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UNITED STATES DEPARTMENT OF THE INTERIOR

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ILLUSTRATIONS

UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

Btu	British thermal unit	mg/m^3	milligram per cubic meter
°F	degree Fahrenheit	min	minute
gal	gallon	pct	percent
in	inch	s	second
kW	kilowatt	ton/h	ton per hour
kW/h	kilowatt per hour	wt pct	weight percent
lb	pound		

ADDING STEAM TO CONTROL DUST IN MINERAL PROCESSING

By Andrew B. Cecala,[1] Jon C. Volkwein,[2] and Edward D. Thimons[3]

ABSTRACT

The Bureau of Mines performed tests to compare the effectiveness of steam and of water sprays to reduce respirable dust levels at mineral processing plants. By applying 0.22 wt pct water vapor as steam to product material, a 64-pct respirable dust reduction was recorded. By applying the same amount of moisture with water sprays, only a 25-pct dust reduction was recorded. By increasing the moisture content up to 0.5 pct using water sprays, the dust reduction was increased to 55 pct, which was still less than the dust reduction achieved by adding less than half that amount of water in the form of steam.

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INTRODUCTION

In a previous study,[4] the Bureau of Mines ran tests to determine how the addition of microfoam helped to reduce dust levels from dried whole-grain silica sand in a mineral processing plant. The addition of a compressed-air-generated foam to the product resulted in dust reductions of 80 to 90 pct downstream of the application point. When just water and surfactant were added to the product, in the same concentration as the foam, the dust reductions obtained were far less. This can possibly be attributed to the fact that the foam has a greater contact area, permitting a more even distribution of moisture throughout the product.

However, foam has some drawbacks that make its use prohibitive in a number of mineral processing plants. This led to the idea of using steam as a possible means of achieving an even distribution of small quantities of moisture. There have been previous studies on the use of steam, but in none of these studies was the steam thoroughly mixed with product material to keep the dust from being generated. The earlier work used an airborne capture technique rather than a generation suppression technique.[5] The objective of this study was to evaluate the dust suppression capabilities of steam as compared with water sprayed onto dried silica sand.

TEST PROCEDURES

Tests were conducted at two mineral processing plants to determine the reduction in dust levels achieved by applying steam during processing. At the second plant, a comparison test was performed to determine the difference between steam and water sprays. At both plants, the moisture was applied at a transfer location to insure thorough mixing with the product because other studies had shown that just wetting the surface was not very effective as a dust suppression technique. At both plants, a diesel-powered steam generator was modified to apply various amounts of steam to the product material at a transfer point. The application point had to be closely monitored to observe any accumulations of product on the inside walls of the transfer point. Any buildup was knocked off periodically to keep the area from restricting flow.

Dust monitors were placed at various locations to determine the amount of dust suppression obtained as the product material flowed through the processing plant. These dust monitors were RAM-1 (real-time aerosol monitors), built by GCA Corp.[6] The instruments use a light-scattering device to calculate the dust concentration from a sample drawn in from the environment. These monitors can be sensitive to changes in the dust content (size, shape, refractive index), but if calibrated to a specific dust content, their accuracy is ±10 pct of gravimetrics samples.[7] Water mist can also affect the RAM-1 readings. To correct this problem, a mist eliminator was used for all testing where mist was considered a problem. (See appendix B.)

[4]Volkwein, J.C., A. B. Cecala, and E. D. Thimons. Adding Foam To Control Dust in Minerals Processing. BuMines RI 8808, 1983, 11 pp.

[5]Cheng, L., and J. E. Emmerling. Collection of Airborne Coal Dust by Steam. BuMines RI 7819, 1974, 13 pp.

Strazisar, A. J., R. L. Stein, and T. F. Tomb. Use of Steam To Control Respirable Coal Dust at the Point of Generation. BuMines RI 7628, 1972, 8 pp.

[6]Reference to a specific manufacturer does not imply endorsement by the Bureau of Mines.

[7]Williams, K. L., and R. J. Timko. Performance Evaluation of a Real-Time Aerosol Monitor. BuMines IC 8968, 1984, 20 pp.

