RI 8519

Bureau of Mines Report of Investigations/1981

Effects of Humidity on Salt Mine Dust: A Preliminary Report

By J. C. Volkwein, R. P. Vinson, and E. D. Thimons

UNITED STATES DEPARTMENT OF THE INTERIOR

Report of Investigations 8519

Effects of Humidity on Salt Mine Dust: A Preliminary Report

By J. C. Volkwein, R. P. Vinson, and E. D. Thimons

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

BUREAU OF MINES

This publication has been cataloged as follows:

Volkwein, Jon C

Effects of humidity on salt mine dust: A preliminary report.

(Report of investigations ; 8519)
Includes bibliographical references.
Supt. of Docs. no.: I 28.23:8519.

1. Salt mines and mining—Dust control. 2. Mine dusts. 3. Humidity. I. Vinson, Robert P., joint author. II. Thimons, Edward D., joint author. III. Title. IV. Series: United States. Bureau of Mines. Report of investigations ; 8519.

TN23.U43 [TN312] 622s [622'.3632] 80-22609

CONTENTS

ILLUSTRATIONS

TABLES

EFFECTS OF HUMIDITY ON SALT MINE DUST: A PRELIMINARY REPORT

by

J. C. Volkwein,[1] R. P. Vinson,[2] and E. D. Thimons[3]

ABSTRACT

A preliminary study was conducted by the Bureau of Mines to determine the effect of humidity on salt mine airborne dust levels. Results showed less dust where the humidity was elevated. Dust reductions appeared to be dependent on the equilibrium between humidity and salt.

BACKGROUND

Total dust levels in salt and other soluble ore mines where silica content is less than 1% are required to be less than 10 milligrams per cubic meter. This nuisance dust level was established to improve visibility and reduce skin and membrane irritation often caused by excessive dust. Many salt mines have difficulty meeting this dust standard because--

1. Water for dust control can be used only in limited quantities since it creates very difficult materials handling problems.

2. The large mine entry sizes make it very difficult to provide adequate ventilation for dust removal.

3. Dry dust collectors for individual mining machines are expensive or unavailable, although the Bureau is conducting research in this area.[4]

---

[1]Physical scientist.
[2]Physicist.
[3]Supervisory physicist.
All authors are with the Pittsburgh Research Center, Bureau of Mines, Pittsburgh, Pa.

[4]Dry Dust Collector, contract H0395039, Donaldson Co., Inc., Minneapolis, Minn.
Dust Control for Cutter Machines, contract H0387010, Donaldson Co., Inc., Minneapolis, Minn.
Hollow and Wet Cutter Bars, contract H0308049, Foster-Miller Associates, Waltham, Mass.
For information on these contracts, contact S. J. Page, Technical Officer, Bureau of Mines, Pittsburgh, Pa.

The National Salt Institute[5] and various Mine Safety and Health Administration officials have observed that salt mines are noticeably less dusty in summer than in winter.[6] It was suggested that the increased summer humidity was responsible for the observed dust reduction.

Salt is a hygroscopic material. It was proposed that a salt mine could absorb water vapor during humid air periods and release water vapor during dry air periods, and therefore, act as a "moisture sink." Figure 1 illustrates this effect when humid summer air and dry winter air enter a mine.

Pure sodium chloride and water vapor establish an equilibrium at a relative humidity of 75%.[7] This relative humidity is termed the critical humidity of pure sodium chloride.[8] If the relative humidity drops below the critical humidity, salt will remain dry, of if damp, will dry out. At a relative humidity above the critical humidity, salt will absorb moisture from the air. Impurities can significantly alter the critical humidity of pure sodium chloride. For example, small amounts of calcium and magnesium chlorides can change the critical humidity from 75% to 35% depending on the amount of impurities present. Defining the critical humidity of a particular type of mine salt can be quite complex; Kaufmann[9] gives a further discussion of this topic.

