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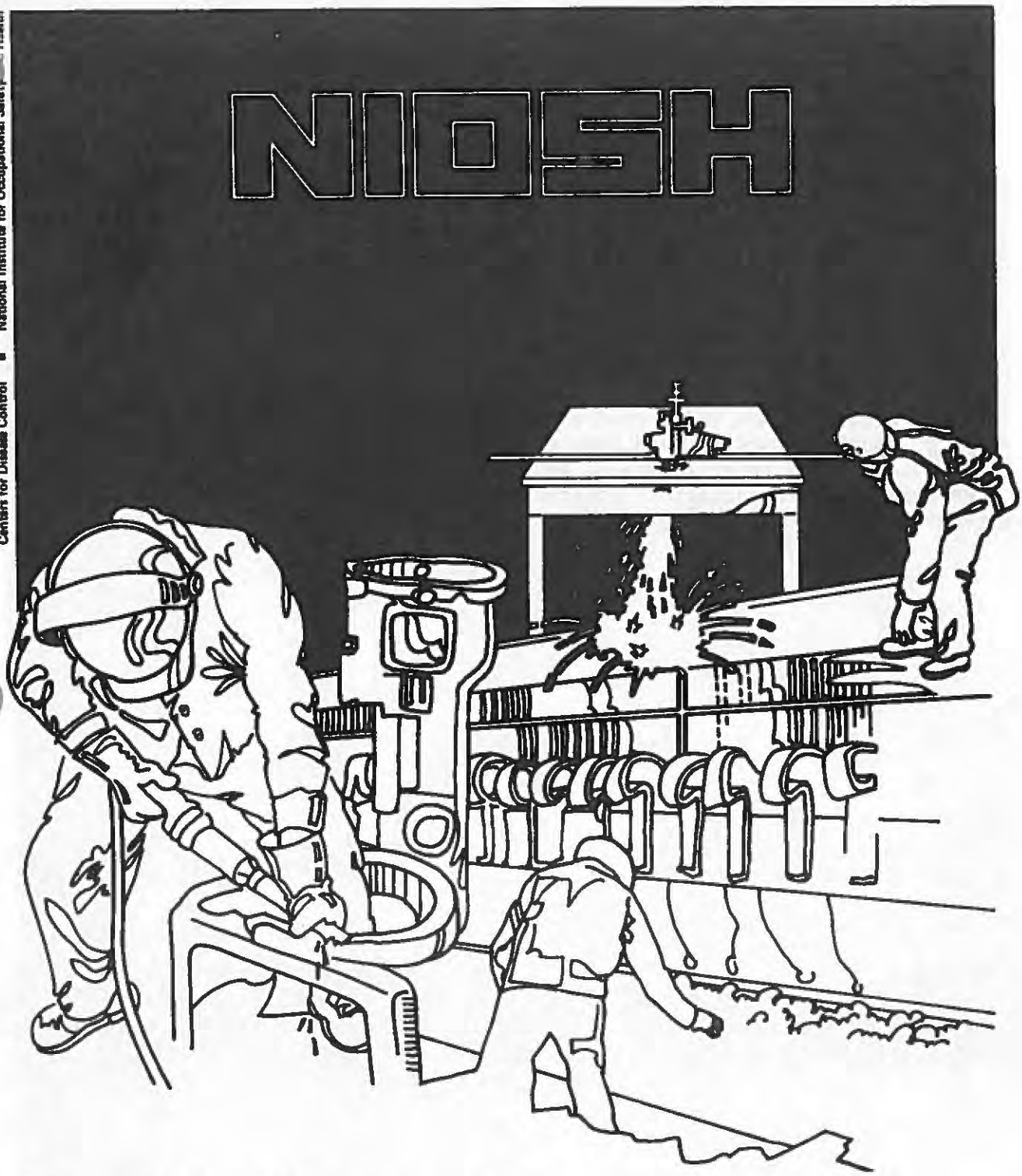

Health Hazard Evaluation Report

HETA 80-144-1109
FILM PROCESSING INDUSTRY
HOLLYWOOD, CALIFORNIA

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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Film Processing Industry
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I. SUMMARY

In May 1980, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation from a representative of employees of the Film Technicians Local No. 683, Hollywood, California. The requestor was concerned about the adverse effects of the numerous chemicals used in the developing and cleaning of movie film. The major chemicals cited were formaldehyde, methyl chloroform, dioxane, perchloroethylene, and the components of the bleach accelerator system which were implicated in the increased incidence of dermatitis. NIOSH selected two laboratories (Technicolor Corporation and Movielab-Hollywood Corporation) for environmental sampling and Technicolor for a medical survey.

On July 15, 1980, environmental air samples for organic solvents were collected in film cleaning, film splicing, and printing areas of Technicolor. Concentrations of methyl chloroform, dioxane, acetone, perchloroethylene, methylene chloride were below CAL/OSHA standards and NIOSH criteria for these substances. On July 15, 1980 and April 15, 1981, air samples for formaldehyde were collected in the film developing areas of Technicolor. All formaldehyde levels were below the CAL/OSHA standard of 2.0 parts per million (ppm). The concentrations ranged between none detectable to 0.62 ppm. Acetic acid air samples were collected at Technicolor on April 15, 1981 in the developing area. All concentrations were below the limit of detection (0.05 milligrams per sample).

On July 16, 1980, air samples for organic solvents were collected in film cleaning, film splicing, and printing areas of Movielab. Concentrations of methyl chloroform, dioxane, acetone, perchloroethylene, and methylene chloride were below CAL/OSHA standards and NIOSH criteria for these substances in all the samples except for one. One general area sample above an ultrasonic cleaning machine where employees did not work showed a methyl chloroform level of 4431 mg/m^3. The NIOSH recommended limit for methyl chloroform is 1900 mg/m^3 (ceiling concentration). Formaldehyde samples were collected at Movielab on three occasions (July 16, 1980, April 16, 1981, and June 24, 1981). There were contamination and analytical problems with some of the samples. On June 24, 1981, all the formaldehyde samples in the work areas were below the limit of detection (8 micrograms per sample). On other sampling days, formaldehyde levels in two samples exceeded the CAL/OSHA standard of 2.0 ppm (ceiling) and the NIOSH recommended ceiling of 1.0 ppm for irritation effects based on a 30-minute sampling period. The levels were 4.4 ppm and 11.6 ppm. The latter sample was collected in an area where an employee had only sporadic exposure. On April 16, 1981, acetic acid air samples were collected in the developing area of Movielab. All acetic acid levels were below the limit of detection.

A medical study was conducted at Technicolor on October 8-9, 1980. The study consisted of a medical questionnaire which attempted to relate work practices and job categories by potential chemical exposures. One hundred thirty-seven workers were contacted and grouped into three categories by their predominant exposures: developing solutions, organic solvents, and final products (intended as a control population). Workers exposed to developing solutions and bleach accelerator were characterized by a persistent irritant contact dermatitis with eye and upper respiratory irritation. Workers exposed to organic solvents were characterized by a transient de-fatting dermatitis and local anesthetic effects on the fingers. The group exposed to final products reported a combination of sensitization and direct irritant effect on eyes and the upper respiratory system, probably as a result of residual formaldehyde on the films

Based on the environmental sample results during the dates of the study, overexposures to methyl chloroform, acetone, dioxane, perchloroethylene, methylene chloride, and acetic acid did not occur at Technicolor and Movielab. Although formaldehyde levels in general did not exceed CAL/OSHA standards, a potential health hazard may exist since NIOSH recommends maintaining formaldehyde levels at the lowest feasible limit based on evidence of carcinogenicity. The bleach accelerator process produced a severe direct irritant dermatitis in a high proportion of workers; organic solvent exposure in another group produced a mild transient irritant dermatitis, and residual formaldehyde on final products was associated with sensitization and direct irritation of eyes and the upper respiratory system among workers in several other plant areas.

KEYWORDS: SIC 3681 (Photographic Equipment and Supplies), motion picture film developing, bleach accelerator process, formaldehyde, acetic acid, methyl chloroform, acetone, perchloroethylene, methylene chloride, dioxane.

II. INTRODUCTION

On May 17, 1980, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) from an authorized employee representative of the Film Technicians Local No. 683 of Hollywood, California. The requestor was concerned about the adverse effects to its members in the movie film processing industry from the numerous chemicals used in the developing and cleaning of film. In the request, the major chemicals of concern noted were formaldehyde, methyl chloroform, dioxane, perchloroethylene, and the components of the bleach accelerator system. Dermatitis problems were also an area of concern.

