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## I. SUMMARY

In late 1987, the National Institute for Occupational Safety and Health (NIOSH) received a request from an authorized representative of the employees at Jostens Incorporated, Princeton, Illinois, to evaluate reports of cancers, breathing problems, kidney problems, and watery eyes, and their possible association with workplace exposures to substances used in the polish and plating departments. Jostens is a jewelry manufacturer which produces rings, medallions, belt buckles, tie tacks, and service awards.

On February 16-18, 1988, NIOSH investigators conducted environmental and medical evaluations. Full-shift breathing zone and general area air monitoring was conducted for cyanides (aerosol and gas), trichloroethylene, and other volatile organic compounds which were present in the two lacquers used in jewelry finishing. The environmental evaluation also included a survey of the local exhaust ventilation systems in the polish and plating departments.

Results from the exposure monitoring for cyanides were all below  $0.1 \text{ mg/m}^3$ , well below the applicable evaluation criteria for cyanides (CN) and hydrogen cyanide (HCN). The Occupational Safety and Health Administration's permissible exposure limit for HCN is currently  $11 \text{ mg/m}^3$  and for cyanides, as  $\text{CN}^-$ , is  $5 \text{ mg/m}^3$ . The NIOSH recommended exposure limit for cyanide salts and HCN combined, as  $\text{CN}^-$ , is  $5 \text{ mg/m}^3$  for a 10-minute sampling period.

Personal breathing zone air concentrations of trichloroethylene (TCE) ranged from 14.7 ppm to 33.4 ppm. Five of the eight personal breathing zone air samples collected on polish and plating department employees exceeded 25 ppm, the level which NIOSH feels can be readily achieved through existing engineering control technology. Area air samples collected by the TCE degreaser and the ultrasonic cleaner had levels of 49.2 ppm and 64.1 ppm, respectively, indicating that these sources were significant contributors to the airborne TCE levels. Exposure monitoring for toluene, xylenes, perchloroethylene, and methyl isobutyl ketone (components of the lacquers) indicated that these substances were present at low levels. All four substances were present in concentrations less than one tenth of the most protective evaluation criteria, with the exception of perchloroethylene, which NIOSH recommends should be reduced to the lowest feasible level, as it is considered a potential carcinogen.

Confidential interviews were conducted with employees in both departments to determine the extent to which workers experienced symptoms of solvent exposure, and to establish the types of cancer that had occurred among active and retired workers. Personnel records were also reviewed to determine if there were medically related reasons for workers leaving employment at

Jostens. Of the 25 employees who responded to a symptom questionnaire, seven (28%) reported multiple symptoms consistent with solvent exposure. The interviews also revealed that the cancers identified among polish department employees were colon cancer, ovarian cancer, kidney cancer, and breast cancer. Only one employee had worked at Jostens more than 10 years before the cancer was diagnosed.

Based on the results of this investigation, a potential health hazard from exposure to TCE exists in the polish and plating departments. Since the potential exposure involves a suspect human carcinogen, reduction of airborne TCE concentrations to the lowest feasible level, as recommended by NIOSH, should be attempted. Based on the diversity of the cancers, the relatively short potential latencies, and the lack of evidence that exposure to TCE results in the types of cancers found at Jostens, no epidemiological association between TCE exposure and the cancers experienced by these workers can be made. Recommendations for improving engineering controls, safe work practices, and the use of personal protective equipment are included in Section VIII of this report.

**KEYWORDS:** SIC 3911 (Jewelry, silverware and plateware), trichloroethylene, cyanide.

## II. INTRODUCTION

In November 1987, the National Institute for Occupational Safety and Health (NIOSH) received a request from an authorized representative of the employees at the Recognition Division of Jostens Incorporated, Princeton, Illinois, to evaluate health effects including cancers, breathing problems, kidney problems, watery eyes, and their possible association with workplace exposure to substances used in the polish and plating departments. Of particular concern was exposure to cyanides, trichloroethylene, lacquer, and Krylon\* (an acrylic lacquer mixed with trichloroethylene).

On February 16-18, 1988, NIOSH investigators visited Jostens to conduct a joint environmental and medical evaluation. On March 3, 1988, a preliminary report was distributed to employee and management representatives. Preliminary medical findings were included in the report, along with recommendations regarding preventive maintenance for the local exhaust ventilation system, safe work practices, respiratory protection, and personal protective equipment use.

## III. BACKGROUND

Jostens is a jewelry manufacturer which produces rings, medallions, tie tacks, belt buckles and service awards. Their average order size is 20 items, which consist of gold, sterling silver, and bronze piecework. The manufacturing process begins with artwork design. From there the pieces are either stamped (using sheet stock) or cast from molds (using molten metal). The type of piece to be produced determines the production method which is used. Rings are cast using the "lost-wax", or "investment casting" process, while belt buckles are mechanically worked from stock metal. The polish and plating departments are responsible for jewelry finishing. Finishing processes include cleaning, degreasing, electroplating, polishing, and buffing.

