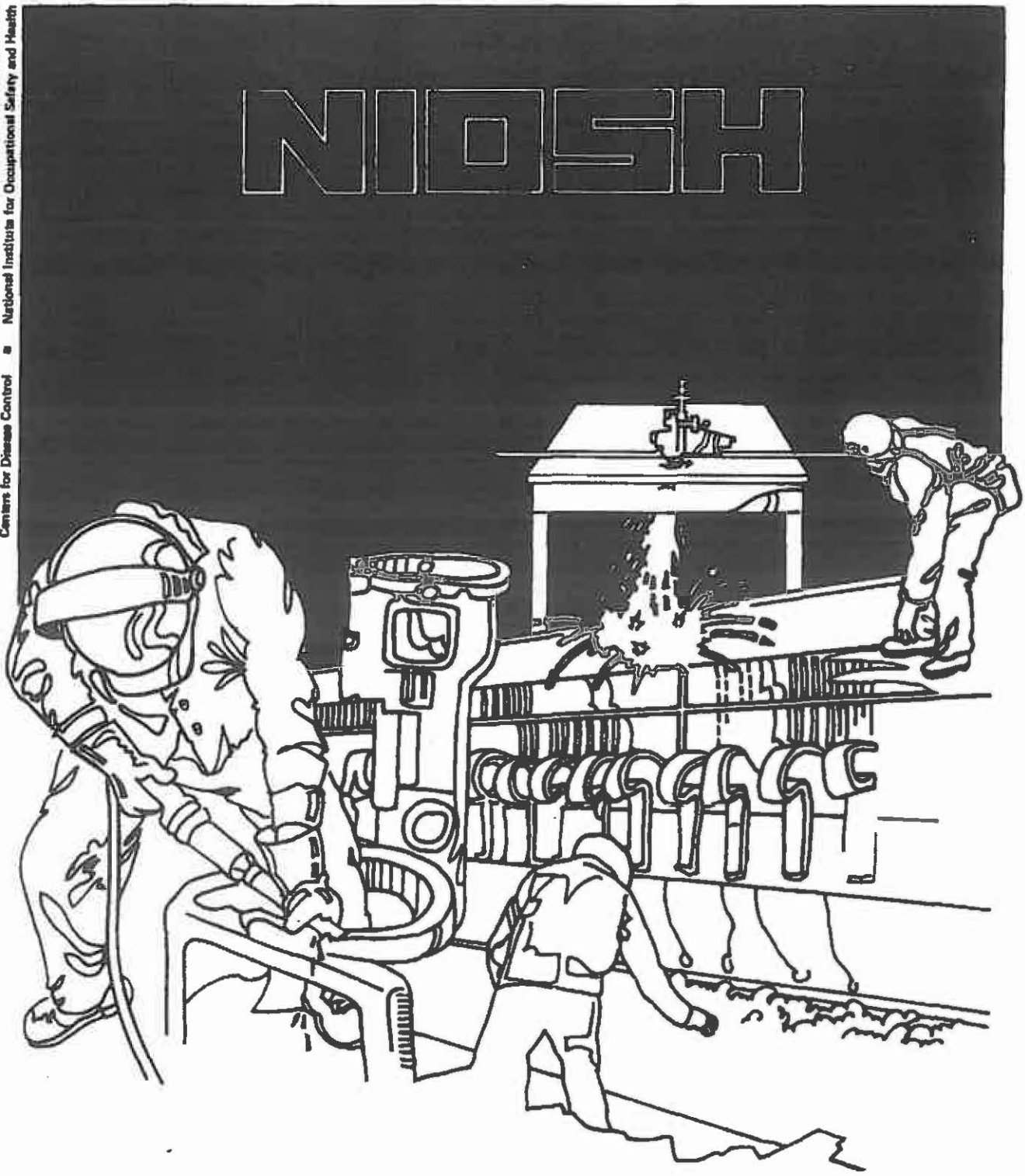
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health



Health Hazard Evaluation Report

HETA 81-383-1151
MAIN POST OFFICE
CHICAGO, ILLINOIS

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AUGUST 1982
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I. SUMMARY

On July 2, 1981, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation from the United States Postal Service, Chicago, Illinois. The requestor was concerned with the toxicity of paints and solvents, particularly those used in silk screen printing, in the sign shop of the Main Post Office, Annex Building.

