

Industrial Hygiene Survey
of the
E.I. duPont de Nemours, Inc.
Plastic Products and Resins Dept.
Cellophane-Clysar Plant
P.O. Box 451
Clinton, Iowa 52732

Survey Date
March 21-23, 1978

Report Written By:
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Date of Report
September 11, 1978

Industry-Wide Studies Branch
Division of Surveillance, Hazard Evaluations and Field Studies
National Institute for Occupational Safety and Health
Center for Disease Control
Cincinnati, Ohio

PLACE VISITED: E.I. duPont de Nemours, Inc.
Plastic Products and Resins Dept.
Cellophane - Clysar Plant
P.O. Box 451
Clinton, Iowa 52732

DATE OF VISIT: March 21-23, 1978

PERSONS MAKING VISIT: Dennis D. Zaebst
Thomas Maham
Terry Boyle
Larry Smith

PERSONS CONTACTED AT PLANT: Myron Haradon, Plant Manager
James B. Howard, Occupational Safety and
Health Coordinator

PURPOSE OF VISIT: To conduct an industrial hygiene survey
of cellophane production operations.

UNION: Transparent Film Worker's Union, Inc.
Leonard Eversoll, President

ACKNOWLEDGEMENTS: Mark Millson, Chemist, MSS, MSB, DPSE
John L. Holtz, Chief, MSS, MSB, DPSE
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INTRODUCTION

The National Institute for Occupational Safety and Health has underway industry-wide studies to evaluate potential health effects in occupational groups exposed to carbon disulfide. These studies include a mortality study (via contract), a study of mutagenesis by administering reproductive history questionnaires to wives of workers, a cross-sectional medical study to investigate the adverse health effects in workers exposed to carbon disulfide, and industrial hygiene studies to determine present CS₂ exposure levels and estimate working lifetime exposures.

Although mortality, reproductive, industrial hygiene, and medical surveys are being conducted primarily within the viscose rayon industry (due in part to their large worker populations and long history of carbon disulfide use) several other sectors of the chemical industry, notably the cellophane, carbon disulfide, and carbon tetrachloride producers, represent a significant portion of the total population of workers potentially exposed to carbon disulfide. Therefore, representative plants within these industries are also being included in the industrial hygiene studies to broaden the environmental data base, and to allow comparison with data collected in the viscose rayon plants.

The Clinton, Iowa facility of E.I. duPont de Nemours, & Co., Inc., is one of four plants presently producing cellophane on a commercial scale in the United States. Three of these use a semi-continuous production scheme and one uses a batch method. This site is one of those using the semi-continuous method, and is one of the larger plants in capacity and size of workforce. For these reasons, this plant was chosen for detailed characterization of worker exposure to carbon disulfide.

A walk-through survey was conducted at this site on August 31 and September 1, 1977 by Dennis D. Zaebst, Sherry G. Selevan, and Terrence Boyle, at which time a description of the plant, workforce, medical, safety, and industrial hygiene practices, and production processes was obtained. In addition, a limited environmental survey was conducted at this time to preliminarily characterize the magnitude of worker exposure to carbon disulfide, and to help plan sampling strategy for a possible subsequent detailed survey. The results of this survey were described previously in an Industry Wide Studies Branch walk-through report.

On March 20, 1978, the survey personnel, Dennis Zaebst, Terrence Boyle, Larry Smith, and Thomas Maham met with plant personnel and made preparations for sampling to begin the following day. The survey continued through March 23, 1978.

During this survey, a total of approximately 140 air samples were obtained for evaluation of airborne concentrations of carbon disulfide and hydrogen sulfide. The majority of the carbon disulfide samples were personal breathing zone samples, but some area samples were obtained in the casting area, viscose ripening room (VRR) and CBX xanthation area. The fifty one samples

obtained for evaluation of airborne hydrogen sulfide consisted of 45 area samples from the casting and coagulating bath areas, and six breathing zone, short duration samples obtained during castoff operations in the casting area.

The following paragraphs describe the plant and its processes, the workforce, medical, safety, and industrial hygiene programs, and the survey methods used. The air sampling data obtained during the survey are summarized in Tables 1-11. Conclusions and recommendations are presented in this report based on that data and subjective observations made during the survey.

DESCRIPTION OF THE FACILITY

This plant, owned and operated by E.I. duPont de Nemours Company, Plastic Products and Resins Dept. is currently composed of three major buildings and associated facilities occupying a 250 acre site near Clinton, Iowa. The two major products are cellophane and Clysar^R, a heat shrinkable polyethylene film.

DuPont began cellophane production operations at this site in 1941. Production capabilities were expanded with the installation of additional casting machines in 1947, and again in 1957. The viscose production process in the chemical building was converted from batch (using barrettes in the xanthation step) to a continuous flow process in 1960. In 1962, duPont began production of Clysar^R heat shrinkable polyethylene film.

Currently, this plant employs a total workforce of 1250, and approximately 1000 of these work in the cellophane department. The number of total employees has varied over the years, reaching a maximum in 1960 of approximately 1450. Approximately 75 workers are potentially exposed to carbon disulfide. Table 12 (appendix) summarizes those jobs in which potential for exposure to CS₂ exists.

Originally, before 1960, in the viscose manufacturing operation, workers rotated jobs, and one worker out of four were exposed to carbon disulfide. After 1960, when the process changed from batch to continuous this rotation of jobs stopped.

There are a total of 77 females in the plant, 48 of whom are hourly employees. The plant population is essentially white; 2.3% are black. Approximately 95% of the population is currently married.

The age distribution of the total population (October, 1975) follows:

<u>Age</u>	<u>Percent</u>
18-25	8%
26-35	26%
36-45	16%
44-55	28%
56-65	22%

At this time, the 18 to 25 age category is larger, probably 15%.

The length of employment as of May 1977 is as follows:

<u>Length of Employment</u>	<u>Percent</u>
<5	21%
5-9	18%
10-14	20%
15-19	2%
20-24	7%
25-29	17%
30-34	12%
>35	3%

The personnel records include:

1. Application - This record includes the name, current and permanent addresses, social security number, and citizenship. It does not include date of birth, marital status, and sex.
2. Report of Hires - The record includes the name, social security number, work area, job title, and date of hire, corrected date of hire (which incorporates leave of absence and lay-offs), and payroll number.
3. Employment Record - The record includes name and employee number and summarized changes in shifts and job titles and includes dates for these changes. It also includes the marital status, education, number of children and name of spouse or nearest relative. This information is accurate at the time of hire and is continually updated with information supplied by employees.
4. The work areas have a personnel card but these are not consistently updated. This is an informal system. The employees' records are accurately maintained in (3.) above.

DESCRIPTION OF MEDICAL AND INDUSTRIAL HYGIENE PROGRAM

Pre-employment physicals are required of all employees. Periodic check-ups are given every two years to those less than 40 years of age, and annually to those over 40 years of age. The check-ups include a chest x-ray, lung function, appropriate blood and urine tests, hearing and visual examinations, and EKG on all employees at the beginning of employment. The examinations do not routinely include neurological or behavioral evaluations, (evaluations however do include peripheral reflex tests) and tests on urine do not include the iodine-azide test. The plant employs one full time physician and five nurses on a shift basis. Accident and health insurance consists of a company paid plan with Blue-Cross Blue Shield and employee paid Major Medical and lost time Accident and Health Insurance Plan. Employee participation is 100% on the company paid plan.

