

Interoffice Communication

To Mr. R. D. Gamblin, Aberdeen, Mississippi

From Ralph C. Williams, Ponca City, Oklahoma

Date January 16, 1975

Subject Indoor Airborne Particulate Survey for Aberdeen PVC Plant

Attached is a copy of the Aberdeen Airborne Particulate Survey conducted from March through June of 1974. The Occupational Safety and Health Act (OSHA) has set specific standards for allowable airborne dust and toxic materials concentrations such as lead and other heavy metals. Although OSHA has not requested any of this information, a particulate monitoring program was conducted to measure dust concentrations, particle sizes, and various metal concentrations for in-house use. The results of that survey, along with brief descriptions of dust sources and recommendations for dust control, are given in this report. Total dust and lead concentrations were found in excess of OSHA standards in three areas of the plant; the scrap line compound blending area; the scrap grinding area; the 2nd floor line 3 compounding area. These three areas should be given special attention.

If you have any further questions, please contact myself or Dan Forbes.

Ralph C Williams

Ralph C. Williams
Chemical Engineer
Design Division
Process Engineering Department

mdn

Encs

CC:

CVF:AJM:RGG

GJF:RAF:RGW

ODS

Mr. R. D. Gamblin, Aberdeen, Mississippi

Mr. Art Gallagher, Aberdeen, Mississippi

Mr. Jerry Powell, Aberdeen, Mississippi

Mr. Tom Low, Aberdeen, Mississippi

Approved by: *Daniel A Forbes*

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SUMMARY

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The Occupational Safety and Health Administration (OSHA) has set specific limitations on employee exposure to various hazardous substances, including nuisance dust and lead. Visual observation of working areas in the Aberdeen compounding and warehouse buildings indicated potential violation of the OSHA standards. As a precautionary measure, a sampling program was initiated to quantitatively confirm problem areas.

The concentrations of nuisance dust, respirable dust, lead and ten other metals regulated by OSHA standards were measured at different locations around the building. Overall, 10 of the 35 samples analyzed were above acceptable nuisance dust, respirable dust, or lead levels. The highest contaminant concentrations were found in three localized areas; 1) the scrap line blender area, 2) the scrap "hog" grinder area, and 3) the second floor of line 3 compounding. The maximum contaminant concentrations measured were 153.5 mg/m³ nuisance dust, 71.975 mg/m³ respirable dust and 1,996 mg/m³ lead near the scrap blender. This sample exceeded OSHA standards by more than a factor of 20.

Actual employee exposure was not measured in this survey. Individual employees may not actually be exposed to the most heavily contaminated areas for a full 8-hour day, since most job requirements are not confined to a specific area. A personnel particulate monitoring program is (using individual portable samplers) is recommended to accurately determine employee exposure. If, however, compliance with OSHA standards can be achieved in potential problem areas, it is improbable that any individual employee would be exposed beyond the OSHA limits.

There are two methods which can be used to reduce dust concentrations -- improved maintenance and equipment operation or adequate ventilation. Improved maintenance and operation can, in some instances, greatly reduce the amount of dust entering the air. Where dust formation cannot be prevented,

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ventilation systems are needed. Local ventilation, such as exhaust hoods, can be used to capture dust at its source and prevent it from entering the ambient air. General ventilation systems can be used to remove contaminants and continuously supply fresh air to larger areas which may have more than one contaminant source.

CONCLUSIONS AND RECOMMENDATIONS

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The major air contamination problems within the compounding building were found to be total dust, respirable dust, and lead. Test results show conclusively that several individual operations in the compounding process are the major dust sources. The dust and lead concentrations in these areas are greater than OSHA exposure limitations:

1. Scrap (hog) grinder.
2. Scrap line blenders
3. Line 3 compound blenders, and dry blend loading.

In addition, one sample taken on the 3rd floor was out of compliance. This is not overly important from a health viewpoint as this area is generally unoccupied. Dust from the area around the Line 1 blenders might also occasionally exceed OSHA limits, even though all samples taken from this area were in compliance.

The actual employee exposure may be somewhat less than results shown by this survey. The greatest dust concentrations were found to be highly localized and changed rapidly depending upon the current level of activity. The OSHA regulations state that an "equivalent exposure" for an 8-hour day may be calculated according to the formula:

$$E = \frac{C_a T_a + C_b T_b + \dots + C_n T_n}{8}$$

where E is the equivalent exposure;
 C is the concentration during any time period
 T where the concentration remains constant;
 T is the duration in hours of exposure at the
 concentration C.

For a completely accurate employee exposure measurement, individual exposure would have to be monitored with a portable sampler carried by the employee throughout the day. A very rough exposure estimate for each job could be made if the

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time each employee spends in areas of high, medium, and low dust concentrations could be estimated. However, the preferred method would be individual sampling.

Under the worst conditions encountered, Sample 42, a reduction of at least 95 percent of the total dust concentration is needed to satisfy OSHA regulations. A reduction of total dust would at the same time reduce the lead and respirable portions to acceptable levels. Most areas require much less than a 95 percent reduction. Reduction of dust levels can be achieved by two methods:

- A. Maintenance and Operational Improvements
- B. Improved Ventilation Systems

A. Maintenance and Operational Improvements

Maintenance is most important in those areas which exceed OSHA standards. If these areas were brought within the exposure limits, compliance would be assured for all employees. Some specific recommendations are given below:

1. Scrap Line: In this area several things can be done. The screw conveyor which transports compound to the extruder should be securely covered during operation. It is now fully exposed.

This problem has been pointed out by PED personnel on several occasions (since April, '74) but no action has yet been taken. The reason given was that the entire scrap line was going to be shut down and modifications were, therefore, unnecessary. At present, the scrap line is still in operation and the extent conveyor is still uncovered.

The present scrap "hog" should also be studied to see if cleaner operation can be achieved. Alternate methods of loading the blenders (i.e. other than simple hand dumping of bagged materials) may be able to reduce some dust from that source.

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2. Second Floor - Line 3: Most of the dust here originates from hand dumping of bagged materials. There may be alternatives to this bag unloading process. Once the bags are unloaded, the blender covers should fit more securely to prevent further dust losses.
3. Many toxic materials are stored in paper sacks. These sacks are easily torn or punctured and dust leaks out. Stored materials should be covered or otherwise separated busy work areas.
4. The baghouses on the 3rd floor dry blend silos need to be cleaned, have bags replaced, and a maintenance schedule initiated if dust in this area is to be reduced.

B. Ventilation

In addition to mechanical improvements some areas definitely need improved ventilation or exhaust systems. Plant personnel have previously investigated this approach and a preliminary design has already been issued by Hollis Martin, dated July 11, 1972.

The most critical ventilation improvements are:

1. Local ventilation at the scrap line blenders to collect dust in this area. This may be extended to include the "hog".
2. Improved local ventilation of the Line 3 compound blenders combined with general ventilation of the entire room.
3. Improved local ventilation over the Line 1 compound blenders and banbury mixers.

Care must be taken to prevent the dust removed from one area from becoming a problem in other areas. Ideally, a single centralized collection system (baghouse) could be used to clean all air before it is exhausted. The final decision should be based upon the relative economics of preventive maintenance dust collection with an improved ventilation system.

DUST SOURCES

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Within the compounding and warehouse building there are about fourteen major sources of airborne dust contamination. Each is described briefly in this section. A rough floor plan of the building showing the location of these sources is given in Figures 1 and 2.

1. Manual Baggers: The manual baggers are used to load PVC resin and compound into 50-pound bags for distribution and sale. The resin is forced into the bags by compressed air. The bags are placed on the machines and removed by hand and thus require close and constant attention by the operators. Dust escapes from the bags during loading and a small amount escapes when the bags are stacked on pallets.
2. Automatic Baggers: The automatic baggers perform the same function as the manual baggers but do not require close operator attention. However, dust produced at the auto-bagger may reach employees working nearby. In general, the entire main floor of the compounding building is open and dust produced in one area can, to some extent, reach all parts of the building.
3. Warehouse Operations: Various warehouse operations, for example - moving containers of resin, compound, and compounding additives - can add dust to the air. Most of the containers are paper sacks which are easily torn or punctured or are inadequately sealed.
4. Gaylord Hopper: The Gaylord hopper loads resin, compound, or pellets into large (1,000-pound capacity) containers known as Gaylords. Some dust may originate here during operation.
5. Line 1 Compounding: The line one compounder has two separate sources of dust. One is the blenders where the compounding additives are introduced and mixed. Materials are dumped through hatches creating considerable dust. The other source is an open bucket type conveyor system which transports the mixed compound to the extruder.

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6. Line 1 Dicer: The line one dicer cuts the extruded compound from line one into small pellets (about 1/8 x 1/8-inch). The dicer area is well enclosed, primarily to control noise.
7. Line 2 Compounding: The line 2 compounder and its dicer are currently inactive and produce no dust emissions.
8. Scrap Line (Hog) Grinder: The hog grinder is used to grind into powder various scrap materials from around the plant. Its operation produces large quantities of dust in an area where workers are often present.
9. Scrap Line Compound Mixers: The scrap line compounders are used to blend the powdered scrap from the hog grinder with various compounding additives. Among the common additives is carbon black which, when mixed with the scrap, produces a dark grey, highly visible dust. All additives are introduced in dry form to the mixers through hatches. The hatches do not fit securely and dust can escape during the blending process. The blended scrap compound is then conveyed from the mixers to the extruder by a screw conveyor, followed by a small bucket-type conveyor. The open screw conveyor churns up large quantities of dust which often form a layer several inches thick on the floor and nearby equipment.
10. Scrap Line Dicer: This dicer is similar to the Line 1 dicer. It is also enclosed for noise abatement.
11. Line 3 Compounding: The line three compound blenders are located on the second floor, above the line three extruder. All compounding additives are introduced manually, from bags, into the blenders. This charging operation is the primary dust source on the second floor. A local ventilation system over the compound blenders helps to reduce the dust concentration in the area, but is not totally effective.
12. Line 3 Dicers: These two small dicers are located on the ground floor of the line three compounding area. They are not enclosed, but are probably not a significant source of dust.

