

PB255440

May 1976 • TPR 97
Respirable Dust Program

BUREAU OF MINES TECHNICAL PROGRESS REPORT

**DUST CONTROL AT A TRANSFER POINT
USING FOAM AND WATER SPRAYS**

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|--|---|---|------------------------------|
| BIBLIOGRAPHIC DATA SHEET | 1. Report No. TPR 97 | 2. | 3. Recipient's Accession No. |
| | 4. Title and Subtitle Dust Control at a Transfer Point Using Foam and Water Sprays | | 5. Report Date May 1976 |
| 7. Author(s) Richard J. Seibel | | 6. Performing Organization Code | |
| 9. Performing Organization Name and Address Division of Mining Research--Health and Safety Bureau of Mines--USDI 2401 E Street, NW Washington, DC 20241 | | 8. Performing Organization Rept. No. | |
| 12. Sponsoring Agency Name and Address Office of Assistant Director--Mining Bureau of Mines--USDI 2401 E Street, NW Washington, DC 20241 | | 10. Project/Task/Work Unit No. | |
| | | 11. Contract/Grant No. | |
| | | 13. Type of Report & Period Covered Technical Progress Report (Research) FY 76 | |
| | | 14. Sponsoring Agency Code | |
| 15. Supplementary Notes | | | |
| 16. Abstracts The Bureau of Mines studied the effectiveness of foam in controlling airborne dust along a mine section belt line, using personal gravimetric samplers to obtain the data. Although foam was significantly more effective than water sprays in controlling airborne respirable dust at a transfer point and along a mine section belt line, a strategically arranged water spray system may be sufficiently satisfactory and comprise a more economical and convenient dust control method. Also, the section belt to main belt transfer point is a significant dust source, and additional foam or water sprays may need to be applied at such transfer points to alleviate respirable dust generation. The application of foam or water spray to the underside of the belt is especially effective for dust control. | | | |
| 17. Key Words and Document Analysis. 17a. Descriptors Water sprays Foam Dust control | | | |
| 17b. Identifiers/Open-Ended Terms | | | |
| 17c. COSATI Field/Group | | | |
| 18. Distribution Statement NTIS release unlimited. | | 19. Security Class (This Report) UNCLASSIFIED | 21. No. of Pages 17 |
| | | 20. Security Class (This Page) UNCLASSIFIED | 22. Price |

PRICES SUBJECT TO CHANGE

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USING FOAM AND WATER SPRAYS

by

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Bureau of Mines Respirable Dust Program

Technical Progress Report 97

May 1976

U.S. DEPARTMENT OF THE INTERIOR

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DUST CONTROL AT A TRANSFER POINT USING FOAM AND WATER SPRAYS

by

Richard J. Seibel¹

ABSTRACT

The Bureau of Mines studied the effectiveness of foam in controlling airborne dust along a mine section belt line, using personal gravimetric samplers to obtain the data.

Although foam was significantly more effective than water sprays in controlling airborne respirable dust at a transfer point and along a mine section belt line, a strategically arranged water spray system may be sufficiently satisfactory and comprise a more economical and convenient dust control method. Also, the section belt to main belt transfer point is a significant dust source, and additional foam or water sprays may need to be applied at such transfer points to alleviate respirable dust generation. The application of foam or water spray to the underside of the belt is especially effective for dust control.

INTRODUCTION

Although cutting at the face is generally considered the main source of airborne respirable dust in most underground coal mining systems, secondary operations involved in the transport system, such as shuttle car dumping, belt conveying, and belt-to-belt transfer, also contribute to the formation of airborne dust. The Federal Coal Mine Health and Safety Act of 1969 requires that the air velocity on all new belt lines be the minimum quantity required to reduce methane concentration to less than 1 vol-pct. The act also requires that "...each operator shall continuously maintain the average concentration of respirable dust in the mine atmosphere to which each miner in the active workings of such mine is exposed at or below 2.0 milligrams of respirable dust per cubic meter of air."

Although most of the belt line can be isolated in relatively still air, the tailpiece and other transfer points are sometimes inby the isolated area; therefore, some intake air may pass through adjacent crosscuts and over these transfer points. Any dust generated at these transfer points may be carried

¹Staff engineer.

toward the working place and thus contribute to the airborne dust concentrations at the face.

Dust enclosures and collectors have reportedly been quite successful as a dust control technique for a belt-to-belt type of transfer operation in industrial processing plants,² but underground mining operations require a more mobile and smaller enclosure and collector assembly.³ Improved arrangements of this type are now being studied,⁴ but no field data are yet available on their effectiveness. Furthermore, while a belt-to-belt transfer can readily be enclosed, other mining operations, such as shuttle cars loading into the chain feeder car, are less adaptable to enclosure.