The RAM-1 instrument uses a 10-mm cyclone to preclassify the dust to allow only the respirable fraction to flow into the instrument. Gravimetric samples were not used because the time needed to obtain a valid sample weight was prohibitive.

The RAM instruments were connected to strip chart recorders. The dust concentrations were calculated from the strip chart recorders for the different segments when steam was turned on and off. The dust reduction for using steam was calculated by comparing the average concentration of the normal segment before and after steam, to the value obtained for using steam.

TEST RESULTS

PRELIMINARY TEST AT PLANT 1

Testing was performed at two mineral processing plants. At plant 1, a simple test was performed to determine the validity of the concept. The steam was applied to the product at a chute transfer point before the product went into a bucket elevator. The material was dumped from the bucket elevator, and dust measurements were taken during the screening process (fig. 1). The amount of steam

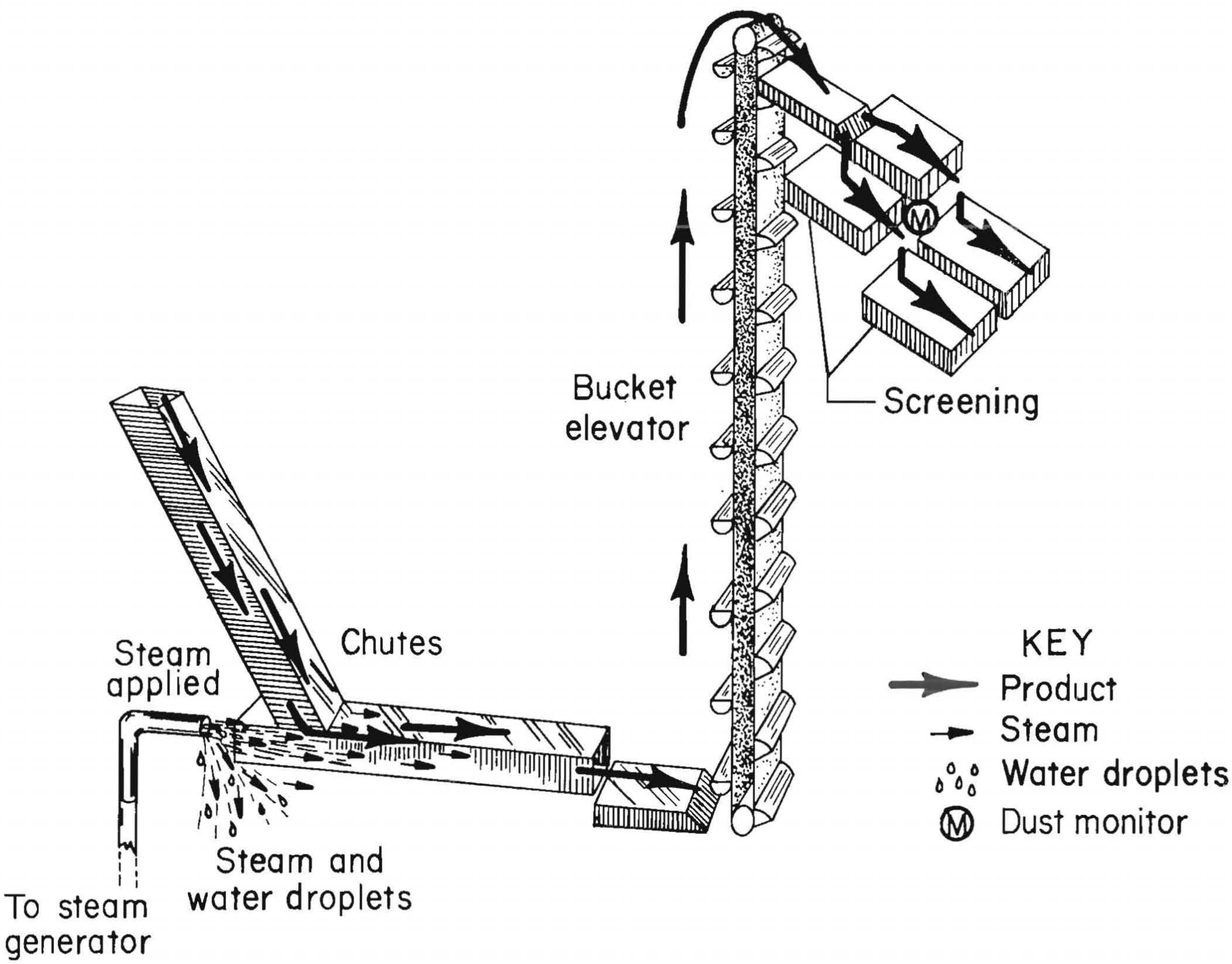

FIGURE 1. - Sampling setup for plant 1.

added to the product material was not calculated for this test. As the steam traveled from the generator to the nozzle, it cooled quickly and there was some water coming out of the nozzle. Also, the amount of steam produced was too great for the amount of product being processed at this plant. For these two reasons, the nozzle was not directed into the chute, but off to one side, so that the water and a portion of the steam simply fell to the ground. Since the chute was under a negative pressure, it drew in a portion of the steam. Because the nozzle was not directed into the chute, the quantity of moisture added to the product material could not be calculated. Short segments, approximately 15 min long, were run in which the steam was turned on and off. No water spray testing was performed at this plant.

RESULTS FOR PLANT 1

The results of five runs at plant 1 indicated that the application of steam to the product could significantly reduce dust and a more in-depth study should be performed. As mentioned previously, the amount of moisture applied to the product could not be measured, and may have varied slightly from one run to another. The average of the five runs showed an average respirable dust reduction of 48 pct.

CONTROLLED TEST AT PLANT 2

The test performed at the second site was more controlled. Steam was applied to the product at two transfer locations simultaneously before combining the material on a belt that transported it to a bucket elevator and then through the screening process. All lines from the steam generator to the application point were insulated to minimize the amount of water coming out of the nozzles. A known amount of steam was applied at each point. The plant processes approximately 180 tons/h. With the steam generator at its maximum output, the total moisture added to the product was only 0.22 pct. Again, short time segments were sampled in which the steam was turned on and off. Two sample locations were monitored for changes in the dust concentration (fig. 2).

