This Health Hazard Evaluation (HHE) report and any recommendations made herein are for the specific facility evaluated and may not be universally applicable. Any recommendations made are not to be considered as final statements of NIOSH policy or of any agency or individual involved. Additional HHE reports are available at http://www.cdc.gov/niosh/hhe/reports

HETA 93-0448-2407
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THATCHER TUBES
DIVISION OF COURTAULDS U.S.
MUSCATINE, IOWA

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I. SUMMARY

On December 21, 1992, the International Chemical Workers Union (ICWU) requested a health hazard evaluation (HHE) at Thatcher Tubes, a division of Courtaulds Packaging U.S., in Muscatine, Iowa. The National Institute for Occupational Safety and Health (NIOSH) was asked to evaluate exposures in the press area of the plastic tube department where ultraviolet (UV) cured inks are used. Workers were concerned about possible skin and respiratory sensitization to emissions from the plastic tube printing and curing operations. Prior investigations had been unable to determine the source(s) of the reported problems.

An initial site visit as performed on October 20-21, 1993. It included a walkthrough survey of the area in question, review of the Occupational Safety and Health Administration (OSHA) 200 Injury and Illness Logs, discussions with plant medical personnel, review of pertinent Material Safety Data Sheets (MSDSs), and collection of air samples for methyl ethyl ketone (MEK), methyl isobutyl ketone (MIBK), ethanol, isopropanol, toluene, trimethylolpropane triacrylate (TMPTA), and ozone.

Levels of MEK obtained from full-shift, personal breathing-zone air samples ranged from 7.2 to 18.5 parts per million (ppm), concentrations well below the exposure criteria of 200 ppm for an 8-hour time-weighted average (TWA) established by NIOSH, the Occupational Safety and Health Administration (OSHA) and the American Conference of Governmental Industrial Hygienists (ACGIH). One short-term (11 minute) air sample for MEK had 52.4 ppm, a level below the MEK short-term exposure limit of 300 ppm adopted by NIOSH, OSHA, and the ACGIH. Levels of MIBK, ethanol, isopropanol, and toluene (the primary organic solvents identified in qualitative bulk air samples) were present at levels well below their exposure limits. No TMPTA or ozone was detected. OSHA 200 log review revealed no cases of respiratory sensitization and several cases of contact dermatitis during the four-year period, 1989-1993.

Based on the environmental data obtained during this investigation, NIOSH investigators concluded that no specific substance(s) or health hazards from airborne exposure to chemicals used in the UV-coating process clearly accounted for the symptoms reported by workers in the evaluated area. OSHA 200 log review revealed no cases of respiratory sensitization and several cases of contact dermatitis during the four-year period, 1989-1993. Recommendations to implement a comprehensive hazard communication program, use appropriate protective gloves, install safety equipment such as eye wash stations and showers, and curtail the use of tobacco products in areas where employees may be exposed to chemical substances are included in this report.

Keywords: SIC 3084 (Plastics Pipe), methyl ethyl ketone, ethanol, isopropanol, toluene, trimethylolpropane triacrylate, ultraviolet-cured inks, plastics, printing, skin sensitization

II. INTRODUCTION

On December 21, 1992, of the International Chemical Workers Union requested a health hazard evaluation (HHE) at Thatcher Tubes in Muscatine, Iowa. The National Institute for Occupational Safety and Health (NIOSH) was asked to evaluate workers' exposures in the plastic tube department where ultraviolet (UV) cured inks are used. Worker complaints of skin and respiratory sensitization were reported in the request.

A site visit was made on October 20-21, 1993. On October 20, 1993, an opening conference was conducted where NIOSH investigators presented an overview of the HHE program and discussed plans for the investigation. Immediately following the opening conference, a walkthrough survey was conducted in the plant. Following the walkthrough, medical and industrial hygiene surveys were conducted. The medical evaluation included reviews of the OSHA 200 Injury and Illness logs, discussions with the plant nurse, and review of pertinent Material Source Data Sheets (MSDS). The environmental survey included a review of work practices, and assessment of industrial hygiene and safety conditions, and the subsequent collection of bulk and personal air samples.

III. BACKGROUND

Thatcher Tubes, a subsidiary of Courtaulds U.S., is a manufacturer of plastic squeeze tubes for cosmetics, food, and industry and employs approximately 300 workers over three shifts. The Iowa site has 277,000 square feet of production area, which includes injection molding, printing, assembly, and packing operations. Based on the information provided in the request and in the opening conference, the investigation focused on (a) the plastic tube department where the UV-cured inks and coatings are applied to the tubes, and (b) the ink mixing room.

