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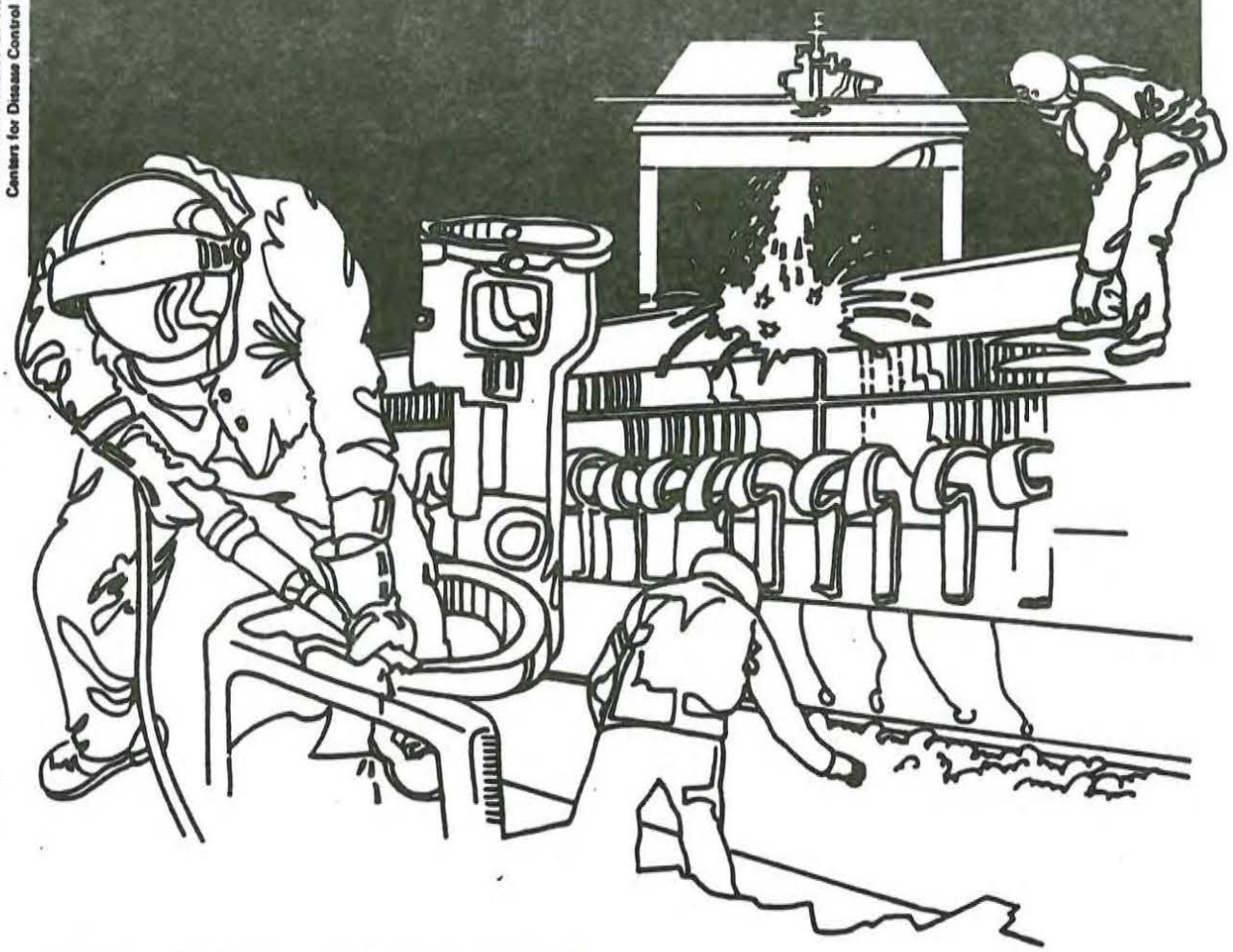

Health Hazard Evaluation Report

HETA 83-341-1557
BUREAU OF RECLAMATION
U.S. DEPARTMENT OF THE INTERIOR
DENVER, COLORADO

PREFACE

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

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

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I. SUMMARY

In July 1983, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Bureau of Reclamation, U.S. Department of the Interior, to evaluate the safety of their pesticide application program.

In August, 1983, and June 1984, NIOSH investigators made site visits to Bismarck, North Dakota, and to three sites in California (Fresno, Tracy, and Red Bluff). Procedures for mixing and applying herbicides were evaluated. Personal breathing zone air samples for measurement of exposure to the herbicides 2,4-D, Banvel™, Buctril™, and Roundup™ were obtained. Airborne exposures were low, ranging from 1.8-2.6 ug/M^3 (micrograms per cubic meter air) for 2,4-D; 1.2-1.4 ug/M^3 for Banvel; less than 2 ug/M^3 for Buctril; and less than 28 ug/M^3 for Roundup. Of these herbicides, only 2,4-D has a published exposure limit (ACGIH TLV and OSHA standard, 10,000 ug/m^3). The low concentrations of active ingredient typically found in liquid pesticide formulations (0.5-3%) undoubtly contributed to the low airborne exposures measured.

