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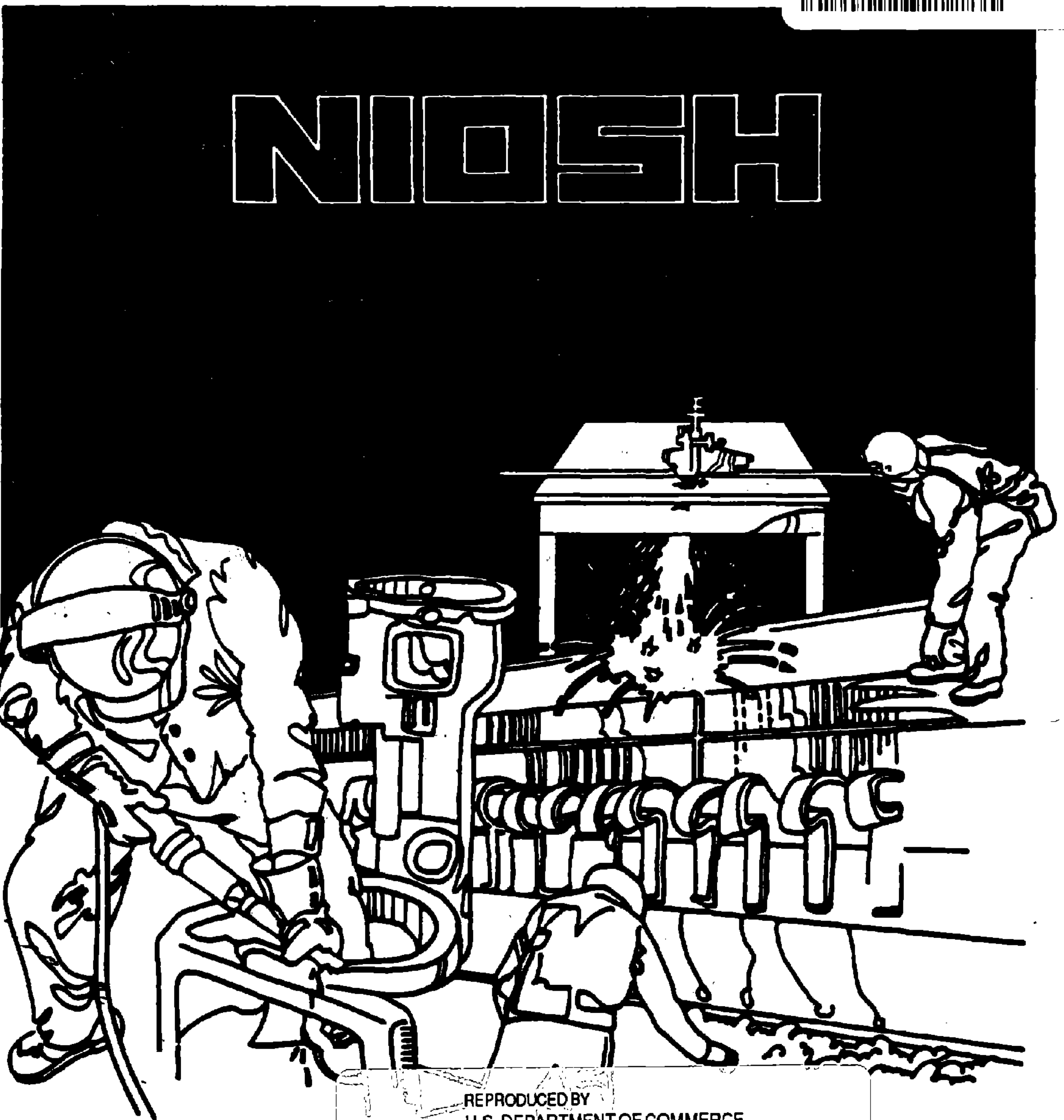




# Health Hazard Evaluation Report

HETA 80-035-1635B
REVISED
BOFORS-NOBEL/LAKEWAY CORPORATION
MUSKEGON, MICHIGAN

# 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.

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BOFORS-NOBEL/LAKEWAY CORPORATION
MUSKEGON, MICHIGAN

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## I. SUMMARY

On October 1, 1979, the National Institute for Occupational Safety and Health (NIOSH) received a request from the International Chemical Workers Union, to evaluate dermatitis and possible reproductive effects among workers exposed to oryzalin at Bofors-Nobel/Lakeway, Muskegon, Michigan. In October 1980 the request was amended to include the evaluation of workers exposed to dichlorobenzidine (DCB) and benzidine.

