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PROCEDURES
FOR

MASTER

RADIATION MONITORING

BATTELLE
BATTELLE MEMORIAL INSTITUTE

NORTHWEST
PACIFIC NORTHWEST LABORATORY

RICHLAND, WASHINGTON

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RADIATION PROTECTION DEPARTMENT
RADIATION MONITORING PROCEDURES

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BATTELLE - NORTHWEST
RADIATION PROTECTION DEPARTMENT
RADIATION MONITORING PROCEDURES

RADIATION MONITORING RESPONSIBILITIES

I. DEFINITION OF PROBLEM

The nature of radiation work at BNW is such that an extensive and continuing radiation control program is necessary to provide a high degree of personnel protection and to assure compliance with the requirements of existing federal and state regulations. The accomplishment of these objectives requires the active participation of operating and service groups as well as groups directly concerned with radiation protection. The basic responsibility for individual employee radiation protection lies with the individual himself and his immediate management. To assist them, many specialized radiation protection functions are performed by the Environmental Health Department. The Radiation Monitoring Section is responsible for performing most of the functions related to day-to-day radiation work, as well as some functions having long-term significance.

II. ORGANIZATION AND FUNCTIONS

A. Organization

The Radiation Monitoring Section is divided into Units, each of which is under the direction of a Supervisor who reports directly to the Section Manager. Each Unit includes one or more health physicists and a number of Radiation Monitors. The responsibility of the Units is divided primarily on a geographical basis.

B. Functions

Radiation Monitoring functions may be arranged into five groups as follows:

1. Routine Surveillance

- a. Maintain a current knowledge of the radiation conditions, radioactive materials, and radiation generating machines present in BNW facilities.
- b. Determine the airborne and surface contamination status of work locations throughout BNW facilities.
- c. Specify those areas to which personnel access must be controlled by establishment as Radiation Zones.
- d. Evaluate temporary Radiation Zones monthly to assure that the posting is adequate and that the temporary Radiation Zone is, in fact, still required by current conditions.

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- e. Advise operating management of appropriate controls for the transfer and disposal of solid radioactive waste.
 - f. Advise appropriate management personnel on the radiation protection aspects of new facilities and modifications to old facilities.
 - g. Advise visitor escorts of the procedures, precautions, and controls appropriate in the facilities being visited.
4. Coordination with Other Sections in the Environmental Health Department
- a. Ensure that Nuclear Safeguards and Engineering has been notified of all proposed work involving very large quantities of radioactive materials or extremely hazardous processes, including shipments of material having an activity greater than 300 curies and an activity density greater than 100 microcuries per gram.
 - b. Ensure that Environmental Studies has been notified of all proposed work which could result in the uncontrolled discharge of significant quantities of radioactive materials to the environs, and of all incidents in which such a release may have occurred.
 - c. Ensure that Nuclear Materials Management has been notified of all shipping requirement violations affecting offsite shipments to or from BNW facilities.
 - d. Advise Personnel Dosimetry of special exposure measurement needs which may arise.
 - e. Provide Personnel Dosimetry with results of measurements useful in the evaluation of radiation exposures.
 - f. Specify those locations where individual neutron exposure estimates are required and the methods by which they are to be obtained, recorded, and forwarded to Personnel Dosimetry.
 - g. Notify Personnel Dosimetry of incidents requiring evaluation of dose, involving loss of control over radioactive materials or radioactive wastes, or having public relations significance.
 - h. Accumulate and retain radiation monitoring information obtained at the time of incidents and make it available to investigating groups.
 - i. Prepare informal investigation reports of incidents and unusual circumstances and forward them to Personnel Dosimetry.

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- j. Accumulate records establishing the conditons under which individuals were exposed in BNW facilities. These records are to include:
 - 1) Radiation safety analysis and evaluation reports;
 - 2) Radiation and contamination survey reports;
 - 3) Radiation Work Procedures;
 - 4) Area monitoring instrument results; and
 - 5) Airborne radioactive contamination monitoring results.
- 5. Radiation Protection Training
 - a. Provide a general orientation on BNW radiation protection program to all new employees.
 - b. Assist management in on-the-job training of employees in radiation protection aspects of work.
 - c. Provide lectures and/or demonstrations on radiation protection as requested by operating supervision or as indicated by radiation protection experience.
 - d. Provide appropriate training for employees engaged in radiation protection and for laboratory supervisors and professional personnel.

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RADIATION MONITORING PROCEDURES

CONTROL OF EXPOSURE TO PERSONNEL

I. IN GENERAL

The basic goals of the radiation protection program at BNW are the elimination of unnecessary radiation exposure and the minimization of necessary radiation exposure.

A. Establishment of Radiation Zones

To accomplish the above objectives, Radiation Zones are established in areas containing sources of ionizing radiation. Access to such zones is controlled by procedures as discussed below.

The Radiation Monitoring Section is responsible for determining the locations and items of equipment which are to be designated as Radiation Zones, applying criteria specified in Section III of Procedure 5, BNWL-MA-6.

In most instances, Radiation Zones are established at the start of laboratory programs when the nature of the work planned is expected to require Radiation Zone control. Radiation Zones also are established when a contamination spread or other event requires control of access to the involved area. Such conditions are normally discovered by Radiation Monitoring surveillance programs or by involved laboratory personnel reporting cases of personnel contamination to Radiation Monitoring.

Operating management is responsible for barricading and posting Radiation Zones as recommended by Radiation Monitoring. Radiation Monitoring is responsible for determining the adequacy of these barricades and signs in accordance with the criteria spelled out in Section III of Procedure 5, BNWL-MA-6.

There are a few instances, such as the following, in which the standard Radiation Zone control system is not strictly applicable:

1. Terminated Radioactive Waste Disposal Facilities.

Radioactive waste disposal facilities such as burial trenches, waste ponds, and cribs are designed to hold radioactive materials in the soil of the disposal site. When the use of such a site is terminated, at least a four-foot layer of uncontaminated soil is spread over the surface to provide shielding and to assure that the material remains in place. Waste Disposal and Decontamination is responsible for marking the boundaries of such terminated radioactive waste disposal sites in a manner specified by Radiation Monitoring. Such boundaries are normally designated by permanent markers, but, if the site contains only relatively short-lived radioactive materials, it may be posted with less durable signs bearing the radiation symbol and the word "underground."

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2. "Controlled" Equipment

Certain equipment such as air and water filters, internally contaminated electric motors, and vehicles contaminated on normally inaccessible surfaces may present no appreciable possibility of personnel exposure and therefore need not be subject to the normal requirements for use and storage within Radiation Zones. In order to be exempt from Radiation Zone requirements, the equipment or vehicle must be free of smearable contamination, be free of highly radiotoxic isotopes, and must have a surface dose rate no greater than 5 mrad/hr. A tag or label bearing the radiation symbol and information regarding the radiological status of the equipment, including directions not to remove the item from BNW facilities without Radiation Monitoring approval, must be firmly attached to the equipment.

B. Use of Written Procedures to Control Access of Personnel to Sources of Radiation Exposure.

Closely related to the Radiation Zone concept is the policy of regulating access to and handling of radioactive materials by means of written procedures. The three types in general use in BNW facilities are Radiation Work Procedures, Onsite Radioactive Shipment Procedures, and Standard Radioactive Shipment Procedures. ~~Radiation Monitoring also has responsibilities relating to the execution of Offsite Radioactive Shipment Records.~~

1. Radiation Work Procedure.

BNW radiation protection policy requires that essentially all radiation work be governed by valid Radiation Work Procedures. Transport of radioactive material between BNW facilities or between BNW facilities and those of other Hanford Contractors, may also be covered by a Radiation Work Procedure if all involved personnel are authorized to use it. Most Radiation Work Procedures are written to cover work of a repetitive nature over a period of one year, but some are written to cover short-term, non-repetitive work.

a. Identification of Radiation Work Procedures

The Radiation Monitoring Section is required to provide a system of identifying numbers for Radiation Work Procedures in BNW facilities. The following system appears the most satisfactory and is currently in use:

CONTROL OF EXPOSURE TO PERSONNEL

If the Radiation Work Procedure is to cover short-term work, a capital "T" is added at the end of the serial number.

b. Content

Radiation Work Procedures contain three basic kinds of information:

- 1) A description of the work, including the particular operation or operations to be conducted, the identity of the nuclides involved, and the approximate amounts of the nuclides to be handled;
- 2) The identification of the facility and the number of the room or laboratory in which the work will be performed; and
- 3) Dosimeter, protective clothing, and radiation monitoring requirements, as well as other special instructions.

c. Assignment of Responsibility

A Radiation Work Procedure is basically a procedure. However, it also represents an agreement between operating management and Radiation Monitoring that the specified procedures provide adequate employee protection and that they will be followed.

Management of each facility is responsible for preparing Radiation Work Procedures relating to work with radioactive materials in that facility. As a practical matter, however, it has proved to be more expedient for Radiation Monitoring to prepare the Radiation Work Procedures following consultation with the appropriate laboratory personnel. Radiation Work Procedures are normally signed by operating management, the RM Engineer or Specialist assigned to the facility, and when appropriate, the management of servicing groups.

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d. Review and Revision

A review of each Radiation Work Procedure is required at least annually although many Radiation Work Procedures are reviewed more frequently.

2. Onsite Radioactive Shipment Procedure

The Onsite Radioactive Shipment Procedure (ORSP) is used primarily for nonroutine, onsite shipments. This procedure is used in lieu of an applicable Radiation Work Procedure (RWP) or when some of the persons involved in the shipment (shipper, transporter or recipient) are not authorized to use the RWP. An ORSP is normally valid for only one shipment and for a period of only one day.

The group making the shipment is responsible for originating the procedure and assuring that personnel involved in the shipment follow its provisions. Radiation Monitoring is responsible for performing the measurements necessary to establish the radiological status of the shipment and noting this information on the form.

Near onsite shipments in transit the radiation level at the nearest approach should not exceed 50 mrem/hr. If it is not practical to reduce the radiation to this level, Radiation Monitoring supervision may make special provisions for the shipment such as arranging for a patrol escort while it is enroute.

3. Standard Radioactive Shipment Procedure

The SRSP is used to cover repetitive onsite shipments of radioactive materials and, like the ORSP, is used for shipments not covered by an applicable RWP. SRSP's, normally valid for one year, are reviewed by operating and Radiation Monitoring personnel before renewal. Execution of SRSP's is similar to that of RWP's as discussed above, with the actual preparation of the procedures being done by the Radiation Monitoring Engineer or Specialist after consultation with the appropriate laboratory personnel.

4. Offsite Radioactive Shipment Record

The ORSR is used for offsite shipments of radioactive materials from BNW facilities. It is originated by the prospective shipper after he has received approvals of his formal request to ship from Nuclear Materials Management and after he has completed and submitted the Offsite Shipping and Receiving Report to Nuclear Materials Management. Radiation Monitoring is responsible for performing the measurements necessary to establish the radiological status of the

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shipment, and noting this information on the form. The procedure for shipping materials is spelled out in some detail in BNWL-MA-5, Nuclear Materials Management Manual.

II. CONTROL OF EXTERNAL EXPOSURE

A. Dose Rate Monitoring

BNW is committed to a radiation protection program which assures that the radiation doses received by personnel will be within established limits. This requires a reasonably accurate continuous knowledge of the radiation levels to which personnel are exposed.

1. Radiation Measurements by Radiation Monitoring Personnel

Certain types of measurements are reserved to Radiation Monitoring personnel because their specific concern with radiation protection and their more thorough training normally assures more accurate measurements and records. Radiation Monitoring personnel should always make the following measurements:

- a. Initial radiation levels when work is started;
- b. All measurements during work in high radiation levels;
- c. All measurements during work in which radiation levels fluctuate widely;
- d. All measurements of neutron radiation;
- e. Initial measurements when containers of radioactive materials are opened; and
- f. Initial measurements when radioactive material is removed from shields or shielded facilities.

2. Self-Monitoring by Laboratory Personnel

In cases where radiation levels are relatively low and work is of a repetitive nature, laboratory personnel may be authorized to make radiation measurements for themselves. Specific authorization for such self-monitoring may be given in RWP's covering work involving stable radiation conditions. Before such authorization is given, however, training in reading dose rate measuring instruments is provided for the involved laboratory personnel by Radiation Monitoring. Such training is by no means as detailed or comprehensive as that provided for Radiation Monitoring personnel, but is adequate for routine work involving stable radiation conditions.

Laboratory personnel who are authorized to do self-monitoring are instructed to contact Radiation Monitoring immediately:

"
"
"

CONTROL OF EXPOSURE TO PERSONNEL

- a. In event of a spill of radioactive materials,
- b. Whenever a significant localized dose to the body is suspected,
- c. Whenever the work procedures are changed in a way that affects the radiation conditions to which personnel are exposed, or
- d. In event of an apparent instrument malfunction.

B. Use of Dosimeters

Dosimeter requirements for exposure record purposes are spelled out in Procedure 2 of BNWL-MA-6. In addition to these programs for recording personnel exposure, pocket condenser ion chamber (gamma pencil) programs are carried out by Radiation Monitoring in some facilities for exposure control purposes.

1. Criteria for Issuing Pocket Ion Chambers

- a. Personnel who frequently receive 50 mrem or more in a one-week period should be assigned pocket ion chambers (self-readers, if available).
- b. Personnel who do not regularly receive significant doses, but who are temporarily assigned to a job in which they may receive a dose in excess of 200 mrem in one day should be assigned pocket ion chambers for the period of exposure.
- c. Other persons who occasionally work in situations where they may receive in excess of 50 mrem in one week should be assigned pocket ion chambers for the period needed.

2. Issuing and Accounting for Pocket Ion Chambers

A list of personnel assigned pocket ion chambers should be maintained at each Radiation Monitoring office. The dosimeter should be identified by serial number, type, and manufacturer. When the dosimeter is returned by the person to whom it is assigned, this fact should be noted on the list. If the dosimeter is malfunctioning, it must be returned to Calibrations for repair or replacement.

3. Use of Pocket Ion Chamber Results

These dosimeters are used in making exposure estimates and enable a current estimate of the wearer's dose.

CONTROL OF EXPOSURE TO PERSONNEL

C. Use of Exposure Estimates

Because of the inherent delay in the return of processed film dosimeter information, it is desirable in many cases to obtain more current information on personnel exposures.

There are two methods by which information on an individual's current exposure status is obtained. As mentioned briefly above, condenser ion chamber dosimeters may be supplied to laboratory personnel for use in gamma radiation fields. Most of these have built-in quartz fiber electroscopes and can be read at any time by the wearer. However, in situations involving large amounts of beta radiation, localized exposure, or neutron radiation, the exposure estimate requires timekeeping based upon dose rate information supplied by the Radiation Monitor. When the dose rates are relatively high, it may be desirable to have one individual serve as timekeeper for others engaged in the work. In this way more accurate exposure estimates are usually obtained than if each individual makes his own.

III. CONTROL OF INTERNAL EXPOSUREA. Radioactive Contamination Control

Radioactive materials of high radiotoxicity or specific activity are usually handled under conditions of complete containment in hot cells or glove boxes, but small quantities of these materials or dilute solutions may be confined in fume hoods.

Radioactive materials of low radiotoxicity or low specific activity are most often handled in hoods, but small quantities of these materials or dilute solutions may be handled in open areas such as on laboratory tables.

Essentially all work with radioactive materials at BNW is performed within Radiation Zones. Entries to and exits from these Radiation Zones are normally made across step-off pads with protective clothing change stations, thus helping to confine any contamination to within the Zones. Ventilating systems in laboratory facilities are designed to cause ventilating air to flow from areas of little or no contamination toward areas of progressively greater contamination. Filters are normally provided between the last contaminated area in the system and the outside atmosphere; this method of concentrating the radioactive material serves as a part of an overall contamination confinement system. A final backup program to confine radioactive contamination is the provision for hand and shoe counts and personnel contamination surveys when leaving Radiation Zones.

Contamination control problems may be broken down into three general categories: surface, airborne, and personnel.

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1. Surface Contaminationa. Types of Surface Contaminants

Both liquid and solid surface contaminants may be present in BNW facilities. Liquid surface contaminants include contaminated water, contaminated solvents, chemical solutions or suspensions of radioactive materials, and concentrated or relatively pure forms of liquid radioactive compounds.

Solid or semi-solid surface contaminants include radioactive dusts, particles or pastes, and greases containing radioactive materials.

b. Control of Surface Contaminants

Large quantities and high concentrations of highly radiotoxic materials are normally controlled by complete containment in hot cells, glove boxes and sealed laboratory or process systems. Except for small samples, materials are removed from these systems only by direct transfer into a receiving vessel or by bagging-out techniques.

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Since there is always some potential for contamination spread during transfers into or out of a containment system, particular attention should be given to contamination surveys of doors and interiors of air locks, couplings of lines used for transfer of liquids, surfaces of sample containers, internal surfaces of sphincters, and cut surfaces of bags used in bagging out.

