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o Portland Cement Operati

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A recent study evaluated respirable dust at portland cement operations to quantify areas of high dust levels and make recommendations for lowering levels in these areas. Part 1 of 2.

Several years ago, the Mine Safety and Health Administration (MSHA) proposed changing the metal/nonmetal dust limit from a 10-mg/m^3 total nuisance dust standard to a 5-mg/m^3 respirable dust standard. Discussions with the Portland Cement Association and a number of member companies were held to determine the potential impact this change could have on the industry.

Shortly after these discussions, a study was initiated by the then-Bureau of Mines to provide insight into typical respirable dust levels at these operations. In addition, researchers wanted to examine the potential impact that the new dust standard would have on the portland cement industry. Once typical respirable dust levels were determined, recommendations would be given on ways to lower dust concentrations in cement operations and lower the dust exposure of workers.

Shortly after this study began, the Bureau of Mines was closed and the research being performed at the Pittsburgh Research Center was transferred to the Department of Energy (DOE), which continued funding for the work. The health and safety research program at Pittsburgh was later transferred to the National Insti... Safety and Health ... the Centers for ... and ultimately ... and Human Services. After being transferred, researchers became aware of a previous NIOSH study performed in the cement industry.

Dust monitoring procedure

The dust monitoring research performed for this study used area sampling methods. Although MSHA's proposed dust regulation change involves personal compliance dust-sampling measurements at the 5-mg/m^3 respirable limit, there are numerous factors that can account for substantial variations when taking these types of measurements.

These factors can involve such things as where workers spend their day, personal work practices, the type and cleanliness of clothing being worn by workers, and weather conditions. The objective was to take area dust samples because it eliminated many of these variables and can indicate a worker's potential dust exposure while working in a particular area of the plant. Instantaneous monitoring equipment can be used to ... variations in respirable dust concen... over the sampling period at a particular mon-itoring location. This also helps to deter... high dust areas and make suggestions on possible methods to reduce respirable dust levels, thus lowering a worker's dust exposure while working in these areas.

Dust sampling for this research study was performed using real-time aerosol dust monitors. These instruments use the 10-mm Dorr-Oliver cyclone to classify the respirable portion of dust, usually considered to have aerodynamic diameters of 10 microns or less.

A sampling instrument was used at each sample location for some portion of the evaluation time. Since these instruments continuously record respirable dust levels, they provide valuable information on variations in dust levels during changes in production, as well as from maintenance work and other incidents that affect dust levels. The dust

