m a year, lower than the city's average of 0.209 mg/cu m. Much sulfur oxide is emitted by sulfuric acid manufacturing and sulfuric minerals handling enterprises. Amagasaki City uses more than 10 times the heavy fuel, mostly by thermal generating stations. The survey showed the damages amounted to approximately $3,360,000 a year to general households and enterprises. While damage to a household in Osaka City averages $39 a year, in Nishiyodogawa Ward it was $87, and damages to enterprises was $59 and $218 respectively. Incidence of chronic bronchitis in the ward is 8.9%, 4.5 times as much as in the rural part of the prefecture. There were 569 patients who were receiving relief under the law, as of May 19, 1970. The immediate target is to decrease the sulfur oxides concentration to a level less than the environmental standards or half of the present level at the end of 1971, by supplying low sulfur concentration fuel, inspecting the sources of pollution, and other measures. Six factories are going to be moved in 1970, and eight more in 1971, plus 3 factories which are the sources of noise. The factory sites bought up by the city will be used as parks, greenbelts, roads, and housing projects. Greenbelts are going to be installed in Nishiyodogawa Ward; the sewer system will be improved, air purifiers will be installed in schools, and a gargling solution is to be distributed among the school children.

28062

Heischkeil, Werner

ENERGY POWER SUPPLY OF IRONWORKS AS BEING INFLUENCED BY THE PROGRES OF ENGINEERING. (Die huettenmaennische Energiewirtschaft im texhnischen Fortschritt). Text in German. Stahl Eisen, 91(5):250-256, March 4, 1971. 8 refs.

After 1950 the metal industry switched to heavy fuel oil for use in Siemen-Martin furnaces, while natural gas was introduced into the German metal industry as a fuel during the 1960s. At that time, oil was being used approximately 50% of

the time. Coke oven gas from neighboring coking plants is also used in ironworks when it has been partially cleaned. Blast furnace gases are used in power plants. Possible price increases of coke should spur the development of metallurgical processes such as the direct reduction process which operates with gas, inexpensive coal, or oil. Processes using electric furnaces will be selected in small ironworks. Development of a high temperature reactor will also be promoted in view of the rising coke prices. However, the blast furnace process with subsequent oxygen lancing will remain the primary metallurgical process for some time to come.

28371

Masek, Vaclav

THE COMPOSITION OF DUSTS ON WORK SITES AND IN THE CLOSE VICINITY OF IRON WORKS. (Ueber die Zusammensetzung der Staeube an den Arbeitsplaetzen und in der nahen Umgebung von Eisenhuettenwerken). Text in German. Staub, Reinhaltung Luft, 31(2):66-68, Feb. 1971. 15 refs.

The grain size distribution, specific surface area, soot content, 3,4-benzopyrene content, arsenic content, and chemical and roentgenographic composition of dusts collected at work sites and in the vicinity of blast furnaces, steel works, rolling mills, and foundries of the industrial area of Ostrava in Czechoslovakia were determined. The dust contained around 30% silicon dioxide, 7% calcium oxide, 3% magnesium oxide, 15% aluminum trioxide, 15-50% ferric oxide, and 0.25% manganese. The share of the dust of a grain size below 1 micron fluctuated between 3 and 24% and above 4 micron, between 5 and 32%. The specific surface of the dust fluctuated between 1.2 and 14.1 sq m/g; the soot content, between 7 and 64%; the 3,4-benzopyrene content, between 0.1 and 13%; and the arsenic content, between 0.02 and 1.18%. Most of this dust falls on cultivated land.

28604

Lownie, Harold W., Jr. and Thomas M. Barnes

THE NAPCA STUDY OF AIR POLLUTION IN THE STEEL INDUSTRY. Preprint, Air Pollution Control Assoc., Pittsburgh, Pa., 40p., 1970. 3 refs. (Presented at the Air Pollution Control Association, Annual Meeting, 63rd, St. Louis, Mo., June 14-18, 1970, Paper 70-96.)

Air pollution arising from sources in the steel industry was studie by review of the literature and by field visits to steel plants and manufacturers of control equipment. Major objectives were to determine the status of the technology of sources, characteristics of emissions, methods for their control, the cost of applying technology on a broader scale to diminish pollution from steel plants, and the subjects on which research, development, and demonstration projects are needed to improve the technology and economics of air pollution control. It is concluded that better emissions control equipment and systems and more rapid temperature- sensing instrumentation, as well as studies on more effective methods of conditioning metallurgical dusts for collection by electrostatic precipitators are needed. It is recommended that cos models be further developed to serve as a basis for estimating control costs. Highlights are given of a coking report which contains a detailed evaluation of technological alternatives for controlling emissions from the manufacture of blast-furnace coke, and which makes recommendations for further research, development, and demonstration projects relating to both conventional coking in slot ovens and new coking processes.

29021

Egorichev, A. P., V. I. Staritskii, and L. M. Sumin

ORGANIZATION OF WORK ON ABATEMENT OF AIR AND WATER POLLUTION BY IRO AND STEEL INDUSTRY ENTERPRISES. Steel (USSR) (English translatio from Russian of: Stal'), no. 10:839-840, Oct. 1970.

A summary is presented of recent Soviet scientific and technical achievements in the sphere of waste gas and water effluent cleaning at metallurgical works. In addition, problems still awaiting solutions are identified and suggestions made for disseminating the practical knowledge that has been gained by institutes and enterprises. Among the problems for which reliable solutions have been found are: cleaning open-hearth furnace gases with dry electrostatic precipitators and wet venturi-tube devices; oxygen- converter gas cleaning in large-diameter venturi tubes; gas cleanin on closed ferroalloy furnaces in two successive venturi tubes; gas cleaning by cyclones, cloth filters, or electrostatic precipitators; on refractories-industry furnaces during firing of magnesite, lime, and clay; cleaning of oily effluent by a flotation method; and clarification of effluent from metallurgical- furnace gas-cleaning systems with a magnetic coagulator.

29348

Spliethoff, H.

STUDIES ON SLAG TAP FURNACES. (Verhaltensuntersuchungen an Schmelzkammerfeuerungen). Text in German. Mitt. Ver. Grosskesselbesitzer, 51(1):8-16, 1971. 7 refs.

Combustion can be understood as a network with fuel and air flows as initial parameters and the carbon monoxide and oxygen concentrations of the waste gases, the combustion chamber temperature, and the flue gas flow as the parameters at the opposite end. Excess air or lack of air and combustion chamber temperature directly or indirectly influence the combustion conditions. Carbon monoxide develops during any combustion process but is not damaging or corrosion-producing as long as it does not occur outside the combustion process. If approximately equal O2 concentrations are measured at the various measuring points at the end of the combustion process independent of the load, the combustion process can be better regulated and handled more economically. From this it cannot be concluded however, that a constant O2 supply to one point yields the same results.

30296

Teworte, W.

THE USE OF FLUORINE-BEARING MATERIALS IN THE GERMAN FEDERAL REPUBLIC. (Einsatz von fluorhaltigen Materialien in der BRD). Text in German. VDI (Ver. Deut. Ingr.) Ber., no. 164:11-18, 1971. 13 refs.

Before World War II, Germany was the world s largest supplier of fluorine. In 1938, it produced 30% or 140,000 tons out of a total world production of 462,000 tons. Since then, the situation has changed completely. In 1969, the world consumption amounted to about 3.6 million tons, out of which Mexico as the largest producer provided one million tons; Germany s participation was only 90,000 tons which placed it eighth after Mexico. This latter production was practically used up completely by the domestic industry; in addition, some 160,000 tons were imported to cover the overall demand of 250,000 tons. Of the world s consumption of fluorine in 1969, 45% were used for steel manufacturing, 15% for aluminum, 33% for producing chemicals, and 7% for glass and ceramics. The chemical industry requires fluorite, CaF2, primarily for producing hydrofluoric acid, HF. Two tons of CaF2 are

needed for producing one ton of HF. Hydrofluoric acid in turn is used as an intermediate product for the manufacture of numerous inorganic and organic fluorine compounds. Among the inorganic compounds are aluminum fluorides, used as flux material in the production of primary aluminum. The organic fluorine compounds include the aliphatic chlorine-fluorine-hydrocarbons, such as freon, which are used as spraying and cooling substances. Other important fluorine- bearing products are synthetic materials, such as teflon. Direct applications for fluorspar can be found in the manufacture of steel, of welding electrodes, enamel, glass wool, and other industrial products.

30446

Sebesta, William

FERROUS METALLURGICAL PROCESSES. In: Air Pollution. Arthur C. Stern (ed.), Vol. 3, 2nd ed., New York, Academic Press, 1968, Chapt. 36, p. 143-169. 40 refs.

Coke, sinter, iron, and steel production and foundry operations are discussed, including process emissions and their control. Bessemer converters, open hearth furnaces, electric arc furnaces, basic oxygen furnaces, and scarfing are included in reviewing steel manufacture, and cupolas and electric melting furnaces are considered in foundry operations.

30598

Masek, Waclaw

COMPOSITION AND CHARACTERISTICS OF DUST IN STEELWORKS. (Sklad i wyglad pylu w przedsiebiorstwie hutniczym). Text in Polish. Hutnik (Prague), 37(11):553-556, 1970.

The results of a study of properties of dust emitted by the metallurgical industry are presented, supplemented by electron microscope photographs of dust. The latter gives information on the finest components of dust, which are most harmful to the human organism. Dispersion curves of dust were measured. Two methods (sedimentation and aspiration) of sample taking are compared; they differ in the size of most numerous dust particles. Chemical analysis of the dust was carried out. Analysis by X-rays enabled specification of chemical compounds present. Inorganic compounds formed more than 50% of the dust. Specific surface of the dust was determined, which gives information on microstructure of dust. Analysis included dtermination of soot and 3,4-benzpyrene content.

30613

Wasilewska, Janina and Urszula Krause

PROPERTIES OF DUST EMITTED BY METALLURGICAL PLANTS. (Wlasnosci pylow emitowanych do atmosfery przez urzadzenia hut zelaza). Text in Polish. Wiad. Hutnicze (Katowice), 27(2): 57-61, 1971. 16 refs.

Chemico-physical properties of dust emitted into the atmosphere by metallurgical plants were studied. The method of determination of these properties is described, as are the method of sample collection and apparatus used. The chemical composition and density of the dust were determined; its fractional analysis was performed. The gases emitted into the atmosphere by metallurgical industry contained mostly carbon, silicon dioxide, and iron oxides; the relative amount depended on the character of a specific plant. Thus gases emitted from blast furnaces contained 33% carbon, 23% SiO_2, 7% iron oxides; those from steel works, 51-55% iron oxides; and gases from foundries, 89-92% SiO_2. The latter appear to be most hazardous to human health, since the gas causes fibrosis of lungs. A quantity of 45% dust from foundries consisted of particles with a diameter less than 20 micron. Fractional composition of dust varied according to plant; the finest is the dust from steel works. The fraction with a diameter lower than 5 micron formed 60%, out of which a considerable part was of a diameter between 0.5-1 micron. Because of its fine structure, the dust emitted by steel works does not settle to the ground, which indicates the necessity of using dust collectors. Further utilization of the steel works dust rich in iron oxides is suggested such as sintering the dust and returning it to production in this form.

30698

Varga, John, Jr.

A SYSTEMS ANALYSIS STUDY OF THE INTEGRATED IRON AND STEEL INDUSTRY. (FINAL REPORT). Battelle Memorial Inst., Columbus, Ohio, NAPCA Contract PH 22-68-65, 518p., May 15, 1969. 316 refs. NTIS: PB 184577

A general description is presented of the various processes used in each manufacturing segment of the iron and steel industry, including process block-flow diagrams and schematic drawings for each process segment. Particulate and gaseous emissions from each manufacturing process are identified at the point of emission. The flow of sulfur through representative models of the process segments is traced. A comprehensive and quantitative review of fuel and energy utilization was undertaken to identify the total industry consumption types of fuel used, quantities of each, the determinants of fuel choice, and the influence on pollutant emissions of fuel chemistry and usuage. Industry growth and process technology changes are projected for the periods 1970-1975 and 1975-1980, emphasizing processes that will come into future use and their associated pollution potential, as well as processes which will be phased out. The principal types of control equipment for the various processes are described, and information on the performance characteristics of the various designs in use is presented. An in-depth analysis of the relative merits and limitations of applied control equipment is included. Pollution control alternatives are identified, with the relative cost and effectiveness of each compared. Gaps in air quality control technology are indicated, and recommendations are suggested for research to fill such gaps.

31737

Petry, Jan Krzysztof

GENERAL OBSERVATIONS ON THE APPLICATION OF SELENIUM (SE) IN INDUSTRY AND THE HISTORY OF ITS DISCOVERY. Przeglad Lekar., 26(4 452-453, 1970. 10 refs. Translated from Polish. Mundus Systems, McGregor, and Werner, Inc., Washington, D. C., 7p.

Applications of selenium in industry are cited, and its effect on the living organism is mentioned. Selenium is used in the steel industry, since it resists abrasion and prevents corrosion. It is used in the production of inks and dyes for coloring plastics and textiles. Also, selenium is a component of insecticides, and permits the proper gradation of colors in photography. The cosmetic industry introduced selenium into hair shampoo. Due to the presence of selenium in the soil, some water and plants have been polluted; it eventually found its way into animals and humans, leading to morbid conditions and numerous deaths. Cases of poisoning to horses are cited.

31919

Krause, Urszula and Janina Wasilewska

EMISSION OF AIR POLLUTANTS DURING THE SMELTING OF IRON ORE IN THE DL SYSTEM. (Emisja zanieczyszczen atmosfery przez spiekalnie rud zelaza systemu DL).

Text in Polish. Wiad. Hutnicze (Katowice), 27(4):105-110, 1971. 10 refs.

The total quantity of dust emitted into the atmosphere from iron ore smelting plants operating a Dwight Lloyd system is generally high in Poland and averages 2893 tons per year or about 0.31% compared to the production of agglomerates. Multicyclic dust collectors placed at strategic sites along the two conveyer belts are only 77% efficient, mainly because the dust particles released are very small approximately 84% of the particles are less than 20 millimicrons in size. Multicyclic collectors, installed for removing dust from gases released at the breaking junctions of the smelting conveyer belts and at the casing of the conveyer belts returning agglomerates, are more efficient than those at other sites, because gases at these points have a fourfold increase in the dust concentration before they reach the multicyclic apparatus. Despite the 84% efficiency at these sites, the average dust concentration in the released gas is 1328 mg/n cu m, yielding an emission of 124 kg/hr or 931 tons/yr. The chemical composition of the dust includes iron metals (38%), silicon dioxide and calcium oxide (11.12%), and calcium carbonate (11.8%). The quantity of sulfur dioxide in the gases emitted from the plants is also very high, averaging 7530 tons per year. To overcome these deficiencies, installation of an electrostatic precipitator is recommended. Poland does not have its own standards for controlling industrial air pollution and applies the norms established by other countries which vary widely in the permissible amounts of dust and sulfur dioxide.

31935

Nakamura, Keigo

ON AIR POLLUTION CAUSED BY HYDROGEN FLUORIDE. (Fukka suiso ni yoru taiki osen ni tsuite). Text in Japanese. Kogai To Taisaku (J. Pollution Control), 6(4):50-58, July 1971. 9 refs.

When the atmosphere contains as little as 10 ppb of hydrogen fluoride, crops can be damaged, because the HF is accumulated in the leaves. Teeth and bones are also affected when cattle eat feed containing 30-50 ppm HF over an extended period of time. Fluoride emissions are issued from plants which process ores containing fluoride compounds. Steel mills in Japan are using about four kg fluorspar/ton steel. Various types of scrubbers are utilized to recover fluoride from aluminum smelter and phosphorus fertilizer exhaust gases. Collectors are then used to trap fluoride and sulfuric acid mists.

32351

Lemke, Eric E., George Thomas, and Wayne E. Zwiacher

PROFILE OF AIR POLLUTION CONTROL IN LOS ANGELES COUNTY. Los Angeles County Air Pollution Control District, Calif., 66p., Jan. 1969.

A profile of air pollution sources, the effectiveness of the control program, and a projection for the future in Los Angeles are presented. The Federal Clean Air Act of 1967 figures prominently in the future projections, because it is assumed that California will set motor vehicle emission standards more stringently than the Federal standards. About 13,500 tons of air contaminants are still being emitted daily, primarily because of automobile emissions which comprise approximately 90% of the uncontrolled emissions. Major sources are listed with data on type and amounts of particulates emitted, and the amounts prevented. Motor vehicle sources include exhaust, blowby, and evaporation in gasoline-powered engines and diesel-powered engines; the prevention methods for motor vehicle emissions include crankcase and exhaust control. Other sources include organic solvents (surface coating, dry cleaning, and degreasing), chemicals (sulfur and sulfuric acid plants), incineration, non-ferrous metal production, cupolas, electric steel furnaces, open hearths, mineral production (including asphalt), and petroleum (refining, marketing, and production). Rule 62 prevents contamination from power plants and other fuel combustion processes. Jet and piston driven aircraft, ships, and railroads are also sources. Contaminants include nitrogen oxides, sulfur dioxide, carbon monoxide, hydrocarbons, and particulates. The distribution of chemical processing equipment, boilers, heaters, paint bake ovens, incinerators, metal melting equipment, concrete batch plants, petroleum processing equipment, rendering equipment, and power plant boilers are shown. Daily emissions from fuel oil, natural gas, and refinery make gas are shown. Also, steam and electric power plants are discussed. When motor vehicle exhaust reacts with the air, photochemical smog can be formed which causes eye irritation; the California Pure Air Act has set standards which should eliminate this. Stationary and mobile sources, air monitoring stations, seasonal changes, ozone concentrations, wind effects, daily concentration levels, oxidant levels, and alerts are also discussed. 32351 Lemke, Eric E., George Thomas, and Wayne E. Zwiacher

32489

Giever, P. M.

CHARACTERISTICS OF FOUNDRY EFFLUENTS. Preprint, American Foundrymen s Society, Des Plaines, Ill., 3p., 1970. 7 refs. (Presented at the Total Environmental Control Conference, Ann Arbor, Mich., Nov. 16-19 1970.)

Effluents from the numerous types of foundry furnaces and products vary over a wide range of physical and chemical characteristics including visible plumes, particulates, irritating fumes, and gases, as well as explosive dusts. Approximately 90% of the gray iron melting furnaces are cupolas and only 15 to 18% of these have air pollution control devices installed. One of the most important characteristics of cupola effluent is the high temperature. In addition to particulates, the effluent from cupolas contains gases which are primarily carbon dioxide and nitrogen with some excess oxygen and varying amounts of sulfur dioxide. Smoke, oil vapor, and fumes make up the remainder of the emissions. Emissions from electric arc furnaces and non-ferrous foundries are also discussed. These include zinc dust, ammonium chloride, carbon monoxide, carbon dioxide, fumes, sulfur oxides, sulfides, sulfates, metal oxides, aluminum oxides, odors, particulates, and many others. Particle size can be an important aspect.

33279

Rondia, D.

THE SOLUTION OF A HYGIENIC PROBLEM IN STEEL WORKS. EXPOSURE OF WORKERS TO A FOG CONTAINING 3,4-BENZOPYRENE. (La solution reelle d un probleme d hygiene dans une acierie. Exposition des ouvriers a un brouillard contenant du 3,4-benzopyrene). Text in French. Arch. Maladies Profess. Med. Trav. Securite Sociale (Paris), 25(7-8):403-406, July-Aug. 1964. 4 refs.

To prevent the too sudden cooling of steel ingots in steel manufacture, molds are sprayed with a mineral oil using a compressed air vaporizer. This procedure exposes workers to skin photosensitivization and to the inhalation of considerable concentrations of an aerosol containing polycyclic hydrocarbons. Since 1 ppm of the carcinogen 3,4-benzopyrene was detected in the oil fog, the oil should be replaced by a heavy kerosene fraction and vaporization replaced by compressed air with high pressure diffusion. While this method is costlier, it

eliminates a definite health hazard and improves working conditions.

33930

IMPROVEMENTS IN THE PROCESSES FOR METAL REFINING. (Perfectionnements aux procedes pour l affinage de metaux). Text in French. (Steel Co. of Wales, Ltd. (Great Britain)) French Pat. 1,511,820. 3p., Dec. 26, 1967. (Appl. Feb. 15, 1967, 8 claims).

A new process for refining of metal is discussed, in particular steel produced in an open hearth furnace or a converter. A flame nurtured by oxygen currents and a carbonized liquid combustible is injected in a refining receptacle containing the liquid steel to be treated. The proportion of oxygen to the combustible, is adjusted to obtain complete combustion. The flame is located inside the receptacle so that the combustion products, and not the flame, come into contact with the molten mass. The quantity of oxygen introduced is far in excess of that necessary for effecting a complete combustion of the combustibles, in the order of 150 to 200% excess oxygen. Depending on the specific case, this excess oxygen supply may even go as high as 1000%. The liquid combustible may be a heavy fuel oil, or a coke oven tar with low sulfur content. The oxygen and combustible mixtures can be injected into the refining receptacle either through a pipe, or with a blow lance with multiple jets. In view of the high combustion temperatures generated, the process permits the use of a substantial percentage of steel scrap and chips in the charge. Ferric oxide, lime and fluorspar are added to the molten steel in the receptacle for the refining process.

B. CONTROL METHODS

00037

B. Basse

GASES CLEANED BY THE USE OF SCRUBBERS. Blast Furnace Steel Plant 1307-12, Nov. 1956.

Venturi scrubbers are among the most efficient devices available for removal of fine fumes from gas streams. They are especially applicable to the steel industry which, because of the high temperature furnace reactions, produce very large quantities of submicron metallic fume. For air pollution applications, the power required can be adjusted to meeet nearly all local ordinance demands, or visual appearance requirements of management. In blast furnace applications, the scrubber supplies sufficiently clean gas so that secondary cleaners are not required before burning the gas in stoves and boilers. (Author's abstract)

00104

D. N. Kalyuzhniy

SANITARY PROTECTION AGAINST AIR POLLUTION BY WASTE PRODUCTS FROM FERROUS METALLURGICAL ENTERPRISES. (Sanitarnaya Okhrana Atmosfernogo Vozdukha ot Vybrosov predpriyatiy Chernoy CFSTI: AD 610 673 Metallurgii.) (Translated as JPRS No. 17, 984.) pp. 166-71. Mar. 6, 1963. CFSTI: AD 402 502

This is a translation of appendices I and II, and of the Table of Contents, of the monograph Sanitarnaya Okhrana Atmosfernogo Vozdukha ot Vybrosov Predpriyatiy Chernoy Metallurgii (Sanitary Protection Against Air Pollution by Waste Products from Ferrous Metallurgical Engerprises). (Appendix I: Model Program for the Inspection of Industrial Enterprises to Reveal and Eliminate Sources of Air Pollution; Appendix II: Sanitary Classification of Industries and Protective Zones).

00322

C. Broman

SCRUBBING FOR CLEAN AIR. Preprint. (Presented at the 59th Annual Meeting, Air Pollution Control Association, San Francisco, Calif., June 20-24, 1966, Paper No. 66-99.)

To meet the competive challenge of Asian and European steel producers, the American steel industry has initiated a continuing program of technological advancement. One of the major advances has been the utilization of ocygen in the steelmaking process which has brought with it the attendant problem of increased emissions to the atmosphere. This paper deals with the basic problems with cleaning gases, in general, and then considers, specifically, the use of a Venturi Gas Scrubber to clean emissions from an oxygen-lanced open hearth furnace. Although there have been mechanical and operational problems, the results have been sufficiently encouraging to proceed with the installation of additional units. (Author)

00323

C. M. Parker

BOP AIR CLEANING EXPERIENCES. Preprint. J. Air Pollution Control Assoc. 16, (8) 446-8, Aug. 1966. (Presented at the San Francisco, Calif., June 20-24, 1966, Paper No. 66-100.) 59th Annual Meeting, Air Pollution Control Association San Francisco, Calif., June 20-24, 1966, Paper No. 66-100.)

Operation of the Basic Oxygen Furnace and the two current air-cleaning methods, employing wet scrubbers and electrostatic precipitators are discussed. Emphasis has been placed upon the variety of mishaps that continually occur to keep either method from operating smoothly. Each method provides highly efficient gas cleaning but shutdowns are fairly frequent. Dust is emitted to the atmosphere when this happens and impels people to complain. No BOP is exactly like any other and a long period of trial-and-error adjustment is necessary to make the equipment function properly. These periods may take a year or more. (Author's summary)

01110

D. L. Benz and R. Bird

CONTROL OF POLLUTION FROM ELECTRIC ARC FURNACES AT OREGON STEEL MILLS CO . Preprint. 1965.

The direct evacuation system installed at Oregon Steel Mills, its operation, and its effectiveness in maintaining complete control of electric melting furnace fumes are reviewed.

01137

G. D. Spenceley and D. I. T. Williams

FUMELESS REFINING WITH OXY-FUEL BURNERS. Steel Times (London), 193(5115):150-158, July 29, 1966.

The use of Shell Toroidal oxygen-oil burners to refine molten steel without producing obnoxious fumes was extensively investigated. Carbon, low alloy, and stainless steels were studied in arc furnaces of up to 30 tons capacity. The process was shown to be an attractive alternative to oxygen lancing for carbon and low alloy steels. No metallurgical drawbacks were encountered and virtually complete fume suppression occurred. The applicability of the technique to stainless steel qualities depends on the chromium content prior to refining. Trials on 17 to 20 % chromium content showed severe hydrogen pick-up and an inability to reduce the carbon to specification (0.06%). (Author summary)

02031

R. L. Chamberlin and G. Moodie

WHAT PRICE INDUSTRIAL GAS CLEANING.? Proc. (Part I) INTERN. CLEAN AIR CONG., LONDON. 1966. (PAPER V/7). PP. 133-5.

This paper gibes a brief description of four standard industrial gas-cleaning tools, electrostatic precipitator, mechanical collector, high-energy scrubber and cloth filter. The application of these collectors to air pollution problems of the power, cement and steel industries is expalined. Finally, capital, utility, maintenance and amortization cost of specific gas-cleaning plants for these industries are given. These cost studies point out approximate cost of solving these specific problems and empahsize the need to go beyond capital costs in choosing gas cleaning equipment. (Author asbaract)

02193

R. D. Hoak and H. C. Brammer.

POLLUTION CONTROL IN THE STEEL INDUSTRY. Chem. Eng. Progr. 62, (10) 48-52, Oct. 1966.

A brief outline of steel manufacture is presented in which sources of air and water pollution have been identified. Methods in use for controlling air and water quality have been identified. Methods in use for controlling air and water quality have been described in broad terms. Many details have been omitted in the interest of emphasizing features of interest to those concerned with pollution abatement.

02229

P.W. Spaite, D.G. Stephen, A.H. Rose, Jr.

HIGH TEMPERATURE FABRIC FILTRATION OF INDUSTRIAL GASES. J. Air Pollution Control Assoc. 11, 243-7 & 58, May 1961. (Presented at the 53rd Annual Meeting, Air Pollution Control Association, Cincinnati, Ohio, May 22-26, 1960.)

The field of industrial filtration over 300 F is assessed in a general way. High temperature media other than fiber glass are not discussed. Thermal effects on equipment, media, chemical attack and power requirements are covered. Applications to gray iron cupolas, nonferrous fumes, perlite processing, carbon black production, cement kilns, and electric arc steel furnaces are reviewed. Potential applications and research are discussed.

02728

A. D. Brandt

CURRENT STATUS AND FUTURE PROSPECTS--STEEL INDUSTRY AIR POLLUTION CONTROL. Proc. Natl. Conf. Air Pollution, 3rd, Washington, D.C., 1966. pp. 236-41.

Air pollution control at blast furnace operations, in general, is excellent. The most important single contributor of particulate air pollutants in the steel industry today, namely, the steel-making furnaces, is being brought under control rapidly and effectively as a result of the change in steel-making technology whereby uncontrolled conventional open hearth furnaces are being replaced by Basic Oxygen Furnace equipped during construction with adequate air pollution control facilities. The nature of the equipment and procedure currently employed in making coke for the steel industry does not permit complete control of the air pollutants created by such operations. A technological breakthrough is essential to the attainment of adequate and satisfactory air pollution control at coke-making operations. Technological improvements are needed to permit effective and practicable control of the sporadic air pollution created when high winds blow across stock piles of coal, ore and stone. The steel industry has made noteworthy progress in air pollution control in recent years and presently is engaged in a program of control which will make steel plants relatively free from major particulate air pollution problems by the end of the next decade. (Author summary)

02730

H. M. Chapman

EXPERIENCE WITH SELECTED AIR POLLUTION CONTROL INSTALLATIONS IN THE BETHLEHEM STEEL COMPANY. J. Air Pollution Control Assoc. 13, (12) 604-6, 629, Dec. 1963. (Presented at the 56th Annual Meeting, Air Pollution Control Association, Detroit, Mich., June 9-13, 1963, Paper No. 63-31.)

Various problems associated with air pollution control in the Bethlehem Steel Company in recent years are reviewed. The problems include the collection of dust and fume from electric furnaces; fume collection from cold charge open hearth furnaces, oxygen lanced open hearth furnaces and from a hot scarfer; the collection of dust from the discharge end of sinter lines; and the development of natural cover on an unused tailings dam to control wind-blown dust. The method of control and the resulting experience in each case are discussed. (Author abstract)

03206

Ddr. D. Fernschild and R. Lohse.

ADOPTION OF THE VENTURI GAS-CLEANING PROCESS BY THE IRON METALLURGICAL INDUSTRY OF EAST GERMANY. Einfuhrung des Venturi-Gasreinigungsverfahrens in der Eisenhuttenindustrie Neue Hutte 11, (10) 594-600, Oct. 1966.

The development of gas cleaning in the iron-metallurgical industry, the theoretical bases of the Venturi gas-cleaning process and the types developed, the design of a two-stage plant and test procedure, factors influencing the content of residual dust, and the development of a plant ready for service are described.

03232

G. W. Thom and A. F. Schuldt

THE COLLECTION OF OPEN HEARTH DUST AND ITS RECLAMATION USING THE SL/RN PROCESS. Can. Mining and Met Bull. (Montreal) 59, (654) 1229-33, Oct. 1966

The authors describe the dust collection system for iron oxide dust from the basic oxygen hearths using electrostatic precipitators, then removing the zinc and lead oxides and sulfur compounds by direct reduction in a rotary kiln using the SL/RN Process. (SL/RN designates the two groups of companies who developed the process.) In this process bentonite is added to the dust to form green balls. Then dolomite and anthracite were added to the balls which were fed into the kiln. The coal acted as a reductant and also provided energy. The dolomite removed released sulfur. The results of kiln tests are presented.

03677

Silverman, L.

RESEARCH AND DEVELOPMENT OF EQUIPMENT FOR CLEANING OF HIGH TEMPERATURE GASES. In: Trans. of Industrial Hygiene Foundation, 21st Annual Meeting Pittsburgh, Pa., 1956, p. 210-232. 15 refs.

Progress is reported on research and development at Harvard under the sponsorship of the American Iron and Steel Institute into inexpensive methods for removing particulate matter from high temperature gas streams, such as the open hearth furnace. A brief review of earlier developments is included. Reported developments on the AISI work cover a fundamental study of the air flow resistance characteristics of a rotary screw agglomerator, used to provide dynamic gas treatment to increase particle size. Efficiency of the screw as an inertial collector for iron oxide fume is presented. The collection efficiency and resistance characteristic of slag wool fiber filters has been extended to other aerosols and gases such as fly ash, sulfur dioxide, hydrofluoric acid and sulfuric acid mist. The filter (one inch thickness, five pounds per cubic foot density) at velocities used for collecting iron fume (50 to 150 feet per minute) showed efficiencies for SO2 of approximately 30 per cent when moist and zero when dry. For hydrogen fluoride dry efficiencies range from 70 to 90 percent. Wet tests are now in progress. For fly ash, when resuspended from Cottrell

ash, efficiencies ranged from 60 to 90 per cent, whereas when freshly formed fly ash was created by burning powdered fuel, efficiencies ranged from 93 to 99 per cent. A revised pilot model slag wool filter, which is described, has been constructed for 750 to 1000 cfm gas flow based on previous results. The discussion is limited to processes where temperatures are in excess of 500 F with particulate material of submicron size. (Author's summary, modified)

03754

G. L. Allen, F. H. Viets, and L. C. McCabe

CONTROL OF METALLURGICAL AND MINERAL DUSTS AND FUMES IN LOS ANGELES COUNTY, CALIF. Bureau of Mines, Washington, D.C. (Information Circular 7627.) Apr. 1952. 85 pp.

The nonferrous pyrometallurgical industry of Los Angeles has three unusual characteristics that contribute to its difficulties in developing suitable fume control: (1) It consists of a multiplicity of relatively small establishments subject to wide variations in products and operating schedules; (2) operations are largely of the secondary or reclaiming nature; and (3) much of the industry is concentrated near the center of a city. A difficulty inherent in most nonferrous foundries is the high volatility of zinc and the extremely small mean particle size of the resulting zinc oxide fume. The nonferrous industry has found only one type of equipment that could be depended upon to adequately remove particulate matter emitted by the larger furnaces in which the gases are characterized by heavy dust loadings at high temperatures. This is a specially equipped baghouse, and its first cost is rather high. For smaller furnaces, particularly of the crucible type, the conventional sock-type baghouse has proved satisfactory. The inert slag cover, which reduces emission at the source, has proved fairly effective and economical, particularly with the crucible-type furnace and pouring ladle, but is successful use depends on the skill of the operators. The gray-iron-foundry branch of the ferrous industries has not fared as well as the nonferrous branch, despite extensive investigation and development of equipment for control of cupola emissions. Appreciable progress has been made in adapting equipment suitable technically and cost-wise for cupola-exit gases, and development continues. Equipment capable of producing the required clearances is available but is not within the financial ability of many small foundries. The baghouse equipped with specially woven glass-fabric bags, as used commercially in the nonferrous industry, has technically been the most successful single device to date for controlling cupola emissions and has been proven in pilot operations. After extensive investigation, electrical precipitation has been adopted for cold-metal open-hearth work, and hydrodynamic scrubbers and baghouses have been adopted for electric-steel-furnace fumes. In addition to the fact that such equipment removes the necessary dust, capital and operating costs were important factors in their selection.

03998

M. J. Greaves

THE EFFECTS OF MODERN BURDENS ON BLAST FURNACE DESIGN. J. Metals (Japan) 18(3):378-384, Mar. 1966.

Longer blast furnace campaigns and maximum benefits from the use of modern burdens are possible by means of better refractories, more effective cooling, and careful attention to details of design and supervision of construction. For a given ironmaking requirement, it costs less to build and operate a blast furnace designed for about 12 psi top pressure and operated at about 6 psi, than one designed for substantially higher or lower top pressure. The greatest savings in blast furnace labor costs may be found in the cast house where the majority of manual labor is concentrated. The four-post furnace design permits maximum use of mechanized equipment to help realize these savings. Use of beneficiated burdens has reduced the amount of flue dust produced per ton of hot metal and has substantially altered the average particle size and settling characteristics of the dust. Consequently, although larger dust-catchers are not required, more efficient gas scrubbers are essential. Three variation of gas cleaning systems are considered. 1. A fixed orifice scrubber and an automatically variable orifice scrubber, in series, with no electrostatic precipitators. The dust content in the gas leaving the first scrubber would be in the range of 0.02 to 0.03 grains per cu ft and about 0.005 grains per cu ft in gas leaving the second scrubber. 2. A single scrubber with two precipitators. This arrangement would reduce the dust content of the gas to about 0.001 grains per cu ft. 3. Two scrubbers, in series, with a single precipitator. Gas going to the boilers and bleeders would be routed there directly from the scrubbers. Only gas for use in the stoves would be cleaned in the precipitator. There is good reason to consider using two high energy scrubber is series. The simple fixed throat scrubber cools the raw blast furnace gas to about 150 degrees F, and removes most of the dust. The relatively clean and cool gas entering the variable throat scrubber would cause minimum wear and thermal shock on the moving parts of this scrubber. The secondary scrubber is located downstream from the pressure equalizing line connection where it can use any excess pressure energy remaining in the gas to obtain further cleaning with little or no additional cost.

04050

A. R. Orban, J. D. Hummell, and G. G. Cocks

RESEARCH ON CONTROL OF EMISSIONS FROM BESSEMER CONVERTERS. J. Air Pollution Control Assoc. 11, (3) 103-13, Mar. 1961. (Presented at the 53rd Annual Meeting, Air Pollution Control Association, Cincinnati, Ohio, May 22-26, 1960.)

This paper is a progress report of a research investigation to establish means for control of smoke from pneumatic steelmaking processes. A 30-ton acid bessemer converter was made available for research in smoke sampling, and the study of dust concentration and composition. For studying the mechanisms of smoke formation, a laboratory model of a bessemer converter was constructed. Among subjects included in the investigation were: the change in quantity of smoke emitted when changes in blowing technique were made; particle size, density, composition, and visibility of smoke; gaseous blast additives; and state of smoke particles as they leave the converter before being oxidized.

04227

E. R. Harris and F. R. Beiser

CLEANING SINTER PLANT GAS WITH VENTURI SCRUBBER. J. Air Pollution Control Assoc. 15, (2) 46-9, Feb. 1965

The installation and operating experience on what is believed to be the first application of a Venturi scrubber for cleaning sinter plant gases is reported. After running pilot plant tests at the stack, the Venturi scrubber was chosen in preference to the dry precipitators because it was believed that this would more effectively eliminate certain odors particular to this plant. A ruggedly built stainless steel fan with a rotor having forwardly curved, backwardly inclined blades was selected with extra heavy steel plate housing for quiet operation. Stainless steel moving parts and a rubber coated carbon steel housing were used to resist corrosion. The installation was

completed and put on the line for the first time April 9, 1963. The discharge from the stack was only a small white plume and the stack dust loading was far below the County requirements and appreciably better than the manufacturer's guarantee. Vibration readings and noise level of the fan were excellent and the only indication of any problem was in carry-over through the fan of an estimated 50 to 60 gallons per minute of dirty water. This was somewhat higher than hoped for but not considered critical. On April 17, 8 days after start-up, a slight increase in vibration of the fan was noticed. Cursory inspection of the damage indicated that the failure was due to abrasion from the dust laden water carried over from the scrubber. Following the failure of the fan, several studies were undertaken in an effort to prevent rapid deterioration of the rotor. After a rebuilt rotor was put into service, an automatic vibration cutoff was installed which would shut the fan down in case of excessive vibration.

04367

S. Tulcinsky and A. Lemaire

COOLING AND SCRUBBING OF SMOKE EMITTED BY LD STEEL CONVERTERS IN SIDMAR IRONWORKS. Le refroidissement et l'epuration des fumees de convertisseurs de l'acierie LD du complexe siderurgique Sidmar. Rev. Met. 63, (9) 659-65, Sept. 1966. Fr.

After a review of the basic principles and of their value as adopted for Sidmar steel plant, the development of a plan of flues and of converted gas scrubbing is given.

04382

A. C. Elliott A. J. Lafreniere

COLLECTION OF METALLURGICAL FUMES FROM OXYGEN LANCED OPEN HEARTH FURNACES. Kinzoku (Metals) (Japan) 18, (6) 743-7, June 1966. (Also published in J. Air Pollution Control Assoc. 14, (10) 401-6, Oct. 1964.)

The facilities provided to control fume emissions from the Steel Co. of Canada's Hilton Works and their operating experiences with electrostatic precipitators are described. The application of electrostatic precipitators to the collection of open hearth metallurgical fumes has proven very satisfactory. This type of equipment, properly engineered seems most suitable for this operation. For this installation, no efforts were spared to make it one of the finest possible. Dust collection in the open hearth is not a paying proposition. To date, approximately $6 million has been spent for precipitators and necessary auxiliary equipment. The economic implications of such expenditures point out that there is a practical limit to the rate beyond which it is not economically feasible. This suggests that total pollution control must, of necessity, be a long term objective. In this connection it will be argued that the long term goal should not be the complete elimination of pollutants. A sounder and more likely attainable objective is the reduction of pollutant emissions to reasonable levels which do not, in any sense, endanger the health and welfare fo the public.

04665

G. Punch

LD AND KALDO FUME CLEANING (CONSETT DEVELOPMENTS). Iron Steel (London) 38, (2) 75-80, 86, Feb. 1965.

The fume cleaning installation at Consett is of particular interest because it includes fume-cleaning equipment for both Kaldo and LD converters, operating side by side, and illustrates very well that the processes are as different from each other from the gas-cleaning point of view as they are metallurgically. The gas-cleaning equipment of the installation at Consett comprises hoods for containing the fume-laden gases emitted by the converters, gas cooling and conditioning equipment, dry plate electrostatic precipitators, induced-draught fans, interconnecting ducting and exhaust stacks. The two 100 ton LD converters each have completely separate systems but the Kaldo units utilize a common precipitator. The gas-cleaning systems of the LD and Kaldo installations are similar inasmuch as they comprise equipment for collecting the converter waste gases, and cooling and conditioning them so that they may be cleaned in dry plate precipitators before being discharged to atmosphere. The systems differ in detail however, and this is entriely due to the fundamental differences between the two converter processes. In the Kaldo process, approximately 90% of the carbon monoxide generated burns to carbon dioxide within the vessel. On the other hand, the waste gases leaving the mouth of an LD converter at the peak of the blow consist of 90% carbon monoxide and 10% carbon dioxide. Thus, in addition ot their high sensible heat, LD waste gases contain very large quantities of potential heat which they release into the gas cleaning system as they burn in the secondary air which is drawn into the converter hood. At Consett, most of the useful heat of the LD gases is removed by waste-heat boiler and evaporative cooling is only used for final adjustment of gas temperature and humidity. In the case of the Kaldo units, recovery is not economic and only evaporative cooling is used to prepare the gases for the cleaning process.

04794

W. Von Jordan

VENTURI AND RADIAL FLOW SCRUBBERS FOR COOLING AND CLEANING OF UTILITY AND WASTE GASES. Venturi- und Radialstrom-wascher zur Kuhlung und Reinigung von Nutz- und Abgasen. Stahl Eisen (Dusseldorf) 86, (8) 399-406, Apr. 8, 1966. Ger.

Two scrubbers are discussed in this paper: The venturi scrubber with central jet and the radial flow scrubber. Operating experiences and results of measurement are given. Venturi scrubbers are used in a variety of industries for gas cooling and dust cleaning. They are used for scrubbing of gaseous components, for instance fluorine washing. The versatile use of the venturi scrubber, it can be operated according to need without or with high pressure losses, has opened a wide field of application. The operation and application by low and high pressure losses are explained. The radial flow scrubber is an adjustable high performance scrubber, developed for cooling and cleaning of large gas masses, for example such from blast furnaces. Design and construction is explained and the effect discussed.

05091

H. P. Willett

CUTTING AIR POLLUTION CONTROL COSTS. Chem. Eng. Progr. 63, (3) 80-3, Mar. 1967.

The purpose was to present a number of case histories where the cost of air pollution control has been drastically reduced by innovations in the basic process which caused the pollution problem. Exhaust systems for electric furnaces; hoods for basic oxygen furnaces; exhaust systems for gray-iron cupolas; incinerators with waste heat recovery; chemical composting; black liqour oxidation, blowers for sulfuric acid concentrators; and automotive engine operation modification are cited as examples of some of the ways in which relatively inexpensive changes in basic process are cutting the cost of air pollution control.

05118

J. Pallinger

A NEW WET METHOD FOR SEPARATION OF VERY FINE DUST. Staub (Duesseldorf),22 (7): 270-5 (1962)1 Ger. (Tr.). (Translated by British Iron and Steel Industry Translation Service, No. BISI 3277.)

The increasing use of oxygen in steelmaking demands gas cleaning methods adequate to meet clean air requirements. Experiments with a new wet scrubber are reported, in which pressure drop and water consumption are reduced to an economic level. In the new Venturi scrubber used there are two processes making a double scrubbing effect. The dust-laden gas in the first instance meets at medium velocity the water drops with approximately zero axial velocity and in the second instance, meets at maximum velocity the reflected curtain of small drops with axial velocity at least zero. In this manner, the washing water is used with maximum efficiency. With a dust concentration in the impure gas of 30.1 g/Ncu m (normal temperature and pressure) of dry gas, the following precipitation efficiencies were obtained: For pressure drops (mm water gauge) of 100, 500, 700, and 900 the total precipitation (%) was, respectively 90.48, 99.44, 99.74, 99.83. Comparable total separation efficiencies are obtained for many other difficult-to-separate very fine dusts, as for example, in cleaning the gases of electric-arc furnaces, both of open and closed design. The scrubber was also effective for cleaning the waste gas of a boiler plant with sulphite waste liquor combustion.

05307

Akerlow, E. V.

MODIFICATION TO THE FONTANA OPEN HEARTH PRECIPITATORS. J. Air Pollution Control Assoc. 7 (1), 39-43 (May 1957). (Presented at the Semi-Annual Technical Conference, Air Pollution Control Association, Houston, Tex., Dec. 3-5, 1956.)

Some of the problems of design, construction, and modifications to electrostatic precipitators are reviewed. Some important problems were: vibration; erratic gas flow, insufficient residence time; low voltage and inadequate control of the connected energy to the discharge electrode system; the sequence and type of rapping which permitted excessive dust build-up; and automatic power control was needed to maintain voltage in the precipitator very close to the sparking potential during the varying conditions of the fume in the unit. The use of selenium rectifiers rather than mechanical rectifiers, special collecting and discharge electrodes; special rapping mechanisms; and the development of gas distribution apparatus are among the most important modifications.

05509

M. Hunt A. T. Lawson

THE CONTROL OF DUST AND FUME EMISSIONS FROM AN INTEGRATED STEELWORKS. Proc. Clean Air Conf., Univ. New South Wales, 1962, Paper 15, Vol. 2, 33p.

The steel industry has progressed in reducing the various emissions as evidenced by the increase in the efficiency of fuel usage. The types of emissions from the main sources within the stell industry, and the choice of sampling equipment employed is discussed. A general description of the main types of collecting equipment available (e.g. mechanical dust collectors, wet washing dust collectors, filtration dust collectors, and electrostatic precipitators) leads to a consideration of the advantages and disadvantages of any particular collecting unit for a specific source in light of the information gained from sampling and testing. It is concluded that the choice of collecting equipment is affected by the available means of dust recovery and whether this dust has a value or is only a waste product. A general summation of the future problems in the steel industry is also presented.

05567

L. Silverman

HIGH TEMPERATURE GAS AND AEROSOL REMOVAL WITH FIBROUS FILTERS. Proc. Air Water Pollution Abatement Conf., 1957. pp. 10-23m.

The use of a slag wool fiber filter as an inexpensive cleaner of high temperature gases and fumes produced in open hearth steel furnaces was described and evaluated. These fibers are small (4 microns mean diameter) and are refractory, thus able to withstand temperatures of 1100 F. ;or high efficiency separation of fine aerosols, fine targets in large number are necessary which packed slag fiber layers can provide. Theoretical, laboratory and field studies show that slag wool filters show efficiencies ranging from 90 to 99%, depending upon fiber layer compositions, density, and thickness. The chief separating mechanisms appear to be diffusion and impaction. Results are presented of the air flow resistance characteristics of a rotary screw agglomerator, used to provide dynamic gas treatment to increase particle size of the efficiency of the screw as an inertial collector for iron oxide fume. The collection efficiency and resistance characteristics of slag wool fiber filters was extended to other aerosols and gases such as fly ash, sulfur dioxide, hydrofluoric acid and sulfuric acid mist. The filter (one inch thickness, five pounds per cubic foot density) at velocities used for collecting iron fume (50 to 150 feet per minute) showed efficiencies for SO2 of approximately 30% when moist and zero when dry. For hydrogen fluoride (dry and wet), efficiencies range from 70 to 90%. For fly ash resuspended from Cottrell ash, efficiencies ranged from 60 to 90%, whereas when feeshly formed fly ash was created by burning powdered fuel, efficiencies ranged from 93 to 99%. A revised pilot model slag wool filter was constructed for 750 to 1000 cfm gas flow based on results of the first field unit.

05597

D. H. Wheeler and D. J. Pearse

FUME CONTROL INSTRUMENTATION IN STEELMAKING PROCESSES. Blast Furnace Steel Plant 53 (12), 1125-30 (Dec. 1965.) (Presented at the 58th Annual Meeting, Air Pollution Control Association, Toronto, Canada, June 20-24, 1965.)

The basic components of an instrumentation system and their functions are briefly discussed. Typical process applications to an L-D basic oxygen furnace, an open hearth furnace, and an electric furnace are discussed.

05604

R. L. Schneider

ENGINEERING, OPERATION AND MAINTENANCE OF ELECTROSTATIC PRECIPI- TATORS ON OPEN HEARTH FURNACES. J. Air Pollution Control Assoc. 13(8), 348-53 (Aug. 1963). (Presented at the 55th Annual Meeting, Air Pollution Control Association, Chicago, Ill., May 20-24, 1962.)

The origin of open hearth dust is reviewed. The stack dust was sampled. The maximum average stack dust loading occurred during the working period and increased when oxygen was introduced. The average dust emission per heat was .9 grain/scf. The particle size of the dust collected by the thimble is extremely fine. Ex- pressed in microns meter, approximately 50% to 55% of the collect- ed dust would fall in the range of 0

to 5 microns; 25% to 30% in the range of 5 to 10 microns; 15% to 20% in the range of the 10 to 20 microns; and the balance over 20 microns. This distribution is true for the major portion of the heat cycle. The total vol- ume of waste gases was determined to be 1,135,000 cfm at 550 F. The waste gas temperatures averaged 500 F after passing through the waste heat boilers and approximately 1200 F when the waste heat boiler was by-passed. The petrographic analysis of the pre- cipitator dust showed that alpha-Fe2O3 (hematite) and gamma- Fe2O3 (maghemite) was present. The moisture content varies from 12 to 25 grains per cubic foot. With this engineering data available, the electrostatic precipitators were designed. In March 1960 acceptability tests showed that the precipitators were operating above their design conditions with efficiency in excess of its 97.5% guarantee.

06083

W. W. Campbell R. W. Fullerton

DEVELOPMENT OF AN ELECTRIC-FURNACE DUST CONTROL SYSTEM. J. Air Pollution Control Assoc. 12 (12), 574-7; 590 (Dec. 1962). (Presented at the 55th Annual Meeting, Air Pollution Control Association, Chicago, Ill., May 20-24, 1962.)

When the smoke-control ordinance of Allegheny County, Pennsylvania, was revised in 1955, intensive research was begun on the control of emissions from electric furnaces. This paper describes the development program, which included the design of a hood, the operation of a pilot plant to study exhaust-gas cleaning, and the design and operation of a full-scale dust-control system for a five-furnace shop. It should be of interest to those associated with air pollution control as an example of how a member of industry solved a difficult pollution problem. Considerable time, energy, and ingenuity have been spent in developing unique facilities to eliminate atmospheric pollution both inside and immediately outside an electric-furnace shop. The results obtained from these efforts, which led to the design of the Duquesne facilities, have been satisfactory. However, it is hoped that continued experience in operating these facilities will produce means to further increase the effectiveness of dust control and, if possible, to reduce operating costs. This would include, for example, determining the optimum method of operating the baghouse to minimize the pressure drop and determining the type of refractory that will yield the longest service life for the expandable hood rings.

06098

R. S. Brief, A. H. Rose, Jr., D. G. Stephan

PROPERTIES AND CONTROL OF ELECTRIC-ARC STEEL FURNACE FUMES. J. Air Pollution Control Assoc. 6(4):220-204 (Feb. 1957). (Presented at the 49th Annual Meeting, Air Pollution Control Association, Buffalo, N.Y., May 20-24, 1956.)

An attempt has been made to assess the properties and quantities of emission from the electric-arc steel melting furnaces and to evaluate control systems in terms of these emission characteristics. Available data concerning these emissions are limited. There is a lack of details on process type, charge composition, melt-down rate, pouring temperature, and other variables associated with furnace operation. Because of this, realistic correlations enabling accurate predictions of fume emissions cannot be developed. At present, little is known about the changes in fume characteristics with respect to process phase. Chemical composition and emission rates should be determined during different periods in the melting cycle for various furnace processes. Such work should assist in developing more economical fume collection systems by indicating the duration of critical collection periods during which extreme conditions are encountered. In order to treat electric-arc steel furnace fume collection theoretically, accurate particle-size distributions for each phase of the melting cycle must be known. Since appreciable weight fractions of fume occur in the range below 5 microns, a more detailed breakdown in this range would be advantageous.

06223

K. Yokomiyo

AIR POLLUTION PREVENTION EQUIPMENT INSTALLED IN MURORAN STEEL AND IRON WORKS, LTD. Clean Air Heat Management (Tokyo) 15, (7-8) 19-28, Aug. 1966. Jap.

In 1950, a venturi scrubber was installed in the Muroran Iron Industry. Since that time, other control equipment has been set up in such places as the raw material factory of the pig iron manufacturer, melting furnace, open hearth, revolving furnace, and fire extinguishing tower of the coke furnace. In the pig iron factory, a settling chamber and cyclone were installed for dust collection in the sintering process. The dust collecting efficiency was 80 to 90%. The chemical composition of the dusts is as follows: total iron 42 to 57%; CaO, 4 to 10%; SiO2, 3 to 7%, S, less than 0.8%. The chemical composition of the exhaust gas was: CO2, 2 to 6%; O2, 13 to 18%; SO2 and SO3, 0.04 to 0.18%; and water 15 to 90 g/Nm3. Particle size distribution is also given. In the melting furnace, wet collectors were installed followed by venturi scrubbers, and electostatic precipitator, and various washers (all more than 95% efficient). Chemical composition and particle size distribution are also tabulated. In the open hearth, dust and soot are generated when the oxide is blown in, when raw materials are inserted, and from incomplete combustion. The average size of dust particles is 0.25 micron consisting of 60% Fe. An electrostatic precipitator was used here and in the revolving furnace. Dusts from brick manufacturing are collected by bag filter.

06249

HOW STEEL COMPANY OF CANADA HAS BATTLED AGAINST AIR AND WATER POLLUTION DURING THE PAST 40 YEARS. Air Eng., 9(2):14-5, Feb. 1967.

Features of air and water pollution elimination at Hilton Works of Steel Co of Canada are described. Some of the topics of this brief discussion are the use of waste gas as a fuel, and the construction of both a phenol-extraction plant and an oil recovery system.

06392

Henschen, H. C.

WET VS DRY GAS CLEANING IN THE STEEL INDUSTRY. J. Air Pollution Control Assoc., 18(5):338-342, May 1968. (Presented at the 60th Annual Meeting, Air Pollution Control Assoc., Cleveland, Ohio, June 11-16, 1967, Paper 67-149.)

Two entirely different gas cleaning systems are presently in basic oxygen furnace service in North America. Both will do an excellent job if properly designed. Either system will cost in excess of $2,000,000 and will require careful control and large amounts of electrical power. One system, the dry electrostatic precipitator, requires humidification of the gas; protection against explosions; elaborate electrical controls, insulators, etc; and a rugged handling system for the bone dry dust collected. The other system, wet washing with water, is easier to control but uses large quantities of water and electric power. As in the case of the 'dry' system, handling the dirt collected is a difficult problem requiring carefll study and choice of equipment. In either case the dust may be discarded or reused, but it must be handled with care lest it become an air

or stream pollution problem all over again. The choice of a wet or dry system is not clear cut and may very well depend on individual preference and local conditions.

06443

Wheeler, D. H.

FUME CONTROL IN L-D PLANTS. J. Air Pollution Control Assoc., 18(2):98-101, Feb. 1968. (Presented at the 60th Annual Meeting, Air Pollution Control Association, Cleveland, Ohio, June 11-16, 1967, Paper 67-94.)

