U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45226

HEALTH HAZARD EVALUATION DETERMINATION
REPORT HE 76-39-604

NEVILLE CHEMICAL COMPANY
PITTSBURGH, PENNSYLVANIA

July 1979

I. TOXICITY DETERMINATION

The National Institute for Occupational Safety and Health conducted a medical and environmental investigation at Neville Chemical Company, Pittsburgh, Pennsylvania.

All the determinations made in this report are based on environmental sampling, medical evaluations, observations of work practices, existing engineering controls, and a review of available toxicological literature.

Personal and area samples were collected for all work shifts to determine the airborne concentrations of respirable dust, benzene, toluene, styrene, xylene, oil mist, and hydrogen chloride. The effects of exposure to these contaminants were evaluated by administering: health questionnaires (i.e., occupational history, past medical history, current symptoms, alcohol and smoking history, and respiratory questionnaires); physical examinations (eyes, nose, throat, skin, blood pressure, as well as respiratory and cardiovascular systems); pulmonary function tests; chest X-ray examinations; and laboratory tests (urine screening for blood, protein and sugar levels, as well as, blood tests for CBC and SMA-23 screening) were performed on the work population at Neville Chemical Company.

During the survey periods investigated, a number of exposures to respirable dust (containing resin) were found to exceed the criteria set for this investigation. The remaining chemicals sampled were not found in concentrations significant enough to pose a health hazard on those dates surveyed. Consequently, control of worker exposure to respirable dust contaminants should be a paramount concern.

The results of the clinical examination has revealed adverse health effects to employees in a portion of those production areas studied. The overall prevalence (i.e., the percentage of the production workers - exposed, versus the non-production workers-control) for the response to the symptoms questionnaire (e.g., chest tightness, eye and nose irritation, and tiredness) reported by the employees were statistically significant. Statistical significant results were also found when employees' symptoms, within individual departments, were compared to the non-production workers in terms of adverse health effects. A statistically significant increase in incidence of tiredness/weakness, eye and nose irritation, and chest tightness (difficult breathing) was also found in resin department employees. The maintenance department employees showed statistically significant difference in only tiredness and weakness, while the NSO/TBC department employees showed statistically significant results in only nose irritation.

The physical examination results on the exposed versus non-exposed groups showed a statistically significant difference in only the incidence of skin abnormalities. However, this difference was of greater significance when the individual departments were compared, e.g., resin, maintenance, and shipping departments. Also a statistically significant result was found with eye problems when the warehouse, shipping and Unichlor departments were compared to the control group. No statistically significant difference was found with the exposed group for nose, throat, neck, heart, lung, and blood pressure (systolic or diastolic) when compared with the control group. This was also the case when these parameters were compared with the control group versus individual departments.

The pulmonary function tests showed no statistically significant differences between exposed and control groups, however, when individual groups (departments) are compared, the exposed group showed a lower FEV value than the control group which indicates a statistically significant result.

There were no significant results for the hematology (blood count), blood chemistry, or chest X-ray test in either the control or exposed groups. This was also the result when the individual departments were compared to the control group. Finally, special attention was given to the respiratory symptoms as they relate to length of employment or smoking habits. No statistically significant difference was observed between the groups or among the subgroups for any of the symptoms in terms of the length of employment. However, when respiratory symptoms were checked against the smoking habit, statistical differences did emerge in the exposed group versus the control group.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are currently available upon request from NIOSH, Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226.

After 90 days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH, Publications Office, at the Cincinnati address.

Copies of this report have been sent to:

a) Neville Chemical Company, Pittsburgh, Pennsylvania
b) Authorized Representative of Local 12046, United Steelworkers of America
c) United Steel Workers of America, Pittsburgh, Pennsylvania
d) U.S. Department of Labor, Region III
e) NIOSH, Region III

For the purpose of informing the approximately 250 "affected employees" the employer shall promptly "post" for a period of 30 calendar days the Determination Report in a prominent place(s) near where exposed employees work.

III. INTRODUCTION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by an employer or authorized representative of employees, to determine whether any substance in the place of employment might have potentially toxic effects as it is used or may be found.

The National Institute for Occupational Safety and Health received such a request from an authorized representative of Local 12046, United Steelworkers of America, regarding exposures to workers to respirable dust, benzene, toluene, styrene, xylene, oil mist and hydrogen chloride.

An Interim Report, dated November 15, 1977, was given to representatives of both management and labor. Discussed in the report were the tentative observations and preliminary findings of the NIOSH medical investigations. Also, the observations and preliminary findings of the environmental portion of the investigation, to that date, were presented to management and labor. Recommendations to help improve the health and safety conditions in the employees work environment were also discussed at that time.

IV. HEALTH HAZARD EVALUATION

A. Process Description - Conditions of Use

Neville Chemical Company is located on a 30 acre site on Neville Island, Pennsylvania and has been in business for approximately 50 years. Neville employs approximately 230 people and is one of the largest producers of hydrocarbon resins, i.e., coumarone-indene (coal tar derived) and petrochemical derived hydrocarbon resins. The Neville Island facility also produces a wide variety of solvents and specialty chemicals including plasticizers, antioxidants, reclaiming oils and ultra-violet light absorbers. A recent addition to the facility is a chlorinated paraffin production unit which produces both liquid and resinous grades of chlorinated paraffins. Thus, the majority of those products produced by Neville serve as feedstock for various final products, e.g., printing inks, synthetic carpets, fibers, roadway coatings, packaging and adhesive products, paints, etc. In general, all of the products manufactured by Neville are produced and handled in closed reactor systems and units. The final products are then either loaded into barrels, drums, tank cars or trucks for shipment. Therefore, besides the maintenance operations being performed at Neville Chemical the only other primary contacts between the worker and the products being manufactured is during the packaging of the final product and an occasional escape of materials from the closed system.

The environmental portion of this investigation centered primarily on: (1) flaker-packaging operations, which normally employ as many as 24 employees; (2) resin production areas which employ approximately 58 workers; (3) Unichlor operation, which employs 8 people; (4) NSO/TBS areas which employ 13 workers; (5) retail packaging platform; and (6) maintenance operations which average 44 employees. These employees are scheduled over three work shifts, seven days a week. The work shifts per day are 12:00 p.m. to 8:00 a.m.; 8:00 a.m. to 4:00 p.m.; and 4:00 p.m. to midnight. A description of the operations relative to each of the departments surveyed and the associated potential health and safety problems in those departments are discussed in the remainder of this section. Part VI of this report offers suggested industrial hygiene practices which will help minimize exposures to the contaminants that were found in those operations evaluated at Neville Chemical Company.

1. Flaker-Packaging Operations

The flaker-packaging operations are located in Building numbers 2, 3, and 10. Building 2 was the only location that had two flaker-packaging operations at the time of this survey. In general, the flaker-packaging operation consists of filling 50 pound bags with flaked resinous material. The resinous material is first pumped from storage kettles, in liquid form (temperature= 230-265^{o}C) onto rubber conveyor belts. The conveyor belts

are approximately 3-4 feet wide by 25-75 feet long depending on the location (building) of the conveyor. Once the liquid is placed onto the conveyor belts it begins cooling and setting-up, and by the time it reaches the end the material has cooled to about 10% of its original temperature. At the end, the material falls into a crusher where it is pulverized into small flakes. From here the material is loaded into bags either by a manual or automatic (Buckel) hopper. The automatic system has a pre-scale mechanism which allows the exact amount of material to be released into the bag. Usually, there are 2-3 operators per conveyor belt, and depending on the demand, they can package between 300-400 bags per shift on a manual packaging operation machine to 600 bags on an automatic packaging machine per shift. The amount of dust and smoke created during this process is primarily a function of the quality of blend (resin batch) which is being packaged, i.e., Nebony® is of a higher quality than LX 1055A®, and therefore, the latter is more of a dust problem during the packaging operation.

In general, most of the packaging centers had both local and general exhaust ventilation systems, however, the flow rates for the majority of those local exhaust ventilation (LEV) systems were below the acceptable level for effectively removing particulates from these operations. The reduced flow rates may have been due to any one of the following: improper exhaust fan size; fan belt slippage; improper hood enclosure design; the distance between the source of particle qeneration and the exhaust hood; blockage at either the branch and/or main ducts; or improper use of dampers. Also, it was noted that cardboard was being used in numerous areas to attempt to encompass those points where dust was being generated and/or to increase the capture velocity of the exhaust hood at those points. The following is a more specific description of the exhaust ventilation systems and the problems in each of the packaging areas that were investigated:

a. No. 3 Warehouse-Packaging Center(Bldg.3) - There were three exhaust ventilation hoods along the conveyor belt in this building. The first was a slot-type exhaust hood (3 x 12 inches) which was positioned just beyond the crusher box and approximately 8 inches above the conveyor belt. The average flow rate measured across the face of this hood was between 20-30 fpm (feet per minute) which was well below the 150 fpm which this hood should be operating at. The second exhaust hood (canopy-type) was located at the point where the one conveyor transfers the material to a second conveyor belt which then carries the material up and into the hopper (Buckel). This exhaust hood is approximately 12 x 20 inches and the flow rates measured across the face of this hood were between 60-100 fpm, which again, is below the 150 fpm level. The last exhaust hood in this area was at the packaging point where the greatest exposure is likely to occur to the operator. The hood (slot-type) is 3.5 inches wide by 24 inches long and the average flow rate obtained at this hood was between 500-600 fpm at the face. This flow rate is well within the acceptable flow rate, however, due to the distance from the hood to the operation, 1-2 feet from hood to the point source, a tremendous drop in the flow rate occurred here (75-125 fpm vs. 500-600 fpm).

b. No. 2 Packaging Center (Bldg.2) - There were two conveyor belt/packaging locations in this building and these were identified as flaker operation 2-2 and flaker operation 2-4. Flaker operation 2-2 is the automatic bag loader mentioned earlier and there were three exhaust hoods measured along the conveyor system used here. The first hood tested was a slot-type exhaust hood which was 3 inches wide by 12 inches long. It was positioned just beyond the crusher box and was approximately 8 inches above the conveyor belt. The average flow rate measured across the face of this hood was between 250-300 fpm which was sufficient for this point. The second exhaust hood tested here was located at the transfer point, i.e., the point where the one conveyor transfers the material onto the Buckel conveyor belt. This was a modified canopy/bin-type of hood which was 25 inches high by 20 inches wide and 20 inches deep. The actual dimensions of the face of this exhaust system was 8 x 20 inches which existed only because of a piece of cardboard that had been placed across the remaining portion of the hoods opening. An 8-inch diameter elephant trunk-type exhaust duct was inserted into the side of the cardboard and this made up the exhaust system here. The flow rate for this system averaged between 100-125 fpm which is not sufficient for this operation. The last exhaust ventilation system measured at the 2-2 flaker operation was at the packaging site. Again, this was an automatic packaging machine which had the exhaust system built into the machine. The flow rates measured here were between 200-250 fpm which is below the 500 fpm required for this type of operation.

The second flaker operation (2-4 flaker) located in this building also had three exhaust ventilation systems that were measured. The first exhaust hood was a slot-type hood (3 x 12 inches) which was located approximately 8 inches above the belt and just beyond the crusher unit. The average flow rate measured at the face of this hood was 225 fpm which was well above the recommended level to successfully remove the contaminant. Also, cardboard was used on the crusher unit here to prevent dust from escaping, and again, this effort was only partially successful. The second exhaust hood measured (canopy/bin-type) was located at the Buckel conveyor belt transfer point. This exhaust hood was also modified, i.e., cardboard placed on each side of the hood in order to reduce spillage and increase the exhausting capabilities of the hood used here. The flow rates obtained at the face of this hood were between 40-50 fpm which is well below the required levels to effectively remove the contaminant. The last exhaust system tested at this operation was that system used to exhaust the dust away from the packaging operation site. The exhaust hood is a slot-type of hood (4 x 24 inches) and the flow rate measured at the face was between 75-125 fpm. Also, when the flow rate was measured at this point source, i.e., where the operator fills the bags, the values dropped to 40-50 fpm or approximately 1/3 the required level.