The company has a formal safety and health program employing three persons fulltime as Safety Supervisor, Assistant Safety Supervisor, and Occupational Health Coordinator. Facilities for taking showers and changing clothes are provided although their use is not required. Personal protective equipment provided by the company includes clothing, safety glasses and shoes; in addition, respiratory protection is required for certain jobs in the wet and casting area (e.g. threadup) or for maintenance or cleanup procedures where there is potential exposure to CS₂ and H₂S. Respiratory protection in these jobs consists of half-mask facepiece connected by flexible tubing to a pressurized supply airline.

Environmental monitoring of airborne CS₂ has been conducted by duPont personnel at this site since 1941. The majority of these data consist of grab samples in which a manually operated pump is used to draw a standard quantity of air (750 ml) into a side-arm flask containing cupric acetate; subsequent analysis is done spectrophotometrically. Sampling by this method (and for H₂S using chemical detector tubes) is conducted monthly in designated areas (e.g. in the chemical building and casting area) or wherever requested by the plant operating personnel. All of this data is recorded and kept at the plant in logbooks. Some sampling for CS₂ is also conducted as needed (for rapid checks) using chemical detector tubes, although the colorimetric method is used wherever possible.

Personal sampling has been conducted since early 1977 using low volume pumps and activated carbon tubes. Typical eight hour, time weighted average exposures of operators in the CBX viscose ripening area and casting area are on the order of 3 ppm ranging up to approximately 10 ppm, based on data supplied by plant personnel.

PROCESS DESCRIPTION

A schematic diagram of the process flow in cellophane production is shown in Figure 1 (Appendix). The major raw materials for cellophane production include carbon disulfide, wood pulp, sodium hydroxide, and sulfuric acid. Rolls of wood pulp are unloaded from railroad cars and are kept in a pulp storage area in the chemical building until needed. Carbon disulfide is received in rail tank cars and is displaced from the cars with water. It is then pumped to one of several supply tanks (located outdoors) where it is stored under a water pad.

The first step in production of cellophane is the formation of ripened alkali cellulose crumb. Pulp is unwound from the rolls on feed racks, treated with NaOH (approximately 18% solution in water), and is then dropped into large, cylindrical steeping (mercerization) tanks to form alkali cellulose. Excess NaOH solution is then pressed out on press rolls and the material is then "aged" on a long, slow moving conveyor to reduce the degree of polymerization of the cellulose. The properly aged alkali cellulose is then prepared for the xanthation step by reducing it to fluffy crumbs in a shredder.

Production of cellulose xanthate (xanthation step) and viscose (solution of cellulose xanthate) takes place in a continuous integrated, production step in one of several large, hermitized vessels called C.B.X. tanks. The alkali cellulose crumb is transported from the shredder via a compacting type feed screw conveyor to one of the cylindrical, horizontally oriented CBX tanks, where it is deposited on the upper of two slow moving conveyor belts inside the tank. As the cellulose crumb advances along the belt, carbon disulfide is sprayed onto the cellulose, resulting in production of cellulose xanthate crumb, a deep yellow colored product. The xanthate crumb is then dropped onto a second conveyor belt within the CBX tank located below the first, which moves in a direction opposite the upper belt. When the crumb reaches the opposite end of the second belt, (allowing sufficient time for reaction and ripening to occur) it is dropped to the bottom of the CBX tank where it is uniformly dispersed into a weak caustic solution by paddlewheel mixing blades to form the viscose.

The liquid viscose, deep orange in color, is then pumped directly in an essentially closed system to blending tanks in the viscose ripening room (V.R.R.) and from there to receiving tanks to await further processing. In the VRR, the viscose is prepared for casting by (1) aging or ripening, which permits a chemical rearrangement and improved distribution of the xanthate groups, (2) deaerating under vacuum, and (3) filtering to remove foreign debris and gels.

Viscose ready for casting is pumped as needed to hoppers located in the casting area at the wet end of each casting machine. At each of the casting machines, the viscose is accurately metered from the hopper through a horizontal slit, across a sloping flat plate, and into the coagulating (acid) bath. Contact of the viscose with the acid bath results in fairly rapid generation of a "raw" cellophane film. The regenerated film is then transported through a series of tanks containing various washing, bleaching, and conditioning solutions, and from there through driers which use heated rolls to remove excess water from the film. The dried film is then taken up on winders at the exit end of the driers, and the rolls are then transported to an intermediate storage area prior to further processing.

INSPECTION OF THE PLANT

Throughout the xanthation and viscose production steps, the alkali cellulose crumb, xanthate, viscose and carbon disulfide are handled in essentially closed systems, which minimizes the potential for generation of airborne carbon disulfide vapor. Potential leak points in the CBX production area (e.g. supply regulator valve, paddlewheel and conveyor belt drive shafts, alkali cellulose feed screw housing, CBX vessel automatic vent valve, CBX vessel site glasses, etc.) are routinely monitored by air sampling to detect excessive emission of CS₂, either during the monthly air analysis program, (described previously) or upon request of the CBX production operators, supervisors, or maintenance personnel.

In the casting area, the wet end of each casting machine is fitted with a canopy hood (located over tanks No. 1-7) connected to an individual 7,000 CFM bifurcator exhaust system. The front end of the acid coagulating bath tank (No. 1 tank) on each casting machine is also fitted with a skimmer exhaust system. Air collected by the bifurcator system is exhausted to the outside through the roof. Air collected by the skimmer system is vented through separate ductwork to tall stacks outside the building.

A CS₂ recovery system, consisting of inverted, exhausted steel trays located over the tanks with the sides submerged in a water bath, was retrofitted in 1953 to the wet end tanks to reduce loss of CS₂ to the atmosphere and to improve system efficiency. Carbon disulfide not trapped by the recovery system, hydrogen sulfide generated in the process, and other potential air contaminants such as acid or caustic mists are removed by the canopy hood-bifurcator exhaust system. Vapors trapped by the recovery system are exhausted to the CS₂ recovery unit located in a room adjacent to the acid coagulating bath room. During threadup of the casting machines (starting the film and threading it through the various tanks to the winder after a temporary shutdown), the CS₂ recovery trays are removed, and the sides of the canopy hoods are swung up to allow the casting machine operators access to the tanks. Half-mask respirators connected by flexible tubing to a pressurized supply airline are worn by the operators during this task.

A total of approximately 75 employees, including maintenance workers, are potentially exposed to carbon disulfide in CS₂ unloading and transfer operations, in the chemical building (CBX and VRR areas), coagulating bath area, and in the casting area. The potential for exposure to CS₂ is subjectively highest in the casting area, particularly during the casting machine threadup, although operators wear respiratory protection during this task. Employees also potentially exposed to hydrogen sulfide included those working in the coagulating bath area and the casting area. Other potential health hazards observed included noise, sodium hydroxide, and sulfuric acid mists.

In general, there was evidence of extensive use of control measures such as process enclosure, exhaust ventilation at critical points, and evidence of use of personal protective equipment by operators and service personnel which should, under normal operating conditions, help to minimize the actual hazard to the workers. Sanitary conditions and housekeeping appeared to be excellent in the cellophane production areas at this site.

SURVEY PROCEDURES

Personal breathing zone and area samples were collected to evaluate workers' exposures to carbon disulfide in the chemical building (CBX xanthation and VRR), in the casting area, and in the coagulating bath area on three consecutive day shifts. Although there is also a potential for exposure to CS₂ during the CS₂ rail car unloading operation (to the essential materials unloader), this operation was not conducted during the survey and conse-

quently could not be evaluated. This unloading operation is normally done once per week on the average and thus may involve 4-6 hours of exposure to the operator per week.