Complex and expensive fume control systems are required in L-D plants due to the cyclic operation and heavy fume emission from the furnace. Evolution of gas and fume from the furnace varies greatly throughout the blowing period, and the blowing period is less than 50% of each cycle. Gas volume in the hood is influenced by oxygen blowing rate, and area of opening between furnace and hood. The principal components of a system are: hood, ductwork, gas cooling equipment, collectors, fans, instrumentation, and dust or sludge handling equipment. Several optional designs are available and should be evaluated in selecting a system. These include: open or closed hoods, dry or wet collectors, steaming or cold water hoods and dust disposal or usage. (Author's abstract)

06568

RESTRICTING DUST EMISSION IN BLAST-FURNACE OPERATION. (Staubauswurf Eisenhuttenwerke Hochofen.) VDI (Verein Deutscher Ingenieure) Kommission Reinhaltung der Luft, Duesseldorf, Germany. (VDI 2099.) (Feb. 1959). 23 pp. Ger. (Tr.)

The aims are to characterize the influences which create dust; to point out measures for the reduction of dust emission; to establsih guide lines for permissible dust emission; and to determine the necessity for dust removal from flue gases and to give indications for the selection of suitable dust separators. Knowledge of the relation between emission and deposition is important for an objective evaluation of the dust level. The factors to be considered in specifying cloth filters, mechanical dust separators, wet electrostatic precipitators, and stacks are reviewed.

06587

R. C. Specht and R. R. Calaceto

GASEOUS FLUORIDE EMISSIONS FROM STATIONARY SOURCES. Chem. Eng. Progr. 63, (5) 78-84, May 1967.

Methods of controlling the emission of fluorides from the brick and tile, steel, aluminum, and phosphate fertilizer industries are examined. The brick and tile industry receives brief treatment and a concluding statement mentions that a venturi type scrubber was used in bottle manufacture with 92% efficiency. In the steel industry, the emission of fluorides from sintering plants exceeds those from open hearth furnaces and different control measures are required. The addition of 6% weight of ground limestone to the sintering mix reduced fluoride emission by nearly one half. The final treatment consists of the means for supplying and injecting pulverized limestone and the final dust separation equipment. Reduction of fluorides is estimated at 96%. The basic difference between the treating systems of the sintering and open hearth processes is the pressure under which they operate and the material used as a reactant; CA (OH) 2 is used in the open hearth process. Among the methods discussed in regard to the aluminum industry are the wetting by sprays of the hot gases escaping through roof monitors, the use of a sieve-plate gas absorber column, and a floating bed type of scrubber which overcomes the tar-fouling problem and is reported to remove 95% of fluorides. Fluoride control is achieved with cyclones and packed towers. The effects of fluorides on vegetation, cattle, and man are briefly discussed including the effects of inhalation of HF at various concentrations.

06611

Rengstorff, G. W.

FORMATION AND SUPPRESSION OF EMISSIONS FROM STEELMAKING PRO- CESSES. In: (Open Hearth Proc., Philadelphia, Pa.), 1961, Vol. 44, p. 120-147. 7 refs. (Presented at the 44th Conf., Nat. Open Hearth Steel Comm. of the Iron & Steel Div., Phila., Pa., April 10-12, 1961.)

Much new information delineating the effect of process variables on iron-smoke formation has been developed from experiments on a 2- lb converter. This information has been combined with detailed analysis of the reactions between gases and molten iron to provide valuable clues for understanding the mechanism of smoke formation. Progress is being made toward achieving this understanding. From a practical standpoint, it appears that the possibility of adding methane to suppress smoke in bessemer converters has merit. The finding that an increased gas-inlet jet velocity decreases smoke in top blowing needs verification. If true, it will probably be of considerable practical importance. (Author's conclusions, modified)

06780

(LIMITATIONS OF EMISSIONS OF IRON METALLURGICAL DUSTS (RED SMOKE.) 1. OXYGEN CONVERTER PROCESS. Limitation des Emissions de Poussieres Siderurgie (Fumees Rousses). 1. Procede a l'Oxygene - Convertisseur. Centre Interprofessionnel Technique d'Etudes de la Pollution Atmospherique, Paris, France. (1967.) 8 pp. Fr. (Rept. No. CI 312.) (C.I.T.E.P.A. Document No. 24.)

The directive of the VDI Reinhaltung der Luft which describes the emission of red smoke from oxygen converters, the available control measures, and the recommended emission standards are summarized. The red fumes which are chiefly iron and manganese oxides with a mixture of ash have an average diameter of 0.01-0.1 micron. The amount of dust evolved varies from 15-25 kg per ton of molten metal. The concentration in the gas depends on the dilution by secondary air. The choice of a dust collector depends on the size and type of the installation, the properties of the dust, and the available means of disposal of the collected dust. Among the methods evaluated were wet collectors, electrostatic precipitators, and filters. A new oxygen converter for iron equipped with all of the available control measures should not emit more than 150 mg/cu m under standard conditions.

06854

J. E. Johnson

WET WASHING OF OPEN HEARTH GASES. Iron Steel Engr., 44(2):96- 98, Feb. 1967.

Wet scrubbing was selected as an economical means of cleaning waste gases from the oxygen lanced open hearth furnace in the steel making industry. A description of the components and operation of the venturi scrubber system and the problems encountered with it are discussed. The bench marks of gas flow system, recycle system, slurry system, draft control, efficiency, materials of construction, and dependability are evaluated; it is concluded that the venturi scrubber is an effective control device.

06936

Smith, W. M. and D. W. Coy

FUME COLLECTION IN A STEEL PLANT. Chem. Eng. Progr., 62(7):119-123, July 1966.

The use of electrostatic precipitators for the collection of iron oxide fumes has cut solids emission by 99.4%. A flow distribution model was the key factor in obtaining high efficiency. Majority of operating difficulties have been with dust handling systems and screw conveyor clogging has been most prevalent problem. (Authors' abstract, modified)

07192

W. W. Bintzer and D. R. Kleintop

DESIGN OPERATION AND MAINTENANCE OF A 150-TON ELECTRIC FURNACE DUST COLLECTION SYSTEM. Iron Steel Engr. 44(l):77-85 June 1967.

The dry-type collecting system installed on a 22-ft diameter, 150-ton electric furnace (with a modification of the snorkel design to provide fume pickup from the furnace) which controls smoke and fume during the meltdown phase is described. Efficient fume control can be maintained during the refining phase if the evacuation rate is controlled when the furnace side doors are opened. The carbon reduction phase using the oxygen blow was not adequately solved, since the thermal head is virtually uncontrollable. Operator-controlled conditions and the maximum exhaust through a fume collection system reduces the fume from around the electrodes, but does not eliminate it. During top charging and tapping, control is nonexistent. The large smoke and fume generation occurs for 3 to 5 min every hour and amounts to 40-50 lb per ton of steel per heat which is not considered objectionable at the present. The collection of smoke and fume from electric arc furnaces is difficult and 100% collection is not practical. The collection of 40 lb of dust per ton of steel is considered to be an excellent dust and fume control system for electric furnace steel production.

07521

Billings, C. E., L. H. Levenbaum, C. Kurker, Jr., E. C. Hickey, and L. Silverman

FURTHER INVESTIGATIONS OF THE CONTINUOUS SLAG WOOL FILTER. J. Air Pollution Control Assoc., 8(1):53-64, May 1958. 9 refs. (Presented at the 50th Annual Meeting, Air Pollution Control Assoc., St. Louis, Mo., June 2-6, 1957)

The second continuous slag wool pilot plant operated normally on open hearth fume was field tested. The plant consists of a 4 ft. diam. flat circular disc of 10 gage perforated sheet steel mounted on a vertical shaft. A slurry of the slag wool fibers in water is used to form the filter bed. The bed advances into the hot gas plenum where it filters 750 cfm. of gas at temperatures over 900 deg F. An average collection efficiency of 50%, ranging from 0% to 89% was indicated. A rotary screw agglomerator preceding the unit gives an average efficiency for the filter of about 55% with a range from 25% to 90%. Stationary slag wool filters gave an average efficiency of about 90%. Resistance of the normally operated continuous filter was controlled by varying rotation speed and was maintained most of the time at about 4 in. of water without difficulty. Average resistance of stationary filters was about 6.5 in. of water ranging from an initial value of 1.2 in. of water to about 10 in. of water finally. Stationary filters operated on the average about 30 min. The rate of resistance increase for stationary filters was 30% lower when the screw agglomerator was included in series with the filter unit. 1se of the screw agglomerator should extend fiber usage about 30%. Average resistance of the screw agglomerator was on the order of 1.5 in. of water. Web packing density and thickness should be more closely controlled during formation. Observations on the 750 cfm. pilot plant indicate that about 4 tons/day of slag wool would be required for an average 250 ton open hearth furnace. Automatic washing and reclaiming of slag wool fibers needs investigation to determine the optimum conditions for maximum cleaning and minimum fiber breakage. Average dust loading to the filter was about 0.1 gr./cu ft. Mechanical operation of the unit and auxiliary equipment was generally good with minor modifications in design being suggested by the field experience.

07542

G. Punch

ELIMINATION OF FUMES IN IRON AND STEEL INDUSTRY. Steel Intern. (London), 3(12):8-18, July-Aug. 1967.

Some of the electrofilter installations made as a part of an intensive program of control of the large amounts of fine fumes of unpleasant appearance and great soiling power that have been carried out by the British steelworks since the passage of the Clean Air Act of 1956 are described. The installations were among the firss of their kind, so that no design information was available from similar applications. The installations described include a sinter plant, an open-hearth furnace, an electric furnace, top-blown converters including Kaldo and LD converters. Not only must a collector be sized for the worst conditions to be expected, but the electrofilter must function efficiently at all times regardless of rapid and violent changes in gas conditions. The temperature of the waste gases at the electrofilter inlet should be safely within the range between their dew point and the maximum permissible operating temperature. Evaporation of water injected directly into the gas is a convenient and cheap method of cooling. The collector electrodes must be designed for easy rapping with the minimum entrainment. The results of the installations described indicate that the dry electrofilter with its low energy consumption, reliablility, small maintenance requirements, and the capability of producing dry dust for immediate disposal or refuse may be adapted to all phases or iron and steel making.

07617

Billings, Charles E.,W. David Small, and Leslie Silverman

PILOT-PLANT STUDIES OF A CONTINUOUS SLAG-WOOL FILTER FOR OPEN- HEARTH FUME. ¼J. Air Pollution Control Assoc., 5(3):159-166, Nov. 1955. (Presented at the 48th Annual Meeting, Air Pollu- tion Control Assoc., Detroit, Mich., May 22-26, 1955).

Laboratory and field results obtained on slag wool when filtering iron oxide and open-hearth furnace fume are discussed. Laboratory equipment used to test slag-wool filters consisted of an iron oxide generator connecting ductwork, a 6 in. diam. holder for the slag- wool test pad, a flowmeter, and a fan. Iron oxide was generated in the laboratory by 2 different methods. In the first, flake iron powder was injected into the air side of an air-oxygen-acetylene flame where it was oxidized exothermally. In the second, iron carbonyl was burned in an oxygen acetylene flame to provide more controlled generation. Modified laboratory test equipment was set up on the basement level of a 100-ton cold-metal open-hearth furnace. A probe was inserted into the furnace stack below the waste-heat boiler to withdraw furnace-gas samples. Results of this investigation are given. An additional series of tests was run on a hot metal furnace. The test equipment was set up on the basement level of a 250 ton open-hearth furnace. Samples were withdrawn below the waste heat boiler. Results of this study are reported. Collection efficiencies over 90% may be

obtained with 1 in. thick pads of slag wool packed to 5 and 10 lb. cu ft density. Resistances initially range from 2 to 8 in. of water, and increase to 2 to 14 in. during filtration of 0.1 gr/cu ft of a fine iron oxide aerosol. Continuous web of slag wool showed variations in efficiency from 10 to 90%. Filter resistance was maintained near 4 in. of water during operating periods ranging from 1/2 to 3 hr. A correlation between inlet fume loading and furnace production was observed which influenced filter requirements. Mechanical factors in the test unit tending to lower the efficiency of the continuous web were determined. Based on field studies, it was found that an average 250 ton hot metal open hearth furnace would require 1 to 3 tons of slag wool/day to filter stack gas.

07660

Davies, E. and W. T. Cosby

THE CONTROL OF FUME FROM ARC FURNACES. In: Fume Arrestment, Special Rept. 83, London, William Lea and Co., Ltd., 1964, p. 133 - 143. (Report of the Proceedings of the Autumn General Meeting, Iron and Steel Inst., London, England, No. 26-27, 1963.)

Various methods are discussed for containing the fumes formed during the production of steel in electric arc furnaces, with particular reference to the application of the 'direct extraction' technique. It is shown how this technique, while preventing the emission of fumes completely in the neighborhood of the furnace and considerably reducing the final volume of gases to be treated by a gas cleaning unit, nevertheless introduces at the same time new problems which must be resolved to produce a safe and efficient installation. The premises are indicated on which the Brymbo extraction system was designed, how far these were supported by practical experience and how the latter emphasized, among other factors, the importance of maintaining adequate facilities for the ignition and combustion of inflammable gases emanating from the furnace, not only during the oxygen blow but also other phases of the steelmaking cycle. It is concluded that, providing attention is paid to orthodox combustion practice and engineering design principles, the control of fume may be safely and effectively achieved with a resultant appreciable saving in the size and hence cost of gas cleaning units. The advantages of the 'direct extraction' technique become more pronounced as the capacity of the furnace increases.

07661

Douglas, I. H.

DIRECT FUME EXTRACTION AND COLLECTION APPLIED TO A FIFTEEN TON ARC FURNACE. In: Fume Arrestment, Special Rept. 83, London, William Lea and Co., Ltd., 1964. p.144-149. (Report of the Proceedings of the Autumn General Meeting, Iron and Steel Inst:, London, England, Nov. 26-27, 1963.)

The direct fume extraction and collection plant fitted to a 15 ton arc furnace and designed primarily to deal with the fume produced during oxygen lancing is described. The fume is extracted through the side of the furnace shell, cooled in a water tube heat exchanger, and cleaned in a bag filter plant; the exhaust gases satisfy the relevant Clean Air Regulations, and have a solids content less than 0.05 grains/cu ft. Recommendations and legislation based on the ratio between gas exhaustion rate and the rate of oxygen blow have been put forward. For the plant described the ratio is approximately 6 : 1, although it is stressed that the effectiveness of ratios applicable to different melting installations may not always be directly compared, as different proportions of the oxygen available are used for oxidizing elements other than carbon. Because of this, in many circumstances, a better comparison can be the ratio between peak carbon removal and the total gas extracted.

07663

Hoff, H. and J. Maatsch

CONVERTER WASTE GAS CLEANING BY THE 'MINIMUM GAS' METHOD AT FRIED. KRUPP. In: Fume Arrestment, Special Rept. 83, London, William Lea and Co., Ltd., 1964, p.104-108. (Report of the Proceedings of the Autumn General Meeting, Iron and Steel Inst., London, England, Nov. 26-27, 1963.)

Steelmaking in an oxygen converter evolves 60-80 200g/cu nm gas / ton of pig iron, with a high CO content and about 200g/cu nm dust. By the dust removal methods so far in use, the gas is burned before cleaning with excess air, thus producing a great quantity of heat and very much increasing the amount of gas to be cleaned. Using the Krupp converter waste gas cleaning sytem according to the 'minimum gas' method, the amount of air getting into the converter gas, and subsequent combustion, are very much reduced by having a suitable shape of hood with a curtain of air round it and by having controlled gas exhaustion. Without this, gas can escape around the converter. The cooled, clean, high-CO gas can either be burned by a torch or recovered for further use. High-pressure scrubbers followed by differential washers with a regulated gap for fine dust removal, offer a good solution to gas cleaning problems. The whole apparatus can be housed along with the waste gas pipe and the burner in a readily inspected tower with very small demand on space and gas lines.

07664

Holland, M. and K. B. Whitman

DIRECT FUME EXTRACTION FOR LARGE ARC FURNACES. In: Fume Arrestment, Special Rept. 83, London, William Lea and Co., Ltd., 1964, p. 150-159. (Report of the Proceedings of the Autumn General Meeting, Iron and Steel Inst., London, England, Nov. 26-27, 1963.)

The development of a suitable fume extraction and cleaning system for large electrical arc furnaces using tonnage oxygen is taken in logical sequence through pilot plant trials to the final design stage. The choice of a wet cleaning plant is influenced by the ease of hot gas conditioning and fluorine removal, the economies due to reduced volumes at the outlet, and an improved effluent treatment and disposal system. The steps taken to ensure complete combustion of the gases evolved during the furnace cycle by the use of an adjustable sealed connection to the furnace, combined with a controlled combustion air and ignition source, are described in detail. Control of furnace pressure is achieved by control of speed of the fan and a water-cooled damper in the furnace offtake. Operational experience and plant reliability are discussed, together with reasons for modifications found to be necessary.

07668

Mitchell, R. T.

DRY ELECTROSTATIC PRECIPITATORS AND WAAGNER-BIRO WET WASHING SYSTEMS. In: Fume Arrestment, Special Rept. 83, London, William Lea and Co., Ltd., 1964, p. 80-85. (Report of the Proceedings of the Autumn General Meeting, Iron and Steel Inst., London, England, Nov. 26-27, 1963.)

The purpose of this paper is to consider two methods of fume cleaning. Electrostatic precipitators have been installed at

Ebbw Vale (30 ton capacity LDAC vessel) and wet washers at Spencer Works (three 100 ton capacity LD vessels). The conditions to be met in each case are defined, and the reasons for the selection of specific equipment are explained. The two systems are compared from the points of view of efficiency and operating costs, and the modifications which have proved necessary to remedy operational difficulties are detailed to enable a more realistic assessment of comparative capital expenditure. Re-use of recovered dust and new equipment are discussed. Maximum efficiency throughout the blow with the variable gas flow and dust loan can be achieved effectively by electrostatic precipitation. If capital cost is the major consideration then wet washing is cheaper, although, if the experience at Spencer Works can be considered applicable to similar installations, the difference in cost between the two processes is much narrower than would have appeared two or three years previously.

07669

Morita, S.

OPERATION AND ECONOMY OF THE OXYGEN CONVERTER GAS RECOVERY PROCESS (OG PROCESS). In: Fume Arrestment, Special Rept. 83, London, William Lea and Co., Ltd., 1964, p. 109-115. (Report of the Proceedings of the Autumn General Meeting, Iron and Steel Inst., London, England, Nov. 26-27, 1963.)

The equipment, installation operational results, and economy of the oxygen converter gas recovery process are discussed. The components and instrumentation of the process are described. The process combines high dust collecting efficiency with high-yield steelmaking operations. Operational records are given, and the characteristics of OG dust analyzed. The economic advantages of the process are detailed in comparison with the waste heat boiler.

07670

Namy, G., J. Dumond-Fillon, and P. A. Young

GAS RECOVERY WITHOUT COMBUSITON FROM OXYGEN CONVERTERS: THE IRSID-CAFL PRESSURE REGULATION PROCESS. In: Fume Arrestment, Special Rept. 83, London, William Lea and Co., Ltd., 1964, p. 98-103. (Report of the Proceedings of the Autumn General Meeting, Iron and Steel Inst., London, England, Nov. 23-27, 1963.)

The recovery of CO without combustion through the control of hood pressure is discussed. The major parameters involved, the inherent problem of safety, and the measures adopted for complete monitoring and control are considered. The nature of the fume produced necessitates a high-efficiency gas cleaning system, and the techniques introduced, including complete air purge of the circuit after each operation, are described. The open joint system with pressure control appears to be the one which ensures the greatest possible independence between metallurgy and gas cleaning (and in this it resembles process with combustion). Unlike processes with combustion, it appears to offer a very economic method of gas cleaning while recovering energy in a high potential form. It seems to lend itself especially well to the control of bath reactions by continuous carbon balance.

07699

Pottinger, J. F.

THE COLLECTION OF DIFFICULT MATERIALS BY ELECTROSTATIC PRECIPITATION. Australian Chem. Process. Eng. (Sidney), 20(2):11-23, Feb. 1967. 11 refs.

Problems encountered in the metallurgical, cement and power generation industries which led to an extensive study of the electrical properties of dust particles and the effects of these properties on precipitator performance are reviewed. Electrical breakdown and resistivity measurement are discussed and a design of a bulk resistivity measuring apparatus is illustrated. Negative resistivity is cited as a problem. The remedial measures in the industries cited are described in technical terms.

07925

Beighton, J.

THE SPECIAL INDUSTRIAL PROCESSES. Roy. Soc. Health J. (London). 87(4):215-218, July-Aug. 1967. 2 refs. (London)

The air pollution problems of a group of industries which produce: sulfuric acid, nitric acid, petroleum and petrochemicals, iron and steel, copper, aluminum, gas, ceramics and electric power are reviewed. The basic technical approach is to avoid the formation of the emission by design of the process, then to require the treatment of any unavoidable emission, and finally to require adequate dispersal of any residual amount which has to be discharged. The legislation is designed to compromise between safeguarding of public health and amenities and providing for a realistic acceptance with adequate control of special processes. Although the loss of gases in the manufacture of sulfuric acid is limited to 2% of the sulfur burned, the loss from a contact acid plant with a 500-ton-per-day capacity may be considerable so that chimney heights as high as 450 ft may be required. Acid mist from contact plants burning sulfur is a special problem as it is difficult to control and its occurrence is unpredictable. There are two nitric acid plants in Britain equipped with catalytic tail-gas reduction units which should solve the problem of brown nitrous fume emission to the air. The use of special flares is required to control H2S and mercaptans emitted by oil refineries. In the steel industry the development of the Fuel-Oxygen-Scrap process is regarded as an alternative to the electric arc furnace. It is claimed that melting and refining can be carried out without exceeding a fume level of 0.05 grains per cu ft.

07931

Ertl, D. W.

ELECTROSTATIC GAS CLEANING. S. African Mech. Engr. (Johannesburg), 16(8):159-168, March 1967.

Electrostatic precipitators are a highly developed and efficient means of cleaning industrial and waste gases, satisfying all modern hygienic and industrial requirements. Each precipitator has to fulfill two functions: (1) electrically charging the dust and capturing it by electrodes which are at earth potential; and (2) passing this precipitated dust, with minimum re-entrainment losses, into the hoppers underneath the precipitation field. Parameters influencing the total dust collecting efficiency are: the ratio of the collecting plate area to gas flow rate, which is a dimension of the precipitator size; the migration velocity or the velocity by which the dust is attracted to the collecting plate under electrical forces, which is dependent on field intensity; the dielectric constant of the dust; the dew-point of the gas/dust mixture, high dew-point being better suited for precipitation than a completely dry gas. Factors adversely affecting precipitation efficiency are space charges, which develop when there are large amounts of very fine dust in the gas, and dust resistivity, which makes precipitation difficult when the dust layers have an electrical resistance of greater than approx. 10 to the 11th power ohm/cm. Precipitators are important for thermal power stations where the dust fineness must also be taken into account in design. The use of precipitators for blast furnaces and steel works, cement

works, and in the chemical industry, is noted. Dust collecting efficiencies of 99.5% are not exceptional and greater efficiency is advisable in continuous operation at numerous plants. For optimum dust collecting results, the specific dust properties have to be taken into account during the planning stage of the whole plant.

08310

Bergmann, Paul Jesdinsky, Walter Reuter, Guido and Werthmoller, Ewald

DEVELOPMENT AND DESIGN OF A MODERN DUST REMOVAL SYSTEM FOR AN ELECTRIC STEEL PLANT. (Uber Entwicklung und Aufbau einer meuzeitlichen Entstaubungsanlage fur ein Elektrostahlwerk.) Text in German. Stahl Eisen (Duesseldorf), 87(22): 1310-1314, Nov. 2, 1967.

Four electric arc furnaces with a capacity of 2.5 tons were equipped with a dust removal system. Special problems were posed by intermittent operations as well as by variable gas production during one smelting and refining cycle. Exhaust volume needed to be regulated. The controlling variable was gaseous pressure under the hood of the furnace. A special non-conducting pressure sonde was developed which was insensitive to the gases ionized by the arc. A scrubber was not used since it would have frozen during winter weekends. The pressure sonde activates baffles which regulate the pressure in the furnace. The flue ducts of all four furnaces are combined in a mixing chamber, which serves as pressure and temperature equalizer. From there the flue gas goes to siliconized glass fiber filters which are located 60 to 70 m. away. Each of the three filters is large enough to process the flue gas of one 25-ton furnace. Filters can be selected by a switchboard. Each filter group consists of four towers with 24 filter hoses each, which are 9.3 m. long and 30.5 cm. wide. They are cleaned by pressure reversal every 24 min. Residual dust content of the flue gas is 8-12 mg./cu m.

09198

F. M. Wilkinson

'WET WASHING OF BOF GASES - LACKAWANNA. Preprint, Bethlehem Steel Corp., Lackawanna Plant, New York, 12p., 1966. (Presented at the AISE Convention, Cleveland, Ohio, Sept. 27, 1966.)

The operations of venturi scrubber equipment in a steel plant are explained. Three venturi scrubbers are utilized for two basic oxygen furnace (BOF) vessels with a nominal capacity of 250 tons. Frequent testing of the dust loading of the stack gases shows that certain unpredictable variations occur in the quantity of dust produced from heat to heat. This is true despite maintenance of identical conditions of pressure drop across the scrubber and water flow to the sprays. Some heats are more active than others and produce more dirt. The average results are best when the mechanical condition of spray nozzles and venturis is good. Such conditions result in dust loadings below .05 grains/c.f. std. Spray nozzles must be accurately positioned above the venturis, they must be free of excessive internal wear and the venturis must be well sealed at the upper flanges and free of wear holes which sometimes develop from erosion in the upper part of the throat.

09248

Muhlrad, W.

REMOVAL OF DUST FROM BASIC-OXYGEN FURNACE BROWN FUMES BY MEANS OF BAG FILTERS. Stahl Eisen, 82(22):1579-1584, 1962. 9 refs. Translated from German. Brutcher (Henry), Altadena, Calif., Technical Translations, HB-5768, ((29))p., 1963.

A gas cooling-bag filter plant utilized for the removal of dust from a basic oxygen furnace is described. The installation of a bag filter for removing the dust from the brown fumes requires the gases to be cooled reliably and quickly. The cooling process allows for the cyclic generation of waste gases, and consists of a heat storage unit in the form of a tower, through which the gases flow downward from the top. It is lined with a checker of refractory brick, which form vertical, straight channels. This checkerwork is so dimensioned that gas cooling is ensured by heat storage during the oxygen blow. Due to the parallel flow of hot gases and cooling air in the regenerator, it is difficult at peak times to keep the exit temperature below 100 to 120 deg C (250 deg F). The cooling action of the regenerator was therefore supplemented by a spray cooler to stabilize the temperature by water atomization: this is only a safety precaution, and operates for very short periods. The bag filter consists of 22 cells, which are systematically and automatically withdrawn from service and cleaned by transverse vibrations with a simultaneous counterflow blast. A polyester fabric was selected as the filter material. The dust is discharged mechanically from the filter, which is provided with automatic bagfilling equipment. The reclaimed dust is charged in paper bags into the converter along with the pig iron, and no visible evolution of dust takes place. The whole of the dust removal plant operates continuously, that is the hot waste gases and the cooling air of the regenerator flow through the plant without interruption. The capital costs and operating cost of the complete plant are outlined.

09270

Graue, Georg and Ronald Flossmann

SOME EXPERIENCES WITH A NOVEL EXPERIMENTAL PLANT FOR DUST REMOVAL FROM BROWN SMOKE. Staub (English translation), 27: (10):7-12, Oct. 1967. 5 refs. CFSTI: TT 67-51408/10

A novel method for removing dust from brown converter smoke has been developed which utilizes the special properties of brown smoke and is very promising as regards economic and technical advantages. Its principles have been fixed by laboratory tests and in an experimental pilot plant. Earlier results have been basically confirmed in an industrial plant of 2 x 25,000 cu m/h. However, as a result of constructional deficiencies concerning gas distribution and constant electrode gap in the filters, the method could not be tested to its maximum capacity. The achieved dust contents of clean gas have, therefore, been higher than the value required by authorities, i.e., 150 mg/cu.m. This value should, however, be reached after improvements in the design. (Authors' summary)

09361

Broman, Carl U. and Ronald R. Iseli

THE CONTROL OF OPEN HEARTH STACK EMISSIONS WITH VENTURI TYPE SCRUBBER. Blast Furnace Steel Plant, 56(2):143-148, Feb. 1968. 6 refs. (Presented at the Regional Technical Meeting, American Iron and Steel Institute, Chicago, Ill., Nov. 9, 1967.)

Early attempts to suppress fuming in open hearth furnaces and the installation and operation of an experimental venturi scrubbing system and the subsequent installation of venturi scrubbers on all the open hearth furnaces in one shop are described. The decision to install the control equipment, the gas flow system, the slurry system, operating and maintenance experience are considered.

09436

Sullivan, R. E.

AUTOMATIC SYSTEMS FOR REMOVAL OF DEPOSITS FROM OPEN HEARTH FLUES, ROOFS, WASTE HEAT AND FUEL FIRED BOILERS. Iron Steel Eng., 44(1):97-103, Jan. 1967.

The open hearth process for making steel produces a large quantity of soot which clogs flues and ducts, reduces draft-fan efficiency, and impairs heat transfer in waste-heat and fuel-fired boilers. The operation, design, and advantages of automatic soot blowing (cleaning) devices are discussed. Shot cleaning, where steel shot is dropped through boiler tube banks to dislodge deposits is described. Also considered are several methods including bag houses, venturi scrubbers, and electrostatic precipitators, for collecting particulates before stack gases are released to the atmosphere.

09796

Hammond, William F., James T. Nance, and Karl D. Luedtke

STEEL-MANUFACTURING PROCESSES. In: Air Pollution Engineering Manual. (Air Pollution Control District, County of Los Angeles.) John A. Danielson (comp. and ed.), Public Health Service, Cincinnati, Ohio, National Center for Air Pollution Control, PHS-Pub-999-AP-40, p. 141-257, 1967. GPO: 806-614-30

The two common steel-refining processes are: the basic process wherein oxidation takes place in combination with a strong base such as lime; and the acid process, wherein oxidation takes place without the base addition. Steel-refining processes are usually accomplished in the open hearth furnace, the electric furnace or the Bessemer converter. The air contaminants vented from steel- melting furnaces include gases, smoke, fumes, and dust. The gaseous emissions result from the combustion of fuels and other combustible contaminants in the furnace charge and from the refining process. Smoke emissions result from incomplete combustion of the combustibles in the furnace charge or of furnace fuel. Particulates originate partially from dirt and impurities in the charge, but the major quantity results from the refining process. Typical particulates discharged from an open hearth and electric-arc furnace are listed. These fume emissions are largely in the form of metallic oxides, where 65 to 70 percent fall into the 0 to 5 micron size range. The methods of making open-hearth, electric-arc and electric induction steel are reviewed. The air pollution problems, the hooding and ventilation requirements, and air pollution control equipment of each are discussed. Particular emphasis is devoted to design consideration of the hood and ventilation systems. Open hearth furnaces have been successfully controlled by electrical precipitators. Test results of a control system wherein a waste heat boiler and electrical precipitator vent an open hearth furnace are shown. Baghouse dust collectors, electrical precipitators, and water scrubbers can be utilized to control electric arc furnace emissions. Some of the design features of baghouses serving electric arc furnaces are outlined and test results of air pollution control systems with baghouses serving electric arc steel-melting furnaces are shown. Operating data for two installations of electrical precipitators serving electric arc furnaces are also shown. Test results on water scrubbers serving electric arc furnaces show that wet collectors collect only the larger particles and allow the submicron particles to be discharged to the atmosphere. Air pollution control equipment for the electric induction furnace is the same as outlined for the electric ore furnace.

09915L

Meldau, R.

GAINFUL USES OF THE DUST FROM BROWN FUMES. Translated from German. 35(3):203-208, 1964. Available from Henry Brutcher Technical Translation, Altadena, Calif.

The brown dust produced in the basic oxygen furnaces of a steel plant can be used as a paint pigment, plaster filler, floor tiles material, soil conditioner, or plastic filler. Other uses include sponge iron, pressing, and molded composite sheets. The effect of heating on particle size, and the degree of thermal and chemical resistance are discussed. The economics of recovery are considered.

09974

Hipp, N. E. and J. R. Westerholm

DEVELOPMENTS IN BLAST FURNACE GAS CLEANING GREAT LAKES STEEL CORP- ORATION. Preprint, Iron Production and Great Lakes Steel Corp., Ecorse, Detroit, Mich., ((20))p., 1967. (Presented at the A. I. S. E. Convention, Cleveland, Ohio, Sept. 27, 1966.)

Blast furnace flue gases are cleaned by passing through a gravity settling chamber, an orifice washer, and then a packed tower (gas cooler). The orifice washer is simply an orifice plate directly upstream from a set of water spray nozzles. The orifice scrubber removes 99.7 percent of the dust passing through it.

09977

Hurst, T. B.

MEMBRANE HOOD OPERATING PERFORMANCE AND IN-PROVEMENTS. Preprint, Association of Iron and Steel Engineers, Cleveland, Ohio, Boiler Div., Barberton, Ohio, ((31))p., 1966. (Presented at the Association of Iron and Steel Engineers, Cleveland, Ohio, Sept. 26 29, 1966.)

Fumes from a basic oxygen furnace contain large quantities of CO. A hood is proposed which collects the furnace exhaust, burns the CO with additional air, and extracts the heat by means of water filled tubed in the hood walls. The advantages of this system are reduction of CO in the exhaust to very low levels, cooling of the gas prior to electrostatic or venturi cleaning, and the extraction of valuable heat in the form of steam. Hood construction, arrangement, control and operation are discussed. Because of the operating cycle of the basic oxygen furnace, the obtainable heat and therefore the production of steam will vary considerably. A 200 ton furnace with a steam generating hood produces from almost none up to about 400,000 pounds per hour of steam during oxygen blowing. To smooth out the flow rate to a continuous level, a steam accumulator is described which absorbs the heat in bursts and releases a constant steam flow of about 70,000 pounds per hour.

10460L

Zimmer, K. O.

DUST-LADEN WASTE GASES EMITTED IN THE BASIC OPEN-HEARTH PROCESS WIT THE USUAL MELTING PRACTICE AND WITH OXYGEN INJECTION: ALSO REMOVAL OF THE DUST FROM THEM. Stahl Eisen, 84(17):1070-1075, 1964. 3 ref Translated from German. Henry Brutcher Technical Translations, Altadena, Calif., HB-6344, 18P., 1964. Avail- able from Henry Brutche Technical Translations, Altdena, Çalif.

Data are presented on the effects of various fuels, ranging from crude tar to coke oven gas, and oxygen lancing on the

volume and composition of waste gases from open hearth furnaces. Variations o dust leading and sulfur content of the gases during different phase of a heat are also described. Dust removal equipment, consisting o a waste heat boiler followed by an electrostatic precipitator, and the economics of dust removal are discussed.

10462L

Baum, K. and A. Hahn

REMOVAL OF DUST FROM ELECTRIC FURNACE WASTE GASES. PART I - EXPERIENCE WITH WET DUST REMOVAL BY VENTURI SCRUBBERS. PART II - EXPERIENCE WITH A DRY ELECTROSTATIC FILTER ON A 100-m TON ELECTRIC ARC FURNACE. Stahl Eisen 84(23):1497 -1500, Nov. 1964. 1 ref. Translations, Altadena, Calif., HB-6418, 11p., 1964. Available from Henry Brutcher Technical Translations, P.O. Box 157, Altadena, Cali

A dry electrostatic filter and a Venturi scrubber were tested for their ability to remove dust from electric furnace waste gases. Th electrostatic filter system required large exhaust ducts and a high capacity sturation system to prevent burning and explosions of the combustible waste gas in the filter. The Venturi scrubber worked well and required little space. The composition and volume of wast gas is discussed with emphasis on the variations due to charge material, point in the heat cycle, presence of oxygen lancing, and leaks in the furnace openings. Exhaust systems and a method of electrode sealing are considered.

10464L

Bruderle, E. U. and G. Urban

REMOVAL OF DUST FROM ELECTRIC FURNACE WASTE GASES. PART III - EXTRACTION OF DUST FROM ARC FURNACES BY MEANS OF ELECTROFILTERS. PA IV - EXPERIENCE WITH DRAWING OFF THE WASTE GASES AND WITH ELECTRICA DUST EXTRACTION ON ARC FURNACES. Stahl Eisen, 84(23):1500-1505, 196 7 refs. Translated from German. Henry Brutcher Technical Translations, Altadena, Calif., HB-6419, 18p., 1964. Available from Henry Brutcher Technical Translations, P.O. Box 157, Altadena, Cali

The operating experience, cost, and general design of a dry electrostatic precipitator is reported for an electric arc furnace installation. A cost comparison is made with a wet electrostatic filter system; the wet system is slightly more expensive, but there is less chance of explosion of the combustible waste gas. The character and quantity of waste gas are discussed in light of how exhaust systems are affected. Pressure differentials, excess air intake, and exhaust gas volume fluctuations are considered as they affect the design and operation of the exhaust system.

10469L

Hoff, H.

FUNDAMENTALS OF THE TREATMENT OF THE BROWN FUMES FROM THE BASIC OXYGEN PROCESS. (PART II.)Stahl Eisen, 81(9):566-571, 1961. 9 refs. Translated from German. Henry Brutcher Technical Translations, Altadena, Calif., HB-5276, 36p., 1961. Available from Henry Brutcher Technical Translations, P.O. Box 157, Altadena, Cali

With the increased use of the basic oxygen process, the dust removal plants for the waste gas issueing from the vessels must als be further developed to minimize air pollution. The starting point of the dust removal problems are the fluctuations in gas formation over the blowing period in the furnace and the volume of gas in the dust extraction installation. Therefore, the possibilities were considered of reducing the volume of the waste gases, and their temperature, and at the same time of utilizing a part of their heat content. It was further investigated what factors in the plant cou influence the selection of the waste gas cooling and dust removal plant and which type of plant is the most economical for specific conditions. Capital and operational costs were briefly considered. In addition, two new methods are being developed for dust removal from the waste gases from top blown steel plants. In one case, the waste gases are exhausted in a controlled manner and burnt downstre of the furnace, and the burnt waste gases are then cleaned and released into the atmosphere. In the second method, the gas is als exhausted in a controlled manner, followed by dust extraction witho after-burning. It can then either be released into the open air an burnt to waste, or can be used as fuel. (Author's summary, modifie

10477L

Morita, Sh., M. Nishiwaki, K. Tagiri, and S. Narita

OPERATING RESULTS OBTAINED IN A 130-TON BASIC OXYGEN FURNACE EQUIPPED WITH AN OG GAS RECOVERY SYSTEM. Tetsu To Hagane, 49(3):405-406, 1963. Translated from Japanese. Henrt Brutcher Technical Translations, Altadena, Calif., HB-5933, 6P., 1963. Available from Henry Brutcher Technical Translations, P.O. Box 157, Altadena, Calif., 91001

A waste gas recovery method, the 'Oxygen Gas' (OG) process, was successfully employed in the operation of a Japanese basic oxygen steel- making furnace. The process uses a water-cooled hood for g cooling, spray and venturi scrubbers for dust removal, and a gas holding vessel for combustible gases released during the middle par of the oxygen blow. Explosions are prevented by purging the system with nitrogen prior to start-up and after the heat, and nitrogen dilution is employed when the CO to O2 ratio is near the explosive limit. The process is controlled and monitored by one man. Installation and operating costs are lower than for a conventional waste heat boiler, and the recovered gas is suitable to be used as boiler fuel.

10479

THE FORMATION OF DUST DURING OXYGEN LANCING ON THE OPEN-HEARTH Serokhvostov, A.L., V.F. Bogatenkov, and D. Ya. Povolotskii STEEL BATH. Izv. Vysshikh Uchebn. Zavedenii Charnaya Met., No: 6:52-55, June 1964. Translated from Russian. Henry Brutcher Technical Translations, Altadena, calif., HE-6335, Henry Brutcher Technical Translations, P.O. Box 157, Altadena, Cali lations, P.O. Box 157, Altadena, Calif. 91001

The effect of oxygen lancing on the dust production from an open hearth steel-making furnace was investigated. Data are presented o the dust production without oxygen lancing and with oxygen lancing throughout the heat. The effect of lance position on dust producti was investigated. A marked effect was discovered; maximum dust occured when the lance was at slag level. Lowest production occure when the lance was 6 inches above the slag, but this also reduced injection efficiency.

11073

Huntington, Robert G. and Donald H. Rullman

ARC FURNACE FUME CONTROL PRACTICES. Preprint, American Air Filter Co., Inc., Louisville, Ky., ((19))p., 1968. (APCA Paper 68-131.)

The percentage of steel produced in electric arc furnaces is expected to increase from about 10% to 15% by 1975. As air pollution codes become more rigid, more new and existing arc furnace installations will require fume control. Many of the factors related to the growth of the electric furnace including high power input, heavy oxygen lancing, oxifuel gas injections, and low cost scrap, all tend to increase the severity of the fume control problem. A successful arc furnace fume control system involves consideration of four parameters. These are - capture fumes at furnace; convey and cool gases allowing safe passage through collector; clean gases to an acceptable code limit; and provide a system with minimum cost and operational interference and maximum reliability. Successful capture technique include canopy hoods, close fitting hoods, and direct evacuation. Satisfactory fume collection is presently restricted by technological development, to three basic methods: Fabric collection, high energy (venturi) scrubbing, and high energy scrubber and electrostatic precipitation. Suitability of fume capture and cleaning methods are primarily a function of experience and analysis. Furnaces up to 10' in diameter represent a range of operating practices which may be compatible to both side draft or direct evacuation methods normally combined with dry fabric collectors. Thermal outputs from larger furnaces require accurate analysis for a safe, adequate gas handling and cleaning system. Arc furnace operating practices are the major influences affecting system design parameters. Those involved in the acquisition of arc fume control equipment should thoroughly investigate available methods in use on similar installations.

11096

Venturini, J. L.

HISTORICAL REVIEW OF THE AIR POLLUTION CONTROL INSTALLATION AT BETHLEHEM STEEL CORPORATION'S LOS ANGELES PLANT. Preprint, Bethlehem Steel Corp., Los Angeles, ((22))p., 1968. 1 ref. (Presented at the 61st Annual Meeting of the Air Pollution Control Association Annual Meeting, St. Paul, Minn., June 23-27, 1968, Paper 68-134.)

With the advent of air pollution control regulations in 1946, the problem encountered at Bethlehem Steel Corporation's Los Angeles plant was to select a suitable collecting system for its furnace operations. The new system provides a greatly improved method of ventilating the three million cubic foot electric furnace building. It consists of a direct roof evacuation type of a water-cooled elbow and a spray chamber at each furnace to temper the gases, damper controlled canopy hoods which are located over the furnaces and above the overhead cranes, and all necessary ductwork connecting collection points. The fume is pulled through 14-foot diameter ducts on the roof of the building and discharged into a distribution manifold. From the distribution manifold the particle laden smoke is diverted into the 26 individual sections of the baghouse. A typical baghouse section contains 120 silicone-treated, glass-fiber bags for a total of 3,120 bags in the complete installation. The actual control equipment consists of two large baghouses with two 1,250 hp driven air blowers. They are operating at a total exhaust capacity of 525,000 cfm at 10 inches of static pressure. The baghouse, operating at an efficiency of 99 percent plus, collects over 125 tons of dust a week. (Author's abstract, modified)

13645

Kawasaki Ironworks, Japan, Mizushima Branch Power Dept., Fuel Sect.

PREVENTION OF AIR POLLUTION BY COMBUSTION CONTROL IN MIZUSHIMA IRONWORKS. (Mizushima seitetsusho ni okeru taikiosen boshi no tameno nensho kanri). Text in Japanese. Netsu Kanri (Heat Engineering, Tokyo), 21(4):10-15, April 1969.

One of the most important industrial hazards to the public produced by ironworks is sulfur oxides in their emissions. At the Mizushima Ironworks, both dry and wet methods, including E. P., V. S., I. C. and Multicyclone systems, have been adopted to reduce dust concentrations. Their purification rates range from 95 to 99.95%. Special attention is paid to proper combustion and ventilation conditions. The combustion control system is checked routinely for minor inadequacies and malfunctions. The addition of 'Tenkazai' to heavy oil also reduces the production of polluted gas caused by water-separating and sludge-distributing effects. However, this procedure is not always economically feasible. To control smoke dispersion, the layout of factory buildings must be considered in relationship to local weather conditions. Buildings producing less smoke should be constructed closer to residential areas, while those producing large amounts should be placed perpendicular to the direction of the wind, so that smoke from one building will have less chance of mixing with that from another. To distribute smoke over a wider area thereby diluting the polluted air, high chimneys, high gas temperatures, and ways of accelerating smoke velocities should be considered.

13811

Singhal, R. K.

FUME CLEANING SYSTEMS USED IN THE STEEL INDUSTRY- PART I. Steel Times (London), 197(8):531-538, Aug. 1969.

Fumes from a small electric arc melting furnace are collected by a full hood system without the need for cooling equipment or a combustion chamber. A semi-direct hood system comprising a main hood connected to a side door hood and port hoods is adaptable for furnaces from 6 to 30 tons. On very large furnaces, direct extraction of the fume is possible with an elbow on the furnace side or roof. Here the fume is contained in the exhaust system before it escapes from the furnace. Electrostatic precipitators find wide application in many phases of metallurgical industry operations. In the iron and steel industry, they are used on blast furnaces, open-hearth furnaces, electric arc furnaces, converters, sinter plants, deseamers, and cupolas. In the non-ferrous industry, they are used in smelting on rotary and reverberatory furnaces and in the recovery of precious metals. The removal of dust from a gas stream by electrostatic precipitation follows three steps: (1) suspended particles are negatively charged; (2) the negatively charged particles then migrate and are precipitated on positively charged collecting electrodes; and (3) precipitated particles are dislodged by rapping or washing. Wet scrubbers bring dust-laden gases in contact with a water film or spray. Some wet collectors involve cyclones or centrifuges; others, multiple sprays. Efficiency of the collectors increases with energy consumption. The range of particle size, concentration, and collector efficiency are plotted for various industries.

13946

American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio, Committee on Air Pollution

PROCESS FLOW SHEETS AND AIR POLLUTION CONTROLS. Cincinnati, American Conference of Governmental Industrial Hygienists, 1961, 40p. 33 refs.

A variety of industrial processes, described in the text and illustrated by flow charts, are categorized according to the odors or pollutants produced by each stage of plant operations. Appropriate primary and secondary air cleaning equipment, including dry centrifuges, wet scrubbers, and fabric and electrostatic filters, are matched to each operation and evaluated as satisfactory or not satisfactory. The suggested controls have applications for asphalt and cement plants, gray iron or malleable foundry operations, the milling of asbestos ores, alfalfa dehydrating plant operations, coffee processing, iron and steel making, and scavenger-type rendering processes. Suggested reference sources are included for each process.

14161

Singhal, R. K.

FUME CLEANING SYSTEMS USED IN THE STEEL INDUSTRY. PART 2. Steel Times (London), 197(9):605-613, Sept. 1969.

A number of wet and dry fabric filters and mechanical cleaners are described and applications are mentioned. In the fabric dust collectors, the dust-laden gas is passed through a semi- porous medium which retains the dust particles and allows the clean gas to pass through. Efficiency is very high and the two main types in use are the mechanical vibration type and the reverse flow type. Fabric filters are widely used in the metallurgical industry and in electric arc furnace fume cleaning. Wet dust removers possess a number of advantages over the cyclone and fabric filter in cases where humidity or space requirements preclude their use. The removal of collected dust presents no problem; it is in the form of sludge or slurry. This is essential with explosive dusts such as magnesium alloys and aluminum. The Medusa gas scrubber consists of a three-fold combination of impingement, venturi and disintegration effects. Alteration to the liquid level provides flexibility for changes in gas volume and efficiency. The Elbair gas scrubber is noted for its high efficiency, low pressure loss, low hp requirements, and compactness. The Tornado Flow Dust collector simulates the flow patterns of a natural tornado by setting up two rotational flows with opposite axial components, occupies a small space and can be fitted into a chimney or can be arranged horizontally in pipelines. The Western Precipitation high-energy venturi scrubber was designed for gas cleaning operations requiring high pressure drops. Its primary applications are for blast furnaces, cupolas, oxygen converters, open hearth, and electric furnaces, and oxygen deseamers. The American Air Filter Type R Roto-clone is a wet centrifugal dust collector. The main component is a series of specially designed double- inlet tubes. In the Pangborn Type CH-3 dust control system, the air is drawn from the dust-producing source by means of ducts to the collector. The self-cleaning collector operates continuously and requires no periodic exhauster shutdown for cloth cleaning.

14889

Huysman, M. and A. Maubon

IMPROVEMENT IN THE REMOVAL OF DUST FROM WASTE GASES OF OXYGEN STEEL CONVERTERS BY EXTRACTION BEFORE COMBUSTION. (Amelioration de la technique de depoussierage des gaz residuels de convertisseurs a l'oxygene par captage sans combustion). Text in French. Rev. Met. (Paris), 65(5):333-343, May 1968. 11 refs.

At the Dunkerque works, carbon monoxides are evolved when steel is refined by blowing oxygen through the melt for about 18 min. A relatively new control technique, used for four years, is to collect the combustible gas without letting it burn at the converter mouth. The collector is a 'skirt' surrounding the mouth, whose internal pressure is adjusted so that just a little air is drawn in at the point of contact with the converter. The temperature of the gas is about 1630 C. The skirt can be raised during the process so that the controllers can inspect the effluent gas. The necessary pressure drop was a few mm of water. The rate of flow in the apparatus is large, so that at the beginning and end of refining, a plug of completely burnt gas separates carbon monoxide from air by intervening between them in the flow and thus prevents explosions. The gas is cooled in an exchanger and then scrubbed in a saturator and washing tower using about 500 cu m of water/hr. Sludge is decanted off, the residue is centrifuged, and the water is recycled. The residual dust content is about 100 mg/N cu m. In four years of operation, the original gas collector, with the joint to the converter sealed with steam, was abandoned for the movable skirt. The introduction of an oxygen injector with three differently directed holes lessened the ejection of metal and slag froth into the gas collector and eliminated blockage. A refractory soot collector was substituted for the first heat exchanger. The jets of the scrubber were redesigned to avoid blocking by the recycled water. The carbon monoxide which evolved from the washing water was directed away from all the work places, however, one small explosion occurred. Old safety valves were replaced by stainless steel valves. The minimum pumping speed was increased to 35,000 cu m/hr. Pumping and lowering of the skirt are never begun before absorption of oxygen has started.

15649

Hayashi, Tesshi

A SMOKE COLLECTOR. (Shuen sochi). Text in Japanese. (Mitsubishi Heavy Industries, Ltd., Tokyo (Japan)) Japanese Pat. Sho 44-12249. 5p., June 3, 1969. (Appl. Aug. 5, 1966, claims not given).

The present invention improves the operations of a smoke collector employed in a tilting furnace, such as an electric furnace for making steel. A fixed stationary duct is connected to a movable duct, which leads to the smoke source. The cross-sectional area of the stationary duct at the junction is larger than the corresponding cross-sectional area of the movable duct. The movable duct is connected to the stationary one in such a way that the former can slide along the latter with a seal between them, preventing the outside air from entering the ducts. The device has a simple construction and is very effective in collecting smoke. These features make the present invention attractive in industrial applications.

15886

Eberhardt, J. E. and H. S. Graham

THE VENTURI WASHER FOR BLAST FURNACE GAS. Iron Steel Engr., 32(3):66-71, March 1965. 11 refs.

Data are presented for a pilot plant venturi blast-furnace gas washer with a nominal capacity of 25,000 cfm and a plant scale venturi with a nominal capacity of 85,000, as installed in a steel co. Data for the 18-in. pilot unit indicate that the dirt content of the cleaned gas depends on the gas pressure loss across the venturi section; the gas pressure loss on the gas flow rate and the water ratio (gas of water per thousand cu ft

of gas). Correlations are presented for pressure drop vs dust loading and for pressure drop vs water ratio at seven gas flow rates. The dust loading of the cleaned gas varies from 0.09 gr/cu ft at a pressure loss of 7 in. of water to 0.015 gr/cu ft at a pressure loss of 24 in. of water. The thickener capacity required for this washer is only 3-5 gal per thousand cu ft rather than the 20 gal per thousand cu ft used in conventional washers. The plant scale washer is generally similar to the pilot plant; but the throat section is rectangular rather than circular, and the cooling tower contains no packing. The gas flow rate is close to 76,000 cfm and the water flow to about 11 gal per thousand cu ft. Pressure loss in this unit depends on factors other than gas velocity and water ratio, although pressure loss is increased by increasing either gas velocity or water ratio. Good cleaning is obtained with a water consumption of about 5 gal per thousand cu ft of gas.

15887

Pettit, Grant A.

ELECTRIC FURNACE DUST CONTROL SYSTEM. J. Air Pollution Control Assoc., 13(12):607-609, 621, Dec. 1963. 14 refs. (Presented at the 56th Annual Meeting of APCA, Detroit, June 9-13, 1963.)

Problems encountered in operating a venturi scrubber to clean waste gases from an electric steelmaking furnace are described. In accordance with state regulations, water clarification and recycling equipment is an integral part of the gas cleaning system. When the pH of the clarified water recycled to the scrubber is maintained at 7.0-7.6 with soda ash and the suspended solids content of the water kept at about 125 ppm with Seperan, the scrubber satisfactorily cleans gases at a water flow rate of 550 gpm and a pressure drop of 28 in. However, the efficiency of the system is reduced by plugging of the spray holes by solids. These holes are difficult to clean, since cyclinder-driven jet reamers often fail to go through them. In addition to the plugging, fine particles accumulate on large surface area, making frequent sludge filtration necessary. The sludge is filtered on a two-disc vacuum filter at an overall filtration rate of 20 lb wet sq ft/hr; cotton duck is used for filter bags. The average sludge analysis is 35% Fe, 9.5% Cr, and 2.5% Ni.

16039

Herrick, Robert A.

A BAGHOUSE TEST PROGRAM FOR OXYGEN LANCED OPEN HEARTH FUME CONTROL. J. Air Pollution Control Assoc., 13(1):28-32, Jan. 1963. 10 refs. (Presented at the 55th Annual Meeting of APCA, Chicago, May 20-24, 1962.)

Tests were undertaken to determine the collection efficiency of glass fabric filter bags for the red iron oxide fumes produced by injecting oxygen into open hearth steelmaking furnaces. The three basic fabric constructions tested were all-filament fiber, bulked or texturized fill fabric, and staple fill fabric. All tests were run at a filter velocity of approximately two ft/min and at bag gas temperatures of about 400 F. The primary variable used to analyze test data was filter drag, the ratio of the pressure drop across the bags to filter velocity. Also evaluated were four methods of removing collected dust cake from the filters: simple collapse, sonic cleaning, pressure jet cleaning, and bag shaking. Collection efficiency was very high during all tests. Although on grain loading efficiency tests were made, no dust plumes were visible and the outside of the filter bags remained clean. While the dust-fabric combination returned to an intermediate rather than low pressure drop after the bag cleaning cycle, the slow rise in pressure drop during cake buildup offset this disadvantage. The level of the pressure drop after cleaning was most affected by the physical intensity of the cleaning operation. No major difficulties were encountered that would prevent the satisfactory operation of a baghouse type dust collecto on an oxygen lanced open hearth furnace. However, it is important to prevent condensation of furnace gases on the bags. A slight amount of furnace leakage is detrimental to a collapse-type cleanin method.

16146

Ministry of International Trade and Industry, Japan. Public Nuisance Section

REMARKS ON THE RESULTS OF GENERAL SURVEY OF INDUSTRIAL PUBLIC POLLUTION IN OSAKA-AMAGASAKI AREA. (Osaka-Amagasaki chiku sangyo kogai sogochosa ni tsuite). Text in Japanese. Sangyo Kogai (Ind. Public Nuisance), 5(8):444-447, Aug. 25, 1969.