In July 1981, NIOSH investigators conducted an initial survey of the sign shop. In August 1981, an environmental survey was conducted during which personal breathing zone and area air samples were collected for benzene, toluene, mineral spirits, and coal tar naphtha. Confidential interviews were conducted with 7 employees in the area.

Two of four short-term personal samples for toluene collected during silk screening cleanup operations revealed concentrations above the NIOSH recommended standard of 200 parts of contaminant per million parts of air (ppm) for a 10 minute ceiling period. The concentrations in these samples were 239 and 213 ppm.

Eight-hour TWA concentrations in personal samples were 34 and 14 ppm for toluene (NIOSH TWA 100 ppm), 43 and 19 milligrams per cubic meter of air (mg/M^3) for mineral spirits (NIOSH TWA 350 mg/M^3), and 20 and 12 mg/M^3 for coal tar naphtha (OSHA TWA 400 mg/M^3) for the silk screen operator and the helper, respectively. All values were below the recommended evaluation criteria. In addition, the combined exposure to these substances was calculated. Eight-hour TWA's for the duration of the process (3 hours) were below the evaluation criteria (unity or 1). However, if the operation had proceeded similarly for the entire 8-hours, the criteria would have been exceeded by the silk screen operator (combined exposure = 1.4).

Results of the medical questionnaires revealed no major health problems that would appear to be work related. Individual employees did cite infrequent instances of drowsiness and other symptoms which might be related to incidents of solvent exposure.

On the basis of the data obtained in this investigation, NIOSH has determined that a hazard from exposures to toluene above the recommended ceiling concentration did exist at the time of this survey. In addition, a potential hazard from combined exposure to toluene, mineral spirits, and coal tar naphtha could exist in silk screen operations conducted for the entire 8-hour work shift. In order to alleviate this hazard, as well as to reduce exposures to other substances used in this process, recommendations are included in the body of the full report.

KEYWORDS: SIC 7333, art hazards, silk screen printing, toluene, mineral spirits, coal tar naphtha

II. INTRODUCTION

On July 2, 1981, a representative of the United States Postal Service, Main Branch, Chicago, Illinois requested a NIOSH health hazard evaluation. The requestor was concerned with the toxicity of paints and solvents used in the sign painting shop located on the fourth floor of the Main Post Office, Annex Building. A particular concern was expressed in regard to silk screen printing operations.

On July 13, 1981, NIOSH investigators conducted an initial survey of the sign painting shop. This included an opening conference with representatives of management and the union, a walk-through inspection of the area of concern, and the administration of confidential medical questionnaires to the employees. On August 12, 1981, an environmental survey was conducted during which personal breathing zone and area air samples were collected. In January 1962, the NIOSH investigator met with management and union representatives to discuss the survey results and make preliminary recommendations.

III. BACKGROUND

The sign painting shop of the Main Post Office provides signs, posters, and other graphic materials required for the various postal facilities in the Chicago metropolitan area. The primary methods of sign production are hand lettering, brush painting, and silk screening. The shop has 8 full time employees working on the day shift, and one full time employee working the evening shift. Seventy percent of the employees activity occurs in the print shop itself, with the remainder of the time spent in the field.

Illustration, lettering, and brush painting are conducted in the main room of the sign shop. These operations require various types of paint and solvents, and depending on the specific job, may be completed either relatively quickly or over a period of a few days. In addition to these activities, this room is utilized for storage of equipment and materials used for all of the sign shop activities.

To the rear of the main sign shop area is an adjoining room in which silk screening operations are conducted. This process usually requires two employees, the silk screen operator and the helper. The length of any single operation will vary with the size of the order and the number of different colors required for the sign. A description of a routine operation is provided below.

