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NIOSH INVESTIGATORS:
Anne T. Fidler, Sc.D.
Raymond Ruhe
Bruce Hills

I. SUMMARY

On June 6, 1986, the National Institute for Occupational Safety and Health received a request from employees of the Commonwealth of Kentucky's Department of Transportation, Traffic Division for a health hazard evaluation of workers at the traffic barn in District 11, Manchester, Kentucky. The request concerned possible health hazards of exposure to toluene and lead used in road painting operations.

An initial site-visit was made on October 9, 1986. Environmental and medical surveys were performed on October 21, 1986. Because the air temperature was cool at the time of the this visit, repeat measurements were taken on August 19, 1987. Workers were notified of the results of blood and urine tests, as well as a summary of the industrial hygiene data on January 20 and December 10, 1987. Environmental data were also sent to the Division of Employee Safety and Health of Kentucky.

The survey conducted in October 1986 revealed airborne levels of toluene ranging from 12 to 114 mg/m^3 (6 samples), all below the NIOSH recommended limit for a time-weighted average (TWA) of 375 mg/m^3. Airborne lead levels ranged from non-detectable to 30 ug/m^3, compared with OSHA's Permissible Exposure Limit (PEL) of 50 ug/m^3. Biologic monitoring resulted in levels of indicators of lead absorption (blood lead and free erythrocyte protoporphyrin) that were all within normal limits. There was an increase in urinary hippuric acid, a measure of absorption of toluene, over the workshift among the painters; however, none of the post-shift levels exceeded the recommended limits. Though the air temperature was much higher (96° versus 60°F), most measurements in August 1987 were also quite low. (One worker had a personal air sample of toluene that exceeded the NIOSH recommended limit.) All air lead levels were non-detectable. All urine and blood levels of toluene and lead metabolites were below recommended limits.

An interim report was sent in January 1987 to the Commonwealth of Kentucky and to employees describing the environmental and medical/epidemiologic results of the October 1986 survey. This final report includes the results of both surveys.

Based on the results of this study, NIOSH investigators did not document excessive exposure to toluene or lead in road painting operations among workers of the Manchester, Kentucky District 11 Traffic Division. However, the potential for exposure exists. Therefore, recommendations to minimize workers' exposures to toxic substances are provided in Section VIII of this report.

KEYWORDS: SIC 1721, traffic lane painting, highway maintenance, toluene, lead, neurotoxic symptoms, blood lead, FEP, hippuric acid

II. INTRODUCTION

On June 6, 1986, the National Institute for Occupational Safety and Health received a request from employees of the Commonwealth of Kentucky's Department of Transportation, Traffic Division for a health hazard evaluation of workers at the traffic barn in District 11, Manchester, Kentucky. The request concerned possible health hazards of exposure to toluene and lead used in road painting operations.

An initial site-visit was made on October 9, 1986. A follow-up visit was made on October 21, 1986, at which time an environmental survey was performed, a health questionnaire was administered, and blood and urine samples were collected for assessment of lead and metabolites of toluene. An interim report of environmental and medical/epidemiologic results was sent to the Kentucky Division of Employee Safety and Health and to District 11 workers in January 1987. Because the air temperature was cool at the time of the the October visit, repeat environmental and medical measurements were taken on August 19, 1987, when weather conditions would be more representative of summer months when most road painting is done. On January 20, 1987 and December 10, 1987, a letter was sent to each participant in the study to notify him of his blood and urine test results, as well as a summary of the industrial hygiene monitoring data. The environmental data were also sent at those times to the Division of Employee Safety and Health.

III. BACKGROUND

Workers at the traffic barn in Manchester perform highway maintenance operations for Kentucky's District 11. Workers are responsible for spray painting roadways, as well as posting and maintaining road signs.

Painting is done primarily during the months of April through October. The yellow and white paints used are lead-based and the solvent used in the operations is toluene (methyl benzene). There are two types of painting operations: road striping, performed on the "big striper," and painting of roadside curbs and traffic islands, using the "little striper." A crew of six to eight men operates the big machine (drivers of striper, lead truck, and back-up truck; traffic director, and spray paint operators). Paint flows from a 55-gallon drum on the striper to a spray gun located at the rear of the machine. There are three supply lines located at that point: the paint line, the anti-freeze line (heats the paints to approximately 200° F.), and a supply line for crushed glass, which is sprayed directly after the paint (to make the paint reflective). Toluene exposure for these workers occurs primarily during cleaning and maintenance operations. The striper breaks down with relatively high frequency. On such occasions, the spray apparatus is dismantled and the parts are cleaned with toluene. The usual procedure involves washing the parts by hand in an open bucket of toluene. Until recently, this was done without gloves, or any other personal protective equipment.

The little striper, with a crew of three, contains a ten-gallon tank connected to a hand-held spray line, used for painting small areas. One worker is responsible for filling the tank and driving, one sprays the paint, and one spreads crushed glass by hand over the freshly painted areas. The tank is filled several times a day by diluting the paint with toluene and stirring the mixture by hand (9 gallons paint to 1 gallon toluene). During this mixing operation, which takes approximately 15 minutes, there is potential for exposure to very high concentrations of both lead-based paint and toluene vapors, especially on hot days during the summer months.