The results of general survey on industrial air pollution conducted in Osaka and Sakai from 1966 through 1968 are summarized. The survey area covering 305 sq km of industrial sites was grouped in three districts. Half of the area was already industrialized and the remaining half in the process of industrialization. Iron-ore and petroleum refinery plants are expected to develop in the district. The fifty plants surveyed were those which generally consume heavy oil at 10 kl/H per day. Present total oil consumption is 901 kl/H and estimated consumption by 1972 is 1,433 kl/H. It is predicted that sulfur dioxide emissions corresponding to oil consumption by 1.4 fold will increase from 19,816 cu nm/H in 1967 to 27,400 cu nm by 1972. If countermeasures are not applied, industrial pollution will continue to grow. Since 1965, there has been a continuous increase in dust fall. Trial countermeasures which appear to be applicable are the conversion of heavy oil to low sulfur- content (1.7%) oil and the construction of tall stacks. If put into practice, there measures will reduce pollution by approximately 40-45% by 1972. Districts which have maintained ambient air quality standards are encouraged to use 1.5% SO2- bearing oil to compensate for estimated increases in oil consumption.

16193

Shapritskiy, V. N.

COMBATING AIR POLLUTION BY EMISSIONS FROM FERROUS METALLURGY ENTERPRISES. (Bor'ba zagryazneniyem atmosfernogo vosdukha vybrosami predpriyatiy chernoy metallurgii). Text in Russian. In: Sanitation Measures Against Air and Water Pollution in the Planning of Cities (Ozdorovleniya vozdushnogo i vodnogo basseynov gorodov). Government Committee on Civil Building and Architecture (ed.), Lecture series no. 2 Kiev, Bodivel'nik, 1968, p. 47-51. 4 refs.

The numerous basic and secondary sources of air pollution associated with various types of ferrous metallurgy installations are reviewed, together with the attendant problems of abatement. Incidental cases pertaining to this subject are cited from the literature. Special attention is given to development of bag filters outside of the Soviet Union. It is noted that living quarters for workers at large installations must be situated at distances of from 6 to as much as 15 km. It is estimated that costs for pollution control will amount to 40 million rubles per year for a plant producing 5 millions tons of steel per year.

16351

Eisenbarth, Manfred

DUST REMOVAL FROM WASTE GASES IN A STEEL PLANT. (La depolverizzazione dei gas di scarico delle acciaierie). Text in Italian. Riv. Ing., 10(10):720-729, Oct. 1969.

Four areas of the steel plant most responsible for the production of dust-laden air are discussed: convertors, electric arc furnaces, electric reduction furnaces, and flame-hardeners. Dust removal is analyzed in three stages: aspiration, cooling, and purification. A cooling stage is necessary, since the waste gases measured at the bottom of the convertor are formed at a temperature of 500-1100 C, whereas mechanical filters require temperatures between 200 and 270 C and electric filters operate best at 150 180 C. Cooling can be effected by running the gases through a long length of tubing; absorbing the heat with refractory bricks in a large reservoir (bricks are cooled with cold air between batches); and by spraying atomized liquid under pressure into a tower containing the gas, so that the evaporating liquid will absorb heat of vaporization from the gas mixture. Four possibilities exist for purification: dry purification with mechanical filter; dry purification with electric filters; wet purification with electric filters; and wet purification with scrubbers. Two wet-press scrubbers are described in detail: the venturi system and the OG process developed by Demag. The various systems and combinations thereof are examined in terms of cost, space requirements, compatability with special conditions, and possible uses for by-products.

16446

Vypov, A. I. and G. N. Makarets

PROTECTION OF THE AIR AND WATER BASINS AT NOVOKUZNETSK. (Zashchita vozdushnogo i vodnogo basseynov v novokuznetske). Text in Russian. In: Sanitation Measures Against Air and Water Pollution in the Planning of Cities. (Ozdorovleniye vozdushnogo i vodnogo basseynov gorodov). Government Committee on Civil Building and Architecture (ed.), Lecture series no. 2, Kiev, Budivel 'nik, 1968, p.37-38.

An overall examination of the pollution problems of Novokuznetsk was made in 1965-1966 by the Deputy Commission on Natural Conservation and the Presidium of the Novokuznetsk Branch of the Association for Natural Conservation. Dust emission from the Kuznetsk cement plant was 260 tons per day in 1962; it was reduced to 50 tons per day by the end of 1966, and the installation of electrofilters at two roasting furnaces in 1968 reduced emission to 10 tons per day. Measures were also taken to reduce emission from the aluminum and iron-smelting plants. Efforts at pollution control in this city are regarded as successful and similar measures are recommended for other Soviet cities.

16553

Narikawa, Hiroshi and Toshitaka Tsutsumi

ON THE SOOT IN TOPGAS OF OIL INJECTION BLAST FURNACE. (Juyu fukikomi koro no rocho dasuto chu susu ni tsuite). Text in Japanese. Kogai to Taisaku, (J. Pollution Control), 1(2):102-104, June 15, 1965.

New techniques in iron manufacturing involving the use of liquid or granular fuel have increased production efficiency but created a soot problem. As the result of incomplete combustion of heavy oil, the topgas in an oil injection blast furnace contains a large quantity of soot. The amount is closely related to the quantity of heavy oil and combustion conditions. The quantitative measurement of the amount is important for the improvement of the process and the control of emissions. Quantitative measurements at several stages of the process, together with investigations of gas cleaning efficiency, were evaluated. The measurements included the quantity of soot in topgas, the change of soot quantity due to the change of operation, the effect of various kinds of soot removers, and the amount of soot remaining in the gas after application of the soot removing process. The gas cleaner comprised a dust remover, venturi scrubber, and electric dust collector. The soot quantity of the topgas under good combustion condition was 11%, while under poor combustion conditions is was 28.5%. The soot quantity at the outlet of the electric dust collector was 91% under stable conditions and 97.8% under unstable conditions. The soot removal rate of the venturi scrubber was 40 to 60%; that of electric dust collector, 98% under stable conditions, but only 77.5% under unstable condition.

16561

Massinon, J.

ATMOSPHERIC POLLUTION AND STEEL MAKING. (Pollution atmospherique et siderurgie). Text in French. Rev. Soc. Roy. Belge. Ingrs. Ind. (Brussels), no. 6/7:333-343, 1969. (Presented at a Conference of the Belgians Royal Society of Engineers and Industrialists, May 7, 1969.)

The efforts made at the national level by numerous organizations engaged in fighting atmospheric pollution are reviewed. The general sources of air pollution, their relative importance, and their actions are examined. The measures taken by the steel- making industry to reduce industrial emissions are reported in considerable detail, and the remaining technical difficulties are pointed out. The pertinent legislative measures in Germany, France and Belgium are likewise discussed in detail, and desirable future developments are pointed out.

16646

Rengstorff, George W. P.

ROLE OF METHANE AND OTHER FACTORS IN CONTROLLING EMISSIONS FROM STEELMAKING PROCESS. Open Hearth Proc., vol. 46:438-456, 1963. 5 refs.

Smoke evolution in a 50-lb steelmaking furnace was successfully suppressed in laboratory experiments by injections of 4-15% methane, premixed with oxygen, introduced through a water-cooled lance. The amount of methane required appears to depend on jet velocity, characteristics of the flow of metal under the lance, and other dynamic conditions that have not yet been fully identified. Four percent of methane was enough to suppress smoke completely at 2800 F; 6.7% was adequate to suppress smoke above 2820 F. At these temperatures, the addition of 10.3% methane suppressed smoke to 2550 F. Complete suppression at 2600 F required about 7% of methane. It is hypothesized that the effect of methane might result from driving hydrogen into the metal. Evolution of this hydrogen into the fraction of an inch above the metal surface that is critical to smoke formation might either prevent formation of FeO or cause it to become more volatile, thus stopping the pumping of iron from the surface. Why the smoke rate is higher at low temperatures and more difficult to suppress is not understood.

16652

Broman, Carl U. and Ronald R. Iseli

THE CONTROL OF OPEN HEARTH STACK EMISSIONS WITH VENTURI TYPE SCRUBBERS. Ind. Heating, 35(6):1085-6, 1088, 1090, 1092, 1094, 1096, June 1968. II PART. Ibid. vol. 35:1985, 1486, 1488, 1490, Aug. 1968. 6 refs. (Presented at the American Iron and Steel Inst. Technical Meeting, Chicago, 1967.)

Designing a scrubber gas cleaning system to control open hearth fume emissions, isokinetic sampling of the stack gases was carried out to determine dust loadings and particle size and composition; average stack gas dust loadings are shown in

Part I for various periods of open hearth heats. The operation of the venturi scrubber, its location, and its design features are described in detail, with diagrams given of the waste heat boiler draft control system, the equipment location and the gas flow and slurry systems. The throat section of the scrubber initially installed was designed to handle a maximum flow of 70,000 scfm of dry gas at temperatures of 600 to 1500 C. The equipment specifically called for minimum pressure drop of 30 in. of water across the venturi in order to obtain the required cleaning efficiency. The induced draft fan constructed had a rating of 93,000 cfm at 41 in. suction. Part II discusses the operating and maintenance problems experienced with the gas flow and water slurry systems. The major problem with the gas flow system, the near-collapse of the spin vane section in the cooling tower, was taken as proof that the common cooling tower built for two gas flow systems was a mistake. The many problems incurred with the slurry system were attributed in part to confining all the equipment within the lean-to area. Discoloration of the sewer water from the red iron oxide also occurred. Design corrections were made for later installations of scrubbers on other furnaces in the same shop. Gas cleaning has been excellent with greater than 99% efficiency and less than .05 grains per standard cubic foot dust loading in the exhaust gases. The scrubbers have not hampered the operations of the furnaces and may have contributed to improved performance; in addition, the source of constant draft from the scrubber induced draft fan was found to benefit furnace operation.

16681

Willet, Howard P.

PROFIT ORIENTED SYSTEMS FOR POLLUTION CONTROL. American Institute of Chemical Engineers, New York, N. Y., American Inst. of Mining, Metallurgical, and Petroleum Engineers (AIME), New York, N. Y., American Society of Civil Engineers, New York, American Society of Heating, Refrigerating and Air Conditioning Engineers, New York, American Society of Mechanical Engineers, New York, and American Society for Testing and Materials, Philadelphia, Pa., Proc. MECAR Symp., Design and Operation for Air Pollution Control, New York, N. Y., 1968. p. 75-85. (Oct. 24).

The development of pollution control systems that provide an economically profitable return on control costs is described; it is believed that such processes will enhance control activities by establishing an economic incentive to add to the public pressures on polluters to install control equipment. Profit-oriented control systems are described for blast furnaces and the basic oxygen processes in steel fabrication, for foundry cupolas, kraft pulping, and for sulfur dioxide recovery from power and sulfuric acid plants. Venturi scrubbers, used to clean blast furnace gases, make it possible to obtain higher hot blast temperatures for preheating air blown into the furnaces and thus improve the economics of their operation. Gas take-offs installed below the charging door on foundry cupolas reduce the size of the gas cleaning equipment required and permit the gas to be used as fuel for preheating air blasts to the cupolas. A new method recently introduced from Japan, called the OG Process, has a great profit potential in its application to the basic oxygen process in steel-making, primarily by collecting carbon monoxide without combustion. A series of pollution control techniques can be applied to the kraft pulping process to reduce capital and operating costs. An absorption system to eliminate SO2 pollution from sulfuric acid plants and to increase plant profits is nearing completion, and a concept called the Central Processing Approach is described, involving the establishment of central processing plants, to permit the profitable recovery of elemental sulfur from the sulfur oxide emissions of both large and small power producers.

16695

Jones, William P.

DEVELOPMENT OF THE VENTURI SCRUBBER. Ind. Eng. Chem., 41(11): 2424-2427, Nov. 1949. 4 refs.

The practical application of the venturi scrubber to the removal of dusts, mists, fumes, odors, and smoke from gas streams is discussed. Factors affecting the scrubbing efficiency of a venturi are the velocity of the gas in the throat, the ratio of liquid to gas, and the distribution of liquid in the throat. Of these variables the first two have an appreciable effect on the pressure drop across the scrubber. Most of the power required for operation is expended in the gas pressure drop, which will vary with the amount of liquid used. In general, increased throat velocity results in higher scrubbing efficiency with less liquid, and with somewhat less pressure drop and fan power. A commercial venturi unit at a pulp and paper mill is recovering 7-10 tons of sodium compounds per day from fumes containing particles from below 0.1 to 1.5 micron. Installations on open hearth steel furnaces are achieving 97-99% efficiencies in removing smoke particles from 0.05 to 0.33 micron. Pilot plant studies indicate that the venturi scrubber has a removal efficiency of 98-99.8% for sulfuric acid mists and a 99.9% efficiency for coarse dust from blast furnace gas.

17115

Punch, G.

GAS CLEANING IN THE IRON AND STEEL INDUSTRY. PART II: APPLICATIONS. In: Fume Arrestment. Iron and Steel Inst., London (England), SR-83, p. 10-23, 1963. 34 refs.

The choice of gas cleaning techniques for various steelmaking processes is reviewed. A dry collection system is judged most applicable for sinter plants, the particular one depending on specific plant needs. Fabric filter and dry plate precipitator methods are described for waste gases from open-hearth furnaces; some wet methods can also be used but involve corrosion and other problems. The high-energy scrubber and irrigated precipitator are the most obvious choices for deseaming process fumes, but they create secondary liquid effluent problems. Fume control from arc furnaces can be achieved by using roof-mounted close-fitting hoods or equipment for direct extraction from the furnace shell; furnace gases, once emitted, may be cleaned to 0.05 gains/cu ft by wet or dry precipitator, fabric filter, high-energy scrubber, or a combination scrubber-precipitator. Wet or dry methods are applicable to both the Kaldo and LD processes. A general summary is given of the effect of fluctuating operating conditions on collector performance, and the technical factors which must be considered in selecting appropriate gas cleaning methods are discussed in detail for each of the steel processes outlined above.

17118

Speer, E. B.

OPERATION OF ELECTOSTATIC PRECIPITATORS ON O.H. FURNACES AT FAIRLESS WORKS. In: Air and Water Pollution in the Iron and Steel Industry. Iron and Steel Inst., London (England), SP-6, p. 67-74, 1958.

Information on the electrostatic precipitators on 330-ton open-hearth furnaces in a steel company is presented. The furnace system is discussed to indicate the scope of the dust-cleaning problem with respect to volumes, pressures, and temperatures. Modern instrumentation enables the operator to accomplish

the steelmaking process with good combustion efficiency and minimum furnace damage. The precipitator is described by presenting the design features of the chamber, collecting electrode system, discharge electrode insulators, electrical supply units, and safety devices. Dust collection from the precipitator hoppers is performed by a vacuum system with hoppers, piping, primary and secondary collectors, scrubber, exhauster, storage bin, and pug mill. Problems and solutions after four years of operation are discussed. Design conditions of inlet loading, draught losses, outlet loading, and efficiency are stated. The testing procedure used to check precipitator performance and the test results obtained are explained. The most serious problems encountered have resulted from gas-velocity increase and boil-period concentrated loading. Recent and anticipated improvements of major importance to decrease outlet loading by 100% are described as a result of data obtained to date. Various flow diagrmas and illustrations are given. (Author abstract modified)

17127

Gaw, R. G.

GAS CLEANING. Iron Steel Engr., 37(10):81-85, Oct. 1960.

Wet and dry process dust collection systems are evaluated for use in steelmaking, where the use of oxygen to speed up molten bath reactions greatly increases the dust and fume generation, with the dust consisting principally of extremely fine iron oxides. In determining the gas volume of a dust collection system, a design volume rating of 25 scfm of waste gases per cfm of oxygen blown is in general use for electrostatic precipitators; for scrubber applications, a lower ratio of 20 to 1 is sometimes used. When designing gas cleaning systems for oxygen converters, allowance should be made for future increases in blowing rates. The venturi wet scrubber and the dry electrostatic precipitator systems are described and diagrammed, evaluated, and their costs compared. Best available figures indicate that the total installation cost of a wet scrubber designed for identically sized vessels and blowing rates would be about the same as for a dry precipitator system. In operating and maintenance costs per ton, the wet scrubber is rated at 140, the dry system at .080, with use of the dry dust, which has a market value of about $15./ton. Advantages of the wet scrubber system are smaller space requirements, tolerance of smaller volumes of exhausted gas, and lower installation costs; those for the dry system are smaller operating costs, flexibility of operation, more effective cleaning, no excessive steam plume, the ability to by-pass gases, the recovery value of the dust, and elimination of potentional stream pollution problems.

17138

Coulter, R. S.

SMOKE, DUST, FUMES CLOSELY CONTROLLED IN ELECTRIC FURNACES. Iron Age, 173(2):107-110, Jan. 14, 1954.

Smoke and fume emissions from three electric furnaces used to make plain carbon and low alloy steels in a single-slag process are successfully controlled by Cottrell type electrical precipitation equipment. Gas and dusts originating in the furnaces are drawn off through a water-cooled vent elbow, one end of which coincides with an opening in the furnace roof. The gases are then drawn through a two-pass flame trap, individual duct and louvre damper, a series of spray towers, and a motor-driven fan which pushes the gas and dust into the single two-unit precipitator serving all three furnaces. Acceptable precipitator efficiencies are achieved at a gas temperature below 127 F and 49% relative humidity. At full capacity, the fan handles 140,000 cfm of moistened dust-laden gases. The precipitated dust is accumulated in hoppers which are emptied by interconnecting screw conveyors. These lead to a drop pipe that discharges into a collection tank. From 12,000 to 20,000 pounds of dust are collected daily. No visible fume or dust issues from any furnace openings or roofs, even with power on and slag doors open.

17141

Akerlow, E. V.

DESIGN AND CONSTRUCTION OF FONTANA OPEN HEARTH PRECIPITATORS. Iron Steel Engr., 34(6):131-138, June 1957.

Design modifications required to make an electrostatic precipitator suitable for collecting fumes from an open hearth furnace in a steel plant are discussed; as currently manufactured, precipitators are too light for open hearth service. Reinforcement of the precipitator and its supporting structure is necessary to minimize vibrations which can cause arcing and short the discharge and collecting electrical systems. Proper gas distribution within the precipitator is achieved by placing a distribution plate comprising three curved, perforated baskets across the width of the precipitator. It is also important that the arc in the precipitator be quickly quenched during high-grain loading conditions. A saturable reactor control with selenium rectifiers has many operating advantages, particularly in maintaining a higher rms voltage than conventional mechanical rectifiers. To eliminate dust buildup and reduce corrosion, rapping of the discharge electrode system is handled through outside rappers mounted on insulators which are in turn mounted in an air-cooled chamber. Problems of condensation inside the precipitator are corrected by the installation of ligh-weight insulating aggregate concrete on the preciptator roof.

17151

Basse, Bernard

GASES CLEANED BY THE USE OF SCRUBBERS. Blast Furn. Steel Plant, 44(11):1307-1312, Nov. 1956. 10 refs.

Venturi scrubbers can successfully handle large volumes of the submicron fumes generated in steel and blast furnace processes. The most practical application of the scrubber is in cleaning blast furnace gas. Furnace top pressure is utilized to provide power for scrubbing: except for the small pumping requirement of 4-8 gallons per 100 cfm at 90 psig, no outside sourcy of power is required. In most furnaces with top pressures of 60-75 in wg, the venturi pressure drop runs 28-35 in wg. These reduce dust loadings in the cleaned gas to 0.01 to 0.05 grain per Scf. A pilot study carried out with a 10,000 cfm venturi unit indicates a 0.0019 grain per Scf loading at a pressure drop of 83.5 in wg. Venturi scrubbers also reduce fumes emitted by oxygen converter processes to a point where they become completely invisible. Dust loadings in the gases are reduced from 8 gr/Scf of iron oxide and graphite particles to between 0.03 and .90 gr/Scf. When operated at 14 in wg, the scrubbers remove over 98% of the fume from oxygen-lanced open hearth furnaces and reduce the dust load in the gas to less than 0.04 gr/Scf. For air pollution applications, the power required by venturi scrubbers can be adjusted to meet nearly all local ordinances and visibility requirements.

17152

Reid, G. E.

EXPERIENCE IN CLEANING BLAST FURNACE GAS WITH THE ORIFICE WASHER. Iron Steel Engr., 37(8):134-139, Aug. 1960. 2 refs.

The performance of orifice washers in cleaning blast furnace gas in a steel plant was evaluated. An orifice washer was first placed in service on a P-6 furnace which was equipped with a twin set of conventional tower scrubbers. The orifice, followed by a water separation tank, was installed in the vertical gas duct on the inlet side of each spray tower. Elaborate water spray piping arrangements are unnecessary. The important need is the continuous addition of spray water sufficient to wet and ensnare the dust. In a typical gas cleaning circuit, with the gas first being cleaned by the orifice washer and then being scrubbed by the spray tower, practically all dust removal is the result of orifice washer action. Results showed a clean gas loading of 0.03 grains per cu ft. This was nearly seven times better than that secured by the conventional method with a clean gas loading of 0.2 grains per cu ft. Similar results were obtained with the washer installed on a P-3 furnace. The installation required little maintenance, and only periodic cleaning of the orifice spray pipes. The orifice washer is relatively inexpensive to construct and is compatible with existing blast furnace facilities. A disadvantage to the system is the added pressure loss which requires about 3% more power to be developed by the furnace wind blowing prime movers. The cleaner gas means that a larger percentage of ore-bearing particles can be withdrawn from the gas stream and sent to the thickeners for reclaim, resulting in an increase in the production of sludge available for sintering. It was estimated that the increase in the recovery of metallics resulting from greater sludge production averages about 3%. The abatement of atmospheric dust discharge coupled with other operational gains made possible by the system, secured enthusiastic endorsement of the use of the orifice washer for cleaning blast furnace gas.

17154

Bishop, C. A., W. W. Campbell, D. L. Hunter, and M. W. Lightner

SUCCESSFUL CLEANING OF OPEN-HEARTH EXHAUST GAS WITH A HIGH-ENERGY VENTURI SCRUBBER. J. Air Pollution Control Assoc., 11(2):83-87, Feb. 1961. (Presented at the Annual Meeting of the Air Pollution Control Association, 53rd, Cincinnati, Ohio, May 22-26, 1960.)

The operation and performance of a venturi scrubber system installed in a full-scale open-hearth process in a steel plant was evaluated. The open-hearth process was briefly described. Because of considerable variability in the properties of the stack gases and dust from the open-hearth process, it was difficult to obtain the desired high level of performance from the gas cleaning equipment. The venturi scrubber consists essentially of a gas restriction and a water-spray system at the restriction. The turbulence created by the gas passing through the restriction atomizes the water and permits intimate contact between the water droplets and the solid dust particles in the gas stream. The wetted particles are then removed from the gas stream as the gas passes into an inertial type entrainment separator. The results of the test indicated that when operating at a pressure drop of 30 in. of water, a venturi scrubber will satisfactorilly clean open-hearth gas to 0.05 grain per standard cu ft, and there will be little or no visible effluent in the exhaust gas other than the steam plume. Satisfactory operation of the recycle scrubbing-water system was achieved by bleeding 5% of the total scrubbing water, containing about 1.5% solids by weight, to a settling basin. The test program also provided sufficient operating-cost and design information to indicate that the investment and operating costs of a venturi-scrubber system would compete very favorably with those of a precipitator-waste-heat boiler system for cleaning the gas from open-hearth shops that have an anticipated operating life of no more than a few years. An economical and efficient method for cleaning the gas from those shops that have an operating life of longer than a few years is still sought.

17158

Uys, J. M. and J. W. Kirkpatrick

THE BENEFICIATION OF RAW MATERIALS IN THE STEEL INDUSTRY AND ITS EFFECT UPON AIR POLLUTION CONTROL. J. Air Pollution Control Assoc., 13(1):20-27, 32, Jan. 1963. 18 refs. (Presented at the 55th Annual Meeting of the Air Pollution Control Association, Chicago, Illinois, May 20-24, 1962.)

The use of beneficiated burdens in blast furnaces has increased during recent years and is expected to accelerate in the near future. Burden beneficiation is practiced through improving the physical nature of the raw material and through increasing the iron content of the charge. This has led to improved furnace performance, 'slips' have been reduced, dust rates, slag volumes, and coke rates have been decreased, and production rates increased. All these factors materially reduced possibilities of air pollution by the steel industry. (Author summary modified)

17234

Arai, Kenya

AIR POLLUTION SOURCES AND THEIR CONTROL IN THE IRON AND STEEL INDUSTRY - COUNTERMEASURES FOR SMOKES FROM BLAST, MELTING, AND HEATING FURNACES. (Tekko gyo ni okeru baien shori gijutsu - Koro, yosenro, kinzuku kanetsuro nado no baien taisaku). Text in Japanese. Kogai to Taisaku (J. Pollution Control), 2(6):379-383, July 15, 1966.

The law of smoke control establishes smoke discharge standards for all establishments generating smoke. No establishment can discharge more smoke than the standard for its category. The standard for a blast furnace is 0.5 g per N cu m; a cupola, 2.0; a metal heating furnace, 0.7; and a drying furnace, 1.2. The law also establishes sulfur dioxide and sulfur trioxide discharge standards. When their concentrations exceed 0.5 ppm, cooperation of the industry is demanded. A blast furnace usually discharges about two thousand N cu m per ton of pig iron, making it a large smog source. The exhaust gas from a blast furnace contains from 5 to 10 grams per N cu m of smog. A primary dust collector lowers the quantity to below 5 gram per N cu m while a secondary dust collector lowers it to below 0.01 gram per N cu m. The primary dust collector utilizes inertial force. Secondary dust collecting methods are classified as dry or wet. The dry method uses electrical dust collectors; the wet method uses mechanical or electrical dust collectors after washing by cleaning columns or venturi scrubbers. Control methods for the smoke of other furnaces are also reviewed. Desulfurization methods are divided into wet and the dry methods. The wet methods involve washing by alkali or amine solutions. Their merits are low costs and high efficiencies; their disadvantages are the lowering of gas temperature. Dry methods are those involving absorption of adsorption by solids.

17423

Lowe, J. R.

AN ORIFICE GAS WASHER. American Inst. of Mining, Metallurgical and Petroleum Engineers (AIME), New York, N. Y., Proc. Am. Inst. Mining Met. Petrol. Engrs. Conf. Blast Furnace, Materials 1957, vol. 16:28-30.

By installing orifice washers on furnaces, a steel company reduced the dust content delivered to the mains of its gas-

cleaning system from 0.22 to 0.032 grains per cut ft. Each orifice washer assembly consists of a 4-ft 9-in. take-off pipe from the dust catcher to the main outlet and an 8-ft diameter tank which serves as the washer shell. The orifice itself is in the take-off pipe which is located only a few feet from the connection to the dust catcher main. Gases from the tank are passed to the original washer, which now serves as the cooling tower. Necessary water for the gas cleaning is introduced one foot above the orifice through 16 open-end pipes spaced equally around the circumference and perpendicular to the gas flow. Through a faulty design in the outlet gas pipe elevation, much water from the orifice tank is carried mechanically to the bottom of the cooling tower. This will be corrected shortly. In addition to reducing the dust content of the gas, the orifice washer system has brought about a fair-sized reduction in furnace flue-dust rate, in addition to a slight reduction in the coke rate and a commensurate increase in iron production.

17568

Campbell, W. W. and R. W. Fullerton

HIGH-ENERGY WET SCRUBBERS CAN SATISFACTORILY CLEAN BLAST FURNACE TOP GAS. American Inst. of Mining, Metallurgical and Petroleum Engineers (AIME), New York, N. Y., Proc. Am. Inst. Mining Met. Petrol. Engrs. Conf. Blast Furnace, Coke Oven, Raw Materials 1969, vol. 18:329-335.

Data on the operation of high-energy wet scrubbers for dust-cleaning blast furnace gas at three steel plants is summarized. High-energy wet scrubbers, if properly designed, can clean blast-furnace gas to a degree that is acceptable for gas-fired auxiliaries. Also, the dust content of the resulting products of combustion will comply with smoke-control ordinances. The cleaned-gas dust loading varies inversely as the pressure drop across the scrubber; the pressure drop is affected by both gas flow and scrubbing-water rate. The effect of water rate on pressure drop is not as pronounced for an orifice scrubber as for a venturi scrubber. For a given pressure drop, cleaner gas will be obtained with a venturi scrubber than with an orifice scrubber. Operating costs (exclusive of those based on capital expenditure) would be essentially the same for both types of scrubbers. Little maintenance is expected for either unit. A rate of at least 5 gal of water per 1000 cu ft of gas is required to satisfactorily clean blast furnace gas with either type of scrubber. Higher water rates will result in higher pressure drops, and hence cleaner gas. The final choice between an orifice and a venturi will depend on the desired gas cleanliness, on the extent to which the top pressure of the furnace can be increased, and on whether the extra cost of the venturi could be offset by the lower stove and boiler maintenance costs which it affords. (Author summary modified)

17746

Hipkin, A. S.

CLEANING OF FUME FROM ARC FURNACES. In: Air and Water Pollution in the Iron and Steel Industry. London, Iron and Steel Inst., 1958, p. 108-114. (SP-61.)

Brief comments are made concerning the requirements of the Clean Air Act in relation to pollution by industrial processes. Information collected on pollution from furnaces is reviewed. Experience of application of equipment to arc furnaces and types of fume-cleaning plants available are outlined. With open-hearth furnaces, the temperatures and quantitative measurements of the air-gas mixtures are known and under control. With arc furnaces, fume escapes through all openings in the shell and roof, and also at the joint between shell and roof ring if the furnace is not in good condition. Fume emission also varies with different furnaces depending on their design, operation, and the type of steel produced. Plants have been installed for extraction of the fumes emitted from arc furnaces without any attempt to collect the solids. These plants have proved effective in producing reasonable working conditions but they have also transferred pollution from the melting shop to the outside air. Whether the principle of direct extraction when producing alloy steel is metallurgically acceptable or not, the advantages of fume control indicate that the method should be carefully considered whenever possible. Types of collectors available include simple cyclones, multi-cyclones, wet arrestors, Venturi scrubbers, bag-type filters, and electrostatic precipitators. Each has merit as a collector, but not all are suitable for application to arc furnaces. In recognition of the Clean Air Act, it is suggested that the cleaning of furnace fume is a process calling for research and experience.

17825

Thomas, F. A.

VENTURI GAS SCRUBBERS. (II). J. Metals, 17(3): 264-266, March 1965.

Several years ago, a venturi gas scrubber was placed in operation at a steel plant on an open-hearth furnace. The general gas scrubber design, operating principles, and results obtained on this installation are outlined. Gas cleaning in the open hearth presents a major challenge, due to the variable dust loading, particle size, and temperature of the exhaust gases. The venturi gas scrubber is designed to overcome these obstacles and to cleanse waste gases to a satisfactory level. The venturi scrubber installation is illustrated. The venturi gas scrubber will clean open-hearth waste gases to 0.05 grains/std cu ft of waste gas with a pressure drop of 30 in. of water across the scrubber, or to 0.01 grains/std cu ft of waste gas with a pressure drop of 40 in. of water, and with an average scrubbing water rate of about 14 gal/1000 std cu ft of gas. Bleeding 5% of the total scrubbing water, containing 1.5% solids by weight, permitted satisfactory operation of the recycle water system. In the older open-hearth shops without waste heat boilers, the venturi gas scrubber, with its ability to handle hot gases directly, provides both satisfactory gas cleaning and increased furnace draft. The lower capital cost, as compared to electrostatic precipitators, makes the scrubber an attractive investment. Also, it is possible to design a scrubber for an open-hearth shop so that it can be used for a future basic oxygen steel making installation, thereby attaining a dual benefit from one capital expenditure.

17913

Bintzer, W. W.

DESIGN AND OPERATION OF A FUME AND DUST COLLECTION SYSTEM FOR TWO 100-TON ELECTRIC FURNACES. Iron Steel Engr., 41(2):115-123, Feb. 1964.

Roof fans are not adequate to remove the dust and fumes generated by an electric furnace. Fumes and dust are not only a safety hazard, but also present poor working conditions. The collection system at a steel plant and some of the unusual modifications to make it work are discussed. The sytem is schematically presented. The material collected has a dry density of 40 to 50 lb/cu ft. It flows like water; however, it can become sufficiently cohesive so as not to flow on a 45-degree slope. About 15 lb of material/ton of steel produced or approximately 10 to 12 cu yd/day are collected. Qualitative spectrograph analysis of particulate as collected is tabulated. A major problem has been extreme temperature in the ducts and the resulting by-passing of the collector. The system was designed to operate normally under 250 F at the bag house, but tem-

peratures of 600 F have been recorded. The high duct temperature that causes this system to by-pass is produced at the end of the water-cooled elbow. This temperature is the result of the heat evolved by the combustion of the various gases produced in the furnace. Even though the system will collect over 95% of all the particulate generated in the furnace if reasonable charging practice and proper furnace operating procedures are followed, the problem of electric furnace smoke and fume formation, collection, and disposal is still far from completely satisfactory. However, this system as installed and properly operated will satisfactorily meet the requirements and intent of any of the present existing codes on air pollution.

17926

Squires, B. J.

ELECTRIC ARC FURNACE FUME CONTROL AND GAS CLEANING. Conf. Filtration Soc., Dust Control Air Cleaning Exhibition, London, 1969, p. 16-21. 4 refs. (Sept. 23-25.)

Electric arc steel melting furnaces emit fumes to the atmosphere at several points: the furnace doors, the pouring spout opening, the roof openings that take the electrodes, and sometimes from the furnace roof ring. This, together with the fact that the furnace roof generally lifts and swings clear for charging, tilts back for slagging, and tilts forward for pouring, presents considerable problems for dust control engineers. Satisfactory systems for collecting the fumes into a duct system for cleaning before discharge to the atmosphere are canopy hoods, full hoods built directly on the furnace roof, semidirect hood control, side draft hoods, and direct shell evacuation. In the latter method, the fumes are drawn directly out of an additional hole in the furnace roof instead of escaping through other openings. Because the gases are practically undiluted, the method requires the smallest volume. Since gas cleaning costs are nearly proportional to the volume being handled, this system is one of the cheapest, particularly for furnaces of 50 tons and over. For cleaning the gases, high temperature fabric filters are used extensively in the U.K. and the U.S. These filters have several advantages over wet scrubbers and electrostatic precipitators: they are very simple to operate and the fluctuating conditions from an arc furnace system do not affect their high efficiency.

19210

Matsuda, Norikazu

ABATEMENT OF AIR POLLUTION CAUSED BY FLUORIDE. (Fukkasuiso oyobi kakushu fukkabutsu niyoru taikiosen no taisaku). Text in Japanese. Kogai to Taisaku (J. Pollution Control), 6(7):509-514, July 15, 1970.

Sources of fluoride pollutants include aluminum refining and phosphate fertilizer, brick, glass, glass-fiber, steel, and cement manufacturing. Fluorides emissions from an aluminum refinery and a phosphate fertilizer plant, both subject to large numbers of damage claims, are shown in a block diagram. Examples of fluoride pollution by the Showa Denko plants in Fukushima and Chiba and Sumitomo Chemicals in Ehime are presented. Regulations applicable to pollutant sources in Osaka and Fukushima Prefectures are noted. A common method of processing fluorine compounds is the use of caustic soda. Fluorine becomes sodium fluoride, which is subsequently converted to calcium fluoride by lime. In aluminum refineries, the recovery rate of fluorine by the method is over 99%. Exhaust gas, however, shows a recovery rate of only 60-70%, even in factories equipped with a recovery device. If the density at the source is lowered to several ppm, the use of chimnneys around 200-m high will reduce the ground concentration to .1 ppb. At present, the recovery of fluorides is accomplished by wet methods, which give rise to mists such as hydrofluoric acid. The efficient processing of the mist is a future problem. Since the demand for aluminum is predicted to be 2,000,000 tons in 1975, an increase in aluminum refineries is expected. In the process of construction, future refineries must be thoroughly evaluated for fluoride pollution.

19403

VDE (Verein Deutscher Eisenhuettenleute), Duesseldorf, Germany

DUST EMISSION CONTROL, STEEL WORKS (BROWN SMOKE) OXYGEN-BLOWN STEEL PROCESSES, CONVERTER. (Staubauswurfbegrenzung Stahlwerksbetrieb (Brauner Rauch) Sauerstoffaufblasverfahren, Konverter). VDI (Ver. Deut. Ingr.) Richtlinien, no. 2112, June 1966, 36 refs. Translated from German by H. Schneider, Isreal Program for Scientific Translations, Jerusalem, 12p. CFSTI: TT 68-50469/6

The advantages of using oxygen for steel production have led to the development of a number of new metallurgical processes, one of the most important being the oxygen converter process wherein oxygen is blown on a metal bath that is charged into the converter from a blast furnace or cupola. Dust in converter gases is generally known as 'brown smoke'; it consists mainly of vaporized iron oxides and manganese oxides, as well as vaporized slag components. Measures to be applied during the blowing period in the converter and designed to reduce the emissions of brown smoke by modification of charge compositions or converter operation are unfeasible with one exception. To keep dust emissions within desirable limits, converter waste gases must be cleaned. Three collectors discussed are filters, electrostatic precipitators, and wet scrubbers. The operating factors influencing the separation efficiencies of these methods are noted. To be suitable for the process, the collectors should have an efficiency of 98%. It is further recommended that each converter be provided with its own waste gas stack from which gases are led by a cooling unit to the collector. Oxygen-blown converter plants should also be equipped with stack flares to insure the ignition of CO-containing waste gases.

19732

Rengstorff, George W. P.

ROLE OF METHANE AND OTHER FACTORS IN CONTROLLING EMISSIONS FROM STEELMAKING PROCESS. Open Hearth Proc., vol. 46:438-456, 1963. 5 refs.

Laboratory experiments on suppression of smoke from steel plant converters and furnaces were conducted to gain an understanding of smoke-forming mechanisms. Most of the studies were made in 2-in. diameter crucibles under one of several blowing conditions; the rate of smoke evolution for a given period was measured in milligrams per second. A specially-designed lance was used in which oxygen and methane were premixed in a water-cooled lance just before ejection through a single hole in the tip. The lance proved highly successful in suppressing smoke evolution when 4-15% methane was added to the jet. The amount required appears to depend on jet velocity, characteristics of the flow of metal under the lance, and other dynamic conditions. Steam is far more effective than liquid water in suppressing smoke. Photographic evidence was obtained of the effect of methane additions, and emission and absorption spectrographs were made of the jet and of the gas above the surface of the metal during blowing with oxygen and with oxygen-methane mixtures. To study effects on a larger scale, a set of experiments was made on 50-lb heats under different oxygen-methane ratios; motion pictures

of the results demonstrate the complete effectiveness of 15% methane on smoke suppression. A hypothesis of smoke suppression and formation is presented, although many questions remain to be answered. An addendum includes a discussion of reaction kinetics by several investigators.

19792

Smith, J. H.

AIR POLLUTION CONTROL IN OXYGEN STEELMAKING. American Inst. of Mining, Metallurgical and Petroleum Engineers (AIME), New York, N. Y., Proc. Open Hearth Steel Conf., 1961, p. 351-357.

The air pollution control system and the results of tests and operation at a California steel plant are described. Electrostatic precipitation had not been tested on basic oxygen steel plants at the time the plant personnel were faced with the task of developing a satisfactory dust cleaning system for the proposed installation. Instead, it was necessary to rely on theory and adaptation of past experiences with the open-hearth electrostatic precipitators. Design specifications for three precipitators for the oxygen furnaces were established. Each of the three precipitators was designed to handle waste gases having a peak rate of 202,000 std cfm or 405,000 cfm at design operating conditions. Results of the performance tests are enumerated. Steam is introduced into the furnace gas stream at about 12,000 to 20,000 lb/hr from the start of the blow. There are seven banks of water sprays around the hood to cool the gases and condition them for the precipitator. The first sprays are automatically turned on at 500 F, and the last sprays, at 560 F. It is concluded that the electrostatic precipitators are a worthwhile investment and its use for dust cleaning in a basic oxygen system is recommended. However, certain design changes must be made.

20096

Hashimoto, Kiyotaka

THE POINT OF PLANNING AND ITS EFFECT ON OPERATION RESULT OF AN ELECTRIC PRECIPITATOR IN VARIOUS INDUSTRY SMOKE ABATEMENT (IV) - TREATMENT FOR WASTE GAS OF IRON AND STEEL INDUSTRY. (Gyoshubetsu ni miru denkishujinsochi no setsubikeikaku to untenkoka (IV) - seitetsu seiko to sono haigasu no jogai). Text in Japanese. Kogai to Taisaku (J. Pollution Control), 3(2):93-102, Feb. 15, 1967. 24 refs.

The waste gas from the iron and steel industry must be cleaned by precipitating equipment according to the properties of smoke and dust. In the manufacture of pig iron, dust is produced in the blast furnace, coke oven, fire extinguishing tower, and sintering furnace. Gas from the blast furnace is most effectively cleaned by an electrical precipitator. Today, a wet electric precipitator is used because of its high rate of precipitation in comparison with the dry electric precipitator. Gas from the coke oven has a higher calorific value than that from a blast furnace. It is cleaned by the double treatment of hot-detarer and cold-detarer. The steel making methods of a revolving furnace and of electricity have been replacing the method of an open-hearth furnace. Although efficiency has increased, the red-brown smoke, mainly composed of oxidized iron, becomes thick and the quantity of waste gas increases. The smoke produced by making steel with oxygen is mainly composed of burned iron fume. The gas should be cooled by a stabilizer and then gathered by a dry electric precipitator. Fumes in the waste gas of a cupola furnace cannot be eliminated in any other way.

20226

Behrendt, Anton

GAS CLEANING IN RELATION TO OXYGEN PRE-REFINING AND THE ROTOR PROCESS AT OBERHAUSEN. In: Air and Water Pollution in the Iron and Steel Industry. London, Iron and Steel Inst., 1958, p. 90-96. 2 refs.

The oxygen lancing and Rotor processes in use at Oberhausen, Germany, and the experimental and final plants used to clean the gases given off are described. The costs of running a bag filter are given; these are exceeded by the value of the iron content of the dust recovered. The differences between the dusts from the processes are described and the reasons for them are advanced. The different methods available for the removal of the troublesome brown color from the gases of the pre-refining in the ladle and in working the Rotor are shown. In contrast to the amount of gas which results from blowing in the converter with or without oxygen enrichment of the blast, the quantities from both the other processes on the production scale can be kept within controlled limits. Where high gas purity is required the Elektro-filter or the Pease-Anthony apparatus could be used. The very high outlet temperature of the Rotor calls for special protection for the gas ducts. On the basis of the observations, the dust formed in the Rotor is estimated at about 15 kg/ton of pig iron. This value is appreciably higher than for pre-refining in the ladle, which amounts to only 4.46 kg/ton. For cooling the gas ducts, 200-240 cu. m. of water/hr are necessary.

20227

Hipp, Norbert E. and John R. Westerholm

DEVELOPMENTS IN GAS CLEANING-GREAT LAKES STEEL CORP. Iron Steel Engr., 44(8):101-108, Aug. 1967.

There are many problems connected with high-energy scrubbers which are unsolved. The high-energy scrubber has made it possible to clean gas efficiently at a low cost in spite of the troublesome problems that have been encountered in the design, maintenance, and operation of this equipment. Many of the weaknesses of these units have been corrected by the simple addition of cooling water, both by volume and by distance of injection ahead of the orifice. This aids in the wetting of the gas and the minimizing of the temperature differences, thus decreasing the abrasiveness of the gas. Great Lakes Steel now has three of its four furnaces equipped with some type of high-energy scrubber and plans on the next reline to install a variable orifice scrubber on the fourth furnace. Future high-temperature operation at 2000 F or more will necessitate the installation of high-energy burners and will create the need for gas cleanliness in the 0.001-grain per scf range. Variable orifice scrubbers approach the level of cleaning gas to the required limits. Only when the maintenance problems are solved will it then become both an efficient and a low- operating cost unit. (Author summary modified)

20248

Public Health Service, Cincinnati, Ohio, National Air Pollution Control Administration

A STATUS REPORT: PROCESS CONTROL ENGINEERING; R & D FOR AIR POLLUTION CONTROL. 37p., Nov. 1969.

The various phases of the work of the Process Control Engineering Division of the National Air Pollution Control Administration are described as of late 1969. These include sulfur oxides control (dry and wet limestone processes, coal cleaning, and new processes such as those employing molten alkali carbonates), industrial process control (nonferrous smelting, iron and steel, sulfuric acid, papermaking, graphic arts, iron

foundries, aluminum smelting, etc.), combustion emissions control (e.g., fluidized-bed combustion, nitrogen oxides), applied equipment research (wet scrubbers, fabric filters, electrostatic precipitators, incinerator control), supporting measurements (detection, spectroscopy, dust- and gas-sampling analysis, holographic determinations, continuous monitors, etc.), and advisory and supporting services. A special report is also given on the alkalized alumina process for control of SO2. A list of 110 specific research projects and 11 services is given. More than eleven million dollars was budgeted for the Process Control Engineering programs in 1969. The 1970 budget is expected to be more limited, necessitating an emphasis on sustaining rather than new programs.

20280

Hoff, Hans

APPARATUS FOR THE REMOVAL OF DUST FROM CONVERTER GASES. (Firma Gottfried Bischoff Bau Komp. Gasreinigungs- und Wasserruckkuhlanlagen Kommanditgesellschaft, Essen (West Germany)) U. S. Pat. 3,497,194. 6p., Feb. 24, 1970. 18 refs. (Appl. Sept. 19, 1967, 7 claims).

An improved apparatus for removing particulate matter from the waste gases of steel-making converters is described. A gas-collecting tube, where the oxygen/carbon monoxide reaction is carried out to completion, is situated above the converter. The tube opens into a dust-separating column and directs the gas against an impingement body. Water is sprayed into the gas between the impingement baffle and the wall of the column. The gas is then passed to a dust-collecting unit, such as an electrostatic precipitator or a filter. (Author abstract modified)

20699

Celenza, G. J.

AIR POLLUTION PROBLEMS FACED BY THE IRON AND STEEL INDUSTRY. Plant Eng., 24(9):60-63, April 30, 1970.

Solutions to the air pollution problems in the iron and steel industry are discussed. The steel producing process involves a number of steps with potentially troublesome exhaust emissions. Coke and sinter operations, which produce raw materials for the blast furnace, contribute to the overall plant pollution problem. Coke ovens emit smoke, dust, and combustion products. These contaminants can be lessened by isolating or enclosing storage areas, using dust control devices, and employing proper operating techniques. The dust emissions from sintering facilities can be controlled by using cyclone separators as primary cleaners and electrostatic precipitators as secondary cleaners. By employing a dust catcher, wet scrubber, and electrostatic precipitator, 96% of the dust from the blast furnace can be eliminated. Pollution control equipment for the refining furnances includes electrostatic precipitators, high energy scrubbers, and bag filters. The specific advantages and limitations of each of these devices are discussed.

21324

Kato, Yujiro

PLANS AND OPERATIONAL EXAMPLES ON FILTER TYPE DUST COLLECTOR SYSTEM AT VARIOUS INDUSTRIES (VI). THE ROLE OF BAG FILTERS IN THE METALWORKING INDUSTRY. (Gyoshubetsu ni miru rokashiki shujin sochi no keikaku to unten jisshi rei (VI). Kinzoku kogyo ni okeru baggu firuta). Text in Japanese. Kogai to Taisaku (J. Pollution Control), 4(10):663-668, Oct. 15, 1968.

The operational conditions of bag filters used for emission control in the metalworking industry are illustrated by examples. In the zinc refining industry, bag filters are used at various points. The baghouse for the independent electric power plant which is provided to allow the exhausted material to cool down is one example. Another is the baghouse for controlling emissions from a smelting furnace exhaust. The applications of bag filters to the aluminum industry is illustrated by the baghouse used to control emissions from an alumina coveying process. In a powdered lead manufacturing plant, a complete dust collector has to be provided since the lead dust is extremely toxic and cannot be allowed to escape into the atmosphere. Complete hooding is also necessary. In the nonferrous metal working industry, emissions are commonly worth recovering. High efficient dust collectors are adequate for this purpose. In the iron and steel industry, the collected material from the exhaust is generally of little value, but dust collectors are necessary for air pollution control. Their use is typified by baghouses equipped for controlling emissions from electric-arc steelmaking furnaces and from electric furnaces for ferro-alloy manufacture. In the metal processing industry, bag filters are also used for controlling emissions from various processes. An example is the baghouse equipped for controlling emissions from the finishing process of iron casting.

21355

Peterson, H. W.

GAS CLEANING FOR THE ELECTRIC FURNACE AND OXYGEN PROCESS CONVERTER. American Inst. of Mining, Metallurgical and Petroleum Engineers (AIME), New York, N. Y., Proc. Am. Inst. Mining Met. Petrol. Engrs. Conf. Electric Furnace, 1956, vol. 14:262-271.

Waste gas cleaning methods for the oxygen converter steelmaking process and 200-ton electric-arc furnaces are reviewed. To cool the dense red smoke produced by the oxygen process to a volume that can be handled, the gases are first cooled to 550-800 F by water sprayed in a spark box located adjacent to the hood covering the mouth of the vessel in which the process is carried out. The gases are then passed upward through a gash washer's four banks of ceramic tiles. The washer has a water spray of 2200 gpm. With 50 F water, the gas temperature is reduced to 85 F. From the washer, the gases are carried to a Freyn disintegrator, where the moisture eliminator fine-cleans them prior to discharge through the stack. The operation of the electric-arc furnaces produces fine dust and fumes which pollute the atmosphere in the vicinity of the melt shop. The procedure used to treat these emissions is similar to that employed for the oxygen process. The gases are drawn off through a water-cooled vent elbow, passed through a spark box, where they are water cooled to 550 F, then carried to the gas washer and passed upward through banks of ceramic tiles. Twenty-two hundred gallons of water per min pass down through the washer concurrent to the flow of gas. In the washer, the temperature is reduced to 125 F, and most particles larger than 5 micron are trapped. After being washed, the gases are treated in a pressure disintegrator and moisture eliminator.

21894

Guthmann, Kurt and Gerhard Will

TECHNICAL MEASURES OF AIR POLLUTION CONTROL IN THE IRON AND STEEL INDUSTRY. Commission of European Communities, Luxembourg (Belgium), 71p., June 1968.

The High Authority, until mid-1967 the executive body of the European Coal and Steel Community, headed a campaign for the control of dust and waste-gas pollution in the sectors for which it was responsible. It was charged with promoting production and safe working conditions of labor. It set up

research programs for the technological control of dusts in mines and the iron and steel industry and has since subsidized many studies in this field. The results achieved by this Community-aided research are summarized and some of the iron and steel industry's difficulties are analyzed, particularly with respect to the technological and economic aspects of air pollution control. Sixteen studies were carried out in the sphere of dust and gas measurement. Nine of these were concerned with the comparison and improvement of dust measurement instruments and the development of new ones. Five were concerned with measuring dust concentrations at work locations. Two related to the emission and ground level concentration of dusts and gases. Considerable progress was made in the control of brown fumes to which 9 studies were devoted. Brown fumes are the waste gases produced when oxygen is blown in Bessemer convertors, open-hearth and electric furnaces. It is composed of minute iron oxide particles of a size comparable to tobacco smoke. Five studies were concerned with the control of other types of air pollution. Dust control methods adapted to the prevailing conditions proved very effective in sintering plants, in the conveyor-loading of blast furnaces, the discharging of fine ores from special skips and car tippers, and at the working area of the driver of the burden-charging carriage. An extremely irritating dust problem arising in the dry granulation of blast- furnace slag was solved in spraying the dust with water in a special suction hood.

22138

Kobayashi, T., G. Shimada, and M. Yokoi

RESEARCH OF SULPHUR OXIDE CONTROL TEST PLANT. (Hai gas datsoolyu no kaihatsoo kenkyu). Text in Japanese. Taiki Osen Kenkyu (J. Japan Soc. Air Pollution), 4(1):70, 1969. (Proceedings of the Japa Society of Air Pollution Annual Meeting, 10th 1969.)

A method of sulfur oxides control in waste gas from the sintering process in the steel industry was tested. The gas absorber as developed by Kanagaw Prefecture Industrial Experiment Station was adopted which is a wet-process and uses a comparatively compact device with a higher absorption rate due to its gas-liquid contact mechanism. It is capable of dust removal and was as an absorbent the ammonia generated at the coke producing process. In an experiment using a small test plant, the removal efficiency of sulfur is 90 to 95% for the case using industrial water as an absorbent and more than 98% for ammonia; dust removal efficiency is approximatley 90%. In the test of a medium size plant which consists of an absorption tower, a blower, pumps, tanks, demister, a heater, and meters, with an original amount of 800 to 1000 ppm of sulfur dioxide, it becomes 10 to 60 ppm, regardless of pH value, for 20,000 N cu m/hr; less than 100 ppm when pH is more than 7.5, for 30,000 N cu m/hr; and less than 100 ppm when pH is above 9, for 50,000 N cu m/hr. When sea water is used as an absorbent, it becomes below 100 to 300 ppm, depending on the gas load. These data will be used for the design of a larger plant.

22940

Palen, A. G. Paul

BOLIDEN IMPROVES WORK AT RONNSKAR SMELTER. Eng. Mining J., 139(9):54-55, 1938.

A flotation process for separating arsenopyrite and copper pyrite from barren pyrite was developed by a Swedish smelter, thus decreasing the tonnage of ore to be smelted and improving the metallurgical practice. The concentrator treats pyrite ore and siliceous ore derived from mineralized wall rock. The pyrite ore yields a smelting concentrate and a pyrite concentrate with about 5.5 sulfur and practically free from copper and precious metals. The siliceous ore gives a smelting concentrate and waste. The ore that goes directly to the smelter is now finer than before since it passes a screen with slots 7 times 12 mm as against 15 times 32 mm. This has greatly improved the reverberatory work, especially when running on a mixture of flotation concentrates of crushed ore. With the decreased amount of material to be treated (700 tons daily instead of 1000 tons), eight 7-m diameter roasting furnaces are sufficient. However, the smelter has introduced wet refining processes to recover arsenic and selenium. To protect forests against smoke damage, sulfur dioxide in roaster gases is catalytically reduced by a reducing gas to elemental sulfur.

23182

Purvance, W. T.

ATMOSPHERIC POLLUTION CONTROL. Chem. Eng. Progr., 55(7):49-53, July 1959. (Presented at the American Institute of Chemical Engineers Meeting, Salt Lake City, Utah, Sept. 1958.)

The development of measures to control fluoride emissions from a Utah steel plant which had caused damage to local animals is described in detail. The open hearth shop and sintering plant were the major sources of emission, while the locally-mined iron ore was the raw material responsible for the greatest quantity of fluorine. On the basis of extensive pilot plant testing, limestone was added to the sintering mix, and equipment for cleaning sintering waste gases were installed, including facilities for injecting pulverized limestone into the gas stream, a battery of mechanical cyclones, and an electrostatic precipitator. A reduction of 96% in fluoride emissions from this source was thus achieved, with important savings from recycling the waste gas. For the open hearth operations, it was decided to collect and blend the waste gas effluent from all the furnaces in a collector main flue, from where it is passed to individual precipitator units. Clean gases are discharged into existing stacks; hydrated lime is the reactant in the process. The major problems encountered were handling of the collected dust, control of gas moisture, and furnace pressure control. The $9 million cost of the entire control program from research through operation is viewed as part of the cost of using Utah iron ore. The equipment is considered unique in that extremely large volumes of gas are continuously undergoing chemical treatment and final cleaning while the final collected product is disposed of.

23245

Bothe, Rolf

PROBLEMS IN DUST REMOVAL FROM THE WASTE GASES OF IRON ORE SINTERING PLANTS. (Probleme der Sinterabgasentstaubung bei Eisenerzsinteranlagen). Text in German. Stahl Eisen, vol. 88:1414-1422, Dec. 12, 1968. 10 refs. (Presented at the Commission on Power Economics and Thermal Engineering, 198th General Session, Duesseldorf, June 14, 1968.)