An additional problem that was noted when the 2-4 flaker process was evaluated was the lack of general exhaust ventilation in the room which houses the 2-4 conveyor belt. Unlike in the 2-2 flaker area, which has a large open door at the beginning of the conveyor system and one open door at the center of the conveyor, the 2-4 flaker has only one door along the side of this conveyor belt. Therefore, the natural flow of air from the two open doors in the 2-2 area allows the dust to escape from these openings while the dust in the 2-4 area is not allowed to escape as easily, and thus, a larger amount of dust builds up in the 2-2 flaker area.

c. Unichlor - Packaging Center (Bldg. 10) - There was one flaker packaging operation here and during the survey periods investigated this process was not operating. However, we were able to turn the exhaust system on and measure the hood, (15-inch diameter elephant trunk-type) and the flow rates obtained here ranged from 300-350 fpm which was more than sufficient. It must be noted that the only true way to determine the overall effectiveness of this exhaust system is during the actual packaging operation.

2. Resin Production Area

The resin production area actually incorporates the majority of those production processes operating at Neville Chemical Company. However, for descriptive purposes the resin production areas discussed in this section will only refer to those areas where coal tar derived hydrocarbon resins are produced. Again the majority of the processes here are performed in closed stills, reactor systems and units, and therefore, the only potential health problems were to the control still and reactor operators who work in the various control houses (i.e., unit 20 and 21 control house; No. 3 still control house; unit 40-30 control house; No. 16-18-19 still control house; and No. 4 control house), as well as those maintenance personnel who work in these areas.

Another major process which was evaluated in this area was the filter house operation where alpha methyl styrene is produced. The following is a more specific description of this process:

a. The control still and reactor operations are performed in small buildings (approximately 20 x 50 feet) and the actual job of developing and maintaining the specifications for the resin blend is performed by 1 to 3 operators per control house. These operations are performed 24 hours a day, seven days per week, and each operator works an 8-hour shift. The only variation to the operators routine is that these employees rotate their shifts every week. The potential exposures to these operators are minimal, however, a few of these control houses are in areas where dust exposure is possible from adjacent operations. Also, some of the control houses have pumps inside the rooms which can produced oil mist if they are not maintained properly.

b. The Filter house (Building No. 2) is located in a two-story building (approximately 70 x 40 x 30 feet high) with a silo attached to one side of the building. A product called Nevex (alpha methyl styrene) is produced here by first polymerizing coal tar distillate by boron trifluoride at 80°C. The material is then neutralized with lime(attapulgus clay), extracted with solvent and this slurry is then drum filtered, via a continuous rotary drum process (thru diatomaceous earth) to extract the final product. The drum filter system is located on the second floor and is designed to scrape the used clay/lime mixture by a blade every rotation. The used material is then transferred, via a conveyor belt, to a silo where it is then dumped onto the ground. The potential health exposure to dust and solvent vapors in this area exists when maintenance operators enter this building to repair machinery or clean up the used clay/lime material which falls from the second floor.

NOTE: The health hazard request which was submitted originated here when two employees were overcome while they were manually shovelling the clay/lime waste material.

3. Unichlor Operation

The unichlor operation is located in Building No. 10 and normally 5 to 6 employees (3 operators and 3 helpers) work in this area per shift. Basically, this operation produces various chlorinated paraffins and the process begins when paraffins are reacted with chlorine. After this reaction process is completed carbon tetrachloride is used to strip the paraffins from the material and the final product is then dried, flaked, and bagged. A by-product of this reaction is hydrogen chloride which, upon completion of the reaction, is transferred to holding tanks which are adjacent to the Unichlor department. Once again, except for packaging the final product (described in section IV A-1) this product is produced and handled in entirely closed systems. Besides the dust produced during the packaging process, this operation was also evaluated for potential exposures to hydrogen chloride.

4. NSO/TBC Operations

Neville Synthese Organics (NSO) and Tertiary Butyl Catechol (TBC) are actually two separate operations which are located near each other, however, due to the number of workers in these two areas (1-2 workers per shift), the nature of the process, i.e., the NSO process is performed in completely closed systems, and the TBC operation which was closed down during each of our investigations, both of these departments will be described together here.

The TBC operation produces 4-tertiary butyl catechol. This is done by first taking bags of pyrocatechol and dumping these into a reactor. The reactor is then heated to 130°C and 8 pounds of sulfuric acid is pumped into the reactor. The reactor is then sealed and 470 pounds of isobutylene is added. The batch is reacted for two hours and then soda ash is added. Finally, the batch is transferred to a neutralizer and eventually to a still where the final product is distilled off. Again, this process was not operating during the survey periods investigated, and therefore, no evaluation could be made of this operation. However, due to the potential health exposure to pyrocatechol during the bag loading phase of this operation additional references will be made regarding this problem later in this report.

The NSO operation produces ultra-violet light absorbers and antioxidants for plastics. This operation normally runs 24 hours per day, seven days a week and there are two operators per work shift. Again, this process is developed in completely closed systems, however, at one stage of the operation hydrogen chloride is bled-off and vapors will occasionally escape into the surrounding area. One safety concern that was noted in this area was in the storage room adjacent to the NSO department, i.e., nitrogen cylinders which were being stored here were not securely fastened in this area.

5. Retail Platform

The retail platform is adjacent to the Unichlor department and primarily boron trifluoride, styrene, and phenol are mixed here to produce a product called Neftain. This is an intermittent operation which is usually performed by one person and the actual time spent in packaging is dependent on consumer request. The packaging operation is performed on a platform which has four open sides. The operator is required to fill 55 gal drums with the product and transfer these to a temporary storage platform or to the loading dock. This area was sampled for the chemicals described above. Also, during our investigation it was noted that no safety rails had been provided along this platform. Management was notified of this safety hazard and upon our follow-up survey a safety rail was being used.

6. Maintenance

Maintenance operations are an ongoing concern at Neville Chemical, and therefore, it was our intention to sample maintenance personnel as deemed necessary. However, due to the nature of the types of maintenance being performed during our investigations, e.g., structural additions, electrical problems, etc., it was felt that it was unnecessary to sample these operations and therefore no personal samples were taken on maintenance employees.

B. Evaluation Progress - Chronology

The following is a chronology of the activities performed at Neville Chemical company by NIOSH:

1. The request for the Hazard Evaluation was received March 5, 1976. Initial walk-through survey postponed due to OSHA involvement.

2. An initial environmental and medical walk-through survey was performed on April 13-14, 1976. It was revealed that two employees were overcome from unknown contaminants while performing a maintenance operation. The request also stated that there were many potential chemical exposures involved in the various operations performed at the plant including some with unknown toxicity.

3. April 14, 1976 and July 28, 1976 medical investigations, of the two employees described above were performed. The preliminary account of this investigation was presented in the medical officers' memo to the Pittsburgh Area OSHA Officer.

4. The first environmental sampling survey was conducted at the company in July 1976. However, the environmental officer resigned his position with NIOSH soon after his investigation and this portion of the survey was suspended.

5. A medical survey of the employees was conducted at Neville Chemical Company in October 1976.

6. An internal report by the medical officer, submitted March 24, 1977 described the progress of evaluation and reasons for delay, e.g., environmental officer re-assignment, analytical problems on environmental samples collected in July, 1976, difficulties in data analysis of medical results, etc.

7. Environmental officer assigned June 1977, and his initial walk-through survey was performed on July 27, 1977.

8. Follow-up environmental investigations were performed on August 15-18, 1977 and November 8-9, 1977.

C. Methods of Evaluation

1. Environmental Methodology

Individual workers' exposure to particulate dust, hydrogen chloride, oil mist, benzene, toluene, xylene, and styrene were measured using the state of the art personal and area sampling apparatus. These consisted of a battery powered pump and some type of filter, charcoal, or impinger collection device (placed at the breathing zone) which would be appropriate for the particular air contaminant being measured. The general area samples were taken in a similar manner as described above, however, the collection device was placed as close to the operators' work site as possible. Also, each of these general area samples were placed in what was considered to be the operator breathing zone. The methods for collection and analyses for these substances are discussed below.

a. Total and Respirable Particulate: The total and respirable dusts were presumed to primarily consist of hardened resin. The respirable dust concentration was measured by drawing air at a flow rate of 1.7 lpm through a size-selective device. The device consisted of a 10-mm nylon cyclone to remove the non-respirable fraction of the total dust prior to collection of the respirable portion on a pre-weighed vinyl membrane filter (VMI) for gravimetric analysis as described for total dust. The total dust level was measured by drawing air at a flow rate of 1.5 liters per minute (lpm) through a pre-weighed vinyl membrane filter mounted in a closed face cassette and then weighing the amount of dust collected.

b. Hydrogen Chloride: Worker exposures to hydrochloric acid mist were measured by bubbling air at 1.5 liters per minute through an impinger containing 0.5 N sodium acetate collecting media. The amount of hydrochloric acid was determined by the turbidimetric method. Drager* colorimetric gas detector units were also used to measure approximate levels of hydrochloric acid gas through these units are not certified for accuracy.

c. Oil Mist: Oil mist samples were collected on VMI filters at a flow rate of 1.5 liters per minute. The samples were desorbed in 10 mls of chloroform, and analyzed by fluorescence spectrophotometry.

*Mention of brand names or commercial products does not constitute an endorsement by NIOSH.

d. Benzene, Toluene, Styrene, and Xylene: Worker exposures to benzene, toluene, styrene, and xylene were estimated by area personal air sampling. Benzene, toluene, styrene, xylene levels were measured by drawing air at 50 cc/minute through tubes containing activated charcoal collection media. Analysis was performed by carbon disulfide desorption and gas chromatography. Drager colorimetric gas detector units were also used to measure the benzene and styrene levels. The benzene and toluene gas detector units are NIOSH certified to have an accuracy of ± 35 percent at one-half the exposure limit and an accuracy of ± 25 percent at one to five times the exposure limit. The styrene and xylene gas detector units are not certified for accuracy.

2. Medical Methodology

The potential health hazards of concern at Neville Chemical are respirable dust particulates, hydrogen chloride, benzene, toluene, styrene, xylene and oil mist. Adverse health effects of the above substances are well known and specific. However, the health effects from dust containing (Coumarone-indene resin) as well as some of the chemicals not sampled for e.g., pyrocatechol and tertiary butyl catechol are not as well known.

Active workers at Neville Chemical Company were requested to participate in the examination. Initially, it was felt that all the workers in the plant were at risk or exposed to toxic substances. The definition of those persons at risk, low vs. high, is further discussed in Section D "Evaluation Criteria-Medical". Consequently, it was felt that it was necessary to study all the departments in the production area namely, resin, warehouse, maintenance, labor, NSO/TBC, shipping and Unichlor areas. Employees in the office were asked to participate to serve as a control group. However, only about one-quarter of the office employees could be studied due to the NIOSH study teams' capacity. The office employees were not randomly selected.

As seen in the above, workers are exposed to multiple chemicals which could produce toxic effects in various organs - skin and mucous membrane irritation, respiratory irritation, respiratory dust deposition (pneumoconiosis), liver or kidney damage, and systemic poisoning. Workers are likely to be exposed to several of these chemicals and it was difficult to isolate a single exposure situation. Also, workers may get various job assignments, or in the case of maintenance workers, work at various operations.