IV. EVALUATION DESIGN AND METHODS

NIOSH investigators visited the Manchester, Kentucky highway maintenance traffic barn on October 21, 1986 to evaluate environmental exposures to toluene and lead, and to assess health effects of these possible exposures. The weather at the time of testing was cool (60° Fahrenheit) and clear. Eighteen workers were employed and available for testing at the time of the study. All but one agreed to participate. (Two participants refused the blood test.) In addition, one retired worker was included in the evaluation. The total of 18 subjects consisted of nine full-time road painters, six sign hangers, one timekeeper, one supervisor, and one retiree. Most of the sign hangers participate occasionally in painting operations; however, none painted during the week of the study. The timekeeper, supervisor, and retiree have not been exposed routinely for several years.

Because the air temperature at the time of the October visit was cool, and, therefore not representative of work during the summer, a second survey was performed on August 19, 1987, at which time environmental and medical data were collected in the same manner as in the October 1986 survey. During this follow-up survey the 2:00 pm air temperature was 96ºF and the temperature of the street surfaces were well in excess of 100ºF. Since the vapor pressure of toluene is three times higher at 100-110ºF than at 60ºF, this survey was conducted to monitor the potentially higher toluene exposures on a very warm day.

Of the total of 15 workers working on that day, 12 agreed to participate. This included 6 painters, 3 sign hangers, and 3 other employees. The painting process was identical to the painting performed during the first survey. The employees did not wear gloves or a respirator during the workshift. Their clothing worn to and from work consisted of shoes, jeans, and short sleeve shirts.

Environmental

On October 21, 1986, six personal breathing-zone air samples for toluene were collected on 150 mg. activated charcoal sorbent tubes, using vacuum pumps operated at flow rates ranging from 0.05 to 1.0 liters per minute (LPM). Members of the crews of both the "big" painter and the "little" painter were sampled. In August 1987, fifteen personal breathing-zone air samples for toluene were collected from both crews on at a flow rate of 200 cubic centimeters per minute. Samples were analyzed according to NIOSH Method 1501[1] with modifications.

Nine personal breathing-zone samples were collected to evaluate worker exposure to lead in October; ten were collected in August). The samples were collected on mixed cellulose ester filters using battery-powered sampling pumps operated at 2.0 liters per minute (LPM). Analysis was by atomic absorption spectroscopy according to NIOSH Method 7082.[1]

A bulk sample of the toluene collected in October 1986 was analyzed for possible benzene contamination.

Medical/Epidemiologic

Biologic monitoring of workers was performed to assess the body's absorption of lead and toluene. Urine samples were collected at the beginning of the workshift and again at the end of the day, for determination of levels of a metabolite of toluene, urinary hippuric acid (corrected for creatinine level). Blood samples were obtained at the beginning of the workshift for determination of blood lead and free erythrocyte protoporphyrin (FEP), an indicator of long-term exposure to lead. Analyses of urine were performed by the Biological Monitoring Research Section of the Division of Biomedical and Behavioral Science of NIOSH. Blood samples were analyzed at ESA Laboratories in Bedford, Massachusetts.

A brief questionnaire was administered to each worker to ascertain information regarding demographics, job and medical history, and symptoms possibly related to exposure to lead and toluene. The symptom questionnaire is a modification of the "Swedish 16" neurotoxic questionnaire[2] and has been used in a number of other studies.[3] Each symptom was scored on a 4-point scale: "not at all" (score=0), "a little" (score=2), "moderately" (score=3), and "quite a bit" (score=4). The symptoms were combined into eight symptom clusters, based largely on previous factor analyses[3] and biologic plausibility. The clusters related to symptoms of memory loss, gastrointestinal disturbances, neurasthenic symptoms (fatigue, irritability, depression), alcohol-related symptoms, cognitive problems (confusion, difficulty concentrating), peripheral nerve dysfunction, and chest and respiratory symptoms. Each cluster score ranged from 0 to 4 (average score for each symptom in the cluster).

Most analyses of exposure effects compare the results of exposed (painters) and unexposed (sign hangers). Though a number of workers participated in both surveys (October and August), several participated in only one. Therefore, no analyses were performed assessing change in individuals between surveys. Statistical analyses were performed using SPSS/PC for the PC.[4]

V. EVALUATION CRITERIA

A. Environmental Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of airborne exposure to which most workers can 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 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 level set by the evaluation criterion. These combined effects are often not considered in the evaluation criterion. 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 workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor (OSHA) occupational health standards. The OSHA standards may be required to take into account the feasibility of controlling exposures in various industries where the agents are used, whereas the NIOSH recommended exposure limits are based primarily on concerns relating to the prevention of occupational disease. In reviewing the exposure levels found in this report, it should be noted that the Commonwealth of Kentucky Department of Transportation is required by the Occupational Safety and Health Act of 1970 to meet those levels specified by OSHA standards.

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 or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures. A summary of the evaluation criteria for the exposures of concern is presented in Table 1.