Another dust control technique at a transfer operation is the use of water sprays or foam. The Bureau of Mines contracted with the DeTer Co., Inc. (H0110929), to develop a low-expansion foam system that would minimize the formation of airborne respirable dust at transfer points and along a section belt line. This paper describes the results of a field test survey where the relative effectiveness of foam and water spray systems was evaluated.

ACKNOWLEDGMENTS

The author would like to thank the following: Welby G. Courtney, Pittsburgh Mining and Safety Research Center, Bureau of Mines, for his valuable technical discussions; Norman Hanna, who was technical project officer for this contract; William McCullough, general mine superintendent, Theodore Zitko, general mine forman, and Francis Dulkoski and Richard Schrickel of Environmental Control, Rose Valley No. 6 mine, Hopedale, Ohio, for their operating assistance; and Frank McCall, Terence Civic, and Alexander Callas of the Dust Control and Life Support Group, Pittsburgh Mining and Safety Research Center, Bureau of Mines, for their assistance in conducting the dust sampling study.

EXPERIMENTAL WORK

The relative effectiveness of foam in reducing respirable dust concentrations was compared to a water spray system at an underground field site. Field tests were conducted in a retreat section of the Hanna Coal Co. Rose Valley No. 6 mine near Hopedale, Ohio. The field dust sampling program was conducted by personnel from the Bureau of Mines Dust Control and Life Support Group, Pittsburgh Mining and Safety Research Center.

The areas of dust generation along the transport system consisted of the chain feeder that transferred coal from the shuttle cars onto the belt, the section belt, and a belt transfer where the coal was dumped from the section belt onto the main belt line (fig. 1). The coal was dropped approximately

²Pring, R. F. Dust Control in Large Scale Ore-Concentrating Operations. AIME Tech. Pub. 1225, 1940.

³Morrison, J. N., Jr. Controlling Dust Emission at Belt Conveyor Transfer Points. Trans. AIME, v. 250, 1971, p. 47.

⁴Bauer, H. D. (A Measurement of Dust Control Effectiveness by Enclosing of a Transfer Point.) Gluckauf v. 108, 1972, p. 204.