On November 5, 1980, an initial industrial hygiene and medical survey was conducted. Two personal breathing-zone air samples and three area air samples were obtained to measure occupational exposure to DCB. In the oryzalin operation, five area air samples were taken for dinitrochlorobenzene (DNCB). Sixty-two employees were interviewed regarding medical problems and occupational history. Urine samples were collected from 22 DCB workers, and gauze-patch skin exposure samples were taken from nine workers. No DCB or DNCB was detected in the air samples. Seven of the nine gauze patches had detectable DCB.

On August 17-19, 1982, NIOSH conducted air sampling for oryzalin; air and surface wipe sampling for DNCB; and air, skin, clothing, water, and surface wipe sampling for DCB. Full-shift exposure to airborne oryzalin among six oryzalin workers ranged from non-detectable to 130 ug/$M^3$, with a mean of 28 ug/$M^3$. Air and surface wipe concentrations of DNCB near the perchloroethylene still and packout areas were below the limits of detection (air: 70 ug/$M^3$; surfaces: 6 ug/100 $cm^2$). Personal breathing-zone concentrations of DCB ranged from non-detectable to 6.5 ug/$M^3$, with a mean of 0.9 ug/$M^3$. Full-shift skin exposures ranged from non-detectable to 72 ug/25 $cm^2$, with a mean of 6.3 ug/25 $cm^2$. DCB surface contamination was found in the packout locker room and inside the operator's personal protective equipment.

No adverse reproductive effects were reported by workers exposed to oryzalin. Nineteen (53%) of 36 workers with potential DNCB exposure reported a skin problem, as did eight (31%) of 26 workers without DNCB exposure ($X^2 = 2.14$, $p > 0.1$). Ten cases of bladder cancer were documented, seven by biopsy and three solely by cytology. The mean time from first exposure to benzidine to diagnosis was 13.3 years (range 5.8 - 18.6 years).

In the first survey, 15 (68%) of 22 DCB-exposed workers had detectable urine DCB . During the second survey (following cleanup operations), 10 of 36 DCB-exposed workers (28%) had detectable urine DCB. In both surveys, the highest mean concentrations (136 and 139 ppb, respectively) were in the four centrifuge operators. None of the six unexposed workers in the first or the second survey had detectable urine DCB.

On the basis of the data collected during this investigation, there was a potential hazard from exposure to dichlorobenzidine. Skin problems were common among workers exposed to dinitrochlorobenzene, but not statistically significantly more so than among unexposed workers. The limited number of reproductive events precluded any determination of whether there was a reproductive hazard from exposure to oryzalin.

In November 1982, the company constructed a new DCB packout facility which it believes will minimize workers exposure to DCB. "Best available technology" is said to have been utilized in all phases of isolation, packout, and ventilation. Recommendations regarding other areas of the plant and medical issues are presented in Section VIII of this report.

KEYWORDS: SIC 2865 [Cyclic (Coal Tar) Crudes, and Cyclic Intermediates, Dyes, and Organic Pigments (Lakes and Toners)], SIC 2879 (Pesticides and Agricultural Chemicals, Not Elsewhere Classified), benzidine, dichlorobenzidene, dinitrochlorobenzene, oryzalin, bladder cancer

## II. INTRODUCTION

On October 1, 1979, the International Chemical Workers Union, Local 854, requested NIOSH to evaluate dermatitis and possible reproductive effects among workers exposed to oryzalin [4-(di-n-proplyamine-3,5-dinitro-1-trifluoromethylbenzene] at Bofors-Nobel/Lakeway, Muskegon, Michigan. In October 1980, the request was amended to include an investigation of reported bladder cancer cases among workers throughout the plant.

On November 5, 1980, an initial industrial hygiene and medical survey was conducted. The year's delay was due to a strike from January to August 1980. In February 1981, a second visit was made to collect additional medical information, and in August 1982, a final industrial hygiene and medical survey was conducted.

Interim reports were sent to the union and company in February 1981 and July 1982.

## III. BACKGROUND

The Bofors-Nobel/Lakeway plant includes four operations: the dichlorobenzidine (DCB) operation, the "OK-salt" (the precurser of oryzalin) operation, the oryzalin operation, and the detergent operation. Additional employees work in maintenance, the laboratory, the office, and other miscellaneous functions.

The plant has manufactured several aromatic amine chemicals since it began operation in 1961 with the production of 3,3'-dichlorobenzidine (DCB). DCB is produced by reducing ortho-nitrochlorobenzene to dichlorohydrazobenzene, which is then rearranged to DCB by means of an acid wash.

Production of benzidine began in 1962 and was later changed to hydrazobenzene (the precurser of benzidine), which continued until 1978. The OK-salt and oryzalin operations began in 1978; previously these areas were used in the production of pesticides, primarily organophosphates. Dinitrochlorobenzene (DNCB), an undesired by-product of the OK-salt and oryzalin operations, is formed when monochlorobenzene is treated with a variety of acids.