Based on a limited assessment of skin contact with herbicides, potential for exposure was considered to exist. Under routine circumstances, however, such exposure would be expected to be minor.

Review of work practices and personal protective equipment use indicated, in general, that Bureau employees had a good understanding of the hazards associated with pesticides. However, the types of protective equipment used, and the degree of use each received, varied from field station to field station.

In the event of an accident, or spraying under windy conditions, Bureau employees would be at risk of increased exposure to herbicides. However, considering the generally low level of toxicity of herbicides and the concentrations used at application, this risk is small. Use of protective clothing during the mixing stage should minimize contact with the concentrated herbicide. Recommendations concerning exposure recordkeeping, work practices, and medical surveillance are contained on Section VII of this report.

KEYWORDS: SIC 9511 (Air and Water Resource and Solid Waste Management), pesticides, herbicides, record keeping, medical surveillance, cholinesterase determination, organophosphates

II. INTRODUCTION

In July 1983, the Bureau of Reclamation, U.S. Department of the Interior, requested the National Institute for Occupational Safety and Health (NIOSH) to evaluate its pesticide application program and provide recommendations for incorporation into a Bureau safety manual. This manual would serve as the Bureau's guide to health and safety for its field personnel.

In August 1983, an industrial hygienist and an epidemiologist visited the Bureau's Heart Butte Resevoir station located approximately sixty miles outside of Bismarck, North Dakota. Due to the seasonal nature of the Bureau's pesticide application program, no further site visits were conducted until June 1984. At that time, an industrial hygienist visited three field stations in California: Red Bluff, Tracy, and Fresno. The purpose of the visits was to evaluate work practices, personal protective equipment, and the potential for exposure to herbicides during mixing and spraying.

III. BACKGROUND

The Bureau of Reclamation's chief responsibility is to develop and conserve water resources within the seventeen westernmost states. The Bureau operates and maintains many storage dams, rights of way, public lands (parks) and hundreds of miles of irrigation canals. Controlling noxious plants at these various sites is a primary maintenance responsibility.

Although the majority of the herbicide application is performed by commercial applicators, state agencies, and water users, approximately one hundred Bureau employees are directly involved in mixing and applying herbicides. The majority of these individuals are located at various field stations in the State of California where the Bureau operates large irrigation canals vital to the agriculture in the desert valleys. Typically, there are only two persons at each site involved in pesticide application - an applicator, who is certified or licensed by the state in which he works, and an assistant, who helps with the mixing and drives the spray vehicle.

IV. EVALUATION DESIGN AND METHODS

A. ENVIRONMENTAL

The extent-of-exposure aspects of this study were limited by the small number of applicators at each site, the weather, (particularily wind speed), and the short, daily duration of exposure. However, an attempt was made to collect personal breathing zone air samples from both the applicator and the driver, during mixing and spraying, at all sites. Since mixing took no more than ten to fifteen minutes to complete, air samples for pesticide exposure were collected covering the exposure period for the entire day. Therefore, mixing exposure vs. spraying exposure is not distinguishable.

Table 1 outlines the sampling and analytical techniques used for each herbicide in this evaluation. The analytical method employed for Roundup for both air samples and patch samples should be considered experimental, since it was developed specifically for this project and the precision and accuracy of the method has not been established.

At one site, an attempt was made to evaluate the opportunity for skin exposure by pinning treated glass fiber pads, held in 35 mm plastic photographic slide mounts, to the clothing on various parts of the person - hand, shoulder, chest, thigh, and shoe. These patch samples were placed on the outside of the clothing in order to assess the amount of herbicide available. No attempt was made to evaluate the penetration of the herbicide through the protective clothing. The method is presented in Table 1.

Work practices were observed during mixing, spraying and cleanup procedures. The protective clothing and respirators used or available, were also examined along with the facilities used for their storage.

B. Medical

Anecdotal interviews were conducted at the Heart Butte Resevoir site in North Dakota to determine if Bureau employees had experienced past or present ill health effects as a result of pesticide exposures.

Information on current medical monitoring practices was also collected.

V. EVALUATION CRITERIA

A. Environmental Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH investigators use established environmental evaluation criteria that assess a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage of workers may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy) to a given substance.