There are approximately 15 employees in the plating department. These employees work as jewelry sorters, jewelry platers, ring platers, sandblasters, buffers, and lead person. Preparation of the jewelry pieces can include sandblasting, which is performed in a glove box enclosure using glass beads, as well as buffing. Jewelry is cleaned by either suspending the piece in a trichloroethylene (TCE) vapor degreaser, or by immersing it in acid or alkali baths. There are six plating lines in this department, all of which are equipped with local exhaust ventilation. The lines are comprised of 6-8 small plating baths which contain aqueous solutions of acids, bases, cyanide salts, and precious metals. Individual jewelry pieces are processed according to the metal composition and desired finish. After electroplating, a protective coating is applied to the pieces using an acrylic lacquer mixed with trichloroethylene (a mixture commonly referred to as "Krylon\*"), or a nitrocellulose-based lacquer (referred to as "lacquer"). Both lacquers are spray-applied in separate hood-type enclosures.

The polish department is located adjacent to the plating department. There are 20 employees in this department, 15 of whom work as polishers. The remaining individuals are employed as utility cleaners and cleaner operators. Polishing is done by machine, using covered wheels and

jeweler's rouge. Personal protective equipment, including gloves and goggles, is worn by polishers. Polishing machines are equipped with local exhaust ventilation. There is an automated ultrasonic trichloroethylene degreaser in this area which is used for fine cleaning and removal of the Krylon\* protective coating. The individual who works as the cleaner operator is responsible for loading and unloading the pieces and for monitoring the overall operation of the degreaser. The utility cleaner is responsible for cleaning pieces which have become soiled or tarnished. This includes dipping the pieces in a potassium cyanide solution, followed by water and steam rinses. Separate spray booths are located in this department for applying lacquer and Krylon\*, a job which is also performed by the utility cleaner.

#### IV. EVALUATION DESIGN AND METHODS

##### A. Environmental

On February 16-17, 1988, exposure monitoring was conducted in the polish and plating departments. Eight personal breathing zone and 7 general area air samples for trichloroethylene were collected. Air samples were collected in both departments since there was the potential for exposure to trichloroethylene from the degreasers as well as from the trichloroethylene-Krylon\* spray. Employees who were involved in the lacquer spray operation or in the operation of the trichloroethylene degreasers were included in the exposure monitoring. General area air samples were collected near the degreasers, as well as outside the lacquer spray area. Samples were collected by drawing air through activated charcoal tubes, at a flow rate of 50 milliliters per minute, using calibrated, battery-operated sampling pumps. Successive air samples (morning and afternoon) were obtained to cover the entire work shift. Samples were analyzed by gas chromatography with flame ionization detection (GC-FID), in accordance with NIOSH Method 1022,<sup>1</sup> with the following modification: a fused silica capillary column coated with DB-5 was used in place of the packed column specified in the method.

Eleven of the above samples were also quantitated for toluene, xylenes (all isomers), perchloroethylene, and methyl isobutyl ketone. These substances are some of the components of Krylon\*, lacquer, and lacquer thinner. A preliminary qualitative analysis of air samples collected in the lacquer spray areas had identified these substances as the major air contaminants. Samples were analyzed by GC-FID, in accordance with NIOSH Methods 1003, 1300, and 1501, with the modification (column substitution) noted above.<sup>1</sup>

Ten full-shift air samples (one personal and nine general area samples) were collected to assess exposures to cyanides (aerosol and gas) in the polish and plating departments. Area air samples were collected above plating tanks which contained solutions of cyanide salts, as well as in the polish department where a potassium cyanide solution was used. Samples were collected by drawing air through a sampling train consisting of a 37-millimeter, 0.8-micron cellulose ester membrane (CEM) filter followed by a bubbler containing 10 ml of 0.1N potassium hydroxide. Battery-operated air sampling pumps were calibrated at

0.5 liters per minute. At the end of the sampling period, the bubbler solution and CEM filter were transferred to a polyethylene container, along with a potassium hydroxide pellet which was added for stabilization. Field blanks were prepared in the same manner and shipped along with field samples. Analysis was performed using visible absorption spectroscopy. Cyanides were released from complexes by ultraviolet digestion and reacted with chloramine-T to produce cyanogen chloride. Cyanogen chloride was then reacted with pyridine and barbituric acid to produce a colored complex. The intensity of the colored complex was then measured at 570 nanometers, using a visible spectrophotometer.

An evaluation of personal protective clothing use, work practices, and local exhaust ventilation system performance was also made during the survey. A calibrated thermoanemometer was used to obtain airflow measurements at the hood face of the Fisher lab fume hood and the lacquer and Krylon\* spray hoods in the plating department. An assessment of the ventilation system serving the degreaser units was also conducted.

#### B. Medical

The medical investigation was divided into three phases: 1) confidential interviews with employees to determine the extent to which workers experienced symptoms of trichloroethylene exposure, 2) verification of reported cancers among workers and retirees, and 3) a review of personnel records to determine if any previously employed workers had left employment due to work-related illnesses.

