Health & Safety Report

Worker Health and Safety Branch

HS-1750

EXPOSURE OF HAND APPLICATORS TO GRANULAR HEXAZINONE IN FOREST SETTINGS, 1993 - 1995

August 11, 1997

Janet R. Spencer, Associate Environmental Research Scientist[1]
Susan Edmiston, Senior Environmental Research Scientist[1]
Cathy Cowan, Environmental Research Scientist[1]
M. Kathryn Orr, Environmental Research Scientist[1]
Bernardo Z. Hernandez, Environmental Research Scientist[1]
Frank A. Schneider, Associate Environmental Research Scientist[1]
James R. Sanborn, Staff Toxicologist[1]
Scott Fredrickson, Agricultural Chemist III[2]

[1]California Environmental Protection Agency
Department of Pesticide Regulation
Worker Health and Safety Branch
1020 N Street, Room 200
Sacramento, California 95814-5624

[2]California Department of Food and Agriculture
Center for Analytical Chemistry
3292 Meadowview Road
Sacramento, California 95832

Access and Excel are registered trademarks of the Microsoft Corp., Redmond, WA
Harvard Graphics is a registered trademark of the Software Publishing Corp., Santa Clara, CA
QuattroPro is a registered trademark of Borland International, Scotts Valley, CA
TLV is a registered trademark of the American Conference of Governmental Industrial Hygienists
ACGIH is a registered trademark of the American Conference of Governmental Industrial Hygienists

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY
DEPARTMENT OF PESTICIDE REGULATION
1020 N STREET, ROOM 200, SACRAMENTO, CALIFORNIA 95814

Exposure of Hand Applicators to Granular Hexazinone in Forest Settings, 1993 - 1995

Sponsor	United States Department of Food and Agriculture, Forest Service Region 5, State and Private Forests 630 Sansome Street San Francisco, California 94111	
Testing Facility	California Environmental Protection Agency[1] Department of Pesticide Regulation Worker Health and Safety Branch 1020 N Street, Room 200 Sacramento, California 95814-5624	
Study Director	Janet R. Spencer, Associate Environmental Research Scientist	
Analytical Laboratory	California Department of Food and Agriculture[2] Center for Analytical Chemistry 3292 Meadowview Road Sacramento, California 95832	
Principal Investigator	Scott Fredrickson	
Final Archives	California Environmental Protection Agency[1] Department of Pesticide Regulation Worker Health and Safety Branch 1020 N Street, Room 200 Sacramento, California 95814-5624	(All raw data related to sample collection)
	California Department of Food and Agriculture[2] Center for Analytical Chemistry 3292 Meadowview Road Sacramento, California 95832	(All raw data related to sample analyses and test/reference substances)

Study Dates

Study Initiation	March 8, 1993
Field Monitoring Start	October 7, 1993
Lab Sample Analysis Start	October 13, 1993
Field Monitoring Completion	November 29, 1995
Lab Sample Analysis Completion	April 5, 1996
Study Completion	August 11, 1997

Signatures of Study Personnel
(original copy contains signatures)

Name	Position	Signature
John Donahue	WH&S Branch Chief	_____
Janet R. Spencer	WH&S, Study Director	_____
Susan Edmiston	WH&S, Study Supervisor	_____
Cathy Cowan	WH&S, Study Scientist	_____
Bernardo Z. Hernandez	WH&S, Study Scientist	_____
Dana Meinders	WH&S, Quality Assurance	_____
Kathryn Orr	WH&S, Study Scientist	_____
Sally Powell	WH&S, Senior Scientist	_____
Lisa Quagliaroli	WH&S, Quality Assurance	_____
James R. Sanborn	WH&S, Staff Toxicologist	_____
Frank Schneider	WH&S, Study Scientist	_____
Sheila Margetich	CDFA, Laboratory Supervisor	_____
Scott Fredrickson	CDFA, Principal Analytical Investigator	_____
Terry Jackson	CDFA, Laboratory Quality Assurance	_____
Marvin Wroe	CDFA, Laboratory Technician	_____

Date _____

Approved by: * _____ _____

John Donahue, Branch Chief Date

*_____ _____

Janet R. Spencer, Associate Environmental Research Scientist Date
Study Director

* original copy contains signatures

QUALITY ASSURANCE STATEMENT

The study was audited at the following intervals:

Audit Date	Phase	Study Director Notified	Management Notified
2/23/93	Protocol	02/23/93	02/23/93
10/21/93	Field Monitoring	10/26/93	10/26/93
10/26/94	Field Monitoring	11/2/94	11/2/94
11/28/95	Field Monitoring	12/21/95	12/21/95
12/20/94 - 2/03/95	Raw Data	02/06/95	02/06/95
12/17/96 - 12/20/96	Raw Data	01/16/97	01/16/97
1/10/97 - 1/31/97	Final Report	01/31/97	01/31/97

* original copy contains signatures
Lisa Quagliaroli, Quality Assurance Officer, DPR Date

Audit Date	Phase	Study Director Notified	Management Notified
03/21/95 - 03/24/95	laboratory activity, analytical process	12/26/96	12/26/96
Sept. - Oct., 1995	data package	12/26/96	12/26/96

*original copy contains signature
Terry Jackson, Quality Assurance Officer, CDFA, Center for Analytical Chemistry Date

EXPOSURE OF HAND APPLICATORS TO GRANULAR HEXAZINONE IN FOREST SETTINGS, 1993 - 1995

STUDY COMPLIANCE STATEMENT

Based on the information supplied to me by the California Department of Food and Agriculture, Center for Analytical Chemistry, (Laboratory Statements of Compliance), I hereby confirm that all aspects of the worker exposure monitoring portion of this study, Project 9303, were conducted in compliance with the U. S. Environmental Protection Agency, Good Laboratory Practice standards (GLP, 40 CFR 160), with the following exceptions:

The test substance characterization was not documented before its use in the study as required in 40 CFR 160.105(a).

The testing facility did not have procedures established for handling reference substances as required in 40 CFR 160.107 before July, 1995.

Supplemental and support data such as weather data were not collected in compliance with GLP.

All required SOPs may not have been in place at the time of study conduct.

Neither analytical reference standards nor reference standards for field fortifications were characterized under GLP before July, 1995.

Protocol and SOP deviations were documented and can be found in Appendix II (available upon request).

*original copy contains signature _____ _____

Janet R. Spencer, Associate Environmental Research Scientist — Date
Study Director
Worker Health and Safety Branch

EXPOSURE OF HAND APPLICATORS TO GRANULAR HEXAZINONE IN FOREST SETTINGS, 1993 - 1995

EXECUTIVE SUMMARY

Objectives The study objective was to estimate dermal and inhalation exposure of workers who apply granular hexazinone (Pronone® 10G) to National Forest Service (USFS) lands and to compare these estimates to those contained in the USFS Environmental Impact Statement (EIS).

Limitations The study was limited to comparing observed worker exposures to granular hexazinone to predicted worker exposures contained in the USFS EIS, which were developed from surrogate data. The study did not attempt to evaluate or assess the risk potential of working with granular hexazinone.

Background The USFS is responsible for managing over 20 million acres of USFS land in the Pacific Southwest Region (Region 5). Vegetation management, including mechanical, manual, thermal, biological and chemical means, is necessary to control competing plant species and achieve timber yield objectives. The USFS EIS presents the hazard, exposure and risk analyses of the thirteen herbicides used in Region 5. When the USFS developed their EIS in1988, liquid formulations of hexazinone were being used on forest lands; granular formulations were not used until several years later. No hexazinone-specific human exposure data were available on which to base the EIS hexazinone exposure estimates. Thus, the exposure estimates relied on surrogate data, which consisted of extrapolations from animal toxicity data, from worker exposure studies with liquid formulations of 2,4-D and 2,4,5-T applied by backpack sprayer, and from estimates of risk based on a range of potential exposure scenarios. 2,4-D and 2,4,5-T worker exposure data were selected as being the most similar to the USFS use of liquid hexazinone. Realistic, conservative and worst case worker exposures were estimated using the 50th, 95th and 99th percentiles, respectively, of the observed distribution of the 2,4-D and 2,4,5-T worker exposure data.

The EIS requires that site-specific worker exposure monitoring evaluate at least 10% of the Region's herbicide application projects annually. When the USFS began using the granular formulation of hexazinone, the agency set a priority on evaluating worker exposure to this new use. In 1993, the USFS contracted with the California Environmental Protection Agency, Department of Pesticide Regulation (Cal/EPA, DPR), Worker Health and Safety Branch (WH&S), to conduct the requisite exposure monitoring of workers handling and applying hexazinone, formulated as the granular product, Pronone® 10G.

Methods Monitoring was conducted over three calendar years. The study evaluated the dermal and inhalation exposure of 29 applicators and flagger/loaders at four sites over 11 study days (105 worker-days). Applicators used a belly grinder, a spreader strapped to the torso, to apply granular hexazinone (Pronone® 10G). Dermal exposure monitoring was conducted using long-sleeved cotton T-shirts and knee-length socks, which were worn next to the skin for the duration of the workday. Dermal exposures to the hand and face/neck regions were evaluated by using commercial baby wipes to wipe these regions at intervals throughout the workday. Personal air pumps drew air through a 37-mm diameter glass fiber filter to measure breathing zone concentrations of hexazinone. Daily estimated absorbed dosages (EAD), with standard deviations where appropriate, were calculated for the whole crew, for applicators, and for flagger/loaders and compared to USFS model estimates. WH&S collected additional samples and data to verify the concentration of the test substance, provide quality control and assurance, and to document various study parameters such as the time spent handling hexazinone, amount of hexazinone applied each day, acreage treated, etc.

Major Findings The USFS EIS exposure estimates were not validated for worker exposure to granular hexazinone. Study data indicated that the EIS surrogate model under-estimated exposure for workers using belly grinders to apply granular hexazinone. The EIS estimated margins of exposure (MOE), for systemic effects (normalized for observed application rates) for workers handling and applying hexazinone were 144, 74 and 58, respectively, for realistic, conservative and worst case exposure scenarios. Study estimates indicated that, on average, crews received nearly three times (2.8) greater exposure than the

EIS worst case estimate. Applicators were more highly exposed than flagger/loaders. Applicator exposures averaged 3.5 times the worst case estimate; flagger/loader exposures were approximately equal to the realistic exposure estimate and averaged only 0.28 times the worst case estimate. Dermal exposure accounted for 74% of applicator EAD and inhalation contributed 26% to EAD. For flagger/loaders, the dermal and inhalation routes contributed 88% and 12%, respectively, to EAD. The upper body received the greatest exposure.

Both study data and on-site observation indicated that granular formulations of hexazinone may contribute to greater exposures than do liquid formulations. During several of the monitoring days, the dustiness was noticeable to the point of causing minor eye and throat irritation for some of the applicators, study personnel and USFS staff. On one day, the dustiness was severe enough to cause moderate discomfort in most workers and staff, accompanied by burning sensations in the eyes, nose and throat and resulting in coughing and splitting to clear the respiratory passages. Both WH&S and the USFS responded quickly and appropriately to this incident. Samples of product were sent to the manufacturer for analysis of total dust and the manager of the sales company furnishing the product provided on-site consultation. Within one month of the incident, USFS sent a policy letter to all forest supervisors requiring that, in the event future incidents occur, use of the product lot involved be immediately suspended. Applications could only be resumed with a new lot of granular hexazinone. With this policy in force, the UCSF Committee on Human Research renewed annual approval to conduct studies involving human subjects for both 1994 and 1995. No incidences of severe dustiness occurred during 1994 and 1995. A search of DPR pesticide use records indicated that hand applications of granular hexazinone are limited to national forests. Most treatments to private forests and rights-of-way are applied aerially and thus do not present an opportunity for worker contact.

When the USFS received preliminary study results indicating average worker exposure was greater than predicted, they took steps to mitigate future exposures. In 1996, a second USFS policy letter required that workers wear coveralls over work clothing and use NIOSH-approved dust/mist/fume respirators when applying hexazinone. The goal of all industrial safety and hygiene programs is to establish administrative and engineering controls to prevent exposures rather than using protective clothing and equipment to mitigate exposures. Thus, these measures should be considered interim remedies for protecting workers from excessive exposures. Permanent exposure mitigation can be achieved by using granular formulations which are less dusty or by reformulating Pronone® 10G to eliminate particles smaller than 100 μm.

INTRODUCTION

The U. S. Department of Food and Agriculture, Forest Service (USFS) is responsible for managing over 20 million acres of National Forest Service land in the Pacific Southwest Region (Region 5), of which 20% (4 million acres) produces commercial wood products. The Region currently sells between 0.5 and 1 billion board feet of National Forest timber each year. Reforestation activities are conducted to reestablish trees and promote stand growth to maintain a continuous supply of timber. Vegetation management is critical to successful reforestation, as control of competing plant species is necessary to achieve timber yield objectives in the Region. Various methods are used to control competition, including mechanical, manual, thermal, biological and chemical means. The USFS, in their 1988 Environmental Impact Statement (EIS), evaluated the potential health, environmental, economic and social effects of the vegetation management practices used in their reforestation program (1). Of the various alternatives, herbicide treatments are often the most effective and efficient methods for controlling competing vegetation. Pronone® 10G (Pro-Serve, Inc., Memphis, TN), is a formulated product used for selective weed control in conifers and to control woody plants in reforestation areas. Pronone® 10G contains 10% hexazinone, the pesticide active ingredient, bound in a coating to clay granules. After application, rainfall dissolves the coating, releasing hexazinone for soil activity.

The USFS EIS presents the hazard, exposure and risk analyses of the thirteen herbicides used in Region 5. Human exposure data for herbicide use in forest conditions are limited. Thus, the exposure estimates developed in the EIS relied on extrapolations from animal toxicity data, from worker exposure studies with liquid formulations of 2,4-D and 2,4,5-T applied by backpack sprayer, and from estimates of risk based on

a range of potential exposure scenarios. Realistic, conservative and worst case worker exposures were estimated using the 50th, 95th and 99th percentiles, respectively, of the observed distribution of the 2,4-D and 2,4,5-T worker exposure data. The USFS desired to both determine the health effects of herbicides used in their program and to develop techniques and equipment to reduce worker exposures. To accomplish these objectives, the EIS requires that site-specific worker exposure monitoring evaluate at least 10% of the Region's herbicide application projects annually. Measurements of exposure that are chemical- and task-specific yield more realistic assessments of risk potential than do those extrapolated from surrogate data. Empirical estimates of exposure permit an evaluation of the protective value of exposure mitigation controls currently in place and may dictate the use of more protective measures such as personal protective equipment or clothing.

In 1993, the USFS contracted with the California Environmental Protection Agency, Department of Pesticide Regulation (Cal/EPA, DPR), Worker Health and Safety Branch (WH&S), to evaluate the dermal and inhalation exposure of workers applying hexazinone, formulated as the granular product, Pronone® 10G. In 1994, hexazinone was the 100th most widely applied chemical in California. Approximately 139,000 pounds were applied, representing about 0.01% of the total weight of the top 100 chemicals used in the state (2). The study was conducted in accordance with US EPA, 40 CFR 160 Good Laboratory Practice Standards (GLPS) and both DPR and USFS regulations (3). Monitoring was conducted over three calendar years. This study evaluated the dermal and inhalation exposure of 29 loaders, flaggers and applicators at four sites over 11 study days (105 worker-days). All toxicity endpoints and exposure data referenced in this document were contained in the USFS EIS (1). Estimates of dermal exposure, inhalation exposure and absorbed dosage were calculated according to WH&S guidelines and compared to EIS estimates for the three exposure scenarios (1,4,5).

MATERIALS AND METHODS

Study Design

Herbicide Applications An average of 15,000 acres, representing less than 1% of the Region's timber-producing acreage, are treated chemically each year (1). The USFS uses herbicides only after evaluating all treatment alternatives and demonstrating herbicides are essential to achieving project objectives. Herbicides are normally applied no more than three times during a forest stand rotation of 50 to 150 years: once if needed to prepare the site for planting, and once or twice to release seedlings from competing vegetation. Site preparation treatments can be applied from spring through fall. Trees are either one or two years old when planted. Release treatments are made from one to seven years post-planting and must be made only when the conifers are dormant and the competing vegetation is growing. This window of opportunity occurs only in the early spring and late fall. Table I provides study site and treatment summary information for each of the four monitoring sites. Study days at each site

Table I. Site Information: Exposure of Hand Applicators to Granular Hexazinone in Forest Settings

Site Information	Site 1	Site 2	Site 3	Site 4
Field Monitoring Dates	10/07/93 - 10/09/93	10/21/93, 10/22/93, 10/25/93	10/26/94 - 10/28/94	11/28/95 - 11/29/95
National Forest, Ranger District	Eldorado, Amador	Eldorado, Pacific	Lassen, Hat Creek	Lassen, Almanor
Target Species	ceanothus, gooseberry, lupine	ceanothus, gooseberry, lupine	grasses	ceanothus, manzanita, chinquapin
Crew Size	10	11	12	6
Total Acres Treated	249	244	302	96
Application Method	Swath	Swath	Swath	Radius
Pronone® 10G Application Rates	20 - 30 lb/acre	20 - 30 lb/acre	25 - 30 lb/acre	19 - 21 lb/acre
Hexazinone Application Rates	2.0 - 3.0 lb/acre	2.0 - 3.0 lb/acre	2.5 - 3.0 lb/acre	1.9 - 2.1 lb/acre
lb hexazinone handled	607	596	760	190

were consecutive, when possible. Site elevation ranged from 4500 - 7200 ft. Terrain varied from flat to 20% slope. Morning temperatures ranged from 36 - 54 °F and daily high temperatures were between 48 and 80 °F. Release treatments were applied at all sites. Pre-plant treatments were applied during one day each at Sites 2 and 3. Plantations consisted of a variety of fir and pine species at each site.

The USFS contracted with private applicators to conduct herbicide treatments. USFS staff were present at each site to ensure that contract obligations were met. Crews were male and Spanish speaking. Crew size was generally between 6 and 12, with the majority of the workers performing application tasks. One worker functioned as the foreman, guiding the crew through the treatment unit and assuring that target application rates were achieved. The foreman may also perform loading and/or flagging tasks. Crews of eight or more generally had one or two workers performing foreman, loading and/or flagging tasks.

Workers applied Pronone® 10G via a belly grinder, a broadcast spreader which dispersed herbicide granules when a side-mounted handle was cranked. The units consisted of a plastic hopper attached to an aluminum tube base, which supported the spreader in a stable, upright position when placed on the ground. Two spreader designs were common. One had a hopper which resembled a bucket, measured approximately 14 inches in diameter at the top, and held approximately 25 pounds of granules. An elasticized vinyl cover was placed over the hopper after loading. The second design was smaller and squarer, with a threaded loading orifice approximately six inches in diameter, and held approximately 10 - 12 pounds of granules. It was capped by a plastic screw-on lid. Spreaders were sometimes modified by attaching a strip of four-inch-wide aluminum sheeting to the broadcast orifice to achieve more consistent herbicide delivery.

A variety of strap configurations were used to secure the spreader to the worker's torso. Applicators detached the spreader and either placed the unit on the ground or held it out for loading. The loader poured herbicide granules into the hoppers from 50-pound sacks of Pronone® 10G. Gross acreage for each treatment unit ranged from two acres to more than two hundred acres. Applications were made to 60 -100% of gross unit acreage. For most applications (Sites 1 - 3), the crew lined up approximately 10 - 20 feet apart and applied to repeated swaths of the unit. The flagger marked the outer edge of each swath by periodically tying survey tape to trees. Applications at Site 4 were made to a five-foot radius around each tree to maintain brush for erosion control and animal habitat. Loading at Sites 1, 2 and 4 was conducted within the treatment unit or on the access road adjacent to the unit. The crew walked between the treatment portions of the unit and the loading site, whose location changed to accommodate crew progress through the unit. At Site 3, the herbicide was brought to the crew on a mobile vehicle.

Standard work clothing and personal protective equipment (PPE) at all sites included a long-sleeved or short-sleeved shirt (knit or woven fabric), denim pants, socks and leather high-top work boots, hard hat and knit gloves, generally worn over vinyl exam gloves. Some workers wore only one pair of gloves, either knit or vinyl; latex or leather gloves were observed occasionally. Use of eye protection and paper dust masks was intermittent. Workers wore jackets if the morning was cold and often removed them as the temperature warmed.