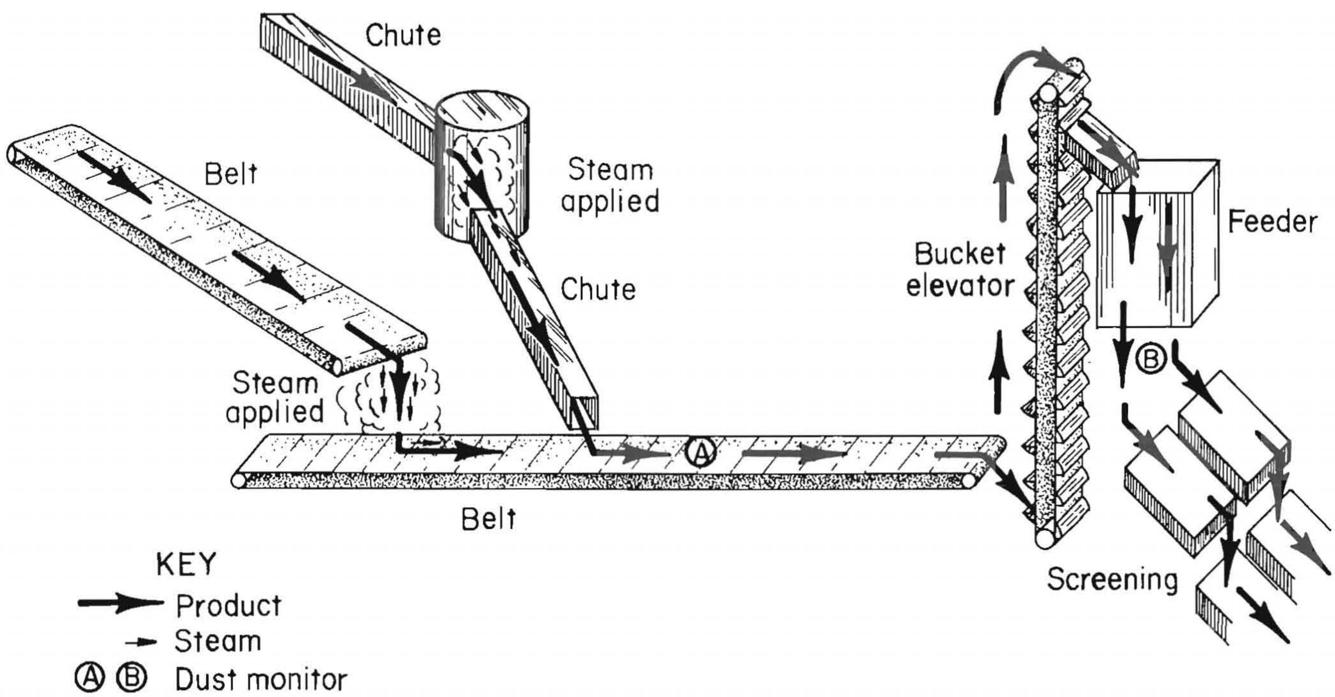

FIGURE 2. - Sampling setup for plant 2.

One aspect that was different at the second site was that the product temperature at the application point was approximately 180° F; at the first plant, it was only 70° F. The 180° F temperature evaporates any moisture that would be added to the product as it travels downstream from the application point.

After the testing was completed using the steam, similiar tests were performed using water sprays. An equivalent 0.22-pct moisture-to-product ratio was applied, the same as for steam. Subsequently, the moisture was increased to 0.35 pct and 0.53 pct.

RESULTS FOR PLANT 2

In the test at plant 2, 0.22-pct steam was applied because the size of the steam generator and the high tonnage of product processed prevented achieving a higher moisture content.

All values given for plant 2 apply to sample location A, which was located on the beltway immediately downstream from the two application points. No noticeable difference was recorded at sample location B for any of the tests performed because the high product temperature (180° F) caused evaporation of the added moisture.

The average reduction obtained for the 0.22-pct steam-to-product ratio was 64 pct. Figure 3 shows a sample section from the strip-chart recorder for sample location A. After completion of the steam testing, the system was switched over to apply water. Only a 25-pct reduction was achieved with water sprays at the 0.22-pct-moisture content. The water sprays were then increased to provide moisture contents of 0.35 pct and 0.53 pct; the dust reduction for these two moisture contents was 59 and 53 pct, respectively. Figure 4 shows a sample section from the strip-chart recorder using 0.35-pct-moisture content with water sprays.

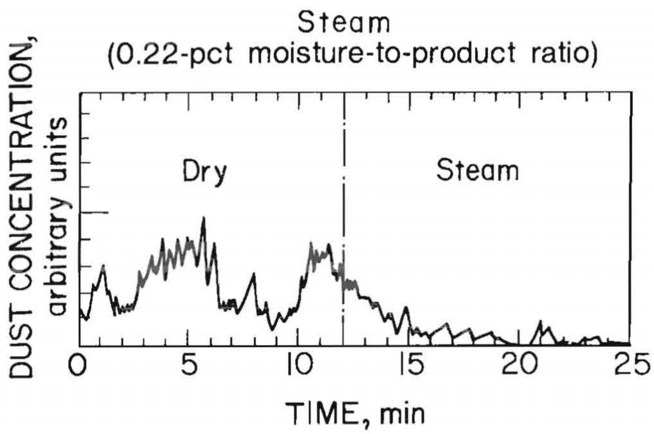

FIGURE 3. - Strip-chart recording for steam at plant 2.

