U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
CENTERS FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH

Health Hazard Evaluation Determination
Report No. 80-107
Mine I.D. No. 1800155

Allied Chemical Corporation
Green River Works
Green River, Wyoming

December 1982

I. SUMMARY

A health hazard evaluation was conducted by the National Institute for Occupational Safety and Health (NIOSH) on April 15, 1980 and May 1, 1980. On February 20, 1980, NIOSH received a request from the President of the United Steelworkers Local #15320 to conduct a health hazard evaluation of the Allied Chemical Company's surface and underground trona mine operations at Green River, Wyoming.

The request was received in conjunction with a request to conduct a similar survey at a neighboring trona mine. A medical and environmental study was conducted at the latter facility and the results can be found in MHHE report 80-106.[1] Only an industrial hygiene survey was performed at Allied Chemical company.

Ambient air samples were collected for total dust, respirable dust, free silica, trace metals, asbestos, ammonia, nitrogen dioxide, particulate aromatic hydrocarbons and formaldehyde. Trona alkalinity was also determined.

From analysis of ambient samples, NIOSH found some excessive levels for total dust and ammonia. There was no asbestos or crystalline silica found. However, crystalline silica has been reported in the past. The other contaminant levels were insignificant. Trona [2,3,4] should be considered a primary skin irritant with a mean pH of (11.5) and is capaple of producing contact dermatitis. Recommendations can be found in the body of this report in Section IX.

Key words: (SIC 1474 trona mining), sodium carbonate, soda ash, dermatitis, respiratory irritants.

II. INTRODUCTION

On February 20, 1980, the National Institute for Occupational Safety and Health (NIOSH) received a request from the President of the United Steelworkers of America Local 15320 to evaluate trona ore and soda ash for its possible effects on the respiratory system of the production and maintenance personnel.

Contact with both substances had been associated with dermatitis. Another request was also sent during that week from USWA District 33 officer to have the miners and refinery workers included in the present survey.

III. BACKGROUND

Allied Chemical Company is second in the world in soda ash production. All United States mining of trona ore (impure sodium sesquicarbonate) is carried out in Sweetwater County, Wyoming, near Green River. This area is associated with Lake Gosiute, a large body of water which covered the area 50 million years ago.

Beds of trona lie at depths of 800-1600 feet and cover an area of about 1000 square miles. Allied is one of five mines extracting trona in this area. It employes approximately 1300 people with about 1000 of these being miners and maintenance personnel. Trona is mined by three methods: continuous, conventional and longwall methods. The ore is mined, partially crushed underground and then transported to the surface via conveyor belts where it is stock piled for further processing. The surface refining process consists of converting the trona to pure sodium carbonate which is called "soda ash". This process includes the removal of insoluble impurities through crushing, dissolving and separation, removal of organic impurities through carbon absorption, removal of excess carbon dioxide and water by calcining and then drying to soda ash.

Allied makes one grade of soda ash and utilizes only one method of refining, the monohydrate process, which is proprietary. The product of this process is used in the manufacture of glass, soap, cleansers, water softeners, and in photography and chemistry laboratories.

IV. EVALUATION DESIGN

Environmental air monitoring was performed at the surface crusher, stockpile and underground at sections representative of the various mining methods. Three shifts were monitored.

Respirable dust, total dust and airborne particle sizing[5] at the surface and underground operations was conducted to determine dust concentrations and particle size distribution.

Other possible contaminants[6] which are known pulmonary irritants were sampled in order to identify potentially confounding exposures. These were the components of diesel engine emissions in the form of particulate aromatic hydrocarbons (pah's) and nitrogen dioxide. Because trona was felt to be an alkaline skin irritant we attempted to determine the pH in a saturated solution.[4] This was done with scintillation vials filled with 20 cc of distilled water and an aliquot of trona dust from various mining locations. PH indicator paper was used and compared with a known colorimetric standard.

Additionally environmental samples were collected for ammonia, free silica, asbestos, formaldehyde, and trace metals. Approximately 14 samples were taken for trace metal analysis of which two samples were collected as bulks. Mineral analysis was performed on the above 12 smaples for: AL, Ca, Fe, Mg, Mn, P, Sn, Zn, Na, Ag, As, Be, Cd, Co, Cr, Cu, Li, Mo, Ni, Pb, Pt, Se, Te, Ti, TL, V, W, Y, Zr. Of these, only sodium was found in excess amounts. This was expected, since trona is impure sodium sesquicarbonate.