Because of this, and since it was impractical to devise a separate examination method for each of the different groups of workers, a uniform line of examinations was used for all subjects. The medical examination included:

1. History review (occupation, illness, alcohol intake and smoking).

2. Review of symptoms.

3. Physical examination: Inspection of eye, nose, throat and skin. Blood pressure measurement. Chest auscultation.

4. Spirometry (FVC, FEV, and FEF_{25-75}): Each subject was asked to exhale maximally into the Ohio Medical Products Model-800 Spirometer with a volumetric type transducer. Automatic calculation of values was done by the Health Guard (formerly Biologics, Inc.) Model CPT-2 system using the best effort of 5 trials. For the group of flakers in resin departments, a comparison of pre- and post-shift spirometry was made to evaluate the effect of dust exposure in the flaking and bagging of resins. For evaluation of the spirometric results, the individual data were compared with the standard values for sex, age and height, and expressed in percentage of the predicted values.

5. Chest X-ray: A 14 x 17 inch PA (postero-anterior) view was taken and read by a certified B reader radiologist.

6. Laboratory Test:

   a. Urine - screening for blood, protein and sugar. If positive, a microscopic examination of urine sediment was done.

   b. Blood - complete blood count (CBC) and 23 item multiphasic serum analyses (SMA-23). The latter included - calcium, phosphorus, sodium, potassium, chloride, iron, blood urea nitrogen (BUN), creatinine, uric acid, glucose, albumin, globulin, total protein, total bilirubin, direct bilirubin, cholesterol, total lipids, triglyerides, SGOT, SGPT, LDH, GGTP, and Alkaline phosphatase.

A total of 172 employees fulfilled the criteria for this study and were requested to participate in the examination. For the questonnaire and medical examination a special examination form, precoded for computer handling of data, was used. Chest X-ray films (PA) were read according to the ILP/UC international classification for pneumoconiosis, by three independent readers; a consensus reading was recorded on a special precoded form. The pulmonary function test results were compared to predicted values (Morris, 1971)[10] for males and females. The criteria for abnormalities were: Restrictive ventilatory dysfunction forced vital capacity (FVC) abnormal=>80% predicted and normal=<80% predicted; obstructive ventilatory dysfunction (forced expiratory volume (FEV) abnormal=>80% predicted and normal=<80% predicted.

A total of 155 employees were examined at Neville Chemical during the medical investigation. This accounted for 90 percent of those employees original requested to participate in this portion of the health hazard evaluation at Neville Chemical.

D. Evaluation Criteria

1. Environmental Criteria

There are several criteria used to evaluate the potential toxicity of air contaminants of an employee's work environment: (1) NIOSH Criteria Documents for Recommended Occupational Health Standards; (2) American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV's); and (3) Federal Occupational Health Standards promulgated by the U.S. Department of Labor. These criteria are based upon the current state of knowledge concerning toxicity of these substances.

The values for each contaminant are designed to allow an occupational exposure for an 8-hour work day up to a 10-hour work day, 40-hour work week. The Time Weighted Average (TWA) is that value given an employee over a normal lifetime, without the worker experiencing undue discomfort. In some instances, a few employees may experience discomfort at or below the criteria. There are some airborne contaminants for which a TWA is inappropriate, consequently, a Ceiling Value for an interval of 15 minutes or less is given. This ceiling concentration should never be exceeded.

The present health criteria has been tabulated below.

Substance	Evaluation Criteria 8-hour Weighted Average (TLV-TWA) (mg/M3)	(ppm)**	Ceiling Value (mg/M3)	(ppm)
Respirable Particulate[1]	5			
Total Particulate[2]	10			
Hydrogen Chloride[C3]	7			
Benzene[4]		10		1
Toluene-skin[5]	375	100	560	
Styrene[6]	420	100		
Xylene-skin[7]	435	100		
Oil Mist[8]	5			

1-2) ACGIH TLV Document (1978).
3) ACGIH TLV Document (1978).
4)NIOSH Update Criteria and Recommended Standard (1976).
5) ACGIH TLV Document (1978) and NIOSH Criteria Document (1973).
6) ACGIH TLV Document (1978).
7) ACGIH TLV Document (1978) and NIOSH Criteria Document (1975).
8) ACGIH TLV Document (1978).
*mg/M3 = appropriate milligrams of substance per cubic meter of air.
**ppm = parts of vapor or gas per million parts of contaminate air by volume.
C = Ceiling limit which would never be exceeded even instantaneously.

2. Medical Criteria

The medical criteria used to determine a toxic response to the substance under investigation consist of symptoms and signs which each agent produces when a toxic exposure occurs. A review of the known toxicological effects of the substances follows:

a. Nuisance Dust

Nuisance dust has little adverse effects on the lungs and does not produce significant disease if exposures are kept under reasonable control. These dusts are biologically inert in that when inhaled the structure of the alveoli remains intact and little or no scar tissue is formed, and thus any reaction provoked is potentially reversible. Excessive concentration in the work area may decrease visibility, cause eye, ear, and nose discomfort. This can also create injury to the skin due to vigorous cleansing procedures necessary for their removal.

b. Coumarone-Indene Resin

Coumarone-indene resin is reported to be non-toxic (in oral route). However its toxicity via the respiratory tract has not been established. It is suspected that larger size non-respirable dust particles may cause mechanical irritation to upper respiratory tract and also to conjunctiva.

c. Hydrogen Chloride

HCl is seldom inhaled in concentrations high enough to cause serious intoxication because of its irritant nature. However, hydrogen chloride is very irritating to the throat on short exposures. The evaluation criteria of 7 mg/M^3 will prevent toxic injury but is borderline as far as irritation is concerned. Skin contact may cause burns depending on concentration.

d. Benzene

Benzene is a flammable, colorless, odorous, aromatic liquid. It is relatively insoluble in body fluids and tissue, thus only small amounts are retained by the body. Benzene can enter the body by inhalation, ingestion and, to a small degree, by direct skin contact. It is toxic to every organ, tissue and cellular system of the body and is an enzymatic poison.

The primary toxic action of acute benzene exposure is exerted on the central nervous system. Symptoms of acute exposure include; dizziness, excitation, euphoria, pallar followed by flushing, headaches, breathlessness, coma, and death. Visual disturbances, tremors and convulsions frequently occur. The chronic effects of benzene intoxication are primarily associated with the blood cells and hemtopoietic tissues. Numerous effects have been documented, the most insedious being aplastic anemia. Symptoms from chronic exposure are varied and vague but include headaches, dizziness, fatigue, anoxeria, and dyspnea. NIOSH considers the accumulated evidence from clinical and epidemiologic data to be conclusive, at this time, that benzene is leukemogenic.

Pregnant women may be more susceptibel to benzene poisoning and may have a higher risk of sterility.

Benzene is eliminated from the body by expiration and urine. The body can also transform some benzene into phenol, pyrocathechol, and hydroquinone which are then excreted in the urine.

e. Toluene

Toluene has been extensively studied and the major concern is its narcotic effects on workers. Such signs and symptoms as muscular weakness, confusion, impaired coordination, sensitivity to light, repeated headaches, nausea and skin irritation are common effects of overexposure to toluene. Mild fatigue and weakness are also found at or above the TLV.

f. Styrene

Styrene vapor at concentration of 200 to 400 ppm were found to have transient irritant effects on the eyes. Styrene sickness characterized by symptoms of headache, sleepiness, nausea, vomiting, general weakness, and loss of appetite has occurred among workers exposed to styrene vapor. Exposure to levels around 200 ppm did not affect the hematopoietic system. It has been reported that chronically exposed workers have prolonged reaction time.

g. Xylene

Xylene is similar in its acute toxic effects to those of toluene, but has more irritant effect on the skin, conjunctiva, and respiratory tract. It also has some variable effects on the liver and kidneys and irritant, nonspecific effects on the gastrointestinal tract. The reported effects on the kidney are albuminuria, microhematuria, and hypuria. It was reported that there was found in one patient serological evidence of hepatitis. Chronic effects on exposure to these agents range from weakness, dizziness and fatigue to dermatitis. Other chronic effects are less well defined.

h. Oil Mist

Inhalation of oil mists may cause mucous membrane irritation and a pulmonary pneumonitis. Prolonged contact with oil mist may cause skin irritation and dermatitis. Oil mist produce "oil acne," which is an inflammatory skin condition characterized by the presence of blackheads, pimples and pustules due to oil blocking and irritating the pores of the skin which is followed by bacterial infection. More rarely an acute inflammatory condition occurs, generally on the hands and forearms, such as might be produced by any powerful skin irritant with redness, much local swelling and blister formation. The arms are most affected, but the rash may occur on any part of the body where there is contact with oil, or oily clothing.

i. Pyrocatechol

Pyrocatechol, as reported in animal experiments, can produce anemia, leukopenia (decrease in white blood cell count), and damage to kidney (renal tubule degeneration). In industrial situations, eczematous dermatitis is reported to be not uncommon. If absorbed in a significant quantity, it may cuase damages to the heart, lungs, liver and kidneys.

j. Tertiary Butyl Catechol

Tertiary butyl catechol is reported to cause leukoderma (depigmentation of the skin).

E. Evaluation Results and Discussion

1. Environmental Evaluation

Employee exposure to airborne particulate dust, hydrogen chloride, benzene, toluene, xylene, styrene, and oil mist during the various stages of resin, antioxidant and chlorinated paraffin production have been assessed.

a. Respirable and Total Dust

During the August 1977 survey a total of eight personal breathing zone samples were collected in building number 2 and 3 packaging warehouses, for respirable dust. Two respirable dust samples were collected in the Packaging Warehouse Number 3 and six respirable samples were collected in Building Number 2. During this sampling period each of the areas sampled were tested for three hours in the morning, at which time, the samples filters were removed and replaced with new filters for an additional four hours. Thus, each flaker operator was sampled twice during the work shift. The results obtained for respirable dust ranged from 0.49 to 4.32 mg/M^3 (Refer to Table 1). All of these samples were below the current ACGIH recommend standard of 5.0 mg/M^3. Therefore, by reviewing this data alone one would assume that these operators are not being exposed to excessive amounts of particulate dust during the work shift, however, this situation did change when these operators were tested for longer periods. During the November 1977 survey, a total of four operators, two in packaging area 2-2 and two flaker packaging operators in building 3 were sampled. Unlike the August investigation, these operators were sampled consecutively for approximately 7 1/2 hours. The results obtained for these respirable dust samples ranged from 3.19 to 7.72 mg/M^3 (Refer to Table 1). Two of these samples exceeded the recommended standard level. Therefore, by comparing the two sampling periods, the conclusion drawn is that, an excessive exposure did not occur for the first 3 or 4 hour sampling period but did exist when these operators were tested for periods greater than 4 hours. An additional conclusion may be that the manufacturing volumes or ventilation conditions were different between the August and November surveys. However, the employees working in this area stated that the November production rate was slower than normal for this period than it was for the August survey. Also, it was the project officer's observation that these ventilation systems were operating the same for both periods.

Total dust particulate values were also taken in both the packaging warehouses that were operating during these survey periods (14 samples in August and 4 samples in November). Again, these samples were taken in locations that would be indicative of the operators general work area. The results obtained for total particulates ranged from 3.78 to 58.81 mg/M^3 for the August survey (5 samples exceeded the standard of 10 mg/M^3) and 19.9 to 150.3 mg/M^3 for the November investigation of which all of these samples exceeded the standard. The sample periods for total particulates were similar to that for respirabel sampling periods, i.e. two sampling periods (3 and 4 hours samples) were tested during the August survey and 7 1/2 hour sampling periods for the November survey. Here again the trend which existed for respirable samples also exists for the total particulate samples, i.e., when sampling periods exceed 3-4 hours a larger percentage of the samples will exceed the standard.

b. Hydrogen Chloride

Hydrogen Chloride area samples were taken for both survey periods on the second story of the Unichlor operation. A total of seven samples were taken of which 3 of the samples were taken in August and the remaining 4 samples were taken during the November survey. All of these samples were below the ACGIH criteria of 7 mg/M^3 (Refer to Table 2).

c. Oil Mist

Oil mist samples were taken in three control room areas during the November survey. The values obtained for oil mist ranged from 0.02 to 0.03 mg/M^3 which is only a fraction of the NIOSH recommended standard of 5 mg/M^3.

d. Benzene, Toluene, Xylene, and Styrene

Personal and general area samples were taken for benzene, toluene, xylene, and styrene in the filter house, NSO, and the retail platform area at Neville Chemical. A total of 14 sampling areas were tested for each of the four chemicals in question. The results for each of these solvents ranged from: non-detectable to 0.48 mg/M^3 for benzene; non-detectable to 0.49 mg/M^3 for toluene; non-detectable to 0.71 for xylene; and non-detectable to 0.49 mg/M^3 for styrene. All of the these values are far below the recommended standards of 3.2 mg/M^3 for benzene, 375 mg/M^3 for toluene, 435 mg/M^3 for xylene, and 420 mg/M^3 for styrene (Refer to Tables 4 and 5).