In the first phase employees were asked to respond to a list of symptoms associated with short term TCE exposure. Responses from both polishers and platers were compared for expected acute effects, which included: headache, dizziness, vertigo, tremors, nausea, vomiting, irregular heart beat, drowsiness, fatigue, blurred vision, feeling intoxicated, itchy nose, and watery eyes.

In addition to the types of acute symptoms experienced by workers, we asked about cancers that have occurred among active and retired workers.

Personnel records were reviewed during the third phase of the investigation to determine if there were medically related reasons for workers leaving employment at Jostens. From these records we were able to ascertain the cause of termination for all employees (voluntary and involuntary) during the years 1984 through 1987.

#### V. EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by work place exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected

from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other work place exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled to the level set by the evaluation criterion. These combined effects are not often considered by the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the work place are: 1) NIOSH Criteria Documents and Recommended Exposure Limits (RELs), 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs), and 3) the U.S. Department of Labor (OSHA) Permissible Exposure Limits (PELs). Often, the NIOSH recommendations and ACGIH TLVs are lower than the corresponding OSHA PELs. The NIOSH RELs and ACGIH TLVs are usually based on more recent information than are the OSHA standards. The OSHA PELs may also be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended exposure limits, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA PEL.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits (STELs) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high, short-term exposures.

#### A. Trichloroethylene

Trichloroethylene is a colorless, noncorrosive, nonflammable liquid that is immiscible in water. It is volatile at room temperature, with a vapor pressure of 58 mm Hg at 20°C.<sup>2</sup> TCE is a powerful degreasing and dry cleaning agent and is used in commercial products such as paints, lacquers, varnishes, and resins.<sup>3</sup> It is also used as an intermediate in the manufacture of other chemicals.

TCE is absorbed rapidly by the lungs following inhalation and eliminated to only a small degree by exhalation.<sup>4</sup> The predominant physiological response is one of central nervous system depression. This is particularly true as a response from acute or short-term exposure. Effects include drowsiness, dizziness, disturbances of vision, impairment of the

senses of smell and touch, tremor, impaired coordination, anxiety, confusion, insomnia, and loss of consciousness. Other effects of TCE include vomiting, abdominal cramps, cardiac arrhythmias, and respiratory tract irritation. Respiratory distress has been observed often, especially following intermittent inhalation exposures, with such symptoms as chest tightness and labored breathing.<sup>5</sup> Liver and kidney injuries in humans attributable to overexposure to TCE are rare.<sup>6</sup> The effects of chronic exposure to humans have not been extensively studied, and thus are not well characterized.

Prolonged skin contact can cause local irritation and blister formation. Repeated immersion of the hands in TCE has caused paralysis of the finger.<sup>7</sup> Although the absorption of toxic quantities of TCE is not generally thought to occur by this route<sup>8</sup>, a recent case report suggests otherwise. In 1988, McCunney reported a finding of toxic encephalopathy, characterized by irritability, short-term memory loss, feelings of inebriation, and personality changes in a degreaser operator at a jewelry company.<sup>9</sup> Skin absorption from repeated skin contact with TCE, was thought to be the primary contributor, since air measurements were reportedly less than 25 ppm.

TCE reduces tolerance to alcoholic beverages. Some individuals who have been exposed to TCE experience "degreaser's flush" after consuming alcohol. This apparently benign condition is typically of short duration, and consists of red areas of skin on the face, neck, shoulders, and back.<sup>10</sup>

NIOSH's initial recommendation for a TCE standard was issued in 1973.<sup>4</sup> This recommended exposure limit, and the current OSHA standard, both 100 ppm, were based upon TCE's known toxic properties at that time and did not include an assessment of its carcinogenic potential. On March 21, 1975, the National Cancer Institute (NCI) reported preliminary results of a carcinogen bioassay which indicated the induction of hepatocellular (liver) carcinomas in mice. No carcinogenic effects were observed in rats. After reviewing the NCI study, NIOSH recommended that TCE be considered a suspect human carcinogen and transmitted this message to industry in a Special Occupational Hazard Review with Control Recommendations.<sup>5</sup> Information at that time regarding engineering feasibility indicated that TWA personal exposures of 25 ppm could be readily attained. It was not felt, however, that this should serve as a final goal; rather, it was felt that industry should pursue further reductions in worker exposure as advancements in technological research allow. Since there is no known safe level of exposure to a carcinogen, NIOSH recommends that exposure be minimized to lowest extent possible. The current ACGIH TLV for TCE is 50 ppm as an 8-hour TWA.<sup>11</sup> The current OSHA PEL is 100 ppm as an 8-hr TWA, with an acceptable ceiling value of 200 ppm and a 5-minute/2-hour peak of 300 ppm.<sup>12</sup> Recently, OSHA amended its existing Air Contaminants standard, 29 CFR 1910.1000. Included in this amended standard are revised exposure limits for trichloroethylene.<sup>13</sup> Effective September 1, 1989, the 8-hour TWA will be 50 ppm. The STEL remains at 200 ppm, but, there will no longer be a ceiling level designation.

