PB85222982

EVALUATION OF A COMMERCIAL VACUUM SYSTEM FOR ASBESTOS REMOVAL

A SAFETY AND COST EVALUATION

PREPARED FOR

NEW JERSEY STATE DEPARTMENT OF HEALTH

DIVISION OF EPIDIEMIOLOGY AND DISEASE CONTROL

UNDER

NIOSH CENTER FOR DISEASE CONTROL

GRANT NO. 1 R18 OH 01071-01

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO.	2.	3. Recipient's Accession No. PB85 222982/AS

4. Title and Subtitle
Evaluation of a Commercial Vacuum System for Asbestos Removal, A Safety and Cost Evaluation

5. Report Date

6.

7. Author(s)

8. Performing Organization Rept. No.

9. Performing Organization Name and Address

NIOSH
4676 Columbia Parkway
Cincinnati, Ohio 45226

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C)
(G)

12. Sponsoring Organization Name and Address

NIOSH
4676 Columbia Parkway
Cincinnati, Ohio 45226

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

In recent years, asbestos has been identified as a cancer inducing agent at what has been termed "low level" exposure. This concern coupled with the presence of friable asbestos and a potential for exposure has led officials throughout New Jersey to undertake numerous, extensive, and costly asbestos removal projects at schools, as well as public and private buildings. The New Jersey Department of Environmental Protection along with the Department of Health realized the need for safe, efficient, and economical methods of asbestos removal. This need is also well recognized by various agencies at the Federal level.

A grant was issued through the National Institute for Occupational Safety and Health, Center for Disease Control, to perform experimental asbestos removal projects utilizing a commercial vacuum system. The program was to involve both wet and dry removal. The resulting sampling data, analytical data, technical and economic evaluations are presented, in detail, in this report.

17. Document Analysis a. Descriptors

asbestos, asbestos-removal, cancer, sampling, measuring-instruments, noise

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
AVAILABLE TO THE PUBLIC	Unclassified	97
	20. Security Class (This Page)	22. Price
	Unclassified	

(See ANSI–Z39.18) See Instructions on Reverse OPTIONAL FORM 272 (4–77)

ACKNOWLEDGMENTS

Kaselaan & D'Angelo Associates wishes to express their gratitude to several individuals and organizations who have contributed to the success of this study. This author is grateful to Mr. William Weisgarber, New Jersey State Department of Health, Dr. D. Patel, New Jersey State Department of Health, and Mr. A.J. McMahon, New Jersey State Department of Environmental Protection for their assistance and efforts in the grant application and Project Design; Dr. Bijan Ghosh, PhD, Mr. Robert Holzer and Ms. Karen Schleehauf, Rutgers University Medical School for their sampling and analytical assistance; Mr. John Brovak, New Jersey State Department of Health for laboratory analysis assistance; Mr. Robert DeMane and Mr. Tucker Deming, Diversified Vacuum Systems, the commercial contractor performing the removal. In addition, Kaselaan & D'Angelo Associates wishes to thank Mrs. Delores Camlet, Elmwood Park Municipal Clerk, Mr. Robert Winter, Mr. Frank Crocetti, Mr. Fred Bauermann, and Mr. Clifford Keezer of Montville High School for their patience, tolerance and coordination.

ABSTRACT

In recent years, asbestos has been identified as a cancer inducing agent at what has been termed "low level" exposure. This concern coupled with the presence of friable asbestos and a potential for exposure has led officials throughout New Jersey to undertake numerous, extensive, and costly asbestos removal projects at schools, as well as public and private buildings. The New Jersey Department of Environmental Protection along with the Department of Health realized the need for safe, efficient, and economical methods of asbestos removal. This need is also well recognized by various agencies at the Federal level.

A grant was issued through the National Institute for Occupational Safety and Health, Center for Disease Control to perform experimental asbestos removal projects utilizing a commercial vacuum system. The program was to involve both wet and dry removal.

An Engineering Consultant was hired to supervise the project as well as oversee safety and health procedures, equipment evaluation, air sampling, and prepare final technical and economic evaluations.

Various air sampling and analysis equipment and procedures were utilized to obtain data for the technical evaluation. Laboratory analysis has been conducted by Phase Contrast Microscopy, Polarized Light Microscopy, Scanning Electron Microscopy with X-Ray Dispersive Analysis and Transmission Electron Microscopy.

In addition, Isokinetic Particulate Sampling was conducted as well as High Efficiency Particulate Apparatus (HEPA) Filtration utilizing the Dioctylphthalate (DOP) Penetration Detection Method. A noise survey was also conducted to investigate other possible detrimental effects of the vacuum system.

Various air sampling locations were selected to investigate present ambient conditions, workers exposure, vacuum filter efficiency, possible ambient contamination, and effectiveness of final clean-up.

In addition to collection of data during this project, previous data accumulated by the Consultant on numerous wet, conventional asbestos removal projects, as well as other vacuum removal projects, was incorporated. A detailed comparison between conventional removal operations and vacuum removal systems has been prepared by the Consultant providing economic and cost effective analysis of the two.

The resulting sampling data, analytical data, technical and economic evaluations are presented, in detail,in this report.

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PART 1.0 EXECUTIVE SUMMARY

In recent years,the concern for incidental exposure to asbestos has been heightened as a result of studies which show increased rates of cancers as a result of what has been termed "low level" exposure, such as; those in families of shipyard workers, insulation workers, and in the vicinity of mines, mills and factories. This knowledge, coupled with the potential for exposure from friable asbestos building materials used for fireproofing, acoustical/decorative, and energy isolation has prompted the Federal Environmental Protection Agency (EPA) to inform school authorities and the general public of the potential danger, and to offer guidelines as to the proper detection and abatement procedures. These warnings, recommendations, and guidelines were published in the Federal Register in September of 1980. Guidance Documents were provided earlier by the Office of Toxic Substances, March 1979.

The concern from exposure to friable asbestos building material had prompted the State of New Jersey, Department of Education and various Boards of Education to undergo extensive asbestos removal operations. In all cases, these projects were conducted by private contracting companies working under specifications prepared by a myraid of private architectural and engineering firms. It became apparent that these conventional methods were costly, inefficient, and, in some cases, unsafe. The New Jersey Department of Environmental Protection sought to investigate new and innovative methods of asbestos removal. In November of 1979, this agency, in conjunction with the New Jersey State Department of Health, presented an application for a grant to conduct tests of an innovative asbestos removal procedure utilizing a vacuum loading truck, application No. RFA 1-OSH-NCI-EHS. On December 22, 1980 the New Jersey State Department of Health assumed responsibility for the grant after a Department of Environmental Protection request for transfer and approval by the granting agency. The grant application included a removal contractor, an engineering consultant, and various State agencies to participate. The grant application stated that all OSHA Regulations (1910.1001) and EPA Regulations (40 CFR Title 60) would be followed with the exception of the National Emissions Standards for Hazardous Air Pollutants (NESHAPS)requirement that the asbestos containing material be sprayed with water prior to removal. This exception was felt necessary to prove the hypothesis that using the vacuum system without water would remove the bulk material and airborne particulates more effectively and economically but just as safe as the conventional wet method. The grant also included the description of the hopper and vacuum system to be utilized. In addition , the grant application detailed the various sampling and analytical techniques to be utilized.

This grant received approval for funding of $110,000 as opposed to the requested $165,000 on March 26, 1980.

Additional project design site selection, contract awards and administrative coordination was conducted by the New Jersey State Department of Health through to May of 1982 when the removal aspect of the project started.

In that interval, a vacuum removal contractor was selected and contracted. The firm chosen was Diversified Vacuum Systems, 671 Frelinghuysen Avenue, Newark, New Jersey. In addition, a contract was provided to Rutgers University, College of Medicine and Dentistry, Department of Physiology and Biophysics to provide quantitative asbestos content determinations via Transmission Electron Microscopy under the direction of Dr. Bijan K. Ghosh.

Kaselaan & D'Angelo Associates had been selected to provide engineering supervision, as well as air sampling, safety and health inspection, and final evaluation in December, 1981.

Project design included scheduling the experimental asbestos removal to take place at two separate locations. At each building, 10,000 square feet of asbestos material was to be removed. The program called for 5,000 square feet at each location to be removed wet, and the remaining material removed under dry conditions. As stated above, the original grant applications included a sophisticated hopper system to be utilized, mounted just below the ceiling on a movable scaffold. The plan included workers physically scraping the material off of the substrate into the hopper, which was connected to the vacuum system. The logic behind choosing two locations allowed both the fluffy, blown-on, friable material applied to concrete decking and steel beams as fireproofing and acoustical treatment, as well as the hard, cementious acoustical plaster applied to scratch a coat sub-ceiling on wire lath, to be investigated. Therefore, the projected experiment would include not only the wet vs. dry removal practices as a variable but would also allow investigation into the effectiveness on the two most commonly encountered asbestos ceiling situations. The experience of Kaselaan & D'Angelo supports this decision as both locations chosen were extremely accurate as to what is encountered throughout the Eastern United States in schools, municipal, and industrial buildings.

For nomenclature purposes in this text, the contractor referred to is Diversified Vacuum Systems of Newark, New Jersey (DVS). The consultant mentioned is the author, Kaselaan & D'Angelo Associates (K&D) of Haddonfield, New Jersey. The State refers to the New Jersey State Department of Health, Asbestos Control Program, within the Division of Epidimeology and Disease Control, Trenton, New Jersey (NJDOH).

PART 2.0 PROJECT LOCATION DESCRIPTIONS

SUBPART 2.1 ELMWOOD PARK MUNICIPAL BUILDING ELMWOOD PARK, NEW JERSEY

This location was chosen by the New Jersey State Department of Health for two reasons. The ongoing asbestos exposure assessment program conducted by NJDOH had identified this site as in need of remedial action and recommended removal of the asbestos. The location also represented a typical application of a blown-on fireproofing and acoustical treatment with a very fluffy, friable asbestos. The structure is a two-story, block ~~frame~~ municipal building. The ground (lower) level has concrete decking as the ceiling with structural steel beams running longitudinal. The lower level consists of the Police Station, offices, jail cells, a large meeting room, corridor, and a large library. There existed asbestos on the entire ceiling (excepting the jail cells) on both the ground level and second level for a total of approximately 24,000 square feet. The entire ground level was designated for removal in this project. All asbestos insulation was to be scraped from the decking and beams.

Preliminary air sampling had been conducted as early as July, 1976 by the Environmental Science Laboratory of the Mt. Sinai School of Medicine, City University of New York. In the four air samples collected, all levels were above 50 nanograms/cubic meter of air, ranging as high as 110 ng/m^3. (See Table I.) These results ranged between two and five times ambient measurements conducted in a nearby community (20 ng/cu meter) by Mt. Sinai. Their observer reported that the insulation was in a deteriorated state, with bare patches, loose insulation hanging, and material on the floor. Initial inspection with bulk sample collection and analysis by the NJDOH indicated Chrysotile asbestos at 23%, along with glass fiber. (See Tabe II.)

The initial inspection along with additional air sampling and analysis was first conducted under this project on May 17, 1982. Sampling on this date included large volume collection with TEM analysis in three indoor locations on the ground floor, as well as ambient air. Sampling this date also included low volume (personal pump) collection with Phase Contrast Analysis as well as the GCA Instantaneous Fibrous Aerosol Monitor. The results obtained correspond closely with the Mt. Sinai testing, indicating the method of quantitation followed was reproducible. (See Table III.)

The high concentrations obtained through the GCA Instantaneous Monitor and the ensuing Phase Contrast Microscopy can be attributed to the high content of glass wool fibers identified in the bulk sample analysis. The high value of the Police locker room was not typical of other areas tested. (See Table III for pre-removal concentrations.)

It should be noted that the ground level of this structure has very low ceilings. This, along with the appreciable damage to the insulation and the low degree of ventilation led to anticipation of a higher value of asbestos airborne that was actually detected both at pre-testing and throughout the study. (See Table V.)

TABLE I

ELMWOOD PARK MUNICIPAL BUILDING

GROUND FLOOR

AIRBORNE ASBESTOS CONCENTRATIONS

Sample No.	Location	Sample Volume (Liters)	Asbestos Concentration Nanograms/Cubic Meter
1	Library	4,800	54
2	Library	5,300	56
3	Secretary's Office	6,700	76
4	Detective Bureau	3,860	110

Ref: Mt. Sinai School of Medicine Report, City University of New York, Authur N. Rohl, PhD. Environmental Science Laboratory, July 27, 1976

TABLE II

BULK SAMPLE DETERMINATIONS

CEILING MATERIAL

Date	Sample No.	Location	Fibrous Constituents PLM	Fibrous Constituents XRD
6/19/81	11981	Elmwood Park Ground Floor	Chrysotile 23% Glass	Chrysotile 23%
10/6/81	WM 15	Montville High School Guidance Office	Chrysotile 4% Cotton, Paper, Glass	Chrysotile 4%
	WM 14	Nurse's Office	Chrysotile 1-3%	Chrysotile 2%
	WM 13	Entrance Hallway	Chrysotile 1% Cotton, Paper	Chrysotile 2%
	WM 12	Boiler Room	Chrysotile 20%	Chrysotile 20%

Ref: New Jersey State Department Health, Environmental Chemistry Laboratories Analysis: M. Feinman, J. Brovak

PLM: Polarized Light Microscopy
XRD: X-Ray Diffraction

TABLE III

PRE-REMOVAL CONCENTRATIONS

ELMWOOD PARK MUNICIPAL BUILDING
GROUND FLOOR

Sampling Date: 5/17/82

Sample No.	Location	Volume Sampled (Liters)	Airborne Fiber Concentration TEM (ng/cubic meter)	PCM (fibers/cc)	GCA (fibers/cc)
1	Multi-Purpose Room	4,284	58	-	-
2	Library	4,284	69	-	-
3	Police Locker Room	4,284	328	-	-
4	Corridor/On GCA	200	-	.069	.024
5	Police Dispatch Area	540	-	.066	-
6	Outside Building	2,210	18	-	-

Ref. Analysis:
TEM - Transmission Electron Microscopy - Rutgers Medical School, B. Ghosh
PCM - Phase Contrast Microscopy - New Jersey Department of Health, J. Brovak

TABLE IV

PRE- AND POST-REMOVAL CONCENTRATIONS

MONTVILLE HIGH SCHOOL

ROTUNDA, CORRIDOR, AND OFFICES

Site	Pre-Removal	Post-Removal
Ambient	12	12
Cafeteria Hall	482	24
Gymnasium Hall Outside	153	140
Gymnasium Wrestling Room	-	25
Vice Principal's Office	707	65
Boiler Room	571	-

Amount of asbestos content (calculated from Chrysotile fiber count) is expressed as ng/cubic meter air volume.

Reference: Rutgers University Medical School, Dr. B.Ghosh
Transmission Electron Microscopy

TABLE V

PRE- AND POST-REMOVAL CONCENTRATIONS

ELMWOOD PARK MUNICIPAL BUILDING

GROUND FLOOR OFFICES

Site	Pre-Removal	Post-Removal
Ambient	18	-
Library	69	14
Police Locker Room	328	31
All Purpose Room	58	4

Amount of asbestos content (calculated from Chrysotile fiber count) is expressed as ng/cubic meter air volume.

Reference: Rutgers University Medical School, Dr. B. Ghosh
Transmission Electron Microscopy

SUBPART 2.2 MONTVILLE HIGH SCHOOL MONTVILLE, NEW JERSEY

This location was chosen for its sharp contrast to the conditions at the Elmwood Park site. This building is maintained in an excellent condition and the accumulation of visible dust is minimal. There are long hallways with a central rotunda. This rotunda center houses administrative offices. Both the circular corridor, as well as the inner offices, included an acoustical plaster applied to scratch coat on wire lath. The material appeared hard, cementious and in structurally good shape, though the surface was uneven. There did exist visible evidence of numerous scratch marks generated deliberately by the students jumping and touching the ceiling while passing through the hallway. The rapid current of air flows through the long hallways into the corridor along with the student abuse generated two significant points to be considered here:

1. The rapid flow of air, while grazing over the surface of the ceiling, strikes the uneven surface and causes local air turbulance. This air movement might have caused gradual erosion of the ceiling surface.

2. The potential erosion is likely to be aggravated by the scratches or surface damage.

The experimental removal project called for the removal of all acoustical plaster in the corridor surrounding the rotunda as well as the inner offices, by scraping only the acoustical treatment and leaving the scratch coat and lath intact. This procedure is common in asbestos removal projects but is quite difficult. There also exists an adjacent boiler room which contains the spray-on fireproofing. The contractor did eventually remove this fireproofing although data has not been included in this evaluation.

It has been reported that structural components of the boiler room contained considerably high concentration of asbestos; i.e., 20% in contrast to 1 - 4% in the acoustical plaster components of the building; however, the boiler room was apparently isolated from the rest of the building. (See Table II.) The results on the asbestos content of the air, prior to the removal of the ceiling materials, has been given in Table IV. The asbestos of ambient air is slightly lower in the Montville area than in the Elmwood Park area. This minor difference might have originated from the differences in the concentration of the industries and highways in the vicinity. The data obtained prior to asbestos removal, unexpectedly, shows a high asbestos content in the building air based on the physical condition of the material as previously discussed. The range of values of the asbestos content in different locations varied 12-59 times higher than the ambient level; i.e., 12 ng/cu meter air. There were significant differences in the fiber contents in one room location to the other. Large rooms with high volume of air movement showed lower asbestos content (e.g., gymnasium hall) than a small room with low air turnover; e.g., Vice Principal's office. The asbestos fibers in the room air certainly originated from the ceiling material. This could be justified from the reduction in the values of the asbestos content of the air after removal of the ceiling material. There was an unexplained phenomenon that the gymnasium hall asbestos content was unchanged before and after removal of the ceiling material. (See Table IV)

MORPHOLOGY OF BULK SAMPLES

TEM PHOTOGRAPHS

No. 3 Elmwood Park Municipal Building
Bulk sample reveals very long chrysotile fibers present in fused bundles. Reference line equals 10.0 microns.

No. 4 Montville High School
Bulk sample reveals randomly dispersed short fibers of approximately uniform length. Reference line equals 1.0 microns.

3

4

PART 3.0 MORPHOLOGY OF BULK SAMPLES

The high asbestos content of the Montville High School air compared to the Elmwood Park Municipal Building air is paradoxical, since the material condition, friability and asbestos content would indicate the opposite.

The characteristics of asbestos fibers within the ceiling material was studied. A bulk sample of the ceiling was collected. Lumps of this material were dispersed in double distilled water by light sonication; after dispersion, the distilled water became slightly opalescent. This material was deposited on an EM grid and negatively stained with 1% amonium molybdate. Large numbers of short Chrysotile Asbestos Fibers of approximately uniform length were seen in the field. The fibers were randomly dispersed throughout the noncrystalline binding material. This dispersion could be seen by high acceleration voltage microscopy. This feature of the bulk sample from Montville High School sharply contrasted the bulk sample of Elmwood Park. The latter, prepared by the same procedure, showed very long Chrysotile Fibers frequently present in bundles of varying sizes. These bundles consisted of fused Chrysotile Fibers.

This morphology is further discussed throughout this report and is believed to be strongly responsible for resulting airborne concentrations during removal and clean-up operations.

PART 4.0 VACUUM SYSTEM DESCRIPTION

A detailed description of the vacuum system not including the remote self-contained packaging system, was available. In a previous study conducted on the Diversified equipment, a detailed explanation was presented.[1] Portions of this description are presented in Appendix A of this report. It is not the intention of this study to evaluate vacuum removal systems as a safe and cost-effective alternative to conventional methods. The system provided by DVS was in two major components, the remote packaging unit and the truck mounted vacuum source.

The packaging unit was a pre-fabricated enclosure which was a modified 20 cubic yard metal waste container. This box-like container was equipped with permanent portals for the flexible intake and vacuum hoses to enter. There was also facilities for a waterline, supplied airline, and hydraulic airline to enter. (See Photo Nos. 1 and 2) This unit was developed primarily to provide a loading system for the bulk asbestos material into either drums or bags. Problems have been experienced by this contractor and others facing transportation and waste dumping regulations. Historically, in all data accumulated in previous studies and as seen by K&D, there existed a great potential for ambient contamination with the bulk dumping of asbestos waste. Various contractors attempted to remedy this by installing wetting (spray) units in the bins of their trucks and applying water during dumping. This method has proved unsuccessful. Either the large quantities of water caused flooding in the bins and asbestos slurry leaking onto the ground during transport, or freezing conditions. There also exists EPA regulations as well as various State and Local regulations prohibiting asbestos be dumped unless contained in plastic or drums. Attempted coordination between landfill operators to pre-excavate and line the hole with plastic to satisfy regulations has also proven difficult.

The packaging unit developed by DVS utilized the vacuum source from the truck to draw the bulk asbestos waste from the work site. A hydraulically operated dual drum system was installed in the unit and operated by an employee inside. By switching between two metal 55 gallon drums lined with plastic, the operator could seal the system, draw a vacuum, and begin extracting the bulk material. As this material entered the manifold in the unit, the velocity decrease caused the bulk material to drop out into a lined drum. The operator simply controlled the vacuum allowing him to rotate between drums. As one was being filled, it allowed him time to remove and seal the adjacent bag and insert a new liner. The unit was equipped with automatic shut-down controls such that if the operator was not present when filling was complete, the vacuum would be diverted. This allowed then for only "fines" or small dust particles to be carried into the vacuum truck itself. Actual particle sizing was not conducted here as its importance is not applicable to our study. Advantages to this system are:

1. When complete, the material is contained in proper plastic bags appropriate for transport and dumping.

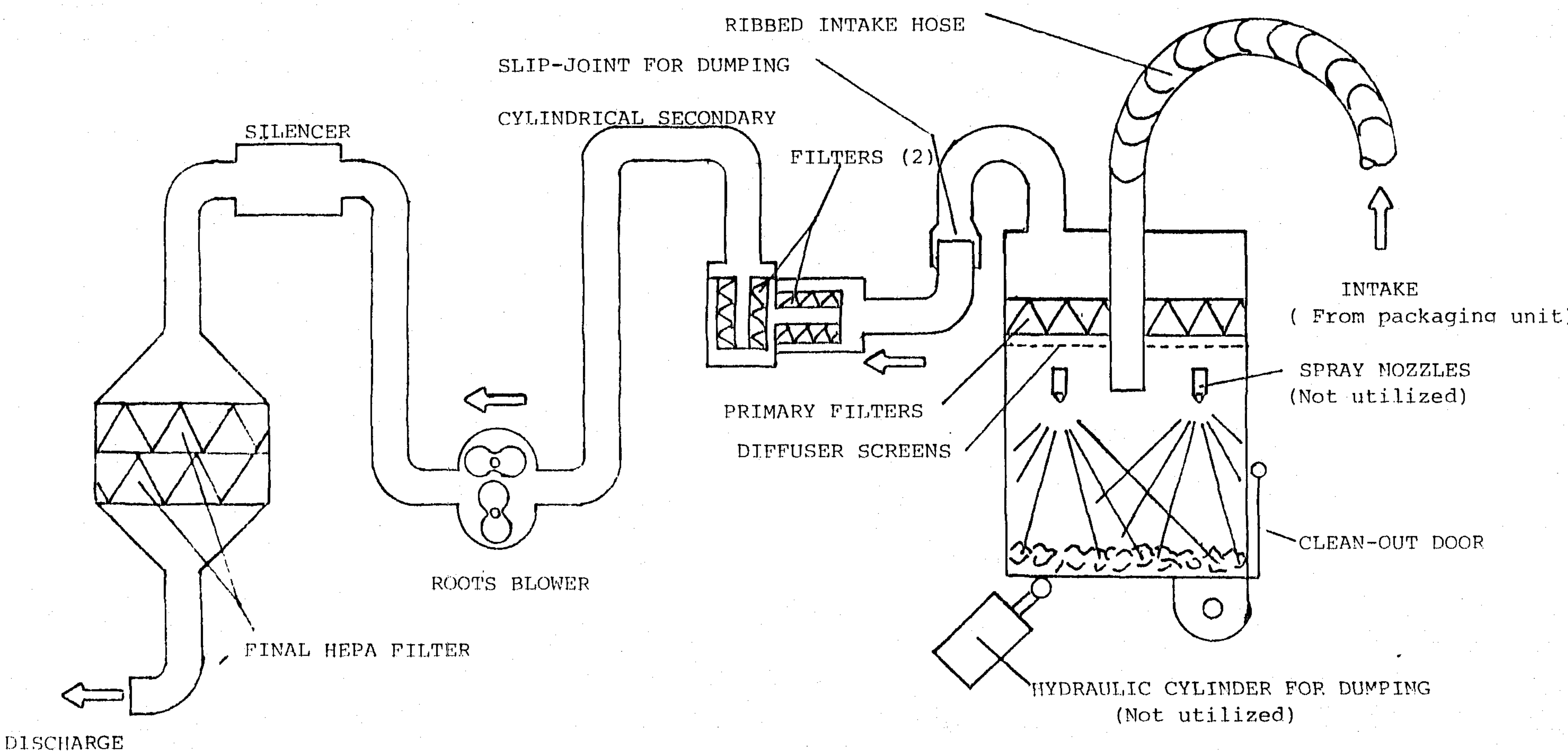
2. The holding capacity of the truck receiving chamber is greatly increased, eliminating the necessity to shut down for intermittent dumping.

The theory of operation is that all airborne fibers generated in the unit will be evacuated by the vacuum created in the system or by an auxillary 4" vacuum hose positioned inside for clean-up. The unit is equipped with plastic baffles or airlocks as well as a small shower for personnel decontamination. As stated previously, this unit is unique to DVS, and a detailed schematic was not provided.

The vacuum truck consisted of a receiving chamber (without spray nozzles operating), two stages of exhaust filtration, a vacuum blower, and a final, HEPA filter (See Figure 1 and Photo 3) The intake of the vacuum was located on top of the receiving chamber and was connected to the packaging unit through a 6" ID ribbed plastic hose. This same type hose connected the packing unit to the work area.

The filter system, as well as the positioning and type vacuum pump, differ between contractors. The utilization of positive or negative HEPA filtration or the actual positioning of final filtration with respect to the vacuum pump varies from vendor to vendor. Our observations and experience with DVS and two other vacuum removal firms has indicated varying preferences. The use of bag filter, cyclonic particle separators and off loading systems also vary. There exists numerous problems with all of the systems we have observed concerning cleaning and decontamination.

Figure 1



Source: Evaluation of Commercial Vacuum System for Asbestos Removal
IIT Research Institute, EPA Report No. 600/2-80-088

SCHEMATIC OF TRUCK MOUNTED VACUUM SYSTEM

The problems we have identified are:

1. Inability to achieve HEPA filtration, especially of particles <5.0 microns.

2. No electronic or pressure sensitive warning systems as to filter (fabric or HEPA) overloading or failing.

3. Inability to decontaminate bag house and internal conveyer mechanisms.

4. Inability to successfully conduct dust free bulk dumping.

As previously stated, it is not objective to evaluate the DVS system per se as the internal components vary from contractor to contractor. Manufacturers' systems are often field modified immediately after purchase. Therefore, intermediate testing of the various components of the DVS system was not conducted. It has been the intention of this investigator to evaluate, on a whole, if the vacuum systems can operate without ambient contamination with special emphasis on the final exhaust. Please review our recommendations and conclusions sections of this report for our evaluation.

During the course of this study, the receiving chamber did not become loaded and there was no observation or sampling of the procedures and methods utilized by DVS to empty and decontaminate this portion of their equipment.

PART 5.0 CONTRACTOR'S STAGING AREA

The contractor's staging area then consisted of the vacuum truck, Model AS-10, as previously described, providing vacuum source and particulate collection. This truck remained stationary throughout the removal operations. The truck was immediately adjacent to the packaging unit. A 6" ID flexible plastic hose connected the two and the initial intake hose was also 6" ID flexible plastic. The intake hose was placed on the ground and sections were added or removed by utilizing metal couplings and hose clamps such that the hose stretched to the exact rooms or sites where removal was being conducted. (See Photos 04,05 and 06) The intake hose was then connected to various metal "Y" connectors which reduced the ID to 3" or 4", to allow multiple crews to be utilizing vacuum simultaneously. At various locations at the "Y" connectors, sheet metal check valves were positioned such that vacuum velocity could be regulated somewhat by the worker himself. The purpose of the vacuum system is two fold as described below:

1. To provide vacuum velocity sufficient to evacuate air inside the work area room or location. This would serve as an air cleaning device, removing suspended or airborne particulates. The vacuum, with sufficient intake velocity, vs. the actual internal cubic area of the work site would then produce a negative pressure in the entire work area.

This would decrease the possibility of fugitive fibers escaping through barrier breaching or incomplete sealing of windows, doorways, HVAC systems, etc. The theory of a negative pressure induced work area would also facilitate an inward airflow through the baffles of the personnel decontamination (shower) chamber.

2. To physically remove bulk insulation material, that which is manually scraped off the ceiling and onto the floor. The hypothesis of the method includes the elimination of certain labor functions in the work area such as sweeping and loading bags, as well as manually removing loaded bags/drums from the building. The removal of the packaged waste from the building is always an operation which threatens ambient air quality. In addition, the 4" ID intake lines can be utilized as vacuum cleaners in the final clean-up operations.

Isokinetic testing via standard EPA Method No. 5, Standards for Stationary Sources,[2] was conducted on the 6" vacuum intake line at Montville to determine capture velocities as well as carrying capacities and particulate loading for system efficiency rating. (See Section II of this report for results.)

In addition to the vacuum system, the contractor positioned an electric air compressor system, complete with filtering and cooling capabilities, to provide supplied breathing air to the workers inside the building and the employee station inside the packaging unit. (See Photo 07.) Also in the staging area, an additional box type walk-in waste container was positioned to serve as a storage facility for tools and the bags of waste generated in the packaging unit. This container was then removed when it became filled with the asbestos waste material

PART 6.0 CONTRACTOR'S PROCEDURES

The intent of the initial grant application was for the contractor to provide pre-fabricated sheet metal hoppers connected to the intake hose such that ceiling insulation could be manually scraped immediately into the hopper (collection) system. By positioning this hopper close to the ceiling, bulk material would not fall to the floor and airborne particulates generated by the scraping would immediately be captured. The capture velocities would be increased due to the confining area of the hopper, and the airflow would be away from the worker, reducing both personnel exposure and general area contamination. This intended procedure would also eliminate a manual task of handling the insulation material on the floor.

These methods were not employed by DVS on the actual execution of the project. At all times during the Elmwood Park removal, the insulation material was manually scraped with hand tools and allowed to fall in large clumps onto the floor. (See Photo 08.) It was the intention to have a 4" ID intake hose immediately adjacent to any scaffold which contained workers scraping or wire brushing the substrate ceiling. It was also the intention to periodically have one worker push or sweep the bulk material across the floor into the intake hose and to utilize the intake hose to maintain housekeeping in the work area; removing all bulk material from horizontal surfaces as quickly as possible, therefore, reducing re-entrainment of fibers through foot traffic.

In actuality, this was not conducted. At times there were four to five workers scraping in various rooms/locations with only two or three intake hoses present. (See Photo 09.)

The vacuum intake was also utilized to evacuate any remaining airborne particles from a room after removal of all bulk materials and wire brushing. This proved effective, but an additional wet cleaning of all surfaces was still required as the intake velocity, with the hose simply lying on the floor in the room, was not intense enough to overcome friction and static attraction of fibers on floors, walls, and fixtures.

During the Montville removal, similar procedures were utilized for those offices within the central hub. (See Photo 10.) On the large circular corridor, an alternate procedure was implemented. Here the contractor fabricated a portable containment chamber using platform scaffold with wheels and wood frame enclosed with plastic duct tape and staples. (See Photo 11.) These chambers were constructed such that their sides rose to within 3" of the ceiling. Two workers entered the chamber through a simple plastic curtain type baffle and conducted scraping with hand tools. A 4" intake hose was placed into each chamber to evacuate the air and remove the bulk material which accumulated on the platform floor. This adaptation of the hopper system was to increase production and reduce work area asbestos concentrations.

At no time, at either location, was the intake hose utilized to physically remove bulk material directly from the ceiling.

Our initial evaluation after visual inspection of this system proved that it was somewhat effective in containing bulk material, but the intake velocity was not sufficient to continuously evacuate the chamber, therefore, increasing worker exposure problems. (See Photo 12) Our initial visual evaluation of the vacuum system at Montville was that it was undesirable. It appeared that the airborne particulates visible to the eye were not being effectively removed by the vacuum. This was presumably caused by many factors, such as the morphology of the dust and fiber particles generated, the increased distance (up to 120 lf) of intake hose, the opening of holes through the ceiling substrate allowing for external make-up air, and the abrasiveness of manually scraping a hard, cementious plaster material. It was extremely difficult for the workers to separate the acoustical plaster from the irregular surface of the scratch coat plaster.

Please review air sampling and analysis data as well as the Conclusions and Recommendations sections of this report for a more precise evaluation.

Based on the actual procedures observed, the use of the portable containment chamber was the only variance in this contractor's methods of removing vs. conventional methods. At one point in Montville, DVS experimented with a grinding machine to automatically and continuously provide abrasive action against the ceiling material. This procedure was not evaluated. (See Photo 13.)

As previously stated in Part 1.0, the grant application also specified that 50% of the material would be removed wet and 50% under dry conditions. Wet removal, the conventional method, involves actually applying water or a solution of commercially available wetting agents (surfactants) mixed with water to the insulation prior to removal. The application method varies between firms to include Hudson sprayers, airless pumps, and simple garden hoses. After saturation, the material is manually scraped from the substrate using hand tools and wire brushes, identical to the methods conducted by DVS. The material is allowed to fall to the floor under conventional methods but must remain moist through sweeping and loading into bags/drums. Water is then applied to the material in the bags immediately before sealing such that the asbestos remains wet through transportation and disposal.

In this evaluation, the contractor under study was not capable of removing wet, slurry, material through the AS-10 systems he provided. Therefore, only an extremely small section of ceiling material was removed (<100 ft^2) under experimental wet conditions at Elmwood Park, and no wet removal was conducted at Montville.

It is obvious that dry removal is capable of generating much higher airborne particulate concentrations, as "misting" or water application is the most simple of engineering controls for dust reduction in any application. It is also known that dry removal, in most cases, is prohibited by EPA, State regulatory agencies and OSHA.[3,4]

The intent of the wet removal portion of the grant application was to provide data for comparison purposes. When informed that DVS was not capable of utilizing the vacuum system on wet or slurry materials, the removal program was not altered. It is the experience of K&D that contractors do exist with vacuum equipment capable of handling wet removal. Air sampling and analysis data has been generated by K&D during such operations which shall be utilized for comparison purposes. In addition, this consultant has conducted a substantial amount of air sample collectionand analysis on all phases and at various locations on over 200 individual asbestos removal projects being conducted utilizing conventional wet removal techniques. Selected removal projects, conducted under similar conditions with similar insulation materials, can then be utilized for data comparison purposes. As it is the responsibility of the air test laboratory to submit all air quality data obtained during public asbestos removal to the New Jersey State Department of Health, Asbestos Control Program, all previous tests conducted by K&D referenced in this report are available through that office. For this reason, only projects conducted in New Jersey, with documented similarities in insulation material, shall be referenced. Data obtained by another consultant firm shall also be presented for comparison purposes.

PART 7.0 CONTRACTOR'S PERSONNEL

The needs of the Contractor to conduct an asbestos removal operation vary with conditions such as work space, available trained personnel, and time constraints. This contractor provided the following:

A. One (1) Working Field Superintendent. This person remained predominantly on the exterior of the building and whose responsibilities included: project supervision, employee supervision, vacuum truck and equipment operation and maintenance, coordination, and on-site decision making and administrative duties.

B. One (1) Working Foreman. This person entered the work area and conducted vacuuming of bulk material, worker supervision, supplied air monitoring, and general inside coordination and communication.