Large quantities and high concentrations of materials of lower radiotoxicity are controlled by confinement in fume hoods. Small samples and low concentrations are frequently handled on open laboratory tables. Normal Radiation Zone controls serve to confine contamination to the room involved.

c. Decontamination

When solid radioactive material is spilled onto a surface it is frequently possible to save most of it by scooping it up and returning it to its container. The spill area may then be vacuumed and wiped or washed to complete the cleanup. Since vacuuming may cause some of the spilled material to become airborne, however, it should be done only after the hazards are thoroughly evaluated. Vacuum sweepings and contaminated swabs or mops are normally placed in solid radioactive waste containers for burial.

Water used in mopping a spill area is normally disposed of to a crib waste sink. However, if the volume of the liquid is small and it contains a high concentration of radioactive material, it should be held for disposal by Waste Disposal and Decontamination. This can be arranged by calling the group on extension 3012. Liquid radioactive material should not be intentionally diluted for disposal to the crib waste system, nor should any radioactive material at all be disposed of to the retention waste system. Liquid waste disposal practices are spelled out in some detail in the 300 Area Waste Management Manual.

2. Airborne Contamination

a. Types of Airborne Contaminants

Airborne contaminants at BNW are found in both aerosol and gaseous form. Aerosols are suspensions of fine dust or liquid droplet (vapor) particles in the air. Radioactive dust aerosols include both powder forms of pure nuclides or compounds of nuclides (for example, promethium oxide) and dust particles of stable materials

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with radioactive gases adsorbed on them (for example, radon). Liquid droplet or vapor aerosol contaminants are usually composed of pure nuclides or compounds of nuclides (for example, iodine - 131 I, T_2O , DTO).

In addition to radon and thoron, which are likely to be adsorbed on dust particles, the most common gaseous radioactive contaminants at BNW are elemental tritium and the radioactive isotopes of the noble gases argon, krypton, and xenon.

b. Control of Airborne Contaminants

Where laboratory operations might generate high levels of airborne contamination, the operations must be completely contained in hot cells or glove boxes. Where the level of airborne contamination is likely to be low but still significant, the operations should be carried out in hoods. Only operations which are unlikely to develop significant airborne contamination should be carried out in open areas such as on laboratory tables.

Hot cells and glove boxes should always show a negative pressure relative to the surrounding room atmosphere. Hoods should always show an air flow from the room into the hood. Hood doors should be closed except when it is absolutely necessary for them to be open. Work in open areas should be arranged so that the natural air flow carries potential airborne contamination away from the person(s) working there.

c. Decontamination

Aerosols which are spread to the atmosphere of a room are normally removed by exhaust filters which concentrate the contamination.

Decontamination of an atmosphere containing radioactive gases is usually accomplished by transferring the gas to the outside atmosphere through the building exhaust system. However, if the concentration of the gas is high and the radioactive half-life short, the room ventilation may be shut off, doors sealed, and the gas allowed to decay before it is exhausted to the atmosphere.

3. Personnel Contamination

a. Types of Personnel Contamination

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All the types of surface and airborne contaminants discussed above may contribute to personnel contamination, but most cases arise from circumstances involving surface contamination.

b. Location of Personnel Contamination

When radioactive contamination giving a high dose rate is deposited on a person's clothing or skin, the primary consideration is likely to be the reduction of the localized body dose. Another important consideration, no matter what level of contamination is involved, is prevention of spread to personal clothing or other unprotected body areas.

c. Modes of Entry into the Body

Inhalation is the most common method of introduction of radioactive contamination into the body. Once the material has been inhaled, little can be done to reduce the contamination levels in the respiratory system aside from nasal irrigation. However, the normal physiological function of the respiratory system involves a cleaning action which tends to appreciably reduce the contamination levels.

Ingestion of radioactive contamination in significant quantities is not a common mode of internal deposition. However, radioactive material originally deposited in the respiratory system can find its way into the GI tract by virtue of the cleaning action of the respiratory system. The material may be transported to the esophagus by this process, where it may be swallowed, thereby entering the GI tract.

Injection, introduction into existing wounds, and skin absorption introduce radioactive contamination directly into body tissues. Of these, injection probably occurs most frequently, but it is still relatively uncommon. Once radioactive materials have been introduced directly into body tissues, transfer from the site of introduction usually progresses at a relatively slow rate through the circulatory system. If the radiotoxicity of the contaminant is high and it is relatively localized, it may be desirable to surgically remove the deposited material.

B. Use of Protective Equipment and Apparel

1. In General

White protective clothing is provided to prevent contamination of personal clothing and skin. The proper use of

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protective clothing reduces the possibility of internal deposition and assists in preventing the spread of radioactive material.

Radiation Monitoring is responsible for defining minimum radiological protective clothing requirements on the Radiation Work Procedure applicable to each Radiation Zone.

2. Guides for the Use of Radiological Protective Clothing

The type and quantity of radiological protective clothing required for a given job assignment is dependent on a number of factors, including the type, amount and physical form of the radionuclides present, the presence or absence of water, oil, or other liquids, and the primary location of the contaminant. Radiation Monitoring personnel in each facility should specify protective clothing requirements based on the work environment and the capabilities of the various types of apparel. The clothing required for a specific job may be changed from time to time as working conditions change. Some protective clothing will normally be required for any work in areas containing loose or smearable contamination in levels exceeding 200 c/m beta-gamma per GM probe area or 500 d/m per 100 square cm for alpha. The minimum protective clothing requirement for entry into any contaminated area is a lab coat and shoe covers. Work in a glove box containing plutonium usually requires the wearing of coveralls, shoe covers, and surgeon's gloves taped to the sleeves of the coveralls. The minimum protective clothing requirement for handling tritiated water is waterproof gloves.

3. Description and Use of Specific Types of Protective Clothing

a. General Body Protection

Cotton coveralls are usually worn when the work area is generally contaminated to low levels. They constitute a moderately effective barrier to most dry particulate materials. Coveralls should be checked for proper fit upon removal from the clean clothing storage location. Buttons should be fastened before entering the Radiation Zone. If gross contamination is present, two pairs of coveralls should be worn. The fly front opening and side openings, if any, in the outer pair of coveralls should be sealed with masking tape.

Lab coats are normally worn over personal clothing in work areas (particularly laboratories) where low-level contamination is present but not widely spread. Lab coats provide moderate protection against contamination and may be put on and taken off quite easily.

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Rubber aprons over coveralls are useful in wet work areas where low-to-moderate levels of contamination may be encountered.

Rubber or plastic suits are frequently worn over regular coveralls when the work area is wet and gross contamination may be present.

b. Hand Protection

Cotton gloves are worn as primary hand protection in zones where dry, low-level contamination is present and are sometimes worn as secondary protection under rubber gauntlet gloves as well.

Waterproof rubber gauntlet gloves provide good protection to the hands and wrists and should be worn when the work in progress is wet or oily or where contamination levels are high. Gauntlets are usually worn over cotton or canner's gloves taped to the inner coveralls. When worn without inner gloves, talcum powder in the gauntlets makes them easier to get on and off and more comfortable to wear.

Plastic-coated gloves are highly water resistant and are useful where wet, low-level contamination may be present.

Canner's and surgeon's gloves are very thin rubber gloves. They are usually worn under gauntlet gloves or in glove boxes and are normally taped to the inner coveralls. Talcum powder in the gloves makes them much easier to get on and off and more comfortable to wear. These gloves are easily torn, so care must be exercised to avoid snagging them.

c. Shoe Protection

Canvas shoe covers are widely used over personal shoes where the work area is dry and the contamination level is low. They are also used as a secondary contamination barrier under rubbers, canvas boots, or British leggings.

Canvas boots have about the same capabilities as canvas shoe covers, but they afford better protection to the ankles. They are commonly used where dry, low-to-moderate level contamination is spread throughout the work area. When worn under rubbers they give good protection to the ankles for work done on wet surfaces.

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Rubbers should be used where floor surfaces may be wet or oily and low-to-moderate levels of floor contamination may be present.

British leggings or boots are worn where protection from water or splashed contamination is desired for the ankles and lower legs and where contamination levels are high. Proper surveying of the boots is difficult because of their depth. For this reason shoe covers or canvas boots should always be worn inside these boots to prevent possible shoe contamination.

d. Head and Neck Protection

Caps are designed to cover the hair and prevent its becoming contaminated. The cap should be large enough so it can be pulled down to cover all of the hair. Some adjustment can be made with the tie tapes on the caps. They are worn where there is a possibility of rubbing the head against contaminated surfaces overhead or where particulate contamination might fall from overhead.

Hoods give complete head and neck protection, leaving only the face exposed. The hood should be inspected to see that the buttons and buttonholes or snaps are in good condition. The hood should be buttoned snugly under the chin. When masks are used they should always be worn under the hood to obtain a proper seal. Hoods are worn where contamination may be blown about, where there is a possibility of splashing or spraying liquid contamination, where large amounts of contamination may fall from overhead, or where it is necessary to place the head and neck against or between pieces of contaminated equipment.

4. Basic Rules for the Handling of Radiological Protective Clothing

Even though the clothing is surveyed for contamination after laundering, a small amount of residual contamination may remain in the fabric. For this reason, radiological protective clothing must be controlled throughout its life. To accomplish this purpose, the following rules are applied to the use of radiological protective clothing.

- a. Radiological protective clothing shall be worn for the purpose of protecting personnel from contamination; it shall not be worn for other purposes such as preventing personal clothing from becoming soiled in non-Radiation Zone areas.

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- b. Radiological protective clothing shall not be worn in lunch rooms or in other non-contaminated areas.
- c. A complete survey shall be made by a person qualified in radiation monitoring before any protective clothing item is released for off-plant use.
- d. Freshly laundered clothing shall be kept segregated from used protective apparel.
- e. Normally, only freshly laundered protective clothing should be worn. However, protective clothing may be reworn by the same individual, provided the article has been surveyed by a person qualified in radiation monitoring and found free of contamination.
- f. Only protective clothing in good repair should be used. Damaged clothing should be segregated and returned to the laundry for repair or disposal.
- g. After use, care must be taken to prevent the spread of contamination from the clothing to clean areas. To provide the necessary control, used radiological protective clothing is kept under Radiation Zone control until laundered.
- h. If used protective clothing is not to be reworn, it should be placed in the clothing hampers provided at the Radiation Zone exit. Other types of protective clothing, such as blue clothing, must not be placed in white clothing hampers.
- i. Cardboard cartons bearing the radiation symbol and the words "High Level Contaminated Clothing" and a supply of clean gloves should be provided at job sites where high level contamination is likely. Such cartons facilitate the prompt removal of highly contaminated clothing at the job site to minimize exposure, to provide a means of segregating the clothing, and to assure that the highly contaminated items are not returned to the laundry. "High Level Contaminated Clothing" cartons which have been used should be removed from the Radiation Zone at the end of the shift during which they were used. Monitoring is required for handling these containers or their contents.
- j. In order to avoid contamination problems at the laundry, operating personnel should assure that used protective clothing is disposed of according to the following criteria:

<u>Contamination Levels</u>		<u>Action</u>
<u>Alpha</u>	<u>Beta-Gamma</u>	
Fixed contamination <5000 d/m per 100 cm ²	Dose rate at surface of clothing <50 mrad/hour; at surface of Laundry bag <6 mrad/hour	Return to the laundry in the normal manner

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<u>Contamination Levels</u>		<u>Action</u>
<u>Alpha</u>	<u>Beta-Gamma</u>	
5000 to 30,000 d/m per 100 cm ² , and any loose contamination	50 mrad/hour to 500 mrad/hour at surface of clothing; Laundry bag to read <50 mrad/hour.	Wrap and seal, label with activity level, and return in a bag marked "Special Handling"
>30,000 d/m per 100 cm ²	>500 mrad/hour at surface	Discard to contaminated waste, or cut out contaminated portion and return balance of item to laundry in the normal manner

- k. It is highly desirable that cotton or canvas protective clothing be separated from rubber or plastic clothing prior to its return to the laundry.

In addition, care should be taken to ensure that towels and respiratory protective equipment, both of which must be processed separately, are not returned in bags with either canvas or rubber clothing.

5. Use of Respiratory Protective Equipment

Although most work with a potential for generating high levels of airborne contamination is conducted within glove boxes, it is necessary at times for personnel to work in locations where high-level airborne activity exists. In such situations, respiratory protective equipment is used.

Radiation Monitoring is responsible for establishing the need for respiratory protective equipment in Radiation Zones based on either actual or potential levels of airborne contamination. Respiratory protective equipment may perform its function in either of two ways; by filtering the contaminated air or by supplying clean air from a self-contained or remote source. The general types of approved equipment are discussed below.

Army assault masks - Before use, inspect the lenses for scratches that would impair vision. Check the straps for elasticity. The anti-fog valves should be in place and not stuck. The exhaust valve should operate easily and seal completely. Make certain the inlet valve at the canister connection is free all around its perimeter. This can be

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done by depressing it with a pencil or other small object. Before entering a Radiation Zone, make certain there is a canister on the mask and that it is screwed down tightly.

The half-mask is assumed to have the same filtering efficiency as the assault mask, although it is usually more difficult to attain a good seal with the face. The half-mask is worn in Radiation Zones where air concentration is not as serious a problem. The mask should be checked to make certain the canister is properly in place before a Radiation Zone is entered.

Scott Air Pacs are used when the inhalation of radioactive gas is a hazard or when the concentration of particulate air contamination is too high to permit the use of a filter-type mask. These masks are mechanically complex and are routinely inspected by ITT/FSS Fire Protection Personnel. The air tanks provide a limited air supply (15 min.) and a timer with an alarm indicates when a five-minute supply remains.

Fresh air masks are used under the same conditions as Scott Air Pacs. They are ordinarily easier and more pleasant to use and are preferred where a fresh air supply is available. An airtight seal is not as important with fresh air masks as with assault masks because positive pressure is maintained inside the masks during use.

Following are some instructions for the proper wearing and handling of masks:

- a. Each person should check the fit of the mask to ensure a proper face-fit before entering the Radiation Zone. In cases where a proper face-fit cannot be made, the person involved should not enter the Radiation Zone.
- b. Personnel should not remove the mask from the face for purposes of conversation or better visibility while in a Radiation Zone. In cases of shortness of breath the mask may be removed, provided the individual involved leaves the Radiation Zone immediately.
- c. After a mask has been removed it may be reworn by the same individual. It should be surveyed before it is reworn, however, to assure that it is free of contamination.
- d. Removing or donning a mask while in a contaminated Radiation Zone introduces the risk of transfer of contamination from the gloves to the mask or face. Masks should not be handled with potentially contaminated gloves.
- e. All used respiratory protective equipment must be surveyed for contamination prior to being boxed for return to the plant laundry.

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- f. Used respiratory protective equipment which is found to be free of radioactive contamination must be boxed separately, and a radiation release sticker must be attached to the box.
- g. In order to avoid contamination problems at the laundry, operating personnel should assure that used respiratory equipment is handled according to the following criteria:

Contamination LevelsAction

alpha -
>500 d/m/100 cm²

decontaminate to below this level. The Laundry will not accept masks with detectable alpha contamination.

beta-gamma -
<50 mrad/hr

place in a carton marked with the radiation symbol and the surface dose rate.

>50 mrad/hr. but
<1 rad/hr

package individually, mark with radiation symbol and surface dose rate, and execute an ORSP for shipment to the laundry.

>1 rad/hr

decontaminate to below this level. If the decontamination is unsuccessful, discard the mask.

6. Requirements for Respiratory Protectiona. High Radiotoxicity Materials

Included in this group are the following isotopes:

<u>Beta Emitters</u>	<u>Alpha Emitters</u>	<u>Spontaneous Fission</u>
Sr-90	Po-210	Am-241
Pb-210	Ra-223	Am-243
Ac-227	Ra-224	Cm-242
Pa-230	Ra-226	Cm-243
Pu-241	Th-227	Cm-244
Bk-249	Th-228	Cm-245
Ra-228	Th-230	Cm-246
Am-242m		Cm-248
Cr-253	Pa-231	Cr-249
		Fm-256

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Beta Emitters

Es-254
Es-255

Alpha Emitters

U-230 Cf-250
U-232 Cf-251
Pu-238 Cf-252
Pu-239 Cf-254
Pu-240 Es-253

Spontaneous Fission

The radiotoxicity of the isotopes in this group is such that one airborne particle could represent a significant portion of an MPBB if it were taken into the body. For this reason the control concentration concept is not applied to these isotopes. If the nature of the work is such that these materials may appear in the breathing air, full-face filter masks should be worn for the work on the basis of potential alone. If a contamination spread does occur when personnel are not wearing respiratory equipment, those persons should evacuate the area until suitable respiratory protection can be obtained.

b. Uranium and Thorium

The average concentration to which personnel are exposed during an eight-hour work shift should be maintained below the following values:

Uranium	6×10^{-11} $\mu\text{Ci/cc}$
Thorium	3×10^{-11} $\mu\text{Ci/cc}$

If air concentrations greater than the above values can be expected, approved filter-type half-masks should be worn. If the air concentration becomes greater than twenty (20) times the above values, approved filter-type full-face masks must be worn.

c. Tritium

If the tritium concentration is likely to exceed 5×10^{-5} $\mu\text{Ci/cc}$, full-face supplied-air masks must be worn. If the tritium concentration is likely to exceed 1×10^{-3} $\mu\text{Ci/cc}$, special apparel such as plastic suits or rubber jackets and trousers must be worn, in addition to full-face supplied-air masks.

d. Noble Gases and Their Daughter Products

In situations involving only noble gases, whole body exposure in the gas cloud is the limiting consideration. No significant dose will result from deposition in the body. In situations where other gases or particulates may also be present, full-face filter masks should be

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worn until an analysis of air samples has established that respiratory protection is not required.

