Industrial Hygiene At American Smelting and Refining Company

PLAINTIFF'S EXHIBIT

ASA-324

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INDUSTRIAL hygiene has been defined by Patty[1] as "the science and art of recognizing, evaluating, and controlling potentially harmful factors in the industrial environment." This definition implies thorough study of operations, evaluation of potentially harmful factors through air sampling, microanalyses and other means, and, finally, appropriate medical and engineering control wherever indicated.

The prevention of industrial health injuries is a vital part of operations of American industry today. Progress and interest in this field has increased steadily for many years, the most rapid progress having been attained, perhaps, during the last three decades. It is significant to note that there are now official agencies in 46 states actively concerned with industrial health problems and that a western field station has been established recently in Salt Lake City by the U. S. Public Health Service to augment its industrial hygiene services directed from headquarters of the National Institute of Health, Bethesda, Md. Many of the larger industries have found it advantageous to establish their own industrial hygiene departments.

The American Smelting and Refining Co. is a world-wide organization engaged in the mining, smelting, and refining of lead, copper, zinc, silver, gold, by-product metals, including cadmium, arsenic, and others. In the United States there are 13 smelters and refineries, 11 secondary smelters or foundries, and a number of mines. Approximately 9000 workers are normally employed.

It has long been the established company policy to seek out occupational hazards and provide safeguards for employee health. Protective equipment has been supplied to individual workers and exhaust ventilation installations have been in use in some operations for more than 40 years. All of the major units have their own medical departments which provide employees with excellent medical and hospital care.

In 1937 full scale industrial hygiene studies were undertaken at the Selby Plant and were extended to most of the other smelters during the next three years. In 1945 the Department of Hygiene was organized with Professor Philip Drinker of Harvard University as Director and with Dr. S. S. Pinto as Medical Director. The department is responsible for coordinating and maintaining a program for the good health of all employees from top management down to the lowest paid day worker. It is essentially a service organization serving all of the United States plants regardless of location or size. Full and part-time physicians employed in all of the company's American plants and working in close cooperation with the Medical Director are responsible for determining the state of health of all the employees and giving treatment when necessary. In general. medical care is confined to accidents or illnesses occurring while the men are on the job. Among the duties of the doctors is the making of careful physical examinations of new employees and routine check-ups of old employees.

In addition to medical care a primary responsibility of the department is the *prevention* of occupational illnesses. In this the main concern is with the working environment in relation to its effect on the worker. Environmental factors may be dusts. fumes, gases, toxic materials, heat, humidity, radiation, or noise. The objectives are: (1) Immediate control of these factors through the education of the worker, through providing the wearing of respirators or other protective devices, and through careful medical examinations and regular analysis of urine specimens; (2) a long range control program which may be accomplished by local exhaust ventilation. wetting of materials, changes in metallurgy, changes in methods of handling, or by use of special devices and special equipment.

To accomplish these objectives a fine industrial hygiene laboratory was built in Salt Lake City and equipped to do routine and experimental work. Trained and experienced industrial hygienists obtain the facts by making frequent hygiene surveys. These surveys include tests of the air, studies of all processes, and careful investigation of ventilation. lighting, and general working conditions. Except in emergencies, the air contaminants and often the substances handled by the worker are sent to the laboratory for analysis by chemists and technicians specially trained in industrial hygiene methods. The findings are evaluated in terms of limits recommended by various State and Federal agencies, and in light of all available medical data.

The methods used for studying the working environment involve all of the usual chemical and physical procedures employed in industrial hygiene. The Impinger, electric precipitator, thermal precipitator, and filter paper sampler have been used to collect atmospheric dust and fume samples. Of special interest here is the filter paper sampler. shown in Fig. 1, which was developed by Dr. Silverman at Harvard University. The instrument has been improved and is used very extensively in field studies. A water manometer connected behind an orifice is used to determine the rate of air flow. Calibration is effected by use of a standard gas meter or rotameter. The dust or fume is collected on a filter paper clamped between two rings, as shown in Fig. 2. The filter paper, such as Whatman No. 52, collects both dust and fume with a very high efficiency. The instrument is very convenient and easily transported.