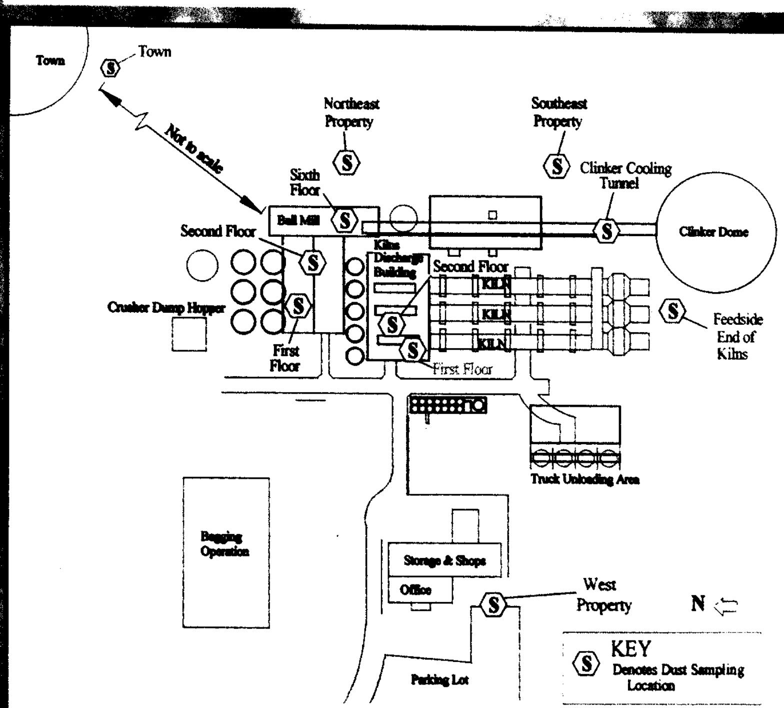


Figure 1. Dust Monitoring Locations at Dry Processing Plant

data from each sampler was collected on a Metrosonic 331 datalogger, which recorded the average concentration every 30 seconds. Periodically throughout the analysis, the information recorded on the datalogger was transferred and stored on computer files. During the time that this data was being transferred to the computer, the sampling instruments were recalibrated, causing breaks (about 45 minutes) in the recording of the respirable dust concentrations at each sample location. Each of the sampling periods in referred to as a "sampling segment." After all testing was complete, this data was analyzed.

Plant evaluation

Two evaluations—a summer and a winter analysis—were performed at each site. Both of these operations were located within 15 miles of each other. Sometimes there can be significant variations from the summer months when everything is open to the winter months when buildings are more closed and sealed. The first evaluation was performed at a dry-process operation, and the second at a wet-process operation. The following presents the test sequence at both of these operations:

In addition to the dust measurements, atmospheric conditions were evaluated at both operations. This became even more important when considering that a number of dust measurements were being taken in outside weather conditions. Atmospheric conditions monitored during testing were: wind speed and direction, outside dry bulb air temperatures, relative humidity, dew point temperature, and barometric pressure.

Much of this information was obtained from a National Weather Bureau station located within 40 miles of these operations. During periods of rain or snow, outside dust monitors were turned off since they would be recording very low dust concentrations and the instruments could be damaged by excessive moisture.

In addition, researchers tried to gather as much production information as possible at both sites during each evaluation to compare relative changes in dust levels based on changes in production. They also tried to determine any maintenance or housekeeping events that could significantly impact respirable dust levels. The main focus was on the kilns and grinding mills.

To indicate the type of data obtained during this study, an example of the measurements taken for atmospheric conditions and for production levels follows.