Five film laboratories were identified by the requestor as representative of the industry as a whole. NIOSH agreed to survey three of the laboratories which were located in Hollywood. These laboratories were Technicolor Corporation, Movielab-Hollywood Corporation, and Deluxe Laboratories Corporation. NIOSH conducted an opening conference and initial surveys at the three film laboratories on July 14, 1980. The basic film processing systems were similar in each of the laboratories. Technicolor was the plant utilizing the bleach accelerator system. Movielab and Deluxe used the basic standard developing system. The film processing industry, for the most part, uses film, chemicals, and processes that were developed by the Eastman-Kodak Corporation. It was decided by NIOSH after the initial visits to conduct environmental sampling at Technicolor and Movielab and a medical survey at Technicolor.

On July 15, 1980, an environmental survey measuring exposure to organic solvents and formaldehyde was conducted at Technicolor. On April 15, 1981, a follow-up survey for formaldehyde and acetic acid was conducted at Technicolor. On October 8-9, 1980, a medical survey was conducted at Technicolor.

On July 16, 1980, an environmental survey measuring exposure to organic solvents and formaldehyde was conducted at Movielab. On April 16, 1981, a follow-up survey for formaldehyde and acetic acid was conducted at Movielab. On June 24, 1981, an additional follow-up survey for formaldehyde was conducted at Movielab.

III. BACKGROUND

The movie film processing laboratory develops and reproduces the exposed film that is shot by the film makers. The exposed film is brought to the laboratory and is removed from a light-tight container in a darkened area. It is automatically sent through a series of tanks which contain the liquid solutions of the various components used in the developing process. The process is divided into the dark side and the light side. The exposed film can only be handled in white light after it has reached the light side of the developing process. There are several variations of the developing process which require different steps and chemicals, but the basic techniques are similar. The end product is the formation of the color images on the film.

A simplified step-by-step list of the major chemicals used in each phase of the developing process is described in the chart below:

Developing Process (Dark Side)	Chemical Solutions
Backing Remover Tank	Sodium Sulfate Sodium Hydroxide
Backing Wash	Water
Developer	Calgon (water softener) Kodak CD-2 Developing Agent Kodak CD-3 Developing Agent Sodium Hydroxide Sodium Sulfite Sodium Sulfate Bromide
Developer Stop	Sulfuric Acid Acetic Acid
Stop Wash	Water

Developing Process (Light Side)	Chemical Solutions
Bleach Accelerator (Only For Positive Developing Accelerated Process)	Kodak PBA-1 Bleach Accelerator Sodium Persulfate Sodium Dihydrogen Phosphate
Bleach	Potassium Dichromate Potassium Ferricyanide Bromide
Sound Track	Hexylene Glycol Sodium Sulfite Hydroquinone Ethylenediamine Sodium Hydroxide
Second Fix	Ammonium Thiosulfate Sodium Sulfite
Second Fix Wash	Water
Stabilizer	Formaldehyde

Each of the solutions are contained in sequential tanks which make up a developing "line." The chemicals listed in the chart are in solutions and are present in varying percentages. The film is processed and run on spools throughout the line at speeds which can vary from 275 feet per minute up to 600 feet per minute (on lines using the bleach accelerator process). Each line has two operators (one each for the dark and light sides). Most major laboratories run at least six to eight developing lines concurrently. The most noticeable chemical in the air was formaldehyde. However, some acetic acid fumes were also noticed. Noise levels seemed high at the developing lines, but past noise measurements, according to management, showed that noise levels were below current standards. Operators occasionally

touch the solutions when parts of the line are raised up from the tanks, but usually they have minimal skin contact. The maintenance mechanics have more frequent and prolonged skin contact with the developing solutions. Mechanics must repair equipment failures and have occasions to place their hands and arms in developing solutions when checking the film for creases. Dermatitis is an on-going concern among the mechanics who come into contact with developing solutions. With the bleach accelerator process, the solutions are kept at a higher temperature thus enabling the film to be processed at a faster rate. Dermatitis problems seemed to occur more frequently at the Technicolor plant where the bleach accelerator process was introduced several years ago.

All large film laboratories have similar types of work practices and support equipment. Generally, there is a chemical storage and mixing area separate from the developing lines. In this chemical area, the compounds are mixed to specified formulas and pumped through chemical lines to the developing sections of the plant. Solvents that are used in large quantities for film cleaning equipment are also pumped automatically to the machines. In a typical laboratory, three employees can handle chemical preparation.

All major laboratories handle the freshly shot film in the same manner. Each day that film is taken, the camera negatives are brought into the lab by the customer for developing. These camera negatives are known as "dailys." The dailys are developed and a positive is made for reviewing by the customer. After the customer's approval,the daily is synchronized with the sound track, reviewed again, and made into a "work print." The original negative is then matched with the work print key number by key number. Next, the optical negatives (which are the special effects) are spliced with the original negative. This final product negative is timed, cleaned, and made into an "answer print." The answer print is the finest refined product.

The release prints for the movie theaters can be made in several ways. For small releases, the release prints can be made from the original negative. Otherwise, an interpositive (master positive) can be made from the original negative. From the interpositive, internegatives (duplicate negatives) can be made. The release prints are made from the internegatives. An alternate method of making negatives from the original negative is a process known as CRI (color reversal intermediate).

Interpositives are made from two kinds of printers. These two machines are the Contact Printer and the Wetgate Printer. Perchloroethylene is used with these printers and is a source of potential solvent exposure. Since perchloroethylene has the same index of refraction as the film itself, the solvent fills in the small scraches in the film so that the interpositive print will be clear. Acetone is used with these printing machines for small cleaning tasks. Laboratories will usually have one of each type of printer. One employee can handle the operation of one machine.

Film splicing requires both a film cement and a cleaning solvent. The solvent is acetone. Splicing is accomplished by hand with a special tool which is used to cut and to place an even edge on each end of the two pieces of film. The operator places a small amount of Kodak film cement on the film ends with a small brush and the film is spliced. The operator wipes any excess cement off of the film splice with a cloth glove. The glove permits skin contact with the cement. The splicing operation requires less than 30 seconds per splice. The number of splices per day by an employee varies greatly. Upwards of 100 splices could be done by an employee in one day. The film cement contains dioxane and methylene chloride.

The cement is used sparingly and is kept in a small bottle. A cap with a brush is left on the bottle except when it is taken off during the application of the cement. It is estimated that less than 10 milliliters of cement is used during a shift by an employee. Splicing is done in an open area without mechanical ventilation. Film labs can employ up to four workers to handle the splicing duties.

Another use for organic solvents is film cleaning. Film cleaning is handled by a machine which is an ultrasonic cleaner. Reels of film are placed in the machine and are automatically cleaned with 1,1,1-trichloroethane (methyl chloroform). The machines are equipped with local exhaust ventilation. During film cleaning, the doors to the machine are closed which means that the system is enclosed. Workers can also operate small hand-cleaning devices for special jobs. These machines are not enclosed, and the primary solvents used are methyl chloroform, perchloroethylene, and acetone. Film laboratories maintain from three to five ultrasonic cleaning machines. In general, fewer than six employees are involved in film cleaning duties.

An evaluation of every potential chemical used in the film processing industry was not done in this study. The major chemicals were evaluated, and a medical study was conducted in the one laboratory which utilized the bleach accelerator process. Sampling methods and environmental criteria for many of the developing compounds were not available, and air samples for these substances were not collected. However, toxicological information on many of the chemicals are included in this report to inform film processing employees of the potential hazards of these compounds. Recommendations based on the results of NIOSH's evaluation are contained in the Recommendations Section of this report.