Study Procedures

Worker Exposure Monitoring

Informed Consent; Number of Workers Monitored The Committee on Human Research, University of California, San Francisco, approved three annual applications (6) to involve humans as research subjects, one for each 12-month period of the field portion of the study (approval numbers H7420-08758-01 through H7420-08758-03). All study volunteers provided their informed, written consent prior to participating in the study. A total of 29 males participated in the study. Some volunteers participated in the study at more than one site. At each study site, the volunteers generally participated in the study each day. However, the crew foreman's duties sometimes prevented his participation in the study (10/09/93, 10/21/93, 10/26/93). Thus, for those three days, sample population is one worker less than crew size. A total of 105 worker-days were monitored over 11 study days. Of this number, 88 applicator and 17 flagger/loader (flag/load) worker-days were monitored. Study volunteers were instructed to perform their work tasks in the usual manner.

Personal Data. The following information was recorded for each study volunteer: age, height, weight, and years of experience applying herbicides in forest settings (see Appendix I, Table 4).

Inhalation Exposure Exposure to hexazinone particulates was measured by a 37-mm glass fiber filter, type AE (1 µm pore size, SKC number 225-7), backed with a support pad (7). The filter was housed in a plastic cassette (SKC number 225-2) and sealed with self-sealing bands (SKC number 225-25-01). It was attached via vinyl tubing to a personal air pump (MSA Fixt-Flo, Model S or Model TD), clipped to a webbed belt. The cassette was secured in the worker's collar region and worn for the duration of the workday. Initial pump flow was set at 2 L/min using a Kurz® mass flow meter (8). Study personnel monitored pump performance throughout the day and replaced pumps as necessary. Initial and final flow rates and elapsed time were recorded for each pump. At the end of the workday, study staff removed the cassettes from the sampling train, capped the ends and stored each cassette in a separate one-quart Ziploc® bag. All bagged samples were then double-bagged in a second one-gallon Ziploc® bag. Samples were stored in insulated coolers on dry ice.

Dermal Exposure Dermal exposure samples consisted of long-sleeved T-shirts (100% cotton, pre-washed), knee-length athletic socks (80% cotton/20% polyester), and skin wipes (Chubs® baby wipes) of both the face/neck regions and of the hands beneath the gloves. Clothing dosimetry permits a direct measurement of dermal exposure to the covered regions without the necessity for extrapolation of patch residues to body surface area (5,9). Shirts and socks were distributed to the workers each morning upon their arrival at the work site. They wore the dosimetry clothing next to the skin, under normal work clothing, for the duration of the workday. The T-shirt covered the torso, arms and hips and was tucked into the worker's pants all day. WH&S exposure monitoring studies have previously included either socks or cotton long johns to measure lower body dermal exposure, as appropriate (10,11). Socks were selected for this study since private changing facilities were not available. Commercial wipes are preferable to hand rinses when sampling in remote field locations as they are widely available, easily transported, and cannot be spilled. A series of two wipes each was used for the hands and the face/neck areas to collect residue samples at lunch, at the end of the workday, and at any other time the worker wished to wash these regions. At each sampling interval, the two hand wipes were collected prior to the two face/neck wipes, to prevent cross-contamination. Each worker's wipe samples were combined, by body region, in a one-pint glass jar. At the end of the day, dermal samples were collected in the following order, to prevent cross-contamination: hand wipes, face/neck wipes, T-shirt, and socks. The wipe sample jars were sealed with aluminum foil, capped with canning lid and ring, and placed in sectioned corrugated cardboard boxes. Each clothing sample was sealed into two one-gallon Ziploc® bags. All dermal samples were stored in insulated coolers on dry ice. Several minor deviations from these procedures occurred, such as a worker using only one wipe rather than two, or removing the dosimetry samples in the wrong order. These deviations may have had a small, negative effect on the study, but their impact could not be measured.

Field Quality Control and Assurance

Test Substance At least one ounce of each lot number of Pronone® 10G applied during the study was collected at each study site. Each sample was collected directly from the fifty-pound bag and placed in a 4-ounce polyethylene bottle. The bottle was capped with a threaded lid, sealed into two one-quart Ziploc® bags and placed on dry ice in a separate insulated cooler from exposure samples.

Field Fortifications and Blanks Field fortifications and blank samples were prepared each study day. The field fortifications provided an index of the stability of hexazinone during sample transport and frozen storage prior to extraction and analysis. Two sets of field fortifications were prepared each morning, with each set containing one replicate per worker. Each replicate, consisting of two Chubs® wipes contained in a four-ounce glass jar, was spiked with 0.5 mL of 300 ppm of hexazinone (150 µg). Each jar was then capped with a teflon-lined lid. One set was stored on dry ice immediately (stored set) and the second set taken to the field and stored on dry ice at the end of the workday (ambient set). Fortification standards, prepared in methanol, were evaluated periodically.

Blank samples assessed the adequacy of sample handling, transport and storage procedures to minimize cross-contamination. One sample of each matrix (two wipes, T-shirt, socks and cassette with glass fiber filter and support pad) was prepared at the end of each workday. Blank samples were handled in the same manner as the exposure samples.

Sample Storage and Shipping All samples were maintained on dry ice until arrival at the laboratory. Upon receipt, samples were logged in and transferred to laboratory freezers.

Analytical Methods, Quality Control and Assurance

Analytical Method Validation Five replicates of each matrix were evaluated at the limit of detection (LOD; 10 times the signal to noise ratio), and at various target levels based on expected exposure sample residue levels. The recovery range for T-shirts and wipes was extended by several orders of magnitude after analyses of exposure samples from the first study site indicated residue levels were much higher than anticipated. All matrices showed acceptable recoveries. Method validation data are summarized in Table II.

Analytical Methods (12) Chubs® wipes, socks and T-shirts were extracted with water containing 0.02% sodium sulfosuccinate. Direct analysis of these extracts was then conducted. Glass fiber filters were extracted with methanol. Injection volumes of 100 µL for clothing and wipe samples and 10 µL for glass fiber filters were analyzed on a Hewlett-Packard 1050 high performance liquid chromatograph (HPLC), using a reversed phase system. Extracts were analyzed in either gradient or isocratic mode, depending on cleanliness of the samples and concentration of the hexazinone residues.

Table II. LOD and Mean Percent Recoveries for Hexazinone from Five Replicates of Sampling Matrices

	Matrix Recoveries: % ± SD			
Fortification Level	T-shirts	Socks	Wipes	Filters
LOD	105.83 ± 16.09	109.75 ± 1.80	102.44 ± 7.63	113.10 ± 7.51
2X LOD	NE	102.43 ± 9.13	NE	NE
4X LOD	106.33 ± 3.01	NE	95.29 ± 0.92	NE
5X LOD	NE	NE	NE	94.68 ± 3.01
8X LOD	NE	96.20 ± 6.44	NE	NE
10X LOD	104.54 ± 1.87	NE	NE	NE
20X LOD	NE	NE	95.31 ± 1.40	91.82 ± 4.41
100X LOD	99.07 ± 3.49	NE	100.96 ± 1.04	NE
1,000X LOD	98.98 ± 0.66	NE	NE	NE
10,000X LOD	NE	NE	103.27 ± 1.98	NE
LOD (µg)	10 µg	5 µg	10 µg	0.2 µg

NE = Not Evaluated

Results were reported as µg hexazinone/sample. The instrument conditions were as follows:
Column: 30 cm x 4.6 mm, 5 µm phenyl Alltech cartridge system with guard column, 1 mL/min flow rate
Gradient: 20/80 acetonitrile/water to 80/20 acetonitrile/water in 16 min
Isocratic: 30% acetonitrile/water, with 1% methanol to retard microbial growth
Detector: HP 1050 UV at 249 nm
Elution time: 10 min for both gradient and isocratic conditions.
Detection Limits: 0.2 ng for glass fiber filters; 2 ng for wipes and clothing

Matrix fortifications were analyzed with every ten exposure samples; at least one confirmation analysis, by GC/MS, was conducted for every 20 positive exposure samples.

Storage Stability Multiple samples of each matrix were fortified and stored in the freezer. T-shirts, socks and wipes were fortified with 200 µg hexazinone; glass fiber filters were fortified with 20 µg hexazinone.

Samples were removed and analyzed in duplicate at day 0, and weeks 1, 2, 4, 8, 17, 30, and in quadruplicate at week 78.

Data Analysis

Data Recorded Field staff recorded each worker's task as either applicator, loader, flagger, or flagger/loader. At least one crew member performed non-application tasks exclusively. The foreman, if present, generally performed flagging or flagger/loader tasks. Field staff also recorded the number of loads, the total pounds of Pronone® 10G used, total acres treated, and the time spent in loading, applying, and driving each day. Loading included the total time for the crew to walk to the loading site, if necessary, load all spreaders, and return to the application area. The crew generally loaded and applied as a group, so that total number of loads, amount of herbicide applied per person, and time spent at loading and application tasks were assumed equivalent for each applicator. Times were adjusted accordingly if a worker was either present for only a portion of the day or if he was assigned flagger/loader tasks for a portion of the day. Field staff recorded crew activity as "other" when workers were not handling hexazinone, for example, time spent at lunch, driving to treatment units, equipment repair and calibration, walking through non-treatment areas within the treatment unit, waiting for delivery of herbicide, collecting exposure samples, etc. The daily average application rate was equal to total pounds hexazinone applied divided by total acres treated. Field staff also noted the types of work clothing and PPE worn by each worker, and, as necessary, the time when each worker removed outer clothing as well as any unusual exposure incidents, such as handling herbicide with bare hands, spills of herbicide, etc.

Dermal Exposure(4) Each sample result was entered into a relational database (see Appendix I, Table 1) (13). Data were analyzed by queries and reports. Dermal exposures (mg) were calculated by summing skin wipe and clothing residues. Study staff noted the number and kind (long-sleeved, short-sleeved, sweatshirt, jacket, woven, knit, etc.) of outer shirt layers. Clothing residues were adjusted for clothing penetration as follows: If a worker wore the study T-shirt as the only layer of upper body clothing for at least three hours of the workday, the dosimetry shirt was assumed to perform as an "outer" layer rather than as a skin surrogate. Assuming a clothing penetration factor of 10%, only 10% of the T-shirt residues were included as dermal residues in calculating upper body exposure. If additional upper body clothing, either long- or short-sleeved, was worn over the dosimetry T-shirt, the dosimetry T-shirt was assumed to perform as a skin surrogate. For these workers, T-shirt residues were considered dermal residues in exposure calculations. The study socks captured the hexazinone residues that the workers' own socks would otherwise have collected. Ten percent of the sock residues were assumed to penetrate the sock to the skin of the lower legs and feet and be available for dermal absorption. The leg was assumed to receive uniform hexazinone deposition, thus thigh exposure (3663 cm^2), whose surface area is similar to lower leg and foot surface area (3711 cm^2), was assumed equal to the unadjusted sock exposure (4). No adjustment for clothing penetration was required for thigh exposure, since the thigh was covered by only the pants and was not protected by an additional layer of clothing. The socks thus performed as skin surrogates for thigh exposure. Leg exposure was equal to the sum of thigh exposure (represented by sock residues) and lower leg exposure (represented by 10% of sock residues), or, a total of 1.1 times the sock residues.

Potential Inhalation Exposure (PIE, mg), Inhalation Exposure (IE, mg) (4) PIE was calculated by adjusting filter residues for pump flow, elapsed time and a 14 L/min breathing rate. IE was calculated by adjusting PIE for 50% uptake and 100% absorption (see Appendix I, Table 2). For Table VI, mean IE (mg/kg) was calculated from individual IE (mg) divided by body weight (kg).

Estimated Absorbed Dosage (EAD, mg/kg) (1,4) Individual data are provided in Appendix I, Table 3. Individual dosages were calculated, using each worker's weight (kg). Daily and group means were calculated as the mean of individual absorbed dosages. Both USFS EIS and DPR calculations assumed 10% dermal absorption (dermal penetration). Dermal contribution (absorbed $dose_D$) to EAD was calculated as 10% of dermal exposure (mg) divided by body weight (kg). Individual daily EAD was calculated as follows:

EAD = [(dermal exposure/10) + inhalation exposure]/kg body weight.

Comparison with USFS Models (1) All toxicity endpoints and exposure data referenced in this document were contained in the USFS EIS (1). Study data were compared to EIS estimates (mg/kg/day) for workers applying liquid formulations of hexazinone by backpack sprayer during ground applications, as this work task most closely resembled Pronone® 10G belly grinder applications. The USFS EIS models used the 50th, 95th, and 99th percentiles of exposure estimates from 2,4-D and 2,4,5-T applicator exposure studies to generate respective estimates of absorbed dosage for realistic (0.0653 mg/kg/day), conservative (0.1262 mg/kg/day) and worst case (0.2142 mg/kg/day) exposures to the 13 herbicides used in their spray program. By defining exposures in this manner, the statistics establish the probability of those exposures occurring, i.e., a worst case exposure would be likely to occur 1% of the time. The USFS models assumed a body weight of 70 kg; the monitoring study used actual worker weights to calculate individual absorbed dosages in mg/kg/day. The EIS models assumed the following application rates: Realistic and Conservative, 2.25 lb/acre; Worst Case, 3.00 lb/acre. Daily and study-wide mean estimated absorbed dosages, with standard deviations where appropriate, were then calculated for the crew, applicators, and flagger/loaders. Observed individual and group exposures were compared to USFS model estimates, normalized for observed daily application rate (observed application rate/USFS model application rate).

Statistical and Graphical Analyses Arithmetic means and standard deviations (SD), calculated using Microsoft® Access™, Relational Database Management System for Windows™, Version 2, are reported for applicator and flagger/loader DE, PE, IE and EAD and for field quality control sample recoveries and storage stability recoveries (13,14). Means and SD were based on individual exposures; calculation using daily means provided in the tables will differ due to rounding. Individual worker exposures (intraday) and mean daily DE and PIE were tested for normal vs. log-normal distribution at the 0.05 significance level using the Shapiro-Wilks W test (15). Geometric means are reported for crew, applicator and flagger/loader DE, PIE and EAD. Figures were generated using Harvard Graphics® and Quattro® Pro software (16,17). One-sample t-tests (two-tailed, alpha = 0.05) were conducted using Microsoft® Excel™ software to compare mean EAD to USFS predicted exposure on each day (18). Within day t-tests were done for all workers and applicators. T-tests were also conducted on the pooled exposure data for all workers, all applicators and all flagger/loaders vs. the USFS models. Flagger/loader data were insufficient for intraday analyses.

A variance components analysis was conducted on EAD for applicators to test whether there was significant variability due to the random effects in the study design (site, study day, and worker) (19,20). There were insufficient data for similar analyses of flagger/loaders.

Margins of Exposure (MOE) (1) The EIS hazard analysis, developed from a review of laboratory studies, indicated hexazinone has no oncogenic potential. Hexazinone is classified as slightly acutely toxic in rats (LD_{50} = 1,690 mg/kg) and has no observed effect levels (NOEL) of 10 mg/kg/day for chronic systemic toxicity (rat) and 50 mg/kg/day for reproductive effects (rat). To evaluate the risks of general systemic and reproductive/teratogenic effects for human exposures, USFS computed a reference dosage by dividing the animal NOEL by an uncertainty factor of 100. Thus, human exposures (absorbed dosages) below 0.5 mg/kg/day (reproductive) and 0.10 mg/kg/day (systemic) are not expected to carry an excess risk of adverse health effects.

MOE (reported as margins of safety or MOS in the USFS EIS) provide indices of relative safety in evaluating human exposures compared to animal NOELs. They are calculated by dividing the animal toxicity endpoints by known or estimated absorbed dosages for human exposures. In general, an MOE of less than 100 is a threshold of concern and indicates the possibility of toxic effects; the lower the MOE, the greater the possibility of these effects occurring. The USFS MOE for systemic effects for realistic, conservative and worst case exposures to hexazinone were 153, 79, and 47, respectively. USFS MOE for reproductive effects were 766, 396, and 233, respectively. The following equations show calculation of the MOE for the USFS realistic estimate for systemic effects, normalized to mean study application rate, and calculation of study MOE:

$$\text{USFS MOE} = \text{NOEL}/[\text{EAD}_{realistic} \times (\text{observed application rate/predicted application rate})]$$
$$= 10\ \text{mg/kg/day}/[0.0653\ \text{mg/kg/day} \times (2.4\ \text{lb/acre}/2.25\ \text{lb/acre})] = 144$$
$$\text{Study MOE} = (10\ \text{mg/kg/day})/(0.520\ \text{mg/kg/day}) = 19.2$$

RESULTS

Table III. Daily Crew Means for Pounds Hexazinone Handled, Number of Loads, Task/Time Summary

Site	Date	lb Hexazinone Handled	No. of loads per applicator	Avg. Time (min)		
				Load	Apply	Other
1	10/07/93	147.0	11	68	226	185
1	10/08/93	193.2	11	43	243	245
1	10/09/93	266.0	18	78	313	111
2	10/21/93	193.0	25	80	307	142
2	10/22/93	219.1	31	110	321	109
2	10/25/93	184.0	24	84	270	166
3	10/26/94	195.0	21	79	176	279
3	10/27/94	330.0	34	92	220	206
3	10/28/94	235.0	30	63	183	136
4	11/28/95	82.5	20	90	221	166
4	11/29/95	107.5	25	72	254	169
Arith. Mean ± SD		195.7 ± 69.4	22.7 ± 7.5	78.1 ± 17.3	248.5 ± 50.0	174 ± 49.9
% of Workday for Each Task				15 ± 3.7	48.0 ± 11.0	± 13.4

Worker Exposures

Exposure results reflect crew means for each monitored workday. Individual worker exposures are provided in Appendix I. Table III presents daily totals for amount of hexazinone handled, the number of belly-grinder loads for each applicator and the average time the crew spent loading, applying and in non-application tasks. Approximately 63% of the workday (315 minutes) was spent handling hexazinone (loading and applying). The overall ratio of application time to loading time was approximately 3:1. On average, about 38% of the work day was spent on non-handling activities ("Other"), such as driving, lunch, repairing equipment, walking to application sites, calibrating the belly grinders, and collecting dermal exposure samples.

Dermal Exposure (DE), Potential Inhalation Exposure (PIE)

Table IV Table IV presents the average DE distribution by day and task (mg hexazinone and % DE for all workers, all applicators and all flagger/loaders) for each monitored body region (face/neck, hand, legs and upper body). PIE (mg hexazinone) is provided in the final column. The mean potential exposure distribution for each dermal region and for inhalation across all study days is provided, by task, in the Summary section and in Figure 1. Calculations were based on individual exposures; calculation from daily means will differ due to rounding.

Applicators received far greater exposures than did flagger/loaders and their exposures varied more widely between days. Overall, applicator DE was about 10-fold greater than flagger/loader DE (summary section, 318.3 mg vs., 31.8 mg, respectively), while applicator PIE was 28 times greater than flag/load PIE (22.61 vs. 0.81, respectively). Daily DE varied by as much as 87-fold for applicators, but varied by only 16-fold for flagger/loaders. However, the regional distribution of hexazinone residues varied more widely between days for flag/load tasks than for application tasks. Flagger/loader DE to the face/neck, hands and legs varied between days by 18- to 27-fold, while applicator DE to these regions varied by only 5- to 6-fold. For both tasks, upper body exposure showed the least between-day variation, with a 6-fold range for flagger/loaders and a 2-fold range for applicators. Workers performing flag/load tasks received approximately 25% of mean applicator DE to the face/neck, hands, and legs, (summary section, range = 2.75 - 8.62 mg vs. 10.3 mg - 36.59 mg, respectively), while receiving only 6% of mean applicator DE to the upper body (15.58 mg vs. 253.53 mg, respectively). Mean flagger/loader DE (31.8 mg) was approximately equal to the amount that applicators collected on the hands alone (36.59 mg). PIE varied by up to 1000-fold between days. Within monitoring days, applicator PIE was 2 - 54 times greater than that of flagger/loaders.

Figure 1 (16) Figure 1 provides a graphical interpretation of the Summary section of Table IV with the distribution of both regional DE and PIE presented as components of potential exposure. The respective

task pie charts are proportional to mean hexazinone residues. Applicator exposure was predominantly to the upper body (mean ~ 75%). The hands, legs and face/neck each contributed between 3.0% - 10.7% (10.3 - 36.6 mg). Overall, flagger/loader exposure was only 10% of applicator exposure (33 mg vs. 341 mg), with the upper body contributing an average of about 50% (15.58 mg) and the legs, hands and face/neck each contributing about 8% - 26% (approximately 3 - 9 mg). Applicator PIE contributed more to potential exposure than did flagger/loader PIE (6.63% vs. 2.48%, respectively). PIE represented approximately 2.5% of flagger/loader potential exposure and about 6.6% of applicator potential exposure.