## B. Organic Vapors

Table 1 presents the evaluation criteria and a brief summary of the primary health effects of the volatile organic contaminants (other than TCE) which were measured during this evaluation. These substances are some of the components of the lacquer, lacquer thinner, and Krylon\* used at Jostens.

## C. Cyanides

Cyanide (CN) is well known as an acute, fast-acting poison, resulting in asphyxia, and even death, at high concentrations. It can affect the body if it is inhaled, ingested, or if it comes in contact with the eyes or skin. There is a common mechanism of action for hydrogen cyanide (HCN) and cyanide (CN) salts.<sup>14</sup> Toxic quantities of HCN and cyanide salts, dry or in solution, may be absorbed readily through the skin.<sup>14</sup> At lower levels of exposure symptoms can include weakness, dizziness, headache, and nausea.<sup>15</sup> Contact with solutions as dilute as 0.5% potassium cyanide (KCN) have resulted in headaches and dizziness for some individuals.<sup>14</sup> Cyanide solutions or cyanide aerosols have also been reported to cause skin irritation, upper respiratory tract irritation, and allergic contact dermatitis.<sup>16</sup>

Cyanide salts such as sodium cyanide and KCN will liberate HCN gas in the presence of acids, acid vapors, large amounts of carbon dioxide (CO<sub>2</sub>), or upon hydrolysis. While the majority of cyanide electroplating solutions contain alkalies such as sodium hydroxide, some gold plating solutions are acidic, containing hydrochloric or sulfuric acids. In addition, the "bombing" procedure, which combines cyanide salts with hydrogen peroxide, also has the potential to liberate HCN. Both HCN and CN salts are reported to have an odor of bitter almonds. At high concentrations, however, its toxic action is so rapid that its odor has no value as a warning.

NIOSH has established a ceiling value of 5 mg/m<sup>3</sup> (expressed as CN<sup>-</sup>) for a 10-minute sampling period.<sup>14</sup> In addition, NIOSH recommends that whenever the air is analyzed for cyanide salts a concurrent analysis should be made for HCN, and the combined values should not exceed 5 mg/m<sup>3</sup> during any 10-minute sampling period. OSHA has established PELs of 11 mg/m<sup>3</sup> for HCN and 5 mg/m<sup>3</sup> for cyanides as CN<sup>-</sup>, with a "skin" notation, indicating a potential contribution to the overall exposure by the cutaneous route.<sup>17</sup> Effective September 1, 1989, the amended STEL for HCN is 5 mg/m<sup>3</sup>.<sup>13</sup> There will no longer be an 8-hour TWA exposure limit for HCN. In addition, there is no change in the 8-hour TWA for cyanide. ACGIH has established an 8-hr TWA-TLV of 5 mg/m<sup>3</sup> for cyanides (as CN<sup>-</sup>), and a ceiling of 10 mg/m<sup>3</sup> for HCN, both of which have a skin notation.

## VI. RESULTS

### A. Environmental

#### Trichloroethylene

Results from the TCE exposure monitoring conducted on February 18 and 19, 1988, are presented in Table 2. Time-weighted average concentrations of TCE in personal breathing zone air samples ranged from 17.3 ppm to 33.4 ppm on the first day, and from 14.7 ppm to 32.4 ppm on the second day of the survey. Of these, 5 sample results exceeded 25 ppm, the level which NIOSH feels can be readily achieved through the use of existing engineering control technology. The highest personal breathing zone exposures were for employees who operate the degreasers as well apply the TCE-Krylon\* spray. Area air sampling results for TCE ranged from 22.3 ppm to 64.1 ppm on the first day, and from 12.9 ppm to 26.6 ppm on the second day of the survey. Air samples collected by the TCE degreasers in the polish and plating departments had the highest TCE concentrations (64.1 ppm and 49.2 ppm, respectively), indicating that these sources are significant contributors to airborne TCE. Improper work practices, such as the use of compressed air to dry jewelry pieces which have been sprayed with lacquer, and the fast removal of pieces from the degreaser, are also suspected to have contributed to the TCE levels in these areas.

#### Organic Vapors

Samples marked with an asterisk in Table 2 were also quantitated for toluene, xylenes, perchloroethylene, and methyl isobutyl ketone - components of Krylon\*, lacquer and lacquer thinner. As noted in Table 2, the ranges of results was as follows: toluene = none detected to 9 ppm; xylenes = none detected to 2 ppm; perchloroethylene = none detected to 2 ppm; and methyl isobutyl ketone = none detected to 2 ppm. All results were less than one tenth of the most restrictive evaluation criteria for the substances with the exception of perchloroethylene, which NIOSH recommends should be controlled to the lowest feasible level, as it is considered a potential carcinogen.<sup>2</sup> A TLV for the mixture was not calculated due to the low levels of individual substances that were measured (other than TCE).