IV. HAZARD EVALUATION DESIGN

A. Environmental Monitoring Criteria

Occupational exposure criteria have been developed to evaluate workers' exposures to chemical substances. Two sources of criteria were used to assess workroom concentrations: (1) NIOSH criteria for recommended standards, and (2) California Occupational Safety and Health Administration (CAL/OSHA) standards. These values represent concentrations to which it is believed that nearly all workers may be exposed for an 8-hour day, 40-hour work week throughout a working lifetime without experiencing adverse health effects. The applicable exposure criteria used in this evaluation are listed below:

Substance	Time-weighted Average (TWA*)	Ceiling Value****
Formaldehyde (NIOSH)	Lowest feasible limit	1 ppm
Formaldehyde (CAL/OSHA)	2 ppm**	2 ppm
Acetic Acid (NIOSH)	---	---
Acetic Acid (CAL/OSHA)	25 mg/m^3***	100 mg/m^3

Substance (cont.)	Time-Weighted Average	Ceiling Value
Methyl Chloroform (NIOSH)	---	1,900 mg/m^3
Methyl Chloroform (CAL/OSHA)	1,900 mg/m^3	4,140 mg/m^3
Acetone (NIOSH)	---	---
Acetone (CAL/OSHA)	2,400 mg/m^3	14,400 mg/m^3
Perchloroethylene (NIOSH)	339 mg/m^3	678 mg/m^3
Perchloroethylene (CAL/OSHA)	670 mg/m^3	1,910 mg/m^3
Dioxane (NIOSH)	---	3.6 mg/m^3
Dioxane (CAL/OSHA)	180 mg/m^3	---
Methylene Chloride (NIOSH)	261 mg/m^3	1,740 mg/m^3
Methylene Chloride (CAL/OSHA)	700 mg/m^3	3,500 mg/m^3

* TWA - NIOSH exposure recommendations are based on a workday up to 10 hours long, whereas CAL/OSHA Standards are based on an 8-hour workday

** ppm - parts of a vapor or gas per million parts of contaminated air by volume

*** mg/m^3 - milligrams of substance per cubic meter of air

**** Ceiling Value - concentration in the workplace not to be exceeded based on the recommended sampling period

B. Environmental Methods

Personal and area samples were collected in the selected areas of the film laboratories using personal sampling pumps with various collecting media:

1) Formaldehyde - formaldehyde was collected by three methods. High-flow pumps were operated at 0.5 liters per minute (lpm) and air was drawn through a midget bubbler (impinger) containing 15 milliliters (ml) of special Gerard T reagent. The samples were analyzed by polarography. Formaldehyde was also sampled with low-flow pumps at 20 or 100 cubic centimeters (cc) per minute with special activated charcoal tubes. These samples were analyzed by ion chromatography. Draeger length-of-stain indicator tubes were also used for direct readings.

The sampling and analytical methods for formaldehyde continue to cause some difficulties in the field and laboratory for industrial hygienists, and these problems necessitated some repeat surveys for formaldehyde. The original impinger solutions for formaldehyde became contaminated in some of the samples collected at Movielab. Therefore, repeat formaldehyde samples were collected at both Movielab and Technicolor, although the impinger samples at Technicolor were judged by NIOSH to be valid. A third visit was made to Movielab to collect formaldehyde samples. These samples were taken to substantiate the results from the second visit to Movielab. Impinger samples were only taken during the first surveys of Technicolor and Movielab.

All subsequent surveys were conducted using an impregnated charcoal tube sampling method which was developed by NIOSH. Early in 1982, research chemists at NIOSH discovered that the impregnated charcoal tube method could, in some instances, result in lower concentrations than the true values if the samples were stored improperly for two weeks or more before being analyzed. All samples collected in the film processing survey were sent immediately to NIOSH laboratories for analysis, and it was anticipated that formaldehyde losses on the tubes were low. Nevertheless, the conclusions of this evaluation were made with the analytical problems in mind.

2) Acetic Acid - acetic acid samples were collected with special charcoal tubes and low-flow pumps which were operated at 100 cc/minute. The samples were analyzed by gas chromatography.

3) Organic Solvents - organic solvent samples were collected with activated charcoal tubes and low-flow pumps which sampled at rates of 20 cc/minute and 100 cc/minute. The samples were analyzed by gas chromatography.

C. Medical Evaluation Methods

During the initial walk-through of the three film processing plants on July 14-17, 1980, complaints of dermatitis, eye irritation, symptoms of central nervous system (CNS) depression, upper respiratory irritation and anesthetized fingers were reported by workers at all three work sites. Primary irritant contact dermatitis was found among a large number of workers on physical examination. Because Technicolor has a larger work population and is utilizing a new bleach accelerator which will soon be introduced industry-wide, it was decided to evaluate the health effects of exposures in the film processing industry at Technicolor.

A questionnaire was prepared for self-administration to detect symptoms of dermatitis, eye irritation, CNS depression, upper respiratory irritation, and anesthetic effects localized to the fingers among film processing workers. Information was sought regarding the workers' length of employment in the film processing industry, years at their current work site, job category, extent of skin contact with chemicals on the job, history of skin problems and allergies, and work shift.

The questionnaire was distributed on October 8 and 9, 1980, to all members of the following categories who were willing to participate: wet and auxillary maintenance, positive and negative developers, and solutions. An effort was made to improve participation by visiting these work areas and offering to collect the questionnaires directly. The management of Technicolor was fully cooperative in this effort, and permitted all participating workers to complete the questionnaires during work hours. Workers from other job categories, intended to serve as a control population, received copies of the questionnaire with no intensive effort at recruitment.

D. Medical Evaluation Criteria

1. Toxicological Effects

(a) Irritants

The film processing industry utilizes a wide range of potentially irritating chemicals. These chemicals may cause skin rashes (primary irritant contact dermatitis),

eye irritation, and nose and throat (upper respiratory tract) irritation. Specifically, these potentially irritating chemicals include:

CD-2 and CD-3 Color Developing Agents

Chemical names: CD-2: 2-amino-5-diethylamino toluene mono-hydrochloride

CD-3: 4-amino-N-ethyl-N(B-methanesulfonamidoethyl)-n-toluidine sesquisulfate monohydrate

Both CD-2 and CD-3 are toluidines, which are strong upper respiratory tract, eye and skin irritants, particularly in alkali solutions as they are used in film processing. Additionally, toluidines may also cause sensitization (development of an "allergic reaction") in some workers. This reaction may develop months or years after the first exposure. There are no NIOSH criteria or CAL/OSHA standards for these compounds.

Kodak Bleach Accelerator (PBA-1)

Chemical name: 5-amino-1,3,4-thiadiazole-2-thio

Generic name: dimethylamino ethanethiol; isothiouronium salt

Certain aliphatic thiols can be incorporated in the color development process to lessen the amount of time necessary for the film in the bleach bath. Such an aliphatic thio is Kodak PBA-1. This product is a fine yellow odorless powder. As a sulfur (thiol) compound, residual amounts of chlorine gas may be produced which causes burning and irritation of the skin or eyes on contact, as well as upper respiratory (nose and throat) irritation.[1] Additionally, the dust may be absorbed through the respiratory tract or orally, and may have an anti-thyroid effect. There are no established NIOSH criteria or CAL/OSHA standard for this compound.

Acetic Acid

Acetic acid fumes may produce irritation of the eyes, nose, throat and lungs. Inhalation of concentrated fumes may cause serious damage to the lining membranes of the nose, throat, and lungs. Contact with concentrated acetic acid may cause severe damage to the skin and serious eye damage, which may result in loss of sight. Repeated or prolonged exposure to acetic acid may cause darkening, irritation of the skin, erosion of the exposed front teeth, and chronic inflammation of the nose, throat and bronchi.[2] The CAL/OSHA standard for acetic acid is 25 mg/m^3 based on a time-weighted average for eight hours. There are no established NIOSH criteria for acetic acid.

Formaldehyde

Formaldehyde gas may cause severe irritation to the mucous membranes of the respiratory tract and eyes. Liquid formaldehyde (aqueous solution) splashed in the eyes may cause eye burns. Hives (urticaria) has been reported following inhalation of the gas. Repeated exposure to formaldehyde may cause dermatitis either from the irritation or an allergy. Some persons become sensitized (allerg

to formaldehyde and subsequently develop eye and respiratory tract irritation at much lower levels than non-sensitized individuals.[3] Formaldehyde has recently been found to cause nasal cancer in exposed laboratory animals.[4] The current CAL/OSHA standard for formaldehyde is 2 ppm (both time-weighted average and ceiling concentration). NIOSH recommends limiting worker exposure to the lowest feasible limit. NIOSH also recommends a ceiling limit of 1 ppm based on a 30-minute sample period for the irritation effects only.

Butanol (n-Butyl Alcohol)

Butanol is an eye, skin and upper respiratory tract irritant. Concentrations over 200 ppm may result in more severe eye damage. Inhalation of high concentrations has also produced transitory and persistent dizzyness with vertigo, and slight headache. Drowsiness may also occur.[5] The CAL/OSHA standard for butanol is 150 mg/m^3 (time-weighted average and ceiling concentration). There are no established NIOSH criteria for butanol.

Ethanol (Ethyl Alcohol)

Ethanol is a very mild irritant of the eyes and nose, but the liquid can defat the skin, producing a dermatitis characterized by drying and fissuring of the skin. Prolonged inhalation of high concentrations may produce headache, drowsiness, tremors, and fatigue.[6] The CAL/OSHA standard for ethanol is 1,900 mg/m^3 based on a time-weighted average. There are no NIOSH criteria for ethanol.