The evolution of processes for the removal of dust from sintering gases is traced, from the earlier mechanical devices to the present-day electrostatic filters. Practical experience with their installation and use are presented, together with comments on the influence of the filter on industrial processing techniques, with reference to its technical possibilities and limitations. The special problems of dust removal in older sintering plants is also dealt with. A basic distinction is made between the dust problems created by the actual sintering process and those created by the transport of materials and other related operations of the plant; the former problem is

dealt with here. In 1960, the first electrostatic filter was installed in Europe in a West German steel mill. At the date of writing, there were four modern iron smelting plants in Europe that made use of the electrostatic process for dust removal. Electrostatic filters operate most efficiently when the electrical resistance of the dust is in the range of 10 to the 4th power -10 to the 11th power OHMS/cm. In the past few years, there has been a dramatic change in the type of iron ore supplied to German steel mills. Whereas previously the domestic ore dominated the market, the amount of domestic ore now used has shrunk to about 1/9th of the total. The new supplies, coming from such places as Africa, has a lower content of chemically bound water and little or no sulfur content. Both water vapor and sulfur oxides have an influence on dust resistance.

23364

Weber, Ekkehard

ANNUAL REPORT ON THE STATE OF AIR POLLUTION CONTROL (SERIES 5). (Jahresuebersicht Reinhaltung der Luft (5. Folge). Text in German. Giesserei (Duesseldorf), 56(12):372-377, June 5, 1969. 88 refs.

A survey is given of literature covering a vast scope of air pollution problems, including legislation, governmental regulations, measurement of the content of sulfur dioxide, carbon monoxide dust fall, etc. in various parts of Germany, France, Italy, and other countries. The emissions of dust and gases from various industries are discussed, including the types of equipment used for their control, such as dry and wet processes, electrostatic filters, and bag filters. Measuring techniques are also reviewed.

23628

Storch, Otakar

EXPERIENCE WITH THE APPLICATION OF WET COLLECTORS IN THE IRON AND STEEL INDUSTRY. (Erfahrungen mit der Anwendung von Nassabscheide in Eisen und Stahlhuettenwerken). National Society for Clean Air, London (England), International Clean Air Congress Proceedings, London, England, 1966, Part 1, p. 119-122. (Oct. 4-7, Paper V/2.) Translated from German. Franklin Inst. Research Labs., Philadelphia, Pa., Science Info. Services, 10p., Oct. 23, 1969.

Since it is impossible to prevent hardening of deposited dust on wet collectors, they are no longer used in Czechoslovakia for the coarse-grained, agglomerative dusts produced in iron and steelmaking processes. For coarse dust, electrostatic precipitators preceded by dry, mechanical separators are used. A new type venturi scrubber has been developed with a high efficiency for removal of metallurgical dusts in the micron and submicron range. The collector operates economically and reliably even when operating conditions are unfavorable. It has the following outstanding properties: a) It permits supply of water simply by mud pump without use of pressure. b) It distributes and atomizes the water uniformly over the entire cross section of the venturi tube. c) Its construction is simple, and each component is protected against corrosion. d) It requires no special maintenance service, since all components are readily accessible. The collector comes in seven sizes. They have standard capacities ranging from 3750 cu m/hr to 90,000 cu m/hr. They can operate with pressure losses from 200 to 900 kg/sq m. Ninety-eight% and 99.8% collection efficiencies are reported for FeMnC and FeSiMn, respectively, at a pressure loss of about 500 kg/sq m.

23808

Adams, Richard W.

HIGH ENERGY WET GAS CLEANING FOR THE BASIC OXYGEN OG PROCESS. Blast Furn. Steel Plant, 58(10):751-753, Oct. 1970. (Presented at the American Society for Metals, Pollution Control Conference, June 9, 1970.)

0A steel company's new basic oxygen steelmaking facilities are equipped with scrubbers that use a pressure drop of 30-60 in. of water to violently impinge particles of water against particles of dirt, thereby causing the wetted particles to agglomerate and drop out of the gas stream. The Oxygen Converter Gas Recovery (OG) process differs in that it uses a moveable 'skirt' which drops down around the mouth of the furnace, enabling the pressure inside the hood to be controlled so that a minimum of air is allowed to enter and combust with the gas. This greatly reduces the amount of heat generated as well as the total volume of gases, permitting a substantial decrease in the size of the gas cleaning equipment and the power required to operate it. Since the OG system handles large quantities of carbon monoxide, it is necessary to keep the ductwork as streamlined as possible; pockets could trap gases and accumulate an explosive mixture. A circulating system was laid out using a cooling tower to remove the heat in a similar fashion to those systems in use in Japan, but water which has been partially softened with a cold lime process and filtered through deep-bed anthracite filters was thought to be more efficient because of its high pH. Polyethylene pillows filled with fiberglass about six inches thick were installed in the discharge duct after the fan to reduce the noise, while the fans were designed with gas-tight seals around the shaft.

23955

Underwood, G.

REMOVAL OF SUB-MICRON PARTICLES FROM INDUSTRIAL GASES, PARTICULARLY IN THE STEEL AND ELECTRICITY INDUSTRIES. Intern. J. Air Water Pollution (London), vol. 6:229-263, 1962. 57 refs.

The basic theory of electro-precipitators, fiber and bag filters, and venturi scrubbers is described, together with modern equipment capable of dealing with submicron dust particles. Difficulties involved in continuous operation at efficiencies over 99% are discussed with particular reference to the steel industry and power stations. However, the information presented should be applicable to small particles in general, and to any industry producing this fine dust. General conclusions drawn are that electro-precipitators are very suitable for collecting dust or fume with a resistivity between 10,000 ohm cm and 2 times 10 to the 10th power ohm cm. To ensure good operation, perforated distribution plates and turning vanes must be used to keep an even flow of dust and gas. Voltage should be maintained at its highest level by means of flat collecting electrodes with stiffeners at the edges of each sheet. Bag filters, especially those cleaned by a blow-ring and reverse jet can handle much higher dust loadings than electro-precipitators. Wool felt bags can handle gas up to 90 C; while silicone-treated glass bags, up to 300 C. The pressure drop of a bag filter can vary from 2 in. wg when clean to 6-8 in. wg when dirty; the pressure drop through an electro-precipitator rarely rises above 0.5 in. wg. The venturi scrubber is able to remove dust or fume of any size with efficiencies of over 99%, but pressure drops can increase to 30 in. wg. In general, venturi scrubbers have lower capital costs but higher running costs than electro-precipitators and bag filters.

24239

Shidara, Masao

MEASURES TAKEN BY IRON AND STEEL INDUSTRY TO PREVENT AIR POLLUTION AND SO FORTH. (Tekko gyokai no sangyo kogai boshi taisaku). Tex in Japanese. Sangyo Kogai (Ind. Public Nuisance), 6(10):578-586, Oct. 25, 1970.

The Iron and Steel Industry Association has established the Industrial Hazards Countermeasure Committee, which has four special subcommittees: Air Pollution Prevention, Factory Effluent, Industrial Wastes, and Factory Safety (which handles high pressure gas, and so forth.) A joint study is being made by more than 10 manufacturers of desulfurization equipment on the desulfurization of smoke issuing from pulverized iron ore process stacks. Joint research by iron and steel makers is being conducted using desulfurizing equipment with a capacity of 150,000 cu ft/hr, with a 3 million dollar research fund. Measures taken by another steel mill include establishment of a pollution prevention committee, watching of smoke, dust collection review circle, liaison council with related organizations, and smoke control staffs. Various equipment used by the iron and steel industry for blast furnace, sintering furnace, LD converter, open hearth, and electric furnace control, such as bag filters, coolers, cyclones, centering chambers, dust chambers, electric dust collectors, multi-cyclones venturi scrubbers, stabilizers, washers, wet filters, and scrubbers are described. Chemical compositions of dust collected from these furnaces are tabulated. Measures for the prevention of sulfurous acid gas taken by the newly operating KM Steel Mill are described, followed by those taken by the newest KKK Steel Mill (first firing in August, 1970). They include not only prevention of air pollution, but also prevention of noise, prevention of pollution of sea water, and construction of a green belt. Investment on anti- air-pollution spent by SY Steel Mill up to 1968 was $33 million, with a monthly operating cost of $133,000. The rate of investment on prevention of industrial hazards, invested by 137 mills in iron and steel industry (as of Oct. 1969, MITI), increased from 3.22% in 1965 to 4.44% in 1969.

24676

Egley, Billy D.

SELECTION OF GAS CLEANING EQUIPMENT FOR AN ORE PREPARATION PLANT. Iron Steel Engr., 47(11):111-115, Nov. 1970.

A Colorado steel corporation established a separate department in 1966 to determine the areas of air and water pollution, to devise methods of treatment for areas requiring some type of pollution control, to initiate the installation of equipment which would provide satisfactory pollution control, and to act as the liaison between the company and the various air and water pollution control agencies. One of the department's first targets was the highly visible red oxide plume emitted from the main sinter plant stack, especially evident when insufficient moisture was added to the sinter mix. A three-phase plan was developed which consisted of stack sampling in order to gather background information, pilot testing of a variety of gas cleaning equipment, and selection and installation of the equipment. The final decision to install an electrostatic precipitator at the sinter plant was based on the following reasons: they were guaranteed to meet the emission specifications of less than 0.025 grains per dry scfm; less maintenance would be required and, as the precipitator contains few moving parts, no additional fans would be required because of the low pressure drop through the unit; normal mechanical and electrical problems could be isolated without disrupting the sinter process while still maintaining reasonable gas cleaning efficiency; cleaning of the gas electrostatically would not involve possible contamination of the plant effluent waste water streams.

24809

Kulikov, V. O., A. E. Prikhozhenko, and N. G. Braginets

IMPROVING THE GAS CLEANING ON 100 T OXYGEN CONVERTERS. Steel (USSR) (English translation from Russian of: Stal'), no. 6: 495-496, 1970. 2 refs.

The original gas-cleaning system for 130-133 ton oxygen converters provided for primary cleaning in 90-96 venturi tubes, each having a throat diameter of 90 m, and final cleaning in foam plates. The system was characterized by high moisture loss and deposition of sludge on fan rotors and in venturi tube atomizers. As a result the average residual dust content amounted to 200-250 mg/cu m. By reducing the number of tubes to 18, increasing their throat diameter to 22 mm, and adopting evolute atomizers, residual dust content was reduced to 85-120 mg/cu m.

24881

Kazarinoff, Andrew

INDUSTRIAL AIR POLLUTION--ITS CONTROL AND COST. Design News, 23(14):18-24, July 5, 1968.

Power generating plants, steel mills, and cement kilns are included in the groups that will be forced by government restrictions to control pollutants. The industrial air pollution control equipment available now, the cost of pollution control to industry, and some air pollution problems for which there are yet no practical solutions are discussed. No real innovations have been made in control equipment for a long time; the major devices are still electrostatic precipitators, bag filters, cyclones, and scrubbers. Research and development is needed on equipment that can control both particulate and gaseous pollutants; equipment that can perform at higher efficiencies without size and cost penalties; equipment whose efficiency curve is relatively flat over broader ranges of particle size; and lower-cost equipment.

25384

Wilcox, Michael S. and Roy T. Lewis

A NEW APPROACH TO POLLUTION CONTROL IN AN ELECTRIC FURNACE MELT SHOP. Iron Steel Engr., 45(12):113-120, Dec. 1968.

Problems encountered by an electric furnace melt shop in Michigan concerned fume collection in and around the furnace and fume cleaning, i.e., the separation of dust and particulate matter from gases in which it was entrained. The total emission control system adopted by the plant meets both existing local and presently proposed state standards. The system uses a roof truss hood for fume collection and a baghouse for fume cleaning. The location, design, and operation of this equipment and related facilities are described. The cloth collector was engineered and guaranteed to capture in excess of 99% by weight of solid and particulate matter entering ductwork, while the roof truss hood portion of the system was guaranteed to capture in excess of 65% of furnace fume emission There is every indication that these guarantees are being met.

25500

Bothe, Rolf

NEW METHODS IN ELECTROSTATIC DEDUSTING OF WASTE GASES WITH HIGH CO CONTENT COMING

FROM STEEL WORKS CONVERTERS. Preprint, International Union of Air Pollution Prevention Associations, 64p., 1970. 12 refs. (Presented at the International Clean Air Congress 2nd, Washington, D. C., Dec. 6-11, 1970, Paper EN-34D.)

In the sixties, a series of modern oxygen converter steel plants was built with controlled minimum gas exhaust with scrubbers used as dust collecting equipment. In many of these cases, the purpose was to utilize the converter gases with a high carbon monoxide content. In the course of the last 2 years, a number of plants were built which presented the novel feature that they combined uncontrolled exhaust, CO-rich converter gases and the application of economically operating wet and dry electro-precipitators. Two are described. In a plant with uncontrolled exhaust, the inert transitory volume between the oxygen rich and the CO-rich gas phase is sufficient to avoid the formation of explosive mixture during the phase with a very high CO content, provided that the whole installation is executed under strict observance of prevailing flow conditions. This fundamental discovery made possible the use of electro-precipitators. In 1968 a plant was erected at Dillinger Huttenwerk AG. It was designed for uncontrolled gas exhaust and for a value of n equals 0.7 during the phase with the high CO content. The whole plant consists of a tube lined cooling stack, a saturator, a wet electro-precipitator, a blower, a stack, a hydro-cyclone for sludge water pre-cleaning and a clarifying plant. The sludge separated in the clarifying plant is pumped into the drum mill of the nearby sinter plant without undergoing any treatment. The lifting forces in the cooling stack and in the vertical precipitator suck off the gas at the converter mouth and convey the gases further on. The plant built in 1969 at Huttenwerk Salzgitter AG was designed for uncontrolled gas exhaust and a value of n equals 0.2 to 0.3 during the phase with the high CO content. The plant consists of a tube-lined cooling stack with a subsequent evaporation cooler, a dry electro-precipitator, a blower and a surplus gas burner. Measurements were made and showed that the design data and the guaranteed dust collection efficiency had been fully attained. Electric current and water consumptions were modest. In the wet-type electrostatic dedusting system, the conveyance of the sludge from the clarifying tank to the sinter plant via a piping system did not present any difficulty at all. Small and medium-sized converters can be fitted with a dus collecting device that provides for gas exhaust and conveyance by natural lifting action. Such a device could be operated without an induced draught system of its own. (Author abstract modified)

25521

Grobel, E. A.

OXY-BURNER LANCE FOR FUME SUPPRESSION. Pollut. Eng., 3(2): 28-29, July-Aug. 1970.

A properly designed oxygen-fuel burner lance can substantially reduce emission of contaminants in electric furnace steelmaking. An inner segment carries the oxygen, the middle segment is the natural gas carrier, and the outer shell provides water for cooling. A 45-deg bend facilitates control of the gas stream-metal surface impingement angle. Proper location of the oxygen carrier with respect to the converging portion of the throat is critical. A converging-diverging throat must be incorporated in the nozzle portion of the burner-lance. This system can be constructed for as low as $2000 per furnace, depending on the sophistication of the metering equipment and burner-lance manipulator.

26003

Harada, G., S. Yamamoto, K. Osumi, H. Shimizu, and H. Omi

TREATMENT OF DUST GENERATED AT IRON MILL. (Seitetsusho ni hasseisuru dasuto shoriho). Text in Japanese. (Japan Magnetic Ore Screening Co.) Japan. Pat. Sho 43-29863. 3p., Dec. 21, 1968. (Appl. Feb. 1965, claims not given).

A method is described for recovering oxidized iron by adding cement or plated lime to the fine wet iron dust particulates from the sedimentation tank, thus making it easier to handle. Even afte the dust from the sedimentation tank is dehydrated with a filter, it still contains 30% water which prohibits its reuse. However, the dust mixed with cement or lime dries and solidifies naturally, permitting reuse for sintering. Because of the capillary action of the small air spaces between the dust particles as well as the water adhering to their surface, mechanical methods are ineffective Evaporation by heat is too expensive. Dust from sticky ores and from the stacks of the sintering mill can also be treated by this method, thus conserving useful resources.

26018

Glinkov, M. A. and N. M. Morekhina

CHEMICAL COMPOSITION OF FINELY-DISPERSED DUST FORMED DURING BLOWING OXYGEN THROUGH THE MELT IN THE HEARTH OF A STEEL FURNACE. 1ST COMMUNICATION. (O khimicheskom sostave melkodispersnoy pyli, obrazuyushcheysya pri produvke kislorodom rasplava v vanne staleplavil'noy pechi. Soobshcheniye 1). Text in Russian. Izv. Vysshikh Uchebn. Zavedenii, Chernaya Met., 13(9):166-168, 1970. 6 refs.

A review of available data leads to the conclusion that dust, produced by blowing oxygen through the melt in a blast furnace, contains ferromagnetic gamma-Fe203 which, in time, converts to hematite (alpha-Fe203). This may be of interest in the development of new methods for removing magnetic particles from exhaust gases by means of a rotating electromagnetic field.

26195

A BRIEF REVIEW OF FLUE GAS TREATMENT. Eng. Mining J., 92(24): 1115-1116, Dec. 9, 1911.

For metallurgical works having long flues, satisfactory deposition of flue dust, and to a certain extent fumes, can be obtained by means of cooling pans and water sprays such as Koerting nozzles. Though not universally applicable, a more effective method is the baghouse. The life of the bags can be prolonged by introducing zinc oxide, or some other base, into the flues to neutralize any acids present. When used with lead and copper furnaces, provisions must be made to reduce the temperature of the gases. The centrifugal scrubber finds a large use in the metallurgy of steel, while perforated plate scrubbers are extremely effective in removing soluble substances from gases. Another control measure is the Cottrell system of electrolytic condensation, which depends on the agglomeration of floating particles by high-potential charges. The use of tall chimneys or lattice work stacks must be considered of doubtful advantage.

26332

Venturini, J. L.

OPERATING EXPERINECE WITH A LARGE BAGHOUSE IN AN ELECTRIC ARC FURNACE STEELMAKING SHOP. J. Air Pollution Control Assoc., 20(12):808-813, Dec. 1970. 2 refs.

Since 1965, visible emissions from the electric furnace department of a Los Angeles steel plant have been controlled by a 525,000 cfm baghouse system. The system collects about 185 tons of particulate matter/week, or about 30 lb of particulate matter/ton of steel produced. The control equipment consists of two large baghouses, two 1250-hp driven exhaust fans, and ducts to form the exhaust system. The latter vents the shell of each furnace, a leaded steel pouring line, a hot scarfing machine, and the entire building housing the furnaces. The exhaust fans draw fume from each furnace into cooled elbow and spray chambers from which the cooled fume is passed to a distribution manifold. Particle-laden fume is diverted into the 26 individual sections of the baghouse from the distribution manifold, each section containing 120 silicone-treated, glass fiber bags. Outlet dust loading measured in the exhaust air to the atmosphere from the baghouse compartments averages 0.0017-0.0047 grains/cu ft. Operational costs of the system have been reasonable, and air pollution control legal requirements have been met.

26546

Inagaki, Koshiro

SMOKE AND DUST EMISSION STATUS IN AICHI PREFECTURE AND CONTROL FACILITIES. (Aichi kenka no baien hasseijokyo to boshi setsubi). Text in Japanese. Kogai (Hakua Shobo) (Pollution Control), 4(6):286-295, Nov. 1969. 9 refs.

Dust and smoke-producing industries in Aichi Prefecture include ceramic, textile, wood fiber board, heavy chemical, and metal industries; the emission sources include boilers, sintering, electric and blast furnaces, and open hearths. The emission data such as the type of furnace, fuel, emission quantity, and sulfur oxides concentrations are given for various industries such as ceramic, wood fiber board, and steel; some of the emission control facilities such as dust precipitators, gas purifiers, and dust precipitators for open hearths are described in detail.

26612

Talbott, John A.

BUILDING A POLLUTION-FREE STEEL PLANT. Mech. Eng., 93(1):25-30, Jan. 1971.

At a scrap steel remelting and rolling plant, the greatest potential sources of air pollution are two electric-arc melting furnaces and a billet reheating furnace. Control of the temperatur and air-fuel ratio of the gas-fired billet heating furnace has successfully prevented objectionable emissions from this source. Fumes from the electric furnaces are rapidly cooled and collected by a side-draft system arranged so that carbon monoxide emitted from the furnace is burned at the duct inlet with a large volume of excess air. This prevents the accumulation of an explosive mixture in the duct or downstream facilities. For treatment of the collected fumes, a spark trap was adopted with a multiple-module bag filter unit provided with a fan on the discharge (or clean) side of the filter. As evidence of the efficiency of the fume cleaning, the filtered air discharge from the fan is at a relatively low level where visible discharge would be readily observable. Water used for cooling plant equipment is obtained from a cooling-water pond surrounded by an earth dike and provided with a drop inlet/outflow to prevent overtopping. There will be no cooling-water discharge from the mill. Slag resulting from mill operations will be used to level irregular areas of the site.

26854

Maehara, Shigeru, Isoji Igarashi, Shigeaki Morita, Koichi Tagiri, and Fumio Kodama

RESEARCH AND DEVELOPMENT OF THE OG METHOD. (OG-ho no kaihatsu to hatten). Text in Japanese. Seitetsu Kenkyu, no. 226:112-136, March 1969.

The oxygen converter gas recovery (OG) process adopted by Yawata Iron and Steel Co., the world's first industrial-scale non- combustion type treatment of waste gas from converter furnaces, was developed in order to avoid the combustion-type treatment of waste gas, especially by waste heat boilers. In pure oxygen converter furnaces, the high-temperature exhaust gas consists mainly of carbon monoxide. In order to cool, reclaim, and store the gas in addition to depriving it of dust particles at non-combustion conditions, the escape of the gas as well as the entrance of outside air through the furnace hatch must be prevented. The basic idea is to form an inert gas curtain around the hatch so that there is an effective resistance between the gas and outside air, and the pressure differential can be detected and the damper in the gas conduit can adjust the gas flow to eliminate the differential. The gas for the curtain is nitrogen. The OG process is lower in installation and operational cost compared to the combustion-type treatment of the waste gas. The reclaimed gas can also be used as fuel.

27553

Ueda, Akiyoshi

PRECIPITATION OF BLAST FURNACE. (Koro no shujin). Text in Japanese. Kagaku Kogaku (Chem. Eng.), 35(1):47-53, Jan. 1971.

The main sources of dust and particles at blast furnace installations are the conveyor for raw materials, the casting bed, and the blast furnace gas. A well-designed suction hood over the conveyor will control airflow; the air itself can be cleaned by wet collision-type cleaners or bag filters. Slurry from the wet cleaners is disposed of by adding it to the thickener used to purify blast furnace gas. Large-scale blast furnaces requiring an airflow of more than 7000 cu m/min can employ an air curtain to abate the wind effect and reduce dust density from 2-5 gr/cu nm to 0.2 gr/cu nm. The size distribution of dust generated by the casting bed is smaller than that of conveyor dust; about 70% of it is less than 30 micron. In terms of quality and pollution control, the purity of blast furnace gas should be 5-10 micrograms/cu nm. Components of the gas are carbon dioxide (18.4%), carbon monoxide (23.5%), hydrogen (3.3%), and nitrogen (54.6%). A dust collector will collect particles larger than 100-300 micron. A venturi scrubber has the advantage that its slot can be varied to correspon to changes in furnace operations. Only wet electrostatic precipitators can be used with blast furnace gas. Their waste water is treated, together with that from the scrubber, with a thickener.

27727

Kovach, J. Louis and David G. Hannan

COMBINED DUST, AEROSOL AND VAPOR REMOVAL EFFICIENCY OF PACKED ACTIVATED CARBON BEDS. Preprint, 14p. 1970. 9 refs. (Presented at the International Dust Conference, Bonn, West Germany, 1970.)

A combined filtration system is described which consists of a deep, packed bed of activated carbon followed by a bank of high efficiency particulate air filters. Conventional air cleaning systems have high cost/efficiency ratios due to the large amount of hardware required, as well as serious shortcomings in the removal efficiency for submicroscopic particles and in

their fragility. Design parameters were established for a boiling water nuclear reactor emergency standby gas filter system to remove particulate and gaseous fission products, particularly iodine species. The particulate filtration efficiency of packed carbon beds exhibited characteristics similar to the fibrous filters, i.e., an increase in efficiency with a decrease in granule size. Carbon, which was loaded with either fly ash or DOP aerosol, did not show a decrease in iodine vapor adsorption efficiency. When finer carbon particles are used, both the gaseous and particulate efficiency of the deep bed is higher than with coarse granules; consideration of the pressure drop and the wider distribution of decay heat within the adsorber favor the use of coarse grain beds. An additional advantage of the coarse grain beds in nuclear applications is the prevention of flooding the bed at high water droplet loadings. The shape of the aerosol removal curves indicates that different removal mechanisms dominate at different carrier gas velocities.

27779

Narita, Kiichi

ON PRELIMINARY DESULPHURIZATION OF MOLTEN PIG IRON. (Yosen no datsuryu ni tsuite). Text in Japanese. Tetsu to Ko (Iron Steel), 57(2):411-429, Feb. 1971. 34 refs.

Various methods of desulfurizing molten pig iron are reviewed with respect to desulfurization efficiency and agents and operating problems. The methods discussed include: shaking ladle, rotary drum (Domnarfvet), mechanical stirring with either hollow or solid stirrers, high-frequency induction furnaces, blow-in or injection, gas injection/stirring, soda ash, and turbulator. When soda ash is employed as the desulfurizing agent, use of the turbulator or relayed ring methods is recommended. Soda ash desulfurization can be made more effective by increasing the amount of soda ash added and carrying out the process at about 1250 C. Corrosion of the ladle by the soda ash is prevented by using a mixture containing 25% soda ash, 25% fluorite, and 50% lime. Further improvements in desulfurization require a stronger desulfurizing agent such as CaC2. Desulfurization conditions should be such that no graphite becomes mixed with the desulfurization dregs, thus slowing down the reaction rate.

27783

Geny, P.

ATMOSPHERIC POLLUTION CONTROL IN THE IRON AND STEEL INDUSTRY. (Lutte contre la pollution atmospherique dans l'industrie siderurgique). Text in French. Ann. Mines (Paris), no. 11:55-62, Nov. 1970.

The various sources of air pollution within the French iron and steel industry are identified, the control possibilities are outlined and a proposal of a law for pollution control elaborated. The introduction of new steel making techniques has aggravated the pollution problem, in that the use of oxygen in the manufacture of steel has resulted in the emission of red fumes. The principal pollutants are dusts of particle diameters from 10 to 100 micron, fine dust particles containing predominantly red iron oxide particles of a diameter below 10 micron, and sulfur dioxide from sulfur in fuels or minerals. These pollutants are emitted during smelting, during steel making, during steel rolling, during sheet metal treatment, from coke ovens, and from auxiliary installations. Dust collectors in the mineral agglomeration shops remove 95% dust at an investment cost of 8.5% of the total investment. Dust emitted during steel making contains 70-72% Fe304,6-8% Fe203, 7% Fe, 10% CaO, 2.5% P205, silica, and sulfur. The red fumes have a median particle diameter of between 0.08 and 0.12 micron. The purification of this emission is at present not possible because of the enormous cost this would entail, but the dust is not noxious.

28221

Wood, A. H.

FUME COLLECTION IN STEEL WORKS. In: Gas Purification Processes. G. Nonhebel (ed.), London, George Newnes Ltd., 1964, Chapt. 13, Part E, p. 573-576. 31 refs.

Oxygen steelmaking processes produce brown iron-oxide fumes predominantly 50 millimicrons to 5 microns in size. The volume of gases to be cleaned can be as high as 200,000 cu ft/min. Depending on the oxygen process used, dust loadings can be as high as 3, 8, or 10 grains/cu ft ntp. For chimney emissions from a large steelmaking vessel to have minimum visibility, the fume content must be reduced to 0.05 grains/cu ft ntp. The only forms of apparatus that will meet the severe requirements of 99-99.5% fume-removal efficiency are electrostatic precipitators, bag filters, and high energy-loss wet scrubbers. When large volumes of gas must be continuously cleaned, electrostatic precipitators are the most certain to give the required performance consistently with minimum power, maintenance, and labor costs.

28402

FUMELESS REFINING BY OXIDE INJECTION. Brit. Steelmaker, 36(12): 14-15, Dec. 1970.

The Steel Castings Research and Trade Association, Sheffield, has developed a fumeless process by which steel is decarburized by injecting iron oxide powder directly into the bath. The oxide promotes a vigorous carbon boil but there is no emission of brown fume. Any kind of iron oxide can be used, or the oxide of an alloying metal, while the carrier gas used is normally compressed air. The reaction is endothermic, but adjustment of heat input during injection makes it possible to control the temperature. (Author abstract)

28497

Venturini, J. L.

OPERATING EXPERIENCE WITH A LARGE BAGHOUSE IN THE ELECTRIC ARC FURNACE STEELMAKING SHOP AT BETHLEHEM STEEL CORPORATION'S LOS ANGELES PLANT. Preprint, Air Pollution Control Assoc., Pittsburg Pa., 28p., 1970. 2 refs. (Presented at the Air Pollution Control Association, Annual Meeting, 63rd, St. Louis, Mo., June 14-18, 1970, Paper 70-28.)

One of the largest and most expensive control systems designed to treat all the emissions from three electric arc furnaces was installed at the Bethlehem Steel Corporation's Los Angeles plant and placed in operation early in 1965. The exhaust system consists of a direct roof evacuation type of water-cooled elbow and spray chamber at each furnace to temper the gases, damper controlled canopy hoods which are located over the furnaces and above the overhead cranes, and all necessary ductwork connecting the collection points. This control system provides a method of ventilating the three million cubic foot electric furnace building, plus a leaded steel pouring line and a hot scarfing machine. Five years of operation are reviewed and experience to date with the fume control system is reported in terms of operational characteristics, development, equipment design and specifications, and cost to maintain. After the equivalent of five years of continuous service, only 50% of the 3120 glass fabric bags have been replaced because of wear. Outlet dust loading measured in the exhaust air of the atmosphere from the baghouse compartments averages 0.0017 to 0.0047 grains/cu ft. Operational costs

have been reasonable. Air pollution control legal requirements have been met. Dust and fume has either been evacuated direct from furnace to baghouse or evacuated from the furnace building in the case of effluent from charging and tapping. The success of the system has been established by the fact that the fume is prevented from escaping into the open atmosphere outside of the furnace building. The company is satisfied with this installation, and believes that the baghouse collector is properly applied. The present system provides adequate ventilation most of the time, but additional modifications may be required in future to avoid peak fume conditions inside the furnace building. (Author abstract modified)

28547

ENVIRONMENTAL POLLUTION CONTROL SYSTEM OF KAKOGAWA STEEL WORKS. (Kagogawa seitetsusho kogai boshi taisei). Text in Japanese. Kobe Seiko Giho (Kobe Steel Eng. Repts.), 21(1):19-28, Jan. 1971. 1 ref.

Sulfur dioxide emissions were controlled at the source by the use of heavy oil with an extremely low sulfur content, and iron ore with a low sulfur content. The heights of approximately 30 stacks were determined on a computer by linear programming so that either the ground concentration for each stack or the total did not exceed the value stipulated in the environmental standard. Wind tunnel experiment were conducted to determine the effects of buildings and the leeward topography around the stacks. The one-hour average of the concentration obtained by the diffusion calculation and the wind tunnel experiment was modified by using the monthly frequency of wind direction to predict a long-term average concentration. As an emergency measure, 10,000 tons of extremely low sulfur oil is constantly stored. The company has its own monitoring stations in addition to prefectural and municipal stations. For dusts, a wet type electrostatic precipitator was employed for particles less than 1 micron. A multicyclone separator, a dry type electrostatic precipitator, a fan and venturi scrubber, and a bag filter were also used. The bag filter was limited to a small scale, because of the difficulty in processing the captured dust. For selecting the capacity of the dust collectors, an inlet speed of 2 to 2.5 m/sec was assumed, with a 20 to 30% reservation. The 60 dust collectors consumed 16,000 kw. Dust covers, water sprinklers, and yard guns were also employed. When necessary, the surfaces of ore and coal depots were flushed with water containing an active sponge agent.

28880

COLLECTION AND REMOVAL OF FUMES AND DUST FROM A 30 TON ELECTRIC ARC STEEL FURNACE. (Captage et depoussierage des fumees d'un four a arc d'acierie de 30 t). Text in French. J. Four Elec. Ind. Electrochim. (Paris), 74(10):259-261, Dec. 1969.

A system for the collection and disposal of dust-carrying fumes was built and installed in a Belgian steel plant in conjunction with a 30-ton electric furnace. The 1700 C fumes are extracted by fans from inside the furnace directly into a long pipeline. The rate of extraction is automatically controlled depending on the pressure in the furnace. In the pipeline, complete combustion of the carbon monoxide gases takes place, and the fumes are cooled to 130 C by th surrounding air, and then pushed into a chamber containing a series of polyester tissue filters, which retain and collect the iron oxid dust and other particles. The purified gases are released to the atmosphere. The filters are cleaned periodically by a counter air stream. The quantity of gas collected amounts to about 350 kg per 30-ton furnace charge, producing 150 to 200 tons per year of iron oxide powder.

28905

Bartecek, J.

DUST REMOVAL FROM THE COMBUSTION PRODUCTS IN OXYGEN INTENSIFIED OPEN HEARTH FURNACES. Hutnik (Prague), 19(9):334-337, 1969. Translated from Czech. British Iron and Steel Industry Translation Service, London (England), 9p., May 1970.

The measured bulk density of dust emitted from oxygen-intensified open-hearth furnaces is 1.81 tons/cu m; particles below one micron constitute 70% of this dust. At the steel plant described, this fine dust is recovered by first cooling combustion gases in stages from 800 C to 130 C and then filtering the dust in a 10-chamber baghouse with a capacity of 120,000 cu m/hr. The dust is collected and pelletized for charging into the open-hearth furnace. This dust-cleaning system is guaranteed to keep dust emissions below the legal limit of 100 mg/cu m.

29083

Cahn, David S.

AGGLOMERATION OF STEEL PLANT FURNACE DUST WITH CEMENT BINDERS. Cement Technol., 2(1):15-17, 20-24, Feb. 1971. 5 refs.

Pilot plant and laboratory tests were made on blends of steel plant flue dust and Portland cement to determine whether the flue dust could be pelletized for use as a source of iron in dry process cement manufacture. Strength and setting time results showed that an acceptable agglomerate can be made with a Type II Portland cement binder. Abrasion-resistant and well-sized pellets were made in a horizontal drum, using simulated closed circuit, with a binder content of 7.5% and a moisture content below 15%. Pellet quality was relatively insensitive to changes in binder concentration above 5%. Simulations of stockpiling and weathering indicate that little difficulty would be encountered with the use of flue dust pellets in cement plants. (Author introduction modified)

29740

Scholz, Hans-Ullrich

DEVELOPMENT OF GAS PURIFICATION INSTALLATIONS FOR ELECTRIC MELTING FURNACES. (Die Entwicklung von Gasreinigungsanlagen fuer Elektrostahloefen). Text in German. Giessereitechnik, 17(1):11-14 1971. (Presented at the Technische Staubbekaempfung, Leipzig, East Germany, Oct. 9-10, 1969.)

In the process of steel manufacture in an electric arc furnace, using the oxygen lance method of refining, a brown colored waste gas develops which contains a dust with iron oxide particles, most of which are well below 5 micron, down to 0.01 micron particle size A method and equipment for removal of the dust from these gases was developed in East Germany since 1958, using water sprays for purification. The waste gas exhaust piping is directly attached to the roof of the furnace, and leads to the purification station whic may serve two furnaces in turn. The gas, leaving the furnace at temperatures between 1100 and 1400 C, is cooled on its path through the long pipe line and by abundant addition of fresh air, down to 60 to 130 C. In a typical design, the purifier consists of vertically disposed large venturi pipes where the gas enters throug the top and passes downward through an intense water shower. The lower extensions of the venturi pipes reach into a water bath container through which the gas will pass, leaving behind the dust particles, and emerging into an exhaust funnel. The suction of the gas out of the furnace and its further circulation is affected by fans. The rate at which the gas leaves the furnace is automaticall controlled by a throttle device, to en-

sure that a constant underpressure of 0.5 to 1.0 mm water column is maintained in the furnace. The water bath of the purifier is arranged to permit pierodic sludge removal and addition of fresh water. A typical recently built purification installation, designed to take care of two 18 ton electric furnaces, is capable of purifying 40,000 cu m gas per hour.

29945

Riha, Karel

REMOVAL OF BROWN FUME FROM WASTE GASES OF OPEN HEARTH FURNACE OXYGEN STEELMAKING PROCESS. (Prispevek k cisteni spalin martinskych peci od hnedeho dymu pri intenzifikaci kyslikem). Text in Czech. Hutnicke Listy (Prague), 26(3):165-170, 1971. 12 refs.

Field trials were made on waste gas/dust collection and utilization in iron and steelworks. The dust clogs the off-take of the open-hearth furnace during the blowing of oxygen into the bath through roof lances. The dust can be collected, pelletized, and used directly as a refining agent in a steel plant.

30018

AIR FILTRATION SYSTEM FOR ELECTRIC FURNACE SWITCH GEAR AT LUKENS STEEL. Blast Furn. Steel Plant, 59(4):222, April 1971.

In order to achieve and maintain a clean atmosphere in two rooms of a steel plant that contain controls for three electric arc melt furnaces, high voltage mercury tube rectifiers, and de-gasser controls, revolving fiberglas filters were replaced by a system called Maxi-Filtration. This system involves bringing all the charging air for the room through a bag filter which utilizes a specially prepared two-part filter medium for high grade filtration. The system is operating with practically no maintenance or cleaning problem in the switch gear rooms.

30534

Oshima, Mamoru

NITROGEN OXIDES TREATMENT. (Chisso sankabutsu shori). Text in Japanese. Akushu no Kenkyu (Odor Research J. Japan), 1(4):55-62, March 1971.

Nitrogen oxides are more difficult to treat than other industrial waste gases. Because no one control method yields the required efficiency, it is necessary to combine methods or to proceed by stages. Treatment by ammonia or by ammonia and chloride are especially dependable methods. Nitrogen forms compounds with oxygen such as nitrous oxide, nitric oxide, nitrous anhydride, and nitrogen dioxide. Nitric oxide and NO2 are emitted from metal surface treatment factories, such as those which wash stainless steel with nitric acid, or eliminate scale from copper wire. It is impossible to eliminate NO and NO2 completely, although the following methods are now used: washing by water or alkali; venturi scrubbers; oxidation or reduction by catalyst; oxidation by chloride; ammonia gas treatment; the oxidized nitrogen, chlorine, and ammonia method; and oxidation by activated charcoal (catalyst). The ammonia gas treatment is relatively simple, with a high elimination rate. The oxidized nitrogen-chlorine-ammonia method requires a venturi scrubber and cottrel to eliminate the white smoke generated. Some acutal examples of treatment are shown including a metal refinery that uses the activated charcoal catalyst ammonia-chlorine method; a steel mill that uses the activated charcoal catalyst-oxidized ammonia method; and a company producing almite that has adopted an alkali washing-ammonia- chlorine pouring method. It is difficult to specify standardized design criteria elimination or costs. Total construction cost is estimated at $22,900 for a twin-tower system with 200 cu m/min capacity.

30583

Kuehnert, K.

STEAM PRODUCTION THROUGH WASTE HEAT UTILIZATION. (Dampferzeugung durch Abwaermeverwertung). Text in German. Tech. Mitt., 64(6):212-218, June. 1971.

Waste gases from heating furnaces and reactors frequently have temperatures which permit the economical production of steam. If the waste gases contain dusts, erosions might occur at an inadequate layout of the heating surfaces. A suitable gas speed must be found which is dependent on the type of dust, the grain size, and the arrangement of the heating surfaces. Practical experience has shown that at parallel flow a speed of eight m/sec is necessary to avoid erosion. Low-temperature corrosion can be avoided by limiting the heating surface temperatures to 400 to 450 C. Overheating of the steam is conducted in separate units. Steam production from waste heat become more economical as the temperature of the waste gas increases. Waste heat boilers can be economically operated in the metallurgical industry. The dust-laden gases from steel manufacturing must be cooled for cleaning; the heat, thus liberated, can be used for steam production. Other examples are the chemical and petrochemical industries.

31092

Shimada, Shoji, Kinichi Sugahara, and Yasumasu Sawamura

METHOD OF TURNING DUST FROM IRON AND STEEL MANUFACTURE INTO PELLETS IN WATER. (Seitetsu fujin no suichu zoryu ho). Text in Japanese (Japan Steel Co., Ltd.) Japan. Pat. Sho 46-2736. 4p., Jan. 23, 1971. (Appl. March 30, 1966, 1 claim).

Oxidized iron powder recovered from converter or open hearth furnaces by wet dust collectors is usually formed into pellets by the addition of large quantities of water and thickener, followed by the elimination of the water with filters. Mud produced in this manner contains about 50% water and is dried in the sun prior to processing. In the present invention, the trapped oxidized iron powder is mixed with bentonite or thermal plasticizing resin and high polymer coagulant. The mixture is then put into a rotating drum where the suspension forms pellet-like flocs. About 0.15% bentonite or thermal plasticizing resin is added to a suspension solution containing oxidized iron powder. After the solution is stirred to distribute the coagulant evenly, 0.01-0.1% of an organic high polymer such as acrylnitril acryl acid or polyacryl acid soluble salts, or their mixtues, is added. The mixture is stirred lightly to promote contact between the coagulant and oxidized iron powder. The suspended oxidized iron powder coagulates rapidly and the liquid is placed in a drum which rotates for 10-15 min at one m/min.

31195

Richard, Jablin

ENVIRONMENTAL CONTROL AT ALAN WOOD: TECHNICAL PROBLEMS, REGULATIONS AND NEW PROCESSES. Iron Steel Engr., 48(7):58-65, Ju 1971. 7 refs.

The environmental control program adopted by the Alan Wood Steel Co. is described. The program includes methods of controlling air and water pollution. A basic oxygen furnace was installed to replace nine open hearth furnaces. Pollution control, which is difficult in the open hearth, is easily incorporated into the new furnace. The blast furnace slag was pelletized to eliminate hydrogen sulfide emissions. Measures taken to reduce coke oven emissions include the provision of cleaning devices for the gas offtakes and various modifications and additions to the mechanism of the larry car. Air pollution control at the sinter plant comprises a proposed baghouse for

the discharge end of the machines and a scrubber for the windbox end. Generally, regulations and enforcement at the local level have been strict, but fair. Reasonableness in the application of the regulations and compromise between the company and the agencies are necessary. By 1975, the environmental problem will provide effective control of all current air and water pollution problems.

31226

PROBLEMS OF DUST, FUME, AND EFFLUENT CONTROL IN THE IRON AND STEEL INDUSTRY. J. Iron Steel Inst., vol. 209:25-26, 28-30, 32, 34, 36-43, June 1971.

In Great Britain, air pollution arising from the main iron and steel manufacturing processes, i.e., coking, ore preparation and sintering, ironmaking, steelmaking, and scarfing, is regulated under the Alkali and Works Regulation Act of 1906, although these processes have only been scheduled under that act since 1958. In common with many other industries, smoke emissions from the fuel-burning processes in the iron and steel industry have been dramatically reduced over the years. This is due in part to the more efficient use of the fuels, and perhaps to a greater extent to the change from solid fuel to oil or gas firing in many applications. While each individual process presents its own engineering and operational difficulties from the point of view of clean air, the biggest challenge of all has been the control of pollution from the oxygen steelmaking processes. The use of high-purity oxygen for the refining of steel gives rise to copious reddish-brown fumes of iron oxide. The particles entrained in the waste gases are extremely fine and very high efficiency cleaning equipment is required to prevent objectionable emissions. Cooling and conditioning of the gases prior to cleaning are critical. Only electrostatic precipitators, fabric filters, and high energy wet scrubbers have sufficiently high efficiencies to cope with the fume problem. Liquid effluents are also of great importance, as well as coke-oven effluent. Several of the major plant manufacturers are featured with an account of the equipment and services they provide for the iron and steel industry in the area of pollution control. Emissions include dust, fumes, carbon monoxide and dioxide, and sludge. Other control equipment mentioned include venturi scrubbers, dust collectors, multicyclones, bag filters, and electrostatic precipitators.

31316

Richardson, H. L.

CONTROL OF SULPHUR EMISSIONS IN AN INTEGRATED STEEL MILL. Iron Steel Engr., 48(7):76-78, July 1971.

The dwindling supply of low-sulfur coal and more rigid environmental standards present major problems in controlling gaseous sulfur emissions. The two chief sulfur gases discussed are hydrogen sulfide from coking operations and sulfur dioxide released from power boilers. The analysis was made per one ton of hot metal produced in the blast furnace. Although they do not exist in these exact quantities in any mill, assumed numerical values are assigned to standardize the analysis. The collection and removal of sulfurous contamination is technically feasible. Among the process considered are the dry removal system, the catalytic oxidation process, a combination wet-dry process utilizing injection of limestone, and an alkaline carbonate system. The summary indicate a need for a pilot plan study of these processes to establish the most desirable solution.

31344

Nishi, Saburo

DUST CONTROL MEASURES. (Funjin taisaku). Text in Japanese. Kinzoku Zairyo (Metals in Engineering), 11(6):12-18, June 1971.

Dust control measures for ironworks are discussed with special reference to the measures adopted by the Sumitomo Kashima ironworks which opened in February 1971. Sources of dust generation in ironworks include the pier where iron ores, material coal, and limestone, are unloaded from freighters; the yard where iron ores, material coal, limestone, cokes, and pellets are stockpiled; the belt conveyors carrying the materials to various pretreatment processes; the crushing and screening process; the process in which the materials are put into respective material tanks through the conveyors and hoppers; the sintering factory where mine fines are pelletized; the blast furnace; the converter section; the calcined lime furnace; the coke manufacturing factory. Dust control measures at the Kashima works include wet dust collectors for the material zone; a dry electric dust collector, multicyclones and a bag filter for the sintering zone; bag filters, a gravity- type collector, a venturi scrubber, and a wet electric dust collector for the blast furnace zone; quencher plus venturi scrubber and bag filters for the converter zone; dry electric dust collector and sealed conveyor for the limestone zone; wet dust collector and cyclone plus venturi scrubbers for the cokes zone; and a wet electric dust collector for the rolling zone. Based on a field investigation, the material zone needs more dust collectors if the desired level of dust removal is to be achieved. Dust removal in the sintering zone is excellent with the present dust collection facilities. All other zones, except the coke furnace, show generally satisfactory levels. Also noted are guidelines used in selecting the hoods, ducts, and blowers that will be incorporated in the dust-control facilities.

31362

Kawamara

MITSUBISHI-LURGI RADIAL FLOW SCRUBBER. (Mitsubishi-Rurugi shiki rajiaru furo sukuraba). Text in Japanese. Mitsubishi Juko Giho (Mitsubishi Heavy Ind. Tech. Rev.), 8(2):367-368, March 1971.

The radial flow scrubber of Mitsubishi-Lurgi Company (West Germany) was recently introduced to Japanese Steel and chemical industries. The structure, operating method, characteristics, and efficiency are briefly discussed. The system employs a high efficiency cleaning apparatus set in the casing, which automatically maintains effective gas cleaning, regardless of drastic changes in gas quantity. The venturi scrubber throat is made of two rings through which the gas passes at a high speed. Usually, dust and high speed create abrasion of rings, so a special abrasion-resistant cast iron is used for the rings. Minute water drops mix with gas in the rings and work as a cooling device. The radial flow scrubber combines the usual two cleaning parts by operating the first cleaning apparatus by low pressure loss and returning relatively high pressure gas to the furnace top. Since the second cleaning apparatus controls the pressure, septum valve is unnecessary. The two-level radial flow scrubber is useful not only for a high pressure blast furnace, but, by separating the first process for cleaning and the second process for cooling, as a high degree cooling system. In this case, the water waste from the second process can be used for cleaning water for the first process. The mixture of gas and water particles is so complete that it can be used for gas absorption up to 95%.

31486

Yokoi, Masao

MEASURES FOR DESULFURIZATION OF FLUE GAS. (Haien datsuryu taisaku). Text in Japanese. Kinzoku Zairyo (Metals in Engineering), 11(6):19-23, 28, June 1971.

The sintering furnace usually accounts for 50% or more of the sulfur dioxide emissions from an ironworks. Gas from the furnace is quite difficult to desulfurize because its volume is large, its dust content high, and its SO2 density low. Of potential desulfurizing processes for sintering furnaces, a special research committee of the Japan Iron and Steel Manufacturers Federation considered that of the Nippon Kokan Company the most promising method. The process is based on the effective utilization of ammonia obtained as a by-product from coke oven gas. In the process, which is described by a flow sheet, gas blown into an absorption column is scrubbed with seawater for removal of dust and partial removal of SO2. The latter is further removed by the ammonia water that is circulating in the system. Ammonia discharged to the gas as a result of scrubbing with wash water is absorbed by fresh wash water in the ammonia removal zone. The circulating ammonia water is formed by dissolving in industrial water coke-oven gas containing ammonia gas. Experimental desulfurization efficiency was satisfactorily stable for a wide range of SO2 density, provided the ammonia water was pH 8 or higher. However, the process discharges a large quantity of effluent which should be further treated for disposal. Another experimental study is now underway, designed primarily for disposal of the excess absorbent.

31589

Elliott, A. C. and A. J. Lafreniere

THE DESIGN AND OPERATION OF A WET ELECTROSTATIC PRECIPITATOR TO CONTROL BILLET SCARFING EMISSIONS. Preprint, Air Pollution Contr Assoc., Pittsburgh, Pa., 10p., 1971. (Presented at the Air Pollution Control Association, Annual Meeting, 64th, Atlantic City, N. J., June 27-July 2, 1971, Paper 71-159.)

The control of emissions generated from a scarfing machine used in steel production was described. A tubular type wet electrostatic precipitator was selected to collect the fumes. The choice of a pipe type over the plate type was made to insure adequate water distribution during the washing cycle. The precipitator installation consists of twin units in parallel designed to handle 70,000 cfm at dust loadings of 1.0 gr/cu ft and maximum temperature of 150 F. Actual operating conditions indicate a flow of 56,000 cfm and temperatures varying between 40 and 70 F. The equipment was described in detail. The precipitator consists of a group of 10 in. diameter collecting pipes and electrode wires, enclosed in two rectangular casings of steel plate. All the interior surfaces of the structure are epoxy coated, and internal parts are made of stainless steel. Voltage control is automatic. The washing system consists of eight stainless steel full cone patterns with internal movable vane nozzles located at the top operating floor level of the casing. The complete wash cycle is done between scarfs and takes approximately 42 sec to complete. It does not interfere with the scarfing operation.

31773

Hall, H. T.

FUMELESS DECARBURIZATION FOR STEELCASTING. Mod. Casting, 59(2):59, Feb. 1971.

As a rule, steelmakers employ oxygen lancing to promote a vigorous carbon boil to bring down high carbon, and this oxygen lancing emits copious brown fumes. By injecting powdered metal oxide directly into the liquid steel bath, a new process avoids this problem, and simultaneous decarburization and alloying can be carried out. Phosphorus removal is also possible, if powdered lime is mixed with the mill scale during injection. If required, chromium and manganese contents can also be reduced by promoting a low temperature boil.

31803

ENVIRONMENTAL FORECAST: INCREASED PRECIPITATION. Chem. Week, 109(7):77-78, 80, 82, Aug. 18, 1971. 1 ref.

In the past five years, the range of application of electrostatic precipitators has been extended from atmospheric pressure to as high as 825 psi and from temperatures below 900 F to 1700 F. Precipitators are also being designed to handle dust concentrations from 0.00001 grains/std cu ft to 156 grains/std cu ft and efficiencies over 99%. Coal-burning electric stations, the steel industry, the pulp and paper industry, and contact sulfuric acid plants continue to be important markets for electrostatic precipitators. Precipitators are also used in processing cement and gypsum. New or potential fields of application include Wulff acetylene production, removal of lube oil mist from gas pipelines, shale-oil processing, and coal gasification.

32037

Hazard, Herbert R.

INDUSTRIAL PROCESSING. In: The Federal R and D Plan for Air- Pollution Control by Combustion-Process Modification. Battelle Memorial Inst., Columbus, Ohio, Columbus Labs., APCO Contract CPA 22-69-147, Rept. APTD-0643, p. IV-1 to IV-22, Jan. 11, 1971. 5 refs. NTIS: PB 198066

Combustion for thermal processing in industry, which includes all uses of heat for processing, but does not include steam generation, power generation, or space heating, is discussed. The principal sources of pollutant emissions in thermal processing are: iron production, steel production, cement and lime production, glass melting, aluminum production, brick, tile, and ceramics production. Emissions that are large enough to warrant attention are combustible particulates, polynuclear aromatics, oxides of nitrogen, and sulfur oxides. Nitrogen oxides are formed by oxidation of the nitrogen in the fuel and in the combustion air, under conditions of high temperature in the presence of oxygen. Thus, formation of NOx can be minimized by minimizing flame temperature, burning under reducing conditions, and two-stage burning which achieves low flame temperatures and reducing conditions. Research and development approaches toward reduction of NOx through combustion modification are discussed.

32134

Hausknecht, E. G.

THE USE OF A GAS TURBINE IN WISCONSIN STEEL WORKS SINTERING PLANT AIR POLLUTION CONTROL INSTALLATION. Preprint, 7p., Nov. 30, 1970

Two induced draft fans, used to draw gases through an electrostatic precipitator are powered by 100 hp gas turbines. Approximately 75 to 100 tons/day of flue dust, with an iron content of about 60% is collected from the precipitator and transported to the sintering plant. A new waste gas cleaning system was installed in series with the dust collecting system. This system was designed to limit the particulate matter of the stack discharge to 0.02 grains/standard cu of gas. A 180 deg bend was installed in the old stack. The gases then pass downward through a venturi section equipped with water

sprays and into the bottom of a moisture eliminator. The gases are drawn to the top of the eliminator by a fan, powered by another 100 hp gas turbine, and are discharged to a new stack. Initial installation cost and operating cost influenced the use of a gas turbine.

32791

Yamaguchi, Takekazu

ON OG EQUIPMENT. (OG sochi ni tsuite). Text in Japanese. Kankyo Sozo (Environ. Creation), 1(1):27-34, Aug. 1971.

In 1970, 80% of the 93 million tons of steel produced in Japan was made by a converter method, in place of open hearth techniques. However, pure oxygen blowing systems generate 100-150 g/N cu m oxidized iron dust and large amounts of carbon monoxide. Many of the converters utilize a non-combustion type of dust disposal equipment. The OG equipment is characterized by the fact that the dust is easy to collect while there is not much gas to be disposed of. With the OG tower, 100-150 g/N cu m of dust can be reduced to .100 g/N cu m. Smoke is made colorless and the sulfur dioxide is reduced. Several pilot plants have been operated, and the OG system is now being used in industry. The OG system consists of a venturi scrubber, an elbow separator, a cyclone separator, a quencher, and a bag filter.

32817

Atsukawa, Masumi, Kazumi Kamei, Naoharu Shinoda, and Tadami Eito

DEVELOPMENT OF DESULFURIZATION EQUIPMENT OF STACK GAS BY WET PROCESSES AND ITS PROBLEMS. (Shisshiki haien datsuryu sochi no kaihatsu to mondaiten). Text in Japanese. Netsu Kanri (Heat Management: Energy and Pollution Control), 23(8):9-24, Aug. 1971.

Environmental standards set in 1969 determined that the sulfur content of fuels used in overcrowded areas must be less than 1%, and by 1978, 0.55%. In 1973, 43.4 million kl of heavy oil will be desulfurized, equivalent to 1.7 million kl of desulfurized stack gases. The energy demand in terms of oil will be 438.5 million kl in 1975 and 933.3-1028.9 million kl in 1985. Sources of sulfur dioxide emissions included heavy oil burning facilities, sintering processes in iron and steel making, non-ferrous metal smelting, sulfuric acid plants, and pulp plants. The volume of SO2 produced would be equal to 10 times the 1.7 million kl of heavy oil. Various desulfurization processes are reviewed with respect to volume capacity, secondary pollution, treatment of by-products, and interference with plant operations. The wet-type desulfurization process which is examined consists of repeated cooling of gases, spray towers, elimination of carbon dust, and various scrubbers. Ammonia, lime, red mud, and oxidized manganese were used as absorbing liquids.

32848

Watanabe, Tamotsu

DUST COLLECTING SYSTEM USING STATIC. (Seidenki riyo no shujin sisutemu). Text in Japanese. Preprint, Reutilization of Resources Technical Assoc. (Japan), 12p., 1971. (Presented at the Seminar on Reutilization of Resources Technology, 2nd, Japan, July 12-14, 1971, Paper 9.)