Methods of collection can be found in Table X.

V. EVALUATION CRITERIA

Environmental standards[7,8] and criteria considered applicable to this evaluation are shown in Table IX. These criteria and standards were established at levels to protect workers occupationally exposed to a substance for an 8-10 hour day, 40 hour week over a normal working lifetime. Ceiling values, given in Table IX, are concentrations that should not be exceeded. Exposures to trona and other contaminants are regulated by MSHA's metal and non-metal division. Applicable standards are contained in the 1973 ACGIH TLV's(R). However, as the MSHA standards are ten years old, they may not always reflect new findings in the toxicological properties of some substances. For comparison purposes, the current recommendations of the ACGIH and NIOSH are also presented.[9,10,11,12,13,14,15]

VI. RESULTS

Allied surface and underground environmental sample results are summarized below. The frequency distribution of the dust samples was more nearly log normal than normal; therefore, appropriate measure of central tendency is the geometric mean ($\bar{X}_g$). The raw data tables will reflect both arithmetic and geometric means.

Table I - Total dust geometric mean concentrations were as follows: underground 14.32 mg/m^3, and surface 3.8 mg/m^3.

Table II - Surface and underground geometric mean respirable dust concentrations were 0.67 mg/m^3 and 2.5 mg/m^3 respectively.

Table III - All of the samples for ammonia were collected underground. The mean concentration was 157 ppm.

Tables IV and V - The crystalline silica and asbestos samples were all below the limit of detection.

Table VI - The underground formaldehyde sampling produced a mean concentration of 0.25 ppm.

Table VII - Specific particulate aromatic hydrocarbons were not detected underground.

Table VIII - Nineteen nitrogen dioxide samples were collected underground with a mean concentration of 0.16 ppm.

The mean pH for a saturated aqueous solution of trona was 11.5.

VII. DISCUSSION

The two day, three shift industrial hygiene survey conducted at Allied Chemical Company in April/May 1980 was performed in the same general period as the comprehensive medical and industrial hygiene study undertaken at a neighboring trona operation (MHHE 80-106). The environmental sampling was conducted in the same manner at both trona operations for respirable and total dust, ammonia, crystalline silica, asbestos, formaldehyde, nitrogen dioxide and particulate aromatic hydrocarbons. At Allied, the latter was sampled because they still had some dieselized equipment in their underground operation. Some particulate aromatic hydrocarbons have been identified as carcinogenic and for this reason they should be discussed briefly. Particulate aromatic hydrocarbons are widely found throughout the environment. Their presence can be attributed to natural processes such as bacteria and plant synthesis, brush or forest fires and other forms of incomplete combustion of organic compounds.[16] Several of the particulate aromatic hydrocarbons such as benzo(a) pyrene (BaP) and benzo(a) anthracene (BaA), which have been found in gasoline and diesel exhaust, are known to be carcinogenic based on animal studies.[17,18] Interpretation of animal tests to estimate the risk of human carcinogenesis is difficult and exposure of workers to any known animal carcinogen is cause for concern and should be minimized.

In this survey, the individual particulate aromatic hydrocarbons analyzed for were pyrene, fluoranthene, chrysene, BaA, and BaP but, if present, were below our limit of detection. At Allied, the only elevated exposures found occurred underground for total dust and ammonia. Locations can be found in Tables I and III. No medical testing was conducted at the Allied Chemical facility, but extensive medical testing was performed at the neighboring trona operation. Inasmuch as both operations were similar, a brief summary of the medical findings at the latter are worth presenting.

The medical study represented a non-random volunteer sample of 230 trona workers from both surface and underground operations. Medical testing included: baseline and shift pulmonary function testing, a limited physical exam and skin patch testing. Testing revealed no significant irreversible impairment of lung function attributable to trona dust. However, it was noted that there was a fall in forced expired volume in the first second over a working shift among surface workers in high dust exposure categories. The significance of this finding remains unclear. Skin patch testing was negative and confirmed that trona is a primary irritant and not an allergen. The latter seldom allows a person to return to a setting of continued exposure without recurrent reactions. Skin irritation found was located on the arms, hands and legs, and was characterized by redness, scaling, ulcerations and scars. From the questionnaire and physical exams, it appeared that trona was also irritating to the nose and nasal passages. At this second facility the trona was found to have a mean pH of 10.5.