Exposures of casting area operators (wet end), and the coagulating bath operators to hydrogen sulfide were evaluated by collecting a series of stationary air samples at six locations in the casting area and three locations in the coagulating bath area. Time weighted average air concentrations at each of these nine locations were determined by collecting sequential stationary samples covering (as near as possible) a full eight hour shift on each of the two day shifts sampled.

In addition, some personal breathing zone samples of a few minutes duration were obtained to evaluate peak exposures of casting area operators to carbon disulfide and hydrogen sulfide during threadup of the casting machines.

Summarized below are brief descriptions of the techniques used to collect and analyze the air samples obtained during the survey.

Carbon Disulfide

Full shift personal (breathing zone) samples were obtained by drawing air at a flow rate of about 20 cc per minute through standard SKC 150 mg. charcoal tubes, using MDA low volume pumps equipped with 20 cc per minute limiting orifices. The pumps were attached to the worker's belt, and the sampling tubes were clipped in a vertical position to his lapel or shirt collar. Full shift area samples were obtained in a similar manner using the same apparatus and sampling tubes, except that the sample tubes and pumps were placed at strategic locations in specific areas. Short duration (peak) breathing zone samples were obtained using 150 mg. charcoal tubes, but at a flow rate of about 500 cc per minute using Mine Safety Appliances Model G pumps. Collected samples were kept frozen in a freezer located in the plant's laboratory (and using dry ice during shipment) to minimize sample loss or migration prior to analysis.

In the laboratory, samples were analyzed using NIOSH analytical method S-248. In this procedure, the sample tubes were desorbed with benzene, and aliquots of the desorbed samples were injected into a gas chromatograph equipped with flame photometric detector and sulfur filter. This method has been validated over a range 14.7 ppm - 58.8 ppm with a precision (total coefficient of variation) within that range of 0.059. The limit of detection in the samples obtained during the survey was determined to be 1.0 ug (microgram) per charcoal tube. Sample results are expressed in terms of parts of carbon disulfide per million parts of air (v/v).

Hydrogen Sulfide

Stationary air samples were obtained by drawing air at a flow rate of approximately 1 liter per minute through midget impingers, containing a suspension of cadmium hydroxide - STRactan 10^R, using Mine Safety Appliances Model G pumps. Sequential samples of approximately two hours each and covering (as near as possible) a full shift were obtained at nine strategic locations in the casting and coagulating bath areas on two successive day shifts. Short duration (peak) breathing zone samples were obtained using the same apparatus except that the midget impingers were fastened to the worker's collar, and the pumps were attached to the worker's belt. Collected samples were kept cool in a refrigerator at the plant (and using ice during transport to the laboratory) to minimize decomposition of the cadmium sulfide formed in the sampling solution. Impingers were also wrapped with aluminum foil during sampling to minimize photodecomposition.

In the laboratory, samples were analyzed using NIOSH analytical method S-4. In this method, the formed cadmium sulfide is determined by spectrophotometric measurement of the methylene blue produced by the reaction of the sulfide with an acid solution of N,N-dimethyl - p-phenylenediamine and ferric chloride.

The coefficient of variation (CV_T) for the total analytical and sampling method in the range of 8.5 - 63 mg/m³ has been estimated as 0.121. The limit of detection in the samples obtained during the survey was determined to be 3.0 ug (microgram) sulfide/impinger. Sample results are expressed in terms of parts of hydrogen sulfide per million parts of air (v/v).

Statistical Analysis

A statistical analysis of the carbon disulfide exposure data was performed, aimed at classifying the eight job categories by magnitude of exposure to CS₂. The statistical protocol consisted of a preliminary analysis which investigated assumptions for the analysis of variance (ANOVA), a single classification analysis of variance which investigated the presence or absence of differences between group (job category) means, and finally, an "a-posteriori"* multiple comparison of means (using the Student-Newman-Kuels multiple range procedure), which simultaneously investigated the presence of possible significant differences between all group means two at a time. (2)

The preliminary analysis consisted of (1) an investigation of the validity of log-normality of the data (normality of logarithmically transformed data) by inspection of log-probability plots(1), and (2) under the assumptions of

* The term "a-posteriori" refers to a procedure which "after the fact" investigates the nature and extent of differences between all group means, and is performed only in the cases where significant results are obtained in an ANOVA.

normality of the transformed data, an investigation of homogeneity of variances using the $F(\max)$ test(2). These tests indicated that log-transforming the data would better satisfy the assumption of normality, and the assumption of homogeneity of variances of the transformed data was valid. Thus, the statistical analysis, consisting of an ANOVA and SNK test, was subsequently performed entirely on log-transformed (coded) data.

RESULTS AND DISCUSSION

The following paragraphs present and discuss the results of personal and stationary air samples obtained during the survey to evaluate workers' exposures to carbon disulfide and hydrogen sulfide. Tables 1-4 and 5-7 present the results of sampling for carbon disulfide and hydrogen sulfide, respectively. Tables 8 and 9 present statistical summaries, by job title or location, of those personal and area samples obtained to evaluate time weighted average exposure to carbon disulfide and hydrogen sulfide, respectively. Table 10 presents the results of a one-way analysis of variance (ANOVA) designed to compare mean exposures to carbon disulfide by job category. Table 11 presents the results of a multiple comparison among mean exposures to CS₂ by job category based on the Student-Newman-Keuls (SNK) procedure.

Carbon Disulfide

As indicated in Table 8, the geometric means of eight hour, time weighted average breathing zone exposures to CS₂ for the eight job categories evaluated ranged from 2.39 ppm (coagulating bath operator) to 6.99 ppm (VRR operator). The lowest recorded single day TWA exposure was 1.54 ppm (coagulating bath operator), and the highest was 20.67 ppm (casting operator).

In general, the exposures to CS₂ within and between the eight job categories were surprisingly uniform. The results of the one way analysis of variance (Table 10) indicated a highly significant difference ($p < 0.005$) between the job categories, but this was apparently due to the unusually small variance seen within each job category, rather than due to a large difference in geometric mean exposures between jobs.

Table 11 presents the results of an a-posteriori multiple comparison of means based on the Student-Newman-Keuls multiple range procedure (SNK test). The results of this table are summarized in figure 2, below. In this figure, the eight job categories are ranked in order of their geometric mean exposure to CS₂ (highest at the top); those job categories in which exposures to CS₂ were not significantly different from each other are connected by vertical lines:

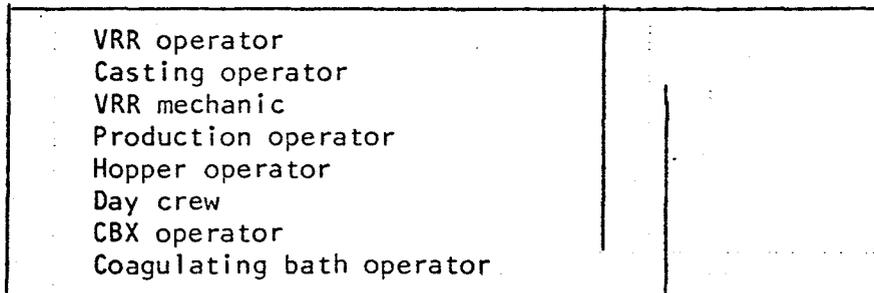


Figure 2

It can be seen that there is no clear differentiation of exposure levels between areas in cellophane production. There are no clear boundaries (gaps) between sets of means (job categories) not significantly different from each other, and the two sets shown overlap. It can be said however, that the VRR operator and casting operator job categories were significantly greater ($p < 0.05$) than the coagulating bath operator category with respect to exposure to carbon disulfide. The remainder of the job categories, with means closer together, were not significantly different from each other.