A new type of electrostatic dust collection system was devised in order to eliminate dust from railway tunnels. The tunnel itself can be treated as an electrode, and the principle can be applied to foundry, cement, iron, and steel plant operations. In order to protect the workers when drills and explosives are in use, the new system employs an electric charge to keep air in the tunnel as clean as in office building. Smoke produced by open burning can also be eliminated. Disadvantages of previous equipment were that they sucked in unnecessary air, thus requiring the equipment to be large. Advantages of electrostatic dust collection systems include easy maintenance, a small electricity requirement, gases can have high temperatures, and a wide range of dusts can be eliminated.

33040

Svidrnoch, Ladislav

EVALUATION OF PERFORMANCE OF DUST SEPARATOR ATTACHED TO AGGLOMERATOR. (Vyhodnoceni funkce odlucovaciho zarizeni za aglomeracnim pasem). Text in Czech. Hutnik (Prague), 16(4):160-164, 1966.

Experiences with operation and performance of a dry dust separator, a multi-cyclone, attached to agglomerator in an agglomerating plant in Rudnany, Czechoslovakia, are surveyed. The measurements were carried out which included determination of output and efficiency of dust separator, initial and final concentration of dust in flue gases, their temperature and chemical composition, and the chemical and granulometric composition of dust. Some problems connected with dedusting of agglomerating equipment in Czechoslovakia are considered. Possibilities of improvement of the performance of agglomerator are discussed and future development in their design outlined.

33081

Morcinek, P. and L. Svidrnoch

CLEANING FLUE GASES FROM A 75-TON TANDEM FURNACE IN THE KLEMENT GOTTWALD STEELWORKS (VZKG). Hutnik (Prague), 18(12):540-544, 1968. 5 refs. Translated from Czech. British Iron and Steel Industry Translation Service, London (England), 14p., Jan. 1970.

The design, performance, and operating costs of a wet gas cleaning plant for removal of dust, ferric oxides, and other impurities are described. In the cleaning plant, gases first pass through a foam cooler, where they are cooled to 120 C. Condensation nuclei are formed, and a part of the dust is separated. The gases, entirely saturated with water vapor, then pass into a venturi washer, where their cleaning is completed. Under favorable conditions of sediment concentration in water and specific water rate, the foam cooler separates up to 58.5% of the whole dust load entering the plant. Under the same conditions, the efficiency of the venturi washer is 40.5%. The gas cleaning plant will be constructed as an integral part of two 75-ton open hearth furnaces and a 30-ton electric arc furnace. Operating costs of the system as related to steel production, are estimated with and without water and sludge service. With increasing utilization of dust, the costs could be reduced.

33168

Bramer, Henry C.

POLLUTION CONTROL IN THE STEEL INDUSTRY. Environ. Sci. Technol., 5(10):1004-1008, Oct. 1971. 6 refs.

All iron and steel manufacturing operations produce waste water effluents, atmospheric emissions, and solid wastes, but the quantities and characteristics from each source vary greatly. A medium-sized mill may discharge 100 million gallons of water per day. Atmospheric emissions and solid waste generation are of similar magnitude; for example, a blast furnace may use air at the rate of more than 100,000 cu ft/min and produce slag in excess of 1000 tons/day. Principal air pollution problems from coke production are sulfur dioxide generation from combustion of coke oven gas, emissions from

ovens during charging and from door and lid leaks, and emissions from waste water quenching of the incandescent coke. Abatement measures include removing hydrogen sulfide from the gas, oven lid and door maintenance, baffling quench towers, using clean water for quenching, and regulating coking times. Other methods under development include negative oven pressures during charging, larry car scrubbers, hood arrangements with collection ducts and gas cleaning equipment, and stack gas cleaning of sulfur dioxide. Principal water pollution potentials in the coke plant operation are in ammonia still wastes and light oil decanter wastes which average about 44 gal/ton of coal carbonized and contain phenols, ammonia, cyanides, chlorides, and sulfur compounds. Abatement measures include biological treatment either on site or by cotreatment with municipal sewage, chemical oxidation, and carbon adsorption. Pollutants and abatement measures are also indicated for blast furnace operations, steelmaking processes, rolling mill operations, and finishing operations. Conservation and reuse practices are discussed.

33170

Gerber, Rheinhold B.

MODERN ELECTROFILTER TECHNOLOGY AND APPLICATION. (Indirizzi attuali della tecnologia nel campo della depolverazione elettrostatica ed applicazioni). Text in Italian. Termotecnica (Milan), 25(6):321-331, 1971.

The main features of modern electrostatic precipitator are reviewed. The demand for increasingly efficient dust removers has led to the construction of some great electrostatic precipitators. Thus, a precipitator built in the U.S.A. is capable of treating three to four million cu m of gas/hr. During the past 10 years, a total of 335 electrostatic precipitators, having a surface of 2,115 millions sq m capable of treating a cumulative amount of 161.4 million cu m of gas/hr have been built by the coal, cement, steel, and other industries. The main problem encountered in the functioning of an electrostatic precipitator is the back-discharge phenomenon (and subsequent blocking of the precipitator) caused by high resistivity dusts. Humidity, temperature, dust concentration and aggregation, the presence of soluble sulfates, carbon, and alkali in the gas, rate of passage of the gas through the filter, dust particle size and the design of the precipitator itself greatly affect its efficiency. The main methods used for designing electrostatic precipitators are Deutsch s equation and Anderson s formula (especially in the United States). Both methods have been modified repeatedly in order to include many of the parameters which affect the functioning of an electrofilter.

33401

Yokoi, Masao

EXHAUST GAS DESULFURIZATION IN IRON MANUFACTURER. (Kotetsugyo ni okeru haien datsuryu). Text in Japanese. Ryusan (J. Sulphuric Acid Assoc., Japan), 24(5):11-19, May 1971.

The absorption of sintering exhaust gas was studied at the Kanagawa Prefectural Industrial Test Station. The gas absorption apparatus was designed to capacitate 3000 N cu m/hr. Exhaust gas from a sintering plant was taken through a flue and led to a dust collector. After dust particulates were trapped by a small amount of water, humidity was eliminated by an ordinary mist separator. The fan sucked in the gas and sent it to the absorption tower. The absorbent was either ordinary industrial water or ammonia water produced by a coke furnace. When using industrial water, the water temperature was high at 34 C; although solubility of SO2 was small, as much as 90-95% was absorbed. When using ammonia water, regardless of the conditions, the desulfurization rate was extremely good, achieving 98% or more at all times. Industrial water was 60 t/hr; temperature, 33-35 C; pH, 7.2-7.4; ammonia water, 30 t/hr; temperature, 36-41 C; pH 8.4-8.6; and the concentration of SO2 at the entrance, 1,400-2,000 ppm. An intermediary size test system was constructed in the Oshima area for Japan Kokan (Steel Pipe) Co., and desulfurization tests were carried out between January and December 1969. A long run operation was started this year in order to test the endurance and deterioration of the material. The SO2 concentration at the absorption emission exit is 40 - 80 ppm at all times, testifying to the efficiency of the apparatus. The capacity of the apparatus is 30,000 N cu m/hr gas treatment; size, 4.6 by 4.6 by 12.0 mH; gas blower capacity, 50,000 N cu m/hr; the capacity of the ammonia and sea water circulation tanks, 23 cu m each; ammonia water circulation pump capacity, 200 cu m/hr, and the capacity of the sea water circulation pump, 150 cu m/hr.

33416

Noda, Hiroshi and Shigeo Asano

DRIVE MECHANISM OF AIR BLOWER FOR DUST COLLECTOR. (Shujin yo sofuki no kudo sochi). Text in Japanese. (Daido Seiko K. K. (Japan)) Japan. Pat. Sho 46-24545. 2p., Aug. 24, 1972. (Appl. Nov. 13, 1968, claims not given).

The capacity of an air blower incorporated in a dust collector is usually determined by the maximum volume of gas handled. To reduce operating costs, blower suction volume is reduced when exhaust gas volume is below the maximum. This adjustment in suction volume is usually achieved with a damper system or by controlling blower rpm. A new blower-drive mechanism features two electric motors with different poles. The motors are connected in series, one being the main motor with larger output and the other the auxiliary motor with smaller capacity. The main motor is operated when gas volume is large and the auxiliary motor when volume is low. The two-motor system is used most advantageously with dust collectors for steelmaking arc furnaces, where gas emission fluctuates drastically and can generally be classified into two volume levels. An air blower with a 4-p 170-kw main motor and a 6-p 75-kw auxiliary motor will reduce the annual operating cost for an arc-furnace dust collector with a capacity of 1200 cu m/mm substantially below that of the damper (vane controller) and rpm control systems. Electric power costs are estimated to be $5208.00 for the two-motor system; $7112.00 for the damper system, and $6132.00 for the rpm control system.

33438

Zdenek, Zdenko

PURIFICATION OF CONVERTOR FLUE GASES IN AN OXYGEN STEEL WORKS OF EAST SLOVAKIAN IRON WORKS IN KOSICE. (Cisteni konvertorovych spalin v kyslikove ocelarne VSZ Kosice). Text in Czech. Hutnik (Prague), no. 8:373-375, 1968. 8 refs.

The purification of dust from convertor gases is described which is based on combustion of convertor gases and cooling of flue gases followed by the purification of dust in two stages. Detailed description of the design of the gas purification equipment is given and technical data are presented. The two-stage purification of dust consists of a dust chamber or stabilizer, where larger particles are separated, and of an electrofilter for fine particle purification. The properties of the collected convertor dust were analyzed. Both chemical and granulometric composition varied depending on where the sample was collected. The average composition of the dust was 65-75% ferric oxide, 15-19% ferrous oxide, 1.2-2.2% manganese oxide, and five to six percent calcium oxide. Magnetic com-

ponents formed 89-94%. Average granulometric composition of the dust was determined. The fraction 0.01-0.04 mm was the largest (38%). About 10-12 kg dust is formed per ton of steel. The problem of its liquidation has not been satisfactorily solved so far. Possibilities of dust processing into brickets or its recycling into a convertor are mentioned.

33548

Brough, John R. and William A. Carter

AIR POLLUTION CONTROL OF AN ELECTRIC FURNACE STEELMAKING SHOP. Preprint, Air Pollution Control Assoc., Pittsburgh, Pa., 31p., 1971. 4 refs. (Presented at the Air Pollution Control Association, Annual Meeting, 64th, Atlantic City, N. J., 1971, Paper 71-158.)

The selection of dust collection equipment was explained. General shop production requirements were established at 100 tons of steel/hr. A conventional swing roof furnace design was selected for the pair of furnaces in the shop. The concept of total emissions control was adopted as the goal. Fume collection methods were studied, and a double collection system was chosen. Roof truss hoods were installed to control all general emissions to the shop atmosphere. The hoods are located directly over each furnace, above the service crane travel area. Each hood is partitioned into three sections to permit localized concentration of the draft over a particular fume generating area. The second collecting method is by direct evacuation from the furnace shell through a water-cooled duct system. The hot furnace gas in the ducts is cooled by mixing with ambient shop air. Gases from the hoods and the dust are mixed together and drawn into large induced draft fans. The fans blow the gases into a baghouse where the dust is filtered out, and the cleaned gases escape to the atmosphere. Temperature of the gases entering the baghouse is closely controlled by regulating the amount of ambient air admitted through the roof truss hoods and the air valves along the ducts. An emergency bypass stack protects the baghouse from system control failure. Dust is processed in a rotating drum where it is mixed with just enough water to cause it to agglomerate into pellets. The pellets are used for landfill. The quantity of dust collected averages about 30 lb/ton steel. Emissions from the shop are negligible and the environment within the building is quite good. (Author abstract modified)

33897

Braginets, N. G.

REDUCTION OF ATMOSPHERIC DUSTINESS. (Snizheniye zapylennosti vozdushnogo basseyna). Text in Russian. Metallurg, no. 11-12:40-41, 1969.

Some improvements in the purification of flue gases in converter production of steel are discussed. The gas purifier TTsP was provided with 18 venturi pipes which were wetted by jets. Two blade separators followed the pipes. Using venturi pipes of a larger diameter than 221 mm stabilized the process of gas purification during the converter operation. Flue gases from open hearth furnaces (remaining dustiness was 100-150 mg/cu m) was achieved by combination of wet gas purifiers, a small number of venturi pipes with cyclones, and scrubbers with a 4400 mm diameter. The addition of 40% lime and fluorite to the cast iron scrap decreased the amount of dust carried away by convection.

33918

Okumura, Eijiro and Hiroyasu Matsumoto

DESIGN OF FLOATING SCRUBBER AND TURBULENT ABSORBER. (Shisshiki shujin oyobi gasu kyushu sochi no sekkei - Furotingu sukurabba, taburento abusoba ni tsuite). Text in Japanese. Kagaku Sochi (Plant and Process), 9(10):11-22, Oct. 1967. 4 refs.

The Floating Scrubber (FBWS), wet type dust collection device, and the Turbulent Absorber (TCA), a gas absorption device, were discussed including their basic mechanisms, construction, and design theories. Practical applications include dust removal in iron manufacturing plants; dust removal, sulfur dioxide recovery, and gas absorption in pulp factories; dust removal in steel manufacturing dust removal in sulfuric acid manufacturing plants; absorption of SO2 from waste gas in H2SO4 manufacturing plants; recovery of fluoride compounds from waste gas phosphoric acid manufacturing industry and from waste gas in aluminum manufacturing industry. Both the FBWS and TCA are scrubber columns filled with lightweight plastic balls between two grids. The washing liquid is sprayed through a nozzle from above and the gas to be treated is fed in from below; the gas causes a violent turbulent motion as it ascends to contact the wash liquid. Since the gas-liquid contact system occurs in the space between the two grids, the balls contact the media, float with the gas and liquid. Since the gas-liquid contact system occurs in the space between the two grids, the balls contact the media, float with the gas and liquid, revolve, and hit each other, thus causing stirring. This keeps the surface of the balls clean so that a new liquid film can form. Also, the area of contact between the gas and the liquid is enlarged for effective dust collection and gas absorption. The constant stirring keeps the grid meshes free from viscous or other substances formed by the absorption reaction. This is known as self-cleaning. Both FBWS and TAC are patented to UPO of the U.S.A. and feature no clogging, even with viscous substances; low pressure loss compared with its high gas velocity; higher contact effect resulting in higher efficiency; and stable and long-life performance.

33952

Vacek, A. and A. Schertler

WASTE-GAS CLEANING SYSTEMS AT OXYGEN STEEL PLANTS. Iron Steel Inst., London, Spec. Rept., no. 61:82-89, 1958. (Presented at the Iron and Steel Institute, Air Pollution Meeting, London, England, Sept. 25-26, 1957.)

The L. D. oxygen steelmaking process consists of oxygen blown through a tuyere onto the surface of the hot metal in a refractory-lined vessel. Outgoing reaction gases continue to burn in the flue at temperatures up to 3632 F. Current types of gas-cleaning systems, however, will only tolerate a maximum gas temperature of about 392 F. The difficult problem of cooling the waste gases was solved when a fume-cleaning system was combined with a waste-heat boiler system. Preliminary work is described, as well as trials with chemical dust collection, soft water, Theisen disintegrators, Baum venturi scrubbers, and the Waagner Biro wet cleaning system. The latter system, comprises an eddy-type washer with direct and counter gas flow. An electrostatic precipitator is connected to the system. Dry cleaning systems which were tested included slag-wool filters, coke filters, electromagnetic filters, and electrostatic filters. The waste-heat boiler and the Lurgi electrostatic precipitator system are described, as well as processes in use elsewhere.

34071

Hashimoto, Haruhiko

ON TECHNOLOGY OF UTILIZATION OF DUST FROM STEEL MAKING. (Sangyo haikibutsu dearu seiko enjin no shigenka gijutsu ni tsuite). Text in Japanese. Preprint, Reutilization of Resources Technical Assoc. (Japan), 5p., 1971.

(Presented at the Seminar on Reutilization of Resources Technology, 2nd, Japan, July 12-14, 1971.)

A process is described which uses the dust from the production of steel for the smelting of zinc and lead. The dust collected from open hearth or electric furnaces is too fine for reclamation and, if not handled properly, may be the cause of secondary pollution. It contains too many other metals to be suitable for a raw material in the production of steel or nonferrous metals. However, taking advantage of the fact that most of the valuable metals in the dust are oxides and, utilizing the difference in pressure of these metals, zinc and lead have been successfully recovered to avoid secondary pollution. The dust is pelletized, and the appropriate amount of reaction controlling reagent and coking coal are mixed before being charged into a rotating kiln. Foreign bodies such as scrap iron and fire-proof refractory materials should be eliminated from the dust before processing it. A special method is described to eliminate the accretion of materials in the rotating kiln to improve its operating efficiency.

34079

Brooks, S. H. and W. J. Calvert

EXTERNAL POLLUTION FROM AN IRON AND STEELWORKS AND MEASURES TOWARDS ITS REDUCTION. Iron Steel Inst., London, Spec. Rept., no. 61:5-15, 1958. 17 refs. (Presented at the Iron and Steel Institute, Air Pollution Meeting, London, England, Sept. 25-26, 1957.)

Emissions from iron and steelworks are examined with respect to specific sources, control methods, and annual costs. Cokemaking, ore preparation, ironmaking, steelmaking, reheating and heat treatment, boilers, locomotives, and steam cranes, along with their various individual processes, emit smokes, dusts, hydrogen sulfide, sulfur in stack gases, iron oxide fumes, sulfur oxides, and grit. The control measures already in use or proposed for future installation included process and constructional modifications, the dry coke quenching technique, cyclone separators, cooling, drying, secondary cleaners (bag filters and electrostatic precipitators), settling chambers, high stacks, venturi scrubbers, continuous slag-wool filters, fuel desulfurization, and monitoring techniques. Data on emissions correlated to source, amount, control method, annual cost, and efficiency are included.

34082

Granville, R. A.

THE CAPITAL COSTS OF SOME WASTE-GAS CLEANING PLANTS FOR USE IN IRON AND STEELWORKS. Iron Steel Inst., London, Spec. Rept., no. 61:23-30, 1958. 11 refs. (Presented at the Iron and Steel Institute, Air Pollution Meeting, London, England, Sept. 25-26, 1957.)

The capital costs of control methods for emissions from various equipment and processes in iron and steel works are examined. The sources of emissions included the open-hearth furnace, emitting iron oxide fumes, scale and slag particles, and waste gases containing sulfur oxides; the sinter plant, emitting sulfur oxides and dust; electric arc furnaces; deseamers; pulverized fuel fired furnaces; crushing, grinding, and sieving plants emitting dusts. Dry and wet electrostatic precipitators, automatic fabric filters, and wet scrubbers were analyzed as controls with respect to inlet gas temperature and pressure, dust concentration, efficiency, plant capacity, and approximate costs.

34084

Septier, Louis G.

A PILOT PLANT FOR THE REMOVAL OF IRON-OXIDE DUST FROM THE FUMES ARISING IN THE PRE-REFINING OF IRON WITH OXYGEN. Iron Steel Inst London, Spec. Rept., no. 61:74-81, 1958. (Presented at the Iron and Steel Institute, Air Pollution Meeting, London, England, Sept. 25-26, 1957.)

For the ladle refining of iron, particularly when using oxygen for pre-refining iron and steel, a pilot plant was developed for the precipitation of iron oxide particles, which would be troublesome if discharged into steelwork sheds or the atmosphere. The pilot plant for dust removal consists of a dry and wet cleaner in series, the essential features of the latter being a venturi scrubber. The largest particles are collected and the fumes are cooled during the preliminary dry purification. The purifier is composed of 49 cells of honeycomb form; each compartment has a vane at the entrance, giving a centrifugal motion to the thin streams of gas. In addition to the venturi, the wet purification utilizes a washing tower and a cyclone. Measurement of concentrations of solid particles in the fumes presents a difficult problem on account of the high temperature, and has made it necessary to devise a special apparatus.

C. MEASUREMENT METHODS

10461

Antipin, V. G.

DUST FORMATION IN THE MELTING CHAMBER OF LARGE-CAPACITY OPEN- HEARTH FURNACES. Izv. Vysshikh Uchehn. Zarecknii Chernaya Met., No. 2:39-44, Feb. 1961. 6 refs. Translated from Russ- ian. Henry Brutcher Technical Translations, Altadena, Calif. HB-5150, 9p., 1961. Available from Henry Brutcher Technical Translations, Altadena, Calif.

A rapid, portable measurement instrument has been developed for determing the amount of dust in waste gases from open hearth fur- naces. The method is based on turbidity measurements of glycerin after bubbling through it a measured volume of stack gas. Samples may be crawn and the dust content determined in three minutes. The old method, employing filters, required more than three hours per determination. Data are presented on the variations in quan- tity and composition of dust given off during an iron production heat. The effect of fuel and mode of its combustion on the dust load is established for the open hearth furnace.

14774

Maatsch, Jurgen, Horst Achterfeld, and Hartmut Kamphaus

METHOD OF AN APPARATUS FOR THE AUTOMATIC OBSERVATION AND REGENERATION OF DEVICES FOR THE SAMPLING OF WASTE GASES. (Beteiligungs- und Patentverwaltungs G.m.b.H., Essen, Germany) U. S. Pat. 3,457,787. 5 p., July 29, 1969. 6 refs. (Appl. Aug. 2, 1966, 22 claims).

A method is described for sampling dust-containing gas from an oxygen-blowing steel production process where the sampler includes a conduit leading from the process, a filter in the conduit, and analyzers for determining the composition of the sampled gas. The steps in the method comprise feeding a gas sample stream through the conduit; sensing the flow condition of the gas through the conduit; adjusting the feeding of sample gas to maintain a substantially constant rate; observing the state of charge of the filter by detecting variations in the flow conditions; and regenerating the filter by passing pressurized gas through the filter in a reverse direction when the state of charge of the filter exceeds a predetermined value.

15940

Wakamatsu, Shigeo

DETERMINATION OF ZINC IN STEELMAKING DUST. (Seikoro dasuto chu no aen no teiryo). Text in Japanese. Tetsu to Hagane, 54(7):787- 795, June 1968. 45 refs.

A simple chelatometric titration method was developed for the determination of zinc in dust generated by steel-making processes. Zinc forms a negatively charged chloride complex which is adsorbed by the strongly basic anion exchange resion. Maximum adsorption of zinc is obtained in 2N HCL. In this medium, most elements with which zinc is associated in dust are not adsorbed by the resin. Therefore, it is possible to separate zinc from iron, aluminum, manganese, calcium, magnesium, chromium, and nickel. Zinc is then eluted from the resin with 0.3N HN03 and titrated with EDTA, with EBT used as the indicator. A subsequent titration procedure obviates interference from adsorbed iron, copper, tin, lead, or arsenic. While having the same accuracy as gravimetric methods, the proposed method has the advantage of speed. (Author abstract modified)

17425

Carney, D. J., A. J. Deacon, and T. L. Batina

CONTINUOUS ANALYSIS OF IRON BLAST FURNACE TOP GAS. American Inst. of Mining, Metallurgical and Petroleum Engineers (AIME), New York, N. Y., Proc. Am. Inst. Mining Met. Petrol. Engrs. Conf. Blast Furnace, Materials 1954, vol. 13:142-157. 7 refs.

Variations in blast furnace top gas composition were determined with a continuous gas analyzer installed on two modern 28-ft hearth furnaces; an attempt was made to correlate the variations with blast furnace operation. In the three-year study, blast furnace operating data were obtained from blast furnace records and were averaged daily. Gas samples were withdrawn periodically at the analyzer and their composition was determined by the Orsat method. The average carbon monixide content varied from 20 to 24%; carbon dioxide, from 12 to 17%; and hydrogen, from 1.2 to 3.0%. One of the few direct relationships observed was the correlation of iron-production rate with top gas composition. Production was greater when the CO/CO2 ratio was low (1.5 to 1.7) than when the ratio was high (2.0 to 2.2). A direct relationship between moisture in the blast and hydrogen in the top gas was also obtained for from 1 to 12.5 grains of moisture per cu ft of blast. Top gas composition calculated by a modification of the Joseph technique agreed reasonably well with actual measured composition.

20434

Foumenteze, J. L.

DIFFICULTIES OF GAS SAMPLING FOR ITS CONTINUOUS ANALYSIS. (Les difficultes de la prise de gaz en vue de son analyse continue). Text in French. Rev. Met. (Paris), 64(1):61-71, Jan. 1967. 6 refs. (Presented at the Journee des Mesures en Siderurgie, l'Association Technique de la Siderurgie, March 3, 1966, Paris.)

The present needs of the steel industry for continuous analyses of the composition of gas originating in blast-, coke-, or iron-ore agglomerating furnaces, gas generators, and the like are considered. Three types of continuous analysis are presented: one involves merely a continuous sampling of these gases and their chemical analysis by traditional methods or those made by an Orsat apparatus; one involves continuous sampling and the use of automatic recording analyzers providing current information regarding the process to a human operator in control of the process; one involves continuous sampling, automatic analysis, and automatic control without the intervention of a human operator. In every individual case, the design of the sampling equipment and procedure depends on the nature of the gases to be analyzed and on the peculiarities and scope of their analysis. Three sources of error are

described: faulty sampling locations; malfunctioning of the sampling equipment due to coarse or fine dust, water or water vapor, high temperature of the sampled gases; and improper handling of the gas samples. The need for utilization of pertinent theoretical knowledge is stressed and, as well as the need for full and honest collaboration between user and maker of continuous sampling equipment in all stages of its design and installation.

22934

Flux, J. H., D. J. Smithson, and R. N. Smithson

SIMPLIFIED DUST SAMPLING APPARATUS FOR USE IN IRON- AND STEELWORKS. J. Iron Steel Inst. (London), vol. 206, part 12: 1188-1193, Dec. 1968. 7 refs.

The development of a simple but reliable probe which operates within a gas duct or stack is described. Although designed to meet the specialized requirements of iron- and steelworks, the equipment and techniques could find applications in other industries. The entire apparatus, which is schematically illustrated, can be passed through a two-in. bore valve and the probe fitted with a sleeve to screw into a standard piece of pipe. When not required for sampling, the pipe is plugged to ensure that the sampling point remains gas tight. The sampling of dust and fumes in gases is divided into four basic states: gas velocity and temperature measurements; dust loading determination; particle size analysis; and particle shape analysis. The dust loading measurements are required to obtain an assessment of the weight of solid to be collected by the proposed gas cleaning plant. Particle shape and size analyses are essential to ensure that the correct type of unit is employed. Velocity measurements are made with pitot tubes, while the temperature of the gas is measured by an appropriate thermocouple and galvanometer. Gas volumes are recorded by a Rotameter and stopwatch, except when fluctuations in flow are experienced. Then a dry gasmeter is used to integrate the total flow. Dust load is determined in a long straight section of pipe upstream and downstream. Particle size is analyzed with the Alpine jet sieve (for sizes down to 20 micron m) or the Coulter counter (for the range 1-50 microns m). Particle shape is examined with an electron microscope.

33045

Triplett, Gary

ESTIMATION OF PLANT EMISSIONS. Preprint, p. 15-27. 1970 (?). 21 refs.

There are times when it is not possible or practical to determine emission rates by stack sampling; in these cases emission rates may be estimated by utilizing available emission factors. An emission factor is the statistical average of the mass of contaminants emitted/unit quantity of material handled, processed, or burned. The emission factor may also be expressed as the quantity of contaminant/unit quantity of final product or effluent volume. These factors have been developed through stack testing or by material balance calculations. Emission factors are normally given in terms of uncontrolled emissions. Therefore, the type and effectiveness of control equipment must be considered when calculating emissions from controlled sources. Particle size distribution and effective stack height should also be considered. Emission factors are given for coal, fuel oil, natural gas, and wood burning; solid waste disposal; incinerators; paint manufacturing; the food and agriculture industry; primary metallurgical processing including iron and steel manufacturing, open hearth furnaces, basic oxygen furnaces, electrical arc furnaces, and blast furnaces; smelting and foundries for aluminum, brass, lead magnesium, steel, and zinc; mineral processing of asphalt, calcium carbide, cement, concrete, glass and lime; petroleum production, and the kraft pulp industry. (Author abstract modified)

33953

Jackson, R. and R. A. Granville

MEASUREMENT OF DUST IN FLUE GAS. Iron Steel Inst., London, Spec. Rept., no. 61:119-128, 1958. 7 refs. (Presented at the Iron and Steel Institute, Air Pollution Meeting, London, England, Sept. 25-26, 1957.)

Principles of dust sampling are reviewed, and the design of sampling equipment is discussed. The primary object in most dust measurements is to determine the amount of dust passing through a selected cross-sectional area of a duct. The equipment consists of a probe tube carrying, at the sampling end, a small high-efficiency cyclone with a removable dust hopper. Many of the iron and steelmaking processes, particularly those involving the use of oxygen, generate an iron oxide fume which is carried out of the system in a stream of hot gas. Since these particles of fume are mainly submicron in size and cannot be collected by a cyclone sampler, equipment has therefore been designed which will permit rapid isokinetic fume sampling in hot corrosive gases. Dust measurements of emissions from batch-type and continuous sinter plants are described, as well as from producer-gas cleaners and open-hearth furnaces. Results from field tests are presented. Dust samples collected in various tests were sized by sieving down to 53 microns.

D. AIR QUALITY MEASUREMENTS

00038

J. Cholak, L.J. Shaffer, D. Yeager

AIR POLLUTION NEAR AN IRON SLAG PROCESSING PLANT. Am. Ind. Hyg. Assoc. Quart., 15(3):220-225, Sept. 1954.

The plant involved in this investigation made a serious effort to reduce the emissions of dust, but when complaints continued to be received, a survey was made to appraise the conditions in the area. The survey is of interest because it illustrates some of the procedures and equipment useful in the investigation of problems of this type. All of the evidence indicated that the contribution of the plant to the pollution of the area, as measured by the quantities of settled dust and by the quantities of matter suspended in the atmosphere, was considerable, although, the total pollution was not excessive as compared to that of other industrial cities.

05145

J. L. Sullivan

THE NATURE AND EXTENT OF POLLUTION BY METALLURGICAL INDUSTRIES IN PORT KEMBLA (PART I OF AIR POLLUTION BY METALLURGICAL INDUSTRIES). Australia Dept. of Public Health, Sydney, Division of Occupational Health. 1962. 62 pp.

Air pollution was surveyed in a metallurgical town, Port Kemble, located on the coast of Australia. Iron and copper ores are smelted and the major emissions consist of solid particulates and sulphur dioxide gas. The presence of the latter is most noticeable in the wake of the plume of the stack of the copper smelter during the north-east winds which prevail in summer. In winter the prevailing winds cause industrial pollution to be blown seawards. Tests for sulphur dioxide were made by daily volumetric sampling instruments and a Thomas automatic recorder. The section of the town most severely affected consisted of a swathe of about 200 yards wide and extending to a point where habitation ceased about 0.6 mile from the 200 feet high stack of the copper smelter. Daily readings of the gas were not spectacular and the highest result was 0.62 part per million. During a little more than three years 24 hour readings of 0.2 part per million or more were measured on 39 days. However, a different picture was obtained from the continuous recorder. This showed that high concentrations of sulphur dioxide tended to occur in episodes of a few hours each. Peaks of greater concentration than 5 parts per million were recorded on numerous occasions and the maximum for the sampling period was 13.5 parts per million at a point 0.45 mile from the source. Complaints of respiratory distress were made frequently and most householders had ceased to try to grow vegetables. Dust-fall rates measured as water insoluble solids by a deposit gauge consisting of a six inch diameter conical glass funnel and bottle were high by normal standards. Average annual rates varied between 17.9 and 86.1 tons per square mile per month. In some locations within a half mile from the edge of the steel industries summer dust-fall rates were found to exceed 100 tons per square mile per month. At one point a mile and a half from the steel industries the monthly rate during 1960 varied between 13.6 and 43.4 tons per square mile. Smoke densities were found to be low by comparison with other cities in New South Wales despite frequent evidence of haze. The introduction of oxygen lancing on open-hearth furnaces, without control measures, had little or no effect on smoke density levels. (Author abstract modified)

05623

E. C. Tabor and J. E. Meeker

EFFECTS OF THE 1956 STEEL STRIKE ON AIR POLLUTION LEVELS IN SEVERAL COMMUNITIES. Proc. Air Pollution Control Assoc., 51st, Philadelphia, Pa., 1958. pp. 24/1-24/20.

This paper reports the results of a study conducted in several steel producing communities during and immediately following the steel strike of July, 1956. The study was limited to the following communities: Homestead, McKeesport, Pittsburgh, and Donora, Pa.; East Chicago, Ind.; and Birmingham, Ala. A continuous sampling program for the collection of suspended particulate matter was set up in all communities. Lower levels were found while the steel mills were shut down as a result of the strike than after the mills resumed operation. No differences in levels of Sb, Ba, Be, Co, molybdenum, and nitrate were observed during the two periods. Statistical analysis of data for iron, zinc, manganese, lead, sulfates and copper demonstrated that significantly lower values were found during the strike period in the following instances: Fe and Zn in all communities; Mn in Birmingham and Donora; Pb in Donora and East Chicago; sulfates in Allegheny County and Donora; Cu in none of the communities. In Donora, it was found that the soiling power of the air during the strike period was half that of the post strike period. The occurrence of occasional high levels of pollutants during the strike period indicates that there are sources contributing to pollution of the air which may not be obvious in the presence of an industry which is frequently looked upon as the major offender.

07406

Terabe, M.

PUBLIC NUISANCE BY AIR POLLUTION. Text in Japanese Kuki Seijo (Clean Air-J. Japan Air Cleaning Assoc., Tokyo), 2(4):1-6, 1965. 6 refs.

The changes in air pollution problems and pollution by soot, dust, and SO2 are discussed. While soot and dust fall presented the greater problem in the past, SO2 is the present menace. In Yokkaichi city, 90% of the fuel used is petroleum and 400 tons of SO2 gas are emitted each day. A maximum peak of SO2 concentration was recorded at more than 1 ppm in the city. Another problem is automobile exhaust gas. In the past 10 years the number of cars has increased seven-fold. The chemical composition of the air in Tokyo and in Los Angeles are tabulated. The concentrations of CO and SO2 are higher in Tokyo. Measurements of dust and soot fall were made in Kawasaki, Tokyo, and Yokohama. The maximum value was 61.2 tons/sq. km. month in Kawasaki and 56.0 tons/sq. km. month in Tokyo. The biggest generators of dust and soot are

the power plants, iron, steel, and cement industries. Dust particles 10 microns in size are radiated to 50 km from a chimney 80 m high by a wind velocity of 3.6 m/sec. The amount of sulfur in heavy oil used in industry is tabulated. Yokkaichi asthma has become an issue since 1962. About 10% of the citizens over 50 has asthmatic disease in 1963 in Isazu in Yokkaichi city. Asthmatic disease increases when SO2 reaches a concentration above 0.3 ppm. Yokohama-Tokyo asthma is also mentioned. SO2 concentration in Kawasaki is higher than in Tokyo. In 1964, the average range was 0.010 to 0.094 ppm in Tokyo and 0.041 to 0.115 ppm in Kawasaki.

10618

George Graue, and Helmut Nagul

DETECTION AND REMOVAL OF FLUORINE IN THE WASTE GASES OF A STEELWORKS AND MEASURING AIR QUALITY IN ITS SURROUNDINGS. Staub (English translation), 28(1):9-17, Jan. 1968. 5 refs. CFSTI: TT 68-50448/1

Air-quality measurements of fluorides were taken near a large steelworks for a period of three years. They revealed that the positioning of the measuring devices is of decisive importance. For example, gross errors are liable to occur if ore dust entrained near ground level is included. After eliminating such errors the total precipitation of fluoride in the course of 3 years was established as between 2 and 6 mg/sq.m./day. No free fluorine is emitted by steelworks, although gaseous fluoride compounds can occur. Downstream of metallurigcal furnaces, particularly where 'brown smoke' is emitted, this fluorine is partically completely adsorbed on the dust. Consequently, even when using excessive quantities of fluorite, it is retained by the dust collectors just like the dust itself. It is irrelevant whether wet or dry collectors are used. Accordingly, there is no reason to avoid the use of fluorite in steel making, provided efficient collecting units are used. Emission of coal-fired boiler plants is less governed by the fluoride content of coal than by the more or less basic character of the ash. Emission of this origin can be largely prevented by dust collection. (Authors' conclusions, modified)

23391

Heller, A.

REPORT ON THE AIR POLLUTION RESEARCH OF THE INSTITUTE FOR WATER, SOIL AND AIR-HYGIENE IN THE FEDERAL HEALTH OFFICE OF THE TOWN DISTRICT OF DUISBURG DURING THE YEARS 1954/1956. World Health Organization, Copenhagen (Denmark), Regional Office for Europe, Proc. Conf. Public Health Aspects Air Pollution Europe, Milan, Italy, 1957, p. 284-296. (Nov. 6-14.)

Following complaints about air pollution from the ironworks, coal mines, and chemical plants in the town of Duisburg, dust and waste gas emissions inside and outside factories and plants were measured from 1954-1956. In 1954, 35 mg sulfur was recorded 300 m from a sulfuric acid plant and 20 mg in the vicinity of another chemical plant. By 1956, the values were lower due to more effective acid-washing processes. A comparison of the results of the interior and outdoor measurements showed that the effect of waste gas in general reaches only about 3 km downwind under normal weather conditions. However, smoke and waste gas streams in the Duisburg area are often superimposed on each other, since the plants are crowded into a narrow zone. The result is a nuisance to the population, despite numerous measures taken by the firms to control air pollution. Zoning laws are needed to prevent the construction of new factories in residential districts. Where existing plants are in close proximity to residences, the effect of emissions should be reduced by buffer strips. New residential communities should not be built in the prevailing downwind direction from industries producing smoke, dust, odors, or discharging sour gas. In some cases, the construction of tall chimneys may be required to protect the population from immoderate waste gas concentrations.

24227

Randerson, Darryl

THE DISTRIBUTION OF MN AND BR IN AN URBAN AREA AS REVEALED THROUGH ACTIVATION ANALYSIS. Atmos. Environ., 4(3):249-257, May 1970. 8 refs.

In an attempt to identify some of the components of air pollution in Houston, fifteen high-volume samplers were operated continuously for 24-hr periods. The major industries in Houston consist of oil refineries and petrochemical plants as well as secondary manufacturers such as steel mills, fertilizer companies, and paper mills. Filter papers from one day of sampling were irradiated in a thermal neutron flux and the resulting radio- nuclides were identified. Manganese and bromine were detected. The primary source of Mn compounds probably would be process losses from cement companies, chemical companies, and a steel mill located upwind from the sampling stations, while it is proposed that the Br compounds may have originated from ethyl fuel combustion. During one 24-hr period, the concentrations of Mn ranged from 0.02 to 0.56 micrograms inverse cu m while those of Br ranged from 0.04 to 1.09 micrograms inverse cu m. The spatial distributions of these two elements were related to the meteorological conditions. Patterns of concentration appeared to be related to the predominant direction of wind. Depending on the elements to be detected, the average cost per sample is estimated to be between $50 and $100. (Author abstract modified)

F. BASIC SCIENCE AND TECHNOLOGY

08439

R. A. Nishchii, I. A. Brazgin

ELECTRON DIFFRACTION STUDIES OF THE STRUCTURE OF SMELTING DUSTS. ((Primenenie metoda elektronnoi difraktsii dlya izucheniya strukturnogo sostova plavil'nykh pylei.)) Hyg. Sanit. (English translation of: Gigiena i Sanit.), 32(4-6):236-241, April-June 1967. 2 refs. CFSTI: TT 67-51409/2

A detailed study of the structure of dust by electron diffraction was made. By means of a rotary device, samples were taken directly from the smoke column (above the arc furnace), and from the steelworkers' breathing zone. The diffraction patterns of the samples were studied by electron microscope. The diffraction image is formed because of the wave character of the electrons. When it encounters the lattice atoms, the electron wave is diffracted and reproduces the diffraction of the atoms of chemical compounds on a photographic plate. By electron diffraction and microdiffraction it was possible to determine the composition of industrial dust discharged into the aerial medium from the electric-arc furnaces. Dust generated by the manufacture of refractory alloys and steels consists mainly of compounds with a complex physico-chemical structure, including complex silicates of iron, aluminum, chromium, manganese, etc. The chemical composition of smelting dust depends upon several factors, such as the grade of steel, the technological process, the smelting stage, etc. With the method proposed for the study of the structural composition of dust, it is possible to apply the electron diffraction method to hygienic investigations.

08572

Sunavala, P. D.

COMPUTATIONS ON INCOMPLETE COMBUSTION J. Mines, Metals Fuels (Calcutta), 15(8):242-244, Aug. 1967.

Incomplete combustion found in the use of equipment such as blast furnaces, cupolas, gas producers and partial oxidation processes for the manufacture of synthesis gas was mathematically analyzed from: (1) CO2 max relations; (2) extension of earlier calculations on complete combustion; and (3) direct elemental balances. The utility of the CO2 max relation arises from the fact that it can be calculated both from the fuel gas as well as the flue gas compositions. Equations for calculating the carbon monoxide content in the flue gases from the carbon dioxide and oxygen analysis are provided in a table. For mixed gas practices in steel plants, the volume ratio of blast furnace gas to coke oven gas, can be evaluated by using CO2 max relations. The direct elemental balances method employs the development of equations for carbon, hydrogen, oxygen, and nitrogen balances in the fuel gas and the flue gases in terms of the unknown parameters which can be evaluated. The ratio of nm to the third power blast furnace gas to nm to the third power coke oven gas in mixed gas practice can be calculated. Fro the straight combustion of any fuel gas, relations obtained, depending on the carbon, hydrogen and oxygen, as well as the carbon and nitrogen balances, ar e given. Equations are provided for the air/fuel and flue and flue gas/fuel gas ratio by volume, if the hydrogen, oxygen and nitrogen balances are employed.

10473L

Kosaka, M. and S. Minowa

EFFECT OF RATE OF CARBON ELIMINATION UPON THE FORMATION OF OXIDE FUMES IN THE OXYGEN BLOWING (OF STEEL). Tetsu to Hagane,50(11:17 1738, 1964. 8 refs. Translated from Japanese, Henry Brutcher Technical Translations, Altadena, Calif., HB-6413, 10p., 1964. Available from Henry Brutcher Technical Translations, P. O. Box 157 Alatadena, Calif. 91001

The reaction kinetics and mechanism of carbon elimination and iron oxide fume formation in steelmaking were studied in a laboratory scale oxygen-lance furnace. The elimination rate of carbon was fou to be an erratic function of the carbon content in the melt. Iron oxide fume production was found to be very small for carbon content of 1.5 to 2.05, proportional to carbon content between 2.0 and 3.55 carbon, and irregular to contant when carbon content was above 3.5. The effect of melt surface area on fume production was small, leadi to the assumption that reaction is localized to the region directly below the oxygen lance. An equation is presented relating the fume formation to the conditions prevailing in the system.

10717

Woehlbier, F. H. and G. W. P. Rengstorff

PRELIMINARY STUDY OF GAS FORMATION DURING BLAST-FURNACE SLAG GRANULATION WITH WATER. Preprint, Batelle Memorial Inst., Columbus, Ohio, (12)p., 1968. (Presented at the 61st Annual Meeting of the Air Pollution Control Association, St. Paul, Minn., June 26, 1968, Paper 68-136.)

The reactions between liquid slag and water or steam were studied in the laboratory and by thermochemical analysis. The experimental approach was to melt 100 grams of slag in a graphite crucible and to drop the liquid slag into a closed container partially filled with water. After the slag had been granulated in this way, the gas in the granulating chamber was analyzed. The experimental procedures were designed to study the gas-forming chemical reaction rather than simulate plant practice in the granulation of slag. The experimental results, which were shown to be well reproducible indicate that major gaseous reaction products include hydrogen and H2S. Under these particular experimental conditions, very little SO2 was formed. A 300 F decrease in slag temperature prior to granulation decreases the amount of H2S formed by about one order of magnitude. The amount of H2S formed is directly proportional to the amount of hydrogen formed. The characteristics of the quenching process, e.g., the amount of water used for granulation, have an effect on H2S formation. A water-slag reaction mechan- ism is proposed according to which a reducing H2-H2O film is developed at the slag-steam interface in which the H2S can form and in which it is dept from burning to S/2. Before it reaches more oxidizing areas outside the H2-H2O layer, the H2S is then cooled below the critical reaction temperature by the quenching action of the water. Introducing oxygen into the slag before granulation appears to prevent the formation of H2S. The propos- ed slag-water interaction model suggests several ways by which H2S formation during blast-

furnace slag granulation might be suppressed but more research is needed to determine their validity. (Au- thors' summary, modified)

13084

Richardson, F. D. and J. H. E. Jeffes

THE THERMODYNAMICS OF SUBSTANCES OF INTEREST IN IRON AND STEEL MAKING. III. SULFIDES. J. Iron Steel Inst. (London), vol. 171:165-175, June 1952. 66 refs.

A survey was made of available data on the thermodynamics of sulfides and gaseous sulfur compounds of interest in iron and steel making. The results are plotted on free energy vs temperature diagrams, and equations and likely accuracies are quoted for each substance. One free energy diagram includes those gaseous sulfides of interest in furnace or laboratory investigations. The metal sulfide free energy diagram includes a number of metals which are not of direct interest in iron and steel making, such as platinum, iridium, and molybdenum, because their behavior limits their use as containers and heating elements in laboratory investigations in sulfide systems. The non-stoichiometry of metal sulfides is discussed.

G. EFFECTS-HUMAN HEALTH

00021

J. J. Schueneman, M. D. High, and W. E. Bye

AIR POLLUTION ASPECTS OF THE IRON AND STEEL INDUSTRY. Public Health Service, Cincinnati, Ohio, Div. of Air Pollution. (999-AP-1.) June 1963. 34 pp.

This report is a summary of published and other information on the air pollution aspects of the iron and steel industry, including coke plants incident thereto. Processes, equipment, and raw materials are briefly described. Air pollutant emissions and means for their control are discussed in detail, with respect to sintering; coke production; blast furnaces; oipen hearth, Bessemer, electric, and basic oxygen steek-making furnaces; and other operations. The effects of pollutants on community air quality are described, and knowledge of health aspects of pollutants is summarized. Laws regulating pollutant emissions are given, and control equipment and measures needed to comply with certain laws are listed. (Author)

05146

A. Bell

THE EFFECTS ON THE HEALTH OF THE RESIDENTS OF EAST PORT KEMBLA (PART II OF AIR POLLUTION BY METALLURGICAL INDUSTRIES). Public Health Dept., Sydney, Australia, Div. of Occupational Health, 1962. 153pp.

948 residents East Port Kembla were asked a standardized questionnaire in order to determine the prevalence of chronic bronchitis. Smaller numbers of people underwent a pulmonary function and sputum test. Individual findings for the regions of high and low pollution were compared. Residents were specifically questioned to determine the prevalence of nasal catarrh, whether head colds 'settled on the chest', number of times they were confined to bed because of chest illnesses, wheeze, cough, phlegm, and dyspnoea. Out of the 471 people who agreed to participate in the tests designed to determine how many have sputum, 333 were found to be so affected. The nature of the samples returned suggests that the bronchitis present in the area is of a mild type. The results of the pulmonary function tests did not show important differences between the residents in the separate areas. It does not appear that the longer a person lives in any of the three areas, the more likely he or she may develop a lower pulmonary function value. Of the people examined in January, 160 were requested to undergo a second lung test in August. The results found on the two occasions differed very little. Out of the people interviewed 6.7% were diagnosed as suffering from chronic bronchitis.

07472

Roshchin, I. V.

THE EFFECT ON THE ORGANISM OF THE AEROSOL LIBERATED BY THE BESSEMER PROCESS. ((Aerozol', obrazuyushchiisya pri konverternom peredele chuguna, i ego gigienicheskaya otsenka.)) Hyg. Sanit. (English translation of: Gigiena i Sanit.), 32(1):31-36, Jan. 1967. CFSTI: TT67-51409/1

Over a period of several years, the dust factor was studied in the course of all the principal operations involved at a smelter. The dust concentrations in the vicinity of the converter, mixer and crane operators were very considerable; the dust concentration in the air of the shop was stable. The largest quantity of aerosol came from the converter necks. Less dust was generated in the course of mixing, pouring the pig iron, charging the ore and discharging the semi-finished products and slags. Electron microscopy showed that in the disperse phase, spherical particles, characteristic of a condensation aerosol, predominated. Chemical analysis of 20 samples of the dust aspirated from the air and deposited on the equipment showed 3.4 to 5.2% of total SiO2 and 1 to 2.1% free SiO2 in the disperse phase, while the carbon content reached 1%. The content of the other admixtures, --chromium, manganese and vanadium and sulfur--did not exceed 0.5% each. As the chromium, manganese and vanadium in the dust are trivalent, their toxicity is relatively low. About 85-93% of the disperse phase is made up of iron oxides. On X-ray examination pneumoconiosis was found in 7 workers and suspected pneumoconiosis in 3 workers. Four workers showed stage II pneumoconiosis, while in the rest it was in the first stage. The capability of aerosol from the converter shops to cause pneumoconiosis was confirmed by intratracheally administering 50 mg portions of settled dust, in the form of a suspension, to 30 albino rats weighing 180 to 230 g. The animals were kept under observation for about 15 months. Groups of animals were killed at 3-month intervals and their organs were microscopically examined. Animals autopsied three months after administration of the dust showed a mild acinous emphysema and small subpleural accumulations of dust. Animals killed after 6 months showed increased pulmonary emphysema, and after 15 months this was still more marked. No pathological changes were found in other internal organs. It is recommended that the maximum permissible dust level in converter shops should be 6 mg/cu m.

08232

SULPHUR DIOXIDE IN THE AIR. Brit. Med. J., No. 5432, p. 339-400, Feb. 13, 1965.

One of the main contaminants of the atmosphere in Great Britain is sulphur dioxide. It is released whenever carbonacesous fuels con- taining sulphur, such as coal, coke, and oil, are burnt, and it has irritant and corrosive properties. Concentrations of sulphur dioxide in the city of London have averaged 0.11 p.p.m. in the summer and 0.17 p.p.m. in winter. The highest recorded concentration of sulphur dioxide in the London smog of 1962 was 1.98 p.p.m. measured over one hour. Since the introduction of the Clean Air Act in 1956 the concentration of smoke in smoke-control areas has fallen apprciably, but the concentration of sulphur dioxide has not followed suit because the technical difficulties are such that is has been considered impractible to impose restrictions on its emission. At present there is no single way of removing sulphur dioxide, but much can and should be done to keep the concentration of this corrosive and possibly harmful gas in the atmosphere as low as possible.

08441

Egorova, T. S.

SOME DATA CONCERNING THE EFFECT OF LOW ATMOSPHERIC CONCENTRATIONS OF SILICON DIOXIDE ON CHILD HEALTH. ((Nekotorye dannye o vliyanii malykh kontsentratsee dvuokisi kremniya v atmosfernom vozdukhe na zdorov'e detskogo naseleniya.)) Hyg. Sanit. (English translation of: Gigiena i Sanit.), 32(4-6):280-284, April-June 1967. 5 refs. CFSTI: TT 67-51409/2

The determination of th e level of atmospheric pollution by silica around a factory manufacturing ferrosilicon alloys and its effect on child health was attempted. The atmospheric dust content was studied at the level of human respiration. Air samples were taken within a radius of 3 km by means of a truck aspirator on filters AFA-18. The samples (136) were tested for total dust concentration, concentration of free silica, and the percentage content of the latter in the dust. The effect of industrial discharges was studied by health statistical analysis of disease incidence in children, based on data of pediatric medical consultations, clinical examination of children and data on their physical development, and a special questionnaire for the population concerned with the effects on health and living conditions of the discharges. For comparability of data on the health of children residing in the area with polluted air and in the control district, studies were made of the livin g and dwelling conditions of the children and the economic means of their families. In the absence of special installations for the treatment of gases, these gases caused considerable atmospheric pollution. Concentrations of finely dispersed dust were 1.75 to 3.1 mg/cu m, considerably in excess of the maximum permissible concentration of 'nontoxic dust.' Some of the determinations revealed the presence of 30-66% of free silica which is the most toxic component of the discharges. Atmospheric pollution by the discharges has an unfavorable effect on the health of children, causing an increased overall morbidity and a higher incidence of respiratory infections and otorhinological disorders; moreover, the children's physical development lagged as compared to controls. Industrial discharges have an unfavorable effect on the sanitary and living conditions of the population. These finding proved the necessity for installations for the treatment of atmospheric discharges from furnaces producing ferrosilicon alloys and for a sanitary-protective zone separating the plants and the residential area.

08575

Mazina, D. V.

CARBON MONOXIDE POISONING DURING SHUT-OFF OF THE BURNER BLOWERS OF THE AIR HEATERS IN BLAST FURNACES. ((Otravleniya okisyu ugleroda pri ostanovke ventilyatorov gorelok vozdukhonogrevatelei domennykh pechei.)) Text in Russina. Gigiena Truda i Prof. Zabolevaniya (Moscow), 10(12):54-55, Dec. 1966.

Three cases of carbon monoxide leakage causing 2 fatalities and 5 heavy and medium poisoning of blast furnace personnel occurred in the Zaporozhiestal and Dneprostal Steel Plants within the past 8 years. The incidents were caused by disconnection of the blowers in the air heaters when the gas nozzles were fully open. To prevent similar accidents, a control system was installed which automatically turns off the gas nozzles when the blowers stop. Such measures are recommended also for Cowper heaters in other plants.

10396

R. V. Borisenkova, T. A. Kochetkova, A. V. Kozlova

THE PROBLEM OF THE INTERMITTENT ACTION OF DUST. (K voprosu ob intermittiruyushchem deistvii pyli.) Text in Russian. Gigiena Truda i Prof. Zabolevaniya 12(2):6-13, 1968. 5 refs.

Six groups of albino rats were exposed to ore dust containing 69.5% Si02, 14.7% Zl203. 5.46% iron oxides, etc. The groups were exposed to different concentrations, ranging from 50 to 500 mg./cu m, and for different periods of time. The product of exposure time and concentration was the same for all groups so that groups exposed at a high concentration were exposed for a shorter time and conversely. Determination of pulmonary collagen lipids, and dust contents as well as microscopic examination, showed that 6-12 months after the inhalations the histochemical changes were similar in all groups. In particular, the group exposed to a lower concentration for a longer period of time exhibited more pronounced pneumoconiotic symptoms. The group exposed to higher concentrations for a shorter period of time exhibited more pronounced pneumoconiotic symptoms. The group exposed to higher concentrations for a shorter period of time exhibited more severe changes in the upper respiratory tract.

11575

Laurence, K. M., C. O. Carter and P. A. David

MAJOR CENTRAL NERVOUS SYSTEM MALFORMATIONS IN SOUTH WALES. I. INCIDENCE, LOCAL VARIATIONS AND GEOGRAPHIC FACTORS. Brit. J. Prv. Soc. Med., 21:146-160, 1967. 47 refs.

The total births, 1956-62, for 12 areas in South Wales are given in a table. The incidence per 1,000 total births of anencephaly, spina bifida, and hydrocephalus (and the number of cases) is given in a table for the 12 areas studied. The bulk of the population lives in townships which are mostly industrial and in straggling industrial communities and villages. Certain towns with light industry and an average population density of 4.8 persons/acre have incidences of malformations of about 11.7/1000 live births. In a relatively flat agricultural area (three small country towns with a total population of less thn 7000) with a population density of less than 0.6/acre the malformation incidence was 5.6 and 4.3 in the two districts studied. There seemed to be a rural-urban gradient in incidence. In Port Talbot, with a large steelworks, the incidence in wards which do not get the prevailing winds from the steelworks was 5.0/1000 live births while in the remaining wards it was 8.0/1000 live births. The local incidence, population density, type of locality (industrial, agricultural,), area, number of cases, total births, population density, and incidence/1000 births are all given in a table. Local variations are discussed in the light of geological background, water supply, rainfall, sunshine, background radiation, radioactive fallout, population density, and urban/rural areas. None seems to explain the local differences.

