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TEXPRINT PRODUCTS
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I. SUMMARY

The National Institute for Occupational Safety and Health (NIOSH) received a request in January 1991, for a Health Hazard Evaluation from union representatives at Texprint Products in Macon, Georgia. The request concerned employee complaints of skin rashes and respiratory symptoms, which were thought to result from exposure to reactive dyes, formaldehyde, and other chemicals. Texprint Products is a fabric dyeing, printing, and finishing facility, which produces home furnishing and Japanese apparel cloth.

Environmental and medical evaluations at the facility were conducted on May 15-16, 1991 and September 11-12, 1991. Personal breathing zone and area air samples were collected for formaldehyde, caprolactam, and mineral spirits. Wet Bulb Globe Temperature (WBGT) measurements, in conjunction with estimated metabolic heat production rates, were used to estimate heat stress exposure. Personal heat stress monitoring, using a Questemp II® monitor, was conducted on one employee. Confidential interviews were conducted with 25 employees from the first and second shifts.

Area air samples for formaldehyde, collected in a fabric finishing area, ranged from 0.06 to 0.23 parts per million (ppm). These sampling results are below the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) and American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLVs) evaluation exposure limits of 1.0 parts per million (ppm) as an 8-hour time weighted average (TWA). NIOSH, however, considers formaldehyde a potential occupational carcinogen, and recommends that formaldehyde exposures be controlled to the lowest feasible level.

Full-shift personal and area samples for caprolactam ranged from less than the limit of quantitation to 0.06 ppm and were well below the OSHA PEL and ACGIH TLV of 5 and 4.3 ppm, respectively. Full-shift personal and area samples for mineral spirits ranged from 3 to 135 mg/m^3 and were below the NIOSH 8-10 hour TWA Recommended Exposure Limit (REL) of 350 mg/m^3.

Area measurements at three locations in the plant indicated that heat stress exposures were in excess of NIOSH and ACGIH recommendations. In addition, core body temperature, measured on one worker throughout the first shift, exceeded the recommended maximum of 38 ºC (100.4 ºF) for most of the day, indicating a heat stress hazard. Personal heat stress measurements correlated with Wet Bulb Globe Thermometer results.

Seven of twenty-five (28%) interviewed employees reported eye irritation, six employees (24%) reported current or chronic rashes, seven employees (28%) reported headaches, and one (4%) employee reported more than one lower respiratory symptom.

Based on the data obtained during this Health Hazard Evaluation, the National Institute for Occupational Safety and Health (NIOSH) investigators determined a health hazard existed at this facility from excessive exposure to environmental heat stress. Other potential health hazards resulted from dermal exposure to caustics and reactive dyes. The environmental data collected indicated that employees were also exposed to low levels of formaldehyde. Since formaldehyde is a potential occupational carcinogen and has irritant properties at low levels, NIOSH recommends that exposures be further reduced to the lowest feasible concentration. Recommendations for implementation of a heat stress management program, installation of engineering controls, and the use of personal protective equipment can be found in Section VIII (see pages 21-25) of this report.

KEYWORDS: SIC 2269 (Finishers of Textiles), reactive dyes, caprolactam, formaldehyde, caustic, sodium hydroxide, hydrocarbons, mineral spirits, carcinogen, heat stress, personal protective equipment, aural temperature.

II. INTRODUCTION

A union representative from Texprint Products in Macon, Georgia requested a Health Hazard Evaluation (HHE) in January 1991, to evaluate employee exposures to a number of chemicals, including formaldehyde, sodium hydroxide, reactive dyes, ammonia, methylene chloride, and others. The request stated that a number of employees were experiencing respiratory symptoms and skin disorders.

National Institute for Occupational Safety and Health (NIOSH) investigators conducted industrial hygiene surveys and medical evaluations at Texprint Products on May 15-16, 1991 and September 11-12, 1991.

III. BACKGROUND

Texprint Products is a fabric dyeing, printing, and finishing facility, which produces cloth for home furnishing and Japanese apparel. The manufacturing facility, located on 30 acres, was built in 1975. Approximately 76 production employees work during three shifts.

Raw greige (unbleached, undyed) cloth is shipped to the facility for processing. Cloth is "plated" from rolls onto buggies, inspected, and transported to the Preparation and Finishing Department, where it is prepared for printing. The preparation process includes washing the cloth to remove starch and smoothing and stabilizing the cloth in a heat-setting tenter. During three shifts, approximately 25 employees work in the Input and Inspection Department, and 13 employees work in the Preparation and Finishing Department.

Raw cotton material is further processed in a mercerization step, which is a conditioning process that results in a flatter, softer product that is more receptive to dyes. The Mercerizer machine treats the cloth with a caustic soda (sodium hydroxide) solution.

The employees in the Stock-Paste Department make a carrier for the dye from a complex recipe. The Stock-Paste carrier is used to adjust the viscosity and application characteristics of the dye. The stock paste consists of Reserve Salt Flake® (*m*-nitro-benzene sulfonic acid sodium salt, sulfuric acid disodium salt, and water), kelgin (a polysaccharide from seaweed), urea, sodium bicarbonate, Revatol-S® (a substituted benzene derivative), Trydet 2675® (stearic acid and a polyglycol ester), water, and up to 40% mineral spirits. Most of the chemicals are weighed manually and added by hand. The management of Texprint has written plans to automate the Stock-Paste Department. One employee works in the Stock-Paste Department.

Ammonium hydroxide is added, infrequently, to the pigment stock-paste. Respirators (optional) are provided to employees for this task. It was not clear how often this material was used. During the initial walk-through survey, management stated that it was used approximately once every three months. Some workers; however, indicated that it is used more frequently.

Stock paste is fed to the Dye Mixing Department ("color kitchen") through pipes. This Department is separated into two distinct areas: a computerized auto-mixing area and a manual mixing area. Eighteen "mother" colors are used to produce the desired dye colors. The auto-mixing machine is operated by one employee. One or two other employees are often in the area performing peripheral tasks (hauling barrels of dye, cleaning barrels, etc.). The manual mixing area is used to make fine adjustments in dye color or prepare low volume colors. Dye is scooped out of vats by hand, weighed, and mixed into other vats. No powder dyes are used. A total of 12 employees work in this area.

Most of the dyes used at Texprint are known as "reactive dyes." Since their introduction in the 1950's, these dyes have gained extensive use because of their bright colors and firm chemical fixation to cellulose, protein, and polyamide fibers. The dye molecule usually contains azo or anthrachinon groups to produce color. Reactive groups on the dye molecule, such as heterocyclic halogens or aliphatic chains with reactive groups, form covalent bonds with hydroxyl or amino groups in the fiber molecule.[1]

Reactive dyes are not permitted for use in food, drugs, or cosmetics. Caprolactam is present (up to 10% by weight) in a commonly-used dye, Procion® Black SP-LA liquid dye. Caprolactam is used as a solvent for high molecular weight compounds.[1]

In the Strike-Off Department (Sample Department), dyes are mixed by hand, and trial patterns and colors are produced on an experimental basis. Dye is added to the roller with a hand-held pump. Then the cloth, which sticks to a belt (referred to as a "blanket") having an adhesive, is drawn under the roller. The ink comes through small holes engraved in the roller, imprinting a pattern on the cloth. Several rollers may be needed to impart different colors or patterns to the cloth. Approximately 15 employees work in this department, which operates over two shifts.