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13. Dryblend Operations: The dryblending process is used to produce various PVC compounds by thoroughly mixing PVC resin and additives in dry, powdered form. There are two sections of the process which produce dust: On the second floor, bags of compounding additives are dumped into a pneumatic conveyor which transfers them to the dryblend silos on the third floor. When the bags are slit open and emptied to the hopper, much dust escapes. The other source is the dryblend silos. Though these silos have baghouses on the air outlets, they are not properly maintained and this area is very dusty. Often, the floor is covered with several inches of dust. No employees are permanently located on the third floor.
14. Housekeeping Operations: Settled dust and spills are routinely cleaned and collected. Use of sweeping compound and washing some areas with hoses keeps much of this dust from re-entering the air. However, it is still a secondary dust source.

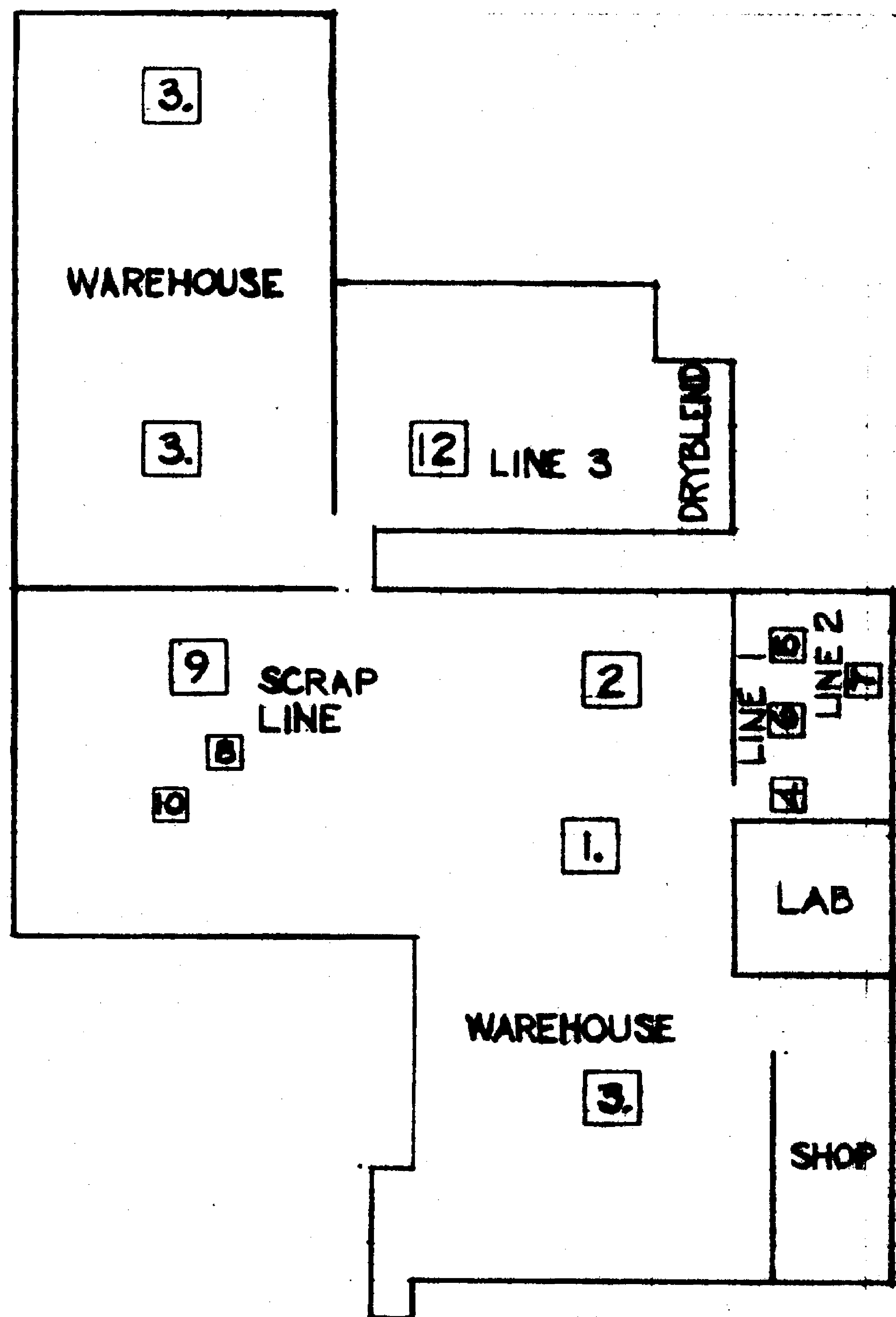


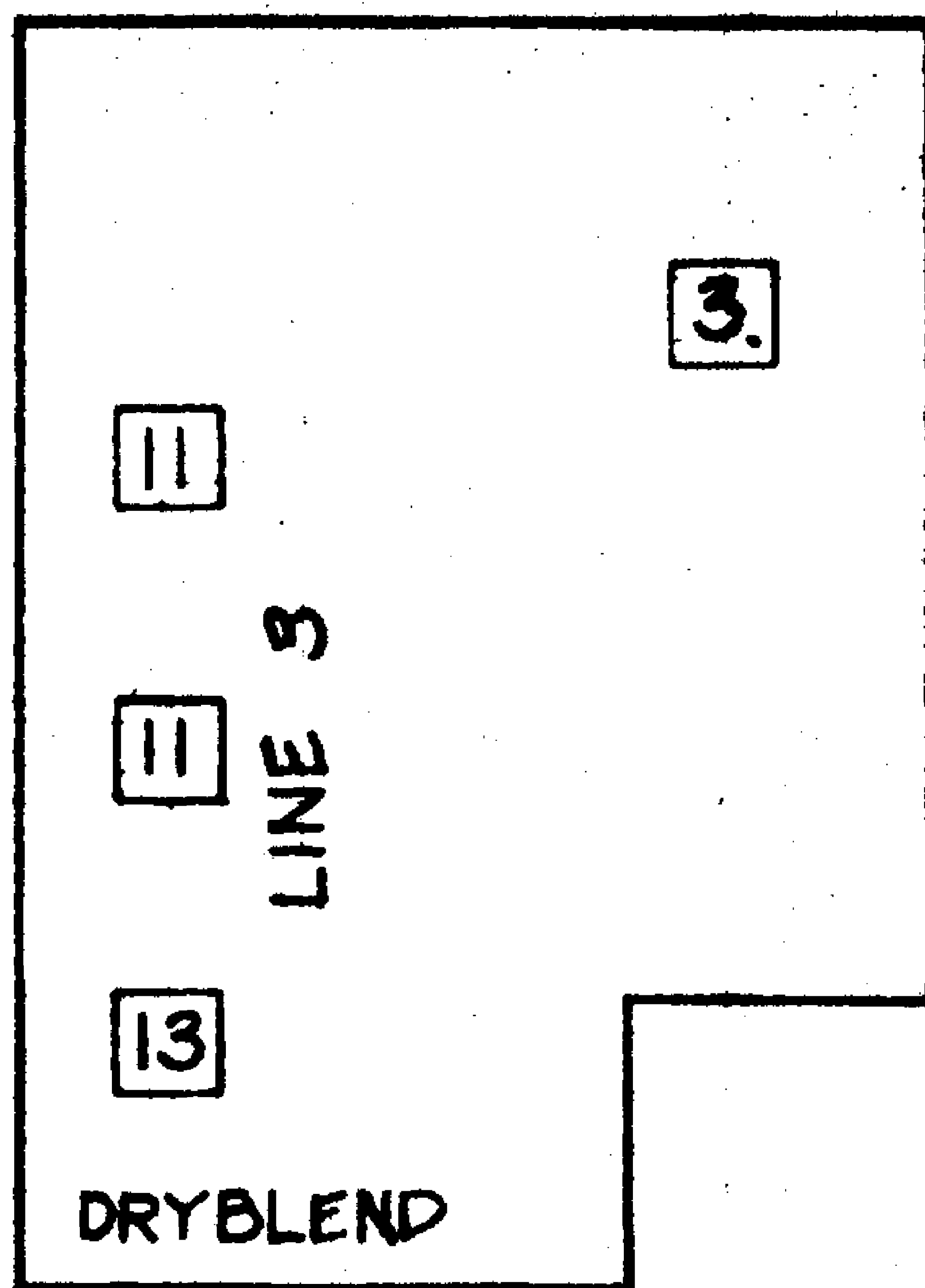
FIGURE 1
DUST SOURCE LOCATION
MAIN FLOOR

4-280 S TJH

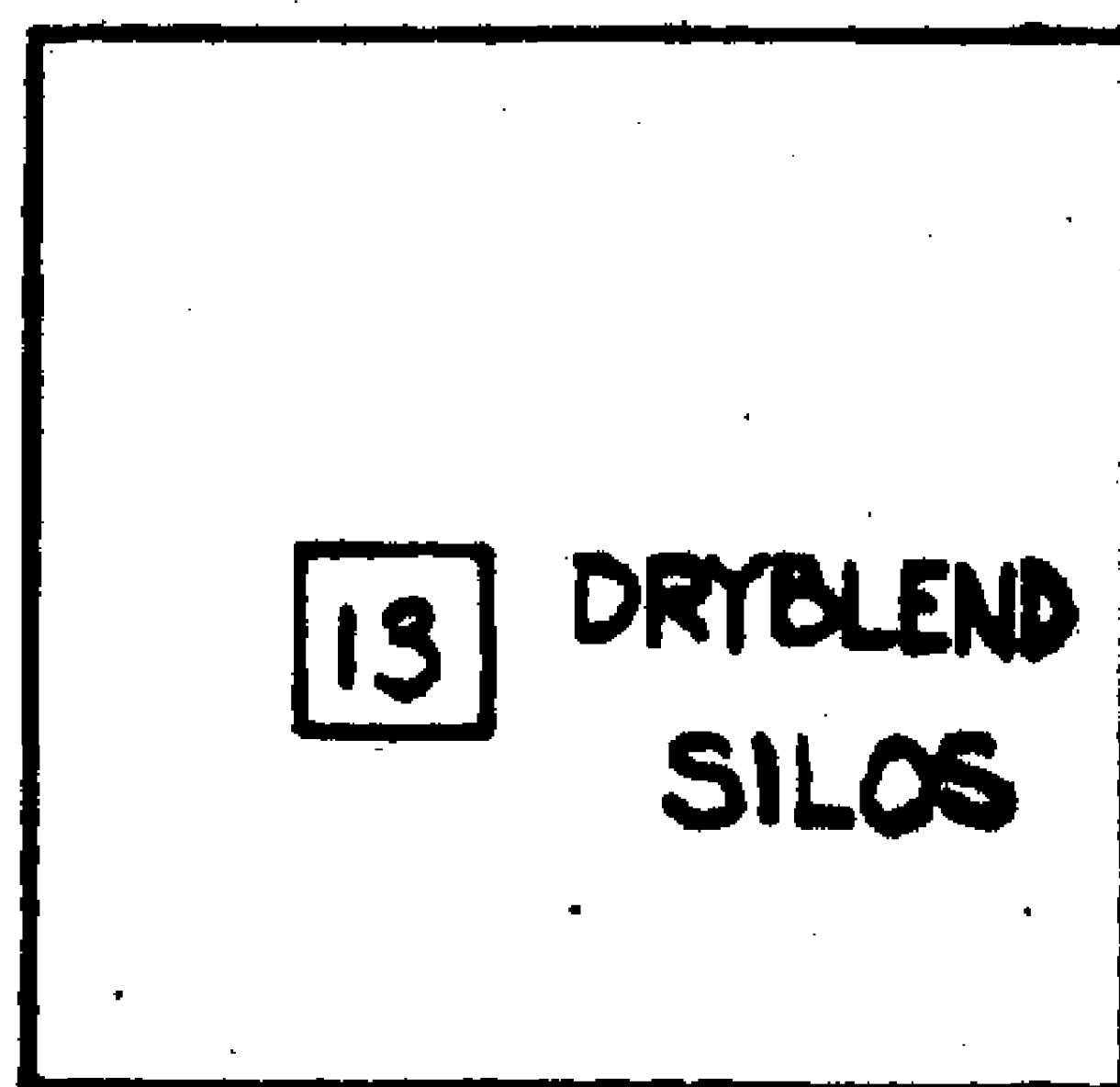
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2ND FLOOR



3RD FLOOR

FIGURE 2
DUST SOURCE LOCATIONS
2ND AND 3RD FLOORS

4-280 S TJH

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SAMPLING EQUIPMENT

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Two high volume air samplers were available for use at the Aberdeen plant: the Gelman High Volume Air Sampler (Model 2000), and the Gelman Hurricane Air Sampler (Model 16003).

Gelman Model 2000

The Model 2000 air sampler consists of a vacuum sweeper motor attached to a filter holder. The filter holder is designed to support an 8-inch x 10-inch filter (Gelman Type A, glass fiber). In sampling, the filter is placed in the holder between the support screen and the sponge rubber gasket on the face plate. The face plate is screwed tightly in place to form an airtight seal. The volume of air drawn through the filter is measured with a small rotameter and varies from 50-60 CFM. The rotameter measures only a small portion of the air flow, but is calibrated to read total air flow directly. Calibration of this flow meter is recommended before use. The air flow rate (50-60 CFM) is not adjustable and will change as the resistance of the filter increases with dust loading. Accordingly, frequent meter readings are required to determine the total volume of sample collected.

Included with the sampler is an aluminum housing to support the sampler with the filter oriented horizontally. An aluminum roof can be placed over the filter for weather protection if the sampler is used out of doors.

Gelman Model 16003

The Gelman Hurricane Air Sampler is a small, high speed, centrifugal type sampler. It can accommodate either a 4-inch diameter or 8 x 10-inch rectangular filter. The air flow rate is measured by the pressure drop across an orifice plate. The flow gauge on the sampler is calibrated to read directly

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in cfm. Three different sized orifice plates are available. With the 4-inch filter, the maximum sampling rate is 20 cfm, but will drop gradually as the filter resistance increases during sampling.

SAMPLING PROCEDURE

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The basic sampling procedure consisted of five steps.

1. The filters were dried to constant weight in a drying oven and tare weights measured. This work was performed in the Aberdeen plant laboratory.
2. A sampling site was selected.
3. The filter was placed in the sampler and sampling started.
4. The air flow rate was then checked and recorded several times during the sampling period.
5. At the end of the sampling period, the filter was carefully removed, dried, and weighed.

The Gelman High Volume Sampler (2000) with the 8-inch x 10-inch glass fiber filter was used most often for convenience since the sampling rate was higher. The sampling time varied from two to eight hours depending upon the dust loading, with a desired final sample weight of at least 20 percent of the filter weight (for accuracy of results).

The sampling sites were chosen to include both clean and dusty areas during active and inactive work periods. In most instances, the sampler was located as close as possible to areas where workers were permanently or frequently present in an attempt to approximate actual employee dust exposure levels.

Examination of a list of compounding additives used in Aberdeen showed that as many as 11 metals could be present in the dust. After weighing, each sample was sent to R&D in Ponca City for spectroscopic analysis. Particle size distributions were also obtained from each sample by sieving and

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microscopic techniques. Included in each analysis were all the materials shown in Table I (next section) except for Carbon Black and Bisphenol A. These compounds were excluded due to a lack of suitable analytical techniques for their determination.

RESULTS