(b) Organic Solvents

The film processing industry also uses a number of solvents, including acetone and those listed below, whose primary health effects are central nervous system (CNS) depression, including headache, nausea, and drowsiness. Prolonged contact with fingers can cause localized numbing, or defatting of the skin with drying and fissuring of the skin. Acetone is not known to have any other potential adverse effects except at extremely high concentrations, but long-term exposure to several other solvents used in film processing may result in these adverse health effects:

Methyl Chloroform: liver and kidney damage.[7]

Perchloroethylene (tetrachloroethylene): liver and kidney damage and cardiac arrhythmias; suspect human carcinogen.[8,9]

Dioxane: liver and kidney damage; suspect human carcinogen.[10]

Freons (fluorocarbons): cardiac arrhythmias.[11]

(c) Ergonomic Effects

In the continuous contact printing room, the workers lift large reels of film off of the winding spools for stacking while they are seated. These reels weigh approximately 20 pounds, and several workers complained of bursitis and tendonitis of the shoulders and elbows as a result of this lifting. Repeated musculo-skeletal trauma of this nature may be associated with the eventual development of bursitis, tendonitis and traumatic arthritis.

V. RESULTS AND DISCUSSION

A. Environmental

On July 15, 1980, samples for organic solvents were collected at selected operations at the Technicolor Corporation. The results are contained in Table I. Four general area samples were collected near the doors of an ultrasonic cleaning machine. The samples were analyzed for methyl chloroform, acetone, and perchloroethylene. The methyl chloroform levels ranged from 600-809 mg/m^3 with a time-weighted average (TWA) of 730 mg/m^3 for an approximate 6 and 1/2 hour sample. The acetone levels ranged from 1.4-2.2 mg/m^3 with a TWA of 1.8 mg/m^3. The perchloroethylene levels ranged from 6.5-11.3 mg/m^3 with a TWA of 9.7 mg/m^3. One breathing zone sample was collected on an ultrasonic cleaning room operator. The methyl chloroform TWA level was 429 mg/m3 over an approximate 6 and 1/2 hour sample. The acetone level was 2.5 mg/m^3 and the perchloroethylene concentration was 9.8 mg/m^3. In all the samples, the acetone and perchloroethylene levels were well below the CAL/OSHA standards of 2,400 mg/m^3 and 670 mg/m^3 respectively. NIOSH's Criteria Document for perchloroethylene recommends a TWA level of 339 mg/m^3. No NIOSH criteria exist for acetone. Therefore, in terms of the environmental criteria for the survey, the acetone and perchloroethylene levels in the ultrasonic cleaning area were very low. The levels of methyl chloroform were also well below the NIOSH recommended ceiling of 1,900 mg/m^3 and the CAL/OSHA standard of 1,900 mg/m^3 (TWA). In the ultrasonic cleaning area, an employee who was involved in manual film cleaning was also sampled for methyl chloroform, acetone, perchloroethylene, and dioxane. The respective TWA levels for an approximate 6 and 1/2 hour time period were 406 mg/m^3, 29.0 mg/m^3, 10.4 mg/m^3, and 3.5 mg/m^3. The dioxane level in this employee's sample approached the NIOSH criteria of a ceiling limit of 3.6 mg/m^3, but was well below the CAL/OSHA standard of 180 mg/m^3 (TWA). The levels of methyl chloroform, acetone, and perchloroethylene for this employee were also well below the NIOSH criteria and the CAL/OSHA standards for these compounds.

Two splicer operators at Technicolor were sampled in the breathing zone for an approximate 6 hours. Two separate samples were taken on the splicer in the main work area. Acetone was not detected; the average level of perchloroethylene was 12.1 mg/m^3; the average level of dioxane was 1.0 mg/m^3; and the average methylene chloride level was 1.5 mg/m^3. All the solvent exposures for this employee were well below the NIOSH criteria and CAL/OSHA standards for these compounds. One breathing zone sample over an approximate 6 hours was collected on the splicer who was located behind a glass door. Acetone was not detected. The respective concentrations of perchloroethylene, dioxane, and methylene chloride were 7.8, 3.1, and 17.3 mg/m^3. The perchloroethylene and methylene chloride levels were well below NIOSH criteria and CAL/OSHA standards. The dioxane level approached the NIOSH recommended ceiling of 3.6 mg/m^3, but was well below the CAL/OSHA standard of 180 mg/m^3.

Breathing zone samples over an approximate 6 hour period were collected on the Wetgate Printer and Continuous Contact Printer operators. The methyl chloroform, acetone and perchlorgethylene levels of the Wetgate operator at Technicolor were respectively 93 mg/m^3, none detected, and 54.5 mg/m^3. The exposures were well below both the NIOSH criteria and the CAL/OSHA standards. For the Contact Printer operator at Technicolor, the respective levels for the same substances were 30 mg/m^3, 12.4 mg/m^3, and 8.3 mg/m^3. These levels were again well below the criteria used.

In conclusion, methyl chloroform, acetone and methylene chloride exposures measured at Technicolor on July 15, 1980, did not represent a health hazard. Perchloroethylene levels were also very low, and did not seem to represent a health hazard, although there is some evidence that perchloroethylene may be a suspect carcinogen and thus exposures should be maintained at the lowest feasible level. Dioxane concentrations were well below the CAL/OSHA standard and slightly below the NIOSH recommended limit. Under the circumstances of use of dioxane at Technicolor, dioxane exposures did not seem to represent a health hazard in the work atmosphere. However, skin contact with dioxane does exist for splicer operators.

On July 15, 1980, general area and breathing zone samples for formaldehyde were collected at Technicolor at the developing lines and the chemical mixing area using midget bubblers and personal sampling pumps. The results are contained in Table II. Three general area samples were collected in four locations: between stations #12 & 13, between stations #15 & 16, in front of#16, and at the worker station of the first floor chemical mixing room. Samples were collected for at least one hour. The formaldehyde levels ranged from 0.02 ppm (parts per million) to 0.05 ppm for all samples. Three one-hour breathing zone samples were collected on the mixing room operator. The formaldehyde levels ranged from 0.02 - 0.03 ppm. The levels were well below the CAL/OSHA standard of 2.0 ppm (ceiling). On April 15, 1981, NIOSH made a recommendation that formaldehyde levels be kept at the lowest feasible level without a recommendation on the quantities. Previous to this date, NIOSH had recommended a ceiling concentration of 1.0 ppm for formaldehyde.

On April 15, 1981, repeat formaldehyde samples were collected at Technicolor using an impregnated charcoal tube sampling method developed by NIOSH. Samples were taken at Technicolor since repeat samples were being collect at Movielab. The results of these samples are contained in Table VII. Five breathing zone samples were collected on five employees: light side operator line #16, light side operator line #14, dark side operator line #14, light side operator line #12, and the dark side operator line #12. All samples (except for the light side operator line #12) were run for an approximate 6 hours. The latter sample was collected for an approximate 3 hours. The formaldehyde concentrations were fairly uniform and ranged from 0.33 ppm to 0.62 ppm. One general area sample was collected over an approximate 6 hours at the dark side of line #16. This formaldehyde level was 0.62 ppm. The formaldehyde levels were still well below the CAL/OSHA standard of a ceiling of 2.0 ppm, but the concentrations were much higher than the levels found on July 15, 1980.

On April 15, 1981, acetic acid samples were also collected at Technicolor using special tubes and low-flow pumps. The results are contained in Table V. The samples were collected at the same locations and employees as for the formaldehyde samples on April 15, 1981. Acetic acid was not detected in any of the samples.

On July 16, 1980, organic solvent samples were collected at Movielab, and the results are contained in Table III. A general area sample for methyl chloroform, acetone, and perchloroethylene was collected on an ultrasonic cleaning machine. The respective concentrations over an approximate 6 hour time period were 4,431 mg/m^3, none detected, and 871 mg/m^3. The methyl chloroform level exceeded the NIOSH recommended limit of 1,900 mg/m^3 (ceiling) and the CAL/OSHA ceiling limit of 4,140 mg/m^3. However, no employee worked in the general area. The sample was taken to detect whether solvents were leaking from the doors. Better enclosure is needed on these cleaning machines. The single employee in the cleaning area was also

sampled. Breathing zone samples for methyl chloroform, acetone, and perchloroethylene were collected over an approximate 6 hours. The respective concentrations were 83 mg/m^3, none detected, and 30 mg/m^3. Therefore, the employee's exposure to these compounds was very low and well below the NIOSH criteria and the CAL/OSHA standards. The general area sample indicated that the perchloroethylene level was in excess of the NIOSH criteria of a ceiling of 678 mg/m^3. The CAL/OSHA standard of 670 mg/m^3 (TWA) was also exceeded. However, no employees work in this area as previously discussed. The operator's sample level of 30 mg/m^3 for perchloroethylene represented the worker's exposure.