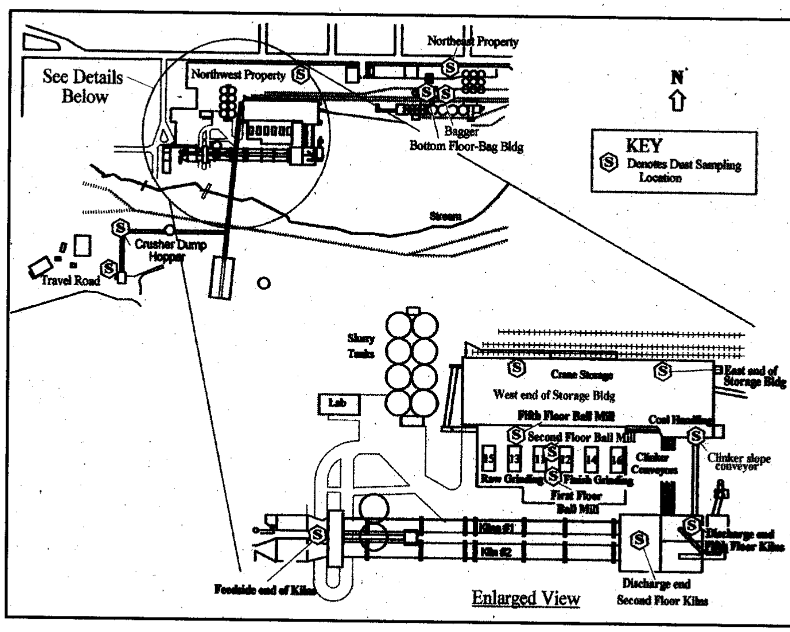


Figure 3. Dust Monitoring Locations at Wet Processing Plant

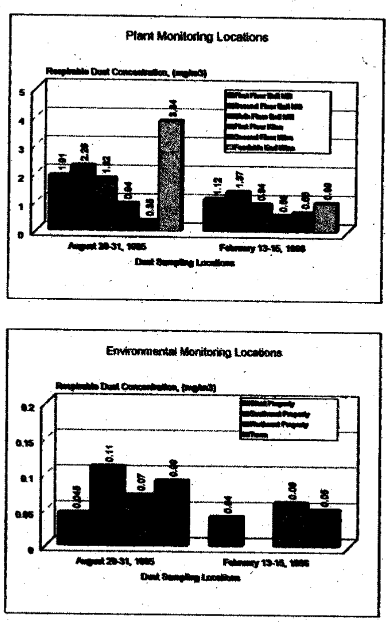


Figure 2. Average Respirable Dust Concentrations at Dry Processing Plant

Results: Dry Processing Portland Cement Evaluation—The dust evaluation sampling at the dry processing operation was performed continuously for 48 hours during Aug. 29 to 31, 1995 and for 50 hours during Feb. 13 to 15, 1996. Eleven dust monitoring locations were used for these two surveys. Figure 1 shows the sampling locations: seven were used for plant monitoring, and four were used for environmental sampling.

Figure 2 shows the average respirable dust concentrations as recorded by the dust monitors for both the summer and winter analysis. This graph compares the monitoring location concentrations for both surveys. Respirable dust concentrations shown on the graph ranged from 0.35 to 3.84 mg/m³ at the plant monitoring locations and from 0.04 to 0.11 mg/m³ for the environmental monitoring locations.

All monitoring locations are shown on the graph except for the clinker cooling tunnel location. As the name implies, the clinker cooling tunnel monitor was underground and measured dust levels in a beltway that carried clinker product from the clinker cooling area to the finish mill.

There were significant variations in respirable dust levels inside this tunnel during the August survey. The sampling segments ranged from 8.93 to 21.21 mg/m³ with an average dust concentration of 16.02 mg/m³. This variation was mainly due to

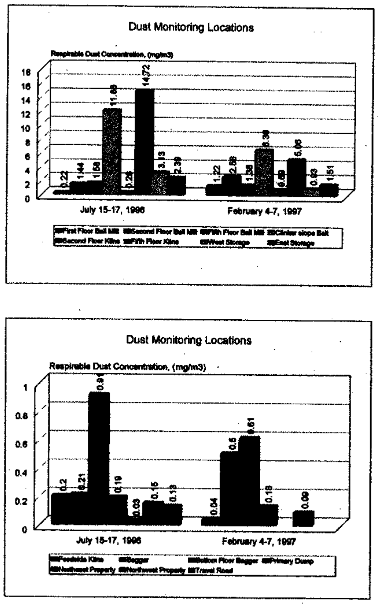


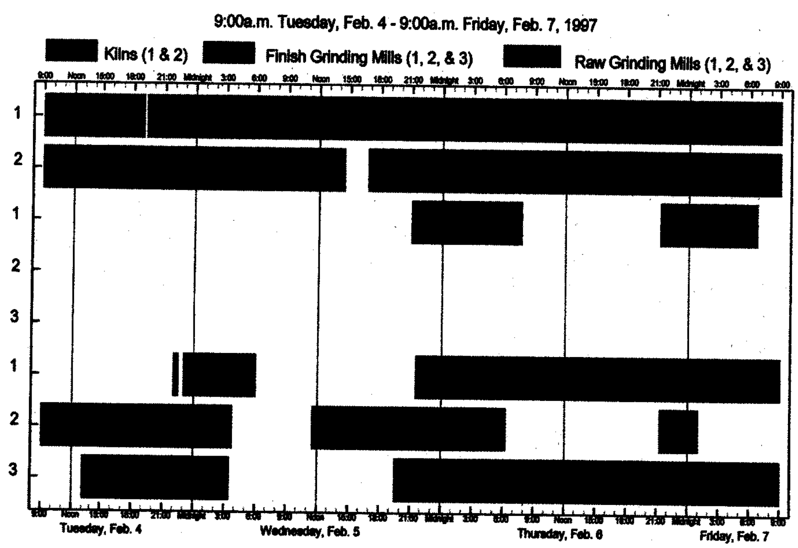
Figure 4. Average Respirable Dust Concentrations at Wet Processing Plant

periods with and without product on the conveyor belt.