C. One (1) Packaging Unit Operator. This person was assigned to operate the automatic drum loading system inside the packaging unit. This work station was inside the unit, although this person continuously moved in and out of the unit due to the extreme heat. At times, the Field Superintendent would act as Packaging Unit Operator, though only when short of manpower.

D. Asbestos Workers. A varying number of laborers were necessary to manually scrape the asbestos, wire brush the ceilings and conduct vacuum and wet wipe cleaning.

The personnel requirements observed in this study vary from those in a conventional removal project by the addition of a Packaging Unit Operator only. The conventional method is believed more labor intensive. It was anticipated that the implementation of the hopper collection system and the vacuum removal system alone would reduce the labor requirements significantly. Accurate determinations of production rates and manpower requirements between contractors is difficult to obtain due to varied prevailing labor rates. It is believed that the number of employees utilized inside the work area here was not directed by needs or cost considerations but by the number of available supplied air respirator hoods. It is believed that this also was a condition which led to DVS conducting two shifts of removal per calendar day.

Our initial evaluation indicates that man-hour savings was not at all apparent with the vacuum system. It is difficult to compare actual labor cost evaluations between projects as this contractor utilized low cost, unskilled laborers from a local temporary labor pool. It is the opinion of this author that this procedure is undesirable. These workers were not only untrained in removal procedures, but more important, completely unfamiliar with proper health and safety practices mandated in asbestos removal, expecially under dry conditions. These workers were unaware of the proper protective measures and unaware of the possible health effects concerning exposure to airborne asbestos dusts.

These reasons are why accurate labor cost comparisons cannot be conducted against previously monitored conventional removal projects:

A. Actual hourly rates for various job classifications, including insurance and benefits, were not provided by DVS.

B. Conventional removal projects predominantly utilize Union labor and pay prevailing wage rates which range from $10.60/hour to $17.30/hour plus insurance and benefits.

PART 8.0 SAFETY AND HEALTH CONSIDERATIONS

Due to the health hazard associated with asbestos dusts and those anticipated high concentrations associated with dry removal, specific engineering controls and personnel protection measures were implemented by the contractor. OSHA Regulation 1910-1001 stresses the employer's responsibility to provide protection against exposure. These regulations were addressed in the following manner:

1. The entire work area was first contained and sealed with plastic sheeting. Barriers were constructed between the designated work area and adjacent clean areas. Doors were sealed airtight. At a minimum, fixtures received two (2) layers of 6 ml. plastic sheeting. Walls received one(1) layer.

2. Caution signs were posted at all points of access warning of Asbestos Dust hazards. A barrier was constructed between the general work area and those areas still open to public access. All signs were in compliance with OSHA Regulation 1910.1001(g). Barriers were fabricated on site utilizing wooden framing with minimum of two (2) layers, 6 ml. plastic sheeting. (See Photos 14 & 15).

3. Decontamination (shower) chambers were temporarily constructed in the corridors for each respective removal zone. These chambers were constructed by 2 x 4 framing and plastic sheeting. Each contained the proper (3) room sequence. Showers were temporarily set up in the center room and fed with a typical garden hose. Waste water was collected and pumped into the closest sanitary drain. A series of airlocks (baffles) were installed within this chamber so that no airflow could cause suspended fibers to migrate out of the contaminated work area.

4. Personnel whose presence was required in the work area were first briefed to the potential health hazards associated with Asbestos Dust. Proper respiratory protection and decontamination techniques were also discussed. Kaselaan & D'Angelo conducted training sessions on site for any new or inexperienced workers from DVS when possible.

5. Respiratory protection was supplied to all DVS employees and visitors due to the anticipated concentrations of airborne asbestos fibers being greater than 20 f/cc (10 times the OSHA PEL of 2.0 f/cc), at least a Class B positive pressure air purifying respirator was required.

In accordance with ANSI Z88.21969, American National Standard Practices for Respiratory Protection, a supplied Air-Line Respirator was provided for the DVS workers. In this type system, respirable air is supplied through a small diameter air line from the remotely positioned (outside) compressor. The airline is attached to the wearer by belt and can be detached rapidly in an emergency. A flow control valve is provided to govern the rate of flow to the wearer. This continous flow, air line respirators maintain a positive pressure in the face piece at all times and are less apt to permit inward leakage of contaminants. (See air test data, Appendix C for various protection factors). DVS provided both the Bullard System 1414 Supplied Air Respirator, MSHA/NIOSH Approval No. TX-19C-131, Type C or CE and the RACAL Air-stream AT30. (See Photo 16).

As a back-up system for the trailer mounted compressor and manifold, capable of six to eight separate airlines, DVS provided the Bullard Free-Air, Portable Electric Air Pumps, Model EDP-2-TE-A.

In addition, DVS periodically provided the 3-M Disposable Dust Mask, Model 8710. These masks were to be worn under the hood and shroud of the Bullard/Racal systems and would serve as protection against airborne contaminants if emergency evacuation was required, if supplied air system failed. The dust masks were also utilized by DVS foreman frequently entering and exiting the work area as well as by all workers during the final wet-mop and cleaning. (See Photo 17) Bodily protection was achieved by disposable Tyvec coveralls with hood and booties. DVS provided sneakers as additional footwear which were left in the work area on a daily basis.

The employees of this consultant, as well as visitors, were required to adhere to the same personnel protection and decontamination procedures as indicated for the contractor. To alleviate the restrictiveness of the supplied air respirator, MSA Model 463355, NIOSH Approval TC-21C-186 was utilized.

Decontamination of all personnel, workers, visitors, and testing agencies was as follows:

All workers entered the work area, removed street clothes, put on clean coveralls in change rooms. Workers then passed through showers to equipment room.

Additional clothing and equipment left in the equipment room required by the workers was put on. These were treated as contaminated clothing and left in the equipment room and disposed of at the end of the project. It is at this location where supplied air respirators were donned.

Workers then proceeded to work area.

Before leaving the work area, the worker removed all gross contamination and debris from the coveralls. This was accomplished by one worker assisting another in brushing each other off.

The worker then proceeded to equipment room and removed all clothing except respiratory protection equipment. Contaminated extra work clothing were stored in contaminated end of the unit. Disposable coveralls were placed in a bag for disposal with other material. The worker then proceeded immediately into the shower room. Respiratory protection equipment should be removed after worker has completely showered to prevent inhalation of fibers. This was not accomplished by DVS, as supplied air respirators were left in the equipment room.

After showering, the worker moved to the clean room and dressed in either new coveralls for another entry or street clothes if leaving.

Workers did not eat, drink, smoke, chew gum or tobacco in the work area. To do any of the above, the worker followed the complete decontamination sequence.

Work footwear remained inside work area (equipment room) until completion of the project and then were disposed of or cleaned by washing in shower at the end of the project.

In addition to the personnel protection described above, the following engineering controls for dust reduction were utilized:

1. Plastic sheeting on all surfaces except floors. The intake velocity of the 3" and 4" vacuum hoses was so strong that plastic on the floor would be drawn into the hose. This procedure was acceptable in all areas where a tile or smooth floor was present but was undesirable for those offices in Montville which were carpeted. (See Photo 18).

2. The use of the vacuum intake hoses to evacuate the work area atmosphere and provide negative pressure.

PART 9.0 AIR MONITORING AND INSPECTION PROCEDURES

Actual project inspection as well as sample collection was conducted by K&D throughout the entire operation at the two locations. Daily inspections were conducted by the technicians of K&D to oversee safety and health requirements and to direct the contractor on proper execution procedures. A daily log was kept by the engineering technician who recorded the following information:

1. General conditions and contractor's progress
2. Overall observations as to housekeeping and cleanliness of the job site
3. Total manpower on site and delineated job tasks
4. Integrity of plastic barriers, masking, and plastic sheeting
5. Type and use of respiratory protection
6. Type and use of bodily protection
7. Use of decontamination shower and location of wastewater drain
8. Visual observation of negative pressure effectiveness and vacuum measured on truck gauges
9. General problems, infractions, and comments

Various methodologies, equipment, and techniques were utilized in both the air sample collection and analysis to provide data at different degrees of sophistication. The intention of the air monitoring program was to determine airborne asbestos concentrations with respect to:

1. Pre-Removal vs. Post Removal indoor air quality
2. Asbestos workers' personal exposure
3. Work area environmental conditions
4. Protection factor of the supplied air systems
5. Effectiveness of negative pressure vs. air quality in the decontamination chamber

6. Ambient air quality outside the building vs. the asbestos removal project in general

7. Effect on ambient air quality vs. the vacuum source emissions

The air sampling and analysis program was designed to satisfy OSHA Regulation 1910.1001 (f). The various sampling and analytical techniques employed with respect to their application in satisfying that which is listed above were:

1. Daily personal sampling as per NIOSH P&CAM No. 239 (Procedures and Certified Analytical Method, Asbestos In Air). A personal sampling pump calibrated to a flow rate of 2.0 lpm is attached to the worker's belt. The field monitor (cassette) is connected via tygon tubing and clipped onto the workers lapel to sample that air most representative of his breathing zone. In addition to Phase Contract Analysis, both Transmission Electron Microscopy and Scanning Electron Microscopy was utilized.

2. Spot check personal sampling as per NIOSH Sampling Data Sheet 29, Inert or Nuisance Dust, with gravimetric analysis to determine total dust concentrations in the work area (Montvile only).

3. Use of Ambient Cascade Impactor stationary inside the work area to investigate total dust loading in regard to particle sizes generated by the scraping operation and the effectiveness of the vacuum system as an air cleaner in regard to particle size.

4. Daily stationary, work area (environmental) sampling as per NIOSH No. 239, in addition to large volume sample collection. Analytical methods included Phase Contrast, Transmission Electron and Scanning Electron Microscopy.

5. Pre and Post Sampling to include ambient air and designated asbestos removal locations. Collection mechanisms included large volume samplers, personal pumps, and the GCA Instantaneous Monitor. Analysis included Phase Contrast, TEM & SEM.

6. Wet/wipe surface dust sampling included in the Post removal inspection with analysis via PCM.

7. Spot check personnel sampling conducted simultaneously inside and outside of supplied air respirator hoods to ensure protection factor and worker safety with PCM analysis.

8. Daily stationary sampling at the entrance to, or immediately inside the clean room of the portable decontamination chamber. In most instances, this was monitored via the GCA Instantaneous Fibrous Aerosol Monitor (FAM-1). This instrument is most applicable for this location such that the delineation between a

contaminated zone and contiguous clean areas can be observed. In the event pressure differential is not sufficient to cause an inward flow of ambient air, fugitive fibers possibly leading to contamination of the clean areas can be immediately detected and corrective actions implemented. In addition to the fibers/cc, LCD digital readout provided by the GCA Monitor, Phase Contrast Analysis was conducted for positive identification of asbestos fibers. At times, spot check, large volume samples were collected utilizing TEM analysis.

9. Daily large volume air sampling outside of the building, at various locations, to investigate the possibility of ineffective negative pressure or insufficient masking and sealing; allowing asbestos fibers to escape into the ambient environment. Particular attention was placed on that location where the vacuum hose exited the building as well as windows and doorways. In the Montville location, temporary plastic barriers were constructed to separate the work area (center rotunda) from adjacent occupied corridors. Concentrated attention was placed on the air quality outside and the integrity of these barriers. Analysis here included both PCM and TEM techniques.

10. Spot check sample collection, via large volume sampling, at various locations in the contractor's staging area. Locations included: atop the vacuum truck, adjacent all side of the vacuum truck, immediately outside the entrance to the Packaging Unit, and waste storage container, etc. Concern existed among the evaluators of the anticipated ambient contamination resulting from fibers escaping from the many possible hose connections or from various seams in the air flow system. Analysis here was predominantly TEM and PCM.

SUBPART 9.1 AIR MONITORING EQUIPMENT

To execute the various sampling procedures and techniques described above, specifically, the following equipment was utilized:

1. Personal sampling via DuPont P2500 Constant Flow Sampler, calibrated via upright bubble burette to ±2.0 lpm. Calibration conducted with representative filter in line and checked on a twice daily basis via DuPont Calibrator Pack.

2. Large volume sampling via Millipore Vacuum/Pressure pump or Gast Vacuum/Pressure pump, pre-calibrated via bubble burette with a Millipore limiting orifice in line to a known flow rate of ±10.0 lpm.

3. Instantaneous fiber counting via GCA Fibrous Aerosol Monitor (FAM-1) as manufactured by GCA Environmental Instruments, Bedford, Massachusetts. (See Appendix B).

4. Large volume ambient sampling and cascade impactor vacuum provided by the Flow Sensor, Constant Flow Vacuum System, ± 14.0 lpm. The cascade impactor utilized was the Flow Sensor Ambient Cascade Sampler with nine particle size fractions from ≥ 9 microns in the preimpactor to ≤ 0.4 microns on the back-up filter at 28.3 ALPM.

Air sampling was conducted in accordance with NIOSH P & CAM No. 239. The collection of particulate contaminants was onto a Millipore Type AA 37 mm .8 micron cellulose esther membrane filter, either white or grid. Collection of nuisance dust was as per NIOSH SDS 29 onto a PVC membrane filter, tared and pre-weighted. Both filter media were packed into 3-stage plastic field cassettes, sealed with cellulose bands. Sampling was conducted open face.

Surface dust sampling was conducted by carefully moistening a cellulose filter with a few drops of distilled water, wearing a plastic disposable surgical glove. The technician simply wipes the filter slowly across a horizontal surface to collect dust and fibers present. The filter is then analyzed under Phase Contrast Microscopy in accordance with NIOSH Method No. 239.

PART 10.0 ANALYTICAL METHODS

Phase Contrast Microscopy was used to assess airborne fiber concentrations in accordance with NIOSH Analytical Method P&CAM No. 239.[5]

Polarized Light Microscopy (PLM) was used to identify the composition of the bulk samples to determine the type and percentage of materials present. A polarizing light microscope equipped with 360° rotating stage, polarizing filters, analyzer, a dispersion staining objective with multiple stops, and high dispersion liquids with several different indices of refraction were used to make the identification. In some cases, specific fibers are teased free of the surrounding non-fibrous insulation material and viewed independently for more precise determination. The PLM method has been conducted in accordance with the "Interim Method of the Determination of Asbestos in Bulk Insulation Samples."[6]

Polarized Light Microscopy was conducted on a Leitz, Model SM-Lux-Pol microscope. A small amount of the bulk sample (50-100 milligrams) is dispersed on a glass slide. High dispersion refractive index liquids or reagent grade glycerin is added. The sample is then examined under low power (100X) for the presence of fibrous materials. Various procedures of stage rotation and light stops in the objective are utilized to identify the mineral (fibers) by color and refraction properties.

As a confirming technique, X-Ray diffraction was utilized in the identification of asbestos in the bulk samples. The equipment utilized consists of a Philips APD-3600 automated powder diffractometer with a

Philips XRG-3100 X-ray generator and a scintillation counter. Integrated peak intensities were measured through the use of a step scanning mode. Samples were mounted in a high resolution sample holder using a Philips copper X-ray tube run at a power level at 1200W, 40 Ku and 30 MA. The range of 20 Degree in regard to analytical peaks examined in each sample was 6° - 40°.

The Scanning Electron Microscopy along with an X-ray Microanalyzer was utilized at various locations to determine airborne concentrations of fibrous materials and to positively identify those fibers as to being the common amphibole or serpentive asbestos. Air samples were collected by techniques similar to the NIOSH Method described above. The filter media used was the Gelman, nucleopore filter at .45 micron pore size. Small pieces of the filters are cut out, mounted on metal studs coated with gold prior to introduction into a high resolution scanning electron microscope (JEOL 35CF). Fibers are counted and analyzed with an energy dispersive X-ray microanalyzer (EDX; PGT System III) at both low (400X) and high (5,000X - 20,000X) magnifications.

The Transmission Electron Microscope was utilized predominantly for large volume ambient sample analysis, large volume impaction samples of the vacuum truck exhaust stream, and to determine both pre- and post-removal conditions in the two project locations.

Quantitative estimates were done by transmission electron microscopy method described by I.J. Selikoff, M.D. and W.J. Nisholson, Ph.D. In essence, the method followed can be subdivided into the following steps:

1. A specific volume of air was passed through a millipore filter.
2. A known portion of the filter was ashed in a low temperature activated oxygen asher, to remove the organic material.
3. The residue after ashing was dispersed in nitrocellulose by a "rubout" procedure. By this procedure, the fibers were disaggregated and finely dispersed which was critical for the identification of chrysotile fibers in TEM.
4. The fibers were screened at 10,000 x instrumental and 100,000 x total magnification. Chrysotile fibers were identified by the following guidelines:
    a. tubular staw-like structure;
    b. partially damaged (by EM beam) fibers exhibiting dense, irregular inner region, frequently with thin capillary and electron transparent irregular outer region.
5. The lengths and diameters of the identified fibers were measured by comparing with the fiduci marks on the viewing screen.

6. The mass of Chrysotile was calculated by a computer analysis based on the following relationship: the known volume of air passed through the filter; the area of the portion of the filter ashed, the entire amount of the residue (about 10% was lost) dispersed in a known area of nitrocellulose film, the known portion of the total area of the nitrocellulose film collected on an EM grid and size as well as number of asbestos fibers counted on a few squares of the EM grid, to generate raw data on the numbers and the sizes (length, diameter) of fibers on the total area of a single grid square.

7. The accuracy of the method is ± 30% - 50%; however, comparative data provided useful information.

In summary, only Chrysotile fibers exhibiting typical morphology were counted; degenerated fibers with atypical morphology were excluded from the count. Therefore, quantitative values were underestimated and quantities greater than ambient have significance.

SECTION II EVALUATION

PART 11.0 - 19.0

PART 11.0 VACUUM SOURCE EVALUATION

In addition to air quality monitoring and project inspection, the vacuum system including Packaging Unit and the truck (source) was evaluated as a single entity in relation to ambient air contamination. The intention of this evaluation was to record vacuum intake and exhaust velocities in relation to carrying capacity of particulates and to evaluate the filter efficiency of the HEPA equipped system.

It was understood and mandated in the original grant application and contract negotiations with DVS that the vacuum system provided must be equipped with HEPA filtration of the final exhaust and with efficiency capabilities of 99.97% to .3 microns. The actual efficiency of the filter system has been determined by three independent methods; particulate impaction of final exhaust onto an open face large volume air sample, simultaneous isokenetic particulate sampling and analysis both on the vacuum intake line and the final exhaust gas, and HEPA filter evaluation utilizing the DOP (aerosolyzed dioctyphthalate) penetration and detection method.

SUBPART 11.1 PARTICULATE IMPACTION

Particulate Impaction was conducted utilizing the Flow Sensor Constant Flow Sample at 14.15 SCFM as measured on a calibrated rotometer. This sampling pump is equipped with a differential pressure flow controller which maintains the constant flow rate for the entire sampling period regardless of pressure changes. The Flow Sensor was utilized to pull a known volume of air through a typical millipore cellulose membrane filter. This filter was mounted in an open face, plastic cassette. The face of the filter was positioned such that the plane of the filter was parallel to the plane of the mouth of the horizontal duct which discharges the final exhaust. The face of the filter was positioned at such a distance removed from the exhaust discharge (8 - 10 lf) and at the exact elevation of the center line of the circular exhaust duct. This positioning was chosen as the expected optimal location such that the volume of air sampled, along with the moderate impaction caused by the exhaust stream, would include an accurate representation of the particulate matter excaping final filtration and without allowing ambient pollutant interferences. Air currents were observed, and this hypothesis appeared accurate, by utilizing the Draeger Smoke Tubes. Visible white smoke was continuously introduced at the mouth of the exhaust duct and currents were observed such that the most complete mixing and moderate impaction properties occurred at that location which was chosen for the collection of particles. All analysis of these samples was conducted by Transmission Electron Microscopy.

SUBPART 11.2 ISOKINETIC TEST DESCRIPTION

Isokinetic sampling was conducted simultaneously as an additional method of assessing particulate removal efficiency of the vacuum system equipped with various stages of filtration. Two sampling ports were provided temporarily, the inlet location being on the intake duct, approximately 22 feet upstream of the packaging unit, and the outlet location being on the final exhaust, downstream of HEPA filtration, approximately 5 1/2' downstream of the 90° bend. At both test locations, sections of Sch 40, PVC pipe, 6" ID, with 6" x 6" x 3" elbows centered in the sections, were inserted. (See Photos 19 and 20). The insertion of the test sections in the inlet line was to create straight, laminar flow conditions and to meet specifications of EPA Stack Test Method No. 2, Determination of Stack Gas Velocity and Volumetric Flow Rate. The same criteria applied to the outlet location and the test port was positioned 5 1/2' downstream of the bend in the duct to achieve 11 duct diameters from the disturbance.[7] (See Photos 21 and 22).

The testing was conducted utilizing the Research Appliance Company "Stacksampler" Portable Gas Sampler, Model No. 2343. Two separate control boxes were provided along with six sample boxes, housing filter and impinger trains, such that three independent runs could be taken simultaneously. All testing was conducted in strict accordance with EPA Method 5, Determination of Particulate Emissions From Stationary Sources, as described in the Federal Register, Volume 42, No. 160, August 18, 1977. In addition, ANSI/ASTM Method D-3685-78 "Standard Test Method for Particulates and Collected Residue Simultaneously in Stack Gases" was consulted for comparison of calculations. This method is intended for sampling of particulate residues in dry or wet gas streams before and after particulate control equipment and for calculation of control device particulate collection efficiency.

SUBPART 11.3 ISOKINETIC TEST METHOD SUMMARY

The test method employed was essentially the standard EPA Test Method 5, with modifications. Due to the size of the ducts (6 inch diameter), it was decided to sample at six locations across the duct at the following points, in inches from the duct walls: 0.5, 1.5, 2.5, 3.5, 4.5, and 5.5. Both the inlet and outlet ducts used the same sampling point locations. Each point was sampled for a period of ten minutes for a total test time of sixty minutes. One sampling port was used at each location. Three individual tests were conducted at the inlet and three individual tests were conducted at the outlet. Each duct sampling port was located in a long straight run, well over eight diameters downstream from flow disturbances.

The inlet and outlet tests were essentially conducted simultaneously, with the exception that the outlet tests were started two minutes prior to the inlet tests to facilitate moving the probe.

Removal Operations During Tests

During the test sequence, the workers were removing ceiling material from the inner office area of the Montville High School. The removal consisted of scraping and wire brushing the ceiling material. During the test series, the vacuum hose was never allowed to function as a vacuum cleaner picking up large pieces of material. Rather, it was used to simply evacuate the ambient air around the workers. The flexible vacuum hose was typically attached to scaffolding in the vicinity of the workers to create a negative pressure. It was decided that if the vacuum hoses were allowed to entrap the large pieces of material, they would clog the small nozzle and disrupt the isokinetic sampling. This also explains the rather small amount of airborne material flowing in the duct to the vacuum truck. The test results do not reflect the amount of material being removed, but rather they display the collection efficiency of the filtering unit for the smaller airborne particles. (Table VI)

This test method is an accurate one during all vacuuming operations and the test results would also be typical for all vacuuming operations for all of the larger pieces of material would drop out at a collection efficiency of 100%.

TABLE VI

RESULTS SUMMARY

Isokinetic Duct Sampling

	Run #1	Run #2	Run #3
Inlet, Lb./Hr.	2.11	0.754	4.23
Outlet, Lb./Hr.	0.009	0.010	0.012
Inlet, Grains/SCF	0.321	0.106	0.599
Outlet, Grains/SCF	0.001	0.001	0.001
Efficiency:	99.68%	98.78%	99.72%
Efficiency:	99.69%	99.06%	99.84%
Average Efficiency:	99.46%		

During test No. 2, the workers were at lunch break. The flexible hose was positioned in the work area to simply evacuate that area.

The pressure drop across the filters was approximately 12" during all three tests, as measured on the truck equipped magnehelic gauge.

Analysis of particulate loading in the isokinetic stack test is conducted by gravimetric measures on the filter media, including the loading attributed to the probe wash. Please see Appendix B for presentation of the test data in its entirety and also for the complete report and caluculations.

SUBPART 11.4 DOP DETECTION TEST

The use of dioctylphthalate (DOP) in an aerosolyzed form has been employed for testing the integrity of the HEPA filter only. In review of ASTM F91-70, Standard Practice for "Testing for Leaks in Filters By Use of a Condensation Nuclie Detector" it was determined the truck mounted HEPA filter should be evaluated independently. As discussed previously in various parts, the utilization of HEPA filtration is essential in the filtering of exhaust air at an asbestos removal project and is mandated under the OSHA Regulation[3] which incorporates ANSI Z9.2 - 1971.[8] For this evaluation, the use of a forward light scattering linear photometer was utilized. The equipment and procedures employed were in accordance with:

- Federal Standard 209B, Paragraph 50
- Air Force Technical Order No. 00-25-203
- ANSI N101-1-1972
- American Association of Contamination Control CS-IT, CS-2T

DOP Test Method and Equipment

The method involves a vacuum pump drawing a gas through the scattering chamber, causing any particulate matter in the sample to pass through the focal point of the cone of light, causing light to be scattered forward through the dark area. The phototube is activated by the forward scattered light and sends a signal to an amplifier and a linear microammeter. This method has proven quite successful in the measurement of leaks in high efficiency filter systems. In establishing the integrity, it is necessary to use a challenge agent, such as the aerosolyzed DOP as a test aerosol. The challenge agent is necessary because it is assumed that pre-filters have removed enough particulate matter that there are insufficient particles to give a valid test.

The test aerosol was introduced into the upstream side of the filter through a 1/4" sampling port. The challenge agent should be introduced such that adequate mixing is insured. A sample of the aerosol air mix is taken from the upstream side and used to set the 100% baseline, since it is the concentration of the challenge aerosol. A handlemeter probe is passed along the perimeter of the filter as well as across the face of the filter in overlapping strokes. Particles passing through/around the filter are then detected as described.

Instrumentation used for this testing included the Alnor 8500, the TDA-2D Particulate Detector as manufactured by Air Techniques, Inc., and the Climet CL-208. (See Photo 23)

Test Summary

The one HEPA filter, mounted downstream of the vacuum pump on the truck, was tested. The filter is 24 x 24 x 11 1/2 inches. The velocity recorded was 2,000 fpm with a pressure drop of 1.5 - 2.0 inches of water across the HEPA. No leaks were detected and an efficiency rating of

99.99% was applied. The highest particle count recorded at the .5 micron size was 57, and the highest at the 5.0 micron size was zero. It was recommended that this filter be tested within 6 months of 1,200 hours of use. Please see Appendix E for the test results.

SUBPART 11.5 VELOCITY DETERMINATIONS

In addition to the test methods described above, gas velocity and volumetric flow rates were developed on both the intake and exhaust lines to investigate carrying capacities of the vacuum system. Sampling ports utilized were as described in the isokinetic method. Here PVC ports were rotated such that both East-West and North-South traverses could be accomplished. Velocity was obtained utilizing a Dwyer Inclined Manometer and Standard Pitot tube, in accordance with EPA Methods 1 and 2, "Determinations of Traverse Points and Velocity of Gas Streams," Federal Register, Volume 42, No. 160 of August 18, 1977 with slight modifications. Six sampling points were chosen across each traverse to determine Δp (avg.). The AS-10 vacuum system provided by DVS was equipped with a magnehelic gauge to measure velocity in inches of water. Please refer to Table V for the results of the velocity determinations.

PART 12.0 TIME WEIGHTED AVERAGES ELMWOOD PARK

The OSHA regulation which governs the permissible exposure to airborne concentrations of asbestos fibers is listed under Code of Federal Regulations Title 29, Part 1910, Section 1910.1001 (b) is stated below to define the TWA exposure limits.

(b) Permissible exposure to airborne concentrations of asbestos fibers.

(1) Standard effective July 7, 1972. The 8-hour time-weighted average airborne concentration 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.

The sampling program conducted by K&D can be more accurately compared to the Ceiling Concentration as our samples were collected in the work area, during actual removal, representative of the worst possible exposure levels.

The 8-hour exposure can then be hypothetically computed based on one representative worker's daily assignment schedule. To determine a TWA exposure, all exposure levels, or all different exposure environments, which the worker is subjected to in an eight (8) hour period must be considered.

For all intents and purposes, a typical DVS worker would divide his day into the following segments:

1) Preparation and suit-up in clean area
2) Morning work session in work area
3) Break and decontamination for lunch
4) Afternoon work session in work area

Therefore, a typical eight (8) hour work day would include:

.5 hours in clean areas, outside
.5 hours in clean areas, inside
7.0 hours inside work area

At any one time, any worker would complete any work task in the contaminated area such as scraping, brushing, vacuuming, and cleaning up.

Below, please see Table VII for the frequency of testing in various areas, at various job tasks, to compile data for the TWA determination. This table includes all samples and analysis conducted during dry removal operations only, utilizing PCM data only.

TABLE VII

ELMWOOD PARK

Summary of Airborne Concentrations of Asbestos

Phase Contrast Analysis Only

Location/Task	No. of Samples Collected	Average C in f/cc	Highest Recorded C in f/cc
Inside Building			
General Work Area	17	1.325	5.0
Personnel, Work Area	14	1.524	4.33
Clean-Up, Area	13	.007	.05
Outside Decontamination Chamber	26	.048	.207
Clean Areas	8	.026	.083
Outside Building			
Packaging Unit	2	.345	.537
Outside, Ambient, Contractor's Area	6	.018	.06

The small amount of data accumulated under the wet removal conditions were not included in Table VII, though the actual concentrations obtained were lower by approximately 41%.

TABLE VIII

ELMWOOD PARK

Worker Exposure: Wet vs. Dry Removal

	Wet (avg)	Dry (avg)
General Area Samples		
During Scraping and Brushing	.875 f/cc	1.325 f/cc
Personnel Samples		
During Scraping and Brushing	.783 f/cc	1.524 f/cc

As listed in OSHA Regulation 1910.100, Sub Part 2 (c) lists the following computation formula for TWA exposure.

The comulative exposure for an 8-hour work shift shall be computed as follows:

$$\frac{(E = C_aT_a + C_bT_b + \ldots\ldots\ldots C_nT_n)}{8}$$

Where: E = equivalent exposure for the working shift

C = concentration during any period of time, where concentration remains the same

T = the duration of exposure (C) in hours

Kaselaan & D'Angelo has computed the average concentration (C) based on our sampling program and recorded the highest concentration encountered which can be directly compared to the ceiling concentration limitation of 10.0 f/cc. (See Table VII)

By utilizing the average concentrations observed, Kaselaan & D'Angelo has computed the TWA for the various job taks as indicated below.

	TWA	Ceiling
Scraping and Removal (Area)	1.16	5.0
Scraping and Brushing (Personnel)	1.34	4.33
Cleaning Up	.01	.05

All concentrations are presented in f/cc.

(For all computations, the concentration of .048 f/cc was utilized to represent exposure levels on clean side of barriers while still in the building where as .018 was assumed for exposure while outside of the building.)

PART 13.0 DATA EVALUATION, ELMWOOD PARK

SUBPART 13.1 WORKER EXPOSURE

The initial observation of the data generated indicates worker exposure is lower than anticipated for a dry removal operation. In comparison, dry removal operations have generated indoor airborne concentrations at 15.0 - 20.0 f/cc[9] under similar bulk material and work practice conditions. The indication here is that the vacuum system has proven effective in serving as a dust reduction control. This can be further exemplified by the extremely high concentrations (3.7 times the average) on the first days of removal. The high concentrations normally occurring on dry removal operations can be attributed to the lack of sufficient air cleaning of residual fibers; therefore, causing a compound loading in regard to length of the project. If the airborne particulate level is not sufficiently reduced on a daily basis, the next day's (shift's) activity will produce additional contaminants as well as cause re-entrainment of the previous day's dust.

The PCM data indicates the vacuum system is also effective in producing an inward flow of air as the levels outside the decontamination chamber and in clean aides of barriers is acceptable. Those instances when fibers were detected at their locations can be attributed to incomplete personnel decontamination.

The use of the supplied air respiratory system is assumed a pre-cautionary measure and has proven sufficient for the concentrations observed in this study. Use of a secondary dust mask to protect workers during the donning and removal of the air hats, as well as an emergency evacuation protection, is recommended. Also, the observed and potential problems with the air compressor system warrant use of the secondary respirator or dust mask.

The SEM analysis indicated the presence of small (less than 5.0 microns) and thin (less than .5 micron) Chrysotile fibers, undetected by the light microscope. This further reinforces use of a supplied or powered air system, effective in protecting against these small thin fibers. The SEM has proven a valuable analytical method, far superior to the Phase Contrast microscope, for assessing the airborne concentration of all asbestiform fibers.

The concentrations obtained during the attempted wet removal are indeed lower than those observed during conventional projects. It has been proven that wet removal can occur with concentrations below 1.0 f/cc ceiling.[10] The average levels detected during dry operations of this study closely resemble those observed in many of the wet removal projects observed by K&D and the NJDOH. This also reinforces the effectiveness of the vacuum system in dust reduction control.

The TEM data indicates extremely high concentrations of asbestos fiber in relation to ambient levels in the work area. This data reinforces the need for the supplied air system as the method allowed for detection of

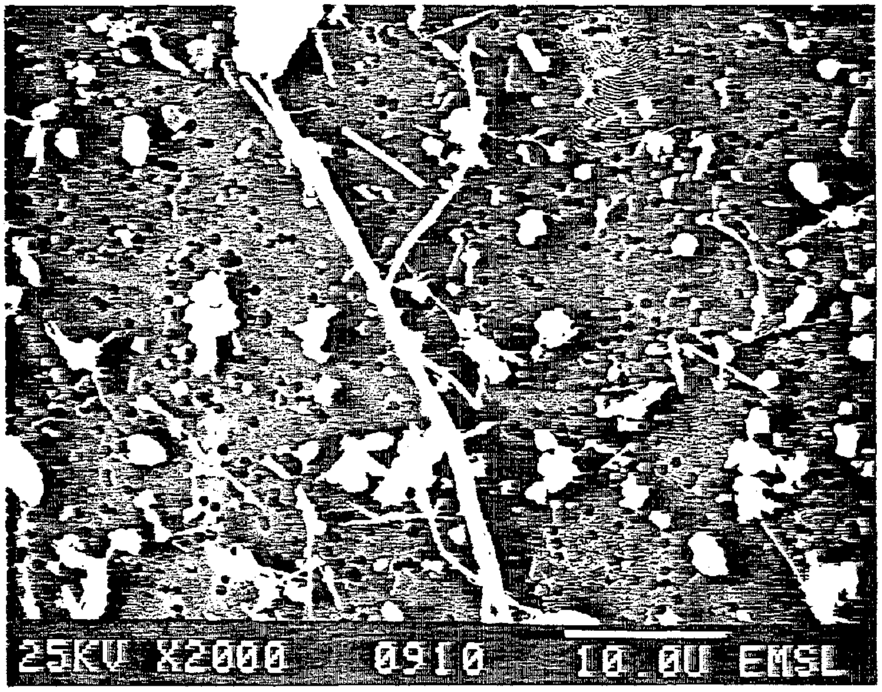
ELMWOOD PARK MUNICIPAL BUILDING

AIR SAMPLE ANALYSIS VIA SEM

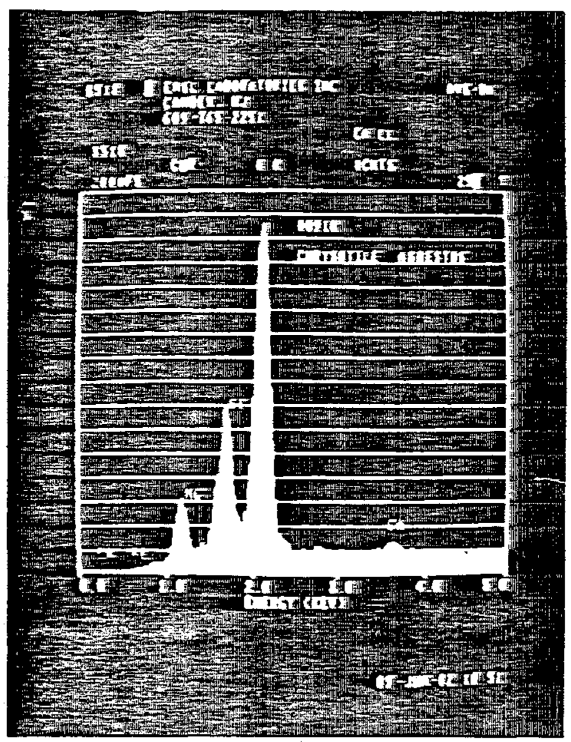
Photo 01. Scanning Electron Microscope indicating high concentration of fibrous materials (Sample 0910). Sample collected on worker during brushing and scraping of ceiling during dry conditions. Vacuum system operating immediately adjacent to worker. Note large chrysotile bundles as revealed in TEM analysis of bulk samples.