A breathing zone and general area sample were collected at Movielab in the splicing area. An approximate 6-hour sample for acetone, dioxane, and methylene chloride was collected. Acetone and dioxane were not detected in either sample. Methylene chloride was 2.9 mg/m^3 in the breathing zone sample and 5.4 mg/m^3 in the general area sample. These levels were well below the NIOSH criteria and the CAL/OSHA standard of 261 mg/m^3 (TWA) and 700 mg/m^3 (TWA) respectively.

A breathing zone sample was taken on the Wetgate Printer operator at Movielab for an approximate 4-hour time period during the day of operation. Methyl chloroform and acetone were not detected in the sample. The perchloroethylene concentration was 30 mg/m^3 which was well below the NIOSH criteria of 339 mg/m^3 (TWA) and the CAL/OSHA standard of 670 mg/m^3 (TWA).

In conclusion, methyl chloroform, acetone, dioxane and methylene chloride exposures to employees at Movielab did not represent a health hazard based on samples collected on July 16, 1980. Perchloroethylene levels were well below the CAL/OSHA standard in the breathing zone sample. Since perchloroethylene is a suspect carcinogen, levels should be maintained as low as possible. In the general area above the ultrasonic cleaning machine, levels of methyl chloroform and perchloroethylene exceeded the criteria used and were an indication that these machines need better engineering controls.

On July 16, 1980, general area and breathing zone samples for formaldehyde were collected at Movielab. The samples were collected using the midget bubbler and high-flow sampling pumps. Breathing zone samples were collected on the Film (#10) Positive operator. Two samples covering at least one hour each were taken. One sample contained a concentration of 1.6 ppm for formaldehyde. The other one was contaminated, and an analysis could not be completed. Three general area samples covering at least one hour each were taken near the film positive dry box. One sample contained 0.03 ppm and the other two samples were contaminated. Three breathing zone samples were collected on the Film Positive operator for lines #13 and 14. The samples were collected for at least one hour. The formaldehyde concentrations were 0.09, 0.09, and 0.05 ppm. Three general area samples covering at least one hour each were collected near the dry box on lines #13 and 14. The formaldehyde levels were 0.04, 0.06, and 0.11 ppm. Based on these samples, the formaldehyde levels were well below the CAL/OSHA standard of a ceiling of 2.0 ppm (except for one sample where the level was 1.6 ppm). Three samples could not be analyzed due to contamination. NIOSH recommended on April 15, 1981, to limit employee exposures to formaldehyde to the lowest feasible limit. However, no numbers were given with this recommendation. The Movielab samples are contained in Table VI.

On April 16, 1981, formaldehdye sampling was repeated at Movielab because of the contamination problem with the previous impinger samples. The results of these samples are contained in Table VIII. Three general area samples were collected over an approximate 6-hour time period in the following locations: near the dry box on line #14, near line #13, and near the reel position on line #10. The samples were collected with a special impregnated charcoal tube and a low-flow pump. The method was developed by NIOSH. The respective formaldehyde levels in the three locations were 0.96 ppm, 0.64 ppm, and 11.6 ppm. Two breathing zone samples were collected on employees near line #10. The samples were collected for an approximate 6 hours. The level of formaldehyde on the shift supervisor was 4.4 ppm and the level for the dry end operator was 1.4 ppm. One personal aample and one general area sample near line #10 were very high for formaldehyde and exceeded the CAL/OSHA standard of 2.0 ppm ceiling. The results were conveyed to management at Movielab who were in the process of redesigning the engineering controls for line #10.

On April 16,1981, acetic acid sampling was also conducted at the developing lines of Movielab. The results are contained in Table VI. Three general area and two breathing zone samples were collected for an approximate 6 hours. Acetic acid was not detected in any of the samples.

On June 24, 1981, management at Movielab indicated that certain engineering changes were made on developing line #10. It was felt that further sampling for formaldehyde at this line would indicate whether the engineering controls were effective in lowering the formaldehyde levels. Table IX contains the results of the formaldehyde sampling. Three breathing zone samples were collected on the dry end operator of line #10. The samples were run for at least 30 minutes at a flow rate of 100 cc/minute. Three general area samples were collected at each of four locations: near the dry box on line #10, near the "knock off" squeegie on line #10, near the dry box on line #13, and on the wet end operator's desk on line #10. These samples were collected for at least 30 minutes at a flow rate of 100 cc/minute. Formaldehyde was not detected in any of the breathing zone or general area samples. One sample was placed inside the dry box of #10 and run for 15 minutes. The level of formaldehyde was 24.4 ppm. Employees do not work inside the dry box, but will open it to check the film. A procedure existed whereby the dry box was supposed to be vented for a few minutes prior to opening the doors.

The levels of formaldehyde in these samples did not seem to reflect the levels that were found in the past. Subsequent to this time, it was noted by the Measurements Support Branch of NIOSH that the laboratory was having difficulty with the impregnated charcoal tube method. There was a possibility of loss of formaldehyde from the sample if there was a delay in analyzing the samples. The loss of formaldehyde in the samples collected on June 24, 1981, was a possibility even though the analysis was completed within a short time period. The sampling and analysis for formaldehyde continues to be troublesome, but a new NIOSH method is now being evaluated in the field. It was judged that the actual formaldehyde levels at Movielab were probably below the CAL/OSHA standard, but the NIOSH recommendation to lower concentrations as low as feasible is still NIOSH's official position. Based on these samples, the engineering controls that were instituted seemed to help.

B. Medical Results

The medical study was limited to the employees at the Technicolor Corporation where the bleach accelerator process was being used. A questionnaire was distributed to employees on October 8-9, 1980. The medical questionnaire sought information on length of employment, handling of chemicals, and on the following potential adverse health effects of exposures in the film processing industry:

1. Dermatitis: red/itchy skin, dry/cracked skin, red skin with blisters, patches of skin with color change, frequent skin sores, cracked/deformed/flaking fingernails.

2. Eye Irritation: red/itchy/watery eyes.

3. Upper Respiratory Irritation: frequent coughing, runny nose, dry/itchy throat, phlegm production, nosebleeds.

4. Lower Respiratory System Effects: shortness of breath, chest tightness.

5. Central Nervous System (CNS) Effects: headaches, phlegm, drowsiness, dizzyness, numbness of fingers.

For positive responses, the workers were asked to relate their symptoms to time of day or night, work or vacation periods, and period of employment. In addition, information was sought on aspects of the workers' previous medical history related to skin and upper respiratory problems, e.g., eczema, boils, acne, psoriasis asthma, and hay fever.

One hundred and thirty-seven workers completed and returned the questionnaire. Before analysis of their responses, the job categories were divided on the basis of potential exposure characteristics of each category. These categories, and the corresponding participation rates, are presented in Table X. The characteristic exposures for the first group ("Developer Solution") are the developer solutions, bleach and accelerator compounds. The characteristic exposures for the second group ("Organic Solvents") are the organic solvents listed in Table X which are common to the film processing industry. The third group ("Final Products") was initially selected as a control group because they were believed to have minimal or no exposure to chemicals which might produce symptoms similar to those in the first and second groups. No significant differences were found between the three groups for history of allergic rashes, previous skin problems, acne, boils, psoriasis, asthma, hayfever, and food allergies.

Skin Irritation:

From Table X, it was noted that the characteristic exposure for the Developer Solution Group was developing material. These materials were developer solutions, bleach, and bleach accelerator compounds. These compounds are all strong primary irritants and can effect the eyes, skin and upper respiratory system. Consistent with this fact, workers in this Group reported a high rate of symptoms of irritation for three target sites. According to the previously defined characteristics for skin irritation, 65% of the workers in the Group reported this condition. The risk

of skin irritation was more than three times higher for workers who were in direct contact with chemical solutions (defined as workers who put their hands or arms into chemical solutions with or without the use of protective gloves). Gloves were provided for most operations. The distribution of symptoms is contained in Table XI. In addition to symptoms of current irritation such as red/itchy skin or dry/cracked skin, many workers had symptoms of long-term persistent irritation such as patches of thickened skin, frequent sores, or unusual patches of skin with color changes. These symptoms are consistent with a persistent irritant contact dermatitis resulting from contact with sulfonated compounds or alkali solutions.

Most workers in the Developer Solution Group reported that their skin irritation bothers them either most of the time (57%) or late in the shift (which is consistent with a persistent primary irritation that is made worse during the course of each day by repeated contact with the chemicals). Skin and/or eye irritation was greater among workers who had spent 1 - 10 years in the film processing industry than those with less than one year, but the numbers declined slightly for workers with more than 10 years in the industry. The frequency of skin and eye irritation by length of years in the industry is contained in Table XII. The initially lower number of complaints may mean that affected new workers are leaving the job rapidly, or that the irritant effect does not become severe until after a year or more of work exposure. The decline in complaints after ten years may reflect an increased acceptance of skin and eye irritation among more experienced workers or the ability to avoid contamination with experience.

