HETA 2000-0020-2793
U.S. Forest Service - Coconino National Forest
Flagstaff, Arizona

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PREFACE

The Hazard Evaluations and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (NIOSH) conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health (OSHA) Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

HETAB also provides, upon request, technical and consultative assistance to Federal, State, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by NIOSH.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Josh Harney, M.S., of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Field assistance was provided by Robert McCleery, M.S.P.H. Analytical support was provided by Ardith Grote. Desktop publishing was performed by Denise Ratliff. Review and preparation for printing were performed by Penny Arthur.

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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.

Highlights of the NIOSH Health Hazard Evaluation

Using Tree Marking Paint to Paint Buildings

The United States Forest Service wondered if there is a health hazard when using petroleum-based tree marking paint (TMP) to paint the outside of buildings, signs, etc. To help answer this question, NIOSH did air sampling on USFS workers at the Coconino National Forest who were using TMP on park buildings.

What NIOSH Did

We took air samples for solvents in paint vapors.

We took air samples for metals from the paint.

We looked at paint mixing, painting, and clean-up.

What NIOSH Found

There was no health hazard from the paint.

Exposures were far below OSHA, NIOSH, and ACGIH limits.

The paints would not have met the current USFS tree marking paint specifications for metals content.

What Coconino National Forest Managers Can Do

Keep telling workers about the possible health risks of their jobs, and training them on how to do their jobs safely.

Make sure workers use the right protective clothing and equipment.

Document and track any reports of health effects that might be from the paint.

What Coconino National Forest Employees Can Do

Whenever possible, mix the paint out in the open where there is lots of fresh air.

Wear nitrile gloves when using mineral spirits.

Clean equipment out in the open where there is lots of fresh air.

Paint from the downwind side of a building to the upwind side if possible.

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

What To Do For More Information:
We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1-513/841-4252 and ask for HETA Report #2000-0020-2793

National Institute for Occupational Safety and Health
NIOSH

Health Hazard Evaluation Report 2000-0020-2793
U.S. Forest Service - Coconino National Forest
Flagstaff, Arizona
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SUMMARY

In October 1999, the National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation request from a management representative of the United States Forest Service (USFS). The USFS sought to evaluate the potential hazards associated with using petroleum-based tree-marking paint (TMP) to paint various wooden structures within the National Forest system. On December 14, 1999, NIOSH industrial hygienists went to the Coconino National Forest near Flagstaff, Arizona, to evaluate worker exposures to various volatile organic compounds (VOCs) and metals during the application of petroleum-based TMPs to the exterior of a wooden building in the park. Paint mixing, painting, and clean-up activities were monitored. Personal breathing zone and area samples were collected for metals, methyl ethyl ketone (MEK), methyl isobutyl ketone, toluene, and total hydrocarbons (using stoddard solvent as the standard). No over exposures were documented during this survey; contaminant levels were generally more than one order of magnitude below their most conservative exposure criterion.

Bulk paint samples of the tree-marking paint and acrylic stain were collected for metals and hydrocarbon analysis. Major hydrocarbon constituents of the paints were C_9-C_{12} aliphatics and C_9-C_{10} alkyl benzenes, and included toluene, xylene, MEK, undecane, and decane. Based on the USFS Draft Specification 2400-400 (May 2000), none of the paints used during this survey would have passed the USFS criteria for metals content.

There was not a health hazard either from the VOCs or metals present in the TMP. Sufficient precautions are being taken by the USFS in preparing the painters to use the TMP. These precautions include conducting a job hazard analysis discussion before painting, using personal protective equipment during paint mixing, painting, and cleanup; mixing the paint and cleaning up outdoors; and minimizing the aerosolization of the paint during its application. Analysis of bulk paint samples demonstrated that paints used during this survey would not have met the current USFS Draft TMP Specification for metals content.

