January 16, 1964

Mr. Clifford H. Seymour
Safety Director
The Carborundum Company
P.O. Box 337
Niagara Falls, New York

Dear Mr. Seymour:

We are pleased to enclose four signed copies of a report giving the results of the analysis of samples of dust collected during a visit to your plant on November 26th, 1963. We believe the report to be self-explanatory and we hope it is satisfactory for your purposes.

Except for Table 2, the tables are the same as the ones sent to Mr. S. D. Mark, Jr., on December 11, 1963. Table 2 has been revised to include a count of the particles less than 2 microns in diameter.

Sincerely yours,

J. Cholak
Director, Division of
Industrial Hygiene Technology

JC/meg
Enclosures
cc: Dr. Robert A. Kehoe

Report

On an Environmental Survey of a Cut-off Operation at the Plant of the Carborundum Company, Niagara Falls, New York

This report gives the results of analyses of particulate matter removed from the atmosphere while leaded, resin-bonded, abrasive, cut-off wheels were being used to cut rods of hot rolled steel. The tests were conducted on November 26, 1963, in the testing laboratory, on the first floor of Building 12-1 of the Carborundum Company in Niagara Falls, New York.

Procedures

Tests were carried out in duplicate with cut-off wheels of three different formulations; a "lead-free" wheel, one containing 3 per cent of lead, and finally one in which the lead amounted to 12 per cent of the weight of the wheel. The abrasive wheels, 16 inches in diameter and 1/8 inch thick, were enclosed in a modified guard on an Allison-Campbell, cut-off machine and were driven at a speed of 3300 revolutions per minute by a 7 1/2 HP motor. Hot rolled steel (C-1020) 1 1/8 inches in diameter was chosen as the metal to be cut dry, and without the benefit of the exhaust ventilation available, in order to simulate the worst possible condition. Each wheel was operated for the period of time required to cut approximately 120 one inch pieces from the rod. Dust produced by the operation was collected during the entire time required to make the 120 cuts with the first (lead-free) test wheel, but in subsequent tests, the air was sampled only during the periods of time required to cut 80 pieces after the first 20 pieces had been

cut from the rods. All exhaust fans in the room were turned off and all windows and doors were kept closed during the cutting operations. Between tests with each type of wheel, the room was aerated for a period of 15 to 20 minutes by turning on the exhaust ventilation and opening the large doors to the outside located in one end-wall of the room.

Dusts were removed from the air at the breathing zone of the operator and at a distance of 12 feet from the machine, by electrostatic precipitation. The precipitator was set-up with the opening of the collector tube parallel to the oncoming particles generated by the cutting operation and about 12 inches from the nose of the operator.

In addition to the samples of dust collected by electrostatic precipitation, several samples of dust were removed from the air, at the breathing zone of the operator, by filtration through paper or membrane filters. The Freon® gas operated "Unijet" air sampler (Industrial Equipment Co.) fitted with a membrane filter and sampling at a rate of 3 liters of air per minute, collected dusts which could be used for the determination of the sizes of the particles and for chemical analysis. The membrane filter was set up in the same plane as the inlet of the electrostatic precipitator but 12 to 15 inches nearer to the cut-off machine. A two stage "respirable" dust sampler, consisting of a Unico Model #240, cyclone, dust collector fitted to a Unico #300 air sampler (Union Industrial Equipment Corp., Port Chester, New York) provided with a 4 inch diameter Whatman #41 filter paper disc, was also employed during some of the tests. At a sampling

rate of approximately 8.5 cfm, only those particles less than 1-2 microns in size reached the paper. This dust sampler, used only during the tests with the leaded abrasive cut-off wheels, was placed at the breathing zone so that the air inlet was in the same plane as the inlets of the other two samplers, but was farthest away from the cut-off machine, about 12 inches from the electrostatic precipitator.

Particulate matter was removed from the collector tubes of the electrostatic precipitator by wetting the inside walls of the tubes with ethyl alcohol and rubbing off the particles by means of a rubber-tipped glass rod. The resulting suspension was made up to a suitable volume with ethyl alcohol, and a small amount (a fraction of a milliliter) of the well shaken mixture was then removed and examined by light field microscopy and at a magnification of 1000, to determine the distribution of particles of varied size. The mixture remaining was then placed in a 16 oz., wide mouth bottle, 2.5 inches in diameter and 5.5 inches tall, with a rubber stopper containing a siphon which extended to within 1 inch of the bottom of the bottle. Alcohol was added to a height of 3.3 cm above the end of the siphon tube, and the bottle was shaken to resuspend the particles. After standing 2 minutes and 42 seconds, the top 120 ml. of alcohol, containing only particles less than 10 microns in diameter, were siphoned off. (A Practical Method for Particle Size Separation of Atmospheric Dusts, Industrial Hygiene Foundation, Pittsburgh, Pa., Feb. 1, 1946.) This suspension was taken to dryness, the residue was weighed and then was analyzed for

its content of lead. The result of this type of analysis was then used to estimate the proportional distribution of the lead, as between the fine and coarse particles, in each sample of dust removed from the air. The particulate matter collected on the membrane filters on the Unijet equipment was first examined by light field microscopy to determine the frequencies of the occurrence of certain ranges of sizes of particles, and then was analyzed for its content of lead. The filter papers used in the "respirable" dust sampler were analyzed only for their content of lead. The cyclone sections of the two stage sampler were rinsed with alcohol and manipulated to remove the dusts which were also analyzed for their content of lead.