B. Toluene[5,6]

Toluene (methyl benzene) is a clear aromatic organic solvent. Inhalation is the primary route of entry into the body, with 40-60% of the inhaled amount absorbed. Significant amounts of toluene may also be absorbed through the skin if there is contact with the liquid form.[7]

Toluene can cause acute irritation of the eyes, respiratory tract, and skin. Because it is an excellent fat solvent, repeated or prolonged exposure can cause drying, fissuring, and dermatitis. A number of blood disorders linked to toluene exposure are thought to be due to exposure to benzene, which is generally present as a contaminant in commercial toluene.[8,9]

The main health effects associated with exposure to toluene are its narcotic and neurotoxic properties. High concentrations (generally above 375 mg/m^3 (200 ppm)) can cause dizziness, drowsiness, headache, nausea and vomiting, and unconsciousness.[9] There are a number of reports of neurologic damage due to deliberate sniffing of toluene-based glues at very high concentrations, resulting in motor weakness, intention tremor, ataxia, and cerebral atrophy. Recovery is usually complete; however, permanent impairment may occur after prolonged glue-sniffing.[10-12]

The NIOSH Recommended Exposure Limit (REL) for toluene is 100 ppm (375 mg/m^3) determined as a time-weighted average (TWA) exposure for an 8-hour workday with a ceiling of 200 ppm for a 10-minute sampling period. OSHA's Permissible Exposure Limit (PEL), the legal standard, is 200 ppm (750 mg/m^3) as a TWA.

Toluene is metabolized in the liver by conversion to benzoic acid, which then conjugates with glycine to form hippuric acid. Hippuric acid is excreted in the urine. This compound is a normal constituent of urine, as a result of a variety of foods containing benzoic acid or benzoates, including canned or bottled drinks and many preserved foods. Urinary hippuric acid levels in individuals not exposed to toluene range from 0.4 to 1.5 g/g creatinine.[13,14] (It is recommended that urinary hippuric acid levels be related to the excretion of creatinine, in order to minimize distortions by variations in the amount of urine produced.)

Hippuric acid levels have been shown to increase in a linear relationship with increasing exposure to toluene, even at low levels.[13-15] Baselt[13] reports that industrial workers exposed to 50 ppm soon developed urine hippuric acid levels with a range of 1.26 to 2.93 g/l. In workers exposed to 200 ppm (OSHA's PEL), the end-of-shift level ranges from 4.12 to 8.65 g/l. Lauwerys[14] suggests that workers exposed to 100 ppm (NIOSH's REL) would produce urinary hippuric acid concentrations with a mean of 2.0 g/l (2.35 g/g creatinine). NIOSH[5] recommends that an end-of-shift level of more than 5 g/l is unacceptable and indicative of toluene exposure at an average of 200 ppm.

C. Inorganic Lead[16]

Occupational exposure to lead occurs primarily by inhalation, and to a lesser extent by ingestion (contamination of hands, food, and smoking materials). The OSHA standard for inorganic lead limits exposure to an eight-hour TWA of 50 micrograms per cubic meter (ug/m^3).[17]

Lead accumulates in the body, primarily in the bones, and is excreted slowly. Inorganic lead poisoning is a chronic process, although symptoms may develop suddenly after sufficient exposure. Manifestations of inorganic lead toxicity in adults include decreased appetite, weight loss, nausea, constipation, and abdominal cramps; fatigue, insomnia, memory impairment, and irritability; headache, muscle pain, and joint pain; pallor; anemia; impaired kidney function; increased blood pressure; and impaired nerve function, resulting in muscle weakness, notably in the muscles that extend the wrists and ankles. It has long been known that women exposed to high lead levels have an increased risk of miscarriage and stillbirth. There is some evidence that lead can impair fertility in occupationally exposed men.[18]

The blood lead test is one measure of the amount of lead in the body and is the best available measure of recent lead absorption. Adults not exposed to lead at work usually have a blood lead concentration less than 30 ug/dl; the average is less than 15 ug/dl.[19,20] Blood lead levels higher than 30 ug/dl may have harmful effects on the mental development of young children. The Centers for Disease Control (CDC) now considers a blood lead concentration of 25 ug/dl or more in a young child to be "elevated."[21] For purposes of compliance with the OSHA lead standard, a blood lead concentration averaging 50 ug/dl or more represents excessive lead exposure, and the affected employee must be removed from further lead exposure until the blood lead concentration is below 40 ug/dl. (The standard protects the earnings, seniority, and other benefits of employees who, because of excessive lead exposure, are removed from jobs involving lead exposure.) A World Health Organization (WHO) study group recommended (in 1980) that blood lead concentrations not exceed 30 ug/dl in occupationally exposed women of childbearing age and not exceed 40 ug/dl in other workers.[22]

One of the earliest adverse health effects of lead is interference with the production of hemoglobin, the oxygen-carrying molecule in red blood cells. One of the steps in hemoglobin synthesis that is blocked by lead causes free erythrocyte protoporphyrin (FEP) to accumulate in red blood cells before they are released from the bone marrow (where they are made) into the blood. Red blood cells containing elevated amounts of FEP can still be circulating three to four months after exposure; therefore, it may be a good indicator of long-term effects of lead. However, FEP is not a good measure of low-level exposure to lead. The FEP level starts to increase significantly at blood lead levels of about 35 ug/dl in males and 25 ug/dl in females.[23] In addition, other conditions, particularly iron deficiency, can affect protoporphyrin metabolism, resulting in an elevated FEP level in persons with no occupational exposure to lead.