The detergent operation produces anionic surfactant raw materials and formulates detergent concentrations based on synthetic sulfates/sulfonates.

The company's bladder cancer surveillance program consists of annual physical examinations, urine cytology testing every four months, and annual cystoscopic examinations beginning three years after initial exposure to benzidine or DCB. The company has attempted to contact past employees to include them in the urine cytology surveillance program.

In November 1982, the company constructed a new DCB packout facility, which the company believes will provide the following advantages over the facility evaluated by NIOSH:

- Operator air suit time would be minimized.
- There would be locker room facilities exclusively for packout operations.
- Centrifuging would be accomplished from a control room.
- Better ventilation and ventilation control would be available, and wall, floor, and ceiling surfaces would be easily cleaned.
- Cement block walls would assure containment of fugitive emissions.
- There would be preventive maintenance capability for most operating equipment, without employee exposure to the isolated area environment.
- There would be best available technology applied to all phases of isolation, packout, and ventilation. Some advanced technology has been specifically developed as a result of this new packout facility.

## IV. EVALUATION DESIGN AND METHODS

### A. Environmental

On November 5, 1980, five air samples for DCB were collected in the DCB operation, and five air samples for DNCB were collected in the oryzalin operation. Gauze patches were used to assess DCB skin exposure among nine workers.

On August 17-19, 1982, NIOSH personnel conducted air sampling for oryzalin; air and surface wipe sampling for DNCB; and air, skin, clothing, water, and surface wipe sampling for DCB.

#### 1. Oryzalin

In August 1982, six personal breathing-zone (PBZ) samples for oryzalin were collected from oryzalin workers. Each sample was drawn at 0.2 liters per minute (Lpm) through a 13-mm glass-fiber filter backed by a tube containing XAD-2 sorbent. The filters and the sorbent were each extracted with 1 milliliter (ml) of 50%/50% acetonitrile/heptane sulfonic acid solution aided by sonication. Analysis was by high pressure liquid chromatography (HPLC), using a RCM $C_{18}$ and a 50%/50% acetonitrile/heptane sulfonic acid solution at 2 ml/minute. The eluate was monitored at 214 um and 254 um by ultraviolet detectors in series.

2. Dinitrochlorobenzene

In August 1982, four area air samples for DNCB were collected near the perchloroethylene still and packout areas. Samples were drawn at a flow rate of 0.2 Lpm through a 13-mm glass-fiber filter followed by a large (200/100 mg) XAD-2 sorbent tube. The surface wipe samples were collected on Whatman smear tabs moistened with cyclohexane. All three media were desorbed with 2% isopropanol in carbon disulfide spiked with 0.1% nitrobenzene as an internal standard. The filter and sorbent media were desorbed with 1 ml, and the smear tabs were desorbed with 2 ml. Analysis was by gas chromatography (FID), using a 30-meter DB-1 bonded-phase fused-silica capillary column in splitless mode.

3. Dichlorobenzidine

a. Air

In August 1982, 18 full-shift PBZ samples for DCB were collected from all DCB production workers and mechanics on three of the four shifts. Six PBZ samples were collected from laboratory technicians who worked with DCB. Each air sample was drawn at a flow rate of 0.2 Lpm through a glass-fiber filter connected in series to a silica-gel sorbent tube. The filter samples were desorbed with 0.5 ml of 0.17% triethylamine in methanol. Following sonication and at least one hour of standing, each sample was filtered and stored under refrigeration prior to analysis by HPLC (NIOSH P&CAM 246).[1] Samples with less than 50 nanograms (ng) of DCB [the instrumental limit of detection (LOD) via spectrophotometry] were re-run using amperometry, which has an LOD of 5 ng/sample.

A recovery study was conducted by spiking glass-fiber filters with five different known amounts of DCB and treating these in the same manner as samples. Also, a longevity study was undertaken to determine the storage stability of DCB when kept at -14°C on glass-fiber filters for one hour, one day, one week, and one month.

The silica-gel tubes were prepared for analysis by desorbing the entire contents of each tube in 0.5 ml of a solution of 0.17% triethylamine in methanol for eight hours with intermittent shaking. The resulting samples were decanted before analysis by HPLC.

b. Skin

To assess skin exposure to DCB during the first survey, gauze patches with a surface area of about 25 $cm^2$ and no impermeable backing were taped to the ventral surface of the forearm of workers. During the follow-up survey, patches with an aluminum-foil backing were used for more complete assessment of exposure. Gauze patches were analyzed by the same contract laboratory as the environmental samples. Each sample was desorbed with 10 ml of triethylamine-buffered methanol. Following sonication, and an hour allowance for standing to enhance desorption, samples were filtered through 0.45 um filters and analyzed by HPLC.