VIII. CONCLUSIONS

1. Fifty per cent (6/12) of Allied's underground total dust samples were above the 10 mg/m^3 1973 TLV $^{(R)}$ nuisance dust standard.

2. Only one respirable dust sample was above the 1982 TLV of 5 mg/m^3.

3. Ammonia exposures were excessive during the tamping of explosives and after blasting.

4. Crystalline silica and asbestos were not present.

5. Trace metals, formaldehyde and nitrogen dioxide exposures were not considered significant.

6. Particulate aromatic hydrocarbon exposures were not considered significant.

IX. RECOMMENDATIONS

A. To prevent dermatitis (skin rash):

(1) Use loose fitting, non-elasticized wrist type rubber gloves that do not make air-tight seals over the wrist or forearms and do not rub. Rubber gloves that are 8" or longer can be cuffed towards the fingers. Thus when roof bolting, the solubilized trona will catch in the cuff. This procedure may serve to reduce the wetting of the forearms.

(2) Workers should be advised that prolonged skin contact with aqueous trona may produce dermatitis. Miners exposed to trona which becomes dissolved in sweat or water frequently experience such irritation. Daily bathing and laundering of work clothes should reduce the potential for dermatitis.

(3) Barrier creams are excellent protectors of the skin, but usually are not widely accepted at mines because they tend to collect dirt. However, they are effective when used for exposed parts of the body.

(4) After the miners shower, skin lotion may serve to replace lost skin oils.

B. To reduce ammonia exposure:

NIOSH/MSHA approved dust masks were available and used by the miners on an as needed basis and this should continue. NIOSH/MSHA chemical cartridge respirators for ammonia should be available for the blaster and helper during tamping and after blasting. This also applies to those working in the cross cuts and room areas of the panel where blasting has occurred.

C. To reduce total dust exposure:

Total dust exposure in the underground mining environment may be reduced by manipulation of ventilation to produce greater air flows as well as through conscientious use of NIOSH approved respirators.

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IX. REFERENCES:

1. NIOSH, Health Hazard Evaluation MHHE # 80-106, FMC Corporation, Green River, Wyoming, 1982.

2. Kamal'dinova, M., Study of the Effect of Calcined Soda Aersol on the Body, Gigiena Truda i Prof. Zabol, 11:55-57, 1976.

3. Patty's Industrial Hygiene and Toxicology, Third Revised Edition, Volume I, Chap. 8, 1978, John Wiley & Sons, New York.

4. Fundamentals of Industrial Hygiene, National Safety Council, Second Edition, Chap. 8, 1979, Chicago, Ill.

5. Casarett, Louis J and Doull, John, Toxicology, Chap 12 and 17, 1980.

6. USDHEW, Occupational Disease; A Guide to their Recognition, June 1977, Publication No. 77-181.

7. ACGIH, Documentation of the Threshold Limit Values, Fourth Edition Cincinnatti, OH, 1980.

8. ACGIH, Threshold Limit Values (TLVs(R)), 1973 and 1982.

9. NIOSH Criteria Document -- Occupational Exposure to Ammonia, July 1974. DHEW (NIOSH) Publication No. 74-136.

10. NIOSH Current Intelligence Bulletin 36, Silica Flour, June 30, 1981.

11. NIOSH Revised Recommended Asbestos Standard, DHEW Publication No. 77-169, Dec 1976.

12. NIOSH Workplace Exposure to Asbestos, DHEW (NIOSH) Publication No. 81-103, Nov 1980.

13. U.S. Environmental Protection Agency, Health Assessment Document for Polycyclic Organic Matter, EPA-600/9-79-008, December 1979.