16113

Kuroda, S. and K. Kawahata

ON THE OCCUPATIONAL ORIGIN OF LUNG CANCER IN GAS-GENERATOR WORKERS. Z. Krebsforsch., 45(1):36-39, 1936. Translated from German by Z. Knowles, National Institutes of Health, Bethesda, Md., Div. of Research Services, 5p., Feb. 15, 1969.

The origin and clinical aspects of lung cancer in gas-generator workers in steel plants were discussed. Twelve cases of lung cancer were found in three years in gas-workers. The average

age of the patients was 42.5 years and the average length of occupation as a gas worker was 15.5 years. Early signs of lung cancer were an irritating cough, a feeling of anxiety, a pain in the side, cardialgia, headaches, bloody sputum, and facial edema. During the course of the illness, all patients complained of throat irritation. In the majority of cases, the tumor was found in the upper lung levels on the right side. Gas-generator workers are in close vicinity to the furnace and are forced to inhale the hot brownish gas and fine dust that usually contains large amount of tars known to contain carcinogens. The carcinogenic substances in tar were being explored.

22118

Bell, Alan and John L. Sullivan

AIR POLLUTION BY METALLURGICAL INDUSTRIES. Public Health Dept., Sydney (Australia), Air Pollution Control Branch, 203p., 1962. 83 refs.

Tests for sulfur dioxide were made in Port Kembla, Australia, where iron and copper ores are smelted, and 947 residents were sent a questionnaire to determine the prevalence of chronic bronchitis, with smaller numbers undergoing a pulmonary function and sputum test. An eastern section of town, in the vicinity of the copper smelter, was the major source of SO2. Gas readings were not spectacular by daily volumetric sampling and an automatic recorder, but a continuous recorder showed that high concentrations of SO2 occurred in episodes of a few hours each. The highest result was 0.62 ppm by the former method, while peaks of concentrations greater than 5 ppm were recorded by the latter approach. Prevailing winds produced higher concentrations during the summer months when they blow frequently from a north-east direction, while pollution is blown seawards during the winter months when westerly winds prevail. When measured as water insoluble solids by a deposit gauge consisting of a six inch diameter conical glass funnel and bottle, summer dust-fall rates exceeded 100 tons per square mile/month within a half mile from the steel industries, but smoke densities were low by comparison with other cities in New South Wales despite frequent evidence of haze. A larger percentage of people living in the area of high pollution considered that they were suffering from either chronic bronchitis or bronchial asthma than in the case of the low pollution area, and only a few people complained of symptoms unrelated to the respiratory tract. Differences between the findings for the two areas were statistically significant, 7 times for women and 3 times for men, when questioned to the prevalence of nasal catarrh, whether head colds settled on the chest, number of times they were confined to bed because of chest illnesses, wheeze, cough, phlegm, and dyspnea. A higher percentage of men wheezed and were affected by cough and phlegm tha was the case for a small group of Englishmen who never worked in the dusty occupations, although this was not the situation when compared with English foundry employees. Out of the 333 sputa collected in East Port Kembla, 84.7% were mucoid and 15.3% of a mucopurulent nature, while pulmonary function tests showed no statistically significant differences between the two areas, except for females aged 70-84. Dental evidence suggested that some external influence might be exerting a harmful effect on the gingival tissues of young people living in the area of high pollution.

24212

AIR ALERT: PART 1. Sciences, 10(10):5-8, 34-36, Oct. 1970. 9 refs.

Related to demography, climate, human and plant physiology, politics and law as well as economics, air pollution control is more complex than most other environmental problems. It is estimated that each year up to 1 times 10 to the 12th power tons of emissions from natural and man-made sources enter the global atmosphere. The most prolific single source of pollution is automotive vehicles, contributing 90.5 million tons of a total 213.8 million tons of emissions yearly. The National Air Pollution Control Administration, is compiling a list of some 30 pollutants that, it believes, must be abated because of their relative abundance and toxicity. In the presence of sunlight and air, these fairly simple chemicals produce the secondary pollutants ozone, nitrogen dioxide, the aldehydes, singlet oxygen and peroxyacetyl nitrate which make up photochemical smog. The cost of respiratory illnesses aggravated, if not caused, by air pollution has recently been estimated at $2 billion a year. Damage from such airborne pollutants as carbon monoxide, sulfur dioxide, nitrogen oxides and ozone, polynuclear hydrocarbons, peroxyacyl nitrates, fly ash, lead, vanadium, and other trace metal is just beginning to be assessed, but a link has already been established between air pollution levels and increased death rates from coronary heart disease and strokes. A close relationshi was found between continuing exposure to air pollution and asthma and eczema in children under 15, especially boys under five. Two New York City researchers have been studying the link between deaths in the city and sulfur dioxide levels. Airborne asbestos particles are doubly dangerous pollutants because they absorb molecules of such gases as SO2. As the result of a collective air clean-up program by citizens, industry and local government, the nation's steelmaking center has become one of the country's cleaner industrial cities. Before the clean-up, Pittsburgh was showered with 170 tons of fine particulates per square mile a month; visibility was so poor that street lamps were turned on at noon. This year, a new law went into effect, more firmly restricting smoke and dust emissions and, for the first time, limiting the amount of sulfur that can be discharged into the atmosphere. Alert warning and emergency procedures have been established; when meteorologists predict an inversion period of 36 hours or more, industry is warned to cut back on emissions.

24586

Wefring, K.

PNEUMONIA IN THE AREA OF THE SAUDA FACTORIES OF RYFLYKE. Tidsskr. Norske Laegeforen., vol. 49:553-568, 602-612, 1929. Translated from Norwegian. 25p.

A description is provided of an investigation in a Norwegian town wherein the residents were blaming a high incidence of pneumonia accompanied by an abnormally high mortality rate on the smoke from a local ferromanganese plant. It is concluded that the function of the plant in the spread of the disease is to provide the point of contact for the contageous transfer of a highly virulent strain of pneumococcus; no case could be presented for causation by the smoke or any of its constituents. The remedy suggested is innoculation of the inhabitants and isolation of pneumonia patients.

26136

Tauda, F.

PRESENT SITUATION AND OUTLOOK OF FLUORIDES AIR POLLUTION PREVENTION TECHNOLOGY--TACKLING WITH ALUMINUM SMELTING POLLUTION. (Fukkabutsu ni yoru taiki osen boshi gijutsu no genjo to tenbo - arumi seiren kogai ni torikumu). Text in Japanese. Kinzoku (Metals) (Tokyo), 41(1):122-125, Jan. 1 and 15, 1971. 9 refs.

Sources of fluoride pollution and the effects of fluorides on man and plants are reviewed. Aluminum electrolysis uses cryolite which is 54% fluoride. Raw materials containing fluorides are also used in the production of phosphate fertilizers and iron and steel. Raw materials containing smaller amounts of fluorides are required for the production of glass fibers, bricks, tiles, cement, and porcelain. Coal burned by thermal power stations can be a problem since coals contain 20-295 ppm of fluorides, averaging 120 ppm. Fluorides affect plants more than any other atmospheric pollutant, accumulating in a large number of species in polluted areas. Fluorides affect man in two ways, directly through air pollution or indirectly through contaminated vegetation. They are present in considerable amounts in both green vegetables and rice. Symptoms of chronic fluoride poisoning in man are abnormal hardening of bones and spots on teeth. Cases of chronic poisoning have appeared among workers exposed to cryolite dust and among individuals whose drinking water contains more than 6 ppm fluorides Existing technology, the use of scrubbers for controlling fluoride emissions from aluminum electrolysis or electric furnaces, is effective only with concentrations up to 1 ppm. New production technologies should be developed which dispense with the use of raw materials containing fluorides.

26577

Suzuki, Y.

ON ENVIRONMENT POLLUTION BY MANGANESE. (Mangan ni yoru kankyo osen ni tsuite). Text in Japanese. Sangyo Igaku (Jap. J. Ind. Health), 12(11):529-533, Dec. 1970. 11 refs.

The effects of manganese on the central nervous system have been frequently observed in Japan, and manganese poisoning is considered an occupational disease. However, cases of Mn-induced pneumonia have not been reported. In the present study, the incidence of pneumonia among workers at a ferromanganese factory was 0.41% compared to 0.019% for other enterprises. The number of pneumonia patients in a hospital near a factory handling Mn was higher than in a control hospital (5.00% for those living within 1.8 km of the hospital and 4.90% for those living within 1.5 km of the control hospital). Of the steel-mill workers surveyed, 20% had had pneumonia in the past, most of whom had worked in the electric furnace shop. The amount of Mn in the workshop atmosphere was less than 1.9 mg/cu nm. The incidence of pneumonia among railroad workers near an Mn factory was 10.7% in contrast to 2.7% for other railroad workers. These findings suggest that comprehensive studies should be undertaken of the relationship between Mn and pneumonia.

28042

Baetjer, Anna M.

CHRONIC EXPOSURES TO AIR POLLUTANTS AND ACUTE INFECTIOUS RESPIRATOR DISEASES. Arch. Ind. Hyg. Occupational Med., 2(4):400-406, Oct. 1950. 23 refs. (Presented at the U. S. Technical Conference on Ai Pollution, Health Panel, Washington, D. C., May 4, 1950.)

A brief summary is given of knowledge of the effects of air pollutants on susceptibility to acute infectious diseases of the respiratory tract, on the basis of published data on occupational exposures and animal experimentation. Nontoxic dusts, smoke, irritant gases and fumes, and carbon monoxide are discussed. Data obtained from studies of the health of persons who have been exposed to specific chemical contaminants of the air have not yielded any definite evidence that chronic inhalation of such chemical contaminants in low concentrations affects susceptibility to acute infections of the respiratory tract. Similarly, the few experiments which have been performed on laboratory animals have yielded chiefly negative results. However, the data available at present are entirely insufficient to enable one to draw any definit conclusions. The need for fundamental research on physiologic effects, effects on susceptibility to infectious diseases, industri morbidity, and epidemiological patterns is stressed.

28556

Adler, P., W. D. Armstrong, Muriel E. Bell, B. R. Bhussry, W. Buettner, H. D. Cremer, V. Demole, Y. Ericson, I. Gedalia, H. C. Hodge, G. N. Jenkins, S. S. Jolly, E. J. Largent, N. C. Leone, T. G. Ludwig, A. E. Martin, G. Minoguchi, J. C. Muhler, E. R. Schlesinger, A. H. Siddiqui, L. Singer, A. Singh, F. A. Smith, G. K. Stookey, D. R. Taves, P. Venkateswarlu, J. C. Weatherell, S. M. Weidmann, and I. Zipkin

FLUORIDES AND HUMAN HEALTH. (Fluoride und menschliche Gesundheit). Text in German. Oeffentl. Gesundheitswesen (Stuttgart), 33(3):173- 182, 1971. 3 refs.

Fluorides present in atmospheric dust and gases are an important health hazard, since fluoride ions are almost completely retained in the lung. The world consumption of calcium fluoride (for steel production and other purposes) amounts to more than 2 million tons per year. Several times 200,000 tons of CaF2 are produced in the United States alone. Since long-term exposure to high fluorine concentrations is harmful, elimination by the body is of importance. Fluorides are eliminated by the feces, urine, sweat, and in small quqntities by skin. Most of the fluorine is discharged with the urine. A long-term intake of more than 2 to 8 mg/day fluoride causes abnormal density of bones.

31664

Yoshizaki, Kazuko

TREND OF COMMUNITY HEALTH OF THE CITIZEN IN PETROLEUM CHEMICAL INDUSTRY CITIES AND ENVIRONMENTAL POLLUTION. PART 1. ECOLOGICAL AND GENERAL STUDY ON THE RELATION BETWEEN THE TREND OF COMMUNITY HEALTH AND LIVING ENVIRONMENT OF THE INHABITANTS IN TOKUYAMA HEALTH CENTER DISTRICT FROM A VIEWPOINT OF MORTALITY BY MAJOR CAUSES. (Sekiyukagakukogyo toshimin no hokendoko to kankyoosen. Dai 1 pen. Shuyoshiinbetsu shiboritsu kara mita Tokuyama hokensho kannai jumin no hokendoko to seikatsu kankyo to no kankei ni tsuiteno seitaigakuteki gaikanteki kosatsu). Text in Japanese. Yamaguchi Sangyo Igaku Nenpo (Ann. Rept. Soc. Yamaguchi Ind. Health), no. 17:48-61, Dec. 1970. 72 refs. The following matters were considered: deaths by major causes of about 220,000 inhabitants in three cities and three towns within the jurisdiction of Tokuyama Health Center during 1958-1965; the relation between death rates for major diseases, soil, and air pollution; and the relation between the growth of school children from six to 17-years-old as of 1965 with local environmental conditions, mainly of soil. Regions studied were divided into petrochemical industrial cities, steel and iron industrial cities, and agricultural-mountainous villages. Major causes of death were divided into two categories, that is, ectogeneous, infectious diseases (tuberculosis, pneumonia, bronchitis, diarrhea, and enteritis) and endogeneous, constitutional diseases (cerebral hemorrhage and cancer). Regional alteration in the death rate for each category was investigated for an earlier period (1958-1961) and a later one (1962-1965). Consequently, regional differences in death rates for both categories did not alter too much annually, and regional accumulation was ob-

served in death rates. A marked degree of regional accumulation was noted in the category of endogeneous, constitutional diseases. Distribution of deaths from endogeneous, constitutional diseases was close connected with soil reactions. Comparison of alteration in regional death rates during the earlier and the later periods indicated decrease in deaths from both disease categories in the petrochemical industrial cities, where air pollution has rapidly decreased since 1964, and in agricultural-mountainous villages, where air has not been polluted. Formerly, both regions had high mortality rates. In the steel and iron industrial cities, where air pollution has increased recently, a yearly alteration different from any other regions was observed for every disease. For example, the death rate by pneumonia increased in Kudamatsu City and Hikari City, and the death rate by bronchitis increased in Kudamatsu City.

32079

Cholewa, Loen, Wieslaw Jedrychowski, Marian Sosin, and Julian Zabicki

CHRONIC NONSPECIFIC RESPIRATORY DISEASES IN CRACOW. XIII. A PILOT FIELD STUDY IN AN INDUSTRIAL ESTABLISHMENT. Epidemiol. Rev. (English translation from Polish of: Przeglad Epidemiol.), 24(2):135-139, 1970. 7 refs NTIS: TT 70-55001/2

An epidemiologic study was conducted to investigate the relations between the prevalence of nonspecific respiratory diseases, especially chronic bronchitis, and working environment and occupation. Pilot studies, in conjunction with periodic health checks, were carried out in the steel mill and railway transport departments of the Lenin Metallurgical Establishment in Krakow. The analysis covered respiratory symptoms, past diseases, smoking habits, and occupational health hazards. Cough and phlegm production were more frequent in the steel mill workers. Effort dyspnea was rare in the transport workers and more frequent in the steel mill. In both groups, smoking and chronic bronchitis were correlated, especially in the steel mill. Comparison of past diseases showed that chronic bronchitis was more frequent in the steel mill workers. Pneumonia occurred more often in the transport workers, but diseases of the nose were more frequent in the mill workers. In the transport department, 60% of the persons were employed under conditions harmful to health; in the steel mill the number was 93.5%. Transport workers were exposed only to atmospheric factors during work, and very little to the various occupational hazards of work in the steel mill.

32842

McCaull, Julian

BUILDING A SHORTER LIFE. Environment, 13(7):2-15, 38-41, Sept. 1971. 48 refs.

Cadmium pollution of the environment is reviewed with respect to basic characteristics, emission sources, uses, concentration levels, and effects on human health. Cadmium dust, fumes, and mist are emitted during the refining of zinc, copper, and lead, as well as during extraction of cadmium. These processes released an estimated 2.1 million pounds (45% of total emissions) into the air in 1968. The single largest source was the roasting and sintering of zinc concentrates. Incineration or disposal of cadmium-containing products contributed 52% of total emissions. The processes included electroplating, recycling of scrap steel, melting down scrapped automobile radiators, and incineration of solid wastes. Cadmium concentrations in the waterways, tap water, food, vegetation, soils, and certain commercial products (fertilizers) were determined. The toxicity of cadmium, levels of ingestion and retention in the body, and correlation with hypertension, liver damage, bone disease, emphysema in industrial workers, cancer, and kidney impairment are examined.

I. EFFECTS-MATERIALS

07553

Yocom, John E.

THE DETERIORATION OF MATERIALS IN POLLUTED ATMOSPHERES. J. Air Pollution Control Assoc., 8(3):203-208, Nov. 1958. 34 refs. (Presented at the 14th Annual Conference and 1958 Exhibition, National Assoc. of Corrosion Engineers, San Francisco, Calif., March 20, 1958.)

A group of spcific air pollutants known to produce deterioration of materials, the principal sources of these pollutants, and the most likely mechanisms by which deterioration of a variety of materials can occur are discussed. Specifically, the pollutants are carbon dioxide, sulfur dioxide, sulfur trioxide, hydrogen sulfide, hydrogen fluoride, ozone and solid particulates.

24417

Yuzvenko, Yu. A., A. F. Tereshchenko, and V. A. Gavrish

ABRASIVENESS OF BLAST-FURNACE FLUE DUST. Steel (USSR) (English translation from Russian of: Stal'), no. 8:695-697, Aug. 1969. 6 refs.

The abrasion of samples of type 45 steel and sormite-deposited alloy no. 1 by flue-dust grains from 9 blast furnaces was studied in the laboratory at a stream temperature of 400, impingement angles of 10 and 45 deg, stream velocity of 480-510 m/s, and pressure of 3.0 atm. Wear was evaluated from weight loss of the specimens. Wear of the steel 45 samples increased with decreasing grain size, reaching a maximum at particle sizes below 0.1 mm. The abrasiveness of quartz-sand mixtures for sormite no. 1 alloy increased almost linearly up to a sand content of 50-60%; addition of 12% sand to the dust raised its abrasiveness about threefold. In the case of the hard alloy, abrasiveness was also related to impingement angle, increasing several times when the angle increased from 10 to 45 deg. The angle of impingement ha far less effect on carbon steel. The abrasive power of the dusts tested varied widely, dusts from one plant abrading carbon steel at 10 and 45 deg impingement, respectively, at rates 71 and 81% lower than those dusts from another plant. Abrasiveness, which generally was close to or exceeded that of sand, was greater where raw ore was smelted than where sinter was smelted. The findings explain variations in the service life of parts on the top of blast furnaces operating under similar conditions.

J. EFFECTS-ECONOMIC

08689

ECONOMICS OF GAS COOLING AND GAS CLEANING SYSTEMS ASSOCIATED WITH THE BOF PROCESS. Combustion, 39(5):31-35, Nov. 1967.

Several fumehood designs are discussed and compared on a cost basis. A shop with a typical set of conditions was used for the study. The total cost for each scheme includes; the fume hood gas cleaning system, the operating charges, payout time and the cost of a package boiler. After a discussion of the various schemes are completed, the effect of including or eliminating the boiler is outlined. A comparison is made of: the estimated first costs, operating costs and total costs of each scheme.

09313

THE RISING COSTS. Mach. Des., 39(17):23-24, July 20, 1967.

Damage from air pollution both direct and indirect has been estimated at 65 dollars per person per year, or 11 billion dollars annually. Agricultural losses are estimated at 325 million dollars annually. A single day of smog in California a few years ago reportedly ruined an entire lettuce crop. On the eastern seaboard, pollution is said to destroy 18 million dollars of crops each year. Atmospheric corrosion from sulfuric-acid mist has been reported to do about 6 million dollars damage per year in New York City alone. The costs of control, although a small per- centate of the 11 billion dollars total, are also significant. The petroleum industry is reported to spend 18 million dollars annually on air pollution control out of a total capital outlay of 350 million dollars. The major steel manufacturers in the Chicago area entered into a 8-yr agreement with the local re- gulatory agency to prevent some 88,000 tons of dust annually from entering the atmosphere. The estimated total cost of the program is 50 million dollars. Research efforts into better detection and control seem pitifully small in comparison to the total damage estimate. Federal Government research allocations will approach 18 million dollars in 1968. The anticipated expenditures at the Federal level to achieve goals in reduction of pollutant levels and in establishing air quality criteria are estimated at 130 million dollars over the next several years.

21300

INVESTIGATIONS OF THE IHK DUISBURG: IN NORDRHEIN WESTFALEN 2300 MILLIONS OF DEUTSCHE MARK HAVE BEEN EXPENDED FOR AIR POLLUTION CONTROL. (Untersuchung der IHK Duisburg: In Nordrhein-Westfalen wurden 2,3 Milliarden DM fuer die Luftreinhaltung aufgewandt). Text in German. Wasser Luft Betrieb, 13(10):387-388, Oct. 1969.

North-Rhine Westphalia spent 2.3 billion German Marks (.575 billion dollars) in the period between 1955 and 1968 in an effort to maintain clean air. Industries increased expensitures for air pollution control from 23.9% in 1964/65 to 27.1% in 1969. Research costs in the field declined from 8.6 million German Marks (2.15 million dollars) to 7 million German Marks (1.75 million dollars) per year. This is due to the fact that several research projects have been completed: the problem of brown smoke has been solved and the study of sulfur dioxide removal has been completed with the development of the so-called 'double contact process'. The iron and steel industry has made the major investment in air pollution control, followed by the chemical industry. The money went primarily into improving existing air pollution control systems.

21968

Linsky, Benjamin

CASE STUDIES OF COSTS (QUALITY AIR--LUXURY OR INEXPENSIVE NECESSITY). Virginia Polytechnic Inst., Blacksburg, Water Resources Research Center, Seminar on the Economics of Air and Water Pollut., Blacksburg, Va., 1969, p. 195-208.

A series of case studies relating pollution control costs, equipment, and effects are discussed. A breakdown of the consumers dollar in terms of what air and water pollution actually cost him is included. A system of concepts and phrases used in considering air pollution is presented. Proposals, reports, and local ordinances relevent to the discussion are included. Estimated costs for air pollution control for the gray iron foundry cupola (afterburners, scrubbers, baghouses, and electrostatic precipitators), steel plant (scrubbers, baghouses, and electrostatic precipitators), and chemical drying operation (primary cyclone, secondary multiple cyclones, secondary wet scrubbers, and baghouses) are subdivided into the following breakdown: air pollution emissions (particulates and droplets, gases); collection efficiency or recovery; and cost (capital investment, operating costs, and plant investment).

24155

MacDonald, Reynold C.

SHOW AND TELL. Iron Steel Engr., 47(7):59-65, July 1970. (Present at the American Iron and Steel Institute General Meeting, 78th, New York, May 27-28, 1970.)

By the end of 1970, steel companies will have spent more than $1,000,000,000 in the past 20 years on environmental control equipment. But even this has not been enough to restore the balance of nature or to deflect criticism of the industry. To meet these challenges, steel companies must demonstrate a continued willingness to attack pollution, each company organizing for pollution control activities as it does for other important company functions. The industry must also accelerate its own research and development programs on control equipment and techniques. Chances are that costs can be minimized and efforts maximized if these activities are coordinated in the future. However, the cost of technology that can reduce pollution to measurable proportions will be considerable; it will not be diminished by slowing down production or the American economy. The consequences of such an action would create higher prices, more unemployment, and a reduced standard of living. Hopefully, once it is informed of these consequences, the public will be willing to pay the bill for environmental quality.

24543

Rowe, A. D., H. K. Jaworski, and B. A. Bassett

WASTE GAS CLEANING SYSTEMS FOR LARGE CAPACITY BASIC OXYGEN FURNACE PLANT. Preprint, United Nations Industrial Development Organization, 35p., 1968. 13 refs. (Presented at the Interregional Symposium on the Iron and Steel Industry, 2nd, Moscow, USSR, Sept. 19-Oct. 9, 1968, Paper ID/WG.14/53.)

A comparison is made of the comprehensive capital and operating costs for the gas cleaning systems suitable for 300-ton-capacity basic oxygen furnaces. The systems are a dry plate electrostatic precipitator equipped with a pressurized hood system, a variable-throat venturi wet scrubber equipped with a pressurized hood system, and the Yawata oxygen gas (O.G.) recovery process. Each system has shown itself to be both technically feasible and economically viable for oxygen steelmaking. Capital costs (given in US dollars) of the three systems are within 10% of each other. The precipitator system has substantially lower operating costs due to the low electrical power requirements for the I.D. fan. The O.G. system has a similar power requirement, but this advantage is offset by the cost of the nitrogen gas required. If nitrogen is replaced by steam, as appears likely, operating costs of the O.G. and precipitator will be similar.

26623

POLLUTION CONTROL. Iron Steel Engr., 48(1):D-56 to D-60, Jan. 1971.

By mid-1970, domestic steel companies had authorized expenditures of more than $385,000 for air and water quality improvement projects to be completed in 1970 or later. The extent of those programs is illustrated by a review of abatement facilities being acquired by several major steel producers, particularly as they relate to cost. On occasion, pollution control devices become prematurely obsolete, as exemplified by one company which replaced a $1,500,000 wet venturi scrubbing system with a $3800,000 electrostatic precipitator.

29186

Vinokurov, I. S., S. T. Zolotukhin, G. R. Ostanovskii, E. I. Ol khovskaya, A. Z. Ryzhavskii, L. N. Raitman, and Yu. M. Yudovich

TECHNICAL-ECONOMIC COMPARISON OF DRY AND WET GAS CLEANERS FOR CONVERTERS WORKING WITH COMPLETE COMBUSTION OF CARBON MONOXIDE. Steel (USSR) English translation from Russian of: Stal), no 11:925-926, Nov. 1970. 3 refs.

Operating, capital, and corrected costs are calculated for three gas cleaning systems for a steelmaking plant with three 130-ton oxygen converters. The three systems compared are as follows: (A) dry electrostatic precipitator; (B) bag filters (with preliminary cooling of gas in a scrubber (B1) and in a regenerator (B2); and a venturi scrubber with a variable 330 times 301 mm throat and film-jet spraying head. Variants B2 and A have clearcut advantages over C in terms of operating costs; the additional capital investments they require will be recovered 4.1 yrs and 1.6 yrs, respectively. Variant B1 is uneconomical. In view of the lack of experience in the use of bag filters, electrostatic precipitators are to be recommended.

29923

Schreiber, Michael

THE COSTS FOR MAINTENANCE OF CLEAN AIR. THE INFLUENCE OF SOCIAL COSTS ON THE SELECTION OF AN INDUSTRIAL SITE. (Kosten der Luftreinhaltung. Der Einfluss der social costs auf die industrielle Standortwahl). Text in German. Wasser Luft Betrieb, 15(4):145-148, 1971. 27 refs.

Because of the cost of eliminating brown smoke emissions, Thomas converters were replaced by oxygen lancing converters. An 80-ton Thomas converter emits about twice as much waste gas as an oxygen lancing converter of the same capacity. Similar changeovers to processes with less waste gas production were made i the chemical industry to save waste gas cleaning costs. Sulfur emissions are reduced mainly by switching to low-sulfur fuels, a much less expensive means than desulfurization of the fuel or the flue gases. Such steps are not always possible. In many cases investment in dust collectors, electrostatic precipitators, and scrubbers are unavoidable. The economy of such units depends on the ratio between collection efficiency and maintenance costs. For electrostatic precipitators investment costs rise proportionally to the degree of collection in the efficiency range between 80 and 95%. A collection efficiency of 95 to 98% requires facilities which are 50% larger, increasing costs by 35% and more. The aluminum industry spends an estimated $50/ton of aluminum of its annual production for facilities to eliminate fluorine emission. The annual operating costs per ton of aluminum are estimated at $8.40. Metallurgical plants spent similar amounts for reduction of their emissions.

30696

LeSourd, D. A., M. E. Fogel, A. R. Schleicher, T. E. Bingham, R. W. Gerstle, E. L. Hill, and F. A. Ayer

COMPREHENSIVE STUDY OF SPECIFIED AIR POLLUTION SOURCES TO ASSESS THE ECONOMIC EFFECTS OF AIR QUALITY STANDARDS. VOL. I. (FINAL REPORT). Research Triangle Inst., Durham, N. C., Operations Research and Economics Div., APCO Contract CPA 70-60, RTI Proj. OU-534, Rept. FR-OU-534, 395p., Dec. 1970. 328 refs. NTIS: PB 197647

Air pollution control costs for mobile sources are presented on a national basis and in terms of unit investment and annual operating and maintenance costs as well as total annual operating and maintenance costs. The analyses cover the estimated emissions and control costs for new cars for Fiscal Year 1967 through Fiscal Year 1976. Control costs for each stationary source, except for residential heating, are shown for 298 metropolitan areas by investment and annual expenditures by Fiscal Year 1976. The impact of control on selected industries and the Nation are also determined. Finally, an extensive bibliography is included. The pollutants from mobile sources selected for analysis are hydrocarbons, carbon monoxide, nitrogen oxides and particulates. The six pollutants for which control cost estimates are made for stationary sources are particulates, sulfur oxides, carbon monoxide, hydrocarbons, fluorides, and lead. Emission standards applied are considered stringent in comparison with many currently in use throughout the Nation. Mobile sources include automobiles and light and heavy-duty trucks. Stationary sources studied include solid waste disposal, commercial and institutional heating plants, industrial boilers, residential heating plants, steam- electric power plants, asphalt batching, brick and tile, coal cleaning, cement, elemental phosphorus, grain handling and milling (animal feed), gray iron, iron and steel, kraft (sulfate) pulp, lime, petroleum products and storage, petroleum refineries, phosphate fertilizer, primary non-ferrous metallurgy (aluminum, copper, lead and zinc), rubber (tires), secondary nonferrous metallurgy, sulfuric acid, and varnish. Data essential for defining metropolitan areas, emission control standards, and relevant process and air pollution control engineering

characteristics required to support the cost analyses for each source and the cost impact on each industrial process are presented and analyzed in separate appendixes to this report. (Author abstract modified)

30951

Japan Development Bank

TREND IN INVESTMENT ON PUBLIC NUISANCE CONTROL FACILITIES. (Kogai kankei setsubi toshi no doko). Text in Japanese. Sangyo Kogai (Ind. Public Nuisance), 7(5):261-262, May 1971.

Questionnaires were sent to 893 industries with a working capital of more than $280,000 concerning their spending plans for 1970 and 1971 for installation of pollution control facilities. The 844 which replied comprised 94.5%. The total spending plan for 1970 was $479,640,000, a 58% increase from 1969 and $767,480,000 for 1971, a 60% increase. A classification breakdown shows that the steel, electric, chemical, petroleum refining, non-steel metals, and paper-pulp industries share 80% of the total spending for both 1970 and 1971. For production of anti- pollution products (improvement of products), $30,240,000 was spent in 1970 and $64,120,000 in 1971 of which the major portion was shared by automobile manufacturers and petroleum refining companies. The ratio of spending for pollution control in relation to working capital for 1971 is 6.3% as compared to 4.7% in 1970 and 4.6% in 1969. Industries with high-ratio investments for pollution control devices in 1971 are petroleumm refining (15%), paper-pulp (11%), non-steel metal (10%), steel (7%), and chemical (7%). The breakdown of spending by classification of pollution types (except for spending for improvement of products) for both 1970 and 1971 is air pollution, 65-66%; water, 27-28%; and others, 7-8%. A geographical breakdown shows that the Tokyo-Yokohama-Chiba coastal area shares 23% of the total spending for 1971; the Nagoya-Yokkaichi-Hamamatsu coastal area, 18%; and the Osaka-Kobe area, 19%. Thus, the three major industrial areas of Japan share 60% of the total industrial anti-pollution spending of Japan (58% in 1970).

K. STANDARDS AND CRITERIA

16228

VDI (Verien Deutscher Ingenieure) Kommission Reinhaltung der Luft, Duesseldorf, Germany

EMISSION CONTROL BLAST FURNACE OPERATION: ORE SINTERING PLANTS (INDUCED-DRAFT PAN AND MOVING-GRATE INSTALLATIONS. (Auswurfbegrenzung Hochofenbetrieb Erzsinteranlagen (Saugzugpfannen und Bandanlagen). VDI (Ver. Deut. Ingr.) Richtlinien, no. 2095, 7p., Feb. 1963. 13 refs. Translated from German by H. Schneider, Israel Program for Scientific Translations, Jerusalem. CFSTI: TT 68-50469/1

The generation of dustlike and gaseous emissions from ore sintering plants and the possibility of reducing flue dust and sulfur dioxide emissions are discussed. About 0.7% of total sinter production is lost as flue dust, while the total amount of the sulfur dioxide content of sintering plant waste gas is about 0.4 vol% (11.7 g SO3/cu m STP). The criteria for limiting dust-like emissions are the permissible pollutant deposition quantities in the area of the plant and the dispersal conditions given by stack height, neighboring emittents, orographic position, etc. Dust collection plants should be designed for a guaranteed value of 150 mg/cu STP of waste gas for normal operating conditions. In continuous operation, the dust content of sintering gas must not exceed 300 cu mg. Attainable total collection efficiency and clean dust content of centrifugal collectors in continuous operation are 75-95% and 0.400 g/cu m STP. For electrostatic precipitators, they are 98% and 0.150 g/cu m STP. concentrations of air pollutants above ground and the dust disposition on the ground can be reduced by high stacks, utilization of thermal plume rise, and high flue-gas exit velocity at the stack mouth.

33815

FUME CONTROL OF THE ELECTRIC ARC FURNACE. Brit. Steelmaker, 37(8):20, Aug. 1971.

Arc furnace fume control brings together two major factors in modern steelmaking, the shift toward electric melting of scrap and the growth of legislation controlling pollution of the environment. For purposes of arrestment plant design, the standard of fume emission from steel refining processes may be taken as not more than 0.05 g/cu ft.

L. LEGAL AND ADMINISTRATIVE

06733

CURRENT STATUS AND FUTURE PROSPECTS - STEEL INDUSTRY AIR POLLUTION CONTROL. 90th Congress 'Air Pollution--1967, Part IV (Air Quality Act)' Senate Committee on Public Works, Washington, D.C., Subcommittee on Air and Water Pollution, May 15-18, 1967. (Presented at the National Conference on Air Pollution, Washington, D.C., December 13, 1966.) p. 2390-6.

Many of the operations involved in steel-making and processing impair the quality of the air used in some degree. Therefore, air treatment or air pollution control equipment is now used extensively in the steel industry. The major sources of air pollutants are divided into the following five groups, and each is discussed: (1) Coke Ovens. (2) Blast Furnaces (including Sinter Plants). (3) Steel-making Furnaces. (4) Boiler Houses. (5) Miscellaneous.

06863

E. A. B. Birse

ONE HUNDRED AND SECOND ANNUAL REPORT ON ALKALI &C. WORKS, 1965. Ministry of Housing and Local Government, Edinburgh, Scotland, Dept. of Scottish Development. (Feb. 28, 1966). 91 pp.

The 102nd annual report on alkali and works was given to the Secretary of State for Wales, and to the Minister of Housing and Local Government, also to the Secretary of State for Scotland. The report, which is on the work done during the year 1965, in the reduction of air pollution by industrial processes, covers the following areas: (1) chemical and allied industries, (2) metal industries, (3) fuel industries and, (4) a group of miscellaneous works. Statistical information is included in appendices.

M. SOCIAL ASPECTS

15567

Creer, Ralph Nuttall

SOCIAL PSYCHOLOGICAL FACTORS INVOLVED IN THE PERCEPTION OF AIR POLLUTION AS AN ENVIRONMENTAL HEALTH PROBLEM. Utah Univ., Salt Lake City, Dept. of Sociology, Thesis (MS), Aug. 1968, 45p. 53 refs.

A survey was made to determine if high economic dependence on a source of air pollution creates such dissonance and strain in an individual that he perceives a less serious air pollution problem than individuals with little or no economic dependence on the source. The data comes from a random sample of residents of American Fork, Utah, where a high proportion of the population is employed by a steel plant. If an individual was employed by the plant, he was considered to have high economic dependence; if not, he was considered to have low economic dependence. To avoid biasing the findings, age, sex, and education were controlled. The data were analyzed first in terms of simple proportions and then by a unique method of the chi square test for a significant association, an extension of the Mantel-Haenszel chi square procedure. The findings indicate that respondents with low economic dependence are slightly more prone to recognize or be aware of a pollution problem than are those with high economic dependence. Age also appears to have a significant influence on the ability to recognize the seriousness of a pollution problem, with females 44 years or younger the most perceptive. On the other hand, level of education has little influence on the perception of an environmental health problem.

18022

UNION OFFICIALS LEARN ABOUT AIR POLLUTION. Environ. Sci. Technol., 3(5):429-430, May 1969.

The first union sponsored, national conference on air pollution was held in Washington, D. C. by the United Steelworkers of America in cooperation with federal officials of the National Air Pollution Control Administration. A primary purpose for the conference was to inform the district and local union officials present of the role they, and their respective unions and communities, play in U. S. pollution abatement. The conference stressed the idea that more responsible citizen participation is a must in curbing air pollution, and that the union officials are in a key position to encourage such participation.

26303

Creer, Ralph N., Robert M. Gray, and Michael Treshow

DIFFERENTIAL RESPONSES TO AIR POLLUTION AS AN ENVIRONMENTAL HEALTH PROBLEM. J. Air Pollution Control Assoc., 20(12):814-818, Dec. 1970. 8 refs.

An attempt was made to determine what influence, if any, economic dependence would have upon one's perception of a pollution problem relative to its seriousness and perceived control effort. The stud is based upon the proposition that the public, in the final analysis, is going to play a major role in determining future programs for dealing with air pollution as well as other environmental health problems. Central to this premise is the notion that people must first recognize a given condition as a problem before they can be expected to respond accordingly, and that their value judgments concerning the problem will affect their willingness to support programs designed to prevent such a condition. Principles of cognitive dissonance were used to predict how individuals would perceive a given problem based on the amount of dissonance or strain they experience as a result of economic dependence upon a local source of air pollution. As propounded by Festinger, the theory of cognitive dissonance states that prolonged inconsistency between the actions and beliefs of a human being creates strain or dissonance which in turn tends to affect one's perception, causing him to selectively perceive or misperceive the various aspects of a problem situation. A small Utah community of approximately 7000 people was selected, since it was only a short distance from a large steel plant which employed an estimated 40% of the town's population. Eighty percent in the low economic dependence group of a random sample of the population were highly 'bothered' compared to only 19% in the high economic dependence group.

N. GENERAL

03341

PERTINENT CHARACTERISTICS OF THE IRON AND STEEL INDUSTRY AS RELATED TO AREA REDEVELOPMENT. Dept. of Commerce, Washington, D.C. 60 pp., Nov. 1964 GPO, 0-753-200

Study represents an initial effort at determining specific characteristics for a specific industry (iron and steel industry) under consideration by the area redevelopment program. The main points of the study are: markets and growth factors; capacity utilizatio(; employment characteristics of the Steel Industry; Steel Industry Location; Product Groups and; Implications for the Area Redevelopment Agency Policy on Iron and Steel Projects.

06146

W. Rayher* and J. T. Middleton

THE CASE FOR CLEAN AIR (SPECIAL REPORT). Mill Factory 80,(4) 41-56, Apr. 1967.

The introduction in the form of a series of questions put to Dr. Middleton is of special interest in indicating the forward thrust of the Federal government in air pollution control since he is the Director of the National Center for Air Pollution Control which has the responsibility for the administration of the Federal air pollution control laws and regulations. His answers indicate vigorous activity by the Federal authorities where local authori- ties fail to act. The major provisions of the proposed Air Quality Act of 1967 are outlined as well as the existing Federal authority under the Clean Air Act of 1963. With this back- ground of increased Federal activity and especially with the issuance of emission standards, this definitive review continues with an outline of the various types of air pollutants, their sources, and the accepted methods of control. In the section covering what is being done by industry today, examples are given of the control measures in effect at a rubber processing plant, a cement plant, steel plant, and a foundry.

21287

MAINTENANCE OF CLEAN AIR. (Reinhaltung der Luft). Text in German. Oel Gasfeuerung, 14(10):1020-1024, 1969.

The major sources of air pollutants are industries, vehicles, and domestic heating. In the industrial sector, power plants, cement kilns, steel plants, and the chemical industry are the primary sources for pollution. Air pollutants may affect humans, animals, and plants. The harmfulness of dusts is determined by their composition, grain size, and shape. Fine dust particles which penetrate into the lungs are particularly dangerous. Soot requires special attention because it may be a carrier of toxic and carcinogenic substances. The most dangerous gaseous pollutants are carbon monoxide, sulfur dioxide, fluorine, chlorine, and unburned hydrocarbons. The federal government is sponsoring a program of air monitoring and research and development; it took legal measures to avoid or reduce air pollution. Large industrial plants must fulfill stringent regulations laid down in the 'Technical Directives for the Maintenance of Clean Air'. The federal law on preventive measures for the maintenance of clean air requires the installation of automatic measuring stations in industrial centers. Automobile exhausts, too, will soon be subject to regulations.

AUTHOR INDEX

A

ABDEL'RAZIK, F A-10466
ACHTERFELD H C-14774
ADAMS R W *B-23808
ADLER P *G-28556
AGATA Y A-17252
AKERLOW E V *B-17141
AKERLOW, E. V. *B-05307
ALLEN, G L *B-03754
ANTIPIN V G A-13261
ANTIPIN, V G *C-10461
ARAI K *B-17234
ARMSTRONG W D G-28556
ASANO S B-33416
ATSUKAWA M *B-32817
AYER F A J-30696

B

BABA T A-17299
BAETJER A M *G-28042
BARNEA M *A-14799
BARNES T M A-28604
BARTECEK J *B-28905
BASSE B *B-17151
BASSE, B *B-00037
BASSETT B A J-24543
BATINA T L C-17425
BAUM, K *B-10462
BEHRENDT A *B-20226
BEIGHTON, J *B-07925
BEISER, F R B-04227
BELL A *G-22118
BELL M E G-28556
BELL, A *G-05146
BENZ, D L *B-01110
BERGMANN, P *B-08310
BHUSSRY B R G-28556
BILLINGS, C E *B-07521, *B-07617
BINGHAM T E J-30696
BINTZER W W *B-17913
BINTZER, W W *B-07192
BIRD, R B-01110
BIRSE, E A B *L-06863
BISHOP C A *B-17154
BLASKOWSKI, H J *J-08689
BOGATENKOV V F A-13261
BOGATENKOV, V F B-10479
BOGDANDY, L V *A-10463
BORISENKOVA, R V *G-10396
BOTHE R *B-23245, *B-25500
BRAGINETS N G B-24809, *B-33897
BRAMER H C *B-33168
BRAMER, H C B-02193
BRANDT, A D *B-02728
BRAZGIN, I A F-08439
BRIEF, R S *B-06098
BROMAN C U *B-16652
BROMAN, C *B-00322
BROMAN, C U *B-09361
BROOKS S H *B-34079
BROUGH J R *B-33548
BROWER M A A-26166
BRUDERLE, E U *B-10464
BUETTNER W G-28556
BYE, W E G-00021

C

CAHN D S *B-29083
CALACETO, R R B-06587
CALVERT W J B-34079
CAMPBELL W W B-17154, *B-17568
CAMPBELL, W W *B-06083
CARNEY D J *C-17425
CARTER W A B-33548
CARTER, C O G-11575
CELENZA G J *B-20699
CHAMBERLIN, R L *B-02031
CHAPMAN, H M *B-02730
CHOLAK, J *D-00038
CHOLEWA L *G-32079
CLENDENIN, J D *A-08392
COCKS, G G B-04050
COLCLOUGH T P *A-24928
COSBY, W T B-07660
COULTER R S *B-17138
COY, D W B-06936
CREER R N *M-15567, *M-26303
CREMER H D G-28556

D

DAVID, P A G-11575
DAVIES, E *B-07660
DEACON A J C-17425
DEMOLE V G-28556
DOUGLAS, I H *B-07661
DUKELOW, D A A-04001
DUMOND FILLON, J B-07670
DUPREY, R L *A-09686

E

EBERHARDT J E *B-15886
EGLEY B D *B-24676
EGORICHEV A P *A-29021
EGOROVA, T S *G-08441
EISENBARTH M *B-16351
EITO T B-32817
ELLIOTT A C *B-31589
ELLIOTT, A C *B-04382
ERICSON Y G-28556
ERTL, D W *B-07931
ETTERICH, O A-10471

F

FERNSCHILD, D *B-03206
FLOSSMANN, R B-09270
FLUX J H *C-22934
FOGEL M E J-30696
FOUMENTEZE J L *C-20434
FUKUOKA S A-17252
FULLERTON R W B-17568
FULLERTON, R W B-06083

G

GAVRISH V A I-24417
GAW R G *B-17127
GEDALIA I G-28556
GEDGAUDAS M J *A-12396
GENY P *B-27783
GERBER R B *B-33170
GERSTLE R W J-30696
GIEVER P M *A-32489
GLINKOV M A *B-26018
GORMAN P G A-27501
GRAHAM H S B-15886
GRANVILLE R A *B-34082, C-33953
GRAUE, G *B-09270, *D-10618
GRAY R M M-26303
GREAVES, M J *B-03998
GROBEL E A *B-25521
GUTHMANN K *B-21894

H

HAHN, A B-10462
HALL H T *B-31773
HAMMOND, W F *B-09796
HANGEBRAUCK, R P *A-05005
HANNAN D G B-27727
HARADA G S *B-26003
HARHAI, J G *A-04001
HARMS, F *A-10467
HARRIS, E R *B-04227
HASHIMOTO H *B-34071
HASHIMOTO K *B-20096
HAUSKNECHT E G *B-32134
HAYASHI T *B-15649
HAZARD H R *B-32037
HEISCHKEIL W *A-28062
HELLER A *D-23391
HENSCHEN, H C *B-06392
HERRICK R A *B-16039
HICKEY, E C B-07521
HIGH, M D G-00021
HILL E L J-30696
HIPKIN A S *B-17746
HIPP N E *B-20227
HIPP, N E *B-09974
HOAK, R D *B-02193
HOFF H *B-20280
HOFF, H *B-07663, *B-10469
HOLLAND, M *B-07664
HUMMELL, J D B-04050
HUNT, M *B-05509
HUNTER D L B-17154
HUNTINGTON, R G *B-11073
HURST, T B *B-09977
HUYSMAN M *B-14889

I

IGARASHI I B-26854
IMANO S A-17252
INAGAKI K *B-26546
ISELI R R B-16652

ISELI, R R B-09361
ISHINISHI N A-17299

J

JACKSON R *C-33953
JAWORSKI H K J-24543
JEDRYCHOWSKI W G-32079
JEFFES J H E F-13084
JESDINSKY, W B-08310
JOHNSON, J E *B-06854
JONES W P *B-16695
JORDAN W VON *B-04794

K

KAHNWALD, H *A-10471
KALYUZHNIY, D N *B-00104
KAMEI K B-32817
KAMPHAUS H C-14774
KARZARINOFF A *B-24881
KATO Y *B-21324
KATORI Y A-17299
KAWAHATA K G-16223
KAWAMURA *B-31362
KIRKPATRICK J W B-17158
KLEINTOP, D R B-07192
KNOP W *A-17471
KOBAYASHI T *B-22138
KOCHETKOVA, T A G-10396
KODAMA F B-26854
KODAMA Y A-17299
KOSAKA, M *F-10473
KOVACH J L *B-27727
KOYANO T A-11974
KOZLOVA, A V G-10396
KRAUSE U A-30613, *A-31919
KUEHNERT K *B-30583
KULIKOV V O *B-24809
KUNITAKE E A-17299
KUNST A A-23977
KURKER, C JR B-07521
KURODA S *G-16223

L

LAFRENIERE A J B-31589
LAFRENIERE, A J B-04382
LAURENCE, K M *G-11575
LAWSON, A T B-05509
LEMAIRE, A B-04367
LEMKE E E *A-32351
LESOURD D A *J-30696
LEVENBAUM, L H B-07521
LEWIS R T B-25384
LIGHTNER M W B-17154
LINSKY B *J-21968
LOHSE, R B-03206
LOWE J R *B-17423
LOWNIE H W JR *A-28604
LUEDTKE, K D B-09796

M

MAATSCH J *C-14774
MAATSCH, J B-07663
MACDONALD R C *J-24155
MAEHARA S *B-26854
MAKARETS G N B-16446
MARKOV B L A-13261
MASEK V *A-26321, *A-28371
MASEK W *A-30598
MASSINON J *B-16561
MATSUDA K A-11974
MATSUDA N *B-19210
MATSUMOTO H B-33918
MAUBON A B-14889
MAZINA, D V *G-08575
MCCABE, L C B-03754
MEEKER, J E A-05005, D-05623
MELDAU, R *A-10474, *B-09915
MIDDLETON, J T N-06146
MILLER, C E *A-09572
MINOWA, S F-10473
MIQAWI, M *A-10466
MITCHELL, R T *B-07668
MOODIE, G B-02031
MORCINEK P *B-33081
MOREKHINA N M B-26018
MORITA S B-26854
MORITA, S *B-07669, *B-10477
MUHLRAD, W *B-09248
MURAKAMI M A-17516

N

NAGEL, H D-10618
NAKAMURA K *A-31935
NAMY, G *B-07670
NANCE, J T B-09796
NARIKAWA H *B-16553
NARITA K *B-27779
NARITA, S B-10477
NEUHOF G *A-23458
NIKAMI K *A-11974
NISHCHII, R A *F-08439
NISHI S *B-31344
NISHIWAKI, M B-10477
NODA H *B-33416

O

ODAIRA T *A-17252
OKUMURA E *B-33918
OL KHOVSKAYA E I J-29186
OMI H B-26003
ORBAN, A R *B-04050
OSHIMA M *B-30534
OSHIO T *A-17199
OSTANOVSKII G R J-29186
OZOLINS, G *A-09737

P

PALEN A G P *B-22940
PALLINGER, J *B-05118
PARK W R A-27501
PARKER, C M *B-00323
PEARSE, D J B-05597
PERBIX, G W *A-04000
PETERSON H W *B-21355
PETRY J K *A-31737
PETTIT G A *B-15887
POTTINGER, J F *B-07699
POVOLOTSKII, D Y B-10479
PRIKHOZHENKO A E B-24809
PUNCH G *B-17115
PUNCH, G *B-04665, *B-07542
PURVANCE W T *B-23182

R

RAITMAN L N J-29186
RANDERSON D *D-24227
RAYHER, W *N-06146
REHMANN, C A-09737
REID G E *B-17152
RENGSTORFF G W P *A-20414, *B-16646, *B-19732
RENGSTORFF, G W *B-06611, F-10717
REUTER, G B-08310
RICHARD J *B-31195
RICHARDSON F D *F-13084
RICHARDSON H L *B-31316
RIEMANN, W A-10467
RIHA K *B-29945
RONDIA D *A-33279
ROSE, A H JR B-02229, B-06098
ROSHCHIN, I V *G-07472
ROWE A D *J-24543
RULLMAN, D H B-11073
RUMP G *A-23977
RYZHAVSKII A Z J-29186

S

SALLEE E E A-27501
SARUTA N *A-17299
SAWAMURA Y B-31092
SCHERTLER A B-33952
SCHLEICHER A R J-30696
SCHNEIDER, R L *B-05604
SCHOLZ H U *B-29740
SCHREIBER M *J-29923
SCHUENEMAN, J J *G-00021
SCHULDT, A F B-03232
SEBESTA W *A-30446
SEFCIK, A J J-08689
SEPTIER L G *B-34084
SEROKHVOSTOV, A L *B-10479
SHAFFER N R *A-26166
SHAFFER, L J D-00038
SHANNON L J A-27501
SHAPRITSKIY V N *B-16193
SHIDARA M *B-24239
SHIMADA G B-22138
SHIMADA S *B-31092
SHIMIZU H B-26003
SHINODA N B-32817
SILVERMAN, L *B-03677, *B-05567, B-07521, B-07617
SINGHAL R K *B-13811, *B-14161
SMALL, W D B-07617
SMITH J H *B-19792
SMITH, W M *B-06936
SMITHSON D J C-22934
SMITHSON R N C-22934
SNOWBALL, A F *A-04946
SOSIN M G-32079
SPAITE, P W *B-02229
SPECHT, R C *B-06587
SPEER E B *B-17118
SPENCELEY, G D *B-01137
SPLIETHOFF H *A-29348
SQUIRES B J *B-17926
STARITSKII V I A-29021
STEPHAN, D G B-06098
STEPHEN, D G B-02229
STORCH O *B-23628
SUGAHARA K B-31092
SULLIVAN J L G-22118
SULLIVAN R J *A-22000
SULLIVAN, J L *D-05145
SULLIVAN, R E *B-09436
SUMIN L M A-29021
SUNAVALA, P D *F-08572
SUZUKI Y *G-26577
SVIDRNOCH L *B-33040, B-33081

T

TABOR, E C *D-05623
TAGIRI K B-26854
TAGIRI, K B-10477
TALBOTT J A *B-26612
TALDYKIN I A A-13261
TAUDA F *G-26136

TERABE, M *D-07406
TERESHCHENKO A F I-24417
TEWORTE W *A-30296
THOM, G W *B-03232
THOMAS F A *B-17825
THOMAS G A-32351
TRESHOW M M-26303
TRIPLETT G *C-33045
TSUTSUMI T B-16553
TULCINSKY, S *B-04367

U

UEDA A *B-27553
UNDERWOOD G *B-23955
URBAN, G B-10464
UYS J M *B-17158

V

VACEK A *B-33952
VANDERGRIFT A E *A-27501
VARGA J JR *A-30698
VENTURINI J L *B-26332, *B-28497
VENTURINI, J L *B-11096
VIETS, F H B-03754
VINOKUROV I S *J-29186
VISHKAREV, A F A-10466
VON LEHMDEN, D J A-05005
VORONOV F D *A-13261
VYPOV A I *B-16446

W

WAKAMATSU S *C-15940
WANGERIN, D D *A-04345
WASILEWSKA J *A-30613, A-31919
WATANABE G *A-17516
WATANABE T *B-32848
WEBER E *B-23364
WEDIN B *A-26929
WEFRING K *G-24586
WERTHMOLLER, E B-08310
WESTERHOLM J R B-20227
WESTERHOLM, J R B-09974
WHEELER, D H *B-05597, *B-06443
WHITMAN, K B B-07664
WILCOX M S *B-25384
WILKINSON, F M *B-09198
WILL G B-21894
WILLET H P *B-16681
WILLETT, H P *B-05091
WILLIAMS, D I T B-01137
WOEHLBIER, F H *F-10717
WOOD A H *B-28221

Y

YAMAGUCHI T *B-32791
YAMAMOTO K O B-26003
YAMAWAKI K A-17516
YASUI T A-11974
YAVOISKII, V I A-10466
YEAGER, D D-00038
YOCOM, J E *I-07553
YOKOI M B-22138, *B-31486, *B-33401
YOKOMIYO, K *B-06223
YOSHIZAKI K *G-31664
YOUNG, P A B-07670
YUDOVICH YU M J-29186
YUZVENKO YU A *I-24417