The silk screen is first prepared by covering certain portions of the screen with a water-based chemical blockout painted directly onto the screen. The poster paint used in the process (containing from 48-58% aromatic hydrocarbons) is then poured from a paint can onto the silkscreen by the helper. The silk screen operator then presses a large rubber-tipped spreader down the entire length of the screen, thus spreading the ink evenly through the stencil onto the cardboard poster positioned below. The screen is lifted up, the poster is removed and the helper places it on a large drying rack located approximately one

foot behind the helper. The process is repeated until the desired number of posters are printed.

Cleaning the screen takes place after the application of each color and at the end of the entire run. The operator and the helper scrape the excess paint off the screen and the rubber-tipped spreader. Next, 4 to 8 ounces of the cleaning solvent is poured directly onto the stencil screen and is wiped by hand, back and forth, across the screen. Solvent soaked rags and paper are then used to remove the remaining ink from the screen. The rags and papers are thrown into an open aluminum trash can (lined with a plastic trash liner). The operator and the helper both use solvent to wash their hands and forearms at the end of the operation.

Both rooms of the sign shop are supplied with general ventilation through the building's air conditioning system. In addition, a window exhaust fan is used to increase ventilation in the silkscreening room. Rubber gloves are available to the employees, but were not utilized during the survey. A variety of NIOSH/MSHA certified and noncertified respirators were available to the employees. Only one employee utilized a respirator during the silkscreening operation.

IV. EVALUATION DESIGN AND METHODS

Since silk screen printing operations were identified as presenting the greatest problem of vapor generation, environmental samples were collected during this process. All air samples were collected using battery powered sampling pumps attached via tygon tubing to a charcoal tube collection media. These included:

4 personal samples collected for 15 minutes at 200 cubic centimeters of air per minute (cc/min) to assess short term exposures to toluene,
2 personal samples collected for 180 minutes at 50 cc/min to assess TWA exposures to toluene and other major organic compounds,
2 personal samples were collected for 60 minutes at 1 liter per minute to assess personal exposures to benzene, and
1 bulk sample of the solvent utilized during the clean-up operations to characterize the hydrocarbon content.

The samples were analyzed via gas chromatography/mass spectrometry for identifiable organic compounds present in significant quantities.

To assess the presence of work related health problems, confidential non-directed medical questionnaires were administered to 7 of 9 employees of the sign shop. These included questions on the employees work and medical histories.

V. EVALUATION CRITERIA

A. Environmental Criteria

The environmental criteria described below are intended to represent airborne concentrations of substances to which workers may be exposed

for eight hours a day, 40 hours per week for a working lifetime without adverse health effects. Because of wide variation in individual susceptibility, a small percentage of workers may experience discomfort from some substances at concentrations at or below the recommended criteria.[1] A smaller percentage may be more seriously affected by aggravation of a pre-existing condition or by a hypersensitivity reaction. The time-weighted average (TWA) exposure refers to the average concentration during a normal 8-hour workday. The Short-Term Exposure Limit (STEL) is the maximum allowable concentration, or ceiling, to which workers can be exposed during a specified period of time.

The primary sources of environmental evaluation criteria considered for this study were: 1) NIOSH criteria documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV's),[1] and 3) the U.S. Department of Labor (OSHA) federal occupational health standards.[2] The criteria judged most appropriate for this study are marked with an (*).

Substance	Short Term Exposure Limits	Source	8 - 10 Hour Time Weighted Average	Source
Benzene	1 ppm (60 min)*	NIOSH[3]	10 ppm	OSHA
Toluene	200 ppm (10 min)*	NIOSH[4]	100 ppm*	NIOSH
	300 ppm (10 min)	OSHA	200 ppm	OSHA
Mineral Spirits	1,800 ppm (15 min)*	NIOSH[5]	350 mg/M^3*	NIOSH
Coal Tar Naphtha			100 ppm* (400 mg/M3)	OSHA[2]

NOTE: ppm = parts per million parts of air
mg/M^3 = milligrams per cubic meter of air