Photo 02. Photo-micrograph depicting X-Ray analysis of fibers counted in Sample 0910. Positive identifications of Chrysotile asbestos.

Photo 03 & 04. Depicts SEM analysis of final (Post) tests conducted after final clean up. Photographs depict no fibrous materials detected.



" PHOTO 01 "



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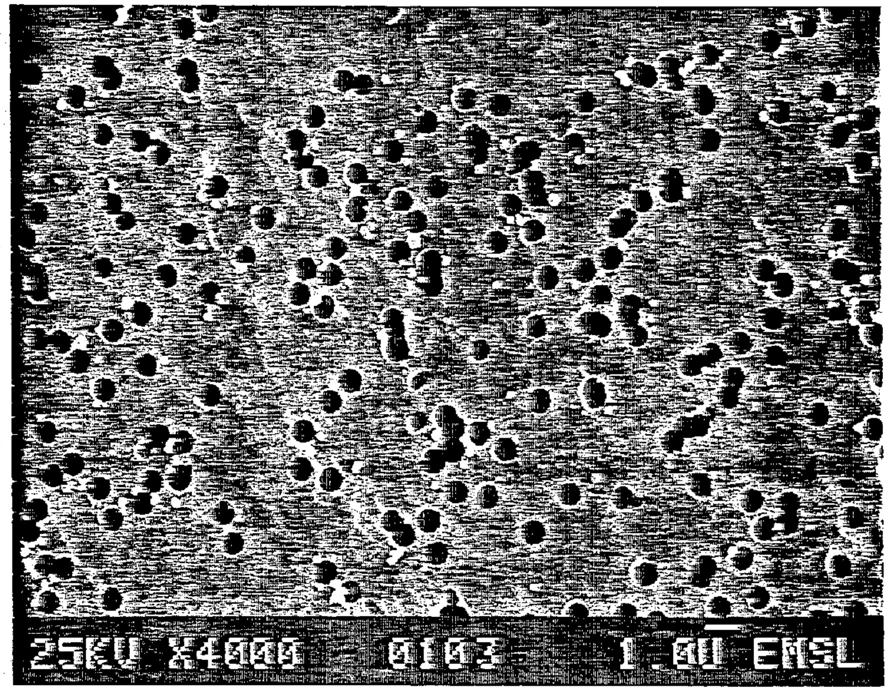

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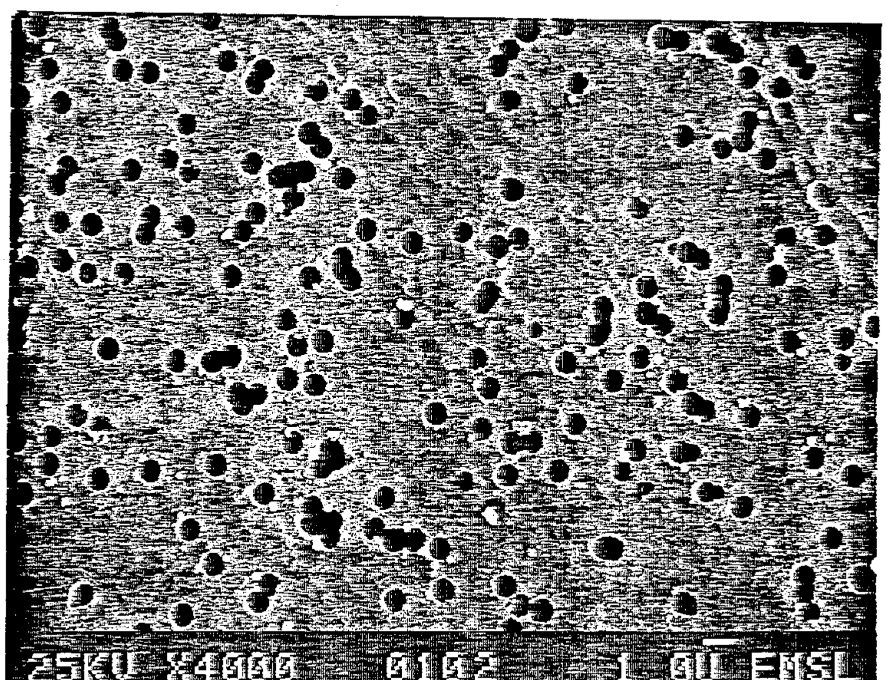


"PHOTO 04"

fibers far beyond PCM. If the EPA's factor for converting fibers to nanograms is utilized, a level of 6.32 f/cc was detected on Day 02 inside the work area, personnel sample.

SUBPART 13.2 REMOVAL SYSTEM

In general, the removal machinery functioned fair from the standpoint of the release of Chrysotile asbestos fiber into the environment through the exhaust system in relation to ambient values. The high value in the first day of operation could be explained by initial maladjustment of the equipment or residual material.

Five problem areas are evident:

1. The vacuum hose might have developed some leak.
2. The connection thru outside window might have developed a leak.
3. The packaging area showed a very high count indicating the need for some sealing.
4. The contractor discovered a window left open while sampling pumps were operating on the first day.
5. The high count around the truck might have originated from the back pressure developed from the stopping of the pump. A shielding of that area may prevent significant release of asbestos fibers into the air. A total sealing of all joints and connections in the system, including gaskets around the bulk container, is recommended.

SUBPART 13.3 MORPHOLOGY OF THE CHRYSOTILE FIBERS COUNTED

Transmission electron micrographs have been presented in Figures 1 - 6. The fibers have characteristic tubular appearance: the beam damage seen in the micrographs developed due to the exposure time taken during the operation of the camera. The damage usually develops within a fraction of a second to a few seconds, depending on the intensity of the electron beam. The brittle nature of the fibers is noted from the rugged end of the fibers. Although quantitative size analysis of the asbestos fiber cannot be done because the samples were prepared by a "rub-out" technique, a qualitative comment on the gross differences can be made. Note that truck exhaust samples or samples from the scraping area show very small size of the fibers. The breakage of the fibers by mechanical shock might have reduced the size of the fibers.

SUBPART 13.4 POST-REMOVAL CONDITION

In order to evaluate the effectiveness of the removal operation on the airborne asbestos content, the room air was monitored following the removal. The uniformity of the evaluation was maintained for comparison

TABLE IX

ELMWOOD PARK MUNICIPAL BUILDING

Airborne Asbestos Concentration

TEM Analysis

Area	Pre-Removal	1	2	3	4	5	6	7	8	Post-Removal
All Purpose	58									4
Library	69									14
Police Locker	328									31
Ambient	18									
Truck Exhaust		9,042	11	62	80	84	97	43	109	
Work Area		TNTC	1,471				TNTC			
							15,068			
Personal Monitoring			32,759				TNTC			
Outside Window		1,516	67				TNTC			
Packaging Unit			204							
Outside Packaging Area		TNTC					487			
By Truck				1,118	28					
Outside Work Area		255								
Court Room Upper Level										25

Numbers in the columns indicate ng/cu meters air.
TNTC Indicates very high density of asbestos fiber >16,000 ng/cu meter air.

A blank filter contained 24 small Chrysotile asbestos fibers in the entire filter. This is an extremely low value because the filters through which ambient air was drawn contained approximately 600 small Chrysotile fibers in the whole filter. These Chrysotile fibers, when considered with respect to the total quantity of air passed through the filter, gave the quantity calculated by standard procedure: 18 ng/cu meter air volume.

Fig. 1

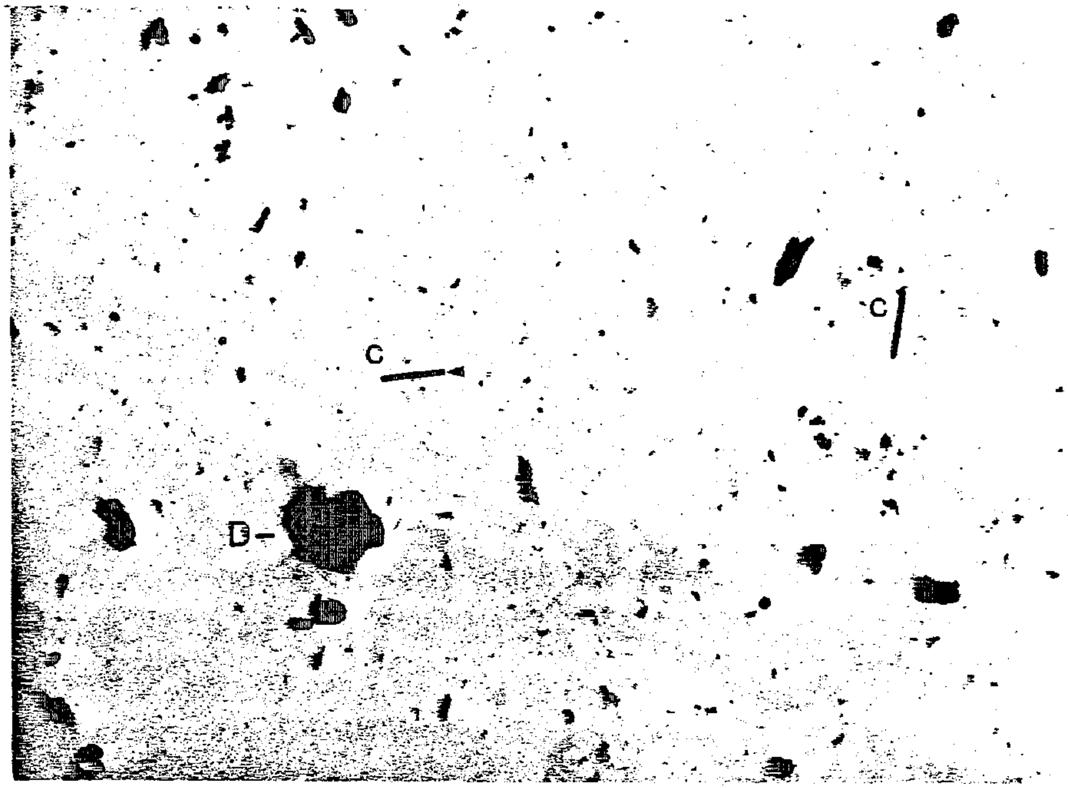


Fig. 2

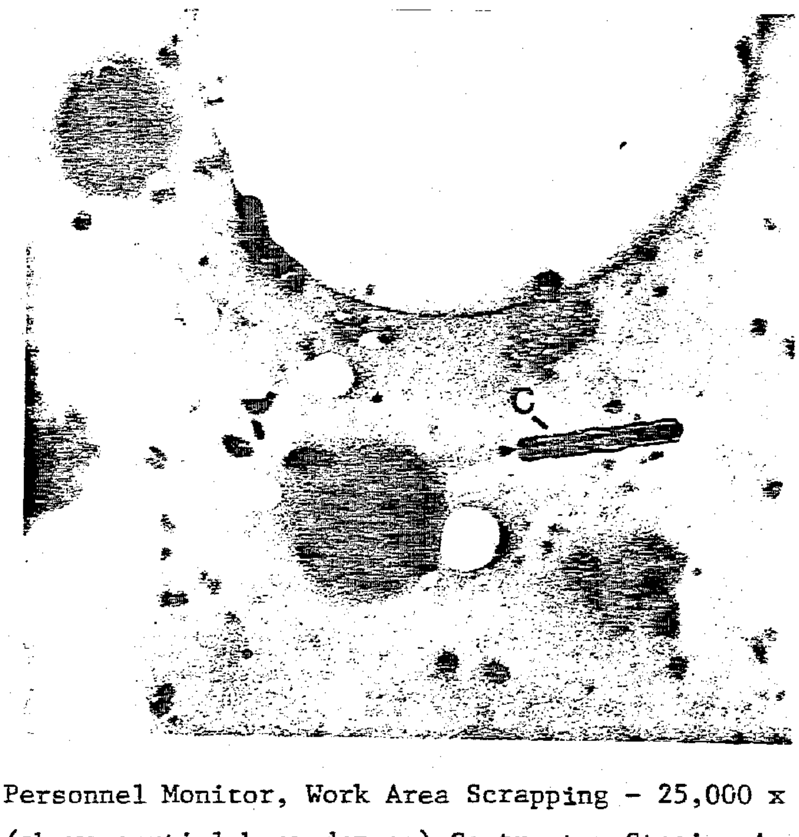


Fig. 1. Day 2, Personnel Monitor, Work Area Scrapping - 25,000 x

Fig. 2. Day 1, (shows partial beam damage) Contractor Staging Area. Intake hose - 100,000 x

D = Dust partical ; C = crysotile asbestos fiber ; Arrowheads show the capillary space at the core of the fiber.

Fig. 3

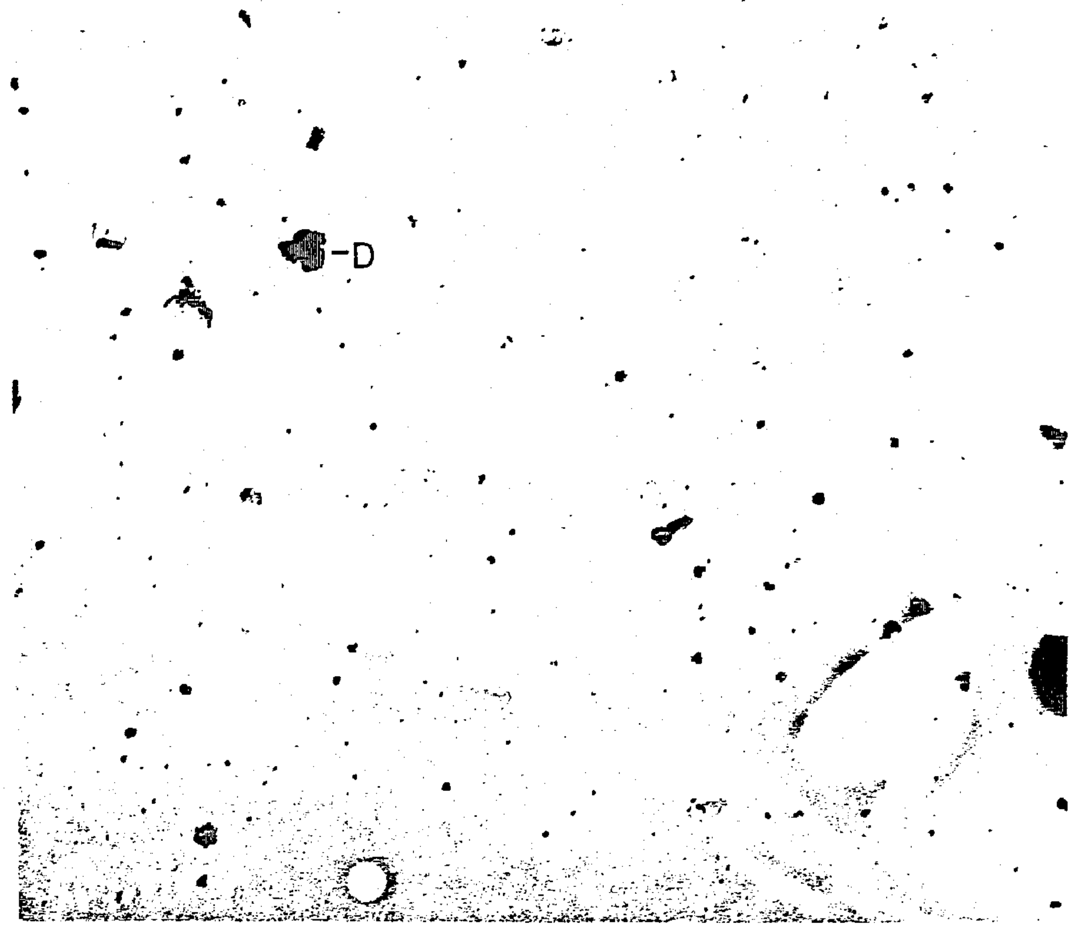


Fig. 4

Fig. 3 - Blank, 25,000 x

Fig. 4 - Day 3 - Large volume outside top of vacuum truck, 25,000 x

Fig. 5

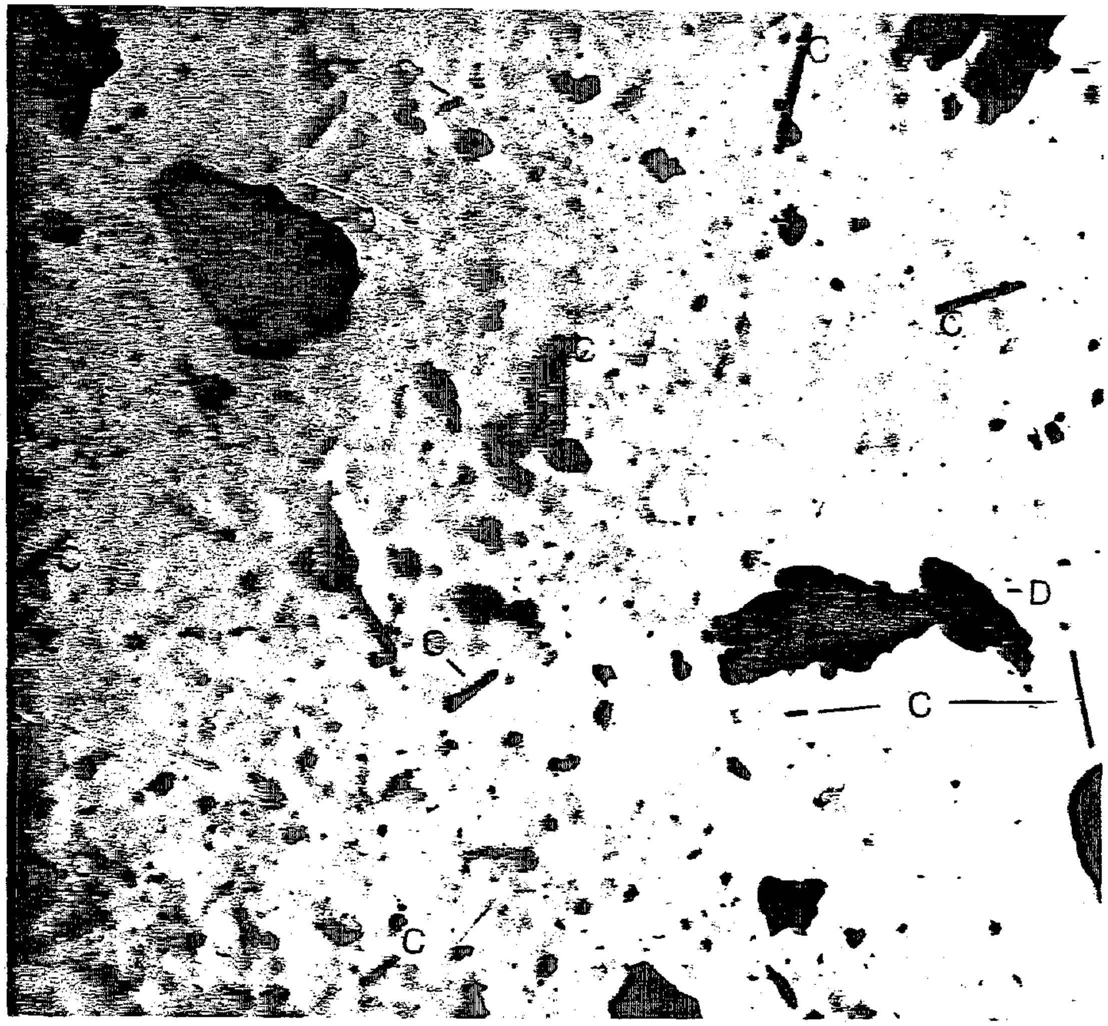


Fig. 6

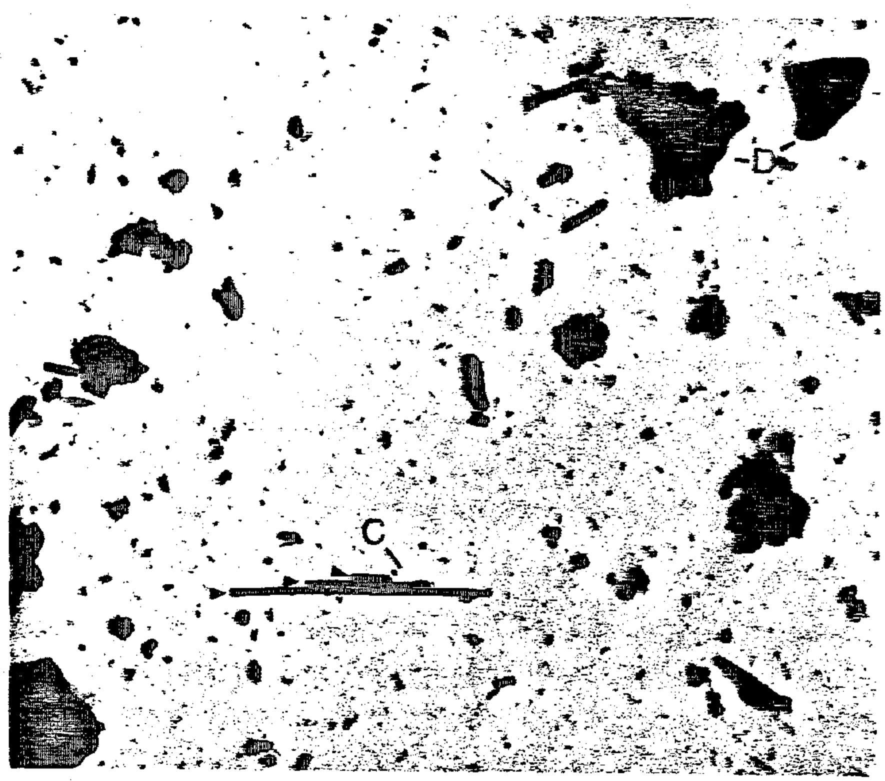


Fig. 5 - Day 4, Large volume down wind truck exhaust, 25,000 x

Fig. 6 - Day 5, Large volume down wind truck exhaust, 25,000 x

between the pre- and post-removal condition; the same rooms and identical sampling conditions are used. The results clearly indicate reduction of the asbestos content to ambient level. However, relatively high value in the Police locker room air indicates residual fibers in this small dead-end room with low circulation.

One significant point is the low Chrysotile asbestos content in the Municipal Court room located in the upper level. The ceiling of this room has not been removed. This low count may have been due to the height of the ceiling and very slow release of the fiber into the environment. The high asbestos content in the lower level might have been caused by both small volume of the room air and its poor circulation. However, a significant but paradoxical point to note is that in spite of high asbestos content and poor condition of the building structural material, the release of asbestos in to the environment was unexpectedly low. Hence, bulk analysis of the building structure material only is a poor indicator of the real contamination of the environment. The form the asbestos takes in the building structure e.g., length of the fiber, binding with other fiber material, low rate of air circulation, etc. determines the net air pollution. Analysis of the environment by high resolution TEM or SEM methods is a valuable guide for the determination of asbestos air pollution.

PART 14.0 TIME WEIGHTED AVERAGES MONTVILLE HIGH SCHOOL

As described under PART 12.0 of this report, the 8-hour time weighted average can be hypothetically computed based on one (1) representative worker's daily assignment schedule. To determine this TWA, all exposure levels or all different exposure environments to which the worker is subjected to in an 8-hour period must be considered.

A typical 8-hour work shift for a DVS employee would include:

.5 hours in clean areas, outside

.5 hours in clean areas, inside

7.0 hours inside work area

At one time, any worker would complete any work task in the contaminated area such as scraping, brushing, vacuuming, or cleaning-up.

Following, please see Table X for the frequency of testing in various areas, at various job tasks to compile data for TWA determinations. This table includes all samples and analysis conducted during the dry removal utilizing PCM data only.

By utilizing the average concentrations observed, K&D has computed the following TWA concentrations:

	TWA	Ceiling
Scraping and Removal, General Area	.164	.942
Scraping and Removal, Mobile Containment	.567	1.170

For all computations, the concentration of .08 was utilized to represent exposure levels on clean side of barriers while still in the building where as -0- was assumed for exposure while outside of the building.

TABLE X

MONTVILLE HIGH SCHOOL

Summary of Airborne Concentrations of Asbestos

Phase Contrast Analysis Only

Location/Task	No. of Samples Collected	Average C In f/cc	Highest Recorded C In f/cc
Inside Building			
General, Work Area	12	.375	.942
Personnel, Work Area	3	.122	.171
General, Inside Mobile Containment	5	.365	.788
Personnel, Inside Mobile Containment	4	.643	1.170
Clean Areas	3	.044	.112
Outside Decontamination Chamber	3	.116	.305
Outside Building	2	-0-	-0-

PART 15.0 DATA EVALUATION, MONTVILLE HIGH SCHOOL

SUBPART 15.1 WORKER EXPOSURE

The visual observation of the effectiveness of the vacuum system in reducing airborne contaminants is considered being unsatisfactory. All visual observations indicated high levels of suspended (airborne) solids. The resulting asbestos concentrations, as indicated by the PCM data, are much lower than anticipated.

As previously discussed, dry removal operations typically produce concentrations as high as 20.0 f/cc.[9&10] The obvious dust levels observed in the inner office removal and again in the mobile containment chambers led observers to anticipate extremely high concentrations of asbestos fiber. Possible reasons for recorded concentrations of asbestos to be low are:

1. Difficulty in viewing and counting fibers via Phase Contrast Microscopy due to the interference of particulates and solids.

2. Low content of asbestos fiber in the ceiling material.

   Bulk samples indicated 1 - 4% Chrysotile.

Therefore, the PCM data does not accurately display the potential exposure problems which existed in the work area. This is further confirmed by the Scanning Electron Microscopy analysis of a work area sample (Day 05) which indicates and depicts the large quantities of debris and solids on the filter. The microscopist included comments as to the difficulty in counting.

Also, by utilizing gravimetric analysis and investigating total, or nuisance, dust concentrations, as accurate determination of airborne contaminants other than asbestos can be made. Personnel exposure to airborne dusts, within the mobile containment systems, reached as high as 293 mg/M^3 or 17 times the OSHA permissible TWA concentration exposure Dust concentrations in the general work area averaged at 30 mg/M^3 or 2 times the 8-hour TWA. The PCM data indicates that the vacuum system was ineffective in creating a substantial negative pressure in the work area. This is exemplified in air samples collected on clean sides of barriers in such areas as the cafeteria. The Contractor attempted to construct plastic barriers utilizing duct tape and staples to wooden strips for fastening. These barriers were ineffective and continuously failing, which prompted air and surface dust sampling immediately adjacent to these barriers on the "clean" side.

The proper construction of temporary plastic barriers and the durability of these barriers throughout the length of the project is a chronic problem among asbestos removal contractors. It had been assumed that the negative pressure produced by the vacuum system would cause sufficient airflow into the work area such that airborne fibers could not migrate out against the airstream. Though actual air currents were not measured at the faulty barriers, it is apparent by the TEM and PCM data that this did not occur. High values were reported in the cafeteria via TEM analysis and the positive presence of asbestiform data was observed via PCM in the "clean" corridors.

This indication that the vacuum system's negative pressure being ineffective conflicts with that observed at Elmwood Park. This is attributed to the large work area and the corresponding volume of the rooms to be evacuated. Whereas the intake, the velocity of the vacuum system,on a whole, has been computed at approximately 800 SCFM. The

TABLE XI

MONTVILLE HIGH SCHOOL

Airborne Asbestos Concentrations

TEM Analysis

Area	Pre-Removal	1	2	3	4	5	6	7	8	9	10	11	12	13	Post Removal
Ambient	12														12
Cafeteria	482														24
Gymnasium	153														140
Wrestling Room	-														25
Vice Principal's Office	707														65
Vacuum Exhaust		27	-	-	7	-	-	-	-	-	-	-	-	20	
Work Area		-	-	-	-	-	-	-	-	-	-	493	205	-	
Inside Mobile Containment		-	-	-	-	-	-	-	-	TNTC	-	-	-	-	
Outside Barriers		-	27	75	-	-	-	-	-	21	-	-	192	151	
Outside Packaging Unit		TNTC	25	-	-	-	320	-	-	-	964	-	-	95	
Inside Packaging Unit		-	-	-	-	-	-	-	-	7,041	TNTC	TNTC	-	-	
By Truck		-	42	-	-	-	-	-	-	-	-	-	94	-	
Cafeteria (Clean Area)		-	-	-	6	-	-	-	-	-	-	249	-	-	

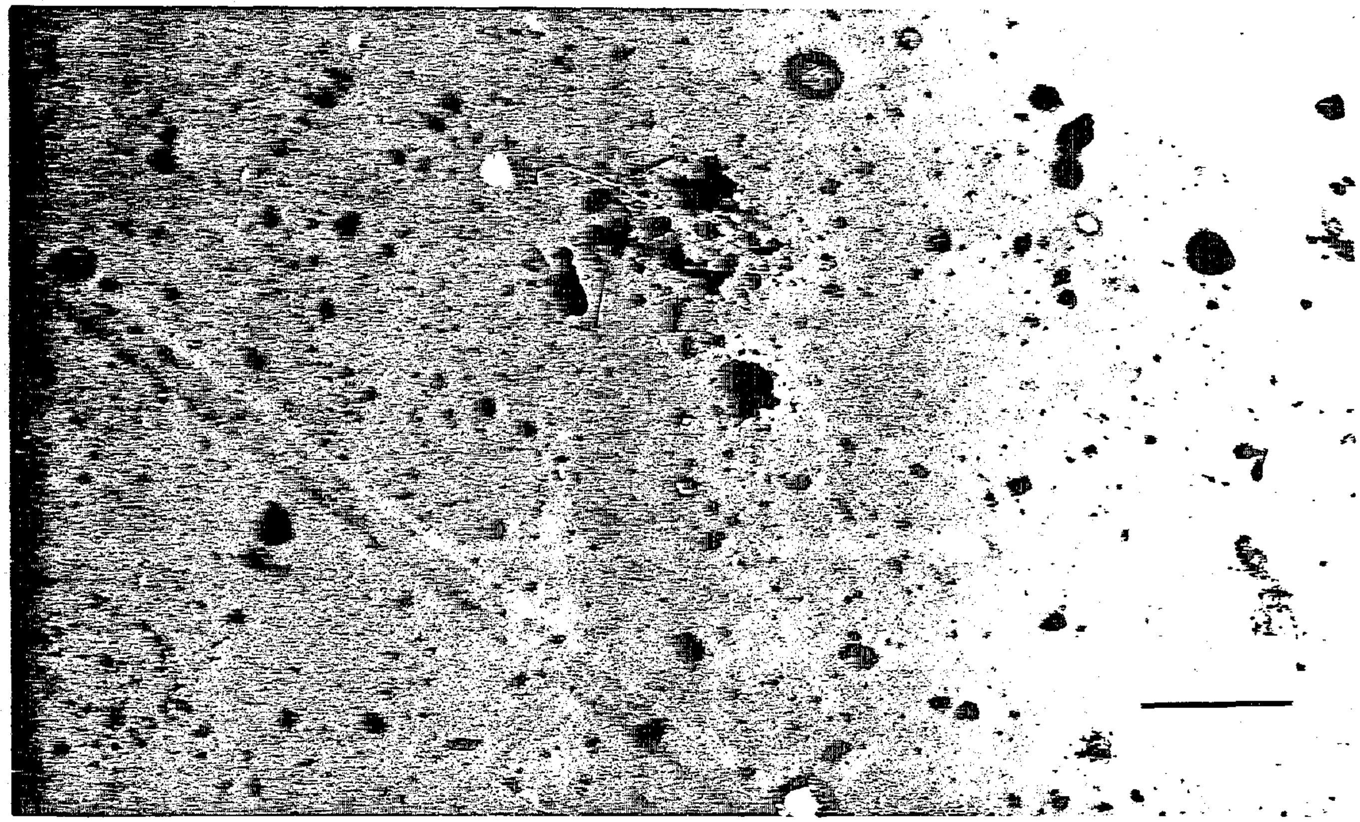
Numbers in columns indicate ng/cubic meter of air

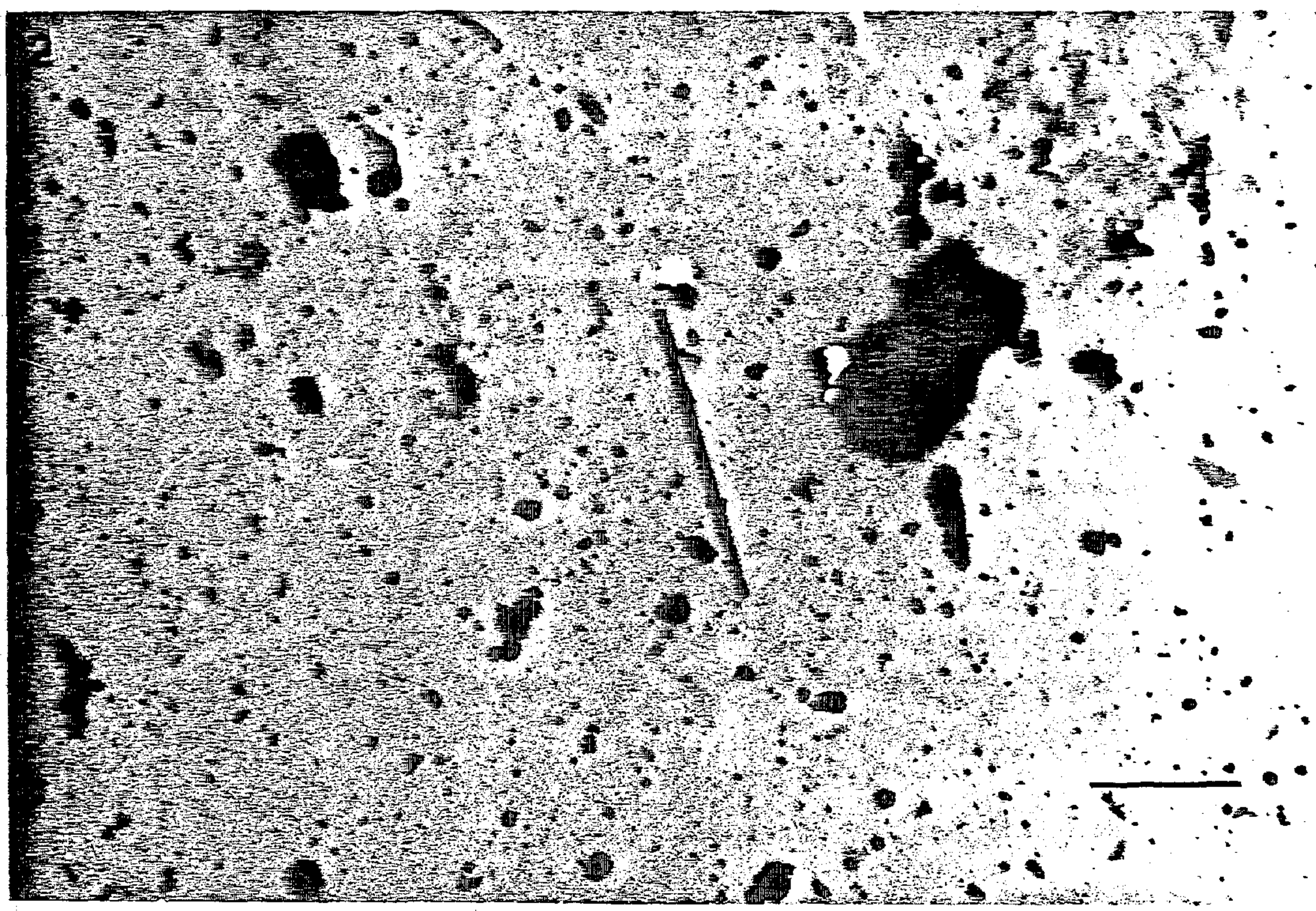
TNTC = Indicates too numerous to count. A very high density of Asbestos Fiber >16,000 ng/cu meter of air.