c. Surfaces

Wipe samples for DCB were collected from various surfaces from the work areas, break room, laundry room, locker room, and from inside personal protective clothing and equipment. The samples were collected on Whatman smear tabs moistened with cyclohexane and were analyzed by HPLC following desorption with 2 ml of 0.17% triethylamine in methanol.

d. Water

Some of the water wells near the Bofors-Nobel/Lakeway plant have been shown to be contaminated with DCB. Since that discovery, the company has brought in bottled water for drinking but was still using water from one of the "clean" wells for showering. NIOSH personnel collected a water sample from the showers in order to check for DCB contamination. The sample was analysed for DCB according to EPA Method 605[2] employing HPLC equipped with an amperometric detector.

B. Medical

1. Interviews and Medical Records

NIOSH personnel administered a questionnaire addressing dermatological problems, urinary tract problems, reproductive history, smoking history, and occupational history. Medical records relevant to the bladder cancer surveillance program were reviewed.

2. Urine DCB Samples

During the first survey, urine samples were collected at the end of a three-day shift from workers exposed to DCB. During the follow-up survey, baseline urine samples were collected from all workers at the start of a three-day shift. End-of-shift urine samples were collected after one, two, or three days of exposure. Samples were collected from unexposed workers during both surveys.

DCB was extracted from the urine samples utilizing the techniques of Nony and Bowman,[3] modified by the addition of a Florisil column cleanup, and quantitated by electron capture-detector-gas-liquid chromatography utilizing a 15-meter WCOT SE-54 capillary column. The limit of quantitation was 10 ppb. Quality control procedures indicated that a reported DCB concentration may have a precision error of up to 22%.

## 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 by the 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), and 3) the U.S. Department of Labor (OSHA) occupational health standards. 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.

B. Specific Substances

1. Oryzalin

Oryzalin is an herbicide considered, on the basis of animal exposure studies, unlikely to have acute toxic effects in humans.[4] A NIOSH investigation of a cluster of congenital heart malformations among children born to wives of workers at a plant that produced oryzalin was inconclusive as to whether the malformations were associated with paternal exposure to oryzalin.[5] There is no OSHA standard or other authoritative recommendation for an occupational exposure limit.

2. Dinitrochlorobenzene

DNCB is a potent skin sensitizer; it is used in dermatologic research for that purpose.[6] There is no OSHA standard or other authoritative recommendation for an occupational exposure limit. Considering its potency as a skin sensitizer, however, direct contact with DNCB should be avoided.

3. Benzidine and Dichlorobenzidine[7,8]

Benzidine and DCB are primary aromatic amines used in the production of dyes and pigments. DCB is a well-documented animal carcinogen, and benzidine has been associated with bladder cancer in humans. Since benzidine and DCB are often produced together, DCB may have been contributed to the association between benzidine and bladder cancer. Primary aromatic amines can also cause irritant dermatitis. OSHA requires a variety of engineering controls, work practices, and personal protective equipment to minimize exposure to benzidine[9] and DCB.[10]

## VI. RESULTS AND DISCUSSION

### A. Oryzalin

1. Environmental

During the first survey, visible accumulations of OK-salt were seen in the vicinity of the centrifuge in Building 3. Similar accumulations of oryzalin were present in the centrifuge and drumming areas of Bldg. 5. Air-purifying respirators were being used in the drumming area of Building 5. That area and the oryzalin centrifuging area were painted an orange color identical to that of oryzalin.

During the second survey, four of six air samples from oryzalin workers had detectable levels of oryzalin, ranging up to 130 $ug/m^3$ (Table 1).

2. Medical

All pregnancies of spouses prior to November 1980 reported by workers exposed to oryzalin (OK-salt department, oryzalin department, maintenance, and laboratory workers) resulted in normal births with no reported birth defects. No miscarriages or stillbirths were reported.

B. Dinitrochlorobenzene

1. Environmental

During the first survey, none of the five air samples from the OK-salt and oryzalin areas (Table 2) had detectable DNCB (limit of detection: 70 $ug/M^3$). Samples were taken during plow-down and drumming in the OK-salt operation, and during drumming in the oryzalin operation. During the follow-up survey, no detectable airborne DNCB was found near the perchloroethylene still or in the packout areas (Table 3). Also, no DNCB was found on wipe samples (limit of detection: 6 $ug/100\ cm^2$), except for the top of a visibly contaminated storage drum which had 1800 $ug/100\ cm^2$.

2. Medical

Table 4 presents the departmental distribution of workers interviewed during the first survey who reported having a skin disorder which first appeared since the start of oryzalin production in October 1978. The prevalence seems greater in the departments associated with DNCB exposure (OK-salt, oryzalin, laboratory, and maintenance), but the difference is not statistically signficant.