2. Medical Evaluation

a. General

A total of 172 people participated in the medical survey but the data from 155 were used for statistical evaluations. Seventeen were not included in the statistical evaluation because they were females (8), blacks (6), or hispanics (3) who were too few in number or for whom standard values are not available for comparison. The 155 consist of 37 (24%) controls and 118 (76%) production workers (exposed). The groupings of department, age, and employment years are shown on Tables 6, 7, and 8. The average years of employment for the control group is 13.3 years, while it is 6.5 years for the exposed, suggesting that the production work force is younger and possibly less stable than those employees who were studied as controls. The labor and warehouse departments had workers with shortest employment length (Table 6).

As seen in Tables 7 and 8, the exposed group was six years younger than the control group. In other comparison, about one-third of the control group are under 30 years old, while about one-half of the exposed were under 30. However, statistical comparison of the age distribution between the groups using X^2-test of association prove to be non-significant, indicating that age is not a confounding factor.

b. Past Illnesses

Frequency of past illnesses as reported by subjects is listed in Table 9. No validation was made as to the time of onset or nature of such illness in regard to whether or not it may be related to the occupation.

As seen in Table 9, no statistically significant pattern has emerged about their past illnesses.

c. Symptoms

Summary of symptoms reported in response to directed questions is listed in Table 10. The exposed group had a greater percentage of people complaining of "tiredness (or weakness)" and "chest tightness (or breathing difficulty)" than did the control group and the difference was statistically significant ($p<0.01$ and $p< 0.03$ respectively). A difference in smaller degree of significance ($p<0.10$) was reported in the incidence of "eye irritation" and "nose irritation". No statistically significant difference was observed for other symptoms such as "trouble sleeping", "dry or sore throat", "headaches", "nausea", "vomiting" and "skin rash". No statistically meaningful comparison was possible for the incidence of "loss of appetite", unexplained weight loss" and "dizziness", since there is an empty cell (zero incidence) in one of the four cells.

Table 11 shows the number of symptoms reported by each department and compares them with that of the control group. Resin department reported increased incidence of "tiredness/ weakness", "eye irritation", "nose irritation", "dry/sore throat", and "chest tightness/difficult breathing", which are statistically significant at $p<0.05$ level. Maintenance department showed such difference only in "tiredness/weakness", and NSO/TBC department showed such difference in the incidence of "nose irritation" only.

d. Respiratory Symptoms

Special attention was paid to respiratory symptoms as they may relate to the length of employment or smoking habit. The result is listed in Tables 12 and 13.

Table 12 shows the frequency of respiratory symptoms for both the control and exposed groups, and also for up to 5 years, and more than 5 years of employment within each group.

However, when respiratory symptoms are checked against the smoking habit, some statistical differences have emerged. Within the exposed group, the current smokers had a higher incidence of cough, phlegm, breathlessness, wheezing, and persistent cough and phlegm, than the non-smokers (non-smokers including ex-smokers). The differences were significant at $p<0.05$ level except for phlegm which was significant at $p<0.10$ level.

Within the control group, there was no statistically significant differences between the current smoker and the non-smoker groups in the frequency of respiratory complaints except for persistent cough and phlegm, which was significantly higher ($p<0.05$) among the current smokers.

e. Physical Examinations

The group results are shown in Table 14-a. When the entire exposed group is compared with the control group, only statistically significant difference is observed in the incidence of skin abnormalities. When the departments are considered, maintenance and shipping had an increased incidence with high degree of significance ($p<0.05$) and resin and labor had some increase with significance level of $p<0.10$. Most of these skin abnormalities were dryness of skin possibly due to exposure to solvents (for cleaning purpose?) and scars from old chemical or thermal burns.

Small in number, but a statistically significant increase of eye findings (mostly mild conjunctional injection) was noted in the warehouse, shipping and unichlor departments. No statistically significant differences were noted in the incidence of findings of nose, throat, neck, heart and lungs. The results of blood pressure measurement (Table 14-b) indicate no statistically significant difference in either systolic or diastolic blood pressures between the control and exposed groups.

f. Pulmonary Function Tests

Summary of the result is listed in Table 15-a. When the number of persons having abnormal values (below 80% of predicted) in each group is considered, there is no statistically significant difference between the exposed and the control groups (Tables 15-b). However, when group means and standard deviations are examined using F-test, the exposed group showed a lower FEV value which is statistically significant.

g. Hematology (Blood Count)

The group result is shown on Table 16. There is no statistically significant difference between the exposed and the control group in any of the values listed.

h. Blood Chemistry

As shown in Table 17, there is no statistically significant difference between the exposed and the control group in any of the tests conducted.

i. Chest X-Ray

Altogether, 118 of the exposed group and 37 of the control group had chest X-ray examinations. There were a total of 10 readings indicating various abnormalities, such as, small diffuse opacities suggestive of pneumoconiosis (3 in the exposed and 2 in the control), pleural changes (2 in the exposed, and 0 in the control) and others (2 in the exposed and 1 in the control). From this data it is concluded that there are no significant differences in chest X-ray findings between the two groups. However, the records of these 10 individuals were reviewed more closely for their occupational history, smoking history and pulmonary function results. The three poeple from the exposed group who had a reading of "small opacities", have worked at the Neville Chemical Company from four to six years as production workers, still operator, or equipment operator. One had worked in a steel company for a few years. Their ventilatory function tests are all above 80% of the predicted but one with slightly low FEF. They are all smokers. Two individuals from the control group who had "small opacities" reading have done clerical type work for 20 to 30 years. Their ventilatory functions are above 80% of the predicted except for somewhat reduced FEF. They are both smokers. From this review, it may be said that the X-ray reading of small opacities such as P1, q1, and S1 are not necessarily indicative of presence of pneumoconiosis, at least in these cases.

The two individuals who had a reading of pleural change have worked in the shipping department, as a laborer, or pump operator for 10 to 20 years. One has a normal ventilatory function and the other moderately reduced. They are both smokers. No past exposure to asbestos has been established.

j. Pre- and Post-shift Examination of Flakers

During this examination, ten flaker operators were studied for pre- and post-shift change in symptomatology, physical examination and ventilatory test. Seven of these ten men completed the tests.

Of this group, there was one person complaining of stuffy nose, dry mouth and tight chest after the shift. However, these complaints were not present as a group. This person had a coarse breath sound in the pre-shift examination and this fact suggests that it is not likely to be due to acute exposure to resin dust. Another person complained of throat irritation in both pre- and post-shift physical examinations.

Comparison of pre- and post-shift physical examinations revealed that only conjunctivae showed reactions possibly due to dust exposure (vascular injection). Four of the seven workers had a change from "normal" to slight injection", or "slight" to moderate injection". Vascular injection of conjunctivae is commonly a result of conjunctival irritation due to foreign body or other irritant, or infection.

Pre- and Post-shift ventilatory functions were compared using the paired t-test. In all of the forced expiratory capacities, the average of 7 persons had a decrease from pre-shift to post-shift. FVC:4333-4308=25 ml; FEV^1: 3581-3452=129 ml; and FEV_{25-75}: 4278-3860=418 ml. However, these reductions were not statistically significant at $p<0.05$ level.

From the above, it may be summarized that dust of coumarone-indene resin is irritating to the eyes, perhaps not because of its chemical action, but because of physical irritation to the eyes. From this small scale study of pre- and post-shift comparison, it may be said that the post-shift ventilatory capacities are slightly reduced from the pre-shift. It is not established at this time whether this reduction is due to the dust exposure or a fatigue factor.

V. SUMMARY AND CONCLUSION

A medical and environmental evaluation was conducted among the workers at Neville Chemical Company. The purpose of this study was to assess the concentrations of air contaminants in the work environment, as well as to detect the potential for acute or chronic health problems resulting from suspected exposure to respirable dust (containing resin), hydrogen chloride, benzene, toluene, styrene, xylene and oil mist. Also, of concern were the suspected health hazards to various chemicals that we were unable to evaluate environmentally due to the infrequency of the operation (e.g. maintenance-filter changes, kettle repairs, etc.) and/or the operation was closed down e.g. TBC-pyrocatechol.

Breathing zone and area samples were taken for respirable and total dust, hydrogen chloride, benzene, toluene, styrene, xylene, and oil mist. In a number of those jobs considered to be at risk, that is, occupations where operators were working at a site where an obvious problem existed (e.g., flaker packaging operations) exposure levels did exceed the recent hygienic standards.

Medical questionnaires, which included occupational history, past medical history, current symptoms, alcohol and smoking history, and respiratory questions were administered; Physical examinations including: eye, nose, throat, skin, blood pressure, respiratory and cardiovoscular system were performed; Pulmonary function tests; Chest X-ray; and laboratory tests (urine and blood) were also performed. A total of 155 individuals were interviewed and examined. The medical data show that 32% of the controls were less than 30 years of age and 47% of the exposed group were under 30 years of age. For the control group, 67% had been employed less than 10 years and for the exposed group 90% had been employed less than 10 years.

There appeared to be no association between reported respiratory symptoms in the exposed group with or without controlling for smoking history. The only association between reported respiratory symptoms and length of employment was seen within the control group but not the exposure group. The symptom "wheezing" was associated with exposure groups within the - employed $\leq$10 year category.

No association between reported past illnesses and exposure group was found. An association between reported allergies and exposure group was due to an excess in the control group reporting asthma and food allergies.

An association between the reported physical symptom "tired and weakness" and the exposure group was due to excessive positives in the resin and maintenance departments. This excess of positives was present for under 40 years but not over 40 years of age. The symptom "chest tightness or difficulty breathing" appeared to be in excess in the resin department again in the $\leq$10 year age group. The symptoms "eye irritation", "nose irritation" and "dry or sore throat" were reported to a greater extent (as compared to controls) in the resin department.

The physician's physical exam showed an association of skin abnormalities with the exposure group. It appears that the maintenance, shipping, labor and resin departments showed a greater prevalence of skin abnormalities as compared to the control group.

Based on the results of this survey it appears that a potentially toxic situation existed and may still exist for those workers considered to be at high risk, e.g., flaker-packaging operators. This conclusion is based on the following evidence: elevated air concentration of respirable and total dust present in the packaging operations; the higher incidence of various physical symptoms e.g., tired, weakness, chest tightness (difficulty breathing), eye and nose irritation, dry or sore throat, and skin abnormalities in the resin-flaker packaging operators.

VI. RECOMMENDATIONS

In view of the findings of NIOSH's environmental and medical study, as well as personal communications with individuals at Neville Chemical, the following recommendations are made to ameliorate potential health hazards and to provide a better work environment for the employees covered by this determination.

A. Medical

Institute a program of pre-employment and periodic medical examinations for employees exposed to toxic substances, which should include:

1. Review of occupational history, past illnesses, and smoking and drinking habits.

2. Physical examination with particular attention to the skin and lungs.

3. Spirometric examination (FVC and $FEV_{1.0}$ at the minimum)

4. Chest x-ray triennially (once every 3 years) or more frequently at the discretion of a physician if any abnormality is suspected.

5. Provide employees with non-irritating cleansing material to remove resin, oil, and other chemicals and dirt from the skin. Prohibit the use of solvents or gasoline for cleaning of the skin.