In the Rotary Printing Department, dye is printed on cloth in a similar manner to that in the Strike-Off Department; except the operation is automated, and the scale of the operation is greater. Dye from the auto-mixer is transferred to the Rotary printers and is blown inside the cylinder for high volume printing. There are four rotary printers, and one or two employees are stationed at each printer. The employees monitor the printing process for quality or mechanical problems and start new rolls of cloth when needed. Twelve employees work in the Rotary Printing Department.

As discussed previously, adhesive compounds are applied to the belts (referred to as "blankets"), which carry the cloth under the dye cylinders. Additional adhesives are added to the belts when needed. Occasionally, old adhesive must be removed from the belts; this is reportedly done with acetone and/or xylene. Management representatives indicated that methylene chloride is no longer used in the plant.

In the Finishing Department, three Hirano® machines are used for heat-tenting and application of soil-resist substances (Scotchgard®, Zonyl®). In addition, "resists," which are actually resins, are applied to the cloth for shrinkage control. One of the "resists," known as Permafresh LO®, contains formaldehyde at a concentration of <0.5%, according the Material Safety Data Sheet. This particular type of resin is designated as a low formaldehyde emission product, according to the manufacturer. It is reportedly mixed with water, an emulsifier, and a catalyst additive before it is applied to the fabric.

Texprint installed a Dynaforce® general ventilation system between the May and September 1991 NIOSH visits. The goal was to better control temperature and humidity in the building. Prior to the installation of this ventilation system, the capacity of the exhaust air fans (totaling 955,000 cubic feet per minute [cfm]) greatly exceeded that of the supply air fan (239,000 cfm). Although the system does not provide air conditioning, it is designed to bring in the amount of make-up air required to match the exhaust. The system can also augment the existing heating system or serve as the primary heating system.

IV. EVALUATION DESIGN AND METHODS

A. Environmental Evaluation

1. *Formaldehyde*

Three area air samples for formaldehyde were collected near the Hirano® machines on May 16, 1991. The samples were collected in midget impingers containing 20 milliliters (mL) of 1% sodium bisulfite solution. Each sampler was assembled with a 37-millimeters (mm) polytetrafluoroethylene (PTFE) membrane filter followed by two midget impingers connected in series. The impingers were connected to pre-calibrated, battery powered, air sampling pumps operating at a flow rate of 0.5 liters per minute (L/min).

The samples were analyzed according to NIOSH Method 3500.[2] Sample volume was measured and a 4-mL aliquot was taken for analysis. Color was developed by adding 0.1 mL 1% chromotrophic acid and 6 mL concentrated sulfuric acid. The collection media was then analyzed by visible absorption spectrophotometry. The limit of detection (LOD) and limit of quantification (LOQ) were estimated to be 1 and 3.3 micrograms (µg) per sample, respectively.

One personal breathing zone and three area air samples for formaldehyde were collected on September 12, 1991, with treated XAD-2 sorbent tubes using pre-calibrated, battery-powered sampling pumps operating at 0.1 L/min. The samples were collected in the area of the Hirano® machine.

The sorbent tube samples were analyzed according to NIOSH method 2541 with modifications.[2] The samples were desorbed in 1.0 mL toluene and analyzed with a Hewlett-Packard 5710A gas chromatograph (GC) equipped with a nitrogen-phosphorus detector. The column was a fused silica capillary coated with DB-1301. The LOD and LOQ were 0.5 and 1.7 µg per sample, respectively.

2. *Caprolactam*

Four personal breathing zone samples and one area air sample for caprolactam were collected on September 12, 1991, with XAD-2 tubes (SKC #226-30-04) using calibrated, battery powered sampling pumps at a flow rate of 1.0 L/min. Two sorbent tubes were arranged in series--one tube acting as a back-up for possible break-through of analyte. The personal samples were collected from employees working in the rotary press area and the automated dye mixing machine area. The area sample was collected in the fabric drying area of Rotary #3.

The XAD-2 samples were desorbed for one hour in 1 mL of methylene chloride and analyzed with a Hewlett-Packard 5890 GC equipped with a flame ionization detector (FID). The column was a fused silica capillary coated with DB-5. The LOD and LOQ was 0.01 and 0.034 milligram (mg) per sample, respectively.

3. *Hydrocarbons*

Charcoal tube samples were collected for qualitative hydrocarbon analysis on May 16, 1991. Three area samples were collected in the Rotary press area using battery-operated air pumps, calibrated at a nominal flow rate of 0.1 L/min.

The charcoal samples were desorbed with 1 mL carbon disulfide and screened by (GC-FID), using a 30 meter DB-1 fused silica capillary column. Since the chromatograms were similar, only one sample was chosen for further analysis by gas chromatography-mass spectrometry (GC-MS).

Five bulk liquids (Stock-paste, "Emulsifier," "Emulsion," Sandozin® liquid, enzyme concentrate, and "BLT") were also collected for qualitative analysis. Portions of each bulk liquid were extracted with either carbon disulfide or ethanol. The extract solutions were then screened by GC-FID and GC-MS.

Two personal and four area air samples were collected for total hydrocarbons (mineral spirits) on September 12, 1991. The personal samples were collected from employees working near Rotary #3 and in the Strike-off Department. The area samples were collected near the rotary presses, Aeroli® machine, and Hirano® machine.

Sampling and analysis were performed according to NIOSH method 1550.[2] The samples were collected with charcoal tubes at a flow rate of 0.2 L/min. The charcoal was desorbed for 30 minutes in 1.0 mL carbon disulfide and analyzed with a Hewlett-Packard 5890A GC equipped with a FID. The column was a fused silica capillary coated with DB-5. The LOD and LOQ was 0.01 and 0.033 mg per sample, respectively.

4. *Heat Stress*

Heat stress measurements were made with two Reuter Stokes RSS 214 Wibget® Heat Stress Monitors and a Questemp II® Personal Heat Stress Monitor on September 12, 1991.

<u>Wet Bulb Globe Temperature</u> The Reuter Stokes RSS 214 Wibget® Heat Stress Monitor assesses environmental heat by the Wet Bulb Globe Thermometer (WBGT) method. The WBGT is the accepted standard method for determining environmental heat stress. The WBGT combines the effect of humidity, air movement, air temperature, and radiant heat into a single measurement. Sample times were set at 10 minutes.

WBGT measurements, in conjunction with metabolic heat production rates can be used to estimate total heat exposure for comparison to recommended standards. During this evaluation, metabolic heat production rates in kilocalories per hour (Kcal/hr) were estimated with observation of body position and work activities, and compared to standard tables. These recommended standards were developed to prevent workers from exceeding a deep body temperature of 38 ^{o}C (100.4 ^{o}F).