OSHA's Permissible Exposure Limit (PEL) for airborne lead is 50 ug/m^3 over an 8-hour day. In addition, the lead standard[16] establishes an "action level" of 30 ug/m^3 (TWA) which initiates several requirements of the standard, including periodic exposure monitoring, medical surveillance, and training and education. For example, if an employer's initial determination shows that <u>any</u> employee may be exposed to over 30 ug/m^3 (and under the PEL), air monitoring must be performed every six months until the results show two consecutive levels of less than 30 ug/m^3 (measured at least seven days apart).

D. Chromates

The Yellow Traffic Safety Paint No. 12Y-D177 (manufactured by DeSantic Coatings) used by the Traffic Division contains chromates of lead. The International Agency for Research on Cancer (IARC) has concluded that there is sufficient evidence of the carcinogenicity of chromium and certain chromium compounds both in humans and experimental animals.[24] Workers in the chromate-producing, chromium alloy, and chromium plating industries have an increased incidence of lung cancer. There is also a suggestion of increased cancer incidence at other sites.[25,26] Likewise, the National Toxicology Program has classified chromium and certain chromium compounds as known carcinogens.[27]

OSHA has adopted a PEL of 0.1 milligrams per cubic meter of air (mg/m^3) for chromic acid and chromates. The NIOSH REL for carcinogenic hexavalent chromium compounds is 1 microgram per cubic meter (ug/m^3) and 25 ug/m^3 for noncarcinogenic hexavalent chromium compounds as a 10-hour TWA, and 50 ug/m^3 sampled over 15 minutes as the ceiling level. As a conservative approach to the assessment of lead chromates in the environment, the OSHA standard for exposure to lead is used in this investigation, as it is lower than the standard for exposure to lead chromate.

VI. <u>RESULTS</u>

The 18 workers evaluated were all males with a mean age of 39.1 ($\pm$ 11.5). The painters were older (39.4 $\pm$ 7.3) than the sign hangers (32.2 $\pm$ 11.7). The three "others" (timekeeper, supervisor, retiree) had a mean age of 51.7 ($\pm$ 13.4). The 15 workers employed at the time of the second survey were of similar age distributions. Because of differences in their jobs and demographics, these last three individuals are considered separately in this report. Most group comparisons are made between painters and sign hangers.

<u>Environmental</u>

Results of the environmental samples for toluene collected in October 1986 are presented in Table 2. Airborne concentrations of toluene for six personal samples range from 12 to 114 milligrams per cubic meter (mg/m^3). All samples were below the NIOSH recommended TWA (375 mg/m^3) and 10-minute ceiling (750 mg/m^3). The highest exposure, 114 mg/m^3, was measured during the operation in which the spray equipment of the little striper was cleaned.

Results of the environmental samples, collected on August 19, 1987, for toluene are presented in Table 3. The 8-hour time-weighted average exposures to toluene for the three workers operating the "little striper" ranged from 4.0 to 9.5 (mg/m^3). The worker who did the spraying had a short term exposure (187 minutes) of 24.3 mg/m^3. Most of his time was spent in preparation for painting rather than actual painting. Painting consisted of roadside curbs and traffic arrows.

The crew of five workers who operated the "big striper" had an 8-hour time-weighted average exposures ranging from 2.1 to 469 mg/m^3. The personal sample from the Heavy Equipment Operator 1 contained toluene in excess of the collection capacity of the collection media. His 8-hour time-weighted average exposure to toluene of 469 mg/m^3 is in excess of the NIOSH recommended exposure limit of 375 mg/m^3.

Table 4 presents the results of the environmental samples for inorganic lead collected in the first survey in October 1986. Airborne concentrations of lead range from less than detectable (2 ug/sample) to 30 ug/m^3. The two samples with detectable levels of lead were both below OSHA's 8-hour TWA Permissible Exposure Limit (PEL) of 50 ug/m^3. Both of these personal samples were from painters on the little striper (painter with hand-held spray line and worker who spreads crushed glass). Other workers sampled, including three members of the crew of the big striper, the foreman, and the other crew from the little striper, yielded personal samples with no detectable lead levels.

Of the eight employees monitored for exposure to airborne lead in August 1987, all had personal samples below the limit of detection (0.5 micrograms per sample) for the sampling-analytical method.

Medical/Epidemiologic

The results of the biologic monitoring performed in October 1986 are presented in Table 5. The blood lead levels of the 16 workers tested are low, ranging from 6 to 14 ug/dl. There is no difference on the levels experienced by painters and sign hangers (p=.82; Mann-Whitney rank sum test). Similarly, free erythrocyte protoporphyrin (FEP) levels were all within acceptable limits (range: 9-41 ug/dl) with no difference across job categories. There was no correlation between blood lead and FEP levels (r = -.01). At the low levels of blood lead observed in this group, this lack of association with FEP is not surprising.