14. NIOSH Criteria Document -- Recommended Standard for Oxides of Nitrogen, DHEW Pub. No. 76-149, March 1976.

15. NIOSH -- Summary of NIOSH Recommendations for Occupational Health Standards, Oct 1978.

16. Pucknat, A.W., Health Impacts of Polynuclear Aromatic Hydrocarbons, Noyes Data Corporation, New Jersey, 1981

17. Criteria for a Recommended Standard; Occupational Exposures to Coal Tar Product, DHEW (NIOSH) Publication No. 78-107.

18. Mentser, M. and A.G. Sharkey, Jr., Chemical Characterization of Diesel Exhaust Particulates: ERDA, RIMS, 07032, Dec. 1976.

X. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. United Steelworkers Of America, Local 15320
2. Allied Chemical Corporation
3. NIOSH Region VIII
4. MSHA

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

TABLE I

ALLIED CHEMCIAL CORPORATION
TOTAL DUST

Sample No.	Date	Shift[1]	Location/Occupation	Liters	Weight (mg)	Conc.[2](mg/m^3)	S/U[3]
1	4/15	3	Crusher Maint	712	2.72	3.82	S
2	4/15	3	NIOSH Worker @ Crusher	574	2.13	3.71	S
3	4/15	2	Foreman B-8-7	850	6.44	7.58	U
4	4/15	2	Shuttle Car Oper. B-8-7	960	9.60	10.00	U
5	4/15	3	Foreman F-1-8	540	5.51	10.02	U
6	4/15	2	Crusher Control Rm	890	1.51	1.70	S
7	4/15	2	3rd Flr. Crusher	892	7.89	8.85	S
8	4/15	2	Shuttle Car Oper. J-4-8	944	18.38	19.47	U
9	4/15	2	Foreman J-4-8	840	4.74	5.64	U
10	4/15	2	Continuous Miner Oper J-4-8	462	63.85	138.20	U
5196	5/1	1	SCO 3R3$^+$	946	36.29	38.36	U
5194	5/1	1	Roofbolter 3R3$^+$	950	6.11	6.43	U
4200	5/1	1	Faceman 3R3$^+$	944	6.29	6.66	U
5177	5/1	1	Miner 3R3$^+$	958	37.05	38.67	U
5191	5/1	1	S-Cat. 3R2$^+$	956	12.94	13.54	U
5195	5/1	1	Foreman D77	932	7.00	7.51	U
					$\bar{X}$=20.01	$\bar{X}_g$=10.3	

Surface $\bar{X}$ was 4.5 mg/m^3, Surface $\bar{X}_g$ was 3.8 mg/m^3
Underground X was 25 mg/m^3, Underground X_g was 14.32 mg/m^3

NOTE: (1) Shift 1 is from 7:30 am-3:30 pm
Shift 2 is from 3:30 pm-11:30 pm
Shift 3 is from 11:30 pm-7:30 pm

(2) TLV$^{(R)}$ of 10 mg/m^3 from the 1973 American Conference of Governmental Industrial Hygienist is recommended by law for Metal/Non-Metal mines.

(3) S = Surface, U = Underground

TABLE II

ALLIED CHEMICAL CORPORATION
RESPIRABLE DUST

Sample No.	Date	Shift[1]	Location/Occupation	Liters	Weight (mg)	Conc.[2] (mg/m^3)	S/U[3]
4276	4/14	3	"A" Oper. Crusher	716	.55	.77	S
4275	4/14	3	Dozer Oper. Crusher	687	.90	1.31	S
4279	4/15	2	Driller B-8-7	816	1.46	1.79	U
4283	4/15	2	Roofbolter B-8-7	816	2.01	2.46	U
4086	4/15	2	Shuttle Car B-8-7	316	1.16	3.67	U
4072	4/15	3	Longwall Oper. F18	442	.75	1.70	U
4071	4/15	3	Longwall Oper. F18	442	1.63	3.69	U
4089	4/15	2	"B" Oper. Crusher	757	.40	.53	S
4079	4/15	2	"C" Oper. Crusher	757	.56	.74	S
4090	4/15	2	Dozer Oper. (New Cat.)	719	.24	.33	S
4073	4/15	3	Cutter D77	668	1.98	2.96	U
4074	4/15	3	Loader D77	785	1.46	1.86	U
4075	4/15	3	Roofbolter D77	791	1.26	1.59	U
4081	4/15	2	Cont. Miner Oper. J48	804	11.95	14.86	U
4087	4/15	2	Utilityman J48	808	1.09	1.35	U
5189	5/1	1	Faceman 3R3+	819	1.64	2.00	U
5186	5/1	1	Loader 3R3+	804	1.67	2.08	U
5185	5/1	1	Driller 3R3+	808	2.60	3.22	U
5192	5/1	1	Shuttle Car Oper. 3R2+	824	2.32	2.82	U
4195	5/1	1	Roofbolter 3R2+	819	2.72	3.32	U
5188	5/1	1	Faceman 3R2+	816	1.34	1.64	U
5178	5/1	1	Headgate F18	799	1.60	2.00	U
5179	5/1	1	Mechanic F18	820	1.60	1.95	U
4467	5/1	1	Longwall F18	823	2.98	3.62	U
						$\bar{X}$=2.6	$\bar{X}_g$=1.9