(a) A Wibget® was placed at the work station adjacent to Rotary Printer #4 between 8:24 a.m. and 3:47 p.m. on September 12, 1991. The monitor was placed on a table approximately 3.5 feet off the floor. Prior to sampling, the wet bulb wick was moistened, the reservoir filled with demineralized water, and the thermometer was allowed 30 minutes equilibration time before readings were made. The unit was operated in the log mode. The comfort fans in the area were not blowing directly on the monitor. The worker, who was standing, was considered to perform whole body, continuous, moderate work.

(b) The other Wibget® was located at the Open Washer work station between 8:35 a.m. and 12:30 p.m. on September 12, 1991. Steam was present at this work station, and the operator, who was standing, was considered to perform whole body, continuous, moderate work. No comfort fans were observed in this area. The operator worked within a 75-foot radius of this work station. Activities include picking up cloth samples and pushing cloth bins. The operator worked an 8-hour shift and took two 20-minute breaks in an air-conditioned break room. The worker indicated that the activities conducted during the monitoring period were consistent with a normal days work.

(c) The Wibget® previously place at the Open Washer was relocated to the back of the Hirano® machine and placed on a tripod 4.5 feet off the floor between 12:31 p.m. and 3:40 p.m. on September 12, 1991. The worker, who was standing, was considered to perform whole body, continuous, moderate work.

Personal Heat Stress Monitor Personal heat stress monitoring, using a Questemp II® monitor (Quest Electronics, Oconomowoc, Wisconsin), was conducted on a printer who was assigned to work on Rotary Printer #4. The monitor measures the aural temperature with a small sensor placed in the ear via an earplug. The difference between the ear and body temperatures are off-set internally by calibrating the instrument directly to the worker's oral temperature. If the body's temperature exceeds a preset limit (38-39 ^{o}C or 100.4-102.2 ^{o}F), the monitor will alarm. The monitor continuously logs body temperature for subsequent evaluation. The ear mold containing the plug and sensor is equipped with a second temperature sensor which monitors the worker's environment. The aural temperature; thus, is used as a measure of core body temperature.

B. Medical Evaluation

The medical evaluation consisted of employee interviews, review of the Occupational Safety and Health Administration (OSHA) 200 logs, and informal interviews with management. The purposes of the interviews were (1) to obtain information on past and current chemical and physical agents in the work environment and (2) to identify the adverse health effects of primary concern to the labor force.

Health effects were considered to be potentially occupational if a employee identified them as occurring exclusively or predominately at work, or specified plausible and specific work conditions related to the symptom(s) at work. Employees were questioned the presence of upper and lower respiratory track symptoms, eye irritation, headache, rash, and other health effects they associated with work.

V. EVALUATION CRITERIA

A. *General Guidelines*

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours/day, 40 hours/week for a working lifetime without experiencing adverse health effects. It is important to note; however, that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the limits set by the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus the overall exposure may be increased above measured airborne concentrations. Evaluation criteria typically change over time as new information on the toxic effects of an agent become available.

The primary sources of evaluation criteria for the workplace are the following: NIOSH Criteria Documents and Recommended Exposure Limits (RELs)[3], the

American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs),[4] and the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[5] These values are usually based on a time-weighted average (TWA) exposure, which refers to the average airborne concentration of a substance over the entire 8- to 10-hour workday. Concentrations are usually expressed in parts per million (ppm) or milligrams per cubic meter (mg/m^3). In addition, for some substances there are short-term exposure limits (STEL) or ceiling limits which are intended to supplement the TWA limits where there are recognized toxic effects from short-term exposures.

The OSHA standards are required to take into account the feasibility of reducing exposures in various industries where the agents are used; whereas, the NIOSH RELs are based primarily on concerns relating to the prevention of occupational disease. In evaluating worker exposure levels and NIOSH recommendations for reducing exposures, it should be noted that employers are legally required to meet the requirements of OSHA PELs and other OSHA standards.

B. *Formaldehyde*

Symptoms of exposure to low concentrations of formaldehyde include irritation of the eyes, throat, and nose; headaches; nausea; congestion; and asthma. Dermatitis may result from formaldehyde contact with the skin. It is difficult to ascribe particular health effects to specific concentrations of formaldehyde which people are exposed because of variability in subjective responses and complaints. Irritation may occur in people exposed to formaldehyde at concentrations as low as 0.1 ppm, but more frequently at exposures of 1.0 ppm and greater. Some sensitive children or elderly, those with preexisting allergies or respiratory diseases, and persons who have become sensitized from prior exposure may have symptoms from exposure to concentrations of formaldehyde between 0.05 and 0.10 ppm. Formaldehyde-induced asthma and bronchial hyperactivity, developed specifically to formaldehyde, are uncommon.[6]

Formaldehyde vapor has been found to cause a rare form of nasal cancer in Fischer 344 rats exposed to a 15 ppm concentration for 6 hours per day, 5 days per week, for 24 months. Whether these results can be extrapolated to human exposure is the subject of considerable speculation in the scientific literature. Conclusions cannot be drawn with sufficient confidence from published mortality studies of occupationally exposed adults whether or not formaldehyde is a carcinogen. Studies of long-term human occupational exposure to formaldehyde have not detected an increase in nasal cancer. Nevertheless, the animal results have prompted NIOSH to recommend that formaldehyde be considered a potential occupational carcinogen, and workplace exposures be reduced to the lowest feasible limit.[7]

OSHA has reduced the PEL for formaldehyde to 1.0 ppm as an 8-hour TWA, with a 0.5 ppm action limit. In addition, a 15-minute STEL was set at 2.0 ppm.[8] The ACGIH has assigned formaldehyde an "A2" designation, indicating that the ACGIH considers formaldehyde a suspected human carcinogen. The current ACGIH TLV/TWA for formaldehyde is 1.0 ppm and the TLV/STEL is 2.0 ppm. The ACGIH limits for formaldehyde have been placed on the "Notice of Intended Changes" list. The proposed ACGIH limit for formaldehyde is a Ceiling concentration of 0.3 ppm with no TWA or STEL. If, after one year, the ACGIH concludes no evidence has come to light that questions the appropriateness of the proposed change, the value will be considered for adoption into the TLV listing.