In the presence of noble gas daughter products (the most common particulate airborne activity at PRTR), the following respiratory protection is required:

<u>Control Concentration ($\mu\text{Ci/cc}$)</u>	<u>Respiratory Protection Required</u>
$<1 \times 10^{-6}$	None
1×10^{-6} to 1×10^{-5}	<1 hr., none; >1 hr, assault mask
1×10^{-5} to 1×10^{-3}	supplied air mask
$>1 \times 10^{-3}$	No entry permitted (except in emergencies) until purged to below this value.

e. Fission Product Mixture

The average airborne concentration of a fission product mixture to which an individual may be exposed during one eight-hour shift should be limited to 1×10^{-9} $\mu\text{Ci/cc}$. If the air concentration of the unknown nuclide mixture exceeds this value by a factor not greater than 10, exposure may be controlled by reducing the exposure time during an eight-hour work shift by the same factor. Respiratory protective equipment shall be required in any case where the air concentration is known to exceed the applicable control concentration by a factor greater than 10.

Full-face, supplied-air equipment is required in any case where the air concentration is known to exceed the applicable control concentration by a factor of 100 or more in the case of particulates or by a factor of 10 or more in the case of gaseous material. Except under emergency situations, personnel shall not be exposed to airborne concentrations which exceed the applicable control concentration by a factor of 1000 or more.

If the work to be performed may be expected to result in high-level airborne radioactivity, respiratory protective equipment should be worn on the basis of the potential alone.

C. Control of Tritium Dose

Tritium is most often encountered at BNW in the heavy water systems at PRTR where it is produced by neutron activation of deuterium. Since heavy water evaporates just as ordinary

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water does, any tritium it contains will become airborne as water vapor. Tritium may also be encountered in the elemental form in a number of laboratories at BNW.

1. Physical Properties of Tritium

Tritium emits a very low-energy beta particle with a maximum energy of 18 KeV and an average energy of 5.7 KeV. Because of this low energy, tritium does not present an external whole body exposure problem. The mean range of a tritium beta particle in air is approximately 0.5 mm (0.020"), and ordinary paper or cotton clothing will shield out tritium beta particles. The radioactive half-life of tritium is 12.3 years, and its specific activity is extremely high; pure tritium water (T_2O) has a specific activity of 2700 curies/cc and tritium gas (T_2) has a specific activity of 2.6 curies/cc under standard conditions. Tritium vapor becomes dispersed in the atmosphere very quickly and will adsorb strongly on many surfaces. It will even penetrate some construction materials.

2. Biological Properties of Tritium

Tritium can enter the body in several ways. Since tritiated water is like ordinary water, it can enter the body by ingestion, skin absorption, inhalation, or through openings in the skin surface, such as cuts and abrasions.

"Most radioactive materials which enter the body will become deposited in specific organs, but tritiated water, since it behaves like ordinary water, becomes distributed uniformly in body fluids. Thus the critical organ for exposure to tritium is the whole body.

Tritium is eliminated from the body in proportion to its fraction of total body water. It is not permanently retained in the body as some other radionuclides are, but is eliminated with a biological half-life of from eight to fourteen days, with an average of twelve days. The biological half-life may be shortened by consuming greater than normal amounts of liquids or by inducing sweating. Excessive liquid intake and induced sweating are not recommended without prior medical consultation, however.

Since tritium is deposited uniformly in body water, the same concentration of tritium is found in water from sweat, expired water vapor, sputum, urine, and blood. Any one of these sources can be used to determine the amount of tritium in the body, but the most widely used method of tritium uptake measurement is by urinalysis.

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3. Tritium Dose Evaluation

Calculation of the dose due to tritium is based on the results of bioassay samples. If the results of a sufficient number of samples are available, the observed biological half-life for the individual is used in dose calculations. If sufficient sample data are not available, a twelve-day biological half-life is used. The final dose credited to exposed personnel is calculated by computer. However, records of the monthly accumulation of dose are maintained in the field. These records are based on bioassay results greater than 5 $\mu\text{Ci T/l}$, using an average twelve-day biological half life. The following procedure is to be used by Radiation Monitoring personnel for field evaluation of the dose due to tritium:

- a. Results greater than 5 $\mu\text{Ci T/l}$ will be telephoned to the field immediately by U. S. Testing Company. Any results in excess of 50 $\mu\text{Ci/l}$ must be telephoned to the Exposure Evaluator, P.D.S., by RM.
- b. Enter sample date, time, and bioassay result on the individual's Tritium Radiation Dose Control Data form.
- c. Determine the length of time in days since the previous bioassay sample. Find this point on the horizontal axis.
- d. Find the result of the previous bioassay sample on the vertical axis.
- e. Using Figure 1, determine the dose from the previous bioassay result for the period in Step c by locating the intersection of the two values found above. If the intersection doesn't fall on one of the dose curves, extrapolation may be necessary.
- f. Record the dose determined in Step e under Dose Increment for the previous bioassay result.
- g. Add the dose increment to the prior exposure received during the month. and record the total under Integrated Dose.
- h. At the end of a badge period, the dose due to a tritium deposition should be split as necessary to credit the dose to the proper badge period. To do this:
 - 1) Perform steps b through f above,
 - 2) Determine the dose due to the previous bioassay result for the period (days) between the sample date and the end of the badge period. This dose is credited to the badge period which has just ended,
 - 3) Subtract the dose determined in Step 2) from that determined in Step 1). The difference is credited to the next badge period.

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FIGURE 1

Accumulated Dose Chart - Tritium Oxide ($T_B=12$ Days)

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- i. Figures 2 and 3 give curves for estimating the dose in special situations.
- j. The dose received from a deposition for which data from only one urine sample is available can be calculated from the following expression:

$$\text{Dose (mrem)} = 8.6 (B) (1 - e^{-0.58t})$$

where B = bioassay result in $\mu\text{Ci T/liter}$

t = exposure time in days

The biological half-life is assumed to be twelve days.

- k. The total dose due to a single deposition of tritium is given by:

$$\text{Dose (mrem)} = 8.6 (B)$$

- l. A rule of thumb for estimating the dose from a single deposition for a period of time not exceeding one week is:

$$\text{Dose (mrem)} = (0.5) (B) (t)$$

4. Tritium Exposure Control

a. Protective Clothing

The minimum protective clothing requirement for work with elemental tritium is rubber gloves and for contact with tritium oxide, rubber gloves and rubbers. If the gloved hands are exposed to tritium oxide for prolonged periods, the gloves should be changed every half hour because some of the oxide may penetrate the rubber in that period of time. If the gloves become wet on the outside they should be changed immediately. Radiation Monitoring should specify additional protective clothing such as British leggings, acid jackets, and pants if it is warranted by a change in the potential for tritium exposure during the course of the work.

b. Respiratory Protective Equipment

The wearing of supplied-air masks or suits shall be based on the potential for tritium exposure alone, taking into account the nature of the work performed and the tritium concentration in the system involved. Whenever the airborne concentration of tritium is likely or known to exceed $1 \times 10^{-3} \mu\text{Ci/cc}$, impervious apparel and supplied air masks should be worn; however, the exposure time of each employee should be limited such that the average airborne concentration of tritium

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FIGURE 2
*Accumulated Body Dose in 28 Days for a Single Administration
of Tritium Oxide*

FIGURE 3
*Accumulated Body Dose in 28 Days for a Sustained Body
Concentration of Tritium Oxide*

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to which he is exposed during the work day does not exceed 5×10^{-5} $\mu\text{Ci/cc}$. Since tritium oxide is absorbed equally through the lungs and skin, supplied air masks alone will reduce personnel exposure by only 50 percent.

c. Work Habits

The primary control of chronic tritium exposure is accomplished by good work practices, especially by keeping systems or equipment containing tritium sealed. The following general rules are presented so that Radiation Monitoring personnel can recognize poor work practices and make appropriate corrective recommendations.

- 1) After a heavy water system is opened, the leakage should be collected in a container which should then be covered or sealed to prevent exposure to tritium vapors.
- 2) Open systems should be sealed temporarily if the work is to be discontinued for a short time.
- 3) Heavy water spills should be mopped up immediately, and unconfined heavy water should be controlled to the extent possible; i.e., by keeping the work area dry.
- 4) Tritium-bearing material should be handled and stored only in well ventilated areas.
- 5) Since tritium readily diffuses through the atmosphere, persons working near a job in which tritium exposure may be received should be evacuated or warned of the potential exposure.
- 6) All equipment which has come into contact with either tritium gas or tritiated water vapor will retain some of the tritium and should be considered contaminated. In particular, stop-cock greases, vacuum pump oils, and plastics readily become contaminated. Materials such as glass and stainless steel retain smaller amounts of tritium and can be decontaminated reasonably well by heating.
- 7) If the skin comes into contact with tritiated water, the affected area should be immediately rinsed with water. After a known contact with tritium, personnel should take full showers immediately.

5. Exposure Guides

Whole body exposure from gamma and neutron radiations and internally deposited tritium must be controlled to one rem per month and four rems per year. No control value has

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been established for exposure from internally deposited tritium alone, so tritium exposure must be considered along with external exposure from gamma and neutron radiations.

Because chronic whole body exposure received by PRTR personnel is rather high, a tritium exposure guide has been established at PRTR in order to limit tritium exposure. The average airborne tritium concentration to which personnel are exposed during a working day should be no greater than 5×10^{-5} $\mu\text{Ci/cc}$. Exposure at this concentration for eight hours will result in a body deposition of one millicurie (the maximum permissible body burden) and a bioassay result of 20 $\mu\text{Ci/l}$. If one maximum permissible body burden were sustained for a month, the resulting dose for that month would be 300 mrem. Therefore, the exposure guide for chronic dose from tritium is 300 mrem per month. Acute exposures which may result in body depositions greater than 20 $\mu\text{Ci/l}$ (bioassay result) are permissible provided that the monthly dose is controlled to less than 350 mrem. The maximum acute exposure allowable is 50 $\mu\text{Ci/l}$ (bioassay result) which would give a dose of 350 mrem in a 30-day period.

IV. REPORTING OF EXPOSURES

A. Reporting Neutron Exposure

1. Neutron Dose Estimation Methods

a. Gamma to Neutron Dose Rate Ratio

In this method, the gamma and neutron dose rates are measured with the CP and BFQ respectively, and the ratio of the two readings is noted. Personnel neutron doses are then determined routinely by multiplying pocket ion chamber dosimeter results by the dose rate ratio. If the dose rate ratio varies between different locations, then the time spent in each location is noted, and the neutron dose adjusted accordingly.

b. Dose Integrating BFQ

In this method, an integrator which totals the neutron dose is plugged into the BFQ instrument. The plug-in unit automatically integrates the neutron dose rate and displays the total dose by means of registers. If the measured dose rate is due to fast neutrons, each register corresponds to 2.3 mrem, and the total dose due to fast neutrons is determined by multiplying the total registers by 2.3. If the measured dose rate is

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due to slow neutrons, each register corresponds to 0.1 mrem, and the total dose due to slow neutrons is determined by multiplying the register indication by 0.1.

2. Recording and Reporting Neutron Exposure Results

For each individual the total neutron dose during the monthly period, and his name and payroll number, are entered on the Neutron Exposure Report Form. A neutron exposure estimate will be completed for each individual who signs out a neutron badge during the month, even if the estimate is zero. The Radiation Monitoring Supervisor will review the recorded exposures for accuracy, and sign the form prior to transmittal to Personnel Dosimetry. The Neutron Exposure Report is to be returned to PDS and the used badges to U.S. Testing no later than three days following the end of the badge period.

B. Reporting Localized Exposure

The Hanford personnel dosimeters normally provide useful measurements of the average whole body dose, the whole body skin dose, and hand dose which the individual receives during the course of radiation work. ~~Occasionally, because of exposure to beams or small sources or because of skin or clothing contamination,~~ a localized portion of the body may receive a significant dose which cannot be properly evaluated by the dosimeters. Any significant localized doses which a person receives must be included in his exposure record file. To assure accurate determinations of dose, all the pertinent details of the exposure must be obtained at the time of the exposure by the Radiation Monitor on the job.

1. Reporting Criteria

In any case where an individual is exposed to sources of radiation so that a localized dose in excess of the following values may have been incurred, the details of the exposure shall be reported by forwarding a completed "Localized Exposure Report" to Customer Services Unit, PDS:

- a. A dose to the eye or localized area of the body, other than the extremities, of 100 mrem in excess of the whole body dose,
- b. A dose to 1/10 of skin area ($\sim 2000 \text{ cm}^2$) of 800 mrem in excess of the dose to the skin of the whole body, or
- c. A dose to a portion of the extremities of 800 mrem in excess of that which is measured by the film ring dosimeter or greater than 800 mrem if a film ring dosimeter was not worn.

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2. Data to be Reported

The following information should be reported in each case:

- a. Type and serial number of the instrument used for measuring the exposure source.
- b. Date, time, and duration of the personnel exposure.
- c. Measurements taken and the date and time of such measurements.

1) Skin Contamination

- a) Open window (OW) and closed window (CW) dose rate instrument dial readings with the screen of the instrument as close to the source as possible.
- b) Same as above except with the screen at six inches from the source.

2) Clothing Contamination

- a) OW and CW dose rate instrument dial readings inside the garment, shielding, and distance duplicated as closely as possible, with the instrument screen centered on the source.
- b) OW and CW dose rate instrument dial readings outside the garment with instrument screen in contact with and centered on the source.
- c) Same as b) above except with instrument six inches from the source.
- d) Estimate of distance from the source to the skin.
- e) Type of intervening shielding materials, if any.

3) Small Source at a Distance

- a) OW and CW dose rate instrument dial readings with the screen at the point of exposure.
- b) Estimate of distance between source and point of exposure.

4) Beam

- a) OW and CW dose rate instrument dial readings with the screen at the point of exposure.

- d. Source size and shape.
- e. Location of the part of the body receiving the exposure.
- f. Whether the source is to be submitted for autoradiographing.

3. Procedure for Handling High-level Skin or Clothing Contamination

- a. Localized Exposure from High-level Skin Contamination

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- 1) Whenever skin or clothing contamination is discovered which has a dose rate high enough to contribute significantly to the dose received by the individual, the first concern is to remove the contamination to stop the exposure of the individual.
- 2) Immediately attempt to remove the source, with masking tape if possible.
- 3) If the source is successfully removed, obtain the required instrument readings (with a CP or Juno) and an estimate of the source size; wrap, identify, and preserve the source for further study.
- 4) If attempts to remove the source intact are unsuccessful, obtain an OW instrument reading as quickly as possible (with a CP or Juno) and estimate the source size before beginning decontamination. Record the information on the survey record form.

b. Localized Exposure From Clothing Contamination

- 1) When contamination levels permit, the radiation dose rate due to the contamination should be evaluated while the clothing is being worn. If dose rates are high, remove the clothing (or contaminated portion) as quickly as possible to stop exposure of the individual. Care should be exercised during removal to prevent the transfer of contamination to the skin, or other clothing, and to preserve the source intact for further investigation which may be necessary to establish the dose received. Protective clothing should be properly identified and segregated. Identify the outer side, locate the source, and mark it. Note the time the clothing was removed, and what clothing, if any, was between the contaminated clothing and the skin.
- 2) Exercising care to avoid spreading contamination or altering the source, obtain the required instrument readings (with a CP or Juno) and an estimate of the source size. Record all pertinent information on the survey record form.

4. Submitting Samples for Autoradiographing

- a. Whenever the initial estimates indicate that a significant localized dose may have been received and the source has been preserved, submit the source to the Customer Services Unit, PDS, for autoradiographing by contacting the Unit Manager.
- b. Attach the following information to the source if possible; this will materially speed up the exposure evaluation.

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- 1) Type and number of instrument used (CP or Juno).
 - 2) WO and WC dial readings (source-screen distance as short as possible).
 - 3) WO and WC dial readings (source to screen distance, six inches).
 - 4) The time the above readings were taken.
- c. Wrap the source in heavy paper, sealing all openings, and attach a radioactive label to the package. Prepare an Onsite Radioactive Shipment Procedure.
- d. The sample is to be delivered to the Radiation Monitoring Office, 3707-C Building, 300 Area.
- e. Results can normally be expected in 48 hours from the time the sample is delivered to the 3707-C Building; however, in cases where decay is important, or in cases of relatively low level sources where the film exposure time may be long, more than 48 hours may be required. The results will be reported to the requesting operation by phone as soon as they are obtained, and will be verified in writing.