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The Occupational Safety and Health Administration (OSHA) of the U. S. Department of Labor has issued a comprehensive list of rules and regulations intended to protect the safety and health of employees. These rules were published in the Federal Register, Vol. 37, No. 202, Part II of October 18, 1972. Section 1910.93 of the Federal Register of this act covers air contamination and sets specific limitations for allowable employee exposure to toxic and nuisance dusts and vapors. The rules also include a method for calculating exposure limits when more than one air contaminant is present.

The primary particulate air contaminant present in the compounding building is PVC resin. PVC resin is not covered specifically in the OSHA standards and as such is treated as general nuisance dust. Besides PVC, many other materials are present, and in some localized areas may form the majority of the dust constituents. Comparison of a list of compounding additives used at Aberdeen with the OSHA standards revealed that many of the materials used are specifically regulated. The sampling and analysis program was designed to measure the total dust concentration and to quantitatively analyze samples for all specifically regulated substances. In addition, the OSHA standards also set a limit on the respirable dust fraction. For this determination, a particle size analysis of the samples was found necessary. Table I summarizes the OSHA standards of interest at Aberdeen. The complete list may be found in the Federal Register (Appendix). Table II provides a definition for the respirable fraction.

The OSHA standards are (except where noted) based on an 8-hour time weighted average. Even though a localized area may exceed the standards, it is possible that no individual employee may be exposed to these high concentrations for the full eight hour day, and the average exposure level could be considerably less than these maximum values. Employees will, in fact, try to avoid the very dusty areas if at all possible. However, for the purpose of this report, any sample exceeding the OSHA

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standards was considered out of compliance. In addition, samples collected over shorter time periods than 8 hours were considered to be the same as an 8-hour sample since equipment operation is normally continuous during an 8-hour shift.

The basic results of the survey are summarized in Table II, and raw data with the results of the R&D analyses are included in the Appendix. The OSHA standard for general nuisance dust is 15 mg/m³. The compliance factor for nuisance dust was calculated by dividing the measured dust concentration in mg/m³ by 15 mg/m³. A compliance factor greater than 1 indicates violation of the nuisance dust standard. Similarly, the compliance factor for respirable dust was calculated by dividing the respirable fraction in mg/m³ by 5 mg/m³. The respirable fraction was determined from the R&D particle size analysis. All particles less than 10 were considered respirable for this report. By definition, however, the respirable fraction is the portion of dust passing through a specific collection device. (Table II gives the device characteristics.) Obviously, using a 10 cutoff results in a conservative value for the respirable fraction.

The OSHA standards also require that when more than one air contaminant is present, a cumulative compliance factor be calculated according to the formula:

$$E_m = \frac{C_1}{L_1} + \frac{C_2}{L_2} + \dots + \frac{C_n}{L_n}$$

where C is the measured concentration, L is the OSHA standard and E is the equivalent exposure (compliance factor). Table III gives two different cumulative compliance factors. For one, the sample was considered to be only nuisance dust and lead. The overall factor considers the sample to be nuisance dust, lead, and all of the 10 other metals detected which are regulated by OSHA standards.

Out of the 35 samples analyzed 10 (28 percent) violated the overall (cumulative) OSHA standards. Of these 10, 6 exceeded the total nuisance dust standard, 7 violated the lead standard, and 4 violated the respirable dust standard. In no instance was any one of the other 10 metals measured found to exceed

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its respective individual standard. A comparison of the nuisance dust plus lead compliance factor with the overall compliance factor also shows that all the other contaminants are relatively insignificant when compared to dust and lead. The individual compliance factors for each metal were not included in the summary, but can easily be calculated from the R&D data (and Table I).

Those samples out of compliance were all taken in three specific areas. Samples 14, 16, 17, and 18 were collected on the 2nd and 3rd floors around line 3 compounding operations and dryblend loading. Samples 37, 38, and 39 were taken near the scrap line (hog) grinder, and Samples 42, 46, and 47 were taken near the scrap line compound blenders. Due to the limited number of samples taken, it is possible that other areas may, at times, be in violation of the OSHA standards. An example is the area around the line one compound blenders. Though none of the samples taken there exceeded the OSHA standards, there are times when this area can be very dusty. Other areas which could potentially exceed the standards are the manual bagger area (Samples 23, 24) and the first floor of line 3 near extruder and dryblend operations.