In addition, some substances may act in combination with other substances found in the workplace, the general environment, or with medications or personal habits of the worker, to produce health effects even if the occupational exposures meet evaluation criteria. These combined effects are often not considered in the evaluation criteria of single substances. Also, some substances are absorbed directly through the skin and mucous membranes, which may increase the overall exposure. Although the assessment of increased risks from skin exposures, to substances that have evaluation criteria based upon inhalation exposures and airborne levels is scientifically tenuous, compliance to environmental criteria may not always protect the employee from significant skin exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of substances becomes available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents (1) and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's) (2,3), and 3) the U.S. Department of Labor (OSHA) Occupational Health Standards. (4) Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards may also take into account the feasibility of controlling exposures in various industries where the agents are used. The NIOSH-recommended standards by contrast, are based primarily on data supporting the prevention of occupational disease. In evaluating the exposures reported in this document and the recommendations for reducing them, it should be noted that industry is legally required to meet only those levels specified by an OSHA standard.

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

B. Specific Herbicides

1. 2,4-D (2,4-Dichlorophenoxyacetic acid, CAS # 000094757) (5,6)

2,4-D is used as a post-emergent herbicide; that is, it is applied to sprouted and formed plants. It is effective against a wide variety of dicotyledonous (two seed leaves) weeds such as mustards, thistles, dandelion, and ragweed. It is used in certain food crop areas (with legal residue tolerances established by the Food and Drug Administration (FDA) at 5 ppm (by weight) for certain fruits to 0.5 ppm for certain grains.)

Other uses include the clearing of weeds from highways, rights-of-way and waterways and for clearing shrubs, bushes, and broad-leafed hardwood trees. It was used extensively as a defoliant along with other herbicides during the Vietnam War.

2,4-D is available in a variety of forms. Most commercial formulations contain an ester or salt, rarely the free acid. For example, commercial preparations are available as salts of the following cations; sodium, lithium, and many substituted primary amines (trimethyl-, ethanol-, triethanol-, dodecyl-); and as esters of the following alcohols- isopropyl, ethyl, n-butyl, ethylhexyl, butoxyethyl, and butoxypolypropylene. The importance of formulation relates to solubility, skin penetration, and volatility. The esters in general are more volatile than the salts, except that the higher molecular weight esters are less volatile. Increased volatility results in increased spray drift. Although it has not been studied, skin penetration may be related to concentrations of alcohol and herbicide.

Much of the information on the toxicity of the phenoxy acid herbicides (2,4-D and 2,4,5-T) has discussed the issue of trace contamination with dioxins. Although 2,4-D production can result in contamination with dioxins (hexachlorodibenzodioxin, 2,7-dichlorodibenzo-p-dioxin), the intrinsic difference in production from 2,4,5-T results in 2,4-D being free of the more toxic tetra-dioxin contaminants.

2,4-D can cause liver and kidney damage in animals. The oral LD_{50} has been reported to range from 350-800 mg/kg in various animal species.

2,4-D is rapidly cleared from the blood after absorption, and is excreted by the kidney primarily as the unmetabolized parent compound. 2,4-D does not accumulate in fat.

Acute exposure to 2,4-D can be irritating to the skin, eyes, and respiratory and gastrointestinal linings. 2,4-D generally is regarded to be fairly nontoxic, although peripheral neuropathy from exposure has been reported. In a few individuals, local depigmentation has resulted from prolonged and repeated dermal contact. The lowest oral lethal dose for humans is reported to be 80 mg/kg.

No human reproductive effects have been verified to date from male or female exposure. However, after 2,4-D was administered to pregnant animals, decreased fetal growth rates were observed.

2,4-D has been assayed for carcinogenicity in rats and mice. Although there were some study design flaws which led investigators to conclude that compelling evidence of carcinogenicity as a result of 2,4-D administration did not exist, the tumors observed could have been caused by 2,4-D. Human epidemiological data are affected by confounding factors (such as 2,4,5-T exposure), and a 2,4-D specific effect cannot be demonstrated.

The American Conference of Governmental Industrial Hygienists has published an 8-hour threshold limit value of 10 mg/M^3, and a short-term (15 minutes) exposure limit of 20 mg/M^3. The OSHA standard is also 10 mg/M^3.

2. Roundup (Isopropylamine salt of n-phosphonomethyl glycine, glyphosate, CAS # 28641940) (7,8)

   Roundup, the tradename of Monsanto for n-phosphonomethyl glycine with 2-propanamine in a 1:1 ratio, is a water soluble liquid which is used as a foliage spray for control of most noxious weeds. The common name is glyphosate. There is very little toxicological information available on glyphosate. However, existing data indicate that glyphosate is an eye and mucous membrane irritant and can be irritating to the abraded skin. Ingestion can result in nausea, vomiting, and abdominal discomfort. When tested in deer mice, it apparently had no adverse effect upon reproduction, growth, or survival after one year.