C. Radiation Occurrences

When situations involving actual or potential loss of control over radioactive materials occur in work with radiation, the primary consideration is the protection of personnel. Once this has been assured, attention must be turned to regaining control of the event site. After measures have been taken to bring the situation under control, radiation protection personnel should review the event to determine the cause and the means of preventing such undesirable situations in the future. To accomplish this goal, it is important to make a written record of all such situations. When the situation is of a minor nature, description in a Radiation Survey Report will usually be adequate. Situations of greater consequence require investigation and reporting as Radiation Occurrences, in addition to being documented in the Radiation Survey Report. The criteria for Radiation Occurrences are found in Procedure 8 of BNWL-MA-6.

All Radiation Occurrences are reported to the Customer Services Unit, PDS, which numbers and classifies them. Occurrences of a severe nature or having a severe potential are classified as Radiation Incidents and are formally investigated.

1. Functions of R. M. Personnela. Radiation Monitors

In most cases a Radiation Monitor will be the first to be aware that an undesirable situation has occurred.

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Certain actions are expected in such cases, including those listed below:

- 1) If personnel have not left the event area, request them to leave.
- 2) Determine the radiation and contamination status of involved personnel and the event area.
- 3) Initiate personnel decontamination, if necessary.
- 4) Promptly notify RM supervision and Operating Management of the conditions observed.
- 5) Make recommendations on personnel safety and contamination control and assist as appropriate.
- 6) Complete written records including Radiation Survey Report, Skin Decontamination Record, and other appropriate records.

b. R. M. Engineers, Specialists, and Supervisors

Except for the initial notifications to Operating Management, RM exempt personnel will be expected to carry out communications with other groups regarding Occurrences. In addition, they are expected to provide technical and administrative support to the Radiation Monitors and Operating Management in controlling problems related to the Occurrence. Among the actions expected in such cases are:

- 1) When the Occurrence is reported, obtain a summary of facts and events, including the time of the Occurrence, the identity of the facility, the room number, the work being performed, the nature of the Occurrence, the identity and chemical form of the nuclides involved, the names and payroll numbers of personnel involved, and the nature of the involvement and period of exposure of each.
- 2) Report the event to the Customer Services Unit, PDS, as soon as the above information is obtained.
- 3) Assist the Radiation Monitors, Operating Management, and the Customer Services Unit, PDS, in their activities. For example, advise who should be bioassayed or whole body counted, who should have immediate processing of assigned film badge dosimeters, who should be temporarily restricted from Radiation Zone entry, etc.
- 4) Conduct an informal investigation of the Occurrence to check previously obtained information and to determine the probable cause of the event.
- 5) Complete written reports as requested by Customer Services Unit, PDS.
- 6) Assist in formal investigation (if one is held) as requested.

CONTROL OF EXPOSURE TO PERSONNEL

2. Situations Which Should be Reported as Potential Radiation Occurrences

In addition to those situations listed in BNWL-MA-6, the following situations should be reported:

a. Uncontrolled Radiation Source

- 1) Any situation in which there was a high potential for exposure to radiation, even though none of the Operational Controls or Limits was exceeded.
- 2) Any situation involving a radiation source left outside a Radiation Zone when the radiation level is such that the source should be kept under Radiation Zone Control at all times (according to criteria in Section III, Procedure 5, BNWL-MA-6).

b. Contamination Spread

- 1) Any situation in which there was a contamination spread within a Radiation Zone requiring controls and/or protective clothing significantly more restrictive than normally required in the zone.
- 2) Any unexpectedly high air sample.

c. Personnel Contamination

- 1) Any situation in which contamination is found on a visitor.
- 2) Any situation involving personal clothing contamination.
- 3) Any situation involving skin contamination other than on the hands.
- 4) Contamination on the hands $>20,000$ c/m $\beta\gamma$ and/or $>5,000$ d/m α .
- 5) Any hand contamination where the source is unknown or contamination was unexpected.
- 6) Nasal contamination >100 c/m $\beta\gamma$ and/or >10 d/m α , either direct or smearable.

d. Incoming Shipments

- 1) Any shipment found to be leaking, contaminated, or showing a radiation level appreciably above that expected, or indicated on the shipping papers.
- 2) Any vehicle contaminated while carrying incoming shipments.

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BATTELLE - NORTHWEST
RADIATION PROTECTION DEPARTMENT
RADIATION MONITORING PROCEDURES

MONITORING TECHNIQUES

I. RADIATION SURVEYS

A. In General

The administrative responsibility for radiation control at BNW is assigned to operating management, but Radiation Monitoring provides the continuity and technical backup necessary to make the program effective. Radiation surveys are an integral part of this program. They are performed to evaluate the radiation and contamination status of facilities and equipment, the conditions to which personnel are exposed, and the effectiveness of existing radiation control and safety measures.

The Radiation Monitoring survey program provides information through two general types of surveys: routine surveys and special surveys. Routine surveys are concerned with the conditions existing in given areas, buildings, and rooms and on equipment, and are performed on a regular schedule. Special surveys are normally performed upon the request of operating or service groups to monitor specific jobs or experiments.

B. Preparation for a Radiation Monitoring Job

Before starting a job, a Radiation Monitor should conscientiously consider what he can do to help the operating group maximize personnel safety. He should then obtain and/or recommend the necessary equipment and perform the work to the best of his ability. A Radiation Monitor who regularly shows up with the proper instruments, an adequate knowledge of the work to be accomplished and the radiation problems associated with it, and a desire to be of as much help as possible will find his work much easier.

Listed below are several items which a Radiation Monitor should consider before beginning a job. The list, though not complete, includes many suggestions which will enable the Radiation Monitor to perform his job more efficiently and thus better accomplish the goals of the BNW radiation protection program.

1. Determine all pertinent facts regarding the job, including the persons who will be doing the work, the types of operations involved, the location of the proposed work, and the time of commencement of the work.
2. Become familiar with the provisions of the applicable Radiation Work Procedure and other pertinent, written procedures.
3. Determine what nuclides will be involved in the work and the chemical and physical form(s) in which they will be handled (liquid, gas, metal, powder, etc.).

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4. Ascertain the radiological properties of the involved nuclide(s) and the practical radiological problems which may result therefrom. Consult the Chart of the Nuclides, the Radiological Health Handbook, or other similar publications to find the half-life, quality, and energies of the decay spectra for the involved nuclides.
5. Determine the current radiological status of the work location prior to commencement of the job. If contaminated with other nuclides, it may be desirable to decontaminate the area before work is begun. This would be true if, for example, the area were contaminated with a nuclide of low radiotoxicity such as uranium and the proposed job involved the handling of a highly radiotoxic nuclide such as plutonium-239.
6. Determine the types of portable instruments necessary to properly monitor the job and make certain that they will be available when needed.
7. Ascertain whether or not special dosimeters such as gamma pencils or finger rings should be assigned to the workers and what types of protective clothing and equipment will be necessary for proper protection of personnel and work environs. Note that the items mentioned under this point will normally have been covered on the RWP, but such RWP (Radiation Work Procedure) requirements are the minimum necessary. Changed conditions or operations may require additional protective equipment and dosimeters.
8. Determine what auxiliary items may be necessary, such as radiation stickers and rope, masking tape, and "walking stick" for GM probe.
9. Make certain that a well-stocked decontamination kit will be readily available if needed.
10. Make arrangements for transportation, if necessary.
11. Make arrangements for procuring additional monitoring assistance if such help may become necessary during the course of the work.

C. Monitoring During a Job or Experiment

Following is a list of actions which should be taken by a competent Radiation Monitor immediately prior to and during monitoring coverage of a job or experiment. The list is not meant to be all-inclusive, and problems not covered by it will undoubtedly be encountered from time to time. In such cases the monitor must rely upon his own common sense and good judgment.

1. Check instruments for proper operation and make certain that auxiliary equipment such as earphones and aural beepers are operating properly. Wrap the instruments, if necessary, to keep them from becoming contaminated during the job.
2. Carry note paper and pen or pencil to record pertinent readings and facts during the job.

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3. Ascertain what the workmen or experimenters will be doing and make certain they understand what types of readings and measurements will be taken during the course of the work.
4. Wear prescribed protective equipment and clothing in the proper manner and check to see that other persons are also wearing it properly.
5. Arrange signals with the timekeeper or the individual workers, if appropriate, in order to keep them informed of personnel dose rates.
6. Enter the work location just prior to the others in order to establish the radiological status before commencement of the work.
7. Determine personnel dose rates and air and surface contamination levels as frequently as conditions warrant, keeping the workers informed of any significant changes in readings.
8. Make recommendations for minimizing personnel exposure and for minimizing the possibility of contamination spread.
9. Stay out of areas of high exposure except when necessary to make dose rate measurements.
10. Notify operating management whenever dose rates encountered become so high that timekeeping exposure estimates are difficult. This is normally the case when the dose rate is about 3 rem/hr or greater.
11. Recommend to the person responsible for the job that work be temporarily discontinued whenever:
 - a. dose rates are too high to be measured by instruments on hand; or
 - b. total doses become unknown and are, or might be, close to the applicable operational control or exposure limit; or
 - c. a contamination spread is known or suspected which would make continuing the job unsafe; or
 - d. unexplained or unexpected skin or clothing contamination is detected.
12. Make it clearly understood, if the Radiation Monitor should have to leave the work area while the job is in progress, just which phases of the work can be safely performed without a Radiation Monitor's presence and exactly how the services of another Radiation Monitor may be obtained if needed.

D. Monitoring Duties Following Completion of the Job

Upon completion of the work which was monitored, a number of tasks still remain for the Monitor to accomplish. Following is a partial list of such tasks.

1. All necessary personnel, material, and equipment exit surveys must be performed.

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2. Guidance must be provided for the decontamination of personnel or equipment. If excessive personnel contamination is found, RM supervision should be immediately notified.
3. All special dosimeters should be collected, properly identified, and forwarded for processing if appropriate.
4. Radiological conditions at the job location should be determined, and appropriate remedial measures should be recommended to correct any substandard conditions.
5. A survey report of the job coverage must be written following completion of each job. Other reports should be written as appropriate.

II. MEASUREMENT OF SURFACE CONTAMINATION

A. In General

If loose contamination is suspected, the surface should be smeared and the smear surveyed with the appropriate instruments as discussed in II C. below. In surveying for surface contamination, the surveyor should hold the instrument close to the surface, but should avoid contact. Where an area larger than the detection window of the instrument is being surveyed, the instrument should be moved over the area to be surveyed at a rate slow enough to permit the instrument response to reach a maximum. ~~To minimize this time constant problem, earphones or other audio signal devices should be used when making direct surveys with detection-type instruments.~~

B. Direct Survey Methods

1. Alpha Contamination

To survey for low-level alpha contamination, use a Portable Poppy, Cart Poppy, or Scintran. Hold the probe 1/4" from the surface being surveyed and move it slowly over the area in question. Check the response against standard sources to determine the contamination level. If the contamination level exceeds the measuring capacity of the instrument, the method described below for high-level contamination should be used. The surveyor should keep in mind that the sensitivity of the probe will probably be higher at the center than it is toward the front.

To survey for high-level alpha contamination, use a Samson or a Juno. Hold the unshielded instrument chamber 1/4" from the surface being surveyed, and move it slowly over the area in question. Check the meter readings against the alpha calibration chart on the side of the instrument to determine contamination levels.

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2. Beta-Gamma Contamination

To survey for low- to intermediate-level beta-gamma contamination, use an Eberline GM, HGM, TGM, or Scintran with a GM detector. Hold the unshielded probe 1/4" from the surface being surveyed, and move it slowly over the area in question. Check the meter readings to determine the approximate contamination level. Repeat the survey with the probe shielded and compare the meter readings. The shielded reading represents the gamma-emitting contamination present, and the difference between the unshielded and shielded readings represents the beta-emitting contamination present.

To survey for high-level beta-gamma contamination, use a Samson, Juno, or CP. Hold the unshielded (beta shield open on CP and Juno) instrument chamber 1/4" from the surface being surveyed, and move it slowly over the area in question. Check the meter readings to determine the approximate contamination levels. Repeat the survey with the beta shield closed and compare the meter readings. The shielded reading represents the gamma-emitting contamination present, and the difference between the shielded and unshielded readings represents the beta-emitting contamination present.

It should be noted that the Samson does not have a beta shield and therefore cannot be used to discriminate between beta- and gamma-emitting contamination. For this reason it should not be used where such discrimination is necessary or desirable.

If low-energy, beta-emitting contamination is suspected, a GM with a "pancake" probe, a Samson, or a Juno with both alpha and beta shields open should be used. The window of the CP prevents an adequate response to low-energy beta radiation.

C. Smear Survey Methods1. Floor Areas

Put on clean shoe covers. Smear the suspected area by sliding the feet over the floor. After smearing, check the shoe covers according to the direct survey methods described above. If the shoe covers are not new, check them with sensitive detection-type instruments before using them for the smear survey. Do not use shoe covers with detectable contamination.

2. Walls, Furniture, and Large Pieces of Equipment

Use a clean glove or absorbent swab. Smear the suspected area by wiping with moderate pressure. After smearing, check glove

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or swab according to the direct survey methods described above. If the glove is not new, check it with sensitive detection-type instruments before using it for the smear survey. Do not use gloves with detectable contamination.

3. Tools and Small Pieces of Equipment

Use an absorbent paper wipe. Smear the entire surface by wiping with moderate pressure. After smearing, check the wipe according to the direct survey methods described above.

4. Smears for Tritium Contamination

a. Wet Smear Method

This technique involves taking a wet smear of a known surface area with a 2" x 2" gauze pad, adding 10 ml of distilled water to the gauze pad and allowing ten minutes for any tritium in the pad to reach an equilibrium mixture with the distilled water. The water is then drawn off and analyzed in the Tri-Carb counter for tritium content.

To convert the figures thus obtained to surface contamination levels, the following formula is utilized:

$$\text{Surface Contamination Level} = \frac{C \cdot V}{E \cdot A}$$

Where C is concentration of sample in μCi tritium/cc,
V is sample volume (here, 10cc),
E is collection efficiency (0.8), and
A is area smeared (in square feet).

For smear areas of 2 and 4 sq. ft. the conversion factors from tritium concentration in $\mu\text{Ci/cc}$ to tritium contamination in $\mu\text{Ci/sq. ft.}$ are 6.3 and 3.1, respectively. The minimum smearable tritium surface contamination detectable by this method is 10^{-4} $\mu\text{Ci/sq. ft.}$ for a 2 sq. ft. area and 5×10^{-5} $\mu\text{Ci/sq. ft.}$ for a 4 sq. ft. area.

b. Dry Smear Method

Use Whatman #41 filter paper, 1 7/8" diameter. With light pressure smear the entire surface of small objects and a 1 sq. ft. area of large objects. After smearing, count the smears with the Pete. Avoid getting lint or other loose foreign material on the smears.

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In the case of material going off site, it may be desirable to count the smears in the laboratory counter because of its greater sensitivity. For contamination limits, see Procedures 6 and 7 of BNWL-MA-6.

5. Standard Smear Technique

Use a piece of Whatman #41 filter paper. Smear a one sq. ft. area by placing the first and second fingers on the center of the disc and applying moderate pressure. A one sq. ft. smear with this filter paper is approximately equal to:

one 6-foot swipe, or
two 3-foot swipes, or
three 2-foot swipes, etc.

After smearing, count the filter paper with a thin-window GM instrument. The contamination level can then be expressed in d/m/sq.ft. Contamination levels expressed in these units may be sufficient for some purposes within BNW, but to be truly meaningful they should be expressed in terms of absolute activity per unit area. This requires a knowledge of the energy of the radiation emitted by the contaminating nuclide(s) and the counting effectiveness of the instrument for that energy. For example, assume that the contaminant is known to be only Pm-147 and that a survey of the smear with the "pancake-probe" GM indicates a contamination level of 300 c/m (gross count rate minus background). The maximum energy of the beta particles emitted by this isotope is 0.23 MeV. The window thickness on the "pancake-probe" is between 1.5 and 2.0 mg/cm², and its counting effectiveness for betas with a maximum energy of 0.23 MeV is approximately 25 percent. The absolute activity on the smear is found by multiplying the indicated count rate by the inverse of the counting effectiveness. In this case,

$$(300 \text{ c/m}) \left(\frac{1}{.25} \right) \approx 1200 \text{ d/m.}$$

Since the area smeared was 1 sq. ft., the contamination level can be expressed as ~1200 d/m Pm-147/sq.ft.

If greater accuracy is desired, the smear should be counted in a laboratory counter. The absolute activity may then be calculated in the same manner as above.

III. PERSONNEL CONTAMINATION SURVEYS

A. In General

Personnel contamination checks are made for the purpose of detecting contamination spread to skin or personal clothing.

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Experience has shown that most personnel contamination resulting from work in low-level contaminated areas is to the hands or shoes. Therefore, in most cases, a check on a hand-and-shoe counter following such work is adequate.

Personnel performing unmonitored work where low levels of contamination may be encountered will normally be instructed to perform periodic contamination checks of themselves and the work to ensure that contamination control is maintained.

In grossly contaminated areas there is a much higher probability of contamination spread to other parts of the body. Following work in such locations, an individual is required to be surveyed for personnel contamination either by a person qualified in radiation monitoring or by himself. Instructions for personnel contamination surveys are normally included in RWP's for work in highly contaminated areas.