Table V Table V presents the data from the DE and PIE columns of Table IV, to better examine their variability. Arithmetic daily means for the entire crew (All Workers, with SD and CV), all applicators (Apply), and all flagger/loaders (Flag/Ld) are given. Crew DE was nearly 15 times greater than PIE (271.89 mg vs. 19.80 mg, respectively). Intraday crew exposures varied by about 50- to 100-fold, with the greatest variation seen for PIE on 10/28/94 (CV = 123). As noted previously, applicator DE averaged about 10 times the DE of flagger/loaders (318.27 mg vs. 31.83 mg) and applicators received about 28 times the PIE of flagger/loaders (22.61 mg vs. 0.81 mg). Both DE and PIE showed a similar greater variation for applicators compared to flagger/loaders. Mean daily exposures for both tasks were log-normally distributed. This is related to the larger variation in exposures among days compared to the variation within days. For example, while DE for all workers varied by no more than about 100% on any one day (CV = 52 - 103), mean applicator DE across all days varied by about 200% (arithmetic mean = 318.27 mg $\pm$ 601.79 mg). There was an 80-fold difference in crew DE (all workers) between the lowest and highest exposure days (Site 1, 10/09/93 vs. Site 3, 10/26/94), while PIE varied by nearly 1000-fold for the same two study days. On the highest exposure day, hexazinone dust was present in unusual amounts (mean DE = 1668.85 mg). There was visible dustiness in the air and workers, USFS staff and study staff all noted ill effects from the presence of excessive dust, including irritation and burning sensations of the nose, mouth and lungs. The workers coughed and spat to clear the dust from their lungs; several workers had a noticeable layer of gray dust on their clothes and faces. USFS halted the applications several times to determine and ameliorate the cause of the excessive dustiness. Halting the applications brought immediate relief from the irritant effects. None of the Pronone® 10G bags contained visibly deteriorated granules, yet the dustiness and accompanying irritation persisted upon resumption of use. Additional samples from each lot of Pronone® 10G applied were tested for total dust and found to contain between 0.3 - 0.4% dust, which was within manufacturer specifications (21). The cause of the excessive dustiness was not determined. However, as a protective measure, the USFS now requires that when dustiness is noted, use of the affected lot of Pronone® 10G be discontinued (22).

Intermittent excessive dustiness was noted on five other days; one additional day at Site 1 (10/08/93), all days at Site 2, (10/21/93, 10/22/93, 10/25/93), and one day at Site 3 (10/28/94). During these five days, dustiness during application was noted, as were the taste and smell of hexazinone, but workers were not visibly coated with dust, nor were more severe effects such as coughing and spitting noted. While the dustiness was less intense compared to conditions on 10/09/93, DE was nonetheless considerably greater on dusty days compared to days where no dustiness occurred. Exposures for the six dusty days

Figure 1. Mean Potential Exposure (PE): Regional Dermal Exposure (DE) and Inhalation Expsosure (PIE), by Task

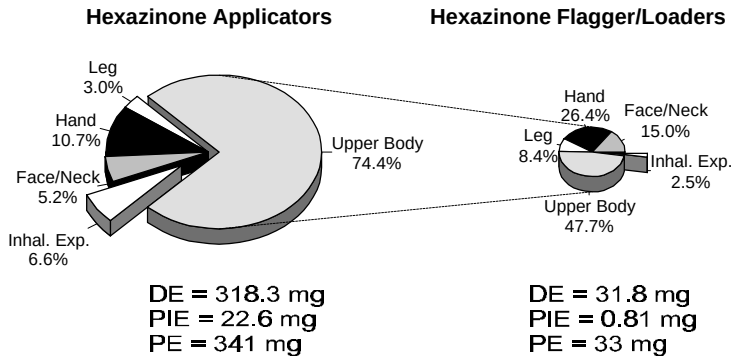


Table IV. Exposure Distribution: Mean[/a] Regional Dermal Exposure (DE), % Dermal Exposure and Potential Inhalation Exposure (PIE); by Day and Task

Date	Task (n)	Face/neck		Hand		Leg		Upper Body		DE	PIE
Site		mg	% DE	mg	% DE	mg	% DE	mg	% DE	mg	mg
10/07/93	All (10)	4.25	7.04	8.62	14.30	2.41	4.00	45.02	74.66	60.30	2.79
1	Apply (9)	4.61	6.94	9.34	14.07	2.62	3.95	49.82	75.04	66.39	3.09
	Flag/Load (1)	1.00	18.43	2.16	39.81	0.50	9.14	1.77	32.62	5.43	0.11
10/08/93	All (10)	10.83	3.65	17.21	5.80	5.80	1.96	262.86	88.60	296.69	23.23
1	Apply (9)	11.79	3.61	19.01	5.82	6.34	1.94	289.67	88.63	326.82	25.76
	Flag/Load (1)	2.13	8.32	0.92	3.59	0.95	3.70	21.60	84.39	25.60	0.48
10/09/93	All (9)	71.94	4.31	141.39	8.47	26.54	1.59	1428.98	85.63	1668.85	170.50
1	Apply (8)	79.68	4.27	158.66	8.50	28.67	1.54	1599.38	85.69	1866.38	191.21
	Flag/Load (1)	10.10	11.39	3.20	3.61	9.54	10.76	65.80	74.24	88.64	4.88
10/21/93	All (9)	9.36	4.12	15.92	7.00	20.86	9.18	181.09	79.70	227.22	4.18
2	Apply (8)	9.86	3.90	17.34	6.86	23.19	9.18	202.31	80.06	252.71	4.64
	Flag/Load (1)	5.30	22.69	4.53	19.39	2.23	9.56	11.30	48.37	23.36	0.52
10/22/93	All (10)	9.02	6.02	24.61	16.43	14.32	9.56	101.84	67.99	149.78	2.19
2	Apply (8)	9.85	5.52	28.52	15.98	17.05	9.56	123.04	68.94	178.47	2.50
	Flag/Load (2)	5.71	16.27	8.93	25.49	3.37	9.60	17.05	48.64	35.06	0.93
10/25/93	All (10)	41.13	11.46	81.57	22.74	21.86	6.09	214.17	59.70	358.72	11.87
2	Apply (8)	48.40	11.30	96.28	22.48	24.15	5.64	259.49	60.58	428.31	14.26
	Flag/Load (2)	12.04	14.97	22.75	28.30	12.70	15.80	32.90	40.92	80.38	2.31
10/26/94	All (11)	1.51	7.53	5.08	25.41	0.39	1.93	13.03	65.13	20.00	0.18
3	Apply (10)	1.57	7.35	5.14	24.04	0.42	1.97	14.25	66.64	21.38	0.20
	Flag/Load (1)	0.86	13.74	4.51	72.49	0.04	0.57	0.82	13.21	6.22	0.05
10/27/94	All (12)	4.51	8.87	11.79	23.22	0.87	1.71	33.61	66.20	50.78	0.68
3	Apply (10)	5.16	8.74	13.15	22.25	1.01	1.71	39.78	67.30	59.10	0.80
	Flag/Load (2)	1.21	13.24	4.99	54.57	0.15	1.62	2.79	30.56	9.14	0.11
10/28/94	All (12)	6.95	5.94	22.10	18.90	2.65	2.27	85.19	72.88	116.89	1.19
3	Apply (10)	8.09	5.87	25.59	18.57	3.15	2.28	101.00	73.28	137.83	1.40
	Flag/Load (2)	1.23	10.09	4.63	37.97	0.18	1.46	6.16	50.48	12.21	0.14
11/28/95	All (6)	4.95	18.47	6.58	24.57	1.10	4.11	14.16	52.85	26.79	0.40
4	Apply (4)	6.73	19.13	7.86	22.37	1.62	4.62	18.95	53.88	35.16	0.55
	Flag/Load (2)	1.39	13.85	4.02	39.96	0.05	0.53	4.59	45.67	10.05	0.10
11/29/95	All (6)	14.30	19.67	21.50	29.57	4.90	6.74	31.99	44.01	72.69	0.57
4	Apply (4)	16.31	19.30	22.10	26.16	7.21	8.54	38.85	45.99	84.46	0.74
	Flag/Load (2)	10.29	20.94	20.30	41.30	0.27	0.56	18.28	37.20	49.16	0.24
Summary: All Tasks (mg)											
All (105)		15.75	5.79	32.06	11.79	9.08	3.34	215.00	79.08	271.89	19.80
Apply (88)		17.84	5.61	36.59	11.50	10.30	3.24	253.53	79.66	318.27	22.61
Flag/Load (17)		4.89	15.36	8.62	27.08	2.75	8.63	15.58	48.94	31.83	0.81

/a Calculations based on individual exposures; calculations from daily means will differ due to rounding.

are shaded in Table V. The highest exposure day (10/09/93) contributed approximately 50% to the arithmetic mean for DE and about 75% to the arithmetic mean for IE. The respective arithmetic and geometric W statistics for DE without the highest exposure day are 0.87 and 0.96 and for PIE, 0.66 and 0.97. This single day's exposure contributed greatly to the strength of the log-normal distribution for interday DE, while PIE was still strongly log-normal without the dusty day.

Table VI Using Table V arithmetic means for DE and PIE for applicators and flagger/loaders, Table VI moves from external exposure to absorbed dosage, and shows the mean amounts and percentages contributed by dermal and inhalation routes to EAD. It presents the grand means (± SD), by task, for the dermal component of absorbed dosage (absorbed $dosage_D$; 10% of DE/kg body weight), IE (50% of PIE/kg body weight), and EAD (absorbed $dose_D$ + IE). Mean applicator EAD was about 12 times greater

Table V. Mean Daily Hexazinone Dermal Exposure (mg) and Potential Inhalation Exposure (mg)
For All Workers (± SD and CV), All Applicators (Apply), and All Flagger/Loaders (Flag/Ld)

		Dermal Exposure				**Potential Inhalation Exposure**			
Date (Site)	N	All Workers	CV	Apply	Flag/Ld	All Workers	CV	Apply	Flag/Ld
10/07/93 (1)	10	60.30 ± 47.53	78.8	66.39	5.43	2.79 ± 2.73	97.8	3.09	0.11
10/08/93 (1)	10	296.69 ± 235.47	79.4	326.82	25.60	23.23 ± 20.72	89.2	25.76	0.48
10/09/93 (1)	9	1668.85 ± 1140.08	68.3	1866.38	88.64	170.50 ± 130.27	76.4	191.21	4.88
10/21/93 (2)	9	227.22 ± 234.07	103.0	252.71	23.36	4.18 ± 3.78	90.2	4.64	0.52
10/22/93 (2)	10	149.78 ± 141.76	94.6	178.47	35.06	2.19 ± 1.22	55.8	2.50	0.93
10/25/93 (2)	10	358.72 ± 257.84	71.9	428.31	80.38	11.87 ± 10.76	90.7	14.26	2.31
10/26/94 (3)	11	20.00 ± 12.57	62.9	21.38	6.22	0.18 ± 0.12	65.9	0.20	0.05
10/27/94 (3)	12	50.78 ± 29.94	59.0	59.10	9.14	0.68 ± 0.53	78.0	0.80	0.11
10/28/94 (3)	12	116.89 ± 97.91	83.8	137.83	12.21	1.19 ± 1.48	123.8	1.40	0.14
11/28/95 (4)	6	26.79 ± 19.34	72.2	35.16	10.05	0.40 ± 0.31	78.3	0.55	0.10
11/29/95 (4)	6	72.69 ± 37.49	51.6	84.46	49.13	0.57 ± 0.37	64.0	0.74	0.24
Arithmetic Mean/b		271.89		318.27	31.83	19.80		22.61	0.81
W Statistic*		0.55		0.56	0.82	0.44		0.44	0.63
SD/b		475.10		601.79	31.33	50.47		56.57	1.48
Geometric Mean		121.38		140.00	20.56	2.58		3.07	0.33
W Statistic**		0.97		0.98	0.94	0.95		0.95	0.94

/a Estimated Absorbed Dosage = (Dermal Exposure/10) + (Potential Inhalation Exposure/2) for 10% dermal absorption and 50% inhalation uptake, 100% inhalation absorption
/b Arithmetic mean, SD From Table IV, Summary section, with calculations based on individual exposures. Calculations from daily means will differ.
* for normality test
** for log-normality test

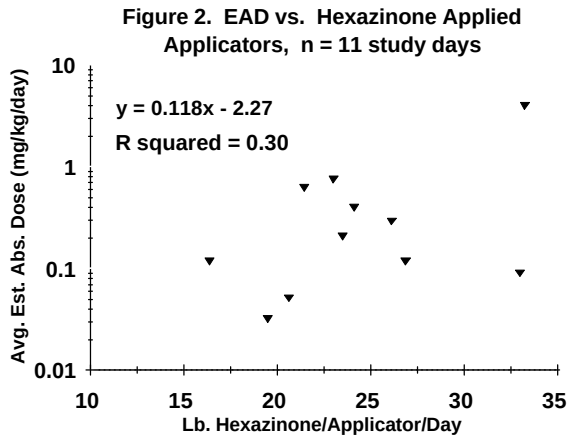
Table VI. Absorbed $Dosage_D$/a and Inhalation Exposure/b (IE) and Percent Contribution to Estimated Absorbed Dosage/c (EAD); Mean ± SD for all applicators (n = 88) and all flagger/loaders (n = 17)

Means	Applicators			Flagger/Loaders		
	Absorbed $Dosage_D$	IE	EAD	Absorbed $Dosage_D$	IE	EAD
Mean ± SD (mg/kg)	0.45 ± 0.44	0.16 ± 0.45	0.61	0.043 ± 0.04	0.006 ± 0.01	0.049
Mean % of EAD	73.8	26.2		87.8	12.2	

/a Table V: [(arithmetic mean DE for Apply and Flag/Ld)/10]/(kg body weight)
/b Table V: [(PIE for Apply and Flag/Ld) X 50% absorption X 100% uptake]/(kg body weight)
/c EAD = Dermal + Inhalation Exposure

than flagger/loader EAD (0.61 mg/kg vs. 0.049 mg/kg). Absorbed $dosage_D$ was the overwhelming contributor to EAD, representing 74.2% of EAD for applicators and 88.4% of EAD for flagger/loaders. IE of flagger/loaders provided a smaller contribution to EAD than that of applicators (12.2% vs. 26.2%, respectively).

Figure 2 (17) Figure 2 shows the plot of applicator EAD vs. daily mean hexazinone applied, with EAD plotted on a log scale so lower EAD values are more apparent. Total daily pounds hexazinone applied (Table III) were divided by the number of applicators for that day (Table IV). The regression of EAD on pounds applied was not significant (R^2 = 0.30). The regression of log(EAD) on pounds applied had an associated R^2 of 0.66.



Variance Components Analysis (19,20) Table VII presents the results of the variance components analysis for applicator EAD. The analysis showed that neither variability among the four sites ($p > 0.50$) nor variability among applicators ($p > 0.10$, $n = 88$) was significant. The variance of the site means, averaged over study days and workers, was small relative to the variability among days and workers. The variance of applicator EAD, averaged over study days, was small relative to the variability from [worker x day] interaction. Thus, there was not a tendency for some individuals to have consistently low, medium or high daily exposures. The relative exposure of each applicator on any two days varied less than the mean exposures for all applicators each day. Variance among study days was highly significant ($p < 0.001$), indicating that day-to-day changes in exposure levels overwhelm differences among sites or among individuals. Removing the extreme day, 10/09/93, from the analysis did not alter the outcome. There were insufficient flagger/loader data for a companion analysis.

Table VII. Variance Components Analysis for Hexazinone Applicator Estimated Absorbed Dosage[/a]

Source	DF	Type I Mean Square	F statistic	p value	Variance Estimate
Sites	3	53854.6	1.13[†]	> 0.50	311.8
Workers (within sites)	26	2794.2	1.3	> 0.10	223.4
Days (within Sites)	7	51658.6	24.0	< .001	6188
Error: workers x days (sites)	49	2149.7			2150

/a EAD (mg/kg/day)

[†] Quasi-F test with denominator $(0.9031)MS_{STUDY} + (0.9352)MS_{WORKER} - (0.8383)MS_{ERROR}$ (19)

Comparison with USFS Model Table VIII presents the daily mean EAD (mg/kg/day) for all workers and the USFS EIS estimates for realistic, conservative and worst case absorbed dosages, normalized for actual application rates. The final three columns show the magnitude of the mean study EAD relative to USFS estimates. Mean EAD ratios averaged 7.0, 3.6 and 2.8 times the model estimates for realistic, conservative case, and worst case exposures, respectively. Excluding the dustiest day's exposure (10/09/93) from the final three columns reduced the mean overall exposures by more than half, to 3.3, 1.7 and 1.3 times the USFS realistic, conservative and worst case estimates, respectively. Mean study EAD exceeded USFS estimates for 9 of 11 days for the realistic model, 8 days for the conservative model and 5 days for the worst case model.

Statistical Analysis of Observed Applicator EAD vs. USFS Estimates (18) The USFS EIS estimates for realistic, conservative and worst case exposures to hexazinone incorporated exposures associated with all work tasks and all formulated products containing hexazinone. In this study of exposure to granular hexazinone applied by belly grinder, applicators represented 90% or more of the crew personnel and had exposures far greater than did flagger/loaders. Thus, for this formulation and application equipment, it was appropriate to examine the model's predictive value for applicator vs. crew exposure. Table IX

Table VIII. Daily Means for Estimated Absorbed Dosage (EAD, mg/kg/day) vs. USFS Models: All Workers (n = 105)

Date	Mean App. Rate (lb/acre)	USFS Model (EAD, mg/kg/day)			Study EAD	Study EAD vs. USFS Models		
		Realistic	Conservative	Worst Case		EAD/R	EAD/C	EAD/WC
10/07/93	2.14	0.062	0.120	0.153	0.106	1.7	0.9	0.7
10/08/93	2.39	0.069	0.134	0.170	0.562	8.1	4.2	3.3
10/09/93	2.69	0.078	0.151	0.192	3.537	45.4	23.5	18.4
10/21/93	2.35	0.068	0.132	0.168	0.358	5.2	2.7	2.1
10/22/93	2.38	0.069	0.134	0.170	0.244	3.5	1.8	1.4
10/25/93	2.65	0.077	0.148	0.189	0.624	8.1	4.2	3.3
10/26/94	2.50	0.073	0.140	0.179	0.030	0.4	0.2	0.2
10/27/94	2.50	0.073	0.140	0.179	0.077	1.1	0.6	0.4
10/28/94	2.50	0.073	0.140	0.179	0.175	2.4	1.2	1.0
10/28/95	2.09	0.061	0.117	0.149	0.039	0.6	0.3	0.3
10/29/95	1.90	0.055	0.107	0.136	0.100	1.8	0.9	0.7
Mean	2.40	0.070	0.135	0.172	0.520	7.0	3.6	2.8

R= USFS Realistic model
C = USFS Conservative model
WC = USFS Worst Case model

Columns 3 - 5 present USFS EIS estimates, normalized to mean observed hexazinone application rate as follows:
Normalized USFS model = model estimate in mg/kg/day x (observed application rate/predicted application rate)
USFS Realistic estimate = 0.0653 mg/kg/day
USFS Conservative estimate = 0.1262 mg/kg/day
USFS Worst Case estimate = 0.2142 mg/kg/day

USFS model application rates = 2.25 lb/acre for Realistic and Conservative, 3.00 lb/acre for Worst Case

Example: EAD for 10/07/93, Realistic Case = 0.0653 mg/kg/day x (2.14 lb/acre/2.25 lb/acre) = 0.062 mg/kg/day

Column 6, Study EAD, adjusted for daily crew average of [each worker's exposure/each worker's weight (kg)].

presents the results for t-test analyses of intraday EAD for all workers (crew) and all applicators (apply). The table entry indicates whether the observed exposure was significantly different from the model and whether that difference was higher or lower than the predicted exposure. Conservative and worst case results are presented together since outcomes were identical. Crew EADs were significantly lower than predicted realistic exposures on one day, within model predictions for six days and greater than the model on four days. On 9 of the 11 study days, crew and applicator EADs had the same relative significance when compared with the USFS realistic model. However, applicator exposures exceeded the realistic model on 10/22/93 and 10/28/94, while overall crew EADs for the same days were within model predictions. For the conservative and worst case models, within-day EADs for both crew and applicators were lower than predicted on three days, did not differ significantly from the USFS models on five days and exceeded the models on three days. Thus, crew exposures were within the statistical limits of the model for the majority of the study days. Applicator EADs were statistically either below or within the USFS conservative and worst case model estimates for 8 of the 11 study days (exceeding the models 27% of the days), while exceeding the realistic model estimates six times (55% of study days). While EADs for most days were statistically equivalent to USFS estimates, exposures were often several times the predicted levels. For realistic and conservative exposure scenarios, EADs up to 5 times predicted levels did not differ significantly from the model. For worst case scenarios, EADs up to 3 times predicted levels were equivalent to the USFS model.

