U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45202

HEALTH HAZARD EVALUATION DETERMINATION
REPORT NO. 73-8-132

OLIN CORPORATION
FILM DIVISION
PISGAH FOREST, NORTH CAROLINA

APRIL 1974

I. TOXICITY DETERMINATION

In response to a request for a Health Hazard Evaluation, investigators from the National Institute for Occupational Safety and Health have determined that acute exposures to carbon disulfide (CS_2) have occurred episodically and these exposures have provoked the expected toxic symptoms in chemical operators engaged in the production of cellophane at the Olin Corporation in Pisgah Forest, North Carolina.

There does not appear to be sufficient medical evidence at this time to warrant a conclusion that chronic exposure capable of causing illness is occurring, although several unusual medical problems involving a small proportion of employees were encountered during the study.

These determinations are based upon (a) environmental levels of CS_2 obtained in July 1973, (b) in depth medical examinations and interviews obtained in October 1973, (c) review of plant environmental and medical records, and (d) available literature on the acute and chronic toxicity of CS_2.

Recommendations contained in the body of the report have been suggested to management to obviate the observed hazard and provide safe and healthful working conditions for affected employees.

II. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of the Determination Report are available upon request from the Hazard Evaluation Services Branch, NIOSH, U.S. Post Office Building, Room 508, 5th and Walnut Streets, Cincinnati, Ohio 45202.

Copies of the Determination Report have been sent to:

a) Olin Corporation, Film Division, Pisgah Forest, North Carolina
b) Authorized Representative of Employees
c) U. S. Department of Labor - Region IV
d) NIOSH - Region IV

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

III. INTRODUCTION

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

The National Institute for Occupational Safety and Health (NIOSH) received such a request from an authorized representative of employees of Local 1971, United Paperworkers International Union, regarding alleged hazardous exposures to production workers from carbon disulfide in the Chemical Building, 2nd floor operations of the Olin Corporation, Cellophane Film Division, Pisgah Forest, North Carolina.

IV. HEALTH HAZARD EVALUATION

A. Initial Survey

On July 27, 1973 NIOSH industrial hygienist, Jerome P. Flesch, met with plant and union representatives at the Olin Corporation to discuss the request for health hazard evaluation.

Following preliminary discussions with these representatives, a walk-through survey was conducted of the chemical building operations, environmental measurements for CS_2 were obtained during the xanthation proce s (second floor), and private interviews conducted with numerous associated chemical operators.

B. Description of Process - Conditions of Use

The alleged hazard is carbon disulfide (CS_2) exposure at the Cellophane Film Division of the Olin Chemical Chemical Works. This Division was built in 1951 and employs a batch process to produce viscose which is extruded, solidified, and dried to form cellophane. The technology is virtually identical to that employed in the manufacture of rayon. Seven employees per shift are employed in the production of viscose and four shifts per week are worked. Exposure occurs largely during the xanthation step in production which is carried out on the second floor. In this step CS_2 is added (metered) to ripened alkali cellulose which is contained in individual barattes which hold 700-800 pounds of cellulose. Following mixing, excess CS_2 is removed by vacuum. Each baratte is manually opened, its walls scraped and the reaction product dumped to the floor below.

Regular operators are rotated principally between the second and third floors where alkali cellulose is ripened. Approximately 38-40 barattes are processed each shift by two operators. This work is virtually continuous and is moderately strenuous. Formerly, a third employee was used on the second floor but following a work-time study several years ago, this position was abolished.

Ambient air levels of CS_2 are monitored daily. Baratte CS_2 concentrations are also monitored prior to actual entry for purposes of thorough cleaning. Several barattes are so cleaned each shift. Employees are questioned weekly regarding symptoms of CS_2 toxicity and their blood pressures recorded.

C. Evaluation Criteria

1. Environmental Standards

The Occupational Health Standards as promulgated by the U.S. Department of Labor (Title 29, Chapter XVII, Part 1910, Subpart 1910.93, Table G-2) applicable to carbon disulfide is summarized below:

Substance	8-hour time weighted average	Acceptable ceiling concentration	Acceptable maximum peak above the acceptable ceiling concentration for an 8-hour shift	
			Concentration	Maximum duration
CS_2	20 ppm*	30 ppm	100 ppm	30 minutes

Occupational health standards are established at levels designed to protect workers occupationally exposed to a substance on an 8-hour per day, 40 hour per week basis over a normal working lifetime.

* Parts of vapor or gas per million parts of contaminated air by volume.