"PHOTO LEGENDS"

Photo 1 - Asbestos filler (chrysotile) in Vice Principal's office preremoval condition. Note short fibers embedded in amorphous inorganic binding material of the ceiling structure.

Photo 2 - Asbestos fibers during removal operation; usually the fibers are long.





necessary time to evacuate an indoor area is substantially increased at Montville. It is assumed that the vacuum intake flows were not capable of providing complete evacuation; therefore, dust reduction control was ineffective. Please see PART17.0 for a more detailed presentation of this principle.

As indicated in the Elmwood Park evaluation, the use of a supplied air system is a precautionary meausure only. In retrospect, the actual values obtained in the work area, subject to OSHA permissible exposure levels, would indicate the required respiratory protection to be Class A. K&D feels the use of the Class C is substantiated by the potential levels which are commonly produced in dry removal operations. In addition, the use of a secondary dust mask is necessary as an emergency protection device should the supplied air system malfunction. Also, the limited TEM data collected within the work space warrants the use of supplied air. The levels obtained via TEM in adjacent clean areas, and again during clean-up operation, exceed ambient levels substantially. Due to the high levels of airborne dust produced in the work area it was difficult to obtain accurate concentrations via TEM. It is assumed that had additional sampling been successfully conducted during actual scraping operations, the subsequent exposure levels would be extremely high in contrast to ambient. In this type evaluation, the SEM analysis proves more desirable than the TEM as the SEM report does indicate a concentration and an explicit micrograph which displays the heavy loading of the filter media; where as TEM report simply indicates Too Numerous To Count.

There was no wet removal conducted at this project location for comparison data. Air concentrations produced on previous wet removal projects monitored by K&D, where similar cementious asbestos plaster was manually removed from a plaster substrate on wire lath, shall be utilized for comparison purposes.

SUBPART 15.2 REMOVAL SYSTEM

Specifically, the removal machinery functioned fair from the standpoint of the detection of Chrysotile asbestos fibers in the exhaust of the vacuum truck via TEM analysis. When compared to ambient levels, the exhaust values were low.

This low count can possibly be attributed to the low percentage of asbestos in the bulk material. Therefore, if vacuum exhaust was the only criteria in the system for possible outside contamination, the increase in levels would equal the exposure one might encounter in most urban, industrial areas in the North East. The efficiency of the vacuum system is also acceptable when evaluated via total particulate removal. As previously presented, simultaneous isokinetic duct sampling at the inlet to the system and the truck exhaust had been conducted. Values obtained indicated a filter efficiency of 99.46%. It was determined by the Elmwood Park data that PCM analysis was ineffective in evaluating the vacuum exhaust and ambient air, and was conducted outside the building only twice at Montville, This is attributed to the low ($<$.1 f/cc) levels, less than the accurate minimum detection level.

PHOTO LEGENDS

MONTVILLE HIGH SCHOOL

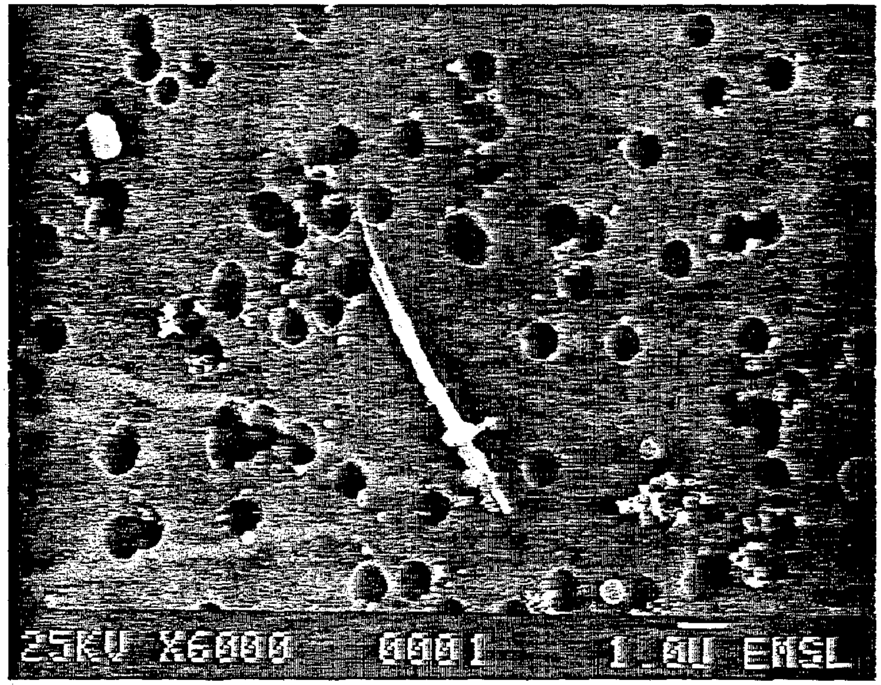
AIR SAMPLE ANALYSIS

Photo 001: Sample of final (post) test after final clean-up of outer rotunda work area. Photo depicts one short, thin fiber counted.

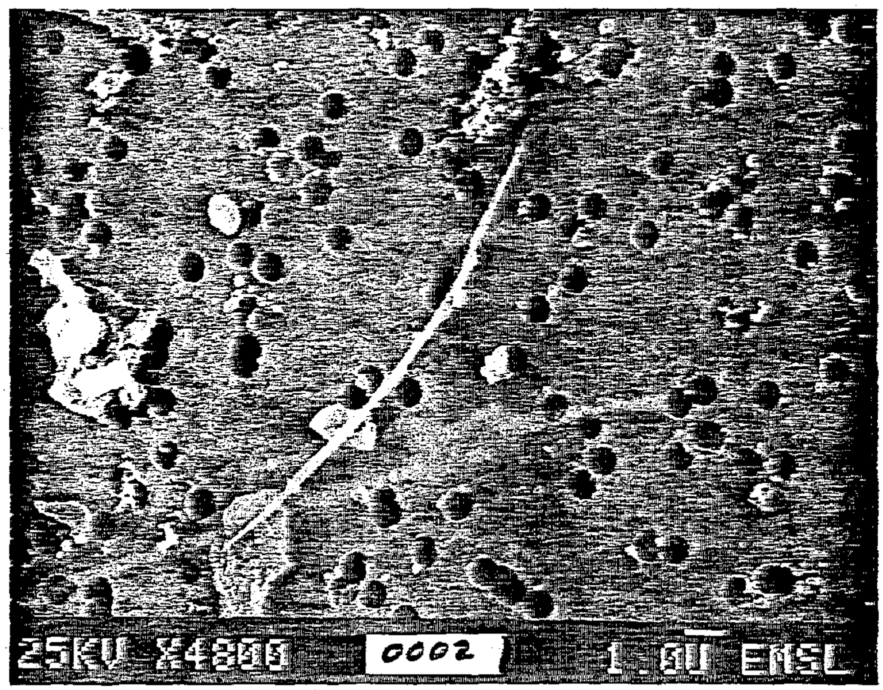
Photo 002: Sample of final (post) test after final clean-up of inner offices work area. Photo depicts one short, thin fiber counted.

Photo 003: Sample of work area (stationary) during removal of ceiling. Filter extremely overloaded and difficult to count. Photo depicts non-fibrous binder with small asbestos fibers present.

Photo 004: Photo of X-ray analysis of fiber counted. Positively identifies chrysotile asbestos.



"PHOTO 001"



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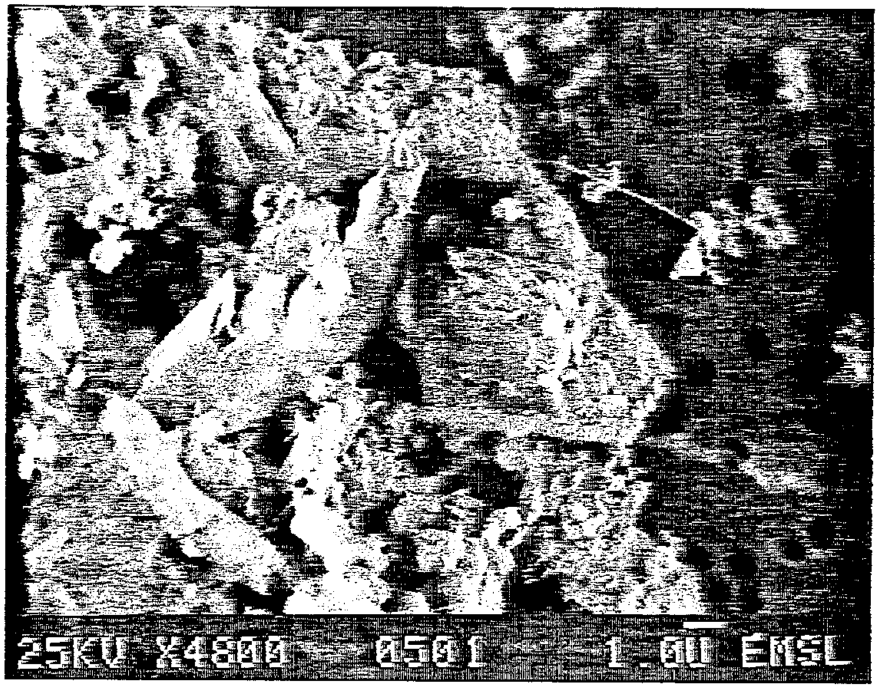

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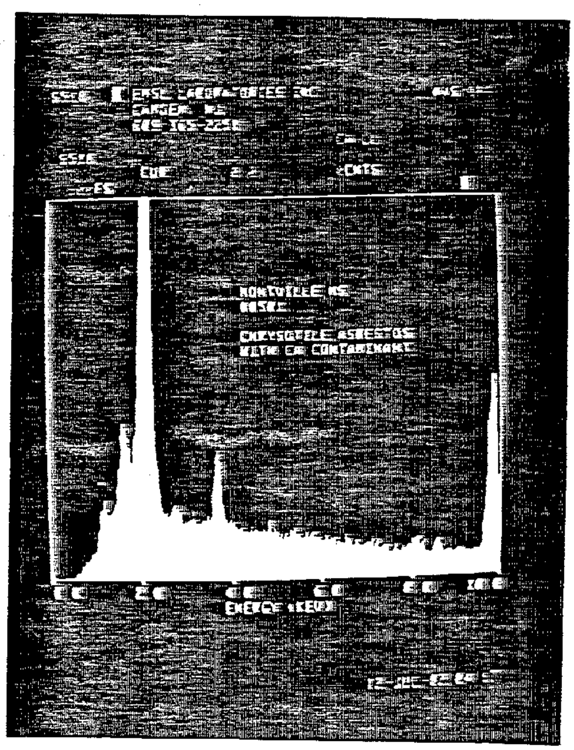


"PHOTO 004"

When evaluated on a whole, the vacuum system, including flexible hoses and packaging unit, is a direct source of ambient air contamination. Levels obtained via TEM analysis, in all samples collected adjacent to the truck and immediately adjacent to the door of the packaging unit, exceeded ambient levels. A sample collected in the Contractor's staging area, adjacent to the packaging unit, indicated levels as high as eighty (80) times ambient. The extreme heat, caused by solar radiation, forced the worker to vacate the unit at frequent intervals. This frequency caused abbreviated versions of proper personnel decontamination and additional openings of the plastic baffles.

The fiber count inside the packaging unit, which was remote of the work area, was very high. Although this high fiber count was natural and anticipated and the worker inside was protected by a respirator, this constituted a potential source for high contamination which was displayed in this area,therefore, should be securely sealed to minimize the problem of possible pollution during the removal process. Four problem areas are evident:

1. Inefficiency of vacuum to successfully create negative pressure within the entire work area along with;
2. Failing of temporary plastic barriers leading to migration of fugitive asbestos fibers.
3. High count around the truck and packaging unit.
4. Necessity to repeatedly wet clean surfaces even after vacuum cleaning.

The increased fiber counts detected in the pre-sampling program, when compared to the Elmwood Park location, has been associated with the release of small asbestos fibers due to the rough surface ceiling and air erosion process. This theory presumes that the smaller fibers are a result of mechanical grinding in the manufacture of the product and the mixing with the binder. It is believed these smaller fibers more readily become airborne when subject to any force; air erosion, abuse of the ceiling, or during scraping. This can be reinforced not only by the high pre-test values but by the high dust concentrations during the removal and the need for repetitive wet cleaning. It is known that the smaller the actual fiber, the greater the settling time. The settling velocity is strongly dependent upon fiber diameter in addition to fiber length and falling orientation.[11] Therefore, it was necessary to re-clean each time settlement of fibers occured. It must be noted that the vacuum system was not being utilized during the final cleaning at Montville.

This theory also presumes that the larger fused Chrysotile bundles evident in Elmwood Park fireproofing would settle faster due to their size. Also, the assumption includes that the large Chrysotile bundles would be more completely bound within the additional fibrous and adhesive materials in the bulk material all leading to higher airborne levels associated with the smaller fiber.

A review of TEM data for both project locations indicates conflicting results. Indeed, higher levels were obtained during pre-sampling in Montville. At all other test locations, higher levels were exhibited on Elmwood Park except in the packaging unit. Perhaps the air erosion theory is accurate, and the higher levels at Elmwood Park are directly co-related to high asbestos percentages of bulk material? There exists only one conclusion which is positive and that is further research concerning fiber size vs. airborne levels produced during asbestos removal must be conducted. Again, the use of Electron Microscopy is essential in the detection of these small fibers and should be included in the evaluation of all asbestos removal operations. Sufficient data is not available where Electron Microscopy has been utilized in monitoring numerous asbestos removal processes.

PART 16.0 NOISE SURVEY

A noise study was conducted outside the building, adjacent to the vacuum truck. As is typical with all contractors observed, the vacuum source is extremely loud and is a serious point to consider when weighing the pros and cons of utilization of this method.

A Bruel & Kjaer, Type 2215 Precision Sound Level Meter was used to obtain sound level readings. At all locations, pressure levels were measured on the A scale, slow response at 1 KH_2 frequency. The instrument was both pre- and post-calibrated at 94dB. Testing was conducted by holding the meter at chest elevation, extended from the body at various distances adjacent to the vacuum truck. In addition, the areas around the large air compressor supplying breathing air to the workers were measured.

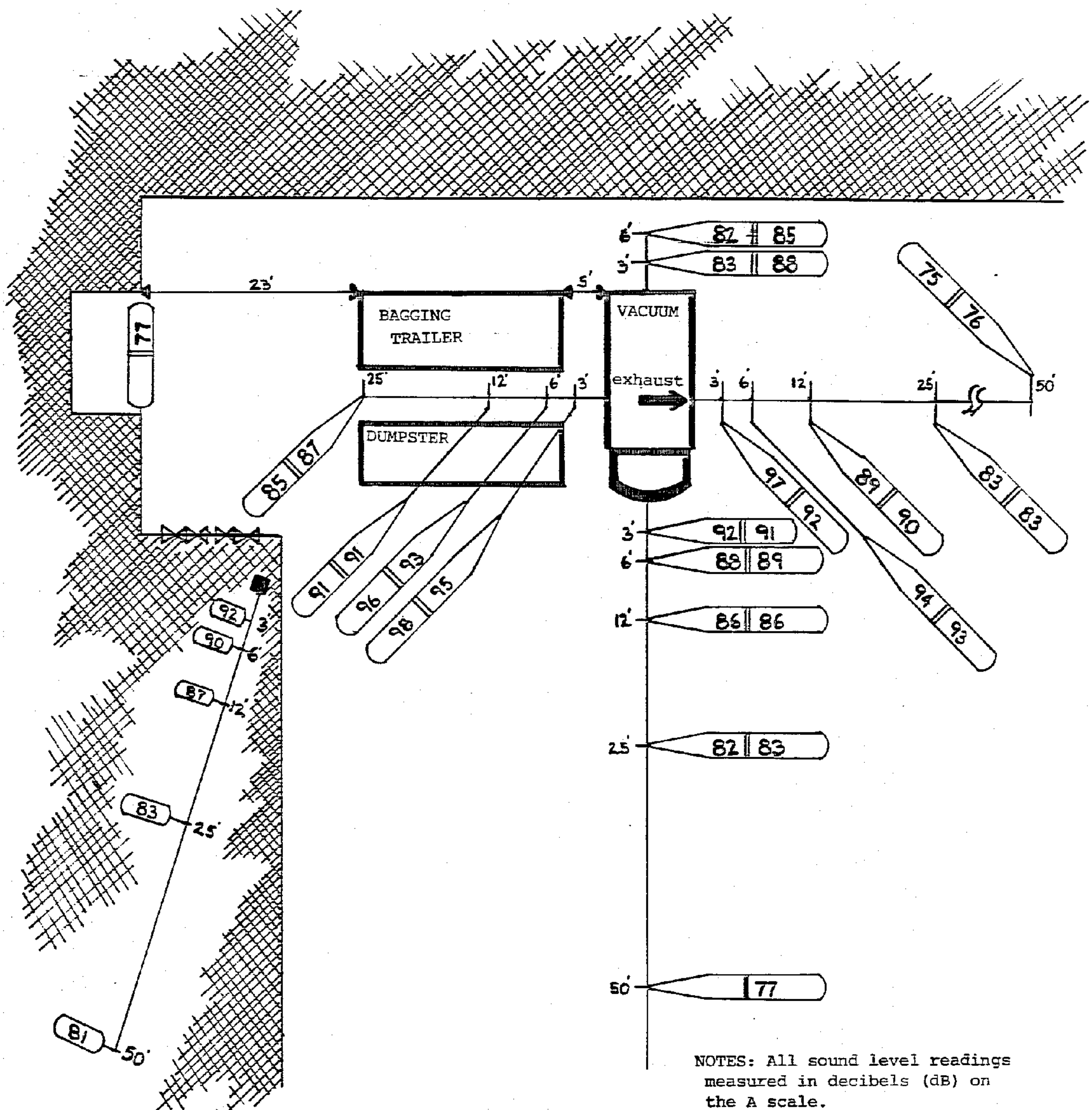
SUBPART 16.1 VACUUM TRUCK LEVELS

As the vacuum system runs continuously throughout this removal, an 8 hour exposure is a continuous dose. The positioning of the vehicle relative to the reflection caused by the large metal dumpster and the metal packaging unit is responsible for the different levels measured (see sketch). As levels of 96 - 98 dBA were not uncommon immediately adjacent to the vacuum truck, any employee whose task required his presence in that zone for a total of 3.0 hours in any 8 hour shift, would have a problem. As indicated in OSHA Regulation 1910.95, the Permissible Noise Exposures are presented as a function of duration exposure vs. sound level. Following please find these levels:

OSHA Regulation 1910.95

Table G-16, Permissible Noise Exposures

Duration Per Day Hours	Sound Level dBA, Slow Response
8	90
6	92
4	95
3	97
2	100



NOTES: All sound level readings measured in decibels (dB) on the A scale.

LEGEND

- 80 | — Sound level readings taken 7/14
- | 80 — Sound level readings taken 7/16
- (80) Sound level readings taken 7/16 inside bldg.
- 3' 6' 12' Distance
- ■ Compressor for supplied air (inside bldg.)
- ⋈ Glass doors
- School building

NOISE SURVEY
COMMERCIAL VACUUM SYSTEM
KASELAAN & D'ANGELO ASSOCIATES, INC. HADDONFIELD, NEW JERSEY
DRW BY VK · JOB NO. 2057-1 · SHEET 1 OF 1
CHK BY WCD'A · SCALE: AS NOTED

It can be concluded that any worker whose job task requires his presence in any zone displaying levels of 90 dBA or greater is capable of violation of the permissible exposure. This situation exists for the superintendent for DVS, and it should be noted, this employee did utilize noise reducing protection equipment.

The potential problem arises with the effects of the noise levels on the general public or those uninvolved personnel whose work or living environment is adjacent to the vacuum truck or compressor. As levels of 90 dBA were detected as far as twenty linear feet from the machine, it is possible that positioning of the truck could cause a noise violation to the general public. It must also be pointed out that the Permissible Levels, as indicated under OSHA, apply to the workplace only. Numerous local ordinances are in effect prohibiting noise levels which are aggravating to the public.

Therefore, not only does a potential worker's hearing problem exist with this equipment, the levels measured indicate a severe problem with positioning and operating this type equipment in noise sensitive areas such as hospital zones or after normal business hours (night shift). It was quite apparent that this noise would have presented quite a problem to instructors in the classroom surrounding the truck had school been in session during this project.

Our recommendation is that mufflers, silencers, noise control enclosures, and operations scheduling be mandated on all uses of the vacuum removal system. In addition, personal protective equipment should be provided by the employer for all workers whose job task requires their presence in the staging area for operation or repair.

PART 17.0 NEGATIVE PRESSURE EFFECTIVENESS

Velocity determinations were conducted at various times on both the intake hose port and the vacuum truck exhaust duct. During these tests, the pressure drop, as measured downstream of the primary filter, was recorded from the magnehelic gauge mounted on the truck. Below please find the results of the duct velocities and volumetric flow rates.

VACUUM SYSTEM

Duct Velocity and Volumetric Flow Rates

Magnehelic	Intake		Exhaust	
(Inches H_2O)	Ft/Sec	ACFM	Ft/Sec	ACFM
10	80.3	948	66.2	780
12	85.8	1,011	70.9	835
28	89.7	1,057	74.5	877
36	102.7	1,210	83.9	988

As measured via Standard Pitot Tube and Inclined Monometer

The velocity determinations accumulated in conjunction with the isokinetic duct sampling indicated slightly lower velocities at 12" H_2O. These are presented below.

Inlet	Run 1	Run 2	Run 3
Duct Gas Velocities (Ft/Sec)	70.9	77.0	76.9
Duct Gas Flow Rate (Standard)*	767	832	826
Duct Gas Flow Rate (Actual)**	835	906	906
Outlet			
Duct Gas Velocities	87.6	91.9	91.5
Duct Gas Flow Rate (Standard)*	891	927	914
Duct Gas Flow Rate (Actual)**	1,030	1,080	1,080

*SCFM, standard temperature and pressure, 70°F, 29.92"Hg, dry
**ACFM,actual temperature and pressure

Therefore, it can be deduced that an average flow rate of 835 ACFM through 1,000 ACFM was occurring on the intake line at the 6" ID and immediately prior to the vacuum unit. When considering the 6" hose was then diverted through various,randomly positioned, "Y" connections and reduced to three separate 3" ID holes, each capable of only approximately 300 ACFM. This estimated flow does not include reduction connections for hose length, connectors, leaks in shutter valves, or bends in the hose due to positioning as is directed in ANSI 29.2-1979. If our calculations included loss, as a fraction of velocity, for type opening, offset elbows due to bending, or the branch entries discussed above, an even lower velocity can be expected. These losses, as well as the contraction losses, were not computed due to the Contractor's versatility in adding or subtracting hose lengths and fittings as well as the constant repositioning of the hose causing bends. It can only be assumed that, at times, the actual capture velocity at the intake line could be lower.

Assuming a flow rate of 1,000 CFM on the intake line at 6" ID and 300 CFM after friction and configuration losses, at each intake, the system's capability is low.

The most desirable exhaust system would be capable of exchanging all internal air at a rate of once every 15 minutes. A system capable of achieving this throughout the designated work area would produce a significant negative pressure if all exhaust air is discharged outside the barriers, as is the case with the vacuum system. Therefore, a room with a floor surface at 200 ft^2 and a 10' ceiling would account for 2,000 cubic feet in volume. Assuming the desired exchange of once every 15 minutes, air flows of ±135 cfm would be necessary.

It is, therefore, apparent that the vacuum system is considerably more effective in small work areas. This is exemplified in the two sites observed. At Elmwood Park, the work area was broken into many small rooms with low (7 - 8') ceilings. It was also easy for the Contractor to achieve a satisfactory sealing due to the concrete decking. This sealing is important in eliminating gross amounts of external make-up air, allowing for a more complete air exchange. It can be concluded that the vacuum system performed satisfactorily in regard to negative pressure in Elmwood Park. This is reinforced by the fact that few fugitive fibers were detected at the clean side of the decontamination chamber and that after the bulk material was removed, the air became free of airborne fibers quite rapidly.

At the Montville location, conditions were somewhat different. The entire inner rotunda was considered one work area. Even though plastic drapes were hung over the doorways to each individual office, and those offices not affected were supposedly sealed, these barriers were not sufficient in providing the destruction of airflow. Assuming the inner rotunda volume was 12,000 cubic feet, a flow rate of 800 cfm would be necessary to achieve the once every 15 minute interval. Therefore, the vacuum system would have been acceptable had the area been properly sealed. In actuality, the "barrier" between the inner offices and the outer rotunda was ineffective, allowing considerable make-up air from the rotunda. This, along with the fact that scraping procedures produced numerous holes through the substrate and wire lath altogether, allowed for incomplete sealing and ineffective vacuum evacuation. This is exemplified in the gross visible dusts in this area and the numerous times re-cleaning was necessary. This concept is further reinforced by our observations and test results in the outer rotunda. The numerous holes through the wire lath and the incomplete sealing of barriers delineating the work area allowed for considerable quantities of make-up air from outside the asbestos removal envelope. This theory was visually observed by conducting air current direction tests using the Draeger Smoke Tubes. The total area of the rotunda and inner offices, coupled with external make-up air made the vacuum system, operating at approximately 1,000 cfm, ineffective.

These observations pertain to the Mobile Containment Systems also, although, these chambers were designed such that the internal capacity of air would be evacuated approximately once every .5 minutes, there was not airtight seals at the interface with the ceiling or at the workers' access opening. This is demonstrated by the high concentrations of visible airborne particulates as well as test data achieved on workers during scraping. This is exemplified by the detection of fibers outside of barriers as well as requirements for three final cleaning operations. Had the vacuum been successful, the problem with airborne particulates settling out on three occasions would not have occurred.

PART 18.0 PACKAGING UNIT VS. CONVENTIONAL METHODS

The incorporation of the external self-contained packaging unit was an attempt to eliminate a handling step of the waste material. Theoretically, these would be a substantial reduction in labor costs as only one employee would be needed to complete packaging of the material.

In the conventional asbestos removal project, the waste material is allowed to fall to the floor where workers manually collect the bulk and fill bags and/or drums. These containers are then carefully removed from the work area through the decontamination chamber where the exterior is first cleaned of fibers. The bags/drums are then manually loaded into a 20 or 30 cubic yard dumpster until being removed to the landfill.

It is our observation that the advantages of the conventional method outweigh the use of the external packaging unit or the related auger off-loading systems seen on various vacuum systems. This is confirmed with the following observation:

1. In the conventional method, the bulk material is handled only once. The labor extended in collecting the bulk material on the floor and loading into bags is equal to the labor necessary to either vacuum the material or compile the material for vacuum removal.

2. The labor necessary for workers to manually relocate the bags from the work area to the dumpster is equal to the labor necessary outside in moving the bags from the packaging unit to the dumpster.

3. In the conventional method, all loading and handling is conducted in the work area which is a known contaminated area. The packaging unit has been identified as a primary source of ambient air contamination either due to ineffective sealing or the need for the worker to continuously abandon the work station due to heat or to remove bags.

4. Costs for design, fabrication, maintenance, and power supply necessary to operate an external packaging system outweigh equipment and labor costs needed in the conventional method.

The most apparent area of concern is the potential for gross contamination of the ambient environment due to the movement of the bulk material out of the work area, uncontained. As stated, the vacuum truck and packaging unit proved sources of contamination in excess of ambient levels as per TEM analysis. The fact that bulk materials are being passed through temporary hose connections into and out of various components at the vacuum system leads to the possibility of a sever in connections and asbestos fibers being "pumped" into the atmosphere. Even the most sophisticated of final exhaust filtration would be irrelevant should leaks develop on components of the system under positive pressure.

PART 19.0 AIRBORNE CONCENTRATION COMPARISONS

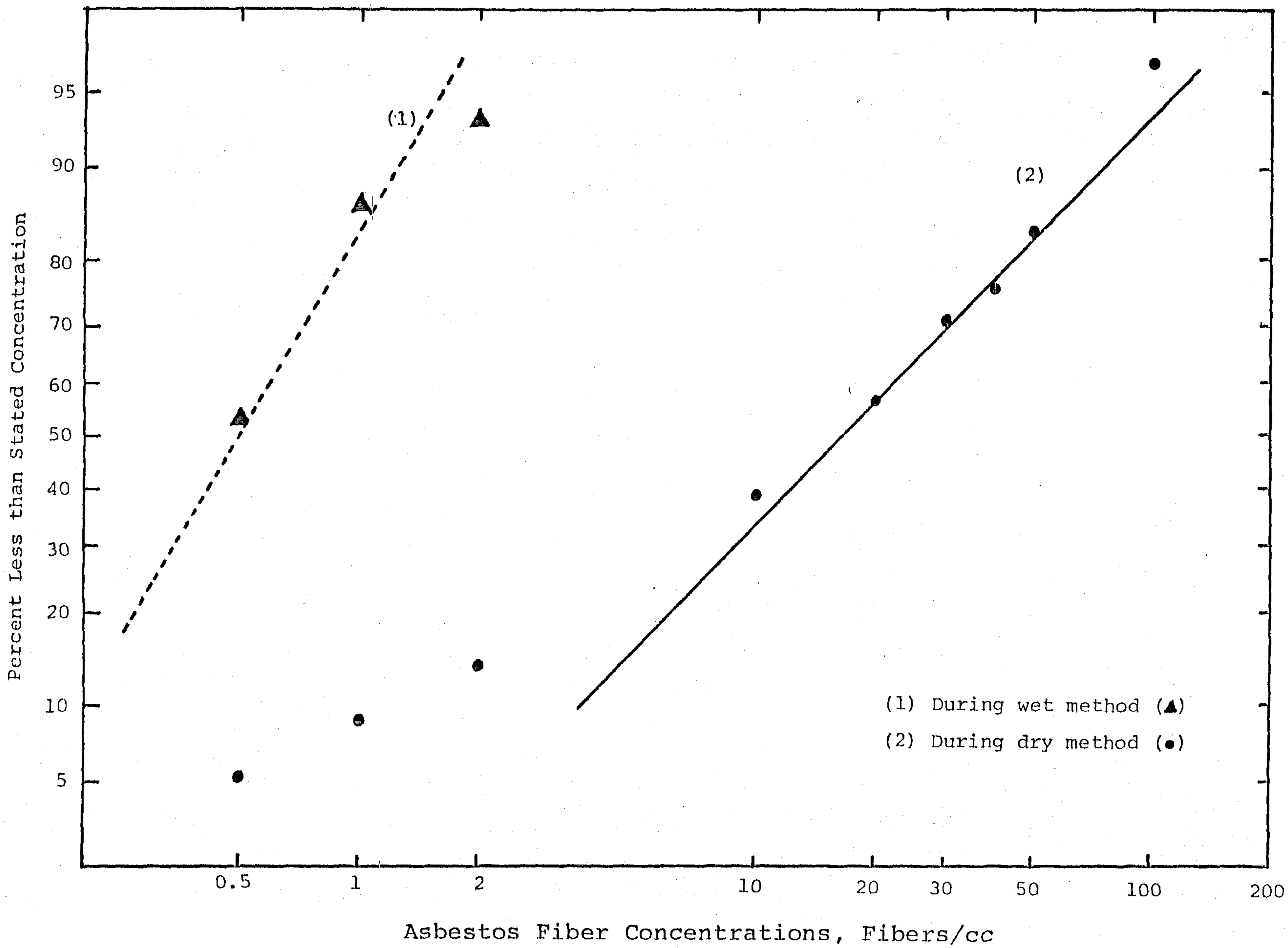
As discussed in the introductory sections of this report, airborne concentrations during wet asbestos removal were not obtained during the course of this study.

Kaselaan & D'Angelo has conducted air sampling and analysis on numerous asbestos removal projects. From our files, data has been compiled which most accurately represents airborne concentrations obtained in and around wet and dry asbestos removal projects. Projects with bulk material and conditions which most accurately match those encountered in Elmwood Park and Montville have been chosen. All data presented has been obtained via Phase Contrast Microscopy analysis. Various project results are presented below for comparison purposes.

		Airborne Concentration			
		Work Area		Outside Barriers	
Project Description	Wet/Dry	Avg.	Ceiling	Avg.	Ceiling
Material Type: Fluffy, Blown-On					
Lippman Hall	D	7.65	29.2	.068	.506
Lakehurst	W	.985	2.44	.018	.05
Material Type: Cementious, Trowel-On					
Woodstown	W	.10	.265	.03	.151
Salem	W	.12	.438	.010	.025
Atco	W	.240	1.35	.003	.017
Yavneh	W	.17	.95	.012	.051
Deptford	W	.23	.50	.017	.075

All Sampling and Analysis Conducted by Kaselaan & D'Angelo via Phase Contrast Microscopy, NIOSH No. 239.

In addition, a study has been conducted by Clayton Environmental Consultants of Southfield, Michigan concerning the exposure of workers during renovation involving asbestos in fireproofing insulation materials sprayed on ceilings. The study was conducted investigating eleven buildings where renovation activities were taking place along with three locations where removal was taking place. The results of their study revealed airborne concentrations of .5 through 2.0 fibers/cc during wet method operations and levels averaging 16.4 fibers/cc during dry removal operations. Concentrations reported were detected utilizing NIOSH Method No. 239 sampling procedures with Phase Contrast Microscopy analytical techniques. As was the case in both sites observed in our study, the type asbestos in the Clayton project was Chrysotile.



Asbestos Fiber Concentrations during Removal of Sprayed Fireproofing Materials.

SOURCE: FOOTNOTE 9.

In relation to the values obtained during this study, the following observations can be made:

1. The vacuum system was effective in reducing workers' exposure levels in relation to dry removal operations without vacuum exhaust as exhibited.

2. The vacuum system was ineffective in reducing workers' exposure levels when compared to those commonly encountered during "conventional" wet removal operations.

SECTION III FINAL ANALYSIS

PART 20.0 - 21.0

PART 20.0 COST EFFECTIVE ANALYSIS

To properly conduct an evaluation of the vacuum system, economic considerations must be considered.

There exists expenditure which would be required under both procedures (vacuum vs. conventional) and these can be eliminated from consideration:

1. Tyvec disposable coveralls, eye protection, etc.
2. Dust Masks
3. Plastic sheeting and duct tape
4. Miscellaneous Hardware, lumber, and scaffolding
5. Medical examination cost
6. Project travel expenses

Specialized Equipment

There also exists items which are peculiar to the vacuum system only, which cause a substantial increase in original capital outlay of a vacuum removal contractural firm. These items would be:

1. Vacuum truck purchase/modification
2. Vacuum truck maintenance and repair
3. Packing unit purchase/fabrication
4. Supplied air respirator system
5. Air compressor purchase and maintenance
6. Power/Fuel consumption for operation

Therefore, based on the estimated costs present below, it is apparent that the vacuum system procedure is substantially more expensive considering specialized equipment.

	Procedure	
Item	Vacuum	Conventional
Vacuum Source	$120,000	N/A
Air Filtration Units	3,000	$ 7,200
Portable Vacuum Cleaner	N/A	8,500
Supplied Air Respirators	4,000	N/A
Air Purifying Respirators	N/A	2,800
Air Compressor	3,900	N/A
Total	$130,900	$18,500

Costs presented above are based on specialized equipment/supplies necessary to equip eight (8) workers in attempting projects of the size of our study. It is quite apparent that capital outlay involved in conducting vacuum system asbestos removal grossly outweighs that required in establishing a conventional removal operation. It is understood that there could exist increased tax advantages and depreciation incentives which might offset capital outlay costs, and these are not considered in our evaluation. The costs estimated for conventional removal operations above includes the preliminary purchase of two (2) portable HEPA air filtration units and two (2) large capacity, HEPA equipped, industrial vacuum cleaners.