Table IX. Results of One-Sample t-test for EAD (mg/kg/day) vs. USFS Realistic, Conservative and Worst Case Models/a

	Realistic		Conservative and Worst Cases	
Date	Crew	Apply	Crew	Apply
10/07/93	0	0	0	0
10/08/93	+	+	+	+
10/09/93	+	+	+	+
10/21/93	+	+	0	0
10/22/93	0	+	0	0
10/25/93	+	+	+	+
10/26/94	-	-	-	-
10/27/94	0	0	-	-
10/28/94	0	+	0	0
10/28/95	0	0	-	-
10/29/95	0	0	0	0

/a USFS models normalized to observed application rates
one-sample t-test, two-tailed, $p \leq 0.05$ (18)
Crew: All Workers
Apply: Applicators Only
0 Not significantly Different from Model
+ Exposure Significantly Greater than Model
- Exposure Significantly Lower than Model

Figures 3 and 4 present mean daily EAD vs. USFS absorbed dosage estimates for applicators (n = 88) and flagger/loaders (n = 17), respectively (16). Data are ranked from lowest to highest daily EAD, with a study day label corresponding to each day's chronology among the 11 study days. Applicator EAD (Fig. 3) is plotted on a logarithmic scale to minimize the influence of the 100-fold variation in daily exposures. Applicator exposure exceeded the USFS realistic estimate on 9 study days and exceeded both the conservative model and worst case models on six days. Conversely, flagger/loader exposure was less than or equal to the realistic estimate on nine study days, and equaled or exceeded the conservative and worst case estimates on one day each.

Test Substance Twenty-five samples of ten lots of Pronone® 10G were analyzed for hexazinone. Expected recovery was 10% by weight. Mean recovery was 10.26% + 0.070% (102.62% of expected). Raw data are provided in Appendix I, Table 5.

Field Fortifications and Blanks The initial concentration of the field spiking solution was confirmed at 300 ppm hexazinone in September of 1993 (No. SS-518-1182C). This solution was used to prepare all 1993 field fortifications (Sites 1 and 2). A second solution was prepared and confirmed at 300 ppm in October, 1994 (No. SS-518-2164B). This latter solution was used to prepare both the 1994 and 1995 field fortifications (Sites 3 and 4). Its concentration was 98.4% of initial following the 1994 exposure monitoring at Site 3. The concentrations prior to and following the 1995 exposure monitoring at Site 4 were 95.5% and 95% of initial, respectively (286.5 ppm and 284.9 ppm, respectively), and recoveries for field fortifications conducted at Site 4 were adjusted. Recoveries for all other field fortifications were unadjusted. Recoveries for the stored field fortification wipes samples were 100.7% ± 9.7% (150.10 µg, n = 114) of expected and for the ambient field fortification samples, 99.6% ± 12.5% (148.38 µg, n = 114) of expected. Raw data are provided in Appendix I, Table 6. Hexazinone results for field blank samples are given in Table X; raw data are provided in Appendix I, Table 7. The highest detects occurred on the highest exposure days, 10/08/93, 10/09/93, and 10/28/94. While contamination is always a source of concern, the relative levels compared to hexazinone present on the exposure samples are minimal (0.01% - 0.63% of mean exposure sample recoveries, by matrix).

Figure 3 USFS vs. Study Estimated Absorbed Dosage (EAD)
Applicators

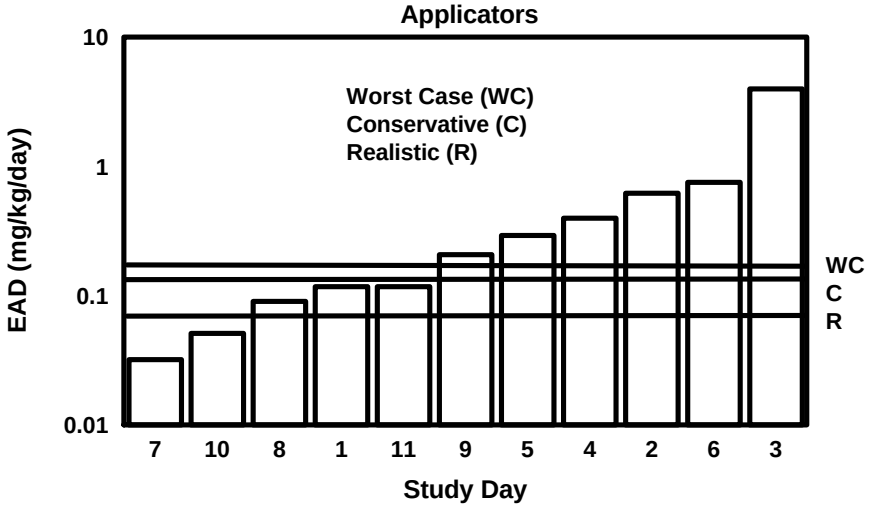


Figure 4 USFS vs. Study Estimated Absorbed Dosage (EAD)
Flagger/Loaders

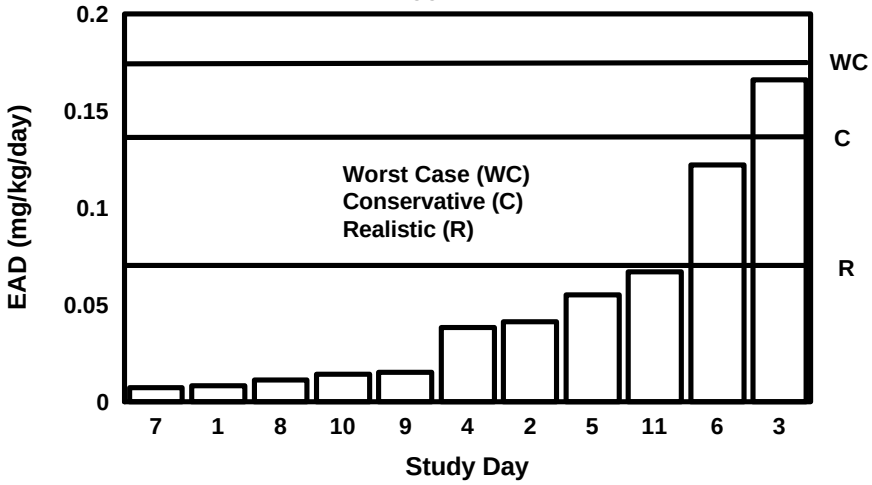


Table X. Hexazinone Results for Field Blank Samples (µg)

Matrix	N	No. with Detects ≥ LOD	Mean of Detects (µg)	Range of Detects (µg)	(Mean of Detects)/(Mean Exposure Sample Recoveries) X 100
Glass Fiber Filter	13	5	0.43	0.25 - 0.55	0.63%
Socks	13	3	9.39	6.75 - 12.2	0.12%
T-shirt	13	9	27.1	11.2 - 51.5	0.01%
Wipes	11	2	29.9	9.64 - 50.2	0.16%

Storage Stability Average recoveries from stored, fortified samples were as follows: glass fiber filters, 97.04% (19.41 µg); socks, 97.63% (195.27 µg); T-shirts, 92.37% (184.74 µg); wipes, 91.69% (183.38 µg). All exposure samples were analyzed within 30 weeks; data were not adjusted for recoveries. Raw data are provided in Appendix I, Table 8.

DISCUSSION AND CONCLUSIONS

Granular Formulations The use of granular herbicides in forest applications differs in several respects from traditional agricultural spraying. Each of these variables may contribute to higher exposures to the forest applicator. Granular formulations have a propensity for generating small-sized particles (fines) and differ from the majority of agricultural sprays, which are liquid formulations. The use of the belly grinder places the worker, especially the torso region, in closer proximity to the herbicide than do enclosed cabs, tractors or spray wands. Unlike agricultural applicators, whose tasks are primarily sedentary, forest herbicide applicators walk continuously and rapidly throughout the workday. While constantly turning the hand crank to release granules, the worker must negotiate around or over obstacles such as trees, slash piles, logs, thorny weeds, gopher holes, and rocks, often hiking through regions with up to 20% grade. Workers are thus not only walking over the area just treated, but are doing so at an aerobic pace, with body movements not required of traditional agricultural workers.

Dermal Exposure (DE) Historically, the hands have been the largest contributors to DE for pesticide handlers, even when gloves are worn (23). Here, the hands contributed only 11.5% to applicator DE while the upper body exposure contributed approximately 80% (~ 254 mg; summary section of Table IV). Flagger/loader DE was about 10% of applicator DE, with the upper body contributing about 50% (~ 16 mg). This suggests that use of the belly grinder alone (task) is the primary determinant of the magnitude and distribution of DE. There are few studies investigating the exposure potential of belly grinders. Weisskopf, et al. (1988), evaluated dermal and respiratory exposure of 15 workers applying granular diazinon with several types of broadcast spreaders commonly used by lawn maintenance and/or residential applicators (24). Six applicators used a belly grinder between 6 and 29 minutes during the workday. Her data indicated that the best predictors of diazinon exposure were task (applicator vs. flagger/loader) and use of the belly grinder spreaders. Similarly, Wolfe et al. (1974) found that applicators hand dispersing fenthion granules received three times the potential DE of hand gun and backpack sprayer applicators using liquid formulations of fenthion (25).

Weisskopf, extrapolating upper back and chest patch residues to the head region, found the head received the greatest exposure (24). The use of face/neck wipes in our study allowed direct measurement of skin residues. Study data indicated this region is minimally exposed, contributing an average of 6% to DE (summary section, Table IV, all workers). Fenske (1990), in studies of orchard and greenhouse applications, found that torso patches were inconsistent predictors of head exposure (26). When he measured head exposure directly, the magnitude of the residues was dependent on worker activity and type of application.

Clothing Penetration When no additional clothing was worn over the study T-shirt, 10% of the residues were assumed to penetrate the T-shirt and be available for dermal absorption (4). This adjustment was made for 18 workers throughout the study, but often pertained to only one or two workers each study day. The small size of this group in combination with the wide variation in observed interday dermal exposures prevented calculation of a study-specific penetration rate. However, a subjective comparison of within-day T-shirt residues for the single vs. multiple shirt groups suggests that a single layer of clothing likely provides only 2 - 3-fold protection rather than the 10-fold protection assumed by the default rate. The default value was developed from studies of traditional pesticide applicators, generally involving liquid formulations, large spray equipment, and a sedentary applicator. Formulation and application equipment may each contribute to higher penetration rates for forest applicators. The clothing penetration rate for forest applicators using granular products and a belly grinder appears to be closer to the 25% rate assumed for harvesters (27). The forest applicator, like the harvester, is in continual motion throughout the workday. The ergonomics of this application task may encourage increased residue penetration through clothing (28).

Estimated Absorbed Dosage (EAD) One strength of the USFS EIS was that estimated exposures were directly compared to observed exposures on a day-by-day basis. No further extrapolations of the data were necessary once EAD was calculated. Had the comparison instead been based on statistically significant differences between observed and predicted dosages, observed exposures of up to five times greater than estimated exposures would have been equivalent to predicted exposures (Table IX).

Study EAD was calculated using 10% dermal absorption, the same value used in the USFS EIS exposure models. In conducting exposure assessments, DPR uses a default dermal absorption of 50% for pesticides (29). EAD would thus be about 5 times greater than when calculated using 10% dermal absorption and the relative contribution of IE to EAD would be similarly reduced (Table VI). While not affecting the magnitude of IE, the dermal absorption value will have a large effect on the relative influence of IE as a component of absorbed dosage. Absorption studies in humans yield more appropriate dermal absorption values than do animal studies, but human data are not available for most pesticides.

Exposure databases such as the Pesticide Handlers Exposure Database (PHED) require observed exposures to be normalized to a variable, preferably total lb a.i. handled, before using the model to generate exposure assessments (30). Observations from this study indicate that, while belly grinder exposure can be quite high as a function of amount handled, amount of hexazinone handled is a poor indicator of exposure (Figure 2, R^2 for EAD vs. lb applied = 0.30). Generic databases such as PHED were developed from agricultural exposure scenarios and generally report hand application data from studies of liquid and wettable formulations applied by tractor-mounted or backpack sprayer.. The use of granular formulations and belly grinders are uncommon in agriculture and may contribute to exposures which do not lend themselves to standard analyses.

Mean applicator EAD was 0.61 mg/kg/day (Table VI). To compare this dosage to that found in Weisskopf's study, we adjusted her data for 10% dermal absorption and an average 70 kg worker body weight, then normalized both data sets for application time and rate. Mean normalized EAD for hexazinone applicators was about 2.5 times the calculated EAD for diazinon applicators (0.0024 mg/kg/min vs. 0.0015 mg/kg/min) (24). Given that dermal data generally varies by at least 100%, these data are in remarkably good agreement.

Inhalation Exposure Hexazinone inhalation exposure supplied an average of 26% to mean applicator EAD, thus contributing substantially to dosage (Table VI). In the Weisskopf study, IE provided an average of 39% to mean calculated EAD, with the larger contribution likely related to a higher vapor pressure for diazinon compared to hexazinone (24). Weisskopf noted that respiratory exposures for some workers using the belly grinders approached the threshold limit value (TLV®) for diazinon of 0.1 mg/m^3 for a time-weighted average (TWA) 8-hour day, 40-hour work week. There is no TLV® established for exposure to hexazinone. However, IE on the dustiest day (95.6 mg for applicators) approached the TLV® TWA of 10 mg/m^3 for nuisance particulates (100 mg, assuming an inspired air volume of 10 m^3 for the workday) (31). The glass fiber filters trapped particulates assumed to be respirable, i.e., those smaller than 15 μm. Recent data indicate that most inhalable particulates have masses ranging from 20 - 100 μm (32). Studies also show that the closed-faced 37 mm samplers used

in this study strongly undersample inspirable aerosols with masses greater than 20 μm (33). Thus, while our samplers probably captured the mass of hexazinone particulates that would reach the deep lung (respirable mass), they may have underestimated the mass of particulates that entered the respiratory system, but were trapped in either the nose, mouth, or thorax. The burning sensations felt in the mouth, nose and throat on the dusty days, as well as the coughing and spitting observed for the dustiest day suggest that significant quantities of hexazinone particulates larger than those measured (> 20 μm) can enter the respiratory airways during extreme exposures and have pronounced irritant effects.

Several investigators have reported higher inhalation exposures for granular vs. liquid formulations, and for belly grinders compared to other application equipment. Hayes et al. (1980) reported 12-fold greater respiratory exposures for belly grinder users vs. other applications (100 $\mu g/m^3$ vs. 8 $\mu g/m^3$) (34). Freeborg et al. (1985) reported 5-fold greater respiratory exposures for workers using a 5% granular diazinon formulation applied by rotary spreader vs. a liquid formulation applied by spray gun (26 μg/hr vs. 5 μg/hr) (35). Dermal exposures were also higher for workers using the granular formulation. Knarr et al. (1985) found 10-fold greater respiratory exposures associated with loading granular Ordram® (8.8 mg/kg/day vs. 0.5 mg/day for liquid Ordram) (36). Wolfe et al. (1974) found 4-fold greater respiratory exposures for applicators using a 1% granular vs. a liquid formulation of fenthion (0.09 vs. < 0.02 mg/hr) (25).

Margins of Exposure (MOE) Table XI presents the predicted MOE for systemic and reproductive effects for the three USFS EIS models (realistic, conservative and worst case) (1), adjusted for study application rate, and the observed MOE for all workers, all applicators and all flagger/loaders, using mean EAD values from Tables VI (applicators, flagger/loaders) and VIII (all workers). Figures 5 and 6 present this data graphically for applicators and flagger/loaders (16). An MOE of 100 is customarily used by risk managers as a prudent margin of safety. The predicted conservative and worst case exposure scenarios had associated MOE of less than 100 for systemic effects, but were expected to occur during no more than 5% of exposures (1). Instead, the mean MOE of 19.2 was dramatically lower than all of the USFS estimates.

Flagger/loader exposures had a mean MOE of 204, but the observed MOE for applicators was only 16.4. Predicted MOE for reproductive effects were between 285 and 700. The observed MOE for reproductive effects for applicators was 82, while the corresponding MOE for flagger/loader exposure was 1020. While the mean MOE is nearly 100, it is nonetheless three- to eight-fold less than the predicted MOE.

Table XI. Predicted[/a] vs. Observed[/b] Margins of Exposure (MOE) for Ground Applications of Hexazinone

MOE	Systemic	Reproductive
Predicted MOE		
Realistic	143	700
Conservative	74	360
Worst Case	58	285
Observed MOE		
Crew (n = 105)	19.2	96
Applicators (n = 88)	16.4	82
Flag/Load (n = 17)	204	1020

/a NOEL/USFS EIS MOE for each model, normalized to mean study application rate of 2.4 lb/acre (1)
/b NOEL/mean EAD; Applicator and Flag/Load EAD from Table VI, Crew EAD from Table VIII

The USFS model, developed from backpack sprayer studies of phenoxy herbicide applications, was a poor predictor of exposure to granular hexazinone. Hexazinone exposure appears to be distinctly associated with task and may be associated with application equipment. The EIS did not estimate exposures for applicators vs. flagger/loaders, but designed their models to encompass the range of likely exposures for all work tasks associated with backpack applications of hexazinone (1). Task-specific exposure assessments are generally considered to provide a more accurate basis for predicting and comparing exposures (4,5). The observed MOE are inherently conservative as they were calculated using the arithmetic means for EAD. As explained in Results, daily exposures were log-normally distributed and the highest exposure day contributed 50% to mean EAD. However, the MOE for systemic effects is unlikely to be greater than 100 even if adjusted for the apparent log-normal distribution of daily exposures. When developing exposure models based on surrogate data, consideration of the exposure potential of pesticide formulation, task and application equipment may improve their predictive value.

Figure 5 Margins of Exposure (MOE): Systemic
USFS vs. Study

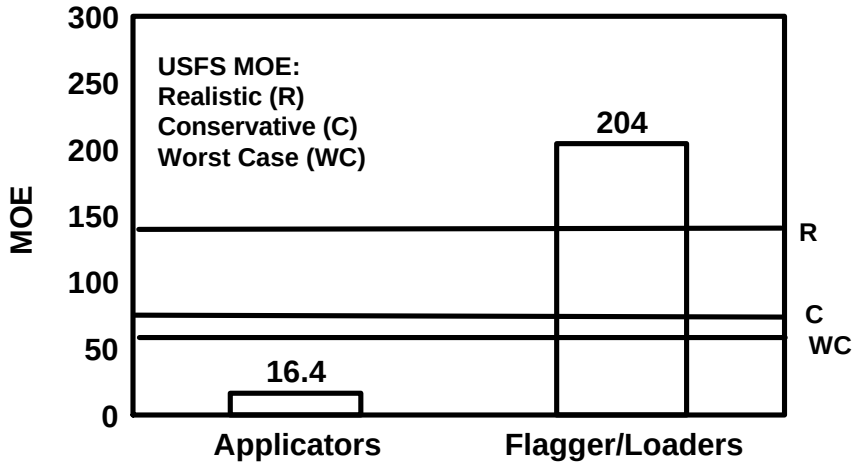
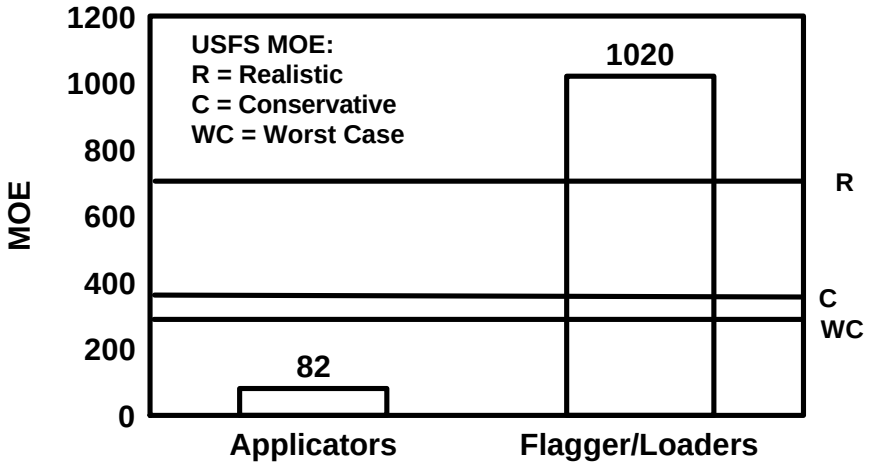


Figure 6 Margins of Exposure (MOE): Reproductive
USFS vs. Study



Exposure Mitigation Measures The USFS was responsive to the results of the exposure monitoring and implemented practices to mitigate excessive exposures as needed. They were very concerned about the high exposures associated with the dustiest days during the 1993 monitoring. Beginning in 1994, all application service companies contracting with the USFS received a written statement that when applications of Pronone® 10G are observed to be excessively dusty (visible dust and/or symptoms of exposure), the applications will cease until the product is replaced with a non-affected lot (22). Historically, excessive dustiness has not been a widespread problem with this product, but it has been observed sporadically. The cause has not been determined, and could result from various sources during manufacturing, packaging, transport, storage or handling.