C. *Caprolactam*

Caprolactam is a white crystalline solid with an unpleasant odor.[9] In animals, caprolactam has been reported to have neuropharmacological properties, which consists of convulsions, tremors, mydriasis (dilated pupils), and salivation. In the rabbit and cat, caprolactam produced cardiovascular effects, consisting of an initial increase in blood pressure, followed by decreased blood pressure and an increase in respiratory rate.[10]

In humans, high exposures to caprolactam has been associated with convulsions and skin and respiratory irritation. Exposure concentrations which produce these effects are not well defined. Workers exposed to vapor at approximately 12 ppm complained of bitter taste, nervousness, upper respiratory tract congestion, nose bleeds, and dry and splitting skin. In another case, workers exposed to vapor concentrations occasionally as high as 100 ppm for 18 years reported severe discomfort from burning nose, throat and eyes.[8,9]

The OSHA PEL/8-hour TWA for caprolactam vapor is 5 ppm and the STEL is 10 ppm. The ACGIH/8-hour TLV is 4.3 ppm and the STEL is 8.6 ppm. Caprolactam, like formaldehyde, is also on the "Notice of Intended Changes" list. The proposed ACGIH limits are 5 ppm as a TWA and 10 ppm as a STEL. There is no NIOSH REL for caprolactam vapor.

D. *Hydrocarbons - Mineral Spirits*

Mineral spirits, defined by a boiling range of 150 - 200 ^{o}C, is a complex mixture of many hydrocarbons.

Mineral spirits at concentrations of 2500 mg/m^3 or greater have been associated with nausea and vertigo in humans. Concentrations of 625 to 2500 mg/m^3 for periods up to two hours had no effect on performance tests, such as perceptual speed, reaction time, short-term memory, numerical ability, and manual dexterity.[11]

Animal studies have not indicated any consistent pattern of hematologic (blood or blood-forming tissues) relationships or any remarkable gross changes except for lung irritation. Deaths were not seen at any concentration in rats, rabbits, dogs, or monkeys; however, some guinea pigs exposed at concentrations in excess of 363 mg/m^3 died. The lung irritation observed was seen mainly in animals exposed at 1353 mg/m^3 for eight hours a day, five days a week, for six weeks.

Mineral spirits have been shown to cause dermatitis, and stoddard solvents (a related hydrocarbon mixture) have been recognized as being capable of causing skin irritation and possibly aplastic anemia after dermal exposure. Dermal exposure to mineral spirits should be avoided if for no other reason than the ability of mineral spirits to defat the skin and cause dermatitis. The NIOSH TWA REL for mineral spirits is 350 mg/m^3. The ACGIH TLV and OSHA PEL (final rule) TWA limit for stoddard solvent, which is similar to mineral spirits, is 525 mg/m^3.

E. *Heat Stress - Background Information*

Heat stress is defined as the total net heat load on the body, which is comprised of contributions from exposure to external environmental sources and from metabolic heat production.

Four factors influence the interchange of heat between the human body and from metabolic heat production: (1) air temperature, (2) air velocity, (3) moisture content of the air, and (4) radiant heat sources. Industrial heat problems involve a combination of these factors which produce a working environment that may be uncomfortable or even hazardous because of an imbalance of metabolic heat production and heat loss.[12]

The fundamental thermodynamic processes involved in heat exchange between the body and its environment may be described by the basic equation of heat balance.

$$S = M - E \pm R \pm C$$

S = Change in body heat content (heat gain or loss)
M = Rate of metabolism (associated with body function and physical work)
E = Heat loss through evaporation of perspiration

R = Heat loss or gain by radiation (infrared radiation emanating from warmer surfaces to cooler surfaces)
C = Heat loss or gain through convection (passage of air over a surface with the resulting in or loss of heat)

Under conditions of thermal equilibrium (essentially no heat stress), heat generated within the body by metabolism is completely dissipated to the environment and deep body (core) temperature remains constant at about 98.6 ^{o}F (37 ^{o}C).[12]

When heat loss fails to keep pace with heat gain, the core temperature begins to rise. At this point certain physiologic mechanisms begin to function in an attempt to increase heat loss from the body. First, there is dilation of the blood vessels of the skin and subcutaneous tissues with diversion of a large part of the body's blood supply to the body surface and extremities. An increase in circulating blood volume also occurs through the withdrawal of fluids from body tissues. These circulatory adjustments enhance heat transport from the body core to the surface. Simultaneously, the sweat glands become active, spreading fluid over the skin, which removes heat from the skin surface by evaporation. Evaporative cooling must balance the combined effects of metabolic and environmental heat load to maintain thermal equilibrium. If this fails, heat storage begins with the resultant strain of increased body temperature.[12]

The acute physical disabilities caused by excessive heat exposure are the following in order of increasing severity: heat rash, heat cramps, heat exhaustion, and heat stroke.

Heat rash (prickly heat) may be caused by unrelieved exposure to hot and humid air. The openings of the sweat ducts become plugged due to the swelling of the moist keratin layer of the skin which leads to inflammation of the glands. There are tiny red vesicles (fluid-filled bumps) visible in the affected area, and if the afflicted area is extensive, sweating can be substantially impaired. This may result not only in discomfort, but in a decreased capacity to tolerate heat.[12]

Heat Cramps may occur after prolonged exposure to heat with profuse perspiration and inadequate replacement of salt. The signs and symptoms consist of spasm and pain in the muscles of the abdomen and extremities.[12]

Heat exhaustion may result from physical exertion in a hot environment when vasomotor control (regulation of muscle tone in the blood vessel walls) and cardiac output are inadequate to meet the increased demand placed upon them by peripheral vasodilation or the reduction in plasma volume due to dehydration. Signs and symptoms of heat exhaustion may include pallor, lassitude, dizziness, syncope, profuse sweating, and cold, moist skin. There may or may not be mild hyperthermia.[12]

Heat stroke is a medical emergency. An important predisposing factor is excessive physical exertion. Signs and symptoms may include dizziness, nausea, severe headache, hot dry skin due to cessation of sweating, very high body temperature (usually 106 ^{o}F or higher), confusion, delirium, collapse, and coma. Often circulation is compromised to the point of shock. If steps are not taken to begin cooling of the body immediately, irreversible damage to the internal organs and death may ensue.[12,13]

Chronic heat illnesses are those occurring as after-effects of acute heat illnesses; those brought on by working in excessively hot jobs for a few weeks, months, or years, but without the occurrence of acute heat illness; and those associated with living in climatically hot regions of the world. Chronic after-effects associated with acute heat illnesses can include reduced heat tolerance, dysfunction of sweat glands, reduced sweating capacity, muscle soreness, stiffness, reduced mobility, chronic heat exhaustion, and cellular damage in different organs, particularly in the central nervous system, heart, kidneys, and liver.[12]

Chronic heat illnesses not associated with an acute incident of heat illness can fall into one of two categories based on the duration of exposure. After several months of exposure to a hot working environment, chronic heat exhaustion may be experienced. Symptoms which may develop include headache and gastric pain. Cumulative effects of long-term exposure which may develop are hypertension, reduced libido, sexual impotence, myocardial damage, and nonmalignant disease of the digestive organs.[12]

Prolonged heat stress may cause increased irritability and anxiety, decreased morale, and an inability to concentrate. This often results in a general decrease in work efficiency and quality.[14]

F. *Heat Stress - Criteria*

Both NIOSH and the ACGIH recommend the use of the WBGT in assessing hot environments. There are no specific OSHA exposure limits for heat stress. However, OSHA has issued a directive to its field staff that provides technical information regarding the investigation of heat stress hazards. This document draws heavily on NIOSH and ACGIH criteria.[15]

Three different temperature measurements are required to calculate the WBGT:[12]

1. Natural Wet Bulb (**WB**) temperature, where the thermometer bulb is kept wet, allowing evaporative cooling.

2. Dry Bulb (**DB**) temperature, which is simply a thermometer reading.

3. Globe Temperature (**GT**), in which the thermometer bulb is located inside a hollow black sphere. This arrangement permits the measurement of radiant heat absorbed by the black globe.