#### Cyanides

Air sampling data for cyanides (aerosol and gas) are presented in Table 3. Results indicated the presence of cyanide in field blanks in quantities of 8.6 and 7.6 micrograms. These quantities exceeded all but one of the field samples, which had a total of 15 micrograms of cyanide per sample. Analysis of field samples collected on a subsequent NIOSH survey<sup>17</sup> suggests that the

cellulose ester membrane filter media itself may either contain cyanide (possibly as a contaminant) or a substance which acts as an interferent in this analysis. Because filter media blanks were not analyzed in sufficient quantity to assign an average media blank value for cyanide, results in Table 3 could not be field blank corrected. The uncorrected TWA concentration of cyanides in personal and area samples were all below 0.1 mg/m<sup>3</sup>. Short-term exposure monitoring was not conducted, as it was not expected that concentrations would vary over the workshift due to the performance of routine operations throughout the work day. In addition to the above measurements, three screening samples for CN were taken using direct reading detector tubes for cyanide above the CN plating tanks. Cyanide was not detected in these samples; the limit of detection was 1 ppm (as CN).

### Ventilation Evaluation

Air velocity measurements made at the hood face of the Fisher lab hood ranged from 25 to 50 feet per minute (fpm), averaging 34 fpm at a sash height of 18 inches. (This hood is used during the "bombing" procedure, which was not performed during the NIOSH survey.) At a sash height of 12 inches, air velocity through the hood opening ranged from 25 to 100 fpm, averaging 62 fpm. Lower face velocities were measured on the right side of the unit where chemicals and apparatus were present, obstructing proper airflow. Although face velocities were slightly higher at the narrower sash opening, the values obtained still did not meet the current ACGIH recommendation of 100 to 150 fpm.<sup>18</sup>

Face velocity measurements obtained for the plating department spray hoods ranged from 25 to 75 fpm for the Krylon\* hood (averaging 55 fpm), and from 50 to 140 fpm (averaging 84 fpm) for the lacquer hood. These measurements indicate that the hoods do not meet current guidelines of 100 to 200 fpm for spray finishing hoods.<sup>18</sup> Based on the toxicity of TCE, the size of the hoods, and the fact that the hoods receive frequent use, the upper end of this range is a more appropriate guideline.

Ventilation measurements made at the face of the three slot exhausts for the ultrasonic cleaner averaged 238, 242, and 333 fpm, all of which exceeded the ACGIH guidelines of 100 fpm for this type of opening.

Airflow measurements made along the slots for the small TCE degreaser ranged from 25 to 1500 fpm, with the highest values obtained by the duct opening, decreasing rapidly to 25 fpm at the outermost edges. A portion of the opening was covered with tape, most likely to increase the velocity at the edges. A more permanent solution is needed, however, to provide more uniform exhaust for this degreaser.

An assessment of the local exhaust ventilation system for the small plating tanks indicated that some of the individual tank slots had heavy salt build-up, decreasing the effective slot area and thereby compromising airflow. The exhaust for the brite gold plate tank (which

contains an acidic cyanide solution) was blocked during our survey. This was brought to the attention of management representatives, who made arrangements to have this repaired. In general, our evaluation indicated that preventive maintenance for the plating tank exhaust system was lacking.

## B. Medical

Twenty five workers (15 polishers and 10 platers), 93% of the available workers in both departments, participated in the questionnaire survey. Participating workers had a mean of 7.7 years of employment at Josten's (range 1.5 to 25). Forty percent of both platers and polishers experienced headaches that they attributed to worksite exposures. Two polishers (13%) and three platers (30%) experienced dizziness while working. Sleepiness was experienced by 33% of the platers and 22% of the polishers, for an overall prevalence of 24%. Short-term, reversible sinus irritation was also reported by 40% of the platers and 47% of the polishers; they attributed these symptoms to the dusts and rouge used in the polishing department. Results of the medical questionnaire indicated that three persons in polishing and four persons in plating experienced multiple symptoms consistent with solvent exposure. These symptoms were reported to occur when local exhaust ventilation malfunctioned, or when solvents leaked from their tanks. Eleven employees (44%) had no symptoms associated with exposures.

Efforts during the second phase of the medical evaluation were directed at verifying the types of cancers reported among workers and retirees at Jostens. The hazard evaluation request specifically noted that several polishing department employees had developed cancer. The cancers identified among four TCE workers were: colon cancer, ovarian cancer, kidney cancer, and breast cancer. Each of these cancers involved different organ systems, and occurred within 5-10 years of employment for three of the four workers. Only one employee had worked at Josten's more than ten years before being diagnosed with cancer.

The third phase of the medical evaluation involved a review of personnel records to identify employees leaving Jostens due to work-related exposures. Approximately 250 exit interviews had been abstracted in a personnel department log, which summarized reasons for employees leaving Jostens since 1984; none of the employees gave a medically-related reason for ending employment.

## VII. DISCUSSION AND CONCLUSION

Results from the exposure monitoring for cyanides (aerosol and gas) were all below 0.1 mg/m<sup>3</sup>, well below the applicable evaluation criteria for CN and HCN. The results did, however, suggest that the blank filter media may contain cyanide (possibly a cyanide salt) or a substance which interferes with this spectrophotometric analysis. Although the absolute quantity of cyanide measured on the blank CEM filters was quite low (7.6 and 8.6 ug), the limit of detection for this

method is such that quantities as little as 0.04 ug per sample are detected. Further analytical work is needed in this area to assess whether a media blank correction can be assigned.