When preliminary study results indicated that USFS EIS exposure estimates were typically exceeded, the USFS again looked for ways to mitigate exposures. In 1996, the USFS drafted a policy letter mandating additional clothing and respiratory protection for all workers who use belly grinders to apply Pronone® 10G (37). The policy stipulates that applicators must wear clean coveralls over their work clothing and a NIOSH-approved Type TC-21C dust/mist/fume respirator (or its equivalent). The coveralls are estimated to reduce dermal exposures by 10-fold and the respirators to reduce inhalation exposures by at least 5-fold (4,38). Observations of relative T-shirt residues for workers wearing a single vs. multiple shirts, described above, indicate that additional clothing may provide only two- to three-fold protection for this task and application equipment. Nonetheless, using applicator means given in Table VI and assuming the mitigation measures reduce absorbed dose by at least 2.5-fold and inhalation exposure by 5-fold, EAD for a 70-kg applicator would be reduced by about 65%, from 0.61 mg/kg to 0.21 mg/kg. The associated MOE for applicators would increase by about 3-fold over those observed for this study (Table XI). Thus, the MOE for systemic effects would increase from 16.4 to about 50 and, for reproductive effects, from 82 to about 235. The MOE associated with systemic effects would approximate the USFS estimate of 57 for worst case exposures.

The use of the PPE mandated by USFS is expected to reduce applicator exposures and is an appropriate interim measure while permanent engineering controls are developed. Ideally, good workplace hygiene is achieved by establishing engineering and administrative controls to make the workplace safer, rather than relying on PPE to prevent exposure. The physical demands of forest applications make the use of respirators unduly burdensome for workers. The required additional clothing is inconvenient at best and, at worst, may increase the risk of worker illness or injury due to heat stress (39). Permanent exposure mitigation could be achieved by locating existing granular hexazinone formulations which control for particle sizes smaller than 100 μm or by reformulating Pronone® 10G. This would eliminate the need for additional respiratory protection. Once this has been accomplished, monitoring studies may indicate whether these measures reduce dermal exposures so that additional clothing is not required. In light of the low observed MOE for both systemic and reproductive effects, it is important to conduct further exposure monitoring studies to confirm that both the interim mitigation measures and product reformulation, when achieved, do indeed reduce exposures to levels predicted by WH&S.

ACKNOWLEDGMENTS

The authors wish to thank the following individuals and groups whose cooperation, patience and dedication made this study possible: the management and staff at California Department of Food and Agriculture, Center for Analytical Chemistry, Worker Health and Safety Branch; USFS Foresters and Silvaculturists and their staff at each of the monitoring sites: Tina Minter (Eldorado National Forest, Amador Ranger District), Bob Norris (Eldorado National Forest, Pacific Ranger District), Rich Coakley (Lassen National Forest, Hat Creek District) and Lauren Payne (Lassen National Forest, Almanor Ranger District); and the twenty-nine participating workers, whose assistance and goodwill are deeply appreciated.

REFERENCES

1. Final Environmental Impact Statement, Vegetation for Reforestation, Vol. II. and III (1988). USDA Forest Service, Pacific Southwest Region, 630 Sansome St., San Francisco, California 94111
2. Information Systems Branch, Pesticide Use Report, Annual 1994, Indexed by Chemical (1996) Cal/EPA, Department of Pesticide Regulation, Sacramento, California, 95814
3. U. S. Environmental Protection Agency (1989) 40 CFR Part 160, FIFRA, Good Laboratory Practice Standards
4. Thongsinthusak, T., Ross, J. H. and D. Meinders (1993) Guidance for the Preparation of Human Pesticide Exposure Assessment Documents. Cal/EPA, Department of Pesticide Regulation, Worker Health and Safety Branch, HS-1612
5. U. S. Environmental Protection Agency (1987) Pesticide Assessment Guidelines, Subdivision U, Applicator Exposure Monitoring. No. PB87-133286. National Technical Information Service, Springfield, Virginia
6. Ross, J. H., Friend, S., Meinders, D. D. and R. I. Krieger (1992) Full Committee Review Process, Committee on Human Research, University of California, San Francisco. Cal/EPA, Department of Pesticide Regulation, Worker Health and Safety Branch, HS-1619
7. SKC, Inc. (1996) Comprehensive Catalog and Guide, P.O. Box 4133, Fullerton, California, 92634-4133
8. Kurz Instruments, Inc. (1980) P. O. Box 849, Carmel Valley, California 93924
9. Wolfe, H. R., Durham, W. F. and J. F. Armstrong (1967) Exposure of Workers to Pesticides. Arch. Environ. Health 14:622-633
10. Edmiston, S., Spencer, J., Orr, K., Cowan, C. and S. Margetich (1995) Exposure of Herbicide Handlers in the Caltrans Vegetation Control Program, 1993-1994. Cal/EPA, Department of Pesticide Regulation, Worker Health and Safety Branch, HS-1700
11. Schneider, F. A., Spencer, J. R., Bissell, S. R. and S. Margetich (1989) Field Worker Exposure to Chlorothalonil While Picking Bush Grown Tomatoes in Stanislaus County, California. Cal/EPA, Department of Pesticide Regulation, Worker Health and Safety Branch, HS-1462
12. Lydon, J., Engelke, B. F. and C. S. Helling (1991) Simplified High-Performance Liquid Chromatography Method for the Simultaneous Analysis of Tebuthiuron and Hexazinone. J. Chromatog. 536:223-228
13. Microsoft® Access™, Relational Database Management System for Windows™, Version 2. Microsoft Corp., Redmond, Washington, 98052
14. Arkin H. and R. R. Colton (1970) Statistical Methods, College Outline Series, 5th Ed. Barnes and Noble, Inc., New York
15. Dong, M. (1993) Program for Arithmetic/Geometric Mean and for (Log)normality (DOS) based on Shapiro and Wilk (1965), Biometrika 52:591. Cal/EPA, Department of Pesticide Regulation, Worker Health and Safety Branch
16. Harvard Graphics® 4.0 for Windows® 95, Software Publishing Corp., 3165 Kifer Road, P.O. Box 54983, Santa Clara, California, 95056-0983
17. Quattro® Pro, Version 5.0 for Windows®, 1993. Borland International, Inc., P. O. Box 660001, Scotts Valley, California, 95067
18. Microsoft® Excel™ Spreadsheet with Business and Graphics Database, Version 4. Microsoft Corp., Redmond, Washington, 98052
19. Neter, J., Wasserman W., and M. H. Kutner. (1985) Applied Linear Statistical Models: Regression, Analysis of Variance and Experimental Designs, 2nd Ed. Richard D. Irwin, Inc.
20. Powell, Sally (1996) memo, Analysis of Applicator Data from Project 9303: Exposure to Hexazinone in Forest Settings. Department of Pesticide Regulation, Worker Health and Safety Branch
21. Scott Johnson (1993), personal communication, Wilbur-Ellis Co., Western Division, Manteca, California
22. Sprague, G. L. (1993), letter to Forest Supervisors, reply to File Code 2150 letter, Pronone (Pelletized Hexazinone) Use Policy. USFS, Pacific Southwest Region
23. Maddy, K. T., Wang, R. G. and C. K. Winter (1984) Dermal Monitoring of Mixers, Loaders, and Applicators of Pesticides in California. Cal/EPA, Department of Pesticide Regulation, Worker Health and Safety Branch, HS-1069
24. Weisskopf, C. P., Seiber, J. N., Maizlish, N. and M. Schenker (1988) Personnel Exposure to Diazinon in a Supervised Pest Eradication Program. Arch. Environ. Contam. Toxicol. 17:201-212

25. Wolfe, H. R., Armstrong, J. F. and W. F. Durham (1974) Exposure of Mosquito Control Workers to Fenthion. Mosquito News, 34:3, 263-267
26. Fenkse, Richard A. (1990) Nonuniform Dermal Deposition Patterns During Occupational Exposure to Pesticides. Arch. Environ. Contam. Toxicol. 19:332-337
27. Brodberg , R. K. and J. R. Sanborn (1996) Compilation of Clothing Penetration Values: Harvesters. Cal/EPA, Department of Pesticide Regulation, Worker Health and Safety Branch, HS-1652
28. Fenske, R. A. (1988) Comparative Assessment of Protective Clothing Performance by Measurement of Dermal Exposure During Pesticide Applications. Appl. Ind. Hyg. 3:7, 207-213
29. Donahue, J. M. (1996) memo, Revised Policy on Dermal Absorption Default for Pesticides. Cal/EPA, Department of Pesticide Regulation, Worker Health and Safety Branch
30. PHED (1995) The Pesticide Handlers Exposure Database, Developed by Versar, Inc., Springfield Virginia
31. ACGIH®, (1996) Threshold Limit Values and Biological Exposure Indices for Chemical Substances and Physical Agents. ACGIH®, Cincinnati, Ohio
32. ACGIH®, (1985) Particle Size-Selective Sampling in the Workplace: Report of the ACGIH® Technical Committee on Air Sampling Procedures. American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio, p 5
33. Vincent, J. H. (1995) Aerosol Science for Industrial Hygienists. Pergamon, Elsevier Science, Ltd. , Tarrytown, New York, pp 278 - 279
34. Hayes, A. L., Wise, R. A. and F. W. Weir (1980) Assessment of Occupational Exposure to Organophosphates in Pest Control Operations. Am. Ind. Hyg. Assoc. J. 41, 568-575
35. Freeborg , R. P., Daniel, W. H. and V. J. Konopinski (1985) Applicator Exposure to Pesticides Applied to Turfgrass. In: Honeycutt, R. C., Zweig, G. and N. N. Ragsdale (eds) Dermal Exposure Related to Pesticide Use. American Chemical Society, Washington, DC, pp 139-161
36. Knarr, R. D., Cooper, G. L., Brian, E. A., Kleinschmidt, M. G., and D. G. Graham (1985) Worker Exposure During Aerial Application of a Liquid and Granular Formulation of Ordram® Selective Herbicide to Rice. Arch. Environ. Contam. Toxicol. 14:523-527
37. Sprague, G. L. (1996) USFS, Pacific Southwest Region, Draft letter to Forest Supervisors, File Code 2150, Herbicide Use Policy - Pronone (Granular Hexazinone)
38. NIOSH, (1987) NIOSH Respirator Decision Logic. Developed by the National Institute for Occupational Safety and Health Respiratory Protection Committee, Cincinnati, Ohio, Publication No. 87-108
39. Nigg, H. N., Stamper, J. H., Easter, E. and J. O. DeJonge (1992) Field Evaluation of Coverall Fabrics: Heat Stress and Pesticide Penetration. Arch. Environ. Contam. Toxicol. 23:281-288

Appendix I, HS-1750: Exposure of Hand Applicators to Granular Hexazinone in Forest Settings, 1993 - 1995

Table 1 Dermal and Inhalation Raw Data (mg Hexazinone)

Date Collected	Worker Ref. Number	Sample Type	Result	Units
10/7/93	1	Faceneck Wipe	6.88	mg
10/7/93	1	GFFilter	0.458	mg
10/7/93	1	Handwipe	23.7	mg
10/7/93	1	Socks	0.811	mg
10/7/93	1	T-shirt	112	mg
10/7/93	2	Faceneck Wipe	1.51	mg
10/7/93	2	GFFilter	0.352	mg
10/7/93	2	Handwipe	1.68	mg
10/7/93	2	Socks	0.884	mg
10/7/93	2	T-shirt	39.4	mg
10/7/93	3	Faceneck Wipe	9.76	mg
10/7/93	3	GFFilter	0.394	mg
10/7/93	3	Handwipe	12.2	mg
10/7/93	3	Socks	2.05	mg
10/7/93	3	T-shirt	43.9	mg
10/7/93	4	Faceneck Wipe	1.85	mg
10/7/93	4	GFFilter	0.24	mg
10/7/93	4	Handwipe	4.37	mg
10/7/93	4	Socks	11	mg
10/7/93	4	T-shirt	14.1	mg
10/7/93	5	Faceneck Wipe	4.24	mg
10/7/93	5	GFFilter	0.897	mg
10/7/93	5	Handwipe	11.3	mg
10/7/93	5	Socks	0.434	mg
10/7/93	5	T-shirt	124	mg
10/7/93	6	Faceneck Wipe	5.91	mg
10/7/93	6	GFFilter	1.26	mg
10/7/93	6	Handwipe	12.9	mg
10/7/93	6	Socks	1.63	mg
10/7/93	6	T-shirt	57	mg
10/7/93	7	Faceneck Wipe	3.41	mg
10/7/93	7	GFFilter	0.157	mg
10/7/93	7	Handwipe	8	mg
10/7/93	7	Socks	2.33	mg
10/7/93	7	T-shirt	16.3	mg
10/7/93	8	Faceneck Wipe	1	mg
10/7/93	8	GFFilter	0.0159	mg
10/7/93	8	Handwipe	2.16	mg
10/7/93	8	Socks	0.451	mg
10/7/93	8	T-shirt	1.77	mg
10/7/93	9	Faceneck Wipe	3.03	mg
10/7/93	9	GFFilter	0.132	mg
10/7/93	9	Handwipe	5.93	mg
10/7/93	9	Socks	1.88	mg
10/7/93	9	T-shirt	23.1	mg
10/7/93	10	Faceneck Wipe	4.88	mg
10/7/93	10	GFFilter	0.0947	mg
10/7/93	10	Handwipe	3.97	mg
10/7/93	10	Socks	0.443	mg
10/7/93	10	T-shirt	18.6	mg
10/8/93	1	Faceneck Wipe	13.28	mg
10/8/93	1	GFFilter	5.16	mg
10/8/93	1	Handwipe	18.7	mg
10/8/93	1	Socks	1.9	mg
10/8/93	1	T-shirt	225	mg
10/8/93	2	Faceneck Wipe	2.67	mg
10/8/93	2	GFFilter	1.29	mg
10/8/93	2	Handwipe	1.95	mg
10/8/93	2	Socks	2.9	mg

Appendix I, HS-1750: Exposure of Hand Applicators to Granular Hexazinone in Forest Settings, 1993 - 1995

Table 1 Dermal and Inhalation Raw Data (mg Hexazinone)

Date Collected	Worker Ref. Number	Sample Type	Result	Units
10/8/93	2	T-shirt	135	mg
10/8/93	3	Faceneck Wipe	9.52	mg
10/8/93	3	GFFilter	1.12	mg
10/8/93	3	Handwipe	9.9	mg
10/8/93	3	Socks	1.62	mg
10/8/93	3	T-shirt	57.8	mg
10/8/93	4	Faceneck Wipe	3	mg
10/8/93	4	GFFilter	1.37	mg
10/8/93	4	Handwipe	6.09	mg
10/8/93	4	Socks	4.63	mg
10/8/93	4	T-shirt	42.2	mg
10/8/93	5	Faceneck Wipe	5.82	mg
10/8/93	5	GFFilter	1.85	mg
10/8/93	5	Handwipe	8.29	mg
10/8/93	5	Socks	1.65	mg
10/8/93	5	T-shirt	499	mg
10/8/93	6	Faceneck Wipe	9.86	mg
10/8/93	6	GFFilter	9.92	mg
10/8/93	6	Handwipe	15.6	mg
10/8/93	6	Socks	6.76	mg
10/8/93	6	T-shirt	443	mg
10/8/93	7	Faceneck Wipe	17.8	mg
10/8/93	7	GFFilter	3.21	mg
10/8/93	7	Handwipe	74.1	mg
10/8/93	7	Socks	23.2	mg
10/8/93	7	T-shirt	452	mg
10/8/93	8	Faceneck Wipe	35.5	mg
10/8/93	8	GFFilter	2.92	mg
10/8/93	8	Handwipe	26.1	mg
10/8/93	8	Socks	2.4	mg
10/8/93	8	T-shirt	592	mg
10/8/93	9	Faceneck Wipe	8.68	mg
10/8/93	9	GFFilter	7.78	mg
10/8/93	9	Handwipe	10.4	mg
10/8/93	9	Socks	6.83	mg
10/8/93	9	T-shirt	161	mg
10/8/93	10	Faceneck Wipe	2.13	mg
10/8/93	10	GFFilter	0.0725	mg
10/8/93	10	Handwipe	0.92	mg
10/8/93	10	Socks	0.86	mg
10/8/93	10	T-shirt	21.6	mg
10/9/93	1	Faceneck Wipe	133.2	mg
10/9/93	1	GFFilter	21	mg
10/9/93	1	Handwipe	229.7	mg
10/9/93	1	Socks	20	mg
10/9/93	1	T-shirt	1630	mg
10/9/93	2	Faceneck Wipe	54.4	mg
10/9/93	2	GFFilter	13.9	mg
10/9/93	2	Handwipe	16.2	mg
10/9/93	2	Socks	27	mg
10/9/93	2	T-shirt	929	mg
10/9/93	3	Faceneck Wipe	122.2	mg
10/9/93	3	GFFilter	16.3	mg
10/9/93	3	Handwipe	245.9	mg
10/9/93	3	Socks	14.5	mg
10/9/93	3	T-shirt	1800	mg
10/9/93	4	Faceneck Wipe	39.2	mg
10/9/93	4	GFFilter	10.4	mg
10/9/93	4	Handwipe	43.7	mg

Appendix I, HS-1750: Exposure of Hand Applicators to Granular Hexazinone in Forest Settings, 1993 - 1995

Table 1 Dermal and Inhalation Raw Data (mg Hexazinone)

Date Collected	Worker Ref. Number	Sample Type	Result	Units
10/9/93	4	Socks	10.6	mg
10/9/93	4	T-shirt	456	mg
10/9/93	5	Faceneck Wipe	85.9	mg
10/9/93	5	GFFilter	46.1	mg
10/9/93	5	Handwipe	231.3	mg
10/9/93	5	Socks	17	mg
10/9/93	5	T-shirt	3630	mg
10/9/93	6	Faceneck Wipe	96.2	mg
10/9/93	6	GFFilter	55.9	mg
10/9/93	6	Handwipe	163.8	mg
10/9/93	6	Socks	49.4	mg
10/9/93	6	T-shirt	2030	mg
10/9/93	7	Faceneck Wipe	45.4	mg
10/9/93	7	GFFilter	14.5	mg
10/9/93	7	Handwipe	293.2	mg
10/9/93	7	Socks	39.2	mg
10/9/93	7	T-shirt	1020	mg
10/9/93	9	Faceneck Wipe	60.9	mg
10/9/93	9	GFFilter	40.4	mg
10/9/93	9	Handwipe	45.5	mg
10/9/93	9	Socks	30.8	mg
10/9/93	9	T-shirt	1300	mg
10/9/93	10	Faceneck Wipe	10.1	mg
10/9/93	10	GFFilter	0.627	mg
10/9/93	10	Handwipe	3.2	mg
10/9/93	10	Socks	8.67	mg
10/9/93	10	T-shirt	65.8	mg
10/21/93	2	Faceneck Wipe	5.19	mg
10/21/93	2	GFFilter	0.292	mg
10/21/93	2	Handwipe	3.16	mg
10/21/93	2	Socks	42.3	mg
10/21/93	2	T-shirt	259	mg
10/21/93	3	Faceneck Wipe	6.55	mg
10/21/93	3	GFFilter	0.431	mg
10/21/93	3	Handwipe	4.73	mg
10/21/93	3	Socks	16.6	mg
10/21/93	3	T-shirt	46.9	mg
10/21/93	4	Faceneck Wipe	8.22	mg
10/21/93	4	GFFilter	1.22	mg
10/21/93	4	Handwipe	11.5	mg
10/21/93	4	Socks	16.1	mg
10/21/93	4	T-shirt	245	mg
10/21/93	5	Faceneck Wipe	15.1	mg
10/21/93	5	GFFilter	1.773	mg
10/21/93	5	Handwipe	53.1	mg
10/21/93	5	Socks	11.3	mg
10/21/93	5	T-shirt	715	mg
10/21/93	7	Faceneck Wipe	13.4	mg
10/21/93	7	GFFilter	0.426	mg
10/21/93	7	Handwipe	24.7	mg
10/21/93	7	Socks	36	mg
10/21/93	7	T-shirt	83.9	mg
10/21/93	9	Faceneck Wipe	10.4	mg
10/21/93	9	GFFilter	0.573	mg
10/21/93	9	Handwipe	22.7	mg
10/21/93	9	Socks	25.7	mg
10/21/93	9	T-shirt	101	mg
10/21/93	10	Faceneck Wipe	5.3	mg
10/21/93	10	GFFilter	0.0817	mg

