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INDUSTRIAL HYGIENE SURVEY OF

VINYL FABRICS DIVISION

BOUND BROOK, NEW JERSEY

BY

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SAFETY AND ENVIRONMENTAL PROTECTION DEPARTMENT

UNION CARBIDE CORPORATION

CHEMICALS AND PLASTICS DIVISION

BOUND BROOK, NEW JERSEY

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INTRODUCTION

An Industrial Hygiene survey was conducted in the Vinyl Fabrics Division from late April through May to evaluate such health stresses as dusts, chemical vapors, noise, etc. against OSHA threshold limit values and generally recognized good Industrial Hygiene practice. Particular attention was given to vinyl chloride as an air contaminant now under strict regulations as a carcinogen. The vinyl chloride portion of the survey was coordinated to enable compliance with the OSHA emergency standard which required three consecutive weeks of monitoring commencing April 22. The survey also incorporated a sampling program requested by Mr. R. N. Wheeler for vinyl chloride impact studies.

SUMMARY

Vinyl Chloride - Calendering Lines, Building 105, and Building 101, Bay 15

Ambient air on the first floor level contains no more than 1 ppm vinyl chloride, while ambient air on the blender mezzanine measures up to 7 ppm, the probable source of contamination being the blenders which, when charged with suspension type (QSAH and QSAN) resins, generate up to 4500 ppm vinyl chloride in their head spaces. Roof exhausts from the extruder and calender fume removal systems do not exceed 6 ppm. (See schematic, Appendix, Figure 1.)

Personnel taking preblend samples from blenders occasionally encountered exposures of up to 175 ppm for periods of less than a minute due to the escape of volatiles when the blenders were opened. Abatement measures are in progress, including addition of controls which permit purging of contaminated air from each blender prior to the operator opening the sampling port. This should eliminate the excursions and reduce the levels in the ambient air by minimizing the escape of vinyl chloride contaminated air into the work area.

Vinyl Chloride - Foam Lines

Vinyl chloride measured in the 1 ± 0.5 ppm range during the bag-dumping of resin into mix tanks. The dispersion-type resins in use contain low residual monomer. Measurements at the oven exits by Miran indicated <1 ppm vinyl chloride in the oven smoke.

Vinyl Chloride - Bulk Resin Unloading

Vinyl chloride in the head space of van boxes in storage measured in the 2000 - 4500 ppm range. However, exposure to personnel during hook-up of the boxes for unloading into airveyors is limited to the 2 ± 1 ppm range.

OSHA Inspection for Vinyl Chloride

A Region 2 OSHA Industrial Hygienist started a vinyl chloride inspection June 20 and 21, but monitoring was interrupted when Line 1000 ran out due to shortage of resin. The inspection is expected to be continued at a later date under normal production conditions.

Notification of Employees

In order to clarify the vinyl chloride situation as regards to Bound Brook employees, eight informational meetings were held on overtime for shift and day employees working in the Building 105 calendering and foam line areas; Building 101 - Bay 10, Bay 15 and resin airveyor operators, mechanics, union safety committeemen and union president. A 20 minute presentation included the background of events that led to the promulgation of the April 5, 1974 emergency temporary standard for vinyl chloride. Data determined from the survey was presented with precautionary procedures for avoiding potential exposure, followed by a question and answer period.

Solvent Vapor - Ink Preparation and Printer Rooms, Building 105

Exposure of operators tending the printers averaged 40 to 50% of allowable dosage, while those preparing strike-offs and ink mixes averaged in the 53 to 70% range. The area of the test bench in the ink room averaged 67 to 92%, indicating the desirability of better ventilation or containment of solvents.

Dusts - Building 105

Exposure of blender operators when resin is charged from tanks is 33% of the allowable TWA of 15 mg./cu. meter for nuisance (inert) dust. However, exposure exceeds the limit when blender operators hand-dump QYNA and other dusty powders into L-1000 blenders without ventilation. (Ventilation has since been provided, essentially eliminating the problem.)

Operators in the foam mix room receive excessive exposure to resin dust while dumping bags of dispersion resin in the preparation of "skin" plastisols. The ventilation system for both mix dissolvers emits visible dust from the roof exhaust fan during bag dumping.

Ventilation

All systems were in operation except the Dynaclone which was operated intermittently, the Trans-Vair system which was plugged, and the hood exhaust for the small weigh-ups on the blender floor. The first two systems have since been restored to continuous service.

Noise

There are no work stations where noise exceeds 90 dBA. Readings up to 96 dBA measured in close proximity to the FCM gear reducers and Line 1000 trim cutter indicate a need to post signs restricting exposure time or the installation of sound-proofing.

Lighting

Lighting is satisfactory except in certain warehouse areas, blender operating aisle, and shower rooms which are below ANSI standards.

Radiation

All eight sources tested satisfactorily.

RECOMMENDATIONS

Vinyl Chloride Abatement

Immediate

1. Caution blender operators against inhalation of odiferous fumes (hydrocarbon solvents, etc.) which may also carry vinyl chloride. To avoid inhalation of such fumes, make certain operators use long-handled scoops and stand away from sample port for at least one minute after opening port before sampling. (This has been done.)

Interim

2. Adjust vent valves on blenders to continuously purge air and vapors from blenders during blending and discharge, thereby avoiding build-up of vinyl chloride in the air space of the blenders.
3. Provide controls for applying full exhaust on blenders during sampling and entry for cleaning or repairs, thereby preventing escape of contaminated air and protecting personnel working in blenders.

Longer-Term

4. Reduce residual monomer content of feedstock resins.
5. Provide a back-up ventilation system to permit continuity of operations in the event of outage of the existing system. Blenders should not be operated without adequate ventilation unless operators are supplied with air-supplied or self-contained breathing apparatus.
6. Install a local exhaust system on the Bay 15 blenders in Building 101, none existing at present.

Solvent Vapors Abatement

1. Replace open containers (pails, dixie cups, etc.) for solvents with closed UL-approved containers.
2. Maintain closer surveillance of existing local exhaust systems, particularly at No. 1 printer, to insure their optimum operation to prevent the escape of solvent vapors into the work area. Hot air blasts should not be allowed to exceed exhaust capacity.

Dust Abatement

Recommendations 3, 5 and 6 under Vinyl Chloride Abatement will significantly reduce exposure in the blender area. In addition, the following are proposed:

1. Improve maintenance of feeders over Line 1000 banburys to prevent material leakage.
2. Eliminate blow-back from Lines 2000 and 3000 trim cyclones.
3. Install a ventilated booth for weighups on the blender floor, similar to that provided for color dispersions.

Dust Abatement (Continued)

4. Install a more effective dust collecting system for the north mixer station in the foam mixing room.
5. Institute special precautions with the use of powdered lead or other toxic compounds, including mandatory wearing of approved respirators.

Ventilation

See Recommendations 2, 3, 5 and 6 under Vinyl Chloride Abatement and Recommendations 3 and 4 under Dust Abatement.

Local ventilation on the blenders appears to be the key to avoiding contamination of the working environment with vinyl chloride released in the blenders. This will become even more critical if and when the present emergency standard is lowered in the direction of "zero tolerance."

Noise Abatement

Line 2000 FCM gear reducer should be posted to limit exposure without ear protection to three hours, and the area north of Line 3000 FCM posted for a six hour limit. The in-line trim cutter should be further sound-proofed for a 5 dBA attenuation.

Lighting

Provide additional lighting in the blender area, blender panel boards, warehouse areas, shower room and lunch room as outlined under Discussion.

DISCUSSION

Test Methods

Vinyl Chloride: Temporary TLV=50 ppm (ceiling limit, no TWA). Vinyl Chloride is collected according to C&P Method 38C-9Cl-R2, drawing a measured amount of air through a glass tube packed with activated charcoal. Any organic vapors are adsorbed on the charcoal, and later desorbed in the laboratory with carbon-disulfide. The extract is then analyzed by gas chromatography. The procedure is designed for four hours of continuous monitoring at a flow rate of 28 ml. per minute. Since such long-term sampling does not detect excursions of short duration, certain tasks with higher potential of exposure were monitored at rates up to 115 ml. per minute for short periods in order to obtain a sample of sufficient quantity to measure. This method has greater accuracy than that used by OSHA which uses commercial charcoal tubes having only 20% of the capacity of the especially prepared UCC/C&P tubes. Samples taken during this survey were analyzed by the C&P Environmental Health Lab at the South Charleston Technical Center.

The Miran I portable infrared gas analyzer which proved useful for continuous area air monitoring at the South Charleston plant was borrowed during the week

Test Methods

Vinyl Chloride (Continued)

of June 17 from the C&P Environmental Health Lab for vinyl chloride monitoring. It proved helpful in confirming that some areas not completely monitored by the charcoal tube method were low in vinyl chloride, but interference at the 10.7 micran wavelength was encountered when monitoring process equipment such as the blenders, mixers and extruders. The interference was traced to non-descript hydrocarbon solvents introduced into the preblend with the stabilizer, causing the Miron I to read higher-than-actual vinyl chloride concentrations. These "mineral spirits" rule out the use of total hydrocarbon analyzers such as the Century Organic Vapor Analyzer. TCA instruments can provide on-the-spot assurance, however, of safe vinyl chloride levels if their total readings, after correcting for vinyl chloride, read under the allowable 50 ppm limit. Instrument noise encountered with the Miron I renders it unreliable for vinyl chloride measurements under 1 ppm.

Solvent Vapors: TLV - See Table, Page 9. Organic solvent vapors are collected according to C&P Method 38C-8A2-Ra, similar to the method for vinyl chloride but using smaller carbon tubes. Complete analysis of all hydrocarbons collected is made by gas chromatography and the data used to calculate micro-grams per cubic meter of air and ultimately, the dosage. Since there are no restrictive ceiling limits on the solvents in use, exposure is best measured by personnel sampling over longer time periods. However, for purposes of control by locating the main sources of contamination, the Century Organic Vapor Analyzer is used to provide on-the-spot direct readings of total hydrocarbons based on 100% response to methane in air.