6. Eye exams, pre-employment and annual eye exams for those persons working in the bag filling (flaker/packaging) departments.

B. Engineering Controls

Whenever possible engineering controls are the preferred method for decreasing environmental exposures to toxic substances for the protection of the employees' health. A number of ventilation problems were noted in Section IV-A of the report. These have been summarized below and recommendations have been given at the end of this section to assist in solving these problems.

In general the greatest number of ventilation problems noted were with the local exhaust ventilation systems in the various flaker/packaging operations. Since the majority of these processes are operated in a similar manner (i.e., liquid resin poured onto a conveyor belt, converyor transfers material to a crusher box, crushed material transferred to hopper, and finally flaked material packaged) the exhaust ventilation problems which existed turned out to be similar at each packaging location. Specifically, the local exahust ventilation problems noted during these survey periods were: (1) Each point where the material is transferred from one conveyor belt to another belt; (2) At the crusher site, as well as that point where the crusher dispenses the flaked material onto the conveyor belt; (3) At that point where the flaked material is loaded into the hopper (Buckel); and (4) At the packaging site.

Therefore, due to the local exhaust ventilation problems described above the following recommendations should be attended to as soon as possible if they have not been already: (a) Any existing exhaust ventilation systems which are damaged e.g., hoods, ducts, and/or filters, should be restored to their original condition or replaced as necessary; (b) Any of these systems that have hoods which are improperly located, i.e., in order to increase the capture velocity the distance from the face of the exhaust hood to the point of particle generation, should be positioned as close to the point of particle generation as is possible; and (c) Hoods which are insufficiently designed should be redesigned in order to increase the capture velocity of these systems, i.e., in such a manner that will encompass the source point without interferring with the operators work, and thus, effectively collect the contaminant at the source (Refer to figures 1-6 for examples of proper exhaust ventilation designs).

An additional ventilation concern that was noted was the need for general exhaust ventilation systems in the 2-4 flaker/packaging area and the first floor of the filter house. The problem in the 2-4 flaker/packaging area, as stated earlier, was the lack of proper air circulation which is necessary to effectively remove the smoke and dust which accumulates along the conveyor belt in this area. This problem attributes to the overall dust and smoke problem here, and therefore, an exhaust fan or fans and a make-up air ventilation system should be installed here.

The exhaust ventilation problem on the first floor of the filter house is only a problem as the need for maintenance arises. Therefore, a means should be designed, general exhaust ventilation, to effectively exhaust the vapors from this area prior to and during maintenance operations in the first floor of the filter house.

C. Personal Protective Procedures

1. Respiratory Protection

When the limits of exposure cannot be immediately met by limiting the concentrations in the work environment, via engineering and administrative controls, Neville Chemical Company should utilize a program of respiratory protection to protect those persons exposed who are working in the flaker/packaging areas, as well as during maintenance in the filter house. This program must be an official written respiratory program. The following is a brief description of some of the primary concerns which should be addressed:

- There should be an established in-plant procedure and means and facilities provided to issue respiratory protective equipment to decontaminate and disinfect the equipment, and to repair or exchange damaged equipment. Records of these activites should be maintained.

- Employees should be given instructions on the use of respirators assigned to them, on cleaning respirators, testing for leakage and proper use.

- Respirators should be issued with caution. There might be individuals in the group for whom wearing a respirator carries certain specific dangers, i.e. highly increased resistance to airflow in a person with compromised pulmonary function may be associated with acute respiratory insufficiency. Employees experiencing frequent and continuous breathing difficulty while using respirators should be evaluated by a physician to determine the ability of the worker to wear a respirator.

Further information on this topic is available in the NIOSH Publication 76-189 "A Guide to Industrial Respiratory Protection." This publication was given to management during are last survey and with this information a respiratory program should be designed, if it has not been already, similar to that described in the OSHA requirements outlined in 29 CFR part 1910, 134. Finally, for those individuals who are not getting a proper respiratory face mask fit alternative respirators should be made available. There are a number of different designs and sizes, both large and small, on the market today and these alternatives should be sought out.

2. Personal protective clothing should be provided to employees working in those areas where dust is presently being generated in excessive amounts. This clothing should be disposable clothing or clothes to be at work only, e.g., impervious gloves, aprons, jump suits, etc. These should be either washed or disposed of according to need, e.g., excess dust accumulation, damage, etc.

3. Protective goggles should be provided and worn by every employee who performs packaging operations.

D. Other Recommendations

1. A number of jobs and areas were not evaluated during our investigation, e.g. TBC deapartment, Unichlor, flaker/ packaging operation, and maintenance operations (especially tanks, kettles, pipelines, etc.) and therefore these jobs and areas should be evaluated for their potential health hazards.

2. Workers should be educated as to the synergistic effects of cigarette smoking and dust exposure in producing bronchitis and obstructive pulmonary disease; and also a higher risk of developing lung cancer.

3. Resin particles and dust should be cleaned by means of a vacuum system and blowing off dust by air nozzels should be prohibited.

4. Establish a safe tank entry procedure which should include, at the minimum, provisions for proper purging, determination of oxygen content in the tank, safety harness and lines, and stand-by personnel.

5. Compressed cylinders throughout the plant must be securely fastened to a stationary object.

6. Establish a good housekeeping system. In particular, resinous materials in the kettle areas should be cleaned off promptly to prevent accumulation. No rain water or process water should be allowed to accumulate on the ground, therefore, by improving the drainage-sewer system this problem will be reduced and/or eliminated.

7. Establish a procedure to ascertain if any ducts, pipes, drums or other containers are free from toxic chemicals before they are worked on.

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Table 1

Summary of Area Sampling Concentration Data for Respirable and Total Particulates

Neville Chemical Company
Pittsburgh, Pennsylvania

August and November 1977

Sample Date	Job Description and/or Classification	Sampling Time (minutes)	Respirable Particulate Volume (M^3)	Respirable Particulate (mg/M^3)	Total Particulate Volume (M^3)	Total Particulate (mg/M^3)
8/17/77	Flaker/Warehouse #2-2	180	-	-	.27	*14.5
8/17/77	Flaker/Warehouse #2-2	240	-	-	.31	8.7
8/17/77	Flaker/Warehouse #2-4	180	-	-	.27	*52.4
8/17/77	Flaker/Warehouse #2-4	240	-	-	.31	4.5
8/17/77	Flaker/Warehouse #3	180	-	-	.27	5.9
8/17/77	Flaker/Warehouse #3	240	-	-	.31	4.5
8/17/77	Flaker/Warehouse #3	180	-	-	.27	5.6
8/17/77	Flaker/Warehouse #3	240	-	-	.31	8.6
8/17/77	Flaker/Warehouse #2	180	.31	.94	-	-
8/17/77	Flaker/Warehouse #2	240	.41	1.4	-	-
8/17/77	Flaker/Warehouse #2-2	180	-	-	.27	*58.9
8/17/77	Flaker/Warehouse #2-2	240	-	-	.36	*14.9
8/17/77	Flaker/Warehouse #2-2	180	.31	4.3	-	-
8/17/77	Flaker/Warehouse #2-2	240	.41	4.2	-	-
8/17/77	Flaker/Warehouse #2-2	180	-	-	.27	7.3
8/17/77	Flaker/Warehouse #2-2	240	-	-	.36	3.8
8/17/77	Flaker/Warehouse #2-2	180	.31	.81	-	-
8/17/77	Flaker/Warehouse #2-2	240	.41	.49	-	-
8/17/77	Flaker/Warehouse #2-4	180	-	-	.27	*10.3
8/17/77	Flaker/Warehouse #2-4	240	-	-	.31	8.6
8/17/77	Flaker/Warehouse #2-4	180	.31	1.71	-	-
8/17/77	Flaker/Warehouse #2-4	240	.41	.61	-	-
11/8/77	Flaker/Warehouse #2-2	330	.54	*6.4	.50	*19.1
11/8/77	Flaker/Warehouse #2-2	330	.54	3.2	.50	*45.
11/8/77	Flaker/Warehouse #3	330	.54	3.3	.50	*150.3
11/8/77	Flaker/Warehouse #3	330	.54	*7.7	.50	*49.6
Environmental Criteria				5 mg/M^3		10 mg/M^3
Limits of Detection				0.0 g		0.01 g

*Exceeds the criteria set
M^3 - Volume of air measured in units of cubic meters
mg/M^3 - Approximate milligrams of substance per cubic meter of air

Table 2

Summary of General Area Air Sampling for Hydrogen Chloride

Unichlor Department
Neville Chemical Company
Pittsburgh, Pennsylvania

August and November 1977

Sample Date	Sample Number	Sampling Time (min.)	Hydrogen Chloride (mg/M^3)
8/17/77	I-1	180	0.1
8/17/77	I-2	180	0.1
8/17/77	I-3	180	0.2
11/28/77	I-4	180	0.3
11/28/77	I-5	180	0.4
11/28/77	I-6	180	0.3
11/28/77	I-7	180	0.2

Environmental criteria	(NIOSH) 7 mg/M^3
Limits of Detection	0.04 mg/M^3

mg/M^3 - Approximate milligrams of substance per cubic meter of air.

Table 3

Summary of General Area Air Sampling for Oil Mist
Still/Reactor Control Rooms

Neville Chemical Company
Pittsburgh, Pennsylvania

November 1977

Sample Date	Sample Number	Sampling Time (min.)	Sampling Volume(M^3)	Oil Mist (mg/M^3)
11/23,77	V-6	120	.180	.02
11/23/77	V-4	120	.180	.03
11/23/77	V-8	120	.180	.03

Environmental Criteria	5 mg/M^3
Limits of Detection	0.02 mg/M^3

M^3 - Volume oa air measured in units of cubic meters
mg/M^3 - Approximate milligrams of substance per cubic meter of air

Table 4

Summary of Personal and Area Sampling for Benzene and Toluene

Filter House/NSO Department/Retail Platform
Neville Chemical Company
Pittsburgh, Pennsylvania

August 17, 1977

Sample Date	Number	Sampling Time (min.)	Sample Area	Benzene mg/M^3	Toluene mg/M^3	Type of Sample
8/17/77	CT-1	195	Filter House	.32	.20	GA
8/17/77	CT-2	190	Filter House	.37	.28	GA
8/17/77	CT-3	130	NSO	.02	.02	GA
8/17/77	CT-4	270	NSO	ND	ND	GA
8/17/77	CT-5	270	Retail	ND	ND	BZ
8/17/77	CT-6	300	Retail	ND	ND	GA
8/17/77	CT-7	300	NSO	ND	ND	GA
8/17/77	CT-8	240	Filter House	.08	.07	GA
8/17/77	CT-9	240	Filter House	.45	.32	GA
8/17/77	CT-10	260	Filter House	.10	.09	BZ
8/17/77	CT-11	135	Filter House	.11	.12	GA
8/17/77	CT-12	150	Filter House	.48	.49	GA
8/17/77	CT-13	180	Retail	ND	ND	BZ
8/17/77	CT-14	180	Retail	ND	ND	GA
Environmental Criteria				3.2 mg/M^3	375 mg/M^3	
Limits of Detection				0.01 mg/M^3	0.01 g/M^3	

mg/M^3 - Volume of air measured in units of cubic meters
GA - General Area
BZ - Breathing Zone
ND - Non-detectable

Table 5

Summary of Personal and Area Sampling for Xylene and Styrene

Filter House (NSO Department/Retail Platform)
Neville Chemical Company
Pittsburgh, Pennsylvania

