Report of Investigations 8614

Effectiveness of Three Water Spray Methods Used To Control Dust During Bagging

By Jon C. Volkwein, Robert P. Vinson,
and Edward D. Thimons

UNITED STATES DEPARTMENT OF THE INTERIOR
James G. Watt, Secretary

BUREAU OF MINES
Robert C. Horton, Director

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. BuMines RI 8614	2.	3. Recipient's Accession No. PB82 195348
4. Title and Subtitle: Effectiveness of Three Water Spray Methods Used To Control Dust During Bagging			5. Report Date: February 1982
			6.
7. Author(s): Jon C. Volkwein, Robert P. Vinson, and Edward D. Thimons			8. Performing Organization Rept. No.
9. Performing Organization Name and Address: Pittsburgh Research Center, Bureau of Mines, Cochrans Mill Road, P.O. Box 18070, Pittsburgh, PA 15236			10. Project/Task/Work Unit No.
			11. Contract(C) or Grant(G) No. (C) (G)
12. Sponsoring Organization Name and Address: Office of the Director--Minerals Health & Safety Technology, Bureau of Mines, U.S. Department of the Interior, Washington, DC 20241			13. Type of Report & Period Covered: Report of Investigations
			14.
15. Supplementary Notes			

16. Abstract (Limit: 200 words)

The industrial sand industry has been exploring new techniques to reduce dust. One company was experimenting with adding water during bagging operations to the surface of the bag, and into the product as it flowed into the bag. The Bureau of Mines, using instantaneous dust sampling instruments, measured the effectiveness of three methods of adding water. Results indicated that various types of water sprays applied in carefully controlled amounts could reduce dust up to 50% at worker locations at the bagging machine and inside a railroad boxcar. This report also discusses constraints such as product handling, customer acceptance, cold weather problems, dust collector performance, and other areas.

17. Document Analysis a. Descriptors

Dust
Silica
Bagging machines
Water sprays

b. Identifiers/Open-Ended Terms

Dust control
Minerals processing

c. COSATI Field/Group 08/09, 04/01, 04/02

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Unlimited release by NTIS.	Unclassified	9
	20. Security Class (This Page)	22. Price
	Unclassified	

(See ANSI-Z39.18) See Instructions on Reverse OPTIONAL FORM 272 (4-77) (Formerly NTIS-35) Department of Commerce

CONTENTS

ILLUSTRATIONS

TABLES

EFFECTIVENESS OF THREE WATER SPRAY METHODS USED TO CONTROL DUST DURING BAGGING

by

Jon C. Volkwein,[1] Robert P. Vinson,[2] and Edward D. Thimons[3]

ABSTRACT

The industrial sand industry has been exploring new techniques to reduce dust. One company was experimenting with adding water during bagging operations to the surface of the bag, and into the product as it flowed into the bag. The Bureau of Mines, using instantaneous dust sampling instruments, measured the effectiveness of three methods of adding water. Results indicated that various types of water sprays applied in carefully controlled amounts could reduce dust up to 50% at worker locations at the bagging machine and inside a railroad boxcar. This report also discusses constraints such as product handling, customer acceptance, cold weather problems, dust collector performance, and other areas.

INTRODUCTION

The bagging of dried, finely sized mineral products is a source of respirable dust in the minerals processing industry. In the past, exhaust ventilation systems have been relied on for dust control.[4] The use of additives such as water for dust control in this area had been suggested but rejected because of possible materials handling problems and suspected poor customer acceptance. The commercial product is, after all, supposed to be "dry".

---

[1]Physical scientist.
[2]Physicist.
[3]Supervisory physical scientist.
All authors are with the Dust Control and Ventilation Group, Pittsburgh Research Center, Bureau of Mines, Pittsburgh, Pa.