Appendix I, HS-1750: Exposure of Hand Applicators to Granular Hexazinone in Forest Settings, 1993 - 1995

Table 1 Dermal and Inhalation Raw Data (mg Hexazinone)

Date Collected	Worker Ref. Number	Sample Type	Result	Units
10/21/93	10	Handwipe	4.53	mg
10/21/93	10	Socks	2.03	mg
10/21/93	10	T-shirt	11.3	mg
10/21/93	11	Faceneck Wipe	9.14	mg
10/21/93	11	GFFilter	0.23	mg
10/21/93	11	Handwipe	8.23	mg
10/21/93	11	Socks	3.26	mg
10/21/93	11	T-shirt	36.7	mg
10/21/93	12	Faceneck Wipe	10.9	mg
10/21/93	12	GFFilter	0.292	mg
10/21/93	12	Handwipe	10.6	mg
10/21/93	12	Socks	17.4	mg
10/21/93	12	T-shirt	131	mg
10/22/93	2	Faceneck Wipe	3.65	mg
10/22/93	2	GFFilter	0.319	mg
10/22/93	2	Handwipe	5.31	mg
10/22/93	2	Socks	15.8	mg
10/22/93	2	T-shirt	476	mg
10/22/93	3	Faceneck Wipe	9.56	mg
10/22/93	3	GFFilter	0.222	mg
10/22/93	3	Handwipe	17.7	mg
10/22/93	3	Socks	12.5	mg
10/22/93	3	T-shirt	52.7	mg
10/22/93	4	Faceneck Wipe	5.26	mg
10/22/93	4	GFFilter	0.282	mg
10/22/93	4	Handwipe	13.5	mg
10/22/93	4	Socks	30.9	mg
10/22/93	4	T-shirt	252	mg
10/22/93	5	Faceneck Wipe	8.32	mg
10/22/93	5	GFFilter	0.713	mg
10/22/93	5	Handwipe	53.1	mg
10/22/93	5	Socks	7.65	mg
10/22/93	5	T-shirt	183	mg
10/22/93	7	Faceneck Wipe	10.8	mg
10/22/93	7	GFFilter	0.406	mg
10/22/93	7	Handwipe	39.2	mg
10/22/93	7	Socks	25.7	mg
10/22/93	7	T-shirt	124	mg
10/22/93	8	Faceneck Wipe	5.81	mg
10/22/93	8	GFFilter	0.0808	mg
10/22/93	8	Handwipe	9.17	mg
10/22/93	8	Socks	2.33	mg
10/22/93	8	T-shirt	15.5	mg
10/22/93	9	Faceneck Wipe	14.3	mg
10/22/93	9	GFFilter	0.299	mg
10/22/93	9	Handwipe	37.3	mg
10/22/93	9	Socks	18.8	mg
10/22/93	9	T-shirt	162	mg
10/22/93	10	Faceneck Wipe	5.6	mg
10/22/93	10	GFFilter	0.179	mg
10/22/93	10	Handwipe	8.7	mg
10/22/93	10	Socks	3.79	mg
10/22/93	10	T-shirt	18.6	mg
10/22/93	11	Faceneck Wipe	16.9	mg
10/22/93	11	GFFilter	0.32	mg
10/22/93	11	Handwipe	54.4	mg
10/22/93	11	Socks	3.71	mg
10/22/93	11	T-shirt	97.3	mg
10/22/93	12	Faceneck Wipe	9.99	mg

Appendix I, HS-1750: Exposure of Hand Applicators to Granular Hexazinone in Forest Settings, 1993 - 1995

Table 1 Dermal and Inhalation Raw Data (mg Hexazinone)

Date Collected	Worker Ref. Number	Sample Type	Result	Units
10/22/93	12	GFFilter	0.217	mg
10/22/93	12	Handwipe	7.68	mg
10/22/93	12	Socks	8.96	mg
10/22/93	12	T-shirt	97.5	mg
10/25/93	2	Faceneck Wipe	12.4	mg
10/25/93	2	GFFilter	0.767	mg
10/25/93	2	Handwipe	17.6	mg
10/25/93	2	Socks	17.4	mg
10/25/93	2	T-shirt	419	mg
10/25/93	3	Faceneck Wipe	32.3	mg
10/25/93	3	GFFilter	0.569	mg
10/25/93	3	Handwipe	67.5	mg
10/25/93	3	Socks	15.2	mg
10/25/93	3	T-shirt	548	mg
10/25/93	4	Faceneck Wipe	30.6	mg
10/25/93	4	GFFilter	5	mg
10/25/93	4	Handwipe	114	mg
10/25/93	4	Socks	27.6	mg
10/25/93	4	T-shirt	693	mg
10/25/93	5	Faceneck Wipe	22.3	mg
10/25/93	5	GFFilter	1.562	mg
10/25/93	5	Handwipe	56.3	mg
10/25/93	5	Socks	14.4	mg
10/25/93	5	T-shirt	1520	mg
10/25/93	7	Faceneck Wipe	80.7	mg
10/25/93	7	GFFilter	3.745	mg
10/25/93	7	Handwipe	131	mg
10/25/93	7	Socks	23.6	mg
10/25/93	7	T-shirt	1610	mg
10/25/93	8	Faceneck Wipe	9.57	mg
10/25/93	8	GFFilter	0.388	mg
10/25/93	8	Handwipe	31.4	mg
10/25/93	8	Socks	15.9	mg
10/25/93	8	T-shirt	56.4	mg
10/25/93	9	Faceneck Wipe	33.4	mg
10/25/93	9	GFFilter	0.768	mg
10/25/93	9	Handwipe	99.8	mg
10/25/93	9	Socks	45.5	mg
10/25/93	9	T-shirt	1950	mg
10/25/93	10	Faceneck Wipe	14.5	mg
10/25/93	10	GFFilter	0.268	mg
10/25/93	10	Handwipe	14.1	mg
10/25/93	10	Socks	7.19	mg
10/25/93	10	T-shirt	93.9	mg
10/25/93	11	Faceneck Wipe	74.5	mg
10/25/93	11	GFFilter	1.552	mg
10/25/93	11	Handwipe	184	mg
10/25/93	11	Socks	13.7	mg
10/25/93	11	T-shirt	1150	mg
10/25/93	12	Faceneck Wipe	101	mg
10/25/93	12	GFFilter	1.931	mg
10/25/93	12	Handwipe	100	mg
10/25/93	12	Socks	18.2	mg
10/25/93	12	T-shirt	1700	mg
10/25/93	31	Faceneck Wipe	2.07	mg
10/25/93	31	GFFilter	0.1	mg
10/25/93	31	Handwipe	2.77	mg
10/25/93	31	Socks	3.27	mg
10/25/93	31	T-shirt	8.16	mg

Appendix I, HS-1750: Exposure of Hand Applicators to Granular Hexazinone in Forest Settings, 1993 - 1995

Table 1 Dermal and Inhalation Raw Data (mg Hexazinone)

Date Collected	Worker Ref. Number	Sample Type	Result	Units
10/25/93	32	Faceneck Wipe	3.14	mg
10/25/93	32	GFFilter	0.171	mg
10/25/93	32	Handwipe	6.66	mg
10/25/93	32	Socks	1.83	mg
10/25/93	32	T-shirt	14.4	mg
10/26/94	13	Faceneck Wipe	0.855	mg
10/26/94	13	GFFilter	0.00762	mg
10/26/94	13	Handwipe	4.512	mg
10/26/94	13	Socks	0.032	mg
10/26/94	13	T-shirt	0.822	mg
10/26/94	14	Faceneck Wipe	1.106	mg
10/26/94	14	GFFilter	0.0155	mg
10/26/94	14	Handwipe	1.795	mg
10/26/94	14	Socks	0.0541	mg
10/26/94	14	T-shirt	34.81	mg
10/26/94	15	Faceneck Wipe	0.619	mg
10/26/94	15	GFFilter	0.0201	mg
10/26/94	15	Handwipe	2.437	mg
10/26/94	15	Socks	0.1044	mg
10/26/94	15	T-shirt	12.21	mg
10/26/94	16	Faceneck Wipe	1.224	mg
10/26/94	16	GFFilter	0.0231	mg
10/26/94	16	Handwipe	3.283	mg
10/26/94	16	Socks	1.558	mg
10/26/94	16	T-shirt	7.991	mg
10/26/94	17	Faceneck Wipe	1.568	mg
10/26/94	17	GFFilter	0.0169	mg
10/26/94	17	Handwipe	4.551	mg
10/26/94	17	Socks	0.2642	mg
10/26/94	17	T-shirt	7.964	mg
10/26/94	18	Faceneck Wipe	2.318	mg
10/26/94	18	GFFilter	0.07	mg
10/26/94	18	Handwipe	10.57	mg
10/26/94	18	Socks	0.0992	mg
10/26/94	18	T-shirt	29.68	mg
10/26/94	19	Faceneck Wipe	2.474	mg
10/26/94	19	GFFilter	0.045	mg
10/26/94	19	Handwipe	10.75	mg
10/26/94	19	Socks	0.6499	mg
10/26/94	19	T-shirt	23.32	mg
10/26/94	20	Faceneck Wipe	1.956	mg
10/26/94	20	GFFilter	0.0314	mg
10/26/94	20	Handwipe	3.805	mg
10/26/94	20	Socks	0.7676	mg
10/26/94	20	T-shirt	6.796	mg
10/26/94	21	Faceneck Wipe	0.896	mg
10/26/94	21	GFFilter	0.0207	mg
10/26/94	21	Handwipe	1.054	mg
10/26/94	21	Socks	0.0918	mg
10/26/94	21	T-shirt	9.452	mg
10/26/94	22	Faceneck Wipe	1.887	mg
10/26/94	22	GFFilter	0.0174	mg
10/26/94	22	Handwipe	9.33	mg
10/26/94	22	Socks	0.0813	mg
10/26/94	22	T-shirt	14.77	mg
10/26/94	23	Faceneck Wipe	1.663	mg
10/26/94	23	GFFilter	0.0206	mg
10/26/94	23	Handwipe	3.81	mg
10/26/94	23	Socks	0.1515	mg

Appendix I, HS-1750: Exposure of Hand Applicators to Granular Hexazinone in Forest Settings, 1993 - 1995

Table 1 Dermal and Inhalation Raw Data (mg Hexazinone)

Date Collected	Worker Ref. Number	Sample Type	Result	Units
10/26/94	23	T-shirt	26.79	mg
10/27/94	13	Faceneck Wipe	1.472	mg
10/27/94	13	GFFilter	0.0173	mg
10/27/94	13	Handwipe	9.435	mg
10/27/94	13	Socks	0.0568	mg
10/27/94	13	T-shirt	2.273	mg
10/27/94	14	Faceneck Wipe	4.391	mg
10/27/94	14	GFFilter	0.1095	mg
10/27/94	14	Handwipe	4.465	mg
10/27/94	14	Socks	0.7805	mg
10/27/94	14	T-shirt	105.56	mg
10/27/94	15	Faceneck Wipe	1.581	mg
10/27/94	15	GFFilter	0.041	mg
10/27/94	15	Handwipe	1.883	mg
10/27/94	15	Socks	0.328	mg
10/27/94	15	T-shirt	33.016	mg
10/27/94	16	Faceneck Wipe	3.833	mg
10/27/94	16	GFFilter	0.0425	mg
10/27/94	16	Handwipe	16.02	mg
10/27/94	16	Socks	1.385	mg
10/27/94	16	T-shirt	19.86	mg
10/27/94	17	Faceneck Wipe	4.713	mg
10/27/94	17	GFFilter	0.1119	mg
10/27/94	17	Handwipe	17.75	mg
10/27/94	17	Socks	0.7097	mg
10/27/94	17	T-shirt	44.56	mg
10/27/94	18	Faceneck Wipe	4.497	mg
10/27/94	18	GFFilter	0.1179	mg
10/27/94	18	Handwipe	20.8	mg
10/27/94	18	Socks	0.3857	mg
10/27/94	18	T-shirt	67.89	mg
10/27/94	19	Faceneck Wipe	10.28	mg
10/27/94	19	GFFilter	0.1191	mg
10/27/94	19	Handwipe	34.88	mg
10/27/94	19	Socks	1.161	mg
10/27/94	19	T-shirt	49.46	mg
10/27/94	20	Faceneck Wipe	3.62	mg
10/27/94	20	GFFilter	0.2825	mg
10/27/94	20	Handwipe	3.102	mg
10/27/94	20	Socks	3.439	mg
10/27/94	20	T-shirt	65.24	mg
10/27/94	21	Faceneck Wipe	3.992	mg
10/27/94	21	GFFilter	0.1107	mg
10/27/94	21	Handwipe	4.689	mg
10/27/94	21	Socks	0.2932	mg
10/27/94	21	T-shirt	29.08	mg
10/27/94	22	Faceneck Wipe	9.146	mg
10/27/94	22	GFFilter	0.1383	mg
10/27/94	22	Handwipe	12.91	mg
10/27/94	22	Socks	0.39	mg
10/27/94	22	T-shirt	376.1	mg
10/27/94	23	Faceneck Wipe	5.593	mg
10/27/94	23	GFFilter	0.0438	mg
10/27/94	23	Handwipe	15.01	mg
10/27/94	23	Socks	0.3217	mg
10/27/94	23	T-shirt	40.49	mg
10/27/94	24	Faceneck Wipe	0.947	mg
10/27/94	24	GFFilter	0.0122	mg
10/27/94	24	Handwipe	0.536	mg

Appendix I, HS-1750: Exposure of Hand Applicators to Granular Hexazinone in Forest Settings, 1993 - 1995

Table 1 Dermal and Inhalation Raw Data (mg Hexazinone)

Date Collected	Worker Ref. Number	Sample Type	Result	Units
10/27/94	24	Socks	0.2131	mg
10/27/94	24	T-shirt	33.11	mg
10/28/94	13	Faceneck Wipe	1.813	mg
10/28/94	13	GFFilter	0.0241	mg
10/28/94	13	Handwipe	8.07	mg
10/28/94	13	Socks	0.1083	mg
10/28/94	13	T-shirt	4.229	mg
10/28/94	14	Faceneck Wipe	6.49	mg
10/28/94	14	GFFilter	0.1606	mg
10/28/94	14	Handwipe	10.09	mg
10/28/94	14	Socks	1.904	mg
10/28/94	14	T-shirt	59.97	mg
10/28/94	15	Faceneck Wipe	2.825	mg
10/28/94	15	GFFilter	0.119	mg
10/28/94	15	Handwipe	4.297	mg
10/28/94	15	Socks	0.7265	mg
10/28/94	15	T-shirt	129.1	mg
10/28/94	16	Faceneck Wipe	4.335	mg
10/28/94	16	GFFilter	0.056	mg
10/28/94	16	Handwipe	18.49	mg
10/28/94	16	Socks	9.8	mg
10/28/94	16	T-shirt	44.85	mg
10/28/94	17	Faceneck Wipe	10.09	mg
10/28/94	17	GFFilter	0.1887	mg
10/28/94	17	Handwipe	55.08	mg
10/28/94	17	Socks	1.269	mg
10/28/94	17	T-shirt	168.82	mg
10/28/94	18	Faceneck Wipe	14.29	mg
10/28/94	18	GFFilter	0.7891	mg
10/28/94	18	Handwipe	49.67	mg
10/28/94	18	Socks	0.5766	mg
10/28/94	18	T-shirt	211.63	mg
10/28/94	19	Faceneck Wipe	6.208	mg
10/28/94	19	GFFilter	0.0883	mg
10/28/94	19	Handwipe	31.19	mg
10/28/94	19	Socks	0.8983	mg
10/28/94	19	T-shirt	45.73	mg
10/28/94	20	Faceneck Wipe	14.62	mg
10/28/94	20	GFFilter	0.2904	mg
10/28/94	20	Handwipe	51.13	mg
10/28/94	20	Socks	10.84	mg
10/28/94	20	T-shirt	207.29	mg
10/28/94	21	Faceneck Wipe	4.404	mg
10/28/94	21	GFFilter	0.1305	mg
10/28/94	21	Handwipe	7.545	mg
10/28/94	21	Socks	0.9089	mg
10/28/94	21	T-shirt	78.75	mg
10/28/94	22	Faceneck Wipe	15.32	mg
10/28/94	22	GFFilter	0.1687	mg
10/28/94	22	Handwipe	22.66	mg
10/28/94	22	Socks	1.098	mg
10/28/94	22	T-shirt	576.56	mg
10/28/94	23	Faceneck Wipe	2.324	mg
10/28/94	23	GFFilter	0.0165	mg
10/28/94	23	Handwipe	5.758	mg
10/28/94	23	Socks	0.5994	mg
10/28/94	23	T-shirt	62.11	mg
10/28/94	24	Faceneck Wipe	0.651	mg
10/28/94	24	GFFilter	0.0158	mg

Appendix I, HS-1750: Exposure of Hand Applicators to Granular Hexazinone in Forest Settings, 1993 - 1995

Table 1 Dermal and Inhalation Raw Data (mg Hexazinone)

Date Collected	Worker Ref. Number	Sample Type	Result	Units
10/28/94	24	Handwipe	1.199	mg
10/28/94	24	Socks	0.2157	mg
10/28/94	24	T-shirt	8.096	mg
11/28/95	24	Faceneck Wipe	1.803	mg
11/28/95	24	GFFilter	0.00864	mg
11/28/95	24	Handwipe	3.459	mg
11/28/95	24	Socks	0.0344	mg
11/28/95	24	T-shirt	0.812	mg
11/28/95	25	Faceneck Wipe	0.982	mg
11/28/95	25	GFFilter	0.0183	mg
11/28/95	25	Handwipe	4.575	mg
11/28/95	25	Socks	0.0618	mg
11/28/95	25	T-shirt	8.37	mg
11/28/95	26	Faceneck Wipe	6.313	mg
11/28/95	26	GFFilter	0.0694	mg
11/28/95	26	Handwipe	7.732	mg
11/28/95	26	Socks	4.63	mg
11/28/95	26	T-shirt	23.34	mg
11/28/95	27	Faceneck Wipe	3.729	mg
11/28/95	27	GFFilter	0.0472	mg
11/28/95	27	Handwipe	2.425	mg
11/28/95	27	Socks	0.1006	mg
11/28/95	27	T-shirt	18.73	mg
11/28/95	28	Faceneck Wipe	4.797	mg
11/28/95	28	GFFilter	0.0632	mg
11/28/95	28	Handwipe	3.572	mg
11/28/95	28	Socks	0.494	mg
11/28/95	28	T-shirt	72.26	mg
11/28/95	29	Faceneck Wipe	12.07	mg
11/28/95	29	GFFilter	0.133	mg
11/28/95	29	Handwipe	17.73	mg
11/28/95	29	Socks	0.683	mg
11/28/95	29	T-shirt	26.49	mg
11/29/95	24	Faceneck Wipe	15.51	mg
11/29/95	24	GFFilter	0.0297	mg
11/29/95	24	Handwipe	23.47	mg
11/29/95	24	Socks	0.154	mg
11/29/95	24	T-shirt	25.44	mg
11/29/95	25	Faceneck Wipe	5.063	mg
11/29/95	25	GFFilter	0.0365	mg
11/29/95	25	Handwipe	17.12	mg
11/29/95	25	Socks	0.343	mg
11/29/95	25	T-shirt	11.12	mg
11/29/95	26	Faceneck Wipe	12.04	mg
11/29/95	26	GFFilter	0.0749	mg
11/29/95	26	Handwipe	30.71	mg
11/29/95	26	Socks	3.29	mg
11/29/95	26	T-shirt	26.07	mg
11/29/95	27	Faceneck Wipe	12.52	mg
11/29/95	27	GFFilter	0.107	mg
11/29/95	27	Handwipe	9.978	mg
11/29/95	27	Socks	4.34	mg
11/29/95	27	T-shirt	47.43	mg
11/29/95	28	Faceneck Wipe	16.32	mg
11/29/95	28	GFFilter	0.056	mg
11/29/95	28	Handwipe	10.711	mg
11/29/95	28	Socks	10.9	mg
11/29/95	28	T-shirt	93.94	mg
11/29/95	29	Faceneck Wipe	24.34	mg
11/29/95	29	GFFilter	0.17	mg
11/29/95	29	Handwipe	36.99	mg
11/29/95	29	Socks	7.7	mg
11/29/95	29	T-shirt	72.5	mg

Appendix I, HS-1750: Exposure of Hand Applicators to Granular Hexazinone in Forest Settings, 1993 - 1995