C. Dichlorobenzidine

1. Environmental

During the first survey, none of the five air samples had detectable DCB (limit of detection: 10 $ug/M^3$) (Table 2). No air samples were taken in the centrifuge tower, however, and air samples were taken in only one of the four work areas with potential exposure to DCB.

During the second survey personal breathing-zone air concentrations of DCB ranged from non-detectable (< 0.05 $ug/M^3$) to 6.5 $ug/M^3$ among the 24 workers who were sampled. The most highly exposed groups of workers were the centrifuge/packout operators and general helpers, who had a mean DCB exposure of 3 $ug/M^3$ (Table 5). The mean personal breathing zone DCB exposure among all other DCB workers was 0.2 $ug/M^3$.

The DCB recovery study yielded an average desorption efficiency of 52%. However, the longevity study gave recovery data that indicated little, if any, sample instability over the period of study, either at high or low concentrations (Table 6). The average overall recovery was 100%.

These results contradict previous findings from the DCB recovery study, which inferred that the analyte was not effectively being desorbed from the filter medium. Possible degradation or conversion to other species prior to analysis could have occurred. The previous work showed an occasional double peak in the chromatograms, but only one peak was apparent on the chromatograms throughout this study. The data thus indicate that with proper storage, samples do not undergo significant conversion to other forms, nor should desorption efficiencies vary significantly from 100 percent. Why much lower values were recorded in previous analyses remains an unanswered question in that the same filter medium was used and the desorption procedure was identical. This study appears to reinforce the reliability of the analytical procedure (NIOSH P&CAM 246[1]).

No DCB was detected on any of the silica-gel sorbent samples, but the desorption efficiency was only 40%. There was also extensive interference arising from the silica-gel matrix; this prevented the use of an amperometric detector. Therefore, the limit of detection for DCB vapor was about 1 ug/$M^3$ for most of the air samples.

2. Skin Exposure Sampling

During the first survey (Table 7) seven of the nine skin gauze exposure samples showed detectable DCB (limit of detection: 1 ug DCB per 25 $cm^2$ of gauze), ranging up to 29 ug/25 $cm^2$. The highest median value was seen in DCB centrifuge workers (15.9 ug/25 $cm^2$). Neither of the two control samples had detectable DCB.

During the follow-up survey (Table 5), forearm skin exposure samples for DCB centrifuge/packout workers revealed DCB levels of 4.6 - 72.0 ug/25 $cm^2$. The highest levels were in DCB centrifuge/packout operators.

3. Wipe Samples

During the follow-up survey, wipe samples for DCB on inside surfaces of personal protective equipment indicated contamination, with levels of 1.2, 1.7, and 8.5 ug/100 $cm^2$ (limit of detection: 0.2 ug/100 $cm^2$ (Table 8).

4. Water Sampling

DCB was not detected (limit of detection: 0.2 ug/liter) in the water sample. However, the EPA method requires that samples be extracted within seven days of collection and analyzed within 30 days. In this case, unfortunately, more than 40 days had elapsed before the sample was prepared and analyzed. Thus, the result cannot be considered reliable.

5. Medical:

Of the 22 employees tested during the first survey who had potential exposure to DCB (DCB centrifuge, DCB plant and acid recovery, maintenance, and laboratory), 15 (68%) had detectable DCB in their urine (limit of detection: 10 ppb) (Table 7). Concentrations ranged up to 296 ppb. None of the six unexposed workers in the oryzalin plant had detectable DCB. All had previously worked in the DCB plant; the individual with the most recent exposure had last worked in the DCB plant 18 months previously. DCB centrifuge workers had a mean of 136 ppb, 2 1/2 to 3 times the means of the other areas. Three of the four centrifuge operators, representing all shifts, had detectable DCB. The DCB centrifuge workers were using air-supplied hoods and wearing all OSHA-required personal protective equipment (boots, rubber suit, gloves, etc.) for carcinogen exposure.

During the follow-up survey of the 37 workers with potential exposure to DCB, 35 (95%) provided a pre-shift urine specimen, and 36 (97%) provided a post-shift specimen. All pre-shift urine DCB concentrations were less than the limit of detection (10 ppb). Ten (28%) of the post-shift specimens had detectable DCB (Table 5). The highest DCB concentrations were again found in the four DCB centrifuge/packout workers (mean: 139 ppb, range 10-340 ppb). Three of four general helpers (who assist centrifuge workers during packout) had detectable DCB (mean: 62 ppb, range: <10 - 141 ppb). Two of 12 DCB tankmen (rotating daily among hydgogenator, precipitator, and conversion) had detectable DCB, 10 and 17 ppb. One of four mechanics had detectable DCB, 19 ppb. None of the seven laboratory technicians, three acid recovery workers, or two warehouse workers tested had detectable urine DCB. Of the 10 urine samples collected from presumably unexposed workers (nine from the oryzalin plant and one from the office), one had detectable DCB, 10 ppb.