The WBGT is calculated using the following formulas:

$$WBGT_{INDOORS} = 0.7\ (WB) + 0.3\ (GT)$$

$$WBGT_{OUTDOORS} = 0.7\ (WB) + 0.2\ (GT) + 0.1\ (DB)$$

The NIOSH criteria and the ACGIH TLV present permissible heat exposure for different work/rest regimens and work load at different WBGT levels.[4] NIOSH has developed two sets of recommended exposure limits; one for unacclimatized workers (Figure 1), and one for acclimatized workers (Figure 2). In addition, a ceiling level has been recommended by NIOSH for both acclimatized and unacclimatized workers. Workers should not be exposed to temperatures reaching or exceeding this ceiling limit without adequate heat-protective clothing and equipment. These ceiling levels are indicated with a "C" in Figures 1 and 2.[12]

The criteria for heat-acclimated workers assume that workers are fully clothed in summer weight clothing, are physically fit, and have good nutrition and adequate salt and water intake. Additionally, they should not have any preexisting medical conditions that may impair the body's thermoregulatory mechanisms. For example, alcohol use and certain therapeutic and social drugs may interfere with the body's ability to tolerate heat.

The recommended heat stress limits have been developed to prevent exposed workers from exceeding a deep body or core temperature of 100.4 °F (38 °C). This temperature is a consensus among physiologists and standard setting organizations as a value above which the risk of heat illness may increase.[12]

G. *Reactive Dyes*

There are several hundred reactive dyes available on the market. The chemical properties required for reactive dye effectiveness seem to ensure that the compounds will have the potential to react with human tissue. However, the reactivity of a dye cannot be used to predict the toxicity. According to the U.S. Consumer Product Safety Commission (USCPSC), 25% of the reactive dyes studied for mutagenicity were positive in the *Salmonella typhimurium* test system. Two out of five dyes tested were positive in carcinogenicity testing in animals; these were Remazol Brilliant Blue R (CAS No. 2580-78-1) and Remazol Black B (CAS No. 12225-25-1). Allergenicity, however, is stated to be the major toxic effect.[16]

Allergic dermatoses (eczema and urticaria) and respiratory disorders induced by occupational exposure to reactive dyes have been reported in the literature.[17] A lethal asthma attack has even been described.[18] In a survey of over 400 workers handling reactive dyes, over 15% had occupationally related lower respiratory or nasal symptoms. Allergic symptoms and atopy resulting from contact with reactive dyes have been associated with high serum titre of specific IgE (antibody).[1,19]

VI. RESULTS AND DISCUSSION

A. Industrial Hygiene Results

1. *Formaldehyde*

During the May 1991 NIOSH visit, the area formaldehyde concentrations near the Hirano Machine ranged from 0.06 to 0.23 ppm, as full-shift 8-hour TWAs. The highest concentration of formaldehyde was found near the Permafresh tank, which contains formaldehyde. At the worker's desk, the TWA concentration was 0.09 ppm. Near the drying oven at the end of the Hirano®, the TWA concentration was 0.06 ppm.

During the return visit in September 1991, four additional formaldehyde samples were collected. Only one employee was assigned to the Hirano on the day of our visit, so only one full-shift personal sample could be collected. Formaldehyde was detected on all the samples; however, the concentrations could not be quantified because of low recovery of formaldehyde from the sorbent in the sample tubes.

Because formaldehyde is a potential occupational carcinogen, NIOSH recommends that exposures be reduced to the lowest feasible limit. Ideally, this objective should be accomplished through the use of engineering controls. However, it should be noted that the formaldehyde concentrations during the May visit were less than the OSHA TWA action level (0.5 ppm) and the current and proposed ACGIH TWA TLVs of 1.0 ppm and 0.3 ppm, respectively.

2. *Caprolactam*

Low concentrations of caprolactam were detected during the September 1991 NIOSH visit. The concentrations ranged from trace (less than the limit of quantitation) to 0.06 ppm, well under the OSHA PEL and ACGIH TLV of 5 and 4.3 ppm, respectively. The highest concentration (0.06 ppm) was found on a personal sample collected from an employee working at Rotary Press #3. Specific sampling results can be found in Table 1.

3. *Hydrocarbons, Mineral Spirits*

Analysis of charcoal tube air samples and bulk dye samples indicated the presence of a complex mixture of hydrocarbons in the air at Texprint. Qualitative analysis by GC/MS indicated that the hydrocarbon mixture was consistent with mineral spirits. The personal sample concentrations, as TWAs, were 38 and 110 mg/m^3. The area sample concentrations ranged from 3 to 135 mg/m^3. The highest concentrations were found at the rotary printers. All concentrations, however, were less than the NIOSH REL (350 mg/m^3) and the OSHA PEL and ACGIH TLV for Stoddard solvent (both 525 mg/m^3). Specific sampling results can be found in Table 2.

4. *Heat Stress*

The employee monitored with the Questemp II® personal heat stress monitor worked on both sides of Rotary #4 (pumps and feed). A Wibget® monitor was placed in the work area.

The employee worked a 12-hour shift with one 10-minute and two 20–minute breaks. The break room was air-conditioned. The employee's clothing consisted of a single layer short-sleeve cotton shirt and jeans, and his weight was approximately 150 pounds. He had spent 1.2 years on the job and was considered to be an acclimatized worker. Monitoring was conducted between 8:24 a.m. and 3:50 p.m.

It should be noted that Rotary #4 is adjacent to the Hirano® machine, which generates heat and steam that affects workers in the printer area. Comfort fans were present at each side of the rotary printer. The work is continuous, whole body, and in the moderate category. Although no heavy lifting is involved in the task, considerable body movement is present. The worker indicated that the tasks conducted were consistent with a normal work day. Based on Table V-3 of the NIOSH Revised Criteria Document for Occupational Exposures to Hot Environments (reproduced in Table 3 of this report), the worker's energy expenditure is considered to be about 6.6 Kcal/minute. This equates to a WBGT REL of 26 ^{o}C.

No breaks are provided from a heat stress control standpoint. Water, from a fountain, is the only fluid provided. The employee was instructed to cease work and drink fluid if the Questemp II monitor were to alarm (indicating a core body temperature of $\geq$38 ^{o}C).