Low-energy beta contamination may be present in some Radiation Zones. Since it cannot be detected by the hand and shoe counters, the same kind of special contamination check noted above (using a thin-window GM instrument) is required when leaving such Radiation Zones.

B. Personnel Contamination Release Criteria

Personnel (and their personal effects) shall not exceed the following limits before they are released to eat or go home, except with the specific approval of Radiation Monitoring supervision:

Beta-Gamma Contamination	<1000 c/m per GM probe area if the contaminant is known to be adsorbed noble gases only.
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<200 c/m per GM probe area for all other contaminants.
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Alpha Contamination	<500 d/m per 100 cm ²
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C. Personnel Contamination Survey Requirements

1. Hand and Shoe Counts

A hand and shoe count or a personnel contamination survey is the minimum contamination check required upon leaving a contaminated Radiation Zone. Other persons in a facility where contaminated Radiation Zones are present should

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perform a hand and shoe count before eating and before leaving the building, even though they have not entered any of the Radiation Zones.

If the hand or shoe count results exceed posted limits, supervision and Radiation Monitoring must be notified, and the person should remain at the counter if at all possible. If no one else is present, assistance should be obtained, but precautions must be taken to minimize the possible spread of contamination. A personnel contamination survey should be promptly performed by a person qualified in radiation monitoring techniques.

2. Special Radiation Zone Exit Surveys

If work performed involves a likelihood for personnel contamination, one RWP requirement should be appropriate special surveys before the person leaves the Radiation Zone change station. Questionable or borderline cases should be referred to Radiation Monitoring supervision for a decision.

3. Periodic Checks During Low-Level Work

During the course of work in areas where low-level contamination is present and where dose rates permit, employees should periodically check themselves and their clothing with appropriate detection instruments. These contamination checks will normally not substitute for the hand and shoe counts and contamination surveys required in Parts 1 and 2 above. If skin or clothing contamination in excess of locally established criteria is found or suspected, a complete survey of the person and his clothing must be made by a person qualified in radiation monitoring techniques.

4. Periodic Checks During High-Level Work

When work is performed in areas in which high levels of contamination are present, high local skin doses may be received if radioactive material is deposited on the protective clothing and is not immediately removed. During the course of radiation work in such locations, all personnel in the Radiation Zone must be given frequent clothing checks by a person qualified in radiation monitoring techniques.

Protective clothing which has become contaminated should be removed immediately if the level of contamination is such that it significantly contributes to the dose rate of the person wearing it. It should be segregated and preserved in the same condition, if possible, for use in determining the dose which may have been received.

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D. Performance of Personnel Contamination Surveys

Sensitive detection equipment appropriate to the type of contaminant involved should be used in personnel contamination surveys. A GM survey instrument is suitable for most beta-gamma radiations. If soft beta emitters such as C-14, S-35, or Pm-147 are involved, a thin-window GM should be used. A Poppy or Scintran would be suitable for alpha radiation.

Skin and clothing surfaces should be carefully scanned with emphasis on the head and hands. After the radiological protective clothing has been removed, a final survey of the body should be made. The speed with which the instrument probe is moved should be adjusted to the response time of the instrument. The use of a speaker or earphones with detection instruments is recommended for personnel surveys.

E. Detection of Nasal Contamination

When inhalation of radionuclides is suspected, the following procedure should be initiated by Radiation Monitoring:

1. Using appropriate survey instruments, obtain a direct radiation measurement at the nostrils.
2. Remove or fix by covering with tape, any extensive contamination in the vicinity of the nostrils.
3. Take nasal smears as follows:
 - a. Cut and mark four strips of filter paper (Whatman #41) for swabs.

Left--wet
Right--wet

Left--dry
Right--dry

These may be attached to a small swab stick and the paper coiled around the stick, or they may be used flat.

- b. Have the patient smear the inside of each nostril using first a dry swab and then a wet one.
- c. Unroll the paper strips and place them with the smear side up on a clean surface.
- d. Survey the strips for contamination using a thin-window GM probe and/or alpha probe to determine if gross contamination is present.
- e. Allow the strips to become completely dry.
- f. Count the strips with air sample counting equipment to make certain no significant contamination was overlooked.
- g. Save any contaminated swabs in clean, well identified envelopes for possible evaluation by the Customer Services Unit.

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- h. If any contamination is detected, initiate nasal irrigation as described in VII B.

F. Personnel Contamination Survey--Follow-up Action

When contamination is detected on personnel or on personal effects, operating supervision and Radiation Monitoring supervision should be notified without delay. The Radiation Monitoring representative notified will be responsible for subsequent decontamination efforts and for completion of appropriate decontamination records. Approved procedures for the decontamination of personnel and personal effects are detailed in VII B below.

IV. SHIPMENT SURVEYS

A. Materials to be Shipped Off-site

1. Administrative Controls

The administrative controls applicable to shipments of radioactive materials from Battelle-Northwest facilities to off-site locations are specified in Procedure 7 of BNWL-MA-6, and more detailed instructions for off-site shipments are described in the Nuclear Materials Management Procedures Manual, BNWL-MA-5, Procedure 3.1. The responsibilities assigned to the Radiation Monitoring Section are:

- a. To perform the measurements which are required to establish dose rates and/or contamination levels, and
- b. To record these results on the Off-Site Radioactive Shipment Record and on the Radiation Survey Report

2. Measurements

a. Direct Radiation

The entire surface of the container must be surveyed with an instrument that can detect gamma radiation of less than 0.5 mR/hr. If the surface gamma dose rate is less than 0.5 mR/hr, check the appropriate box on the Off-Site Shipment control form. When the surface gamma dose rate exceeds 0.5 mR/hr, enter the actual surface measurement and the gamma dose rate at one meter in the correct space on the form. All readings recorded must be the maximum gamma dose rate emanating from the container at the specified distances.

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b. Contamination

In addition to the dose rate measurements, all outside surfaces of the container must be smeared and the smears counted with a beta-gamma and alpha detection instrument. For unconditional release, the smears must read less than 100 c/m beta-gamma and less than 500 d/m alpha per 100 cm².

3. Recording of Measurements

All pertinent dose rate measurements obtained on the shipment container must be recorded on the Off-Site Radioactive Shipment Record form and on a Radiation Survey Report sheet.

B. Materials Received from Off-Site

Offsite shipments to all Hanford contractors are received by ITT/FSS, and are surveyed by BNW Radiation Monitoring upon receipt. These surveys normally include measurements of both the direct radiation level and the contamination level, if any. An ITT/FSS shipping form is prepared and the radiation measurements are noted on the form by the Radiation Monitor making the survey. If the conditions are normal, the shipment is sent on to the appropriate Hanford contractor.

If a shipment is found to be leaking, contaminated, or showing a radiation level appreciably above that expected, AEC-RL and ITT/FSS Receiving personnel should be notified immediately. AEC-RL personnel will determine the need for offsite radiation surveys, and notifications to offsite personnel. ITT/FSS Receiving personnel will inform the assigned on-plant receiver of the condition of the shipment. If the shipment is assigned to BNW, the local Radiation Monitoring Supervisor and Nuclear Materials Management should be notified of the condition of the shipment without delay.

Notifications to AEC-RL should be directed to the Duty Officer, phone extension 6-5441. The following information should be included:

1. Radiation levels and locations relative to the package sides. The distance of the instrument from the package during the measurements should be included.
2. The instrument type(s).
3. Contamination levels per 100 cm², and location of contamination. Both direct and smear surveys should be made, if possible.

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4. Name of both consignee and consignor.
5. Type of container and material involved.
6. Bill of lading number.
7. Identification of persons and vehicles surveyed and others probably requiring survey.

C. Materials to be Shipped Between Facilities On-Site

On-site shipments of radioactive materials between Battelle facilities must be covered by an applicable SRSP (Standard Radioactive Shipment Procedure) or ORSP (On-site Radioactive Shipment Procedure). Shipments from Battelle facilities to other on-site contractors must be covered by the same procedures.

The conditions under which a shipment may be made (radiation levels, etc.) are normally specified on the SRSP. The ORSP, which is valid only for a single shipment, contains no such limiting conditions. However, all on-site shipments should be governed by the following guidelines:

1. The radiation level at the closest approach to shipments in transit should not exceed 50 mrem/hr.

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2. If the radiation level is in excess of 50 mrem/hr, the matter should be referred to the appropriate Radiation Monitoring Supervisor who may specify special provisions covering the shipment. Such special provisions may include a patrol escort of the shipment or notification to the recipient of special precautions which should be taken with the shipment.
3. If the shipment involves material with an activity greater than 300 curies, review by the Nuclear Safeguards and Engineering Section is required prior to shipment unless the activity concentration is less than 100 microcuries per gram.
4. If the shipment involves fissionable materials, a Critical Mass Safety Specification must be executed when the shipment involves more than 1/5 of a critical mass (cf.O.G.70.1).

D. Materials Received from Other Contractors On-site

Normally, when a shipment is received from another Hanford contractor, the recipient notifies the resident RM office and requests a survey of the shipping container and material. If the shipment was made under the provisions of an ORSP, the radiation conditions at the time of shipment are noted on the form and may be compared to the measurements obtained upon receipt. If there is a significant difference in these measurements, or if smearable contamination has been detected on the outer container, or if some other non-standard condition is discovered, the appropriate Radiation Monitoring Supervisor and operating supervision should be notified at once.

V. SURVEYS OF OFF-PLANT LOCATIONS

A. In General

Off-plant surveys are those performed outside the Hanford reservation. Included are surveys performed in Richland, West Richland, Pasco, and Kennewick, etc. Regardless of whom may be present, the Radiation Monitor must exercise extreme tact, consideration of others and their property, and good judgment since he is on private property and is dealing with persons who are very probably under emotional stress. The Radiation Monitor must also allow RM Supervision to make all information releases through the proper channels.

B. Residence Surveys

1. Request for Survey

Where there is reason to believe that an employee has carried contamination to his home, a residence survey may be scheduled. The request may originate from the

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person himself, from his management, or from the appropriate Radiation Monitoring group. When such a survey is considered necessary by Radiation Monitoring, the Exposure Evaluator, Customer Services Unit, 713 Building, should be notified.

2. Information Required

When a residential survey is requested, RM personnel shall be provided with the following information by the involved individual and his supervisor:

- a. The employee's name and payroll number.
- b. The residence address. If address alone is insufficient for locating the residence, directions for reaching it shall be obtained.
- c. A description of the provoking incident, including the types of radiation to be expected and the probable location of contamination at the residence.
- d. Information concerning the best time to conduct the survey and whether a male resident will be present at the time chosen.

3. Crew

If only a female resident will be present at the residence, a female employee must accompany the survey crew. It may be advisable to have the involved individual accompany the survey crew if he is available.

4. Transportation

A vehicle for the trip shall be obtained as follows:

- a. The car assigned to the group or an Environmental Monitoring car shall be used for surveys of residences within the Tri-Cities.
- b. A vehicle shall be obtained at the Bus Dispatcher's Office, 1170 Building, for surveys of residences outside the Tri-Cities.

5. Supplies and Equipment

Supplies and equipment taken along for possible use at the residence should include:

- a. Alpha and beta-gamma detection meters,
- b. Skin decontamination kit,
- c. Masking tape,
- d. Emery cloth,
- e. Spatula,
- f. Cloth or surgeon's gloves,
- g. Kraft paper,

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h. Ice cream cartons, and

i. Receipt book

6. Survey Action

If no contamination is detected, the resident should be informed that the results are completely negative. This is usually the case. If contamination is detected, the general nature of the findings should be explained to the resident without specifying numbers. A sample of the contaminant should be obtained by smearing or, if necessary, by confiscation. Decontamination of household items should be attempted. If decontamination is not feasible or is unsuccessful, the items should be obtained for decontamination on the Hanford Project or for replacement. A receipt must be given for each item removed.

7. Follow-up

- a. The Exposure Evaluator, Customer Services Unit, must be notified of results when the survey is completed.
- b. A copy of the Radiation Survey Report, a copy of each receipt issued, and samples of the contaminant or confiscated items must be submitted to the Exposure Evaluator.
- c. The vehicle must be returned.
- d. Home survey equipment and supplies should be replaced as required.

8. Diplomacy

Following are some tips on diplomacy necessary when dealing with housewives or other persons not employed by Battelle-Northwest. Remember:

- a. The person is already uneasy.
- b. You are on private property and cannot make demands.
- c. Treat a lady of the house as you would wish to have your wife or mother treated if she thought she had hazardous materials in her house.
- d. Be pleasant and calm.
- e. Introduce yourself and explain the purpose of your call; emphasizing that the survey is a routine follow-up and that the possibility of contamination is low.
- f. Explain that you are there to help and will try not to interfere with any work or plans. Ask for assistance in choosing likely locations to survey.
- g. Survey less intimate locations first.
- h. If only a female resident is present, have the female employee accompany you during the entire survey.

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- i. If you are refused access to survey a location you consider important, accept the refusal pleasantly and report the omission in your survey writeup.
- j. If you feel it is necessary to consult with the Exposure Evaluator, Customer Services Unit, use a telephone where you cannot be overheard. If calling from outside of Richland, call Richland 942-1111, Extension 6-5245, Collect.

VI. MEASUREMENT OF AIRBORNE CONTAMINATIONA. In General

The air sample program at Battelle-Northwest serves several functions, among which are: determination of the radiological status of the air breathed by personnel in a work area and estimation of the internal deposition that personnel may receive; evaluation of the effectiveness of control measures and establishment of design criteria for future operations; determination of the amount of gaseous waste discharged to the environment from a process or facility; and detection of equipment failure or malfunction.

The problems in determining the air concentrations of radioactive materials are numerous. A wide variety of equipment has been designed to deal with these problems and, if properly used, will yield meaningful data. One of the problems results from the very low levels of activity under consideration. For example, the control concentration of plutonium in breathing air is 0.126 d/m per cubic foot of air. This emphasizes the necessity of concentrating the radioactivity in the air in some way. Another problem is that the air an individual breathes and the air at the point of sampling may not be the same. The representativeness of the air at the point of sampling is a question that must be evaluated on a continuing basis. On occasion it is necessary or desirable to determine not only the activity but also the actual size of the airborne particles and the solubility of any radioactive materials present.

It is the responsibility of Radiation Monitoring to maintain the air sampling program and to provide accurate records of the results for both present and future use.

B. Radioactive Airborne Contaminants

A certain amount of naturally occurring radioactive material is present in the air at all times, regardless of location. The differentiation between activity due to these naturally occurring radionuclides and that which has resulted from some process or experiment utilizing radioactive material can be a considerable problem. Of the naturally occurring emitters, radon (Rn-222)

FIGURE 4
Radon and Thoron Decay Chains

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and thoron (Rn-220) are the most significant with regard to air sampling. They are short half-lived alpha emitters and are gaseous decay products of the naturally occurring elements radium and thorium. These two gases escape from the ground into the atmosphere and are normally dispersed by wind and rain. However, certain atmospheric conditions will hold the gases near the point from which they escaped, forming radon and thoron "clouds." These "clouds" may last from a few hours to an entire day; several may be detected in a single month, or several months may elapse between their occurrence. Radon and thoron and their daughter products are usually adsorbed on dust particles which may be collected on a filter sample. During periods of high radon-thoron concentrations, the activity due to deposition of the daughter products of these nuclides on a filter may mask the presence of unacceptably high concentrations of plutonium or other alpha emitters. As a result, the true activity of radionuclides other than radon and thoron daughters can be determined only after an accurate correction is made for the presence of these naturally occurring nuclides.

In almost any physical or chemical process involving radioactive material, a potential exists for part of this material to become airborne and thus contaminate the breathing air. A great variety of radionuclides are handled in BNW facilities. Identification of each of the nuclides deposited on an air sample would, therefore, be an extremely difficult task were it not for the two following considerations. First, in unknown situations all the activity on air samples from a laboratory or facility is assumed to be due only to the most hazardous nuclide which is present in that laboratory or facility. Second, a large number of the commonly found airborne nuclides are fission products, formed when fissile material has been bombarded by neutrons in a reactor. Limits for concentrations of these nuclides in various groupings are well established, permitting quick assessment of situations involving airborne fission product contamination. The following list includes the most commonly found airborne contaminants resulting from the work performed at Battelle-Northwest:

1. Uranium,
2. Plutonium,
3. Fission Products, and
4. Tritium.

C. Sampling Media

The most widely used method of air sampling is to collect and concentrate the material on a filter through which air from the breathing environment is drawn. This is accomplished through use of a vacuum system which draws the air through the filter

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at a known rate. The sampling media, or filter, must meet certain criteria. It must be reasonably efficient in removing particles of the size in question from the air. Moreover, the particles must not become embedded too deeply in the filter since their radiation could be absorbed in the filter, making detection difficult or impossible. The filtering media most commonly used at Battelle-Northwest is an asbestos mat paper with a thickness of 0.018 inches (Hollingsworth and Vose HV-70). The flow rate is normally adjusted to between 2 and 10 cubic feet per minute.

The media used to remove gases from the air must utilize a different mechanism than that used in particulate filtering. For example, two methods are used to remove iodine from the breathing air. In the first method, charcoal-impregnated paper is used in the same fashion as the HV-70 paper, the iodine being adsorbed on the fine charcoal particles. In the other method, the air is passed through a system of caustic scrubbers which chemically remove the iodine from the air.

