U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
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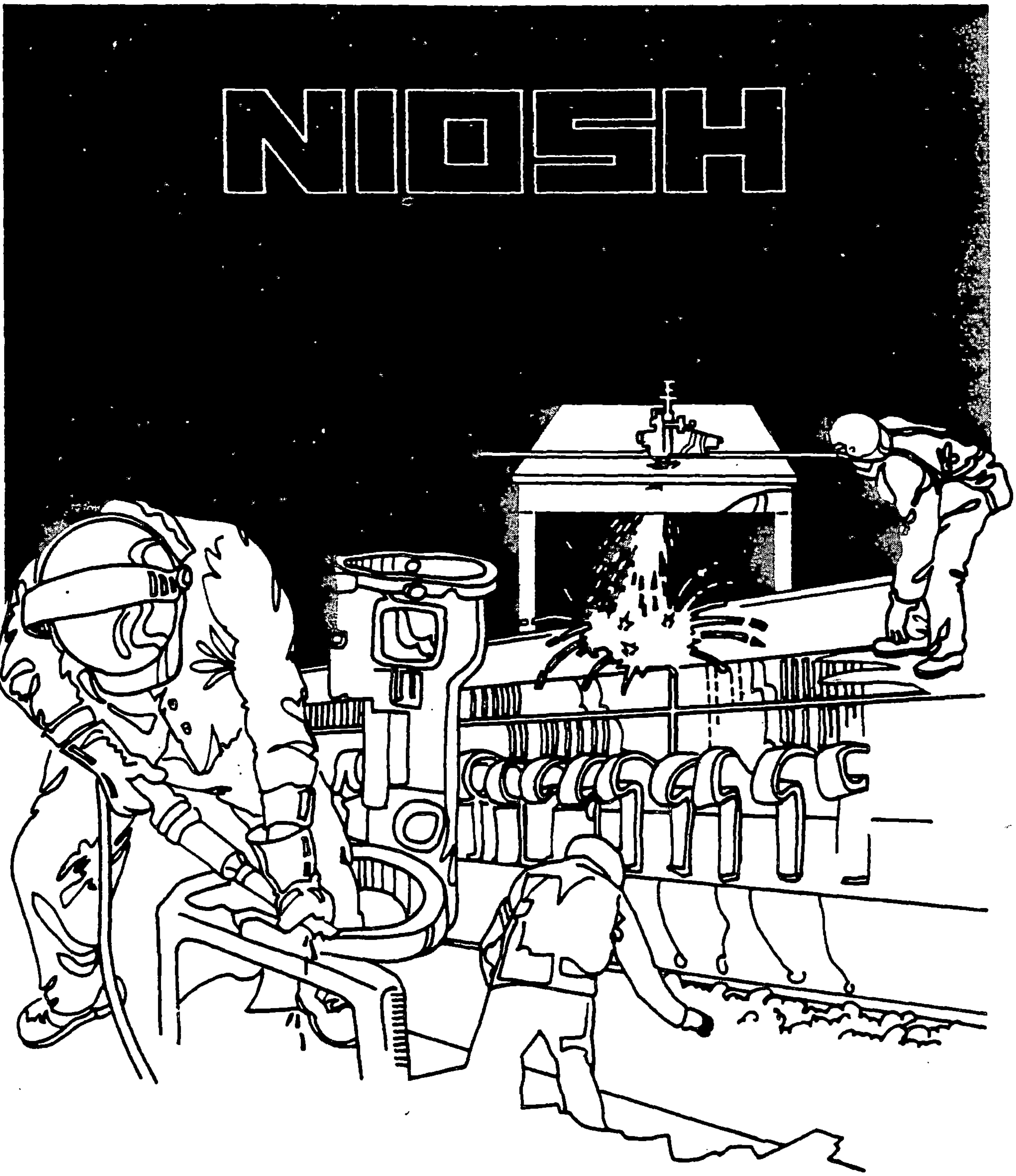