B. Toxicity

The adverse health effects from excess exposure (exposures to airborne concentrations above the evaluation criteria) are summarized below:

Benzene - Acute exposure to benzene may cause irritation of the skin and mucous membranes and central nervous system depression. Chronic exposure to benzene may cause aplastic anemia and leukemia. NIOSH recommends that benzene should be considered a human carcinogen and emphasis should not be used as a solvent in open type operations.[3,6]

Toluene - Repeated contact with the skin may lead to removal of the natural lipid barrier, resulting in skin drying and dermatitis. Inhalation may cause central nervous system depression, the symptoms of which can include headache, fatigue, drowsiness, and incoordination. Absorption of toluene through the skin may contribute to the systemic effects.[4,6]

Refined Petroleum Solvents - This group includes petroleum ether, rubber solvent, varnish makers' and painters' naphtha, mineral spirits, Stoddard solvents, and kerosene. Other hydrocarbon solvents, such as

thinners, whose total aromatic hydrocarbon content is over 20%, are not included in this group. Skin contact with these solvents may lead to dermatitis. Inhalation may cause irritation to the eyes, nose, and throat, and central nervous system depression.[5]

Coal Tar Naphtha - Coal tar naphthas are mixtures of aromatic hydrocarbons, principally trimethyl benzenes, toluene, xylene, and cumene; however, benzene is often present in appreciable amounts in those coal tar naphthas with lower boiling points. Due to their higher aromatic hydrocarbon content, coal tar napthas have a higher order of toxicity than those derived from petroluem. Skin contact with napthas may cause skin chapping and photosensitivity. Inhalation may cause irritation of the eyes, nose, and throat, and central nervous system depression.[6,7]

Combined Exposures

Many of the aromatic and aliphatic hydrocarbon solvents exert similar toxicological actions, and can act "additively" to produce irritation, central nervous system depression, and other adverse effects. To assess the combined effect from exposure to more than one solvent, the following equation is used:

$$\left[\frac{C_1}{E_1} + \frac{C_2}{E_2} + \frac{C_n}{E_n} \right]$$

where C_1 indicates the measured atmospheric concentration of compound 1, C_2 the concentration of compound 2, and so forth (C_n), and E_1 the evaluation criteria for compound 1, E_2 the criteria for compound 2, and so forth $[(C_n)/(E_n)]$. Therefore, if the sum of the above fraction exceeds the number 1 (unity), the overall criteria should be considered as being exceeded. The combined exposures were calculated for long-term exposures to toluene, mineral spirits, and coal tar naphtha.

VI. RESULTS AND DISCUSSION

Qualitative analysis of the personal air samples collected during the silk screening process revealed the major contaminant to be toluene, with lesser amounts of various aromatic and aliphatic hydrocarbons falling into the categories of mineral spirits and coal tar naphtha.

Two of the four short term personal samples collected during cleanup operations revealed concentrations of toluene above the NIOSH recommended standard of 200 ppm for a 10 minute ceiling period. The concentrations in these samples were 239 and 213 ppm. Concentrations in the remaining two samples were 115 and 1 ppm, with the lowest value representing a sample collected during which a very short period of time was spent in the vicinity of the operation.

Eight-hour TWA concentrations in personal samples were 34 and 14 ppm for toluene, 43 and 19 mg/M3 for mineral spirits, and 20 and 12

mg/M^3 for coal tar naphtha for the silk screen operator and the helper, respectively. All values were below the recommended evaluation criteria. When the combined exposures were calculated for these employees, the resulting values were 0.5 and 0.2, neither of which exceed unity, thus the overall evaluation criteria was not exceeded.