[4]National Industrial Sand Association. Guidance and Solutions To Reducing Respirable Dust Levels in the Bagging of Wholegrain Silica Products. Silver Spring, Md., 1977, 35 pp.
U.S. Bureau of Mines. Dust Control Box for Bag-Filling Machines. Technology News, No. 54, August 1978.
Vinson, R. P., J. C. Volkwein, and E. D. Thimons. SF_6 Tracer Gas Tests of Bagging Machine Hood Enclosures. BuMines RI 8527, 1981.
Volkwein, J. C. Dust Control in Bagging Operations. Proc. ACGIH Topical Symp. on Industrial Hygiene for Mining and Tunneling, Cincinnati, Ohio, Nov. 6-7, 1978, pp. 51-57.

Some minerals processors, faced with increasing regulation of dust levels, more complex ventilation systems, and mounting energy costs have decided to reexamine the potential benefits of carefully controlled water addition for dust suppression in their plants.

One industrial sand plant designed and purchased an air-atomized water system and designed it into their silica flour bagging area to control dust. They also conducted full-shift filter sampling of the system. Substantial dust reductions were obtained; however, to better understand the specific benefits of different water application methods, the Bureau of Mines evaluated the effects of the individual methods, using instantaneous dust-sampling instruments.

Concurrent with this experimentation, both industry and Bureau engineers have been exploring various other engineering dust controls for bag filling machinery. Some promising new ideas include novel bag filling spout designs, nozzle cleaning before the bag is released from the machine, improved bag sealing, bag cleaning, and disposal of broken bags.

TYPES OF WATER APPLICATION TESTED

Dust suppression effectiveness was evaluated for three methods of water application:

1. Water injection into the bag as it filled with product.

2. Wetting the external surface of the bag with atomized water sprays while the bag was being filled and conveyed.

3. Wetting the external surface of the bag with a plain water mist as the bag was conveyed.

Method 1.--The water injection system used a hollow-cone spray nozzle, mounted inside the bag-filling tube (fig. 1). The water pressure was 60 psi, and the flowrate was 0.8 gpm. The water flow was synchronized with the filling cycle; that is, as long as the product valve was open, water flowed. The system was designed to add moisture to the product based on a 15-sec filling time.

Method 2.--Externally applied air-atomized water sprays were generated using a Sonic Dry Fog Dust Suppression System,[5] consisting of a central panel from which many water nozzles could be controlled. Water for the system was pressurized to 40 to 60 psi and delivered to the spray nozzle through plastic tubing. In-house compressed air was delivered to the control unit and spray nozzles at 60 to 80 psi. The compressed air and water were mixed in the nozzle and generated the fog. Water flowrate of each nozzle was about 10 gph. According to Sonic Development, the droplet size of the fog is 1 to 20 μm.

---

[5]Sonic Development Corp., Mahwah, N.J. Reference to specific trade names is made for identification only and does not imply endorsement by the Bureau of Mines.