Keywords: SIC 0851 (Forestry Services), Tree-marking paint, MEK, total hydrocarbons, MIBK, metals, VOCs

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INTRODUCTION

In October 1999, the National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation (HHE) request from a management representative of the United States Forest Service (USFS). The USFS seeks to eval-uate the potential hazards associated with using petroleum-based tree-marking paint (TMP) to paint various wooden structures within the National Forest system. The USFS no longer uses this type of paint for marking trees, and is seeking acceptable means to dispose of their inventory of petroleum-based TMP. At the time of the request, this practice was not yet being done so there were no reported health effects among workers. The types of paints the USFS planned to use in this way had historically been used in tree-marking activities, for which NIOSH has performed a previous evaluation.[1] During December 1999, NIOSH industrial hygienists evaluated USFS personnel's exposures to volatile organic compounds (VOCs) and airborne metals (from TMP pigment) during painting of a wooden building with petroleum-based TMP.

BACKGROUND

Two previous HHEs have been conducted regarding the use of TMP by the USFS. One involved an extensive epidemiologic study focusing on adverse reproductive outcomes in 10,000 female foresters who had worked with petroleum-based TMP in the ten year period 1986-1996. Industrial hygiene surveys were also conducted during TMP application at four national parks.[1] All personal breathing zone (PBZ) samples for various VOCs and metals were below relevant occupational exposure limits, and urinalysis for toluene and methyl ethyl ketone (MEK) indicated very low exposures to these two contaminants. As a good industrial hygiene practice, and to minimize the acute symptoms reported during these studies, NIOSH recommended that the USFS investigate the use of a low-solvent, high-solids content TMP for future use.

NIOSH reported on airborne VOC and metals exposure during the use of a newly formulated low–solvent, waterborne TMP.[2] During this study, exposures to total hydrocarbons were either below the limit of detection (LOD) or were at trace concentrations. Propylene glycol was detected in concentrations below 1 part per million (ppm). MEK was detected in most employees' urine samples, but was below the limit of quantification (LOQ). Therefore, NIOSH did not substantiate a health hazard from the TMP used in this study under these conditions. The USFS subsequently decided exclusively to use this type of TMP for future tree marking activities.

In evaluating possible disposal methods for the inventory of petroleum-based TMP, the USFS considered brokering the paint to other markets, recycling the paint, disposing of the paint outright, or finding an alternate use. The USFS decided to investigate the feasibility of using a mixture of the stored TMP to paint various Forest buildings, signs, etc. The USFS therefore requested an HHE to characterize the exposures during building painting when applying the TMP in ways that were expected to aerosolize less paint than the means used to apply paint to trees during tree marking activities.

On December 14, 1999, NIOSH industrial hygienists evaluated worker exposures to various VOCs and metals during the application of petroleum-based TMP to the exterior of a wooden building in the Coconino National Forest near Flagstaff, Arizona. The day began with the head forester and the forester/painters going over the job hazard analysis (JHA) for painting buildings with TMP using rollers and brushes. The paint mixing (6:1:1 mixture of orange:red:black TMP) was conducted outdoors by pouring each paint (from 1-quart containers) into a large bucket and mixing with a small stationary electric powered mixer. This mixing process did not produce any splashing, due to the relatively low speed of the mixer blades and the viscous nature of the paint. Workers wore coveralls, gloves (cotton or rubber-coated cotton), leather boots, and safety glasses to minimize dermal exposure during mixing and painting. In the morning, workers painted one half of a 16' x 24' wooden building using the acrylic stain currently used by the USFS for building painting. In the afternoon when the acrylic stain had completely dried, workers painted the other half of the building using the mixed TMP. PBZ and area samples were collected for metals, MEK, methyl isobutyl ketone (MIBK), toluene, and total hydrocarbons (using stoddard solvent as the standard in analysis). Bulk paint samples of the TMP and acrylic stain were collected for metals and hydrocarbon analysis.

METHODS

Air Samples

PBZ and area air samples for metals from the paint pigment were collected on mixed cellulose ester (MCE) filters within 37-millimeter (mm) polysty-rene cassettes, connected by Tygon® tubing to air sampling pumps calibrated to a flow rate of 2 liters per minute (Lpm). A total of seven personal samples, four area samples, and two field blanks were submitted for analysis. The samples were analyzed by inductively coupled plasma atomic emission spectroscopy (ICP-AES) according to NIOSH Method #7300, modified for microwave digestion.[3] The various analytical limits for each metal are listed in Table 1.