August 17, 1977

Sample Date	Sample Number	Sampling Time (min.)	Sample Area	Xylene mg/M^3	Styrene mg/M^3	Type of Sample
8/17/77	CT-1	195	Filter House	.31	.49	GA
8/17/77	CT-2	190	Filter House	.42	.48	GA
8/17/77	CT-3	130	NSO	ND	ND	GA
8/17/77	CT-4	270	NSO	ND	ND	GA
8/17/77	CT-5	270	Retail	ND	ND	BZ
8/17/77	CT-6	300	Retail	ND	ND	GA
8/17/77	CT-7	300	NSO	ND	ND	GA
8/17/77	CT-8	240	Filter House	.10	.14	GA
8/17/77	CT-9	240	Filter House	.47	.37	GA
8/17/77	CT-10	260	Filter House	.14	.06	BZ
8/17/77	CT-11	135	Filter House	.19	.10	GA
8/17/77	CT-12	150	Filter House	.71	.39	GA
8/17/77	CT-13	180	Retail	ND	ND	BZ
8/17/77	CT-14	180	Retail	ND	ND	GA
Environmental Criteria				435 mg/M^3	420 mg/M^3	
Limits of Detection				0.01 mg/M^3	0.01 g/M^3	

mg/M^3 - Volume of air measured in units of cubic meters
GA - General Area
BZ - Breathing Zone
ND - Non-detectable

TABLE 6

Subject Distribution by Department

Neville Chemical Company, Pittsburgh, PA
HHE 76-39 (October 1976)

Department	Employees Listed	Employees Examined *	Examined / Listed %	Examinee Years of Employment mean ± S.D.
Office-Lab (control)	151	37	24.5	13.3 ± 11.6
Production (exposed)	165	118	71.5	6.5 ± 7.8
Resin	58	39	67.2	6.0 ± 7.6
Warehouse	24	19	79.2	3.2 ± 2.8
Maintenance	44	34	77.3	8.6 ± 9.4
Labor	12	6	50.0	2.0 ± 2.4
NSO/TBC	13	11	84.6	7.2 ± 6.8
Shipping	6	5	83.3	12.1 ± 9.8
Unichlor	8	4	50.0	8.6 ± 10.3

* The figures do not include 17 females and minority males who were examined.

TABLE 7

Age Distribution (years)

Neville Chemical Company, Pittsburgh, PA

HHE 76-39 (October 1976)

	≤20	21-30	31-40	41-50	51-60	>60	Mean	Median	S.D.	Mini-mum	Maxi-mum	N
Control	0 (0)*	12(32.43)	6(16.22)	4(10.81)	13(35.14)	2(5.41)	40.9	44	0.72	22	61	37
Exposed	6(5.08)	55(46.61)	23(19.49)	11(9.32)	22(18.64)	1(0.85)	34.9	30	1.98	19	65	118

* % of total group

TABLE 8

AGE DISTRIBUTION BY DEPARTMENTS

	Controls	Resin	Ware-house	Mainte-nance	Labor	NSO/TBC	Shipping	Uni-chlor
<30	12 (32,4)*	27 (69.2)	5 (27.8)	13 (38.2)	3 (50.0)	4 (36.4)	2 (40.0)	2 (40.0)
≥30	25 (67.6)	12 (30.8)	13 (72.2)	21 (61.8)	3 (50.0)	7 (63.6)	3 (60.0)	3 (60.0)

* Percentage of the total for that department

TABLE 9

Summary of Past Illnesses

Neville Chemical Company, Pittsburgh, PA
HHE 76-39 (October 1976)

Past Illnesses	Group / Response	Control (%)	Exposed (%)	X^2 Value	P Value
Chest Injury				.009	.926
	yes	2(5)	9(7)		
	no	35(94)	109(92)		
Bronchitis				1.083	.298
	yes	6(16)	10(8)		
	no	31(83)	108(91)		
Pneumonia				.354	.552
	yes	3(8)	16(13)		
	no	34(91)	102(86)		
Pleurisy				1.186	.276
	yes	4(10)	5(4)		
	no	33(89)	113(95)		
Bronchial Asthma				.001	.970
	yes	1(2)	1(0)		
	no	36(97)	117(99)		
Other Chest Trouble				.273	.601
	yes	1(2)	8(6)		
	no	36(97)	110(93)		
Skin Rash/ Condition				.014	.907
	yes	5(13)	15(12)		
	no	31(86)	102(87)		
Stomach/Intestinal Condition				.029	.864
	yes	5(13)	15(12)		
	no	32(86)	102(87)		
Nervous Condition				.284	.594
	yes	1(2)	8(6)		
	no	36(97)	109(93)		

TABLE 10

Frequency of Symptoms
(Response to Directed Questions)

Neville Chemical Company, Pittsburgh, PA
HHE 76-39 (October 1976)

SYMPTOMS	GROUP / RESPONSE	CONTROL	EXPOSED	χ^2 VALUE	P VALUE
Trouble Sleeping				.18	.67
	Yes	6(16)[1]	25(21)		
	No	31(84)	93(79)		
Tiredness or Weakness				6.03	.01 *
	Yes	5(14)	43(37)		
	No	32(86)	74(63)		
Eye Irritation				2.69	.10
	Yes	14(38)	63(55)		
	No	23(62)	53(45)		
Nose Irritation				2.60	.10
	Yes	7(19)	41(35)		
	No	30(81)	77(65)		
Dry or Sore Throat				2.43	.12
	Yes	8(22)	44(37)		
	No	29(78)	74(63)		
Chest Tightness or Difficulty Breathing				4.72	.03*
	Yes	4(11)	36(31)		
	No	33(89)	81(69)		
Headaches				.63	.42
	Yes	9(24)	39(33)		
	No	28(76)	79(67)		
Nausea				.41	.52
	Yes	4(11)	20(17)		
	No	33(89)	98(83)		
Vomiting				.01	.95
	Yes	1(3)	5(4)		
	No	36(97)	113(96)		
Skin Rash/ Condition				.08	.77
	Yes	9(24)	24(20)		
	No	28(76)	94(80)		
Loss of Appetite					
	Yes	0(0)	3		
	No	37(100)	9[illegible]		
Unexplained Weight loss					
	Yes	0(0)	3		
	No	37(100)	11[illegible]		
Dizziness					
	Yes	0(0)	17		
	No	37(100)	10[illegible]		

1 Number of positive responses, Number in parenthesis is percent of total responses in group.

* Indicates association of symptom and exposure group at P<.05 level.

TABLE 11

Frequency of Symptoms by Department

Neville Chemical Company, Pittsburgh, PA
HHE 76-39 (October 1976)

DEPT. / SYMPTOM	N (Positive Answers)	RESIN n = 39	WARE-HOUSE n = 18	MAINTE-NANCE n = 34	LABOR n = 6	NSO/TBC n = 11	SHIPPING n = 5	UNICHLOR n = 5	CONTROL n = 37
Trouble Sleeping	25	9 (23) (1)	5 (28)	8 (24)	1 (17)	1 (9)	1 (20)	0 (0)	6 (16)
Tiredness or Weakness	43	17 (44)*	3 (17)	15 (63)*	2 (33)	4 (36)	1 (20)	1 (20)	5 (14)
Eye Irritation	65	26 (67)*	10 (56)	17 (50)	1 (17)	5 (45)	3 (60)	3 (60)	14 (38)
Nose Irritation	41	16 (41)*	5 (28)	11 (32)	1 (17)	6 (55)*	0 (0)	2 (40)	7 (19)
Dry or Sore Throat	44	18 (46)*	7 (39)	12 (35)	0 (0)	3 (27)	1 (20)	3 (60)	8 (22)
Chest Tightness or Diffic.Breathing	36	19 (49)*	3 (8)	8 (24)	1 (17)	2 (18)	1 (20)	2 (40)	4 (11)
Headaches	39	13 (33)	5 (28)	9 (26)	1 (17)	5 (45)	3 (60)	3 (60)	9 (24)
Nausea	20	9 (23)	1 (6)	8 (24)	0 (0)	1 (9)	0 (0)	1 (20)	4 (11)
Vomiting	5	3 (8)	0 (0)	1 (3)	0 (0)	1 (9)	0 (0)	0 (0)	1 (3)
Skin Rash/Condition	24	13 (33)	1 (6)	4 (12)	0 (0)	4 (36)	1 (20)	1 (20)	9 (24)
Loss of Appetite	20	11 (28)	1 (6)	7 (21)	0 (0)	1 (9)	0 (0)	0 (0)	0 (0)
Unexplained Wt. Loss	3	3 (8)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Dizziness	17	6 (15)	1 (6)	7 (21)	0 (0)	2 (18)	0 (0)	1 (20)	0 (0)

(1) Number of positive answers and percent of total department (in parenthesis)
* Significant at $P \leq .05$ (Significantly different from controls).

TABLE 12

Respiratory Symptoms and Length of Employment

Neville Chemical Company, Pittsburgh, PA
HHE 76-39 (October 1976)

Symptom		Years of Employment			
		Control		Exposed	
		≤5y (%) (a)	>5y (%) (b)	≤5y (%) (c)	>5y (%) (d)
Cough	yes	7 (44)	5 (28)	35 (39)	11 (39)
	no	9 (56)	13 (72)	54 (61)	17 (61)
Phlegm	yes	5 (31)	4 (22)	30 (34)	7 (25)
	no	11 (69)	14 (78)	59 (66)	21 (75)
Breathlessness	yes	2 (13)	7 (39)	25 (28)	9 (32)
	no	14 (87)	11 (61)	64 (72)	19 (68)
Wheezing	yes	2 (13)	3 (17)	29 (33)	8 (29)
		14 (87)	15 (83)	60 (67)	20 (71)
Persistent cough and phlegm	yes	7 (44)	6 (33)	45 (51)	11 (39)
	no	9 (56)	12 (67)	44 (49)	17 (61)

TABLE 13

Respiratory Symptoms and Smoking Habit

Neville Chemical Company, Pittsburgh, PA
HHE 76-39 (October 1976)

Symptom		Control		Exposed	
		Non Smoker Ex Smoker (%)	Current Smoker (%)	Non Smoker Ex Smoker (%)	Current Smoker (%)
		(a)	(b)	(c)	(d)
Cough	yes	4 (22)	8 (44)	14 (24)	33 (55)
	no	14 (78)	10 (56)	44 (76)	27 (45)
Phlegm	yes	2 (11)	7 (39)	16 (28)	22 (37)
	no	16 (89)	11 (61)	42 (72)	38 (63)
Breathlessness	yes	4 (22)	6 (33)	12 (21)	23 (38)
	no	14 (78)	12 (67)	46 (79)	37 (62)
Wheezing	yes	2 (11)	4 (22)	12 (21)	25 (42)
	no	16 (89)	14 (78)	46 (79)	35 (58)
Persistent cough and phlegm	yes	3 (17)	10 (56)	19 (33)	38 (63)
	no	15 (83)	8 (44)	39 (67)	22 (37)

TABLE 14-a

Results of Physical Examinations

Neville Chemical Company, Pittsburgh, PA
HHE 76-39 (October 1976)

Observation / DEPARTMENT	N	SKIN	EYE	NOSE	THROAT	NECK	HEART	LUNG	NO POSITIVE FINDINGS
Controls	37	6 (16)[1]	2 (5)	4 (11)	2 (5)	1 (3)	6 (16)	5 (14)	18 (49)
Exposed	118	49 (42)*	17 (14)	7 (6)	11 (9)	9 (8)	18 (15)	17 (14)	33 (28)
Resin	39	14 (30)**	2 (5)	4 (10)	5 (13)	5 (13)	10 (26)	6 (15)	10 (26)
Warehouse	18	6 (33)	8 (44)*	2 (11)	3 (17)	1 (5)	1 (6)	3 (17)	3 (17)
Maintenance	34	16 (47)*	1 (3)	1 (3)	2 (6)	3 (8)	2 (6)	5 (15)	12 (35)
Labor	6	3 (50)**	0 (0)	0 (0)	1 (17)	0 (0)	1 (17)	0 (0)	1 (17)
NSO/TBC	11	4 (36)	2 (18)	0 (0)	0 (0)	0 (0)	1 (9)	2 (18)	4 (36)
Shipping	5	5 (100)*	2 (40)*	0 (0)	0 (0)	0 (0)	2 (40)	1 (20)	2 (40)
Unichlor	5	1 (20)	2 (40)*	0 (0)	0 (0)	0 (0)	1 (20)	0 (0)	1 (20)

1 - Number of observed abnormalities. Number in parenthesis is percent of total response in the group (department).