D. Sample Collection Techniques

The radioactive material deposited on a filter is considered to be representative of the material found in the air being sampled. Whether or not such a sample is truly representative of the air which an individual breathes during his normal work period is a subject of continuing debate. However, there are requirements which can assure that the sample is the best possible under the conditions which exist. First of all, the sampling point should be as close as possible to the heads of the workers in the facility without presenting operational or safety problems. As projects change and traffic patterns are altered, sampling locations should also be changed to provide the most representative samples possible. The frequency at which samples are changed should be such that the amount of radioactive material deposited on the filter will yield good counting statistics. For example, a ten-minute sample taken from an atmosphere containing the control concentration of plutonium (2×10^{-12} $\mu\text{Ci/cc}$) at a flow rate of ten cubic feet per minute would result in an activity of a little over ten d/m being deposited on the filter. The resulting low count rate would yield very poor statistics.

Since information on day-to-day fluctuations in the air concentration is of importance, samples collected for more than a 24-hour period should be taken only under the most stable circumstances. However, sampling the air on a seven-day frequency would be satisfactory in areas where radioactive contaminants are normally not expected but may infrequently occur.

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A variety of systems which draw air at a known rate through the sampling media are used.

1. Building Vacuum System

This is a fixed system of piping and outlets continuously evacuated by a central exhaust system. These outlets are usually at the wall or ceiling of a room, but with the use of extension hoses it is possible to obtain samples from almost any location. The building vacuum system is most widely used in connection with spot sample heads which are designed to utilize HV-70 filter paper. Flow rates for spot sample heads should be between 2 and 10 cubic feet per minute.

2. Motoaire Pump

This vacuum pump utilizes a building electrical power supply and is sometimes mounted on a cart for mobility. The sampling medium may be attached directly to the pump or to the end of an extension hose. This latter system can be utilized to collect samples of highly contaminated air with minimal contamination spread to the pump itself. The motoaire sampler is also calibrated routinely with a flow meter. Motoaire samplers are usually operated at flow rates between 7 and 10 cubic feet per minute.

3. Staplex Air Sampler

This is a small portable air sampler which may be hand-held for taking samples over short periods of time. The flow rate is determined by reading a vacuum gauge attached to the head of the sampler during filter sample collection. A calibration curve is provided which relates this gauge reading to air flow rates. Flow rates up to 25 cubic feet per minute may be obtained.

4. Constant Air Monitors

Several types of constant air monitors are presently being used at Battelle-Northwest. There are two basic classifications of these instruments: those with fixed filters and those with a moving filter tape. The detection principle can be the same for either type; namely, a scintillator or GM tube continuously monitoring the filter through which air is being drawn at a preset rate. In the fixed filter type the instrument either records the buildup of activity on the filter or simply monitors the gross activity on the filter. It is necessary to change the filter frequently in this type of constant air monitor. In the other type, the moving filter tape passes by a detector

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which measures the contamination on the filter. In addition to being able to alter the air flow through this type of instrument, one can also alter the tape speed and the distances of the detector from the point where the air passes through the filter. Most of the constant air monitors in use are designed to use HV-70 filter paper. Many of these instruments also are equipped with an alarm system which indicates levels of buildup or buildup rate in excess of some preset value.

5. Tritium Bubbler Sampler

This sampler consists of a gas wash bottle filled with ordinary water and a vacuum source. Air is bubbled through the water at a constant flow rate. This sampling method is rapid, reliable, and sensitive and has been proved under a variety of field conditions. The minimum detectable tritium oxide air concentration that can reliably be measured is 1×10^{-7} $\mu\text{Ci/cc}$. Detailed procedures for the tritium bubbler sampler are discussed in Section H below.

6. Portable Impactor Sampler

This type of sampler is used to collect airborne plutonium and uranium particulate material without collecting the naturally occurring radon and thoron daughter products. It does not use the filtration principle. The air to be sampled is drawn into an annulus at a high velocity, then is turned at a sharp angle. The heavy plutonium and uranium particles are impacted against a collecting plate but the lighter dust particles with the radon and thoron daughter products are not.

E. Sample Counting Equipment

The objective of any counting system is to accurately measure the radioactive material which is contained on or in the sample. The principal components of such a system are a detector, an amplifier, and a count register.

Not all particles or rays emitted from the sample during the counting period will be registered on the scaler. The losses may be categorized into two groups:

Geometry - This is the fraction of the total radiation emitted from the source that impinges upon the face of the detector. Included in the term "geometry" are such factors as self-absorption in the source, backscatter from the mounting medium, and scatter from the counting equipment.

Efficiency - This is the fraction of the radiation impinging upon the face of the detector that is counted.

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Included in the term "efficiency" are such factors as window transmission, energy dependence, electronic losses, and scatter within the detector assembly.

Losses of both types are included in the counting apparatus effectiveness which is defined by:

$$E = \frac{N}{A} \quad (3-1)$$

Where E is the counting apparatus effectiveness,
N is the observed counting rate of the standard,
and
A is the actual disintegration rate of the standard.

The scintillation counter uses a scintillating medium and photomultiplier as the detector and is efficient and stable. Scintillating media which respond to beta and gamma radiations and others which respond to alpha radiation are available; some systems use both types to simultaneously detect alpha and beta-gamma emitters. The coincidence counter used at BNW is of this type.

The standard scintillation counter designed for alpha counting cannot differentiate between the alpha particles from radon and thoron and those from such elements as plutonium or uranium. This can considerably impair the determination of the airborne concentration of specific alpha emitters. Two methods have been employed to correct counting measurements for the contribution of radon and thoron. The first is to make successive counts for several days following collection. The half-lives of radon and thoron and their daughters are less than four days while those for the alpha-emitting isotopes of interest may be thousands of years. Thus, one can correct for radon and thoron in an air sample by measuring the rate of decay. This method is obviously time-consuming, so to circumvent this problem another technique was developed which allows the immediate determination of non-radon-thoron-associated alpha contamination collected on a filter.

The coincidence counter was designed to detect alpha emitters in the presence of naturally occurring radon and thoron. The following diagrams of the radon and thoron decay chains will be of help in understanding the principle of coincidence counting. The counter consists of two opposed scintillating crystal detectors, one which responds to alpha particles and another which responds to beta and gamma radiations. These function in the conventional manner with the addition of an electronic circuit and one additional scaler. The added electronic circuit and scaler allow one to count "coincidence"

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events. It will be noticed in the decay chains of radon and thoron that Bi-214 and Bi-212 decay by beta emission followed by Po-214 and Po-212, both alpha emitters with half-lives of 150 microseconds and 0.3 microseconds, respectively. The coincidence events are the result of a pulse from the beta-gamma detector (initiated by the decay of Bi-214 and Bi-212 by beta emission) which opens an electronic "gate" for 200 microseconds, during which time any alpha particles detected are registered on the coincidence scaler as well as on the normal alpha scaler. Therefore, a "coincidence" count should represent the unique event in either the radon or thoron chain--a beta emission followed within 200 microseconds by an alpha emission. Obviously, any beta particle detected will open the "gate" and any alpha particle detected during this 200-microsecond period will be counted as a coincidence event, not just coincident beta and alpha counts from radon and thoron. However, the ratio of beta to alpha emissions for radon and thoron is constant, and, if the counting period is sufficiently long (at least one minute), one can accurately estimate the contribution of radon and thoron to the total number of alpha particles counted.

F. Alpha Counting

1. Preparation for Counting

Before counting is begun, the counter should be checked and the results plotted on the control chart. An operational check should consist of 5 to 7 one-minute counts of a standard source and a five-minute background count. At least five of the first seven operational checks should fall within the acceptable limits indicated on the control chart.

2. Counting Procedure

Two methods are available for counting air samples using the coincidence counter, the preset-time method and the preset-count method. Either method may be used with accuracy, but the preset-time method is normally used since it is quicker. The preset-time method is most accurate if the count is started at least one hour after collection of the filters.

a. Preset-Time Method

- 1) After making certain that the counter is operating properly, count three or four samples from normally clean areas to determine the coincidence ratio factor. This factor is obtained by dividing the number of total alpha counts by the number of coincidence counts. For example, if the scaler shows

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100 total alpha counts and 27 coincidence counts, the coincidence ratio is $100 \div 27$ or 3.7. The ratios thus obtained for the three or four clean area samples are averaged, and this figure is used for the coincidence ratio in subsequent calculations (on that shift).

- 2) If it is likely that a particular filter is grossly contaminated, survey it with an appropriate instrument prior to inserting it into the counter. Do not insert it into the counter if the count is greater than 50,000 d/m with an alpha survey probe. Contamination of the counter may thus be avoided.
- 3) Determine sample activity by subtracting both the background and the product of the coincidence counts and the coincidence ratio factor from the gross alpha counts.

Example: Coincidence ratio factor = 4

Background = 2 c/m

A sample indicates 148 gross alpha counts and 17 coincidence counts.

Net sample counts = $148 - [2 + (4 \times 17)]$ c/m

Net sample counts = $148 - 70 = 78$ c/m

b. Preset-Count Method

- 1) Determine the coincidence ratio by counting three or four samples from a normally clean area in the preset counting mode.
- 2) Average the total alpha counts for the background samples.
- 3) Count potentially contaminated samples in the same preset counting mode as the background samples. Set the control so that the preset coincidence count will be reached in approximately one minute.
- 4) To determine net sample counts subtract the average background gross alpha count from the sample gross alpha count and divide by the length of time taken to reach the preset count.

Example: Preset Count = 30

The background samples have the following total alpha counts:

#1 - 176 total alpha - 30 coincidence

#2 - 165 total alpha - 30 coincidence

#3 - 184 total alpha - 30 coincidence

#4 - 195 total alpha - 30 coincidence

Sum of total alpha counts = 720

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Average of background samples alpha count = $\frac{720}{4} = 180$
for 30 coincidence counts.

A sample indicates 348 total alpha counts for 30
in one minute and 12 seconds.

1 min. and 12 sec = 1.2 min

$$\text{Sample activity} = \frac{348 - 180}{1.2} = \frac{168}{1.2}$$

$$\text{Sample activity} = 141 \text{ c/m}$$

3. Calculation of Air Concentration

The following equation is used to convert sample activity to
air concentration when the sample is counted for alpha
emitters:

$$C_a = \frac{N_s}{V \cdot K_a} \quad (3-2)$$

Where C_a is the air concentration in $\mu\text{Ci/cc}$,

N_a is the sample counting rate in c/m ,

V is the volume of air sampled in ft^3 , and

K_a is the alpha air sample conversion factor.

K_a , the conversion factor, is found from the following
formula:

$$K_a = (2.22 \times 10^6 \text{ d/m}/\mu\text{Ci})(2.83 \times 10^4 \text{ cc/ft}^3)(A)(E)(F),$$

Where A is the absorption factor of HV-70 filter paper
(taken as 0.7 for Pu, U, and Th),

E is the counting effectiveness of the system as given
by equation (3-1), and

F is a factor which is defined by

$$\frac{\text{percent of the sample filter counted by the detector}}{\text{percent of standard source counted by the detector}}$$

When the filter is too highly contaminated to risk contamination
of the counter, an approximation of the air concentration
can be obtained by checking the filter with a Juno and
applying the following equation:

$$C_a = \frac{J N_j}{V} \quad (3-3)$$

Where J is the Juno correction factor, equal to
 $2.66 \times 10^{-11} \mu\text{Ci-ft}^3\text{-min/d-cc}$

N_j is the activity of the filter in d/m as measured
by the Juno, and

V is the volume of air sampled in ft^3 .

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4. Entry of Results in Air Sample Log

An important part of the air sample counting procedure is the proper recording of results in the air sample log. After all the information has been calculated and recorded, the individual performing the calculations must sign or initial the form in the column provided for this purpose.

5. Disposition of Samples

If the air concentration calculated for the sample is no greater than the background level, the filter may be discarded to contaminated waste. If the concentration exceeds the background level, the filter should be retained for further counting and analysis. If the concentration is much higher than expected, the Radiation Monitoring Specialist or Supervisor should be notified at once.

G. Beta-Gamma Counting1. Preparations for Counting

Before any counting is done, operational checks of the equipment should be made and recorded on a control chart. At least five of the first seven source checks should fall within acceptable limits indicated on the control chart. A five-minute beta-gamma background count should also be taken. This can be done simultaneously with taking the alpha background since, as noted in the above discussion, the counter can count both alpha and beta-gamma emissions simultaneously.

2. Counting Procedure

- a. In some areas there is a possibility of both alpha and beta-gamma contaminants being present on the sample filter. In such cases, the counts can be taken and recorded at the same time. In many sampling areas, however, beta-gamma contaminants such as fission products may be found without any alpha emitters being present and vice versa; in such situations the unneeded portion of the equipment can be inactivated. In counting for beta-gamma activity either the preset-time or preset-count method, as explained above, can be used, but to save time the preset-time method is most commonly used.
- b. Before counting the potentially contaminated filter, inspect it for excessive dust, lint, etc. If such foreign materials are present or if there is a reasonable probability of the filter being grossly contaminated, it should be surveyed with appropriate instruments prior to being inserted into the counter.
- c. After counting the filter, determine the sample activity by subtracting the background counts from the total

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beta-gamma counts. In most cases the number of beta-gamma counts due to natural radioactivity will be small compared to the counts from any beta-gamma-emitting contaminants deposited on the filter.

3. Calculation of Air Concentration

The following equation is used to convert the net sample activity to air concentration when the sample is counted for beta-gamma emitters:

$$C_a = \frac{N_s}{V \cdot K_b} \quad (3-4)$$

Where C_a is the air concentration in $\mu\text{Ci/cc}$,
 N_s is the sample counting rate in c/m ,
 V is the volume of air sampled in ft^3 , and
 K_b is the beta-gamma air sample conversion factor.

K_b is found from the following formula:

$$K_b = (2.22 \times 10^6 \text{ d/m}/\mu\text{Ci})(2.83 \times 10^4 \text{ cc/ft}^3)(A)(E)(F)$$

Where A is the absorption factor for HV-70 filter paper (taken as 0.5 for beta-gamma counting),
 E is the counting effectiveness of the system as given by equation (3-1), and
 F is a factor defined by

$$\frac{\text{percent of the sample filter counted by the detector}}{\text{percent of the standard source counted by the detector}}$$

When the filter is too highly contaminated to risk contamination of the counter, an approximation of the air concentration can be obtained by checking the filter with a CP and applying the following equation:

$$C_a = \frac{P \cdot D}{V} \quad (3-5)$$

Where P is the CP correction factor, equal to $1 \times 10^{-6} \mu\text{Ci-ft}^3\text{-hr /cc-mrad}$
 D is the exposure rate at the surface in mrad/hr as measured by a CP, and
 V is the volume of air sampled in ft^3 .

H. Tritium Sampling (at PRTR)

1. A sample should be taken at least once per shift.
2. Fill the bubbler with 100 ml of tap water.
3. Connect the hose from the vacuum pump to the arm of the bubbler which includes the bulb.
4. Take the unit to the area to be sampled and plug it into a 110 volt outlet to actuate the pump. Collect a sample for

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- five minutes. (Note: The flow rate through a 100 ml solution has been calibrated at ~3000 cc/min.)
5. After the five-minute sample has been collected, unplug the pump, pour a small sample from the bubbler into a sample bottle, and mark the sample number and date on the bottle. Discard the remaining solution.
 6. Record the following information on a "Tritium Air Sample Log" sheet: Sample number, date and time sampled, sample location, volume of water (100 ml), and air volume.
 7. Deliver the sample to PRTR for tritium analysis in the Tri-Carb counter.
 8. Wash the entire bubbler in soap and warm water and dry thoroughly.
 9. When the tritium result is received from the lab, record this result on the "Tritium Air Sample Log" for the proper sample number.
 10. Calculate the tritium air concentration by the following formula:

$$C_a = \frac{C_w \cdot V_w}{V_a} \quad (3-6)$$

Where C_a is tritium air concentration in $\mu\text{Ci/cc}$,
 C_w is tritium water concentration in $\mu\text{Ci/ml}$,
 V_w is the total volume of water used in the sampler
(100 ml), and
 V_a is the volume of air sampled in cc.

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RADIATION MONITORING PROCEDURES

PERSONNEL DECONTAMINATION AND CONTROL OF RADIATION ZONE INJURIES

I. CONTROL OF RADIATION ZONE INJURIES

A. In General

Serious internal exposure of personnel may result when radioactive material enters the body through skin breaks such as unhealed wounds and skin injuries such as lacerations, abrasions, punctures, blisters, and burns. Plutonium, other transuranic elements, certain fission products, and a few other radionuclides can be quite hazardous in these circumstances, especially when in soluble form. Other radionuclides, while hazardous, are less troublesome because of more rapid decay, faster elimination from the body, or selective deposition in less vital parts of the body.

In any case of personal injury, the general welfare of the injured person is the primary consideration. In a contaminated injury of a minor nature, the deposition of radioactive material could be more detrimental to the individual than the effects of the injury itself; but if the injury is of a serious nature, deposition problems are usually of less importance than immediate care of the injury. Flushing the wound with clean water will minimize the potential for deposition of any contamination which may be present in the wound. Tourniquets must not be utilized for purposes of deposition control unless specifically approved in each instance by a Medical Doctor of the Hanford Environmental Health Foundation.