It should be noted that the above interpretation applies only to conditions as measured during the survey. Any seasonal or long term variations in conditions at the plant might or might not invalidate the above conclusions regarding relative magnitude of exposure between jobs. Seasonal trends or minor process changes/variations might not, for example, have parallel effects on all job categories. However, the order of magnitude of exposure for all job categories at this plant should, barring major process change, remain relatively constant.

Table 4 presents the results of short duration samples obtained in the breathing zones of operators in the casting area to evaluate their peak exposures to CS₂ during castoff (threadup) of casting machines. As indicated, these exposures ranged from 1.72 ppm to 5.54 ppm over sampling periods of from 10 to 18 minutes. These concentrations (measured in the operator's breathing zones) are of the same order of magnitude as the full shift breathing zone measurements, and probably do not significantly contribute to the operator's TWA exposures. It is apparent that the local exhaust hoods are relatively effective (even during castoff) in preventing high, short term exposures to CS₂.

Table 8 also presents a summary of the results of stationary air samples obtained in the CBX xanthation room, the VRR room, and the casting area, wet end. As indicated, general area TWA concentrations in the CBX xanthation room ranged from 2.28 to 9.67 ppm, with a geometric mean of 5.23 ppm, and lower and upper confidence limits of 2.91 ppm and 9.43 ppm, respectively. Time weighted, average concentrations in the VRR room ranged from 7.05 ppm to 11.2 ppm, with geometric mean of 8.67, and lower and upper confidence limits of 4.83 ppm and 15.56 ppm, respectively. Time weighted, average area concentrations in the casting area, wet end, ranged from 2.54 to 11.75 ppm, with a geometric mean of 4.50 ppm, and lower and upper confidence limits of 3.43 ppm and 5.90 ppm, respectively.

Hydrogen Sulfide

Table 9 presents a statistical summary of the results of systematic stationary air sampling for hydrogen sulfide in the casting area and coagulating bath area. As indicated, TWA concentrations in the casting area ranged from 0.17 ppm to 0.56 ppm, with a geometric mean of 0.29 ppm, and lower and upper 95% confidence limits of 0.22 ppm and 0.37 ppm, respectively.

Time weighted, average concentrations at three locations in the coagulating bath area ranged from 0.20 ppm to 0.42 ppm, with a geometric mean of 0.29 ppm, and lower and upper 95% confidence limits of 0.23 and 0.37 ppm, respectively.

These concentrations are very low relative to the most recent recommendations of the American Conference of Governmental Industrial Hygienists (ACGIH) for continuous exposure (10 ppm) and should not, under normal conditions, present a serious hazard to employees working in these areas.

Table 7 presents the results of measurement of concentrations of hydrogen sulfide in the breathing zones of the casting area operators during casting machine castoff (threadup). As indicated, breathing zone concentrations ranged from 1.6 ppm to 4.8 ppm over sampling periods of from 7 to 18 minutes.

These peak concentrations are approximately greater by a factor of 10 than TWA concentration measurements in the casting area. This would indicate that, during castoff (when the sides of the canopy hoods are raised), slightly higher concentrations are encountered, but these are still well within current acceptable guidelines for peak (short duration) exposures (NIOSH criteria document recommendation of 10 ppm for up to 15 minutes, ACGIH-TLV-STEL, 15 ppm, and an OSHA ceiling standard of 20 ppm, which can be exceeded for 10 minutes once only up to a maximum peak of 50 ppm). It should be noted that these measured breathing zone concentrations do not represent actual exposures since the men wore supplied air, half-facepiece, respiratory protection during castoff.

CONCLUSIONS

The following conclusions are based on the results of sampling data and subjective observations made during the survey of March 21-23, 1978:

- 1) Time weighted average exposures of cellophane manufacturing area operators to carbon disulfide were relatively uniform within and between job categories. Individual full shift TWA exposures for all job categories ranged from 1.54 ppm (coagulating bath operator) to 20.67 ppm (casting operator). Geometric means of time weighted average exposures ranged from 2.39 ppm (coagulating bath operator) to 6.99 ppm (VRR operator). Statistical analysis of the data indicated that the VRR and casting operators' true, long-term, interday average exposures were significantly greater ($p < 0.05$) than that of the coagulating bath operator. However, other job categories with means closer together could not be differentiated.
- 2) Peak concentrations of carbon disulfide measured in the breathing zones of casting operators during castoff were

of the same order of magnitude as TWA measurements on the same operators. Therefore, it can be concluded that the exposures of operators during this procedure probably did not contribute substantially to their TWA exposures.

However, this conclusion should be confirmed with additional sampling. The limited carbon disulfide exposure data obtained during this survey would not itself warrant removing the requirement for the use of respiratory protection during this procedure.

- 3) Time weighted average exposures of the operators working in the casting and coagulating bath areas to hydrogen sulfide should have been quite low (averaging well below 1 ppm) based on the results of systematic stationary samples obtained in these areas, and assuming that exposures during castoff were minimal due to the use of respiratory protection.
- 4) Peak exposures of casting area operators to hydrogen sulfide during castoff should be near zero, since air supplied respirators are worn by the operators. However, personal breathing zone concentrations measured during this procedure were substantially higher (by a factor of approximately 10) than general area TWA concentrations measured in the casting area, although the peak concentrations were well within current standards and guidelines for short term exposure. These measurements indicate the prudence of continuing the use of respiratory protection during the castoff procedure, since not using the respirators would undoubtedly increase operator's actual peak and TWA exposures to hydrogen sulfide. Based on the measurements obtained during this survey, however TWA exposures without the use of respirators during castoff probably would not normally exceed the current Threshold Limit Value (10 ppm) currently recommended by the ACGIH continuous, eight hour, exposure.

RECOMMENDATIONS

- 1) Based on the measurements of breathing zone concentrations of hydrogen sulfide during castoff, the use of respiratory protection should be continued during this task. Although peak exposures to H₂S probably would not be hazardous, it is probable that a substantial reduction of casting area operators' peak and TWA exposures is accomplished by the use of the respirators.
- 2) Monitoring of worker's exposures to carbon disulfide by means of systematic personal breathing zone sampling should be continued by plant personnel to delineate seasonal or other trends which may affect exposures to CS₂. Although exposures in general were well within the current OSHA standard (20 ppm) during the survey, exposures during other times of the year should also be documented.

Records of the monitoring data should be retained indefinitely; the data would be valuable should epidemiological or medical studies become necessary in the future.

REFERENCES

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2. Sokal, R.R., and F.J. Rohlf: Biometry, The Principles and Practice of Statistics in Biological Research. W.H. Freeman and Company, San Francisco, California, 1969.

Table 1-A
Sampling Summary Sheet

Date _____

Carbon Disulfide

Plant : E.I. duPont de Nemours

Process or Area: Chemical Bldg.