Eye Irritation:

Eye irritation was reported by 49% of those in the Developer Solution Group, which is almost twice the rate reported by the Organic Solvents Group. As shown in Table XII, the number of years of work in film processing showed the same trend as was exhibited for skin irritation. That is, eye irritation was greater among those workers who had spent 1 - 10 years in the film processing industry. Those workers with less than one year of exposure had the least eye irritation. Those with over 10 years of exposure had a little less eye irritation than the 1 - 10 year exposure group.

Respiratory Irritation:

Complaints of respiratory irritation were also significantly higher among the Developer Solutions Group workers than the other two Groups. The Developer Solutions Group reported three times as many complaints of cough and twice as many complaints of coughing up phlegm as the Organic Solvents Group and the Final Products Group combined. Respiratory irritation as a whole (which is defined as complaints of cough,phlegm, runny/dry nose, nosebleeds, chest tightness and/or shortness of breath) was 60% higher for the Developer Solutions Group than for the other two Groups.

The characteristic exposures for the Organic Solvents Group were such solvents as perchloroethylene, methyl chloroform, freons, acetone, butanol and ethanol. Potential exposures for workers in this Group occurred primarily from inhalation, but some of the jobs required that the workers' fingers be wet with some of the solvents. Cotton gloves were worn, but these gloves did not preclude skin contact.

Skin irritation symptoms reported by the Organic Solvents Group (Table X) followed a different pattern from those in the Developer Solutions Group. One-third of the Organic Solvents Group reported dry, cracked skin, which is the most common skin problem to be expected from the defatting action of solvents. Seventy-five percent of those reporting skin problems found them worse late in the work shift; only 13% were bothered by these problems most of the time as opposed to 57% of the workers in the Developing Solutions Group. The dermatitis among the Organic Solvents Group, therefore, seemed to be transient and left fewer persistent problems such as thickened skin, unusual patches, or frequent sores.

CNS effects as previously defined were not found to be significantly different between Groups except for a higher prevalence of numbness of fingers in the Organic Solvents Group. A comparison between the Organic Solvents Group and the Developer Solutions Group and the Final Products Group combined for this symptom indicated that the Organic Solvents Group showed a three-fold higher prevalence for numbness of the fingers than the other two Groups combined. Numbness of the fingers was a frequent complaint described by employees during the walk-through visits in areas where workers apply acetone with or without the use of cotton gloves. This local anesthetic effect may be due to either a direct solvent effect or to the simple physical effect of prolonged wetting.

The Final Products Group employees had been initially selected as a control group composed of workers who were not known to be exposed to irritants. All of these workers handle films after they have been completely processed, either in optical printing, release viewing, as a projectionist, Hazeltine timer, or in the vault and shipping areas. In analyzing the questionnaire responses, it was found that eye irritation was much more prevalent than expected, and in fact, was more prevalent than among employees in the Developer Solutions Group.

Respiratory irritation as a whole was much more frequent among the Final Products Group than among the Organic Solvents Group (53% versus 39%). The major respiratory complaints among the Final Products Group were runny nose and dry itchy throat. These symptoms were two and one-half times more frequent among the Final Products Group employees than the workers of the Organic Solvents Group, and slightly higher than the employees in the Developer Solutions Group. Additionally, while vacation breaks markedly improved symptoms of irritation for almost everyone in the Developer Solutions and Organic Solvents Groups, 49% of the Final Products Group reported that their symptoms of eye irritation remained the same over vacation periods.

In the developing process, the final step is the stablizing stages where the film is immersed in formaldehyde and dried in a dry box. There is undoubtedly some formaldehyde residue left on the film. This formaldehyde may continue to off-gas for a time period after it reaches the various workers in the Final Products Group. Some of the timers, in fact, reported that they had long ago learned to avoid touching their hands to their glasses or eyes after beginning work each day because of the resulting eye irritation. Consistent with this explanation, the difference in complaint rates by years in the industry was even more exaggerated for eye irritation, suggesting that beginning workers may not yet be sensitized to formaldehyde and a larger percentage of them may leave by the end of the first ten years after becoming sensitized or may learn ways of reducing contact with formaldehyde residue. The lack of improvement in eye irritation from formaldehyde frequently does not resolve itself for several weeks to months after removal from exposure.

VI. CONCLUSIONS

A. Environmental

At both Technicolor and Movielab, exposures of employees to solvents did not represent a health hazard. The majority of airborne concentrations where employees worked were well below the CAL/OSHA standards and below the NIOSH criteria. The organic solvents sampled by NIOSH were methyl chloroform (1,1,1-trichloroethane), perchloroethylene, acetone, dioxane, and methylene chloride. Even though environmental levels of perchloroethylene and dioxane were low, efforts should be maintained to keep employee exposures to a minimum since both chemicals are suspect carcinogens. Where solvent levels were high, these areas were non-employee sections of the plant. Samples were taken to determine if solvents were leaking from equipment and, therefore, into employee areas.

Acetic acid levels were below the limits of detection in samples collected at Technicolor and Movielab. Acetic acid samples were taken at the developing lines.

Formaldehyde concentrations were below the CAL/OSHA standard of 2.0 ppm (ceiling) at the Technicolor plant. The samples were collected on several developing lines on both the wet and dry sides. The highest concentration found at Technicolor was 0.62 ppm. Since formaldehyde is a suspect carcinogen, NIOSH recommends that formaldehyde exposures be maintained at the lowest feasible limit. No air concentration limit was made with the NIOSH recommendation, but continued sampling and efforts to reduce formaldehyde exposure are advisable for Technicolor.

The levels of formaldehyde at Movielab did not remain uniform throughout the NIOSH sampling effort. The impinger sampling method resulted in some contaminated samples, but of the valid samples, the highest formaldehyde level found was 1.6 ppm. This concentration is below the CAL/OSHA standard. Samples repeated at Movielab with an impregnated charcoal tube method resulted in one personal sample level of 4.4 ppm and a general area sample level of 11.6 ppm. These concentrations exceeded the CAL/OSHA standard, and some engineering changes were made in these areas of the plant. A return sampling visit resulted in all the samples being below the limits of detection for formaldehyde except for the sample inside the dry box. Since the impregnated charcoal tube method has had reliability problems, these negative readings must be accepted with reservations. However, the lowest feasible limit recommendation by NIOSH is still an official position, and periodic formaldehyde monitoring is advised.

B. Medical

Although the response rates for employees at Technicolor in the Organic Solvents and Final Products Groups were lower than desired, the pattern of symptoms reported were consistent with the following assessment of exposures for each Group:

Developer Solutions Group:

A persistent irritant contact skin dermatitis, with upper respiratory irritation and eye irritation, associated with exposure to strong sulfonated and alkali solutions. Because of the toluidines involved, there may be some cases of sensitization within the group which were not distinguishable by the questionnaire.

Organic Solvents Group:

A transient defatting irritant dermatitis and local anesthetic effect on the fingers associated with mixed solvent exposures. Lower frequency of upper respiratory and eye irritation complaints than the other two Groups.

Final Products Group:

A sensitization combined with direct irritant effect on the eyes, and a moderate but persistent frequency of skin irritation, associated with formaldehyde contact.

VII. RECOMMENDATIONS

Based on the environmental and medical findings and an assessment of work practices in the film processing industry, the following recommendations are made to assist the industry in assuring a safe and healthful work environment:

1. Medical surveillance of the following type: because their predominant exposures may lead to chronic bronchitis, lung function tests (spirometry for FVC and FEV_1) is recommended for pre-employment examination and yearly for all maintenance workers, developers, and solutions department workers. Audiometry is also recommended on the same schedule for all maintenance workers, developers, and continuous contact printers because of noise exposure in their work areas. Noise levels were reported by management to be in excess of 85 dBA in some areas which means that compliance with the new OSHA noise standard would be necessary. Eye and skin checks for irritation are recommended on a yearly ba: for all job categories included in this investigation because of the high rate. of these complaints found.

2. In accordance with Technicolor memorandum on "Procedure for Skin Protection" (April 7, 1980), any employee whose skin is contacted by developer solution should leave the area, wash the affected skin with mild acid bath and water, rinse thoroughly and dry before returning to the process. Acid mantle cream should also be used after each skin contamination by employees with skin problems and at the end of the day by all employees. The mild (acetic acid) bath and cold water should be placed near all work areas using developer solution.