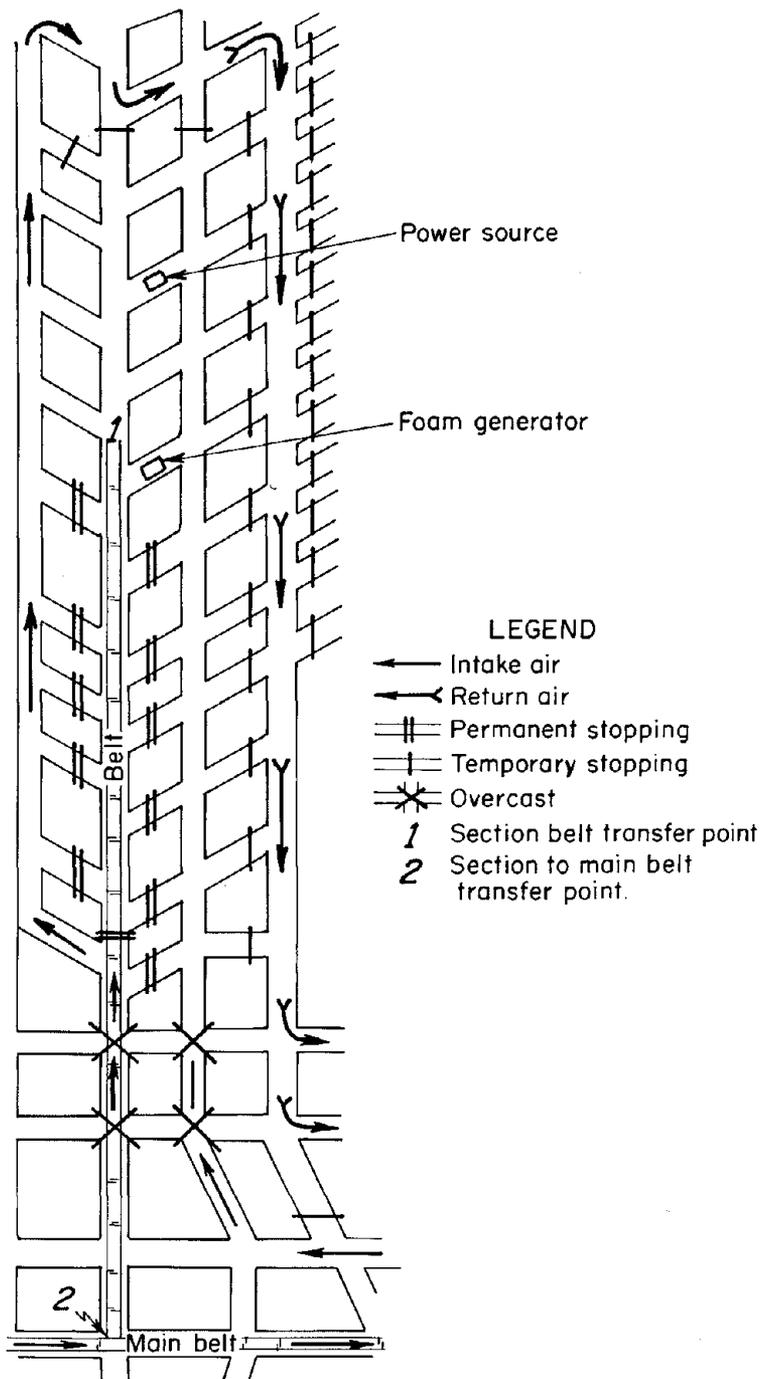


FIGURE 1. - Schematic of section belt line.

3 feet from the feeder to the belt. Foam or water spray was applied at the chain feeder station. Single approved personal dust samplers with cyclones were suspended about 2 feet above the center of the belt at the designated transfer points and along the belt line. Air velocity along the belt line was less than 30 ft/min. Table 1 shows the sampling locations.

A gross airborne dust sample was also taken at the chain belt feeder using a personal sampler without the cyclone. Full-shift samples were taken; an acceptable shift was defined as one for which the tonnage was 60 pct of the average shift tonnage for the prior month. Initial work indicated that rock dusting or walking the belt line might lead to spurious results. Therefore, traffic along the belt line was kept to a minimum during a test shift, and belt cleaning and rock dusting were done on the idle shifts.

The DeTer foam system produced foam in a central, wheel-mounted generator by mixing chemical reagent with water under pressure (typically, 50 psi) and passing the mixture through a cartridge containing wire screen. The foam was then distributed through a 1-inch hose to multiple delivery nozzles. The chemical reagent was custom-blended for DeTer, and the chemical composition is proprietary information. The liquid contained 2.5 pct of the reagent. The expansion ratio for the foam was approximately 50. Four foam nozzles were mounted in front of the feeder discharge to inject foam into the falling coal at 15 to 20 cfm. Later, a fifth nozzle was located under the

belt to inject foam onto the underside of the belt at 5 to 7 cfm. Figure 2 shows the positions of the foam nozzles. A more detailed description of the foam system is available on open file.⁵

TABLE 1. - Dust sampling locations

| <u>Location</u> | <u>Sampling site</u> |
|-----------------|---|
| 1..... | Chain feeder transfer point. |
| 2..... | 1st crosscut outby the chain feeder. |
| 3..... | 5th crosscut outby the chain feeder. |
| 4..... | Last crosscut outby the chain feeder. |
| 5..... | Belt transfer of section belt to main belt. |

Foam generation was controlled by the chain feeder operating switch. When the shuttle car operator started the loader, the foam system went from standby to the operating conditions and started to eject foam. The chain feeder was sequenced to run 1 minute 55 seconds, during which time the 8-ton load of the shuttle car was discharged and transferred to the section belt. After the feeder was started, there was a 10-second lag time before the first coal appeared at the drop point and a 20-second run of the feeder after the last coal had been transferred to the section belt. Therefore, the foam was applied before, during, and after coal transfer. When the foam system was operated on "standby," a small amount of cooling water (about 0.8 gal/min) was steadily discharged onto the belt. The belt thus was kept constantly wet during the foam tests.

For the water spray tests, eight Preiser model 1188/4 spray nozzles⁶ rated at 2.4 gal/min per nozzle were used. They were positioned on a bar above the chain and sprayed down onto the coal as it fell onto the belt (fig. 3). The weight of the coal on the belt triggered the pump and sprays. Consequently, only about 90 pct of the dumped coal was sprayed before it reached the belt.

⁵DeTer Co., Inc. Dust Suppression in Coal Mines. BuMines Open File Rept. 24-73, 1972, 44 pp.; available for consultation at the Bureau of Mines libraries at Denver, Colo., Pittsburgh, Pa., Spokane, Wash., and Twin Cities, Minn.; and at the Central Library, U.S. Department of the Interior, Washington, D.C.