The solids collected on the filter paper are analyzed in the laboratory usually by use of a polarographic procedure. By this procedure it is possible to measure quantitatively in a single analysis the

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Discussion of this paper, TP 2989 D, may be sent (2 copies) to AIME by March 1, 1951. Manuscript, June 22, 1950; New York Meeting, February 1950.

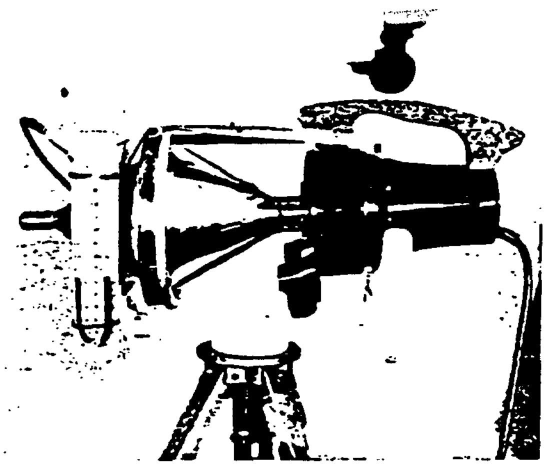

Fig. 1—Filter paper sampling apparatus ready for use.

copper, lead, cadmium, and zinc in each sample. Polarographic methods are also used for the determination of a number of other elements.

Dusts of various types are the most common contaminants found in the atmosphere of the various plants. Fumes containing lead oxide may be found in certain smelter and refinery work areas and are given special attention since lead oxide is more readily absorbed than other less soluble lead compounds, such as the sulphide. Other contaminants such as carbon monoxide, hydrogen sulphide, sulphur dioxide, selenium, tellurium, cadmium, and arsenic may be found and require study. Certain of the gases mentioned may be toxic or irritant. In order to be constantly on the alert and to be warned in advance, rapid field tests have been developed for hydrogen sulphide, chlorine, and arsine from a basic British method. In this method a small hand pump is used to draw air through filter paper disks impregnated with various reagents which produce a stain if traces of gas are present, see Fig. 3. These stains are compared with standards to estimate the gas concentrations. By use of this method chemists and safety directors are able to check the working environment for suspected dangers. For one plant where hydrogen sulphide is being used in one of its operations, a machine is being developed to sound automatically an alarm before any escaping gas reaches dangerous concentrations.

From time to time certain analyses requiring highly specialized training or very expensive equipment are performed by the research laboratory or outside laboratories; for example, spectrographic and petrographic analyses. Certain types of research work involving animal experimentation have been performed through grants to Harvard University.

As a part of the fact-finding function of the Hygiene Department, urine specimens and frequently blood specimens are obtained from all workers exposed to lead and other metals and examined at

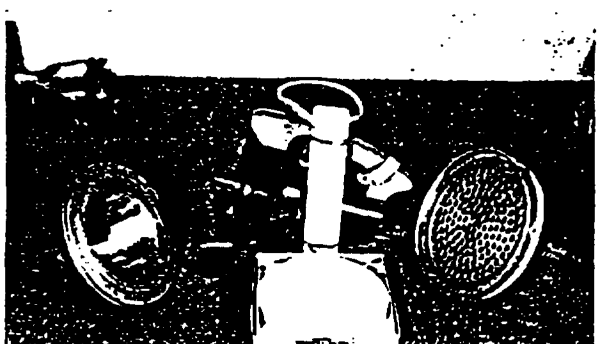

Fig. 2—Sampling apparatus unassembled.

the Hygiene Laboratory. These tests indicate what the worker has been breathing, usually long before illness occurs. During the past year more than 5000 determinations for lead in urine were made. On the basis of these and other medical findings, the Medical Director may make recommendations for immediate protection of the employee.