It should be noted that the 8-hour TWA values were calculated for an operation which lasted only 3 hours. Since the length of time which employees spend on a given silk screening operation may exceed this, a "process TWA" was also calculated. This value was calculated as a time weighted average only for the duration of the operation, and represents what concentration would be expected if the operation had proceeded similarly for the entire 8-hour shift. The process TWA's were 92 and 34 ppm for toluene, 114 and 50 mg/M^3 for mineral spirits, and 54 and 32 mg/M^3 for coal tar naphtha for the silk screen operator and helper respectively. Although these values would not exceed the specific criteria for any individual substances, the combined exposure for the silk screen operator would equal 1.4, which would be considered as exceeding the overall evaluation criteria. A complete listing of the results of the long-term samples and combined exposure calculations is provided in Tables 1 and 2.

Benzene was detectable only at trace levels (less than 0.1% by volume) in the cleaning solvent. Trace amounts of benzene were detected in the personal air samples, but were below the limit of quantitation (less than 4 microgram per sample).

The two primary sources of the employee exposures were the poster paint and the cleaning solvent. A significant amount of the vapor generated during the silk screening process originated from the poster paint through the constant use of the paint on the screen, open cans of paint sitting on the work table, and the drying paint on the prints. The location of the silk screen operator between the exhaust fan and the silk screen operation and the racks of drying prints would further increase his exposure.

Laboratory analysis of the cleaning solvent revealed this to contain 80% toluene and 20% C_6-C_7 alkanes; including cyclohexane, methylhexanes, heptane, and methylcyclohexane. The short term samples indicated that a significant amount of solvent vapors were generated during the 10-15 minute cleanup operation. In addition, the presence of solvent soaked rags in the open disposal container further contributed to the overall airborne concentrations of the vapors. Skin contact with the solvent, especially when washing the screen and the hands, would provide a further source of exposure since skin absorption of solvents can increase their systemic effects upon the body and lead to increased susceptability to dermatitis.

Results of the medical questionnaires revealed no major health problems that would appear to be work related. Individual employees did cite infrequent instances of drowsiness and other symptoms which might be related to incidents of solvent exposure.

VII. RECOMMENDATIONS

In order to reduce exposures to substances used in the silk screening operation, as well as other processes, the following recommendations are made:

A. Work Practices, Materials Handling, and Personal Hygiene

1) Prior to beginning silk screening operations, the work station and drying racks should be set up between the operator and the exhaust fan in order to pull the vapors away from the operators breathing zone.

2) Lids on all containers should be kept closed when not being used to prevent the escape of vapor into the environment.

3) Rags and paper soaked with solvents should be stored in approved waste disposal cans with self-closing lids, and emptied daily.

4) Hands should be cleaned using a waterless hand cleanser and soap and water when possible. Avoid the use of solvents to clean hands.

5) Smoking, eating, and drinking should not be allowed in the area during silk screening or cleanup operations in order to avoid the possibility of fire or inadvertent ingestion of the materials.

6) Solvents should be kept in appropriately labeled containers and stored in fire resistant and well ventilated cabinets.

B. Personal Protection

1) Protective gloves should be worn when using solvents for cleaning screens, brushes, and other items where hand contact is necessary.

2) When pouring or utilizing solvents in such a manner that a potential for splashing occurs, safety goggles should be worn to prevent eye injury.

3) During cleanup operations or other instances when a potential for high exposures exists, the proper respiratory protection should be utilized. NIOSH/MSHA approved respirators with organic vapor cartridges should provide protection against most solvents utilized in these operations.

C. Product Substitution and Engineering Controls

1) The best means of controlling solvent exposure is to substitute a less hazardous solvent. The relative toxicity and fire hazard should be considered when selecting art materials. Solvents containing large percentages of toluene or other aromatic or chlorinated hydrocarbons should be replaced with mineral spirits or other less toxic materials when possible. Solvents containing benzene should not be used. Material safety data sheets should be obtained when available.

2) Local exhaust ventilation provides a means of eliminating contaminants at their point of generation. Installation of a properly designed local exhaust ventilation system would provide an area in which cleanup or other activities which produce noxious or irritating vapors could be conducted.

VIII. REFERENCES

1. American Conference of Governmental Industrial Hygienists. Threshold limit values for chemical substances and physical agents in the workroom environment with intended changes for 1981. Cincinnati, Ohio: ACGIH, 1981.

