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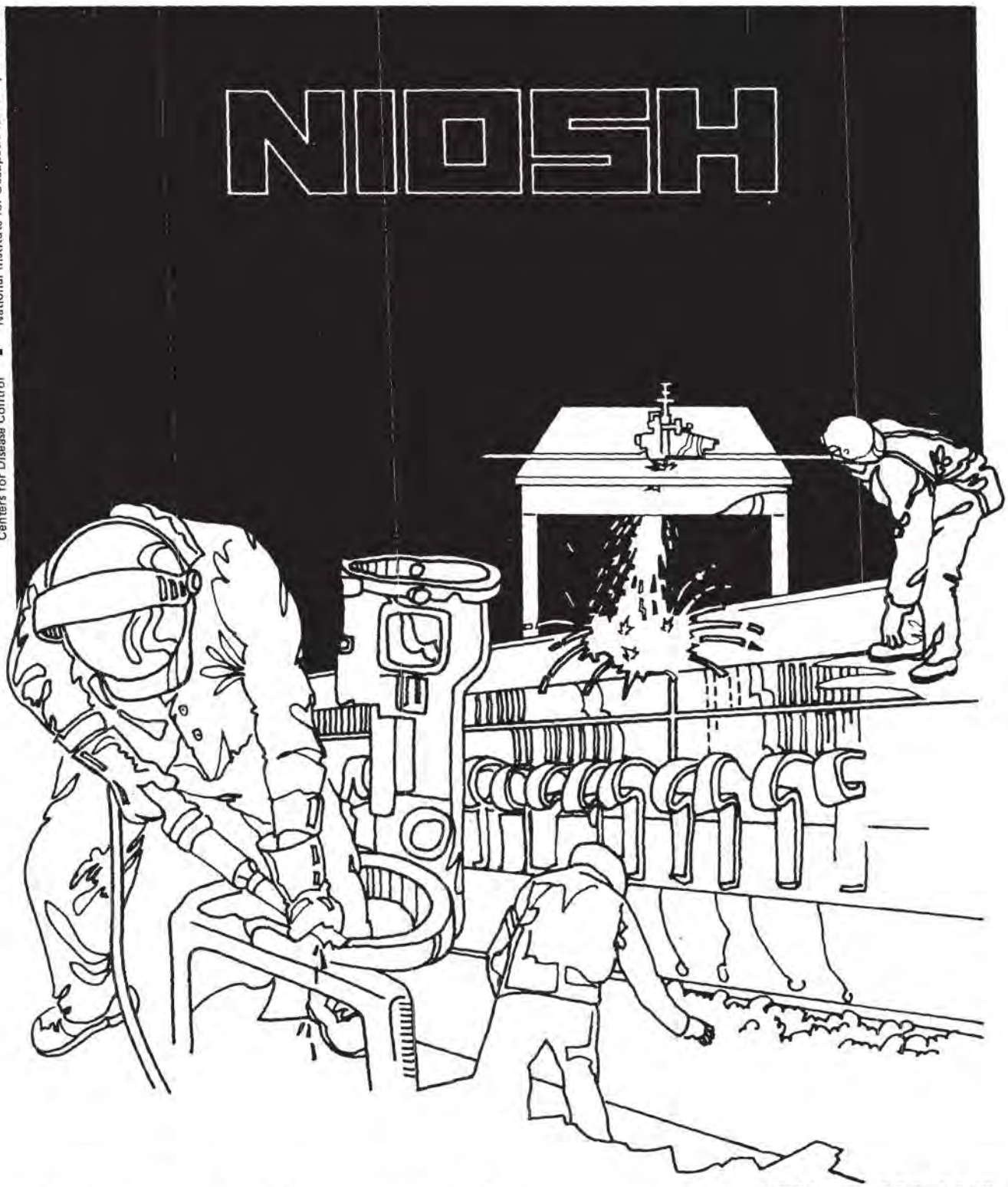

Health Hazard Evaluation Report

HETA 81-125-1029
DHHS
WASHINGTON, D.C.

HETA 81-352-1029
IBM
LEXINGTON, KENTUCKY
GAITHERSBURG, MARYLAND

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.

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

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I. SUMMARY

In December 1980 the National Institute for Occupational Safety and Health (NIOSH) received a request from the Director of the Office of Safety and Occupational Health of the Department of Health and Human Services (HHS) to determine whether HHS should install further International Business Machines (IBM) 3800 Printing Subsystems based on occupational health considerations. The 3800 Printing Subsystem contained gram quantities of the substance trinitrofluoreneone (TNF), an electrically active material used in the photoconductor of transfer process electrostatic printers and copiers. TNF is mutagenic in microbial and mammalian cell culture test systems and is associated with tumors in rats and mice.