D. Benzidene

Medical records from all six urologists who had provided annual bladder cancer screening, follow-up, or treatment for 66 workers were reviewed. Urine cytology records for 58 workers were collected from a local pathologist. Ten cases of bladder cancer were identified. One additional bladder tumor was reported during an interview, but the individual did not give permission to review his medical records. Also, the NIOSH medical investigator heard of a twelfth case, but the individual declined to be interviewed. Of the 10 documented cases, seven were confirmed by biopsy, and three were diagnosed solely by cytology. In two of the cases confirmed by biopsy, cytology was positive 11 - 20 months prior to detection by biopsy. The mean age of the 10 cases was 45 years, with a range of 32 - 57 years. The mean time from first exposure to benzidene to diagnosis was 13.3 years, with a range of 5.8 - 18.6 years. No individual reported occupational exposure to dyes prior to employment at Bofors-Nobel/Lakeway.

VII. CONCLUSIONS

DCB was found in the urine of 68% of the DCB-exposed workers tested in the first survey. The proportion decreased to 28% in the second survey, which followed cleanup operations. Based on the universally negative pre-shift urine samples during the second survey, this exposure appears to represent exposure during the same workday. Skin problems were common among workers exposed to dinitrochlorobenzene, but not statistically significantly more so than among unexposed workers. The limited number of reproductive events precluded any determination of whether there was a reproductive hazard from exposure to oryzalin.

VIII. RECOMMENDATIONS

1. A daily cleaning regimen should be established in the vicinity of the OK-salt centrifuge in Building 3. Cleaning should be done by wet methods or with a vacuum machine equipped with high efficiency filters. Likewise, a similar cleaning regimen should be instituted in the centrifuge and drumming areas for oryzalin in Building 5.

2. To aid in housekeeping procedures, the areas where OK-salt and oryzalin accumulate should be painted with a color that does not mask the contaminant.

3. The production process for oryzalin should be carefully reviewed to determine if there is any alternative procedure which would decrease production of DNCB.

4. If any worker is diagnosed as having allergic contact dermatitis due to DNCB, that worker should be removed to a job involving no exposure to DNCB.

5. The medical surveillance program should be explained to all workers, and workers should be informed of all medical test results, their interpretation, and what action should be taken concerning abnormal or suspicious test results.

6. The bladder cancer screening program should continue to be available to all current and former workers who were potentially exposed to benzidine or other bladder carcinogens. All such workers should be informed of their increased risk of bladder cancer. They should be advised that this increased risk continues after assignment to a different job or termination of employment, even though exposure has ceased, and that they should continued indefinitely to have periodic screening. The screening program should actively maintain contact with eligible workers; former employees, especially, are more likely to participate if given pertinent, understandable information and timely reminders.

7. Urine cytology is the best available screening test for bladder cancer. Each screening session should ideally include three separate urine specimens. Semi-annual screening is preferable to annual screening in that it provides a margin of safety in case all three specimens are not obtained at each session. (For workers no longer at the plant or near the screening site, collecting two specimens a few hours apart may be more practical than collecting specimens on two or three different days.)

8. In addition to urine cytology, each screening session should include (a) an inquiry about urinary tract symptoms, and (b) a routine microscopic examination of blood for red blood cells.

9. Anyone with urinary tract symptoms, microhemoturia, (red blood cells in the urine), or non-negative cytology should have further medical evaluation. This might include repetition of the screening tests, additional diagnostic tests or procedures, and/or observation of the effect of treatment or time. Not all symptoms or test abnormalities are due to bladder cancer, and invasive diagnostic procedures are not always necessary. Since the screening program participants are presumably at increased risk of bladder cancer, however, invasive procedures, such as cystoscopy, are appropriate when cytologic abnormalities, microhematuria, or urinary tract symptoms are not otherwise readily explained.

10. Cystoscopy should not be done as a routine screening procedure on persons without symptoms or other findings suggestive of a consequential, persistent urinary tract disorder. Cystoscopy is an uncomfortable, invasive procedure with risks of injury, infection, and adverse reactions to the anesthetic or accompanying medications. Fewer persons will experience the untoward side effects and complications of cystoscopy (or any other procedure),

and the risks are justifiable, when the procedure is done on patients selected for medical reasons (symptoms, microhematuria, or non-negative cytologic findings) rather than on large numbers of asymptomatic persons in a screening program. Omission of routine cystoscopy does not compromise the effectiveness of the screening program, since cytology detects asymptomatic bladder cancer earlier in the course of disease.[11,12]

11. Since DCB is not known to be a human bladder carcinogen, it is debatable whether workers exposed to DCB but not other aromatic amines should be included in a bladder cancer screening program. Certainly, we would not recommend including such workers in a screening program that includes an invasive procedure, such as cystoscopy, on a routine basis. Since it is a reasonable possibility, however, that DCB <u>might</u> be a human bladder carcinogen, it would be acceptable to include such workers in a screening program that does not include such procedures routinely.