Surface $\bar{X}$ was .74 mg/m^3, Surface $\bar{X}_g$ was .67 mg/m^3
Underground $\bar{X}$ was 3.1 mg/m^3, Underground $\bar{X}_g$ was 2.5 mg/m^3

NOTE: (1) Shift 1 is from 7:30 am-3:30 pm
(2) TLV(R) is 10 mg/m^3
(3) S = Surface, U = Underground

TABLE III

ALLIED CHEMICAL CORPORATION
AMMONIA

Sample No.	Date	Shift	Location/Occupation	Liters	Weight(mg)	Conc.(1)ppm	U(2)
AM-1	4/15	2	Inby 2XC B-8-7	25	.18	10.4	U
AM-2	4/15	2	NIOSH 1 Rm B-8-7	20	3.9	280.5	U
AM-3	4/15	2	Area Rm B-8-7	28	3.6	185.1	U
AM-4	5/1	1	5 Rm, D77 (After blast)	20	3.3	237.6	U
AM-5	5/1	1	5 Rm, D77 (Tamping)	20	.98	70.56	U
						$\bar{X}$=157	

NOTE: (1) TLV(R) is 25 ppm. Per Appendix D, personal and area sampling indicated that the permissible excursion was excessive and exceeded the limits in the 1973 TLV(R) (37.50 ppm).
(2) U = Underground

TABLE IV

ALLIED CHEMICAL CORPORTAION
FREE SILICA (2)*

Sample No.	Date	Shift	Location/Occupation	Liters	Weight (mg)	Concentration(1) (mg/m^3)
4276	4/14	3	"A" Oper. Crusher	716	.03	Not significant
4275	4/14	3	Dozer Oper. Crusher	687	.03	Not significant
4279	4/15	2	Driller B-8-7	816	.03	Not significant
4283	4/15	2	Roofbolter B-8-7	816	.03	Not significant
4086	4/15	2	Shuttle Car B-8-7	316	.03	Not significant
4072	4/15	3	Longwall Oper. F18	442	.03	Not significant
4071	4/15	3	Longwall Oper. F18	442	.03	Not significant
4089	4/15	2	"B" Crusher Oper.	757	.03	Not significant
4079	4/15	2	"C" Crusher Oper.	757	.03	Not significant
4090	4/15	2	Dozer Oper. (New Cat.)	719	.03	Not significant
4073	4/15	3	Cutter D77	668	.03	Not significant
4074	4/15	3	Loader D77	785	.03	Not significant
4075	4/15	3	Roofbolter D77	791	.03	Not significant
4081	4/15	2	CMO J48	804	.03	Not significant
4087	4/15	2	Utilityman J48	808	.03	Not significant
5189	5/1	1	Faceman 3R3+	819	.03	Not significant
5186	5/1	1	Loader 3R3+	804	.03	Not significant
5185	5/1	1	Driller 3R3+	808	.03	Not significant
5192	5/1	1	SCO 3R2+	824	.03	Not significant
4195	5/1	1	Roofbolter 3R2+	819	.03	Not significant
5188	5/1	1	Faceman 3R2+	816	.03	Not significant
5178	5/1	1	Headgate F18	799	.03	Not significant
5179	5/1	1	Mechanic F18	820	.03	Not significant
4467	5/1	1	Longwall F18	823	.03	Not significant