⁶Reference to specific equipment does not imply endorsement by the Bureau of Mines.

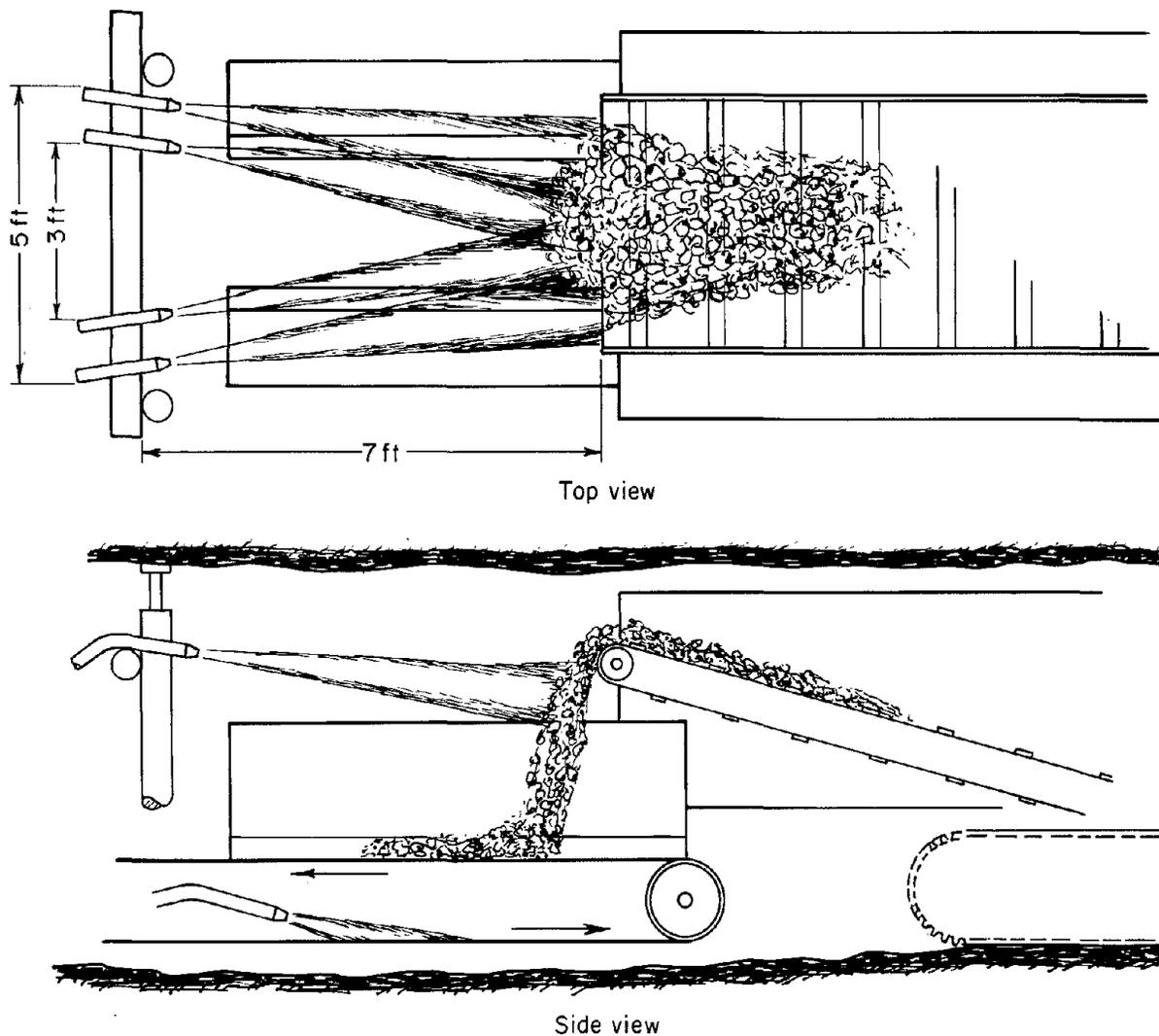
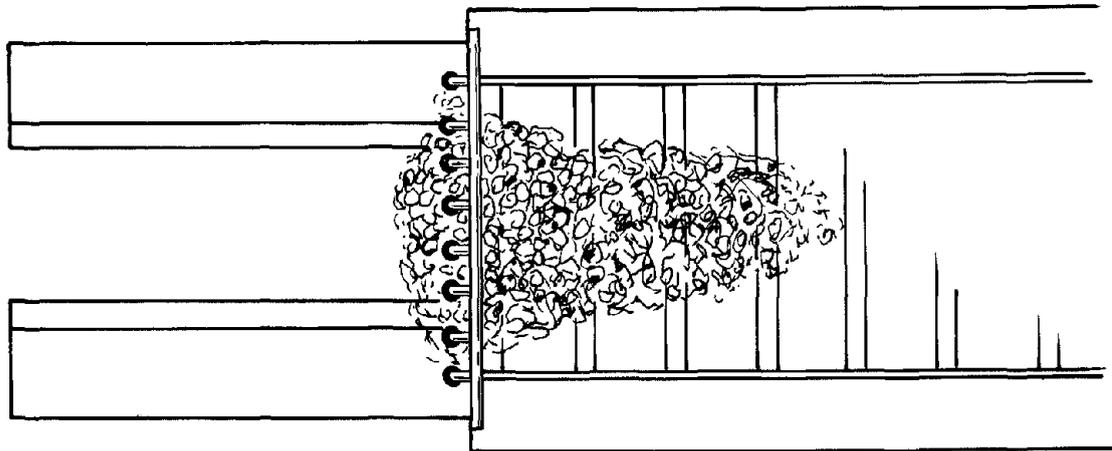
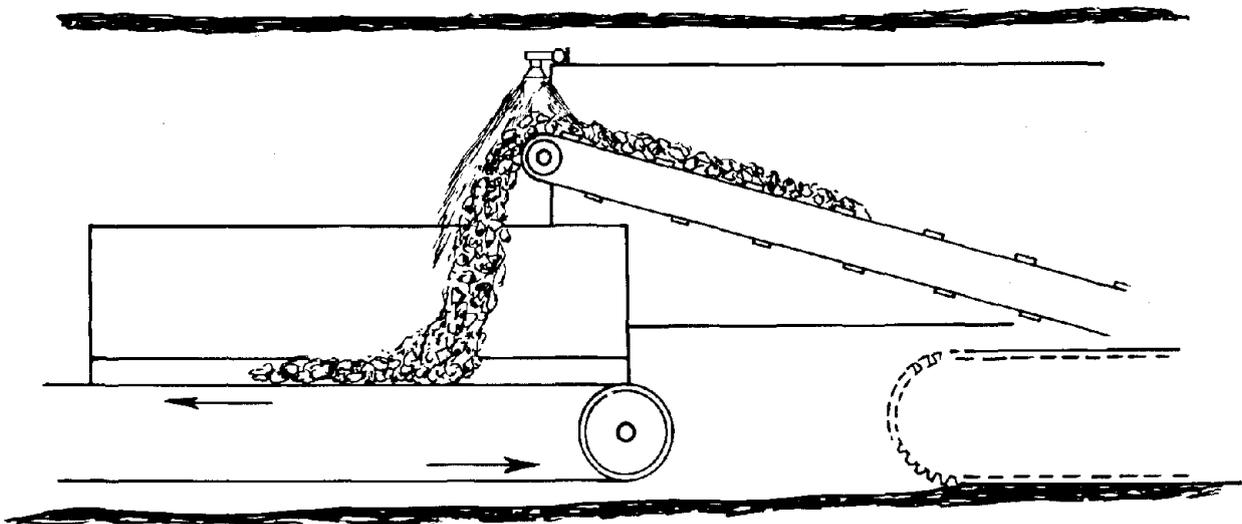