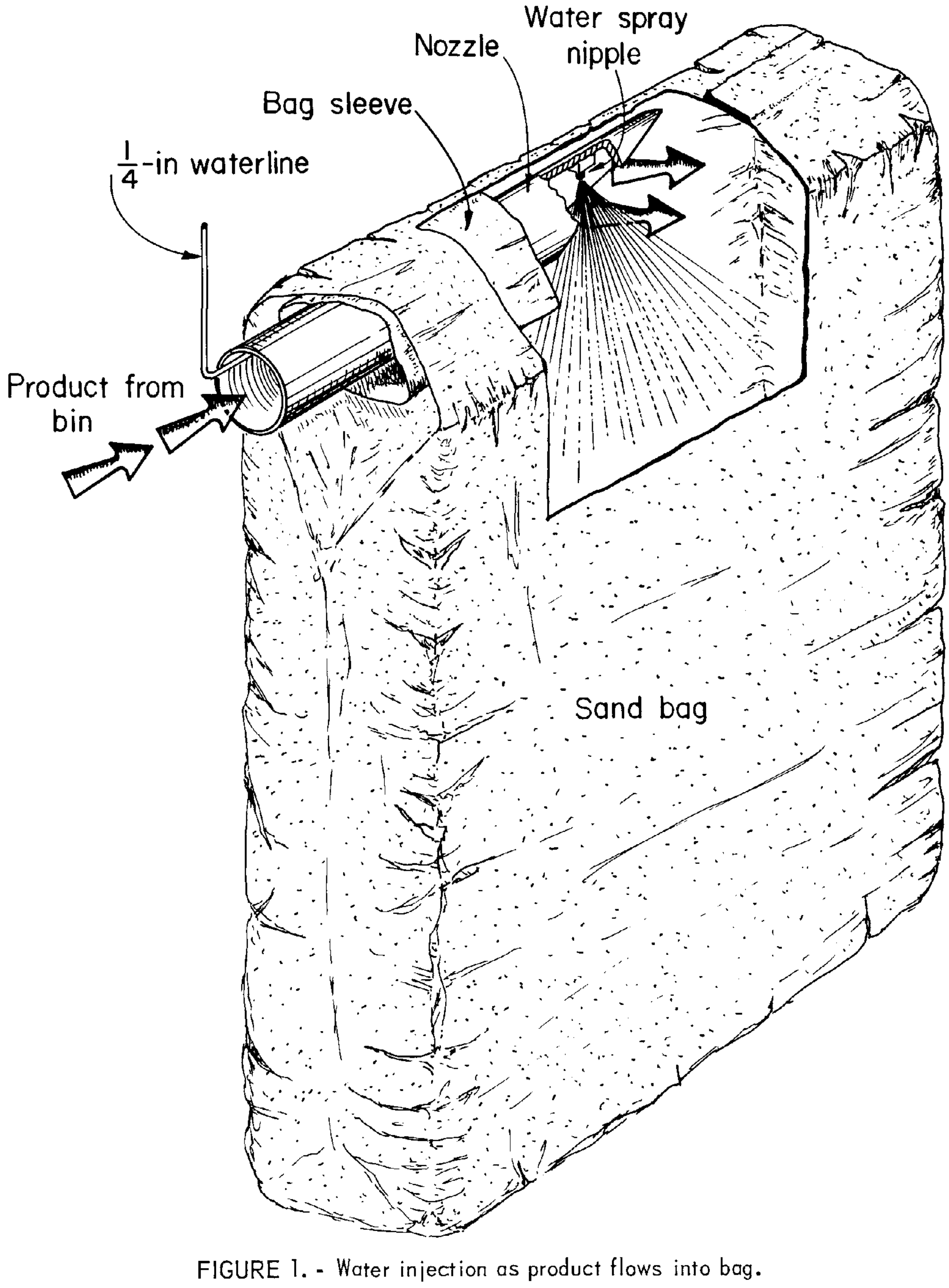

FIGURE 1. - Water injection as product flows into bag.

Several atomized spray nozzles were located about 2 feet over the bag-transport conveyor and in a descending conveyor. Most of the conveyor systems where the sprays were located were enclosed and vented to a dust collector. One atomized-fog spray was located at the side of the filling tube and bathed the bag-nozzle interface. All fog nozzles ran continuously. The purpose of the atomized fog nozzles were twofold--to wet the bag surface and to capture airborne dust.

Method 3.--Two water-mist Spraying Systems 1/4 LNN-8 nozzles[6] for external bag wetting were also tested. Water was supplied to the nozzles at 60 psi, and the flowrate through the nozzles was about 10 gph. The water droplet diameter of these sprays was about 70 µm. The nozzles were installed one above and one below the bag transport conveyor. Their purpose was to lightly wet the top and bottom surface of the bags as they were conveyed into a rail car.

These experimental water spray systems were designed to supplement, not to replace, existing exhaust ventilation systems.

TEST METHODS AND EQUIPMENT

The testing was conducted in the flour bagging area, on the second floor of a building adjacent to the grinding mills and bulk loading areas. The bagged product was conveyed to the lower level of the same building, where it was loaded into rail cars or trucks (fig. 2).