   The oral LD_{50} in rats is reported to be 4320 mg/kg, which indicates it is not acutely toxic. However, glyphosate has been reported to be mutagenic in the human lymphocyte as demonstrated by sister chromatid exchange (interchange of metaphase chromosomal DNA between cell division products at apparently homologous loci).

   There are no exposure standards or criteria for glyphosate.

3. Banvel (3,6-Dichloro-2-methoxybenzoic acid, dicamba, CAS # 001918009) (9)

   Banvel (Velsicol tradename) is a water soluble liquid herbicide which is used as a foliage spray for brush control. The common name is dicamba. There are numerous oral LD_{50} citations, ranging from 1040 mg/kg for the rat to 3000 mg/kg for the guinea pig. Apparently, it is acutely toxic only in high concentrations, and can cause muscular spasms, urinary incontinence, dyspnea (labored breathing), and exhaustion (following repeated spasms) in experimental animals. There are no exposure standards or criteria for Banvel.

E. Medical Surveillance

There are literally thousands of chemicals currently registered as pesticides. It is impractical to address specific health effects for each one. Rather, it is recommended to establish a program of medical surveillance that combines background or baseline information, worker education, prevention-oriented training and a common sense approach to dealing with exposure incidents and accidents.

Underlying the medical surveillance program should be a strong emphasis on worker awareness and education. Proper training to prevent pesticide exposures should be basic. Awareness of routes of entry into the body (especially skin contact) and the onset of symptoms specific to the substances being used can alert workers to the presence of a problem and early treatment.

1. Medical History: This record should include an occupational history which reviews previous occupations, exposures and work related illnesses. Particular attention should be given to current or past conditions that may place the employee at increased risk or susceptibility to experiencing adverse health effects from exposures to pesticides. These include:
   - -skin problems;
   - -neurologic (nervous system) problems;
   - -respiratory problems (asthma, emphysema, etc.);
   - -allergies;
   - -smoking history (past or present); and
   - -alcohol use (past or present).

2. Physical Examination: The American College of Physicians has recommended minimal preventive measures for asymptomatic persons at low medical risk.(16) A physical examination guided by these recommendations, with attention to organ systems specific for age and sex, skin status and neurological assessment should be considered basic. Other clinical evaluation should be performed when a problem is presented or suspected.

3. Laboratory Tests Broad-based laboratory screening tests are not generally recommended. Consideration for obtaining baseline laboratory tests should be guided by the medical history and if illnesses are currently suspected. Baseline determination for blood (plasma and red blood cell) cholinesterase (ChE) levels is highly recommended - if products containing organophosphates are going to be used.

   a. Cholinesterase Determination: Obtaining baseline red blood cell and plasma cholinesterase levels should be considered basic when organophosphate compounds are going to be used. The NIOSH Criteria for a Recommended Standard During the

Collection of these data would serve the following purposes: 1) provide a record of the pesticide (name and concentration) to which the worker was potentially exposed; 2) indicate the duration of this exposure; 3) indicate whether or not protective equipment was used and correct operating procedures were followed; 4) account for any accidents that might have occurred; and 5) provide data which can be reviewed on a yearly basis, in order to spot shortcomings in the protection system.

These records should be kept for each individual involved in pesticide work. Exposure records should be maintained for 30 years after termination of the employee. An example of a form that could be used is illustrated in Attachment 2.

2. Medical Records

Medical records should include an occupational history which reviews previous occupations, exposures and work related illnesses. Current or past conditions that could place the employee at increased risk to experiencing adverse health effects from exposures to pesticides should be documented. Accidents or job-related illinesses should be well documented and should include medical courses of action taken.

3. Training Records

A record of each training course taken by each employee should be maintained. Training should include such topics as toxicity of pesticides, routes of exposure, recognition of health effects of exposure, and respirator use. In addition to the standard pesticide training required by the respective states, the Bureau should establish minimum training standards that would at least meet or exceed training requirements of individual states. Such standards would provide assurances that bureau personnel receive the same consistent base of information and eliminate possible gaps that may exist in training requirements from one state to the next.

4. Other

A file of Material Safety Data Sheets (MSDS) should be kept in the office. Each person involved with pesticides should receive a copy. MSDS as they come from the pesticide manufacturer are notoriously incomplete. It may be necessary for the Bureau Safety and Health Office to provide complete information so the MSDS are more meaningful to the workers.

Rubber boots are necessary to prevent the applicator's feet from becoming contaminated. The most likely part of the body to become contaminated should a spill occur during pouring are the feet. Note that the highest value (43 ug/cm^2) in Table 2 is from the feet. These rubber boots should be rinsed on the outside after each use and hung up in a clean place for the next use.