Two screening area air samples for VOCs were collected (one near the open acrylic stain bucket, one near the open mixed TMP bucket) with thermal desorption tubes at a flow rate of 50 cubic centimeters per minute (cc/min). The thermal desorption tubes contained three sorbent beds: 90 milligram (mg) Carbopak Y, 115 mg Carbopack B, and 150 mg Carboxen 1003. Prior to sampling, the tubes were conditioned by heating at 375 degrees Celsius (°C) for two hours. After sampling, the tubes were dry purged with helium for 30 minutes at 100 cc/min to remove any residual water. The chemical analysis was com-pleted using gas chromotography (GC) (30 meter DB-1 fused silica capillary column) with a mass selective detector according to NIOSH Method #2549.[4] The thermal desorption tube samples were taken in order to identify VOCs for the subsequent quantitative analysis of the other sorbent tube samples described below.

Seven PBZ charcoal tube samples for VOCs were collected from painters, in addition to four area samples, using air sampling pumps calibrated to a flow rate of 200 cc/min. They were analyzed for toluene, MIBK, and 'total hydrocarbons' (the sum of all peaks in the chromatogram starting with the nonane peak) based on a stoddard solvent standard. These analytes were chosen because they were either major peaks on the thermal desorption tubes chromatograms or were of special interest to the HHE requestor and union representing the foresters. The analysis was done with a GC with a flame ionization detector based on NIOSH Method #1500, with modifications for these particular analytes.[5] The GC had a 30 meter (m) x 0.32 mm fused silica capillary coated internally with 0.5 micrometer (µm) of DB-5ms. Six MEK PBZ samples, in addition to two area samples, were collected on Anasorb CMS tubes in the same manner as the other hydrocarbons. They were analyzed according to NIOSH Method #2500 using a GC (30 m x 0.32 mm fused silica capillary coated internally with 0.5 µm of DB-wax) with a flame ionization detector.[6]

Bulk Samples

Five liquid paint samples (brown acrylic stain, orange TMP, red TMP, black TMP, mixed TMP) were analyzed for metals and hydrocarbons. Metals analysis was done by ICP-AES according to NIOSH method #7300, modified for paint digestion.[3] This method of analysis does not include mercury, therefore, the paint samples were also analyzed by cold vapor atomic absorption spectroscopy according to Environmental Pro-tection Agency (EPA) SW-846 method # 7471, modified for microwave digestion.[7] To identify the relative concentrations of VOCs in the paint, liquid paint was analyzed two different ways. Portions of the paints were extracted with carbon disulfide, filtered, and the extracts analyzed by GC-mass spectrometry (MS) using a 30 meter RTX-5 Amine column. Separately, headspace samples were also collected above the paint samples using thermal desorption tubes and analysis was conducted according to NIOSH Method #2549, described above.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assess-ment 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 even though 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 criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increases 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 Recommended Exposure Limits (RELs),[8] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[9] and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[10] Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criteria.

OSHA requires an employer to furnish employees a place of employment that is free from recognized hazards that are causing or are likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970, Public Law 91–596, sec. 5.(a)(1)]. Thus, employers should understand that not all hazardous chemicals have specific OSHA exposure limits such as PELs and short-term exposure limits (STELs). An employer is still required by OSHA to protect their employees from hazards, even in the absence of a specific 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 higher exposures over the short-term.

Methyl Ethyl Ketone

MEK is a colorless, flammable organic solvent with a characteristic odor similar to acetone and is typically used as a solvent in the surface coating and synthetic resin industries.[11] MEK is absorbed primarily through inhalation and causes irritation of the eyes, mucous membranes, and skin; at high concentrations MEK may cause central nervous system depression. Short duration inhalation exposure to 100 parts MEK per million parts air, by volume, (ppm) of MEK was reported to cause slight nose and throat irritation, 200 ppm caused mild eye irritation, and 300 ppm was associated with headaches, throat irritation, as well as an objectionable odor.[12] Additional studies indicate that MEK by itself does not cause neurologic toxicity of the extremities (peripheral neuropathy), but may potentiate the toxic effects of substances known to cause peripheral neuropathy, such as n–hexane.[13,14] Continued or prolonged skin contact with MEK liquid can cause dermatitis.