3. Employees who come in contact with developer solutions should be encouraged to rinse off and change to dry clothing whenever their work clothes are wetted with developer solution.

4. The ventilation systems should be left operational, including weekends, whenever employees must work near the developing solutions.

5. Timing devices for ultrasonic cleaning machine doors should be checked to insure that doors cannot be opened prior to the required exhausting time period. Ultrasonic cleaning machines should also be checked to make sure that the solvent cleaning parts are completely enclosed to prevent leakage of methyl chloroform.

6. The ventilation systems for the developing solution tanks should be serviced regularly to insure that they are functioning properly.

7. Employees should not be allowed to open the dry boxes until such time that the formaldehyde concentrations have dropped to the lowest feasible level. Measurements should be made inside the dry boxes to determine the safe time.

8. A periodic environmental monitoring program for formaldehyde should be instituted to make sure that airborne concentrations are kept at the lowest feasible levels.

9. Employees should be instructed to avoid direct skin contact with methyl chloroform, perchloroethylene, acetone, butanol, dioxane and other solvents used in film processing. Neoprene or other appropriate impervious gloves should be worn by employees while handling solvents.

10. A regular education program regarding potential health hazards of noise and chemical exposures in the film processing industry and ways of preventing these exposures should be provided to the affected employees.

11. Chairs with adjustable heights and firm back supports are recommended for workers in the continuous contact printing area. These employees should also receive training on correct lifting procedures.

12. Smoking and eating in work areas with solvents should be prohibited.

VIII. REFERENCES

1. Eastman Kodak Company: Material Safety Data Sheet - Kodak Persulfate Bleach Accelerator, October, 1978.

2. NIOSH: Occupational Diseases - A Guide to Their Recognition, DHHS (NIOSH) Publication No. 77-181, June 1977, pp 178-179.

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4. Formaldehyde: Evidence of Carcinogenicity, NIOSH Current Intelligence Bulletin, No. 34, DHHS (NIOSH) Publication No. 81-111, April 15, 1981.

5. NIOSH: Occupational Diseases - A Guide to Their Recognition, DHHS (NIOSH) Publication No. 77-181, June 1977, pp 153-154.

6. ibid. pp 154-155

7. ibid. pp 216-217

8. ibid. pp 213-214

9. NIOSH: 1979 Registry of Toxic Effects of Chemical Substances, DHHS (NIOSH) Publication No. 80-111, Vol. 1, September 1980, p 669.

10. NIOSH: Criteria For a Recommended Standard ... Occupational Exposure to Dioxane, DHHS (NIOSH) Publication No. 77-226, September, 1977.

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IX. AUTHORSHIP

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X. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this Determination Report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22151. Information regarding its availability through NTIS can be obtained from the NIOSH Publications Office at the Cincinnati address.

Copies of this report have been sent to:

1. Film Technicians Local No. 683, Hollywood, California
2. Technicolor Corporation, Hollywood, California
3. Movielab-Hollywood Corporation, Hollywood, California
4. U.S. Department of Labor/OSHA - Region IX
5. CAL/OSHA
6. NIOSH - Region IX

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

TABLE I. CONCENTRATIONS OF SOLVENTS IN MILLIGRAMS PER CUBIC METER OF AIR (mg/m^3) IN SAMPLES COLLECTED AT THE TECHNICOLOR PLANT, JULY 15, 1980.

Sample#	Job Title or Operations	Type of Sample	Sample Period	MC[1]	ACE[2]	PERC[3]	DIOX[4]	MECL[5]
				mg/m^3				
CT-1	Ultrasonic Cleaning Machine	General Area	9:10a-10:40a	600	2.2	6.5	---*	---
CT-8	" " "	" "	10:40a-12:15p	690	1.4	11.3	---	---
CT-10	" " "	" "	12:15p- 1:45p	795	1.5	9.2	---	---
CT-12	" " "	" "	1:45p- 3:45p	809	2.0	11.1	---	---
CT-3	" "Operator	Breathing Zone	9:10a- 3:35p	429	2.5	9.8	---	---
CT-2	Splicer(behind glass doors)	" "	9:45a- 3:25p	---	ND**	7.8	3.1	17.3
CT-7	Splicer(main room)	" "	9:40a-11:20a	---	ND	9.8	ND	1.0
CT-11	" " "	" "	11:30a- 3:45p	---	ND	14.5	1.4	2.1
CT-4	Manual Film Cleaning	" "	9:10a- 3:35p	406	29.0	10.4	3.5	---
CT-5	Wetgate Duplicator Operator	" "	9:20a- 3:30p	93	ND	54.5	---	---
CT-6	Continuous Contact Printer	" "	9:25a- 3:40p	30	12.4	8.3	---	---

1 - (MC) methyl chloroform or 1,1,1-trichloroethane
2 - (ACE) acetone
3 - (PERC) perchloroethylene
4 - (DIOX) dioxane
5 - (MECL) methylene chloride
* - analysis not requested since substance not expected
** - (ND) not detected--below limits of detection for the analytic method

TABLE II. CONCENTRATIONS OF FORMALDEHYDE IN PARTS PER MILLION (ppm) IN AIR SAMPLES COLLECTED AT THE TECHNICOLOR PLANT, JULY 15, 1980.

Sample#	Job Title or Plant Operation	Type of Sample	Sample Period	Formaldehyde
T-1	Between Stations #15 & 16	General Area	9:27a-10:50a	0.05 ppm*
T-6	" " "	" "	10:53a- 1:11p	0.05 "
T-11	" " "	" "	1:12p- 2:28p	0.04 "
T-2	Front of Station #16	" "	9:30a-10:55a	0.04 "
T-7	" " "	" "	10:57a- 1:09p	0.05 "
T-12	" " "	" "	1:10p- 2:31p	0.03 "
T-3	Between Stations #12 & 13	" "	9:33a-10:58a	0.03 "
T-8	" " "	" "	11:00a- 1:13p	0.03 "
T-13	" " "	" "	1:13p- 2:29p	0.02 "
T-4	1st Floor Mixing Room	" "	9:56a-11:02a	0.04 "
T-9	" " "	" "	11:05a- 1:18p	0.03 "
T-14	" " "	" "	1:20p- 3:25p	0.03 "
T-5	Mixing Room Operator	Breathing Zone	10:05a-11:05a	0.03 "
T-10	" " "	" "	11:07a-12:05p	0.02 "
T-15	" " "	" "	1:18p- 2:18p	0.02 "

*ppm - parts of vapor or gas per million parts of contaminated air

CAL/OSHA Standard - 2.0 ppm ceiling concentration

NIOSH Criteria - 0.8 ppm ceiling concentration, 30 minutes

TABLE III. CONCENTRATIONS OF SOLVENTS IN MILLIGRAMS PER CUBIC METER OF AIR (mg/m^3) IN SAMPLES COLLECTED AT THE MOVIELAB PLANT, JULY 16, 1980.

						mg/m³		
Sample#	Job Title or Operation	Type of Sample	Sample period	MC[1]	ACE[2]	PERC[3]	DIOX[4]	MECL[5]
CT-14	Ultrasonic Cleaning Machine	General Area	8:35a- 2:20p	4431	ND*	871	---**	---
CT-13	" "Operator	Breathing Zone	8:30a- 2:20p	83	ND	30	---	---
CT-15	Splicer	" "	8:40a- 2:15p	---	ND	---	ND	2.9
CT-16	Splicing General Area	General Area	8:45a- 2:15p	---	ND	---	ND	5.4
CT-17	Wetgate Printer Operator	Breathing Zone	8:55a- 1:35p	ND	ND	30	---	---

1 - (MC) methyl chloroform or 1,1,1-trichloroethane
2 - (ACE) acetone
3 - (PERC) perchloroethylene
4 - (DIOX) dioxane
5 - (MECL) methylene chloride
* - (ND) not detected--below limits of detection for the analytical method
** - analysis not requested since substance not expected

TABLE IV. CONCENTRATIONS OF FORMALDEHYDE IN PARTS PER MILLION (ppm) IN AIR SAMPLES COLLECTED AT THE MOVIELAB PLANT, JULY 16, 1980.