The results of the area (WBGT) and personal heat stress monitoring (Questemp, ear/core body temperature) can be found in Figure 3 and Tables 4 and 5. The WBGT increased throughout the day and was over the REL of 79.7 ^{o}F (26.5 ^{o}C) for the entire day. The core body temperature exceeded the recommended limit of 100.4 ^{o}F (38 ^{o}C) at 9:35 a.m. Decreases in core body temperature occurred when the employee was on break (around 10:45 a.m. and 2:00 p.m.)

Employees in the other areas (Open Washer and Hirano®) were also considered to be conducting full body, continuous, moderate work.
The WBGT area results for the Open Washer can be found in Figure 4 and Table 6. The results for the Hirano® can be found in Figure 5 and Table 7. The WBGT values in these areas were also in excess of the NIOSH REL.

At noon on September 12, 1991, the outdoor temperature was 91 ^{o}F, and the relative humidity was 52%.

A heat stress program has not been established at Texprint. There is no worker training, acclimatization, or medical monitoring program addressing heat stress.

5. *Other Observations*

Consistent protocols for the proper use and care of personal protective equipment (PPE) have not been established. Employees have not been given direction regarding the need for PPE (gloves, faceshields, boots, aprons, eyewear, etc.) and the use of this equipment is optional. Stained hands and arms indicated that many employees came into frequent contact with dyes and other materials. The OSHA 200 logs also indicated that caustic/chemical burns have occurred.

Texprint provides some respirators (3M 7281 half-mask, 3M 7890 full-face, and GPI GP-500 disposable dust masks). The cartridge respirators were all equipped with ammonia/methylamine cartridges. The respirators had not been maintained properly, and one of the 3M respirators had damaged inhalation and exhalation valves. Respirators are not assigned to individuals, but are available for anyone to use for any activity. The dust masks are used primarily by workers conducting equipment "blow-downs" with compressed air. A respirator training program has not been established, employees have not been trained or fit-tested, and the need for respirators has not been determined (no air sampling).

NIOSH investigators examined some of the respirators used at Texprint. Two of the respirators had defective exhalation valves and would not provide protection to the wearer. It was evident that the respirators had not been properly inspected or cleaned.

The facility provides BEST® latex gloves for employee use. In many areas, gloves were not properly cared for or stored properly. This was most notable in the area of the Rotary Printers and the Dye Mixing area.

B. Medical Results

Twenty-five first and second shift employees were privately interviewed; 22 of the 25 (88%) employees were randomly chosen from the production departments' employee lists. The remaining three were referred to be interviewed by other employees because of possible work-related health effects. Nineteen males and six females were interviewed. Ages ranged from 22 years to 47 years, with an average of 35 years. Duration of employment ranged from one to 16 years, with an average of slightly over 7 years.

Seven employees (28%) reported irritation of the eyes, nose, or throat; 4 of the 7 attributed the irritation to airborne lint. Seven workers (28%) reported headaches that occurred predominately at work, and 6 employees (24%) reported current or chronic skin rashes. One employee (4%) reported more than one of the lower respiratory symptoms: cough, shortness of breath, wheezing, and chest pain. Occurrence of two or more of these symptoms may suggest the presence of asthma. No one reported using bronchodialators or other medication to aid in breathing.

The six employees with rashes were further interviewed, and the rashes were visually examined. The rashes were predominately on the upper body, but differed from each other in appearance. Four rashes were diffuse, involving the arms and/or torso, and the remaining two were limited to the hands. Employees reported that the rashes were chronic; several reported symptom relief with topical therapies.

VII. CONCLUSIONS

A large number of skin, eye, and respiratory irritants, including caustics and reactive dyes, are present in the work environment at Texprint. NIOSH investigators observed that dermal contact with many potential irritants is common. The environmental data collected indicate that employees are exposed to low levels of airborne formaldehyde. Formaldehyde is a potential occupational carcinogen and has irritant properties at low levels. Although specific chemical causes were not directly associated with the reported symptoms, it is likely that dermal and air exposure to a complex variety of chemicals present at Texprint may be contributing to some employees' symptoms.

In addition, NIOSH investigators determined that workers at Texprint are at risk of harmful exposure to excessive environmental heat. Heat stress may also be aggravating some of the reported rashes and possible respiratory symptoms.

VIII. RECOMMENDATIONS

The following recommendations are offered as prudent measures to reduce or prevent possible work-related health symptoms.

1. A heat stress management program should be implemented at Texprint. The program should address the topics listed in the NIOSH document *Criteria for a Recommended Standard....Occupational Exposure to Hot Environment,* which is included with this report. A good program includes the following items:

    (a) Education of employees in safety and health procedures for work in hot environments, including the signs and symptoms of heat stress and heat stroke and initiation of the correct course of action should symptoms occur. The effects of non-occupational factors such as drugs, alcohol, obesity, etc., on tolerance to occupational heat stress should be covered. The need for fluid replenishment, and knowledge that reliance on the thirst mechanism is insufficient, are other important elements of worker training.

    (b) Limiting exposure time to hot environments (scheduling hot jobs for the cooler part of the day, altering the work-rest regimen, etc.) During the summer months, Texprint may need to implement specific work-rest cycles to lower core body temperatures and reduce the potential for heat stress or stroke.

(c) Ensuring that all workers are full acclimatized for working in hot environments. Acclimatization efforts should begin at the start of the hotter months of the year and should include new employees, and those returning from vacation or transferred to a hot area. For new workers the schedule should be 20% exposure on the first day, and a 20% increase on each additional day. For workers who have had previous experience with the job, the exposure should be 50% on day 1, 60% on day 2, 80% on day 3, and 100% on day 4.

(d) Implementation of a Heat-Alert Program (HAP). The main idea of such a program is quite simple and straightforward. If a hot spell is predicted for the next day or days, a state of Heat Alert is declared to make sure that measures to prevent heat casualties will be strictly observed.

(e) Medical screening for workers with heat intolerance. The ability to tolerate heat stress varies widely even among normal healthy individuals with similar heat exposure experiences. Tolerance to heat is related to physical fitness and work capacity (the higher the physical fitness and work capacity, the greater ability to tolerate heat). Medical screening for heat intolerance should include a history of any previous incident of heat illness. Workers who have experienced a heat illness may be less heat tolerant.

(f) Ensuring that the worker break area is continually air conditioned to maintain a cool environment.

2. If respirators are to be used, Texprint should implement a respiratory protection program that is consistent with the guidelines found in the NIOSH Publication No. 87-116, *Guide to Industrial Respiratory Protection,*[20] and the requirements of the OSHA respiratory protection standard (29 Code of Federal Regulations 1910.134). A respirator program includes written procedures, respirator selection protocols, training, fit-testing, respirator maintenance and cleaning, storage procedures, air monitoring, and medical monitoring.

3. Texprint should develop and implement procedures to ensure that proper personal protective equipment (PPE) is provided and utilized. PPE is needed in the following areas: working with dyes, caustic handling, preparation activities, and other chemical handling tasks.

Employees who have direct skin contact with caustic sodium hydroxide, used in the mercerizer machine, should be protected with goggles and face shield, rubber latex gloves, rubber boots, and aprons.