The pre-shift urinary hippuric acid (HA) levels were low, with a range of 0.05 to 0.64 g/g creatinine, excluding the value of 4.25, measured in a subject believed to be taking the prescription drug methenamine. This medication used in the treatment of prostatic disease is known to elevate urinary HA levels. There was no difference in pre-shift HA levels between painters and sign hangers (p=.21; Mann-Whitney rank sum test). The post-shift levels were, overall, higher than pre-shift levels. The post-shift HA levels were higher among the painters than sign hangers (p=.06). The change in HA (post-shift minus pre-shift) was higher among painters (0.14 g/g creat.) than the sign hangers (0.02 g/g creat.); however, the difference was not statistically significant (p=.51). One individual had a post-shift HA level of 1.26 g/g creat. (acceptable lower limit = 1.5 g/g creat.). It is quite probable that during hot months when the exposure is higher, this individual's post-shift HA level may exceed the recommended level. This individual was observed to have the highest potential exposure at the time of the study. His job was to dilute and mix the paint used on the little striper. In addition to substantial inhalation exposure, during clean-up from this procedure, his usual practice is to wash his hands in toluene.

Table 6 presents the results of biologic monitoring performed in August 1987. Despite the high temperatures, and therefore, the presumed higher levels of exposure than in the previous survey, there were essentially no differences in the blood lead, FEP, or urinary hippuric acid levels. All lead and FEP levels were quite low and well within normal limits. As seen in the first survey, the change in HA (post-shift minus pre-shift) was higher among painters (0.16 g/g creat.) than the sign hangers (0.03 g/g creat.). This difference was not statistically significant (p=.57).

For analysis of the prevalences of the 35 individual symptoms assessed in the questionnaire, the categories "not at all" and "a little" were combined, as were "moderately" and "quite a lot." In the October survey, the prevalences of symptoms reported as occurring "moderately" or "quite a lot" among the 18 subjects ranged from 6 to 67% (mean=34%). The rate of positive responses to these symptoms appeared quite high. To evaluate the influence of a reporting bias, the results from this group were compared with those of two other studies of solvent-exposed populations in which the same questionnaire was administered. A group of 101 painters had a mean prevalence of symptoms of 6.8% (range: 0 to 22%).[3] In another study[28], 39 printers reported a mean prevalence of 14.8% (range: 0 to 41%).

There was no difference in the reported prevalence of individual symptoms between painters and sign hangers, except dry skin (Relative Risk (RR) = 4.7; p=.03, Fisher's exact) and numb fingers (RR = 7.7; p=.04), the latter due most probably to dry skin.

The scores of the symptom clusters of painters and sign hangers from the October survey were compared and the results are reported in Table 7. In all cases, the mean scores were higher among the painters, although only for the cluster relating to "peripheral nerve symptoms" was this difference significant (p=.04, Student's t test). However, this difference is due largely to the influence of "numb fingers" which, as stated previously, is more likely due to dry skin than peripheral neuropathy.

Table 8 presents results of the comparison of symptom cluster scores between painters and sign hangers performed from the August survey questionnaires. As with the October survey, the mean scores are slightly higher among the painters than the sign hangers. This difference is significant for chest symptoms (p=.05) and peripheral nervous system symptoms (p=.09). Again, this is due in large part to the symptom of "numb fingers," probably a reflection of dry skin.

VII. DISCUSSION AND CONCLUSIONS

The results of both the environmental sampling and the biologic monitoring of the workers at the Manchester, Kentucky Highway Maintenance Department indicate that high exposure to toluene and lead did not occur at the time of either survey. There are two exceptions to this. In October, there was relatively high toluene exposure to the worker whose job entailed diluting paint for use on the little striper. However, there are a number of other individual tasks as described by the workers, primarily in clean-up and maintenance procedures, which could result in considerable exposure, particularly to toluene.

There was one elevated personal air sample to toluene observed in August. Since it was anticipated that the "little striper" crew had the greatest potential for exposure to toluene, the NIOSH investigators spent nearly all of their time observing this crew. Meanwhile, the crew of the "big striper" painted approximately 30 miles of highway. The tasks performed by each worker on the "big striper" are uncertain, because of some rotation of job duties. Added to the uncertainty of tasks performed by each worker and his exposure was a mix-up of sampling equipment. At noon the workers removed their sampling equipment. It was discovered by mid-afternoon that several workers had mistakenly donned the wrong equipment. The personal sample from one of the "big striper" workers is in excess of the NIOSH recommended exposure limit. However, the source of his exposure cannot be identified. It should be noted that, as a conservative approach to the assessment of lead chromates in the environment, the OSHA standard for exposure to lead is used in this investigation, as it is lower than the standard for exposure to lead chromate.

A high reporting of neurotoxic and dermatologic symptoms was found across the study group. Except for skin-related symptoms and respiratory symptoms in August, there were no significant differences in the occurrence of symptoms among the exposed painters and the unexposed sign hangers. There was, however, a consistent trend toward more symptom reporting among the painters.