Dust: TLV - $15\text{mg}/\text{M}^3$ for Total Inert Dust. C&P Method 38C-10X2-R2.4 is used for measuring total airborne dust by gravimetric analysis. A measured stream of the sample air is drawn through a preweighted PVC membrane filter by means of a battery-operated personal monitoring pump (MSA Model G) carried by the operator. After vacuum drying, the filter is reweighed to yield a measure of the dust concentration.

Noise: TLV - 8 hours at 90 dBA, with a 50% reduction in time allowed for every increase of 5 dBA. A Model 2209 Bruel and Kjaer impulse precision sound level meter was used to measure sound pressure levels from noticeable noise sources.

Lighting: ANSI Specification A11.1-1965 (R 1970) in lieu of OSHA specifications.

For Chemical and Rubber Manufacturing:	30	ft-candles
Toilets and Washrooms	:	30 "
Panel Boards	:	50 "

Light intensities were measured with a Weston "Photronic" meter.

Radiation: Code of Federal Regulations, Title 10, Part 20. Maximum allowable leakage - 0.005 microcuries.

Wipe tests are conducted by Industrial Nucleonics Corporation on a contract basis.

Ventilation: As required to limit air contaminants to concentrations listed under Subpart G, Section 1910.93.

Air velocities were measured with an Alnor Jr. Velometer.

Test Results

Vinyl Chloride - See Appendix, Table 1

The scheduling of the Vinyl Fabrics Division survey to coincide with the mandatory monitoring specified in the OSHA emergency standard afforded an excellent opportunity to thoroughly examine the effects of the new regulation on Bound Brook operations with a minimum of delay and effort. These effects were not fully anticipated at the outset, the general consensus being that the new regulation was mainly directed at the VC chemical and PVC polymerizing plants rather than the downstream fabrication plants. However, detection of up to 9700 ppm VC in the air space of a van box loaded with QSAN resin clearly demonstrated the presence of VC at Bound Brook and the need to control any further release of VC in downstream operations. The high level of VC would be expected since a typical load of 40,000 pounds of PVC resin with a residual monomer content of 0.2% contains 80 pounds of VC. If only 1% of this diffuses into the air space above the resin, assuming the air volume to be 20% of the volume of the box, or $\frac{(0.2)(1900)}{(62.5 \text{ mw})} = 380$ cu. ft., the 0.8 pounds of VC entering the air could amount to $\frac{(0.8 \text{ lb.})}{(359 \text{ cu. ft.})} \left(\frac{1 \text{ lb-mol}}{1 \text{ lb-mol}} \right)$

$$\left(\frac{10^6}{380 \text{ cu. ft.}} \right) = 12,000 \text{ ppm at standard conditions.}$$

Some dilution of these high concentrations can be expected as the box is emptied, but proper precautionary procedures for safe entry should be followed by personnel prior to entering for cleaning or repair. However, there is presently no such occasion for entry at Bound Brook.

If the portion of OSHA's May 10 proposed "zero" tolerance standard specifying labelling becomes law which is expected, van boxes of PVC resin will probably be treated as containers of VC, requiring the posting of conspicuous warning signs. Refilling empty containers may also require the restriction of VC emission from the atmosphere if EPA imposes tight regulations.

In contrast, personnel who connect the van box outlets to the airveyors experience exposure of only up to 2 ppm. Evidently the hook-up procedure of inserting the rubber spout into the airveyor inlet confines the resin within essentially a closed system, while the operator breathes fresh air from outdoors. Although there are usually visible accumulations of resin dust in the airveyor shed (Bldg. 102) any residual VC evolving therefrom is evidently highly diluted by the high volume of naturally-circulated ambient air.

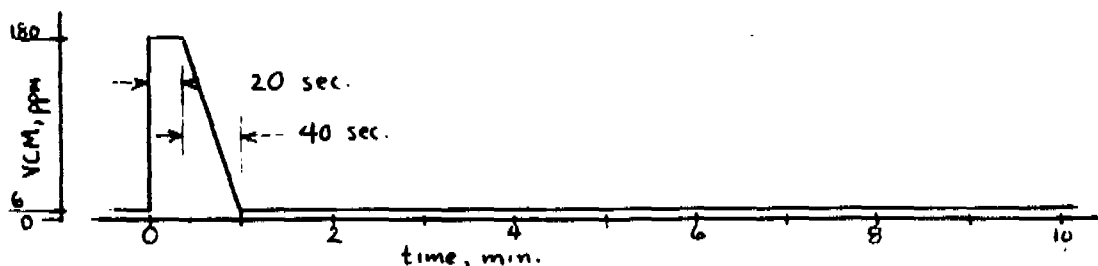
The next evolution of appreciable quantities of VC measuring up to 4450 ppm occurs in the ribbon blenders, probably accelerated by the heating and agitation. An existing ventilation system connecting all eleven blenders to a dust collector and exhaust fan was designed to abate dusting during the gravity feed of resin to the blenders and the charging of liquids. However, during the survey, this "Trans Vair" system was inoperative due to pluggage. As a result, sufficient VC evidently contaminated the air during charging operations to raise the level in the ambient air on the blender floor to 7 ppm. During the week of May 13 the ventilation system was cleaned out and reactivated, but No. 3 blender on Line 3000 and Nos. 1 and 3 on Line 2000 received little or no vacuum from the system due to misalignment of connections causing the flexible connecting sleeves to constrict and pinch off air flow. These misalignments have since been corrected so that all eleven blenders are properly connected to the vent system.

The importance of ventilation on the blenders as a prime means of abating exposure of operators to VC was demonstrated by measurements taken while the blenders were

Test Results - Vinyl Chloride (Continued)

being manually charged without benefit of ventilation. Escape of VC bearing fumes into the breathing zone of the operator was evidenced by values of up to 46 ppm VC for on-the-man samples during bag-dumping. Subsequent tests taken with the local exhaust system operating were substantially reduced, one measurement being under 1 ppm. Although the vent system automatically vents each blender during the charging cycle, thereby protecting the operator by draining air inward through the charging hatch rather than releasing fumes into the room, there is no such protection to operators when they reach into the blenders to scoop samples of preblend for color-checking. This is done after about 45 minutes of blending after the air confined within the head space has picked up VC from the heated and tumbled resin. The high levels of VC in the airspace of closed blenders, and lack of negative pressure in the blenders, caused high excursions of up to 175 ppm measured while operators sampled unventilated blenders. Although the time required to scoop a sample of preblend is less than a minute, the fact that the operator's face is so close to the hatch opening accounts for the excursions measured. The total exposure from the excursions is probably less than three minutes per eight hour shift, considering that each sampling of preblend takes less than 20 seconds, and no more than eight blenders are sampled by any one operator. While considering the high excursion levels measured for short time periods, it is important to note the significance of selecting the time span for testing. Present OSHA monitoring procedures call for a ten-minute sampling period at a rate of 100 ml/min. Under such conditions, a short-lived excursion of less than a minute would not be detected, and the integration with time which occurs during such sampling could result in an average level well within the present limit of 50 ppm. This is apparent if we assume a likely profile of VC levels and calculate the time-weighted average according to the following plot, assuming an initial level of 180 ppm for the first 20 seconds the blender hatch is opened, and an average of 90 ppm while the level decays after the hatch is closed for the next 40 seconds, and an ambient level of 6 ppm in the blender area. The ten-minute time-weighted average (TWA) would be given by:

$$\frac{\left(\frac{20 \text{ sec.}}{60}\right) (180 \text{ ppm}) + \left(\frac{40 \text{ sec.}}{60}\right) 90 \text{ ppm} + (9 \text{ min.}) (6 \text{ ppm})}{10} = \frac{60+60+54}{10} = 17.4 \text{ ppm}$$



There is, however, the possibility that OSHA might revert to the NIOSH "grab" sample method of monitoring, in which case an air sample could be collected in less than one minute during the time of the excursion, and thereby indicate a violation of the 50 ppm ceiling limit. It is for this reason, in addition to detecting excursions in order to design abatement measures, that the short term samples were taken.

As a preliminary safeguard, the blender operators have been provided with long-handled scoops which permit the withdrawal of material from blenders at a safer distance from the hatch opening. In addition, the operating department is planning to provide manual controls for the vent valves which will permit the operator to place a blender under the reduced pressure of the exhaust system prior to opening the blender hatch for sampling. This should afford complete

Test Results - Vinyl Chloride (Continued)

protection to the operator and serve to lower the VC present in the ambient air of the building.

Exposure of personnel downstream from the blenders appears minimal, evidently no higher than 1.4 ppm. This would be expected from the high volatility of VC and the extensive high temperature and mechanical working received in the mixers, extruders and calenders, which tends to strip out volatiles, exhausting them through the roof vents.

Tests conducted in the foam operation indicated negligible exposure to VC under 1 ppm. This is probably due to the use of dispersion-type resins low in residual monomer as compared with suspension resins.

Tests of the Bay 15 in Building 101 operation indicated no levels above 1 ppm on the first floor including the banbury operator, and only an excursion to 5 ppm at the blender while the operator added colorants through a small hatch. However, exposure may be greater during bag-dumping since no ventilation is provided.