Changes in mine humidity may change the dust levels in a salt mine. The Bureau proposed that increasing mine humidity above the critical humidity could cause salt dust particles to increase in particle size with added moisture. Larger damp particles can settle faster and/or adhere to surfaces. Conversely, decreasing the humidity below the critical humidity could decrease particle size, causing the dust to float longer and/or detach from surfaces more readily, Figure 2 illustrates this proposed model for humidity effects on salt mine airborne dust levels.

The purpose of this study was to determine to what extent dust concentrations and mine humidity vary between summer and winter. Dust and humidity data were then correlated after normalizing the data for other dust contributing parameters.

---

[5]Davis, Jack L. Secondary Crushing. Screening and Dust Collection. Proc. Salt Inst. Dust and Noise Seminar, Cleveland, Ohio, Jan. 28, 1976.

[6]Mine Enforcement and Safety Administration. Dust Control in Salt Mines Through Humidity. MESA Project Proposal, FY 1978; available for inspection at the Pittsburgh Research Center.

[7]Kaufmann, Dale W. Sodium Chloride. Reinhold Publishing Corp., New York, 1960, p. 527.

[8]Pages 528-532 of work cited in footnote 7.

[9]Work cited in footnote 7.

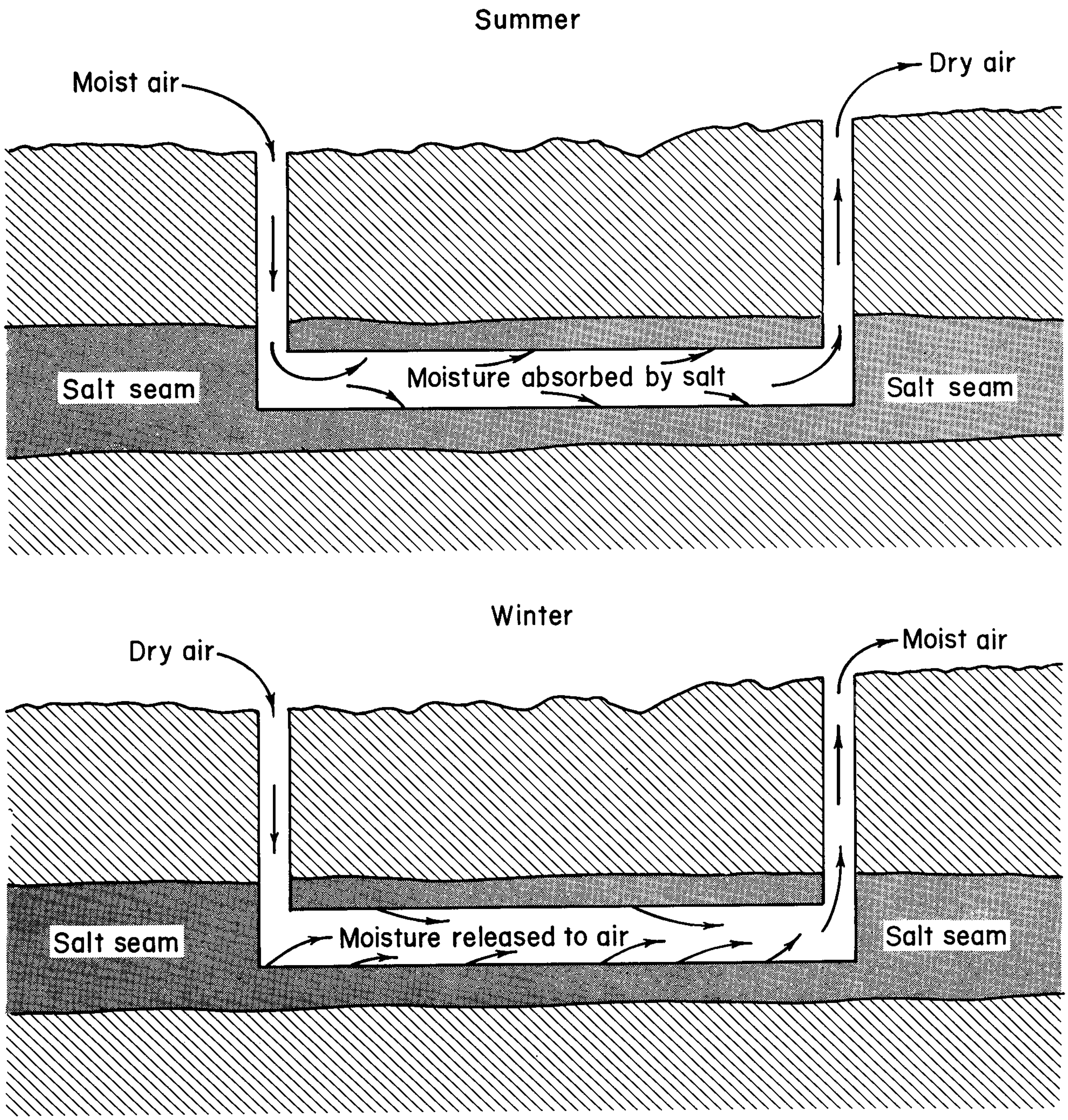

FIGURE 1. - Effect of moisture during summer and winter in a salt mine.

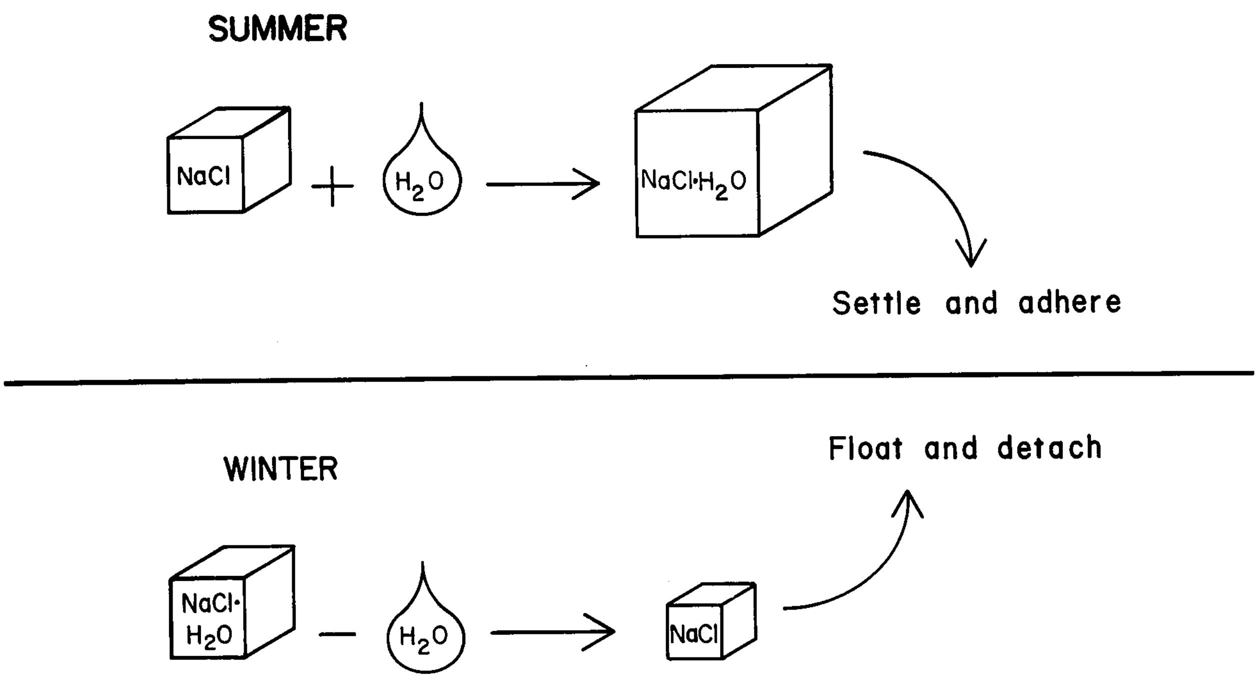

FIGURE 2. - Proposed model of humidity effects on salt dust.

ACKNOWLEDGMENTS

The authors wish to thank the following mines and personnel for their help in conducting these tests: International Salt's Retsof Mine, Art Geary; International Salt's Detroit Mine, Jim MacDonald; Morton Salt, Fairport Harbor Mine, Jim Stouffer; and the respective mine employees. Chuck Urban and Anthony Covelli of the Bureau's Research Center also helped in conducting the underground survey portions of this survey.