SUBPART 20.1 COST COMPARISONS

Elmwood Park Municipal Building

The vacuum removal contractor has reported his actual costs for each site on his invoice forms submitted the the State of New Jersey, Department of Health. These costs are presented following:

Elmwood Park Municipal Building

Personnel	\$ 7,575.85
Travel Expense	1,100.00
Supplies	5,238.53
Vacuum - DAS-10 Rental	14,000.00
Packaging Unit Rental	9,100.00
Air Compressor Rental	2,450.00
ASB Storage and Waste Containers	2,940.00
Portable Vacuums	990.00
	\$42,894.38

Therefore, a square footage unit price could be extrapolated out to \$4.29 per square foot of material. This unit price is competitive with what the industry is experiencing at this time. Conventional asbestos removal contractors commonly charge between \$4.00 and \$6.00 per square foot depending on conditions peculiar to the project and current market conditions, as well as geographic location.

The unit price of \$4.29 as exhibited by Diversified Vacuum Systems is somewhat deceiving. The invoice indicates labor costs at \$7,575.85 including supervision. Further discussion with the accounting department of DVS revealed a total of 1,100 man hours were expended. At the total labor cost reported, the average hourly rate would be computed at \$6.89 per hour. This is obviously inaccurate as supervisor's rates are normally at \$12.50 per hour or more. Our observations indicated the duration of the project to be at twelve (12) days. It can, therefore, be assumed that if supervisory labor at eight (8) hours per day was removed, a more accurate total labor determination would be 1,004 hours. Therefore, supervisory labor can be assumed at \$1,200.00 for the project which, when subtracted out, leaves \$6,375.85 for workers' labor. Extrapolating this cost against total labor hours, a pay rate of approximately \$6.35 per hour can be assumed for the workers.

As previously discussed, the use of a temporary labor force allowed DVS to escape with this low labor rate. The prevailing wage most commonly applied to a common laborer in the building trades is presently $10.60 per hour. It is not uncommon for local labor union pressure, Federal project prevailing rates, or insulation worker rates at $17.30 per hour be paid to asbestos removal laborers.

Therefore, in evaluating the total costs of labor vs. conventional methods in a realistic sense more accurate labor costs should have been at:

Normal Prevailing Wages

Supervisor Labor --------------------	$ 1,200.00
Workers' Labor @ $10.60/hr.----------	10,642.40
	$11,842.40

Federal Prevailing Wages

Supervisor Labor --------------------	$ 1,200.00
Workers' Labor @ $17.30/hr.----------	17,369.20
	$18,569.20

Using these labor rates, total contract costs would be more accurately computed at $47,160.93 and $53,887.73 with respective square footage prices being raised to $4.72 and $5.40.

When comparing man hours and labor rates actually expended on this project vs. what might have been expected had the asbestos removal been conducted under conventional methods, the vacuum system appears more expensive. Using production rates expressed below, a labor cost using conventional methods can be computed.

Asbestos Removal:	250 ft^2/day per man
Wire Brushing:	400 ft^2/day
Final Cleaning:	1,100 ft^2/day

At these production rates, a total of approximately 75 man days or 600 man hours would have been necessary for laborers to execute the project. An additional 72 man hours should be included for work area preparation and an additional 24 man hours for de-mobilization, bringing the total to 696 man hours.

Allowing the same twelve (12) days for execution, supervisory labor would be at 96 hours. Therefore, costs could be computed as follows if conventional methods were used:

Normal Prevailing Wages

Supervisor Labor (96 hrs. @ $12.50/hr.)	$1,200.00
Workers' Labor (696 hrs. @ $10.60/hr.)	7,377.60
	$8,577.60

Federal Prevailing Wages

Supervisor Labor (96 hrs. @$12.50/hr.)	$ 1,200.00
Workers' Labor (696 hrs. @ $17.30/hr.)	12,040.80
	$13,240.80

These labor costs are in excess of the labor paid by DVS only because of the temporary labor force hired for this project. Had DVS paid at either the general construction prevailing wage rate for laborers or the Federal project prevailing wage rate, the labor costs would have substantially exceeded those anticipated under conventional methods.

Montville High School

At the Montville High School, the situation is essentially the same. The vacuum removal contractor reported total costs as follows:

Personnel	$13,799.50
Travel Expense	1,650.00
Supplies	7,672.38
Vacuum Rental	20,000.00
Packaging Unit Rental	13,000.00
Air Compressor Rental	3,500.00
ASB Storage and Waste Containers	4,200.00
Portable Vacuums	700.00
Scaffold Supplies	6,179.50
	$70,681.38

Unit prices would, therefore, be at $7.01 per square foot of material. This unit price is slightly higher than what the industry is experiencing at this time. As was previously discussed, this unit price is believed biased low due to the lower pay rates associated with the temporary labor force. DVS has offered information indicating total man hours expended at 1,300. These numbers conflict with what was reported at Elmwood Park when compared to the invoices submitted by DVS. According to their figures, an average hourly rate of $6.89 was paid at Elmwood Park as opposed to $10.62 average per hour at Montville.

Our observations indicated the project duration was a total of fifteen (15) days. As was discussed in the Elmwood Park evaluation, more realistic labor costs for the Montville site using quantities supplied by DVS should have been:

Normal Prevailing Wages

Supervisor Labor (120 hours @$12.50/hr.)	$ 1,500.00
Workers' Labor (1,180 hrs. @$10.60/hr.)	12,508.00
	$14,008.00

Federal Prevailing Wages

Supervisor Labor (120 hours @$12.50/hr.)	$ 1,500.00
Workers' Labor (1,180 hours @$17.30/hr.)	20,414.00
	$21,914.00

Using these labor rates, total contract costs would be escalated to $70,889.88 and $78,795.88 with respective square footage prices being raised to $7.09 and $7.88.

Using production rates expressed below, a labor cost using conventional methods can be hypothetically computed.

Asbestos Removal:	200 ft^2/day
Wire Brushing:	300 ft2/day
Final Cleaning :	1,000 ft^2/day

At these production rates, a total of approximately 93 man days or 744 man hours would have been necessary for laborers to execute the work. An additional 72 man hours should be included for work area preparation and an additional 24 man hours for final demobilization, raising the total to 840.

Allowing the same fifteen (15) days for execution, supervisory labor would be at 120 hours. Therefore, costs could be computed as follows, had conventional methods been utilized.

Normal Prevailing Wages

Supervisor Labor (120 hours @$12.50/hr.)	$ 1,500.00
Workers' Labor (840 hours @$10.60/hr.)	8,904.00
	$10,404.00

Federal Prevailing Wages

Supervisor Labor (120 hours @$12.50/hr.)	$ 1,500.00
Workers' Labor (840 hours @$17.30/hr.)	14,532.00
	$16,032.00

It can be deduced that, had conventional methods been employed at Montville High School, labor costs at either wage, would have been lower.

The following conclusions can, therefore, be drawn:

1. Capital outlay costs of the vacuum system grossly outweigh capital outlay necessary for a firm entering the conventional asbestos removal trade.

2. Equipment maintenance, upkeep, and repair costs on the extensive sophisticated equipment associated with the vacuum system outweigh maintenance cost associated with conventional operations.

3. There existed no apparent labor reduction and relative labor cost savings associated with the vacuum system.

4. Estimated labor costs to complete the project under conventional methods are substantially lower than labor expended by the removal contractor on this experimental study.

5. There exists certain costs associated with asbestos removal that are common to both the conventional and vaccum system, such as: wetting agent, safety supplies, disposable

coveralls, plastic sheeting, container storage, and dump costs, etc.

6. Increased labor costs can be attributed to substantial "down time" associated with the malfunction or the potential for malfunction of the more sophisticated equipment associated with the vacuum system.

This theory was exemplified in our observation of this experimental project. At the on-set of Elmwood Park, substantial production time was lost due to the malfunction of the supplied air system. Again, at Montville, down time was attributed to problems with the vacuum truck when foreign objects were drawn in and damaged the primary filters.

PART 21.0 CONCLUSIONS AND RECOMMENDATIONS

An overall evaluation of the vacuum system, as presented in various preceeding sections, must be established after careful review of the complex interaction of all concepts observed. It would be inaccurate to judge or comment on the effectiveness and safety of the system utilizing limited data variance. Kaselaan & D'Angelo has attempted to describe all facets of the system, individually, and to now merge the unique testing and appraisal data into some definite statements. At first, a summary of all findings is presented.

1. There existed a definite need to evaluate the possibility of pursuing innovative asbestos removal procedures, methods, and technologies based on the growing concern for: low level exposure effects, new EPA regulations concerning inspection for friable materials, stricter state guidelines and an increasing number of asbestos removal projects being conducted on a country wide level.

2. There existed a need, through varied and more sophisticated test methods, to evaluate the truck mounted vacuum system for asbestos removal as more private enterprises are making the equipment available for contractural arrangements and purchase.

3. Utilizing Phase Contrast Microscopy data only, there existed no serious worker exposure problem throughout the duration of the project, including all possible job tasks at both sites. At no time did airborne concentrations exceed the levels controlled by the type respiratory protection being utilized, as delineated in OSHA Regulation and ANSI Z88.2 1980.

4. Utilizing Phase Contrast Microscopy data, any/all worker exposure problems were a direct result of workers' improper practices; in decontamination or respirator usage.

5. Utilizing Phase Contrast Microscopy Analysis, the vacuum system, including all individual components, does not present an exposure problem to unprotected personnel outside, nor does the system produce contamination to ambient environment.

6. Utilizing the DOP smoke penetration evaluation on the final, HEPA filter, the system effectively achieves filtration efficiency of 99.97% at .3 microns, indicating the exhaust would be clean.

7. Utilizing simultaneous, isokinetic, suspended particulate sampling in the duct intake and final exhaust, the vacuum system, on a whole, achieves filtration efficiency of 99.46% (average).

8. Incorporating TEM and SEM data indicates serious contamination of ambient air and indication of possible worker exposure problems. The majority of levels of airborne asbestos outside of the building, either adjacent to the components of the vacuum system or directly in the final exhaust, revealed significantly higher levels than that detected under optical microscopy. This is also true for limited TEM data collected in known contaminated zones.

9. Use of gravimetric analysis indicated high levels of airborne, inert dust yet the use of the ambient cascade impactor was impractical and aborted.

10. There existed no substantial or obvious labor-saving advantages to the vacuum system as opposed to conventional methods.

11. Various test data and observations indicated the vacuum system was somewhat effective in evacuating airborne particulates in Elmwood Park yet uneffective at Montville High School.

12. Economic evaluations indicate no substantial cost savings utilizing the vacuum system vs. conventional methods.

There existed numerous obvious problems observed in the evaluation as well as identification of sources of serious potential hazards. Specifically, these undesirable qualities are presented below;

1. The concept of drawing the asbestos material, along with high concentrations of airborne particulates, unpackaged, out of the work area presents a possibility of ambient contamination of catastrophic proportions. Should the equipment overload, malfunction, or breech on the positive side, or should final HEPA exhaust filter puncture, asbestos fiber could be literally pumped into the atmosphere.

2. The higher level of technical and sophisticated equipment mandates more extensive training as to proper operation and the increased possibility of down time associated with malfunction.

3. The lack of power interruption or carbon monoxide detection alarms on the supplied air system makes possible serious health and safety problems. Should the supplied air system go down, the contractor made no provisions for safe evacuation from the work area.

The inability of this system to successfully move wet or slurry asbestos material forced the entire operation to be conducted under dry removal conditions. This alone results in the following specific problems:

4. The asbestos material being loaded into bags and drums was completely dry. Should rupture occur in transport, storage, or dumping, airborne asbestos would be maximum.

5. Needed emergency medical assistance in the work area would be delayed until additional supplied air systems could be provided.

6. There existed no emergency or back-up air filtration units should vacuum source malfunction.

7. Historically, our observations have indicated that contractors involved in asbestos removal have continuous problems with securing and maintaining temporary plastic barriers. As was observed in this study, should barriers be breached or faulty, the potential for contamination spreading is increased due to the removal being conducted under dry conditions.

Additional questions raised as to the effectiveness as well as health and safety of the workers would be:

8. The vacuum system makes necessary increased time, labor, and materials to successfully decontaminate the flexible hoses, packaging unit and bulk collection bin of asbestos fibers between projects. These procedures and actions were not monitored or evaluated during this study; therefore, it is unknown what additional monies would be involved as well as potential health risks to workers performing these tasks.

9. The mandated use of supplied air hats was a good precautionary measure; although, the design of the system did not allow workers to keep the units on until they had entered the shower. Respiratory protection was, therefore, removed in the contaminated zone. Secondary dust masks were not provided at all times.

10. The use of temporary, unskilled labor is undesirable for this type work: OSHA required training and/or medical examinations was not apparent.

Negative pressure effectiveness, as observed overall, was ineffective. Problems associated with this concept would be:

11. Contractors' inability to completely seal the work area (specifically, Montville School) along with causing holes through substrate allowing for gross quantities of make-up air.

12. Length of pick-up hose, volumetric flow rate capacity, configuration of pick-up hose as well as volume of air in the work area all contributed to the fact that the vacuum system did not remove airborne particulates as expected.

13. Final wet mopping and clean-up operations, expected to be unnecessary with the vacuum system, were required at the same intensiveness and frequency as observed in conventional procedures.

Final characteristics associated with the vacuum truck, which were found undesirable would be:

14. The large diesel trucks commonly utilized as the power source for vacuum removal operations are a confirmed source of noise, producing levels above OSHA regulations in some areas and prohibiting use of the system in sensitive noise areas, such as night hours in most municipalities or hospital zones.

The final evaluation of the system indicates it as being undesirable. Based on observations presented above the following conclusions can be drawn:

1. The vacuum method appears effective in removing construction materials from a building into a packaged "product" ready for disposal.

2. The vacuum method for dry asbestos removal is unacceptable from a health and safety viewpoint as observed in this study.

    a. Increased risk to workers as compared to conventional wet methods of asbestos removal is evident.

    b. Increased potential for ambient air contamination due to increased handling of the material outside of the buildings exists, along with the possibility of equipment malfunction causing disastrous (gross) contamination of ambient air has been exemplified.

    c. Ineffective final (HEPA) exhaust as per TEM results was indicated by asbestos concentrations in exhaust air and around truck higher than measured ambient levels.

3. The final (HEPA) exhaust system proved to be efficient when utilizing test procedures such as DOP smoke penetration and detection, isokinetic, particulate capture and Phase Contrast Microscopy, yet TEM results indicate asbestos material not removed by final filtration.

4. The use of the Electron Microscope analysis, both SEM and TEM proved essential in accurately determining presence of airborne asbestos fibers.

5. The use of the Instantaneous Fibrous Aerosol Monitor (GCA) proved necessary in monitoring the clean side of temporary barriers during the asbestos removal, allowing for immediate corrective actions or engineering controls to be instituted when needed.

6. It appears that the degree of friability or the releasability of asbestos fibers from the construction material matrix cannot be judged from the visual appearance of the material. Evidence accumulated in this study indicated the size fiber and relation to the degree of mechanical destruction experienced in the original milling of the mineral, play an integral part in the ensuing airborne levels produced by the natural deterioration of the material and that produced during removal activities.

7. The Phase Contrast Microscopy analytical technique proved inferior and insufficient in accurately determining the degree of ambient contamination resulting from the vacuum system. The Scanning Electron Microscopy with X-Ray Spectrophotometry capabilities is the most desirable in counting and identifying particulate and fibrous material on an air sample.

8. The overall cost evaluation of the vacuum system proved more expensive than the conventional methods in equipment costs and equipment operation costs. There existed no cost savings attributed to labor reduction as a result of using a vacuum system.

9. The overall evaluation and observation of all facets of the removal and packaging of asbestos materials via vacuum systems proved undesirable when compared to conventional, manual wet removal operations.

10. The potential for related contamination problems is substantially more evident when the vacuum removal system is utilized.

The following recommendations can be offered:

1. Additional study should be considered of conventional wet removal operations utilizing Transmission Electron Microscopy and Scanning Electron Microscopy.

2. Additional study should be considered on innovative asbestos removal operations using bulk asbestos vacuum systems under wet conditions.

3. Additional study into the constituents, structure, and size of the asbestos fibers found in bulk samples of fireproofing, acoustical, or insulation materials should be considered in the overall decision as to corrective actions. These criteria, along with extensive study utilizing Electron Microscopy, should be conducted on all bulk samples prior to removal operations to aid in anticipation of airborne concentrations during, and after, the removal process.

4. Additional study should be undertaken concerning co-relation between concentrations obtained via the GCA Instantaneous Monitor vs. Phase Contrast Microscopy and Scanning Electron Microscopy.

Although the overall observations of the vacuum system in this report deem the method undesirable, it is our opinion that there exists situations where the system could be used. Our experience in the industry has shown that contractural firms do exist that operate systems believed to be safer than observed in this study. Our experience has allowed us to observe:

1. Removal of wet (slurry) asbestos material via the vacuum truck with no visible emissions or visible dust levels in the work area.

2. The utilization of high flow (2,000 cfm pick-up) vacuum trucks for emergency decontamination clean-up projects where large surface areas needed to be cleaned of microscopic fibers in a short time period.

3. The utilization of oversized and over-rated auxillary HEPA filtration on both the positive and negative side of the vacuum pump.

4. Bulk loading of wet asbestos material and bulk dumping of that material without ambient air contamination as per Phase Contrast Microscopy.

Therefore, although our observations have indicated the vacuum system is more expensive, more time consuming and potentially hazardous, those firms presently operating such systems should not be prohibited from competitive bidding and utilization of their systems provided the following is met:

1. Certification of the final HEPA exhaust as per DOP smoke penetration conducted by an indenpendent engineering firm. Frequency of the testing should be every 1,000 hours and a certified log must be kept.

2. Certification of the absence of asbestiform fibers, of any size, in the final exhaust and around the truck, as conducted by an independent engineering firm utilizing Electron Microscopy.

3. Written guarantees and acceptance of liability for damages which might be incurred should the respective Contractor experience equipment malfunction causing clean area contamination.

4. Vacuum trucks equipped with Electronic Monitoring Devices along with audible warning alarms which would indicate overloading of the primary, secondary, and final filtration systems, such that problems could be avoided.

5. Supplied air compressor systems equipped with power interruption and carbon monoxide detection alarms, along with emergency escape facilities for all workers.

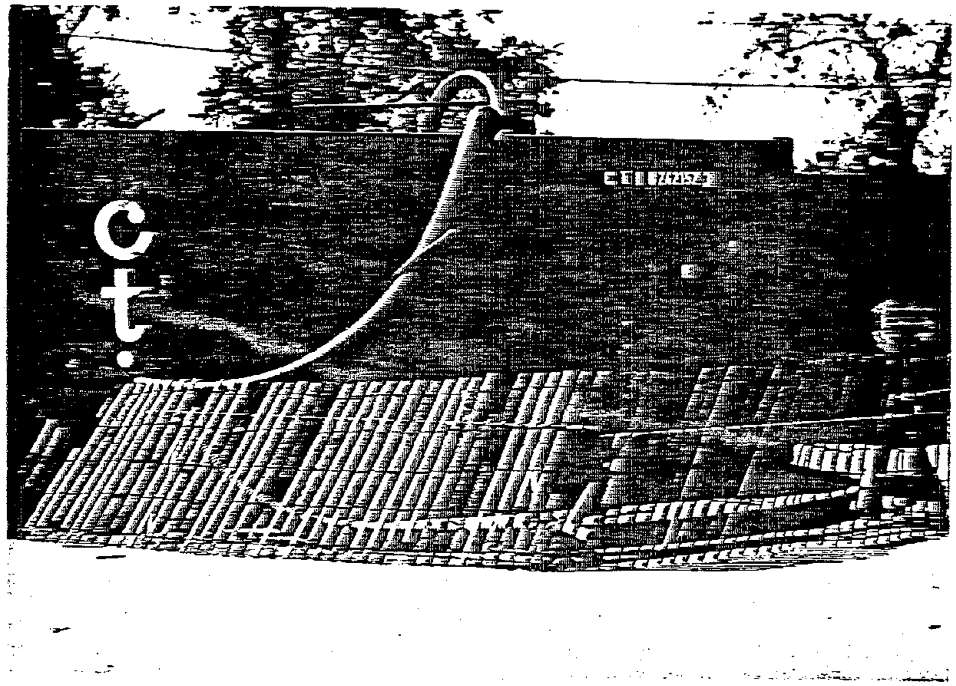
6. Back-up respiratory protection (dust masks) worn at all times, as well as back-up air filtration units and portable vacuum cleaners to correct any problem in the event of vacuum truck malfunction.

Lastly, it is our opinion that with increased technological advancements and the individual innovation displayed by various firms in the industry, a vacuum removal system which is safe, economical and efficient can be developed.

LEGEND OF FIELD PHOTOGRAPHS

Photo # 1	Exterior of self-contained Packaging Unit, Contractor's Staging Area, Elmwood Park.
Photo # 2	Employee access to Packaging Unit. Note utility hoses and flexible duct to vacuum truck.
Photo # 3 & 4	Truck mounted vacuum system, Diversified Vacuum Systems, AS-10, Montville High School.
Photo # 5	Contractor's staging area with vacuum truck, Packaging Unit and waste container.
Photo # 6	Packaging Unit in staging area. Note flexible intake hose to vacuum source.
Photo # 7	Contractor's trailer mounted supplied air compressor, Elmwood Park.
Photo # 8 & 12	Workers scraping and brushing inside Mobile Containment System. Note vacuum intake and supplied air respirators. (Racal)
Photo # 9	Montville High School, workers positioning Mobile Containment Systems inside rotunda area.
Photo # 10	Montville High School, asbestos materials on floors, area extremely dirty. Note walls and floors unprotected.
Photo # 11	Montville High School, Mobile Containment Systems in rotunda area. Note vacuum line and ceiling where scraping has occurred.
Photo # 13	Montville High School, Automatic Abrasion Machine attempting scraping.
Photo # 14	Montville High School, access to work area (personnel). Note large volume air sample collection and warning signs.
Photo # 15	Elmwood Park, access to work area. Note plastic airlocks.
Photo # 16	Elmwood Park, supplied air hats (Bullard & Racal) stored in personnel decontamination chamber.
Photo # 17	Elmwood Park, workers performing final clean-up. Note wet-mopping techniques in addition to vacuum hose. Personnel protection reduced to dust masks.

Photo # 18	Elmwood Park, library work area. Note plastic protection and clean sub-ceiling (concrete deck).
Photo # 19	Montville High School, isokinetic sample collection via RAC equipment via EPA Method No. 5.
Photo # 20	Montville High School, isokinetic sampling probe inserted into PVC sampling port, intake line.
Photo # 21 & 22	Montville High School, isokinetic sampling equipment inserted into PVC extension and sampling port, exhaust line.
Photo # 23	HEPA filter test (DOP) being performed on final filter, truck mounted vacuum system.
Photo # 24	Montville High School, inner office work area. Sub-ceiling after scraping of asbestos. Note holes and damage thru sub-ceiling and plastic protection of heating system failing.



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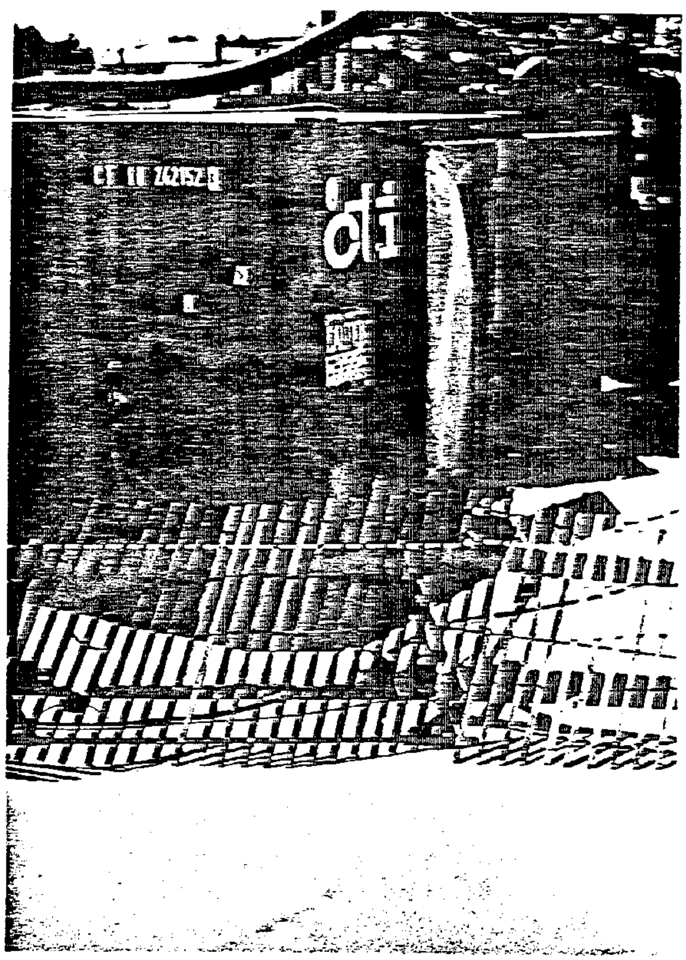

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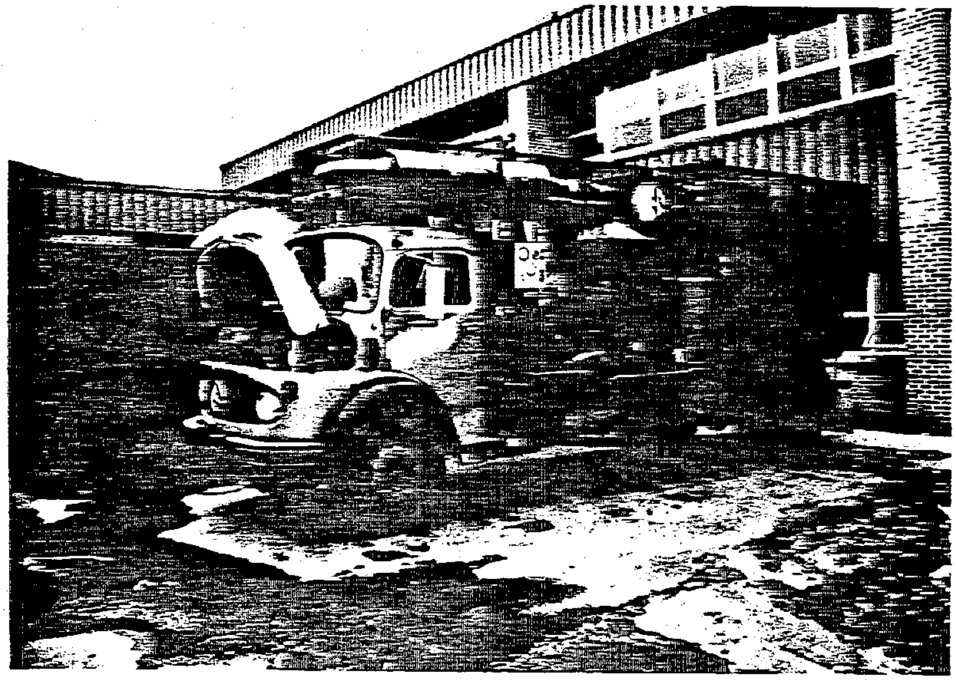

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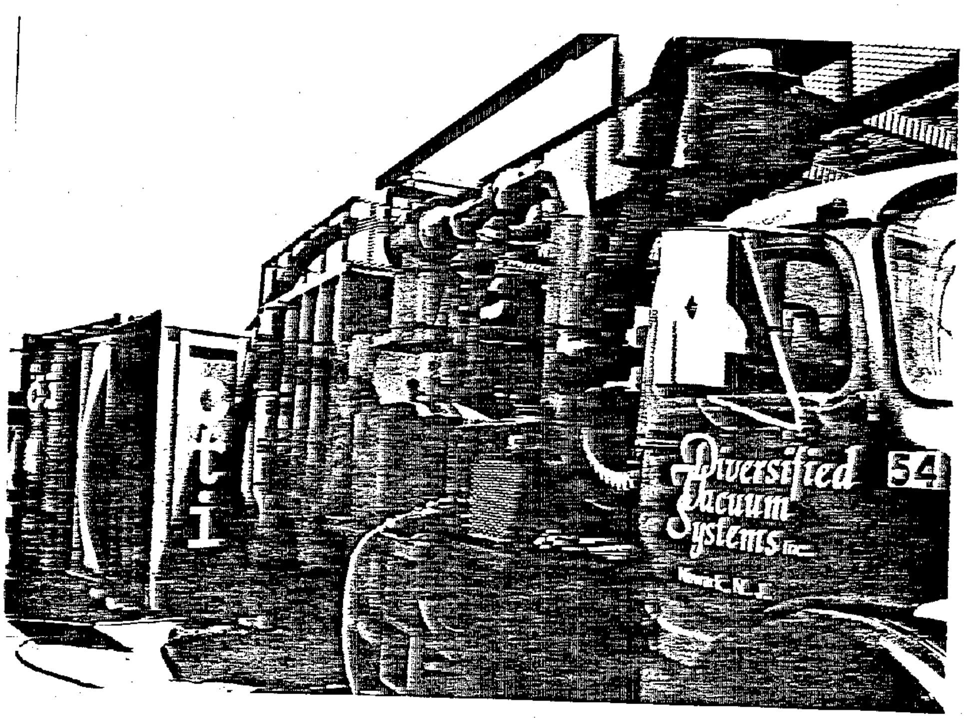

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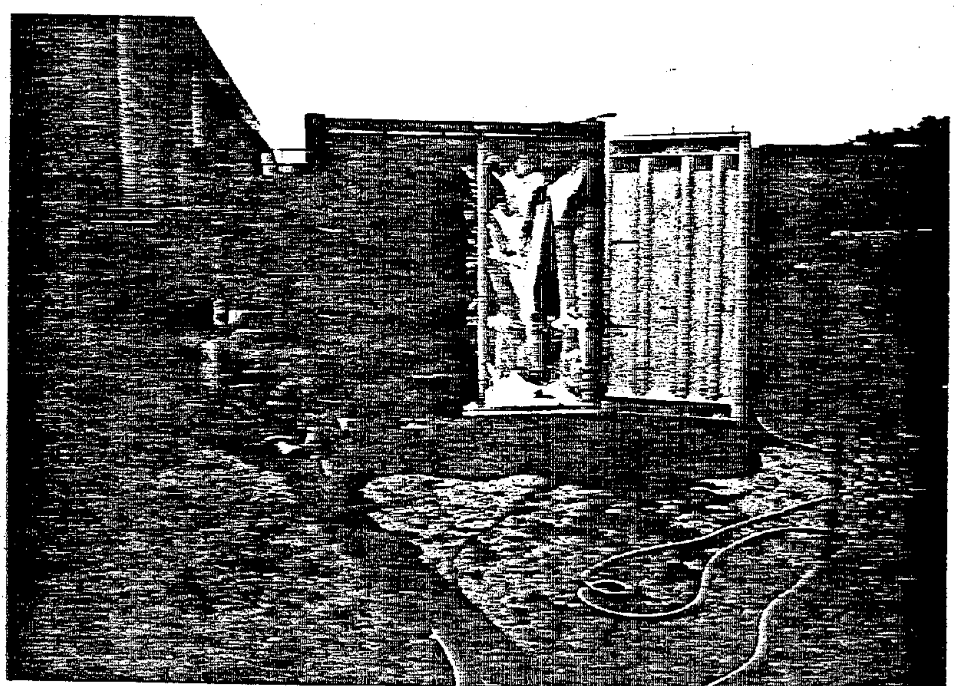

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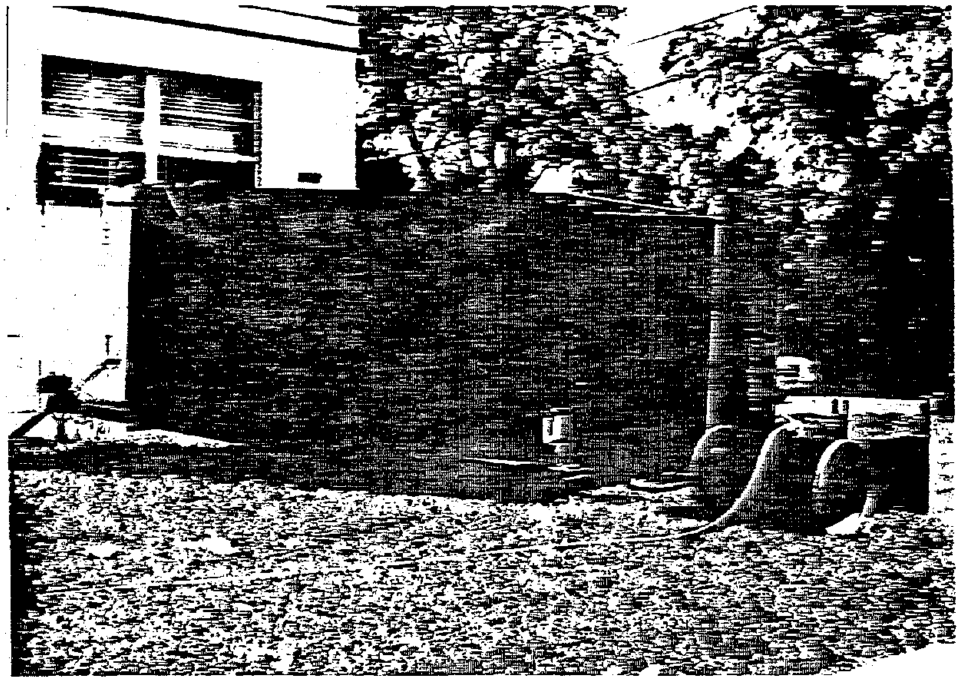

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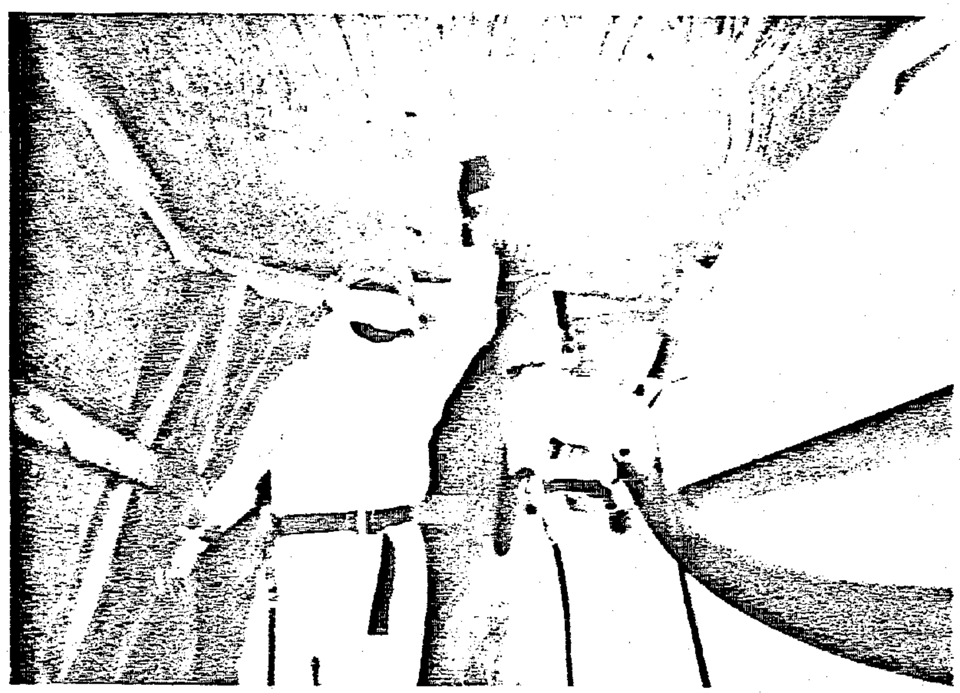