NIOSH considers TCE a potential human carcinogen based upon animal experimentation conducted by the National Cancer Institute which showed TCE to be a liver carcinogen in laboratory rats. TCE, however, has not been shown to produce colon cancer, ovarian cancer, breast cancer, or kidney cancer in humans (the four cancers observed among Jostens workers). A study of Swedish TCE workers<sup>19</sup> and a Study of Finnish TCE workers<sup>20</sup> showed no significant difference in mortality patterns between exposed and unexposed persons. Both studies observed fewer cancers occurring among the exposed workers than would be expected for an unexposed population of identical size. The Finnish study also found no increased risk of malformation among babies born to TCE-exposed mothers.

Based upon the results of this investigation, namely, the diversity of the cancers, the relatively short latency period, and the lack of evidence that exposure to TCE results in the types of cancers found at Jostens, no epidemiological association between TCE exposure and the cancers experienced by these four workers can be made.

Air sampling data for TCE indicated that 5 of the eight personal breathing zone air samples collected for polish and plating department employees exceeded 25 ppm, the level which NIOSH feels can be readily achieved through existing engineering control technology. In addition, several employees noted symptoms consistent with short-term exposures to TCE, including headaches, dizziness, and sleepiness. Of the 25 employees who responded to a symptom questionnaire, seven (28%) reported multiple symptoms consistent with solvent exposure. Since the potential exposure involves a suspect human carcinogen, reduction of airborne concentrations to the lowest feasible level, as recommended by NIOSH, should be attempted using the recommendations in the following section.

## VIII. RECOMMENDATIONS

Some of the recommendations listed below were included in a letter dated March 3, 1988. Additional recommendations are offered to help reduce potential TCE exposures, in an attempt to reach the lowest feasible level. Recommendations include improved engineering controls, proper work practices, and the use of personal protective equipment to minimize airborne chemical exposures and to protect against skin contact with acids, alkalies, cyanide salts, and volatile organic compounds.

1. Product substitutions should be made where possible to eliminate potential exposure to substances which are considered potential carcinogens.

## 2. Preventive Maintenance

A preventive maintenance program should be implemented for all local exhaust ventilation units in the polish and plating departments. This program should include a visual evaluation of the system, as well as ventilation measurements to determine the effectiveness of the units (hoods, booths, and plating tank exhaust). During our survey we observed that dampers were not always open on the individual plating tanks, and in some cases, the salt build-up was so extensive that airflow was obstructed.

## 3. Engineering Controls

Air velocity measurements made for the plating department lab fume hood indicated that face velocities did not meet current guidelines established by the ACGIH. This situation should be corrected. In addition, the hood should not be used to store chemicals or apparatus, as this compromises the effectiveness of the exhaust system by obstructing airflow patterns.

The plating department spray hoods also did not meet current capture velocity guidelines of 100 to 200 fpm for spray finishing hoods. Face velocities should be increased to meet these guidelines. The use of rigid duct work (in place of the flexible material), a reduction in the surface area of the hood face, and the use of larger capacity fans are all ways of increasing the velocity at the face of the hood. Cardboard or other combustible materials should not be placed in these hoods.

The exhaust ventilation for the small TCE degreaser should be improved. Airflow measurements indicated that capture velocity was not uniform, ranging from 1500 fpm by the duct opening to 25-75 fpm along the sides where the operator stands. The degreaser should be checked periodically to ensure that the condenser water temperature and the solvent temperature meet design specifications, so that the rate of vapor generation does not exceed recommended guidelines.<sup>18</sup> The degreaser should be covered when not in use. Pedestal fans should not be used in the plating department because they create cross-drafts, compromising the effectiveness of the exhaust ventilation at the degreaser and the buffing stations. An alternate system for cooling that does not create cross-drafts should be investigated. If necessary, conditioned make-up air should be provided to this department.

A determination of the capture velocity for the polish department spray booths was not made during our survey. These booths should be evaluated on a periodic basis to determine whether they meet current guidelines for spray finishing hoods.<sup>18</sup>

#### 4. Work Practices

Compressed air should not be used to dry parts which have been sprayed with Krylon\* or lacquer, as this practice contributes to airborne solvent levels in the workers' breathing zone. In addition, to take advantage of the local exhaust ventilation, jewelry pieces should be left in the hood until the solvent has evaporated.

Employees should be encouraged to remove parts from the TCE degreaser more slowly, so as not to upset the vapor layer, and hence, the effectiveness of the exhaust ventilation. The drying time for jewelry pieces should also be increased, by allowing the basket to remain at the level of the condensing coils until all solvent has evaporated. Our observations indicated that parts were being removed while still wet, a practice which contributes to TCE levels in this area.