Solvent Vapors - See Appendix, Table 2

Operators in the printer and ink preparation areas have chronically expressed concern over the levels of solvents in the air, largely due to the low odor threshold values of the solvents used which tends to emphasize their presence even at safe low levels. Fears were exacerbated by the cases of peripheral neuropathy reported out of the Columbus Coated Products episode involving MBK and MIBK. Previous monitoring in the printer and ink room areas was done by the Century Organic Vapor Analyzer, a useful direct-reading instrument for hydrocarbons. This is very effective for locating sources of emissions and measuring total hydrocarbons. Its limitation is lack of identification capability; one must know by other means what particular hydrocarbon is present in order to determine actual PPM. Moreover, the Centruy OVA is not adaptable as a dosimeter for personnel monitoring. Therefore for the first time at Bound Brook, charcoal tubes worn by operators were used to accurately measure exposure of operators working in the solvent areas. The measurements reported herein were taken in February in anticipation of an inspection by a New Jersey Department of Labor Industrial Hygienist as the result of an employee complaint. The charcoal tube method was selected as the most effective means of monitoring and considered superior or at least equal to any method expected to be used by the State Hygienist. A State inspection was actually made a month later, the Industrial Hygienist using a J&W Model SS-P combustible gas detector rather than charcoal tubes. The reason given for not using charcoal tubes was the lack of analytical personnel. Readings on the J&W PPM scale were considered satisfactory by the State Hygienist, hence there was no need to submit our charcoal tube findings. We would, however, expect OSHA to use the charcoal method instead of the J&W "sniffer" which has insufficient sensitivity in the 0 to 200 ppm range.

The principal solvents in use during the monitoring, plus MBK used at Borden's Columbus Coated Products, are listed below with pertinent data:

	TLV		VP @ 20°C MM	BP @ 760MM °C
	PPM	mg/M ³		
Methyl ethyl ketone (MEK) or 2-Butanone	200	590	70	80
*Methyl butyl ketone (MBK) or 2-Hexanone	100	410	2.6	127
Methyl isobutyl ketone (MIBK) or Hexone	100	410	15	116
Tetrahydrofuran (THF)	200	590	138	65
2-Nitropropane (2-NP)	25	90	13	120
*Not used at Bound Brook.				

Test Results - Solvent Vapors (Continued)

MEK and THF, being the more volatile of these solvents, readily generate odiferous vapors locally and are therefore subject to complaint if operators get too close to containers. Fortunately, these have the highest TLVs. MIBK, having low odor threshold level, is quite noticeable. Moreover, its nomenclature is often confused with the MBK associated with the Bordon problem. The low volatility of the more toxic 2-NP renders it a minor factor in the working environment. An appreciation for how these solvents contribute to the overall dosage can be seen by reference to the Appendix, Table 2, which lists the amounts of the various solvents collected from the air on charcoal. Although MEK and MIBK are generally used on a 50-50 weight basis in the No. 1 Printer, the amounts evaporated into the air are roughly in proportion to their vapor pressures, resulting in considerably lower concentrations of the more toxic MIBK than the less toxic MEK.³ The chief operator's intake analyzed in the ratio of 151 MEK to 29 MIBK (mg/M³) while the relief operator performing similar tasks analyzed 185 MEK to 37 MIBK. Actual exposure is calculated from the chromatographic analysis of the sample, taking into consideration the amount of each component and its ratio to the TLV for the maximum dosage allowed for eight hours. Using the general formula for calculating dosage:

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \dots + \frac{C_n}{T_n} = 1 \text{ For Maximum}$$

Permitted dosage for n number of components.

C = Actual Measured Concentration (mg/M³)

T = TLV Concentration (mg/M³)

The dosage imparted by each of the four components is calculated in the last columns of Table 2. It is worthy of note that these solvents have no ceiling limits, therefore there is no need to test for excursions and long sampling times are quite proper for determining exposure. Nevertheless, it is important to periodically monitor the printers with the direct-reading Century to maintain control of solvent vapors in the working environment. Certain zones within the printers yield measurements in the 100-300 ppm range as follows:

- Inside No. 1 Printer, between Ink Stations 2 and 3
- Inside No. 1 Printer, between Ink Stations 1 and Unwinder
- Inside No. 3 Printer, between Ink Stations 1 and 2
- Inside No. 3 Printer, between Ink Stations 3 and 4
- Outside No. 3 Printer, between No. 1 and 2 Ink Pots

Although the chief and relief operators frequent these zones in which the air may contain contaminants above the TLV, time studies indicate they spend less than half their time in such areas. This is confirmed by the charcoal monitoring results of 0.40 to 0.50 (40 to 50%) of allowable dosage. The other members of the printer crews were not tested since their tasks do not involve handling solvents, their time being spent in the wind-up and packing areas away from the solvent fumes. The strike-off day shift operator appeared to have the greatest exposure of 70%, probably due to a particularly active day of color matching and frequent cleaning with solvents. The ink coordinator, in preparing mixes in the ink room where area sampling indicated 67 to 92% dosage, analyzed only 53% allowable exposure. The area samples are representative of extreme conditions in the ink room, having been taken in a poorly-ventilated corner near the Cowles mixers.

Dust - See Appendix, Table 3

Dust monitoring was conducted in the two areas of greater concern to personnel: the blender mezzanine and the foam line mix room. Dusting appeared highest during the charging of resin and fillers into the blenders, there being no ventilation on the blenders during monitoring. Dusting was particularly severe in the area of the Line 1000 blenders which were being charged largely by hand-dumping QYNA resin. Even with the highly visible releases of dust, all long-term samplings analyzed in an acceptable range of 2 to 7 mg/M³. With no ceiling limit on dust exposure, there are no violations from the excursions which occur during charging. However, such excursions, one of which was measured at 170 mg/M³ during the hand-dumping of QYNA, create a housekeeping problem and concern on the part of employees. This source of dusting is effectively eliminated when the blender is connected to a vacuum source such as the Trans-Vair blender exhaust system. When this system is operating effectively, the capture velocity at the open blender hatch exceeds 100 fpm, thereby conforming to the control velocity specified in the State of New Jersey Department of Labor Chapter 122, Exhaust Systems (proposed).

Other sources of dust observed during the survey were leaks from the Line 1000 overhead feed system. There were dust emissions from the skip hoist dumping location where a side plate had been removed and there was no exhaust due to the Dynaclone dust collector system being down. Considerable leakage occurred from the screw conveyor feeding the banburys. Other principal sources were the hoppers of Lines 2000 and 3000 FCMs where blow-back of preblend occurred due to a high flow of air from the trim recycle cyclones.

Dusting in the foam mix room was highly visible during bag-dumping of resin at the mixing stations. However, on-the-man samplings taken during bag-dumping gave values within limits. Dusting at the foam mixer (south station) measured lower at 5 mg/M³ than that at the skin mixer (north station) which measured 18 mg/M³ during 15 minutes of bag-dumping. However, this averages to a much lower level when time away from the dust emission is added. Nevertheless, improvement is recommended for this station where ventilation system for the mixers produces visible emissions from the roof exhaust fan, evidently due to resin by-passing the filters in the entrance chambers. This will require correction for compliance with EPA requirements.

During monitoring in the blender charging area, several operators expressed concern over the use of Cab-O-Sil, a particularly light and dusty powder. Vendor's data indicates this to be amorphous, containing no toxic crystalline silica. The problem from breathing the dust is its high affinity for moisture, causing drying of the throat if inhaled. Another concern pertained to the weigh-up and handling of toxic powders. None were seen in use during monitoring, but a pallet load of "Dyphos", dibasic lead phthalate, was noticed on the blender floor. It was explained that this was used for a short run of a customer's formula, and may not be run again. If necessary to use such material, approved (Dustfoe) respirators should be required during handling, full ventilation should be available at the charge point, and the formula should be adjusted to permit the use of full weight bags rather than requiring weigh-ups.

Noise

No noise levels above 90 dBA were measured in any operating areas. High levels were measured in the immediate vicinity of the FCM drives and the Line 1000 on-line trim blower enclosure. Sound pressure levels are as follows:

Noise (Continued)

<u>Item</u>	<u>Location</u>	<u>dBA</u>	<u>Allowable Time, Hrs.</u>
<u>Line 1000</u>			
1	Within two feet of trim blower enclosure in aisle between L-1000 and L-2000 calenders	86-95	4
2	Two feet west of lower calender roll	88	8
3	Foot of stairway to calender	87	8
4	Aisle between cooling rolls and take-off	87	8

Line 2000

5	Directly below inlet to trim cutter housing	85	8
6	Within one foot of FCM gear drive	97	3

Line 3000

7	Between FCM and panel, north of drive	91	6
8	Hydrotherm blowers, within one foot Motor-Generator Room	88 92-99	8 2*

* Already Posted

Items 1, 6 and 7 require posting of signs reading "CAUTION - EAR PROTECTION MUST BE WORN WHEN WORKING IN THIS AREA FOR MORE THAN _____ HOURS PER DAY."

Since Item 1 is on the "fringe" of the take-off area, it is recommended that damping material be added to the enclosure and conveying lines in order to reduce noise levels below 90 dBA. Ventilation openings may have to be closed or baffled to achieve sufficient noise reduction.

Lighting

Lighting in most operating areas is above standard with the exception of the blender floor where intensity along the main aisle between the panel boards and blender charge hatches measures as low as 3 ft-cdl. Lowering the upper fluorescent fixtures or installing local lighting would improve illumination in this busy area. The panels are in need of local lighting to facilitate reading controls and indicators. Local lighting is recommended for the log table to increase illumination from 3 ft-cdl. to 50 to improve readability of work sheets.

Warehouse areas are minimal, largely due to lights no longer centering on aisles. The east warehouse foam roll storage racks are in need of better illumination measuring 1 ft-cdl. along the C and E racks. Lights obscured by these racks should be centered over the aisles between D and E racks and C and CC racks. A minimum of 5 ft-cdl. should be available, with 10 being desirable. A similar situation applies to the storage area for the embossing rolls.