The National Toxicology Program, an interagency research program, has not found evidence supporting an association between MEK exposure and the development of cancer in humans or experimental animals.[15] NIOSH, OSHA, and ACGIH have proposed the same full–shift inhalation criteria for MEK at 200 ppm (590 milligrams per cubic meter of air [mg/m^3]) averaged over an 8–hour (hr) exposure and a STEL of 300 ppm (885 mg/m^3) for 15 minutes.

Toluene

Toluene is a colorless, aromatic organic liquid containing a six carbon ring (a benzene ring) with a methyl group (CH_3) substitution. It is a typical solvent found in paints and other coatings, and used as a raw material in the synthesis of organic chemicals, dyes, detergents, and pharmaceuticals.

Inhalation and skin absorption are the major occupational routes of entry. Toluene can cause acute irritation of the eyes, respiratory tract, and skin. Since it is a defatting solvent, repeated or prolonged skin contact will remove the natural lipids from the skin which can cause drying, fissuring, and dermatitis.[16,17]

The main effects reported with excessive inhalation exposure to toluene are central nervous system depression and neurotoxicity.[17] Studies have shown that subjects exposed to 375 mg/m^3 of toluene for six hours complained of eye and nose irritation, and in some cases, headache, dizziness, and a feeling of intoxication (narcosis).[18,19,20] No symptoms were noted below 375 mg/m^3 in these studies. There are a number of reports of neurological damage due to deliberate sniffing of toluene–based glues resulting in motor weakness, intention tremor, ataxia, as well as cerebellar and cerebral atrophy.[21] Recovery is complete following infrequent episodes, however, permanent impairment may occur after repeated and pro-longed glue–sniffing abuse. Exposure to extremely high concentrations of toluene may cause mental confusion, loss of coordination, and uncon-sciousness.[22,23]

Originally, there was a concern that toluene exposures produced hematopoietic toxicity because of the benzene ring present in the molecular structure of toluene. However, toluene does not produce the severe injury to bone marrow characteristic of benzene exposure as early reports suggested. It is now believed that simultaneous exposure to benzene (present as a contaminant in the toluene) was responsible for the observed toxicity.[16,22]

The NIOSH REL for toluene is 100 ppm (375 mg/m^3) for an 8–hour TWA.[8] NIOSH has also set a recommended STEL of 150 ppm (560 mg/m^3) for a 15–minute sampling period. The OSHA PEL for toluene is 200 ppm (753 mg/m^3) for an 8–hour TWA.[10] The ACGIH TLV is 50 ppm (188 mg/m^3) for an 8–hour exposure level.[9] This ACGIH TLV carries a skin notation, indicating that cutaneous exposure contributes to the overall absorbed inhalation dose and potential systemic effects.

RESULTS AND DISCUSSION

Bulk Sample Analysis

Liquid paint analyses for volatile organic compounds in TMP were conducted by two different means. Solvent extraction of the four TMP samples followed by direct analysis of the extract showed the major constituents to include primarily C_9-C_{12} aliphatics plus C_9-C_{10} alkyl benzenes. Analysis of the headspace above each paint, including the mixed TMP, also showed major peaks for the C_9-C_{12} aliphatics and C_9-C_{10} alkyl benzenes, but the latter analysis also showed toluene, MEK, xylene, undecane, and decane among its major constituents. Headspace analysis for the acrylic stain identified very low levels of C_9-C_{12} aliphatics plus C_9-C_{10} alkyl benzenes, and relatively larger amounts of butyl ether, butanol, and $C_{12}H_{24}O_3$ propanoic acid esters. Extract analysis of the acrylic stain showed primarily $C_{12}H_{24}O_3$ propanoic acid esters. It would therefore be reasonable to anticipate some of these chemicals to be among those identified in the thermal desorption tube screening samples taken during painting.