Dust levels were measured, using a GCA Real-Time Aerosol Monitor (RAM). The RAM is a near-forward, light-scattering dust detection instrument.[7] Respirable dust, as classified with a 10-mm Dorr-Oliver cyclone, enters the instrument and scatters light, which is detected by a photodiode. The signal is processed and displayed digitally by a liquid crystal display. An analog voltage (0 to 10 VDC), proportional to the concentration, is recorded using a battery-powered Soltec[8] strip-chart recorder. A polar planimeter was used to integrate the area under the curves on the strip chart. The total area divided by chart speed gave the average dust concentration for various test conditions. The response of the light-scattering dust monitors was dependent on the size distribution and refractive index of the dust being measured. To obtain an accurate measurement, our RAM instruments were calibrated at the Bureau's Pittsburgh Research Center, using Supersil-silica flour as the test aerosol, and compared with gravimetric filter samples. Laboratory results showed the RAM instruments to read ±10 of the gravimetric filter samples.

The RAM instruments provide an instantaneous dust concentration reading. This makes it an extremely useful engineering tool, since the effect of a particular dust control technique can be quickly evaluated before background dust levels change or other variables interfere. Filter samples on the other hand require a long sample time to acquire enough mass for weighing. During

[6] Spraying Systems Co., Wheaton, Ill.
[7] U.S. Bureau of Mines. Improved Respirable Dust Monitor. Technology News, No. 72, October 1979.
[8] Soltec, Sun Valley, Calif.