4. Gloves

Either disposable, surgical-type or reusable rubber gloves could be used. Reusables are usually thicker and last longer; disposables are very convenient and do not compromise dexterity.

5. Chemical Safety Goggles and Faceshields

Both may not be necessary. However, since the practice is accepted, it is a conservative measure that cannot hurt.

6. Shower Facilities

This can be loosely interpreted to mean any way of providing enough water to decontaminate any part of the body that might become contaminated. This should be in reasonable proximity to the pesticide mixing area. Of course, where there are clean/dirty locker room arrangements, employees usually shower before putting on street clothes.

7. Eyewash Facilities

Eyewash facilities should be available both at the mixing site and in the field. Enough water should be present to flush the eyes with a constant stream for at least 10 minutes.

8. Field Washing Facilities

If workers are to eat their lunch in the field, hand soap (liquid, dispensed as used), water and towels should be provided. The eyewash tank should not serve a dual purpose. A mirror should be provided to facilitate face washing. The face and neck are more susceptible to increased pesticide absorption over the hands due to greater blood supply and the lack of callouses.

D. Recordkeeping

1. Exposure Records

Inhalation exposure and skin contact generally is minor, with the exception of potential accidents. Therefore, daily records should be kept that address three areas of information: 1) type of and duration of potential pesticide exposure; 2) protective measures taken (clothing used); and 3) details of any accidental pesticide exposure or unusual circumstances that may have occurred.

3. Any article that becomes saturated with concentrate must be removed immediately. This includes personal clothing as well. Such contaminated clothing must be discarded or thoroughly decontaminated before reuse.

4. If there has been skin contact, throroughly wash the area with soap and water. Report this contact to your supervisor and document the accident.

5. If eye contact occurs, flush the eyes with water for 10-15 minutes. If redness or swelling occurs, seek medical attention. Report all eye contact with pesticides to your supervisor.

6. When finished mixing the pesticide, wash any areas (top of tank, tools) which may have become contaminated with concentrate with water. This is important so that future contact with these areas does not result in exposure.

C. Personal Protective Clothing, Equipment, and Facilities

1. Respirators

When respirators are considered necessary, the OSHA Regulations (29 CFR 1910.134) require that the employer have a written respirator program. The most important aspects of this program are training of the worker in respirator use, so that the proper respirator is selected, and care of the respirator, so that it continues to function properly.

2. Coveralls

There are two choices available: washable and reusable cotton work clothes, and disposable coveralls. The disposable types, especially those that have been treated to repel liquids, are recommended. Using disposable coveralls eliminates the need for separate laundering and clean/dirty locker room arrangements. If reusable work clothes are selected, then arrangements for laundering must include finding a vendor who will provide the service when informed that, because the clothing is potentially contaminated with pesticides, it must be washed separate from other clothing and the wash water disposed of in an EPA approved fashion. Locker arrangements require separate rooms; a clean locker room for street clothes and a "dirty" locker room for storing work clothes. In addition, a clean set of work clothes should be worn daily.

3. Rubber Boots

protective equipment such as gloves, boots, face/eye protection, and suits, should eliminate or minimize this exposure. If testing is needed, very sophisticated and controlled approaches are necessary in order to quantitatively evaluate this dermal exposure. Therefore, it is inappropriate to recommend either an air sampling program or attempts by the Bureau to evaluate the extent of skin exposure at this time. However, an industrial hygienist should be employed by the Bureau to: 1) assist in the ongoing effort to evaluate the Bureau safety and health program regarding the need to institute air monitoring (if and when new conditions arise) and the use of protective clothing; 2) periodically review safety records; 3) provide training; and 4) act as an information resource.

B. Work Practices

Written work practice guides should be provided for each operation in which the potential for pesticide exposure exists. These written work practice guides should serve two functions: 1) to guide the worker in the routine performance of the job; and 2) to provide emergency procedures in case of accident. Each worker should become familiar with the guides that apply to his work and be given a copy, with one copy on file. It might be helpful, if possible, to post the guides at the location where the job takes place.

An example, dealing with adding a concentrated pesticide to a tank truck, follows.

1. Handling (opening, pouring, washing out) containers of concentrated pesticide requires the use of the following protective clothing articles. These must be donned before pesticide handling.

    a. Tyvek Coveralls.

    b. Rubber boots. The coveralls shall be placed over the boot tops in order to prevent any spilled pesticide from entering the boot.

    c. Respirator with organic vapor (black band) cartridges.

    d. Chemical splash eye goggles or face shield.

    e. Hard hat.

    f. Disposable rubber gloves.

2. Any non-disposable articles (rubber boots, hard hat, respirator) which become contaminated during the process must be rinsed thoroughly before putting them away. Store each in its proper place.