Because there was concern that exposures at the time of the initial survey in October 1986 were not representative of the true exposures during hot summer months, retesting was performed in August 1987, when afternoon temperatures reached 96° F. However, there were no real differences in ambient air exposure, biologic monitoring results, or symptom reports between the first and second surveys, despite a difference in temperature of 36 degrees. Although the employees' exposure to toluene was well below the NIOSH recommended exposure limit (except for one) on the days surveyed, factors such as weather conditions, employee work practices, and the volume of paint used can effect toluene exposure levels.

VIII. RECOMMENDATIONS

The following recommendations contained in the Interim Report No. 1, and restated below, should be followed.

1. Because the paint used in the "little striper" must be diluted with toluene before use, a high exposure potential to both toluene and lead exists at the time of the mixing operation. It is recommended that paint with a higher toluene content be ordered from the supplier for use by that machine, rather than ordering the same paint for both stripers. Eliminating the need for that step during the painting operation would substantially decrease the potential solvent exposure.

2. An educational program should be instituted so that employees are made aware of potential hazards associated with the materials used at Manchester, Kentucky Highway Maintenance Department, as well as the other districts in Kentucky which perform road painting operations.

3. All containers of solvent and paints should be properly labeled.

4. Good personal hygiene and good work practices should be observed by all employees; washing of hands before smoking, eating, and drinking will help reduce contamination.

5. During the pouring of liquid toluene, gloves will help to prevent skin contact with the toluene. In situations where the hands may be occasionally splashed with toluene, any liquid proof glove will be sufficient. However, if the gloves are in frequent contact with toluene, then a glove made of polyvinyl alcohol should be used. To reduce the amount of paint that adheres to the skin of the hands and forearms, an extra thick coat of vaseline may be applied to the skin before mixing operations. This, followed by use of a waterless hand cleaner, may eliminate the use of toluene as a cleaning agent.

6. During the course of a working day, a great deal of toluene and paint is splashed on workers' clothes, often making them quite damp by the end of a shift. Therefore, it is recommended that protective clothing (cover-alls) be provided at the worksite, so that workers can change clothes before leaving at the end of the day.

7. Until further environmental controls are implemented or existing ones improved, a conscientious respirator program should be initiated. A NIOSH document, "A Guide to Industrial Respiratory Protection"[30] will serve as a reference source with information for establishing and maintaining a respirator program which meets the requirements of 29 CFR Part 1910.134. A NIOSH-approved organic vapor respirator should be used for toluene by painters, especially during mixing, clean-up, and maintenance operations.

8. Respirators should be issued with caution. There may be individuals in this group for whom wearing a respirator carries certain specific dangers, e.g., highly increased resistance to airflow in a person with compromised pulmonary function may be associated with acute respiratory insufficiency. Therefore, any person who needs to wear a respirator should have a medical examination, including pulmonary function testing.[31]

9. Environmental and medical monitoring should be performed in accordance with OSHA's lead standard.[17]

IX. REFERENCES

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X. AUTHORSHIP AND ACKNOWLEDGEMENTS

Project Officer:	Anne T. Fidler, Sc.D. Supervisory Epidemiologist Medical Section
Medical Officer:	Thomas Laubli, M.D. Guest Researcher Medical Section
Industrial Hygienist:	Raymond Ruhe Industrial Hygienist Industrial Hygiene Section Bruce Hills Industrial Hygienist Industrial Hygiene Section Hazard Evaluations and Technical Assistance Branch Division of Surveillance, Hazard Evaluations, and Field Studies
Laboratory Analyses:	W. Anthony Smallwood Chemist Division of Biomedical and Behavioral Science

XI. DISTRIBUTION AND AVAILABILITY

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Publications Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, 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. Kentucky Department of Transportation (DOT), Traffic Division, Frankfort, Kentucky
2. Kentucky DOT, Traffic Division, District 11, Manchester, Kentucky
3. NIOSH Region IV
4. OSHA Regional Administrator, Region IV

TABLE 1

HETA 86-428
District 11, Traffic Division
Department of Transportation
Commonwealth of Kentucky
Manchester, Kentucky

October 1986; August 1987

Evaluation Criteria

EVALUATION CRITERIA
(Time-Weighted Average)

SUBSTANCE	NIOSH	OSHA	ACGIH	PRIMARY HEALTH EFFECTS
Toluene	100 ppm	200 ppm	100 ppm	Toluene can cause fissure dermatitis and irritation of the respiratory tract, eyes, and skin. Acute exposure can result in central nervous system depression. Symptoms include headache, dizziness, fatigue, incoordination.
Lead	<100 ug/m^3	50 ug/m^3	150 ug/m^3	Early symptoms include fatigue, sleep disturbance, headache, gastrointestinal symptoms, abdominal pains. Lead can also result in anemia, kidney damage, and adverse reproductive effects. Peripheral and central nervous system damage can occur.
Lead Chromate	0.1 mg/m^3	1 ug/m^3		Chromates have been associated with ulceration of the skin and nasal mucosa, and perforation of the nasal septum. Some chromium (VI) compounds, including lead chromate, have been associated with an increased incidence of lung cancer.