Z

ZABICKI J G-32079
ZDENEK Z *B-33438
ZIMMER, K O *B-10460
ZIPKIN I G-28556
ZOLOTUKHIN S T J-29186

SUBJECT INDEX

A

ABATEMENT A-29021, A-32351, B-11096, B-16193, B-31195, B-31226, G-24212, J-09313, J-21300, J-24155, J-26623, J-30951, M-18022, N-06146
ABSORPTION A-26929, B-16351, B-33918, D-10618, N-06146
ABSORPTION (GENERAL) B-16681, B-17234, B-22138, B-32817, B-33401, B-33918
ACETYLENES B-07925, B-31803
ACID SMUTS B-16695
ACIDS A-04946, A-09686, A-09737, A-17471, A-27790, A-30296, A-31935, A-32351, B-05091, B-05567, B-06587, B-07925, B-07931, B-20248, B-31316, B-33918, D-05145, G-08232, G-28042, I-07553, J-09313, J-30696
ACUTE G-28042, G-32842
ADHESIVES B-31092
ADMINISTRATION A-02146, A-04946, A-09737, A-17299, A-27790, A-28604, A-29021, A-32351, B-00104, B-02193, B-06249, B-11096, B-16146, B-16446, B-16561, B-20096, B-20248, B-31195, B-32037, D-05145, D-05623, D-23391, J-09313, J-21300, J-24155, J-26623, J-30951, L-06863, M-15567, N-06146
ADSORPTION B-27727, D-10618, N-06146
ADSORPTION (GENERAL) B-17234
AEROSOL GENERATORS B-09974
AEROSOLS B-03677, B-05567, B-07521, B-27727, G-07472
AFRICA B-07931
AFTERBURNERS B-07663, B-07925, B-10469, J-21968, N-06146
AGE G-08441, G-31664, M-15567
AIR POLLUTION EPISODES A-32351, G-24212
AIR POLLUTION FORECASTING A-27501
AIR QUALITY MEASUREMENT PROGRAMS A-09737, A-17299, A-27790, A-32351, B-16146, D-05145, D-05623, M-15567
AIR QUALITY MEASUREMENTS A-04946, A-05005, A-09737, A-10467, A-10471, A-12396, A-17299, A-22872, A-26321, A-27501, A-27790, A-28371, A-28604, A-30598, A-30613, A-31919, B-01110, B-04050, B-06780, B-07669, B-09248, B-10460, B-10462, B-23364, B-26018, B-26546, B-33040, B-33438, C-33953, D-00038, D-05145, D-05623, D-07406, D-10618, D-23391, D-24227, F-08439, F-10473, G-00021, G-07472, G-08441, G-22118
AIR QUALITY STANDARDS A-32351, B-06780, G-08232
AIR-FUEL RATIO A-33930, B-03754, B-26612, F-08572
AIRCRAFT A-32351
ALABAMA D-05623
ALCOHOLS B-02193
ALDEHYDES A-09686, G-24212
ALERTS A-32351, G-24212
ALIPHATIC HYDROCARBONS B-06611, B-07925, B-16646, B-19732, B-31803
ALKALINE ADDITIVES B-17234, B-20248, B-23182, B-31316, B-31486, B-32817
ALUMINUM A-09686, A-17471, A-26166, A-30296, A-31935, B-03754, B-06587, B-07925, B-16446, B-19210, B-20248, B-21324, B-33918, C-33045, G-26136, J-29923, J-30696
ALUMINUM COMPOUNDS A-26321, A-32489, B-07925, B-20248, F-13084
ALUMINUM OXIDES A-17471, A-28371, B-05604, B-09796, B-20248, F-08439, G-00021, G-10396
AMMONIA A-09686, B-07699, B-30534, B-31486, B-32817, B-33401
AMMONIUM COMPOUNDS A-04946, A-09686, B-07699, B-30534, B-31486, B-32817, B-33401
ANALYTICAL METHODS A-04000, A-05005, A-22000, B-10460, B-20248, B-32791, B-33168, B-34079, C-14774, C-15940, D-00038, D-05145, D-10618, D-24227, I-07553
ANIMALS A-31737, A-31935, B-06587, G-00021, G-07472, G-08232, G-10396, G-28042, G-32842
ANNUAL A-09737, A-27790, A-31919, B-34079, G-31664, G-32842
ANTHRACENES A-05005
ANTIMONY COMPOUNDS B-09796
AREA SURVEYS A-09737, A-17299, A-27790, A-32351, B-16146, D-05145, D-05623
AROMATIC HYDROCARBONS B-07925
ARSENIC COMPOUNDS A-28371
ASBESTOS B-03754, B-13946, G-24212
ASHES A-04345, B-07925, D-05145
ASIA A-11974, A-17199, A-17252, A-17299, A-17516, A-27790, A-31935, B-07669, B-10477, B-13645, B-15649, B-16146, B-16553, B-17234, B-19210, B-20096, B-21324, B-22138, B-24239, B-26003, B-26546, B-26854, B-27553, B-28547, B-30534, B-31092, B-31344, B-31362, B-31486, B-32791, B-32817, B-32848, B-33401, B-33416, B-33918, B-34071, C-15940, D-07406, F-08572, F-10473, G-16223, G-26136, G-26577, G-31664, G-32842, J-30951
ASPHALT A-05005, A-09686, A-32351, B-13946, C-33045, J-30696
ASPIRATORS A-30598, B-10460
ASTHMA D-07406, G-05146, G-22118, G-24212
ATMOSPHERIC MOVEMENTS A-04946, A-27790, A-32351, D-00038, D-05145, D-05623, D-23391, D-24227, G-11575, G-22118
ATTACK RATES G-08441
AUSTRALIA B-07699, D-05145, G-05146, G-22118
AUTOMATIC METHODS C-14774, G-22118
AUTOMOBILES A-05005, A-09686, A-32351, D-07406, G-24212, J-30696, N-21287
AUTOMOTIVE EMISSION CONTROL A-32351, A-33930, B-03754, B-05091, B-26612, F-08572, J-30696
AUTOMOTIVE EMISSIONS A-05005, A-09686, A-17299, A-32351, D-07406, D-24227, N-21287

B

BAFFLES B-06854, B-09270, B-33168, N-06146
BAG FILTERS A-02146, A-17252, A-26166, B-01110, B-02031, B-02229, B-02730, B-03754, B-06083, B-06098, B-06223, B-06568, B-06780, B-07192, B-07661, B-07925, B-08310, B-09248, B-09436, B-09796, B-10469, B-11096, B-15887, B-16039, B-16193, B-17746, B-20226, B-20699, B-21324, B-21894, B-23364, B-23955, B-24239, B-24881, B-25384, B-26195, B-26332, B-26612, B-27553, B-28221, B-28497, B-28547, B-28905, B-31195, B-31226, B-31344, B-32791, B-33548, B-34079, D-10618, G-00021, J-21968, J-29186
BARIUM COMPOUNDS B-09796
BASIC OXYGEN FURNACES A-04000, A-04001, A-04345, A-09686, A-09737, A-11974, A-22000, B-00323, B-02728, B-03232, B-04367, B-04665, B-05091, B-05509, B-05597, B-06392, B-06780, B-07542, B-07661, B-07663, B-07668, B-07669, B-07670, B-07925, B-09198, B-09248, B-09270, B-09915, B-09977, B-10460, B-10462, B-10469, B-10477, B-17127, B-19732, B-19792, B-20699, B-23808, B-31195, B-31226, C-33045, D-10618, F-10473, G-00021, J-08689, J-24543, L-06733, N-03341
BATTERY MANUFACTURING G-32842
BELGIUM A-33279, B-04367, B-16561, B-21894
BENZENE-SOLUBLE ORGANIC MATTER A-05005, D-05623
BENZENES B-07925
BENZO(3-4)PYRENE A-05005, A-28371, A-30598, A-33279
BENZOPYRENES A-05005, A-26929, A-28371, A-30598, A-33279
BERYLLIOSIS A-04000, B-00322, B-01110, B-03232, B-04050, B-06223, B-07664, D-00038, G-00021
BESSEMER CONVERTERS A-09686, A-20414, A-23977, B-04050, B-06611, B-07542, B-07699, B-09796, B-17115, B-19732, B-20699, B-21894, B-26854, B-32791, C-33045, G-00021, G-07472, N-03341
BIOMEDICAL TECHNIQUES AND MEASUREMENT G-05146, G-07472, G-08232, G-08441, G-08575, G-10396, G-11575

BIRMINGHAM,ALABAMA D-05623
BLACK LIQUOR OXIDATION A-04345, B-05091
BLAST FURNACES A-04345, A-09572, A-09686, A-09737, A-23977, A-28371, A-30613, A-33279, B-00037, B-02193, B-02728, B-03998, B-04794, B-06568, B-07931, B-09974, B-13811, B-15886, B-16553, B-16681, B-16695, B-17151, B-17152, B-17158, B-17234, B-17423, B-17568, B-20096, B-20226, B-20227, B-20699, B-21894, B-24239, B-26018, B-26546, B-27553, B-31092, B-31195, B-31316, B-31362, B-33168, C-17425, C-33045, D-00038, F-08572, F-10717, G-00021, G-08575, I-24417, K-16228, L-06733
BLOOD PRESSURE G-32842
BLOWBY A-32351
BODY CONSTITUENTS AND PARTS G-05146, G-08232, G-08441, G-10396, G-11575
BODY PROCESSES AND FUNCTIONS B-06587, G-05146, G-07472, G-08232, G-08441, G-08575, G-11575
BOILERS A-04345, A-05005, A-23977, A-32351, B-02728, B-04665, B-05091, B-05118, B-07699, B-07925, B-09436, B-10460, B-10469, B-26546, B-30583, B-31316, B-33952, B-34079, D-10618, J-08689, J-30696
BONES A-31935, G-28556, G-32842
BREATHING G-05146, G-32079
BRICKS B-06587, B-19210, B-32037, I-07553, J-30696
BROMINE D-24227
BRONCHI G-10396
BRONCHITIS A-27790, G-05146, G-22118, G-31664, G-32079
BUBBLE TOWERS B-07925
BUDGETS B-20248, J-09313, J-30951
BUSES D-07406
BY-PRODUCT RECOVERY A-30296, B-02193, B-03232, B-07668, B-07669, B-07670, B-09915, B-10477, B-16681, B-19210, B-22940, B-26003, B-26854, B-28905, B-29083, B-29945, B-30583, B-31092, B-31316, B-33081, B-33168, B-33438, B-33548, B-34071

C

CADMIUM A-22872, L-06863
CADMIUM COMPOUNDS A-17471, A-22872, G-32842
CALCIUM COMPOUNDS A-04001, A-26321, A-28371, A-30296, A-31919, B-01110, B-05604, B-06098, B-09248, B-09796, B-26003, B-33438, D-00038, F-13084, G-00021, G-28556
CALCIUM SULFATES D-00038
CALIFORNIA A-32351, B-03754, B-05307, B-11096, D-07406, J-09313
CANADA A-04946, B-06249, B-31589
CANCER A-33279, G-16223, G-31664, G-32842
CARBIDES A-10466
CARBON BLACK A-05005, A-08392, A-10466, A-10467, A-10471, A-10474, A-30613, B-02229, B-10469, B-10479, B-27727, B-31773, B-33170, F-10473, G-07472
CARBON DIOXIDE A-10467, A-10471, A-11974, A-32489, B-04367, B-06392, B-06611, B-07660, B-07661, B-07664, B-07670, B-09248, B-10469, B-27553, B-31226, C-17425, F-08572, F-10473, G-00021, I-07553
CARBON DISULFIDE B-07925, F-13084
CARBON MONOXIDE A-09686, A-09737, A-10463, A-10467, A-10471, A-10474, A-11974, A-29348, A-32351, A-32489, B-04367, B-04665, B-05091, B-06392, B-06611, B-07660, B-07661, B-07663, B-07664, B-07669, B-07670, B-09198, B-09248, B-09977, B-10462, B-10469, B-10477, B-14889, B-16681, B-20280, B-23364, B-23808, B-25500, B-26612, B-26854, B-27553, B-28880, B-31226, B-32791, C-17425, D-07406, F-08572, F-10473, F-10717, G-00021, G-08441, G-08575, G-24212, G-28042, J-09313, J-30696, N-06146, N-21287
CARBONATES A-31919, B-03232, B-20248, B-26003, I-07553
CARBONYLS B-07617
CARCINOGENS A-33279, B-01110, D-00038, G-00021
CARDIOVASCULAR DISEASES G-24212, G-31664
CASCADE SAMPLERS A-17252
CATALYSIS A-05005, B-22940
CATALYTIC AFTERBURNERS B-07925, N-06146
CATALYTIC OXIDATION A-04345, B-05091, B-30534, B-31316, N-06146
CATTLE A-31935, B-06587
CELL GROWTH G-31664
CEMENTS A-08392, A-09737, A-26929, A-27501, B-02031, B-02229, B-07699, B-07931, B-13946, B-16446, B-19210, B-23364, B-24881, B-26003, B-29083, B-31803, B-32037, B-32848, B-33170, C-33045, D-07406, D-24227, J-30696, L-06863, N-06146, N-21287
CENTRIFUGAL SEPARATORS A-02146, A-05005, A-09686, A-29021, B-03754, B-06587, B-07521, B-10469, B-11073, B-13946, B-17746, B-20699, B-23182, B-23364, B-24239, B-24881, B-26546, B-31226, B-31344, B-32791, B-33040, B-33438, B-33897, B-34079, C-33953, J-21968, J-26623, K-16228, N-06146
CERAMICS A-09686, A-30296, B-06587, B-07925, B-26546, B-32037
CERIUM COMPOUNDS F-13084
CHAMBER PROCESSING B-07925, D-05145
CHARCOAL A-08392, A-10467, B-10469, B-30534
CHEMICAL COMPOSITION A-04946, A-05005, A-10467, A-10471, A-26321, A-28371, A-30598, A-30613, A-31919, B-04050, B-07669, B-09248, B-10460, B-10462, B-26018, B-33040, B-33438, D-05623, D-07406, F-08439, F-10473
CHEMICAL METHODS A-04000, B-10460
CHEMICAL PROCESSING A-04345, A-04946, A-05005, A-08392, A-09686, A-09737, A-17199, A-26929, A-27790, A-30296, A-32351, B-02728, B-04794, B-05091, B-07925, B-07931, B-16681, B-20248, B-26546, B-30583, B-31362, B-31803, B-32817, B-33918, C-33045, D-05145, D-23391, D-24227, G-31664, I-07553, J-09313, J-21300, J-21968, J-29923, J-30951, L-06863, N-21287
CHEMICAL REACTIONS A-10463, A-10466, A-10471, A-10474, A-17252, A-32351, B-02229, B-07192, B-09796, B-09915, B-10469, B-20280, B-22940, B-30534, B-32037, F-08439, F-08572, F-10473, F-10717, N-06146
CHICAGO J-09313
CHILDREN G-08441, G-24212, G-31664
CHLORIDES A-32489
CHLORINE A-09686, B-30534
CHLORINE COMPOUNDS A-32489, N-21287
CHLOROPLASTS B-03754
CHROMATOGRAPHY A-05005, I-07553
CHROMIUM A-10471, B-07661, F-08439, L-06863
CHROMIUM COMPOUNDS B-07661, B-09796, B-15887, B-31773, F-08439, G-07472, I-07553
CHRONIC A-27790, G-10396, G-26136, G-28042, G-32079, G-32842
CITRUS G-00021
CITY GOVERNMENTS A-27790
CLEAN AIR ACT B-07542, B-07925, G-08232, N-06146
COAL A-05005, A-08392, A-09572, A-09686, A-09737, A-13261, B-02031, B-03232, B-07699, B-07925, B-07931, B-31226, B-31344, B-31803, B-33170, C-33045, D-10618, G-08232, G-26136, I-07553, J-30696
COAL CHARACTERISTICS A-09737
COAL PREPARATION A-08392, B-20248, B-31803
COAL TARS G-16223
CODES B-06780, B-11073
COFFEE-MAKING A-09686, B-13946
COKE A-05005, A-08392, A-09572, A-09737, A-28604, A-30446, A-33930, B-02193, B-02728, B-07925, B-31195, B-31226, B-31316, B-31344, B-33168, B-34079, F-08572, G-00021, G-08232, L-06733
COLLECTORS A-02146, A-05005, A-09686, A-29021, A-31919, A-31935, B-01110, B-02031, B-03754, B-05509, B-06223, B-06443, B-06568, B-06587, B-06854, B-06936, B-07521, B-07542, B-07664, B-07669, B-09270, B-10469, B-10477, B-11073, B-11096, B-13946, B-14161, B-14889, B-15649, B-16553, B-17234, B-17746, B-17913, B-20280, B-20699, B-21324, B-23182, B-23245, B-23364, B-23628, B-24239, B-24881, B-25384, B-26546, B-27553, B-27783, B-28880, B-29945, B-31092, B-31226, B-31344, B-32791, B-33040, B-33168, B-33401, B-33416, B-33438, B-33548, B-33897, B-34079, C-33953, D-00038, D-10618, J-21968, J-26623, J-29923, K-16228, N-06146
COLORIMETRY D-05145
COLUMN CHROMATOGRAPHY A-05005
COMBUSTION A-05005, A-10474, A-24928, A-29348, B-05597, B-06223, B-07660, B-07663, B-07699, B-10469, B-28880, F-08572, F-10473
COMBUSTION AIR A-04345, A-33930, B-05091, B-06780, B-07664, B-09796, B-09977, B-26612, B-29740, B-32037
COMBUSTION GASES A-04946, A-05005, A-09686, A-09737, A-10467, A-10471, A-11974, A-14799, A-17252, A-17516, A-24928, A-29021, A-29348, A-30446, A-30613, A-30698, A-31919, A-32489, A-33930, B-01137, B-03677, B-03754, B-04050, B-04227, B-04794, B-05567, B-06223, B-06611, B-06780, B-06854, B-07660, B-07661, B-07663, B-07664,

B-07925, B-07931, B-09796, B-09974, B-09977, B-10460, B-10462, B-10464, B-10469, B-10477, B-13645, B-14889, B-16553, B-17152, B-17154, B-17746, B-17825, B-20096, B-20226, B-20280, B-20699, B-22138, B-22940, B-23182, B-24239, B-24676, B-26018, B-26195, B-26546, B-26854, B-28547, B-29083, B-29740, B-29945, B-30534, B-30583, B-31226, B-31316, B-31486, B-32134, B-32817, B-33040, B-33081, B-33168, B-33170, B-33401, B-33438, B-33897, B-33918, B-33952, B-34079, B-34082, C-10461, C-14774, C-33045, D-05145, D-07406, D-10618, D-23391, F-08572, G-08441, G-32842, I-07553, I-24417, J-21300, J-26623, K-16228

COMBUSTION PRODUCTS A-02146, A-04345, A-04946, A-05005, A-09686, A-09737, A-10467, A-10471, A-11974, A-14799, A-17252, A-17516, A-24928, A-29021, A-29348, A-30446, A-30613, A-30698, A-31919, A-32489, A-33930, B-00037, B-01137, B-03677, B-03754, B-04050, B-04227, B-04794, B-05567, B-06223, B-06392, B-06611, B-06780, B-06854, B-07660, B-07661, B-07663, B-07664, B-07925, B-07931, B-09796, B-09974, B-09977, B-10460, B-10462, B-10464, B-10469, B-10477, B-13645, B-14889, B-16553, B-16561, B-17152, B-17154, B-17746, B-17825, B-20096, B-20226, B-20280, B-20699, B-22138, B-22940, B-23182, B-24239, B-24676, B-26018, B-26195, B-26546, B-26854, B-28547, B-29083, B-29740, B-29945, B-30534, B-30583, B-31226, B-31316, B-31486, B-32037, B-32134, B-32817, B-33040, B-33081, B-33168, B-33170, B-33401, B-33438, B-33897, B-33918, B-33952, B-34079, B-34082, C-10461, C-14774, C-33045, D-05145, D-07406, D-10618, D-23391, F-08572, G-08441, G-32842, I-07553, I-24417, J-21300, J-26623, K-16228

COMMERCIAL AREAS A-17299

COMMERCIAL EQUIPMENT B-00322, B-01110, B-16681

COMMERCIAL FIRMS A-02146, B-16681, B-24239, B-31195, J-30951

COMMON COLD G-05146, G-22118

COMPLAINTS D-23391

COMPOSTING B-05091

COMPRESSION B-07660

COMPUTER PROGRAMS A-04001

CONCRETE A-09686, A-32351, B-03754, C-33045

CONDENSATION A-10463, B-07660, B-33081

CONDENSATION (ATMOSPHERIC) D-05145, G-08232

CONSTRUCTION MATERIALS A-05005, A-08392, A-09686, A-09737, A-26929, A-27501, A-32351, B-02031, B-02229, B-03754, B-06587, B-07699, B-07931, B-09915, B-13946, B-16446, B-19210, B-23364, B-24881, B-26003, B-29083, B-31803, B-32037, B-32848, B-33170, C-33045, D-07406, D-24227, I-07553, J-30696, L-06863, N-06146, N-21287

CONTACT PROCESSING B-07925, B-07931, B-31803

CONTINUOUS MONITORING A-05005, B-07669, B-07925, B-20248, B-34079, C-14774, C-17425, C-20434, D-05145, D-24227, G-22118

CONTROL AGENCIES A-27790

CONTROL EQUIPMENT A-02146, A-04345, A-04946, A-05005, A-08392, A-09686, A-10471, A-17252, A-22000, A-26166, A-28604, A-29021, A-30296, A-30446, A-31919, A-31935, A-32489, B-00037, B-00322, B-00323, B-01110, B-02031, B-02193, B-02229, B-02730, B-03206, B-03232, B-03677, B-03754, B-03998, B-04227, B-04367, B-04382, B-04665, B-04794, B-05091, B-05118, B-05307, B-05509, B-05567, B-05597, B-05604, B-06083, B-06098, B-06223, B-06392, B-06443, B-06568, B-06587, B-06780, B-06854, B-06936, B-07192, B-07521, B-07542, B-07617, B-07660, B-07661, B-07663, B-07664, B-07668, B-07669, B-07670, B-07699, B-07925, B-07931, B-08310, B-09198, B-09248, B-09270, B-09361, B-09436, B-09796, B-09974, B-09977, B-10460, B-10462, B-10464, B-10469, B-10477, B-11073, B-11096, B-13645, B-13811, B-13946, B-14161, B-14889, B-15649, B-15886, B-15887, B-16039, B-16193, B-16351, B-16446, B-16553, B-16652, B-16681, B-16695, B-17115, B-17118, B-17127, B-17138, B-17141, B-17151, B-17152, B-17154, B-17234, B-17423, B-17568, B-17746, B-17825, B-17913, B-17926, B-19210, B-19403, B-19792, B-20096, B-20226, B-20227, B-20248, B-20280, B-20699, B-21324, B-21355, B-21894, B-22138, B-23182, B-23245, B-23364, B-23628, B-23808, B-23955, B-24239, B-24676, B-24809, B-24881, B-25384, B-25500, B-26195, B-26332, B-26546, B-26612, B-27553, B-27727, B-27783, B-28221, B-28497, B-28547, B-28880, B-28905, B-29740, B-29945, B-30018, B-30534, B-31092, B-31195, B-31226, B-31344, B-31362, B-31486, B-31589, B-31803, B-32037, B-32134, B-32791, B-32817, B-32848, B-33040, B-33081, B-33168, B-33170, B-33401, B-33416, B-33438, B-33548, B-33897, B-33918, B-33952, B-34079, B-34082, B-34084, C-10461, C-14774, C-33045, C-33953, D-00038, D-10618, G-00021, G-26136, I-07553, J-08689, J-21968, J-24543, J-26623, J-29186, J-29923, K-16228, N-06146

CONTROL METHODS A-04345, A-04946, A-08392, A-09572, A-09686, A-23458, A-26166, A-26929, A-28604, A-29021, A-30296, A-30446, A-30598, A-30698, A-32351, A-33279, A-33930, B-00037, B-00104, B-01137, B-02193, B-02730, B-03232, B-03677, B-03754, B-04227, B-04382, B-04665, B-05091, B-05307, B-05597, B-05604, B-06098, B-06392, B-06443, B-06611, B-06780, B-07192, B-07521, B-07542, B-07617, B-07660, B-07663, B-07664, B-07668, B-07669, B-07670, B-07925, B-07931, B-09361, B-09796, B-09915, B-09974, B-09977, B-10462, B-10477, B-11096, B-13645, B-13946, B-16146, B-16193, B-16351, B-16561, B-16646, B-16652, B-16681, B-17118, B-17152, B-17158, B-17234, B-19210, B-19732, B-20248, B-20699, B-21894, B-22138, B-22940, B-23182, B-23364, B-24239, B-26003, B-26546, B-26612, B-26854, B-27727, B-27779, B-27783, B-28402, B-28497, B-28547, B-28905, B-29083, B-29740, B-29945, B-30534, B-30583, B-31092, B-31195, B-31316, B-31486, B-31773, B-31803, B-32037, B-32791, B-32817, B-32848, B-33081, B-33168, B-33401, B-33438, B-33548, B-33918, B-34071, B-34079, C-14774, D-10618, F-08572, J-21300, J-24543, J-29923, J-30696, K-33815, N-06146

CONTROL PROGRAMS A-04946, B-00104, B-02193, B-06249, B-11096, B-20096, B-20248, B-31195, J-09313, J-21300, L-06863, N-06146

CONTROLLED ATMOSPHERES B-30018

CONVECTION B-10469

COOLING A-10471, A-23977, B-01110, B-02229, B-04367, B-04665, B-07661, B-07669, B-07931, B-09248, B-09796, B-10469, B-10477, B-23808, B-25521, B-26612, B-28905, B-31362, B-33081, B-33438, B-33952, B-34079, J-08689

COPPER A-09686, A-17471, B-03754, B-07925, C-33045, D-05145, G-05146, G-22118, G-32842, I-07553, J-30696, L-06863

COPPER ALLOYS B-03754, C-33045

COPPER COMPOUNDS B-05604, B-07925, B-09796, F-13084, G-00021

CORE OVENS I-07553

CORONA B-09270

CORROSION A-31737, B-30583, G-08232, I-07553

COSTS A-09572, A-28062, A-28604, A-30698, B-01110, B-02031, B-05091, B-05509, B-06443, B-07192, B-07668, B-09248, B-09436, B-09977, B-10460, B-10464, B-10469, B-10477, B-16193, B-16351, B-16681, B-17127, B-17154, B-20226, B-23182, B-23955, B-24239, B-24881, B-25521, B-26854, B-27783, B-28497, B-30534, B-32134, B-33081, B-33416, B-34079, B-34082, D-24227, J-08689, J-09313, J-21300, J-21968, J-24155, J-24543, J-26623, J-29186, J-29923, J-30696, M-18022, N-03341, N-06146

COTTONS I-07553

COUGH G-05146, G-32079

CRACKING I-07553

CRANKCASE EMISSIONS A-32351

CRITERIA B-19403, N-03341, N-06146

CROPS B-02730, G-32842, J-09313

CRYSTAL STRUCTURE B-09915, F-08439

CUPOLAS A-09737, A-32351, A-32489, B-02229, B-03754, B-04794, B-05091, B-07925, B-13811, B-16681, B-20096, C-33045, F-08572, J-21968

CZECHOSLOVAKIA A-04000, A-04001, A-26321, A-28371, B-04050, B-23628, B-28905, B-29945, B-33040, B-33081, B-33438, D-00038

D

DATA ANALYSIS G-11575, M-15567

DATA HANDLING SYSTEMS A-04001, G-11575, M-15567

DEGREASING A-32351

DENSITY A-30613, B-27553, B-31803, B-33170

DEPOSITION B-06568, N-21287

DESIGN CRITERIA A-23977, B-02193, B-05118, B-05509, B-06443, B-07660, B-07664, B-07925, B-09248, B-09270, B-09436, B-09796, B-09977, B-10464, B-10469, B-14161, B-15649, B-15886, B-16652, B-17115, B-17118, B-17138,

B-17141, B-17154, B-17423, B-17568, B-17825, B-17913, B-17926, B-19792, B-20096, B-20226, B-20227, B-20280, B-23245, B-23808, B-23955, B-24809, B-25384, B-25521, B-27727, B-28497, B-29740, B-31362, B-33081, B-33170, B-33416, B-33918, B-34084, C-20434, C-22934, J-08689, J-24543
DESULFURIZATION OF FUELS A-08392, B-16146, B-20248, B-31803, B-32817, B-34079
DIAGNOSIS G-05146, G-16223
DIESEL ENGINES A-05005, A-09686, A-32351
DIFFRACTION F-08439
DIFFUSION A-10463
DIGESTIVE SYSTEM G-05146, G-08441, G-32842
DIOLEFINS B-07925
DISCOLORATION A-22000, I-07553
DISPERSION A-10463, A-17199, A-26929, A-30598, A-32489, B-01110, B-06568, B-13645, D-05145, D-23391
DISTILLATE OILS A-09737, A-33279
DIURNAL A-32351
DOMESTIC HEATING A-05005, A-08392, A-09737, G-08232, J-30696, N-21287
DONORA D-05623
DROPLETS A-10463, B-05118, I-07553
DRY CLEANING A-32351
DRYING B-26003, B-34079
DUMPS A-09737
DUST FALL A-04946, A-26321, B-23364, D-00038, D-05145, D-07406, D-10618, G-00021, G-07472
DUSTS A-02146, A-04345, A-05005, A-10463, A-10467, A-10471, A-13261, A-17471, A-26166, A-27790, A-28371, A-30598, A-30613, A-31919, A-32489, B-00323, B-01110, B-02031, B-02728, B-02730, B-03206, B-03232, B-03754, B-03998, B-04050, B-04227, B-04382, B-04794, B-05118, B-05509, B-05604, B-06083, B-06223, B-06392, B-06443, B-06568, B-06780, B-06854, B-06936, B-07192, B-07542, B-07661, B-07663, B-07664, B-07669, B-07699, B-07925, B-07931, B-08310, B-09248, B-09361, B-09436, B-09796, B-09915, B-09974, B-10460, B-10462, B-10464, B-10469, B-10477, B-10479, B-11096, B-13645, B-13811, B-13946, B-14161, B-14889, B-15886, B-15887, B-16039, B-16351, B-16446, B-16695, B-17127, B-17138, B-17151, B-17152, B-17154, B-17158, B-17423, B-17568, B-17746, B-17913, B-19403, B-19792, B-20096, B-20226, B-20227, B-20280, B-20699, B-21355, B-21894, B-22138, B-23245, B-23628, B-23955, B-24239, B-24809, B-25384, B-25500, B-26003, B-26018, B-26195, B-26332, B-26546, B-27553, B-27727, B-27783, B-28221, B-28497, B-28547, B-28880, B-28905, B-29083, B-29740, B-29945, B-30018, B-30583, B-31092, B-31226, B-31344, B-31486, B-31589, B-31803, B-32134, B-32791, B-32848, B-33040, B-33081, B-33170, B-33401, B-33416, B-33438, B-33548, B-33897, B-33918, B-33952, B-34071, B-34079, B-34082, B-34084, C-10461, C-14774, C-15940, C-22934, C-33953, D-00038, D-05145, D-07406, D-10618, D-23391, F-08439, F-10473, G-00021, G-08441, G-10396, G-22118, G-28042, G-28556, G-32842, I-24417, K-16228, N-06146, N-21287
DYE MANUFACTURING A-31737

E

ECONOMIC LOSSES A-27790, B-09436, J-09313, J-21968
ELECTRIC CHARGE B-07699, B-07931
ELECTRIC FURNACES A-09686, A-10467, A-10471, A-17252, A-32351, A-32489, B-01110, B-02229, B-02728, B-02730, B-03754, B-05091, B-05509, B-05597, B-06083, B-06098, B-07192, B-07542, B-07660, B-07661, B-07664, B-07925, B-08310, B-09796, B-10462, B-10464, B-11073, B-11096, B-15649, B-15887, B-17115, B-17138, B-17746, B-17913, B-17926, B-21355, B-21894, B-24239, B-25384, B-25521, B-26332, B-26546, B-26612, B-28497, B-28880, B-29740, B-33081, B-33416, B-33548, B-34071, B-34082, C-33045, D-10618, F-08439, G-00021, G-08441, G-26577, K-33815, L-06733, N-06146
ELECTRIC POWER PRODUCTION A-05005, A-08392, A-09737, A-17199, A-26929, A-27501, A-27790, A-32351, B-02031, B-07699, B-07925, B-07931, B-09977, B-10469, B-16681, B-21324, B-23955, B-24881, B-27727, B-31803, B-32817, D-07406, D-10618, G-08232, J-30696, J-30951, N-21287
ELECTRICAL PROPERTIES B-05307, B-07699, B-07931, B-09270, B-23955, B-32848, B-33170
ELECTRICAL RESISTANCE B-07699, B-07931, B-33170
ELECTROCONDUCTIVITY ANALYZERS D-05145
ELECTRON MICROSCOPY A-30598, F-08439
ELECTROSTATIC PRECIPITATORS A-02146, A-05005, A-09686, A-22000, A-26166, A-29021, A-31919, B-00323, B-02031, B-02730, B-03232, B-03754, B-03998, B-04382, B-04665, B-04794, B-05307, B-05597, B-05604, B-06098, B-06223, B-06392, B-06443, B-06568, B-06780, B-06936, B-07542, B-07664, B-07668, B-07699, B-07925, B-07931, B-09270, B-09796, B-09974, B-09977, B-10460, B-10462, B-10464, B-10469, B-11073, B-11096, B-13645, B-13811, B-13946, B-16351, B-16446, B-16553, B-17115, B-17118, B-17127, B-17138, B-17141, B-17746, B-19403, B-19792, B-20096, B-20248, B-20280, B-20699, B-21894, B-23182, B-23245, B-23364, B-23628, B-23955, B-24239, B-24676, B-24881, B-25500, B-26195, B-27553, B-28221, B-28547, B-31226, B-31344, B-31589, B-31803, B-32134, B-32848, B-33170, B-33438, B-33952, B-34079, B-34082, D-00038, D-10618, G-00021, J-08689, J-21968, J-24543, J-26623, J-29186, J-29923, K-16228, N-06146
EMISSION INVENTORIES A-09737, A-12396, A-22872, A-27501, A-28604, B-26546
EMISSION STANDARDS A-32351, B-06780, B-07542, B-17234, J-30696, K-16228, K-33815, N-06146
EMPHYSEMA G-32842, J-09313
ENFORCEMENT PROCEDURES B-31195
ENGINE EXHAUSTS A-05005, A-09686, A-32351, D-07406, N-21287
ENGINE OPERATION MODIFICATION A-33930, B-03754, B-05091, B-26612, F-08572
EPIDEMIOLOGY G-24212, G-24586, G-28042, G-32079
EQUIPMENT CRITERIA B-19403, N-03341
EQUIPMENT STANDARDS K-16228
ESTERS B-09248
ETHYLENE B-07925
EUROPE A-04000, A-04001, A-04345, A-10463, A-10466, A-10467, A-10471, A-10474, A-13261, A-14799, A-17471, A-23458, A-23977, A-26321, A-26929, A-28062, A-28371, A-29348, A-30296, A-30598, A-30613, A-31737, A-31919, A-33279, B-00037, B-00104, B-01110, B-02229, B-02730, B-03206, B-04050, B-04367, B-04665, B-04794, B-05118, B-06223, B-06568, B-06780, B-07542, B-07661, B-07663, B-07664, B-07668, B-07670, B-07925, B-07931, B-08310, B-09248, B-09270, B-09915, B-10460, B-10462, B-10464, B-10469, B-10479, B-13811, B-14161, B-14889, B-16193, B-16351, B-16446, B-16561, B-17115, B-17746, B-17926, B-19403, B-20226, B-20280, B-21894, B-22940, B-23245, B-23364, B-23628, B-23955, B-24809, B-25500, B-26018, B-27783, B-28221, B-28402, B-28880, B-28905, B-29740, B-29945, B-30583, B-31226, B-31773, B-33040, B-33081, B-33438, B-33897, B-33952, B-34079, B-34082, B-34084, C-10461, C-14774, C-20434, C-22934, C-33953, D-00038, D-10618, D-23391, F-08439, F-13084, G-07472, G-08232, G-08441, G-08575, G-10396, G-11575, G-24586, G-28556, G-32079, I-24417, J-21300, J-24543, J-29186, J-29923, K-16228, K-33815, L-06863, N-21287
EXCESS AIR A-33930, B-09796, B-26612, B-29740
EXCRETIONS G-28556
EXHAUST SYSTEMS A-04345, A-10471, B-01110, B-04367, B-04665, B-05091, B-05597, B-06083, B-06098, B-07192, B-07660, B-07661, B-07663, B-07664, B-07669, B-07670, B-08310, B-09198, B-09248, B-09436, B-09796, B-09977, B-10462, B-10464, B-10469, B-10477, B-11073, B-11096, B-13811, B-17115, B-17746, B-17913, B-17926, B-20699, B-23808, B-25384, B-26332, B-26612, B-27553, B-28497, B-29945, B-31344, B-32134, B-33168, B-33416, B-33548, J-08689, J-24543
EXPERIMENTAL EQUIPMENT A-04000, B-03677, B-09270
EXPERIMENTAL METHODS A-04000, A-10467, D-10618, F-10473, G-10396
EXPLOSIONS A-32489, B-10477, B-32848
EXPOSURE METHODS G-10396
EYE IRRITATION A-32351
EYES G-08232

F

FALLOUT G-11575
FANS (BLOWERS) B-01110, B-04665, B-05091, B-05597, B-07192, B-09248, B-09436, B-11096, B-17913, B-20699, B-23808, B-26332, B-26612, B-29945, B-31344, B-32134, B-33416
FARMS G-11575, G-31664
FEASIBILITY STUDIES B-09915

FEDERAL GOVERNMENTS B-07925, G-08232, J-09313, N-06146, N-21287
FEMALES G-05146, M-15567
FERTILIZER MANUFACTURING A-26929, A-31935, B-19210, D-24227, G-26136
FERTILIZING A-04946, A-08392, B-02730, B-06587, B-09915, G-32842
FIELD TESTS A-10467, A-10471, B-07521, B-07617, B-09974, B-10462, B-10477, B-10479, B-29945, C-33953, D-10618
FILTER FABRICS A-05005, A-09686, A-30296, B-02229, B-03677, B-03754, B-05567, B-06083, B-06780, B-07617, B-08310, B-09796, B-11073, B-11096, B-14161, B-16039, B-19210, B-20248, B-23955, B-26332, B-28497, B-31226, B-32037, B-33952, B-34079, B-34082, C-33045, G-00021, I-07553
FILTERS A-02146, A-05005, A-08392, A-09686, A-17252, A-22000, A-26166, A-29021, A-30296, B-01110, B-02031, B-02229, B-02730, B-03677, B-03754, B-05567, B-06083, B-06098, B-06223, B-06568, B-06780, B-07192, B-07521, B-07617, B-07661, B-07925, B-08310, B-09248, B-09436, B-09796, B-10464, B-10469, B-11073, B-11096, B-13946, B-14161, B-15887, B-16039, B-16193, B-16351, B-17115, B-17746, B-17926, B-19210, B-19403, B-20226, B-20248, B-20280, B-20699, B-21324, B-21894, B-23245, B-23364, B-23955, B-24239, B-24881, B-25384, B-26195, B-26332, B-26612, B-27553, B-27727, B-28221, B-28497, B-28547, B-28880, B-28905, B-30018, B-31195, B-31226, B-31344, B-32037, B-32791, B-33548, B-33952, B-34079, B-34082, C-10461, C-14774, C-33045, D-10618, G-00021, I-07553, J-21968, J-29186, N-06146
FIRING METHODS A-04345, A-09572, A-33930, B-01137, B-05091, B-06780, B-07664, B-07925, B-09796, B-09977, B-26612, B-29740, B-32037
FLAME AFTERBURNERS B-07925, B-10469, N-06146
FLARES B-04367, B-07925
FLOW RATES A-04345, B-01110, B-02730, B-05604, B-07670, B-23628, B-25500, B-27727, B-30583, B-31589, B-33170, C-22934, C-33045, I-24417
FLOWERS B-09915
FLOWMETERS A-10471
FLUID FLOW A-04345, B-01110, B-02730, B-04665, B-05118, B-05307, B-05597, B-05604, B-07670, B-09270, B-09361, B-23628, B-25500, B-27727, B-30583, B-31589, B-33170, C-22934, C-33045, I-24417
FLUORANTHENES A-05005
FLUORIDES A-17471, A-30296, A-31935, B-06587, B-07664, B-09796, B-19210, B-23182, B-33918, D-10618, G-00021, G-26136, G-28556, I-07553, J-30696
FLUORINATED HYDROCARBONS A-30296
FLUORINE B-04794, B-07664, J-29923
FLUORINE COMPOUNDS A-17471, A-30296, A-31935, B-06587, B-07664, B-07925, B-09796, B-19210, B-23182, B-33897, B-33918, D-10618, G-00021, G-26136, G-28556, I-07553, J-30696, N-21287
FLUOROSIS B-06587, G-26136, G-28556
FLY ASH A-04345, A-09686, B-03677, B-05567, B-07699, B-07925, G-24212
FOG G-08232
FOOD AND FEED OPERATIONS A-09686, B-13946, C-33045, J-30696
FOODS G-32842
FORESTS A-26929
FRANCE A-04001, B-14889, B-16561, B-27783, B-28880, B-34084, C-20434
FRUITS G-00021
FUEL CHARGING A-09572, A-33930
FUEL EVAPORATION A-32351
FUEL GASES A-05005, A-08392, A-09737, A-23977, A-32351, B-07925, B-10460, B-25521, B-31226, C-33045, F-08572
FUEL OILS A-05005, A-09737, A-27790, A-32351, A-33279, A-33930, B-05604, B-07925, B-09796, B-16146, B-31226, B-32817, C-33045, D-07406, G-08232, I-07553
FUEL STANDARDS B-32817
FUELS A-04345, A-05005, A-08392, A-09572, A-09686, A-09737, A-13261, A-23977, A-24928, A-27790, A-28062, A-28604, A-30446, A-30698, A-32351, A-33279, A-33930, B-02031, B-02193, B-02728, B-03232, B-05509, B-05604, B-07699, B-07925, B-07931, B-09796, B-10460, B-16146, B-25521, B-26546, B-31195, B-31226, B-31316, B-31344, B-31803, B-32817, B-33168, B-33170, B-34079, B-34082, C-10461, C-33045, D-07406, D-10618, F-08572, G-00021, G-08232, G-26136, I-07553, J-30696, L-06733, L-06863
FUMES A-04345, A-10463, A-10466, A-10467, A-10471, A-10474, A-26166, A-32489, B-00037, B-00322, B-00323, B-01110, B-01137, B-02229, B-02728, B-02730, B-03677, B-03754, B-04367, B-04382, B-04665, B-05091, B-05509, B-05597, B-06098, B-06443, B-06936, B-07192, B-07521, B-07542, B-07617, B-07660, B-07661, B-07664, B-07668, B-07670, B-07699, B-07925, B-09248, B-09361, B-09796, B-09915, B-09974, B-10462, B-10464, B-10469, B-10477, B-10479, B-11073, B-11096, B-13811, B-14161, B-16039, B-16652, B-16695, B-17115, B-17127, B-17138, B-17141, B-17151, B-17746, B-17913, B-17926, B-19792, B-20096, B-20699, B-21894, B-23955, B-25384, B-25521, B-26195, B-26332, B-26612, B-28221, B-28402, B-28497, B-28880, B-29945, B-31226, B-31589, B-31773, B-33548, B-33952, B-34079, B-34082, B-34084, C-22934, C-33953, D-10618, F-10473, G-00021, G-28042, G-32842, J-08689, K-33815, N-06146
FUNGI I-07553
FURNACES A-02146, A-04000, A-04001, A-04345, A-05005, A-09572, A-09686, A-09737, A-10463, A-10467, A-10471, A-11974, A-13261, A-17252, A-20414, A-22000, A-23977, A-26166, A-28062, A-28371, A-29348, A-30446, A-30613, A-32351, A-32489, A-33279, A-33930, B-00037, B-00322, B-00323, B-01110, B-01137, B-02031, B-02193, B-02229, B-02728, B-02730, B-03232, B-03677, B-03754, B-03998, B-04050, B-04367, B-04382, B-04665, B-04794, B-05091, B-05307, B-05509, B-05567, B-05597, B-05604, B-06083, B-06098, B-06223, B-06392, B-06443, B-06568, B-06587, B-06611, B-06780, B-06854, B-06936, B-07192, B-07521, B-07542, B-07617, B-07660, B-07661, B-07663, B-07664, B-07668, B-07669, B-07670, B-07699, B-07925, B-07931, B-08310, B-09198, B-09248, B-09270, B-09361, B-09436, B-09796, B-09915, B-09974, B-09977, B-10460, B-10462, B-10464, B-10469, B-10477, B-10479, B-11073, B-11096, B-13811, B-15649, B-15886, B-15887, B-16039, B-16553, B-16646, B-16652, B-16681, B-16695, B-17115, B-17118, B-17127, B-17138, B-17141, B-17151, B-17152, B-17154, B-17158, B-17234, B-17423, B-17568, B-17746, B-17825, B-17913, B-17926, B-19403, B-19732, B-19792, B-20096, B-20226, B-20227, B-20280, B-20699, B-21355, B-21894, B-23182, B-23808, B-24239, B-24809, B-25384, B-25521, B-26018, B-26332, B-26546, B-26612, B-26854, B-27553, B-28497, B-28880, B-28905, B-29083, B-29740, B-29945, B-30583, B-31092, B-31195, B-31226, B-31316, B-31344, B-31362, B-31486, B-32037, B-32791, B-33081, B-33168, B-33416, B-33548, B-33897, B-33952, B-34071, B-34082, B-34084, C-10461, C-14774, C-17425, C-20434, C-33045, C-33953, D-00038, D-07406, D-10618, F-08439, F-08572, F-10473, F-10717, G-00021, G-07472, G-08232, G-08441, G-08575, G-26577, I-24417, J-08689, J-21968, J-24543, J-29186, K-16228, K-33815, L-06733, N-03341, N-06146

G

GAS SAMPLING A-05005, B-04050, B-20248, C-14774, C-17425, C-20434, D-05145
GAS TURBINES B-32134
GASES A-04946, B-00037, B-02229, B-04794, B-05118, B-07660, B-07663, B-07669, B-07670, B-07931, B-17151, B-20227, F-08572, F-10717, G-28042, G-28556, I-07553, J-08689, N-06146
GASIFICATION (SYNTHESIS) A-08392, B-31803
GASOLINES A-05005, A-09737
GERMANY A-10463, A-10466, A-10467, A-10471, A-10474, A-17471, A-23458, A-23977, A-28062, A-29348, A-30296, B-03206, B-04794, B-05118, B-06568, B-06780, B-08310, B-09248, B-09270, B-09915, B-10460, B-10462, B-10464, B-10469, B-16351, B-16561, B-19403, B-20226, B-20280, B-23245, B-23364, B-25500, B-29740, B-30583, C-10461, C-14774, D-10618, D-23391, G-28556, J-21300, J-29923, K-16228, N-21287
GLASS FABRICS A-05005, A-09686, A-30296, B-02229, B-03754, B-06083, B-08310, B-09796, B-11096, B-16039, B-19210, B-26332, B-28497, B-32037, C-33045, I-07553
GOVERNMENTS A-27790, B-07542, B-07925, B-16446, B-31195, G-08232, J-09313, L-06863, N-06146, N-21287
GRAIN PROCESSING J-30696
GRAPHITE B-17151, F-10473
GRASSES B-02730
GRAVITY SETTLING A-09686, B-09974
GREAT BRITAIN B-04665, B-07542, B-07661, B-07663, B-07664, B-07668, B-07670, B-07925, B-13811, B-14161, B-17115, B-17746, B-17926, B-23955, B-28221, B-28402, B-31226, B-31773, B-34079, B-34082, C-22934, C-33953,

F-13084, G-08232, G-11575, J-24543, K-33815, L-06863
GUINEA PIGS G-08232

H

HALOGEN GASES A-09686, B-04794, B-07664, B-27727, B-30534, D-24227, J-29923
HALOGENATED HYDROCARBONS A-30296
HAZE D-05145
HEALTH IMPAIRMENT D-07406, G-05146, G-08441, J-09313
HEALTH STATISTICS G-11575
HEARINGS L-06733
HEAT CAPACITY A-23977
HEAT OF COMBUSTION B-10469
HEAT TRANSFER A-10471, A-23977, B-01110, B-02229, B-04367, B-04665, B-07661, B-07669, B-07670, B-07931, B-09248, B-09796, B-10469, B-10477, B-23808, B-25521, B-26612, B-28402, B-28905, B-31362, B-33081, B-33438, B-33952, B-34079, J-08689
HEIGHT FINDING A-17516, C-33045
HI-VOL SAMPLERS A-05005, D-24227
HIGHWAYS A-17299
HOURLY G-22118
HOUSTON D-24227
HUMANS A-22000, A-31737, G-05146, G-07472, G-08232, G-08441, G-08575, G-11575, G-16223, G-24212, G-24586, G-26577, G-28042, G-31664, G-32079, G-32842, M-15567
HUMIDITY B-33170, I-07553
HYDROCARBONS A-05005, A-09686, A-09737, A-26321, A-26929, A-28371, A-30598, A-32351, A-32489, A-33279, B-06611, B-07925, B-16646, B-19732, B-31803, B-32037, J-30696, N-06146, N-21287
HYDROCHLORIC ACID B-06587, G-28042
HYDROFLUORIC ACID A-17471, A-30296, A-31935, B-05567, G-28042
HYDROGEN A-10466, B-06611, B-07670, B-27553, F-08572, F-10717, G-00021
HYDROGEN SULFIDE B-02728, B-07925, B-31195, B-31316, B-33168, B-34079, F-10717, F-13084, I-07553

I

ILLINOIS J-09313
IMPINGERS A-22000, G-00021
INCINERATION A-02146, A-05005, A-09686, A-09737, A-32351, B-05091, B-20248, C-33045, G-32842, N-06146
INDIANA A-09737, D-05623
INDUSTRIAL AREAS A-14799, A-17199, A-17299, A-27790, A-28371, B-16146, D-05145, G-00021, G-07472, G-08441, G-11575, G-31664, G-32079, G-32842, J-30951
INDUSTRIAL EMISSION SOURCES A-02146, A-04000, A-04001, A-04345, A-04946, A-05005, A-08392, A-09572, A-09686, A-09737, A-10463, A-10466, A-10467, A-10471, A-10474, A-11974, A-12396, A-13261, A-14799, A-17199, A-17252, A-17299, A-17471, A-17516, A-20414, A-22000, A-22872, A-23458, A-23977, A-24928, A-26166, A-26321, A-26929, A-27501, A-27790, A-28062, A-28371, A-28604, A-29021, A-29348, A-30296, A-30446, A-30598, A-30613, A-30698, A-31737, A-31919, A-31935, A-32351, A-32489, A-33279, A-33930, B-00037, B-00104, B-00322, B-00323, B-01110, B-01137, B-02031, B-02193, B-02229, B-02728, B-02730, B-03206, B-03232, B-03677, B-03754, B-03998, B-04050, B-04227, B-04367, B-04382, B-04665, B-04794, B-05091, B-05118, B-05307, B-05509, B-05567, B-05597, B-05604, B-06083, B-06098, B-06223, B-06249, B-06392, B-06443, B-06568, B-06587, B-06611, B-06780, B-06854, B-06936, B-07192, B-07521, B-07542, B-07617, B-07660, B-07661, B-07663, B-07664, B-07668, B-07669, B-07670, B-07699, B-07925, B-07931, B-08310, B-09198, B-09248, B-09270, B-09361, B-09436, B-09796, B-09915, B-09974, B-09977, B-10460, B-10462, B-10464, B-10469, B-10477, B-10479, B-11073, B-11096, B-13645, B-13811, B-13946, B-14161, B-14889, B-15649, B-15886, B-15887, B-16039, B-16146, B-16193, B-16351, B-16446, B-16553, B-16561, B-16646, B-16652, B-16681, B-16695, B-17115, B-17118, B-17127, B-17138, B-17141, B-17151, B-17152, B-17154, B-17158, B-17234, B-17423, B-17568, B-17746, B-17825, B-17913, B-17926, B-19210, B-19403, B-19732, B-19792, B-20096, B-20226, B-20227, B-20248, B-20280, B-20699, B-21324, B-21355, B-21894, B-22138, B-22940, B-23182, B-23245, B-23364, B-23628, B-23808, B-23955, B-24239, B-24676, B-24809, B-24881, B-25384, B-25500, B-25521, B-26003, B-26018, B-26195, B-26332, B-26546, B-26612, B-26854, B-27553, B-27727, B-27779, B-27783, B-28221, B-28402, B-28497, B-28547, B-28880, B-28905, B-29083, B-29740, B-29945, B-30018, B-30534, B-30583, B-31092, B-31195, B-31226, B-31316, B-31344, B-31362, B-31486, B-31589, B-31773, B-31803, B-32037, B-32134, B-32791, B-32817, B-32848, B-33040, B-33081, B-33168, B-33170, B-33401, B-33416, B-33438, B-33548, B-33897, B-33918, B-33952, B-34071, B-34079, B-34082, B-34084, C-10461, C-14774, C-15940, C-17425, C-20434, C-22934, C-33045, C-33953, D-00038, D-05145, D-05623, D-07406, D-10618, D-23391, D-24227, F-08439, F-08572, F-10473, F-10717, F-13084, G-00021, G-05146, G-07472, G-08232, G-08441, G-08575, G-10396, G-11575, G-16223, G-22118, G-24212, G-24586, G-26136, G-26577, G-28042, G-28556, G-31664, G-32079, G-32842, I-07553, I-24417, J-08689, J-09313, J-21300, J-21968, J-24155, J-24543, J-26623, J-29186, J-29923, J-30696, J-30951, K-16228, K-33815, L-06733, L-06863, M-15567, M-18022, M-26303, N-03341, N-06146, N-21287
INFANTS G-11575
INFECTIOUS DISEASES G-08441, G-31664
INGESTION G-32842
INORGANIC ACIDS A-04946, A-09686, A-09737, A-17471, A-27790, A-30296, A-31935, A-32351, B-05091, B-05567, B-06587, B-07925, B-07931, B-20248, B-31316, B-33918, D-05145, G-08232, G-28042, I-07553, J-09313, J-30696
INSTRUMENTATION B-05597, C-10461
INTERNAL COMBUSTION ENGINES A-05005, A-08392, A-09686, A-32351, B-05091
INVERSION A-04946, I-07553
IODINE B-27727
IONIZATION B-07699, B-07931, B-09270, F-08439
IONS B-07931, F-08439
IRON A-02146, A-04000, A-04001, A-04345, A-04946, A-05005, A-08392, A-09572, A-09686, A-09737, A-10463, A-10466, A-10467, A-10471, A-10474, A-11974, A-12396, A-13261, A-14799, A-17199, A-17252, A-17299, A-17471, A-17516, A-20414, A-22000, A-22872, A-23458, A-23977, A-24928, A-26166, A-26321, A-26929, A-27501, A-27790, A-28062, A-28371, A-28604, A-29021, A-29348, A-30296, A-30446, A-30598, A-30613, A-30698, A-31737, A-31919, A-31935, A-32351, A-32489, A-33279, A-33930, B-00037, B-00104, B-00322, B-00323, B-01110, B-01137, B-02031, B-02193, B-02229, B-02728, B-02730, B-03206, B-03232, B-03677, B-03754, B-03998, B-04050, B-04227, B-04367, B-04382, B-04665, B-04794, B-05091, B-05118, B-05307, B-05509, B-05567, B-05597, B-05604, B-06083, B-06098, B-06223, B-06249, B-06392, B-06443, B-06568, B-06587, B-06611, B-06780, B-06854, B-06936, B-07192, B-07521, B-07542, B-07617, B-07660, B-07661, B-07663, B-07664, B-07668, B-07669, B-07670, B-07699, B-07925, B-07931, B-08310, B-09198, B-09248, B-09270, B-09361, B-09436, B-09796, B-09915, B-09974, B-09977, B-10460, B-10462, B-10464, B-10469, B-10477, B-10479, B-11073, B-11096, B-13645, B-13811, B-13946, B-14161, B-14889, B-15649, B-15886, B-15887, B-16039, B-16146, B-16193, B-16351, B-16446, B-16553, B-16561, B-16646, B-16652, B-16681, B-16695, B-17115, B-17118, B-17127, B-17138, B-17141, B-17151, B-17152, B-17154, B-17158, B-17234, B-17423, B-17568, B-17746, B-17825, B-17913, B-17926, B-19210, B-19403, B-19732, B-19792, B-20096, B-20226, B-20227, B-20248, B-20280, B-20699, B-21324, B-21355, B-21894, B-22138, B-22940, B-23182, B-23245, B-23364, B-23628, B-23808, B-23955, B-24239, B-24676, B-24809, B-24881, B-25384, B-25500, B-25521, B-26003, B-26018, B-26195, B-26332, B-26546, B-26612, B-26854, B-27553, B-27779, B-27783, B-28221, B-28402, B-28497, B-28547, B-28880, B-28905, B-29083, B-29740, B-29945, B-30018, B-30534, B-30583, B-31092, B-31195, B-31226, B-31316, B-31344, B-31362, B-31486, B-31589, B-31773, B-31803, B-32037, B-32134, B-32791, B-32817, B-32848, B-33040, B-33081, B-33168, B-33170, B-33401, B-33416, B-33438, B-33548, B-33897, B-33918, B-33952, B-34071, B-34079, B-34082, B-34084, C-10461, C-14774, C-15940, C-17425, C-20434, C-22934, C-33045, C-33953, D-00038, D-05145, D-05623, D-07406, D-10618, D-23391, D-24227, F-08439, F-08572, F-10473, F-10717, F-13084, G-00021, G-05146, G-07472, G-08232, G-08441, G-08575, G-10396, G-11575, G-16223, G-22118, G-24212,