E. Protective Clothing and Equipment

Different articles of protective clothing were available at each field station. Generally, they were of the same caliber: Tyvek™ body suits (with and without booties and head covering), rubber gloves, hard hats and safety eyewear (chemical safety goggles, chemical safety shields, impact-type glasses), rubber boots, and respirators (half-face, organic vapor cartridges). Depending on the field station location and the preferences of the user, some of these articles were not used. For example, respirators were always used by the applicator during mixing, but sometimes not used during spraying. The only serious shortcoming observed regarding protective clothing concerned respirators. In one instance, it was determined that respirator parts were being interchanged, with no consideration given to compatability. In another, a dust, fume, and mist cartridge was available for pesticide use. Both these shortcomings point to the need for a formal, written respirator program.

Showers, eyewash equipment, and clothes and respirator storage lockers were provided at all stations. However, in some cases, respirator cartridges were stored with other work equipment which could cause contamination. Also, no work clothing changes were provided. Work clothes were worn home. Separate clean/dirty locker arrangements were not seen. Emergency eyewash equipment ranged from small, plastic squeeze bottles to large, pressurized cylinders with eyecup nozzles. Clean wash or drinking water generally was not carried in the field.

F. Medical Surveillance Program

No medical program pertaining to either pre-pesticide (baseline) exposure or periodic monitoring was in place. Anecdotal interviews conduct among employees at the Heart Butte site did not identify health problems related to pesticide exposure. Employees had a good understanding of the risks involved with spraying pesticides, as well as related risks posed by operating the machinery in fairly rough terrain and avoiding risks posed by entering the habitant of rattlesnakes, bees and other insects.

VII. RECOMMENDATIONS

A. Environmental Monitoring

Since inhalation exposure appears to be minor, a comprehensive program of environmental air monitoring is not warranted. We support fully the Bureau's policy of prohibiting spraying in windy conditions. Rather, we feel that employee education concerning the health effects of pesticides and proper work practices will be more productive in protecting workers. The risk of dermal exposure, although present, appears to be small. The greatest risk of dermal exposure to pesticides exists at the mixing point. Proper use of

that Bureau employees spray primarily along smooth road ways and do not walk through weed areas using back pack sprayers (Libich, et al (15), showed that increased pesticide exposure occurred when mist blowers were used and when boom spraying rough terrain), it appears that further concern about inhalation exposure, such as periodic air monitoring and respirator use during spraying activities, is unnecessary. The policy of spraying only during calm wind conditions (less than 10 miles/hour) is probably the most important factor in maintaining low exposures during boom spraying.

Air samples for acrolein exposure were not collected since the procedure is an enclosed process and the setup takes only minutes to perform. After observing the procedure, it was judged that only an accident, such as a leak in the delivery line, would result in exposure to the applicator.

B. Skin Contact Assessment

The results of the skin exposure assessment are in Table 2. These results should be considered approximate only since the filter pads sustained some damage during sample collection. Where two samples from the same body site were collected, a range of values has been reported. The data indicate that the applicator is more heavily exposed than the driver. Information does not exist which allows comment on whether or not this is a significant exposure in terms of contact. In addition, the distribution of the pesticide, as observed from the dye stain on the filter pad, indicated that the exposure was not uniform, and it was not possible to determine a total dose from skin exposure by calculating the area of exposed skin. However, the data indicate that the potential for skin contact exists, and if reduction in total body exposure is desired, then protective clothing is warranted.

C. Exposure Recordkeeping

Since the Bureau does not have an environmental monitoring program, exposure data does not exist. The closest to an exposure record is the daily herbicide use log maintained at one field station. This record detailed the amount of herbicide used, the applicator and driver names, and the location sprayed.

D. Work Practices

Overall, Bureau employees demonstrated a good understanding of the hazards associated with herbicide use. In every situation, it was evident that the employees had considered the potential for inhalation exposure as well as skin contact. No unsafe work practices were noted. However, some of the uncertainty about procedures, particularly in emergency situations, could be alleviated with written work practice guides.

VI. RESULTS AND DISCUSSION

The amount of time devoted to pesticide spraying at any given field station is determined by the growth cycle, and the degree of the problem the particular noxious plant is causing, and the climatic conditions where the field station is located. For example, in the Upper Missouri Valley Region, spraying could be described as a part-time function. With a short growing season in the northern latitudes, spraying may typically be limited to four or five months. When one considers mixing time and travel time from site to site, actual spraying time on a daily basis may amount to no more than four or five hours. On the other hand, the Mid-Pacific Region is more temperate with essentially a year-around growing season. Although actual spraying time on a daily basis may be similar to that in the Upper Missouri Valley Region, pesticide spraying is a full-time activity performed all year. The type and strength of pesticide used depends on the noxious plant to be controlled. Concentrated pesticide, as received from the manufacturer, generally contains approximately 50 percent active ingredient. After diluted with water, the application strength is reduced to one-half to three percent.