Also, there was no testing performed during the February analysis because there was 6 to 12 in. of water in the tunnel and the dust monitor must be electrically powered. The results were not included on the August graph because it skews the entire graph and makes it much more difficult to see changes at the remainder of the monitoring locations.

Concentrations at the three raw and finish mill dust-monitoring locations, as well as the two kiln-monitoring locations on the discharge side, remained fairly consistent. Some of the changes in the ball mills were due to changes in production levels that impacted the number of mills being operated. The lowest concentrations recorded in the plant were at the two monitoring locations on the discharge end of the kilns. Due to the amount of product that accumulated on the floor over a shift, the researchers originally anticipated that the first floor kiln location would have a higher respirable dust level than was actually recorded. This lower concentration indicated that a significant portion of the particle size range of this material was greater than the respirable range (10 microns).

The respirable dust levels at the four environmental locations were very low dust concentrations measured throughout the plant. The highest concentrations for the environmental monitors was 0.11 mg/m^3 at the southeast property location. Visually, the researchers could see roadway dust from travel areas around the clinker dome passing over the dust monitor during some periods of the August survey. The town monitoring location was about ½ mile from the plant and showed relatively low respirable-dust levels over the entire sampling period with average respirable dust concentrations of 0.09 and 0.05 mg/m^3, respectively for the August and February surveys.



Figrue 5. Operatinvg Time of Kilns and Ball Mills

When comparing the summer survey with the winter survey, the most obvious difference was that the dust concentrations at the plant monitoring locations were on average about 50% higher for the August survey compared with the February survey. There was a substantial difference for all the dust monitoring locations in the raw and finish mill for the two surveys with respirable dust concentrations for locations #1, #2, and #3 for August as compared with February's data. These measurements correspond to the first-floor, second-floor, and sixth-floor sampling location, respectively. The flooring material used at this operation is steel grating, which allows air and dust to readily move between floors.

One major difference between the two dust surveys was that the final ball mill on the west side of the building was not running during the 50 hours of the survey in February. This finish mill is where the clinker material and gypsum are combined, and ground for the final process. Because of this, supporting equipment also was not operating during this time, and it is believed to be the major factor in the difference in dust levels in the mill building between the two evaluations. The first-floor kilns monitoring location was substantially higher for the August survey, whereas the second-floor kilns locations were higher for the February survey. The dust monitoring location at the feedside end of kilns also was significantly lower during the February analysis, but there was a time segment during the August analysis where dust levels were extremely high.

The first dust analysis segment for the feedside end of kilns averaged 13.12 mg/m^3 (about a seven-hour sampling period). This was followed by 7.83 mg/m^3 for the remainder of the test. These high dust levels at this location were believed to be caused by a plug-up problem in one of the feeder chutes that was corrected during the second sampling period.

The environmental sample locations were 26.5% lower for the February analysis compared with the August analysis. This change was expected when one considers the weather conditions during both surveys. In August, the temperature ranged between 70° and 90° F with very dry conditions. In February, there was a blanket of snow over the ground, the ground was frozen, and it was snowing during a good portion of the evaluation and lower dust levels would definitely be expected.