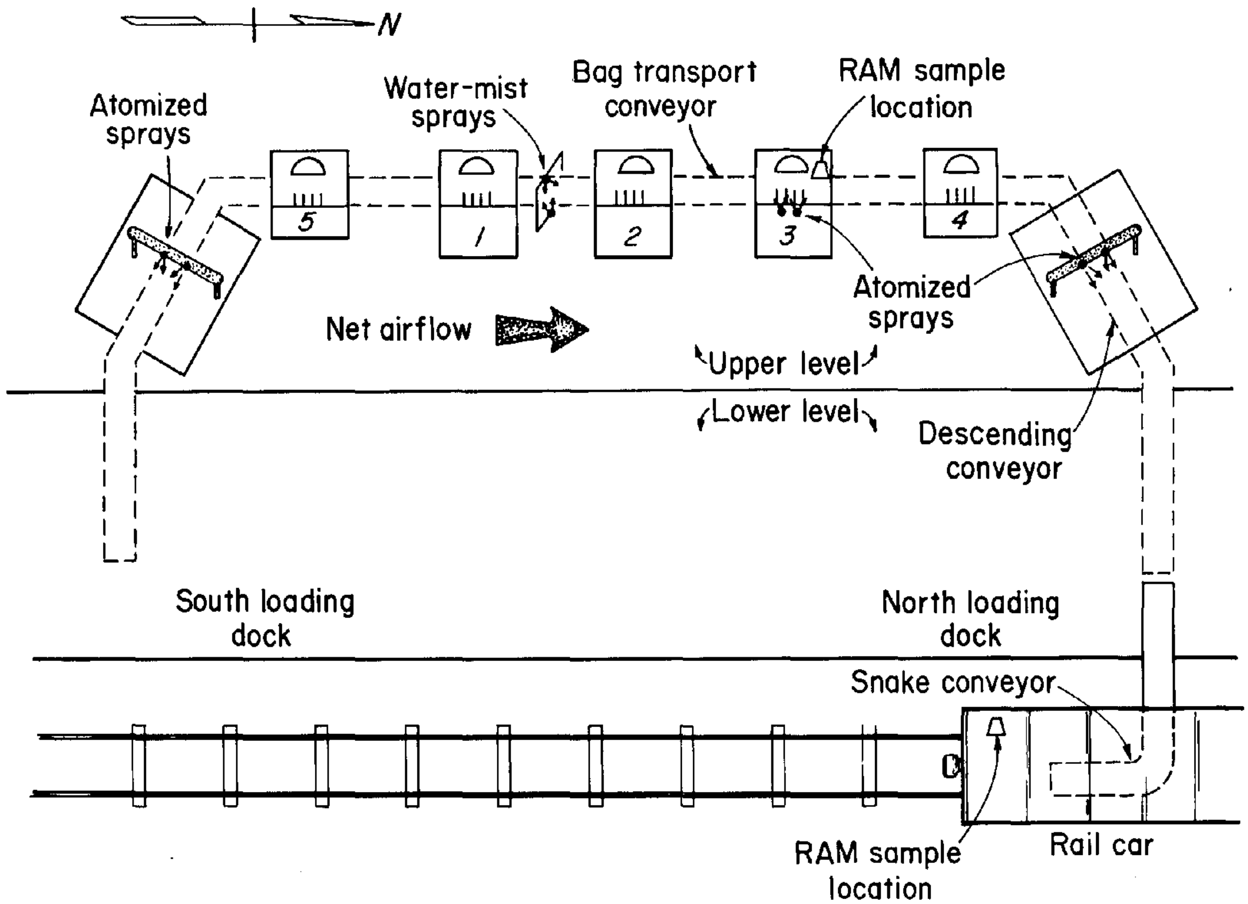

FIGURE 2. - Plan view of test location.

that time, many variables can change, falsely enhancing or diminishing the effectiveness of the technique being evaluated. Short-term results, however, cannot be compared with time-weighed, full-shift gravimetric filter samples, since they represent only a small portion of the total daily exposure.

Dust concentrations were measured with the RAM instrument at two locations. One location was on the north side of the platform, beside bagging machine 3. There was slight airflow from the bagging machine towards the sampler, so that dust which escaped the exhaust ventilation system on the machine would be measured by the sampler. The other sampling location was inside of the rail car. The rail car sampler was moved during the testing, placing it each time on top of the bags of the previously filled pallet. In this way, it followed the workers as the car was loaded. The rail car sample represents the dust generated inside the car.

Test conditions with various combinations of the water-spray systems were tightly controlled. The company allocated a complete boxcar load of material for test purposes. Two pallets (sixty 100-pound bags) of silica flour were loaded under each of the following conditions:

From the north end of the car to the door:

1. Dry (no sprays)

2. Air-atomized sprays (at bag nozzle and on conveyors)

3. Injection into the flour bag (only)

4. Injection and air-atomized sprays

From the south end of the car to the door:

Sequence was repeated in reverse order (from wet to dry).

The next test sequence was designed to compare the air-atomized sprays and the mist sprays. The rail car was first moved from the north loading door to the south loading door, because the mist sprays had been installed on the conveyor system feeding the south loading door. The same bagging machine was used, but the conveyor was reversed. Two pallets (60 bags) were loaded under each of the following conditions:

1. 2 water-mist nozzles + injection

2. 2 water-mist nozzles

3. 2 air-atomized spray nozzles

4. 2 air-atomized spray + injection

Water consumption of the individual nozzles was about 10 gph for both systems. Spot checks with a RAM were made to insure that background dust levels did not change during the tests.

RESULTS AND DISCUSSION

Data collected beside the bag-machine operator are shown in table 1. The most effective wet system was water injection, which reduced dust concentrations at the operator by 50%. The air-atomized water sprays directed toward the bag-filling tube appeared to be ineffective in suppressing dust at the operator.

TABLE 1. - Average dust concentrations beside bagging machine for various test conditions and the percent dust reduction from dry conditions

Number of tests	Condition	Dust concentration mg/m^3	Reduction from dry, %
2.......	Dry..................	1.21	0
2.......	External wetting.....	1.26	-4
2.......	Injection............	.61	50
2.......	External wetting plus injection.	.87	28

Data collected inside the rail car (table 2) show that surface-bag wetting reduced the concentration by 15%; water injection also reduced car concentrations by 23%. The cumulative effect of both systems was a net reduction of 48% inside the car.