TABLE I

OSHA STANDARDS

<u>Substance</u>	<u>Allowable Exposure mg/m³</u>	<u>Remarks</u>
Nuisance Dust	15	8 Hr. Avg.
Respirable Dust*	5	8 Hr. Avg.
Lead	0.2	8 Hr. Time Weighted Avg.
Barium	0.5	Soluble Compounds
Cadmium	0.2	8 Hr. Time Weighted Avg., 0.6 Ceiling
Antimony	0.5	8 Hr. Avg.
Titanium	15	As TiO_2 , 8 Hr. Avg.
Chromium	0.5	8 Hr. Avg., Metal and Insoluble Salts - 1.0 Ceiling
Silicon	10	As SiO_2 , 8 Hr. Avg.
Copper	1	8 Hr. Avg.
Molybdenum	5	8 Hr. Avg., Insoluble Compounds - 15 Ceiling
Tin	.1	8 Hr. Avg. Organic Compounds
Manganese	5	Ceiling Concentration
Carbon Black	3.5	8 Hr. Avg.
Bisphenol A	2.8	Ceiling Concentration

* Refer to Table II.

TABLE II
RESPIRABLE DUST DETERMINATION*
SAMPLING REQUIREMENTS

<u>Particle Size</u> <u>(Aerodynamic Diameter For</u> <u>Unit Density Sphere)</u>	<u>Percent Passing</u> <u>Selector</u>
2	90
2.5	75
3.5	50
5.0	25
10	0

* For this report all dust less than 10 was considered respirable since a suitable collection device could not be obtained for the sampling program.

TABLE III
SUMMARY OF RESULTS

Sample No.	Sampling Location	Total Dust mg/m ³	Nuisance Dust Compliance Factor	Resp. Dust mg/m ³	Resp. Dust Compliance Factor	Lead mg/m ³ x 10 ³	Lead Comp. Factor	Nuisance Dust + Lead Comp. Factor	Overall Comp. Factor (Dust + Lead + Others)
9	Line 3, 1st Floor, Near Loading Door	1.01	0.0673	0.0235	0.0047	4.4	0.022	0.089	0.0938
10	Line 3, 1st Floor, Near Extruder	0.75	0.050	0.0153	0.0031	1.3	0.0065	0.056	0.0568
11	Line 3, 1st Floor, Dicer	5.61	0.374	0.1326	0.0265	30	0.150	0.524	0.542
12	1st Floor, Dryblender	5.11	0.341	0.0404	0.0081	2.1	0.0105	0.352	0.352
13	Line 3, 2nd Floor, Near Control Room	2.28	0.152	0.0922	0.0184	22.8	0.114	0.266	0.269
14	Line 3, 2nd Floor, Blenders*	13.21	0.881	2.90	0.580	291.0	1.455	2.336	2.393
15	2nd Floor, Dryblend	8.14	0.543	0.481	0.096	20.0	0.100	0.643	0.675
16	Line 3, 2nd Floor, Ribbon Blender*	14.61	0.974	1.150	0.230	540	2.700	3.674	3.641
17	Line 3, 2nd Floor, Blenders	20.40	1.360	1.830	0.366	690	3.450	4.810	4.810
18	3rd Floor	17.29	1.153	8.840	1.768	210	1.050	2.200	2.266
19	Automatic Bagger	0.98	0.065	0.03138	0.0063	41	0.205	0.270	0.284
20	Automatic Bagger Hoppers	0.89	0.059	0.04854	0.0097	10	0.050	0.109	0.123
21	Near Color Mix Room	0.58	0.039	0.04692	0.0094	6.4	0.032	0.071	0.071
22	Warehouse Area	2.71	0.181	0.3476	0.0695	25	0.125	0.306	0.330
23	Manual Bagger	7.44	0.496	0.251	0.0502	19	0.095	0.591	0.613
24	Manual Bagger	4.99	0.333	0.1164	0.0233	8.0	0.040	0.373	0.381
25	Line 1, Banbury Hopper	1.01	0.067	-	-	4.3	0.022	0.089	0.101
26	Line 2, Extruder	1.38	0.092	0.0519	0.0104	8.0	0.040	0.132	0.160
27	Line 2, Dicer	1.64	0.109	0.0424	0.0085	11	0.055	0.164	0.169
28	Scrap Hog (Inactive)	1.83	0.122	0.0924	0.0185	18	0.090	0.212	0.257
29	Scrap Hog (Inactive)	0.51	0.034	0.0940	0.0188	13	0.065	0.099	0.099
31	Gaylord Hopper	4.35	0.290	-	-	-	-	-	-
32	Gaylord Hopper	0.96	0.064	0.0421	0.0084	24	0.120	0.184	0.185
33	Line 1, Dicer	0.83	0.055	0.1058	0.0212	21	0.105	0.160	0.162

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Table III
Summary of Results
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Sample No.	Sampling Location	Total Dust mg/m ³	Nuisance Dust Compliance Factor	Resp. Dust mg/m ³	Resp. Dust Compliance Factor	Lead mg/m ³ x 10 ³	Lead Comp. Factor	Nuisance Dust + Lead Comp. Factor	Overall Comp. Factor (Dust + Lead + Others)
34	Line 3, Blender	1.80	0.120	0.2975	0.0595	25	0.125	0.245	0.238
35	Line 3, Blender	0.39	0.026	0.03833	0.0076	2.5	0.012	0.038	0.037
36	Line 3, Blender	1.75	0.117	0.04099	0.0082	7.4	0.037	0.154	0.154
37	Hog Area*	13.93	0.929	2.3188	0.4638	38	0.190	1.119	1.420
38	Hog (Inactive)*	4.99	0.333	0.8634	0.1727	175	0.875	1.208	1.282
39	Hog Area*	26.40	1.760	3.9053	0.7811	240	1.200	2.960	2.973
40	Auto. Bagger	0.58	0.039	0.1749	0.0350	8.7	0.044	0.083	0.095
41	Auto. Bagger	0.55	0.037	0.0745	0.0149	5.5	0.027	0.064	0.069
42	Scrap Blender*	53.50	10.233	71.975	14.395	1.996	9.98	20.213	21.176
46	Scrap Line*	32.11	2.140	10.425	2.085	116	0.58	2.720	2.839
47	Scrap Line*	29.67	1.978	6.789	1.358	234	1.17	3.148	3.427

* Locations in violation of any compliance factor.

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APPENDIX

TABLE 4 ABERDEEN AIR-MONITORING SAMPLES

A) Sample Description

Sample	Location	Volume Filtered (cu. ft.)	Filter Loading (g)	Particulate Concentration (mg/m ³)
RCW-AB-9 ^a	Line 3, Near Door	8,192	0.2310	1.01
-10 ^a	Line 3, Near Extruder	7,475	0.1569	0.75
-11 ^a	Line 3, Milling Machine	8,316	1.3080	5.61
-12 ^a	Line 3, 1st Floor Near Dry Blender	7,808	1.1290	5.11
-13 ^a	Line 3, 2nd Floor Near Control Room	9,425	0.6016	2.23
-14 ^a	Line 3, 2nd Floor Compounding Mixers	8,450	3.1342	13.21
-15 ^a	Line 3, 2nd Floor Dryblend Area	7,875	1.7954	8.14
-16 ^a	Line 3, Near Ribbon Blender	7,580	3.1084	14.61
-17 ^a	Line 3, Compound Mixers	8,128	4.6459	20.4
-18 ^a	Line 3, 3rd Floor	8,505	4.1164	17.29
-19 ^a	Near Automatic Bagger	7,680	0.2106	0.98
-20 ^a	Near Hoppers for Automatic Bagger	7,686	0.1873	0.87
-21 ^a	Near Color Mix Room	7,119	0.5405	2.71
-22 ^a	Warehouse Area	7,680	0.1242	0.58
-23 ^a	Near Manual Bagger	6,720	1.3977	7.44
-24 ^a	Near Manual Bagger	6,170	0.8472	4.9
-25 ^a	Line 1, Near Banbury Hopper	8,040	0.2290	1.01
-26 ^a	Line 2, Near Extruder	7,686	0.3003	1.38

(a) Collected on 8 x 10 inch fiber glass filter

(b) Collected on 4 inch diameter fiber glass filter

Sample Description (continued)
Page 2-A

<u>Sample</u>	<u>Location</u>	<u>Volume Filtered (cu. ft.)</u>	<u>Filter Loading (g)</u>	<u>Particulate Concentration (mg/m³)</u>
RCW-AB-27 ^a	Line 2, Near Dicer	6,520	0.3019	1.64
-28 ^a	Hog Area (not running)	6,112	0.3159	1.83
-29 ^a	Hose Area (not active)	7,210	0.1033	0.51
-30 ^a	Line 1, Near Extruder	Not Submitted		
-31 ^a	Gaylord Hopper	7,550	0.9289	4.35
-32 ^a	Gaylord Hopper	7,845	0.2139	0.96
-33 ^a	Near Line 1	6,170	0.1443	0.83
-34 ^a	Line 3	8,060	0.4102	1.80
-35 ^a	Line 3	9,412	0.1036	0.39
-36 ^a	Line 3	8,372	0.4104	1.75
-37 ^a	Hog Area	10,312	4.0216	13.93
-38 ^a	Hog Area (not running)	16,450	2.2989	4.99
-39 ^a	Hog Area	35,714	26.3881	44.0
-40 ^b	Vent Fan (Auto Bagger)	8,400	0.1372	0.58
-41 ^b	Vent Fan (Auto Bagger)	8,800	0.1356	0.55
-42 ^a	Scrap Compound Blender	18,580	79.8593	153.50
-43	Not Submitted	-----	-----	-----
-44	Not Submitted	-----	-----	-----
-45	Not Submitted	-----	-----	-----
-46 ^a	Scrap Line	10,800	9.7108	32.11
-47 ^b	Scrap Line	9.600	7.9751	29.67