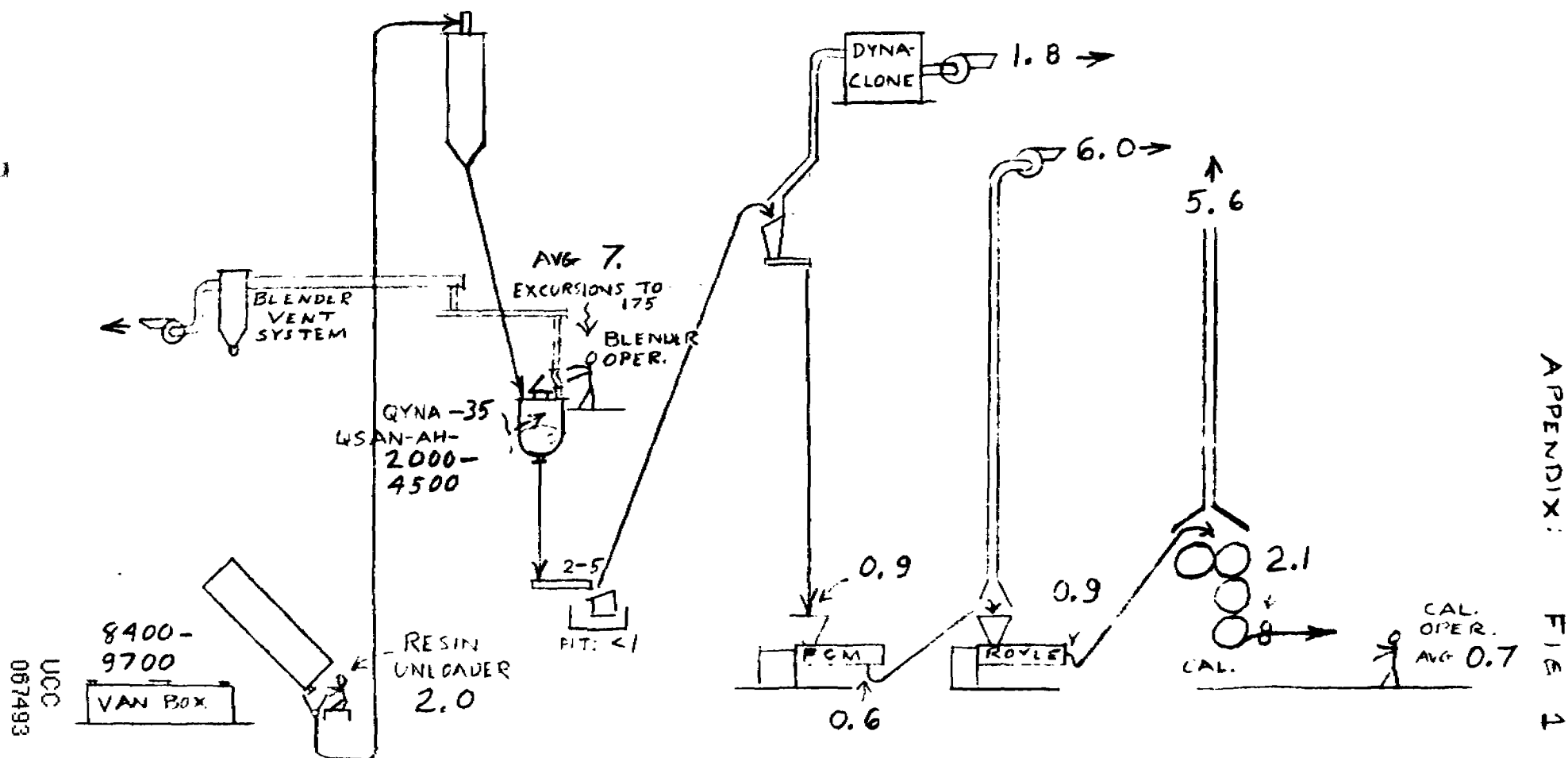
Illumination in the main men's room area ranges between two extremes: 125-150 ft-cdl. in the lavatory-toilet room versus ANSI standard of 30 ft-cdl. and 3 ft-cdl. in the shower room. Better lighting is therefore recommended to bring the level up to 30 ft-cdl. in the shower room and drying area. The locker room is satisfactory. Lighting in the lunch room measured in the 3-5 ft-cdl. range. An improvement to 10 ft-cdl. is recommended.

Radiation - See Appendix, Table 4

Results of the last semi-annual inspection of March 19, 1974 by Industrial Nucleonics Corporation are reported.

APPENDIX FIG. 1 VINYL CHLORIDE MEASUREMENTS - BLDG 105

EMERGENCY STANDARD: 50 PPM MAX.
 PROPOSED " " "No detectable" - zero



APPENDIX, TABLE 1

RESULTS OF CHARCOAL TUBE SAMPLING AND ANALYSIS FOR VINYL CHLORIDE

LOCATION OR JOB POSITION	SAMPLING		Sample Volume Liters	Vinyl Chloride	
	Time min.	Rate ml/min		Mgms	PPM
<u>AREA SAMPLES:</u>					
Air space in van box loaded with QSAN, Blend 1603	66	30.5	2.02		8400
Air space in van box loaded with QSAN, Blend 4948	52	31	1.61		9700
Air space in van box loaded with QSAN, Blend 5027	30	32	0.96	714	292
L-1 Blender immediately after charging QYMA	34	30	1.02	90	35
L-2 Blender after blending of QSAN, plasticizers, etc.	77	31	2.38	27000	4448
L-2 Blender after charging QSAN, before plasticizers, etc.	34	33	1.12	7180	2514
L-2 Blender after charging QSAN, before plasticizers, to.	20	31	0.62	3191	2017
L-3 Blender panel board area	138	31	4.27	78	7.2
Bldg. 101, Bay 15 blender area	20	87	1.74	5.7	1.3
Bldg. 101, Bay 15, banbury discharge	34	77	2.62	0.75	0.1
Dynalene exhaust (vent from L-1 banburys)	127	31	3.94	18	1.8
L-2 Preblend feed to PCM	104	30	3.12	7.5	0.9
L-2 PCM discharge	120	33	3.96	6.0	0.6
L-3 PCM discharge	12	110	1.32	9.0	2.7
L-2 Exhaust from Royle extruder hopper	210	33	6.91	106	6.0
L 1 Exhaust from Royle extruder hopper	11	110	1.21	1.1	0.35
L-2 Discharge from Royle extruder dis	125	33	4.13	9.0	0.85
Rear of L-3 Calender rolls	10	100	1.00	1.9	0.74
L-2 Calender stack exhaust	60	28	1.68	24	5.6
L-2 Calender embossing rolls	85	30	2.55	13.5	2.1
<u>PERSONNEL SAMPLES:</u>					
Resin Airveyor Operator connecting van box No. 657 of QSAN	4	30	0.12	0.6	1.96
Resin Airveyor Operator connecting van box No. 807 of QSAN	2.1	85	0.18	< 1.8	< 3.9

APPENDIX, TABLE 1 (cont.)

LOCATION OR JOB POSITION	SAMPLING		Sample Volume Liters	Vinyl Chloride	
	Time min.	Rate ml/min		Mgms	PPM
L-3 Blender Operator	152	31	5.46	90	6.5
L-2 Blender Operator	183	30	5.50	90	6.4
L-1 Blender Operator	173	30	5.19	37.5	2.8
L-2 Blender Operator, charging blender	3.5	31	0.108	2.5	9.1
L-3 Blender Operator, charging blender	3.3	31	0.103	1.0	3.8
L-3 Blender Operator	96	30	2.88	19.8	2.7
L-3 Blender Operator, charging blender	11.5	30	0.345	4.5	5.1
L-2 Blender Operator, charging blender	2.8	32	0.09	5.1	22.2
L-1 Blender Operator, charging blender	9.7	90	0.87	101.7	45.8
L-3 Blender Operator, charging blender, (blender vented)	3.5	105	0.368	< 0.9	< 0.9
L-2 Blender Operator, charging blender, (blender vented)	4.0	115	0.460	11.9	10.1
Bay 15 Blender Operator, charging blender	2.0	85	0.170	2.3	5.2
Bay 15 Banbury Operator	35	105	3.68	< 1.8	< 0.2
Bay 15 Calender Operator	38	71	2.70	< 1.8	< 0.3
L-2 Calender Operator	152	32	4.96	13.5	1.1
L-3 Calender Operator	155	30	4.65	8.1	0.7
L-2 Calender Operator	148	30	4.44	2.7	0.2
L-1 Calender Operator	34	81	2.76	4.1	0.6
L 1 Blender Operator, sampling blender	4.5	82	0.37	165	175
L-1 Blender Operator, sampling blender	1.0	105	0.105	1.7	6.3
L-2 Blender Operator, sampling blender	1.0	105	0.105	4.1	15.3
L-2 Blender Operator, sampling blender	0.5	95	0.0475	3.4	28.1
L-3 Blender Operator, sampling blender	1.0	105	0.105	29.4	110
L-3 Blender Operator, sampling blender	1.0	105	0.105	34.5	129
Blender Operator, roll-milling sample of preblend	5.0	105	0.525	< 0.8	< 0.6
Blender Operator, roll-milling sample of preblend	4.0	108	0.432	< 0.8	< 0.7
Foam Line, Skin Mixer	19	30	0.56	< 1.5	< 1.1
Foam Line, Foam Mixer	15.9	30	0.48	0.6	0.5
Bay 10, Bldg. 101, Preblend Operator, charging tote bin	19	90	1.71	< 0.6	< 0.14
Bay 10, Bldg. 101, Preblend Operator, charging Bay 7 blender	8	105	0.84	< 0.6	< 0.28
Bay 10, Bldg. 101, Mill Operator	30	85	2.55	0.6	0.1