Table 2 Hexazinone Inhalation Exposure (IE) = mg GFFilter residues ("Analysis") adjusted for pump flow(s), elapsed time, standard breathing rate, 50% uptake (0.5) and 100% (1.0) absorption as follows: IE (mg) = [(Analysis) x sum of [(End Flow - Begin Flow)/2 x elapsed time] for each pump used x (14 L/min breathing rate)] x 0.5 (uptake) x 1.0 (absorption) = mg hexazinone inhalation exposure

Date	Worker	Analysis	IE (mg)	End Flow 1	Begin Flow 1	Mins. 1	End Flow 2	Begin Flow 2	Mins. 2
10/7/93	1	0.46	1.49	2.3	2	491	0	0	0
10/7/93	2	0.35	1.20	2.1	2	489	0	0	0
10/7/93	3	0.39	1.35	2.1	2	488	0	0	0
10/7/93	4	0.24	0.82	2.1	2	490	0	0	0
10/7/93	5	0.90	3.14	2	2	488	0	0	0
10/7/93	6	1.26	4.41	2	2	497	0	0	0
10/7/93	7	0.16	0.54	2.1	2	492	0	0	0
10/7/93	8	0.02	0.06	1.95	2	487	0	0	0
10/7/93	9	0.13	0.64	0.9	2	500	0	0	0
10/7/93	10	0.09	0.32	2.1	2	459	0	0	0
10/8/93	1	5.16	16.05	2.5	2	515	0	0	0
10/8/93	2	1.29	4.20	2.3	2	506	0	0	0
10/8/93	3	1.12	3.78	2.15	2	514	0	0	0
10/8/93	4	1.37	4.51	2.25	2	517	0	0	0
10/8/93	5	1.85	6.32	2.1	2	521	0	0	0
10/8/93	6	9.92	31.56	2.4	2	517	0	0	0
10/8/93	7	3.21	10.83	2.15	2	507	0	0	0
10/8/93	8	2.92	12.08	0	2	173	2.1	2	334
10/8/93	9	7.78	26.57	2.1	2	510	0	0	0
10/8/93	10	0.07	0.24	2.25	2	511	0	0	0
10/9/93	1	21.00	73.50	2	2	514	0	0	0
10/9/93	2	13.90	47.46	2.1	2	512	0	0	0
10/9/93	3	16.30	60.05	1.8	2	509	0	0	0
10/9/93	4	10.40	34.67	2.2	2	510	0	0	0
10/9/93	5	46.10	161.35	2	2	510	0	0	0
10/9/93	6	55.90	195.65	2	2	510	0	0	0
10/9/93	7	14.50	50.75	2	2	506	0	0	0
10/9/93	9	40.40	141.40	2	2	502	0	0	0
10/9/93	10	0.63	2.44	1.6	2	501	0	0	0
10/21/93	2	0.29	1.20	1.4	2	526	0	0	0
10/21/93	3	0.43	1.47	2.1	2	521	0	0	0
10/21/93	4	1.22	4.38	1.9	2	520	0	0	0
10/21/93	5	1.77	6.05	2.1	2	524	0	0	0
10/21/93	7	0.43	1.57	1.7	2	343	2	2	178
10/21/93	9	0.57	2.06	1.9	2	532	0	0	0
10/21/93	10	0.08	0.26	2.4	2	530	0	0	0
10/21/93	11	0.23	0.82	1.95	2	523	0	0	0
10/21/93	12	0.29	1.02	2	2	526	0	0	0
10/22/93	2	0.32	1.24	1.6	2	547	0	0	0
10/22/93	3	0.22	0.74	2.2	2	546	0	0	0
10/22/93	4	0.28	1.04	1.8	2	537	0	0	0
10/22/93	5	0.71	2.56	1.9	2	552	0	0	0
10/22/93	7	0.41	1.42	2	2	545	0	0	0
10/22/93	8	0.08	0.29	1.9	2	549	0	0	0
10/22/93	9	0.30	1.05	2	2	543	0	0	0
10/22/93	10	0.18	0.64	1.9	2	549	0	0	0
10/22/93	11	0.32	1.15	1.9	2	541	0	0	0
10/22/93	12	0.22	0.80	1.8	2	544	0	0	0
10/25/93	2	0.77	2.98	1.6	2	513	0	0	0
10/25/93	3	0.57	1.94	2.1	2	522	0	0	0
10/25/93	4	5.00	17.50	2	2	520	0	0	0
10/25/93	5	1.56	6.53	1.35	2	522	0	0	0
10/25/93	7	3.75	12.48	2.2	2	522	0	0	0
10/25/93	8	0.39	1.29	2.2	2	534	0	0	0
10/25/93	9	0.77	2.56	2.2	2	519	0	0	0
10/25/93	10	0.27	1.01	1.7	2	516	0	0	0
10/25/93	11	1.55	5.72	1.8	2	514	0	0	0
10/25/93	12	1.93	7.31	1.7	2	510	0	0	0

Appendix I, HS-1750: Exposure of Hand Applicators to Granular Hexazinone in Forest Settings, 1993 - 1995

Table 2 Hexazinone Inhalation Exposure (IE) = mg GFFilter residues ("Analysis") adjusted for pump flow(s), elapsed time, standard breathing rate, 50% uptake (0.5) and 100% (1.0) absorption as follows: IE (mg) = [(Analysis) x sum of [(End Flow - Begin Flow)/2 x elapsed time] for each pump used x (14 L/min breathing rate)] x 0.5 (uptake) x 1.0 (absorption) = mg hexazinone inhalation exposure

Date	Worker	Analysis	IE (mg)	End Flow 1	Begin Flow 1	Mins. 1	End Flow 2	Begin Flow 2	Mins. 2
10/26/94	13	0.01	0.03	2.2	2	495	0	0	0
10/26/94	14	0.02	0.05	2	2	503	0	0	0
10/26/94	15	0.02	0.07	2	2	502	0	0	0
10/26/94	16	0.02	0.08	2	2	509	0	0	0
10/26/94	17	0.02	0.06	2	2	517	0	0	0
10/26/94	18	0.07	0.25	2	2	510	0	0	0
10/26/94	19	0.05	0.16	2	2	512	0	0	0
10/26/94	20	0.03	0.11	2.1	2	350	2	2	170
10/26/94	21	0.02	0.07	2	2	511	0	0	0
10/26/94	22	0.02	0.06	1.7	2	408	2	2	113
10/26/94	23	0.02	0.08	1.8	2	128	1.8	2	394
10/27/94	13	0.02	0.06	1.8	2	538	0	0	0
10/27/94	14	0.11	0.40	1.8	2	525	0	0	0
10/27/94	15	0.04	0.14	2	2	534	0	0	0
10/27/94	16	0.04	0.15	2.1	2	529	0	0	0
10/27/94	17	0.11	0.39	2	2	531	0	0	0
10/27/94	18	0.12	0.41	2	2	534	0	0	0
10/27/94	19	0.12	0.42	2	2	534	0	0	0
10/27/94	20	0.28	1.01	1.9	2	524	0	0	0
10/27/94	21	0.11	0.39	2	2	527	0	0	0
10/27/94	22	0.14	0.52	1.7	2	535	0	0	0
10/27/94	23	0.04	0.16	1.9	2	522	0	0	0
10/27/94	24	0.01	0.04	1.9	2	526	0	0	0
10/28/94	13	0.02	0.09	1.8	2	393	0	0	0
10/28/94	14	0.16	0.55	2.1	2	379	0	0	0
10/28/94	15	0.12	0.41	2.1	2	335	0	0	0
10/28/94	16	0.06	0.20	2	2	386	0	0	0
10/28/94	17	0.19	0.66	2	2	352	0	0	0
10/28/94	18	0.79	2.76	2	2	385	0	0	0
10/28/94	19	0.09	0.31	2	2	385	0	0	0
10/28/94	20	0.29	1.02	2	2	388	0	0	0
10/28/94	21	0.13	0.45	2.1	2	388	0	0	0
10/28/94	22	0.17	0.62	1.8	2	389	0	0	0
10/28/94	23	0.02	0.06	2	2	153	0	0	0
10/28/94	24	0.02	0.06	2	2	373	0	0	0
11/28/95	24	0.01	0.03	2	2	417	0	0	0
11/28/95	25	0.02	0.07	1.9	2	417	0	0	0
11/28/95	26	0.07	0.24	2	2	421	0	0	0
11/28/95	27	0.05	0.17	2	2	421	0	0	0
11/28/95	28	0.06	0.22	2	2	421	0	0	0
11/28/95	29	0.13	0.47	2	2	413	0	0	0
11/29/95	24	0.03	0.10	2.1	2	448	0	0	0
11/29/95	25	0.04	0.13	1.8	2	459	0	0	0
11/29/95	26	0.07	0.30	1.5	2	459	0	0	0
11/29/95	27	0.11	0.38	1.9	2	464	0	0	0
11/29/95	28	0.06	0.21	1.8	2	450	0	0	0
11/29/95	29	0.17	0.60	2	2	457	0	0	0

Appendix I, HS-1750: Exposure of Hand Applicators to Granular Hexazinone in Forest Settings, 1993 - 1995

Table 3 Individual Dermal and Inhalation Exposure (IE) and Estimated Absorbed Dosage (EAD)
EAD = [10% dermal + IE]/Wt (kg); (Leg exposure = (1.1) x sock residues; upper body = shirt residues, or 10% of shirt residues if only study T-shirt was worn (indicated by * after Upper body value))
("mg IE" from Table 2; Wt (kg) from Table 4)

		mg Exposure (Dermal = sum of 4 body regions)					mg			
DATE	ID No.	Faceneck	Hand	Leg	Upper body	Dermal	IE	wt (kg)	EAD (mg/kg)	Task
10/7/93	1	6.88	23.7	0.89	112	143.47	1.49	73	0.2170	Apply
10/7/93	2	1.51	1.68	0.97	39.4	43.56	1.20	59	0.0942	Apply
10/7/93	3	9.76	12.2	2.26	43.9	68.11	1.35	63	0.1295	Apply
10/7/93	4	1.85	4.37	12.10	14.1	32.42	0.82	66	0.0615	Apply
10/7/93	5	4.24	11.3	0.48	124	140.02	3.14	76	0.2255	Apply
10/7/93	6	5.91	12.9	1.79	57	77.60	4.41	66	0.1844	Apply
10/7/93	7	3.41	8	2.56	16.3	30.27	0.54	75	0.0475	Apply
10/7/93	8	1	2.16	0.50	1.77	5.43	0.06	79	0.0076	Flag/Load
10/7/93	9	3.03	5.93	2.07	23.1	34.13	0.64	90	0.0450	Apply
10/7/93	10	4.88	3.97	0.49	18.6	27.94	0.32	68	0.0458	Apply
10/8/93	1	13.28	18.7	2.09	225	259.07	16.05	73	0.5748	Apply
10/8/93	2	2.67	1.95	3.19	135	142.81	4.20	59	0.3132	Apply
10/8/93	3	9.52	9.9	1.78	57.8	79.00	3.78	63	0.1854	Apply
10/8/93	4	3	6.09	5.09	42.2	56.38	4.51	66	0.1538	Apply
10/8/93	5	5.82	8.29	1.82	499	514.93	6.32	76	0.7607	Apply
10/8/93	6	9.86	15.6	7.44	443	475.90	31.56	66	1.1993	Apply
10/8/93	7	17.8	74.1	25.52	452	569.42	10.83	75	0.9036	Apply
10/8/93	8	35.5	26.1	2.64	592	656.24	12.08	79	0.9836	Apply
10/8/93	9	8.68	10.4	7.51	161	187.59	26.57	90	0.5036	Apply
10/8/93	10	2.13	0.92	0.95	21.6	25.60	0.24	68	0.0412	Flag/Load
10/9/93	1	133.2	229.7	22.00	1630	2014.90	73.50	73	3.7670	Apply
10/9/93	2	54.4	16.2	29.70	929	1029.30	47.46	59	2.5490	Apply
10/9/93	3	122.2	245.9	15.95	1800	2184.05	60.05	63	4.4200	Apply
10/9/93	4	39.2	43.7	11.66	456	550.56	34.67	66	1.3594	Apply
10/9/93	5	85.9	231.3	18.70	3630	3965.90	161.35	76	7.3413	Apply
10/9/93	6	96.2	163.8	54.34	2030	2344.34	195.65	66	6.5164	Apply
10/9/93	7	45.4	293.2	43.12	1020	1401.72	50.75	75	2.5456	Apply
10/9/93	9	60.9	45.5	33.88	1300	1440.28	141.40	90	3.1714	Apply
10/9/93	10	10.1	3.2	9.54	65.8	88.64	2.44	68	0.1662	Flag/Load
10/21/93	2	5.19	3.16	46.53	259	313.88	1.20	59	0.5524	Apply
10/21/93	3	6.55	4.73	18.26	46.9	76.44	1.47	63	0.1447	Apply
10/21/93	4	8.22	11.5	17.71	245	282.43	4.38	66	0.4943	Apply
10/21/93	5	15.1	53.1	12.43	715	795.63	6.05	76	1.1265	Apply
10/21/93	7	13.4	24.7	39.60	83.9	161.60	1.57	75	0.2364	Apply
10/21/93	9	10.4	22.7	28.27	101	162.37	2.06	90	0.2033	Apply
10/21/93	10	5.3	4.53	2.23	11.3	23.36	0.26	68	0.0382	Flag/Load
10/21/93	11	9.14	8.23	3.59	36.7	57.66	0.82	57	0.1155	Apply
10/21/93	12	10.9	10.6	19.14	131	171.64	1.02	59	0.3082	Apply
10/22/93	2	3.65	5.31	17.38	476	502.34	1.24	59	0.8725	Apply
10/22/93	3	9.56	17.7	13.75	52.7	93.71	0.74	63	0.1605	Apply
10/22/93	4	5.26	13.5	33.99	25.2*	77.95	1.04	66	0.1338	Apply
10/22/93	5	8.32	53.1	8.42	183	252.84	2.56	76	0.3664	Apply
10/22/93	7	10.8	39.2	28.27	124	202.27	1.42	75	0.2886	Apply
10/22/93	8	5.81	9.17	2.56	15.5	33.04	0.29	79	0.0455	Load
10/22/93	9	14.3	37.3	20.68	16.2*	88.48	1.05	90	0.1099	Apply
10/22/93	10	5.6	8.7	4.17	18.6	37.07	0.64	68	0.0640	Flag/Load
10/22/93	11	16.9	54.4	4.08	9.73*	85.11	1.15	57	0.1695	Apply
10/22/93	12	9.99	7.68	9.86	97.5	125.03	0.80	59	0.2255	Apply
10/25/93	2	12.4	17.6	19.14	41.9*	91.04	2.98	59	0.2049	Apply
10/25/93	3	32.3	67.5	16.72	548	664.52	1.94	63	1.0856	Apply
10/25/93	4	30.6	114	30.36	693	867.96	17.50	66	1.5802	Apply
10/25/93	5	22.3	56.3	15.84	152*	246.44	6.53	76	0.4102	Apply
10/25/93	7	80.7	131	25.96	161*	398.66	12.48	75	0.6980	Apply
10/25/93	8	9.57	31.4	17.49	56.4	114.86	1.29	79	0.1618	Load
10/25/93	9	33.4	99.8	50.05	195*	378.25	2.56	90	0.4487	Apply
10/25/93	10	14.5	14.1	7.91	9.39*	45.90	1.01	68	0.0824	Flag/Load
10/25/93	11	74.5	184	15.07	115*	388.57	5.72	57	0.7820	Apply

Appendix I, HS-1750: Exposure of Hand Applicators to Granular Hexazinone in Forest Settings, 1993 - 1995

Table 3 Individual Dermal and Inhalation Exposure (IE) and Estimated Absorbed Dosage (EAD)
EAD = [10% dermal + IE]/Wt (kg); (Leg exposure = (1.1) x sock residues; upper body = shirt residues, or 10% of shirt residues if only study T-shirt was worn (indicated by * after Upper body value))
("mg IE" from Table 2; Wt (kg) from Table 4)

		mg Exposure (Dermal = sum of 4 body regions)					mg			
DATE	ID No.	Faceneck	Hand	Leg	Upper body	Dermal	IE	wt (kg)	EAD (mg/kg)	Task
10/25/93	12	101	100	20.02	170*	391.02	7.31	59	0.7866	Apply
10/26/94	13	0.855	4.512	0.04	0.822	6.22	0.03	91	0.0071	Flag/Load
10/26/94	14	1.106	1.795	0.06	3.481*	6.44	0.05	80	0.0087	Apply
10/26/94	15	0.619	2.437	0.11	12.21	15.38	0.07	77	0.0209	Apply
10/26/94	16	1.224	3.283	1.71	7.991	14.21	0.08	71	0.0212	Apply
10/26/94	17	1.568	4.551	0.29	7.964	14.37	0.06	76	0.0197	Apply
10/26/94	18	2.318	10.57	0.11	29.68	42.68	0.25	59	0.0765	Apply
10/26/94	19	2.474	10.75	0.71	23.32	37.26	0.16	58	0.0670	Apply
10/26/94	20	1.956	3.805	0.84	6.796	13.40	0.11	73	0.0198	Apply
10/26/94	21	0.896	1.054	0.10	9.452	11.50	0.07	73	0.0167	Apply
10/26/94	22	1.887	9.33	0.09	14.77	26.08	0.06	80	0.0334	Apply
10/26/94	23	1.663	3.81	0.17	26.79	32.43	0.08	91	0.0365	Apply
10/27/94	13	1.472	9.435	0.06	2.273	13.24	0.06	91	0.0153	Flag/Load
10/27/94	14	4.391	4.465	0.86	10.556*	20.27	0.40	80	0.0304	Apply
10/27/94	15	1.581	1.883	0.36	33.016	36.84	0.14	77	0.0497	Apply
10/27/94	16	3.833	16.02	1.52	19.86	41.24	0.15	71	0.0601	Apply
10/27/94	17	4.713	17.75	0.78	44.56	67.80	0.39	76	0.0944	Apply
10/27/94	18	4.497	20.8	0.42	67.89	93.61	0.41	59	0.1657	Apply
10/27/94	19	10.28	34.88	1.28	49.46	95.90	0.42	58	0.1725	Apply
10/27/94	20	3.62	3.102	3.78	65.24	75.74	1.01	73	0.1177	Apply
10/27/94	21	3.992	4.689	0.32	29.08	38.08	0.39	73	0.0575	Apply
10/27/94	22	9.146	12.91	0.43	37.61*	60.10	0.52	80	0.0817	Apply
10/27/94	23	5.593	15.01	0.35	40.49	61.45	0.16	91	0.0693	Apply
10/27/94	24	0.947	0.536	0.23	3.311*	5.03	0.04	77	0.0071	Load
10/28/94	13	1.813	8.07	0.12	4.229	14.23	0.09	91	0.0166	Flag/Load
10/28/94	14	6.49	10.09	2.09	59.97	78.64	0.55	80	0.1052	Apply
10/28/94	15	2.825	4.297	0.80	129.1	137.02	0.41	77	0.1832	Apply
10/28/94	16	4.335	18.49	10.78	44.85	78.46	0.20	71	0.1133	Apply
10/28/94	17	10.09	55.08	1.40	168.82	235.39	0.66	76	0.3184	Apply
10/28/94	18	14.29	49.67	0.63	211.63	276.22	2.76	59	0.5150	Apply
10/28/94	19	6.208	31.19	0.99	45.73	84.12	0.31	58	0.1504	Apply
10/28/94	20	14.62	51.13	11.92	207.29	284.96	1.02	73	0.4043	Apply
10/28/94	21	4.404	7.545	1.00	78.75	91.70	0.45	73	0.1317	Apply
10/28/94	22	15.32	22.66	1.21	57.656*	96.84	0.62	80	0.1288	Apply
10/28/94	23	2.324	5.758	0.66	6.211*	14.95	0.06	91	0.0171	Apply
10/28/94	24	0.651	1.199	0.24	8.096	10.18	0.06	77	0.0139	Load
11/28/95	24	1.803	3.459	0.04	0.812	6.11	0.03	77	0.0083	Load
11/28/95	25	0.982	4.575	0.07	8.37	13.99	0.07	73	0.0201	Flag
11/28/95	26	6.313	7.732	5.09	23.34	42.48	0.24	69	0.0651	Apply
11/28/95	27	3.729	2.425	0.11	18.73	24.99	0.17	82	0.0325	Apply
11/28/95	28	4.797	3.572	0.54	7.226*	16.14	0.22	73	0.0251	Apply
11/28/95	29	12.07	17.73	0.75	26.49	57.04	0.47	77	0.0801	Apply
11/29/95	24	15.51	23.47	0.17	25.44	64.59	0.10	77	0.0852	Load
11/29/95	25	5.063	17.12	0.38	11.12	33.68	0.13	73	0.0480	Flag
11/29/95	26	12.04	30.71	3.62	26.07	72.44	0.30	69	0.1093	Apply
11/29/95	27	12.52	9.978	4.77	47.43	74.70	0.38	82	0.0958	Apply
11/29/95	28	16.32	10.711	11.99	9.394*	48.42	0.21	73	0.0691	Apply
11/29/95	29	24.34	36.99	8.47	72.5	142.30	0.60	77	0.1925	Apply