(a) Collected on 8 x 10 inch fiber glass filter

(b) Collected on 4 inch diameter fiber glass filter

TABLE 4 ABERDEEN AIR-MONITORING SAMPLES

B) Particle Size Analysis

<u>Sample</u>	<u>Filter Loading (g)</u>	<u>Wt. % Recovery</u>	<u>Wt. % >105μ</u>	<u>Wt. % <105 >44μ</u>	<u>Wt. % <44 >20μ</u>	<u>Wt. % <20μ</u>
RCW-AB-9 ^a	0.2310	50.2	3.4	37.1	38.8	20.7
-10 ^a	0.1569	59.2	17.2	34.4	30.1	18.3
-11 ^a	1.3080	83.0	16.7	32.7	29.8	20.8
-12 ^a	1.1290	87.5	13.8	39.4	37.0	9.8
-13 ^a	0.6016	53.7	0.6	2.1	31.2	66.1
-14 ^a	3.1342	78.5	6.3	14.4	15.4	63.9
-15 ^a	1.7954	79.8	24.0	23.1	25.9	27.0
-16 ^a	3.1084	86.3	0.5	7.6	32.8	59.1
-17 ^a	4.6459	85.8	0.3	7.9	25.4	66.4
-18 ^a	4.1164	84.4	5.8	5.3	10.0	78.9
-19 ^a	0.2106	48.9	7.8	13.6	38.8	39.8
-20 ^a	0.1873	66.8	7.2	12.8	32.0	48.0
-22 ^a	0.5405	173.1	3.7	13.3	27.0	56.0
-21 ^a	0.1242	8.5	0.0	9.4	28.3	62.3
-23 ^a	1.3977	51.4	49.8	14.6	5.0	30.6
-24 ^a	0.8472	42.4	47.5	21.4	13.1	18.0

(a) Collected on 8 x 10 inch fiber glass filter

Particle Size Analysis (continued)

Page 2-B

<u>Sample</u>	<u>No. % 10-20μ</u>	<u>No. % 2-10μ</u>	<u>No. % 0.5-2μ</u>
RCW-AB-9 ^a	5.5	10.1	84.4
-10 ^a	9.4	17.8	72.8
-11 ^a	7.1	13.5	79.4
-12 ^a	15.1	20.1	64.8
-13 ^a	0.4	3.2	96.4
-14 ^a	1.2	9.0	89.8
-15 ^a	1.8	7.1	91.1
-16 ^a	2.9	5.4	91.7
-17 ^a	4.6	10.1	85.3
-18 ^a	0.1	2.0	97.9
-19 ^a	11.1	14.5	74.4
-20 ^a	10.3	20.0	69.7
-22 ^a	7.8	35.7	56.5
-21 ^a	11.9	27.2	60.9
-23 ^a	12.7	22.7	64.6
-24 ^a	19.1	20.6	63.3

(a) Collected on 8 x 10 inch fiber glass filter

Particle Size Analysis (continued)
Page 3-B

Sample	Filter Loading (g)	Wt. % Recovery	Wt. % >105	Wt. % <105 >44	Wt. % <44 >20	Wt. % <20
RCW-AB-25 ^a	0.2290	24.4	0.00	17.9	53.6	28.6
-26 ^a	0.3003	56.9	14.0	20.5	20.5	45.0
-27 ^a	0.3019	57.6	10.8	25.8	32.0	31.4
-28 ^a	0.3157	36.1	23.7	29.0	21.0	26.3
-29 ^a	0.1033	29.0	3.3	6.7	30.0	60.0
-30	Not Submitted	----	----	----	----	----
-31	Not Submitted	----	----	----	----	----
-32 ^a	0.2139	49.1	10.5	5.7	24.8	59.0
-33 ^a	0.1443	19.4	0.0	10.7	35.7	53.6
-34 ^a	0.4102	17.6	2.8	5.6	22.2	69.4
-35 ^a	0.1036	24.1	0.0	4.0	16.0	80.0
-36 ^a	0.4104	42.6	17.1	34.3	33.7	14.9
-37 ^a	4.0216	85.1	6.6	14.7	35.4	43.2
-38 ^a	2.2989	76.4	0.3	1.9	21.1	76.7
-39 ^a	26.3881	95.8	8.7	24.2	23.9	43.2
-40 ^b	0.1372	24.0	6.1	3.0	9.1	81.8
-41 ^b	0.1356	53.8	0.0	26.0	31.5	42.5
-42 ^a	79.8593	97.9	4.3	10.6	12.7	72.4
-46 ^a	9.7108	74.2	1.0	7.0	11.4	80.6
-47 ^b	7.9751	----	5.08	18.6	25.4	50.8

(a) Collected on 8 x 10 inch fiber glass filter

(b) Collected on 4 inch diameter fiber glass filter

Particle Size Analysis (continued)
Page 4-B

<u>Sample</u>	<u>No. % 10-20μ</u>	<u>No. % 2-10μ</u>	<u>No. % 0.5-2μ</u>
RCW-AB-25 ^a	14.9	19.2	6.6
-26 ^a	25.3	35.7	39.0
-27 ^a	23.7	32.8	43.4
-28 ^a	5.3	19.0	75.7
-29 ^a	5.7	39.0	55.2
-30	Not Submitted	----	----
-31	Not Submitted	----	----
-32 ^a	22.1	27.3	50.7
-33 ^a	5.7	27.2	67.1
-34 ^a	6.2	29.7	64.1
-35 ^a	17.5	37.9	44.6
-36 ^a	9.8	28.0	62.2
-37 ^a	4.6	44.6	50.8
-38 ^a	6.0	26.7	67.3
-39 ^b	4.6	36.9	58.5
-40 ^b	3.7	33.2	63.0
-41 ^b	4.4	31.6	64.0
-42 ^a	1.4	39.8	58.8
-46 ^a	3.9	40.6	55.5
-47 ^b	1.3	15.9	82.8

(a) Collected on a 8 x 10 inch fiber glass filter

(b) Collected on 4 inch diameter fiber glass filter

TABLE 4 ABERDEEN AIR-MONITORING SAMPLES

C) Spectrographic Analysis

	<u>RCW-AB-11</u>	<u>RCW-AB-12</u>	<u>RCW-AB-13</u>	<u>RCW-AB-14</u>
Analysis Date	5/10/74	5/10/74	5/10/74	5/10/74
Particulate Concentration (mg/m ³)	5.61	5.11	2.28	13.21
Metals Content (µg/m ³)				
Pb	30	2.1	22.8	291
Ba	0.84	0.18	1.33	15
Cd	<0.27	<0.12	0.22	<1.7
Sb	8.9	<0.12	0.22	22
Zn	<0.27	<0.12	0.22	<1.7
Ca	>270	87	219	>1700
Ti	6.7	9.2	219	24
Fe	7.8	7.7	2.19	22
Sn	<0.27	<0.12	0.22	<1.7
Si	56	50	50.44	440
Mg	6.2	2.1	4.37	67
Sr	0.42	<0.12	0.25	2.9
Cr	<0.27	<0.12	0.22	<1.7
Mo	<0.27	<0.12	0.22	<1.7
Al	15	11.2	39.0	360
Cu	<0.27	<0.12	0.22	<1.7
Na	2.7	1.9	16.2	20
Mn	0.34	0.17	0.22	<1.7
Ash Weight (g)	0.3972	0.1797	0.2416	2.3382
Sample Weight (g)	1.0523	0.9587	0.3357	2.4070
% Ash	37.7	18.7	72.0	97.1

Values labeled < or > are outside of the calibrated concentration range of Spectroscopy Method No. 85.

	<u>RCW-AB-15</u>	<u>RCW-AB-16</u>	<u>RCW-AB-17</u>	<u>RCW-AB-18</u>
Analysis Date	5/16/74	5/16/74	5/16/74	5/16/74
Particulate Concentration (mg/m ³)	8.14	14.61	20.4	17.29
Metals Content (μg/m ³)				
Pb	20	540	690	210
Ba	1.1	16	20	4.2
Cd	<0.35	<1.7	<2.4	<2.1
Sb	<3.5	<17	<24	<21
Zn	<0.35	<1.7	<2.4	<2.1
Ca	>350	>1700	630	2100
Ti	220	124	130	100
Fe	4.9	22	31	62
Sn	2.2	<1.7	<2.4	<2.1
Si	26	1400	>2400	830
Mg	4.3	28	67	45
Sr	0.51	<1.7	<2.4	2.9
Cr	<0.35	<1.7	<2.4	<2.1
Mo	<0.35	<1.7	<2.4	<2.1
Al	13	1200	2000	690
Cu	<0.35	<1.7	<2.4	<2.1
Na	8.1	9.9	12	17
Mn	0.90	<1.7	<2.4	3.8
Ash Weight (g)	0.4684	2.3594	3.6678	3.2921
Sample Weight (g)	1.4099	2.6191	3.9190	3.4989
% Ash	33.2	90.1	93.6	94.1

Values labeled < or > are outside of the calibrated concentration range of Spectroscopy Method No. 85.

Spectrographic Analysis (continued)
Page 3-C

	<u>RCW-AB-9</u>	<u>RCW-AB-10</u>	<u>RCW-AB-19</u>	<u>RCW-AB-20</u>
Analysis Date	5/23/74	5/23/74	5/23/74	5/23/74
Particulate Concentration (mg/m ³)	1.01	0.75	0.98	0.89
Metals Content (µg/m ³)				
Pb	4.4	1.3	41	10
Ba	0.43	0.098	1.4	1.5
Cd	0.17	<0.020	0.76	1.0
Sb	1.0	0.44	2.1	1.1
Zn	0.55	0.020	0.76	0.82
Ca	42	19	>98	>87
Ti	18	8.3	12	14
Fe	7.4	2.2	6.4	10
Sn	0.33	0.045	0.12	0.13
Si	45	>20	47	42
Mg	1.9	0.74	3.0	2.8
Sr	0.16	0.044	0.24	0.17
Cr	0.10	<0.020	0.18	0.12
Mo	<0.064	<0.020	<0.098	<0.087
Al	8.9	3.9	15	16
Cu	0.094	<0.020	<0.098	0.48
Na	0.79	0.17	3.2	2.1
Mn	0.22	0.090	0.30	0.30
Ash Weight (g)	0.0539	0.0176	0.0654	0.0525
Sample Weight (g)	0.1106	0.0854	0.0839	0.0990
% Ash	48.7	20.6	77.9	53.0

Values labeled < or > are outside of the calibrated concentration range of Spectroscopy Method No. 85.