Health Hazard Evaluation Report

HETA 78-004-1511
SHELL CHEMICAL COMPANY
AXIS, ALABAMA

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from 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 Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

HETA 78-004-1511
JANUARY 1985
SHELL CHEMICAL COMPANY
AXIS, ALABAMA

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I. SUMMARY

In October of 1977 the National Institute for Occupational Safety and Health received a request from employees to evaluate exposures and related health effects at the Shell Chemical Plant in Axis, Alabama. This plant had intermittently produced dibromochloropropane (DBCP) from April 1976 until early July 1977. Shell became aware of reports that DBCP might impair sperm production in male employees in late July or early August 1977 and DBCP production was not resumed.

On December 6, 1977, and February 2-3, 1978, environmental surveys were conducted. Seventeen breathing zone air samples were obtained for the three pesticides being manufactured at that time; Vapona, Dibrom, and Aldicarb. In addition, wipe samples from various locations thoughout the plant were obtained to check for surface pesticide contaminations. No measurements were made for DBCP because it had not been manufactured for approximately six months. All 17 breathing zone exposures for Vapona and Dibrom were very low. The highest level measured was 0.013 mg./M^3 (1.3% of the exposure criterion). Thirteen of the 17 Aldicarb samples were below the limits of detection, and the highest Aldicarb level was 0.005 mg/m^3. The wipe samples indicated that there was very little residual pesticide, even in production areas where pesticide residues would be expected.

A medical evaluation was conducted during the period January 16-20, 1978. The evaluation consisted of a general physical examination, a health and chemical exposure questionnaire, a routine urine analysis, and analysis of a fasting blood sample for blood lipids, complete blood cell count (CBC), chemical panel (SMA_{12}), plasma cholinesterase, and the gonadotropins: follicle stimulating hormone (FSH), leutinizing hormone (LH), and testosterone. Males were asked to submit a semen sample obtained at least 48 hours after their last previous ejaculation. One hundred and eight employees, 98 (91%) males and 10 (9%) females participated in the evaluation. Semen samples from 42 DBCP-exposed and 26 non-exposed male plant employees were analyzed. On the health questionnaire there were few abnormal conditions reported and no appreciable differences in the prevelance of any disease or health symptom between the various plant departments or DBCP exposure groups was found. Likewise there were no appreciable differences in the results between the various job classification or high and low DBCP exposure groups for the prevalance of abnormalities in the results of the physical exam, urine analysis, CBC, chemistry panel, plasma cholinesterase, blood lipids, or gonadotropins.

Although only one man exposed to DBCP had a sperm count of zero, the results of the NIOSH semen examination suggested an association between DBCP-exposure and depression of sperm counts. In addition, a company conducted semen study of 71 DBCP exposed and 34 non-exposed plant employees done prior to the NIOSH study found a statistically significant association between the log of hours of DBCP exposure and the log of sperm count.[2] These results along with data [1,3,4,5] from other worksites showing depression of sperm counts in DBCP-exposed men suggest, that some Shell Axis employees may have experienced adverse spermatogenic effects.

At the time of the survey the level of pesticide exposure measured at the plant was very low, and a health hazard did not exist. However data showing a depression in the sperm density of Plant employees who received DBCP exposure at the plant suggests that some workers may have experienced adverse spermatogenic effects due to exposure to DBCP prior to July 1977 when DBCP production ceased.