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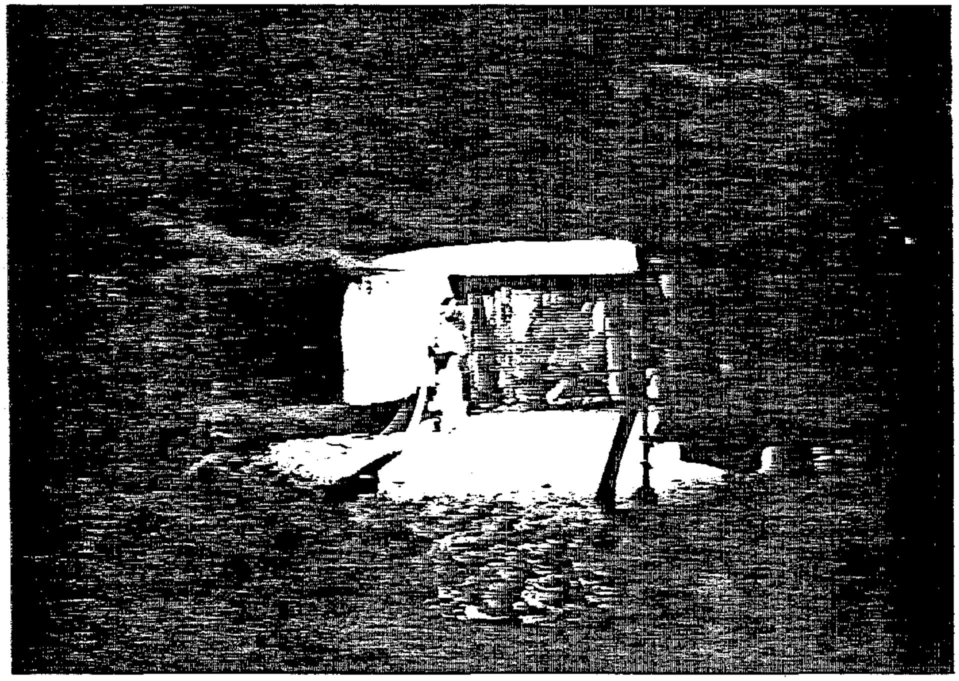

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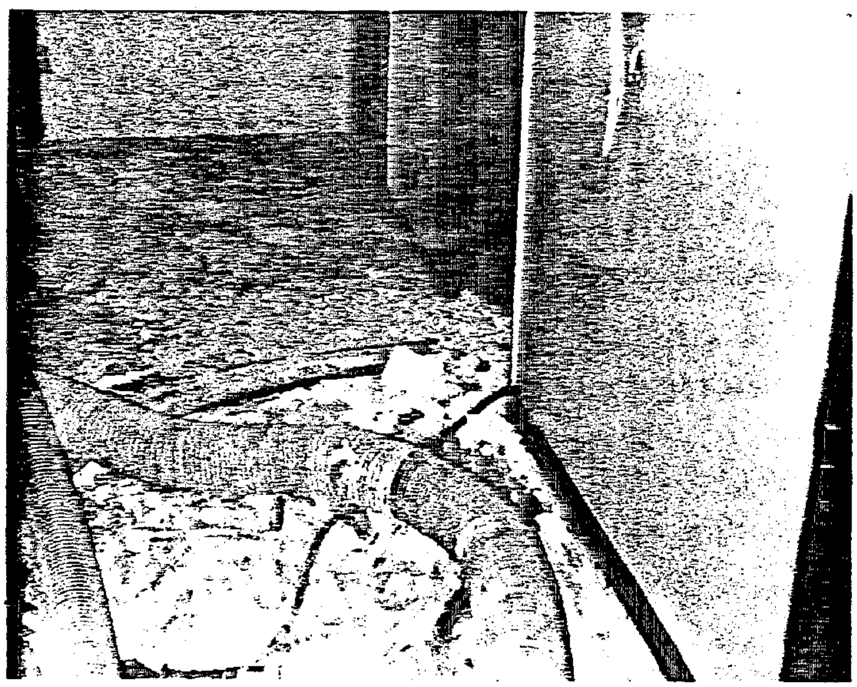

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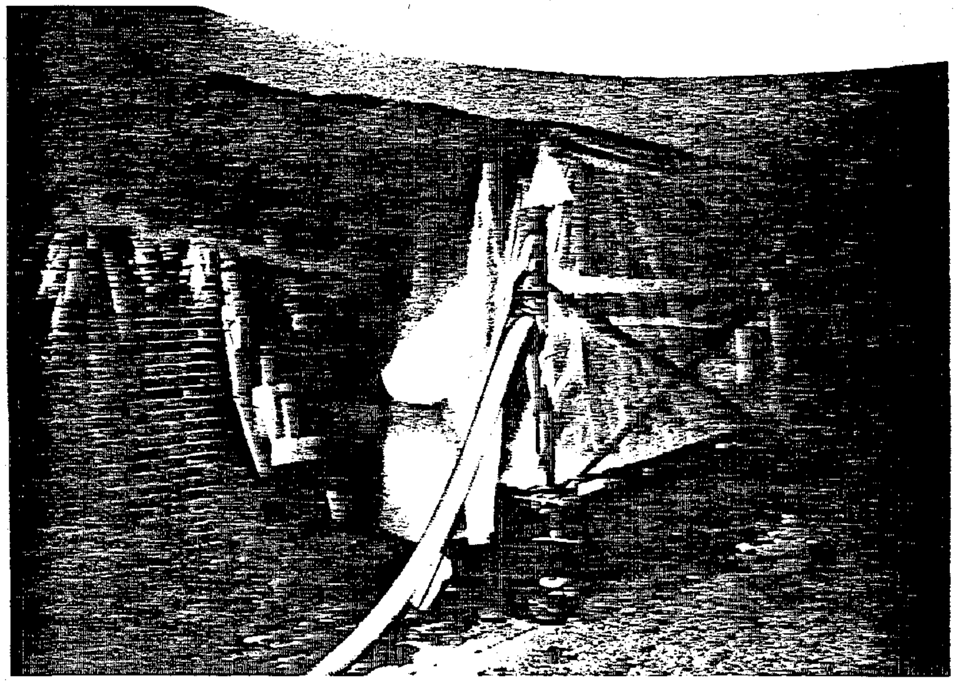

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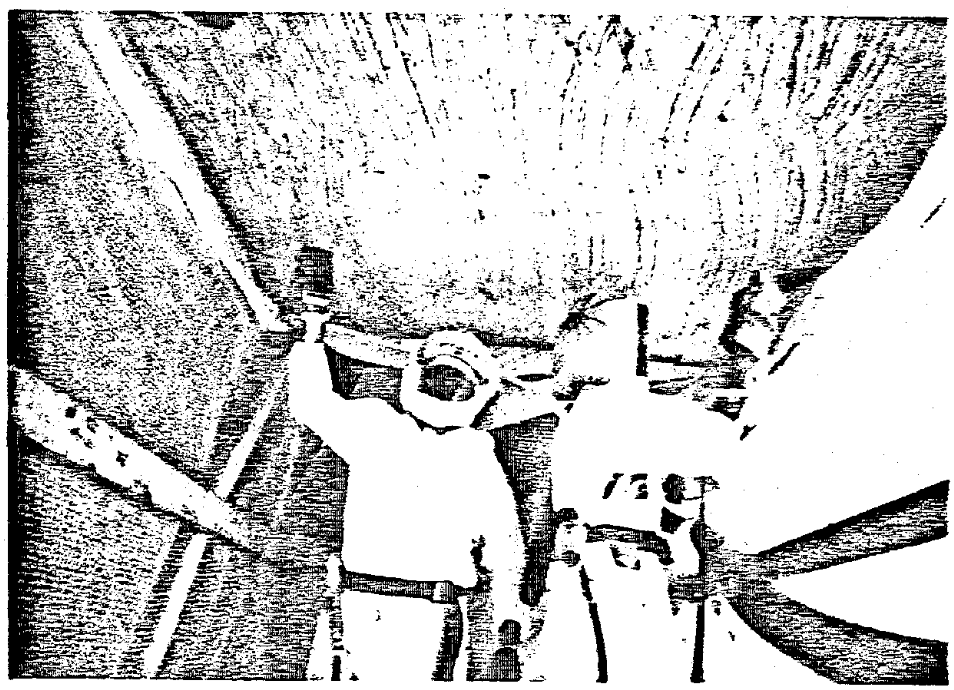

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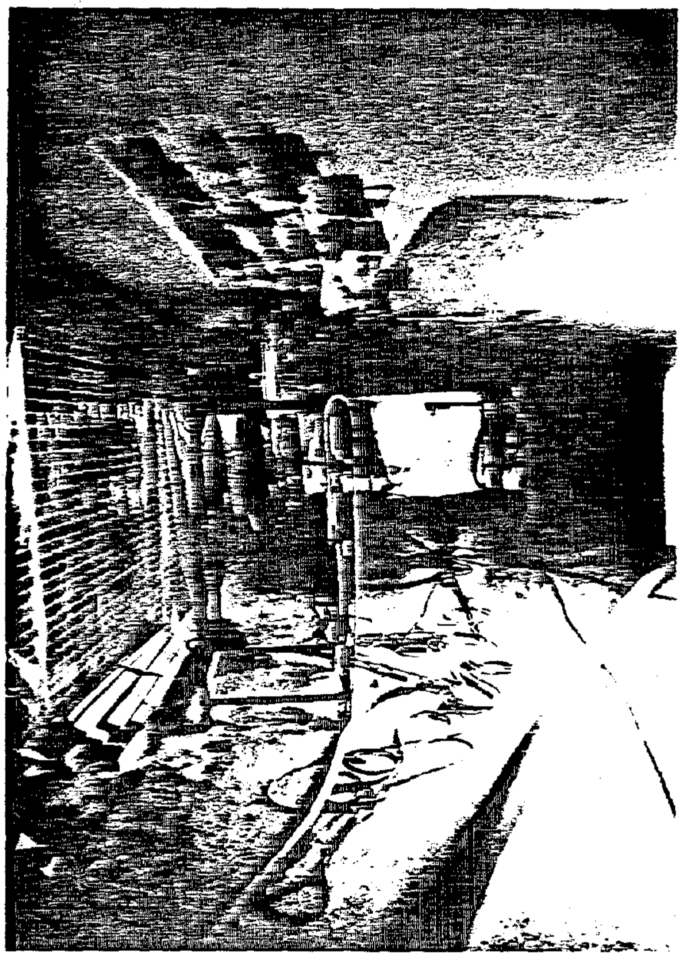

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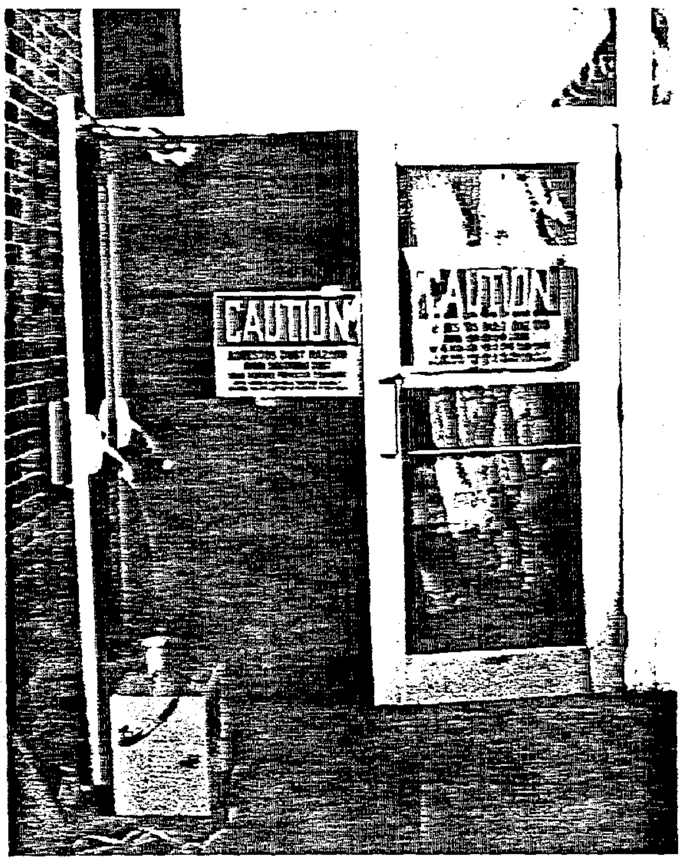

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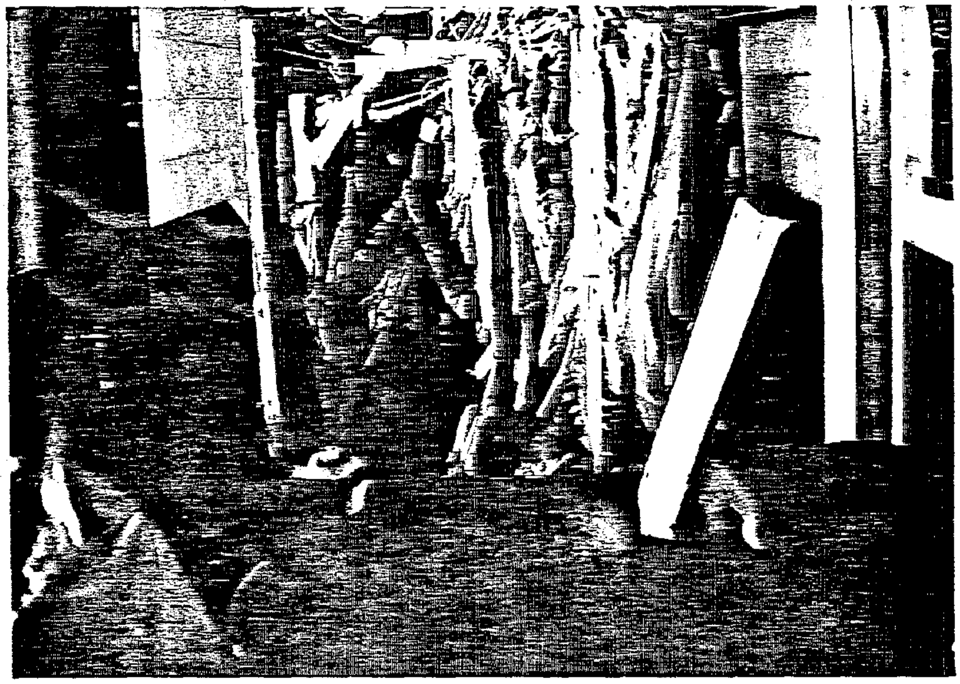

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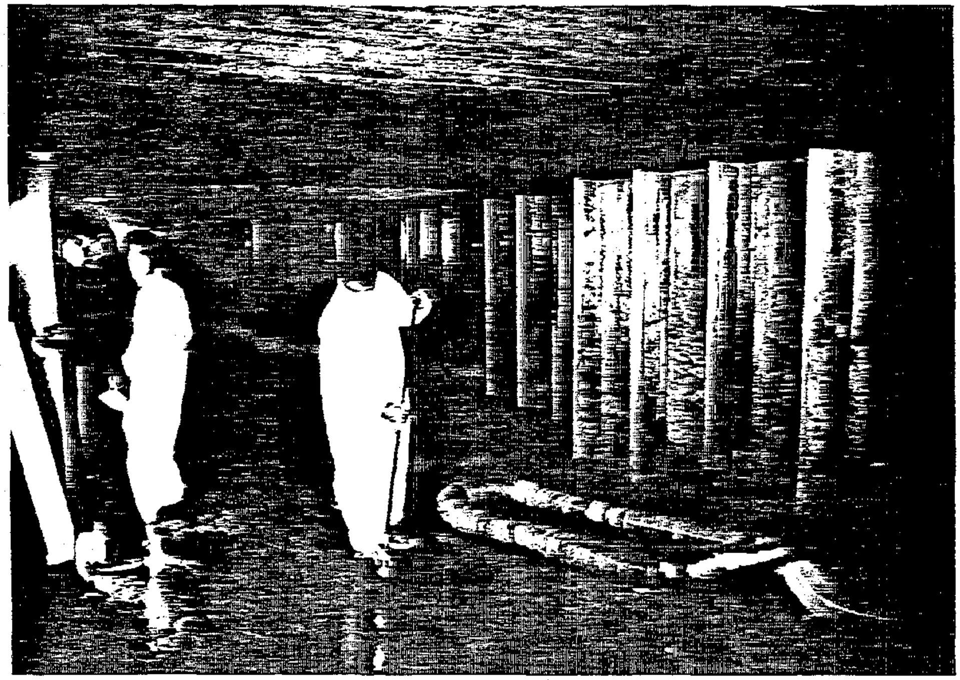

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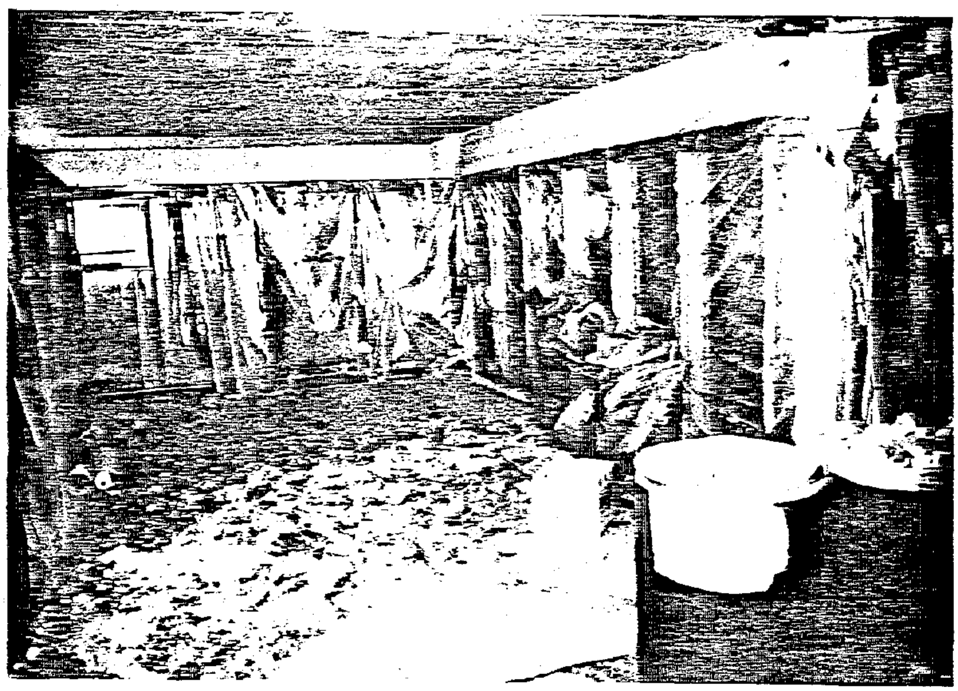

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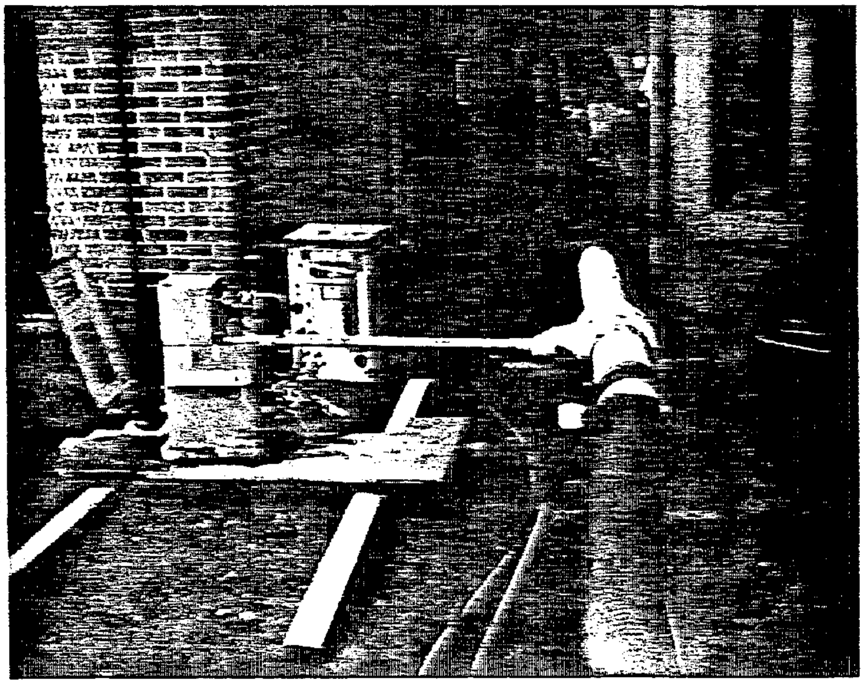

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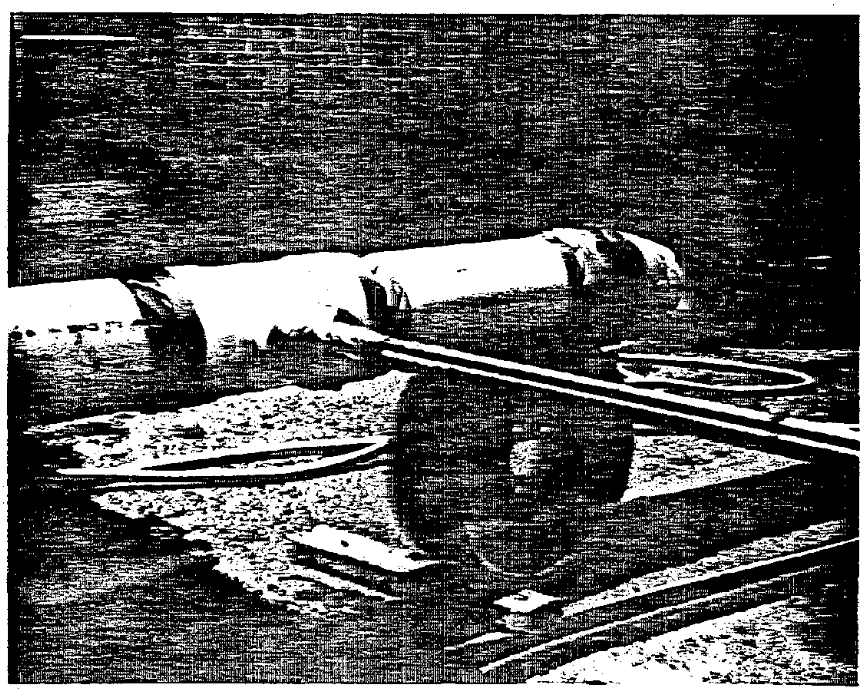

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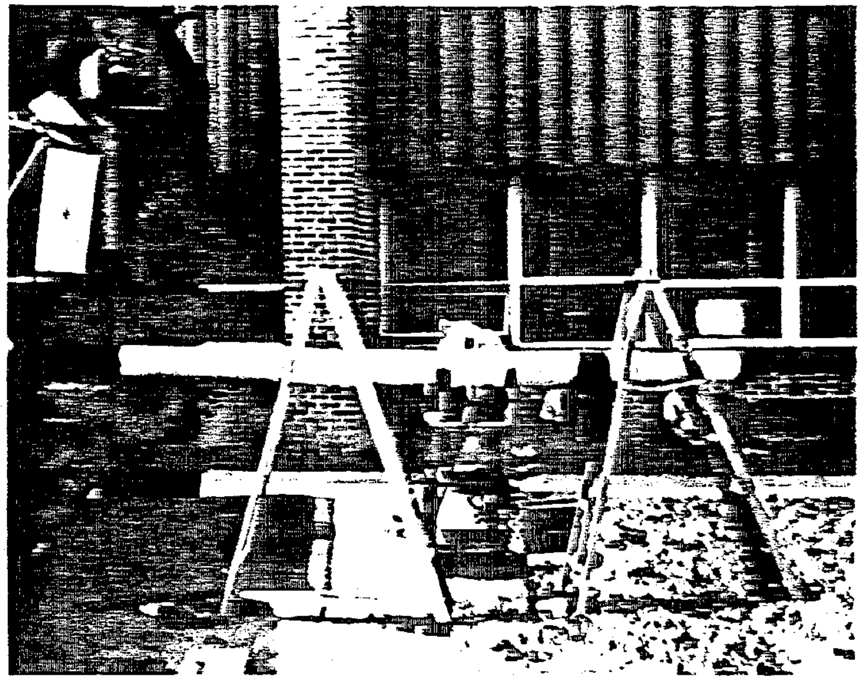

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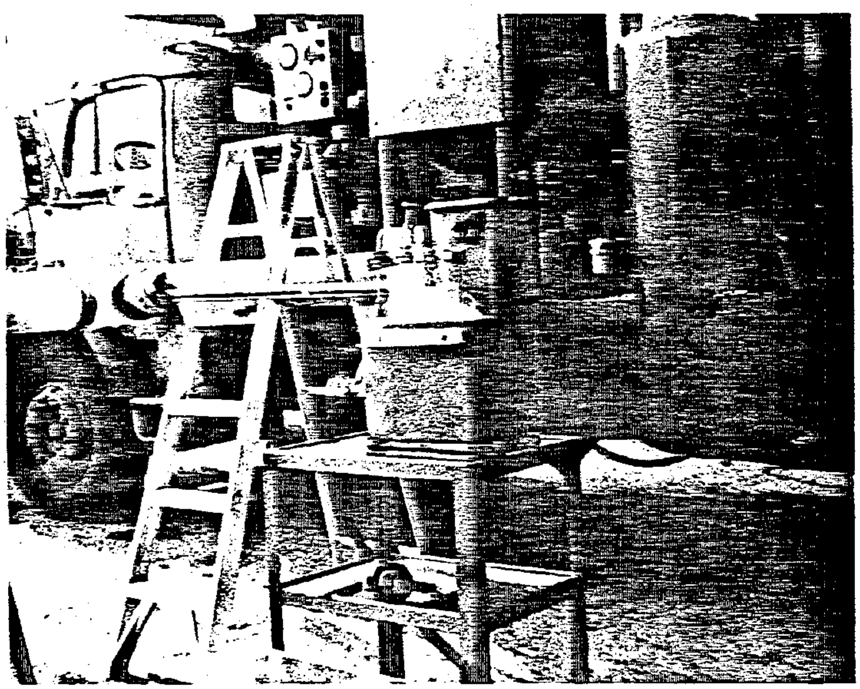

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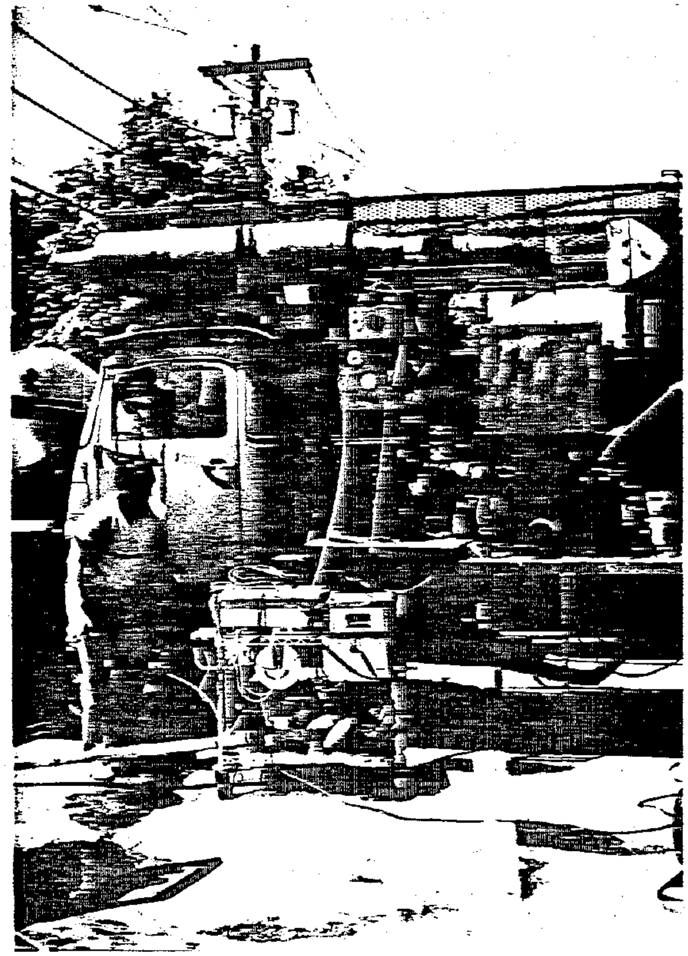

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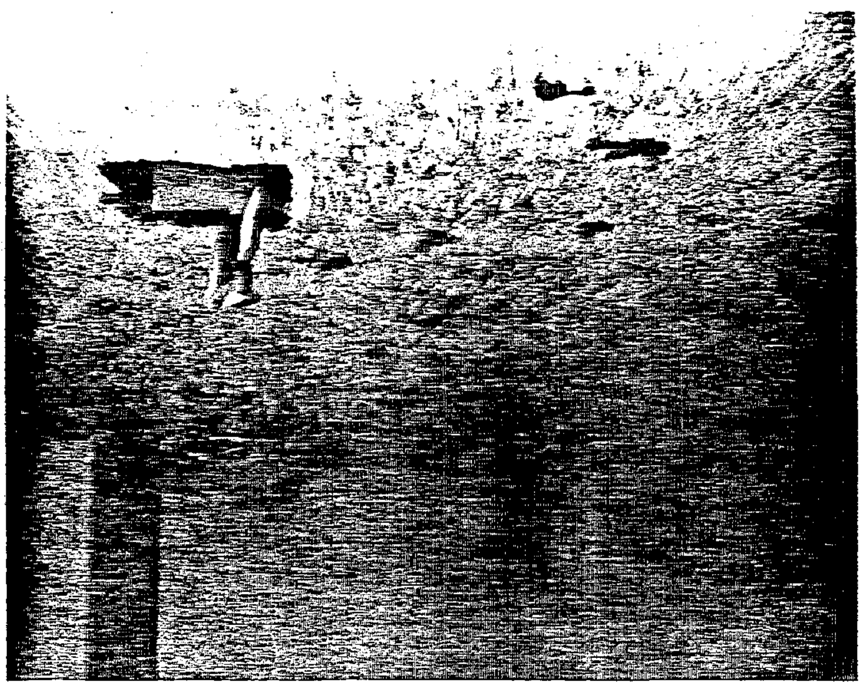

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FOOTNOTES

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APPENDIX A

DESCRIPTION OF VACUUM SYSTEM

ADVANCED
SERVICE SYSTEMS INC.

661 - 671 FRELINGHUYSEN AVENUE
NEWARK, NEW JERSEY 07114
(201) 344-7400

TRUCK MOUNTED VACUUM LOADER

MODEL AS-10

General Description

The Model AS-10 is a truck mounted mobil vacuum loader. The unit utilizes a heavy duty, reinforced vacuum receiving chamber. The vacuum loader truck is capable of vacuuming materials such as; dusts, sludges, slurries, gravel, catalyst and oil spills. Various materials can be air conveyed at distances up to 700'.

Body Assembly

Body construction consists of one, 10 cu. yd., heavy duty reinforced vacuum chamber. Chamber is fabricated from 3/16" steel plate, braced internally and externally with structural channel.

Blower

One heavy duty positive displacement, roots type blower. Consisting of two figure eight impellers, rotating in opposite directions to move entrapped air around the case to the port outlet.

ADVANCED
SERVICE SYSTEMS INC.

651-671 FRELINGHUYSEN AVENUE
NEWARK, NEW JERSEY 07114
(201) 344-2400

Filtration

Primary filtration centrifugal type seperators. 50 micron and larger to 90% efficiency. Secondary filtration, high performance cyclones with spin out and high velocity section. 15 micron and larger to 95% efficiency. Final filtration, dry element 99.50% all particle size 3 micron and larger. Safety element built in to final filtration section.

Special Filtration and Modification

Filtration

Three stage, heavy duty, dry type system. Primary filtration stage, multiple element sections in parallel. Nominal efficiancy, 99.50%. Secondary filtration, two stage, heavy duty high efficiency in series, nominal efficiency 99.95%. Third stage, positive pressure side of blower, special modified and coated type element, nominal efficiency, 99.99%.

Control Circuit Protection and Controls

Complete air control circuitry, fail-safe type with redundant back-up. Each stage of filtration is differentially sensed and protected by electronic cells. Automatic system shut down will occur at any time pressure drop reaches 25% of maximum safe value. Equipment shut-off is a two stage operation. Blower R.P.M. is dropped to minimum operating speed. System vents and blower speed are brought to idle, after a pre-set interval, complete shut down occurs. L.E.D. fault indicating lights identify reason for system shut-off.

ADVANCED
SERVICE SYSTEMS INC.

661-671 FRELINGHUYSEN AVENUE
NEWARK, NEW JERSEY 07114
(201) 344-2400

Engine and Blower Protection

Diesel engine is protected by automatic low water shut-off, low oil pressure, and over temperature watch guard system.

Blowers and body are protected against:

- Maximum vacuum level
- Blower exhaust temperature
- Differential final filtration pressure
- Full body level
- Out phase fault shut-off
- Blower P.T.O. interlock
- Locked blower shut-down
- Pre-filter warning

Instrumentation

- Blower Vacuum 0-30" Hg.
- Filter differential pressure
- Oil pressure
- Ampmeter
- Water tank pressure
- L.E.D. status lights

Instrumentation - Additional for Asbestos

- 0-30" Hg. Vacuum gage, glycerin filled and pulsation dampened
- 2-12 Gal./min. water flow
- 0-100" W.C. differential gage with dual 12 position selectors
- 0-100 P.S.I. Primary air pressure
- 0-100 Secondary air pressure
- 0-75 Water tank pressure
- 100-250°F. Primary air temperature
- 150-350°F. Secondary air temperature
- 0-3600 R.P.M. Indicator
- 1500-3000 P.S.I. Hydraulic pressure gage.
- Full body depth sensor, R.F. type
- Liquid level - Mechanical type

ADVANCED
SERVICE SYSTEMS INC.

661-671 FRELINGHUYSEN AVENUE
NEWARK, NEW JERSEY 07114
(201) 344-2400

Hydraulic System

P.T.O. drive continuous duty 420 Vickers pump. Three bank manual control valve with built in pressure relief. Full return line filter, 10 micron rating.

Paint

Cab and chassis, Imron Silver. Body and pipe racks, Imron Blue.

APPENDIX B

ISOKINETIC TEST REPORT

KASELAAN & D'ANGELO

ASSOCIATES, INC.

(609) 227-7841

Shipping Address:
1233 BLACK HORSE PIKE
HILLTOP, N.J. 08012

Mailing Address:
P.O. BOX 165
HADDONFIELD, N.J. 08033

CLIENT: New Jersey State Dept. of Health

TEST LOCATION: Montville High School
Montville, New Jersey

UNIT TESTED: Portable commercial vacuum truck
Diversified Vacuum System, AS-10

TEST PURPOSE: Determine the particulate removel efficiency of a vacuum truck equipped with various stages of filtration.

TEST EQUIPMENT: Research Appliance Company "STAKSAMPLR" Portable Gas Sampler, Model #2343

TEST METHOD: Environmental Protection Agency Method 5- Determination of Particulate Emissions from Stationary Sources, as described in the Federal Register, Vol. 42, No. 160, August 18, 1977.

TEST ENGINEER:

Michael J. Mease
New Jersey Professional Engineer No. 24320

TEST METHOD SUMMARY

The test method employed was essentially the standard EPA Test Method 5, with modifications. Due to the size of the ducts (6 inch diameter), it was decided to sample at six points across the duct at the following points, in inches from the duct walls: 0.5, 1.5, 2.5, 3.5, 4.5, and 5.5. Both the inlet and outlet ducts used the same sampling point locations. Each point was sampled for a period of ten minutes for a total test time of sixty minutes. One sampling port was used at each location. Three individual tests were conducted at the inlet and three individual tests were conducted at the outlet. Each duct sampling port was located in a long straight run, well over eight diameters downstream from flow disturbances.