	²² <u>RCW-AB-21</u>	²¹ <u>RCW-AB-22</u>	<u>RCW-AB-23</u>	<u>RCW-AB-24</u>
Analysis Date	5/29/74	5/29/74	5/29/74	5/29/74
Particulate Concentration (mg/m ³)	2.71	0.58	7.44	4.99
Metals Content (µg/m ³)				
Pb	25	6.4	19	8.0
Ba	1.7	0.52	0.33	0.85
Cd	1.1	0.14	0.16	0.70
Sb	<3.0	<0.75	<0.25	<1.3
Zn	<0.30	0.57	0.23	1.0
Ca	>300	3.5	>33	>130
Ti	3.0	3.9	2.5	5.5
Fe	3.8	12	5.6	11
Sn	<0.30	0.16	<0.033	<0.13
Si	54	75	33	55
Mg	22	5.3	2.8	7.0
Sr	<0.30	<0.075	0.038	0.13
Cr	<0.30	0.093	0.038	<0.13
Mo	<0.30	<0.075	<0.033	<0.13
Al	27	16	6.6	10
Cu	<0.30	0.57	0.16	0.21
Na	4.1	13	4.1	7.5
Mn	<0.30	0.64	0.28	0.36
Ash Weight (g)	0.7909	0.0065	0.0173	0.0788
Sample Weight (g)	0.9233	0.0066	0.5055	0.3741
% Ash	85.7	98.5	3.4	21.1

Values labeled < or > are outside of the calibrated concentration range of Spectroscopy Method No. 85.

Spectrographic Analysis (continued)

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	<u>RCW-AB-25</u>	<u>RCW-AB-26</u>	<u>RCW-AB-27</u>	<u>RCW-AB-28</u>
Analysis Date	7/25/74	7/25/74	7/25/74	7/25/74
Particulate Concentration (mg/m ³)	1.01	1.38	1.64	1.83
Metals Content (µg/m ³)				
Pb	4.3	8.0	11	18
Ba	2.2	1.5	0.82	0.44
Cd	1.0	2.1	0.46	3.7
Sb	<0.28	<0.43	<0.46	<0.40
Zn	0.36	<0.13	0.31	0.31
Ca	64	>134	>144	64
Ti	2.0	1.5	2.6	12
Fe	2.8	1.4	3.1	2.7
Sn	0.089	0.40	<0.14	<0.12
Si	45	9.8	39	18
Mg	2.2	4.3	3.1	1.7
Sr	0.15	0.33	0.26	<0.12
Cr	<0.089	<0.13	<0.14	0.18
Mo	<0.089	<0.13	<0.14	<0.12
Al	9.6	10	13	4.4
Cu	0.17	<0.13	<0.14	0.33
Na	5.5	2.9	3.1	4.2
Mn	0.19	<0.13	<0.14	<0.12
Ash Weight (g)	0.0297	0.1043	0.1022	0.0507
Sample Weight (g)	0.0440	0.1394	0.1513	0.0978
% Ash	67.5	74.8	67.5	51.3

Values labeled < or > are outside of the calibrated concentration range of Spectroscopy Method No. 85.

Spectrographic Analysis (continued)
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	<u>RCW-AB-29</u>	<u>RCW-AB-32</u>	<u>RCW-AB-33</u>	<u>RCW-AB-35</u>
Analysis	7/25/74	7/25/74	7/25/74	7/25/74
Particulate Concentration (mg/m ³)	0.51	0.96	0.83	0.39
Metals Content (µg/m ³)				
Pb	13	24	21	2.4
Ba	0.15	1.8	0.63	0.31
Cd	0.19	0.19	0.66	0.098
Sb	<0.15	<0.34	<0.33	<0.12
Zn	0.40	0.33	0.53	0.23
Ca	>47	>106	>100	>36
Ti	1.2	2.9	4.0	1.2
Fe	0.51	2.0	15	4.3
Sn	0.051	<0.11	<0.10	<0.036
Si	33	65	>100	>36
Mg	3.0	2.4	3.2	2.2
Sr	0.13	<0.11	<0.10	<0.036
Cr	0.092	<0.11	<0.10	<0.036
Mo	<0.050	<0.11	<0.10	<0.036
Al	7.1	28	33	9.0
Cu	0.13	0.19	1.0	0.098
Na	8.2	0.19	0.15	0.098
Mn	0.11	<0.11	0.26	0.086
Ash Weight (g)	0.0142	0.0654	0.0205	0.0079
Sample Weight (g)	0.0199	0.0772	0.0215	0.0110
% Ash	71.4	84.7	95.3	71.3

Values labeled < or > are outside of the calibrated concentration range of Spectroscopy Method No. 85.

Spectrographic Analysis (continued)
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	<u>RCW-AB-34</u>	<u>RCW-AB-36</u>	<u>RCW-AB-37</u>	<u>RCW-AB-38</u>
Analysis Date	8/8/74	8/8/74	8/8/74	8/8/74
Particulate Concentration (mg/m ³)	1.80	1.75	13.93	4.99
Metals Content (µg/m ³)				
Pb	25	7.4	38	175
Ba	0.83	0.21	31	12
Cd	<0.17	0.13	24	7.0
Sb	<0.56	<0.11	<5.6	<2.0
Zn	0.72	<0.035	<1.7	<0.64
Ca	>171	>35	>1670	>649
Ti	4.5	7.9	24	12
Fe	22	0.74	24	23
Sn	<0.17	<0.035	<1.7	<0.65
Si	>171	16	153	294
Mg	6.3	1.2	64	31
Sr	0.23	<0.035	3.9	1.7
Cr	<0.17	<0.035	<1.7	<0.65
Mo	<0.17	<0.035	<1.7	<0.65
Al	52	10	63	250
Cu	0.76	0.10	2.5	0.75
Na	12	3.0	29	9.0
Mn	0.47	0.047	<1.7	1.0
Ash Weight (g)	0.0479	0.0244	3.1160	1.6798
Sample Weight (g)	0.0653	0.1618	3.2965	1.7200
% Ash	73.4	15.1	94.5	97.7

Values labeled < or > are outside of the calibrated concentration range of Spectroscopy Method No. 85.

Spectrographic Analysis (continued)
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	<u>RCW-AB-39</u>	<u>RCW-AB-40</u>	<u>RCW-AB-41</u>	<u>RCW-AB-42</u>
Analysis Date	8/8/74	8/8/74	8/8/74	8/8/74
Particulate Concentration (mg/m ³)	26.4	0.58	0.55	153.50
Metals Content (µg/m ³)				
Pb	240	8.7	5.5	1996
Ba	9.6	3.7	1.4	68
Cd	1.9	0.20	0.11	74
Sb	6.6	<0.18	<0.12	<60
Zn	1.9	3.5	1.5	<18
Ca	1,926	>56	>38	>18,420
Ti	28.8	0.87	0.47	184
Fe	9.0	2.6	1.9	94
Sn	1.9	<0.56	<0.038	<18
Si	144	24	10	2456
Mg	28.8	1.5	0.94	599
Sr	1.9	0.15	0.088	37
Cr	1.9	<0.56	0.35	46
Mo	1.9	<0.56	<0.038	<18
Al	80	10	2.9	1689
Cu	1.9	0.087	0.094	<18
Na	1.9	5.8	2.5	<18
Mn	1.9	0.10	0.14	<18
Ash Weight (g)	1.6881	0.0253	0.0449	2.1188
Sample Weight (g)	2.9982	0.0343	0.0845	2.2846
% Ash	56.3	73.8	53.1	92.7

Values labeled < or > are outside of the calibrated concentration range of Spectroscopy Method No. 85.

Spectrographic Analysis (continued)
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	<u>RCW-AB-46</u>	<u>RCW-AB-47</u>
Analysis Date	8/26/74	8/26/74
Particulate Concentration (mg/m ³)	32.11	29.67
Metals Content (μg/m ³)		
Pb	116	234
Ba	13	193
Cd	<3.9	<1.8
Sb	<13	<5.9
Zn	<3.9	151
Ca	>3850	>1780
Ti	16	28
Fe	30	104
Sn	<3.9	<1.8
Si	196	1365
Mg	109	28
Sr	9.3	10
Cr	<3.9	<1.8
Mo	<3.9	<1.8
Al	10	23
Cu	<3.9	1.9
Na	<13	193
Mn	<3.9	<1.8
Ash Weight (g)	1.4777	0.0215
Sample Weight (g)	1.5646	0.0463
% Ash	94.4	46.4

Values labeled < or > are outside of the calibrated concentration range of Spectroscopy Method No. 85.

TABLE G-1—Continued

Substance	p.p.m.*	mg./M ³ b
Rhodium, metal fume and dusts, as Rh.....		0.1
Soluble salts.....		0.001
Ronnel.....		10
Rotenone (commercial).....		5
Selenium compounds (as Se).....		0.2
Selenium hexafluoride.....	0.05	0.4
Silver, metal and soluble compounds.....		0.01
Sodium fluoroacetate (100%)—Skin.....		0.05
Sodium hydroxide.....		2
Stibine.....	0.1	0.5
*Standard solvent.....	500	2,950
Strychnine.....		0.15
Sulfur dioxide.....	5	13
Sulfur hexafluoride.....	1,000	6,000
Sulfuric acid.....		1
Sulfur monochloride.....	1	6
Sulfur pentafluoride.....	0.025	0.25
Sulfonyl fluoride.....	5	20
Systox, see Demeton ©.....		
T.A.T.....		10
Tantalum.....		5
T.E.P.—Skin.....		0.2
Tellurium.....		0.1
Tellurium hexafluoride.....	0.02	0.2
T.E.P.—Skin.....		0.05
C Terphenyls.....	1	9
1,1,1,2-Tetrachloro-2,2-difluoroethane.....	500	4,170
1,1,2,2-Tetrachloro-1,2-difluoroethane.....	500	4,170
1,1,2,2-Tetrachloroethane—Skin.....	5	35
Tetrachloroethylene, see Perchloroethylene.....		
Tetrachloromethane, see Carbon tetrachloride.....		
Tetrachloronaphthalene—Skin.....		2
Tetraethyl lead (as Pb)—Skin.....		0.075
Tetrahydrofuran.....	200	590
Tetramethyl lead (as Pb)—Skin.....		0.07
Tetramethyl succinonitrile—Skin.....	0.5	3
Tetranitromethane.....	1	8
Tetryl (2,4,6-trinitrophenyl-methylnitramine)—Skin.....		1.5
Thallium (soluble compounds)—Skin as TL.....		0.1
Thiram.....		5
Tin (inorganic compds, except oxides).....		2
Tin (organic compds).....		0.1
C Toluene-2,4-diisocyanate.....	0.02	0.14
o-Toluidine—Skin.....	5	22
Toxaphene, see Chlorinated camphene.....		
Tributyl phosphate.....		5
1,1,1-Trichloroethane see Methyl chloroform.....		
1,1,2-Trichloroethane—Skin.....	10	45
Titanium dioxide.....		15
Trichloromethane, see Chloroform.....		
Trichloronaphthalene—Skin.....		5
1,2,3-Trichloropropane.....	50	300
1,1,2-Trichloro 1,2,2-trifluoroethane.....	1,000	7,600
Triethylamine.....	25	100
Trifluoromonomobromomethane.....	1,000	6,100
2,4,6-Trinitrophenol, see Picric acid.....		
2,4,6-Trinitrophenylmethyl-nitramine, see Tetryl.....		
Trinitrotoluene—Skin.....		1.5
Triorthocresyl phosphate.....		0.1
Triphenyl phosphate.....		3
Turpentine.....	100	500
Uranium (soluble compounds).....		0.05
Uranium (insoluble compounds).....		0.25
C Vanadium:		
V ₂ O ₅ dust.....		0.5
V ₂ O ₅ fume.....		0.1
Vinyl benzene, see Styrene.....		
*C Vinyl chloride.....	500	1,300
Vinylcyanide, see Acrylonitrile.....		
Vinyl toluene.....	100	450
Warfarin.....		0.1
Xylene (xylol).....	100	435
Xylidine—Skin.....	5	25
Yttrium.....		1
Zinc chloride fume.....		1
Zinc oxide fume.....		5
Zirconium compounds (as Zr).....		5