Low and high density polyethylene pellets are delivered via rail car and stored in two large hoppers. The pellets are weighed in barrels and then taken to the extruder where the tubes are formed. The plastic is heated and formed into open-ended tubes. Consecutive layers may be applied, depending upon the desired thickness of the tube. The head and shoulders of the tube are then added through the use of pressure and temperature. The tubes are placed in a transfer hopper and then manually or automatically loaded on the corona tree prior to printing. In the printing process, the corona tree transfers the ink onto the tube. The ink is then cured in the UV oven. Printed plastic tubes which receive a protective coating are dried in another UV oven. The finished tubes are then mechanically capped and stored in the warehouse.

IV. ENVIRONMENTAL METHODS

Environmental monitoring included evaluation of exposures to trimethylolpropane triacrylate (TMPTA), isopropanol (IPA), ethanol, methyl ethyl ketone (MEK), methyl isobutyl ketone (MIBK), and toluene.

Trimethylolpropane Triacrylate

Personal breathing zone air samples for TMPTA were collected on XAD-7 tubes according to the OSHA "*stop-gap*" method. Presently, this method has not been validated and has desorption efficiencies which are slightly less (69.7% ± 6.4) than the minimum acceptable value of 75%. There is no NIOSH sampling and analytical method for this compound.

Eight-hour time-weighted average (TWA) samples were obtained by using XAD-7 sorbent tubes

connected via Tygon® tubing to Gillian Lo Flow Sampler® battery-operated personal sampling pumps. Air was sampled through the tubes at a nominal flow rate of 0.02 liters per minute (ℓ/min). After sampling, the XAD-7 tubes were removed and desorbed with 2 milliliters (ml) of methanol. The samples were analyzed using high performance liquid chromatography (HPLC) using an UV detector. The analytical limit of detection (LOD) was 0.1 micrograms (µg) per sample.

Methyl Ethyl Ketone

Personal breathing zone (PBZ) and area samples for MEK were collected on Orbo-90 tubes by NIOSH Method 2500.[1] Samples were collected at a flow rate of 0.02 and 0.20 ℓ/min for 8-hour TWA and short-term sampling, respectively. After sampling, the analyte was desorbed using carbon disulfide containing benzene and analyzed by gas chromatography-flame ionization detection (GC-FID). The NIOSH Method 2500 for MEK has a LOD of 0.01 mg/sample.

Organic Solvents

Area and PBZ air samples for organic solvents were collected using charcoal tubes as the collection media. The tubes were connected via Tygon® tubing to Gillian Lo Flow Sampler® battery-operated personal sampling pumps. Air was sampled through the tubes at a nominal flow rate of 0.2 ℓ/min for qualitative air samples and 0.05 ℓ/min for quantitative air samples. After sampling, the charcoal tubes were removed and desorbed in carbon disulfide. Three bulk air samples were qualitatively analyzed for organic compounds using gas chromatography-mass spectrometer (GC-MS). Based on the results of the bulk samples, samples were quantitatively analyzed for isopropanol, ethanol, methyl isobutyl ketone (MIBK), and toluene using a combination of NIOSH Methods 1300, 1400, and 1501.[1] The quantitative samples were analyzed using gas chromatography-flame ionization detection (GC-FID). The analytical limits of detection for these four compounds using these NIOSH Methods are listed in the adjacent chart.

Compound	Limit of Detection	Limit of Quantitation
Ethanol	0.9 ug/sample	2.7 ug/sample
Isopropanol	0.8 ug/sample	2.4 ug/sample
MIBK	0.8 ug/sample	2.4 ug/sample
Toluene	0.9 ug/sample	2.7 ug/sample

All of the Gillian Lo Flow Sampler® pumps were calibrated prior to and after sampling using the Gillian Gilibrator®. The Gillian Gilibrator® was calibrated against a primary standard. For subsequent calculations of sample volumes, the mean pre- and post flow rates were used. A minimum of 10% of the sampled XAD-7 and charcoal tubes were prepared and submitted as field blanks with the sample sets.

V. MEDICAL METHODS

A NIOSH occupational medicine physician reviewed the OSHA 200 logs for the plant from 1989 through 1993. The plant nurse was consulted regarding conditions in the plant and any questions arising from the review of the OSHA 200 logs. NIOSH, union, and plant personnel informed employees that confidential medical interviews were available during the site visit, although no one chose to speak with the NIOSH physician. From the OSHA 200 logs and the plant nurse, the physician obtained information regarding occupational illnesses and injuries at the plant. The

Company's extensive file of MSDS sheets, a copy of which is maintained in the medical station, was also reviewed concerning chemicals used in the areas in question.