Table 2 lists the concentration (microgram [µg] metal/g wet paint) of the various metals in the paints used during this survey as compared to the criteria listed in the USFS Draft TMP Specification (as of May 2000). None of the paints used, including the acrylic stain, would have met all the currently proposed USFS TMP metal content specifications. All five samples, however, did meet the Draft Specifications for lead, manganese, mercury, nickel, and vanadium. The NIOSH, ACGIH, and OSHA inhalation exposure criteria are appropriate only for airborne contaminants. These organizations do not promul-gate guidelines for metal or VOC content of bulk paints.

Air Sample Analysis

Thermal desorption tube air samples contained only low levels of VOCs during both acrylic stain and TMP use. The analysis done for these tubes is highly sensitive for contaminant identification, but is qualitative and not quantitative. Therefore, airborne concentrations cannot confidently be generated from these results. The compounds identified on these field samples included methanol, benzene, hexanes, toluene, and various aliphatic and aromatic hydrocarbons. The relative amounts of these compounds, while identifiable, were very low. Hexanes and MIBK were not detected in the sample collected nearest the acrylic stain bucket.

The results of quantitative air sampling for MEK, MIBK, toluene, and total hydrocarbons collected on the charcoal tubes are listed in Table 3. None of these contaminants were detected while acrylic stain was being used. Of the six samples collected while the mixed TMP was used, all six yielded 8–hr TWA exposures two orders of magnitude below the ACGIH TLV-TWA for MEK, toluene, and MIBK. The highest total hydrocarbon exposures occurred during painting with TMP. All six samples for total hydrocarbons were at least one order of magnitude below the TLV. Combining the exposure received during each task does not appreciably change any worker's full-shift exposure. All 8–hr TWA calculations assume that the worker received no other exposure during the day other than that measured during the air sampling. The average concentration of each contaminant over the entire time sampled was at least one order of magnitude below all the exposure criteria, with the exception of total hydrocarbons for workers #1 and #3. Total hydrocarbon concentrations for workers #1 and #3 were still more than 200 mg/m^3 below the TLV of 573 mg/m^3, however. If workers painted under these conditions for an entire day, their exposures would more likely approximate the average concentrations listed in Table 3. These average concentrations, while still well below the exposure criteria, were higher than the calculated 8-hr TWAs.

Table 1 lists the analytical limits for metals analysis by ICP-AES. Table 4 details those air samples that yielded metals concentrations above the minimum quantifiable concentration (MQC). Those metals for which analysis was done, listed in Table 1, but that are not listed in Table 4, were all below their respective LOQ and/or LOD. Therefore airborne concentrations can be assumed to be less than at least their MQC. All metals in these air samples were at least four orders of magnitude below their respective exposure criterion.

CONCLUSIONS AND RECOMMENDATIONS

There was not a health hazard either from the VOCs or metals present in the TMP during the activities monitored during this HHE. Painters did not report any acute symptoms such as respiratory irritation, nausea, vomiting, headaches, or fatigue. Sufficient precautions are being taken by the USFS in preparing the painters to use the TMP, such as conducting a JHA discussion before painting, using personal protective equipment (PPE) during paint mixing, painting, and cleanup; mixing the paint and cleaning up outdoors; and minimizing the aersolization of the paint during its application. It therefore seems unlikely that a health hazard would present itself in the future. During future JHA discussions with painters in different forests, it is recommended that the potential hazards associated with the paint constituents be discussed. Results from this and the previous HHEs related to TMP could be included as a part of these hazard communication efforts. While it is anticipated that the use of TMP as evaluated during this study may result in fewer health complaints than occurred during its use for tree marking, the USFS should develop an effective means of documenting and tracking reports of acute symptoms among the workers using the TMP to paint Forest buildings, signs, etc. In this way, the USFS can effectively evaluate the acceptability of this means of 'disposal' of their inventory of petroleum-based TMP. Workers should immediately report any acute health effects to their supervisor and/or union representative.