B. Procedure in the Event of a Radiation Zone Injury

In the case of a severe injury, immediate medical treatment should take precedence over contamination control. However, if significant radioactive contamination is present on clothing, uninjured skin areas, or hair, consideration must be given to preventing spread of the contamination into the wound. The following action should be taken in case of a severe injury:

1. Make the injured person available at once for medical treatment if movement is permitted by approved first aid practices. If the injured person is unconscious or for other reasons cannot get out of the Radiation Zone by himself, others should enter to aid him. Any severe bleeding should be promptly controlled. If caustic or corrosive agents are present, they should be immediately flushed off. If the medical situation is urgent, protective clothing requirements and other radiological controls should be disregarded. The welfare of the injured is the important thing; contamination can be cleaned up later. Surveys, step-off pad procedures, and procedures to prevent contamination spread should be completed only to the extent that medical treatment is not delayed.

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2. A Radiation Monitor should accompany the injured person when he is taken to the first aid station. The Radiation Monitor should survey the wound, protective clothing, and the object causing the injury, if available, as soon as circumstances permit. Medical personnel should promptly be advised of the contamination status of the wound.
3. If the wound is probably contaminated, it should be flushed with clean running water. This flushing, and any subsequent decontamination which may be required, should be under the direction of medical personnel.
4. Radiation Monitoring supervision responsible for the facility shall inform the Personnel Dosimetry Customer Services Unit of the injury, and whether or not the injury is probably contaminated.

In case of minor injuries involving no risk of permanent injury, consideration should be given to controlling the spread of contamination. In case the injury was incurred in a contaminated area, the following action shall be taken immediately:

1. The injured person should be assisted in removing contaminated clothing, leaving the Radiation Zone, and reaching sanitary water. Care should be exercised to prevent contaminated clothing from coming into contact with the wound.
2. If caustic or corrosive agents were involved they should be flushed off promptly.
3. Flush the wound under running tap water for five minutes.
4. A Radiation Monitor should survey the injured area, the object causing the injury, the clothes pierced by the object inflicting the wound, the exposed skin surface, and any available blood smears. The exit route from the Radiation Zone should also be surveyed to assure that any spread of contamination is promptly detected and controlled.
5. If skin contamination at other than the wound site is detected, it should be removed as described under II below before the individual is taken to the first aid facility.
6. A Radiation Monitor should accompany the injured person to the first aid facility, taking along appropriate survey instruments. He should advise the nurse of the probable contamination status of the wound.
7. If the wound is probably contaminated, decontamination should be done under the direction of medical personnel.
8. Radiation Monitoring supervision responsible for the facility shall inform the Customer Services Unit of the injury and the probable contamination status of the injury.

C. Protection of Injuries Prior to Radiation Zone Entry

Persons who work with unconfined radioactive materials should report any skin breaks which they have to the first aid nurse. Skin breaks include unhealed wounds, open cracks from chapping, and injuries such as lacerations, abrasions, punctures, blisters,

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or burns. The first aid nurse will provide a dressing or protection for the skin break, if advisable from a medical point of view.

A person having skin breaks shall perform radiation work with unconfined radioactive materials only with the specific prior approval of his supervisor and the concurrence of Radiation Monitoring supervision. The individual's supervisor shall ensure that the degree of protection afforded the skin break is adequate in view of the nature of the work to be performed by the injured person and the existent or potential contamination status of the work location. The supervisor should consult the first aid nurse if information is required concerning the injury or the capabilities of any dressing provided.

II. DECONTAMINATION OF SKIN AND PERSONAL CLOTHING AND EFFECTS

Whenever personnel work with radioactive materials, there is a possibility of their person or clothing becoming contaminated. In such circumstances, certain general considerations should influence the remedial action to be taken. They are:

1. Seriousness of the physical damage to the individual from the incident - shock, severe bleeding, burns, etc.,
2. External or internal dose rate to the individual from the contamination,
3. Type of contaminant and the carrier - beta, alpha, acids, alkalies, water, organics, etc., and
4. Condition of contaminated skin and adjacent areas.

Decontamination of personnel shall be directed by Radiation Monitoring or responsible personnel from HEHF and shall be accomplished by approved procedures for personnel decontamination.

Medical attention to serious injuries will generally take priority over removal of contamination. However, if the contamination is carried by either a strong acid or a strong base, immediate steps should be taken to remove the chemical with tap water without regard to the spread of contamination. Information on hazardous substances can be found in the Chemical Safety Guides Section of BNWL-MA-43.

When high dose rates or skin absorption are not a problem, more care should be exercised to localize and remove skin contamination. For general low-level hand contamination with no cuts or abrasions present, a normal hand wash will usually suffice.

If decontamination is under the direction of Radiation Monitoring and a reduction of contamination to the minimum detectable limits cannot be achieved, Radiation Monitoring shall notify Personnel Dosimetry who in turn shall inform HEHF of the situation. Further treatment will be determined by the physician contacted.

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A skin decontamination form should be completed for each known case of personnel contamination in which the contamination is not easily removed by normal washing with soap and water. The forms should be filled in completely and attached to the radiation survey record describing the associated incident. These forms should be forwarded by the Radiation Monitoring Supervisor at the end of each monthly reporting period to the 3705 Building, 300 Area for storage.

A. Skin Decontamination

1. Supplies Needed

Each facility should have ready access to kits containing materials and equipment expressly for personnel decontamination. These kits should be inventoried routinely and should include the following supplies and equipment or the equivalent:

Applicators, cotton tipped	about 500,
Cleansing tissues.	2 boxes,
Cotton balls or rolls.	100 balls,
Directions for personnel decontamination . . .	1 copy,
Directions for taking nasal smears	1 copy,
Flushing tubing.	1 foot,
Sterile gauze sponges, 2" x 2"	about 200,
Hand brush	1,
Masking tape, 1"	1 roll,
Nasal swabs (1" x 2" filter paper strips). . .	1 envelope,
Paper cups, 4 oz.	10,
Paper cups, 1 oz.	25,
Scissors	1 pair,
Spotting shield.	1,
Surgical gloves, pre-talced	2-3 pairs,
Tongue depressors	5-10;
Tourniquet Kit	1;
Water.	16 oz. bottle,
Waxed bags (for waste disposal)	10;

Approved Decontamination Agents:

Lan-O-Kleen.	1 oz. jar,
Lava Soap.	1 bar,
Na ₄ EDTA solution.	1 jar,
pHisoHex	4 oz. bottle,
Potassium Permanganate Capsules.	20 packages,
Sodium Bisulfite Capsules.	20 packages, and
Wool Wax Cream	1 jar.

2. Preparation of Chemical Reagents

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a. Na₄ EDTA

The stock solution should be prepared in advance and be available when needed. It can be prepared by dissolving 16 grams of 70 percent active Na₄ EDTA chemical salt in 100 ml of distilled water. This gives a solution of 10 percent active ingredient (EDTA). A small amount of detergent should be added to the solution to provide a sudsing or lifting action which will help in the removal of contamination.

b. KMnO₄

A saturated solution of potassium permanganate is made by dissolving one capsule of KMnO₄ crystals (v1 gram) in a one ounce waxed paper cup of water. This solution is usable even while crystals remain undissolved in the bottom of the cup.

c. NaHSO₃

A four percent solution of sodium bisulfite is made by dissolving one capsule of NaHSO₃ crystals (v1 gram) in a one ounce waxed paper cup of water. This solution should be made immediately before use.

3. Pre-Decontamination Considerations

- a. Closely observe the condition of the skin at and adjacent to the contaminated area. If any breaks or abrasions are observed, notify the Radiation Monitoring Supervisor responsible for the facility.
- b. If beta-gamma emitting contamination is suspected, make appropriate surveys of the contaminated person to determine the dose rate. If the level exceeds 1 R/hour, take immediate steps to reduce the level. Contaminated clothing should be removed immediately and the person given a complete body survey for skin contamination.
- c. Make an alpha survey of the person if alpha contamination is suspected. If contamination is found, determine the surface area of the skin contaminated and the approximate quantity of alpha-emitting material involved.

4. Immediate Actions Required

a. Injury in Addition to Contamination

If the injury is major (shock, severe bleeding, burns, etc.), notify HEHF. Medical attention will generally take priority over removal of contamination.

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If the injury is minor and the wound is, or may be, contaminated, flush it with running water for 5 minutes. Notify HEHF and discontinue decontamination action in the immediate area of the wound except as HEHF personnel may direct. Proceed as required with decontamination efforts at other locations on the body.

b. High Levels of Contamination

If protective clothing is contaminated such that the dose rate to the adjacent skin area is greater than 100 mrad per hour, the clothing should be removed promptly to minimize the exposure. Identify and preserve the source for further study. Perform a complete body survey for contamination. If high dose rates are observed, reduce the level promptly by any means available. Record dose rates and locations involved. If contamination on the person or clothing worn is greater than 2 R/min, decontamination action shall have priority over medical treatment other than artificial respiration or stoppage of severe bleeding. If loose high-level contamination is found, consideration should be given to the use of respiratory protection, and care should be taken to avoid spread of contamination.

c. Contamination Associated with a Caustic or Corrosive Carrier

Skin contamination known or suspected to have originated from radioactive material in a caustic, corrosive, or organic carrier should receive an immediate application of water by means of a damp cotton ball or by flushing under running tap water to dilute any reagent which might react with the skin. Extreme care should be taken to prevent contamination spread to any skin or body opening. Notify HEHF personnel and take no further action unless dose rates exceed 100 R/hour.

d. Contamination in/or Possibly in, Eyes or Mouth

If the contamination is in the eyes or mouth, flush with running water only and notify HEHF personnel immediately. If it is in the nose and may be a highly radiotoxic material, nasal irrigation should be immediately initiated by a trained person. Notify HEHF personnel.

If contamination is in the nose and is not a highly radiotoxic material, have the person blow his nose thoroughly and save the tissues used. Notify HEHF personnel.

5. Skin Decontamination Procedure - Step One

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a. General Contamination of a Major Portion of the Whole Body

Have the person shower with tepid water. Showers which drain to the crib waste retention waste systems should be used if they are available in the building. Such specially marked showers are presently available in 309, 324, and 327 Buildings. Soap, preferably pHisoHex, should be used; a light scrubbing with a brush is permissible. Lava or Lan-O-Kleen may be used on the hands. Following this, wash the face, head, and neck, in that order, being careful to keep contamination from body openings and any skin breaks or abrasions which may be present.

After the individual has thoroughly dried himself, perform a thorough body survey, locate any residual contamination and treat as in 6 below.

b. Localized Contamination

1) Hair

If contamination is confined to the hair, shampoo using pHisoHex and water. Use a towel and/or apron as necessary to avoid contamination spread. Survey and repeat as necessary, but limit effort to three shampoos. Do not let contamination get into eyes, mouth or nose. If contamination remains on scalp use the Procedure outlined in 6 below.

2) Hands

Scrub hands. Use soap, pHisoHex, Lan-O-Kleen, Lava soap, and brush as desired. If contamination remains after thoroughly scrubbing, use the procedure outlined in 6 below.

3) Small Skin Area

Scrub with soap or pHisoHex and water. Lava or Lan-O-Kleen and a brush may be used with care if the skin is not damaged or abraded. If several localized spots are involved and contamination spread is not of great concern, a shower may be more practical. If contamination remains after scrubbing or shower, use the procedure outlined in 6 below.

6. Skin Decontamination Procedure - Step Two (Use of Chemical Reagents)

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- a. Only three chemical reagents are approved for use; Na_4EDTA and potassium permanganate followed by sodium bisulfite to remove the stain.
- b. First try Na_4 as follows:

Apply EDTA solution to the contaminated area using a cotton-tipped applicator or a cotton ball. Work toward the center of the spot. Do not reuse the applicators or cotton. Rinse with clean water and dry skin surfaces well. Resurvey the contaminated skin areas. Repeat the decontamination procedure as necessary, but not for more than three washings. If no contamination remains, apply wool wax cream to prevent chapping. If smarting or excessive reddening of the skin is encountered, refer the case to HEHF.

- c. If Na_4EDTA does not remove the contamination, paint the spot with KMnO_4 solution. Allow the KMnO_4 solution to dry thoroughly. Repeat the painting two more times. When dry, remove the dark brown coloration by applying NaHSO_3 . When coloration is gone, rinse once, dry, and resurvey. If necessary, repeat this application of KMnO_4 and NaHSO_3 one additional time. If smarting or excessive reddening is encountered or if residual contamination remains, refer the case to HEHFI.

7. Termination of Decontamination

- a. After decontamination, make a final survey with the skin dry.
- b. If contamination remains, refer the case to HEHFI; if no contamination remains (i.e., <500 d/m alpha per 100 cm^2 or <200 c/m beta-gamma per GM probe area), apply lanolin (wool wax) to prevent chapping.
- c. An individual may be released to go home with residual fixed skin contamination up to $10,000$ d/m alpha per 100 cm^2 or 600 c/m β - γ per GM probe area with the approval of Radiation Monitoring supervision if further decontamination is not feasible or appropriate at that time. In such cases, plastic spray may be used to increase assurance that the contamination remains fixed to the skin until decontamination is resumed.
- d. Complete the decontamination record.

B. Nasal Irrigation

The preferred treatment of nasal contamination is with normal (isotonic) saline irrigation equipment which should be provided at each permanent personnel decontamination station. Nasal irrigations should normally be performed only under the direction of medical personnel. They may, however, be done as emergency procedures by non-medical personnel who have been adequately trained in such procedures.

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In any case where caustic solutions may have actually gotten into the mouth or nose, the rinsing should be done at once at the nearest available source of sanitary water.

1. Supplies Needed

- a. Irrigator stand,
- b. Irrigator bottle,
- c. Six (6) feet rubber tubing,
- d. Pinch clamp,
- e. Glass stem from nose dropper,
- f. Patient's throw (plastic apron),
- g. Small diameter rubber tubing (2" long),
- h. One gallon ice cream carton,
- i. Several waxed paper cups,
- j. Swabs,
- k. Rubber gloves,
- l. Paper bags, and
- m. Normal Saline solution.

2. Pre-irrigation Action

Preliminary to nasal irrigation the employee should blow his nose in tissue to be saved and clear his throat and spit the mucous into a waxed cup to be saved.

3. Nasal Irrigation Procedure

- a. Take nasal smears and save them for counting and analysis. Seat the individual and have him don a plastic apron or other covering to protect his clothing from liquids.
- b. Prepare the nasal irrigation equipment by placing the irrigator bottle filled with normal saline solution directly above the patient's head, then place a clean tip of small diameter rubber tubing on the end of the glass stem so that it extends one-half its length beyond the glass. Rubber tubing, not glass, should be inserted in the nose.
- c. Place a gallon ice cream carton in the patient's lap to collect the irrigation water.
- d. Have the patient insert the rubber tip into the lower portion of his nostril (about 1/2 to 3/4 inch).
- e. Make sure the patient's head is held erect and over the ice cream carton so that the water will run into the lower part of the nostril and drain back out the same nostril. If head is tilted forward the water may run into the sinuses.
- f. Allow the patient to regulate the flow by pinching the tube with his fingers.
- g. Allow one-half irrigation bottle of saline solution to each nostril.
- h. Retain the solution for analysis.

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- i. Blow the nose and clear the throat again and save.
- j. Take new smears of each nostril; dry and count. If they are positive, repeat the nasal irrigation procedure.
- k. If the patient complains of irritation in the nasal passage, discontinue the irrigation procedure and refer him to HEHF medical personnel.

C. Contaminated Personal Belongings

Personnel who work in areas where radioactive contamination is present are responsible for complying with the provisions of the applicable Radiation Work Procedures. Radiation Monitoring prescribes sufficient protective clothing to protect personal effects from becoming contaminated; if reasonable care is taken by the employee.

Occasionally, personal effects become contaminated in an accident or despite precautions taken by the employee and his supervision. In such cases, these effects must be satisfactorily decontaminated or turned over to operating management for disposal.

The general practice upon finding personal effects contaminated is to have them removed immediately and have a body survey performed. If personnel contamination is detected, this has priority. If not, attention should be given to the contaminated effect(s).

Decontamination of personal items is the responsibility of the owner and his supervisor. Radiation Monitoring personnel may assist; however, by advising as to the most efficient method for decontamination. Occasionally, it may prove expedient for the Radiation Monitor to assist in the decontamination efforts; for example, it might be easier and quicker to remove particulate contamination using masking tape than to isolate and mark the exact location for later decontamination by the owner.

Under normal circumstances, Radiation Monitoring personnel should not cut or otherwise damage personal clothing to decontaminate, even with the owner's consent.

1. Procedure for Decontamination

a. Shoes

If the contaminant is dry, masking tape may be used. If this proves unsuccessful, the following method should be tried:

1) Leather Soles

Scrape with a wire brush, being careful to brush from the body. Respiratory protection may be required for high level contamination. Do not use liquids as this might cause the contaminant to soak deeper into the sole.