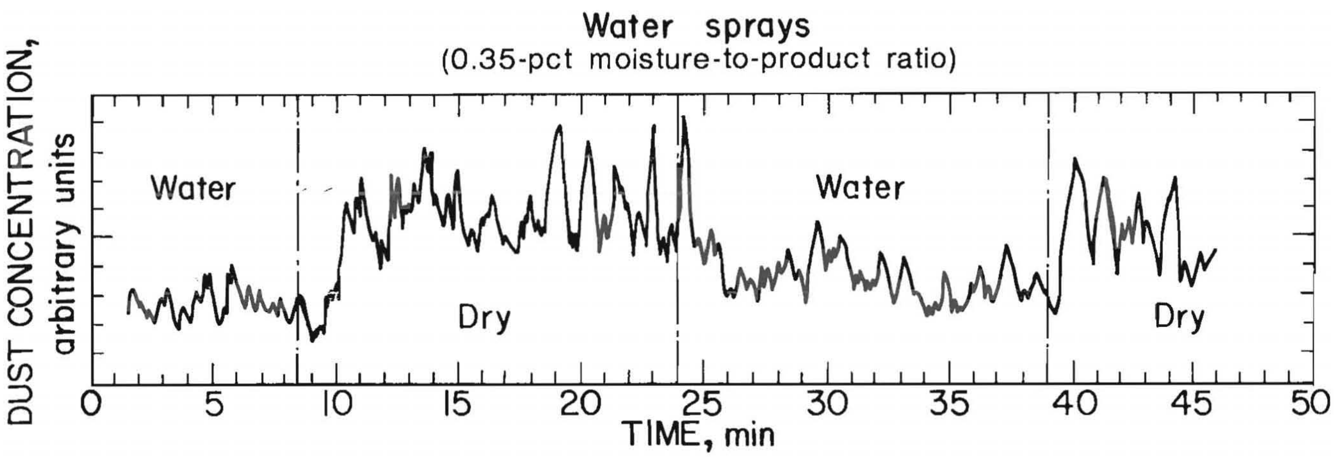

FIGURE 4. - Strip-chart recording for water sprays at plant 2.

DISCUSSION

Steam is effective as a dust suppressant in mineral processing because like foam, it offers a larger contact area than does sprayed water.

When using steam, the application point must be correctly engineered and monitored periodically. Since steam represents a gaseous state, it flows everywhere, condensing on the inside walls of the application point and collecting product. The application point must be designed to direct all the steam onto the product so that the amount of overspray can be minimized. During testing at plant 2, the steam applied at the belt transfer point (fig. 5) created less accumulation problems than did chute application. This is because at the belt transfer, the steam just covered the product as it fell from the belt, whereas in the chute, there was no way to prevent contact with the inside walls.