FIGURE 2. - Chain feeder transfer point illustrating spraying of foam onto coal.

The original test schedule was to sample 5 consecutive working shifts using the water spray, followed by 5 shifts using DeTer foam, followed by a repeat of this 10-shift sequence. In practice, miner strikes and equipment breakdowns interfered with the schedule, and no systematic schedule was followed. The total number of tests included 9 foam shifts run with an additional foam nozzle located under the belt, 4 water spray shifts run using a water spray nozzle under the belt, and 10 water spray shifts run without the spray under the belt. Also, three dry shifts were run randomly throughout the testing period.



Top view



Side view

FIGURE 3. - Chain feeder transfer point illustrating spraying of water onto coal.

RESULTS AND DISCUSSION

The raw data for these tests are presented in tables 2 through 7 at the end of the report and are summarized in table 8. Table 9 represents the results of the statistical analysis and indicates the confidence levels at which a difference between dust levels may be asserted. The statistic employed was a t-test to determine the amount of difference between two population means; that is,

$$t = \frac{\bar{x}_1 - \bar{x}_2 - d}{\sqrt{\frac{(n_1 - 1)(S_1^2) + (n_2 - 1)(S_2^2)}{n_1 + n_2 - 2}}} \sqrt{\frac{n_1 n_2}{n_1 + n_2}}$$

where t has t -distribution with $n_1 + n_2 - 2$ degrees of freedom,

n_1 , \bar{x}_1 , and S_1^2 are the sample size, sample average, and sample variance for one set of data,

n_2 , \bar{x}_2 , and S_2^2 are the sample size, sample average, and sample variance for the second set of data,

and d is the percentage difference tested between the two sets of data.