With the cooperation of IBM, NIOSH conducted monitoring for TNF release from 3800 and Copier II systems at IBM facilities in Gaithersburg, Maryland, on May 19, 1981 and June 11, 1981. Medical records were reviewed and air samples collected at IBM photoconductor production facilities in Lexington, Kentucky on June 9, 1981 and June 25, 1981. Further sampling was conducted at the National Institutes for Health, Bethesda, Maryland and the National Library of Medicine, Bethesda, Maryland on June 10, 1981 and the Parklawn Computer Center, Rockville, Maryland on June 26, 1981.

Forty-four air samples, 17 swipe samples, and 3 bulk samples were collected between May 19, 1981 and June 18, 1981 and analyzed for TNF. One air sample at the IBM photoconductor manufacturing facility contained 1.8 ug/M^3 of TNF. No airborne TNF was detected in 39 samples collected in the vicinity of IBM 3800 Printer and Copier II products. Six of 17 swipe samples taken at the site of a spent toners spill and on interior surfaces of the 3800 and Copier II products contained detectable TNF up to 193 ng/in^2.

No remarkable patterns of medical outcomes or of laboratory value abnormalities were discerned from review of IBM medical records.

Based on the medical and industrial hygiene information collected, NIOSH has determined that there is no health hazard to operators during routine use of the IBM 3800 Printing Subsystem and Copier II Systems from exposure to TNF. Recommendations for wear of polyethylene or polyethylene lined protective gloves when working with TNF are given on page 11.

KEYWORDS: SIC 9431, Trinitrofluoreneone (TNF), IBM 3800 Printing Subsystems, IBM Copier II, (Administration of Public Health Programs).

II. INTRODUCTION

A. IBM

In April 1980 International Business Machines (IBM) submitted information to the U.S. Environmental Protection Agency under the Toxic Substance Control Act which suggested that the substance 2,4,7-trinitro-fluorene-9-one (TNF) was mutagenic in microbial and mammalian cell culture test systems and was associated with tumors in rats and mice.[1] TNF is a photoelectrically active material used in the charge transfer processes of electrostatic photocopiers. While TNF is used in a number of IBM products including the IBM 3896 Tape-Document converter and the Model 6800 copier, the most numerous products are the IBM 3800 laser printer and IBM Copier II (Model 6801). There were approximately 60,000 of these TNF containing models in use as of the end of 1979.[2]

B. Department of Health and Human Services

In December 1980, the Director of the Office of Safety and Occupational Health of the Department of Health and Human Services (HHS) requested that the National Institute for Occupational Safety and Health (NIOSH) determine whether HHS should install further IBM 3800 Printing Subsystems based on health considerations. It was also requested that NIOSH determine whether control measures or procedures more stringent than those recommended by IBM (operator training during installation, operator adherence to established procedures, removal of spent photoconductor material containing TNF by IBM personnel, operation of copying systems with the covers closed to prevent airflow disruption within the units, and provision of general ventilation in the copier area) were necessary to reduce the risk of already installed equipment to acceptable levels.[3,4]

An interim response based on a literature review was furnished on February 13, 1981.[5] It cited a memorandum prepared by the Chief of the Experimental Toxicology Branch of the NIOSH Division of Biomedical and Behavorial Sciences which stated that TNF should be considered a mutagen and a potential human carcinogen and exposure minimized.[6] A National Institute of Health Memorandum[7] was reviewed which suggested that NIH employees not be involved in any servicing of the IBM equipment, including removal of the bags containing spent toner, until instruction in proper methods was provided. Further comment was reserved until field data could be obtained.

C. NIOSH Actions

Since an estimated population of more than 50,000 workers, including all users of IBM 3800 laser printers and Copier II products, were

potentially at risk, a NIOSH Current Intelligence Bulletin was contemplated. Work had begun on this document in 1980. At that time, IBM had conducted the only available TNF exposure studies, but there were no measurements of user exposure to TNF in operational office and computer center installations. A NIOSH field study was planned but was delayed until May 1981, when the development of an analytical method for industrial hygiene sampling of TNF was completed.