VI. EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ evaluation criteria for the assessment of a number of chemical (and physical) agents. The primary sources of environmental evaluation criteria for the workplace are the following: **1)** NIOSH Criteria Documents and Recommended Exposure Limits (RELs), **2)** the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs), and **3)** the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values® (TLVs).[1,2,3] The objective of these criteria for chemical agents is to establish levels of inhalation exposure to which the vast majority of workers may be exposed without experiencing adverse health effects.

Full-shift and shorter duration inhalation criteria are available depending on the specific physiologic properties of the chemical substance. Full-shift limits are based on the time-weighted average (TWA) airborne concentration of a substance that most workers may be repeatedly exposed to during a normal eight or 10-hour day, up to 40 hours per week for a working lifetime, without adverse effect. Some substances have recommended short-term exposure limits (STELs) or ceiling limits which are intended to supplement the full shift criteria where there are recognized irritative or toxic effects from brief exposures to high airborne concentrations. STELs are based on TWA concentrations over 15 minute time periods, whereas ceiling limits are concentrations which should not be exceeded even momentarily.

Occupational health criteria are established based on the available scientific information provided by industrial experience, animal or human experimentation, and epidemiological studies. Differences between the NIOSH RELs, OSHA PELs, and the ACGIH TLVs® may exist because of different scientific philosophy and interpretations of technical information. When comparing the exposure criteria, it should be noted that **employers are legally required to meet those levels (and any conditions) specified by an OSHA PEL**. The legal rulemaking process for promulgation of OSHA PELs is an arduous and time consuming task and the OSHA PELs may be required to take into account the technical and economical feasibility of controlling exposures in various industries where the agents are used. Hence, OSHA PELs may not be established based on the most current scientific information. In contrast, the NIOSH RELs are primarily based upon the prevention of occupational disease without assessing the economic feasibility of the affected industries and as such tend to be very conservative. ACGIH is not a governmental agency; it is a professional organization whose members are industrial hygienists or other professionals in related disciplines and are employed in the public or academic sector. TLVs® are developed by consensus agreement of the ACGIH TLV® committee and are published annually. The documentation supporting the TLVs® (and proposed changes) is periodically reviewed and updated if believed necessary by the committee. It is not intended by ACGIH for TLVs® to be applied as the threshold between safe and dangerous inhalation exposure.

It is important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these occupational health exposure criteria. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, previous exposures, or an allergy. In addition, some hazardous substances may act in combination with other workplace exposures, or with medications or personal habits of the worker (such as smoking, etc.) to produce health effects even if the occupational exposures are controlled to the limit set by the evaluation criterion. These combined effects are often not considered by the chemical specific evaluation criteria. Furthermore, many substances are appreciably absorbed by direct contact with the skin and thus potentially increase the overall exposure and biologic response beyond that expected from inhalation alone. Finally, evaluation criteria may change over time as

new information on the toxic effects of an agent become available. Because of these reasons, it is

prudent for an employer to maintain worker exposures well below established occupational health criteria.

Methyl Ethyl Ketone (MEK)

Methyl ethyl ketone (MEK) is a colorless, flammable organic solvent with a characteristic odor similar to acetone and is typically used as a solvent in the surface coating and synthetic resin industries.[4]

MEK is absorbed primarily through inhalation. At high concentrations, it may cause central nervous system (CNS) depression. MEK also causes irritation of the eyes, mucous membranes, and skin. Short duration inhalation exposure to 100 ppm of MEK was reported to cause slight nose and throat irritation, 200 ppm caused mild eye irritation, and 300 ppm was associated with headaches and throat irritation, as well as an objectional odor.[5] Additional studies indicate that MEK by itself does not cause neurologic toxicity of the extremities (peripheral neuropathy), but may potentiate the toxic effects of substances known to cause peripheral neuropathy, such as n-hexane.[6,7,8] Continued or prolonged skin contact with MEK liquid can cause dermatitis.[5]

The National Toxicology Program, a interagency research program, has not found evidence supporting an association between MEK exposure and the development of cancer in humans or experimental animals.[9]

NIOSH, OSHA, and ACGIH have the same full-shift TWA exposure limit for MEK of 200 ppm and a 15-minute STEL of 300 ppm.