KEYWORDS: SIC 2879 Pesticides, Vapona, Dibrom, Aldicarb, Dibromochloropropane

II. INTRODUCTION

In October of 1977 the National Institute for Occupational Safety and Health received a request from employees to evaluate potential health effects from chemical exposures at the Shell Chemical Plant in Axis, Alabama. This plant had intermittently produced dibromochloropropane (DBCP) from April 1976 until July 1977. DBCP production had been suspended after that time because of reports from a California pesticide formulator that DBCP might impair sperm production in male employees.[1] At that time approximately 85 Shell Axis, Alabama employees had had exposure to DBCP, and the Shell Corporation initiated an extensive health evaluation of employees at the Axis plant. The preliminary analysis of the data showed that DBCP exposed workers had lower sperm counts than a group of non-DBCP-exposed workers, but that the distribution of sperm counts for the DBCP exposed workers was similar to the distribution found in a recent study of normal males.[6] The requestors asked NIOSH to perform an independent medical study and an industrial hygiene evaluation of the plant. On December 6, 1977, and February 2-3, 1978, environmental surveys were conducted. The medical evaluation was conducted during the period January 16-20, 1978. Interim reports were sent on February 23, 1978, and Feb 7, 1979.

III. BACKGROUND

The Shell Chemical Company at Axis, Alabama manufactures pesticides. The amounts of various pesticides manufactured depend upon commercial demand. When a sufficient amount of pesticide had been manufactured, the processing equipment was used to manufacture another pesticide. The pesticide Aldicarb was manufactured year around; other pesticides were manufactured for from one to four months per year. DBCP was produced during April to May 1976, August through December 1976, and January to July 1977.

At the time of the NIOSH study, approximately 120 employees worked in areas with potential exposure to pesticides; 70 process technicians, 42 maintenance technicians, and 5 laboratory technicians. The company also occasionally utilized "contract personnel" to provide extra manpower, mostly in pesticide drumming operations. At the time of the survey, the pesticides Aldicarb, Vapona, and Dibrom were being manufactured.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

On December 6, 1977, and February 2-3, 1978, environmental surveys were conducted. Seventeen breathing zone samples were obtained for the three pesticides being manufactured at that time: Vapona, Dibrom, and Aldicarb. The personal sampling train consisted of a

MSA model G portable sampling pump calibrated to pull one liter of air per minute. The pump was connected to a ground-glass stoppered impinger which contained fifteen milliliters of pesticide-grade (phosphate- free) ethylene glycol as the absorbing medium. The sampling train was worn by employees for a period of time approximating the full shift.

The Shell Chemical Company had made extensive attempts to reduce their employees' exposure to pesticides and to contain any contamination to a specified area. In an effort to assess the success of their program, smear tab samples were taken for the three pesticides being manufactured at that time (Vapona, Dibrom, and Aldicarb) in areas normally suspected of being contaminated with pesticides and in other areas supposedly free of pesticides to determine the presence or absence of pesticide. An additional pesticide - Phosdrin was analyzed for on the smear tabs since Phosdrin had been manufactured in the recent past. No measurements were made for DBCP because it had not been manufactured for approximately six months.

The procedure for analysis of the pesticides is indicated in Table I. Different methods of extraction were used for the impinger solutions and the smear tab samples. Also, there was initial difficulty in analyzing for Dibrom; it appeared to debrominate back to Vapona when it came in contact with metal surfaces (syringe needle, certain GC columns). The GC column indicated in Table I was found to preserve the Dibrom so that it could be analyzed.

B. Medical

The medical evaluation was conducted during the period January 16-20, 1978. All plant employees were invited to participate. The evaluation consisted of a general physical exam, a health and chemical exposure questionnaire, routine urine analysis, fasting blood sample for blood lipids [cholesterol, triglycerides, high density lipoprotines (HDL), low density lipoprotines (LDL), complete blood cell count (CBC), chemical panel (SMA_{12}), plasma cholinesterase, and the gonadotropins: follicle stimulating hormone (FSH), leutinizing hormone (LH), and testosterone. Males were asked to submit a semen sample obtained at least 48 hours after their last previous ejaculation.