Sample#	Job Title or Plant Operation	Type of Sample	Sample Period	Formaldehyde
M-1	Film Positive Operator	Breathing Zone	9:18a-10:38a	*
M-6	" " "	" "	10:40a-11:50a	1.6 ppm**
M-2	Film Positive Dry Box	General Area	9:22a-10:41a	0.03 "
M-7	" " " "	" "	10:41a-11:53a	*
M-9	" " " "	" "	11:53a- 1:47p	*
M-3	Film Positive #13 & 14 Operator	Breathing Zone	9:33a-10:36a	0.09 ppm
M-5	" " " "	" "	10:37a-11:42a	0.09 "
M-11	" " " "	" "	12:12p- 1:36p	0.05 "
M-4	#13 & 14 Near Dry Box	General Area	9:38a-10:44a	0.11 "
M-8	" " " "	" "	10:44a-11:58a	0.06 "
M-10	" " " "	" "	11:58a- 1:44p	0.04 "

*samples contaminated with interfering substance

**ppm - parts of vapor or gas per million parts of contaminated air

CAL/OSHA Standard - 2.0 ppm ceiling concentration

NIOSH Criteria - 0.8 ppm ceiling concentration, 30 minutes

TABLE V. CONCENTRATIONS OF ACETIC ACID IN MILLIGRAMS PER CUBIC METER (mg/m^3) OF AIR IN SAMPLES COLLECTED AT THE TECHNICOLOR CORPORATION PLANT ON APRIL 15, 1981

AREA OR OPERATION	TYPE OF SAMPLE	SAMPLE PERIOD	CONCENTRATION (mg/m^3)
Line #12 Light Side	Personal	9:00 a - 12:00 p	N.D.*
Line #12 Dark Side	"	9:15 a - 3:00 p	N.D.
Line #14 Light Side	"	9:00 a - 3:40 p	N.D.
Line #14 Dark Side	"	9:15 a - 3:30 p	N.D.
Line #16 Light Side	"	8:45 a - 3:30 p	N.D.
Line #16 Dark Side	General Area	9:00 a - 3:35 p	N.D.

*N.D. - None detected; below the limits of detection (0.05 milligrams per sample) for the analytical method used.

TABLE VI. CONCENTRATIONS OF ACETIC ACID IN MILLIGRAMS PER CUBIC METER (mg/m^3) OF AIR IN SAMPLES COLLECTED AT THE MOVIELAB CORPORATION PLANT ON APRIL 16, 1981

AREA OR OPERATION	TYPE OF SAMPLE	SAMPLE PERIOD	CONCENTRATION (mg/m^3)
Line #13 near Dry Box	General Area	9:00 a - 3:15 p	N.D.*
Line #14 near Dry Box	" "	9:15 a - 3:15 p	N.D.
Line #10 Light Side	Personal	9:00 a - 3:10 p	N.D.
Line #10 Dark Side	"	9:00 a - 3:15 p	N.D.
Line #14 Dark Side	General Area	9:00 a - 3:10 p	N.D.

*N.D. - None Detected; below the limits of detection (0.05 milligrams per sample) for the analytical method used.

TABLE VII CONCENTRATIONS OF FORMALDEHYDE IN PARTS PER MILLION (PPM) IN AIR SAMPLES COLLECTED AT THE TECHNICOLOR PLANT, APRIL 15, 1981

JOB TITLE OR PLANT OPERATION	TYPE OF SAMPLE	SAMPLE PERIOD	FORMALDEHYDE
DRY END (LIGHT SIDE) OPERATOR LINE # 16	BREATHING ZONE	8:45a-3:30p	0.33ppm*
DARK SIDE LINE # 16	GENERAL AREA	9:00a-3:30p	0.62ppm
DRY END OPERATOR LINE # 14	BREATHING ZONE	9:00a-3:40p	0.59ppm
DARK SIDE OPERATOR LINE # 14	" "	9:15a-3:30p	0.50ppm
DRY END OPERATOR LINE # 12	" "	12:00a-3:30p	0.52ppm
DARK SIDE OPERATOR LINE # 12	" "	9:15a-3:00p	0.49ppm

*ppm - parts of vapor or gas per million parts of contaminated air

TABLE VIII CONCENTRATION OF FORMALDEHYDE IN PARTS PER MILLION (PPM) IN AIR SAMPLES COLLECTED AT THE MOVIELAB PLANT, APRIL 16, 1981

JOB TITLE OR PLANT OPERATION	TYPE OF SAMPLE	SAMPLE PERIOD	FORMALDEHYDE
NEAR DRY BOX LINE # 14	GENERAL AREA	9:15a-3:15p	0.96ppm*
NEAR DRY BOX LINE # 13	" "	9:00a-3:10p	0.64ppm
DRY END OPERATOR LINE # 10	BREATHING ZONE	9:00a-3:10p	1.4ppm
SHIFT SUPERVISOR LINE # 10	" "	8:45a-3:05p	4.4ppm
NEAR REEL POSITION LINE # 10	GENERAL AREA	9:00a-3:05p	11.6ppm

*ppm- parts of gas or vapor per million parts of contaminated air

TABLE IX CONCENTRATIONS OF FORMALDEHYDE IN PARTS PER MILLION (PPM) IN AIR SAMPLES COLLECTED AT THE MOVIELAB PLANT, JUNE 24, 1981

JOB TITLE OR PLANT OPERATION	TYPE OF SAMPLE	SAMPLE PERIOD	FORMALDEHYDE
DRY END OPERATOR LINE # 10	BREATHING ZONE	9:00a- 9:30a	ND*
" " " " "	" "	9:30a-10:00a	ND
" " " " "	" "	10:55a-11:25a	ND
" " NEAR DRY BOX	GENERAL AREA	9:05a- 9:35a	ND
" " " " "	" "	9:35a-10:05a	ND
" " " " "	" "	10:05a-10:35a	ND
WET END OPERATOR'S DESK	" "	9:08a- 9:38a	ND
" " " "	" "	9:38a-10:08a	ND
" " " "	" "	10:09a-10:42a	ND
DRY END LINE # 13	" "	9:10a- 9:40a	ND
" " " "	" "	9:40a-10:10a	ND
" " " "	" "	10:10a-10:45a	ND
DRY END LINE # 10 NEAR "KNOCK OFF" SQUEEGIE	" "	9:12a- 9:42a	ND
" "	" "	9:42a-10:16a	ND
" "	" "	10:16a-10:40a	ND
IN DRY BOX LINE # 10	" "	10:20a-10:35a	24.4 ppm**

*ND - none detect; below limits of detection (less than 8 micrograms per sample) for the method used.

**ppm - parts of vapor or gas per million parts of contaminated air

TABLE X. TABULATION OF JOB CATEGORIES, RESPONSE RATES, AND CHARACTERISTIC EXPOSURES OF TECHNICOLOR EMPLOYEES PARTICIPATING IN THE STUDY.

JOB CATEGORY	WORKERS IN CATEGORY	WORKERS PARTICIPATING	%PARTICIPATION	%PARTICIPATION BY GROUP	MAJOR EXPOSURES BY GROUP
DEVELOPER SOLUTIONS GP				61%	
Wet maintenance	12	9	75%		developer solutions bleach accelerator formaldehyde acetic acid
Developers (+,-)	70	50	71%		
Auxiliary maintenance	9	1	11%		
Solutions	17	6	35%		
ORGANIC SOLVENTS GP				25%	
Dry maintenance	14	5	36%		vydax (freons) perchloroethylene methyl chloroform acetone methylene chloride dioxane butanol ethanol
Ultrasonic cleaners	9	4	44%		
Assembly (+,-)	78	17	22%		
Continuous contact printer	19	11	58%		
Contact printing	45	4	9%		
FINAL PRODUCTS GP				37%	
Optical printing	13	8	62%		formaldehyde residue on film
Shipper	15	6	40%		
Vault	15	1	7%		
Release viewing	14	2	14%		
Projectionists	9	2	22%		
Timers/others	15	11	73%		

TABLE XI. FREQUENCY OF SYMPTOMS OF SKIN IRRITATION BY GROUP AMONG RESPONDENTS AT THE TECHNICOLOR CORPORATION

SYMPTOM	DEVELOPER SOLUTION GROUP	ORGANIC SOLVENTS GROUP
Red/itchy skin	49%	24%
Dry/cracked skin	33%	34%
Cracked/deformed nails	24%	25%
Red skin with blisters	21%	2%
Unusual patches of skin with color changes	17%	0.5%
Frequent sores	14%	5%
Patches of thickened skin	12%	2%

TABLE XII. FREQUENCY OF SKIN AND EYE IRRITATION BY YEARS IN THE FILM PROCESSING INDUSTRY FOR THE DEVELOPER SOLUTIONS GROUPS & ALL GROUPS COMBINED

YEARS IN INDUSTRY	ALL GROUPS COMBINED: SKIN & EYE IRRITATION	DEVELOPER SOLUTIONS GP: SKIN IRRITATION	DEVELOPER SOLUTIONS GP: EYE IRRITATION
1 year or less	56%	33%	17%
1 - 10 years	83%	74%	67%
More than 10 years	69%	64%	40%

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