2. Toxic Effects

Carbon Disulfide (CS_2)

This compound in low concentrations is metabolized by the body and 90% is eliminated in the urine as various sulfur compounds. The balance is largely exhaled. When concentrations exceed the body's ability to eliminate the compound, toxicity ensues. The effects depend upon the nature of exposure, i.e., acute or chronic. Acute effects cause symptoms progressing from restlessness, mucous membrane irritation, blurred vision, nausea, vomiting, and headache to unconsciousness and respiratory paralysis. Irritability and psychosis have been observed during recovery. Skin contact can lead to irritation and burns. Chronic poisoning results in bizarre sensations in the extremities, sensory loss and muscular weakness. Irritability, memory loss, blurred vision, depressed appetite, insomnia, depression, partial blindness, dizziness and parkinsonian tremor are reported. In addition, headache, fatigue, impairment of sexual functions, gastrointestinal disturbances, hallucinations, mania and chronic dementia occur. Sleep disorders are almost invariably present. Nightmares are common. Symmetrical polyneuritis is the most common finding (88%) followed by gastric disturbances (28%), headache and vertigo (18%), sexual disturbances and tremors (16%), myopathic changes in calf muscles (15%)

mental deterioration (6%), and extra-pyramidal symptoms (3%). There have been reports of an increased incidence of cardiac atherosclerosis and diabetes among CS_2 workers. These conditions have primarily been noted in Europe where chronic exposure to higher levels of CS_2 appear to have been more common than in American industrial experience. Chronic exposure may result in renal vascular damage in the form of glomerulonephritis with albuminuria and hypertension. Liver damage seems to be quite rare. All of these problems stress the fact that much of the toxicology for man is yet ill defined and that a myriad of signs and symptoms resembling those of many other conditions appear possible. All authorities agree that the differential diagnosis is very difficult.

D. Environmental Evaluation

Results of the environmental and ventilation tests, Tables I and II, indicate that:

(1) the internal vacuum cycle normally applied to the baratte near the end of the mixing cycle occasionally clogs or malfunctions and is not effective in removing CS_2 vapors prior to "cracking" of baratte doors (Baratte #7).

(2) the local exhaust slot ventilation cycle applied after "cracking" is generally effective in exhausting the remaining CS_2 vapors following the internal vacuum cycle if a full 2-minute exhaust cycle is followed.

(3) potentially toxic and very excessive air concentrations of CS_2 can be emitted into the workroom atmosphere when the ventilation control systems, especially the internal vacuum system, are not functioning properly with adequate time cycles for all barattes.

(4) additionally, exposure to CS_2 occurs episodically when (a) leaks in gaskets, pipes or valves occur, (b) a "double dose" of CS_2 is inadvertently added to the baratte, this being in excess of what can be removed by the vacuum system, and (c) the air intake valve which opens during the vacuum stage of the cycle is accidently not closed and the baratte is charged with CS_2.

TABLE I
ENVIRONMENTAL CS_2 CONCENTRATION DATA*
CHEMICAL BUILDING 2ND FLOOR
JULY 27, 1973

Baratte*	Time	Concentration	Comment
3BZ	2:40	≤24 ppm	Operator scraping baratte
5BZ	2:50	ND	After 2 minute "local ventilation" completed
7A	3:05	144-288	Door first being open
7BZ	3:10	36-48	Operator scraping baratte
6BZ	4:25	ND	Operator cleaning baratte
3A	5:00	ND	CS charging
A	5:05	ND	Front/side
1BZ	5:10	ND	Operator opening door/prior to local ventilation
3BZ	5:20	ND	Operator opening door/prior to local ventilation
7A	5:45	≤24	Before door opened
7A	5:50	≤288	Door being opened
7A	5:52	<24	After 2 minute local ventilation

* CS_2 measurements obtained via direct reading Drager chemical indicator tubes (lower limit of detection 19 ppm, upper limit 288 ppm).

BZ Sample taken in operator's breathing zone
A Sample taken in area proximate to baratte door.
ND - None detected.

TABLE II
VENTILATION OBSERVATIONS
Local Exhaust Systems

Baratte*	Velocity* (ft. per minute)	Comments
7	800	At slot entrance
5	800	At slot entrance
5	100**	1-2 feet from slot

*Alnor, Jr. Velometer

** Smoke generated via "Bendix" smoke tube effectively captured by external system at 2 feet from slot entrance.

E. Employee Interviews

Non-directed medical questionnaires were administered to workers on second and third floor operations on the first and second shifts to determine whether they had any health problems at work or felt were related to their work.

Five of eleven employees interviewed indicated having some symptoms on occasion which are consistent with excessive exposure to CS_2.