V. EVALUATION CRITERIA

A. Environmental Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set bythe evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's),[7] and 3) the U.S. Department of Labor (OSHA) occupational health standards.[8] Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet only those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

The following criteria were used in this study to assess employee exposure to pesticides:

Pesticide	Recommended TWA Criteria	Source
Vapona	1.0 mg/M^3*	OSHA Standard
Phosdrin	0.1 mg/M^3*	OSHA Standard & ACGIH TLV
Dibrom	3.0 mg/M^3*	OSHA Standard & ACGIH TLV
Aldicarb	No Criteria	

*milligrams pesticide/cubic meter of air

B. Toxicity

1. Insecticides[9]

Aldicarb is a carbamate insecticide which can be absorbed through ingestion, inhalation, or skin contact. Note that there is no NIOSH Criterion, Federal Standard or ACGIH TLV for Aldicarb, however, the Shell guideline policy was to strive for no employee exposure. Dibrom, Phosdrin, and Vapona are organophosphate insecticides They can be absorbed through ingestion, inhalation, or skin contact and can cause dermatitis and eye irritation. The major toxic effect of Aldicarb and the three organophosphate pesticides is inhibition of acetylcholinesterase. Acute overexposure can result in chest tightness, wheezing, excessive salivation, blurring of distant vision, frontal headache, anorexia, nausea, vomiting, and diarrhea. With severe acute overexposure, confusion, ataxia, convulsion, and coma may result. It is also thought that some people with long-term exposure to organophosphate pesticides may experience chronic neurologic symptoms such as headache, impaired memory, excessive fatigue, disturbed sleep, or psychic disorders.

2. Dibromochloropropane[10]

Dibromochloropropane is a liquid nematocidal agent that was introduced in the mid-1950's. It is a skin and mucous membrane irritant. Occupational exposure has been shown to cause depression of sperm counts in male workers. Animal exposure has been shown to cause testicular atrophy, depression of sperm production and damage to the liver and kidney. Daily ingestion of DBCP in rats and mice has resulted in the appearance of gastric and mammary cancer. In September, 1977, NIOSH recommended to the Department of Labor that exposure to DBCP be controlled so that no worker will be exposed in excess of 10 ppb (0.1 mg/m^3) TWA, and published the Criteria Document in January, 1978.[10] The Federal OSHA standard is 1 ppb TWA.[8] The EPA has banned the use of DBCP in the United States.

VI. RESULTS

A. Environmental

Table II lists the results of the personal breathing zone samples taken to assess employee exposure to pesticides. All samples for Vapona and Dibrom were well below their evaluation criteria. Thirteen of the 17 Aldicarb samples were below the limits of detection, and the highest Aldicarb level was 0.005 mg/m^3. Four samples for Aldicarb indicated that three workers were exposed to low levels of Aldicarb (one worker was sampled on both days of the survey). Three of the detectable levels were measured on the same day; they may have resulted from a leak that was repaired during the tanktruck loading that occurred that day. The exposure of the Vapona operator to Aldicarb cannot be explained unless the Vapona operator was in the Aldicarb unit briefly that day. Since the measured level is so small, it may have come from such a brief exposure. It is also possible that samples could have been inadvertantly switched.

The wipe samples (Table III) indicated that there was very little residual pesticide, even in production areas where pesticide residues would be expected. The areas which should be free of pesticides (e.g. the medical clinic, locker clean rooms, lunch room, etc.) were pesticide-free.

B. Medical

One hundred and eight employees, 98 (91%) males and 10 (9%) females participated in the health and work history questionnaire and the physical examination segments of evaluation. Ninety-four of the males and nine of the females submitted urine samples and had blood drawn for the laboratory blood studies. Seventy-three males provided semen samples. Samples from five of these donors (two workers who had had previous DBCP exposure at another plant, and three who had had vasectomies) were not included in the statistical analyses.