One very important influence on spraying is wind speed. Bureau policy states that spraying will not be conducted when wind speed exceeds five to seven miles per hour. This is done for two reasons: protecting the employee against blowback, and protecting non-targeted plants from pesticide drift.

Depending on the geographic character of the site, spraying can be performed from a moving vehicle with a boom attachment or by walking along side the vehicle with a hand-held hose. These two methods were observed when spraying was done along flat, rights-of-way, irrigation canals and on rather rough slopes along river banks. Backpack-type sprayers were also available, but are reportedly infrequently used and were not observed during this investigation.

A. Air Sampling

The results of air samples for pesticide exposure, collected from three field sites (Heart Butte, Tracy, and Fresno), are presented in Table 2. All exposure levels were very low. Exposures to 2,4-D ranged from 1.8 ug/M^3 for the driver to 2.6 ug/M^3 for the applicator, for the time period sampled. Conversion to 8-hour TWAs results in exposures less than 0.01 percent of the ACGIH TLV of 10,000 ug/M^3. Other herbicide exposures were: Banvel, 1.2 - 1.4 ug/M^3; Buctril, less than 1.8 ug/M^3; and Roundup, less than 28 ug/M^3. These data are limited and were subject to many environmental variables, including; atmospheric turbulence, terrain, concentration of the active ingredient in the spray solution, application rate, etc., which could have caused higher exposures. However, the belief that inhalation exposure represents a minor portion of the total exposure of pesticide applicators is shared by other investigators (14). Considering

4. Acrolein (CAS # 00107028) (10,11)

Acrolein is used as an aquatic herbicide in specific situations where the release of the vapor is controlled by submersion and mixing directly in the water (irrigation canal) to be treated. Its timed release forms a plume that treats submerged weeds as the plume follows the canal flow.

Acrolein is intensely irritating to the eyes and nose even after a low level exposure of short duration. It is immediately detectable at 2.5 mg/M^3, and unbearable at 60 mg/M^3. In liquid form, it can cause severe corneal injury and skin burns. Inhaled, it can cause pulmonary edema and decreased pulmonary function. Long-term exposure can cause skin irritation and occasionally skin allergy appearing as hives or a rash. Acrolein has a piercing, disagreeable odor; however, its odor threshold (reported to be from 0.2 to 15 ppm, by volume) is not low enough to serve as a good warning.

The ACGIH 8-hour TWA TLV for acrolein is 0.25 mg/M^3, with a short term exposure limit (15 minutes) of 0.8 mg/M^3. The OSHA standard is 0.8 mg/m^3.

5. Buctril (3,5-Dibromo-4-hydroxybenzonitrile, bromoxynil, CAS #001689845) (12,13)

Information on the toxicity of Buctril is limited. The common name is bromoxynil. It is one of a class of herbicides known as nitrile herbicides. Similar herbicides are 2,6-dichlorobenzonitrile (dichlobenil) and 4-hydroxy-3,5-diiodobenzonitrile (ioxynil). The toxicity of bromoxynil and ioxynil are very similar in animals. Ioxynil LD_{50}s range from 76 mg/kg in the guinea pig to 180 mg/kg in the rabbit, bromoxynil LD50s range from 63 mg/kg for the guinea pig to 260 mg/kg for the rabbit.

Ioxynil was not mutagenic in bacterial systems, either with or without metabolic activation.

Workplace exposure (level not reported) in a operation manufacturing both ioxynil and bromoxynil resulted in four workers suffering from inordinant sweating and thirst, fever, headache, dizziness, vomiting, asthenia (weakness), weight loss, and/or myalgia of the legs. The health effects were attributed to an increase in production resulting in increased exposure. No further cases were observed after the ventilation was increased, hours of work were shortened, and personal hygiene was improved.

There are no exposure standards or criteria for Buctril.

Manufacture and Formulation of Pesticides(17) defines baseline cholinesterase determination as; "the mean of two ChE determinations, each of which is derived from a separate sample of blood taken at least one day apart after a period of at least 60 days without known exposure to any ChE inhibiting compounds. Additionally, the criteria recommend that the two tests do not differ by more than 15%.

Depending upon the toxicity of the products being used, ChE activity should be measured at intervals ranging from weekly (for highly toxic compounds) to every 6-8 weeks. More frequent monitoring of ChE may be indicated if organophosphate illness is presented or suspected.

b. Unacceptable Exposure: Unacceptable exposure to organophosphates is defined as a 30% decrease of the ChE baseline determination.(18) In this situation it is recommended that the source of exposure be investigated and corrected and ChE monitoring of the employee is continued. If a 40% decrease of the ChE baseline determination occurs, then the employee should be removed from the exposure and placed under medical observation.