Clinton Plant

Personal Samples

Date 19 78	Sample No.	Sample Description	Time Start	Time Stop	Sample Volume (liters)	Total Weight (ug)	Concentration	
							Carbon Disulfide (ppm)	Estimated TWA (ppm)
3-21	C-4	CBX Production • operator	0834	1529	11.6	180	4.95	
3-22	C-38	CBX Production operator	0832	1531	11.7	150	4.09	
3-23	C-91	CBX Production operator	0827	1527	9.5	70	2.35	
3-21	C-1	VRR operator	0817	1520	9.8	190	6.18	
3-21	C-3	VRR operator	0821	1523	10.0	320	10.21	
3-21	C-5	VRR operator	0824	1520	9.5	310	10.41	
3-22	C-69	VRR operator	0824	1526	11.0	300	8.77	
3-22	C-74	VRR operator	0820	1528	10.1	310	9.79	
3-22	C-61	VRR operator	0815	1525	9.9	200	6.44	

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Table 1-B
 Sampling Summary Sheet
 Carbon Disulfide

Date _____

Plant: E.I. duPont de Nemours

Process or Area: Chemical Bldg.

Clinton Plant

Personal Samples

Date 1978	Sample No.	Sample Description	Time Start	Time Stop	Sample Volume (liters)	Total Weight (ug)	Concentration	
							Carbon Disulfide (ppm)	Estimated TWA (ppm)
3-23	C-94	• VRR operator	0812	1519	9.2	140	4.85	
3-23	C-89	VRR operator	0820	1520	9.9	150	4.83	
3-23	C-93	VRR operator	0823	1522	10.3	150	4.65	
3-21	C-2	VRR area mechanic	0828	1527	9.2	270	9.36	
3-22	C-70	VRR area mechanic	0858	1527	12.5	260	6.64	
3-23	C-92	VRR area mechanic	0818	1523	6.0*	60	3.19	

*This pump may not have operated for the full sample period.

Table 1-C
 Sampling Summary Sheet
 Carbon Disulfide

Date _____

Plant: E.I. duPont de Nemours

Process or Area: Chemical Bldg.

Clinton Plant

Area Samples

Date 1978	Sample No.	Sample Description	Time Start	Time Stop	Sample Volume (liters)	Total Weight (ug)	Concentration	
							Carbon Disulfide (ppm)	Estimated TWA (ppm)
3-21	C-19	CBX xanthation room; on catwalk between #1 & #2 tanks, 2nd floor	0948	1531	8.8	140	5.07	
3-22	C-71	DO C-19	0840	1533	9.9	300	9.67	
3-23	C-96	DO C-19	0838	1528	9.8	70	2.28	
3-21	C-20	CBX room; 1st floor between #1 and #2 tanks	0943	1530	8.3	170	6.50	
3-22	C-72	DO C-20	0846	1534	10.8	290	8.57	
3-23	C-90	DO C-20	0835	1529	5.8 *	60	3.30	
3-21	C-17	VRR, operator's desk	0938	1525	8.6	190	7.05	
3-22	C-66	DO C-17	0826	1527	9.4	330	11.20	

*This pump may not have run for the full sample period.

1.9

Table 1-D
 Sampling Summary Sheet

Date _____

Carbon Disulfide

Plant : E.I. duPont de Nemours

Process or Area : Chemical Bldg.

Clinton Plant

Area Samples

Date 1978	Sample No.	Sample Description	Time Start	Time Stop	Sample Volume (liters)	Total Weight (ug)	Concentration	
							Carbon Disulfide (ppm)	Estimated TWA (ppm)
3-23	C-95	DO C-17	0816	1521	11.2	290	8.26	

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Table 2
Sampling Summary Sheet
 Carbon Disulfide.

Date _____

Plant : E.I. duPont de Nemours
Clinton Plant

Process or Area: Coagulating
bath area; Personal samples

Date 1978	Sample No.	Sample Description	Time Start	Time Stop	Sample Volume (liters)	Total Weight (ug)	Concentration	
							Carbon Disulfide (ppm)	Estimated TWA (ppm)
3-21	C-29	Coagulating bath operator	0818	1519	11.0	140	4.06	
3-22	C-39	Coagulating bath operator	0944	1524	8.3	40	1.54	
3-23	C-49	Coagulating bath operator	0824	1518	8.8	60	2.17	

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Table 3-A
 Sampling Summary Sheet
 Carbon Disulfide

Date _____

Plant : E.I. duPont de Nemours
Clinton Plant

Process or Area : Casting, wet
end; Personal samples

Date 19 78	Sample No.	Sample Description	Time Start	Time Stop	Sample Volume (liters)	Total Weight (ug)	Concentration	
							Carbon Disulfide (ppm)	Estimated TWA (ppm)
3-21	C-6	• Hopper operator	0850	1524	9.5	350	11.90	
3-21	C-21	Hopper operator	0828	1522	10.4	160	4.97	
3-21	C-26	Hopper operator	0820	1517	9.6	180	6.06	
3-22	C-55	Hopper operator	0829	1530	9.3	110	3.82	
3-22	C-42	Hopper operator	0824	1526	8.3	110	4.28	
3-22	C-64	Hopper operator	0830	1522	8.7	80	2.97	
3-23	C-79	Hopper operator	0813	1518	12.1	110	2.94	
3-23	C-44	Hopper operator	0823	1523	8.9	60	2.18	
3-23	C-48	Hopper operator	0815	1518	3.7 *	50	4.36	

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* This pump may not have run for the full sample period.

Table 3-B
 Sampling Summary Sheet
 Carbon Disulfide

Date _____

Plant : E.I. duPont de Nemours
Clinton Plant

Process or Area : Casting, wet
end; Personal samples

Date 19 78	Sample No.	Sample Description	Time Start	Time Stop	Sample Volume (liters)	Total Weight (ug)	Concentration	
							Carbon Disulfide (ppm)	Estimated TWA (ppm)
3-21	C-10	Production operator	0858	1521	9.6	140	4.71	
3-21	C-8	Production operator	0850	1517	5.9*	80	4.38	
3-21	C-25	Production operator	0836	1520	8.2	180	7.09	
3-22	C-51	Production operator	0821	1532	10.8	130	3.89	
3-22	C-52	Production operator	0825	1530	6.7	70	3.37	
3-22	C-67	Production operator	0828	1529	9.7	140	4.66	
3-23	C-59	Production operator	0815	1520	10.3	120	3.75	
3-23	C-36	Production operator	0813	1522	10.2	190	6.02	
3-23	C-86	Production operator	0830	1519	14.5	120	2.67	
	*This pump may not have run for the full sample period.							

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Table 3-C
Sampling Summary Sheet

Date _____

Plant: E.I. duPont de Nemours

Carbon Disulfide

Process or Area: Casting, wet

Clinton Plant

end; Personal samples

Date 19 78	Sample No.	Sample Description	Time Start	Time Stop	Sample Volume (liters)	Total Weight (ug)	Concentration		
							Carbon Disulfide (ppm)	Estimated TWA (ppm)	
3-21	C-23	Casting operator	0845	1525	10.5	580	17.84		
3-21	C-30	Casting operator	0826	1519	9.0	270	9.65		
3-21	C-28	Casting operator	0830	1520	8.6	160	6.01		
3-22	C-60	Casting operator	0825	1531	11.5	140	3.93		
3-22	C-63	Casting operator	0938	1532	10.2	270	8.55		
3-22	C-45	Casting operator	0935	1532	8.4	80	3.08		
3-23	C-85	Casting operator	0827	1521	8.1	80	3.19		
3-23	C-56	Casting operator	0813	1524	9.6	150	5.04		
3-23	C-46	Casting operator	0817	1518	5.0*	320	20.67		
		*This pump may not have run for the full sample period.							