It is recommended that workers wear nitrile gloves, or those providing equivalent protection, while using mineral spirits or other solvents to clean paint equipment. If mixing or painting is anticipated to splash and potentially reach the eye, then safety glasses or face shields should be used. Further steps which could be taken to minimize the amount of paint getting onto painters' skin include wearing thin gloves, long sleeved garments, and/or a head covering, but these practices are not indicated solely by the results of this HHE. When painting various structures, workers should paint from the downwind side to the upwind side whenever possible in order to minimize vapor exposures.

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Table 1. Analytical Limits for ICP Analysis of Air Samples
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Analyte	LOD (µg/sample)	LOQ (µg/sample)	MDC* (mg/m^3)	MQC* (mg/m^3)
Al	0.8	3	0.0039	0.0146
Ag	0.08	0.3	0.0004	0.0015
As	0.9	3	0.0044	0.0146
Ba	0.04	0.1	0.0002	0.0005
Be	0.007	0.02	0.00003	0.0001
Ca	2	6	0.0097	0.0291
Cd	0.1	0.4	0.0005	0.0019
Co	0.2	0.6	0.0010	0.0029
Cr	0.5	2	0.0024	0.0097
Cu	0.1	0.4	0.0005	0.0019
Fe	0.4	1	0.0019	0.0049
Li	0.03	0.1	0.0001	0.0005
Mg	0.9	3	0.0044	0.0146
Mn	0.04	0.1	0.0002	0.0005
Mo	0.1	0.4	0.0005	0.0019
Ni	0.3	1	0.0015	0.0049
Pb	0.9	3	0.0044	0.0146
P	2	5	0.0097	0.0243
Sb	0.8	3	0.0039	0.0146
Se	4	10	0.0194	0.0485
Na	2	6	0.0097	0.0291
Te	2	7	0.0097	0.0340
Tl	2	7	0.0097	0.0340
Ti	0.07	0.2	0.0003	0.0010
V	0.1	0.4	0.0005	0.0019
Zn	0.3	1	0.0015	0.0049
Zi	0.04	0.1	0.0002	0.0005

**Based on a sample volume of 206 L.*

Table 2. Metals Analysis for Bulk Paint Samples
HETA 2000-0020-2793, U.S. Forest Service - Coconino National Forest

Analyte concentrations listed as µg/g wet paint													
Sample	**As**	**Sb**	**Ba**	**Be**	**Cd**	**Cr**	**Co**	**Pb**	**Mn**	**Hg**	**Ni**	**V**	**Zn**
acrylic stain	trace*	nd	nd	nd	trace	nd	32	nd	trace	nd	nd	trace	25
orange TMP	trace	83	2800	trace	nd	trace	440	trace	370	nd	210	nd	770
red TMP	nd	trace	1300	trace	nd	nd	410	trace	260	nd	110	trace	20
Black TMP	trace	nd	29	0.43	trace	160	420	trace	350	nd	trace	nd	110
mixed TMP	nd	79	2200	trace	nd	trace	450	trace	370	nd	160	nd	610
USFS Draft Spec.	**6.7**	**254**	**5**	**0.28**	**0.2**	**60**	**250**	**100**	**313**	**10**	**4254**	**23**	**226**
LOD	**20**	**20**	**0.7**	**0.1**	**2**	**10**	**4**	**20**	**0.8**	**0.1**	**7**	**2**	**0.4**
LOQ	**50**	**50**	**2**	**0.4**	**8**	**40**	**10**	**60**	**3**	**0.3**	**20**	**7**	**1**

**indicates the element was present in a concentration below the LOQ but above the LOD*
nd = not detected (below the LOD)
trace = detected, but not quantifiable (between the LOD and LOQ)

Table 3. Air Sampling Results for Hydrocarbons
HETA 2000-0020-2793, U.S. Forest Service - Coconino National Forest