III. BACKGROUND

A. The Use of TNF in the Transfer Photocopy Process

IBM is the major user of TNF in photocopiers and printers.[8] TNF is the photoelectrically active ingredient of the coating mixture which is deposited on the photoconductor film on the exterior of the printing drum in transfer process copiers and printers. The transfer electrostatic photocopy process involves the charging and exposure of a light-effected photoconductor, the developing and transfer of the image, and the fusing of the image to the paper. It is the photoconductor which contains the charge-transfer complex composed of a TNF and polyvinyl carbazole resin coating on an aluminized Mylar^{R} sheet. The total TNF content of the film roll is either 50 or 511 grams.[2] Used photoconductors are collected for disposal as part of the normal IBM replacement procedure.[3]

B. The Relationship of TNF to Toner

The TNF containing surface comes in direct contact with toner during image development. Having formed an electrostatic image on the photoconductor surface, a carrier of plastic coated beads brings the toner into contact with the photoconductor. Toner clings to the charged areas forming a visible image. The image is transfered to the paper electrostatically by bringing the paper into contact with the photoconductor. The image is fused to the paper with heat. The spent toner is scavenged by a closed loop air circulation/filtration system inside the copier and deposited in a filter bag.

C. Description of the Copying and Printing Systems Surveyed

The IBM Copier II is a console electrostatic dry copier 41 inches in length, 28 inches in width and 43 inches in height. It produces 11-inch and 14-inch legal size copy. The photoconductor is located in the lower part of the console near its centerline beneath the equipment case. The spent toner collector bag is located in the upper left hand quadrant. The vacuum system is located in the right hand side panel as the operator faces the copier.

The IBM 3800 is a high speed, non-impact printing subsystem that

consists of an electronic control component, a process assembly which contains the photoconductor drum, a transport assembly where the toner is fused to the paper, and an optional burster-trimmer stacker module. It is approximately 200 inches long, 60 inches high, and 32 inches in depth. The vacuum cleaner outlet, which is operated by both the IBM customer engineer and the operator to control toner and paper debris within the machine, is located in the rear of the 3800 in the transport assembly. The spent toner collector bag and paper/toner cutting cyclone is located in the rear of the 3800 in the process assembly.

D. The Manufacture of Organic Photoconductor

Organic photoconductor (OPC) containing TNF is manufactured at the IBM facility in Lexington, Kentucky. TNF is received as a powder in 30 pound plastic bags inside a fiber drum. The TNF is combined with tetrahydrofuran and polyvinyl carbazole in a mixing vat. In this process, each 30 pound bag of TNF is used in toto, such that there are no partial bags of TNF and there is no occasion to need to re-seal a bag; there is no weighing or preliminary handling or manipulation of TNF; and there are no buckets, scoops, shovels or similar implements involved in the transfer of TNF to the mixing vat. The charging port of the mixing vessels is provided with a local exhaust system. The resulting liquid mixture is pumped in a closed system to the coater. A mylar film is coated with the liquid mix as it is fed through the equipment.

The coated mylar passes through a drying oven and is taken up on a reel as it exits from the oven. The finished product is split into two different widths. The OPC used in the Copier II receives an additional coat of acrylic. Both widths are then fed to a cutter that cuts the roll of finished OPC into appropriate lengths. The finished reel is individually packaged for shipment.[9]

E. Reconditioning of Copier I and II Equipment

All Copier I and II reconditioning is done in Lexington. When a copier arrives at the plant for reconditioning, its covers are removed on the loading dock. The copier is then moved to a room where the developer, used OPC, spent toner collection bag, and drum are removed. Local exhaust ventilation is provided for OPC operations. Workers wear gloves and company furnished workclothes.[9]

IV. METHODS

A. Analytical

There is no validated analytical method for TNF. IBM has used a variety of collection and analytical methods to measure TNF exposure

in its Lexington plant between 1969 and 1981.[10] Two additional efforts to quantify TNF in industrial hygiene samples have been identified.[11,12]

NIOSH initiated an analytical method development for TNF in late 1980.[13] In the draft method, TNF is collected on polytetrafluoroethylene filters at a flow rate of 2 liters per minute. Analysis is accomplished by normal phase liquid chromatography with UV Detection.[14]

B. Industrial Hygiene

At the beginning of this study, the major point of operator contact with TNF was believed to be spent toner bag removal. Normally no direct contact with the photoconductor material would be anticipated during other operator procedures on either system. However, the photoconductor is abraded during visible image formation and photoconductor cleaning procedures and fragments of TNF and the photoconductor matrix can be released within the machine.

The sampling strategy assessed the extent of TNF control. Incomplete control in the fuser section, the maintenance vacuum cleaner, the spent toner collector bag, and the vicinity of the drum was suspected. The 3800 cover was left open during sampling if this procedure was routinely used. This work practice could disrupt planned patterns of air movement within the printer and was believed to create the maximum TNF release conditions. Exposure to IBM customer engineers was not evaluated.