Rather than reiterate the percentage differences between each set of data for each sampling location (contained in table 9), only the general highlights will be presented here. The efficacy of foam application at the chain feeder transfer is evidenced by the 48-pct dust reductions at this location compared with water spray results and by the 91-pct reduction compared with results of dry operation. Dust reductions along the belt line were similar to those observed at the chain feeder transfer, while a slight reduction was observed at the belt-to-belt transfer with foam as compared with results using water.

Dust levels at the belt-to-belt transfer were 53 pct higher (90-pct confidence level) than the respirable dust levels at the chain feeder transfer, indicating that additional dust control measures are needed at this point. Since the dry dust levels were the same at the chain feeder transfer and at the belt-to-belt transfer, it can be speculated that similar reduction of dust could be obtained at the belt-to-belt transfer if an additional foam or water spray system was utilized at that location. Also, the application of foam or water very significantly lowered the gross airborne dust concentration at the chain feeder transfer point compared with that of a dry operation (77 pct and 64 pct, respectively).

Moistening the underside of the belt reduced the airborne dust levels at the chain feeder by 15 pct when compared with tests without the additional spray.⁷ The fact that this effect was not evidenced along the entire belt line suggests that the movement of the belt dried the belt, and thus the dust was free to become airborne.

Summarizing, the results suggest that a low-expansion foam is a better dust suppressant at a transfer point and belt line than the water spray system tested here. However, the foam is expensive (10 cents/ton) and its implementation involves the use of extra equipment and materials, and sufficient dust suppression may be achievable with a strategically designed water spray system.⁸

⁷The effect of the underside of the belt was not realized until after the initial foam and water test data were analyzed. This is the reason that all water spray tests were not conducted with the additional spray under the belt.

⁸Cheng, L. Formation of Airborne Respirable Dust at Belt Conveyor Transfer Points. AIHA J., v. 34, No. 12, December 1973, pp. 540-546.

CONCLUSIONS

1. The application of foam to the coal at the chain feeder transfer lowered dust levels significantly at this point and along the section belt line, compared with a water spray or a dry operation. However, a strategically arranged water spray system may be a sufficiently satisfactory and a more economical and convenient dust control method. Conversely, the extra cost of foam may be relatively low if application of foam reduces the number of other dust control measures required.

2. The underside of a dry belt is a significant contributor to the air-borne dust formed at the belt transfer operation.

3. The section belt to main belt transfer point is a significant dust-producing operation. Additional dust control by foam or water sprays may be required at these main transfer points when excessive dust levels exist.

4. These tests and results demonstrate the state of the art of dust control at transfer points with foam. No future work in this area is needed. Future work should include testing different water spray systems along section and main belt lines.

TABLE 2. - Chain feeder transfer (personal)

| A | B | C | D |
|-----------------|----------------|-----------------|-----------------|
| 5.9 | 0.1 | 2.2 | 1.2 |
| 5.2 | .1 | 1.6 | 1.1 |
| 6.0 | .3 | 1.4 | 1.9 |
| | .1 | 1.7 | .3 |
| | .1 | .8 | |
| | .4 | 1.7 | |
| | .5 | 3.6 | |
| | .5 | 2.7 | |
| | .4 | 3.6 | |
| | | 6.0 | |
| $\bar{X} = 5.7$ | $\bar{X} = .2$ | $\bar{X} = 2.5$ | $\bar{X} = 1.1$ |
| $\sigma = .4$ | $\sigma = .1$ | $\sigma = 1.5$ | $\sigma = .6$ |

A--Belt dry.

B--Belt with 4 foam sprays plus 1 on underside of belt.

C--Belt with 8 water sprays.

D--Belt with 8 water sprays plus 1 on underside of belt.

\bar{X} = average of N numbers.

σ = standard deviation of N numbers.

NOTE.--All data are expressed in mg/m³, MRE equivalents.