METHODS

Salt mines sampled in this study were located in the northern United States. The Salina rock deposit is a multibedded rock salt deposit underlying a good portion of the Northeastern United States. Conventional room-and-pillar techniques are used to mine this deposit. Underground primary crushers and belt haulage are used in all mines.

The simplest method to measure dust variations with humidity is to sample both parameters when the natural humidity fluctuations are at their extremes. These extremes occur in the northern United States in summer and winter. The air used to ventilate salt mines is generally warm and moist in summer and cool and dry in the winter.

Wet and dry bulb temperature measurements were taken with a sling psychrometer. Measurements were taken on the surface, the bottom of the intake air shaft, the return airway, and at various mine face locations. Corrections were made for barometric pressure and elevation. The relative and specific humidities at these locations were calculated.

Sampling locations were positioned such that they would remain constant between summer and winter seasons. Since part of our goal was to determine a difference in total mine dust concentrations from summer to winter, accurate assessment of dust concentrations was vital to this study. Sample locations were chosen where minimal dust fluctuations would be expected between summer and winter. Consistent dust levels generally occurred downstream from underground crushers and in return airways. Two underground crushers and two return airways were sampled. (One mine was sampled at both locations.)

Total dust concentrations were measured using conventional gravimetric dust samplers. Samplers were arranged in an area sampling package (ASP) that consisted of four individual gravimetric samplers, with the filters within a 6-inch linear horizontal array and with filter openings oriented down. Figure 3 shows an ASP having the flowrate adjusted, a procedure conducted 30 minutes after the pumps were started and at hourly intervals thereafter. Individual filters from the gravimetric samplers were preweighed and postweighed at the Pittsburgh Research Center, Bruceton laboratory. Filters were equilibrated for 24 hours at 50% ± 5% relative humidity before weighing. Filters were charge neutralized just prior to weighing.

Area sampling packages were distributed across the airways. From one to four packages were used, depending on the size of the area or number of airways to be monitored. Results were then averaged to give one dust concentration per sampling location.

Dust concentrations are a function of the mass of dust generated and the volume of air in which that mass is dispersed. Both of these parameters vary with time. It was very important that these variables be normalized, not only day to day but also summer to winter. It was assumed that the mass of dust generated was a function of the amount of mining activity that would correspond with the daily tonnage output of either the crusher being sampled, or the total mine output in the case of the return airway samples. Mine records were used for the mine tonnages.

The volume of air in which the dust was dispersed was measured by using vane anemometers at appropriate locations. Three anemometer traverses were made each morning and afternoon in all airways affecting our test locations. Smoke tubes were used in one airway where velocities were too low to measure with vane anemometers. Cross sectional areas and daily average velocity measurements were then used to calculate daily volumes of air at our test locations.

Dust concentrations, air volumes, and production tonnages were then used to calculate a mass emission rate of the mine or crusher. The mass emission rate is in terms of milligrams of dust per ton of salt produced and is thus normalized for production and volume of air in which the dust is dispersed. The mass emission rate can then be readily compared to similar data taken months later under different production and dilution air volume conditions.