NIOSH conducted industrial hygiene field studies at IBM facilities in Gaithersburg, Maryland, on May 19, 1981 and June 11, 1981. Medical records were reviewed and industrial hygiene samples collected at IBM photoconductor production facilities in Lexington, Kentucky on June 9, 1981. A follow-up medical visit was conducted on June 25, 1981. A survey of a proposed 3800 Printer installation was conducted at the Department of Health and Human Services, 330 Independence Avenue, S.W., Washington, D.C. 20201 on May 20, 1981. Air sampling at operating installations was conducted at the National Institutes for Health, Bethesda, Maryland, and the National Library of Medicine, Bethesda, Maryland on June 10, 1981 and the Parklawn Computer Center, Rockville, Maryland on June 26, 1981. The details of these visits are discussed below.

1. IBM, Gaithersburg, Maryland

Sampling locations were chosen after orientation briefings by IBM field and corporate staff concerning the operating principles of the 3800. The 3800 was located in a temperature

and humidity controlled room. The Copier II was in routine use by IBM Gaithersburg personnel and was located adjacent to a rest/break area. Smoke tubes were used to observe the pattern of air movement around the machines.

NIOSH collected fixed location air samples for TNF, carbon black, and four common polynuclear aromatic hydrocarbons (PNAs) in the vicinity of an operating IBM 3800 printer and Copier II. The samples for carbon black and PNAs were collected to identify any possible exposure to these substances. The toner contains carbon black which can absorb PNA materials. Electron microscopy was used to estimate the size and visual character of particulates in the vicinity of the 3800 printer and Coper II.

Samples for each of the three classes of analytes were taken in each sampling location. This included the vicinity of the 3800 control panel, the vicinity of the toner collector bag and paper/toner cutting cyclone and the vicinity of the vacuum system. Replicate samples were collected with a "Lippman" Sampler[15] near the 3800 control panel. A personal sample was collected during toner addition and spent toner bag change operations and a second personal sample was collected during the photoconductor advance procedure. Samples were collected near the operator position and the paper release on the Copier II. The Copier II was operated continuously during the sampling period. The 3800 was operated as continuously as possible. The cover of the 3800 remained open during the sampling period. Swipe samples using dry Wattman 41 swipe tabs were collected at various locations on the 3800 and Copier II devices. A bulk sample of the contents of the CE filter bag was collected and analyzed for TNF. The sampling and analytical methods used are detailed in Appendix I.

The 37 mm PTFE filters utilized for TNF determination had been loaded into the filter cassettes with the polyethylene backing towards the front of the cassette during the first site visit. Because the analytical consequences of this reversal were not known, the location was resampled on June 11, 1981 to ensure uniformity of procedure and comparability of results.

2. IBM, Lexington, Kentucky

A NIOSH physician and two industrial hygienists visited the IBM plant in Lexington, Kentucky on June 9, 1981. TNF had been used at this facility since about 1969. Most of the IBM industrial hygiene and medical data concerning TNF has been developed at the Lexington plant.

A walk through inspection of the TNF receiving, storage, mixing, and film coating areas was conducted. The Copier II reconditioning line was visited; however, current operations involving photoconductor handling were minimal.

Area samples of 2-3 hours duration were collected for TNF in two adjoining rooms which contained the mixing, coating, spooling, and cutting operations where TNF solutions were prepared and deposited on the photoconductor film on the exterior of the printing drums. No personal samples were collected.

3. HHS, 330 Independence Avenue, S.W., Washington, D.C.

The site proposed for installation of an additional IBM 3800 printer was visually inspected.

4. HHS, National Institute for Health, Bethesda, Maryland

Five 3800 Printing Subsystems were positioned parallel to each other in a temperature and humidity controlled facility. Air samples were collected at the operator position on four machines and above the fuser section on two. Swipe samples were collected on the machine cover over the fuser section. A swipe sample of a spill of used toner on the floor was obtained. Bulk samples of spent and fresh toner were collected. Smoke tubes were used to observe air flow patterns in the vicinity of the machines. The machine covers were open during the entire sampling period.

5. The National Library of Medicine, Bethesda, Maryland

The single 3800 Printing Subsystem surveyed was located in a temperature and humidity controlled facility. Area samples for TNF were collected at the control panel and above the fuser section. A swipe sample was collected on the machine cover above the fuser section. Smoke tubes were used to observe air flow patterns in the vicinity of the machine. The machine cover was closed during the entire sampling period.

6. HHS, Parklawn Computer Center, Rockville, Maryland

Air samples were collected at the control panel and above the fresh toner bag on two 3800 printing subsystems located in a temperature and humidity controlled facility. Swipe samples were obtained on the machine cover above the fresh toner bag.