Worker	Task	Paint type	Sample time (min)	Contaminant concentration given in mg/m^3							
				MEK		Toluene		MIBK		Total hydrocarbons	
				Av.	*8hr.‡ TWA*	Av.	*8hr.‡ TWA*	Av.	*8hr.‡ TWA*	Av.	*8hr.‡ TWA*
Worker #1	roll	acrylic	100	nd		nd		nd		nd	
	brush	mixed TMP	70	14.3	*2.1*	4.6	*0.67*	0.7	*0.1*	204	*30.2*
Worker #2	brush	acrylic	100	nd		nd		nd		nd	
	clean-up	mixed TMP	30	not sampled		nd		nd		68.3	*4.27*
Worker #3	roll	acrylic	100	nd		nd		nd		nd	
	mix TMP	TMP	60	nd*		nd		nd		8.6	*1.04*
	roll	mixed TMP	100	16.3	*3.33*	7.4	*1.56*	1.5	*0.31*	317	*66.7*
area	clothes line	acrylic	90	nd		nd		nd		nd	
area	truck	acrylic	90	not sampled		nd		nd		nd	
area	on fence	mixed TMP	100	1.3	*0.42*	trace	trace	nd		22.5	*4.69*
area	truck	mixed TMP	100	not sampled		nd		nd		nd	
ACGIH TLV-TWA 8hr., mg/m^3				***590***		***188***		***205***		***573****	
NIOSH REL, TWA, mg/m^3				***590***		***375***		***205***		***2004****	
OSHA PEL, TWA, mg/m^3				***590***		***753***		***410***		***2900****	
MDC, mg/m^3				0.2		0.2		0.4		4	
MQC, mg/m^3				0.5		0.5		1.5		15	

*pump failed after 6 minutes of sampling
** as stoddard solvent
nd = not detected (below the MDC)
trace = detected but not quantifiable (between MDC and MQC)
MDC/MQC based on sample volume of 2L for MEK, and 2.02L for other hydrocarbons
‡8-hr. TWA calculation assumes no additional exposure occurred during the rest of the work day

Table 4. Airborne Metals Air Sampling Results
HETA 2000-0020-2793, U.S. Forest Service - Coconino National Forest

Worker #	Task	Paint type	Sample time (min.)	Sample #	Contaminant concentration given in mg/m^3							
					aluminum		iron		barium		titanium	
					Av.	*8hr.‡ TWA*	Av.	*8hr.‡ TWA*	Av.	*8hr.‡ TWA*	Av.	*8hr.‡ TWA*
Worker #2	brushing	acrylic	100	ICP-4	trace		trace		nd		trace	
	clean-up	oil	30	ICP-11	trace		nd		nd		nd	
Worker #1	rolling	acrylic	100	ICP-3	trace		trace		trace		trace	
	rolling	oil	70	ICP-6	trace		0.008	*0.001*	nd		trace	
Worker #3	rolling	acrylic	100	ICP-2	trace		trace		nd		trace	
	mixing TMP	oil	60	ICP-7	nd		nd		nd		nd	
	rolling	oil	100	ICP-10	0.018	*0.004*	0.013	*0.003*	0.0007	*0.0001*	0.0019	*0.0004*
Area	on truck	acrylic	85	ICP-1	trace		0.008	*0.001*	nd		trace	
	clothes line	acrylic	90	ICP-5	nd		nd		nd		nd	
	on truck	oil	100	ICP-8	trace		0.008	*0.002*	nd		0.001	*0.0002*
	clothes line	oil	100	ICP-9	nd		trace		nd		nd	
ACGIH TLV-TWA, mg/m^3					***10***		***5***		***0.5***		***10***	
NIOSH REL, mg/m^3					***10***		***5***		***0.5***		***LFL****	
OSHA PEL, mg/m^3					***15***		***10***		***0.5***		***15***	

**NIOSH considers titanium dioxide to be a human carcinogen, and recommends reducing workplace exposures to the 'lowest feasible level'*

Table 4. Airborne Metals Air Sampling Results, Continued
HETA 2000-0020-2793, U.S. Forest Service - Coconino National Forest

‡8-hr. TWA calculation assumes no additional exposure occurred during the rest of the work day
nd = not detected (below the MDC)
trace = detected but not quantifiable (between MDC and MQC)

For Information on Other
Occupational Safety and Health Concerns

Call NIOSH at:
1–800–35–NIOSH (356–4674)
or visit the NIOSH Web site at:
www.cdc.gov/niosh