*1970 Addition.

* Parts of vapor or gas per million parts of contaminated air by volume at 25° C. and 760 mm. Hg pressure.

^b Approximate milligrams of particulate per cubic meter of air.

(No footnote "c" is used to avoid confusion with ceiling value notations.)

^c An atmospheric concentration of not more than 0.02 p.p.m., or personal protection may be necessary to avoid headaches.

^d As sampled by method that does not collect vapor.

^e For control of general room air, biologic monitoring is essential for personal control.

G-1, G-2, or G-3 for the material involved.

(ii) To illustrate the formula prescribed in subdivision (i) of this subparagraph, note that isoamyl acetate has an 8-hour time weighted average limit of 100 p.p.m. (table G-1). Assume that an employee is subject to the following exposure:

Two hours exposure at 150 p.p.m.
Two hours exposure at 75 p.p.m.
Four hours exposure at 50 p.p.m.

Substituting this information in the formula, we have

$$\frac{2 \times 150 + 2 \times 75 + 4 \times 50}{8} = 81.25 \text{ p.p.m.}$$

Since 81.25 p.p.m. is less than 100 p.p.m., the 8-hour time weighted average limit, the exposure is acceptable.

(2) (i) In case of a mixture of air contaminants an employer shall compute the equivalent exposure as follows:

$$E_m = \frac{C_1}{L_1} + \frac{C_2}{L_2} + \dots + \frac{C_n}{L_n}$$

Where:

E_m is the equivalent exposure for the mixture.

C is the concentration of a particular contaminant.

L is the exposure limit for that contaminant, from table G-1, G-2, or G-3.

The value of E_m shall not exceed unity (1).

(ii) To illustrate the formula prescribed in subdivision (i) of this subparagraph, consider the following exposures:

Material	Actual concentration of 8-hour exposure	8-hour time weighted average exposure limit
Acetone (Table G-1)	500 p.p.m.	1,000 p.p.m.
2-Butanone (Table G-1)	45 p.p.m.	200 p.p.m.
Toluene (Table G-2)	40 p.p.m.	200 p.p.m.

Substituting in the formula, we have:

$$E_m = \frac{500}{1,000} + \frac{45}{200} + \frac{40}{200}$$

$$E_m = 0.500 + 0.225 + 0.200$$

$$E_m = 0.925$$

Since E_m is less than unity (1), the exposure combination is within acceptable limits.

(e) To achieve compliance with paragraph (a) through (d) of this section, administrative or engineering controls must first be determined and implemented whenever feasible. When such controls are not feasible to achieve full compliance, protective equipment or any other protective measures shall be used to keep the exposure of employees to air contaminants within the limits prescribed in this section. Any equipment and/or technical measures used for this purpose must be approved for each particular use by a competent industrial hygienist or other technically qualified person. Whenever respirators are used, their use shall comply with § 1910.134.

TABLE G-1

Substance	p.p.m.*	mg./M ³ *
Acetaldehyde	200	360
Acetic acid	10	25
Acetic anhydride	5	20
Acetone	1,000	2,400
Acetonitrile	40	70
Acetylene dichloride, see 1, 2-Dichloroethylene		
Acetylene tetrabromide	1	14
Acrolein	0.1	0.25
Acrylamide—Skin		0.3
Acrylonitrile—Skin	20	45
Aldrin—Skin		0.25
Allyl alcohol—Skin	2	5
Allyl chloride	1	3
**C Allyl glycidyl ether (AGE)	10	45
Allyl propyl disulfide	2	12
2-Aminoethanol, see Ethanol-amine		
2-Aminopyridine	0.5	2
**Ammonia	50	35
Ammonium sulfamate (Am-mate)		15
n-Amyl acetate	100	525
sec-Amyl acetate	125	650
Aniline—Skin	5	19
Anisidine (o, p-isomers)—Skin		0.5
Antimony and compounds (as Sb)		0.5
ANTU (alpha naphthyl thiourea)		0.3
Arsenic and compounds (as As)		0.5
Arginine	0.05	0.2
Asinphos-methyl—Skin		0.2
Barium (soluble compounds)		0.5
p-Benzoquinone, see Quinone		
Benzoyl peroxide		5
Benzyl chloride	1	5
Biphenyl, see Diphenyl		
Bisphenol A, see Diglycidyl ether		
Boron oxide		15
C Boron trifluoride	1	3
Bromine	0.1	0.7
Bromoform—Skin	0.5	5
Butadiene (1, 3-butadiene)	1,000	2,200
Butanethiol, see Butyl mercaptan		
2-Butanone	200	590
2-Butoxy ethanol (Butyl Cellosolve)—Skin	50	240
Butyl acetate (n-butyl acetate)	150	710
sec-Butyl acetate	200	950
tert-Butyl acetate	200	950
Butyl alcohol	100	300
sec-Butyl alcohol	150	450
tert-Butyl alcohol	100	300
C Butylamine—Skin	5	15
C tert-Butyl chromate (as CrO ₃)—Skin		0.1
n-Butyl glycidyl ether (BGE)	50	270
*Butyl mercaptan	10	35
p-tert-Butyltoluene	10	60
Calcium arsenate		1
Calcium oxide		5
**Camphor	2	5
Carbaryl (Sevin®)		5
Carbon black		3.5
Carbon dioxide	5,000	9,000
Carbon monoxide	50	55
Chlordane—Skin		0.5
Chlorinated camphene—Skin		0.5
Chlorinated diphenyl oxide		0.5
*Chlorine	1	3
Chlorine dioxide	0.1	0.3
C Chlorine trifluoride	0.1	0.4
C Chloroacetaldehyde	1	3
α-Chloroacetophenone (phenacylchloride)	0.05	0.3
Chlorobenzene (monochlorobenzene)	75	350
α-Chlorobenzylidene malononitrile (OCBM)	0.05	0.4
Chlorobromomethane	200	1,050
2-Chloro-1,3-butadiene, see Chloroprene		
Chlorodiphenyl (42 percent Chlorine)—Skin		1
Chlorodiphenyl (54 percent Chlorine)—Skin		0.5
1-Chloro-2,3-epoxypropane, see Epichlorohydrin		
2-Chloroethanol, see Ethylene chlorohydrin		
Chloroethylene, see Vinyl chloride		
C Chloroform (trichloromethane)	50	240
1-Chloro-1-nitropropane	20	100
Chloropicrin	0.1	0.7
Chloroprene (2-chloro-1,3-butadiene)—Skin	25	90

TABLE G-1—Continued

Substance	p.p.m.*	mg./M ³ *
Chromium, sol. chromic, chromous salts as Cr		0.
Metal and insol. salts		1
Coal tar pitch volatiles (benzene soluble fraction) anthracene, BaP, phenanthrene, acridine, chrysene, pyrene		0.1
Cobalt, metal fume and dust		0.1
Copper fume		0.1
Dusts and Mists		1
Cotton dust (raw)		1
Crag® herbicide		15
Cresol (all isomers)—Skin	5	22
Crotonaldehyde	2	6
Cumene—Skin	50	245
Cyanide (as CN)—Skin		5
Cyclohexane	300	1,050
Cyclohexanol	50	200
Cyclohexanone	50	200
Cyclohexene	300	1,015
Cyclopentadiene	75	200
2, 4-D		10
DDT—Skin		1
DDVP, see Dichlorvos		
Decaborane—Skin	0.05	0.5
Demeton®—Skin		0.1
Diacetone alcohol (4-hydroxy-4-methyl-2-pentanone)	50	240
1,2-diaminoethane, see Ethylenediamine		
Diazomethane	0.2	0.
Diborane	0.1	0.1
Dibutylphthalate		5
C o-Dichlorobenzene	50	300
p-Dichlorobenzene	75	450
Dichlorodifluoromethane	1,000	4,050
1,3-Dichloro-5,5-dimethylhydantoin		0.
1,1-Dichloroethane	100	400
1,2-Dichloroethylene	200	700
C Dichloroethyl ether—Skin	15	90
Dichloromethane, see Methylenechloride		
Dichloromonofluoromethane	1,000	4,200
C 1,1-Dichloro-1-nitroethane	10	60
1,2-Dichloropropane, see Propylenedichloride		
Dichlorotetrafluoroethane	1,000	7,000
Dichlorvos (DDVP)—Skin		1
Dieldrin—Skin		0.2
Diethylamine	25	75
Diethylamino ethanol—Skin	10	50
Diethylether, see Ethyl ether		
Difluorodibromomethane	100	800
C Diglycidyl ether (DGE)	0.5	2.1
Dihydroxybenzene, see Hydroquinone		
Diisobutyl ketone	50	200
Diisopropylamine—Skin	5	20
Dimethoxymethane, see Methylal		
Dimethyl acetamide—Skin	10	35
Dimethylamine	10	15
Dimethylaminobenzene, see Xylidene		
Dimethylaniline (N-dimethylaniline)—Skin	5	25
Dimethylbenzene, see Xylene		
Dimethyl 1,2-dibromo-2,2-dichloroethyl phosphate, (Dibrom)		3
Dimethylformamide—Skin	10	30
2,6-Dimethylheptanone, see Diisobutyl ketone		
1,1-Dimethylhydrazine—Skin	0.5	1
Dimethylphthalate		5
Dimethylsulfate—Skin	1	5
Dinitrobenzene (all isomers)—Skin		1
Dinitro-o-cresol—Skin		0.
Dinitrotoluene—Skin		1.
Dioxane (Diethylene dioxide)—Skin	100	350
Diphenyl	0.2	1
Diphenylmethane diisocyanate (see Methylene bisphenyl isocyanate (MDI))		
Dipropylene glycol methyl ether—Skin	100	600
Di-sec, octyl phthalate (Di-2-ethylhexylphthalate)		5
Endrin—Skin		0.
Epichlorohydrin—Skin	5	10
EPN—Skin		0.
1,2-Epoxypropane, see Propyleneoxide		
2,3-Epoxy-1-propanol, see Glycidol		