B. Medical

Medical evaluation of new employees at the IBM facility in Lexington, Kentucky includes questionnaire, physical examination, and laboratory

evaluation of blood and urine. Workers in certain job categories are reassessed periodically during the time of employment.
IBM has identified 92 workers at the Lexington facility who might have been exposed to TNF since it was introduced in 1967. During this period, 23 of these workers have been categorized as having had extensive involvement with TNF and have received additional medical evaluation during and after this involvement. Sixty-nine additional workers have been identified by way of efforts made since 1979 to identify all individuals who might have had any potential for contact with TNF at any time since the substance was introduced to the plant. A NIOSH physician was provided access on premises to medical records in identifier-deleted form for these workers. These records were reviewed on June 9 and 25, 1981.

V. EVALUATION CRITERIA

There are no occupational health standards or regulatory criteria for TNF at this time.

TNF has shown positive results in in vitro mutagenicity bioassays in both bacterial and mammalian cells and the results suggest that TNF is a direct acting mutagen.[16] The mutagenicity of TNF has not been tested in vivo. The degree to which animal or human metabolism might alter the mutagenic response is unknown.

Single oral doses of TNF have induced mammary tumors in rats and the combination of subcutaneous injection and dermal application has induced a significant increase in lung adenomas in mice.[17,18] In three other studies, cancer incidence was not significantly increased in mice by chronic inhalation;[19] by maximum tolerated doses administered subcutaneously, intraperitoneally, and orally;[20] and by repeated dermal application.[21]

Preliminary results indicate that the 6-hour LC_{50} for TNF in mice is greater than 3,500 mg/M^3,[19] and that the oral LD_{50} exceeds 21,500 mg/kg in rats and 2,000 mg/kg administered dermally to rabbits.[22]

In tests for skin and eye irritation in rabbits, TNF was considered slightly irritating to abraded skin and after direct application into the conjunctival sac. In a skin sensitization study in guinea pigs, TNF generally produced slight erythema after a series of intracutaneous injections. After a later challenge dose, the reaction of two of the eight animals suggested sensitization.[22]

Preliminary results of skin absorption studies of 1% TNF solutions in acetone and 1,1,1-trichloroethane applied to the skin of rats and pigs suggest that small amounts of TNF could pass through intact skin when dissolved in solvent carriers.[23]

VI. RESULTS

A. Analytical

The samples collected at Gaithersburg on May 19, 1981 were analyzed at the NIOSH Measurement Support Branch facilities in Cincinnati, Ohio. All subsequent samples were analyzed in a single set by a contractor. Two blind spikes containing 400 ng of TNF each were included in the contractor's set. The results of the spiked samples, which were replicated, were reported as 378.8, 379.3, 322.8, 377.3 ng.[24,25] The contractor reported successful method check out by triplicate analysis of five standards over the concentration range of 40-1300 ng/2mL (r=0.998). Recovery studies, and spikes of two field samples for positive identification of TNF were performed.[25]

B. Industrial Hygiene

1. IBM, Gaithersburg, Maryland

The results of this survey are presented in Tables 1-4. All samples for airborne TNF were negative in both the May 19, 1981 and June 11, 1981 sample sets. Carbon Black and PNAs were not detected in any sample (Tables 1 and 2).

There was removable TNF on swipe samples taken on the inside of the door covering the drum on the 3800 system and on a structural member immediately below the drum position in the Copier II. Small amounts of TNF, below the limit of accurate quantitation, were detected inside the 3800 near the paper/toner cutting cyclone and the vacuum system collector bag accessible to operator and maintenance personnel. The contents of the vacuum system filter bag contained 81 ug of TNF per gram of dust (Table 3). Small circular particles composed of tin and non-circular particles, probably organic in nature, were observed in photomicrographs of filters exposed near the 3800 and Copier II. The particles were respirable with a mean diameter between 0.3 and 0.4 microns. Fibers 1.6 to 3.2 microns in length and 0.04 to 0.11 microns in width composed of tin were observed on the filter exposed on the Copier II (Table 4).

2. IBM, Lexington, Kentucky

A single sample contained TNF at a concentration of 1.8 ug/M^3 (Table 5).

3. HHS, 330 Independence Avenue, S.W., Washington, D.C.

A memorandum to the Director of the HHS Office of Safety and Occupational Health dated June 3, 1981 stated that NIOSH had

received a telephone report that 1-2 ug/M^3 of TNF had been measured in the vicinity of 3800 printers. It concluded that there was no health reason not to install further 3800 printers, but that management should be willing to modify installations to recommended standards, if needed.[26]

4. The National Library of Medicine, Bethesda, Maryland

No airborne TNF was detected. No removable TNF was demonstrated on swipe samples (Tables 6-7).

5. HHS, National Institute for Health, Bethesda, Maryland

No airborne TNF was detected. 235 ug/g of TNF was demonstrated in spent toner and 193 ng/in^2 of TNF was found in a spent toner spill (Tables 8-9).