Ten women (four process technicians, four maintanance techicians and two clerical employees) participated in the evaluation. Their mean age was 26.6 (range 22 to 32) and their mean duration of employment was 18.9 months (range 3 - 36 months). Seven reported having had exposure to DBCP. No significant abnormalities were noted on physical examination. Only one women had a medically significant laboratory abnormality (elevated triglycerides and low density lipoproteins). Two reported experiencing menstrual irregularities. One women reported frequent episodes of upper respiratory infections and gastroenteritis.

For analysis of the medical data in the male employees, the men were grouped according to their job classification (process technician (44 blood samples, 37 semen samples), maintenance technician (29 blood, 16 semen samples), management personnel (18 blood, 12 semen samples), and miscellaneous (3 blood and 2 semen samples). For analysis of the gonadotropin hormone and sperm density data, the male employees were grouped by their history of exposure to DBCP. Any male employee who reported being exposed to DBCP during production, maintenance, or drumming operations was classified in the high exposure group (61 blood, 42 semen samples). The other male employees were classified in the low exposure group (33 blood, 26 semen samples).

The descriptive statistics for the male participants, grouped both by job classification and by DBCP exposure, are shown in Table IV. The process and maintenance technicians were of comparable age but the administrative personnel were an average of six years older.

On the health questionnaire there were few abnormal conditions reported. No appreciable differences in the prevalance of any disease or health symptom between the various plant departments or DBCP exposure groups were found. There were no appreciable differences in the results between the various job classifications, or between high and low DBCP exposure groups, for the prevalance of abnormalities in the results of the physical examination, urine analysis, CBC, chemistry panel, or plasma cholinesterase.

The results for blood lipids are shown in Table V. The maintenance and process technicians tended to have lower concentrations of cholesterol, triglyceride, and low density lipoprotein than did the men in the management catagory. The results of the gonadotropin analysis are shown in Table VI. No significant difference in the level of LH, FSH, or testosterone occurred between the two DBCP exposure groups.

The distribution of sperm counts obtained from the high and low DBCP exposure groups is shown in Table VII. Only one man (who had been exposed to DBCP) was aspermic. The mean and median counts are somewhat lower for the DBCP exposed group, and this group has a greater proportion of men with counts below 20 million. However T-test analysis of the log transformation of the sperm counts (done to normalize the count distribution) showed that the differences in the means of the sperm counts were not statistically significant.

In Table VIII, the distribution of sperm counts for DBCP-exposed men obtained by NIOSH is shown, along with the distribution of sperm counts found in four studies of fertile men[11-14] and one study of infertile men.[11] Also shown is the distribution of sperm counts found in the sperm count study done on the Axis Plant DBCP-exposed employees by the Shell company several months prior to the NIOSH study.[2] In the NIOSH data, the DBCP-exposed Shell employees tended to have a greater proportion of men with counts below 20 million and above 100 million than did the published studies or the Shell sponsored study. It is of interest that the percentage of DBCP-exposed men with counts below 20 million in the Shell Company study did not differ greatly from that reported by Smith et. al. that was conducted on a population of fertile men.[14]

VII. DISCUSSION

The medical interviews and examinations did not reveal an unusual prevalence of any medical abnormalities, with the exception of decreased sperm densities in some male workers who had been exposed to DBCP. The sperm count distribution of the DBCP-exposed population was lower than that of the control population and also lower than the distributions for fertile men reported in the available literature. It is possible that this apparent difference could have occurred by chance (the means of the sperm counts of the DBCP exposed and non-exposed groups were not statistically different) or by selection bias (the NIOSH semen study included only 42 of the estimated 85 DBCP-exposed males). Thus, from just the NIOSH data, it would be difficult to determine conclusively that male workers had experienced sperm count depression secondary to DBCP exposure. However, the comparatively low sperm count distribution in the high DBCP-exposure group, along with data from other worksites showing even more marked depression of sperm counts in DBCP-exposed men, suggests, that some Shell Axis employees may have experienced adverse spermatogenic effects. These adverse effects may have been less severe in the Axis employees than those effects found in the other locations,[1,3,4,5] because the Axis plant had a shorter length of DBCP production and/or less employee DBCP exposure.