4. Pulmonary Function Tests: Pulmonary function tests offer a simple, inexpensive and non-invasive screen that can detect impaired breathing or lung obstruction fairly early.

F. Other Specific Recommendations

These recommendations are based on observations made during site visits and pertain to specific situations.

1. During the California visit, repeated referral to the EPA classes of toxicity was made. While this is (with some minor variations) the system of classification NIOSH has adopted, caution should be exercised against accepting these classifications as absolute and never changing. The fact is that research continually is changing the beliefs held about pesticides. As research techniques become more sophisticated, investigators are better able to pinpoint or discover subtle health effects. For example, 2,4-D, a class III herbicide, is relatively non-toxic from an acute exposure standpoint. However, newer information (13) suggests that 2,4-D may be a carcinogen. Further, the long term effects, as well as the effects of two or more pesticides together (synergism), have not been studied. It would be best to consider them all class I chemicals and minimize exposure to the extent feasible.

2. When adding granulated or powdered herbicide to the mixing tank, crosscurrents of air reportedly create aerosols which could be inhaled. an enclosure connecting the tank lip with the herbicide container could be used to eliminate these

crossdrafts. This possibly could be accomplished by using a modified cloth clothes bag with a drawstring closure at both ends. One end would be secured to the tank with one drawstring and the other end connected to the container. It should be long enough to be fastened at both ends while the container is sitting on the top of the tank. After its use, the bag should be stored in a place where residual dust will not be spread about, or washed out.

3. When connecting the nitrogen and acrolein pressure lines, use a soap solution (commercially called Snoop®, available from any laboratory supply house or make your own) to check for leaks. The only problem with the acrolein operation was the possibility of a high pressure leak spraying the applicator. If each joint was "Snooped" and checked for leaks while under slight positive pressure, the possibility of a high pressure leak could be eliminated.

4. In addition to carrying the telephone numbers of local emergency rooms or hospitals with the field vehicles, the medical facilities should be provided with a list of the pesticides used and any health effects/antidote information available. This may facilitate treatment if it is ever needed.

5. A chain of command for a worker to obtain information on safe procedures, toxicity of pesticides, etc. should be established. One way would be through the field station supervisor who has ready access by telephone to the Health and Safety Office in Denver, Colorado.

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2. OSHA, Region VIII
3. Bureau of Reclamation, Department of the Interior

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Table 1
Sampling and Analytical Methodology
Bureau of Reclamation/Department of the Interior
North Dakota and California
HETA 83-341

Substance	Sampling Method	Analytical Method
Buctril Method 5010 (19)	personal sampling pump, PTFE filter, 2.0 Lpm flowrate, ship refrigerated and in dark	Acetonitrile desorption Liquid Chromatography Absordance detector with 254 nm filter 40/60 Acetonitrile/H_2O 0.8 mL/min flowrate
2,4-D and BANVEL modified FDA method (20)	personal sampling pump ORBO - 42 pesticide tube preceeded by glass fiber filter, 1.0 Lpm flow rate	KOH hydrolysis, acidification, diethylether extraction Gas Chromatography, Electron capture detector, DB-5 wide bore capillary column, temperature programming 150 -250°C.
Roundup (air) (experimental method)	personal sampling pump, ORBO - 42 pesticide tube preceeded by glass fiber filter, 1.7 Lpm flow rate	H_2O desorption, one hour sonification 0.45 mn filtration, Liquid chromatography, Differential Refractometer Detector, Sulpelco Lc-18 column, isocratic H_2O, 0.8 mL/min flow rate
Roundup (patch)	glass fiber filter held in 35 mn plastic photographic slide mount, pinned to clothing	same as above for Roundup air sample

Table 2
Inhalation Exposure to Pesticide Applicators
Bureau of Reclamation/Department of the Interior
North Dekota and California
HETA 83-341

Survey Location	Job classification	Pesticide used	Sampling time (min)	Pesticide concentration (ug/m^3)	8 hour TWA (ug/m^3)	Lower limit of detection (ug/m^3	Concentration (percent)	Recommended Exposure limit (ug/m^3)
Heart Butte Resevoir	Application	Dicamba	160	1.4	0.5	0.3	0.5	
Bismark, ND		2.4-D	160	2.6	0.9	0.3	1.0	10,000
	Driver	Dicamba	160	1.2	0.4	0.3		
		2.4-D	160	1.8	0.6	0.3		
Tracy, CA	Applicator	Bromoxynil	421	<2	<2	1.8		
	Driver	Bromoxynil	424	<2	<2		0.5	
	Applicator	Roundup	430	<28	<26	0.01	0.5	
Fresno, CA	Driver	Roundup	425	<28	<26	0.01		

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