6. HHS, Parklawn Computer Center, Rockville, Maryland

No airborne TNF was detected. A swipe sample demonstrated a small amount of removable TNF above the fresh toner bag (Tables 10-11).

C. Ventilation

All copiers and printers were located in temperature and humidity controlled environments. No contaminant control ventilation outside the 3800 printer or Copier II was observed.

Smoke patterns suggested thermal rise near the drum and fuser sections of the 3800. Turbulent air flow was observed during paper transport. There was no consistent pattern of air movement from potentially contaminated parts of either the 3800 or Copier II into the operator's breathing zone.

D. Medical

No remarkable pattern of medical diagnoses was perceived among workers who had extensive involvement with TNF. One worker had a malignancy that had been diagnosed prior to his first involvement with TNF. One worker had diagnosed emphysema, one had a history of spontaneous pneumothorax, and one had a history of rhinitis.

Review of routine blood tests (blood counts, electrolytes, kidney functions, liver functions, liver enzymes) and urine values did not reveal any patterns of abnormality among workers.

Ongoing medical surveillance of workers with a history of possible exposure to TNF did not include acquisition of data that would relate to fertility or to reproductive outcomes.

VII. DISCUSSION AND RECOMMENDATIONS

A. Industrial Hygiene

1. Operator Exposure to TNF: 3800 and Copier II Systems

The absence of airborne TNF in 38 samples collected in the vicinity of IBM 3800 Printing Subsystems and Copier II installations suggests that most TNF released from the photoconductor is collected on spent toner or by the internal machine ventilation. Removable TNF in one third (6/17) of the swipe samples was associated with spent toner spills and the internal surfaces of the machines. This finding shows that some TNF escapes from the 3800 Printer and Copier II control devices. However, it is not resuspended in the workroom air.

No airborne TNF could be demonstrated in a single measurements of spent toner bag changing and photoconductor advance procedures. TNF was present in the 3800 printer vacuum system bag and on access panels and structural members of both the 3800 and Copier II systems.

Subsequent to the field study, IBM furnished animal test data which suggested that small amounts of TNF could pass through intact skin when dissolved in solvent carriers, most significantly 1,1,1-trichloroethane which was used in maintenance procedures usually conducted only by IBM personnel.[23] Additional IBM data suggested that polyethylene gloves withstood 6 hour challenges of TNF in 1:5 weight to volume solutions of methyl chloroform (trichloroethane), cover cleaner containing 0.5% butyl cellosolve, and isopropyl alcohol as well as dry TNF powder and film.[27] One variety of latex glove tested was not an effective barrier against dry TNF powder and film.

These results indicate that skin protection should be worn during routine cleaning (vacuuming) and spent toner bag removal by 3800 printer and Copier II operators. Maintenance personnel should wear gloves during all activities in TNF contaminated areas on the 3800 printer and Copier II, especially when solvents are in use. IBM has already adopted this procedure for maintenance personnel.[27] The tendency of polyethylene to tear suggests the use of double gloves or use of polyethylene as a liner inside other materials.

B. Medical

Appropriate monitoring and surveillance of workers possibly exposed to a known mutagen is not a well documented process. Usual measures

of biological function would not be expected to reveal mutagenic changes that might occur. Oncogenic changes cannot be discerned in general prior to manifestation of an overt malignancy. The 14 or fewer years that have passed since the first potential exposure of each worker to TNF clearly is less than the 20-30 year interval that elapses typically in humans between exposure to a carcinogen and diagnosis of malignancy. Surveillance of fertility and reproductive outcome more clearly demonstrate mutagenic changes. However, given the many factors that may affect the reproductive process, such surveillance may have low sensitivity unless the population under study is very large.

No remarkable patterns of medical outcome or laboratory value abnormality were discerned from review of IBM medical records. Laboratory data might have been analyzed further to seek trends within the accepted normal range. However, several factors militated against such an approach: (a) the paucity of abnormal laboratory values; (b) the imprecision of estimates both of duration of potential exposure to TNF and of the overall effectiveness of personal and environmental efforts to minimize potential exposures; and (c) the need for comparable data from a population not potentially exposed to TNF in order to factor out changes attributable to age of workers and/or to possible variability of laboratory data over time. In the absence of clear evidence of biological abnormality in potentially exposed workers, development of a case-control analysis of existing laboratory data does not seem warranted.