APPENDIX, TABLE 2

RESULTS OF CHARCOAL TUBE SAMPLING AND ANALYSIS FOR SOLVENT VAPORS

	SPL Time min.	Rate ml/min	Sample Volume Liters	M E K ngms mg/m ³		M I B K ngms mg/m ³		T H F ngms mg/m ³		2 - NP ngms mg/m ³		Calculation of Dosages				
												M E K	M I B K	T H F	2 - NP	TOTAL
TLV					590		410		590		90					
<u>No. 1 Printer</u>																
Chief Operator - D. M.	142	104	14.8	2230	151	425	29	1060	72	70	5	$\frac{151}{590} + \frac{29}{410} + \frac{72}{590} + \frac{5}{90} =$				0.50
Relief Operator - J. G.	108	88	9.6	1770	185	350	37	270	28	<40	4	$\frac{185}{590} + \frac{37}{410} + \frac{28}{590} + \frac{4}{90} =$				0.49
<u>No. 3 Printer</u>																
Chief Operator - H. A.	113	115	13.0	2150	166	40	3	130	10	<40	<3	$\frac{166}{590} + \frac{3}{410} + \frac{10}{590} + \frac{3}{90} =$				.40
Relief Operator - H. J.	116	120	13.9	2240	161	40	3	870	63	70	5	$\frac{161}{590} + \frac{3}{410} + \frac{63}{590} + \frac{5}{90} =$				.50
<u>Strike-Off Operator</u> - P. T.	104	95	9.9	1190	120	1290	130	780	79	<40	<4	$\frac{120}{590} + \frac{130}{410} + \frac{79}{590} + \frac{4}{90} =$				.70
<u>Ink Coordinator</u> - H. W.	117	120	14.0	2430	174	130	9	1440	103	60	4	$\frac{174}{590} + \frac{9}{410} + \frac{103}{590} + \frac{4}{90} =$				.53
<u>Ink Room (Area)</u>	94	80	7.5	1600	214	175	23	930	124	<40	<5	$\frac{214}{590} + \frac{23}{410} + \frac{124}{590} + \frac{5}{90} =$				.67
<u>Ink Room (Area)</u>	144	125	16.6	7406	447	230	14	1134	68	<40	<2	$\frac{447}{590} + \frac{14}{410} + \frac{68}{590} + \frac{2}{90} =$				.92

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APPENDIX, TABLE 3

RESULTS OF GRAVIMETRIC ANALYSIS FOR RESIN DUST

	SAMPLING		Air Vol. Liters	Sample Weight Mgms.	mg/M ³
	Time min.	Rate ml/min			
CALENDER LINES:					
L-1 Bl nder operator, made small weigh-ups, no blender charging	103	1650	170	980	5.8
L-2 Blender operator, 2 blender charges, minimum bag-dumping	128	1690	216	810	3.8
L-3 Blender operator, 2 blender charges, moderate bag-dumping	103	1600	165	920	5.6
Log table, blender mezz., (Area sample)	150	1600	240	560	2.3
L-1 Blender operator, Dumped 45 bags QYMA into blender	10	1675	16.75	284	170
L-1 Blender operator, dumped 7 bags of fillers, $\frac{1}{2}$ bag Cab-O-Sil, 2 weigh bags	12	1750	21	125	60
L-1 Blender operator, prepared 5 weigh bags of Cast, 411AB, and charged 1 blender	75	1750	131	870	6.6
Above samplings were made without ventilation on blenders.					
FOAM LINE:					
"Skin" mixer: made 2 mixes, dumping 11 bags of Marvinol resin and 5 bags of Pliovic into each	14.9	1725	25.7	470	18.3
"Foam" mixer: dumped 22 bags of QYJVI:A	22.0	1700	37.4	190	5.1

FIELD WIPE TEST REPORT

(Long rm)

APE IX, TABLE 4

1a Customer

Union Carbide Corp.

1b Address

Bound Brook, N.J.

Due Date

1c Source No.	1d Frame No	1e Gauge No.	2 Labels	3 W. T.	4 Shutter	5 Indica.	6a Test By	6b Date	7 Remarks	Lab Test
K-2545	04624121	04624121	OK	N/A	OK	OK	1/16.6 ft.	3/19/74	BIOS 1.5 Link 1000	
S-361-T	00414176	00424171	OK	NIS	OK	OK	1/16.6 ft.	3/19/74	BIOS 1.5 Link 2000 A	
S-367-T	00424179	004624172	OK	NIS	OK	OK	1/16.6 ft.	3/19/74	BIOS 1.5 Link 2000 B	
S-362-T	04624170	004624173	OK	NIS	OK	OK	1/16.6 ft.	3/19/74	BIOS 1.5 Link 2000 C	
K-2572	046241214	046241221	OK	N/A	OK	OK	1/16.6 ft.	3/19/74	BIOS 1.5 Link 3000	
K-3165-X	002639425	002639421	OK	N/A	OK	OK	1/16.6 ft.	3/19/74	BIOS 1.5 Link 1000	
S-634-T	002639426	002639423	OK	NIS	OK	OK	1/16.6 ft.	3/19/74	BIOS 1.5 Link 1000	
CS-2601	6472	1000	OK	NIS	OK	OK	1/16.6 ft.	3/19/74	BIOS 1.5 Link 1000	
CS-2607	3539	NONE	OK	NIS	*	*	1/16.6 ft.	3/22/74	BIOS 137 Storage	
CS-255-1	7022	NONE	OK	NIS	*	*	1/16.6 ft.	3/22/74	BIOS 137 Storage	
3080	NONE	451-602	OK	NIS	*	*	1/16.6 ft.	3/22/74	BIOS 137 Storage	
30-61-275	54631	NONE	OK	NIS	**	**	1/16.6 ft.	3/22/74	BIOS 137 Storage	
6045	NONE	7061	OK	N/A	**	**	1/16.6 ft.	3/22/74	BIOS 137 Storage	
110-5	613-2579	NONE	OK	NIS	NONE	NONE	1/16.6 ft.	3/22/74	BIOS 200 (NIGHT PACKING)	
Notes:	* Storage in Storage. Area Each in a wooden Shipping Crate.									
	W.T. A Storage. Power Control. Switches Locked Closed &									
	Storage Area Down. Indicators Not in-Service.									
	Storage BIOS is kept locked at all times. Previous									
	Storage in BIOS 134.									
	* Storage in Storage. Switches Locked AND All Power Removed.									
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ACKNOWLEDGEMENTS

The execution of this survey was particularly facilitated through the unlimited cooperation of the following individuals:

Operations:

J. Kerman, H. Koenig, S. Molnar, M. Shvidrik,
W. Westcott, F. Wick and T. Zambo, Production
Supervisors

Analytical Service:

J. Cavender, G. Hurley and J. Neff, Chemicals
and Plastics Environmental Health Lab, South
Charleston; Safety and Environmental Protection;
R. E. Rosfjord

D I S T R I B U T I O N

Mr. J. D. Baker - BB
Mr. R. A. DeCoudres - BB
Mr. L. F. Doyle - BB
Mr. J. L. Goodson/Shift Superintendents - BB
Mr. P. Granger- BB
Mr. N. H. Ketcham - SCTC
Mr. F. J. McCarthy - Chicago
Dr. C. S. McKinley - BB
Mr. R. E. Peele/R. E. Graebert - SCTC
Mr. E. B. Sharp/F. L. Wiegler - BB
Dr. A. B. Steele - NY-28
Mr. R. N. Wheeler - SC
Mr. D. L. Wiley - NY-21

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JUL 24 1974
R. N. WHEELER, JR.

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DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
CENTER FOR DISEASE CONTROL
ATLANTA, GEORGIA 30333

RECEIVED

MAY 09 1974

R. N. WHEELER, JR.

April 23, 1974

1) RNW 2) ME Givens
T.C.
Info

R. W. Holland, M.D.
Union Carbide Corporation
437 McCorkle Avenue, S.W.
South Charleston, West Virginia 25303

3) MZ file

Dear Dr. Holland:

384 Brady

Enclosed is a copy of our proposal for medical screening at the Union Carbide plant in South Charleston. As we discussed over the phone, this protocol is in the preliminary drafting stage and subject to further revision. When completed, the finished version will be forwarded to you, along with the appendices.

Respectfully,

A. Scott Grivas, Jr.

A. Scott Grivas, Jr., M.D.
Cancer Section
Cancer and Birth Defects Division
Bureau of Epidemiology

Enclosure

ASG/mc

UCC
067501

EVALUATION OF MEDICAL SCREENING FOR THE
DETECTION OF LIVER DISEASE AMONG VINYL CHLORIDE WORKERS

Background and Objectives

The recent recognition of angiosarcoma of the liver among workers engaged in the polymerization of vinyl chloride, together with preliminary results of animal toxicologic studies, strongly implicate vinyl chloride monomer as a serious carcinogenic hazard for occupationally-exposed individuals. Preliminary evidence also suggests that VCM may induce toxic liver alterations, portal fibrosis in particular, long before the development of frank liver malignancy.

It is the purpose of this study 1) to determine those diagnostic laboratory procedures best suited, both in specificity and sensitivity, for the detection of liver disease among workers at vinyl chloride polymerization plants; 2) to identify as completely as possible specific workers with liver abnormalities so that they may be removed from vinyl chloride exposure and referred for appropriate medical evaluation and therapy; and 3) to identify other medical illnesses which might conceivably be related to vinyl chloride exposure.

Investigators

1. A. Scott Grivas, Jr., M.D., EIS Officer, Cancer Section, CDC.
2. Joseph Mallov, M.D., physician with NIOSH.
3. ~~John~~ Holland, M.D., Plant Medical Director, Union Carbide Corporation, South Charleston, West Virginia.

4. Coleman Carter, M.D., EIS Officer, Cancer Section, CDC.
5. Henry Falk, M.D., EIS Officer, Cancer Section, CDC.
6. Clark W. Heath, Jr., Director, Cancer and Birth Defects Division, CDC.

Study Design

[The study will be performed jointly by the CDC/NIOSH and the Union Carbide Corporation at the Union Carbide plant located at South Charleston, West Virginia. Three groups of plant workers will be selected for intensive medical screening. They are (1) plant personnel currently engaged in the polymerization of vinyl chloride, (2) administrative personnel, such as salaried persons, clerks, secretaries, etc., and (3) plant personnel involved in non-vinyl chloride-related jobs, such as the production of rubber, other synthetic plastics, etc.] Participation in this study will be by volunteer consent. It is hoped that virtually all persons directly engaged in vinyl chloride polymerization work be enrolled in the study. Union officials at the plant will be informed in detail of the purposes of the study and their cooperation will be sought to encourage all union members to participate. A special consent form will be signed by each participant (Appendix A).