Employees should avoid direct skin contact with dyes. The greatest potential for contact is in the Dye Mixing Department. Goggles, aprons, and gloves should be required in this area. Consideration should be given to changing equipment and/or procedures so that the dye does not have to be scooped out of vats by hand. This work practice results in a high potential for eye and skin contact.

4. The NIOSH staff noticed eye irritation, presumably from caustic sodium hydroxide, in the mercerizer area during the May visit and during the September walk-through. Since the process was not in operation following the September walk-through survey, NIOSH personnel were not able to conduct air sampling for sodium hydroxide in this area.

   The exhaust ventilation system for the mercerizer should be evaluated. The mercerizer machinery should be enclosed, if technically feasible. Air sampling for caustic sodium hydroxide should be conducted in this area as part of the process evaluation.

5. Formaldehyde exposures in the area of the Hirano machine should be reduced to the lowest feasible limit. Ideally, this should be accomplished through the use of engineering controls, when technically feasible. Texprint should continue to work with suppliers to utilize resin systems offering lower formaldehyde release.

   Periodic exposure monitoring for formaldehyde should be performed. Exposure monitoring should also be conducted after ventilation changes are made, when new resin treatments are used, and following other work practice changes which may affect airborne formaldehyde levels.

   Under the OSHA formaldehyde standard, Texprint should note that mixtures or solutions composed of greater than 0.1 percent formaldehyde, and materials capable of releasing formaldehyde into the air under any normal condition of use at concentrations reaching or exceeding 0.1 ppm shall be considered a health hazard.[8]

6. Texprint has plans to automate the Stock-Paste Department. This area should be automated as soon as possible. Employees currently working near the Stock-Paste Department complained of eye, nose, and throat irritation when powdered chemicals, notably Revatol®, were dumped into the hopper.

7. The interior of the plant appeared cloudy. On the roof, exhaust from a rotary printer was going directly into one of the Dynaforce® building ventilation units. Exhaust stack heights definitely need to be increased. Rain-caps on the exhausts should not be used because they severely restrict the flow of air and redirect it down toward the roof, aggravating the reintrainment problem.

8. Removal of adhesive, which holds the cloth during printing, from belts ("stripping blankets") was not conducted during the NIOSH visit. Air monitoring for solvent exposures should be performed to determine if respirators or other control measures are required.

9. The ammonium hydroxide drum in the Stock-Paste Department, showed signs of deterioration or swelling and should be removed from the facility.

10. The Hazard Communication policy at Texprint should be reviewed. Areas that should be addressed should include information on labels, material safety data sheets, and employee information and training. If employee health symptoms are reported to union officials or management, a system should be implemented that documents and addresses the hazard, so that corrective measures can be made.

11. Texprint should implement specific safety policies for each department in the plant. The development of new safety policies could be accomplished through Texprint's monthly management/union meetings. Safety policies should be in written form and accompanied by training programs. Employees must understand safety policies.

For further evaluation or technical expertise, a list of industrial hygiene consultants who are members of the American Industrial Hygiene Association (AIHA) is available from the following address:

American Industrial Hygiene Association
345 White Pond Drive
Akron, Ohio 44311-1087

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Copies of this report have been sent to:

1. Texprint Products, Inc.
2. Amalgamated Clothing and Textile Workers Union, Local 2437
3. NIOSH, Region IV
4. OSHA, Region IV

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

Table 1
Texprint Products, Inc.
Macon, Georgia
HETA 91-169
Personal and Area Samples
Formaldhyde Vapor

Job Title	Date	Location	Sample Time (minutes)	Formaldehyde Concentration (TWA - ppm)
Area	5/16/91	Near Permafresh tank of Hirano #2	336	0.23†
Area	5/16/91	On electrical box near Hirano #2	347	0.09†
Area	5/16/91	Back end of Hirano #2, after the drying oven	283	0.06†
Machine Operator	9/12/91	Hirano #1	436	detected‡
Area	9/12/91	Chemical tank on Hirano #1	435	detected‡
Area	9/12/91	Back end of Hirano #1, after drying oven	430	detected‡
Area	9/12/91	Work desk of Hirano #2	433	detected‡

TWA: time weighted average

ppm: parts per million

† Air sampling performed according to NIOSH method 3500, using impingers.
‡ Air sampling performed according to NIOSH method 2541, with XAD sorbent tubes. Because of low recoveries of formaldehyde on laboratory-spiked sorbent tubes, the quantity of formaldehyde found on the field samples could not be reliably determined, although it was detected.

Table 2
Texprint Products, Inc.
Macon, Georgia
HETA 91-169
Personal and Area Samples
Total Hydrocarbons
September 12, 1991

Sample Type	Job Title/ Location	Sample Time (minutes)	TWA Total Hydrocarbon Concentration (mg/m^3)
Personal	Printer/ Rotary #3	304	110
Personal	Operator/ Strike-off	354	38
Area	Rotary #3, roller area	406	135
Area	Ariole Machine	401	55
Area	Rotary #3, drying area	220	48
Area	Hirano #2	186	3

TWA: 8-hour time weighted average

mg/m^3: milligrams per cubic meter air

Table 3
Estimating Energy Cost of Work by Task Analysis
Texprint Products, Inc.
Macon, Georgia
HETA 91-169

A. Body position and movement	**kcal/min***
Standing	0.3
Walking	0.6
Walking uphill	2.0-3.0
Sitting	add 0.8 per meter rise

B. Type of Work	**Average Kcal/min**	**Range kcal/min**
Hand work		
light	0.4	0.1-1.2
heavy	0.9	
Work one arm		
light	1.0	0.7-2.5
heavy	1.8	
Work both arms		
light	1.5	1.0-3.5
heavy	2.5	
Work whole body		
light	3.5	2.5-9.0
moderate	5.0	
heavy	7.0	
very heavy	9.0	

C. Basal metabolism	1.0

D. Sample calculation**	**Average kcal/min**
Assembling work with heavy hand tools	

1.	Standing	0.6
2.	Two-arm work	3.5
3.	Basal metabolism	1.0
Total		5.1 kcal/min

* For standard worker of 70 kg body weight (154 lbs) and 1.8 m^2 body surface (19.4 ft^2).