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Copies of this report have been sent to:

1. International Business Machines Corporation, 1801 K Street, N.W., Washington, D.C. 20006

2. Director, Office of Safety and Occupational Health, HHS, 330 Independence Avenue, S.W., Washington, D.C. 20201

3. Chief, Technical Assistance Section, Occupational Safety and Health Branch, Division of Safety, National Institutes of Health, Bethesda, Maryland 20205

4. Director, Parklawn Computer Center, HHS, 5600 Fishers Lane, Rockville, Maryland 20857

TABLE 1

Air Sample Results

International Business Machines
Gaithersburg, Maryland

May 19, 1981

Location	Sample Duration (hr + min)	TNF ug/M^3	Carbon Black ug/M^3	Other* PNAs ug/M^3
3800 Printing Subsystem				
Control Panel (Lippman Sampler, 12 samples)	6+37	N.D.	----	----
Control Panel	6+26	N.D.	-----	----
Control Panel	6+26	N.D.	N.D.	N.D.
Near Cutter Cyclone	6+02	N.D.	N.D.	N.D.
Near Vacuum System	6+03	N.D.	----	----
Personal Sample During Toner Addition and Bag Change	0+08	N.D.	N.D.	N.D.
Personal Sample During Photoconductor Advance	0+07	N.D.	N.D.	N.D.
Copier II				
Top of Machine	1+47	N.D.	N.D.	N.D.
Near Paper Release	1+54	N.D.	N.D.	N.D.

Note:
1. For TNF the limit of detection was 30 ng per sample. The limit of quantitation was 120 ng per sample. N.D. means not detected.
2. *The PNAs analyzed were fluoranthene, pyrene, benz (a) anthracene, and benzo (e) pyrene.
3. The 3800 printer was operated with the covers open.
4. All samples were collected at a flow rate of 2.0 liters per minute.

TABLE 2

Air Sample Results

International Business Machines
Gaithersburg, Maryland

June 11, 1981

Location	Sample Duration (hr + min)	TNF ug/M^3
3800 Printing Subsystem		
Control Panel	5+40	N.D.
Control Panel	5+36	N.D.
Near Cyclone Cutter	5+34	N.D.
Near Vacuum System	5+33	N.D.
Copier II		
Top of Machine	2+20	N.D.
Near Paper Release	2+16	N.D.

NOTE:
1. The 3800 printers were operated with the covers open.
2. The limit of detection for this sample set was 40 ng/sample.
3. All samples were collected at a flow rate of 2.0 liters per minute.

TABLE 3

Swipe Sample Results

International Business Machines
Gaithersburg, Maryland

May 19, 1981

Location	TNF Detected ng	Swipe Area in^2	Removable TNF ng/in^2
3800 Printing Subsystem			
Near Vacuum	N.D.	16	--
Near Toner Transfer	N.D.	16	--
Back of Door Enclosing Drum	233	16	15
Next to Cyclone Bag (Relay Box)	37	16	2
Vacuum Box (Top)	57	16	4
Copier II			
Inside Exit Pocket	N.D.		--
At Operator Position	N.D.	5	--
Right Caster Well	N.D.	8	--
Bottom Frame Near Drum	471	13	36
Bulk			
CE Filter Bag	81 ug TNF/ g of Dust		

Note:
1. The limit of detection was 30 ng per sample. The limit of quantitation was 120 ng per sample. N.D. means not detected.

TABLE 4

Particle Size Analyses

International Business Machines
Gaithersburg, Maryland

May 19, 1981

Location	Magnification	Number of Particles Analyzed	Median Area Equivalent Diameter	Mass Median* Diameter
			um	um
3800 Printing Subsystem	1000X	1000	0.33	3.02
Copier II	1006X	1006	0.40	4.71

Fiber Analysis

Location	Number of Fibers Found	Qualitative Chemistry (EDXRA)	SAED Identification
Copier II	17	16 - Primarily Sn 1 - Mg, Fe, Si	No Patterns Obtained Chrysotile

NOTE:
1. *Calculated assuming a particle specific gravity of 1.0.
2. All samples were collected at a flow rate of 2.0 liters per minute.

TABLE 5

Air Sample Results

International Business Machines
Lexington, Kentucky

June 9, 1981

Location	Sample Duration (hr + min)	TNF ug/M3
At top of Mixing Vat #9 (TNF was added during one 15 minute period included in the sample)	2+45	Destroyed
On Barrels Containing TNF in Mixing Room	2+47	N.D.
Coater Head Inside Ventilated Enclosure	2+39	N.D.
On Operations Desk (Between Coater/Dryer and Spooler)	2+16	N.D.
Near Spooler Operator/Reader	2+26	1.8
Near Wind Up End of Coater	2+33	N.D.

NOTE:
1. The limit of detection for this sample set was 40 ng/sample.
2. All samples were collected at a flow rate of 2.0 liters per minute.