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Table 3-D
 Sampling Summary Sheet
 Carbon Disulfide

Date _____

Plant : E.I. duPont de Nemours

Process or Area : Casting, wet

Clinton Plant

end; Personal samples

Date 1978	Sample No.	Sample Description	Time Start	Time Stop	Sample Volume (liters)	Total Weight (ug)	Concentration	
							Carbon Disulfide (ppm)	Estimated TWA (ppm)
3-21	C-7	Day crew	0852	1518	9.6	100	3.36	
3-21	C-9	Day crew	0856	1522	8.5	140	5.32	
3-21	C-24	Day crew	0838	1517	9.2	130	4.56	
3-21	C-22	Day crew	0843	1520	9.4	120	4.12	
3-21	C-27	Day crew	0848	1524	8.9	120	4.36	
3-22	C-53	Day crew	0831	1525	9.6	100	3.36	
3-22	C-54	Day crew	0834	1523	9.3	110	3.82	
3-22	C-47	Day crew	0838	1525	7.8	140	5.78	
3-22	C-65	Day crew	0835	1524	10.5	110	3.38	
3-22	C-41	Day crew	0831	1525	9.6	90	3.03	

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Table 3-E
Sampling Summary Sheet

Date _____

Carbon Disulfide

Plant : E.I. duPont de Nemours
Clinton Plant

Process or Area : Casting, wet
end; Personal samples

Date 1978	Sample No.	Sample Description	Time Start	Time Stop	Sample Volume (liters)	Total Weight (ug)	Concentration	
							Carbon Disulfide (ppm)	Estimated TWA (ppm)
3-23	C-88	Day crew	0819	1525	7.7	90	3.78	
3-23	C-81	Day crew	0823	1525	10.6	70	2.13	
3-23	C-87	Day crew	0821	1524	9.6	170	5.72	
3-23	C-50	Day crew	0817	1529	11.2	120	3.46	
3-23	C-57	Day crew	0820	1532	9.3	60	2.08	

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Table 3-F
 Sampling Summary Sheet

Date _____

Carbon Disulfide

Plant: E.I. duPont de Nemours

Process or Area: Casting

Clinton Plant

Area samples

Date 1978	Sample No.	Sample Description	Time Start	Time Stop	Sample Volume (liters)	Total Weight (ug)	Concentration	
							Carbon Disulfide (ppm)	Estimated TWA (ppm)
3-21	C-12	Casting; east wall, east of #3 line	0918	1537	4.9*	100	6.46	
3-22	C-58	DO C-12	0905	1538	9.2	90	3.16	
3-23	C-80	DO C-12	0833	1527	9.8	120	3.96	
3-21	C-11	Casting; east wall, east of #15 line	1302	1531	3.2*	40	4.04	
3-22	C-75	DO C-11	0856	1535	9.9	110	3.59	
3-23	C-84	DO C-11	0835	1533	11.2	90	2.60	
3-21	C-13	Casting; between hot water wash tanks, lines #2 & #3	0926	1538	4.4*	160	11.75	
3-22	C-62	DO C-13	0908	1539	8.0	130	5.25	

*This pump may not have run for the full sample period.

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Table 3-G
 Sampling Summary Sheet
 Carbon Disulfide

Date _____

Plant : E.I. duPont de Nemours

Process or Area : Casting

Clinton Plant

Area samples

Date 1978	Sample No.	Sample Description	Time Start	Time Stop	Sample Volume (liters)	Total Weight (ug)	Concentration	
							Carbon Disulfide (ppm)	Estimated TWA (ppm)
3-23	C-82	DO C-13	0837	1529	8.6	160	6.01	
3-21	C-18	Casting; between hot water wash tanks, lines #14 & #15	0935	1533	8.8	130	4.77	
3-22	C-37	DO C-18	0859	1536	7.7	120	5.03	
3-23	C-43	DO C-18	0840	1535	14.0	110	2.54	

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Table 4
Sampling Summary Sheet
 Carbon Disulfide

Date _____

Plant : E.I. duPont de Nemours

Process or Area : Casting;

Clinton Plant

Exposures during castoff

Date 19 78	Sample No.	Sample Description	Time Start	Time Stop	Sample Volume (liters)	Total Weight (ug)	Concentration	
							Carbon Disulfide (ppm)	Estimated TWA (ppm)
3-21	C-31	Hopper operator; peak exposure during castoff	1430	1448	9.0	60	2.15	
3-21	C-14	Casting operator	1433	1447	7.0	90	4.15	
3-21	C-16	Production operator	1432	1445	6.5	100	4.97	
3-21	C-15	Casting operator	1431	1445	7.0	120	5.54	
3-23	C-83	Hopper operator	0940	0955	7.5	40	1.72	
3-23	C-78	Production operator	0942	0953	5.5	70	4.11	
3-23	C-76	Production operator	0943	0954	5.5	40	2.35	
3-23	C-77	Casting operator	0944	0954	4.8	30	2.02	

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Table 5-A

Date _____

Sampling Summary Sheet

Hydrogen Sulfide

Plant : E. I. duPont de Nemours

Process or Area: Casting;

Clinton Plant

wet end

Date 1978	Sample No.	Sample Description	Time Start	Time Stop	Sample Volume (liters)	Total Weight (ug)	Concentration	
							H ₂ S (ppm)	Estimated TWA (ppm)
3-22	HS-4	East wall, operator's desk east of #2 and #3 lines	1044	1252	127	35.9	0.20	
3-22	HS-17	DO HS-4	1254	1500	125	51.4	0.30	0.25
3-23	HS-31	DO HS-4	0948	1151	122	35.4	0.21	
3-23	HS-36	DO HS-4	1152	1351	118	102.4	0.63	
3-23	HS-43	DO HS-4	1351	1600	128	22.7	0.13	0.32
3-22	HS-5	Aisle between wet tanks, #2 and #3 lines	1045	1256	117	18.3	0.11	
3-22	HS-18	DO HS-5	1257	1501	111	58.6	0.38	0.24
3-23	HS-29	DO HS-5	0950	1152	109	40.5	0.27	
3-23	HS-40	DO HS-5	1153	1351	99	114.5	0.83	
3-23	HS-45	DO HS-5	1355	1601	134	28.2	0.15	0.41

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Table 5-B
 Sampling Summary Sheet
 Hydrogen Sulfide

Date _____

Plant : E.I. duPont de Nemours
Clinton Plant

Process or Area : Casting,
Wet end

Date 1978	Sample No.	Sample Description	Time Start	Time Stop	Sample Volume (liters)	Total Weight (ug)	Concentration	
							H2S (ppm)	Estimated TWA (ppm)
3-22	HS-6	East wall; east of Lines #8 and #9	1049	1300	117	46.8	0.29	
3-22	HS-21	DO HS-6	1301	1502	113	119.8	0.76	0.52
3-23	HS-27	DO HS-6	0953	1153	118	38.9	0.24	
3-23	HS-38	DO HS-6	1154	1358	122	23.7	0.14	
3-23	HS-51	DO HS-6	1354	1602	114	25.9	0.16	0.17
3-22	HS-7	Aisle between wet tanks, #8 and #9 lines	1051	1302	117	67.4	0.42	
3-22	HS-20	DO HS-7	1306	1503	104	105.6	0.73	
3-23	HS-28	DO HS-7	0957	1155	117	37.7	0.23	
3-23	HS-35	DO HS-7	1157	1354	116	30.6	0.19	
3-23	HS-48	DO HS-7	1358	1604	139	34.5	0.18	0.20