To evaluate more completely the possible gonadotoxic effects of DBCP exposure, the Shell Company engaged medical consultants from Baylor University, the University of Texas and the University of California. Between January and June 1978, 14 of the 15 DBCP-exposed plant workers who had sperm densities under 20 million per milliliter were hospitalized for an extensive evaluation that included a testicular biopsy. Subsequently, 10 of the participants submitted sperm samples at approximately 6, 12, and 18 months. The biopsies revealed a varied morphological picture. Most showed patchy to severe tubule hyalinization. Some tubules revealed normal cell association, while others displayed a sparsity of germ cells. Four biopsies displayed markedly impaired spermatogenisis. The mean sperm density of the 10 men who submitted serial semen samples showed a statistically significant increase from 9.2 to 26.7 million per milliliter over the subsequent 18 to 21 months of observation.[15] In addition, a reanalysis of the sperm density data obtained during the fall of 1977 from the 105 employees who participated in the company-sponsored semen study revealed a significant association between the log of the hours of potential DBCP exposure and the log of the sperm count. The consultants concluded that "the data from this study appear to substantiate that DBCP does have a specific gonadotoxic effect in humans."[2] The Shell Company continued to try to follow workers with depressed sperm counts, but found that there was a lack of employee interest after 1979, and only three DBCP-exposed employees were willing to participate in 1980. Due to the potential-long term effects of DBCP exposure, the DBCP-exposed workers at the plant were enrolled in the NIOSH DBCP registry.

The industrial hygiene survey found that the exposures to the pesticides being manufactured at the time of the survey were quite low compared to the relevant exposure criteria and that the facility was close to being free of pesticide contamination. The most likely sources of employee exposure to pesticides or other contaminants were equipment malfunction and employee error. If the equipment continues to be well-maintained, and good work practices continue to be employed during production, equipment repair, and spill cleanup, employee exposures should remain well within acceptable levels.

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X. DISTRIBUTION AND AVAILABILITY OF REPORT

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1. Shell Corporation
2. Requestor
3. NIOSH, Region IV
4. OSHA, Region IV

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

TABLE I

PARAMETERS FOR ANALYSIS OF PESTICIDES

SHELL CHEMICAL COMPANY
AXIS, ALABAMA
FEBRUARY 2-3, 1978

Pesticide	Extraction	GC Column	Temperature	N_2 Flow Rate	Detector
Vapona	5 ml water + 2 ml benzene(impinger) 1 ml acetonitrile (smear tab)	3 ft. 5% PV-210 on Chromosorb GHP	120° C	160 cc/min.	Flame photometric with 5250 Å wavelength filter for phosphorous
Phosdrin	1 ml acetonitrile (smear tab)	3 ft. 5% OV-210 Chromosorb GHP	120° C	160 cc/min.	Flame photometric with 5250 Å wavelength filter for phosphorous
Dibrom	5 ml water + 2ml benzene (impinger) 1 ml acetonitrile (smear tab)	3 ft. 5% OV-210 on Chromosorb GHP	120° C	160 cc/min.	Flame photometric with 5250 Å wavelength filter for phosphorous
Aldicarb	Chloroform, evaporation to dryness Reconstitution with acetonitrile (impinger) Chromosorb GHP 1 ml acetonitrile (smear tab)	3 ft. 5% OV-210	120° C	100 cc/min.	Flame photometric with 3930 Å wavelength filter for sulfur