Cleaning practices within the plating department should be improved. During our survey we noticed that glass beads were scattered around the sandblasting unit and that there were wet areas around the plating baths. Spills and leaks should be attended to immediately to avoid the potential for slip and fall injuries and potential contact with substances which can cause skin irritation.

The solution level for the plating baths should be carefully monitored to avoid overflow of solution and prevent formation of HCN gas due to mixing of strong acid solutions with cyanide salts. Plating baths should also be covered when not in use.

No eating, drinking, or smoking should be allowed in the polish and plating departments. These practices may pose an added health risk, as chemicals present on the hands or other surfaces may be transferred to the mouth. These activities should be restricted to designated areas away from production.

#### 5. Personal Protective Equipment

A respirator program consistent with the guidelines found in DHHS (NIOSH) Publication No. 87-116, "A NIOSH Guide to Industrial Respiratory Protection", and the requirements of the General Industry Occupational Safety and Health Standards (29 CFR 1910.134) should be implemented.

Employees working by the acid and alkali plating baths should be provided with, and required to use, rubber aprons, rubber gloves, and goggles, to protect against spills and splashes from sulfuric, nitric, and hydrochloric acids, as well as from alkaline plating solutions. Skin contact with TCE, Krylon\*, and lacquer should be minimized through proper work practices and the prompt removal of solvent from the skin with soap and water. The use of chemical resistant gloves (and goggles) may be necessary on specific operations, including spray finishing and degreasing, and when cleaning tarnished pieces, to fully eliminate skin contact and prevent skin absorption and dermatitis.

6. Environmental Monitoring

Environmental monitoring for trichloroethylene (as well as other potentially hazardous substances) should be conducted periodically, and whenever process or work practice changes are made, in order to evaluate potential worker exposures and the effectiveness of the recent changes.

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XI. DISTRIBUTION AND AVAILABILITY OF REPORT

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

1. Jostens Incorporated
2. Confidential Requestor
3. OSHA, Region V

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

Table 1  
Environmental Evaluation Criteria  
Jostens Recognition Division  
Princeton, Illinois  
HETA 88-082

Substance	Evaluation Criteria (ppm) <sup>a</sup>			Primary Health Effects
	NIOSH	OSHA <sup>b</sup>	ACGIH	
Toluene	100 200 (10-min)	200 300 (ceiling) 500 (10-min peak)	100	Exposure can result in central nervous system depression with symptoms of fatigue, weakness, confusion, dizziness, headache, and muscular fatigue. Dermatitis can result from repeated skin contact.
Xylenes	100 200 (10-min)	100	100	Xylene vapor can irritate the eyes, mucous (all isomers) membranes and the skin. It can also cause dizziness, drowsiness, and incoordination.
Perchloroethylene	LFL 200 (ceiling) 300 (5-min/3-hr peak)	100	50	Exposure can result in central nervous (tetrachloroethylene) system depression with symptoms of dizziness light-headedness, inebriation, headache and nausea. Mild irritation of the eyes, nose and throat may occur. Because it has caused liver cancer in mice, NIOSH considers it a potential carcinogen and recommends exposure be kept to the lowest feasible level
Methyl isobutyl ketone	50	100	50	High vapor concentrations may irritate (hexone) eyes, nose, and throat, and repeated exposure to high concentrations may produce symptoms of headache, nausea, light-headedness, vomiting and dizziness.

<sup>a</sup>. Evaluation criteria are expressed as time weighted average concentrations in parts per million (ppm);  
LFL = lowest feasible level.

<sup>b</sup>. Effective September 1, 1989, the OSHA permissible exposure limit (PEL) for toluene and xylenes will be 100 ppm as an 8-hr TWA and 150 ppm as a short-term exposure limit (STEL). The PEL for perchloroethylene will be 25 ppm as an 8-hr TWA. The PEL for methyl isobutyl ketone will change to 50 ppm as an 8-hr TWA and 75 ppm as an STEL.

Table 2 / Trichloroethylene Air Sampling Data  
 Jostens Recognition Division, Princeton, Illinois  
 HETA 88-082 / February 18-19, 1988

Job or Location	Sample	Sampling	Sample Volume (liters)	TCE Conc. (ppm) <sup>b</sup>	TCE-TWA Conc. (ppm) <sup>c</sup>	Location	Type <sup>a</sup>	Time
<b>Plating Department: (2-17-88)</b>								
Ring Plater	PBZ	0810-1124	9.6	29.1	1124-1527	8.1	25.2	27.1*
Sorter	PBZ	0753-1242	14.3	15.7	1242-1515	7.8	20.4	17.3*
Sandblaster	PBZ	0749-1124	10.8	34.4	1245-1518	8.2	32.0	33.4*
Lacquer spray area (on table outside booths)	GA	0758-1253	14.9	22.6	1253-1515	6.9	25.8	23.6*
Lacquer spray area (on rack beside booths)	GA	0812-1254	13.2	22.5	1254-1515	6.2	22.1	22.3*
Outside small TCE degreaser	GA	0746-1242	14.5	49.0	1242-1520	7.5	49.6	49.2*
<b>(2-18-88)</b>								
Sandblaster	PBZ	0715-1122	11.5	35.7	1247-1457	6.0	26.2	32.4*
Lacquer spray area (outside spray booth)	GA	1248-1518	6.7	26.2	0716-1248	11.1	26.8	26.6*
<b>Polish Department: (2-17-88)</b>								
Cleaner Operator	PBZ	0803-1259	13.9	18.8	1259-1510	6.1	43.0	26.2
Utility Cleaner	PBZ	0912-1255	9.6	23.2	1350-1629	6.7	26.2	24.4*
Trichloroethylene	GA	0756-1257	14.4	44.2	1257-1508	6.1	109.7	64.1