TABLE 2. - Average dust concentrations inside rail cars for various test conditions and the percent dust reduction from dry conditions

Number of tests	Condition	Dust concentration mg/m^3	Reduction from dry, %
2.......	Dry..................	1.76	0
4.......	External wetting.....	1.50	15
2.......	Injection............	1.35	23
4.......	External wetting plus injection.	.91	48

Water Injection

The primary dust suppression function of water injection appears to be the wetting of the bag sleeve. A wet-bag sleeve reduces the amount of spillage that occurs when the bag leaves the machine, thereby reducing dust levels near the operator. More importantly, water injection reduces dust levels inside the car. Bag-sleeve leakage contributes to the dust load inside the car, and when bag sleeves are wet, this leakage is reduced. Bag handlers preferred water-injected bags because they made better palletized loads than the more "pillowy" uninjected bags. A secondary benefit of water injection could be dust reductions when bags break; however, no broken bags were observed during these tests.

Water injection does impose certain constraints. Of primary importance to the mineral producer is customer acceptance of their product with additional moisture. In some cases, the uneven addition of water will cause portions of the bag to freeze in cold weather. Moisture may also change the flow characteristics of the material, which may adversely affect user acceptance.

Such adverse effects could be reduced by injecting water only in the bag-sleeve area, after the bag has been filled. A short 1- to 2-second squirt of water before the bag leaves the machine should be just as effective as continuous injection in controlling the primary dust sources around the bag sleeve.

However, some of the secondary benefits of continuous injection, such as reduced dust during bag breakage and improved handling, would be lost. Further testing of this procedure is planned.

Bag Wetting--Atomized Fog Versus Water Mist

Wetting the external surface of the bag did not reduce the dust exposure of the bag-machine operator. About 15% dust reduction was observed inside the rail car using only external bag wetting. Figure 3 shows portions of RAM-generated strip charts for water added in different ways. Surface misting plus water injection halved dust levels inside the rail car. Misting sprays used alone or with water injection were slightly but consistently better than the atomized-fog sprays.

These data cannot firmly support or negate the contention that atomized sprays capture airborne dust. Since the micrometer-sized droplets would rapidly evaporate or be carried into the existing exhaust ventilation system, airborne capture of dust could occur only on a short-term localized basis. We