The inlet and outlet tests were essentially conducted simultaneously, with the exception that the outlet tests were started two minutes prior to the inlet tests to facilitate moving the probe.

REMOVAL OPERATIONS DURING TESTS

During the test sequence the workers were removing ceiling material from the inner office area of the Montville High School. The removal consisted of scraping and wire brushing the ceiling material. During the test series, the vacuum hose was never allowed to function as a vacuum cleaner picking up large pieces of material. Rather, it was used to simply evacuate the ambient air around the workers. The flexible vacuum hose was typically attached to scaffolding in the vicinity of the workers to create a negative pressure. It was decided that if the vacuum hoses were allowed to entrap the large pieces of material, they would clog the small nozzle and disrupt the isokinetic sampling. This also explains the rather small amount of airborne material flowing in the duct to the vacuum truck. The test results do not reflect the amount of material being removed, but rather they display the collection efficiency of the filtering unit for the smaller airborne particles.

During test #2 the workers were at lunch break. The flexible hose was positioned in the work area to simply evacuate that area.

The pressure drop across the filters was approximately twelve inches during all three tests.

This test method is an accurate one during all vacuuming operations and the test results would also be typical for all vacuuming operations, for all of the larger pieces of material would drop out for a collection efficiency of 100%

SUMMARY TEST DATA

Process: Vacuum Truck, Outlet from Filters

	Run #1 Outlet	Run #2 Outlet	Run #3 Outlet
Test Date & Times	7/8/82 8:34-9:34am	7/8/82 10:51-11:51am	7/8/82 1:16-2:16pm
Duct Diameter, Inches	6.00	6.00	6.00
Sampling Nozzle Diameter, In.	0.188	0.188	0.188
Testing Time, Minutes	60	60	60
Duct Gas Temperature, °F	142	149	151
Duct Gas Moisture Content, %	1.88	1.63	2.10
Duct Gas Molecular Weight	28.6	28.7	28.6
Duct Gas Volume Sampled, $Ft.^3$	55.722	58.180	58.110
Duct Gas Volume Sampled, SCF @ 70°F, 29.92 in.Hg., dry	51.2	52.9	52.7
Duct Gas Velocity, Ft./Sec.	87.6	91.9	91.5
Duct Gas Flowrate, ACFM	1030	1080	1080
Duct Gas Flowrate, SCFM @ 70°F, 29.92 in.Hg., dry	891	927	914
Particulate Captured, Grams	0.0038	0.0043	0.0051
Particulate Concentration, Grains/SCF	0.001	0.001	0.001
Particulate Emission Rate, Lb./Hr.	0.009	0.010	0.012
Percent Isokinetic of Test	97.6	96.7	97.8

Mease Engineering Associates

Environmental Consultants

LABORATORY WORKSHEET

Client: K&D　　Run No. & Date: 1 INLET

Process: MONTVILLE/VACUUM　　Sample Box No.: 1

Filter Analysis:

Filter Wt., grams	1.0879
Filter Tare, gms	0.6252
Part. Increase, gm.	0.4627

Impinger Water Increase:

Silica Gel Impinger (#4):

Final Wt., gms	305.0
Tare Wt., gms	29?.?
H_2O Increase	13.1

Total Water Volume Increase:

Impinger #1	5	ml
Impinger #2	2	ml
Impinger #3	0	ml
Impinger #4	13.1	ml
TOTAL INCREASE	20.1	ml

Impinger Analysis:

Wash Bottle No.	
Filter Wt., gms	
Filter Tare, gms	
Total Insoluble	
Final Beaker Wt.	
Tare Wt. (No.___)	
Total Soluble	

Particulate Weight Summary:

Filter	0.4627	
Probe Wash	0.4499	
Impingers (Sol.)		
Impingers (Insol.)		
Total (w/imp.)		grams
Total (w/o imp.)	0.9126	grams

Signature: Michael J Mease

Date: 7/12/82

Probe Wash Analysis:

Wash Volume, ml.	255
Acetone Density, mg/ml	
Blank Volume, ml	
Blank Residue	
Final Wt.	
Tare Wt.	
Part. Wt.	
Wash Analysis, Bottle No.	
Beaker Wt., gms	145.375
Tare Wt. (No. 4)	144.92
Part. Wt., gms	0.44

Mease Engineering Associates

Environmental Consultants

LABORATORY WORKSHEET

Client: K & D Run No. & Date: 1 OUTLET

Process: MONTVILLE/VACUUM Sample Box No.: 2

Filter Analysis:
- Filter Wt.,grams 0.6335
- Filter Tare,gms 0.6328
- Part.Increase,gm. 0.0007

Impinger Water Increase:
- Silica Gel Impinger (#4):
  - Final Wt.,gms 316.3
  - Tare Wt.,gms 301.5
  - H_2O Increase 14.8

Total Water Volume Increase:

Impinger #1	1	ml
Impinger #2	5	ml
Impinger #3	0	ml
Impinger #4	14.8	ml
TOTAL INCREASE	20.8	ml

Impinger Analysis:
- Wash Bottle No. ____
- Filter Wt.,gms ____
- Filter Tare,gms ____
- Total Insoluble ____
- Final Beaker Wt. ____
- Tare Wt. (No.___) ____
- Total Soluble ____

Particulate Weight Summary:

Filter	0.0007	
Probe Wash	0.0031	
Impingers (Sol.)		
Impingers (Insol.)		
Total (w/imp.)		grams
Total (w/o imp.)	0.0038	grams

Signature: Michael J. Mease

Date: 7/12/82

Probe Wash Analysis:
- Wash Volume,ml. 130
- Acetone Density,mg/ml ____
- Blank Volume,ml ____
- Blank Residue
  - Final Wt. ____
  - Tare Wt. ____
  - Part.Wt. ____
- Wash Analysis, Bottle No.____
  - Beaker Wt.,gms 44.4597
  - Tare Wt.(No.6) 144.4566
  - Part.Wt.,gms 0.0031

Mease Engineering Associates

Environmental Consultants

LABORATORY WORKSHEET

Client: K&D   Run No. & Date: 2 - INLET

Process: MONTVILLE/VACUUM   Sample Box No.: 3

Filter Analysis:
- Filter Wt., grams 0.8886
- Filter Tare, gms 0.6326
- Part. Increase, gm. 0.2560

Impinger Water Increase:
- Silica Gel Impinger (#4):
  - Final Wt., gms 283.2
  - Tare Wt., gms 270.3
  - H_2O Increase 12.9

Total Water Volume Increase:

Impinger #1	6	ml
Impinger #2	2	ml
Impinger #3	1	ml
Impinger #4	12.9	ml
TOTAL INCREASE	21.9	ml

Impinger Analysis:
- Wash Bottle No. ______
- Filter Wt., gms ______
- Filter Tare, gms ______
- Total Insoluble ______
- Final Beaker Wt. ______
- Tare Wt. (No.___) ______
- Total Soluble ______

Particulate Weight Summary:

Filter	0.2560	
Probe Wash	0.0014	
Impingers (Sol.)		
Impingers (Insol.)		
Total (w/imp.)		grams
Total (w/o imp.)	0.3174	grams

Signature: Michael J. Mease

Date: 7/12/82

Probe Wash Analysis:
- Wash Volume, ml. 220
- Acetone Density, mg/ml ______
- Blank Volume, ml ______
- Blank Residue
  - Final Wt. ______
  - Tare Wt. ______
  - Part. Wt. ______
- Wash Analysis, Bottle No. ______
  - Beaker Wt., gms 147.340
  - Tare Wt. (No. 19) 147.2785
  - Part. Wt., gms 0.06..

Mease Engineering Associates

Environmental Consultants

LABORATORY WORKSHEET

Client: K&D Run No. & Date: 2 OUTLET

Process: MONTVILLE/VACUUM Sample Box No.: 5

Filter Analysis:
- Filter Wt., grams: 0.6320
- Filter Tare, gms: 0.6314
- Part. Increase, gm.: 0.0006

Impinger Water Increase:
- Silica Gel Impinger (#4):
  - Final Wt., gms: 275.0
  - Tare Wt., gms: 264.4
  - H_2O Increase: 10.6

Total Water Volume Increase:
- Impinger #1: 2 ml
- Impinger #2: 5 ml
- Impinger #3: 1 ml
- Impinger #4: 10.6 ml
- TOTAL INCREASE: 18.6 ml

Impinger Analysis:
- Wash Bottle No. ____
- Filter Wt., gms ____
- Filter Tare, gms ____
- Total Insoluble ____
- Final Beaker Wt. ____
- Tare Wt. (No.___) ____
- Total Soluble ____

Particulate Weight Summary:
- Filter: 0.0006
- Probe Wash: 0.0037
- Impingers (Sol.) ____
- Impingers (Insol.) ____
- Total (w/imp.) ____ grams
- Total (w/o imp.) 0.0043 grams

Signature: Michael J. Mease

Date: 7/12/82

Probe Wash Analysis:
- Wash Volume, ml.: 150
- Acetone Density, mg/ml ____
- Blank Volume, ml ____
- Blank Residue
  - Final Wt. ____
  - Tare Wt. ____
  - Part. Wt. ____
- Wash Analysis, Bottle No. ____
  - Beaker Wt., gms: 145.379
  - Tare Wt. (No. 4): 145.3754
  - Part. Wt., gms: 0.0037

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LABORATORY WORKSHEET

Client: K&D   Run No. & Date: 3 INLET

Process: MONTVILLE/VACUUM   Sample Box No.: 2

Filter Analysis:
- Filter Wt., grams 1.1154
- Filter Tare, gms 0.6309
- Part. Increase, gm. ______

Probe Wash Analysis:
- Wash Volume, ml. 260
- Acetone Density, mg/ml ______
- Blank Volume, ml ______
- Blank Residue
  - Final Wt. ______
  - Tare Wt. ______
  - Part. Wt. ______
- Wash Analysis, Bottle No. ______
  - Beaker Wt., gms 148.7563
  - Tare Wt. (No. 19) 147.3402
  - Part. Wt., gms 1.4161

Impinger Water Increase:
- Silica Gel Impinger (#4):
  - Final Wt., gms 328.9
  - Tare Wt., gms 316.3
  - H_2O Increase 12.6

Total Water Volume Increase:

Impinger #1	7	ml
Impinger #2	5	ml
Impinger #3	1	ml
Impinger #4	12.6	ml
TOTAL INCREASE	25.6	ml

Impinger Analysis:
- Wash Bottle No. ______
- Filter Wt., gms ______
- Filter Tare, gms ______
- Total Insoluble ______
- Final Beaker Wt. ______
- Tare Wt. (No.___) ______
- Total Soluble ______

Particulate Weight Summary:

Filter	0.4845	
Probe Wash	1.4161	
Impingers (Sol.)		
Impingers (Insol.)		
Total (w/imp.)		grams
Total (w/o imp.)	1.9006	grams

Signature: Michael J. Mease

Date: 7/12/82

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LABORATORY WORKSHEET

Client: K&D Run No. & Date: 3 OUTLET

Process: MONTVILLE / VACUUM Sample Box No.: 5

Filter Analysis:

Filter Wt., grams	0.6308
Filter Tare, gms	0.6303
Part. Increase, gm.	0.0005

Impinger Water Increase:

Silica Gel Impinger (#4):

Final Wt., gms	286.0
Tare Wt., gms	275.0
H_2O Increase	11.0

Total Water Volume Increase:

Impinger #1	8 ml
Impinger #2	3 ml
Impinger #3	2 ml
Impinger #4	11.0 ml
TOTAL INCREASE	24.0 ml

Impinger Analysis:

Wash Bottle No.	
Filter Wt., gms	
Filter Tare, gms	
Total Insoluble	
Final Beaker Wt.	
Tare Wt. (No.___)	
Total Soluble	

Particulate Weight Summary:

Filter	0.0005
Probe Wash	0.0046
Impingers (Sol.)	
Impingers (Insol.)	
Total (w/imp.)	grams
Total (w/o imp.)	0.0051 grams

Signature: Michael J. Mease

Date: 7/12/82

Probe Wash Analysis:

Wash Volume, ml.	140
Acetone Density, mg/ml	
Blank Volume, ml	
Blank Residue	
Final Wt.	
Tare Wt.	
Part. Wt.	
Wash Analysis, Bottle No.	
Beaker Wt., gms	144.4665
Tare Wt. (No. 6)	144.4619
Part. Wt., gms	0.004

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2 MIN APART (BEHIND)

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Initial leak check 0.005 cfm @ ...
Final leak check 0.004 cfm @ 15

PARTICULATE FIELD DATA

RUN No. 1 INLET
LOCATION Montville / Vacuum
DATE 7/9/82
OPERATOR Mease / D'Angelo
SAMPLE BOX No. 1

TIME, START 8:36
TIME, FINISH 9:36
WASH BOTTLE No. 3/3
STACK DIMEN. 6" d
SAMPLE BOX TEMP. °F 250
STACK PRESS., In. H_2O -1.5"

AMBIENT TEMP. °F 85
BAR. PRESS. "Hg. 30.04
ASSUMED MOISTURE % 1-2
HEATER BOX SETTING, °F 250
PROBE TIP DIA., 0.186 " No.
PROBE LENGTH 3'SS No.
PROBE HEATER SETTING 40

INITIAL DRY GAS METER READING 972.328

POINT	CLOCK TIME	DRY GAS METER, CF	PITOT In. H_2O ΔP	ORIFICE ΔH In. H_2O DESIRED	ACTUAL	DRY GAS TEMP. °F INLET	OUTLET	PUMP VACUUM In. Hg. GAUGE	IMPINGER TEMP. °F	STACK TEMP. °F
1	10	979.974	1.60	2.12	2.12	97	94	8.0	64	82
2	10	987.655	1.55	2.16	2.16	127	100	8.0	68	82
3	10	996.092	1.75	2.43	2.43	127	103	10.0	68	82
4	10	1004.2	1.00	2.25	2.25	128	108	9.0	70	83
5	10	11.276	1.20	1.67	1.67	127	108	8.0	70	83
6	10	18.272	1.20	1.67	1.67	123	109	8.0	68	83
	TOTAL		AVG.	AVG.	AVG.	TOTAL AVG.				AVG.

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*CLOSED PACKAGING UNIT AT 8 MIN. INTO TEST

Initial leak check 0.003 cfm @ 15"
Final leak check 0.003 cfm @ 16"

PARTICULATE FIELD DATA

RUN No. 1 OUTLET
LOCATION Montville / Vacuum
DATE 7/8/82
OPERATOR Mease / D'Angelo
SAMPLE BOX No. 2

TIME, START 8:34 am
TIME, FINISH 9:34 am
WASH BOTTLE No. 1/1
STACK DIMEN. 6' ø
SAMPLE BOX TEMP. °F
STACK PRESS., In. H_2O -1.6" H_2O

AMBIENT TEMP. °F 85
BAR. PRESS. "Hg. 30.04
ASSUMED MOISTURE % 1-2
HEATER BOX SETTING, °F 250
PROBE TIP DIA., 0.188 " No.
PROBE LENGTH 3' SS No.
PROBE HEATER SETTING 40

INITIAL DRY GAS METER READING 603.150

POINT	CLOCK TIME	DRY GAS METER, CF	PITOT In. H_2O ΔP	ORIFICE ΔH In. H_2O DESIRED	ORIFICE ΔH In. H_2O ACTUAL	DRY GAS TEMP. °F INLET	DRY GAS TEMP. °F OUTLET	PUMP VACUUM In. Hg. GAUGE	IMPINGER TEMP. °F	STACK TEMP. °F
1	10	612.448	2.50	3.10	3.10	115	101	12.0	64	137
2	10 *	622.568	2.50	3.10	3.10	129	106	15.0	68	140
3	10	632.311	2.28	2.93	2.93	135	110	15.0	68	141
4	10	642.–	2.15	2.86	2.86	140	114	13.0	68	143
5	10	650.388	1.65	2.14	2.14	139	117	9.0	70	145
6	10	658.872	1.70	2.19	2.19	136	119	9.0	67	145
	TOTAL	TOTAL	AVG.	AVG.	AVG.	TOTAL AVG.				AVG.

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Initial leak check 0.012 in
Final leak check 0.010 in

PARTICULATE FIELD DATA

RUN No. 2 INLET
LOCATION Montville/Vacuum
DATE 7/8/82
OPERATOR Mease/D'Angelo
SAMPLE BOX No. 3

TIME, START 10:53 am
TIME, FINISH 11:53 am
WASH BOTTLE No. 5
STACK DIMEN. 6" ∅
SAMPLE BOX TEMP. °F 250
STACK PRESS., In. H_2O -18" H_2O

AMBIENT TEMP. °F 85
BAR. PRESS. "Hg. 30.04
ASSUMED MOISTURE % 1-2
HEATER BOX SETTING, °F 250
PROBE TIP DIA., 0.186 " No.
PROBE LENGTH 3' No.
PROBE HEATER SETTING 40

INITIAL DRY GAS METER READING 18.484

POINT	CLOCK TIME	DRY GAS METER, CF	PITOT In. H_2O ΔP	ORIFICE ΔH In. H_2O DESIRED	ORIFICE ΔH In. H_2O ACTUAL	DRY GAS TEMP. °F INLET	DRY GAS TEMP. °F OUTLET	PUMP VACUUM In. Hg. GAUGE	IMPINGER TEMP. °F	STACK TEMP. °F
1	10	26.646	1.80	2.49	2.49	106	108	22	70	82
2	10	34.828	1.90	2.67	2.50	122	108	24	68	83
3	10	43.074	1.90	2.67	2.50	129	110	24	68	82
4	10	51.398	1.90	2.67	2.50	132	113	24	68	82
5	10	59.698	1.80	2.55	2.50	137	115	24	68	82
6	10	67.470	1.20	1.71	1.71	134	117	18	69	82
TOTAL		TOTAL	AVG.	AVG.	AVG.	TOTAL	AVG.			AVG.

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Initial leak check 0.004 cfm @ 15"
Final leak check 0.002 cfm @ 13"

PARTICULATE FIELD DATA

RUN No. 2 OUTLET
LOCATION MONTVILLE / VACUUM
DATE 7/8/82
OPERATOR MEASE / D'ANGELO
SAMPLE BOX No. 5

TIME, START 10:51
TIME, FINISH 11:51
WASH BOTTLE No. 4
STACK DIMEN. 6" ϕ
SAMPLE BOX TEMP. °F 250
STACK PRESS., In. H_2O -1.6" H_2O

AMBIENT TEMP. °F 85
BAR. PRESS. "Hg. 30.04
ASSUMED MOISTURE % 1-2
HEATER BOX SETTING, °F 250
PROBE TIP DIA., 0.188" No.
PROBE LENGTH 3'55 No.
PROBE HEATER SETTING 40

INITIAL DRY GAS METER READING 659.085

POINT	CLOCK TIME	DRY GAS METER, CF	PITOT In. H_2O ΔP	ORIFICE ΔH In. H_2O DESIRED	ORIFICE ΔH In. H_2O ACTUAL	DRY GAS TEMP. °F INLET	DRY GAS TEMP. °F OUTLET	PUMP VACUUM In. Hg. GAUGE	IMPINGER TEMP. °F	STACK TEMP. °F
1	10	669.087	2.50	3.15	3.15	118	118	10.0	70	143
2	10	679.042	2.50	3.15	3.15	134	121	10.0	68	149
3	10	688.946	2.40	3.07	3.07	140	122	9.0	68	149
4	10	698.568	2.24	2.88	2.88	140	123	8.0	67	149
5	10	708.135	2.24	2.88	2.88	140	123	8.0	68	150
6	10	717.265	2.02	2.60	2.60	139	123	8.0	69	150
	TOTAL	TOTAL	AVG.	AVG.	AVG.	TOTAL	AVG.			AVG.

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PARTICULATE FIELD DATA

Initial leak check 0.010 @ 25"
Final leak check 0.008 @ 25" 0

RUN No. 3 INLET
LOCATION Montville/Vacuum
DATE 7/8/82
OPERATOR Mease/D'Angelo
SAMPLE BOX No. 2

TIME, START 1:18 pm
TIME, FINISH 2:18 pm
WASH BOTTLE No. 7
STACK DIMEN. 6" Ø
SAMPLE BOX TEMP. °F 250
STACK PRESS., In. H_2O -18" H_2O

AMBIENT TEMP. °F 95
BAR. PRESS. "Hg. 30.04
ASSUMED MOISTURE % 1-2
HEATER BOX SETTING, °F 250
PROBE TIP DIA., 0.186" No.
PROBE LENGTH 3'SS No.
PROBE HEATER SETTING 40

INITIAL DRY GAS METER READING 67.825

POINT	CLOCK TIME	DRY GAS METER, CF	PITOT In. H_2O ΔP	ORIFICE ΔH In. H_2O DESIRED	ORIFICE ΔH In. H_2O ACTUAL	DRY GAS TEMP. °F INLET	DRY GAS TEMP. °F OUTLET	PUMP VACUUM In. Hg. GAUGE	IMPINGER TEMP. °F	STACK TEMP. °F
1	10	76.900	1.80	2.54	2.54	121	117	17.0	68	85
2	10	85.800	1.80	2.54	2.54	142	126	17.0	66	85
3	10	95.313	2.15	3.10	3.00	143	120	22	68	85
4	10	104.750	1.95	2.81	2.81	140	120	20	69	85
5	10	113.008	1.55	2.23	2.23	139	120	15.0	68	84
6	10	120.393	1.20	1.73	1.73	136	119	12.0	69	84

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PARTICULATE FIELD DATA

Initial leak check 0.008 cfm
Final leak check — VAC. GAGE NOT FUNCTIONAL 0.003 cfm (HIGH VACUUM)

RUN No. 3 OUTLET
LOCATION MONTVILLE/VACUUM
DATE 7/8/82
OPERATOR MEASE/D'ANGELO
SAMPLE BOX No. 5

TIME, START 1:16 pm
TIME, FINISH 2:16
WASH BOTTLE No. 6
STACK DIMEN. 6" Ø
SAMPLE BOX TEMP. °F 250
STACK PRESS., In. H_2O −1.6" H_2O

AMBIENT TEMP. °F 95
BAR. PRESS. "Hg. 30.04
ASSUMED MOISTURE % 1-2
HEATER BOX SETTING, °F 250
PROBE TIP DIA., .188 " No.
PROBE LENGTH 3'±5 No.
PROBE HEATER SETTING 40

INITIAL DRY GAS METER READING 717.532

POINT	CLOCK TIME	DRY GAS METER, CF	PITOT In. H_2O ΔP	ORIFICE ΔH In. H_2O DESIRED	ORIFICE ΔH In. H_2O ACTUAL	DRY GAS TEMP. °F INLET	DRY GAS TEMP. °F OUTLET	PUMP VACUUM In. Hg. GAUGE	IMPINGER TEMP. °F	STACK TEMP. °F
1	10	728.132	2.80	3.54	2.54	123	120	10.0	67	150
2	10	738.2 —	2.60	3.33	3.33	145	124	5.0	68	151
3	10	748.493	2.40	3.09	3.09	143	124	5.0	70	152
4	10	758.366	2.35	3.02	3.02	141	123	5.0	70	152
5	10	767.461	2.00	2.57	2.57	138	121	4.0	70	152
6	10	775.642	1.60	2.05	2.05	135	120			

SAMPLING TRAIN COMPONENTS, METHOD OF USE, AND ANALYTICAL TECHNIQUES

A. Components

1. Stainless steel or glass probe with minimum 3/16 inch diameter opening, heated above the dew point of the gas stream to be sampled.

2. Glass cyclone efficient for removal of particles of 5 microns or greater, and cyclone collection flask. In cases of low particulate loadings, a glass cyclone eliminator may be substituted.

3. In-line filter of 0.3 micron porosity.

4. Heated chamber for maintaining glass fiber filter and cyclone above the dew point of the gas stream to be sampled.

5. Impingers placed in the following order:

   a. A 500 ml. modified Greenburg-Smith impinger filled with 100 mls. of distilled deionized water.

   b. A 500 ml. Greenburg-Smith impinger filled with 100 mls. of distilled deionized water.

   c. A 500 ml. modified Greenburg-Smith impinger left dry to act as a water trap to remove entrained water.

   d. A 500 ml. modified Greenburg-Smith impinger containing approximately 200 grams of precisely weighed silica gel.

6. An ice bath in which the impingers are partially submerged to maintain exit temperature well below the dew point of the gas to be sampled.

7. Dry gas meter equipped with a vacuum gage registering up to 30 inches of mercury, and a calibrated orifice.

B. General Sampling Procedure

1. Starting with clean equipment, a leak check is performed by drawing a vacuum of 15 inches on system as indicated on the vacuum gage. Leak checks are also performed post-test and corrections may be necessary to account for increases in the leakage rate.

2. The sample is collected at isokinetic rates based upon a velocity profile determined with the use of an "S" type pitot tube.

3. Samples are taken at multiple points across the gas stream representing equal areas of cross-sectional flow, and each point is sampled for as long a time as is feasible.

4. Moisture content of the gas stream is determined by the condensation method, using a series of cooled impingers described above (A-5).

5. The duration of the test depends on the number of sample points and the time required to equally sample each point. In no case will the sample time be less than that required to collect a sufficient sample for complete analysis.

C. Analytical Techniques

1. Before use, the filter is desiccated for a period of 24 hours and weighed to the nearest 0.1 mg.

2. When processing the sample, any material deposited inside the sample probe, glass cyclone (or cyclone eliminator) and the front half of the filter holder is washed into a container using acetone, or other suitable solvent, evaporated to dryness at either ambien conditions or below the boiling point of acetone (55°C), desiccated for a period of 25 hours, and weighed to the nearest 0.1 mg.

3. After sampling, the in-line glass fiber filter is desiccated for a period of 24 hours and weighedto the nearest 0.1 mg.

4. The moisture content is determined by collecting the liquid in the impingers described above and measuring. The difference between 200 ml. and the measurement is recorded as increase in water. The spent silica gel is weighed to the nearest 0.1 gram and the increase is included in the moisture content determination.

5. The liquid in the impingers may be analyzed for particulate matter and the weights may be included in the particulate catch.

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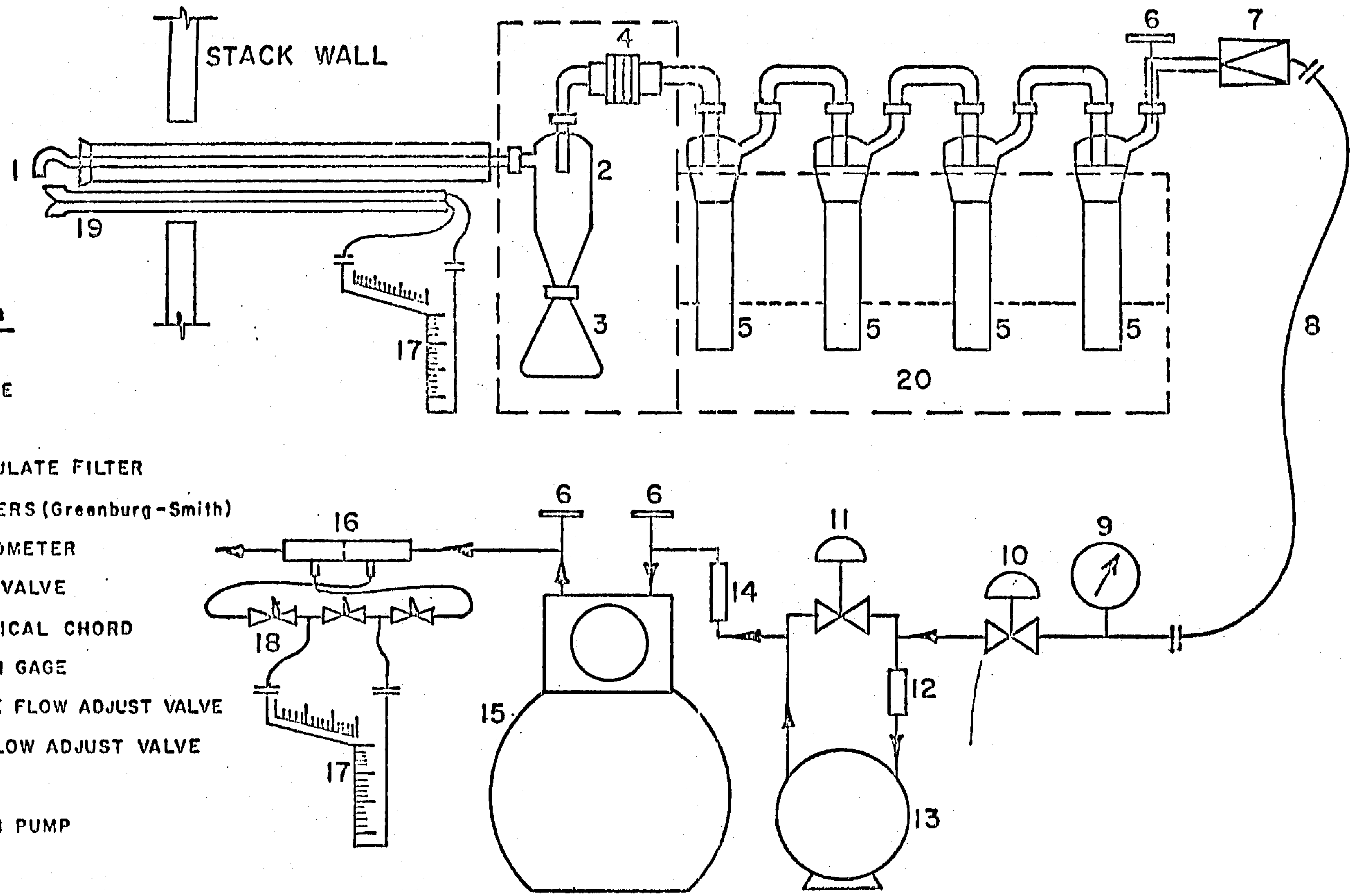
6. The total particulate in the system is the sum of that collected in Nos. 2,3 and possibly 5. The contribution of each portion shall be individually identified. The inclusion of the impinger particulate catch is to be considered on an individual basis.

7. The emission rate and calculations are made from suitable measurements of gas temperature, moisture content, velocities and materials collected. In order for a test to be considered valid, isokinetic sampling rates shall be between 90% and 110%.

8. All equipment, including orifice meter, probe tip nozzles, dry gas meter, and temperature measuring devices is calibrated on a regular basis, dependent on the frequency of equipment use.

9. The stack gas content is determined by collecting a sample of stack gas and analyzing the contents with an Orsat analyzer or Fyrite analyzer.



LEGEND:

1. PROBE
2. CYCLONE
3. FLASK
4. PARTICULATE FILTER
5. IMPINGERS (Greenburg-Smith)
6. THERMOMETER
7. CHECK VALVE
8. UMBRILICAL CHORD
9. VACUUM GAGE
0. COURSE FLOW ADJUST VALVE
. FINE FLOW ADJUST VALVE
2. OILER
3. VACUUM PUMP
4. FILTER
5. DRY GAS METER
6. ORIFICE TUBE
7. INCLINE MANOMETER
. SOLENOID VALVES
. PITOT
0. ICE BATH

FIGURE 1

GENERAL ARRANGEMENT
SOURCE SAMPLING TRAIN

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DRY GAS METER AND ORIFICE METER CALIBRATION

Model Number [illegible]

Serial Number 1895

Meter Box No. D (MFW)

Wet Test Meter No. AL-20 14524

Calibration Date 7/6/92

Signature [illegible]

Barometric Pressure, Pb 30.0[illegible]

Orifice Manometer ΔH	Gas Volume		Temperature			Time		
	Wet	Dry	Wet	Dry				
in. H_2O	V_w ft^3	V_d ft^3	t_w °F	In t_{di} °F	Out t_{do} °F	θ Min.	Y	$\Delta H_@$
0.5	5.000	5.031	77	80	[illegible]	12.5[illegible]	0.9963	1.78
1.0	5.300	5.367	77	84	79	9.553	0.9934	1.82[illegible]
2.0	[illegible]	10.121	77	89	[illegible]	12.853	0.9979	1.3[illegible]
3.0	[illegible]	10.139	77	93	83	10.853	0.9992	1.96[illegible]
						AVERAGE	0.997	1.89

$$Y = \frac{V_w P_b (t_d + 460)}{V_d \left(P_b + \frac{\Delta H}{13.6}\right)\left(t_w + 460\right)}$$

$$\Delta H_@ = \frac{0.0317 \Delta H}{P_b (t_d + 460)} \left[\frac{(t_w + 460)\ \theta}{V_w}\right]^2$$

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DRY GAS METER AND ORIFICE METER CALIBRATION

Model Number 2343 Calibration Date 7/6/82

Serial Number 1984 Signature [signature]

Meter Box No. C Barometric Pressure, Pb 30.08

Wet Test Meter No. AL-20 14524

Orifice Manometer ΔH in. H_2O	Gas Volume Wet V_w ft^3	Gas Volume Dry V_d ft^3	Temperature Wet t_w °F	Temperature Dry In t_{di} °F	Temperature Dry Out t_{do} °F	Time θ Min.	Υ	$\Delta H_@$
0.5	5.000	4.923	77	84	81	12.855	1.0248	1.85…
1.0	5.015	4.970	77	87	82	9.133	1.0206	1.851
2.0	10.000	9.944	77	89	84	13.462	1.0184	2.016
3.0	10.000	9.916	77	94	85	10.842	1.0244	1.95…
						AVERAGE	1.022	1.91

$$\Upsilon = \frac{V_w\, P_b\, (t_d + 460)}{V_d \left(P_b + \frac{\Delta H}{13.6}\right)\left(t_w + 460\right)} \qquad \Delta H_@ = \frac{0.0317\,\Delta H}{P_b\, (t_d + 460)} \left[\frac{(t_w + 460)\,\theta}{V_w}\right]^2$$

PITOT TUBE CALIBRATION

All pitot tubes are geometrically aligned and within the limits as prescribed in the Federal Register. Therefore, they are assigned a value of 0.84.
In the event that a pitot tube tip is altered during transport, and the geometric qualifications cannot be met, the pitot tube is calibrated according to the Federal Register. In this case, the new calibration factor is listed in the report and used in the calculations.

TEMPERATURE SENSING DEVICE CALIBRATIONS

All temperature sensing devices used during a test series, including thermocouples and thermometers are calibrated after each test series, as specified in the Federal Register. In the event that these calibration factors fall within the limits as specied, no corrections are necessary. In the evnt that a device is outside the limits, as specified, the correction factor is listed and used in the calculations.

SAMPLING NOZZLE CALIBRATION

The sampling nozzle used during the test series is determined after each test series using a micrometer on several diameters as specified in the Federal Ragister.

SOURCE SAMPLING CALCULATIONS: NOMENCLATURE

An = Nozzle Area, $ft.^2$

As = Stack Area, $ft.^2$

Bwo = Water Vapor Proportion, by volume, dimensionless

Cm = Meter Correction Factor, dimensionless

Cp = Pitot Coefficient, dimensionless

Cs = Particulate Concentration, units specified

$\Delta H_{avg.}$ = Average Pressure Drop Across Orifice, in.H_2O

$\%H_2O$ = Water Vapor Content, dimensionless

Is = Percent Isokinetic of Test, dimensionless

Kp = 85.48, unit correction

Md = Molecular Weight of Dry Gas

Mn = Total Particulate Catch, grams

Ms = Molecular Weight of Stack Gas

$(\sqrt{\Delta P})_{avg}$ = Average of the Square Roots of the Velocity Head

Pbar = Barometric Pressure, in. Hg.

pmr = Pollutant Mass Rate, lb./hr.

θ = Time, minutes

Pstd = 29.92 in. Hg.

Qs = Stack Gas Flowrate, actual cubic feet per minute

(Qs)std = Stack Gas Flowrate, standard cubic feet per minute

Ts = Stack Gas Temperature, ^{o}R

Tstd = $530^{o}R$

Vfc = Increase in Liquid Volume in Impingers, ml.