Additionally, reports were received which indicated a number of workers may have been affected but were presently absent or had been transferred from the chemical building.

It was determined upon reviewing results of the initial survey that an in-depth medical evaluation should be conducted to further explore the reports of alleged toxicity indicated above.

F. Medical Evaluation

The follow-up medical survey was conducted by NIOSH physician, James B. Lucas, M.D. on October 15-18, 1973.

All available operators on all shifts were seen, interviewed and briefly examined. Emphasis was placed on neurologic aspects of the physical examination and history. Reflexes were checked in all instances and sensory examinations performed where indicated. In addition, certain individuals who formerly worked in the division and some maintenance personnel were similarly worked-up. The attached form (see appendix) was used to gather and record various responses and findings.

In a number of instances clinical records were reviewed with the plant's chief physician. A total of 29 men participated.

Results:

The 29 employees ranged in age from 19 to 55 with an average age of 38. They averaged 15.4 years of service with the company and averaged 13 years exposure in the chemical building for a total of 378 man years of exposure.

Ten men specifically related episodes of acute illness associated with accidental exposures to high concentrations of CS_2. Such exposures apparently varied from approximately two per year to once in several years. These were primarily associated with work on the second floor. Symptoms included headache (9/10), abdominal pain (2/10), nausea (3/10), and vomiting (1/10). Most also noted some disturbance in sleep pattern following such exposure. This usually took the form of nightmares.

As expected, most of the other symptoms related were harder to correlate with toxicity since the effects of chronic exposure to low levels are far from clear-cut. Nine other men experienced headaches on an occasional basis (1-3 per month). This was not judged to be excessive. One individual

experienced one headache per week and another noted headaches only when cleaning barettes. One individual also suffers from migraine. Abdominal pain was not uncommon. Seven men either have had diagnosed ulcers or very suggestive symptoms. Two had gastric distress associated with hiatus hernias. This incidence of ulcer seems high and is in agreement with other reports of CS_2 workers. However, the age, race, and sex of these individuals certainly predispose them to this common condition. The stress of the work situation, which is both physically hard and conducted at a rapid pace, is probably more important than actual CS_2 exposure.

Among sleep pattern disturbances, insomnia and nightmares were prominent. Fourteen men complained of insomnia but in eight men this was definitely related to the readjustment in sleep habits necessitated by shift work. Thus, it was noted only when working certain shifts (usually graveyard). Bad dreams were noted by 14 men on a more or less regular basis. Five more men had such dreams less frequently or only after accidental over-exposures.

Mental aberrations were not particularly common; irritability (8/29); episodes of anger (7/29); mood swings (one each of depression and elation); and loss of memory (two cases--one in a heavily medicated man with idiopathic epilepsy).

Neurologic-type symptoms were also encountered with some frequency. These included vertigo (12/29), but half of these were associated with positional changes such as standing from a stooped position, etc. While tremor was mentioned by nine individuals, only two men were noted to be tremulous on examination. Occasional involuntary muscle twitching or jerking was reported in five men. Eight reported occasional muscle cramps; four occasional weakness; four staggering on occasion; and five some numbness of extremities (in two this was related to position and in two to traumaticly "pinched nerves." Only two individuals reported a decrease in libido and it was determined that one of these is probably a latent diabetic. Nine men had histories of various skin lesions including caustic burns.

All men had normal blood pressures for their ages; only one had an abnormal pulse (rate 52) and this bradycardia may have been on the basis of excellent physical conditioning in a young man. Four men had various dermatologic findings (probable basal cell epitheloma of face, fungus infection, primary irritant dermatitis and acne). The mental status was judged normal in all except for one individual who seemed to have a very flat affect. A number of bizarre neurologic findings were noted. These cases are summarized as follows:

1. A 34 year old man worked 14-1/2 years in the chemical building prior to transfer. He has a several year history of numbness, pain, and tingling involving the right side of face and head. Initially, these sensations were constant, but quickly assumed an episodic pattern. He now has definite hyperalgesia in right trigeminal nerve distribution. No motor deficit was observed. A neurologic consultant has diagnosed "atyptical facial neuralgia."

2. A 37 year old man with 16 years exposure. He had the onset of a convulsive disorder two years ago beginning with a three day period of status epilepticus. This was controlled with medication until November, one year ago, when he again had seizures. This probably was precipitated by a reduction in medication. He relates that one physican told him his seizure was due to a "swelled blood vessel in the temporal area." An extensive report to the company by a neurologic consultant indicates no such finding to explain the onset of his epilepsy. He is currently depressed by his downgrade position (janitor). His neurologic examination was normal.