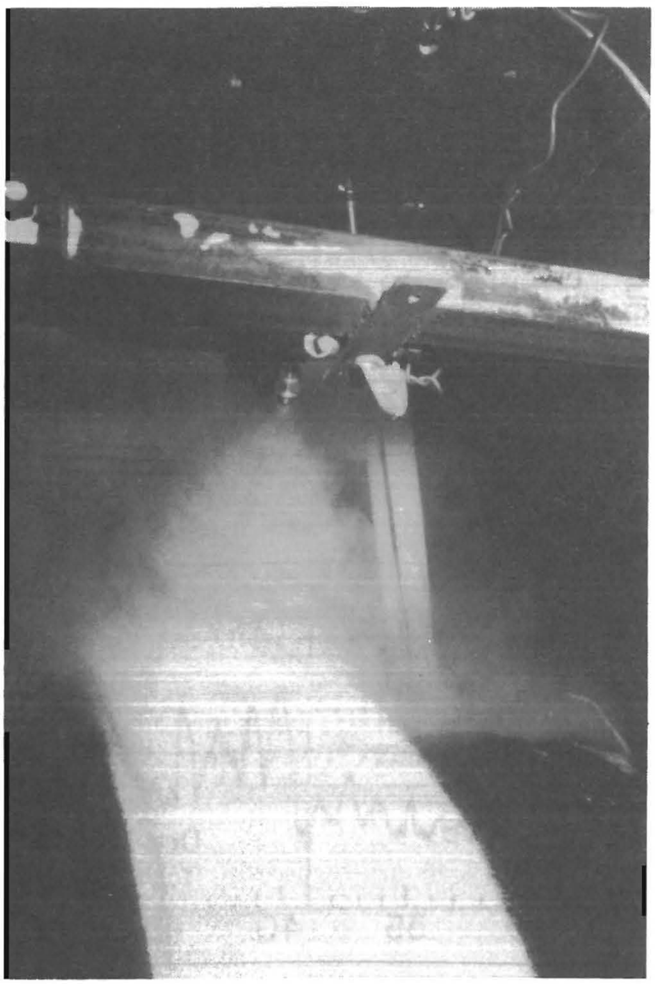

FIGURE 5. - Steam application at belt transfer point.

At plant 2, the 0.35-pct-moisture content with water sprays gave a slightly higher dust reduction than 0.53-pct-moisture content with water sprays. It is attributed to sampling fluctuations, and if sampled for a long period of time, the higher moisture level should always give a dust reduction equal to or greater than a lower moisture value. Although, it is felt that 0.4 to 0.5 pct moisture is near the upper limit for dust reductions achieved when adding water. It is believed that if higher levels of steam had been added (above 0.22 pct), the percent dust reduction would have been higher than was achieved using water sprays.

Adding steam in the 0.2- to 0.5-pct range is relatively inexpensive. The cost will vary depending on the needs of the operation and the power cost, but a rough estimate for the 0.2- to 0.5-pct-moisture range would be approximately \$0.05 to \$0.20 per ton of product. Appendix A shows a sample calculation to determine the cost per ton of product to add steam as a dust suppressant.

At plant 2, where the product was approximately 180° F, no dust suppression was noticed a good distance downstream from the application point because the water was evaporating. In a laboratory study, it was determined that approximately 50 pct of the moisture added to the product material would evaporate in 3 min.[8] A higher evaporation rate would be anticipated at the plant than in the laboratory because of all the transfer points which expose a greater surface area. In such a case, the steam or water sprays would be used as a point suppression technique.

[8]Work cited in footnote 4.

CONCLUSION

Testing was performed at two mineral processing plants to determine the effectiveness of using steam as compared to water sprays to reduce respirable dust levels. When 0.22 pct moisture was added in the form of steam to the product material at a transfer point, a 64-pct respirable dust reduction was recorded. Larger amounts of steam should have been tested, but because of the limitation of the steam generator, 0.22 pct was the maximum value during this testing. The same amount of moisture using water sprays only gave a dust reduction of 25 pct. By increasing the moisture up to 0.5 pct with water sprays, the respirable dust reduction was increased to 55 pct, which is still less than the 64-pct reduction obtained with 0.22 pct steam.

APPENDIX A.--Sample Calculation of Cost of Using Steam

- Determine the percent moisture that is to be added to the product. (Assume 0.2 pct will be added.)

- Determine the pounds of water added to each ton of product.

$$\frac{(A)\ \text{lb}\ H_2O}{2{,}000\ \text{lb (1 ton) product}}$$

$$= 0.002\ (0.2\ \text{pct moisture}).$$

A = 4 lb of water must be added to each ton of product.

- Convert pounds of water to gallons of water.

4 lb water × 0.1198 = 0.48 gal of water.

(Assume initial water temperature of 50° F.)

- Determine Btu to raise water to boiling.

212° F - 50° F = 162° F.

(Note: It takes 1 Btu to raise 1 lb of water 1° F, and it takes 965 Btu to vaporize 1 lb of water.)

- Calculate the total Btu for 1 gal of water.

162 Btu raise 1 lb water to boiling
965 Btu vaporize 1 lb water
1,127 Btu

- Determine kilowatts.

(Note: Btu divided by 3,412 equals kilowatts.)

$$\frac{1{,}127\ \text{Btu}}{3{,}412} = 0.33\ \text{kW for 1 lb water.}$$

(Assume 180 tons/h of product processed.)