Table 4 Worker Data: Individual Weights (kg) used to Calculate Estimated Absorbed Dosage (EAD)

Worker Ref. No.	Age (yrs)	Sex	Height (in)	Wt (kg)	Years Experience
1	30	M	70	73	4
2	19	M	65	59	2
3	22	M	67	63	2
4	19	M	68	66	2
5	21	M	70	76	1
6	30	M	65	66	2
7	20	M	69	75	2
8	31	M	70	79	3
9	28	M	66	90	2
10	26	M	64	68	2
11	23	M	66	57	2
12	33	M	63	59	3
13	24	M	72	91	4
14	30	M	68	80	4
15	45	M	68	77	0
16	26	M	66	71	0
17	22	M	69	76	2
18	21	M	68	59	2
19	27	M	66	58	2
20	32	M	67	73	0
21	29	M	69	73	0
22	24	M	67	80	1
23	26	M	70	91	2
24	22	M	71	77	2
25	32	M	69	73	5
26	34	M	68	69	4
27	26	M	72	82	4
28	25	M	70	73	3
29	21	M	71	77	2

Table 5. Analyses of Test Substance (Pronone® 10g) for % Hexazinone

Lab Sample No.	Results (%)	% Recovery	Anal. Date	Comments
1125	10.67	106.70	10-21-93	Expected recovery = 10%, lot no. IR122054, JS11
1126	11.27	112.70	10-21-93	Expected recovery = 10%, lot no. IR122051, JS11
1220	11	110.00	10-21-93	Expected recovery = 10%, lot no. IR122051, JS12
1221	10.28	102.80	10-21-93	Expected recovery = 10%, lot no. IR122054, JS12
1288	10.97	109.70	10-25-93	Expected recovery = 10%, lot no. IR122054, JS10
1287	11.08	110.80	10-21-93	Expected recovery = 10%, lot no. IR122051, JS10
1426	9.44	94.40	11-10-93	Expected recovery = 10%, lot no. IR122053, JS13
1427	9.31	93.10	11-10-93	Expected recovery = 10%, lot no. IR122053, JS13
1509	9.57	95.70	11-10-93	Expected recovery = 10%, lot no. IR122053, JS14
1510	11.14	111.40	11-10-93	Expected recovery = 10%, lot no. IR122054, JS14
1594	10.88	108.80	11-10-93	Expected recovery = 10%, lot no. IR122053, JS15
1595	9.08	90.80	11-10-93	Expected recovery = 10%, lot no. IR122053, JS15
1511	11.44	114.40	11-10-93	Expected recovery = 10%, lot no. IR122052, JS14
883	9.35	93.50	04/07/95	Expected recovery = 10%, Lot no. IR094049, JS16
971	9.85	98.50	04/07/95	Expected recovery = 10%, Lot no. IR094049, JS17
972	9.97	99.70	04/07/95	Expected recovery = 10%, Lot no. IR054034, JS17
973	10.4	104.00	04/07/95	Expected recovery = 10%, Lot no. IR094051, JS17
1062	9.55	95.50	04/07/95	Expected recovery = 10%, Lot no. IR094051, JS18
1064	9.96	99.60	04/07/95	Expected recovery = 10%, Lot no. IR094049, JS18
1063	9.85	98.50	04/10/95	Expected recovery = 10%, Lot no. IR049080, JS18
P60544	10.67	106.70	03/13/96	Expected recovery = 10%, Lot no. 1R105-043, JS19
P60545	10.6	106.00	03/11/96	Expected recovery = 10%, Lot no. 1R105-041, JS19
P60546	9.61	96.10	03/13/96	Expected recovery = 10%, Lot no. 1R105-043, JS20
P60547	10.76	107.60	03/11/96	Expected recovery = 10%, Lot no. 1R105-041, JS20

Table 6 Field Fortifications (mg hexazinone); Expected Recovery = 150 µg

Date Collected	Interval	Result (ug)	Time Prepared	Time Frozen
10/7/93	Ambient	144.25	0500	1600
10/7/93	Ambient	139.19	0500	1600
10/7/93	Ambient	140.7	0500	1600
10/7/93	Ambient	143.33	0500	1600
10/7/93	Ambient	141.38	0500	1600
10/7/93	Ambient	141.33	0500	1600
10/7/93	Ambient	134.72	0500	1600
10/7/93	Ambient	138.44	0500	1600
10/7/93	Ambient	141.75	0500	1600
10/7/93	Ambient	139.45	0500	1600
10/7/93	Ambient	141.86	0500	1600
10/7/93	Ambient	140.74	0500	1600
10/7/93	Stored	152	0500	0525
10/7/93	Stored	145	0500	0525
10/7/93	Stored	148	0500	0525
10/7/93	Stored	148	0500	0525
10/7/93	Stored	149	0500	0525
10/7/93	Stored	149	0500	0525
10/7/93	Stored	146	0500	0525
10/7/93	Stored	149	0500	0525
10/7/93	Stored	151	0500	0525
10/7/93	Stored	146	0500	0525
10/7/93	Stored	144	0500	0525
10/7/93	Stored	144	0500	0525
10/8/93	Ambient	139.8	0515	1518
10/8/93	Ambient	145.78	0515	1518
10/8/93	Ambient	146.18	0515	1518
10/8/93	Ambient	140.74	0515	1518
10/8/93	Ambient	144.29	0515	1518
10/8/93	Ambient	141.1	0515	1518
10/8/93	Ambient	142.11	0515	1518
10/8/93	Ambient	144.93	0515	1518
10/8/93	Ambient	137.48	0515	1518
10/8/93	Ambient	141.33	0515	1518
10/8/93	Ambient	142.02	0515	1518
10/8/93	Ambient	138.89	0515	1518
10/8/93	Stored	150	0515	0540
10/8/93	Stored	152	0515	0540
10/8/93	Stored	153	0515	0540
10/8/93	Stored	146	0515	0540
10/8/93	Stored	149	0515	0540
10/8/93	Stored	147	0515	0540
10/8/93	Stored	150	0515	0540
10/8/93	Stored	150	0515	0540
10/8/93	Stored	151	0515	0540
10/8/93	Stored	146	0515	0540
10/8/93	Stored	144	0515	0540
10/8/93	Stored	148	0515	0540
10/9/93	Ambient	145.17	0515	1530
10/9/93	Ambient	151.49	0515	1530
10/9/93	Ambient	141.11	0515	1530
10/9/93	Ambient	146.59	0515	1530
10/9/93	Ambient	146.29	0515	1530
10/9/93	Ambient	146.49	0515	1530
10/9/93	Ambient	149.28	0515	1530
10/9/93	Ambient	146.43	0515	1530
10/9/93	Ambient	150.73	0515	1530
10/9/93	Ambient	148.53	0515	1530
10/9/93	Ambient	151.68	0515	1530

Table 6 Field Fortifications (mg hexazinone); Expected Recovery = 150 µg

Date Collected	Interval	Result (ug)	Time Prepared	Time Frozen
10/9/93	Ambient	143.07	0515	1530
10/9/93	Stored	160	0515	0540
10/9/93	Stored	149	0515	0540
10/9/93	Stored	151	0515	0540
10/9/93	Stored	154	0515	0540
10/9/93	Stored	148	0515	0540
10/9/93	Stored	152	0515	0540
10/9/93	Stored	151	0515	0540
10/9/93	Stored	154	0515	0540
10/9/93	Stored	150	0515	0540
10/9/93	Stored	155	0515	0540
10/9/93	Stored	151	0515	0540
10/9/93	Stored	154	0515	0540
10/21/93	Ambient	143	0500	1639
10/21/93	Ambient	141	0500	1639
10/21/93	Ambient	140	0500	1639
10/21/93	Ambient	144	0500	1639
10/21/93	Ambient	141	0500	1639
10/21/93	Ambient	140	0500	1639
10/21/93	Ambient	139	0500	1639
10/21/93	Ambient	146	0500	1639
10/21/93	Ambient	137	0500	1639
10/21/93	Ambient	138	0500	1639
10/21/93	Stored	150	0500	0525
10/21/93	Stored	140	0500	0525
10/21/93	Stored	146	0500	0525
10/21/93	Stored	151	0500	0525
10/21/93	Stored	147	0500	0525
10/21/93	Stored	149	0500	0525
10/21/93	Stored	146	0500	0525
10/21/93	Stored	149	0500	0525
10/21/93	Stored	143	0500	0525
10/21/93	Stored	145	0500	0525
10/22/93	Ambient	145	0500	1625
10/22/93	Ambient	146	0500	1625
10/22/93	Ambient	147	0500	1625
10/22/93	Ambient	145	0500	1625
10/22/93	Ambient	142	0500	1625
10/22/93	Ambient	144	0500	1625
10/22/93	Ambient	143	0500	1625
10/22/93	Ambient	139	0500	1625
10/22/93	Ambient	128	0500	1625
10/22/93	Ambient	144	0500	1625
10/22/93	Stored	146	0500	0520
10/22/93	Stored	149	0500	0520
10/22/93	Stored	151	0500	0520
10/22/93	Stored	148	0500	0520
10/22/93	Stored	150	0500	0520
10/22/93	Stored	141	0500	0520
10/22/93	Stored	142	0500	0520
10/22/93	Stored	148	0500	0520
10/22/93	Stored	148	0500	0520
10/22/93	Stored	149	0500	0520
10/25/93	Ambient	142	0730	1609
10/25/93	Ambient	134	0730	1609
10/25/93	Ambient	139	0530	1609
10/25/93	Ambient	141	0730	1609
10/25/93	Ambient	144	0730	1609
10/25/93	Ambient	154	0730	1609

Table 6 Field Fortifications (mg hexazinone); Expected Recovery = 150 µg

Date Collected	Interval	Result (ug)	Time Prepared	Time Frozen
10/25/93	Ambient	145	0730	1609
10/25/93	Ambient	147	0730	1609
10/25/93	Ambient	148	0730	1609
10/25/93	Ambient	144	0730	1609
10/25/93	Stored	146	0730	0741
10/25/93	Stored	151	0730	0741
10/25/93	Stored	149	0730	0741
10/25/93	Stored	153	0730	0741
10/25/93	Stored	149	0730	0741
10/25/93	Stored	143	0730	0741
10/25/93	Stored	154	0730	0741
10/25/93	Stored	151	0730	0741
10/25/93	Stored	149	0730	0741
10/25/93	Stored	153	0730	0741
10/26/94	Ambient	142.5	0530	1533
10/26/94	Ambient	141.2	0530	1533
10/26/94	Ambient	139.1	0530	1533
10/26/94	Ambient	148.6	0530	1533
10/26/94	Ambient	147.3	0530	1533
10/26/94	Ambient	145.3	0530	1533
10/26/94	Ambient	145.6	0530	1533
10/26/94	Ambient	143.6	0530	1533
10/26/94	Ambient	144.7	0530	1533
10/26/94	Ambient	145.3	0530	1533
10/26/94	Ambient	144.9	0530	1533
10/26/94	Ambient	146.1	0530	1533
10/26/94	Stored	147.6	0530	0630
10/26/94	Stored	147.7	0530	0630
10/26/94	Stored	140.5	0530	0630
10/26/94	Stored	147.1	0530	0630
10/26/94	Stored	149.1	0530	0630
10/26/94	Stored	148.5	0530	0630
10/26/94	Stored	150.4	0530	0630
10/26/94	Stored	148.7	0530	0630
10/26/94	Stored	146.5	0530	0630
10/26/94	Stored	139.5	0530	0630
10/26/94	Stored	146.1	0530	0630
10/26/94	Stored	146	0530	0630
10/27/94	Ambient	148	0530	1630
10/27/94	Ambient	141	0530	1630
10/27/94	Ambient	146	0530	1630
10/27/94	Ambient	148.2	0530	1630
10/27/94	Ambient	143.5	0530	1630
10/27/94	Ambient	142.4	0530	1630
10/27/94	Ambient	144.9	0530	1630
10/27/94	Ambient	146	0530	1630
10/27/94	Ambient	146.7	0530	1630
10/27/94	Ambient	147.1	0530	1630
10/27/94	Ambient	145.8	0530	1630
10/27/94	Ambient	146.1	0530	1630
10/27/94	Stored	138.5	0530	0600
10/27/94	Stored	140.8	0530	0600
10/27/94	Stored	140.9	0530	0600
10/27/94	Stored	146.2	0530	0600
10/27/94	Stored	143.7	0530	0600
10/27/94	Stored	142.4	0530	0600
10/27/94	Stored	147.4	0530	0600
10/27/94	Stored	144.1	0530	0600
10/27/94	Stored	142	0530	0600

Table 6 Field Fortifications (mg hexazinone); Expected Recovery = 150 µg

Date Collected	Interval	Result (ug)	Time Prepared	Time Frozen
10/27/94	Stored	144.8	0530	0600
10/27/94	Stored	142	0530	0600
10/27/94	Stored	146.8	0530	0600
10/28/94	Ambient	145.5	0545	1400
10/28/94	Ambient	140	0545	1400
10/28/94	Ambient	144.5	0545	1400
10/28/94	Ambient	144.4	0545	1400
10/28/94	Ambient	139.4	0545	1400
10/28/94	Ambient	143.7	0545	1400
10/28/94	Ambient	144.5	0545	1400
10/28/94	Ambient	140.3	0545	1400
10/28/94	Ambient	145.2	0545	1400
10/28/94	Ambient	144.9	0545	1400
10/28/94	Ambient	143.8	0545	1400
10/28/94	Ambient	137.6	0545	1400
10/28/94	Stored	140.4	0545	0615
10/28/94	Stored	147.1	0545	0615
10/28/94	Stored	143	0545	0615
10/28/94	Stored	137.7	0545	0615
10/28/94	Stored	143.8	0545	0615
10/28/94	Stored	136.9	0545	0615
10/28/94	Stored	143.8	0545	0615
10/28/94	Stored	143.9	0545	0615
10/28/94	Stored	141.7	0545	0615
10/28/94	Stored	141.4	0545	0615
10/28/94	Stored	145.7	0545	0615
10/28/94	Stored	140.9	0545	0615
11/28/95	Ambient	190	0615	1600
11/28/95	Ambient	194	0615	1600
11/28/95	Ambient	196	0615	1600
11/28/95	Ambient	193	0615	1600
11/28/95	Ambient	187	0615	1600
11/28/95	Ambient	196	0615	1600
11/28/95	Stored	196	0615	0635
11/28/95	Stored	193	0615	0635
11/28/95	Stored	199	0615	0635
11/28/95	Stored	193	0615	0635
11/28/95	Stored	195	0615	0635
11/28/95	Stored	189	0615	0635
11/29/95	Ambient	211	0610	1535
11/29/95	Ambient	207	0610	1535
11/29/95	Ambient	201	0610	1535
11/29/95	Ambient	142	0610	1535
11/29/95	Ambient	190	0610	1535
11/29/95	Ambient	186	0610	1535
11/29/95	Stored	137	0610	0625
11/29/95	Stored	186	0610	0625
11/29/95	Stored	163	0610	0625
11/29/95	Stored	184	0610	0625
11/29/95	Stored	138	0610	0625
11/29/95	Stored	133	0610	0625

Table 7 Field Blanks (µg hexazinone),ND = none detected

Date Collected	Sample Type	Results	Units
10/7/93	GFFilter	0.4	ug
10/7/93	Socks	ND	ug
10/7/93	T-shirt	8.89	ug
10/7/93	Wipes	ND	ug
10/8/93	GFFilter	0.55	ug
10/8/93	GFFilter	0.44	ug
10/8/93	GFFilter	0.50	ug
10/8/93	Socks	ND	ug
10/8/93	Socks	ND	ug
10/8/93	Socks	ND	ug
10/8/93	T-shirt	51.5	ug
10/8/93	T-shirt	22.1	ug
10/8/93	T-shirt	35.4	ug
10/8/93	Wipes	ND	ug
10/9/93	GFFilter	ND	ug
10/9/93	Socks	12.2	ug
10/9/93	T-shirt	48	ug
10/9/93	Wipes	50.2	ug
10/21/93	GFFilter	0.25	ug
10/21/93	Socks	6.75	ug
10/21/93	T-shirt	17	ug
10/21/93	Wipes	3.44	ug
10/22/93	GFFilter	ND	ug
10/22/93	Socks	3.65	ug
10/22/93	T-shirt	17.7	ug
10/22/93	Wipes	ND	ug
10/25/93	GFFilter	ND	ug
10/25/93	Socks	9.24	ug
10/25/93	T-shirt	22	ug
10/25/93	Wipes	ND	ug
10/26/94	GFFilter	ND	ug
10/26/94	Socks	ND	ug
10/26/94	T-shirt	ND	ug
10/26/94	Wipes	ND	ug
10/27/94	GFFilter	ND	ug
10/27/94	Socks	ND	ug
10/27/94	T-shirt	ND	ug
10/27/94	Wipes	ND	ug
10/28/94	GFFilter	ND	ug
10/28/94	Socks	ND	ug
10/28/94	T-shirt	ND	ug
10/28/94	Wipes	ND	ug
11/28/95	GFFilter	ND	ug
11/28/95	Socks	ND	ug
11/28/95	T-shirt	19.3	ug
11/28/95	Wipes	ND	ug
11/29/95	GFFilter	ND	ug
11/29/95	Socks	ND	ug
11/29/95	T-shirt	11.2	ug
11/29/95	Wipes	9.64	ug

Table 8 Storage Stability Sample Results (µg hexazinone)

Storage Interval, Week	Matrix	ug /sample spike	% Recovery
0	GFFilter	20	99.35
0	GFFilter	20	94.05
0	Socks	200	96.00
0	Socks	200	97.70
0	T-shirt	200	88.06
0	T-shirt	200	87.65
0	Wipes	200	91.51
0	Wipes	200	88.50
01	GFFilter	20	94.70
01	GFFilter	20	96.25
01	Socks	200	95.86
01	Socks	200	95.98
01	T-shirt	200	87.78
01	T-shirt	200	90.22
01	Wipes	200	89.62
01	Wipes	200	88.89
02	GFFilter	20	91.07
02	GFFilter	20	97.20
02	Socks	200	96.59
02	Socks	200	94.85
02	T-shirt	200	90.62
02	T-shirt	200	72.50
02	Wipes	200	88.27
02	Wipes	200	88.60
04	GFFilter	20	101.10
04	GFFilter	20	101.10
04	Socks	200	102.13
04	Socks	200	105.02
04	T-shirt	200	97.68
04	T-shirt	200	98.72
04	Wipes	200	95.80
04	Wipes	200	98.92
08	GFFilter	20	99.65
08	GFFilter	20	103.75
08	Socks	200	104.27
08	Socks	200	103.53
08	T-shirt	200	97.19
08	T-shirt	200	100.13
08	Wipes	200	90.65
08	Wipes	200	91.08
17	GFFilter	20	99.18
17	GFFilter	20	100.71
17	Socks	200	104.20
17	Socks	200	103.00
17	T-shirt	200	99.85
17	T-shirt	200	87.84
17	Wipes	200	95.02
17	Wipes	200	93.89
30	GFFilter	20	98.28
30	GFFilter	20	97.24
30	QCWipes	200	97.90
30	QCWipes	200	99.67
30	Socks	200	107.97
30	Socks	200	107.28
30	T-shirt	200	95.38
30	T-shirt	200	99.15
30	Wipes	200	91.97
30	Wipes	200	97.33
30	Wipes	200	99.70

Table 8 Storage Stability Sample Results (µg hexazinone)

Storage Interval, Week	Matrix	ug /sample spike	% Recovery
30	Wipes	200	89.82
78	GFFilter	20	90.10
78	GFFilter	20	91.60
78	GFFilter	20	95.10
78	GFFilter	20	96.20
78	Socks	200	85.78
78	Socks	200	85.70
78	Socks	200	85.28
78	Socks	200	86.26
78	T-shirt	200	90.70
78	T-shirt	200	93.25
78	T-shirt	200	93.01
78	T-shirt	200	92.92
78	Wipes	200	90.45
78	Wipes	200	88.22
78	Wipes	200	87.45
78	Wipes	200	88.12