[The size of the study group is estimated at approximately 320 persons. This could include 160 current vinyl chloride workers together with an equal number of controls, matched for age and duration of employment and selected by systematic sampling from administrative staff and non-PVC plant personnel.

Medical screening, as detailed below, will be conducted in collaboration with Union Carbide medical personnel, utilizing the medical facilities at

the plant and in the South Charleston, West Virginia, area. CDC/NIOSH will provide a team of physicians to assist with the screening procedure. It is estimated that all 320 workers can be medically evaluated within 1-2 weeks. Forty-five minutes to 1 hour will be appropriated for the screening of each individual worker. Screening is tentatively scheduled to begin Monday, July 1, 1974.

Whenever possible, arrangements will be made for local laboratories to perform the analysis of the more commonplace medical tests. The facilities of specialized research laboratories, however, will be utilized for special tests (e.g., proline hydroxylase, alpha fetoprotein, sarcoma specific antigens, etc.). Contractual arrangements for the performance of these tests will be made during May 1974. The costs of such tests will be assumed by CDC/NIOSH.

Medical Screening

Screening will consist of 1) medical history, b) physical examination, and 3) laboratory testing. Special forms will be used for recording findings of medical history and physical examination (Appendices B and C). The following laboratory tests will be performed on each study participant:

1. Hematology

- a. CBC with a differential
- b. Platelet count
- c. Reticulocyte count

2. Urinalysis

- a. Routine urinalysis
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3. Serology

- a. Direct and indirect reacting bilirubin
- b. Alkaline phosphatase, gamma-glutamyl transpeptidase, LDH
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- e. Proline hydroxylase
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- g. Carcino-embryonic antigen, alpha fetoprotein, F-antigen, and sarcoma-specific antigens.
- h. B-12 binding protein
- i. Serum protein electrophoresis

4. Spirometry

- a. Vital capacity
- b. Forced expiratory volumes

5. Radiologic procedures

- a. Chest x-ray
- b. Hand x-rays
- c. KUB film plate abdomen
- d. Liver spleen scan.

Comments

Any worker identified by such a screen procedure as having possible liver impairment will be removed from vinyl chloride exposure and referred to his personal physician for further diagnostic evaluation and therapy.

5.

If a liver biopsy is then felt indicated, an attempt will be made to obtain biopsy slides and tissue blocks for review by Drs. Thomas and Popper at NIH. In this manner, we hope to uncover any additional cases of angiosarcoma of the liver and also identify any premalignant hepatotoxicity, possibly associated with exposure to vinyl chloride.

Workers found to have abnormalities of other organ systems, unrelated to hepatobiliary disease, will also be referred to their private physicians for appropriate evaluation and therapy. A special letter (Appendix D) will then be sent to these physicians requesting, for each worker thus referred, specific follow-up information, such as final diagnoses, therapy, and prognosis. In this manner information regarding overall morbidity among workers at polymerization plants may be obtained.

As a result of this study and of related work elsewhere, it is hoped that decisions can be made regarding the sensitivity and specificity of the various screening procedures aimed at detecting liver disease among asymptomatic workers at vinyl chloride polymerization plants. Comparison of test results between vinyl chloride workers and non-vinyl chloride controls (administrative staff and plant personnel employed in non-PVC related jobs) will help validate judgments concerning the usefulness of these various tests. Hopefully on the basis of test results obtained from this study, more precise recommendations can be developed concerning medical screening procedures which should be employed to protect the health of persons potentially exposed to vinyl chloride in industrial settings.



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ASG/mc

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Texas City, Texas
Brain Tumor -
Epidemiology
Study

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9/29/80

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DRAFT VI

Brain Cancer in Petrochemical Workers - A Case Series Report

Nineteen primary brain cancer deaths have been found among workers at one United States petrochemical plant. We believe this is the largest single series of presumably occupationally-related brain cancers reported in the medical literature.

In November, 1978, the Occupational Safety and Health Administration (OSHA), the Federal occupational health enforcement agency of the U.S. Department of Labor, received an employee complaint that work-related chemical exposures might have caused brain tumors in fellow workers as well as his own recently diagnosed brain cancer.

OSHA's Office in Houston, Texas began an investigation of brain cancer mortality at the employee's worksite, a moderate-sized petrochemical production facility in Texas City, located in Galveston County south of Houston. Workers, family members and surviving relatives, union officials, local physicians and hospital staff, Texas state health officials and company personnel were interviewed. Four primary brain tumor deaths were discovered among former employees in this way. It is ironic that the worker who filed the original complaint with OSHA was found to have a metastatic carcinoma to the brain, and is not counted among the cases. The plant physician subsequently reviewed death information maintained by the medical department, primarily covering workers who died while employed and who by virtue of 15 years of company service were eligible for death benefits. Ten deaths from primary brain cancer were identified. These ten

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- 2 -

DRAFT VI

included the four previously found. OSHA then requested technical assistance from the National Institute for Occupational Safety and Health (NIOSH), its companion research agency in the U.S. Department of Health, Education, and Welfare.

In February, 1979 OSHA, NIOSH, and the company established a collaborative study plan to investigate the apparent excess of brain cancers. An historical prospective cohort mortality study was begun to determine the Standardized Mortality Ratio (SMR) for brain cancer, and whether there exists any other unusual mortality pattern. Also included within the cohort study is a case-control study of all primary brain cancer cases to establish whether a particular job or chemical exposure at the plant is associated with an excess risk of brain cancer. A reference neuropathology laboratory has agreed to examine autopsy and surgical pathology specimens to provide histologic confirmation of the cause of death. Each of these studies is well underway, and results are expected within a few months.

An experimental case-finding technique was added to the study design to provide an early estimate of the extent of the problem. A computer-assisted search was conducted of Texas Bureau of Vital Statistics data maintained by the M.D. Anderson Tumor Institute Department of Epidemiology. Since company records showed that 99% of plant employees reside in Galveston, Harris and Brazoria counties, a list of all primary brain cancer deaths among males more than twenty years of age from 1950 through 1977 was obtained for these three counties. This list of 732 primary brain

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cancer deaths was matched against company personnel files. Four additional confirmed cases resulted. Further investigation of company records revealed two more cases. Three other employees became ill during the preliminary period of the study. All cases were deceased as of March, 1980. The current total of 19 cases is the subject of this case series report.

Work history data for the 19 cases are provided in Table 1. The average age at death for the cases was 52; the youngest died at age 30, and there were four deaths after age 60. Over half the deaths occurred between ages 50 and 59. The age distribution observed in this series does not differ significantly from that reported in other series.^(1,2,3)

Total length of employment at the plant ranged from 1 month to slightly more than 35 years, with a median value of 20 years. Two cases had short exposure periods of 38 and 29 days respectively. Median length of employment excluding these two cases was 22 years. The interval from first employment to death, which provides an estimate of latency, varied from as few as 3 1/2 years to nearly 36 years, with a median of 24 years. The median values for exposure and latency period in this series are typical of those found for other tumor types in occupational cancer investigations and are consistent with a hypothesis of occupational etiology resulting from chemical exposures.

No particular trend or clustering by hire date among the cases has been identified as compared to the general plant population. One case was

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hired in late 1940 as part of a small plant start-up crew. Three more were hired in 1941 during the first year of plant operation, and the others at fairly regular intervals until the last group of four started work during 1953. The first death occurred in 1956, followed by five others during the 1960's. Twelve of the deaths occurred after 1970, three of them during the past year. No established pattern is evident from the observed years of death, but there is no evidence that the rate of appearance of cases is declining.

The plant has a current workforce of slightly more than 2,200, including nearly 1,500 hourly and production employees. The average age is 44, and approximately 1,050 current employees have 25 or more years of company service. Since the plant began operation in 1941, there have been a total of 8,850 employees. These include 6,802 white males, 884 black males, 1,083 white females, and 81 black females through December, 1979. The distribution by county of residence for current workers is provided in Table 2. The plant also engages a temporary independent contractor workforce of 100-250 daily, mostly for construction jobs. Unfortunately, no employment records are available for this group.

Demographic and cause of death data from the death certificates are provided in Table 3. All cases occurred among male employees, 18 whites and 1 black. The mortality rate for primary brain cancer in Texas among black males is about one-half that for white males.⁽⁴⁾ However, very little can be said regarding the racial distribution of cases, since it appears

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that increased numbers of black employees have been employed at the plant only in recent years.

All but one of the cases were native-born Americans; the lone exception was Norwegian. The great majority of the cases were born in Texas, two were from Louisiana, and one each was from Massachusetts, New Mexico, and Oklahoma. None of the U.S. states of origin have a particularly high risk for brain cancer, compared to the U.S. national average. There is presently no information available about the age of the cases when they moved to Texas, or where else they may have lived.

Sixteen of the cases were Galveston County residents at the time of death; the other three were from Harris County. The possibility of an environmental etiology related to Galveston County was considered. County-wide data from the National Cancer Institute on the brain cancer mortality rates for Harris, Galveston, and Brazoria Counties from 1950-1969 are in the mid-range for Texas and U.S. national values as shown in Table 4. A survey made by the Texas State Department of Health for 1977 showed that the Galveston County brain cancer crude mortality rate was 3.6/100,000. There is no evidence from these data that local environmental factors outside the plant are responsible for the apparent excess of brain cancer. ✓

To obtain an initial estimate of the brain cancer risk, brain cancer deaths among adult white males in Galveston County were analyzed using the list described previously. A total of 54 primary brain cancer deaths occurred in the county from 1962 through 1977. To establish a rough

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comparison, information from the Health Services Administration on county population characteristics was used.⁽⁵⁾ In 1970 Galveston County was 68% white, and 62% of the population were between the ages of 14 and 64. A 1970 county population estimate was 170,000 of whom 49% were males.⁽⁶⁾ Thus, the white male population of employment age at risk during 1962-1977 was somewhat less than 38,000; the plant white male population was about 1,800 or about 5% of the county total. Yet during this period, 11 of 54 brain tumor deaths among county residents occurred in plant employees, nearly 20% of the total. This suggests an approximate plant-wide risk of about four-fold.