* - Indicates significantly different from control group at $p \leq .05$.

**- Indicates significantly different from control group at $p \leq .10$.

TABLE 14-b

Blood Pressure

	Systolic		Diastolic	
	Controls	Exposed	Controls	Exposed
Number of persons examined	37	116	37	116
Mean	125.9	127.1	75.8	76.6
Standard Deviation	±18.5	±15.5	±9.5	±9.8

TABLE 15-a

Summary of Ventilatory Functions

Neville Chemical Company, Pittsburgh, PA
HHE 76-39 (October 1976)

TABLE 15-a Number of Subjects with Reduced Functions

Function \ Group	Control (%)	Exposed (%)	X^2 Value
FVC<80	5 (14)	7 (6)	2.33
FVC≥80	31 (86)	109 (94)	
FEV_1<80	3 (9)	13 (11)	0.24
FEV_1≥80	33 (81)	103 (89)	

Table 15-b Comparison of Group Values by F-test

Function		Control	Exposed	F-test
FVC	Mean	105.31	112.06	0.12
	S.D.	11.17	103.93	
	Number	29	95	
FEV_1	Mean	100.31	94.52	4.63*
	S.D.	12.75	12.67	
	Number	29	95	
FEF 25-75	Mean	84.00	92.25	0.16
	S.D.	22.46	109.29	
	Number	29	95	

* Significant at $p<0.05$ level
S.D. = Standard deviation

TABLE 16

Result of Blood Count

Neville Chemical Company, Pittsburgh, PA
HHE 76-39 (October, 1976)

HEMATOLOGY	GROUP	NUMBER	MEANS	STANDARD DEVIATION
WBC ($x10^3/mm^3$)				
	Control	35	8.06	2.39
	Exposed	117	7.68	1.76
RBC ($x10^6/mm^3$)				
	Control	35	5.32	.40
	Exposed	117	5.21	.38
HGB (g/100 ml)				
	Control	35	15.70	1.07
	Exposed	117	15.56	.90
HCT (per cent)				
	Control	35	46.91	3.14
	Exposed	117	46.56	2.66
MCH (μμg)				
	Control	35	29.60	1.94
	Exposed	118	29.96	1.71
MCHC (percent)				
	Control	35	33.48	.68
	Exposed	118	33.42	.86
MCV (μ^3)				
	Control	35	88.20	5.94
	Exposed	118	89.42	5.05

WBC: white blood cells; RBC: red blood cells
HGB: hemoglobin HCT: hematocrit
MCH: mean corpuscular hemoglobin (per cell HGB)
MCHC: mean corpuscular hemoglobin concentration
MCV: mean corpuscular volume

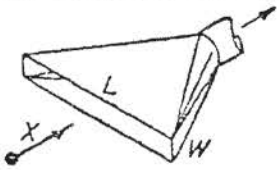
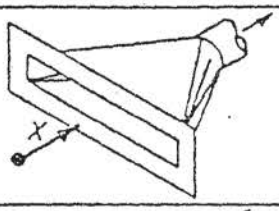
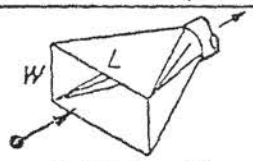
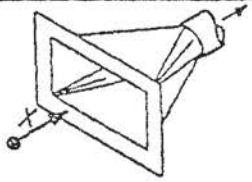
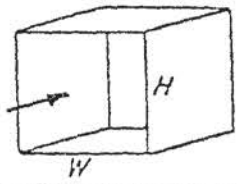
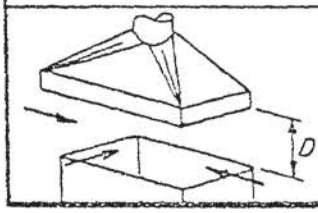
Table 17
Result of Blood Chemistry

Neville Chemical Company, Pittsburgh, PA
HHE 76-39 (October 1976)

BLOOD CHEMISTRY	GROUP	NUMBER	MEANS	STANDARD DEVIATION
Calcium				
	Control	36	10.31	.47
	Exposed	117	10.33	.49
Phosphorous				
	Control	36	2.99	.45
	Exposed	117	3.17	.52
BUN				
	Control	36	15.22	2.85
	Exposed	113	15.64	3.37
Creatinine				
	Control	36	1.29	.21
	Exposed	113	1.25	.25
Uric Acid				
	Control	36	6.00	1.16
	Exposed	117	5.74	1.39
Glucose				
	Control	36	99.89	38.46
	Exposed	113	96.31	15.03
Total Protein				
	Control	36	7.58	.47
	Exposed	117	7.65	.49
Albumin				
	Control	36	4.51	.31
	Exposed	117	4.50	.28
Globulin				
	Control	36	3.07	.28
	Exposed	117	3.15	.43
Total Bilirubin				
	Control	36	.64	.25
	Exposed	117	.68	.32
Direct Bilirubin				
	Control	36	.13	.08
	Exposed	117	.14	.10
SGOT				
	Control	36	30.06	6.76
	Exposed	117	33.91	16.87
SGPT				
	Control	36	35.94	16.18
	Exposed	117	36.98	20.13
Alkaline Phosphatase				
	Control	36	30.17	10.64
	Exposed	117	30.92	17.52
LDH				
	Control	36	176.50	32.44
	Exposed	116	182.47	55.03
Cholesterol				
	Control	36	216.67	40.80
	Exposed	117	204.82	49.04
Iron				
	Control	36	105.72	28.55
	Exposed	116	118.10	45.97
Total Lipids				
	Control	36	.60	.18
	Exposed	116	.63	.28
Sodium				
	Control	36	138.58	3.04
	Exposed	117	137.91	2.75
Potassium				
	Control	36	4.09	.26
	Exposed	117	4.13	.40
Chloride				
	Control	36	102.28	2.92
	Exposed	117	102.61	2.97
G-glutamic transpeptidase	Control	36	17.11	10.09
	Exposed	116	14.88	9.15
Triglycerides				
	Control	36	171.95	64.56
	Exposed	117	215.84	184.66

FIGURE 1

INDUSTRIAL VENTILATION

HOOD TYPE	DESCRIPTION	ASPECT RATIO, $\frac{W}{L}$	AIR VOLUME
	SLOT	0.2 or less	$Q = 3.7\,LVX$ (Reference 38)
	FLANGED SLOT	0.2 or less	$Q = 2.8\,LVX$ (Reference 38)
 A=WL (sq. ft.)	PLAIN OPENING	0.2 or greater and round	$Q = V(10X^2+A)$ (Reference 9)
	FLANGED OPENING	0.2 or greater and round	$Q = 0.75V(10X^2+A)$ (Reference 9)
	BOOTH	To suit work	$Q = VA = VWH$
	CANOPY	To suit work	$Q = 1.4PDV$ See VS-903 P = perimeter of work D = height above work

Capture Velocities

Capture velocity is the velocity at any point in front of the hood necessary to overcome opposing air currents and to capture the contaminated air by causing it to flow into the exhaust hood.

Exceptionally high volume hoods (example, large side-draft shakeout) require less air volume than would be indicated by the capture velocity values recommended for small hoods. This phenomenon is ascribed to:

1. The presence of a large air mass moving into the hood.
2. The fact that the contaminant is under the influence of the hood for a much longer time than is the case with small hoods.
3. The fact that the large air volume affords considerable dilution as described above.

Table 4-1 offers capture velocity data. Additional information is found in Section 5, Table 5-9-2.

FIGURE 2

INDUSTRIAL VENTILATION

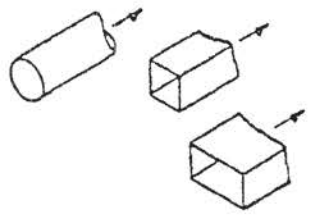
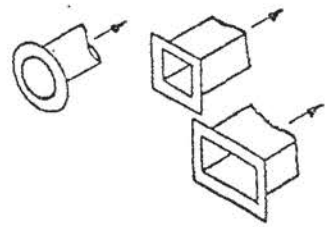
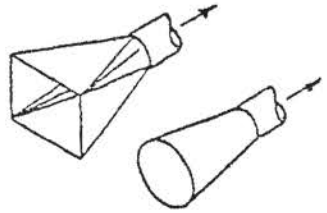
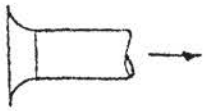
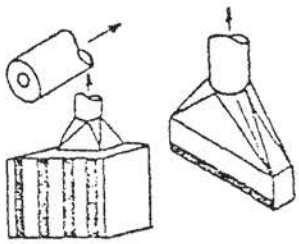
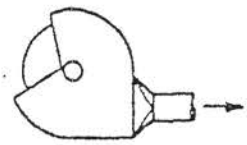
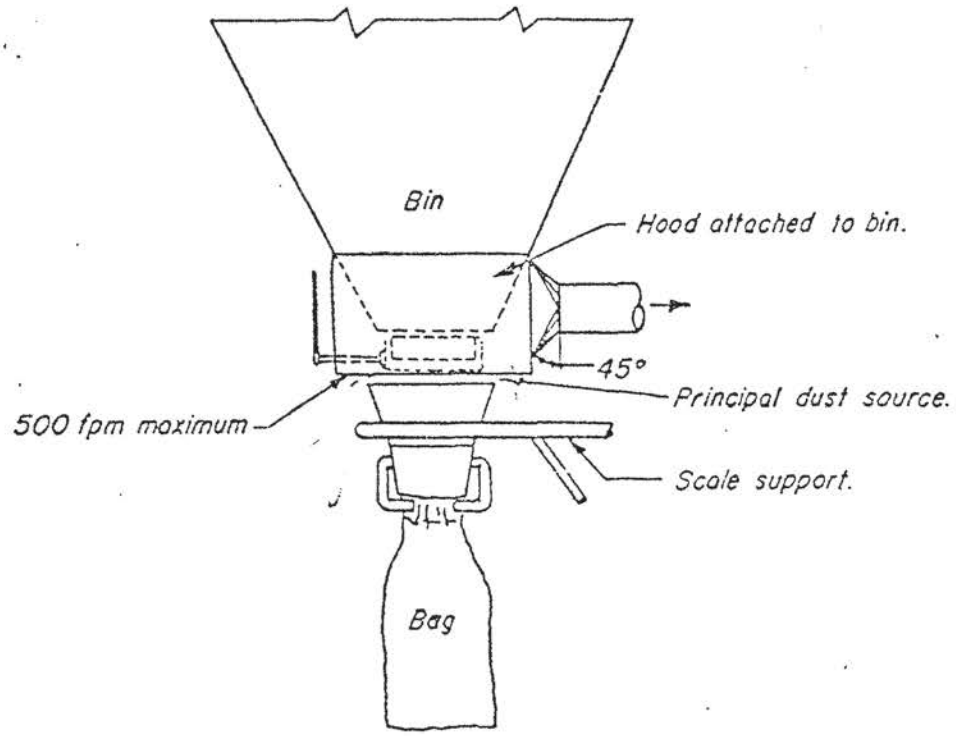
HOOD TYPE	DESCRIPTION	COEFFICIENT OF ENTRY, Ce	ENTRY LOSS
	PLAIN OPENING	0.72	0.93 VP
	FLANGED OPENING	0.82	0.49 VP
	TAPER or CONE HOOD	Varies with angle of taper or conc. See Fig. 6-10	
	BELL MOUTH INLET	0.98	0.04VP
	ORIFICE	See Fig. 6-10	
	TYPICAL GRINDING HOOD	STRAIGHT TAKE-OFF: 0.78	0.65 VP
		TAPERED TAKE-OFF: 0.85	0.40 VP