The evaluation of all findings is an important function of the Hygiene Department. This involves in part an appraisal of air studies and the correlation of these studies with medical data. When all the facts are brought together, an overall evaluation of the environment is made, the need for control measures determined, and a coordinated control program outlined. Recommendations for control are made to the plant manager and passed on to engineers especially trained in industrial hygiene ventilation. The plant manager and the superintendent with his operating staff decide what method of control should be carried out. This is logical because control may be accomplished by changes

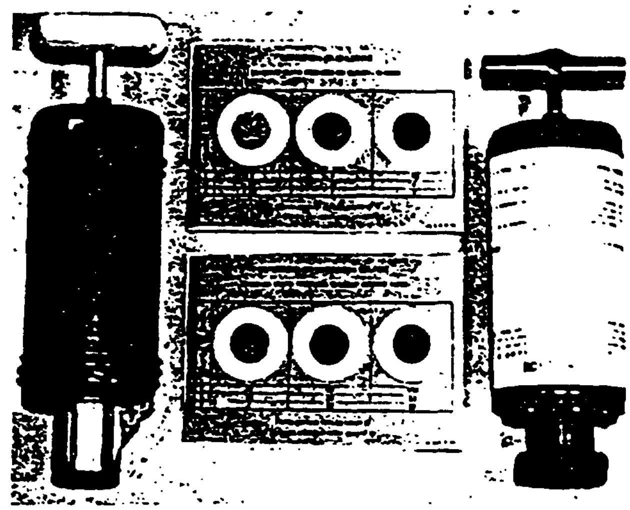

Fig. 3—Sampling pumps and standard stains for field determinations of hydrogen sulphide and chlorine.

in metallurgy or methods of handling rather than by local exhaust ventilation or other engineering or chemical means. Occasionally control is not possible by engineering means and it is necessary to rely on respiratory protective devices and medical control procedures. Sometimes the recommendations for plant improvements are based on comfort alone rather than a health hazard.

The ventilation engineers form a unit or a division of the Western Engineering Department but work in the closest cooperation with the Hygiene Department in carrying out the detailed recommendations. Frequent conferences are held with these engineers and general plans are approved.

Plant Improvements

Elimination or control of all potentially harmful factors in the environment is the major long-range objective. Since 1938, and particularly during the past four years, much progress has been made toward this objective. In some cases, such as in the mills, the cost has been very high—from ten to twenty thousand dollars per worker. Following are some of the highlights of control of dusts, fumes, and gases in the various plants achieved through the combined interest and effort of managers, superintendents, metallurgists, foremen, the specially trained staff of ventilation engineers of the Western

Engineering Department and the Department of Hygiene:

Mills: Wetting has long been used to control dusts in mills. However, because wetted materials in some cases clog up screens and chutes and hinder proper cleaning of equipment between ore lots, other means of control have had to be used also, chiefly local exhaust ventilation and dust collection by small baghouse units and centrifugal impingement washers. Because of the very high cost, experimental work has been conducted to find other methods. Mist-sprays produced by atomizing water with compressed air have been tried. The minute droplets of water produced by these sprays actually wet dust particles and help to reduce the escape of dusts at the source, yet they avoid objectionable wetting of the flowing material. With this method of control a 50 pct reduction in dust concentrations has been achieved in one mill.

In certain instances protection of the worker has been accomplished by ventilating and air conditioning small areas where men work, such as crane cabs, when the general ventilation of the room would be difficult if not impossible, see Stevenson.[3] In other words, the man has been "ventilated" instead of the operation. Cabs of cranes handling ores, carrying hot metals over furnaces, etc., are examples. This approach is being tried now in mills by building booths kept under positive pressure with filtered air for workers whose duties can be carried out from such an enclosure.

Sampling Rooms: Local exhaust ventilation and good housekeeping have been used exclusively to control dusts in sampling rooms, see Fig. 4. Modern grinding and sampling equipment are easily enclosed and the dust can be controlled at a very moderate cost.