See footnotes at end of table.

TABLE G-2

Material	8-hour time weighted average	Acceptable ceiling concentration	Acceptable maximum peak above the acceptable ceiling concentration for an 8-hour shift.	
			Concentration	Maximum duration
Benzene (Z37.4-1969)	10 p.p.m.	25 p.p.m.	50 p.p.m.	10 minutes.
Beryllium and beryllium compounds (Z37.20-1970)	2 $\mu\text{g}/\text{M}^3$	5 $\mu\text{g}/\text{M}^3$	25 $\mu\text{g}/\text{M}^3$	30 minutes.
Cadmium fume (Z37.5-1970)	0.1 mg./M ³	3 mg./M ³		
Cadmium dust (Z37.5-1970)	0.2 mg./M ³	0.6 mg./M ³		
Carbon disulfide (Z37.3-1968)	20 p.p.m.	30 p.p.m.	100 p.p.m.	Do.
Carbon tetrachloride (Z37.17-1967)	10 p.p.m.	25 p.p.m.	200 p.p.m.	5 minutes in any 4 hours.
Ethylene dibromide (Z37.31-1970)	20 p.p.m.	30 p.p.m.	50 p.p.m.	5 minutes.
Ethylene dichloride (Z37.21-1969)	50 p.p.m.	100 p.p.m.	200 p.p.m.	5 minutes in any 8 hours.
Formaldehyde (Z37.10-1967)	3 p.p.m.	5 p.p.m.	10 p.p.m.	30 minutes.
Hydrogen fluoride (Z37.28-1969)	do.			
Fluoride as dust (Z37.28-1969)	2.5 mg./M ³			
Lead and its inorganic compounds (Z37.11-1969)	0.2 mg./M ³			
Methyl chloride (Z37.18-1969)	100 p.p.m.	200 p.p.m.	300 p.p.m.	5 minutes in any 3 hours.
Methylene Chloride (Z37.3-1969)	500 p.p.m.	1,000 p.p.m.	2,000 p.p.m.	5 minutes in any 2 hours.
Organo (alkyl) mercury (Z37.30-1969)	0.01 mg./M ³	0.04 mg./M ³		
Styrene (Z37.15-1969)	100 p.p.m.	200 p.p.m.	600 p.p.m.	5 minutes in any 3 hours.
Trichloroethylene (Z37.19-1967)	do.	do.	300 p.p.m.	5 minutes in any 2 hours.
Tetrachloroethylene (Z37.22-1967)	do.	do.	do.	5 minutes in any 3 hours.
Toluene (Z37.12-1967)	200 p.p.m.	300 p.p.m.	500 p.p.m.	10 minutes.
Hydrogen sulfide (Z37.2-1966)		20 p.p.m.	50 p.p.m.	10 minutes once only if no other measurable exposure occurs.
Mercury (Z37.8-1971)		1 mg./10M ³		
Chromic acid and chromates (Z37.7-1971)		do.		

TABLE G-3—MINERAL DUSTS

Substance	Mppcf*	Mg/M ³
Silica:		
Crystalline:		
Quartz (respirable).....	250 [†]	10mg/M ³ =
Quartz (total dust).....	%SiO ₂ +5	%SiO ₂ +2 30mg/M ³
		%SiO ₂ +2
Cristobalite: Use 1/2 the value calculated from the count or mass formulae for quartz.		
Tridymite: Use 1/2 the value calculated from the formulae for quartz.		
Amorphous, including natural diatomaceous earth.....	20	30mg/M ³
		%SiO ₂
Silicates (less than 1% crystalline silica):		
Mica.....	20	
Soapstone.....	20	
Talc (non-asbestos form).....	20 [‡]	
Talc (fibrous). Use asbestos limit.		
Tremolite (see talc, fibrous)		
Portland cement.....	50	
Graphite (natural).....	15	
Coal dust (respirable fraction less than 5% SiO ₂).....		2.4mg/M ³ or 10mg/M ³
For more than 5% SiO ₂		%SiO ₂ +2
Inert or Nuisance Dust:		
Respirable fraction.....	15	5mg/M ³
Total dust.....	50	15mg/M ³

NOTE: Conversion factors—
mppcf $\times 35.3$ =million particles per cubic meter
=particles per c.c.

* Millions of particles per cubic foot of air, based on impinger samples counted by light-field techniques.

† The percentage of crystalline silica in the formula is the amount determined from air-borne samples, except in those instances in which other methods have been shown to be applicable.

‡ As determined by the membrane filter method at 430 $\times$ phase contrast magnification.

§ Both concentration and percent quartz for the application of this limit are to be determined from the fraction passing a size-selector with the following characteristics:

• Containing < 1% quartz; if > 1% quartz, use quartz limit.

Aerodynamic diameter
(unit density sphere)

Percent passing
selector

2
2.5
3.5
5.0
10

90
75
50
25
0

The measurements under this note refer to the use of an AEC instrument. If the respirable fraction of coal dust is determined with a MRE the figure corresponding to that of 2.4 Mg/M³ in the table for coal dust is 4.6 Mg/M³.

§ 1910.93a Asbestos.

(a) **Definitions.** For the purpose of this section, (1) "Asbestos" includes chrysotile, amosite, crocidolite, tremolite, anthophyllite, and actinolite.

(2) "Asbestos fibers" means asbestos fibers longer than 5 micrometers.

(b) **Permissible exposure to airborne concentrations of asbestos fibers—**(1) **Standard effective July 7, 1972.** The 8-hour time-weighted average airborne concentrations of asbestos fibers to which any employee may be exposed shall not exceed five fibers, longer than 5 micrometers, per cubic centimeter of air, as determined by the method prescribed in paragraph (e) of this section.

(2) **Standard effective July 1, 1976.** The 8-hour time-weighted average airborne concentrations of asbestos fibers to which any employee may be exposed shall not exceed two fibers, longer than 5 micrometers, per cubic centimeter of air, as determined by the method prescribed in paragraph (e) of this section.

(3) **Ceiling concentration.** No employee shall be exposed at any time to airborne concentrations of asbestos fibers in excess of 10 fibers, longer than 5 micrometers, per cubic centimeter of air, as determined by the method prescribed in paragraph (e) of this section.

(c) **Methods of compliance—**(1) **Engineering methods.** (i) **Engineering controls.** Engineering controls, such as not limited to, isolation, enclosure, exhaust ventilation, and dust collection shall be used to meet the exposure prescribed in paragraph (b) of this section.

(ii) **Local exhaust ventilation.** Local exhaust ventilation and dust collection systems shall be designed, constructed, installed, and maintained in accordance with the American National Standard Fundamentals Governing Design and Operation of Local Exhaust Systems, ANSI Z9.2-1971, which is incorporated by reference herein.

(b) See § 1910.6 concerning the availability of ANSI Z9.2-1971, and maintenance of a historic file in connection therewith. The address of the American National Standards Institute given in § 1910.100.

(iii) **Particular tools.** All hand operated and power-operated tools which may produce or release asbestos fibers in excess of the exposure limits prescribed in paragraph (b) of this section, such as, but not limited to, saws, sanding abrasive wheels, and drills, shall be provided with local exhaust ventilation systems in accordance with subdivision of this subparagraph.

(2) **Work practices—**(i) **Wet methods.** Insofar as practicable, asbestos shall be handled, mixed, applied, removed, scored, or otherwise worked in a state sufficient to prevent the emission of airborne fibers in excess of the exposure limits prescribed in paragraph (b) of this section, unless the usefulness of the product would be diminished thereby.

(ii) **Particular products and operations.** No asbestos cement, mortar, grout, plaster, or similar material containing asbestos shall be removed from bags, cartons, or other containers in which they are shipped, without being either wetted, or enclosed, or ventilated so as to prevent effectively the release of airborne asbestos fibers in excess of limits prescribed in paragraph (b) of this section.

(iii) **Spraying, demolition, or removal.** Employees engaged in the spraying of asbestos, the removal, or demolition of pipes, structures, or equipment covered or insulated with asbestos, and in the removal or demolition of asbestos insulation or coverings shall be provided with respiratory equipment in accordance with paragraph (d) (2) (iii) of this section and with special clothing in accordance with paragraph (d) (3) of this section.

(d) **Personal protective equipment.** (1) Compliance with the exposure limit prescribed by paragraph (b) of this section may not be achieved by the use of respirators or shift rotation of employees, except:

(i) During the time period necessary to install the engineering controls or to institute the work practices required by paragraph (c) of this section;

(ii) In work situations in which the methods prescribed in paragraph (c) of this section are not feasible.