** Example of measuring metabolic heat production of a worker when performing initial screening.

Table 4
Texprint Products, Inc.
Macon, Georgia
HETA 91-169
Wibget Measurements, Rotary Printer #4
September 12, 1991

Recording Time	Wet Bulb Temperature ºF	Dry Bulb Temperature ºF	Globe Temperature ºF	Indoor WBGT ºF
0834	77.7	86.0	88.9	81.1
0844	77.0	85.7	88.5	80.4
0854	77.0	85.8	88.3	80.4
0904	77.5	86.1	88.8	80.9
0914	77.7	86.8	89.6	81.2
0924	78.1	87.4	90.0	81.6
0934	78.2	87.9	90.5	81.9
0944	77.9	87.7	90.4	81.6
0954	78.4	88.3	90.6	82.1
1004	78.2	88.5	90.9	82.0
1014	78.1	88.7	91.1	82.0
1024	78.9	89.3	91.6	82.9
1034	78.9	89.5	92.2	82.9
1044	79.3	90.1	92.2	83.1
1054	79.4	90.4	92.9	83.4
1104	79.5	90.8	93.2	83.6
1114	79.6	91.1	93.5	83.8
1124	79.6	91.7	93.9	83.9
1134	79.4	92.0	94.0	83.8
1144	80.1	93.1	95.0	84.6
1154	80.3	93.6	95.5	84.8
1204	80.9	93.8	96.2	85.5
1214	81.1	94.3	96.4	85.7

1224	80.8	94.7	96.7	85.6
1234	80.5	94.4	96.8	85.4
1244	80.5	95.0	96.4	85.3
1254	80.1	94.6	96.5	85.0
1304	79.7	94.2	96.6	84.8
1314	79.8	94.7	96.7	84.8
1324	79.7	95.3	97.1	84.9
1334	79.8	95.6	97.2	85.0
1344	79.4	95.0	96.8	84.6
1354	79.9	95.4	97.4	85.2
1404	79.7	95.7	97.9	85.2
1414	79.8	96.4	98.3	85.3
1424	80.0	96.4	98.3	85.5
1434	79.8	97.9	99.3	85.6
1444	79.6	96.6	99.0	85.4
1454	79.4	96.6	98.7	85.2
1504	79.7	96.6	98.7	85.4
1514	80.6	97.2	98.9	86.1
1524	80.5	97.2	99.6	86.2
1534	79.2	97.4	99.2	85.2
1544	80.0	98.2	100.2	86.0
1547	80.3	98.3	101.4	86.7

Table 5
Texprint Products, Inc.
Macon, Georgia
HETA 91-169
Questemp II Personal Temperature Monitor
September 12, 1991

Recording Time (24 hour)	Mold Temperature (ºF)	Ear Temperature (ºF)	Ear Temp. in Excess of 100.4 oF (38 ºF)
0815	86.9	93.3	
0825	86.2	98.3	
0835	85.0	98.5	
0845	84.4	97.4	
0855	85.6	97.5	
0905	85.7	97.5	
0915	88.7	99.0	
0925	89.1	99.0	
0935	88.1	101.7	+
0945	88.8	102.2	+
0955	88.8	102.3	+
1005	89.8	102.2	+
1015	90.0	102.2	+
1025	80.6	101.7	+
1035	86.4	101.9	+
1045	91.3	100.5	+
1055	92.8	100.8	+
1105	92.2	100.8	+
1115	93.4	101.2	+
1125	92.2	100.9	+
1135	95.5	100.9	+
1145	99.8	101.3	+
1155	93.8	101.7	+
1205	94.2	101.0	+

1215	93.9	101.0	+
1225	93.4	100.9	+
1235	93.4	100.8	+
1245	93.7	100.8	+
1255	93.6	101.0	+
1305	93.6	100.8	+
1315	93.8	100.8	+
1325	93.8	100.8	+
1335	94.5	100.8	+
1345	90.3	101.0	+
1355	82.7	100.5	+
1405	83.1	99.9	
1415	95.0	99.3	
1425	89.5	102.3	+
1435	88.7	102.6	+
1445	95.8	102.5	+
1455	95.8	102.9	+
1505	97.4	103.0	+
1515	96.6	103.0	+
1525	96.4	103.0	+
1535	90.8	103.0	+
1545	96.9	103.0	+

Table 6
Texprint Products, Inc.
Macon, Georgia
HETA 91-169
Wibget Measurements, Open Washer
September 12, 1991

Recording Time	Wet Bulb Temperature ºF	Dry Bulb Temperature ºF	Globe Temperature ºF	Indoor WBGT ºF
0845	79.8	88.5	84.2	81.1
0855	80.7	88.6	93.8	84.7
0905	81.2	89.9	95.0	85.3
0915	80.8	90.2	95.6	85.2
0925	80.3	89.4	94.4	84.8
0935	80.7	89.9	95.1	85.0
0945	81.0	90.2	95.3	85.3
0955	81.4	91.3	96.3	85.9
1005	82.1	92.5	96.8	86.5
1015	81.5	92.3	97.1	86.2
1025	81.8	92.4	97.3	86.5
1035	82.2	92.8	97.4	86.7
1045	82.2	93.1	98.1	86.9
1055	81.8	93.1	98.0	86.6
1105	81.9	93.3	98.1	86.7
1115	82.3	94.3	98.2	87.0
1125	82.4	94.3	98.5	87.2
1135	83.3	95.2	99.2	88.0
1145	82.5	94.7	99.5	87.6
1155	83.3	96.3	99.6	88.2
1205	82.7	95.2	100.0	87.9
1215	83.8	96.5	100.3	88.8
1225	83.0	95.7	100.4	88.2
1230	83.3	96.3	100.4	88.4

Table 7
Texprint Products, Inc.
Macon, Georgia
HETA 91-169
Wibget Measurements, Hirano Machine
September 12, 1991

Recording Time	Wet Bulb Temperature ºF	Dry Bulb Temperature ºF	Globe Temperature ºF	Indoor WBGT ºF
1241	82.4	97.9	98.6	87.3
1251	81.7	97.8	97.7	86.5
1301	81.4	97.7	97.6	86.3
1311	81.3	98.2	98.0	86.3
1321	81.4	98.4	98.2	86.4
1331	81.2	98.7	98.3	86.3
1341	80.9	98.9	98.6	86.2
1351	80.6	99.3	98.7	86.0
1401	80.3	99.5	99.3	86.0
1411	80.8	99.8	99.4	86.3
1421	80.7	99.9	99.7	86.4
1431	80.4	99.6	99.8	86.2
1441	80.2	99.6	100.1	86.2
1451	80.0	99.3	99.2	85.7
1501	79.6	98.1	99.3	85.5
1511	79.3	97.9	98.9	85.2
1521	79.6	98.6	99.2	85.5
1531	79.7	98.9	99.3	85.6
1540	80.6	99.8	99.8	86.3

Table 8
Texprint Products, Inc.
Macon, Georgia
HETA 91-169
Personal and Area Samples
Caprolactam Vapor
September 12, 1991

Sample Type	Job Title/ Location	Sample Time (minutes)	Caprolactam Concentration TWA (ppm)
Personal	Printer/ Rotary #1	439	trace†
Personal	Printer/ Rotary #2	341	0.03
Personal	Chief Printer/ Rotary #3	239	0.06
Personal	Operator/ Automated Dye Mixing	448	trace†
Area	Rotary #3, drying area	451	0.02

TWA: 8-hour time weighted average

ppm: parts per million

† Trace concentrations represent a quantity of caprolactam between the limit of detection (0.01 mg/sample) and the limit of quantitation (0.034 mg/sample).