TABLE 6

Air Sample Results

National Library of Medicine
Washington, D.C.

June 10, 1981

Location	Sample Duration (hr + min)	TNF ug/M^3
3800 Printing Subsystem		
Control Panel	4+45	N.D.
Above Heat Seal	4+46	N.D.

NOTE:
1. The estimated paper usage during the sampling period was approximately 3,400 sheets.
2. The 3800 printers were operated with the covers closed.
3. The limit of detection for this sample set was 40 ng/sample.
4. All samples were collected at a flow rate of 2.0 liters per minute.

TABLE 7

Swipe Sample Results

National Library of Medicine
Washington, D.C.

June 10, 1981

Location	TNF Detected ng	Swipe Area in^2	Removable TNF ng/in^2
3800 Printing Subsystem			
On Machine Cover Near Heat Seal	N.D.	2	--

NOTE:
1. The limit of detection for this sample set was 40 ng/sample.

TABLE 8

Air Sample Results

National Institute for Health
Building 12A
Washington, D.C.

June 10, 1981

Location	Sample Duration (hr + min)	TNF ug/M^3
3800 Printing Subsystem		
Control Panel (Machine A)	5+42	N.D.
Control Panel (Machine B)	5+43	N.D.
Above Heat Seal (Machine B)	5+09	N.D.
Control Panel (Machine C)	5+13	N.D.
Above Heat Seal (Machine C)	5+04	N.D.
Control Panel (Machine D)	5+30	N.D.

NOTE:
1. The 3800 printers were operated with the covers open.
2. The estimated paper usage of Machines A and B during the sampling period was 32,000 sheets. The estimated paper usage of Machine C was 10,000 sheets, and the estimated paper usage of Machine D was 2,000 sheets.
3. The limit of detection for this sample set was 40 ng/sample.
4. All samples were collected at a flow rate of 2.0 liters per minute.

TABLE 9

Swipe Sample Results

National Insititute for Health
Building 12A
Washington, D.C.

June 10, 1981

Location	TNF Detected ng	Swipe Area in^2	Removable TNF ng/in^2
3800 Printing Subsystem			
On Machine Cover Near Heat Seal (Machine A)	N.D.	2	---
On Machine Cover Near Heat Seal (Machine B)	N.D.	2	---
On Machine Cover Near Heat Seal (Machine C)	N.D.	2	---
On Machine Cover Near Heat Seal (Machine D)	N.D.	2	---
Toner Spill on Floor Between Machines C and D	285.6, 243.3	2	193
Bulk Sample			
Fresh Toner for Machine C			Less than the limit of detection, which was 51 ug/g
Spent Toner from Machine C			235 ug/g

NOTE:
1. The limit of detection for the 3800 sample set was 40 ng/sample.

TABLE 10

Air Sample Results

Parklawn Computer Center
Rockville, Maryland

June 18, 1981

Location	Sample Duration (hr + min)	TNF ug/M^3
3800 Printing Subsystem		
Control Panel (Machine E)	6+12	N.D.
Above Fresh Toner Bag (Machine E)	5+59	N.D.
Control Panel (Machine D)	6+06	N.D.
Above Fresh Toner Bag (Machine D)	5+51	N.D.

NOTE:
1. The estimated paper usage of Machine E during the sampling period was 18,000 sheets. The estimated paper usage of Machine D was 2,600 sheets.
2. The limit of detection for this sample set was 40 ng/sample.
3. All samples were collected at a flow rate of 2.0 liters per minute.

TABLE 11

Swipe Sample Results

Parklawn Computer Center
Rockville, Maryland

June 18, 1981

Location	TNF Detected ng	Swipe Area in^2	Removable TNF ng/in^2
3800 Printing Subsystem			
Above Fresh Toner Bag	N.D.	5	--
Above Fresh Toner Bag	64.5, 93.2	5	16

NOTE:
1. The limit of detection for this sample set was 40 ng/sample.

APPENDIX I

Sampling and Analysis Methodology

Health Hazard Evaluation Project
No. HETA 81-125 and HETA 81-352
May - June 1981

Substance	Collection Device	Flow Rate	Analytical Method	Limit of Detection	Reference
TNF	Polytetrafluoroethylene Filters	2 lpm	Normal Phase Liquid Chromatography with UV Detector	30 ng	14
Carbon Black	Preweighed PVC Filters	2 lpm	Weight Determination		28
PNAs	Glass Fiber/Silver Membrane Filters	2 lpm	Reverse Phase HPLC with Fluoresence Detector	0.1 ug	30
Particle Size and Composition	Nuclepore Filter	2 lpm	Electron Microscopy, Energy Dispersive X-Ray Analysis Selected Area Electron Diffraction		30,31

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