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## X. AUTHORSHIP AND ACKNOWLEDGEMENTS


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## XI. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. International Chemical Workers Union, Local 854
2. Bofors-Nobel/Lakeway, Inc.
3. NIOSH - Region V
4. OSHA - Region V

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 1

NIOSH RESULTS OF PERSONAL BREATHING-ZONE AIR
SAMPLES FOR ORYZALIN

BOFORS-NOBEL/LAKEWAY CORPORATION
MUSKEGON, MICHIGAN
HETA 80-035

AUGUST 18-19, 1982

| Job/Location | Sampling Period | Concentration (ug/m$^3$) |
|---|---|---|
| Centrifuge Packout | 11:00 - 18:36 | 14 |
| Centrifuge Packout | 7:53 - 17:32 | 130 |
| Aminator | 12:56 - 18:35 | N.D.* |
| Aminator | 7:57 - 17:23 | 1.8 |
| Amidator | 13:00 - 18:45 | N.D. |
| Amidator | 7:59 - 17:26 | 20 |

*N.D. = None detected; limit of detection: 0.1 ug/M$^3$

TABLE 2

AIR SAMPLING RESULTS

BOFORS-NOBEL/LAKEWAY CORPORATION
MUSKEGON, MICHIGAN
HETA 80-035

NOVEMBER 1980

Dinitrochlorobenzene (DNCB)

| Area | Operation | Sampling Period (Min.) | Concentration |
|---|---|---|---|
| OK-Salt centrifuge | Plow-down | 60 | N.D.* |
| OK-Salt centrifuge | Drumming | 55 | N.D. |
| Still bottom | Drumming | 12 | N.D. |
| Desk near OK-salt centrifuge | Plow-down & drumming | 66 | N.D. |
| Oryzalin | Drumming | 43 | N.D. |

3,3'-Dicholorobenzidene (DCB)

| | Sampling Period (Min.) | Concentration |
|---|---|---|
| Area Samples | | |
| First floor near packout tower door | 555 | N.D.** |
| Manway of precipitator #403 | 553 | N.D. |
| Conversion Tank #300 | 553 | N.D. |
| Personal Samples | | |
| General helper | 570 | N.D. |
| Hydrogen helper | 562 | N.D. |

*N.D. = None detected; limit of detection for DNCB: 70 ug/$M^3$)
**Limit of detection for DCB: 10 ug/$M^3$

TABLE 3

NIOSH RESULTS OF AREA AIR SAMPLES AND
SURFACE WIPE SAMPLES FOR DINITROCHLOROBENZENE

BOFORS-NOBEL/LAKEWAY CORPORATION
MUSKEGON, MICHIGAN
HETA 80-035

AUGUST 18-19, 1982

| Location | Sample Type | Sampling Period | Concentration |
|---|---|---|---|
| Perchloroethylene still, Building 3 | Air | 11:15 - 18:50 | N.D.* |
| OK salt | Air | 12:05 - 18:54 | N.D. |
| Packout area | | | |
| Building 5, 2nd floor packout, attached to control panel | Air | 8:05 - 17:35 | N.D. |
| Building 3 ladder | Air | 8:09 - 17:32 | N.D. |
| Desk near packout | Wipe | - | N.D.** |
| Top of storage | Wipe | - | 1800 ug/100 $cm^2$ |

*N.D. = None Detected (< 70 ug/$m^3$)
**N.D. = None Detected (< 6 ug/100 $cm^2$)

TABLE 4

PREVALENCE OF SKIN PROBLEMS SINCE OCTOBER 1978

BOFORS-NOBEL/LAKEWAY CORPORATION,
MUSKEGON, MICHIGAN
HETA 80-035

NOVEMBER 1980

| Current Department | Number Interviewed | Number and (%) With Skin Problems |
|---|---|---|
| Potential DNCB esposure | | |
| OK-salt | 8 | 5 (63) |
| Oryzalin | 12 | 6 (50) |
| Maintenance | 10 | 6 (60) |
| Laboratory | 6 | 2 (33) |
| Total | 36 | 19 (53)* |
| No DNCB exposure | | |
| Detergent | 7 | 3 (43) |
| DCB | 16 | 3 (19) |
| Acid | 3 | 2 (67) |
| Total | 26 | 8 (31)* |