NOTE: (1) Limit of Detection (LOD) for the free silica analysis was .03 mg.
(2) $TLV^{(R)}$ is $\frac{10 \text{ mg}}{\% \text{ Quartz} + 2}$

TABLE V

ALLIED CHEMICAL CORPORATION
ASBESTOS

Sample No.	Date	Shift	Location/Occupation	Liters	Concentration (1) (fibers/cc)
A-1	4/15	3	"C" Crusher Oper.	184	.03
A-2	4/15	3	3rd Flr. Crusher	148	.03
A-3	4/15	3	3rd Flr. Crusher	184	.03
A-4	4/15	3	Longwall Crew F18	238	No analysis done
A-5	4/15	3	Longwall Crew F18	196	.03
A-6	4/15	3	Cutter D77	408	.03
A-7	4/15	3	Cutter D77	128	No analysis done
A-8	4/15	3	Return	459	No analysis done
A-9	4/15	2	CMO J48	408	No analysis done
A-10	5/1	1	Crusher D77	102	.03
A-11	5/1	1	Haulage Way D77	298	.03
A-12	5/1	1	Longwall	247	.03
A-13	5/1	1	Longwall	214	.03
A-14	5/1	1	3R2^{+} G21	110	.03
A-15	5/1	1	3R2^{+} G21	264	.03

NOTE: (1) Limit of Detection (LOD) is .03 mg

TABLE VI

ALLIED CHEMICAL CORPORATION
FORMALDEHYDE

Sample No.	Date	Shift	Location/Occupation	Liters	Weight(mg)	Conc.[1]ppm	U[2]
F-1	4/15	3	Loader B-8-7	37	.015	.34	U
F-2	4/15	3	Roofbolting mach. B-8-7	33	.012	.30	U
F-3	4/15	3	Longwall Crew Member	51	---	Void	--
F-4	4/15	3	Roofbolter 18	94	.012	.11	U
F-5	4/15	3	Shuttle Car J48	48	.010	.17	U
F-6	5/1	1	Continuous Miner D77	---	---	Lost in analysis	--
F-7	5/1	1	Powder Wagon D77	56	.024	.35	U
						$\bar{X}$=.25	

NOTE: [1]Recommended ceiling TLV(R) is 2 ppm per 1973 ACGIH. NIOSH recommends 0.8 ppm for a 30 minute ceiling.

[2]U = Underground

TABLE VII

ALLIED CHEMICAL CORPORATION
PARTICULATE AROMATIC HYDROCARBONS

Sample No.	Date	Shift	Location/Occupation	Liters	PAH(1)	U(2)
PAH-1	4/15	2	Loader B-8-7	374	LOD	U
PAH-2	4/15	2	Shuttle Car B-8-7	470	LOD	U
PAH-3	5/1	1	Powder Wagon D77	560	LOD	U
PAH-4	5/1	1	Longwall Crew F18	544	LOD	U
PAH-5	5/1	1	Area J48	530	LOD	U

Note: (1) The 1973 TLV(R) does not address PAH's. For the type of PAH exposures found, there is no current standard. Pyrene, chrysene, fluoranthene, BaP, BaA were all below the limit of detection (LOD).

(2) U = Underground

TABLE VIII

ALLIED CHEMICAL CORPORATION
NITROGEN DIOXIDE

Sample No.	Date	Shift	Location/Occupation	Conc.(1) ppm	S/U(2)
3470	4/15	2	Utilityman, J48	.05	U
2132	4/15	2	Roofbolter, B-8-7	.16	U
5135	4/15	2	SCO J48	.27	U
2139	4/15	3	Loader D77	.16	U
3880	4/15	2	Foreman J48	.05	U
2137	4/15	2	Foreman B-8-7	.32	U
4096	4/15	2	NIOSH J48	.22	U
179	4/15	3	Maint. D77	.06	U
3040	4/15	2	"C" Crusher Oper.	.02	S
3	4/15	3	Roofbolter D77	.24	U
3020	4/15	2	Roofbolter J48	.05	U
3610	4/15	3	NIOSH D77	.11	U
339	4/15	3	Cutter, D77	.13	U
3660	4/15	2	"B" Crusher Oper.	.30	S
3220	4/15	3	Longwall Maint. F18	.08	U
4486	4/15	2	Blaster D77	.21	U
3360	4/15	2	NIOSH B-8-7	.07	U
4486	5/1	1	Faceman 3R3+	.21	U
4786	5/1	1	Loader 3R3+	.32	U
4766	5/1	1	Driller 3R3+	.08	U
5135	5/1	1	Faceman 3R3+	.27	U