2. Occupational Safety and Health Administration. OSHA safety and health standards. 29 CFR 1910.1000. Occupational Safety and Health Administration, revised 1980.

3. National Institute for Occupational Safety and Health. Revised recommendation for an occupational exposure standard for benzene, Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1977. (USGPO no. 757-009/8).

4. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to refined petroleum solvents. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1977. (DHEW publication no. (NIOSH) 77-192).

5. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to toluene. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1973. (DHEW publication no. (NIOSH) 73-11023).

6. National Institute for Occupational Safety and Health. Occupational diseases: a guide to their recognition. Revised ed. Cincinnati, OH: National Institute for Occupational Safety and Health, 1977. (DHEW (NIOSH) publication no. 77-181).

7. American Conference of Governmental Industrial Hygienists. Documentation of the threshold limit values. 3rd ed. Cincinnati, Ohio: ACGIH, 1971.

IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

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X. DISTRIBUTION AND AVAILABILITY OF REPORT

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1. United States Post Office, Main Branch, Chicago Illinois
2. NIOSH, Region V
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
RESULTS OF LONG TERM SAMPLES FOR TOLUENE AND MINERAL SPIRITS

Employee Job Title	Sample Time (min)	Concentration Toluene Process TWA*	Concentration Toluene 8-hr TWA	Concentration Mineral Spirits** Process TWA	Concentration Mineral Spirits** 8-hr TWA	Concentration Coal Tar Naphtha*** Process TWA	Concentration Coal Tar Naphtha*** 8-hr TWA
Silk Screener	180	92 ppm	34 ppm	114 mg/M^3	43 mg/M^3	54 mg/M^3	20 mg/M^3
Helper	180	34 ppm	14 ppm	50 mg/M^3	19 mg/M^3	32 mg/M^3	12 mg/M^3

* Process TWA's are calculated to reflect the time weighted average concentration only for the duration of the process (180 minutes). Eight-hour TWA's reflect the total exposure averaged over the entire work day (480 minutes)

**Mineral Spirits represents the sum of the C_6-C_7 hydrocarbon fractions detected by GC/MS analysis, including cyclohexane, heptane, methyl cyclohexane, and a small amount of pinene.

***Coar Tar Naptha represents the sum of all aromatic peaks after toluene detected by GC/MS analysis. This includes a small amount of xylene and a variety of C_3-C_4 alkyl substituted benzenes (trimethylbenzene, tetramethylbenzene, etc.)

TABLE 2
CALCULATION OF COMBINED EXPOSURES

Formula: $\frac{\text{Measured - Toluene}}{\text{Criteria - Toluene}} + \frac{\text{Measured - Mineral Spirits}}{\text{Criteria - Mineral Spirits}} + \frac{\text{Measured - Coal Tar Naphtha}}{\text{Criteria - Coal Tar Naptha}}$

Calculations:

Silk Screener - For Process Duration $\frac{92 \text{ ppm}}{100 \text{ ppm}} + \frac{114 \text{ mg/M3}}{350 \text{ mg/M3}} + \frac{54 \text{ mg/M3}}{400 \text{ mg/M3}} = 1.4$

- For Eight-Hours $\frac{38 \text{ ppm}}{100 \text{ ppm}} + \frac{43 \text{ mg/M3}}{350 \text{ mg/M3}} + \frac{20 \text{ mg/M3}}{400 \text{ mg/M3}} = 0.5$

Helper - For Process Duration $\frac{34 \text{ ppm}}{100 \text{ ppm}} + \frac{50 \text{ mg/M3}}{350 \text{ mg/M3}} + \frac{32 \text{ mg/M3}}{400 \text{ mg/M3}} = 0.6$

- For Eight-Hours $\frac{14 \text{ ppm}}{100 \text{ ppm}} + \frac{19 \text{ mg/M3}}{350 \text{ mg/M3}} + \frac{12 \text{ mg/M3}}{400 \text{ mg/M3}} = 0.2$