* $X^2 = 2.14$, $p > 0.1$

TABLE 5

DCB EXPOSURE

BOFORS-NOBEL/LAKEWAY CORPORATION
MUSKEGON, MICHIGAN
HETA 80-035

AUGUST 17-19, 1982

| | Air[1] | | Skin[2] | | Urine[3] | |
|---|---|---|---|---|---|---|
| | No. Samples | Mean (ug/M$^3$) | No. Positive/ No. Samples | Median (ug/25cm$^2$) | No. Samples | Mean (ppb) |
| xposed Workers | | | | | | |
| CB centrifuge area | | | | | | |
| Operators | 3 | 3.1 | 4/4 | 13.5 | 4 | 139 |
| General helpers | 3 | 3.0 | 4/4 | 3.0 | 4 | 62 |
| B production area | | | | | | |
| Maintenance | 3 | <0.6 | 3/4 | 5.4 | 4 | 10 |
| Tankmen | 9 | <0.05 | <8/11 | 1.3 | 12 | 10 |
| utside DCB area | | | | | | |
| DCB acid plant and warehouse | 0 | -- | 2/3 | 0.3 | 5 | * |
| Laboratory | 6 | 0.05 | 3/6 | <0.2 | 7 | * |
| nexposed workers | 0 | -- | 0/2 | ** | 6 | * |

-- Limit of detection: 0.05 ug/m$^3$
-- Limit of detection: 0.2 ug/25 cm$^2$
-- Limit of detection: 10 ppb
-- Less than 10 ppb in all samples
-- Less than 0.2 ug/25 cm$^2$ in both samples

# TABLE 6

## % RECOVERY OF 3,3'-DCB ON GLASS FIBER FILTERS

BOFORS-NOBEL/LAKEWAY CORPORATION
MUSKEGON, MICHIGAN
HETA 80-035

| Set # | Approximate Storage Time (hours) | Concentration Level (ng/ml) | Number of Determinations | % Recovery | S.D.* (%) |
|---|---|---|---|---|---|
| I | 1 | 204 | 12 | 98 | 7 |
| | 1 | 4085 | 12 | 101 | 3 |
| II | 21 | 204 | 11 | 101 | 10 |
| | 21 | 4085 | 12 | 100 | 2 |
| III | 163 | 204 | 10 | 103 | 7 |
| | 163 | 4085 | 12 | 100 | 3 |
| IV | 716 | 204 | 12 | 103 | 4 |
| | 716 | 4085 | 12 | 99 | 2 |

*S.D. = Standard deviation

TABLE 7

DCB EXPOSURE

BOFORS-NOBEL/LAKEWAY CORPORATION
MUSKEGON, MICHIGAN
HETA 80-035

NOVEMBER 1980

| | Urine | | Air | | Skin | |
|---|---|---|---|---|---|---|
| | No. Samples | Mean (ppb) | No. Samples | Amount | No. positive/ No. samples | Median ($ug/25\ cm^2$) |
| Exposed Workers | | | | | | |
| Laboratory | 2 | 41 | 0 | -- | 1/1 | 1.4 |
| Maintenance | 5 | 45 | 0 | -- | --- | -- |
| DCB plant & acid recovery | 11 | 51 | 5 | N.D.[1] | 4/6 | 8.1 |
| DCB centrifuge | 4 | 136 | 0 | -- | 2/2 | 15.9 |
| Unexposed workers | | | | | | |
| Oryzalin plant | 6 | N.D.[2] | 0 | -- | 0/2 | N.D.[3] |

1 -- N.D. means none detected; limit of detection: 0.05 $ug/m^3$
2 -- less than 10 ppb
3 -- limit of detection: 0.2 $ug/25\ cm^2$

TABLE 8

NIOSH RESULTS OF SURFACE WIPE
SAMPLES FOR 3,3'- DICHLOROBENZIDINE

BOFOR-NOBEL/LAKEWAY CORPORATION
HETA 80-035

AUGUST 17-19, 1982

| Location | Concentration (ug/100 $cm^2$) |
|---|---|
| Laboratory sink | 0.5 |
| Break room | N.D.* |
| Break room, soda machine | N.D |
| Break room, doorway floor | 1.7 |
| Conversion tank operator, palm of left glove | 0.2 |
| Conversion tank operator, palm of left hand | N.D |
| Building #1, laundry room table top | N.D |
| Packout tower operator, inside back of top half of rubber suit | 8.5 |
| Packout tower operator, inside back of bottom half of rubber suit | 1.2 |
| Packout tower operator, inside air helmet | 1.7 |
| Packout locker room bench | 28 |
| Packout locker room wall | 1.0 |

*N.D. = None detected; limit of detection: 0.2 ug/100 $cm^2$