Ethanol (Ethyl Alcohol)

This solvent is flammable, colorless, and possesses a distinct odor. Under typical industrial exposure conditions, the acute toxicity of ethanol is low. Effects resulting from over-exposure to ethanol may include incoordination and drowsiness.[5] Eye and skin irritation may result following contact with the liquid. In its vapor form ethanol is irritating to the eyes and upper respiratory tract at concentrations well below the current exposure limits.[5] The NIOSH REL, OSHA PEL, and ACGIH TLV exposure limits are all 1000 ppm for an 8-hour TWA.

Isopropanol (Isopropyl Alcohol)

Isopropanol is a colorless, volatile, flammable liquid of low toxicity that is used as a chemical intermediate, as a general purpose solvent, and is present in skin lotions, cosmetics, and pharmaceuticals.[4,5] The vapor of isopropanol is irritating to the eyes and mucous membranes; inhalation of high concentrations can cause depression of the central nervous system.[5,10] The potential effects from skin contact with the liquid are insignificant; cutaneous absorption should not contribute to systemic toxicity and generally does not produce skin irritation, except with allergic individuals.[4,5,10]

The inhalation exposure limits established for isopropanol by NIOSH, OSHA, and ACGIH are equivalent -- a full-shift TWA of 400 ppm, and a 15-minute STEL of 500 ppm.

Methyl Isobutyl Ketone (MIBK)

Used in paints, glues, and as a cleaning agent, MIBK can irritate the eyes, skin, and mucous membranes.[5] Exposures to concentrations between 50 to 500 ppm in humans have caused eye irritation, headache, irritation, loss of appetite, and weakness.[6] This compound has a distinctive camphor-like odor which is detectable at a level of 100 ppm.[5]

The NIOSH REL and ACGIH TLV for MIBK are both set at 50 ppm for up to an 8-hour TWA and

75 ppm for a 15-minute STEL. The OSHA PEL for this chemical is 100 ppm for an 8-hour TWA.

TMPTA

Trimethylolpropane triacrylate (TMPTA) is one of several multifunctional acrylates used in UV-cured inks. In use since the early 1970's, these acrylates, which act as cross-linkers and diluents, quickly polymerize following exposure to UV.[11] The uncured inks may contain constituents (such as TMPTA or other acrylates) which are skin irritants or sensitizers. For example, studies have shown workers developing dermatitis of the hands and skin following direct skin contamination with TMPTA-containing inks.[12] Allergic contact dermatitis from UV-curing acrylate used in the manufacture of optical fibers has also been documented.[13]

NIOSH, OSHA, and the ACGIH have not established occupational exposure criteria for trimethylolpropane triacrylate (TMPTA).

VII. RESULTS

Industrial Hygiene

TMPTA

No TMPTA was detected in any of the air samples collected as part of this evaluation. Assuming an average sample volume of 9 liters, the minimum detectable concentration (MDC) for this sample set was 9 parts per billion.

Methyl Ethyl Ketone

As shown in Table 1, the results from all of the personal breathing-zone air samples were below NIOSH, OSHA, and ACGIH exposure limits for both 8-hour TWA exposures and short-term exposures.

Ethanol, Isopropanol, Methyl Isobutyl Ketone, Toluene

Based on the results of the gas chromatography-mass spectrometry analysis of two of the charcoal tube field samples, ethanol, isopropanol, MIBK, and toluene were selected for quantitation. As shown in Table 2, the concentrations of these four solvents were well below their respective occupational exposure limits. MIBK was detected in only two, and toluene in only one of the nine personal samples collected.

Medical

No evidence of respiratory sensitization was uncovered through review of the OSHA 200 logs and discussions with plant health and safety personnel. MSDS review revealed several chemical compounds in the inks which may cause acute skin and mucous membrane irritation, and also irritant or allergic contact dermatitis. Some upper respiratory irritation occurred in two employees once during 1991 when a press was enclosed in an attempt to prevent dust and other airborne particles from landing on the tubes during the printing process. This situation was resolved within one day. The affected workers were evaluated by medical personnel. The chemical inhalation caused primarily mucous membrane irritative symptoms.

Several cases of contact dermatitis were recorded in the OSHA 200 logs for the four-year period,

1989-1993 (1989 - 1case; 1990 and 1991 - no cases; 1992 - 2 cases; 1993 - 3 cases). The majority of the dermatitis was on the hands and forearms. No records were available to determine whether these cases represented irritant or allergic dermatitis .