The underlying causes of death as recorded on the death certificates are listed in Table 2. Nine cases of glioblastoma multiforme were recorded directly on the certificate. Further investigation of hospital and physicians' records provided evidence that there were six additional cases of glioblastoma multiforme among the total of 19. According to these records one case also was reported to be a metastatic lesion to the cerebellum. Preliminary medical evidence thus suggests that 81% (15/19) of the tumors were glioblastomas. Because this type of tumor usually accounts for 40-55% of deaths in reported brain cancer series, this would indicate an excess of glioblastoma multiforme among these cases.^(1,2,3,7,8) The difficulty of precise neuropathological diagnosis for brain cancer is recognized, and the pathology review is expected to better define this observation.

The plant is a diversified petrochemical manufacturing facility with a large number of major product lines, including ethylene, butadiene, naphtha,

ethylene dichloride, diethyl sulfate, glycols, aldehydes, acetates, alcohols, amines, organic acids, and plastics and resins (polyethylene, vinyl chloride-vinyl acetate copolymers, phenol-formaldehyde resin). Review of the plant's chemical inventory reveals the presence of at least 11 recognized or suspect carcinogens in significant quantities as raw materials, reaction by-products, or manufactured compounds. These are shown in Table 5. Careful preliminary examination of the work histories of affected employees does not yet establish any common job title, department code, or chemical exposure. Eight of the men were chemical operators in production departments but they were spread throughout the plant, and worked on different chemical processes. Six others were maintenance workers who may have had the opportunity for plant-wide exposures over the years. Two worked in the chemical shipping department as weighmasters with likely multiple exposures. Five worked in various construction trades. Work histories on the cases are limited to employment by the company with two exceptions. Case 1 was a salaried employee at a nearby petrochemical plant from 1948-1964, and Case 6 worked as a pipefitter from 1952-1974 in the same plant. No information about other potential chemical exposures is presently available. The detailed examination of work histories in the case-control study offers the best opportunity to establish a connection between a particular chemical exposure or type of work and an excess risk of brain cancer. ✓

A detailed literature search for compounds inducing brain cancer has identified 26 different chemicals from experimental animal studies as shown in Table 6. Review of available epidemiological studies provided in Table 7

offers several intriguing clues, but little solid documentation for occupationally-related brain tumors, except in the case of vinyl chloride.^(9,10) Recent mortality studies of oil refinery workers in Canada⁽¹¹⁾ and petrochemical workers in Texas⁽¹²⁾ suggest the possibility of an excess brain cancer risk among these groups, although as yet no specific causative agent has been identified.

A comparison of experimental studies, epidemiological data, and the plant chemical inventory shows that vinyl chloride, acrylonitrile, and diethyl sulfate are possible suspect agents for inducing brain cancer in these workers. On the basis of prior knowledge from human and animal studies, and its presence in the work environment under poorly controlled circumstances in the past, vinyl chloride must be the first compound considered. However, to date, examination of the work histories of the 19 cases does not support a significant positive association with vinyl chloride exposure, and other agents must be carefully evaluated.

The information available indicates that this number of brain tumors is excessive in a population of this size, and that the tumors are likely to be occupationally-related. There is no good evidence to implicate non-plant, general environmental factors. A very careful and thorough investigation of this situation must be made, since a previously unsuspected chemical exposure may be responsible for this striking appearance of brain cancers in a single petrochemical plant.

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Table 1.

WORK HISTORY DATA FOR 19 PRIMARY BRAIN
CANCER CASES IN A TEXAS PETROCHEMICAL PLANT

<u>Case</u>	<u>Date of Hire</u>	<u>Date of Death</u>	<u>Age at Death</u>	<u>Length of Employment (years-months)</u>	<u>Job Title</u>	<u>Department</u>
-1	12/16/40	05/15/64	51	3-6	Operator	Production
-2	05/18/41	02/19/66	56	24-8	Operator	Production
-3	07/29/41	05/18/76	66	31-8	Foreman	Maintenance
-4	11/30/41	12/13/65	55	20-4	Operator	Production
-5	07/09/44	10/28/79	59	35-0	Boilermaker	Structural Shop
-6	09/18/44	05/21/74	55	0-1	Operator	Production
-7	09/19/46	03/07/79	55	32-3	Laborer/Oiler	Maintenance
-8	09/26/46	03/22/73	63	26-6	Operator	Production
-9	01/12/48	01/26/71	53	1-2	Painter	Maintenance
-10	09/21/48	07/02/75	49	2-1	Pipefitter	Maintenance
-11	03/02/49	06/05/71	61	22-3	Operator	Production
-12	01/25/50	01/13/68	66	16-7	Equip. Operator	Maintenance
-13	10/19/50	05/14/74	59	17-1	Operator	Energy Systems
-14	10/23/50	02/18/80	57	28-10	Operator	Production
-15	09/19/51	01/08/74	52	22-3	Machinist	Machine Shop
-16	04/27/53	10/03/56	33	0-1	Machinist	Maintenance
-17	03/17/53	04/05/62	30	8-7	Weighmaster	Shipping
-18	08/21/53	05/05/71	44	17-3	Operator	Production
-19	10/30/53	12/21/78	49	24-8	Weighmaster	Shipping

Table 2. CURRENT PLANT WORKFORCE BY COUNTY OF RESIDENCE

<u>County of Residence</u>	<u>Type of Employee</u>		<u>Total</u>	<u>Percent</u>
	<u>Hourly</u>	<u>Salaried</u>		
Galveston	1,389	609	1,998	90.0
Harris	44	110	154	6.9
Brazoria	41	15	56	2.5
Other	<u>7</u>	<u>4</u>	<u>11</u>	<u>0.5</u>
Total	1,481	738	2,219	100.0

Source: Data provided by company

Table 3.

DEATH CERTIFICATE DATA FOR 19 PRIMARY
BRAIN CANCER CASES IN A TEXAS PETROCHEMICAL PLANT

Case	Race/ Sex	Residence	Place of Birth	Cause of Death	
				Death Certificate	Medical Records
1	WM	Galveston	Texas	Carcinoma of Brain	Glioblastoma (MR)*
2	WM	Galveston	Missouri	Malignant Brain Tumor	Meningioma (A)
3	WM	Harris	Texas	Brain Tumor	Glioblastoma (A)
4	WM	Galveston	Texas	Brain Tumor-Meningioma	Meningioma (MR)
5	WM	Galveston	Louisiana	Glioblastoma	Glioblastoma (SP)
6	WM	Galveston	Texas	Brain Tumor-Glial IV	No Records Available
7	WM	Galveston	Texas	Glioblastoma	Glioblastoma (MR)
8	WM	Galveston	Texas	Glioblastoma	Glioblastoma (SP)
9	WM	Galveston	Massachusetts	Cerebellar Tumor	Metastatic Cerebellar Tumor (SP)
10	WM	Harris	Texas	Astrocytoma	Astrocytoma-Grade I (SP)
11	WM	Galveston	Texas	Malignant Glioma	Glioblastoma (MR)
12	WM	Galveston	New Mexico	Glioblastoma	Glioblastoma (A)
13	WM	Galveston	Norway	Glioblastoma	Glioblastoma (SP)
14+	WM	Galveston	Texas	Glioma-Grade III	Astrocytoma-Grade IV (MR)
15	WM	Galveston	Texas	Glioblastoma	Glioblastoma (A)
16	WM	Harris	Texas	Glioblastoma	No Records Available
17	WM	Galveston	Louisiana	Brain Tumor	Glioblastoma (A)
18	WM	Galveston	Texas	Malignant Glioma	Glioblastoma (SP)
19	WM	Galveston	Texas	Brain Tumor	Glioblastoma (A)

+Data from company records, death certificate not available

*Source: MR-Medical Records; A-Autopsy; SP-Surgical Pathology

Table 4.

**BRAIN AND OTHER CNS CANCER MORTALITY, 1950-1969:
AVERAGE ANNUAL AGE ADJUSTED RATES PER 100,000**

<u>Location</u>	<u>White Male</u>	<u>White Female</u>	<u>Black Male</u>	<u>Black Female</u>
United States	4.4	2.9	2.3	1.5
Texas	4.3	2.9	1.9	1.5
Galveston County	4.5	2.9	2.5	2.1
Harris County	4.5	3.6	2.0	1.9
Brazoria County	3.1	3.9	1.2*	1.5

*Based on one case

The range of U.S. rates for males for counties with >10 deaths from 1950-1969 were 3.1-5.4 (white) and 1.3-3.9 (black). The range of Texas rates for white males for counties with >deaths from 1950-1969 was 2.3-10.8.

Source: U.S. Cancer Mortality by County, 1950-1969, National Cancer Institute, DHEW Pub. No. (NIH) 74-615, Bethesda, Maryland, 1974

**Table 5. RECOGNIZED AND SUSPECT CARCINOGENS IN
A TEXAS PETROCHEMICAL PLANT**

Acrylonitrile	Isopropyl Oils
Benzene	Trichloroethane
Diethyl sulfate	Trichloroethylene
Dioxane	Vinyl chloride
Ethylene dichloride	Vinylidene chloride
Hydrazine	

Table 6.