Table 2 (Continued)

Job or Location	Sample	Sampling	Sample Volume (liters)	TCE Conc. (ppm) <sup>b</sup>	TCE-TWA Conc. (ppm) <sup>c</sup>	Location	Type <sup>a</sup>	Time
<b>Polish Department: (2-18-88)</b>								
Lead Person	PBZ	0720-1123	12.4	27.2	1245-1456	6.8	25.4	26.6*
Cleaner Operator	PBZ	0728-1127	12.1	12.8	1252-1524	7.6	17.8	14.7
TCE ultrasonic cleaner (in bin on right)	GA	0743-1126	10.6	19.3	1252-1523	7.3	14.0	17.2
Outside spray booth (on storage bin side)	GA	0724-1126	12.2	11.8	1126-1525	7.8	14.0	12.9*
NIOSH Recommended Exposure Limit (REL)			25					
OSHA Permissible Exposure Limit (PEL) <sup>d</sup>			100 (Ceiling) 200 (5-min/2-hr) 300					
ACGIH Threshold Limit Value (TLV)			50					

<sup>a</sup>. PBZ = personal breathing zone air sample; GA = general area air sample.

<sup>b</sup>. Trichloroethylene (TCE) concentration expressed in parts per million (ppm).

<sup>c</sup>. TCE-TWA refers to the time-weighted average concentration of TCE averaged over the entire sampling period, in ppm.

\* Indicates samples which were also quantitated for xylenes, toluene, perchloroethylene and methyl isobutyl ketone. The range of results was as follows: xylenes = none detected (ND) to 2 ppm; toluene = ND to 9 ppm; perchloroethylene = ND to 2 ppm; and methyl isobutyl ketone = ND to 2 ppm. The limit of detection was 0.01 milligrams (mg) per sample and the limit of quantitation was 0.03 mg per sample, for all four substances.

<sup>d</sup>. Effective September 1, 1989, the OSHA PEL for trichloroethylene will be 50 ppm as an 8-hr TWA and 200 ppm as a short-term exposure limit (STEL).

Table 3 / Air Sampling Data for Cyanides  
 Jostens Recognition Division, Princeton, Illinois  
 HETA 88-082 / February 18-19, 1988

Job or Location <sup>a</sup>	Sampling Time	Sample Volume (liters)	Micrograms of CN per sample	Concentration of Cyanides as CN (mg/m <sup>3</sup> ) <sup>b</sup>
<b>(2-17-88)</b>				
Brite plate line above gold strip	0830-1523	175.5	0.8	.005
Black plate line above electro-black plate	0830-1531	210.5	15.0	.071
Electro-strip CN by silver smut	0717-1526	244.5	0.3	.001
Gold plate line above #1 rose CN	0827-1513	203.0	1.3	.006
On sink in polish dept. lacquer/layout area	0905-1512	183.5	0.5	.003
Brite plate operator	0730-1120	230.0	1.1	.005
Field blank #1	-----	-----	8.6	----
<b>(2-18-88)</b>				
Gold plate line, by gold strip CN	0752-1512	214.0	0.5	.002
On desk in front of Ni plate	0704-1515	245.5	0.6	.002
On desk by black and silver plate	0702-1514	246.0	0.5	.002
In front of watch dial tank	0708-1515	219.2	0.8	.004
Field blank #2	-----	-----	7.6	----
NIOSH REL (10-minute ceiling for HCN and salts combined, as CN)			5	
OSHA PEL <sup>c</sup> (8-hr TWA for HCN)			11	
(8-hr TWA for cyanides as CN)			5	
ACGIH TLV (8-hr TWA for cyanides as CN)			5	
(ceiling)			10	

<sup>a</sup>. Collected as general area air samples with the exception that a single personal breathing zone air sample was collected for the brite plate operator.

<sup>b</sup>. Concentration of cyanides (gas and aerosol) is expressed as a time-weighted average over the sampling period, in milligrams per cubic meter (mg/m<sup>3</sup>).

Results shown have not been field blank corrected. The limit of detection was 0.04 micrograms of CN per sample.

<sup>c</sup>. Effective September 1, 1989, the OSHA PEL for HCN will be 5 mg/m<sup>3</sup> as a short-term exposure limit (STEL). The 8-hr TWA for cyanides as CN remains at 5 mg/m<sup>3</sup>.