TABLE 2

HETA 86-428
District 11, Traffic Division
Department of Transportation
Commonwealth of Kentucky
Manchester, Kentucky

<u>Survey I: October 1986</u>

Airborne Concentrations of Toluene
Personal Samples

JOB	SAMPLE TIME	SAMPLE VOLUME (liters)	TOLUENE CONCENTRATION (mg/m^3)
Heavy Equipment Operator	1148-1420	31.6	12
Heavy Equipment Operator	1155-1438	33.8	36
Light Equipment Operator	1219-1410	25.1	80
Light Equipment Operator	1217-1414	22.0	24
Light Equipment Operator	1215-1412	23.3	28
Operator Cleaning Spray Equipment	1410-1424	28.0	114
OSHA Permissible Exposure Limit (mg/m^3)			750
NIOSH Recommended Exposure Limit (mg/^{3})			375
NIOSH Ceiling Limit (10-minutes)			750
Limit of Detection (ug/sample)			0.01

* mg/m^3 = milligrams of toluene per cubic meter of air sampled

TABLE 3

HETA 86-428
District 11, Traffic Division
Department of Transportation
Commonwealth of Kentucky
Manchester, Kentucky

<u>Survey I: October 1986</u>

Airborne Concentrations of Inorganic Lead
Personal Samples

JOB	SAMPLE TIME	SAMPLE VOLUME (liters)	LEAD CONCENTRATION (ug/m^3)
Heavy Equipment Operator	1148-1420	304	LD **
Heavy Equipment Operator	1155-1438	326	LD
Heavy Equipment Operator	1149-1440	342	LD
Foreman	1150-1415	290	LD
Light Equipment Operator	1152-1441	338	LD
Light Equipment Operator	1145-1440	350	LD
Light Equipment Operator	1219-1410	222	LD
Light Equipment Operator	1217-1414	234	30
Light Equipment Operator	1215-1412	234	21
OSHA 8-Hour TWA PEL (ug/m^3)			50
Limit of Detection (ug/sample)			2

* ug/m^3 = micrograms of lead per cubic meter of air sampled
** LD = less than detectable limits

TABLE 4

HETA 86-428
District 11, Traffic Division
Department of Transportation
Commonwealth of Kentucky
Manchester, Kentucky

<u>Survey II: August 1987</u>

Airborne Concentrations of Toluene
Personal Samples

Job Title	Sample Time	Toluene Actual	Concentration mg/m^3 8-hour TWA
Light Equipment Operator 1			
(mixed the paint)	912-1015	8.7	
(applied crushed glass)	1230-1540	8.4	4.5
Light Equipment Operator 2			
(set up the equipment)	912-1015	ND	
(paint spraying)	1230-1537	24.3	9.5
Light Equipment Operator 3			
(drove the little striper)	912-1015	6.3	
(drove the little striper)	1230-1536	8.1	4.0
Heavy Equipment Operator 1	1000-1300	1250*	469*
Heavy Equipment Operator 2	1000-1300	4.7	
(paint spraying)	1313-1336	260	14.3
Heavy Equipment Operator 3			
(paint spraying)	1000-1300	4.9	
(paint spraying)	1313-1514	3.8	3.6
Heavy Equipment Operator 4	1000-1445	5.8	
(drove back-up truck)	1313-1336	93	7.9
Heavy Equipment Operator 5			
(paint spraying)	1000-1230	ND	
(drove the big striper)	1338-1513	10.5	2.1

TWA = time-weighted average
ND = non-detectable
* = toluene level was in excess of the collection capacity of the collection media, therefore the validity of this sample is questionable.
Limit of Detection = 0.01 mg/sample
Limit of Quantitation = 0.03 mg/sample

TABLE 5

HETA 86-428
District 11, Traffic Division
Department of Transportation
Commonwealth of Kentucky
Manchester, Kentucky

Survey I: October 1986

Biologic Monitoring Results by Job

	Number of workers	Median Value (Range)	p Value *
Blood Lead (ug/dl)			
Painters	8	9 (6 - 14)	.82
Sign Hangers	5	10 (7 - 10)	
Others **	3	6 (6 - 11)	
TOTAL	16	9 (6 - 14)	
Free Erythrocyte Protoporphyrin (FEP) (ug/dl)			
Painters	8	14.5 (9 - 41)	.41
Sign Hangers	5	15 (12 - 26)	
Others	3	13 (10 - 14)	
TOTAL	16	14.5 (9 - 41)	
Urinary Hippuric Acid (g/g creatinine)			
Pre-shift			
Painters	9	.35 (.07 - .64)	.21
Sign Hangers	6	.20 (.05 - .39)	
Others	2 ***	.12 (.10 - .13)	
TOTAL	17	.26 (.05 - .64)***	
Post-shift			
Painters	9	.39 (.17 - 1.26)	.06
Sign Hangers	6	.21 (.08 - .68)	
Others	2	.34 (.30 - .39)	
TOTAL	17	.31 (.08 - 1.26)	
Change (post - pre)			
Painters	9	.14 (-.26 - .79)	.59
Sign Hangers	6	.02 (-.18 - .29)	
Others	2	.23 (.20 - .26)	
TOTAL	17	.05 (-.26 - .79)	

* Comparison of painters and sign hangers: Mann-Whitney Rank Sum Test

** Includes persons who were neither painters nor sign hangers. They were essentially unexposed to toluene and lead.

*** Excludes one subject with a urinary hippuric acid level of 4.25, most probably due to the action of a prescription drug.