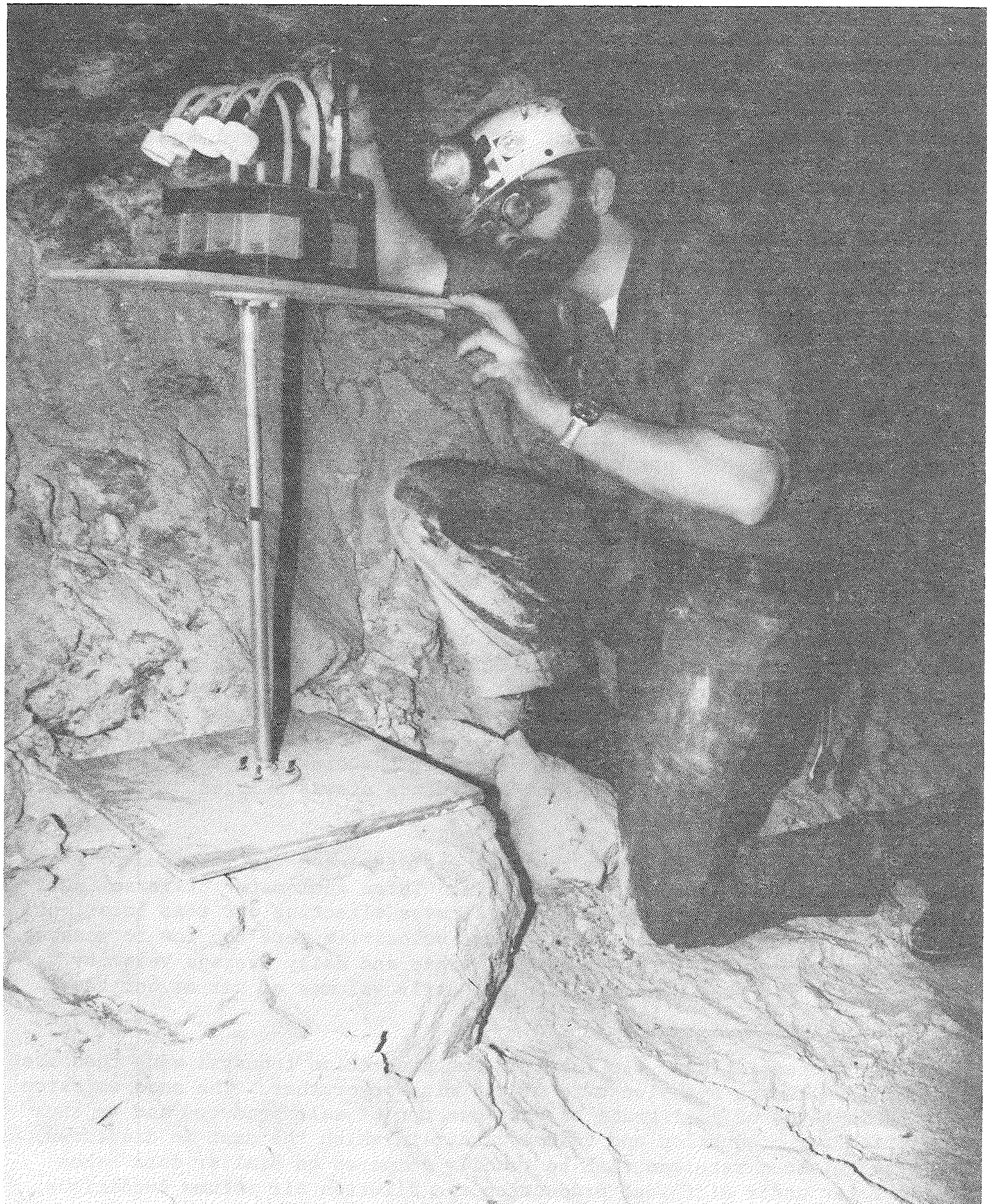

FIGURE 3. - An area sampling package having the flow rate checked.

RESULTS AND DISCUSSION

A summary of the specific humidities in table 1 shows the difference in summer to winter variations. All mines show more water vapor in the mine airways during the summer. Intake humidities vary, as expected, with changes in surface humidity. The return air humidities at Morton and Retsof show larger changes between summer and winter than the Detroit mine. The return air measurement is important, since our spot checks indicated that this measurement typifies air humidities throughout the working face areas.