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Table 5-C
 Sampling Summary Sheet
 Hydrogen Sulfide

Date _____

Plant: E.I. duPont de Nemours

Process or Area: Casting,

Clinton Plant

Wet end

Date 1978	Sample No.	Sample Description	Time Start	Time Stop	Sample Volume (liters)	Total Weight (ug)	Concentration	
							H2S (ppm)	Estimated TWA (ppm)
3-22	HS-8	East wall, east of • line #15	1054	1309	121	55.4	0.33	
3-22	HS-23	DO HS-8	1312	1505	101	35.8	0.26	0.30
3-23	HS-26	DO HS-8	1000	1159	118	23.0	0.14	
3-23	HS-42	DO HS-8	1200	1356	103	29.8	0.21	
3-23	HS-46	DO HS-8	1357	1605	126	32.2	0.18	0.18
3-22	HS-9	Aisle between wet tanks, #14 and #15 lines	1056	1315	141	55.8	0.20	
3-22	HS-24	DO HS-9	1315	1505	111	75.4	0.49	0.38
3-23	HS-30	DO HS-9	1002	1201	111	19.9	0.13	
3-23	HS-41	DO HS-9	1202	1358	108	29.8	0.20	
3-23	HS-47	DO HS-9	1358	1606	119	32.9	0.20	0.18

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Table 6-A

Date _____

Sampling Summary Sheet

Hydrogen Sulfide.

Plant: E.I. duPont de NemoursProcess or Area: CoagulatingClinton Plantbath area

Date 19 78	Sample No.	Sample Description	Time Start	Time Stop	Sample Volume (liters)	Total Weight (ug)	Concentration	
							H ₂ S (ppm)	Estimated TWA (ppm)
3-22	HS-10	Desk area, center of room, • main level	1059	1253	102	68.9	0.49	
3-22	HS-19	DO HS-10	1254	1500	95	45.7	0.35	0.42
3-23	HS-33	DO HS-10	0938	1143	112	49.4	0.32	
3-23	HS-34	DO HS-10	1144	1346	125	36.6	0.21	
3-23	HS-44	DO HS-10	1346	1557	130	51.4	0.29	0.28
3-22	HS-11	On circuit breaker box, main level	1100	1255	107	23.7	0.16	
3-22	HS-13	DO HS-11	1258	1502	92	56.5	0.44	0.31
3-23	HS-25	DO HS-11	0944	1148	123	40.5	0.24	
3-23	HS-37	DO HS-11	1149	1349	101	30.6	0.22	
3-23	HS-49	DO HS-11	1350	1559	109	55.4	0.37	0.28

Table 6-B

Sampling Summary Sheet
Hydrogen Sulfide

Date _____

Plant : E.I. duPont de Nemours
Clinton Plant

Process or Area : Coagulating
bath area

Date 1978	Sample No.	Sample Description	Time Start	Time Stop	Sample Volume (liters)	Total Weight (ug)	Concentration	
							H2S (ppm)	Estimated TWA (ppm)
3-22	HS-12	Basement, above acid pump • motor	1103	1259	114	24.7	0.16	
3-22	HS-22	DO HS-12	1302	1503	90	28.7	0.23	0.20
3-23	HS-32	DO HS-12	0941	1146	112	51.7	0.33	
3-23	HS-39	DO HS-12	1147	1347	125	39.1	0.23	
3-23	HS-50	DO HS-12	1348	1558	121	62.4	0.37	0.31

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Table 7
Sampling Summary Sheet

Date _____

Hydrogen Sulfide:

Plant: E.I. duPont de Nemours

Process or Area: Casting; Peak

Clinton Plant

exposures during castoff

Date 1978	Sample No.	Sample Description	Time Start	Time Stop	Sample Volume (liters)	Total Weight (ug)	Concentration	
							H2S (ppm)	Estimated TWA (ppm)
3-22	HS-1	Casting operator	0941	0959	17.8	39.1	1.6	---
3-22	HS-2	Production operator	0944	0959	14.9	41.6	2.0	---
3-22	HS-3	Casting operator	0943	0959	15.1	85.5	4.1	---
3-22	HS-14	Casting operator	1547	1554	6.9	25.8	2.7	---
3-22	HS-15	Production operator	1545	1553	8.1	54.4	4.8	---
3-22	HS-16	Production operator	1545	1554	8.9	21.2	1.7	---

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Table 8

Carbon Disulfide Sampling Summary

Location or Job Title	No. of TWA Determination	Range (Lo-Hi) ppm	Mean (ppm)	Standard Error (ppm)	Geometric Mean (ppm)	Geometric Std. Dev.	L1* (ppm)	L2* (ppm)
<u>(1) Chemical Bldg.</u>								
CBX Production Opr.	3	2.35-4.95	3.80	0.76	3.62	1.47	1.39	9.48
VRR Operator	9	4.65-10.41	7.35	0.81	6.99	1.40	5.38	9.07
VRR Mechanic	3	3.19-9.36	6.40	1.79	5.83	1.73	1.49	22.86
Area; CBX xanthation room	6	2.28-9.67	5.90	1.19	5.23	1.75	2.91	9.43
Area; VRR room, opr. desk	3	7.05-11.2	8.84	1.23	8.67	1.27	4.83	15.56
<u>(2) Coagulating Bath Area</u>								
Coagulating bath opr	3	1.54-4.06	2.59	0.76	2.39	1.63	0.70	8.09
<u>(3) Casting Area</u>								
Hopper opr.	9	2.18-11.90	4.83	0.97	4.28	1.63	2.94	6.25
Production opr.	9	2.67-7.09	4.51	0.45	4.34	1.34	3.46	5.44
Casting opr.	9	3.08-20.67	8.68	2.15	6.91	2.02	4.03	11.87
Day crew	15	2.08-5.78	3.88	0.29	3.72	1.36	3.14	4.41
Area; east wall, east of #3 line	3	3.16-6.46	4.53	0.99	4.32	1.44	1.74	10.72
Area; east wall, east of #5 line	3	2.60-4.04	3.41	0.43	3.35	1.26	1.90	5.91
Area; between hot water wash tanks, line #2 and #3	3	5.25-11.75	7.67	2.05	7.18	1.54	2.46	20.98

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Table 8 (con'd)

Location or Job Title	No. of TWA Determination	Range (Lo-Hi) ppm	Mean (ppm)	Standard Error (ppm)	Geometric Mean (ppm)	Geometric Std. Dev.	L1* (ppm)	L2* (ppm)
(3) Casting Area (con'd)								
Area; between hot water wash tanks, lines #14 and #15	3	2.54-5.03	4.11	0.79	3.94	1.46	1.53	10.12
All locations, casting wet end	12	2.54-11.75	4.93	0.72	4.50	1.53	3.43	5.90

*L1 and L2 are the lower and upper 95% confidence limits based on the geometric mean and geometric standard deviation of the individual estimates of daily time weighted average concentration.