TABLE 3. - Chain feeder transfer (gross)

| A | B | C | D |
|------------------|-----------------|------------------|-----------------|
| 95.8 | 6.2 | 41.9 | 10.0 |
| 47.4 | 8.0 | 29.2 | 6.1 |
| 62.8 | 6.7 | 35.3 | 9.8 |
| | 6.4 | 14.2 | 8.9 |
| | 4.9 | 21.9 | |
| | 4.6 | 26.5 | |
| | 3.4 | 30.1 | |
| | 2.9 | 22.2 | |
| | 5.4 | 35.5 | |
| | | 33.6 | |
| $\bar{X} = 68.6$ | $\bar{X} = 5.3$ | $\bar{X} = 29.0$ | $\bar{X} = 8.7$ |
| $\sigma = 24.7$ | $\sigma = 1.6$ | $\sigma = 8.1$ | $\sigma = 1.8$ |

A--Belt dry.

B--Belt with 4 foam sprays plus 1 on underside of belt.

C--Belt with 8 water sprays.

D--Belt with 8 water sprays plus 1 on underside of belt.

 \bar{X} = average of N numbers. σ = standard deviation of N numbers.NOTE.--All data are expressed in mg/m³.TABLE 4. - First crosscut outby the chain feeder

| A | B | C | D |
|-----------------|----------------|-----------------|----------------|
| 3.5 | 0.1 | 1.2 | 1.1 |
| 3.8 | .1 | 2.0 | .4 |
| 3.6 | .3 | 1.7 | 1.4 |
| | .1 | 1.7 | .3 |
| | .1 | .4 | |
| | .4 | .8 | |
| | .1 | 4.4 | |
| | .1 | 4.4 | |
| | .1 | 1.6 | |
| | | 1.1 | |
| | | 1.1 | |
| $\bar{X} = 3.6$ | $\bar{X} = .1$ | $\bar{X} = 1.8$ | $\bar{X} = .8$ |
| $\sigma = .1$ | $\sigma = .1$ | $\sigma = 1.3$ | $\sigma = .5$ |

A--Belt dry.

B--Belt with 4 foam sprays plus 1 on underside of belt.

C--Belt with 8 water sprays.

D--Belt with 8 water sprays plus 1 on underside of belt.

 \bar{X} = average of N numbers. σ = standard deviation of N numbers.NOTE.--All data are expressed in mg/m³, MRE equivalents.

TABLE 5. - Fifth crosscut outby the chain feeder

| A | B | C | D |
|-----------------|----------------|-----------------|-----------------|
| 1.4 | 0.4 | 0.1 | 2.2 |
| 1.1 | .3 | .6 | 1.8 |
| .9 | .1 | .6 | 1.2 |
| | .1 | .3 | .3 |
| | .1 | .1 | |
| | .6 | .8 | |
| | .1 | 1.2 | |
| | .1 | 2.7 | |
| | .1 | 1.6 | |
| | | .9 | |
| | | 2.4 | |
| $\bar{X} = 1.1$ | $\bar{X} = .2$ | $\bar{X} = 1.0$ | $\bar{X} = 1.3$ |
| $\sigma = .2$ | $\sigma = .1$ | $\sigma = .8$ | $\sigma = .8$ |

A--Belt dry.

B--Belt with 4 foam sprays plus 1 on underside of belt.

C--Belt with 8 water sprays.

D--Belt with 8 water sprays plus 1 on underside of belt.

 \bar{X} = average of N numbers. σ = standard deviation of N numbers.NOTE.--All data are expressed in mg/m³, MRE equivalents.TABLE 6. - Last crosscut outby the chain feeder

| A | B | C | D |
|-----------------|----------------|----------------|----------------|
| 1.4 | 0.4 | 0.1 | 1.4 |
| 1.6 | .3 | .1 | 1.1 |
| 1.6 | .1 | .4 | .2 |
| | .1 | .4 | .2 |
| | .1 | .6 | |
| | .6 | .8 | |
| | .2 | .6 | |
| | .3 | .8 | |
| | .4 | 2.0 | |
| | | .8 | |
| $\bar{X} = 1.5$ | $\bar{X} = .2$ | $\bar{X} = .7$ | $\bar{X} = .7$ |
| $\sigma = .1$ | $\sigma = .1$ | $\sigma = .5$ | $\sigma = .6$ |

A--Belt dry.

B--Belt with 4 foam sprays plus 1 on underside of belt.

C--Belt with 8 water sprays.

D--Belt with 8 water sprays plus 1 on underside of belt.

 \bar{X} = average of N numbers. σ = standard deviation of N numbers.NOTE.--All data are expressed in mg/m³, MRE equivalents.