Vm = Volume Sampled at Meter Conditions, $ft.^3$

Vmstd = Volume of Air Metered at Standard Conditions

Vs = Stack Gas Velocity, ft./sec.

Vsstd = Stack Gas Velocity, standard conditions, ft./min.

Vwc = Volume of Liquid Collected, cubic feet

<u>SAMPLE CALCULATIONS</u>: Run #1, Inlet

(1.) VOLUME OF WATER COLLECTED

$$V_{WC} = (0.04707)(V_{fc})$$
$$= (0.04707)(20.1)$$
$$= 0.946$$

(2.) VOLUME OF AIR METERED

$C_{M_{IN}} = 1.0$
$C_{M_{OUT}} = 0.9$

$$VM_{STD} = \left(V_M\right)\left(\frac{T_{STD}}{T_M}\right)\left(\frac{P_{bar} + \frac{\Delta H}{13.6}}{P_{STD}}\right)\left(C_M\right)$$
$$= (45.944)\left(\frac{530}{572.58}\right)\left(\frac{30.04 + \frac{2.05}{13.6}}{29.92}\right)(1.022)$$
$$= 43.856$$

(3.) MOISTURE CONTENT

$$B_{WO} = \frac{V_{WC}}{V_{WC} + VM_{STD}}$$
$$= \frac{0.946}{0.946 + 43.856}$$
$$= 0.0211$$

(4.) MOLECULAR WEIGHTS

$$M_D = (\%CO_2 \times 0.44) + (\%O_2 \times 0.32) + [(\%N_2 + \%CO) \times 0.2$$
$$= (0 \times 0.44) + (21 \times 0.32) + (79 \times 0.28)$$
$$= 28.84$$

$$M_S = M_D(1 - B_{WO}) + 18 B_{WO}$$
$$= 28.84(1 - 0.0211) + 18(0.0211)$$
$$= 28.61$$

SAMPLE CALCULATIONS: Continued

(5.) VELOCITY OF DUCT GASES

$$V_S = K_P C_P \sqrt{\frac{T_S}{P_S M_S}} \left(\sqrt{\Delta P}\right)_{AVG.}$$

$$= (85.48)(0.84)\sqrt{\frac{542.33}{(28.72)(28.61)}}(1.215)$$

$$= 70.87 \text{ FT./SEC.}$$

(6.) FLOWRATES

$$Q_S = (A_S)(V_S)(60)$$

$$= (0.1963)(70.87)(60)$$

$$= 834.76 \text{ ACFM}$$

$$Q_{S_{STD}} = (Q_S)\left(\frac{T_{STD}}{T_S}\right)\left(\frac{P_S}{P_{STD}}\right)(1-B_{WO})$$

$$= (834.76)\left(\frac{530}{542.33}\right)\left(\frac{28.72}{29.92}\right)(1-0.0211)$$

$$= 766.5 \text{ SCFM}$$

(7.) ISOKINETICS

$$V_{S_{STD}} = \frac{Q_{S_{STD}}}{A_S} = \frac{766.5}{(0.1963)} = 3$$

$$I_S = \frac{VM_{STD}}{(A_N)(\theta)(V_{S_{STD}})}$$

$$= \frac{43.856}{(0.000189)(60)(3905)}$$

$$= 0.9904 \text{ OR } 99.0\%$$

SAMPLE CALCULATIONS: Continued

(8.) PARTICULATE CONCENTRATION

$$C_s = \frac{M_N \times 15.43}{VM_{STD}}$$

$$= \frac{(0.9126)(15.43)}{43.856}$$

$$= 0.321 \text{ GRAINS/SCF}$$

(9.) PARTICULATE MASS RATE

$$pmr = \frac{(M_n)(Q_{SSTD})(60)}{(454)(VM_{STD})}$$

$$= \frac{(0.9126)(766.5)(60)}{(454)(43.856)}$$

$$= 2.11 \text{ LB./HR.}$$

APPENDIX C

HEPA TEST (DOP) REPORT

ATMOS·TECH INDUSTRIES

HEPA Filter and Laminar Flow
Certification and Test Reports

Customer: Kaselaan + D'Angelo

Customer Contact: Chip - D'Angelo
Your order No. Verbal
Our order No. 32593
Date of Test: 6/9/82
Certification conducted by: L. Malsie

Test Instruments Used

Nomenclature	Manufacturer	Serial No.	Calibration Date	Calibrated By
8500	ALNOR	4519	3/82	ALNOR Instr.
TDA-2D	Air Tech	0714	9/81	Air Tech
CLIMET	CL-208	78158	9/81	Climet Instr.

All HEPA Filters and/or Laminar Flow Equipment has been tested in accordance with Federal Standard 209B and Air Force Technical Order #00-25-203.

Certification and test reports are attached.

ATMOS·TECH INDUSTRIES

Air Velocity Certification and Report

Document No. LM060982-1
Page 1 of 3

Laminar Flow Equipment Tested

Type: MOBIL EXHAUST HEPA, TRUCK MOUNTED
Manufacturer and Model:
ID. and/or Serial No.
Location:

HEPA Filters

Quantity	Size	Efficiency	Manufacturer	Model
1	24"x 24"x 11 1/2"	99.99%		

Pressure drop across HEPA filter(s) 1.5 - 2.0 " of WATER
Condition of prefilters ☒ Good ☐ Damaged ☐ Clean ☐ Dirty

2,000+

HEPA filter face outline

Lowest velocity reading * 2000
Highest velocity reading * 2,000
Average velocity reading * 2,000

Remarks:

This document will certify that the above described Laminar Flow Equipment was inspected and the air flow velocity meets or exceeds requirements per specifications of Federal Standard 209B.

Certified by (Atmos-Tech Ind. Rep.) L. Maline Date 6/9/82
Recommended recertification date: 12/9/82 or 1200 hr. USE

*Velocity readings taken 1"-6" from HEPA filter face unless otherwise specified.

DESIGNERS & MANUFACTURERS OF CONTROLLED ENVIRONMENTS
204 Pinebrook Rd., Eatontown, N.J. 07724 201-542-1200

ATMOS·TECH INDUSTRIES

DOP Certification and Report

Document No. LM 060982
Page 2 of 3

Laminar Flow Equipment Tested: Mobil Exhaust hepa.

ID. and/or Serial No. On TRUCK

HEPA filter face outline

Leaks found: NONE
Leaks repaired: NONE

Remarks: ______

This document will certify that the above described Laminar Flow equipment was inspected using the TDA-2D Detector which indicate any leaks greater than .01% DOP penetration (03. Micron size particles).

The TDA-2 probe was passed over the entire area of the filter media and around the filter seal.

This document will also certify the HEPA filters in the above described Laminar Flow equipment are of the Absolute (HEPA) type, rated 99.99% or more efficient on particles of 0.3 Micron size and are functioning according to the requirements of Federal Standard 209B and Air Force Technical Order No. 00-25-203.

Certified By (Atmos-Tech Ind. Rep.) L. Maline Date: 6/9/82

Recommended recertification date: 12/9/82 or 1,200 hr. USE

DESIGNERS & MANUFACTURERS OF CONTROLLED ENVIRONMENTS
204 Pinebrook Rd., Eatontown, NJ 07724 201-542-1200

ATMOS·TECH INDUSTRIES

Particle Count Certification and Report

Document No. HN. 060982-1

Page 3 of 3

Laminar Flow Equipment Tested: Mobil Exhaust hepa

ID. and/or Serial No. On Truck

.5u = 33, 57, 11

5.0 = 0, 0

HEPA filter face outline

Highest particle count recorded: (0.5 micron size) 57

(5. micron size) 0

Remarks:

This document will certify the above described Laminar Flow equipment was inspected, and that this equipment was inspected, and that this equipment will meet or exceed particle count requirements for Class 100, per Federal Standard 209B.

Certified by (Atmos-Tech Ind. Rep.) L. Malone

Date: 6/9/82

Recommended recertification date: 12/9/82 or 1200 hr. USE.

DESIGNERS & MANUFACTURERS OF CONTROLLED ENVIRONMENTS

204 Pinebrook Rd., Eatontown, N.J. 07724 201-542-1200

129

APPENDIX D

ACTUAL INVOICED COSTS

54 = UA | 0 | OF | 8 3 0 8 2 4 92

INVOICE — NEW JERSEY

(9) VENDOR STATUS

BLANK = NO CHANGE
1 = NEW VENDOR
2 = ADDRESS CHANGE
3 = LOCATION CODE
4 = NEW VENDOR AND LOCATION
5 = VENDOR NO. CORRECTION

(10) ACCOUNT NUMBER

ORGANIZATION	FUND	PROGRAM	OBJECT	(11) COST CENTER	(12) PROJECT ACTIVITY	(13) EXTENDED NUMBER	(A) (14) TOTAL AMOUNT		(15) AGENCY P.O. NO.	(16)	(17) OBLIGATION NUMBER
4230	215	032880	63	714			$17,105	62		P	17176

PAYEE NAME AND ADDRESS

(18) NAME (19) (20) STREET (21) CITY (22) STATE (23) ZIP CODE

Diversified Vacuum Systems
71 Frelinghuysen Ave.
Newark, N.J. 07114

(D) PAYEE DECLARATION:
I certify that the within invoice is correct in all its particulars, that the described goods or services have been furnished or rendered, and that no bonus has been given or received on account of said invoice.

PAYEE SIGNATURE: [signature]

TITLE: [signature] DATE: 8/11/82

DEPARTMENT/AGENCY

N.J. State Dept of Health
Div. Epi/Disease Control Rm 705
CN360
Trenton, N.J. 08625
Attn: Phyllis Jackson

(24) COMMODITY CODE	(25) 1099 INDICATOR	(E) (26) PAYEE REFERENCE – (LIMIT 34 CHARACTERS)	(F) (27)	(28) PAYEE IDENTIFICATION NUMBER		(29)	(30) CONTRACT NUMBER
7713			V	222279887	0 0		

(31) LAST INVOICE	(32) CHECK SERIES	CHECK NUMBER	(33) ACCOUNTING USE ONLY (34) SUSPENSE NUMBER	ERROR	(35) DEL REPL	(G) TERMS	(H) BILLING DATE MONTH	DAY	YEAR	PAYMENT DUE DATE MONTH	DAY	YEAR
						Net						

● PAYEE – SEE INSTRUCTIONS ON REVERSE SIDE ●

DELIVERY IS ☐ F.O.B. DESTINATION ☐ F.O.B. SHIPPING POINT

ITEM NO.	QUANTITY	UNIT	DESCRIPTION	UNIT PRICE	AMOUNT
			D-Equipment:		
			1-DAS-10 Vacuum		$ 20,000.00
			E-Rental Equipment:		
			1-Packaging Unit		13,000.00
			2-Positive Air Resperation Air Compressor		3,500.00
			F-Other Direct Expense:		
			1-ASB Storage & Transport Containers		4,200.00
			2-Portable Vacuums		700.00
			3- Scaffold Supplies		6,179.50
			ACTUAL TOTAL COST		70,681.38
			First Job Site		42,894.38
			Second Job Site		17,105.62
				TOTAL	$ 17,105.62

OF THE STATE OF NEW JERSEY 1776

CERTIFICATION BY RECEIVING AGENCY
I CERTIFY THAT THE ABOVE ARTICLES HAVE BEEN RECEIVED OR SERVICES RENDERED AS STATED HEREIN.

SIGNATURE

TITLE DATE

CERTIFICATION BY APPROVAL OFFICER
I CERTIFY THAT THIS INVOICE IS CORRECT AND JUST, AND PAYMENT IS APPROVED.

AUTHORIZED SIGNATURE

TITLE DATE

US4 (6/80)

ORIGINAL

0 | 8 20 8 2 7 8 2

INVOICE OF NEW JERSEY

(9) VENDOR STATUS

BLANK = NO CHANGE
1 = NEW VENDOR
2 = ADDRESS CHANGE
3 = LOCATION CODE
4 = NEW VENDOR AND LOCATION
5 = VENDOR NO. CORRECTION

(10) ACCOUNT NUMBER

ORGANIZATION	FUND	PROGRAM	OBJECT	(11) COST CENTER	(12) PROJECT ACTIVITY	(13) EXTENDED NUMBER	(A) (14) TOTAL AMOUNT	(15) AGENCY P.O. NO.	(16) (17) OBLIGATION NUMBER
4230	215	032880	63	714			$17,105.62		P 17176

(B) PAYEE NAME AND ADDRESS
(18) NAME (19) (20) STREET (21) CITY (22) STATE (23) ZIP CODE

Diversified Vacuum Systems
671 Frelinghuysen Ave.
Newark, New Jersey 07114

(C) DEPARTMENT/AGENCY

N.J. State Dept. of Health
Div. Epi/Disease Control Rm 705
CN 360
Trenton, N.J. 08625
AttN; Phylis Jackson

(D) PAYEE DECLARATION:
I certify that the within invoice is correct in all its particulars, that the described goods or services have been furnished or rendered, and that no bonus has been given or received on account of said invoice.

[signature]
PAYEE SIGNATURE

[signature] 8/14/82
TITLE DATE

(24) COMMODITY CODE	(25) 1099 INDICATOR	(E) (26) PAYEE REFERENCE – (LIMIT 34 CHARACTERS)	(F) (27) (28) PAYEE IDENTIFICATION NUMBER	(29) (30) CONTRACT NUMBER
7713			V 222279887 0-0-	

(31) LAST INVOICE	(32) CHECK SERIES	CHECK NUMBER	(33) ACCOUNTING USE ONLY (34) ERROR SUSPENSE NUMBER	(35) DEL REPL	(G) TERMS	(H) BILLING DATE MONTH	DAY	YEAR	PAYMENT DUE DATE MONTH	DAY	YEAR
					Net						

• PAYEE – SEE INSTRUCTIONS ON REVERSE SIDE •

DELIVERY IS ☐ F.O.B. DESTINATION ☐ F.O.B. SHIPPING POINT

ITEM NO.	QUANTITY	UNIT	DESCRIPTION	UNIT PRICE	AMOUNT
			Asbestos Removal Project using the Vacuum Removal System.		
			A-Personnel:		$ 13,779.50
			B-Travel:		1,650.00
			1-Gas alowence: $1,500.00		
			2-Tolls 150.00		
			C-Supplies:		
			1-Asbestos West		192.98
			2-Bags		251.75
			3-Coveralls		2,046.00
			4-Aircroan Helment		840.87
			5-Booklets		197.00
			6-Signs		75.00
			7-Mask		292.50
			8-Removal Supplies		980.28
			9-H.E.P.A. Air Filters		1,440.00
			10-Primary Air Pre-Filter		,1356.00
				TOTAL	$17,105.62

SEAL OF THE STATE OF NEW JERSEY

CERTIFICATION BY RECEIVING AGENCY
I CERTIFY THAT THE ABOVE ARTICLES HAVE BEEN RECEIVED OR SERVICES RENDERED AS STATED HEREIN.

SIGNATURE

TITLE DATE

CERTIFICATION BY APPROVAL OFFICER
I CERTIFY THAT THIS INVOICE IS CORRECT AND JUST, AND PAYMENT IS APPROVED.

AUTHORIZED SIGNATURE

TITLE DATE

0/54 (6/80)

ORIGINAL

APPENDIX E

DAILY SUMMARIES OF EXPOSURE

8.0 PRESENTATION OF DATA

8.1 Elmwood Park Project Evaluation

Day 01 - Preparation

- Workers installing plastic sheeting, constructing decontamination chamber.
- Workers wearing no respiratory protection in AM.

Work Area

On Scaffold	5.0
Packaging Unit Stationary	.537

Outside Decontamination Chamber

Instantaneous, AM	.122
Stationary, AM	.207
Instantaneous, PM	.056
Stationary, PM	.194

Clean Areas

Base of Stairs	.028

Phase Contrast Microscopy Only,
*Heavy in solids, difficult to count.

Day 02 - Removal, Dry

- Two (2) workers inside removing asbestos, two (2) workers vacuuming, one (1) packaging unit, one (1) foreman
- Respirators (Racal AC-30) and personnel protection satisfactory

Work Area

Personnel, Scraping	4.33
Personnel, Vacuuming	3.95
Stationary, Scraping	2.35
Stationary, General Area	.74
Stationary, Corridor	.10

Outside Decontamination Chamber

Instantaneous, AM	.009
Instantaneous, PM	.021
Stationary	.037

Clean Areas

Upstairs, on Foyer	.011

Outside Building

Staging Area	.022

PCM analysis only, presented in fibers/cc

Day 03 - Removal, Dry

- Four (4) workers removing asbestos (compressor not running), only four (4) portable supplied air systems operating, one (1) inside foreman with dust mask only, one (1) packaging unit, one (1) supervisor
- Vacuum hoses present in work areas
- Removal very visibly dusty, workers wire brushing
- Visible negative pressure observed through plastic baffles
- Protection factor of Bullard shroud investigated

Work Area

On Scaffold, AM	1.143
On Scaffold, PM	1.253
Personnel Scraping	1.166
Personnel Scraping	.454
Inside Bullard Hat	-0-
Outside on lapel	1.676

Protection Factor at 100%

Outside Decontamination Chamber

Instantaneous, AM	.021
Instantaneous, Workers Exit	.035
Instantaneous, PM	.008
Stationary	.050

Clean Areas

Top of Steps, 2nd Floor	.018

(PCM Analysis only, presented in fibers/cc.)

Day 04 - Removal, Dry

- Workers inside removing and using power tools to cut wire around beams
- Repair and reinforcing of barriers required
- Air compressor for supplied air is repaired

Work Area

On Scaffold, Scraping	1.515
On Scaffold, Brushing (no vacuum)	2.75
Personnel, Scraping	1.098

Outside Decontamination Chamber

Stationary Sample	.109*
In Chamber	.015

Clean Areas

Upstairs in Foyer, Instantaneous	.007
Upstairs in Foyer, Stationary	.027
Upstairs in Council Chambers, Instantaneous	.014
Upstairs in Council Chambers, Stationary	.083

Day 04 - Continued

Outside Building

Inside Packaging Unit	.153
Blank Filter	-0-

PCM analysis only, presented in f/cc
*Indicates outside contamination caused by workers' insufficient decontamination (showering).

Day 05 - Removal, Dry

- Five workers inside removing, one (1) inside foreman, one (1) inside packaging unit. Two shifts started this date, seven (7)-nine (9) workers inside for 2nd shift
- Air compressor operating
- Plastic protection inside and at windows is failing
- Vacuum and negative pressure visibly efficient

Work Area

On Scaffold, Scraping	1.44
Stationary, General Area	.028
Personnel, Scraping	.954

Outside Decontamination Chamber

Instantaneous, PM	.014
Stationary Sample	.083

(PCM Analysis only, presented in fibers/cc.)

Day 06 - Removal, Dry

- Five (5)-nine (9) workers inside removing, one (1) inside foreman, outside supervisor operating packaging unit
- Wet removal experiment conducted this date
- Supplied air respirators for dry removal and dust masks only during wet removal
- No vacuum hose present in wet removal room
- Insufficient variables for accurate comparison of wet vs. dry condition. One small office chosen for wet removal. Water and surfactant (Asbestos-Stop, Squa-Gro Controls, Pennsauken, New Jersey) applied with hand sprayers insufficiently.

Work Area, Dry

On Ladder, Removing Lathe	.611
Personnel, Scraping	.959
On Scaffold, Scraping	.830
On Scaffold, Scraping	.805

Day 06 - Continued

Work Area, Wet

Personnel, Scraping and Spraying	.783
Window Ledge, Stationary	1.19
On Scaffold, Stationary	.560

Outside Decontamination Chamber

Instantaneous, Three (3) Test Average	.017
Stationary Sample	.037

Clean Areas

Lower Foyer, Outside Work Area	.021

PCM analysis only, presented in fibers/cc

Day 07 - Removal, Dry

- Four (4)-six (6) workers inside, one (1) superintendent outside in 1st shift; seven (7) workers, one (1) foreman inside, one (1) superintendent outside 2nd shift. Respiratory and personal protection satisfactory. Samples collected to investigate protection factor of Racal air hat.

Work Area

Stationary, On Scaffold, PM	1.795
Personnel, Outside Air Hat, On Lapel	1.949
Personnel, Inside Air Hat	.046

Samples collected simultaneously during wire brushing of ceiling.
Protection factor of 97.64%, sufficient

Outside Decontamination Chamber

Instantaneous, AM	.012
Instantaneous, PM	.074
Stationary	.005

Blank Sample . . . . -0-

PCM Analysis only, presented in fibers/cc.

Day 08 - Clean-Up, Office Area

- Samples collected during clean-up of first removal area (offices and police area). Few workers present. Vacuum System operating to evacuate air only. Bulk material removal completed this area.

Work Area

Stationary, Multi-Purpose Room	-0-
Stationary, Corridor	.05

Day 08 - Continued

Outside Decontamination Chamber

Stationary, All-Day Collection	.055

Samples Collected From Port On Intake Line	.197*

*Heavy in solids and glass fibers.
PCM Analysis only, presented in f/cc.

Day 09 - Clean-Up and Removal Dry

- Two (2) workers conducting wet mopping and wiping for final cleaning in first area, police and offices. No vacuum lines or negative pressure in this area. Visual inspection and prelininary final testing conducted in this area.

Work Area

Stationary, Police Dispatch Area	.007
Stationary, Multi-Purpose Room	.004

Entire work area has been changed to large library, south side of building. Decontamination chamber has been relocated. Library is large removal area.

Workers (six) inside scraping, brushing, removing wire from around beams.

Three (3) small (3" ID) vacuum hoses present; area extremely dusty.

All personnel with supplied air respirators; some missing protective hoods, no auxilliary dust masks on workers.

Cascade impactor sampling conducted in work area this date as well as SEM determinations.

Work Area

Personnel, Outside Racal Air Hat	.653*
Personnel, Inside Racal Air Hat	.919

Only two (2) 3" ID hoses operating during this test; indicates high concentrations of dust and ineffective protection

On Scaffold, During Brushing		.751
On Scaffold, During Scraping		1.88
General Area, SEM Analysis	all fibers	.484
	asbestos only	.242
	including fibers < 5 microns	6.655

Outside Decontamination Chamber

Instantaneous	.031
Stationary	.033

Day 09 - Continued

Outside Building

Ambient Air, Downwind Staging Area	.06

PCM & SEM data presented in f/cc.

Day 10 - Removal

- Seven (7) workers inside scraping, wire brushing, and vacuuming bulk material. One (1) superintendent outside and one (1) worker in packaging unit.

- Workers scraping in library directly adjacent to decontamination chamber and and plastic barrier. Respiratory and personnel protection satisfactory.

Work Area

On Scaffold During Wire Brushing	1.40
Personnel, Outside Air Helmet	.832
Personnel, Inside Air Helmet	.618

Samples collected simultaneously to investigate protection factor of supplied air system. Indicates ineffective protection or improper sampling techniques.

Outside Decontamination Chamber

Instantaneous Read-Out	.007
Stationary, At Barrier	.001

Outside Building

Large Volume, Downwind Packaging Unit	.001

Day 11 - Removal, Clean-Up

- Testing conducted on HEPA filter (DOP method) this date
- Workers conducting final vacuum operations of residual bulk asbestos and beginning wet clean-up

Inside Building

Stationary, Outside Barriers	.005

Outside Building

Ambient, Downwind Vacuum Exhaust	.009
Outside Entrance to Packaging Unit	.008
Outside Window, Adjacent Hose Exit	.008
Inside Vacuum Intake Hose	.202

Day 12 - Preliminary Post-Test

- Preliminary visual inspection in library, along with air sampling throughout entire ground floor
- Visual inspection revealed residual visible dust present. Contractor instructed to re-clean using wet mopping techniques

Inside, General Area Samples

Civil Defense Room, Instantaneous	.005
Civil Defense Room, Stationary	.009
Patrol Captain's Office	.008
Secretary's Office, Juvenile Bureau	-0-
Corridor, Adjacent Vault	.004
Library, Rear	-0-
Board of Health, Kitchen Area	-0-
Library, Front, Instantaneous	.001
Library, Front, Stationary	-0-

Day 13 - Final Inspection and Post Testing

- Final inspection along with final air and surface sampling. Minimum air movement during testing. Technician created activity. DVS personnel and equipment has been removed

Visual Inspection Comments

- General condition of ceiling and beams acceptable, no residual material on ceiling or in expansion cracks, voids, etc.

- Visible dust evident on remote horizontal surfaces, apparently missed in wet wipe cleaning, approximately 10% surface area. Surface dust samples collected.

- White dust layer on floor, footprints evident, and visible pieces of ceiling material in corners and behind bookshelves in library. Surface dust samples collected.

- Beams appear clean, surface samples conducted.

- Large volume air sampling conducted in Library and Police Locker Room for SEM determinations. (See Photos.)

Inside, Area Air Samples

Upstairs Foyer	-0- *
Library, Center of Room	.003**
Locker Room, Center	.002**

Outside Building, Contractor's Staging Area . . . . -0-

Inside, Surface Dust Samples

Police Dispatch Area, Atop Air Conditioner . . . . . . .11.8 f/mm^2*

*PCM Analysis, presented in fibers/cc
**SEM Analysis, presented in fibers/cc

Day 13 - Continued

Department of Health, On I Beam	47.3 f/mm^2*
Library, Floor	14.2 f/mm^2*

*PCM Analysis, presented in fibers/cc

8.2 Montville High School Project Evaluation

Day 01, June 30, 1982 - Removal Begins, Dry

- Six (6) workers, insider scraping asbestos finish plaster off scratch coat plaster and wire lathe. Removal taking place in inner office areas. 3" vacuum hose present adjacent each team of workers.
- Work area visibly extremely dry and dusty.
- Insufficient plastic protection on walls.
- Carpet on three office floors with no protection (see photos).
- Temporary plastic barriers at corridors failing.
- Removal operations causing holes to be broken through substrate plaster (see photo 24)
- Personnel protection sufficient.

Work Area

On Scaffold, Scraping . . . . .256 f/cc
Personnel, Scraping .171 f/cc

Outside Decontamination Chamber

Stationary, In Clean Room . . . . .025 f/cc

Clean Areas

Corridor, Outside Barrier (Failing) . . . . .005 f/cc

Day 02, June 31, 1982 - Removal, Dry

- Six (6) Workers removing from inner offices.
- Insufficient plastic masking and sealing, closets not sealed, floors and walls uncovered, outlets and fixtures not covered.
- Considerable amount of holes being punctured through substrate and lathe.
- Vacuum system visibly insufficient as area has visible dust present airborne.
- Air compressor placed in clean area (cafeteria), insufficient seal on doorway.
- Insufficient decontamination chamber as workers pass equipment into adjacent clean areas without decontamination.
- Personal protection sufficient.

Work Area

Stationary, During Brushing . . . . .209 f/cc
Personnel, while wire brushing . . . . .096 f/cc

Outside Building

Vacuum Truck Exhaust . . . . -0- f/cc

Outside Building

Vacuum Truck Exhaust . . . . -0- f/cc

PCM only, presented in fibers/cc

Day 03, July 2, 1982 - Removal, Dry

- Visual inspection and minimum testing conducted approximately one (1) hour after end of shift. Contractor removed all equipment from site for holiday weekend.
- Visual inspection revealed an extremely fine dust throughout entire work area, inner offices, and outer rotunda corridor.
- Plastic barriers and masking/sealing is faulty and failing.
- HVAC register has become uncovered.
- Personal protection satisfactory.

Work Area

Stationary, No Work Being Performed	.474 f/cc
(Approximately one (1) hour after removal operations had ceased.)	

Wipe (surface dust) samples collected this date to investigate possible contamination of adjacent clean areas.

Floor In Corridor Outside Barrier, Adjacent Room 344	4.73 f/mm^2
Library Shelves Adjacent Windows to Rotunda	<2.36 f/mm^2

PCM only.

A bulk sample of the dust collected from the floor of the work area revealed 2% Chrysotile Asbestos and Cellulose fibers, along with sand, silicates, and cement.

Day 04, July 6, 1982 - Removal, Dry

- Six (6) workers removing from inside inner offices, utilizing pneumatic chisels to assist removal.
- Personal protection sufficient
- Plastic barriers failing

Work Area

Personnel, Inside Air Hat, Brushing	-0- f/cc
Personnel, Outside Air Hat, Brushing	.099 f/cc

Samples collected simultaneously to investigate protection factor of Racal supplied air head.

Stationary, During Brushing	.147
Stationary, During Scraping	.450
Stationary, During Chiseling	.575

PCM only, presented in fibers/cc

Outside work area samples analyzed via TEM this date.

Day 05, July 7, 1982 - Removal, Dry

- Six (6) workers utilizing pneumatic tools for removal, inner office area.
- Area visibly dusty, airborne and all surfaces.
- Plastic barriers are failing; masking and sealing grossly insufficient.
- Isokinetic sampling ports installed this date and preparation for testing.

Work Area

Stationary, During Removal	all fibers >5 microns	.481 f/cc
(SEM Analysis, See Photos)	asbestos only	.048 f/cc
	including fibers < 5 microns	1.07 f/cc
Stationary, Outer Corridor		.942 f/cc

Outside Packaging Unit

Stationary	-0-

Day 06, July 8, 1982 - Removal, Dry

- Six (6) workers scraping and brushing inner office area.
- Area visibly extremely dusty, airborne and horizontal surfaces.
- Isokinetic testing conducted this date on inlet/outlet of vacuum system.
- Sample collected outside Packaging Unit using low flow, personal sampler, for TEM analysis
- Vacuum hoses positioned in work area to act as negative pressure only, no bulk materials removed during isokinetic testing.

Day 07, July 9, 1982 - Removal, Dry

- Workers conducting preliminary cleaning in inner offices via vacuum (4).
- Workers preparing outer rotunda corridor with additional plastic and repairing barriers of decontamination chamber.
- Construction of containment chambers this date also.
- Sampling conducted for total airborne dust this date.

Work Area

Stationary, On Scaffold During Vacuum Clean-Up Operations 44.6 mg/m^3

Total inert (nuisance) dust via gravimetric analysis.

Day 08, July 12, 1982 0 Removal, Dry

- Removal underway in outer rotunda corridor utilizing specific mobile containments. Vacuum hose (3") present inside each containment (2).
- Removal being conducted immediately adjacent to library; wipe (dust) sample collected in library.
- New plastic masking/sealing has been installed sufficiently on walls, fixtures, and at workers' entrance.
- Personal protection safesfactory.

Work Area

Stationary, Inside Containment	.411 f/cc
Stationary, Outside Containment	.071 f/cc

Day 08 - Continued

Clean Areas

Stationary, Corridor Outside Work Area	.112 f/cc
Wipe Sample, Library Shelf	<2.36 f/mm^2

Day 09, July 14, 1982 - Removal, Dry

- Workers utilizing mobile containment system to conduct removal in outer rotunda area.
- Vacuum system being utilized inside two (2) containments and to clean miscellaneous debris on floor.
- Personal protection satisfactory.
- Sampling this date also includes investigation into total dust loading inside mobile containments via gravimetric analysis.

Work Area

Stationary, Outside Mobile Containment (AM)	.080 f/cc
Stationary, Inside Mobile Containment (AM)	.134 f/cc
Stationary, Inside Mobile Containment (PM)	.223 f/cc
Stationary, Outside Mobile Containment (PM)	.358 f/cc
Personnel, Inside Mobile Containment (PM)	.416 f/cc
Stationary, Inside Mobile Containment (PM).	.270 f/cc*

Outside Decontamination Chamber	.019 f/cc

*Filter extremely difficult to count; high concentrations of debris and solid particulates.

PCM only, presented in fibers/cc.

Personnel, Inside Mobile Containment	.293 mg/m^3
Stationary, Outside Mobile Containment	9.2 mg/m^3
Stationary, Inside Mobile Containment	7.0 mg/m^3

Day 10, July 16, 1982 - Removal, Dry

- Workers conducting removal of rotunda corridor utilizing Mobile Containments.
- Personal protection satisfactory.

Work Area

Personnel, Inside Mobile Containment Outside Racal Air Hood	.229 f/cc*
Personnel, Inside Mobile Containment Inside Racal Air Hood	-0-
Personnel, Inside Mobile Containment Outside Racal Air Hood	.758 f/cc
Personnel, Inside Mobile Containment Inside Hood	-0-

Sampling conducted simultaneously to investigate protection factor of Racal Supplied Air Hood.

Day 15 - Continued

- Visible white dust on floors.
- Informed contractor that additional cleaning is required prior to final air testing.
- Plastic barriers present but failing

Day 16, July 29, 1982 - Inspection, Recleaning

- Two (2) workers present wet mopping of floors.
- Detailed visual inspection along with wipe (surface dust) sampling for cleanliness.
- Visible white dust on all horizontal surfaces, i.e., ledges, shelves, telephones, etc.
- Walls and floors have white film due to using contaminated water for wet wiping (not emptying buckets frequently).
- Foreman from DVS claims dust is originating from ceiling and that he has cleaned twice.
- Instructed contractor to clean again.

Work Area

Inner Office, Doors of Counselor's Office	14.2 f/mm^2
Outer Rotunda, Atop Door Molding	18.9 f/mm^2
Inner Offices, Atop Door Room No. 210	16.5 f/mm^2
Outer Rotunda, Shelf At Public Phone	11.8 f/mm^2

Results indicate positive presence of asbestos fibers as per PCM analysis.

Day 17, July 30, 1982 - Inspection, Final Test

- No workers present
- Final visual inspection and air sampling conducted this date.
- Area visually clean, surface samples collected

Work Area (Air Samples)

Stationary, Outer Rotunda	all fibers >5 microns . . .	.022 f/cc
	including fibers <5 microns	.031 f/cc

Analysis conducted via SEM (see photos)

Work Area (Surface Dust Samples)

Door Sill, Principal's Office	<2.4 f/mm^2
Door Sill, Main Office	<2.4 f/mm^2
Hand Rail, Steps in Outer Corridor	4.7 f/mm^2
Atop Trophy Case, Outer Corridor.	<2.4 f/mm^2

Personnel, Inside Mobile Containment . . . . 1.17 f/cc
Stationary, Outside Mobile Containment . . . . .459 f/cc
Stationary, Inside Mobile Containment . . . . .788 f/cc

*Filter extremely difficult to count; high concentrations of debris and solid particulates

PCM data presented in fibers/cc

Day 11, July 19, 1982 - Removal, Dry

- Workers completing bulk material removal.
- Plastic barriers failing, masking/sealing of cafeteria (clean area) is down. Visible dust in cafeteria and visible footprints of dust to water fountain.
- No PCM testing this date. See TEM data for test conducted in cafeteria.
- Personal protection satisfactory.

Day 12, July 22, 1982 - Vacuum Cleaning

- Removal of bulk materials completed. Workers conducting vacuum cleaning of rotunda corridor.
- Workers not utilizing supplied air; have decreased respiratory protection to 3M Dust Masks only. No hoods or head covering.
- No PCM testing this date. See TEM data for stationary work area samples.

Day 13, July 23, 1982 - Clean-Up

- Workers conducting vacuum clean-up operations in all work areas.
- Personal protection unsatisfactory; no hoods, no foot coverings, insufficient personal decontamination.
- Contractors personnel beginning to prepare Boiler Room for Asbestos removal (not included this contract).
- No PCM data this date, see TEM report.

Outside Work Area

Instantaneous, Outside Boiler Room Doors . . . . .305 f/cc*
Instantaneous, Center of Library (Clean Area). . . . . . .016 f/cc

*Concentration indicates airborne fibers escaping boiler room, possibly contaminating outside air samples being collected for TEM.

Day 14, July 26, 1982 - Clean-Up

- Visual inspection only this date.
- Workers conducting wet wipe cleaning inside work area, offices, and rotunda.
- Unsatisfactory respiratory and personal protection.
- No vacuum system in work area.

Day 15, July 28, 1982 - Inspection

- No workers present
- Visual inspection to determine cleanliness of area.
- Visible asbestos materials present; all corners, over door moldings, etc.