TABLE II

PERSONAL BREATHING ZONE SAMPLES FOR PESTICIDES

SHELL CHEMICAl COMPANY
AXIS, ALABAMA
FEBRUARY 2-3, 1978

Job Description/Location	Time Sampled (minutes)	Volume Sampled (meters)	Vapona (mg/M3)	Dibrom (mg/M3	Aldicarb (mg/M3)
Vapona operator/Vapona Unit	434	0.43	0.013	ND*	0.001
Supervisor/A-2 Area	430	0.43	0.006	0.001	ND
Dibrom operator/Aldicarb Unit	420	0.42	0.003	ND	ND
Aldicarb operator/Aldicarb Unit	233	0.23	0.002	ND	0.005
Aldicarb operator/Aldicarb Unit	417	0.42	0.001	ND	ND
Aldicarb operator/Aldicarb Unit	415	0.42	0.002	ND	0.001
Vapona operator/Vapona Unit	417	0.42	0.002	ND	ND
Aldicarb operator/Aldicarb Unit	399	0.40	0.011	ND	0.002
Aldicarb operator/Aldicarb Unit	398	0.40	0.003	ND	ND
Wet Lab operator/Laboratory	412	0.41	0.003	0.001	ND
Capping & stencilling/Central Drumming	85	0.08	0.009	ND	ND
Palletizer/Central Drumming	84	0.08	0.008	ND	ND
Forklift operator/Central Drumming	83	0.08	0.010	ND	ND
Drumfiller/Central Drumming	83	0.08	0.005	ND	ND
Board operator/Central Drumming	82	0.08	0.009	ND	ND
Contract instructor/Central Drumming	80	0.08	0.008	ND	ND
Contract instructor/Central Drumming	77	0.08	0.009	ND	ND
Limits of Detection			0.00002	0.00016	0.00029
Recommended criteria			1.0	3.0	No exposure

*ND - non detectable, below limits of detection for analytical method used

TABLE III

SMEAR TAB SAMPLES FOR PESTICIDES

SHELL CHEMICAL COMPANY
AXIS, ALABAMA
FEBRUARY 2-3, 1978

Location	Vapona	Dibrom	Aldicarb	Phosdrin
Desk top - Industrial Hygiene Technician	0.0005	ND	ND	ND
Dispensing counter and sink - Clinic	ND	ND	ND	ND
Desks in Reception Room - Clinc	ND	ND	ND	ND
Lockers and benches -Change Room #5, "Dirty" side	ND	ND	ND	ND
Sink and shower area - Change Room #5, Transition area	0.0003	ND	ND	ND
Lockers and benches - Change Room #5, "Clean" side	ND	ND	ND	ND
Desk - Laundry Room	0.0002	ND	ND	ND
Desks - Main Control Room, Vapona	0.0005	ND	ND	ND
Refrigerator, microwave oven, tabletop - Main Control Room, Lunch Area, Vapona	ND	ND	ND	ND
Benches - Locker Room Main Control Room, Vapona	0.0004	ND	ND	ND
Gloves - VL 601 Sampling Station, Aldicarb	ND	ND	ND	ND
Control station - Truck Loading, Aldicarb	ND	ND	ND	ND
Desks - Control Room, Aldicarb	0.0003	ND	ND	ND
Refrigerator, microwave oven, tabletop - Control Room Lunch Area Aldicarb	0.0009	ND	ND	ND
Tabletop, GC top, gloves - Laboratory, Aldicarb	ND	ND	0.0005	ND
Desk and window sill - Supervisor's Room, Central Drumming	ND	ND	ND	ND
Empty DBCP drum - Central Drumming	ND	ND	ND	ND
Surge tank, weight scales - Central Drumming	0.0246	ND	ND	ND
Gloves - Phosdrin Unit, Central Drumming	ND	ND	ND	0.0001
Water - Dibrom Unit, Central Drumming	0.0027	ND	ND	ND
Money changer - Main Lunch Room	ND	ND	ND	ND
Coke dispenser - Main Lunch Room	ND	ND	ND	ND
Tabletop - Main Lunch Room	ND	ND	ND	ND
Limits of Detection	$2.2x10^{-4}$mg	$7x10^{-5}$mg	$1.7x10^{-4}$mg	$2.3 x10^{-6}$mg