Beds and Charge Bins: Wetting, enclosure and local exhaust ventilation are being used for control of dusts in such equipment. Dust control in these departments is one of the most difficult problems. Wetting can only be used to a limited degree because excess moisture may affect the roasting of certain types of charges.

The unloading of truckloads of ores and concentrates for storage or making up charges was a difficult problem to control in one plant. The final solution was found in a semi-enclosure and hood with high volume air intake.

Fig. 4—Ore sample being screened at bucking table with use of exhaust ventilated hood.

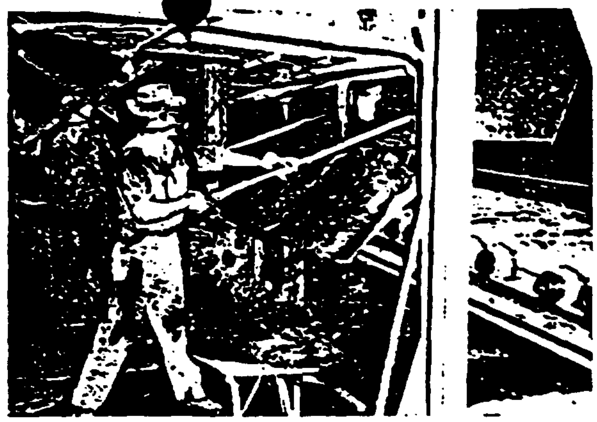

Fig. 5—Workers removing wetted dust from wind boxes of a first-over Dwight-Lloyd sinter machine.

Dwight-Lloyd Sinter Plants: Wetting, enclosure and local exhaust ventilation have been the principal methods of controlling dust and fume in the Dwight-Lloyd sinter plants. Water may be added to both first and second-over charges at the belt tripper, at the mixing tables and sometimes with use of pugmills. Water is used to quench the sinter after it is roasted and the discharge ends of the machines are kept tightly enclosed.

The control of dusts from crushing first-over sinter has been effected with local exhaust ventilation and collection of dusts with centrifugal impingement washers.

The dustiest Dwight-Lloyd operation is the removal of deposits from wind boxes. Control of these dusts has been effected by (1) use of enclosed pan or screw conveyor along wind boxes with draft maintained on the boxes, (2) wetting by inserting into the dust piles a water pipe with flowing water and (3) maintenance of a water seal in the bottom of the wind boxes which completely wets the accumulating dusts. In Fig. 5 is shown the absence of visible dusts after wetting with inserted water pipes. The water seal has been applied only to second-over machines.

Good housekeeping with frequent wash down of floors is very important in control of dusts. Thermal air currents plus vibration can redisperse settled dusts.

Considerable improvement in dust and fume concentrations was effected in one Dwight-Lloyd plant by a change in metallurgy, that is, a lowering of the percentage of coke in the charge.

Excessive heat has been controlled by insulating wind boxes and air ducts and by use of large hoods mounted over the pallet immediately behind burners and connected to a stack for gravity ventilation.

Lead Blast Furnaces: The make up of blast furnace charges may involve dusty operations if the second-over sinter is not sufficiently wetted. The sinter is usually stored in hoppers and it has been found necessary to provide exhaust ventilation when the sinter is withdrawn.

The control of dust and fume at the feed to the blast furnace is accomplished chiefly by good draft on the furnace.

The lead blast furnace cannot be tapped for slag, or for lead if the temperature is high, without the generation of much lead fume. Fume from these points is controlled with local exhaust ventilation at all furnaces. It is necessary to raise and lower these hoods occasionally and workers have sometimes neglected this duty because of the little extra work

Fig. 6—Lead and slag being tapped from a blast furnace with use of an improved exhaust ventilated hood.

required. To overcome this and provide heavier construction to resist the heat, a hood has been very recently designed which can be raised and lowered by an electric motor merely by pressing a button as shown in Fig. 6. Stand-by empty or filled lead pots sometimes cause considerable fume. To control this an exhaust ventilated hood with a flexible fireproof duct has been developed.