TABLE 1. - Humidity data summary

Mine and location	Summer		Winter		Summer to winter differences to specific humidity, lb H_2O / lb dry air
	Specific humidity, lb H_2O / lb dry air	Relative humidity, %	Specific humidity, lb H_2O / lb dry air	Relative humidity, %	
Morton:					
Surface...	0.0135	68	0.0037	44	+0.0098
Intake....	.0132	66	.0074	46	+.0095
Return....	.0135	59	.0037	32	+.0061
Detroit:					
Surface...	.0134	72	.0047	48	+.0087
Intake....	.0101	73	.0061	58	+.0040
Return....	.0072	64	.0047	62	+.0003
Retsof:					
Surface...	.0185	79	.0022	84	+.0163
Intake....	.0155	74	.0022	34	+.0133
Return....	.0078	63	.0056	48	+.0022

These results support the hypothesis that a salt mine acts like a moisture sink. When warm, moist air enters a mine, the hygroscopic nature of the salt extracts water from the air. The air leaving the mine then has a lower specific humidity than the air entering. The opposite occurs in winter. When cool, dry winter air enters a mine, the salt adds moisture to the air. The specific humidity of the exhaust air is higher than that of the intake air.

Known sources of water in the mine included water for dust control in the cutting machines and water vapor from diesel engines. Less than 100 gal of water per shift at the Retsof mine were used for dust control. Diesel combustion engines have water vapor as a combustion product. This will add water to the mine air. However, stoichiometric calculations for combustion of diesel fuel show that about one-fourth the total fuel volume is converted to water vapor. At the Retsof mine, for example the average fuel consumption was 260 gal/shift. This yields about 65 gal/shift of water vapor. Assuming all water used for dust control evaporates, the total known addition of water to the mine air at Retsof was about 165 gal. Our data indicated that during winter, 1,026 gal of water were added to the mine air per shift, or more than 6 times the volume generated by known water sources.

Dust emission rate sampling showed in general that the salt mines sampled were less dusy in summer than in winter. Table 2 is a summary of the summer and winter dust emission rates normalized for production and airflow. Dust reduction results fluctuated substantially between mines. In some cases data showed as much as an 81% reduction in dust between summer and winter. An intramine comparison at Morton showed fairly consistent reductions of 81% and 74% at two different locations in the same mine. The fluctuations in dust concentrations between mines may be due to different impurities changing the critical humidity of the salt at each mine, hence changing the relative effects of humidities on the dust concentrations from mine to mine.

TABLE 2. - Dust emission rate summary

Mine and location	Summer		Winter		Summer to winter reduction, %
	Emission rate,[1] mg/ton	Standard deviation	Emission rate,[1] mg/ton	Standard deviation	
Morton:					
Crusher................	8,390	4,180	32,690	12,430	74
Return[2]...............	910	280	4,710	1,150	81
Retsof: Return.........	134	16	191	22	30
Detroit: Crusher.......	1,741	218	1,076	58	[3]-62

[1]3-day average.
[2]Near skip loading conveyors.
[3]Increase.

The Detroit mine showed an increase in dust levels from winter to summer. This mine was different from the others in several ways:

1. Dust levels were low throughout the mine in summer and winter.

2. Moisture content of the ore was quite high, 0.5% at Detroit compared with 0.03% and less than 0.2% at Retsof and Morton, respectively.

3. The mine was cooler than the other two mines.

4. There was very little change in the moisture content in the return air of the Detroit mine from summer to winter.

These facts imply that conditions in the Detroit mine already exceeded the critical humidity in both summer and winter.

The critical humidity is dependent on chemical impurities in the salt. All mines have different levels of chemical impurities. Calcium and magnesium sulfates and chlorides comprise the largest percentage of impurities. The distribution of these impurities varies with the size of the product. This factor could affect the role the impurities have on changing the critical humidity of the salt. However, note that the return air summer relative humidities in all mines are between 59% and 64%. The Detroit mine, with no dust problems, is within this range all year. This implies that the critical humidity of those mines is in the range 59% to 64%. A more detailed analysis of this and its effect on a proposed dust suppression model is needed.

CONCLUSION

The data presented in this report support the observation that some salt mines may be noticeably less dusty in summer than in winter. We feel that humidity fluctuations are responsible for the dust reductions and have proposed a model by which this dust reduction occurs. However, the small data base of this report precludes firm conclusions. A Bureau contractor will confirm these preliminary measurements and investigate the feasibility of whole-mine or localized humidification to control dust.

☆U.S. GOVERNMENT PRINTING OFFICE: 1980-603-102/149

INT.-BU.OF MINES,PGH.,PA. 25130