TABLE 6
HETA 86-428
District 11, Traffic Division
Department of Transportation
Commonwealth of Kentucky
Manchester, Kentucky

Survey II: August 1987

Biologic Monitoring Results by Job

	Number of workers	Median Value (Range)	p Value *
Blood Lead (ug/dl)			
Painters	6	8 (3 - 8)	.26
Sign Hangers	3	2 (0 - 8)	
Others **	3	6 (5 - 6)	
TOTAL	12	6 (0 - 8)	
Free Erythrocyte Protoporphyrin (FEP) (ug/dl)			
Painters	6	22.5 (3 - 54)	.71
Sign Hangers	3	10 (12 - 32)	
Others	3	38 (10 - 49)	
TOTAL	12	25 (9 - 54)	
Urinary Hippuric Acid (g/g creatinine)			
Pre-shift			
Painters	6	.22 (.16 - .30)	.39
Sign Hangers	6	.05 (.04 - .52)	
Others	2	.44 (.40 - .49)	
TOTAL	14	.22 (.04 - .52)	
Post-shift			
Painters	5	.43 (.22 - .70)	.57
Sign Hangers	3	.07 (.07 - .81)	
Others	3	.41 (.30 - .44)	
TOTAL	11	.41 (.07 - .81)	
Change (post - pre)			
Painters	5	.16 (.05 - .40)	.57
Sign Hangers	3	.03 (.01 - .76)	
Others	2	-.23 (-.19 - .04)	
TOTAL	10	.09 (-.19 - .76)	

* Comparison of painters and sign hangers: Mann-Whitney Rank Sum Test

** Includes persons who were neither painters nor sign hangers. They were essentially unexposed to toluene and lead.

TABLE 7
HETA 86-428
District 11, Traffic Division
Department of Transportation
Commonwealth of Kentucky
Manchester, Kentucky

Survey I: October 1986

Comparison of Painters and Sign Hangers
Symptom Scores (Mean (S.D.))

	Painters (N=9)	Sign Hangers (N=6)	t-test (p value)
Memory Symptoms[a]	2.3 (1.1)	1.7 (1.3)	.56
G.I. Symptoms[b]	1.8 (0.9)	1.4 (0.8)	.39
Alcohol-Related[c] Symptoms	1.3 (0.8)	0.7 (0.6)	.14
Neurasthenic[d] Symptoms	2.2 (0.6)	2.0 (1.0)	.55
Cognitive[e] Symptoms	1.8 (1.2)	1.2 (0.9)	.31
Skin Symptoms[f]	2.4 (1.7)	1.4 (1.6)	.26
Chest Symptoms[g]	2.2 (0.9)	1.5 (0.9)	.15
Peripheral Nerve[h] Symptoms	2.1 (1.2)	0.9 (0.8)	.04

a. trouble remembering, relatives notice trouble remembering, have to make notes
b. loss of appetite, weight loss, diarrhea, indigestion, nausea, cramps, constipation
c. trouble driving home, decreased tolerance to alcohol, "high" from chemicals
d. tired, weak, depressed, irritable, dizzy, trouble sleeping, trouble falling asleep
e. trouble concentrating, confused
f. dry skin, rash
g. short of breath, cough, chest pain, heart palpitations, increased perspiration
h. decreased arm strength, decreased leg strength, numb fingers, numb toes, incoordination

TABLE 8

HETA 86-428
District 11, Traffic Division
Department of Transportation
Commonwealth of Kentucky
Manchester, Kentucky

Survey II: August 1987

Comparison of Painters and Sign Hangers
Symptom Scores (Mean (S.D.))

	Painters (N=6)	Sign Hangers (N=6)	t-test (p value)
Memory Symptoms[a]	2.3 (1.1)	2.1 (1.2)	.74
G.I. Symptoms[b]	2.0 (0.8)	1.5 (0.5)	.25
Alcohol-Related[c] Symptoms	1.6 (0.6)	1.3 (0.4)	.36
Neurasthenic[d] Symptoms	2.0 (0.4)	1.6 (0.7)	.30
Cognitive[e] Symptoms	1.8 (0.7)	1.8 (1.0)	.99
Skin Symptoms[f]	2.0 (1.1)	1.3 (0.5)	.18
Chest Symptoms[g]	2.1 (0.6)	1.4 (0.6)	.05
Peripheral Nerve[h] Symptoms	2.0 (0.5)	1.4 (0.6)	.09

a. trouble remembering, relatives notice trouble remembering, have to make notes
b. loss of appetite, weight loss, diarrhea, indigestion, nausea, cramps, constipation
c. trouble driving home, decreased tolerance to alcohol, "high" from chemicals
d. tired, weak, depressed, irritable, dizzy, trouble sleeping, trouble falling asleep
e. trouble concentrating, confused
f. dry skin, rash
g. short of breath, cough, chest pain, heart palpitations, increased perspiration
h. decreased arm strength, decreased leg strength, numb fingers, numb toes, incoordination