EXPERIMENTAL BRAIN CARCINOGENS

2-Acetylaminofluorene (13)	Elaionycin (21)
Acrylonitrile (14)	Ethyl methanesulphonate (22)
1-Aryl-3,3-Dialkyltriazenes (15)	Ethyl nitrosobiuret* (16)
Azoethane* (16)	Ethyl nitrosoourea* (23)
Azoxyethane* (16)	1-Methyl-2-Benzyl-Hydrazine* (15)
Azoxymethane (15)	Methyl methanesulphonate (24)
Butyl nitrosoourea (17)	Methyl nitrosoourea* (25)
Cycasin (18)	Methyl nitrosoourethane (intraplacental) (26)
1,2-Diethylhydrazine (15)	Procarbazine* (23)
Diethylnitrosamine* (15)	Propane Sultone (27)
Diethyl Sulfate* (19)	Propylene Imine (27)
Dimethylbenzanthracene* (20)	Pyrrolizidine Alkaloids (28)
Dimethyl Sulfate* (19)	Vinyl Chloride (29)

*Transplacental carcinogenesis

Table 7.

EPIDEMIOLOGICAL STUDIES:
CLUES TO HUMAN BRAIN CANCER ETIOLOGY

Aluminum Workers (30)	Machinists (39)
Anti-Convulsant Use (31,32,33)	Oil Refinery Workers (11)
Farm/Rural Residents (3)	Petrochemical Workers (12)
Geographic Clustering Kentucky (34,35), Rhone Valley (36)	Rubber Workers (40,41,42)
Halomethanes in Drinking Water (37)	Toxoplasmosis (43)
Lead Smelter Workers (38)	Vinyl Chloride Workers (9,10,44,45)

Brain Cancer Cluster Investigation
in a
Texas City, Texas
Chemical Plant

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Victor Alexander, MD, MSPH

October, 1980

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Introduction:

In February of 1979, The National Institute for Occupational Safety and Health (NIOSH) of the Department of Health and Human Services, the Occupational Safety and Health Administration (OSHA), of the Department of Labor, and the Union Carbide Corporation began an investigation of a cluster of brain tumors at the company's Texas City, Texas plant. The initial events and the characteristics of the cases have been described by Dr. Victor Alexander. We here describe the conduct and present status of a case-control study of occupational histories of employees of that plant who developed primary brain tumors.

Methods and Materials:

The method of case identification has been described by Dr. Alexander; the company was able to identify 12 cases, matching company records with lists of all adult males who were residents of surrounding counties and who died of malignant brain tumors yielded four more cases, three additional cases became ill and died during the course of the study, and three cases have been found so far in the course of determining the vital status of all workers ever employed in the plant. Medical records and tissue specimens were obtained, where possible, and a best diagnosis was chosen from the available evidence.

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Following the advice of Schoenberg et al., we included all deaths due to primary intracranial neoplasms except those of the pituitary. This excluded one case with a metastatic lesion and one with a congenital anomaly but with no tumor found at autopsy. Two of the most recently discovered cases have not been included, pending confirmation of the diagnosis. Analyses of the residual 18 cases will be done both for the group as a whole and for the 15 proven gliomas. ref?

For each employee, the company completed coding sheets containing identifying personal data, date of each new job title or department code, job code, department accounting code, and date of each layoff or date of termination. Vital status was coded, when known. Every 50th record was copied and sent to NIOSH for independent verification of coding. A random sample of the original records will be drawn by NIOSH and used for verification of completeness of cohort identification. SS 11/11/81

Six controls were drawn for each case from the pool of all people ever employed at the plant. Cases were matched to potential controls by race and sex; date of birth was matched to within three years; date of first hire for the control was before that of the case, but not more than three years before; the date the control was last employed was later than the case's last date of employment. The control could be living but, if dead, must not have died of a malignancy. Pools of controls meeting the criteria outlined above were formed and the actual controls used were drawn by random number from the pool.

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The company provided translations for the job and department codes and provided a list of chemicals encountered in each major department - *few many*
group. The departmental coding schemes used for accounting purposes - *completeness*
within the plant have changed over the years, so a common list tracing the history of each department was prepared and all codes were transformed to conform to a single coding scheme. Although catalysts have changed often, there appears to be no problem in characterizing the feedstocks, intermediate products, and output of each department through the years the plant has been in operation. *the data*

Each job, department, major department group, or chemical exposure represented by at least three cases was tested for possible significance by χ^2 or Fisher's Exact Test. Since this approach is a multiple sampling technique which should lead to about one "significant" association for every twenty jobs, departments, or exposures considered, it is used here as an hypothesis generating mechanism, not as a means of properly testing the hypotheses. For example, since at least one case was exposed to each of nearly 200 chemicals, chance alone should lead to identification of about 10 chemicals whose proportion is significantly different between cases and controls. About half of the ten would be positive and half would be negative associations.

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Results:

Only one job code, "Operator" was represented by more than three cases. Table I shows the distribution of operators among the cases and controls. There is no significant difference in proportions.

When analyzed by department accounting code, only the maintenance department, with eight cases, was represented by more than three cases. Table II shows the distribution of maintenance department workers among the cases and controls. Grouping the accounting codes into major departments did not yield any new concentrations of three or more cases. There were no significant differences in proportions.

When cases and controls were analyzed by chemical exposures, a new problem was encountered: the exact exposure of a maintenanceman is difficult to characterize accurately, due to their mobility throughout the plant. Accordingly, as a first step, we have examined the data in three ways: in the first, maintenancemen are excluded from analysis; in the second, they are considered to have been exposed to everything in the plant; in the third, they are considered to have been exposed to nothing in the plant. The data are presented in Tables III, IV, and V; only those chemicals to which more than three cases were exposed and which showed a relative risk greater than 1.0 are tabulated.

Discussion:

So far in the course of this investigation, no convincing association has been found between any historical exposure and the development of brain tumors at this plant. The incomplete characterization of the maintenance employees' exposures is a significant weakness in the analysis done so far, but fortunately can be corrected, at least in part, by further review of existing records. Some of the maintenance department employees had reasonably well defined exposures; for example, one case was an instrument repairman whose work rarely took him out of the instrument shop. We plan to define exposures of cases and controls who worked for the maintenance department as completely as possible and study the full data set. At that time, there should also be enough information at hand to study the exposures by latency.

It is possible that the tumors seen are the result of a more general effect or exposure. We plan to examine the geographic location within the plant of cases and controls, to see if any pattern emerges, and will attempt to determine the residence at time of first hire, to see if there appears to be any unusual clustering outside the plant.

Finally, we must ask whether we are really seeing an effect which requires explanation. The excess of observed over expected reported earlier², combined with an apparent excess when compared to local rates³, could be the result of chance. The reported correlations

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with duration of employment and latency since first employment argue against this hypothesis but do not refute it. Inquiry into exposures present in other populations with apparent excesses of brain tumors may provide needed additional clues.

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Table I: Distribution of Operators Among
Cases and Controls :

IA. All Cases	Cases	Controls	Total
Operators	9	49	58
Non-operators	9	59	68
Total	18	108	126

Odds ratio = 1.2; $\chi^2 = 0.045$; p greater than 0.75

IB. Proven Gliomas	Cases	Controls	Total
Operators	7	40	47
Non-operators	8	50	58
Total	15	90	105

Odds ratio = 1.1; $\chi^2 = 0.024$; p greater than 0.75

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Table II: Distribution of Maintenance Workers
Among Cases and Controls

IIA. All Cases	Cases	Controls	Total
Maintenance workers	7	46	53
Non-maintenance workers	11	62	73
Total	18	108	126

Odds ratio = 0.86; $\chi^2 = 0.087$; p greater than 0.75

IIB. Proven Gliomas	Cases	Controls	Total
Maintenance workers	7	37	44
Non-maintenance workers	8	53	61
Total	15	90	105

Odds ratio = 1.3; $\chi^2 = 0.163$; p greater than 0.75

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Table III: Distribution Among Cases and Controls
of Workers Exposed to Selected Chemicals
(Maintenance men Excluded)

IIIA. All Cases		Cases	Cont.	Total	Odds	p*
Exposed	1. Diethyl ether	3	2	5	7.87	0.07
	2. Ethanol	3	2	5		
	3. Sodium phosphate salts	3	2	5		
	4. Lubricating oil	6	15	21	3.20	0.30
	5. Monoethanolamine	4	10	14	1.73	0.42
	6. Ethylene glycol	3	8	11	1.41	0.80
	7. Naphtha	3	8	11		
	8. Potassium hydroxide	2	5	7	1.44	0.81
Unexposed	1. Diethyl ether	4	21	25		
	2. Ethanol	4	21	25		
	3. Sodium phosphate salts	4	21	25		
	4. Lubricating oil	1	8	9		
	5. Monoethanolamine	3	13	16		
	6. Ethylene glycol	4	15	19		
	7. Naphtha	4	15	19		
	8. Potassium hydroxide	5	18	23		
Total		7	23	30		

* Fisher's exact test

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Table III (Con't): Distribution Among Cases and Controls
of Workers Exposed to Selected Chemicals
(Maintenance men Excluded)

IIIB. Proven Gliomas			Cases	Cont.	Total	Odds	p*
Exposed	1. Diethyl ether		2	1	3		
	2. Ethanol		2	1	3	13.0	0.11
	3. Sodium phosphate salts		2	1	3		
	4. Lubricating oil		4	9	13	inf.	0.23
	5. Monoethanolamine		3	6	9	4.00	0.29
	6. Ethylene glycol		2	5	7	1.80	0.86
	7. Naphtha		2	5	7		
	8. Potassium hydroxide		2	2	4	6.00	0.98
Unexposed	1. Diethyl ether		2	13	15		
	2. Ethanol		2	13	15		
	3. Sodium phosphate salts		2	13	15		
	4. Lubricating oil		0	5	5		
	5. Monoethanolamine		1	8	9		
	6. Ethylene glycol		2	9	11		
	7. Naphtha		2	9	11		
	8. Potassium hydroxide		2	12	14		
Total			4	14	18		

* Fisher's exact test

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**Table IV: Distribution Among Cases and Controls
of Workers Exposed to Selected Chemicals
(Maintenancemen Counted as Exposed)**

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