TABLE IV

DESCRIPTIVE STATISTICS FOR AGE AND LENGTH OF EMPLOYMENT

Variables	PRESENT JOB				DBCP EXPOSURE	
	PROCESS TECHNICIAN n=47	MAINTENANCE TECHNICIAN n=30	MISCEL-LANEOUS n=3	ADMINIS-TRATORS n=18	HIGH EXPOSURE n=42	LOW EXPOSURE n=26
Age (years)						
Mean	26.1	29.8	41.3	38.5	31.1	31.8
Range	20-43	22-56	31-56	25-59	21-46	20-59
Employment at Shell (mos.)						
Mean	30.5	27.1	24.2	44.4	47.1	15.9
Range	0.5-162	1-108	10-52	5-126	7-162	0.5-108
Employment at Present Job (mos.)						
Mean	30.3	20.1	24.0	21.4	42.9	11.9
Range	0.5-162	1-108	10-52	5-48	5-162	0.5-108

TABLE V

MEAN CONCENTRATIONS FOR BLOOD LIPIDS BY DEPARTMENT

	Range of Normal	PRESENT JOB PROCESS (n=44) Mean	MAINTENANCE (n=29) Mean	MISCELLANEOUS (n=3) Mean	ADMINISTRATION (n=18) Mean
Cholesterol	134-263 mg/dl	196.5	181.6	188.1	211.6
Triglycerides	50-252 mg/dl	100.8	83.2	79.0	117.5
High Density Lipoproteins	38-70 mg/dl	53.3	53.2	62.3	53.5
Estimated Low Density Proteins	Less than 185 mg/dl	121.8	111.8	103.6	134.6

TABLE VI
MEAN BLOOD GONADOTROPIN CONCENTRATION

	Range of Normal	DBCP EXPOSURE HIGH (61 men) MEAN	DBCP EXPOSURE LOW (33 men) MEAN
Leutinizing Hormone	0-30 mIU/ml	15.6	14.0
Follicle Stimulating Hormone	5-28 mIU/ml	7.5	6.9
Testosterone	320-1040 ug/dl	638.0	640.5

TABLE VII
DISTRIBUTION OF SPERM DENSITY FOUND IN
NIOSH STUDY OF EMPLOYEES OF SHELL PLANT IN AXIS ALABAMA

Sperm Density Million/ml	Percentage of 42 DBCP Exposed Subjects	Percentage of 26 Non-DBCP Exposed Subjects
0.0-10	14	4
10.1-20	12	8
20.1-40	5	19
40.1-60	12	8
60.1-80	7	12
80.1-100	12	8
Over 100	36	42
Median Sperm Density Million/ml	64	80
Mean Sperm Density Million/ml	84	106
Standard Deviation Million/ml	±80	±92

TABLE VIII

COMPARISON OF SPERM DENSITY DISTRIBUTION OF SHELL AXIS EMPLOYEES
TO SPERM DENSITY DISTRIBUTIONS OF PUBLISHED STUDIES OF FERTILE AND INFERTILE MEN

Sperm Density million/ml	MacLeod, et.al		Rehan, et.al.	Nelson, et.al.	Smith, et.al	Axis Alabama Shell DBCP Exposed Workers	
	Fertile	Infertile	Fertile	Fertile	Fertile	NIOSH Data	Company Data
0.0-10	2	9	2	4.7	9.6	14	10
10.1-20	3	5	5	15.5	9.5	12	7
20.1-40	12	13	16	30.8	20.7	5	27
40.1-60	12	11	18	21.0	15.5	12	17
60.1-80	14	13	21	14.3	12.2	7	17
80.1-100	13	9	13	6.7	9.4	12	7
> 100	44	38	24	7.0	23.1	36	15
Number Subjects	1000	1000	1300	386	2543	42	71
Mean Sperm Density Million/ml	107±74	90±76	79±57	48±40	70±65	84±80	46 (median)

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