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Table 9
Hydrogen Sulfide Sampling Summary

Location	No. of TWA Determination	Range (Lo-Hi) ppm	Mean (ppm)	Standard Error (ppm)	Geometric Mean (ppm)	Geometric Std. Dev.	L1* (ppm)	L2* (ppm)
Casting, wet end all locations	12	0.17-0.56	0.31	0.04	0.29	1.52	0.22	0.37
Coagulating bath area; all locations	6	0.20-0.42	0.30	0.03	0.29	1.27	0.23	0.37

*L1 and L2 are the lower and upper 95% confidence limits based on the geometric mean and geometric standard deviation of the individual estimates of daily time weighted average concentration.

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Table 10

One Way ANOVA Comparing Geometric Mean
Exposures to CS₂ for Eight Job Titles

Source of Variation	df	SS	MS	FS
Among Job Categories	7	1.023	0.1461	3.95***
Within Job Categories	<u>52</u>	<u>1.923</u>	0.0370	
TOTAL	59	2.946		
$F_{.05} [7,52] = 2.20$ $F_{.01} [7,52] = 3.02$ $F_{.001} [7,52] = 4.23$				

*** = P < 0.005

Conclusion: There is a significant (P < 0.005) added variance component among job categories for exposure to carbon disulfide.

Table 11

SNK - Multiple Range Test Comparing CS₂ Exposures Group Means

	\bar{y}	ni	\bar{y} ni	CB 0.378 3	CBX 0.559 3	DC. 0.571 15	HO 0.631 9	PDO 0.637 9	VRRM 0.766 3	CAO 0.839 9	VRROP 0.844 9
CB	0.378	3		--							
CBX	0.559	3		0.181	---						
D.C.	0.571	15		0.193	0.012	---					
H O	0.631	9		0.253	0.072	0.060	---				
PDO	0.637	9		0.259	0.078	0.066	0.006	---			
VRRM	0.766	3		0.388 ns	0.207	0.195	0.135	0.129	---		
CAO	0.839	9		0.461*	0.280	0.268	0.208	0.202	0.073	---	
VRROP	0.844	9		0.466*	0.285ns	0.273	0.213	0.207	0.078	0.005	---

* Tested and found to be significant (p < 0.05).

ns = Tested and found not to be significant at p = 0.05. Unmarked differences were not tested because a larger range was found to be not significant.

Table 12

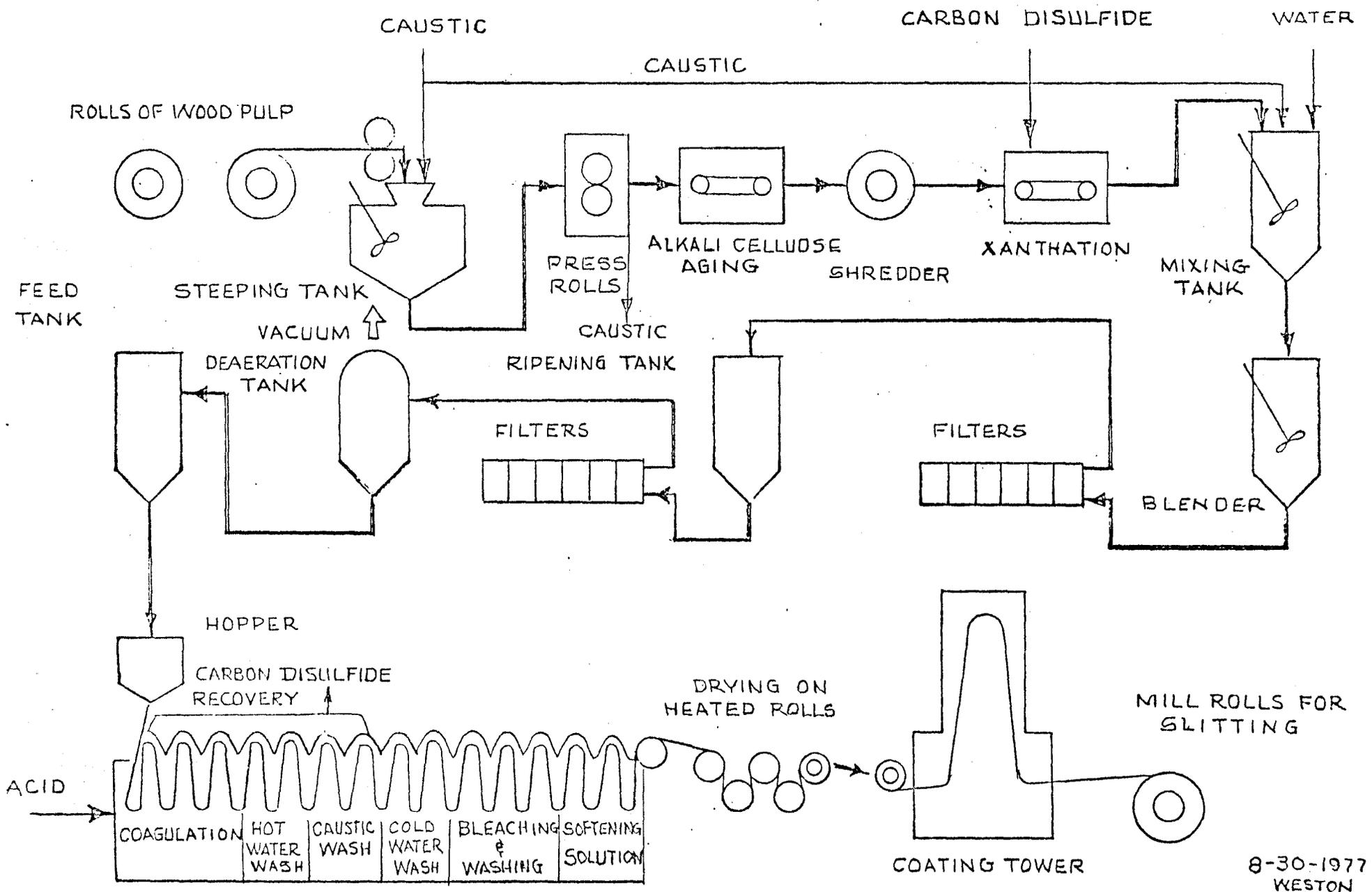
JOB CLASSIFICATIONS

(Employees Potentially Exposed to CS₂)

E.I. duPont de Nemours
Clinton Plant

<u>AREA</u>	<u>JOB DESCRIPTION</u>
CS ₂ Unloading	Essential materials unloader. Unloads CS ₂ and transfers recovered CS ₂ . Days.
Chemical Building	C.B.X. production operator. Operates controls in the CBX control room and equipment in the CBX area. Four shifts.
" "	V.R.R. operator. Regenerates presses and operates and controls equipment in the VRR area. Four shifts.
" "	One maintenance person works full time in VRR and others part time. Days.
Coagulating Bath	Coagulating bath and recovery operator. Operates equipment to supply bath to casting and to control the CS ₂ recovery system. Four shifts.
" "	All maintenance personnel work part time in this area. Days.
Casting Wet End	Hopper operator. Primarily responsible for control and operation of the hopper and No. 1 tank. Four shifts.
" "	Production operator. Primarily responsible for control and operation of the Nos. 2-6 tanks. Four shifts.
" "	Casting operator. Primarily responsible for control and operation of the Nos. 7-15 tanks. Four shifts.
	Day crew. Primarily responsible for cleaning of equipment. Two persons work in V.R.R. two days per week. Days
	Ten Maintenance persons work full time on casting wet end and all others part time. Days.

CELLOPHANE MANUFACTURING



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