FIGURE 3
INDUSTRIAL VENTILATION



Q = 400 - 500 cfm - non-toxic dust
1000 - 1500 cfm - toxic dust
Duct velocity = 3500 fpm minimum
Entry loss = 0.25 VP

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BAG FILLING	
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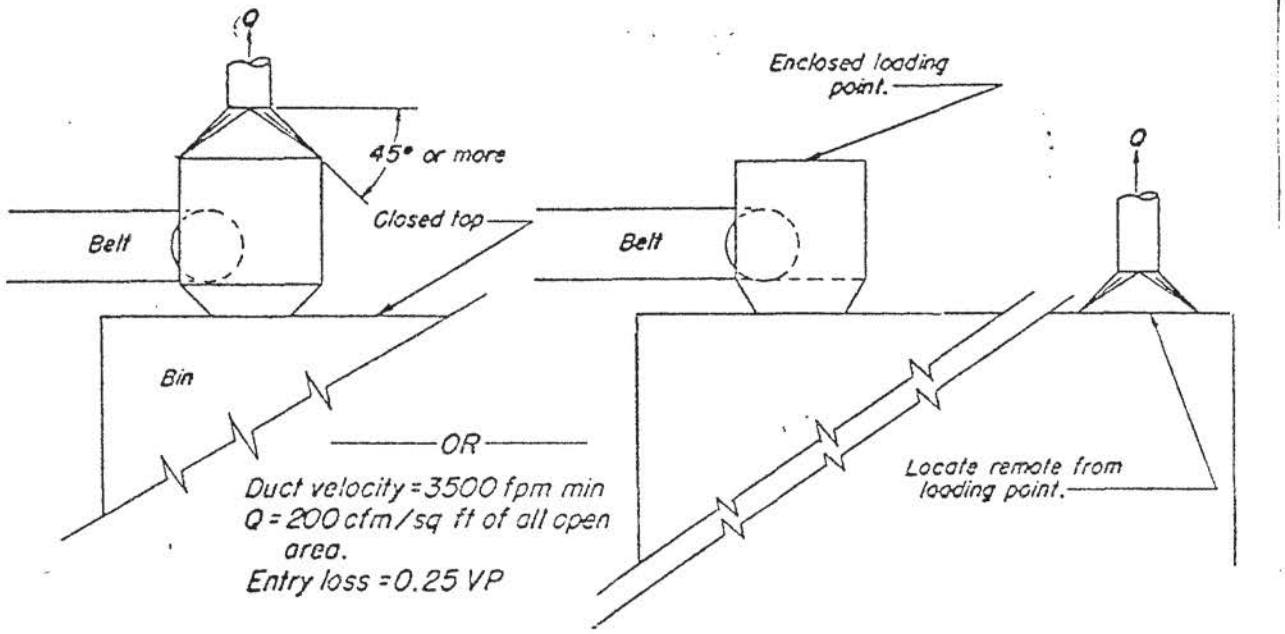
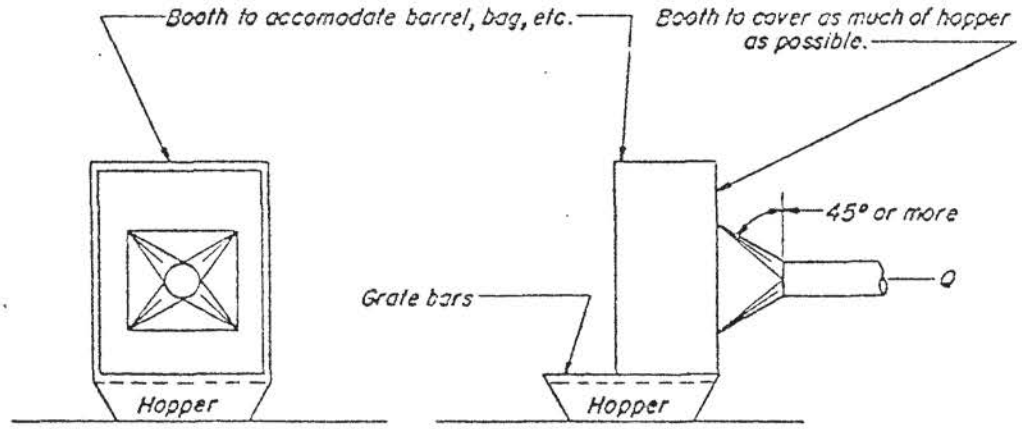
FIGURE 4

SPECIFIC OPERATIONS



MECHANICAL LOADING *



Duct velocity = 3500 fpm minimum
Q = 150 cfm/sq ft face
Entry loss = 0.25 VP

MANUAL LOADING

*BELT SPEED — VOLUME

Less than 200 fpm - 350 cfm/ft of belt width. Not less than 150 cfm/ft of opening.

Over 200 fpm - 500 cfm/ft of belt width. Not less than 200 cfm/ft of opening.

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BIN & HOPPER VENTILATION

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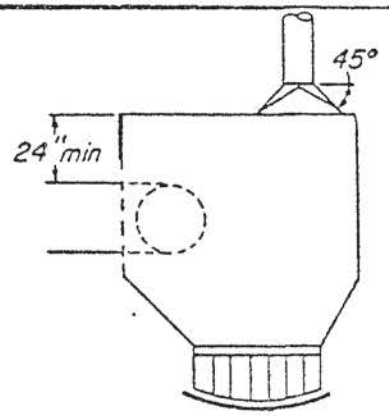
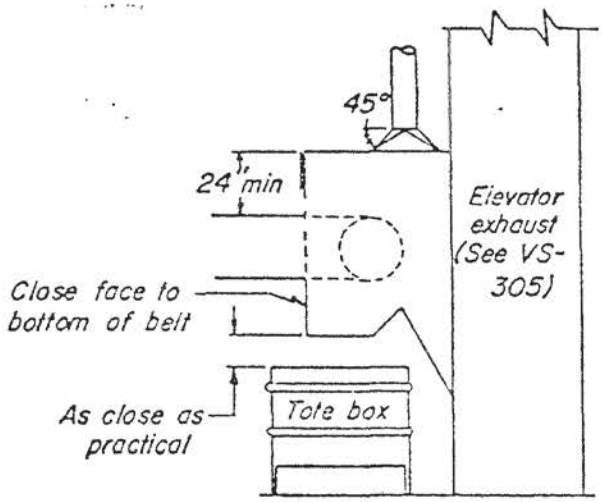
FIGURE 5

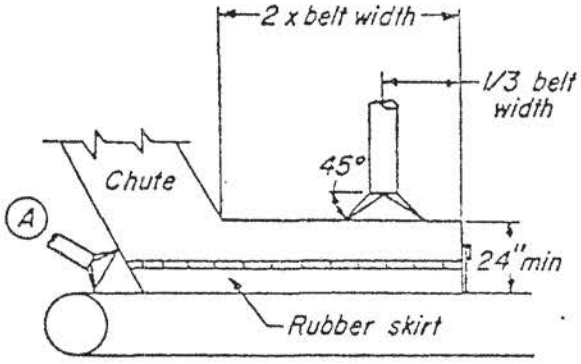
SPECIFIC OPERATIONS



1. Conveyor transfer less than 3' fall. For greater fall provide additional exhaust at lower belt. See 3 below.



2. Conveyor to elevator with magnetic separator.



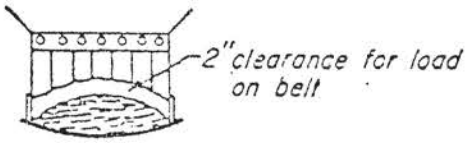
3. Chute to belt transfer and conveyor transfer, greater than 3' fall.
Use additional exhaust at (A) for dusty material as follows:
Belt width 12"-36", Q=700 cfm
above 36", Q=1000 cfm

DESIGN DATA

Transfer points:
- Enclose to provide 150-200 fpm indraft at all openings.
- Minimum Q=350 cfm/ft belt width for belt speeds under 200 fpm
  = 500 cfm/ft belt width for belt speeds over 200 fpm and for magnetic separators
- Duct velocity = 3500 fpm minimum
- Entry loss = 0.25VP

Conveyor belts:
- Cover belt between transfer points
- Exhaust at transfer points
- Exhaust additional 350 cfm/ft of belt width at 30' intervals. Use 45° tapered connections.
- Entry loss = 0.25 VP

Note:
Dry, very dusty materials may require exhaust volumes 1.5 to 2.0 times stated values.



Detail of belt opening

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CONVEYOR BELT VENTILATION

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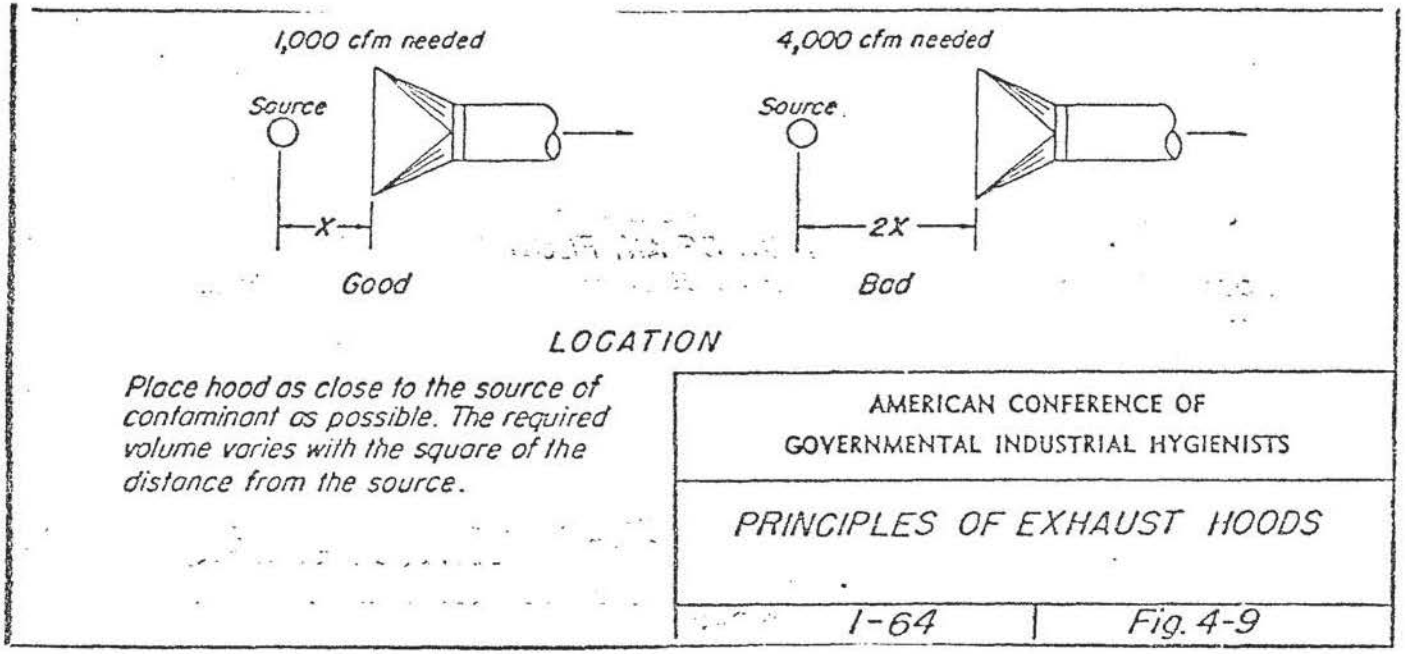
FIGURE 6


1,000 cfm needed
Source
X
Good
4,000 cfm needed
Source
2X
Bad
LOCATION
Place hood as close to the source of contaminant as possible. The required volume varies with the square of the distance from the source.
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PRINCIPLES OF EXHAUST HOODS
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Fig. 4-9