G-24586, G-26136, G-26577, G-28042, G-28556, G-31664, G-32079, G-32842, I-07553, I-24417, J-08689, J-09313, J-21300, J-21968, J-24155, J-24543, J-26623, J-29186, J-29923, J-30696, J-30951, K-16228, K-33815, L-06733, L-06863, M-15567, M-18022, M-26303, N-03341, N-06146, N-21287
IRON COMPOUNDS A-04946, A-10463, A-22000, A-26321, A-30446, A-31919, B-05604, B-07521, B-07617, B-07661, B-07925, B-10460, B-15887, B-22940, B-27783, C-10461, D-05623, F-08439, G-00021, G-10396
IRON OXIDES A-04000, A-09572, A-10463, A-10466, A-10474, A-13261, A-17471, A-20414, A-26321, A-28371, A-30613, B-03232, B-04382, B-05091, B-05604, B-06098, B-06611, B-06780, B-06936, B-07521, B-07617, B-07661, B-07664, B-07699, B-07925, B-09198, B-09248, B-09270, B-09796, B-09915, B-10460, B-16039, B-16652, B-17127, B-17151, B-24676, B-26018, B-27783, B-28221, B-28402, B-28880, B-29083, B-29740, B-31092, B-31226, B-32791, B-33081, B-33438, B-34079, B-34082, B-34084, C-33953, F-08439, F-10473, G-00021, G-07472, G-10396, I-07553

J

JAPAN A-11974, A-17199, A-17252, A-17299, A-17516, A-27790, A-31935, B-07669, B-10477, B-13645, B-15649, B-16146, B-16553, B-17234, B-19210, B-20096, B-21324, B-22138, B-24239, B-26003, B-26546, B-26854, B-27553, B-28547, B-30534, B-31092, B-31344, B-31362, B-31486, B-32791, B-32817, B-32848, B-33401, B-33416, B-33918, B-34071, C-15940, D-07406, F-10473, G-16223, G-26136, G-26577, G-31664, G-32842, J-30951
JET AIRCRAFT A-32351

K

KEROSENE A-33279
KIDNEYS G-32842
KILNS A-08392, B-03232, B-07699, B-07925, B-07931, B-24881, B-31773, B-32037, B-33897, C-33045, N-21287
KRAFT PULPING A-04345, A-09686, B-05091, B-16681, B-20248, B-31803, C-33045

L

LABORATORY ANIMALS G-00021, G-07472, G-08232, G-10396, G-28042, G-32842
LABORATORY FACILITIES B-07617
LANDFILLS A-09737, B-33548
LARYNX G-08441
LEAD A-04946, A-09686, A-26166, B-03754, B-21324, C-33045, G-32842, J-30696, L-06863
LEAD ALLOYS B-03754
LEAD COMPOUNDS A-04946, B-01110, B-03232, B-34071, D-05623, J-30696
LEATHER I-07553
LEAVES A-31935
LEGAL ASPECTS A-26166, A-27790, A-32351, B-06780, B-07542, B-07925, B-11073, B-11096, B-16561, B-17234, B-23364, B-31195, B-31226, D-23391, G-00021, G-08232, K-33815, L-06733, N-06146, N-21287
LEGISLATION A-27790, A-32351, B-07542, B-07925, B-16561, B-17234, B-23364, B-31226, G-00021, G-08232, K-33815, N-06146
LIGHT RADIATION G-11575
LIGHT SCATTERING B-04050
LIME A-08392, B-07699, B-07931, B-31773, B-32037, B-33897, C-33045
LIMESTONE B-06587, B-07521, B-23182, B-31344, B-32817, D-10618, I-07553
LIPIDS G-10396
LIQUIDS B-05118, B-05604, B-07542, B-09248, B-20280, B-23245, B-26003, B-31486, B-33081, F-10717, I-07553
LITHIUM COMPOUNDS B-09796
LIVER G-32842
LOCAL GOVERNMENTS B-07542, B-16446, B-31195, N-06146
LONDON G-08232
LOS ANGELES B-03754, B-11096, D-07406
LUNG CANCER G-16223
LUNG CLEARANCE G-32079
LUNGS G-08441, G-10396, G-28556

M

MAGNESIUM B-03754, C-33045
MAGNESIUM COMPOUNDS A-26321, A-28371, B-01110, B-05604, F-13084
MAGNETOHYDRODYNAMICS (MHD) A-32351
MAINTENANCE B-05604, B-06443, B-07192, B-07542, B-09361, B-10462, B-16652, B-17118, B-17152, B-32848, B-33168, B-33918, C-14774, J-30696
MALES G-05146, M-15567
MANAGEMENT PERSONNEL A-02146
MANGANESE B-06780, B-07661, F-08439, G-07472, G-24586, G-26577, L-06863
MANGANESE COMPOUNDS A-04000, A-04001, A-26321, A-28371, B-01110, B-05604, B-06780, B-07661, B-09796, B-31773, B-32817, B-33438, D-24227, F-08439, F-13084, G-00021, G-07472, G-26577
MANGANESE SULFATES B-09796
MATERIALS DETERIORATION A-22000, A-31737, B-04227, B-30583, G-08232, I-07553, I-24417
MATHEMATICAL ANALYSES A-10463, B-07699, B-07931, B-28547, B-33170, C-33045, F-08439, F-08572, F-10473
MATHEMATICAL MODELING A-10463, F-10473
MAXIMUM ALLOWABLE CONCENTRATION G-08232
MEASUREMENT METHODS A-05005, A-10467, A-22000, B-04050, B-07664, B-07669, B-07670, B-07925, B-10460, B-20248, B-21894, B-23364, B-28547, B-34079, B-34084, C-10461, C-14774, C-17425, C-20434, C-33045, D-05145, D-10618, D-24227, G-22118
MEETINGS M-18022
MERCAPTANS B-07925
METAL COMPOUNDS A-04000, A-04001, A-04946, A-09686, A-10463, A-17471, A-22000, A-22872, A-26321, A-28371, A-30296, A-30446, A-31919, A-32489, B-01110, B-03232, B-03998, B-05604, B-06098, B-06780, B-07521, B-07617, B-07661, B-07925, B-09248, B-09796, B-10460, B-15887, B-20248, B-22940, B-26003, B-27783, B-31773, B-32817, B-33438, B-34071, C-10461, C-15940, D-00038, D-05623, D-24227, F-08439, F-13084, G-00021, G-07472, G-08232, G-10396, G-24212, G-26577, G-28556, G-32842, I-07553, J-30696
METAL FABRICATING AND FINISHING A-08392, A-09737, A-17199, A-17471, A-22872, A-26929, A-28371, A-30446, A-30613, A-31935, A-32351, A-32489, B-02229, B-03206, B-03754, B-07925, B-16681, B-20248, B-21324, B-27783, B-30534, B-32037, B-32848, B-33168, C-33045, D-07406, G-28042, G-32842, J-21968, J-29923, J-30696, N-06146
METAL POISONING G-32842
METALS A-02146, A-04000, A-04001, A-04345, A-04946, A-05005, A-08392, A-09572, A-09686, A-09737, A-10463, A-10466, A-10467, A-10471, A-10474, A-11974, A-12396, A-13261, A-14799, A-17199, A-17252, A-17299, A-17471, A-17516, A-20414, A-22000, A-22872, A-23458, A-23977, A-24928, A-26166, A-26321, A-26929, A-27501, A-27790, A-28062, A-28371, A-28604, A-29021, A-29348, A-30296, A-30446, A-30598, A-30613, A-30698, A-31737, A-31919, A-31935, A-32351, A-32489, A-33279, A-33930, B-00037, B-00104, B-00322, B-00323, B-01110, B-01137, B-02031, B-02193, B-02229, B-02728, B-02730, B-03206, B-03232, B-03677, B-03754, B-03998, B-04050, B-04227, B-04367, B-04382, B-04665, B-04794, B-05091, B-05118, B-05307, B-05509, B-05567, B-05597, B-05604, B-06083, B-06098, B-06223, B-06249, B-06392, B-06443, B-06568, B-06587, B-06611, B-06780, B-06854, B-06936, B-07192, B-07521, B-07542, B-07617, B-07660, B-07661, B-07663, B-07664, B-07668, B-07669, B-07670, B-07699, B-07925, B-07931, B-08310, B-09198, B-09248, B-09270, B-09361, B-09436, B-09796, B-09915, B-09974, B-09977, B-10460, B-10462, B-10464, B-10469, B-10477, B-10479, B-11073, B-11096, B-13645, B-13811, B-13946, B-14161, B-14889, B-15649, B-15886, B-15887, B-16039, B-16146, B-16193, B-16351, B-16446, B-16553, B-16561, B-16646, B-16652, B-16681, B-16695, B-17115, B-17118, B-17127, B-17138, B-17141, B-17151, B-17152, B-17154, B-17158, B-17234, B-17423, B-17568, B-17746, B-17825, B-17913, B-17926, B-19210, B-19403, B-19732, B-19792, B-20096, B-20226, B-20227, B-20248, B-20280, B-20699, B-21324, B-21355, B-21894, B-22138, B-22940, B-23182, B-23245, B-23364, B-23628, B-23808, B-23955, B-24239, B-24676, B-24809, B-24881, B-25384, B-25500, B-25521, B-26003, B-26018, B-26195, B-26332, B-26546, B-26612, B-26854, B-27553, B-27779, B-27783, B-28221, B-28402, B-28497, B-28547, B-28880, B-28905, B-29083, B-29740, B-29945, B-30018, B-30534, B-30583, B-31092, B-31195, B-31226, B-31316, B-31344, B-31362, B-31486, B-31589, B-31773,

B-31803, B-32037, B-32134, B-32791, B-32817, B-32848, B-33040, B-33081, B-33168, B-33170, B-33401, B-33416, B-33438, B-33548, B-33897, B-33918, B-33952, B-34071, B-34079, B-34082, B-34084, C-10461, C-14774, C-15940, C-17425, C-20434, C-22934, C-33045, C-33953, D-00038, D-05145, D-05623, D-07406, D-10618, D-23391, D-24227, F-08439, F-08572, F-10473, F-10717, F-13084, G-00021, G-05146, G-07472, G-08232, G-08441, G-08575, G-10396, G-11575, G-16223, G-22118, G-24212, G-24586, G-26136, G-26577, G-28042, G-28556, G-31664, G-32079, G-32842, I-07553, I-24417, J-08689, J-09313, J-21300, J-21968, J-24155, J-24543, J-26623, J-29186, J-29923, J-30696, J-30951, K-16228, K-33815, L-06733, L-06863, M-15567, M-18022, M-26303, N-03341, N-06146, N-21287
METEOROLOGY A-04946, A-27790, A-32351, B-33170, D-00038, D-05145, D-05623, D-10618, D-23391, D-24227, G-08232, G-11575, G-22118, I-07553
METHANES B-06611, B-16646, B-19732
MICROORGANISMS G-24586, I-07553
MINERAL PROCESSING A-04946, A-08392, A-09737, A-22872, A-26929, A-27501, A-27790, A-30296, A-31935, A-32351, B-02031, B-03754, B-07699, B-07925, B-07931, B-13946, B-16446, B-19210, B-23364, B-26546, B-27783, B-31344, B-31803, B-32037, B-32848, B-33170, B-34079, C-33045, D-23391, G-08441, G-10396, G-26136, J-30696, L-06863, N-06146
MINERAL PRODUCTS B-03754, B-06587, B-07521, B-13946, B-17151, B-23182, B-31344, B-32817, D-10618, F-10473, G-10396, G-24212, I-07553, L-06863
MINING A-04946, G-10396
MISSOURI B-02229, B-02730, B-03998, B-04050
MISTS B-05567, B-07925, B-16695, G-32842, J-09313, N-06146
MOBILE A-32351, J-30696
MOLYBDENUM COMPOUNDS B-09796, F-13084
MONITORING A-05005, B-07664, B-07669, B-07670, B-07925, B-20248, B-28547, B-34079, C-14774, C-17425, C-20434, D-05145, D-24227, G-22118
MONTHLY D-05145
MORBIDITY G-08441, G-26577, G-28042
MORTALITY A-31737, G-08575, G-24586, G-28042, G-31664
MOUNTAINS G-31664
MOUTH G-05146
MULTIPLE CHAMBER INCINERATORS A-05005

N

NATURAL GAS A-09737, A-32351, B-25521, C-33045
NERVOUS SYSTEM G-11575
NEUTRON ACTIVATION ANALYSIS D-24227
NEW YORK CITY J-09313
NEW YORK STATE J-09313
NICKEL F-08439
NICKEL COMPOUNDS B-09796, B-15887, F-08439
NITRATES G-24212, N-06146
NITRIC ACID A-09686, B-07925
NITRIC OXIDE (NO) B-30534, F-10717
NITROGEN A-10466, A-10471, A-32489, B-07661, B-07664, B-10477, B-26854, B-27553, B-30534, F-08572, G-00021
NITROGEN DIOXIDE (NO2) A-09686, B-30534, D-05145, G-24212, N-06146
NITROGEN OXIDES A-09686, A-09737, A-32351, B-07925, B-30534, B-32037, D-05145, F-10717, G-24212, G-28042, J-30696, N-06146
NITROUS OXIDE (N2O) B-30534
NON-INDUSTRIAL EMISSION SOURCES A-04946, A-05005, A-08392, A-09686, A-09737, A-27501, A-29021, A-31737, B-02730, B-05091, B-06392, B-06587, B-07521, B-07670, B-09915, B-20227, B-29740, B-31195, B-31226, B-32848, B-33081, B-33168, B-33548, C-33045, G-08232, G-32842, I-07553, J-26623, J-30696, J-30951, N-21287
NON-URBAN AREAS A-27790, G-11575, G-31664
NOSTRILS G-10396, G-32079
NUCLEAR POWER PLANTS B-27727
NUCLEATION A-10463
NYLON I-07553

O

OCCUPATIONAL HEALTH A-33279, B-32848, G-07472, G-08232, G-08575, G-16223, G-26577, G-28042, G-32079, G-32842
ODOR COUNTERACTION B-01137, B-04227, B-13946
ODORS A-30446, A-32489, B-13946, B-16695, N-06146
OIL BURNERS B-01137
OIL RESOURCES A-09737
OLEFINS B-07925, B-31803
OPEN BURNING A-05005, A-09686, A-09737, B-32848
OPEN HEARTH FURNACES A-02146, A-04345, A-09686, A-09737, A-10463, A-32351, A-33930, B-00037, B-00322, B-02193, B-02728, B-02730, B-03232, B-03677, B-03754, B-04382, B-05307, B-05509, B-05567, B-05597, B-05604, B-06223, B-06587, B-06854, B-06936, B-07521, B-07542, B-07617, B-07699, B-09361, B-09436, B-09796, B-10460, B-10479, B-11096, B-13811, B-16039, B-16652, B-16695, B-17115, B-17118, B-17141, B-17151, B-17154, B-17746, B-17825, B-19732, B-19792, B-20699, B-21894, B-23182, B-24239, B-26546, B-28905, B-29945, B-31092, B-31195, B-33081, B-33897, B-34071, B-34082, C-10461, C-33045, C-33953, F-10473, G-00021, L-06733, N-03341
OPERATING CRITERIA N-03341
OPERATING VARIABLES A-04001, A-10474, A-20414, A-29348, A-30446, A-30698, B-06443, B-10460, B-10479, B-15887, B-16351, B-16652, B-16695, B-17115, B-17118, B-17913, B-19403, B-19792, B-20096, B-21324, B-23245, B-23955, B-25384, B-26332, B-28497, B-31362, B-31589, B-32817, B-33040, B-33081, B-33168, B-33170, B-33401, B-33897, B-33952, B-34071, B-34082, B-34084, C-17425, C-33953, D-10618
OPINION SURVEYS M-26303
OREGON B-01110
ORGANIC ACIDS A-09686
ORGANIC SULFUR COMPOUNDS B-07925
ORSAT ANALYSIS C-20434
OXIDANTS A-32351, N-06146
OXIDATION A-10463, A-10466, A-10471, A-10474, A-17252, B-07192, B-09796, B-09915, B-10469, B-32037, F-08439, F-08572, F-10473
OXIDES A-04000, A-04946, A-09572, A-09686, A-09737, A-10463, A-10466, A-10467, A-10471, A-10474, A-11974, A-13261, A-14799, A-17199, A-17471, A-17516, A-20414, A-26321, A-27790, A-28371, A-29348, A-30613, A-31919, A-32351, A-32489, B-01110, B-01137, B-02728, B-03232, B-03754, B-04367, B-04382, B-04665, B-05091, B-05567, B-05604, B-06098, B-06223, B-06392, B-06611, B-06780, B-06936, B-07521, B-07617, B-07660, B-07661, B-07663, B-07664, B-07669, B-07670, B-07699, B-07925, B-07931, B-09198, B-09248, B-09270, B-09796, B-09915, B-09977, B-10460, B-10462, B-10469, B-10477, B-13645, B-14889, B-16039, B-16652, B-16681, B-17127, B-17151, B-20248, B-20280, B-23245, B-23364, B-23808, B-24676, B-25500, B-26003, B-26018, B-26546, B-26612, B-26854, B-27553, B-27783, B-28221, B-28402, B-28880, B-29083, B-29740, B-30534, B-31092, B-31226, B-31773, B-32037, B-32791, B-32817, B-33081, B-33168, B-33438, B-33918, B-34071, B-34079, B-34082, B-34084, C-17425, C-33953, D-00038, D-05145, D-05623, D-07406, D-10618, F-08439, F-08572, F-10473, F-10717, F-13084, G-00021, G-05146, G-07472, G-08232, G-08441, G-08575, G-10396, G-22118, G-24212, G-28042, I-07553, J-09313, J-30696, K-16228, L-06733, N-06146, N-21287
OXYGEN A-04000, A-10463, A-10467, A-10471, A-10474, A-29348, A-32489, A-33930, B-06611, B-07660, B-07669, B-07670, B-10460, B-10477, B-19732, B-20280, B-28221, B-33952, F-08572, F-10473, G-00021, I-07553
OXYGEN LANCING A-09686, A-10466, A-10467, A-10471, A-10474, A-11974, B-03232, B-06098, B-07192, B-07660, B-07661, B-07664, B-09198, B-09361, B-09436, B-10460, B-10462, B-10464, B-10477, B-10479, B-16039, B-19732, B-20226, B-23808, B-25521, B-29740, B-29945, F-10473, J-24543, J-29923
OZONE A-32351, G-24212, I-07553

P

PACKED TOWERS B-03754, B-06587, B-09974, B-21355, B-23808, B-27727
PAINT MANUFACTURING A-09686, A-32351, C-33045, G-32842
PAINTS B-09915, I-07553
PAPER CHROMATOGRAPHY I-07553
PAPER MANUFACTURING A-04345, A-09686, A-27501, B-16695, B-26546, B-31803, B-33918, D-24227, J-30951
PARIS A-04001
PARTICLE GROWTH A-10463, A-10474, B-03677, B-07521, B-09915, B-33170
PARTICLE SHAPE A-17252, C-22934
PARTICLE SIZE A-09572, A-10463, A-17252, A-28371, A-30598, A-30613, A-31919, A-32489, B-00322, B-03677, B-04050, B-05118, B-05604, B-06098, B-06223, B-06780, B-07617, B-07669,

B-07699, B-09248, B-09270, B-09796, B-16695, B-17151, B-23628, B-23955, B-27553, B-27727, B-27783, B-29740, B-33170, B-33438, C-10461, C-22934, C-33045, C-33953, D-07406, F-10473, I-24417
PARTICULATE CLASSIFIERS A-09572, A-10463, A-17252, A-28371, A-30598, A-30613, A-31919, A-32489, B-00322, B-03677, B-04050, B-05118, B-05604, B-06098, B-06223, B-06780, B-07617, B-07669, B-07699, B-09248, B-09270, B-09796, B-16695, B-17151, B-23628, B-23955, B-27553, B-27727, B-27783, B-29740, B-33170, B-33438, C-10461, C-22934, C-33045, C-33953, D-07406, F-10473, I-24417
PARTICULATE SAMPLING B-04050, B-20248, C-10461, F-08439
PARTICULATES A-02146, A-04345, A-04946, A-05005, A-09686, A-09737, A-10463, A-10466, A-10467, A-10471, A-10474, A-13261, A-14799, A-17299, A-17471, A-20414, A-23458, A-26166, A-26321, A-27501, A-27790, A-28371, A-30446, A-30598, A-30613, A-30698, A-31919, A-32351, A-32489, B-00037, B-00322, B-00323, B-01110, B-01137, B-02031, B-02229, B-02728, B-02730, B-03206, B-03232, B-03677, B-03754, B-03998, B-04050, B-04227, B-04367, B-04382, B-04665, B-04794, B-05091, B-05118, B-05509, B-05567, B-05597, B-05604, B-06083, B-06098, B-06223, B-06392, B-06443, B-06568, B-06611, B-06780, B-06854, B-06936, B-07192, B-07521, B-07542, B-07617, B-07660, B-07661, B-07663, B-07664, B-07668, B-07669, B-07670, B-07699, B-07925, B-07931, B-08310, B-09198, B-09248, B-09270, B-09361, B-09436, B-09796, B-09915, B-09974, B-10460, B-10462, B-10464, B-10469, B-10477, B-10479, B-11073, B-11096, B-13645, B-13811, B-13946, B-14161, B-14889, B-15649, B-15886, B-15887, B-16039, B-16351, B-16446, B-16553, B-16646, B-16652, B-16695, B-17115, B-17127, B-17138, B-17141, B-17151, B-17152, B-17154, B-17158, B-17234, B-17423, B-17568, B-17746, B-17913, B-17926, B-19403, B-19732, B-19792, B-20096, B-20226, B-20227, B-20280, B-20699, B-21355, B-21894, B-22138, B-23245, B-23628, B-23955, B-24239, B-24809, B-24881, B-25384, B-25500, B-25521, B-26003, B-26018, B-26195, B-26332, B-26546, B-26612, B-27553, B-27727, B-27783, B-28221, B-28402, B-28497, B-28547, B-28880, B-28905, B-29083, B-29740, B-29945, B-30018, B-30583, B-31092, B-31226, B-31344, B-31486, B-31589, B-31773, B-31803, B-32037, B-32134, B-32791, B-32848, B-33040, B-33081, B-33170, B-33401, B-33416, B-33438, B-33548, B-33897, B-33918, B-33952, B-34071, B-34079, B-34082, B-34084, C-10461, C-14774, C-15940, C-22934, C-33953, D-00038, D-05145, D-05623, D-07406, D-10618, D-23391, F-08439, F-10473, G-00021, G-07472, G-08232, G-08441, G-10396, G-22118, G-24212, G-24586, G-28042, G-28556, G-32842, I-07553, I-24417, J-08689, J-09313, J-26623, J-30696, K-16228, K-33815, N-06146, N-21287
PATHOLOGICAL TECHNIQUES G-07472, G-10396
PENNSYLVANIA B-06083, D-05623
PERMEABILITY B-02730
PEROXIDES G-00021
PEROXYACETYL NITRATE G-24212, N-06146
PEROXYACYL NITRATES G-24212, N-06146
PERSONNEL A-02146
PESTICIDES A-31737
PETROLEUM DISTRIBUTION A-32351
PETROLEUM PRODUCTION A-09737, A-17199, A-32351, B-07925, B-16146, D-24227
PETROLEUM REFINING A-04345, A-05005, A-09686, A-09737, A-17199, A-26929, A-32351, B-07925, B-30583, B-31803, D-24227, G-31664, I-07553, J-09313, J-30951
PH B-23808, B-31486
PHENOLS B-02193
PHOSPHATES A-04946, B-06587, D-05145
PHOSPHORIC ACID A-09686, B-06587, B-33918
PHOSPHORUS COMPOUNDS A-04946, B-05604, B-06587, B-07661, B-09248, B-09796, B-31773, D-05145, G-00021
PHOTOCHEMICAL REACTIONS A-32351, N-06146
PHYSICAL STATES A-04946, A-32489, A-33279, B-00037, B-02229, B-04794, B-05118, B-05597, B-05604, B-06611, B-07542, B-07660, B-07663, B-07669, B-07670, B-07931, B-09248, B-17151, B-20227, B-20280, B-23245, B-26003, B-27727, B-30583, B-31486, B-33081, F-08572, F-10717, G-28042, G-28556, I-07553, J-08689, N-06146
PILOT PLANTS A-10471, B-03677, B-07521, B-07617, B-07664, B-07670, B-09270, B-15886, B-22138, B-24676, B-29083, B-32791, B-34084
PITTSBURGH D-05623
PLANNING AND ZONING D-23391
PLANS AND PROGRAMS A-02146, A-04946, A-09737, A-17299, A-27790, A-32351, B-00104, B-02193, B-06249, B-11096, B-16146, B-16446, B-20096, B-20248, B-31195, D-05145, D-05623, J-09313, J-21300, J-26623, L-06863, M-15567, N-06146
PLANT DAMAGE A-31935, B-06587, D-05145, D-10618, G-08232, J-09313
PLANTS (BOTANY) A-26929, A-31737, A-31935, B-02730, B-09915, D-10618, G-00021, G-08232, G-26136, G-32842, J-09313
PLASTICS B-09248, B-31092, B-33918, G-32842
PLATING G-32842
PLUME BEHAVIOR A-32489, B-01110, D-05145
PNEUMOCONIOSIS G-07472, G-10396
PNEUMONIA G-24586, G-26577, G-31664, G-32079
POLYNUCLEAR COMPOUNDS A-05005, A-26321, A-26929, A-28371, A-30598, A-33279, B-32037
PORTABLE C-10461
POTASSIUM COMPOUNDS B-03998, B-09796
POWER SOURCES A-05005, A-08392, A-09686, A-32351, B-05091, B-32134, B-34079
PRECIPITATION D-05623, D-10618, G-11575
PRESSURE A-10467, A-23977, B-02229, B-02730, B-03998, B-05118, B-05597, B-06083, B-07521, B-07617, B-07664, B-07668, B-07670, B-08310, B-10469, B-10477, B-17118, B-17151, B-23628, B-27727, B-28880, B-31803, B-33168, B-34082
PRIMARY METALLURGICAL PROCESSING A-02146, A-04000, A-04001, A-04345, A-04946, A-05005, A-08392, A-09572, A-09686, A-09737, A-10463, A-10466, A-10467, A-10471, A-10474, A-11974, A-12396, A-13261, A-14799, A-17199, A-17252, A-17299, A-17471, A-17516, A-20414, A-22000, A-22872, A-23458, A-23977, A-24928, A-26166, A-26321, A-26929, A-27501, A-27790, A-28062, A-28371, A-28604, A-29021, A-29348, A-30296, A-30446, A-30598, A-30613, A-30698, A-31737, A-31919, A-31935, A-32351, A-32489, A-33279, A-33930, B-00037, B-00104, B-00322, B-00323, B-01110, B-01137, B-02031, B-02193, B-02229, B-02728, B-02730, B-03206, B-03232, B-03677, B-03754, B-03998, B-04050, B-04227, B-04367, B-04382, B-04665, B-04794, B-05091, B-05118, B-05307, B-05509, B-05567, B-05597, B-05604, B-06083, B-06098, B-06223, B-06249, B-06392, B-06443, B-06568, B-06587, B-06611, B-06780, B-06854, B-06936, B-07192, B-07521, B-07542, B-07617, B-07660, B-07661, B-07663, B-07664, B-07668, B-07669, B-07670, B-07699, B-07925, B-07931, B-08310, B-09198, B-09248, B-09270, B-09361, B-09436, B-09796, B-09915, B-09974, B-09977, B-10460, B-10462, B-10464, B-10469, B-10477, B-10479, B-11073, B-11096, B-13645, B-13811, B-13946, B-14161, B-14889, B-15649, B-15886, B-15887, B-16039, B-16146, B-16193, B-16351, B-16446, B-16553, B-16561, B-16646, B-16652, B-16681, B-16695, B-17115, B-17118, B-17127, B-17138, B-17141, B-17151, B-17152, B-17154, B-17158, B-17234, B-17423, B-17568, B-17746, B-17825, B-17913, B-17926, B-19210, B-19403, B-19732, B-19792, B-20096, B-20226, B-20227, B-20248, B-20280, B-20699, B-21324, B-21355, B-21894, B-22138, B-22940, B-23182, B-23245, B-23364, B-23628, B-23808, B-23955, B-24239, B-24676, B-24809, B-24881, B-25384, B-25500, B-25521, B-26003, B-26018, B-26195, B-26332, B-26546, B-26612, B-26854, B-27553, B-27779, B-27783, B-28221, B-28402, B-28497, B-28547, B-28880, B-28905, B-29083, B-29740, B-29945, B-30018, B-30534, B-30583, B-31092, B-31195, B-31226, B-31316, B-31344, B-31362, B-31486, B-31589, B-31773, B-31803, B-32037, B-32134, B-32791, B-32817, B-32848, B-33040, B-33081, B-33168, B-33170, B-33401, B-33416, B-33438, B-33548, B-33897, B-33918, B-33952, B-34071, B-34079, B-34082, B-34084, C-10461, C-14774, C-15940, C-17425, C-20434, C-22934, C-33045, C-33953, D-00038, D-05145, D-05623, D-07406, D-10618, D-23391, D-24227, F-08439, F-08572, F-10473, F-10717, F-13084, G-00021, G-05146,

G-07472, G-08232, G-08441, G-08575, G-10396, G-11575, G-16223, G-22118, G-24212, G-24586, G-26136, G-26577, G-28042, G-28556, G-31664, G-32079, G-32842, I-07553, I-24417, J-08689, J-09313, J-21300, J-21968, J-24155, J-24543, J-26623, J-29186, J-29923, J-30696, J-30951, K-16228, K-33815, L-06733, L-06863, M-15567, M-18022, M-26303, N-03341, N-06146, N-21287
PROCESS MODIFICATION A-04345, A-09572, A-33279, A-33930, B-01137, B-05091, B-06611, B-06780, B-07660, B-07664, B-07925, B-09796, B-09977, B-16681, B-17158, B-19732, B-26612, B-28402, B-29740, B-31195, B-32037, B-33168, B-34079
PROPELLER AIRCRAFT A-32351
PROPOSALS A-29021, B-16146, D-23391
PROTEINS G-10396
PUBLIC AFFAIRS D-23391, M-18022, M-26303
PUBLIC INFORMATION M-18022
PULMONARY FUNCTION G-05146, G-22118
PULVERIZED FUELS A-09572, B-07699, B-34082
PYRENES A-05005, A-26929, A-28371, A-30598, A-33279

Q

QUARTZ G-10396
QUENCHING B-32791, B-33168, B-34079
QUESTIONNAIRES G-05146

R

RADIOACTIVE RADIATION B-27727, G-11575
RADIOGRAPHY G-07472, G-08441
RAIN D-05623, G-11575
RAPPING B-04382, B-04665, B-05307, B-07931
RATS G-07472, G-10396
REACTION KINETICS A-10463, B-19732, F-10473
REACTION MECHANISMS A-10463, A-10474, A-20414, B-09796, F-10473
REACTORS (NUCLEAR) B-27727
REDUCTION A-17252, B-22940, B-30534
REFRACTORIES A-10463, A-29021, B-03998, B-09436
REGIONAL GOVERNMENTS A-27790, N-06146
REGULATIONS A-26166, B-11073, B-11096, B-23364, B-31195, N-21287
RENDERING A-32351, B-13946
REPRODUCTION G-11575
RESEARCH METHODOLOGIES A-08392, A-12396, A-30698, B-04050
RESEARCH PROGRAMS A-28604, B-16561, B-32037, J-09313, J-21300, N-06146
RESIDENTIAL AREAS D-23391, G-05146
RESIDUAL OILS A-09737, A-27790, B-05604, B-32817
RESPIRATORY DISEASES A-27790, D-07406, G-05146, G-07472, G-08232, G-08441, G-10396, G-22118, G-24212, G-24586, G-26577, G-28042, G-31664, G-32079, G-32842, J-09313
RESPIRATORY FUNCTIONS A-22000, B-06568, G-05146, G-08232, G-22118, G-32079, N-21287
RESPIRATORY SYSTEM G-05146, G-08232, G-08441, G-10396, G-28556, G-32079
RETENTION G-28556, G-32842
RUBBER B-04227, I-07553, J-30696
RUBBER MANUFACTURING N-06146

S

SAFETY EQUIPMENT A-23977, G-08575
SALTZMAN METHOD D-05145
SAMPLERS A-05005, A-17252, A-22000, A-30598, B-05509, B-07617, B-10460, C-33953, D-24227, G-00021
SAMPLING METHODS A-05005, A-10467, A-17252, A-22000, A-30598, B-04050, B-05509, B-07617, B-10460, B-20248, B-24676, B-34084, C-10461, C-14774, C-17425, C-20434, C-22934, C-33045, C-33953, D-00038, D-05145, D-10618, D-24227, F-08439, G-00021
SAMPLING PROBES B-07617, C-22934, C-33953
SCRUBBERS A-02146, A-04946, A-05005, A-09686, A-29021, A-31935, B-00037, B-00322, B-00323, B-02031, B-03206, B-03754, B-03998, B-04227, B-04367, B-04794, B-05091, B-05118, B-05509, B-05597, B-06098, B-06223, B-06392, B-06443, B-06568, B-06587, B-06780, B-06854, B-07663, B-07664, B-07668, B-07669, B-07670, B-07925, B-07931, B-09198, B-09248, B-09361, B-09796, B-09974, B-09977, B-10462, B-10469, B-11073, B-13645, B-13811, B-14161, B-14889, B-15886, B-15887, B-16351, B-16553, B-16652, B-16681, B-16695, B-17115, B-17127, B-17151, B-17152, B-17154, B-17234, B-17423, B-17568, B-17746, B-17825, B-19403, B-20227, B-20248, B-20699, B-21355, B-21894, B-22138, B-23628, B-23808, B-23955, B-24239, B-24809, B-24881, B-25500, B-26195, B-27553, B-27727, B-28221, B-28497, B-28547, B-29740, B-30534, B-31195, B-31226, B-31344, B-31362, B-31486, B-32134, B-32791, B-32817, B-33081, B-33168, B-33897, B-33918, B-33952, B-34079, B-34082, B-34084, G-00021, G-26136, J-08689, J-21968, J-24543, J-26623, J-29186, J-29923, N-06146
SEASONAL A-27790, A-32351, B-09248, D-05145, G-08232, G-22118
SECONDARY AIR B-06780
SEDIMENTATION A-09686, A-30598, B-09974, B-26003, B-33081
SELENIUM COMPOUNDS A-31737
SETTLING CHAMBERS B-03754, B-06223, B-31344, B-34079, N-06146
SETTLING PARTICLES A-02146, A-04345, A-05005, A-10463, A-10467, A-10471, A-13261, A-17299, A-17471, A-26166, A-26321, A-27790, A-28371, A-30598, A-30613, A-31919, A-32489, B-00323, B-01110, B-02031, B-02728, B-02730, B-03206, B-03232, B-03754, B-03998, B-04050, B-04227, B-04382, B-04794, B-05118, B-05509, B-05604, B-06083, B-06223, B-06392, B-06443, B-06568, B-06780, B-06854, B-06936, B-07192, B-07521, B-07542, B-07661, B-07663, B-07664, B-07669, B-07699, B-07925, B-07931, B-08310, B-09248, B-09361, B-09436, B-09796, B-09915, B-09974, B-10460, B-10462, B-10464, B-10469, B-10477, B-10479, B-11096, B-13645, B-13811, B-13946, B-14161, B-14889, B-15886, B-15887, B-16039, B-16351, B-16446, B-16553, B-16695, B-17127, B-17138, B-17151, B-17152, B-17154, B-17158, B-17423, B-17568, B-17746, B-17913, B-19403, B-19792, B-20096, B-20226, B-20227, B-20280, B-20699, B-21355, B-21894, B-22138, B-23245, B-23628, B-23955, B-24239, B-24809, B-25384, B-25500, B-26003, B-26018, B-26195, B-26332, B-26546, B-27553, B-27727, B-27783, B-28221, B-28497, B-28547, B-28880, B-28905, B-29083, B-29740, B-29945, B-30018, B-30583, B-31092, B-31226, B-31344, B-31486, B-31589, B-31803, B-32134, B-32791, B-32848, B-33040, B-33081, B-33170, B-33401, B-33416, B-33438, B-33548, B-33897, B-33918, B-33952, B-34071, B-34079, B-34082, B-34084, C-10461, C-14774, C-15940, C-22934, C-33953, D-00038, D-05145, D-07406, D-10618, D-23391, F-08439, F-10473, G-00021, G-08441, G-10396, G-22118, G-28042, G-28556, G-32842, I-24417, K-16228, N-06146, N-21287
SEWAGE B-20227, B-29740, B-31226, B-33081, I-07553
SEWAGE TREATMENT I-07553
SHIPS A-08392, A-32351, B-31344
SIEVE ANALYSIS A-28371, C-33953
SILICATES B-07521, F-08439, G-10396
SILICON COMPOUNDS B-01110, B-06587, B-07521, B-07661, B-08310, F-08439, G-07472, G-08441, G-10396
SILICON DIOXIDE A-26321, A-28371, A-30613, A-31919, B-05604, B-06223, B-09248, B-09796, D-00038, F-08439, G-00021, G-07472, G-08441, G-10396
SILVER COMPOUNDS B-09796
SIMULATION A-04000, B-04050, B-06611
SINGLE CHAMBER INCINERATORS A-05005
SINTERING A-02146, A-04946, A-09737, A-17471, A-17516, A-30446, B-04227, B-06587, B-07542, B-09915, B-20096, B-20699, B-21894, B-22138, B-23182, B-24239, B-24676, B-26003, B-26546, B-31195, B-31344, B-31486, B-32134, B-32817, B-33401, B-34082, C-33953, D-10618, G-00021, G-32842, J-26623, K-16228, L-06733
SKIN CANCER A-33279
SLUDGE B-20227, B-29740, B-31226, B-33081
SMOG A-32351, I-07553, J-09313, N-06146

SMOKEMETERS B-04050
SMOKES A-05005, A-10466, A-10474, A-13261, A-17299, A-20414, A-23458, A-32489, B-04050, B-04367, B-06611, B-06780, B-07192, B-07542, B-07925, B-09270, B-09796, B-11096, B-13645, B-13946, B-15649, B-16646, B-16695, B-17138, B-17234, B-17746, B-17913, B-19732, B-20096, B-20699, B-21355, B-24239, B-26546, B-31226, B-32791, B-32848, B-34079, D-05145, G-00021, G-08232, G-24586, G-28042
SMOKING G-05146, G-32079, G-32842
SOCIAL ATTITUDES J-24155, M-15567
SOCIO-ECONOMIC FACTORS G-24212, J-21968, J-24155, J-30696, M-15567, M-26303
SODIUM CHLORIDE G-08232

SODIUM COMPOUNDS B-03998, B-09796, F-13084, G-08232
SOILING I-07553
SOILING INDEX D-05623
SOILS A-31737, G-31664, G-32842
SOLAR RADIATION G-11575
SOLID WASTE DISPOSAL A-05005, A-09737, B-05091, B-31195, B-33168, B-33548, C-33045, J-30696
SOLIDS I-07553
SOLVENTS A-32351
SOOT A-04345, A-17299, A-26321, A-28371, A-30598, B-09436, B-16553, B-34079, C-10461, D-07406, N-21287
SOOT FALL D-07406
SOURCE SAMPLING B-24676, B-34084, C-17425, C-22934, C-33045, C-33953
SO2 REMOVAL (COMBUSTION PRODUCTS) B-07521, B-07617, B-16561, B-16681, B-17234, B-20248, B-22138, B-22940, B-23182, B-26546, B-31316, B-31486, B-32791, B-32817, B-33168, B-33401, B-33918, B-34079, J-21300
SPARK IGNITION ENGINES A-05005, A-08392, A-09686, B-05091
SPECTROMETRY A-05005, A-22000, B-20248, D-00038
SPECTROPHOTOMETRY A-22000, B-32791, B-33168, B-34079
SPRAY TOWERS A-05005, B-06587, B-07663, B-07669, B-07670, B-09248, B-09974, B-13811, B-17152, B-28497, B-32817, B-34084
SPRAYS N-06146
ST LOUIS B-02229, B-02730, B-03998, B-04050
STABILITY (ATMOSPHERIC) A-04946, I-07553
STACK GASES A-04946, A-09686, A-10471, A-14799, A-17516, A-24928, A-29021, A-30613, A-31919, A-32489, B-01137, B-03677, B-03754, B-04227, B-04794, B-06223, B-06611, B-06780, B-07660, B-07661, B-07663, B-07664, B-07925, B-07931, B-09974, B-09977, B-10460, B-10462, B-10464, B-10469, B-17746, B-20280, B-20699, B-22940, B-23182, B-24239, B-24676, B-26018, B-26195, B-26546, B-28547, B-29083, B-30534, B-31226, B-31486, B-32134, B-32817, B-33040, B-33081, B-33168, B-33170, B-33401, B-33438, B-33897, B-33918, B-33952, B-34079, B-34082, C-10461, C-33045, D-05145, D-07406, D-10618, D-23391, F-08572, G-08441, G-32842, I-24417, J-26623, K-16228
STACK SAMPLING B-24676, B-34084, C-33045
STACKS A-04946, A-17516, B-04665, B-06568, B-06780, B-06854, B-07925, B-16146, B-26195, B-32134, B-34079, D-05145, J-26623
STANDARDS A-32351, B-06780, B-07542, B-17234, B-32817, G-08232, J-30696, K-16228, K-33815, N-06146
STATE GOVERNMENTS N-06146
STATISTICAL ANALYSES D-05623, G-05146, G-31664, J-30696
STEAM B-05597, B-06611, B-30583, J-08689
STEAM ENGINES B-34079
STEAM PLANTS A-08392, A-09737, A-32351, B-07699, B-07925, B-07931, B-09977, B-10469, D-07406, D-10618, G-08232
STEEL A-02146, A-04000, A-04001, A-04345, A-04946, A-05005, A-08392, A-09572, A-09686, A-09737, A-10463, A-10466, A-10467, A-10471, A-10474, A-11974, A-12396, A-13261, A-14799, A-17199, A-17252, A-17471, A-20414, A-22872, A-23458, A-23977, A-24928, A-26166, A-26321, A-26929, A-27501, A-27790, A-28371, A-28604, A-29021, A-29348, A-30296, A-30446, A-30598, A-30613, A-30698, A-31737, A-31935, A-32351, A-33279, A-33930, B-00037, B-00104, B-00322, B-00323, B-01110, B-01137, B-02031, B-02193, B-02728, B-02730, B-03232, B-03677, B-03754, B-04050, B-04227, B-04367, B-04382, B-04665, B-04794, B-05091, B-05118, B-05307, B-05509, B-05567, B-05597, B-05604, B-06083, B-06098, B-06249, B-06392, B-06443, B-06587, B-06611, B-06854, B-06936, B-07192, B-07521, B-07542, B-07660, B-07661, B-07663, B-07664, B-07668, B-07669, B-07670, B-07699, B-07925, B-07931, B-08310, B-09198, B-09248, B-09270, B-09361, B-09436, B-09796, B-09915, B-09977, B-10460, B-10462, B-10464, B-10469, B-10477, B-10479, B-11073, B-11096, B-13811, B-13946, B-14161, B-14889, B-15649, B-15886, B-15887, B-16039, B-16351, B-16561, B-16646, B-16652, B-16681, B-16695, B-17115, B-17118, B-17127, B-17138, B-17141, B-17151, B-17152, B-17154, B-17158, B-17234, B-17423, B-17568, B-17746, B-17825, B-17913, B-17926, B-19210, B-19403, B-19732, B-19792, B-20096, B-20226, B-20227, B-20248, B-20280, B-20699, B-21324, B-21355, B-21894, B-22138, B-23182, B-23364, B-23628, B-23808, B-23955, B-24239, B-24676, B-24809, B-24881, B-25384, B-25500, B-25521, B-26018, B-26195, B-26332, B-26546, B-26612, B-26854, B-27553, B-27783, B-28221, B-28402, B-28497, B-28547, B-28880, B-28905, B-29083, B-29740, B-29945, B-30018, B-30534, B-30583, B-31092, B-31195, B-31226, B-31316, B-31362, B-31589, B-31773, B-31803, B-32037, B-32134, B-32791, B-32817, B-32848, B-33081, B-33168, B-33170, B-33401, B-33416, B-33438, B-33548, B-33897, B-33918, B-33952, B-34071, B-34079, B-34082, C-10461, C-14774, C-15940, C-20434, C-22934, C-33045, C-33953, D-05145, D-05623, D-07406, D-10618, D-24227, F-08439, F-08572, F-10473, F-10717, F-13084, G-00021, G-05146, G-07472, G-08232, G-08441, G-08575, G-11575, G-16223, G-24212, G-26136, G-26577, G-28042, G-28556, G-31664, G-32079, G-32842, I-07553, I-24417, J-08689, J-09313, J-21300, J-21968, J-24155, J-24543, J-26623, J-29186, J-29923, J-30696, J-30951, K-33815, L-06733, L-06863, M-15567, M-18022, M-26303, N-03341, N-06146, N-21287
STONE A-09686, A-27501, B-03754, B-31803, I-07553
STRONTIUM COMPOUNDS B-09796
SULFATES A-32489, B-33170, D-05623
SULFIDES A-04946, A-32489, B-02728, B-07925, B-31195, B-31316, B-33168, B-34079, F-10717, F-13084, I-07553
SULFUR COMPOUNDS A-04001, A-04946, A-24928, A-30698, A-32351, A-32489, B-02728, B-02730, B-03232, B-05604, B-07925, B-09248, B-10460, B-16681, B-27779, B-31195, B-31316, B-33168, B-33170, B-34079, D-05623, D-23391, F-10717, F-13084, I-07553, J-29923
SULFUR DIOXIDE A-04946, A-09686, A-14799, A-17199, A-17471, A-17516, A-31919, A-32351, A-32489, B-02728, B-03754, B-05567, B-06223, B-07521, B-07617, B-07925, B-10460, B-23364, B-26546, B-27783, B-33168, B-33918, D-05145, D-05623, D-07406, D-10618, F-10717, F-13084, G-05146, G-08232, G-22118, G-24212, G-28042, I-07553, J-09313, K-16228, L-06733, N-21287
SULFUR OXIDES A-04946, A-09686, A-09737, A-14799, A-17199, A-17471, A-17516, A-27790, A-31919, A-32351, A-32489, B-01110, B-01137, B-02728, B-03754, B-05567, B-06223, B-07521, B-07617, B-07699, B-07925, B-07931, B-09796, B-10460, B-13645, B-23245, B-23364, B-26546, B-27783, B-32037, B-33168, B-33918, B-34082, D-05145, D-05623, D-07406, D-10618, F-10717, F-13084, G-00021, G-05146, G-08232, G-22118, G-24212, G-28042, I-07553, J-09313, J-30696, K-16228, L-06733, N-06146, N-21287
SULFUR OXIDES CONTROL A-04946, A-08392, A-09572, B-07521, B-07617, B-16146, B-16561, B-16681, B-17234, B-20248, B-22138, B-22940, B-23182, B-23364, B-24239, B-26546, B-28547, B-31316, B-31486, B-31803, B-32791, B-32817, B-33168, B-33401, B-33918, B-34079, J-21300, J-29923
SULFUR TRIOXIDE A-09686, A-32489, B-01110, B-06223, B-07617, B-07699, B-07931, B-09796, F-13084, G-00021, G-08232, G-28042, I-07553
SULFURIC ACID A-04946, A-09686, A-09737, A-27790, A-31935, A-32351, B-05091, B-05567, B-06587, B-07925, B-07931, B-20248, B-31316, B-33918, D-05145, G-08232, G-28042, I-07553, J-09313, J-30696
SUPERSATURATION B-20226
SURFACE COATING OPERATIONS A-08392, A-09686, J-30696
SURFACE COATINGS A-09686, A-32351, B-09915, I-07553, J-30696
SURFACE PROPERTIES A-10463, A-26321, A-30598, B-30583, B-33918, F-08439
SURVEY METHODS M-15567
SUSPENDED PARTICULATES A-04345, A-05005, A-09686, A-10463, A-10466, A-10467, A-10471, A-10474, A-13261, A-17299, A-20414, A-23458, A-26166, A-26321, A-32351, A-32489, B-00037, B-00322, B-00323, B-01110, B-01137, B-02229, B-02728, B-02730, B-03677, B-03754, B-04050, B-04367, B-04382, B-04665, B-05091, B-05118, B-05509, B-05567, B-05597, B-06098, B-06443, B-06611, B-06780, B-06936, B-07192, B-07521, B-07542, B-07617, B-07660, B-07661, B-07664, B-07668, B-07670, B-07699, B-07925, B-09248, B-09270, B-09361, B-09796, B-09915, B-09974, B-10462, B-10464, B-10469, B-10477, B-10479, B-11073, B-11096, B-13645,

B-13811, B-13946, B-14161, B-15649, B-16039, B-16646, B-16652, B-16695, B-17115, B-17127, B-17138, B-17141, B-17151, B-17234, B-17746, B-17913, B-17926, B-19732, B-19792, B-20096, B-20699, B-21355, B-21894, B-23955, B-24239, B-25384, B-25521, B-26195, B-26332, B-26546, B-26612, B-28221, B-28402, B-28497, B-28880, B-29945, B-31226, B-31589, B-31773, B-32791, B-32848, B-33548, B-33952, B-34079, B-34082, B-34084, C-22934, C-33953, D-00038, D-05145, D-05623, D-10618, F-10473, G-00021, G-08232, G-24212, G-24586, G-28042, G-32842, I-07553, J-08689, J-09313, K-33815, N-06146
SWEDEN A-04000, A-04345, A-26929, B-00037, B-01110, B-02229, B-02730, B-04050, B-04367, B-06223, B-22940
SYNERGISM A-26929, G-08232
SYNTHETIC FIBERS B-09248, B-09796, I-07553
SYNTHETIC RUBBER I-07553

T

TAR A-33930, B-05604
TEMPERATURE A-10463, A-10467, A-10471, A-10474, A-23977, A-29348, A-32489, A-33930, B-02229, B-02730, B-04050, B-05597, B-05604, B-06098, B-06611, B-07192, B-07542, B-07617, B-07660, B-07664, B-07699, B-08310, B-09248, B-09796, B-10462, B-10469, B-11073, B-11096, B-16646, B-17118, B-17913, B-28880, B-29740, B-30583, B-31589, B-31803, B-32037, B-32848, B-33081, B-33170, B-33401, B-33548, B-33952, B-34082, C-22934, F-08439, F-10473, F-10717
TEMPERATURE SENSING INSTRUMENTS A-10471, A-28604, F-10473
TESTING FACILITIES B-07617
TEXAS D-24227
TEXTILE MANUFACTURING A-09686, B-26546
TEXTILES B-03677, B-05567, B-09248, B-09796, B-26546, I-07553
THERMAL RADIATION B-10469
THERMODYNAMICS A-04000, F-13084
TIN COMPOUNDS B-09796
TISSUES G-10396
TITANIUM COMPOUNDS B-09796, F-08439
TOKYO D-07406
TOLUENES B-07925
TOPOGRAPHIC INTERACTIONS A-17516, A-26929, I-07553
TOXIC TOLERANCES B-06587
TOXICITY A-31737, G-07472, G-08441, G-08575, G-32842
TRACE ANALYSIS D-00038
TRACHEA G-10396
TRADE ASSOCIATIONS M-18022
TRAINS A-08392, A-32351, B-32848, B-34079, G-26577
TRANSPORTATION A-05005, A-08392, A-09686, A-09737, A-17299, A-32351, B-05091, B-31344, B-32134, B-32848, B-34079, D-07406, G-24212, G-26577, J-30696, N-06146, N-21287
TRAPPING (SAMPLING) A-05005
TREATED FABRICS B-08310, B-11096
TREATMENT AND AIDS G-05146, G-07472, G-08441, G-16223
TREES A-26929, B-02730, G-32842
TRUCKS A-05005, D-07406, J-30696
TUBERCULOSIS G-31664
TUNNELS B-32848
TURBIDIMETRY C-10461

U

ULTRAVIOLET SPECTROMETRY A-05005
UNITED STATES M-18022
URBAN AREAS A-09737, A-14799, A-17199, A-17299, A-27790, A-28371, A-32351, B-16146, B-16446, D-05145, D-07406, D-23391, G-00021, G-05146, G-07472, G-08232, G-08441, G-11575, G-31664, G-32079, G-32842, J-30696, J-30951
URINALYSIS G-00021
USSR A-13261, B-00104, B-10479, B-16193, B-16446, B-24809, B-26018, B-33897, F-08439, G-07472, G-08441, G-08575, G-10396, I-24417, J-29186
UTAH M-15567

V

VALLEYS I-07553
VANADIUM F-08439, G-07472
VANADIUM COMPOUNDS B-09796, F-08439, G-07472
VAPOR PRESSURE A-23977
VAPORS A-32489, A-33279, B-05597, B-06611, B-27727, B-30583, F-10717, J-08689
VARNISHES J-30696
VEGETABLES G-32842, J-09313
VEHICLES A-05005, A-08392, A-09686, A-09737, A-17299, A-32351, B-32848, B-34079, D-07406, G-24212, G-26577, J-30696, N-06146, N-21287
VENTILATION B-09796, B-09977, B-11096, B-13645, B-20699, B-28497
VENTURI SCRUBBERS A-29021, B-00037, B-00322, B-00323, B-03206, B-04227, B-04367, B-04794, B-05091, B-05118, B-06223, B-06587, B-06780, B-06854, B-07668, B-07669, B-07670, B-07931, B-09198, B-09361, B-09977, B-10462, B-10469, B-11073, B-13645, B-13811, B-14161, B-15886, B-15887, B-16351, B-16553, B-16652, B-16681, B-16695, B-17127, B-17151, B-17154, B-17568, B-17746, B-17825, B-20699, B-23628, B-23808, B-23955, B-24239, B-27553, B-28547, B-29740, B-30534, B-31226, B-31344, B-31362, B-32134, B-32791, B-32817, B-33081, B-33897, B-33952, B-34079, B-34084, J-24543, J-26623, J-29186
VIRUSES G-24586
VISIBILITY B-01110, B-04050, B-06780
VOLTAGE B-05307, B-07699, B-23955

W

WASHOUT D-10618
WATER B-05118, B-05604, B-07542, B-09248, B-20280, B-23245, B-26003, B-31486, B-33081, F-10717
WATER POLLUTION A-29021, A-31737, B-06392, B-31195, B-33168, G-32842, J-26623, J-30951
WET CYCLONES A-02146, B-00322, B-00323, B-04794, B-06223, B-06392, B-06587, B-06780, B-13645, B-13811, B-14161, B-24239, B-28547, B-31344, B-34084
WETTING B-17154, B-20227
WIND ROSE D-00038, D-05145, D-05623
WINDS A-04946, A-27790, A-32351, D-00038, D-05145, D-05623, D-23391, D-24227, G-11575, G-22118
WOOD B-26546, C-33045
WOOLS B-03677, B-05567, I-07553

X

XYLENES B-07925

Y

YOKOHAMA D-07406

Z

ZINC A-04946, A-09686, A-17471, A-22872, A-26166, B-03754, B-03998, B-21324, C-33045, G-32842, J-30696, L-06863
ZINC COMPOUNDS A-04946, A-32489, B-01110, B-05604, B-06098,

☆ U. S. GOVERNMENT PRINTING OFFICE :1972—484-487 (335)