All determinations of lead were made by a colorimetric procedure using dithizone, which is a method in regular use in the Laboratory.

Results

In Table 1 are recorded the weights of dust in the air, as collected by electrostatic precipitation only, the proportion (in per cent) of particles less than 10 microns in diameter, and the concentration of lead in each entire sample, as well as that in the fraction made up of particles less than 10 microns in diameter.

The frequencies of the occurrence of particles, within certain limits of size, in the material collected by electrostatic precipitation or on membrane filters, while the leaded wheels were in use, are recorded in Table 2.

Table 3 compares the findings obtained by the analysis of samples collected simultaneously by the three different types of sampling equipment.

The results of sedimentation tests made with samples collected by electrostatic precipitation during periods of use of the leaded, abrasive, cut-off wheels are tabulated in Table 4.

Discussion

Resin-bonded, lead-bearing, abrasive, cut-off wheels when used without the benefit of adequate exhaust ventilation yielded concentrations of lead in the air at the breathing zone of the operator, and in the general work area, 12 feet from the cut-off machine, which were 2.2 to 15 times greater than the threshold limit recommended for industrial operations (Table 1). When the exhaust ventilation of the cut-off machine was in operation, the dispersion of lead-bearing dusts into the air was greatly reduced, as was indicated by the concentration of 0.1 mg. of lead per cubic meter of air, when a sample was obtained during the operation of a wheel containing 12 per cent of lead (sample 9, Table 1).

On the average, 84 per cent of the particles of dust produced by the use of the leaded, cut-off wheels were smaller than 10 microns in diameter. The greater portion of the air-borne lead was found in these finer dust particles. Particles of dust within this range in size averaged 75.0 per cent of the total lead; the findings varied from 60.5 per cent in a sample collected 12 feet from the cut-off machine, while a wheel containing 3 per cent of

lead was being used, to 85 per cent of the total lead in the breathing zone of the operator during the use of a wheel containing 12 per cent of lead.

The data in Table 2 indicate that most of the particles dispersed into the air by the leaded wheels were below 10 microns in diameter, and that the median diameters of the particles in all of the samples were well below 5 microns. Examination of the particles trapped on the membrane filters (3C and 8C) revealed that 98 per cent of the particles observed by light field microscopy were smaller than 5 microns in diameter, and that the median diameter was considerably less than 1 micron in size. Most of the particles were spherical in shape, and there were many aggregates of these small particles (this phenomenon is characteristic of particles forming metallic fumes). As may be seen from the data presented in Table 3, higher levels of concentration of lead were found in the dust collected on membrane filters, as compared with those found in dust collected by other means. The higher values are probably due to the relative nearness of the membrane sampler, to the source of the lead dust. The physical and chemical examinations of the particles deposited on the membrane filters support the conclusion that the lead in the air was present mainly as fume. Such a result, we believe, can be expected from the nature of the formulation of the wheel, the wear of the wheel, and the heat generated in the cutting operation.

Although the results obtained by the use of the three types of samplers reported in Table 3 are not strictly comparable

because of their different locations in the breathing zone relative to the cut-off machine, and the different entrance velocities due to the different rates of sampling, they are consistent in showing that most of the lead in the air was represented by the smaller particles suspended therein. Of the three pieces of equipment employed in this investigation, only the "respirable" dust sampler directly separated the air-borne dust into so called "respirable" and "unrespirable" fractions. The device had been used by the A.E.C. with some success to study the inhalation of respirable uranium dioxide. (Lippmann, M. and Harris, W. B., "Size-Selective Samplers for Estimating "Respirable" Dust Concentrations" Health Physics, 8, 155, 1962.) Since the densities of lead and lead oxide are not too different from that of uranium, the equipment was considered satisfactory for determining the quantities of lead which could reach the lungs. From theoretical considerations it was determined that 80 per cent of the particles of lead, 0.7 microns in diameter and 50 per cent of those 1 micron in diameter would be collected on the filter and be representative of the sizes of particles which could reach the lungs. As was mentioned earlier, approximately 80 per cent of the particles deposited on the membrane filter were less than 2 microns in size and only 2 per cent were greater than 5 microns in diameter (Table 2).

Table 4 shows the distribution of the total lead between the fine and coarse particles. These data were obtained from the sedimentation studies in which the concentration of lead in the portion of the fine particles removed for analysis was used to calculate the amount of lead in the fine particles suspended at the

end of 2 minutes and 42 seconds in the total volume of ethyl alcohol used in the sedimentation vessel. The concentrations listed are evidently on the low side, since many fine particles accompanied the coarse particles and were included in the latter findings.

All of the evidence, therefore, points to the fact that the greater portion of the total lead present in the air is present in the fine particles and most likely is present in the air as fume. It is also evident that abrasive, cut-off wheels containing lead will need to be operated in equipment provided with adequate exhaust ventilation in order to collect the lead dusts and fumes produced in their use.

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Director

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