$\bar{X}$=.16 $\bar{X}_g$=.13

Note: (1) 1973 TLV(R) recommends 5 ppm as a ceiling value not to be exceeded. NIOSH recommends 1.0 ppm.

(2) S = Surface, U = Underground

TABLE IX

ALLIED CHEMICAL CORPORATION
EXPOSURE CRITERIA AND LIMIT OF DETECTION

Contaminant	NIOSH(1)	ACGIH(2)	OSHA(3)	LOD(4)	Ceiling(5)
Total Dust		10 mg/m^3	15 mg/m^3	.01 mg	---
Respirable Dust		(7)	5 mg/m^3	.01 mg	---
Ammonia	50 ppm	25 ppm	50 ppm	.002 mg	(a)
Free Silica	.05 mg/m^3	(6)	(6)	.03 mg	---
Asbestos	.1 fiber/cc	5 fibers/cc	2 fibers/cc	.03 fibers/field	---
Formaldehyde	Lowest feasible below 0.8 ppm	2 ppm	5 ppm	.003 mg	(b)
Particulate Aromatic Hydrocarbons	.1 mg/m^3	.2 mg/m^3	None	.02 mg	---
Nitrogen Dioxide	1 ppm	5 ppm	5 ppm	----	(c)

(1) NIOSH - Criteria for a Recommended Standard

(2) ACGIH - 1973 TLVs(R) Approved as the standard for Metal/Non-Metal Mines

(3) OSHA - Legally enforceable Occupational Health Standards - Time weighted average

(4) LOD - Limit of Detection for sample analysis

(5) Ceiling
- (a) NIOSH recommends a ceiling of 5 minutes
- (b) NIOSH recommends the lowest feasible below 0.8 ppm and OSHA recommends a ceiling of 30 minutes, while ACGIH's is not to be exceeded
- (c) NIOSH, ACGIH and OSHA's ceiling is not to be exceeded.

(6) $\frac{10 \text{ mg}}{\% \text{ Quartz} + 2}$

(7) ACGIH - 1982 TLV(R) recommends 5 mg/m^3

TABLE X
EVALUATION DESIGN
ALLIED CHEMICAL CO
GREEN RIVER, WYOMING
APRIL 15, 1980

Compound Sampled	Sampling Media	Flow Rate*	Analytical Method	Analytical Method Reference
Total Dust	MSA Model G pump with PVC filter.	2.0 LPM	Gravimetric Analysis	None
Respirable Dust	MSA Model G pump with PVC filter and 10 mm nylon cyclone	1.7 LPM	" "	None
Ammonia	Dupont P-2500 pump with diluted sulfuric acid in a midget impinger	1.0 LPM	colorimetric	NIOSH P&CAM 205
Free Silica	MSA Model G Pump with PVC filter and 10 mm nylon cyclone	1.7 LPM	X-ray diffraction	NIOSH P&CAM 259
Asbestos	MSA Model G Pump with mixed cellulose ester filter	1.7 LPM	Phase contrast microscopy	NIOSH P&CAM 239
Trace Metals	Dupont P-2500 pump with mixed cellulose ester filter.	1.5 LPM	Inductive coupled plasma actomic emission spectroscopy	NIOSH P&CAM 351
Formaldehyde	Dupont Low Flow pump with charcoal tube	200 cc	Ion chromatography	NIOSH P&CAM 318
Particulate Aromatic Hydrocarbons	Dupont P-2500 pump with glass fiber and silver memrane filter and porous polymer tube.	2.0 LPM	High pressure liquid chromatography	NIOSH P&CAM 206
Nitrogen Dioxide	Palmes Dosimeter	None	Colorimetric	None

* Flow rate is in liters per minute (LPM) or cubic centimeters (cc).