TABLE 7. - Belt-to-belt transfer

| A | B | C | D |
|-----------------|-----------------|-----------------|-----------------|
| 6.8 | 4.9 | 2.5 | 6.9 |
| 5.9 | 2.2 | 1.1 | 1.9 |
| 5.9 | 1.4 | 2.5 | 2.8 |
| | 2.7 | 1.2 | 3.0 |
| | 1.4 | 2.0 | |
| | 1.7 | 4.9 | |
| | .4 | 1.1 | |
| | 2.0 | 3.5 | |
| | .1 | 6.7 | |
| | | 3.8 | |
| $\bar{X} = 6.2$ | $\bar{X} = 1.8$ | $\bar{X} = 2.9$ | $\bar{X} = 3.6$ |
| $\sigma = .5$ | $\sigma = 1.4$ | $\sigma = 1.8$ | $\sigma = 2.2$ |

A--Belt dry.

B--Belt with 4 foam sprays plus 1 on underside of belt.

C--Belt with 8 water sprays.

D--Belt with 8 water sprays plus 1 on underside of belt.

\bar{X} = average of N numbers.

σ = standard deviation of N numbers.

NOTE.--All data are expressed in mg/m³, MRE equivalents.

TABLE 8. - Summary of field tests

| Condition | Number of shifts | Average tonnage | Average respirable dust concentration (mg/m ³ , MRE equivalents) | | | | | |
|-----------|------------------|-----------------|---|------------|--------------------------------------|--------------------------------------|---------------------------------------|----------------------------|
| | | | Section belt transfer | | 1st cross-cut outby the chain feeder | 5th cross-cut outby the chain feeder | Last cross-cut outby the chain feeder | Main belt-to-belt transfer |
| | | | Resp. dust | Total dust | | | | |
| A | 3 | 563 | 5.7 | 68.6 | 3.6 | 1.1 | 1.5 | 6.2 |
| B | 9 | 550 | .2 | 5.3 | .1 | .2 | .2 | 1.8 |
| C | 10 | 486 | 2.5 | 29.0 | 1.8 | 1.0 | .7 | 2.9 |
| D | 4 | 523 | 1.1 | 8.7 | .8 | 1.3 | .7 | 3.6 |

A--Belt dry.

B--Belt with 4 foam sprays plus 1 on underside of belt.

C--Belt with 8 water sprays.

D--Belt with 8 water sprays plus 1 on underside of belt.

TABLE 9. - Confidence levels at which a difference
between dust levels may be asserted

| Sampling location | Foam ¹ versus water ² | | Water ² versus water ⁴ | |
|----------------------------|---|----------------|--|------------------------------|
| | C.L. ³ | Pct difference | C.L. ³ | Pct difference |
| Chain feeder..... | 95 | Foam 40% lower | 95 | No difference |
| | 90 | Foam 48% lower | 90 | Water ² 12% lower |
| Chain feeder (gross)..... | 95 | Foam 17% lower | 95 | Water ² 44% lower |
| | 90 | Foam 22% lower | 90 | Water ² 50% lower |
| 1st crosscut outby..... | 95 | Foam 40% lower | 95 | No difference |
| | 90 | Foam 50% lower | 90 | Water ² 5% lower |
| 5th crosscut outby..... | 95 | Foam 48% lower | 95 | No difference |
| | 90 | Foam 57% lower | 90 | No difference |
| Last crosscut outby..... | 95 | Foam 8% lower | 95 | No difference |
| | 90 | Foam 23% lower | 90 | No difference |
| Belt-to-belt transfer..... | 95 | No difference | 95 | No difference |
| | 90 | Foam 11% lower | 90 | No difference |
| | Foam ¹ versus dry | | Water ² versus dry | |
| | C.L. ³ | Pct difference | C.L. ³ | Pct difference |
| Chain feeder..... | 95 | Foam 89% lower | 95 | Water 66% lower |
| | 90 | Foam 91% lower | 90 | Water 70% lower |
| Chain feeder (gross)..... | 95 | Foam 72% lower | 95 | Water 56% lower |
| | 90 | Foam 77% lower | 90 | Water 64% lower |
| 1st crosscut outby..... | 95 | Foam 92% lower | 95 | Water 63% lower |
| | 90 | Foam 93% lower | 90 | Water 66% lower |
| 5th crosscut outby..... | 95 | Foam 60% lower | 95 | No difference |
| | 90 | Foam 65% lower | 90 | No difference |
| Last crosscut outby..... | 95 | Foam 69% lower | 95 | No difference |
| | 90 | Foam 72% lower | 90 | No difference |
| Belt-to-belt transfer..... | 95 | Foam 45% lower | 95 | Water 3% lower |
| | 90 | Foam 51% lower | 90 | Water 20% lower |

¹Foam plus foam under belt.

²Water plus water under belt.

³C.L.--Confidence level, pct.

⁴Water.