Reverberatory Furnaces: Control of dust and fume from operation of lead dross reverberatory furnaces has been effected by adequate draft on furnaces to prevent escape of fume at the charge door and by local exhaust ventilation at the tap holes and launders for speiss and matte.

Kettles: One of the most difficult problems has been control of dusts and fume from refining operations in kettles. Complete or partial hoods with exhaust ventilation have been effective where metals are transferred to kettles or when stirring is done to separate drosses. Fig. 7 shows a partial hood with a high volume air intake to control the fume over the surface of a lead kettle. As another approach to reducing dustiness during dross skimming, experimental work is now under way to (1) change the metallurgy, (2) remove drosses with a screw-type conveyor with local exhaust ventilation at point of discharge into skip and (3) use of a high velocity slot type exhaust around edge of kettle. A fair degree of success has been achieved with use of the screw-type conveyor.

Flues: The removal of settled dusts from flues has long been a dusty and unhygienic operation. To control the dusts from this operation, engineers and metallurgists from the Federal Plant[3] developed the telescopic tube device shown in Fig. 8. This device serves as an enclosure and wetting chamber combined. A circular water spray located near the top partially wets the dusts as they pass from flue to car. The wetting of the dusts is continued in the car and minimizes dusting in later handling.

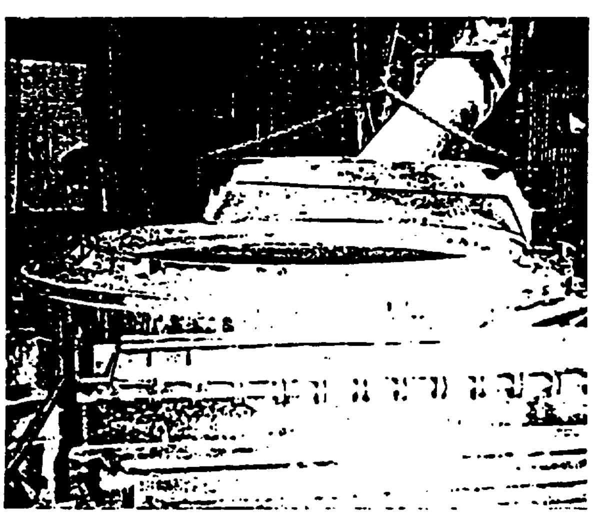

Fig. 7—Partial hood with high volume air intake over a lead kettle for control of lead fume.

Cottrells: The control of atmospheric dusts resulting from the cleaning of cottrell hoppers has been difficult. Enclosed and ventilated conveyors along hoppers have not been adequate. Spills which create airborne dusts do occur in spite of the best care. The problem has finally been solved by replacing the workers with automatic equipment. Electric vibrating hammers have now been installed on most of the cottrell units.

By-Products Metals: The control of dusts and gases in the refining and packaging of by-product elements, such as selenium, tellurium, and cadmium, has been accomplished by use of local exhaust ventilation almost exclusively.

Fig. 8—Workmen extracting flue dust with use of telescopic tube device designed for control of dusts by wetting and enclosure.

The hygiene program and some of the work that has been done to improve working conditions in the American Smelting and Refining Co. have been reviewed briefly. In presenting this information there is no wish to convey the impression all objectives have been reached. There are problems yet to solve, and changes in operations and new processes continually arise which require study and control. In one smelter recently the minutest details of control in a new process were worked out before the plant was built in order that no chances would be taken. Top management and operating staffs displayed keen interest and cooperated to the fullest extent. The same interest and cooperation from managements of all plants have existed in all other phases of the industrial hygiene program and are largely responsible for what measure of success has been achieved.

References

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[2] B. R. Small, with supplement by C. A. Stevenson: Air Conditioned Crane Cabs. Engineering Series publication by Industrial Hygiene Foundation of America. Mellon Institute, Pittsburgh, Pa. 1946.

[3] Federal Plant, American Smelting and Refining Co., Alton, Ill.; Luther J. Buck, Manager.