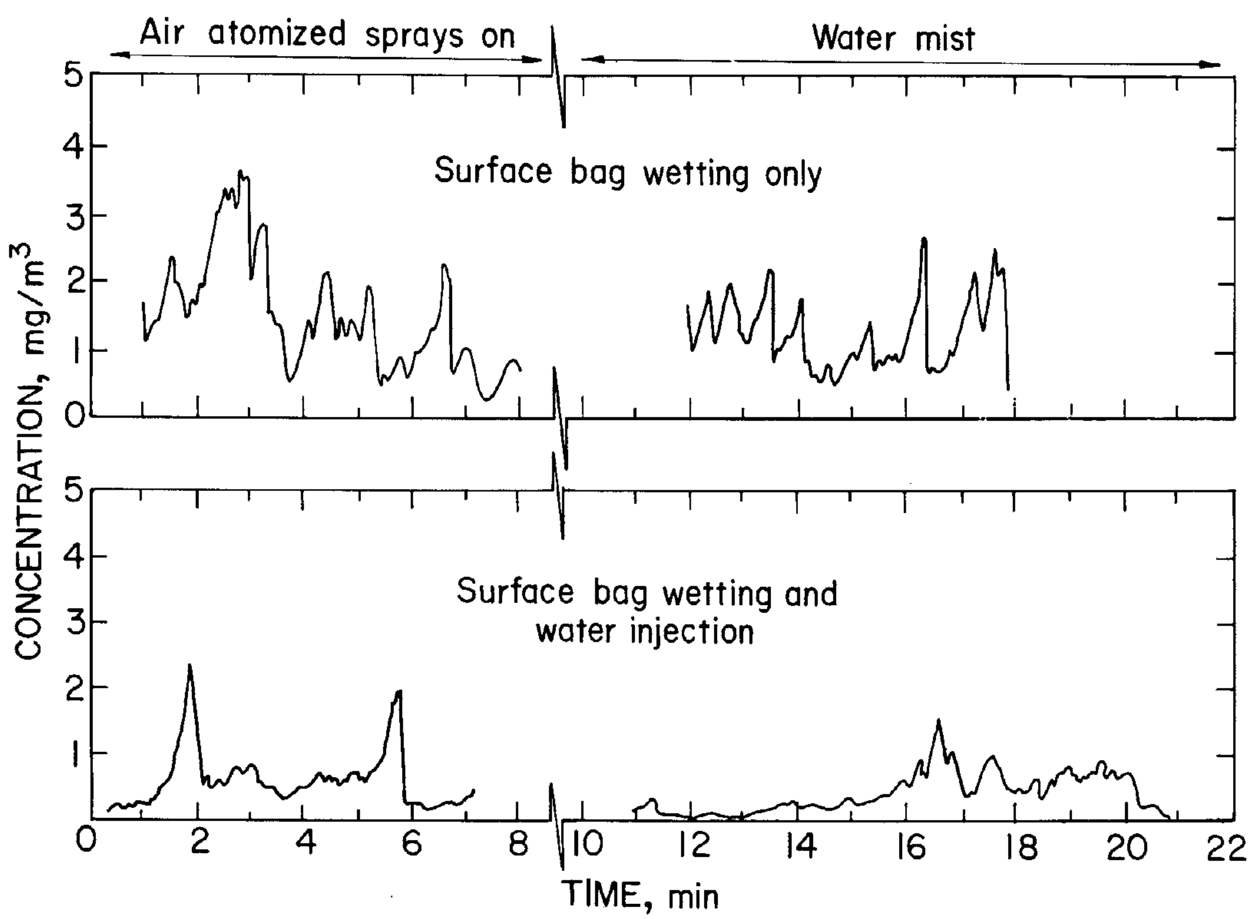

FIGURE 3. - RAM-generated strip charts showing dust levels for the different surface bag-wetting sprays.

can say that atomized sprays offer no dust reduction benefit over water-mist sprays at the two principal working locations. The primary benefit of surface bag-wetting appears to be preventing surface dust from becoming airborne.

Constraints

The experimental work reported here was intended only to assess the effectiveness of using water to control dust in the bagging area. Secondary effects of adding water, such as customer acceptance, product handling, bag strength, cold weather operations, dust collector performance, and others need to be studied in detail.

Another potential problem is clogging of the dry-dust collector by water-saturated air. This was not a problem in our study because the exhauat air from the bagging areas was only a small fraction of the large plant bag-house system. The dust collector bags on a smaller dedicated system might clog if they processed only water-saturated air from an individual bagging machine using atomized sprays.

Previous laboratory tests of the RAM dust monitors had indicated that the instruments were insensitive to large water droplets typically generated by coal mine spray systems. However, during this study it was found that the RAM's could measure water droplets generated by the atomized-fog nozzles if the RAM's were close to, and downwind from, the nozzles. This did not affect our test results because the RAM instruments were properly located. A quick check of water-spray interference was made by turning the atomized-water sprays on and off, while no other activity was in progress. The RAM instruments did not change, indicating that no water droplets were being measured.

The effectiveness of dust suppression by applying water to the surface of bags was fairly short-term, since the product was warm and water evaporated rapidly from the exposed bag surface. Thus, although the moist bags reduced the loaders' exposure to dust, this may not help the customer's dust exposure when unloading the cars.

CONCLUSIONS

The possibility of using water to control dust in the processing of dried minerals products is still in the experimental stage. The addition of water, if carefully controlled, could offer a simple and economic means of dust control. This investigation showed that adding limited amounts of water could reduce dust levels by one-half.

☆U.S. GOVERNMENT PRINTING OFFICE: 1981-505-002/127 INT.-BU.OF MINES,PGH.,PA. 25796