3. A 44 year old man with 22 years exposure. He has been on leave for two years with a vague arthritis-like ailment. On examination the right knee jerk was considerably more active than the left as was the ankle jerk. Otherwise no obvious abnormalities. A specialist has diagnosed his illness as "non-articular rheumatism."

4. A 55 year old man with 22 years exposure. He has noted numbness in his right leg for the past 5-6 years. On examination the deep tendon reflexes (DTRS) were found intact and equal, but a definite area of hypoalgesia was noted on the anterior and lateral aspects of the right thigh and knee.

5. A 46 year old man with 22 years exposure. He notes numbness in both legs, especially the left. On examination the DTRs were brisk and equal. Generalized hyperalgesia was noted for the left leg. He attributes this symptom to a "spinal problem and pinched nerve."

6. A 42 year old man with 19 years exposure who complains of siatica. On examination some hypoalgesia was noted on the anterior aspect of the right leg. The knee jerk was diminished and the right ankle jerk was less than the left. His problem appears to be due to a ruptured intravertebral disc.

7. Three apparently otherwise normal men had diminished knee jerks. However, their other reflexes were entirely normal and equal. Some difficulty in eliciting knee DTRs is, of course, expected in the examination of any large group of individuals.

8. Two individuals had rather conspicuous tremors, but again this is a common finding without specific etiologic significance.

9. Five men complained of blurry vision. In two this was definitely associated with overdose exposures. Its significance in the others is cryptic.

Other findings include two individuals with proteinuria. In one instance it was present on a preemployment examination, but not noted for some months after placement was made. This man has been reassigned elsewhere. In the other case protein was first detected as a trace in March of 1969 and has continued to be present in the 2-3+ range since. He was transferred to another department in August 1966, i.e., more

than two years before the abnormality was first detected. Urinalyses performed periodically from 1958 through 1967 were normal. The time span between last exposure and detection of proteinuria makes a causal relationship to CS_2 exposure unlikely.

Few other findings were noted during the survey. The lack of coronary heart disease was impressive in a group this size which contained numerous individuals over forty years of age. This is also a large group to be all normotensive, but this may be a selective feature of the group, i.e., hypertensives are screened out as they appear and reassigned. No employee was found with a psychotic history and no instances of psychosis have apparently developed during the 20 year history of this operation.

G. Conclusions

There is no doubt that occasional acute exposures to CS_2 have occurred episodically and that these exposures have provoked the expected medical symptoms. These episodes have not been frequent. There does not appear to be sufficient medical evidence at this time to warrant a conclusion that chronic exposure is occurring in a sufficient degree to provoke illness. The number of men exposed is fairly large and the total exposure in man years approximates ten entire working life times. If chronic toxicity was occurring, more in the way of classic manifestations would be expected. Without question several atypical and unexplained illnessess were encountered during the study. Time may eventually resolve these diagnostic problems. They do not fit classic descriptions of chronic CS_2 toxicity either in onset (sudden in most instances), type or anatomic distribution. It is difficult to postulate that such diverse and asymmetric neurologic problems are due to a common exposure to toxic substances or due to some unusual personal susceptibility. Local problems of this type are probably related to chance distribution. Nonetheless, it is felt that long term follow-up of this and similarly exposed groups of men is probably justified to clarify whether this type of effect is possibly valid. Such a study would also help clarify suspicions raised by other investigators regarding arteriosclerosis, etc.

RECOMMENDATIONS

1. While regular operators are rotated on a weekly basis, relief operators are often assigned to the second floor area for prolonged periods. Provisions should be made to permit this group to also rotate out of the area after each regular work period.

2. Management should give serious attention to the possiblity of assigning another man to the second floor on a half-time basis. This would help insure compliance with all safety precautions and permit more frequent monitoring of the work area. This should also help lower the generally high level of anxiety found among the operators.

3. Maintenance of the barattes and vacuum systems should be increased. Ventilation control systems should be properly applied by all operators, in the work cycle and, as necessary, extra time allotted in order to allow the ventilation to perform effectively.

4. At the times of acute high exposures to CS_2; operators should be provided with and wear approved respirators until levels have been reduced.

5. A training program should be set up to fully discuss the hazardous nature of CS_2, the precautions necessary for safe handling, emergency procedures, and the need for strict compliance. Medical, safety and laboratory personnel should participate in such a program. Each new employee should receive this instruction prior to assignment to the area. Current employees would also definitely benefit from such thorough orientation.

VI. AUTHORSHIP AND ACKNOWLEDGMENT

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