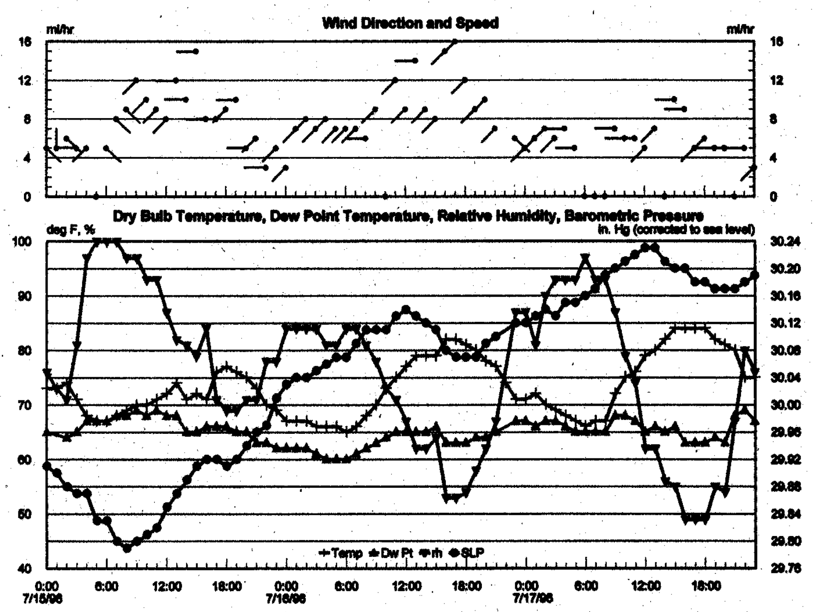


Figure 6. Monitoring of Weather Conditions

Results: Wet Processing Portland Cement Evaluation—The dust evaluation at the wet processing operation was performed continuously for 48 hours during July 15 to 17, 1996 and for 68 hours during Feb. 4 to 7, 1997. Fifteen dust monitoring locations were used at various times throughout the surveys, as seen in Figure 3. Eleven locations were used for plant monitoring: four were located outside (one at the primary crusher location, one at the travel road near the primary crusher dump hopper, and two along the front of the plant near a residential area). These outdoor monitor locations were used on a limited basis during February evaluation because of rain and snow.

The average respirable dust concentrations as recorded by the dust monitors for both July and February are listed in Figure 4. There were two sample locations with high respirable dust levels. These were the clinker slope conveyor and the fifth-floor kilns sample location. At the clinker slope conveyor location, dust levels ranged from 3.25 to 25.53 mg/m³ for the various sampling segments. There also was a similar concentration variation at the fifth-floor kilns location, which ranged from 1.80 to 22.16 mg/m³. Both of these locations were measuring dust generated as clinker product was being transported to the cooling area. The substantial variation in dust levels at both locations can be mainly attributed to periods when the clinker cooling belt was, and was not, loaded with clinker product.

Some locations saw substantial variations during the survey due to changes in production levels. Dust levels in the storage building ranged from 0.02 to 5.56 mg/m³ for the various sampling segments (normally six to 10 hours), based upon how much production and storage activity was occurring. Variation in dust levels in different areas of the plant throughout the day was based upon when processes were turned on and off. A good example of this is the raw and finish mill area.

Figure 5 shows the operating times of the kilns and the various raw and finish grinding mills during the winter survey at this plant. This gives an example of the type of production information obtained for these surveys. Both kilns operated almost continuously over the sampling period, but the number of ball mills varied significantly. There were times when none of the six ball mills were operated compared with times when four mills were operated. Finish ball mills #2 and #3 were not operated at all during the entire monitoring period because of maintenance work. The variation in dust levels for the raw and finish mill monitoring locations can be directly correlated with the number of mills operating.

Figure 6 shows an example of the type of environmental measurements obtained during the July analysis. The top of the figure shows the wind velocity and wind direction for every hour during the evaluation period. The wind was blowing from the west and southwest directions for almost the entire test period. The bottom of the figure shows the air temperature, dew point, relative humidity, and barometric pressure over the test period. The temperature ranged from 65° to 84° F. These measurements were obtained to allow for a correlation of any environmental factors on dust levels.

Another factor that greatly impacted dust levels at some sampling locations during the August analysis was a summer crew performing housekeeping work in the raw and finish mill building. These workers were cleaning beltways and walkways in the raw and finish mill building during the daylight shift, and this clearly influenced dust levels in and around their work area.

There are only a few noticeable differences in comparing the summer and winter surveys. The clinker slope conveyor belt, the discharge-end fifth-floor kilns, and the two monitoring locations in the storage building were all significantly higher during the July analysis. The increase at the first two locations can be attributed to summer employees cleaning the conveyor belt areas around these monitoring locations. The increase in the storage building resulted from more production being performed in the building during the summer months than during the winter. At all other monitoring locations, the differences between the summer and winter analysis seemed minor, and there were no other detectable trends.

In **Part 2** of this report, the authors review the previous NIOSH study (1979-82), discuss the results of this most recent study, offer recommendations on reducing respirable dust, and present their conclusions. **CA**

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