VIII. DISCUSSION AND CONCLUSIONS

The concentrations of isopropanol, trimethyl benzene, and total hydrocarbons measured during this survey do not exceed OSHA, NIOSH, or ACGIH occupational exposure limits. Although trimethylolpropane triacrylate (TMPTA) was not detected in any of the general area and PBZ air samples collected at part of this evaluation, it is still appropriate that personal protective clothing be used during the press clean-up. Skin contact with this acrylate, or with the other solvents used at Thatcher, may cause dermatitis.

Based on the medical evaluation, no cases of respiratory sensitization were identified from the OSHA 200 logs. There are several compounds in use which have properties known to cause allergic and irritant contact dermatitis. These compounds, used in conjunction with the solvents present, may be causing a combination of allergic and irritant contact dermatitis.

IX. RECOMMENDATIONS

1. Labeling of chemicals, worker training, and other aspects of the hazard communication should be improved. According to OSHA Title 29, Code of Federal Regulation 1910.1200, Thatcher Tubes is required to transmit all information regarding the hazards of the chemicals used at this facility to the employees. This can be accomplished by means of a comprehensive hazard communication program, which includes a written program, labeling of containers, distribution of accurate and updated MSDSs, and employee training regarding the hazards of chemicals and protective measures which should be taken. Employee training should include identifying the physical and health hazards of the chemicals in the work area, the measures employees can take to protect themselves from these hazards, an explanation of both the labeling system and MSDSs, and how the employees can obtain and use this information.

2. Solvents used throughout Thatcher Tubes contain flammable liquids which are regulated by OSHA, primarily under 29 CFR 1910.106. In the manufacturing areas, the solvent-drenched rags were stored in appropriate containers; however, the containers were not emptied frequently and were overflowing onto the floor. From the manufacturing areas, the rags were placed into cloth laundry bags. These bulk storage bins are inappropriate containers for solvent-drenched rags. Thatcher Tubes should provide noncombustible storage containers with self-closing covers for rags soaked with solvents.

3. Appropriate personal protective gloves should be used during the ink mixing and clean-up operations. According to Forsberg and Mansdorf's *Quick Selection Guide to Chemical Protective Clothing*, polyvinyl chloride (PVC), Teflon™, or Viton™ gloves are recommended when handling toluene. For MEK, butyl rubber or Viton™ gloves are recommended.[14] According to the manufacturer of TMPTA, nitrile gloves should be used. Thatcher Tubes should have gloves in a variety of sizes available to ensure proper fit for all workers. As part of the hazard communication program, the employees should also be trained on the specific type of gloves which should be worn for specific chemical hazards.

4. Eye wash stations and safety showers should be installed in the immediate work area and readily accessible as set forth by the OSHA standard 29 CFR 1910.151.[2] According to the American National Standards Institute, the maximum time required to reach the eyewash should be determined by the potential effect of the chemical.[15]

5. NIOSH recommends that the use of tobacco products be curtailed in situations where

employees may be exposed to chemical substances which may interact with tobacco products and where non-smoking workers may be exposed to side-stream cigarette smoke. The best method for controlling worker exposure to tobacco smoke is to eliminate smoking from the workplace. Until this is achieved, smoking should be restricted to areas outside of the plant or to a designated area such as a smoking room which has additional dedicated ventilation. The air from this smoking area should be exhausted directly to the outside and not recirculated within the building.[16]

6. Smoke tubes were used to evaluate the effectiveness of the local exhaust ventilation systems. The smoke released near the ink or coating tray moved towards the workers, rather than being captured with the hood. Also, the ductwork has 90° bends, and leaks in lines 1, 3, and 4. Finally, canopy hoods are effective for hot processes, but are not appropriate for the printing presses or hazardous waste storage.

   Although environmental monitoring conducted during this survey did not identify employee over-exposures, NIOSH investigators consider it prudent for an employer to maintain worker exposures below established occupational health criteria. These occupational health criteria may change over time as new information on the hazardous effects of agents becomes available. With this in mind, an engineering firm should be consulted to re-design and/or upgrade the ventilation systems. The installation or upgrade of these systems should use standardized design practices such as those provided in the ACGIH's *Industrial Ventilation, 20th Edition, A Manual of Recommended Practice.*[17]

7. In order to prevent injury, workers should shut down the print presses whenever there is a jam in the system, instead of placing their hands within the machine to remove the tubes.

8. The job or work practice which results in a case of contact dermatitis case should be evaluated to determine the causative agent(s). Attempts should be made to eliminate or minimize the exposure(s) primarily through engineering controls, and secondarily via use of personal protective equipment (PPE).