720 lb of water/h necessary for 0.2 pct moisture.

- Determine kilowatts per hour.

720 lb water/h × 0.33 = 237.82 kW/h.

Assume 6 cents kilowatt per hour. (This varies throughout the country.)

238 kW/h × $0.06 = $14.28

$14.28/180 ton = $0.08 per ton.

Cost approximately 8 cents per ton to produce steam to process 180 tons/h at a 0.2-pct-moisture content.

APPENDIX B.--MIST ELIMINATOR

The RAM 1, which is a light-scattering device, interprets certain size water mist as dust particles. To avoid a misreading, a mist eliminator was developed and used for all field testing where water vapor or mist was suspected to be present (fig. B-1). The mist eliminator consists of a 24-in-long, 1-in diam wire mesh tube surrounded by 2 in of calcium sulfate desiccant. Flexible plastic 1/4-in-ID tubing connects one end of the mist eliminator to the 10-mm cyclone used to preclassify the respirable size range; the other end is connected to the RAM instrument. As the sample is drawn through the mist eliminator, any water particles that could be misread by the RAM as dust particles are absorbed by the calcium sulfate desiccant.

To verify this, two RAM-1 instruments were used, one with the mist eliminator and the other without. The two cyclones were located in a water vapor environment. The RAM without the mist eliminator recorded substantial concentrations, while the RAM with the mist eliminator was reading zero. The RAM's were switched, the process repeated, and the results were identical.

The procedure was duplicated with the cyclones placed in a dust environment. In this case, the RAM's recorded identical readings except that the RAM with the mist eliminator had approximately a 7-s delay. Because the dust was preclassified with the cyclone and the residence time within the eliminator was so short, we were unable to detect any dust capture by the eliminator. Thus the mist eliminator was effective in removing water vapor or mist from a sample, without eliminating the dust. Mist eliminators were used in all field testing where water vapor was believed to be a problem.

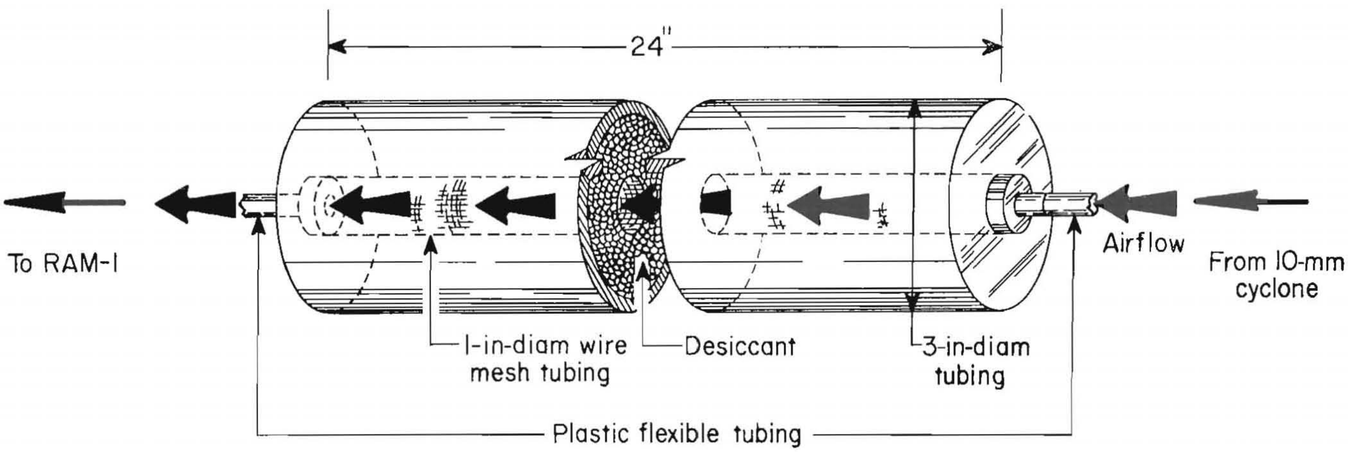

FIGURE B-1. - Mist eliminator.