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Copies of this report have been sent to:

1. Thatcher Tubes
2. International Chemical Workers Union
3. OSHA Region VII

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

Table 1
Results of Personal Breathing-Zone Samples for Methyl Ethyl Ketone
Sampling Location: Thatcher Tubes, Muscatine, Iowa
Sampling Date: 10/21/93
HETA 93-0488

Sample Location	Sampling Time (military time)	Sample Flow Rate	Sample Volume (liters)	Concentration of Methyl ethyl ketone, ppm
Lines 3 and 4, Press Coater Set-up	0713 to 1454	20 cc/min	9.2	7.4
Line 2, Press Coater Set-up	0714 to 1453	20 cc/min	9.2	7.4
Lines 7 and 8, Press Coater Set-up	0715 to 1452	20 cc/min	9.1	10.1
Line 6, Press Coater Set-up	0716 to 1453	20 cc/min	9.1	10.1
Line 9, Press Coater Set-up	0719 to 1508	20 cc/min	9.4	11.2
Line 4, Press Coater Operator	0736 to 1504	20 cc/min	9.0	9.4
Line 7, Press Coater Operator	0747 to 1505	20 cc/min	8.8	18.5
Line 8, Press Coater Operator	0751 to 1506	20 cc/min	8.7	9.4
Line 6, Press Coater Operator	1233 to 1502	20 cc/min	3.0	7.2
Line 6, Press Coater Set-up	1327 to 1338	200 cc/min	2.2	52.4
Minimum Detectable Concentration (MDC)			9.0	0.38
Minimum Quantifiable Concentration (MQC)			9.0	1.24
Exposure Criteria for Methyl Ethyl Ketone: NIOSH Recommended Exposure Limit (REL) OSHA Permissible Exposure Limit (PEL) ACGIH Threshold Limit Value (TLV)				200 ppm for an 8-hour time weighted average (TWA); 300 ppm for a Short-term exposure limit (STEL) of 15 minutes

Table 2
Results of Personal Breathing-Zone Samples for Ethanol, Isopropanol, Methyl Isobutyl Ketone, and Toluene
Sampling Location: Thatcher Tubes, Muscatine, Iowa
Sampling Date: 10/21/93
HETA 93-0488

Sample Location	Sampling Time (military time)	Sample Flow Rate	Sample Volume (liters)	Concentration, parts per million			
				Ethanol	Isopropanol	MIBK	Toluene
Ink Room - Ink Mixer	0707 to 1514	50 cc/min	24.4	30.6	0.43	0.13	0.03
Line 3, Press Coater Operator	0729 to 1504	50 cc/min	22.8	4.7	0.36	Trace	ND
Lines 3, Capper Attendant	0732 to 1506	50 cc/min	22.7	3.1	0.13	ND	ND
Line 4, Capper Attendant	0735 to 1305	50 cc/min	16.7	4.4	0.29	ND	ND
Line 4, Capper Attendant	1313 to 1505	50 cc/min	5.6	2.8	1.53	ND	ND
Line 6, Capper Attendant	0740 to 1458	50 cc/min	21.9	3.3	0.41	ND	ND
Line 6 and 9, Capper Set-up	0743 to 1501	50 cc/min	21.9	2.9	0.26	ND	ND
Line 7, Capper Attendant	0746 to 1504	24 cc/min	10.5	6.3	0.58	ND	ND
Line 8, Capper Attendant	0752 to 1506	50 cc/min	21.7	3.0	0.28	ND	ND
Minimum Detectable Concentration (MDC)			20.0	0.02	0.02	0.01	0.01
Minimum Quantifiable Concentration (MQC)			20.0	0.07	0.05	0.03	0.04
Exposure Criteria							
NIOSH Recommended Exposure Limit (REL)				1000 TWA	400 TWA; 500 STEL	50 TWA; 75 STEL	100 TWA; 150 STEL
OSHA Permissible Exposure Limit (PEL)				1000 TWA	400 TWA; 500 STEL	100 TWA	200 TWA
ACGIH Threshold Limit Value (TLV)				1000 TWA	400 TWA; 500 STEL	50 TWA; 75 STEL	50 TWA

Abbreviations:
MIBK = Methyl isobutyl ketone
TWA = Time Weighted Average (8-hours)
STEL = Short-term Exposure Limit (15 minutes)
ND = Not detected
Trace = Between the MDC and the MQC