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2) Rubber Soles

Wash with soap and water and scrub using a stiff brush.
This may be followed by scraping.

b. Personal Clothing

When clothes are found to be contaminated, they should be removed with care to prevent further spread of the contamination. A complete body check should always follow. If the contamination cannot be readily removed by masking tape or by washing with soap and water, the item(s) should be wrapped in paper or plastic bags. The person's name and the level and type of contamination, along with the date of occurrence, should be marked on or attached to the package. Final disposition should be agreed upon by the owner, his supervisor, and Radiation Monitoring.

2. Confiscation of Personal Belongings

Personal clothing which is contaminated to no more than 25,000 c/m beta-gamma, 8,000 d/m alpha other than Pu, or 2,000 d/m Pu may be turned over to the employee for decontamination. However, Radiation Monitoring must survey all decontaminated clothing for release afterwards. If decontamination is unsuccessful or if the contamination is in excess of the above-mentioned limits, the item(s) must be adequately wrapped and identified until disposition is agreed upon by the owner, his supervisor, the supervisor of the operating group, and Radiation Monitoring.

3. Reimbursement for Confiscated Clothing

If it is decided that the owner shall be reimbursed, the supervisor of the component having responsibility for the Radiation Zone shall prepare, within five days after confiscation, two copies of "Report of Contaminated Personal Effects." Included in this form should be a monetary value for each item agreed upon by the owner and the operating supervisor. The signatures of the appropriate Radiation Monitoring Supervisor, the owner, and operating supervision are necessary before payment can be recommended. The signature of a Radiation Monitoring representative attests to the fact that the article was in fact contaminated and does not indicate a recommendation for reimbursement. Operating Supervision has the responsibility for approving payment.

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CALIBRATION AND TESTING OF EQUIPMENT

This section deals primarily with the calibration and testing of semi-stationary monitoring equipment. The manual on the use and interpretation of monitoring instruments discusses the uses and capabilities of portable monitoring instruments used at BNW.

I. CALIBRATION AND ROUTINE TESTS OF LABORATORY COUNTERSA. Determination of Counting Apparatus Effectiveness

The counting apparatus effectiveness is defined in equation (3-1).

When the source material has a half-life short enough to require a periodic correction of its value, the half-life and date of original calculation will be shown on the label. A corrected value for the activity of the source in d/m may be calculated at any later date by the formula:

$$A = A_0 e^{-\lambda t} \quad (5-1)$$

Where A = Activity (in d/m) of the source at time t,

A₀ = Original activity of the source (in d/m),

$\lambda = \frac{0.693}{T_r}$ (day⁻¹),

T_r = Physical half-life of the nuclides in the source (days), and

t = Time (in days) since the date on the source label when the source activity was A₀.

B. Chi-Squared Test1. Purpose of the Test

The chi-squared test is a statistical test to check the degree of variation in counting rates between successive counts on the same standard source. The purpose of the test is to determine if variations in the counting rates are those normally expected from the random nature of radioactive decay or if they are due to erratic instrument behavior. The test should be performed monthly during normal operation of the counter. If maintenance work is performed on the counter or if five of the seven routine operational checks do not fall within the 90 percent confidence limits on the control chart, a chi-squared test should also be performed. Care should be taken to avoid confusion between the Greek letter Chi (X or χ) and the Roman x which is used in the English alphabet.

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2. Performance of the Test

The Chi-Squared Counter Test Sheet is designed to facilitate performance of the test. To perform the test, proceed as follows:

- a. Tabulate a series of 10 or 20 one-minute counts and enter the appropriate figures in the proper columns,

	<u>x</u>	<u>x - $\bar{x}$</u>	<u>(x - $\bar{x}$)²</u>
1.			
2.			
3			
.			
.			
.			
n	<u>Σx</u>	<u>$\Sigma (x - \bar{x})$</u>	<u>$\Sigma (x - \bar{x})^2$</u>

Where x = number of counts obtained during each of the one-minute counting periods

$\bar{x}$ (called x -bar) = average number of counts obtained or $\frac{\Sigma x}{n}$, where n is the total number

of one-minute counts taken, and x is the total number of counts registered during all the counting periods.

$$\chi^2 = \frac{\Sigma (x - \bar{x})^2}{\frac{\Sigma x}{n}}$$

If χ^2 does not fall within the limits indicated in the table below, the counter is malfunctioning and should be repaired before it is used to count air sample filters.

TABLE 5-1
CHI² LIMITS

Confidence Level	n = 10		n = 20	
	Lower	Upper	Lower	Upper
90%	0.3325	1.6919	0.5058	1.5072
95%	0.2700	1.9022	0.4453	1.6464
99%	0.1735	2.3589	0.3422	1.9853

CALIBRATION AND TESTING OF EQUIPMENT

C. Control Chart1. Purpose of the Chart

A control chart must be prepared for each counter to assure satisfactory performance with respect to both effectiveness and counting behavior. On every shift during which the counter is used the counting effectiveness must be checked by using a standard source.

2. Preparation of the Chart

The following steps should be followed in preparing a control chart:

- a. Make a series of 10 or 20 one-minute counts and apply the chi-squared test to see if the χ^2 (chi-squared) value falls between the acceptable upper and lower limits (see discussion under B, above).
- b. Divide the average counting rate by the corrected activity of the source in d/m to find the counting effectiveness. The minimum acceptable counting apparatus effectiveness is 12 per cent for scintillation alpha counters, and 6 per cent for scintillation beta-gamma counters.
- c. Calculate the standard deviation as follows:

$$\sigma = \frac{(x - \bar{x})^2}{n - 1} \quad (5-2)$$

- d. Calculate the counting uncertainty at various confidence levels from the standard deviation as follows:

$$U = \frac{K\sigma}{\sqrt{P}} \quad (5-3)$$

Where K is a mathematical constant dependent on the desired confidence level (see table below), and

P is the ratio of the length of time the standard is to be counted for future operational checks to the length of time it is counted in preparation of the control chart. If one-minute counts are used for both the operational checks and the preparation of the control chart, P = 1.

<u>Confidence Level</u>	<u>K</u>
90%	1.65
95%	1.96
99%	2.57

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e. Prepare the control chart as follows:

- 1) Ordinate (vertical axis) - count rate in c/m
- 2) Abscissa (horizontal axis) - time in days (or shifts)
- 3) Plot the average counting rate of the standard source as a solid line extending the full width of chart.
- 4) Show the limits of uncertainty for the 90 percent and 95 percent confidence levels as dotted lines extending the full width of chart.
- 5) Enter on the chart the identity of the source used, the correction factor for air sample calculations (determined from the counting apparatus effectiveness), the operating voltage, and the discriminator setting.

D. Determination of Counter Gate Width

This test should be applied to all coincidence counters as follows:

1. Using a standard source, take a one-minute count under coincidence operation and record the number of coincidence counts (N_c) and the number of total alpha counts (N_α).
2. With the instrument in total beta operation, take a one-minute count and record the number of total alpha counts (N_α) and total beta counts (N_β). The number of total alpha counts (N_α) should be very nearly the same in steps 1 and 2. If they are not exactly the same, determine the average value and utilize it as N_α .
3. Calculate the gate width from the following equation:

$$\Gamma = \frac{N_c}{(N_\alpha) \times (N_\beta)} \quad (5-4)$$

Where Γ is the gate width in seconds,

N_c is the number of coincidence counts per second,

N_α is the number of total alpha counts per second, and

N_β is the number of total beta counts per second.

The gate width should be between 180 and 210 microseconds.

If it is not, the instrument is malfunctioning and should be repaired before air sample filters are counted.

E. Retention of Records

All chi-squared and gate width tests and control charts showing routine operational checks are important permanent records and should be maintained and handled as such.

CALIBRATION AND TESTING OF EQUIPMENT

II. CALIBRATION OF HAND AND SHOE COUNTERSA. Fourfold Alpha Hand Counter1. Operation

The Fourfold Hand Counter is an alpha (only) detection instrument. It gives no audible response, but has two registers which record the count for the right and left hand, with another light provided to indicate "jamming." Depending upon the type of instrument, the count is started either by pushing inward on the treadle switch before inserting the hands, or downward on the treadle switch after inserting the hands. The counting interval may vary from 10 to 24 seconds, depending on the instrument, but a standard counting interval of 15 seconds is most commonly used.

2. Calibration

All Fourfold Hand Counters should be calibrated in the following manner, monthly or after being serviced by Instrument Maintenance.

- a. Determine the average background count for ten background measurements and record it on the Alpha, Beta, Gamma Hand and Shoe Counter Test Log sheet.
- b. From Table 5-II, find the warning levels and limits for background counts, and enter these on the Hand and Shoe Counter Test Log sheet for each hand. (This table also appears on the reverse side of the Log Sheet). The warning levels should be posted conspicuously on the counter.

TABLE 5-II

<u>Average Background</u>	<u>Background Limits</u>	<u>Warning Level</u>
0-0.9	0-1	3
1.0-1.5	0-2	4
1.6-2.5	1-3	5
2.6-3.5	1-4	6

- c. Using a standard wedge-shaped alpha source, run 10 checks for each hand with the source facing one direction and then 10 more checks with the source facing the opposite direction.
- d. Calculate the average response for each probe.

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- e. Subtract the average background obtained at step a from the average source response obtained at step d to find the average net response to the source. Enter this number on the Hand and Shoe Counter Test Log sheet.

3. Daily Operational Checks

- a. Take one background count and record the result on the Hand and Shoe Counter Test Log sheet. Check to see if the count falls within the acceptable limits for future background counts listed in Table I. If it does not, take a second count. If this is within limits, the counter is functioning satisfactorily. If the second count is not within limits, tag the machine out of service and notify Instrument Maintenance.
- b. Make one source check on each probe using the wedge-shaped source. Enter the results on the Hand and Shoe Counter Test Log sheet. Compare the results to limits for future source checks listed in Table 5-III below. If the count is outside these limits, take a second count. If the second source check is low, tag the counter out of service and notify Instrument Maintenance. If the source check is higher than the limits, recalibrate and leave the counter in service.

TABLE 5-III

<u>Average Source Response</u>	<u>Limits for Future Source Checks</u>
3	2-5
4	2-6
5	3-7
6	4-8
7	5-9
8	6-10

B. Fivefold Hand and Shoe Counter

1. Operation

The Fivefold Hand and Shoe Counter uses an arrangement of Geiger-Mueller tubes as detecting elements. These GM tubes are connected to registers which record counts for the left hand, right hand, and for the shoes. The counting cycle is begun by inserting the hands and pressing downward on the treadle switch. The counting interval is normally 15 seconds but may be set from 10 to 24 seconds.

CALIBRATION AND TESTING OF EQUIPMENT

2. Calibration

All hand and shoe counters should be calibrated following maintenance or repair before being returned to service. The following procedure should be followed for calibrating the counters:

- a. With the small source provided (or with a wrist watch having a radium dial), check each GM tube individually and observe the response of each on the register. All show responses that are approximately the same.
- b. Determine the average background count for ten background measurements and record it on the Hand and Shoe Counter Test Log sheet.
- c. Consult Table 5-IV below to determine the warning level corresponding to the average background count.

TABLE 5-IV

<u>Average Background</u>	<u>Background Limits</u>	<u>Warning Level</u>
4	1-7	9
5	2-8	11
6	2-10	12
7	3-11	14
8	4-12	15
9	4-14	17
10	5-15	18
11	6-16	20
12	7-17	21
13	7-19	22
14	9-20	24
15	9-21	25
16	10-22	26
17	11-23	28
18	11-25	29
19	12-26	30
20	13-27	32

CALIBRATION AND TESTING OF EQUIPMENT

- d. Post the corresponding warning levels for the hands and shoes.
- e. Make ten checks with a standard, wedge-shaped, beta-gamma source and record the average count on the Hand and Shoe Counter Test Log sheet.

3. Daily Operational Checks

- a. Check each GM tube with a small source and observe that each responds to the register. If any tube does not respond, tag out the counter and notify Instrument Maintenance.
- b. Take one background count and record the results on the Hand and Shoe Counter Test Log sheet. Consult the table on the back of the sheet to see that the count falls within the limits listed for future background checks. If it does not, take a second check. If this is within limits, the counter is functioning properly. If the second count is not within limits, check to see if the counter is contaminated. If it is not contaminated, recalibrate the instrument and post new warning levels.
- c. Make one source check using the wedge-shaped source. If the response is equal to or greater than the warning level, the instrument is operating satisfactorily. If the response is less than the listed warning level, tag the counter out of service and notify Instrument Maintenance.
- d. Change the paper on the shoe counter daily so the paper over these tubes can be kept as clean as possible. This will help to keep the background count down to the level it was when the instrument was calibrated.

C. Alpha, Beta, Gamma Hand and Shoe Counter1. Operation

This counter is both an alpha and beta-gamma detection instrument. The hand probes contain zinc-sulfide scintillation detectors for alpha radiation and GM tube detectors for beta-gamma radiation. The shoe probes utilize GM tube detectors and are for beta-gamma detection only. A separately operated, cable-connected alpha probe is attached to the side of the instrument for surveying clothing and other body surfaces. Some of these instruments contain an external GM probe as well.

The count cycle is begun by lifting up lightly on the back of the right hand as it is inserted in the detector. The "on" light will go off and the "count" light will come on and remain on during the 15-second counting period. At the end of the counting period the "count" light again comes on. Any

CALIBRATION AND TESTING OF EQUIPMENT

contamination present is indicated by the alpha alarm lights turning on, or by counts on the beta-gamma registers above posted levels. High level contamination will usually result in the beta-gamma indicating lights failing to flash at all and/or failure of the beta-gamma register to operate.

2. Calibration

The calibration of the alpha hand probes is the same as that for the Fourfold Hand Counter described in subsection A above. The calibration of the beta-gamma hand and shoe probes is the same as that for the Fivefold Hand and Shoe counter described in subsection B above. A complete calibration should be performed about once per month and each time the instrument is adjusted or repaired by Instrument Maintenance.

3. Daily Operational Check

An operational check similar to those performed on the Four- and Fivefold Instruments should be conducted daily. The warning level for the alpha detecting portion of the instrument is normally set at 8 counts; the beta-gamma ~~warning level is normally set as it is for the Fivefold instrument.~~ The external probes are checked for response in the normal manner for Scintran and GM probes.

III. INSTALLED RADIATION RECORDING INSTRUMENTS

A. In General

Fixed monitoring systems with continuous recorders are used for three purposes:

1. To provide data on radiation levels in areas where those levels are frequently so high that personnel entry cannot be permitted,
2. To confirm continuous low radiation levels at locations where portable instrument monitoring is not usually required, and
3. To better follow daily trends in radiation levels in the location of interest.

B. Operation

1. Master switch

On new systems the two-position toggle switch on the amplifier should be on "Automatic" (printed in red). On older systems the four-position selector switch marked "Input volts" (inside the small door on the amplifier) should be in the extreme left position, marked "M.S."

CALIBRATION AND TESTING OF EQUIPMENT

2. Range Selection

In the old systems, one switch on the amplifier selects either 10^8 ohms or 10^{11} ohms resistance; each of four other selector switches has three positions, marked 0.1, 1.0, and 10 volts. In the new systems, a knob on the amplifier may be used to select one of four quadrants (numbered with Roman numerals in red), while each of four other selector switches has four positions, marked A, B, C, and D. The two groups of four selector switches correspond, from left to right, with the four detectors listed as controlled by the amplifier assembly. These combinations of switches make possible the selection of one of six ranges (old system) or sixteen ranges (new). Full scale field gamma responses are as follows:

OLD SYSTEMS

<u>Resistance (ohms)</u>	<u>Voltage (volts)</u>	<u>Radiation Level (full scale)</u>
10^{11}	0.1	3 mR/hr
10^{11}	1.0	30 mR/hr
10^{11}	10	300 mR/hr
10^8	0.1	3 R/hr
10^8	1.0	30 R/hr
10^8	10	300 R/hr

NEW SYSTEMS

<u>Red Arc and Value in ohms</u>	<u>A (0.1 v)</u>	<u>B (0.3 v)</u>	<u>C (1 v)</u>	<u>D (3 v)</u>
I 3.33×10^{11}	0.9 mR/hr	2.7 mR/hr	9 mR/hr	27 mR/hr
II 1×10^{11}	3 mR/hr	9 mR/hr	30 mR/hr	90 mR/hr
III 1×10^9	300 mR/hr	900 mR/hr	3 R/hr	9 R/hr
IV 1×10^7	30 R/hr	90 R/hr	300 R/hr	900 R/hr

Additional clip-in resistances may be inserted by instrument personnel in one of four receptacles at the upper left of the small panel on the amplifier. The cap over the receptacle is then marked with punched dots, each dot denoting an increase by a factor of ten over the original resistance.

In locations where negligible dose rates are expected, the amplifiers are generally set on the most sensitive range. In Radiation Zones where some gamma radiation is expected, a range should be chosen so that the normal background produces a small chart deflection.

CALIBRATION AND TESTING OF EQUIPMENT

3. Printing Order Selection

The five-point selector switch on the chart recorder marked "Auto," "1", "2", "3", and "4" should be left in the "Auto" position for normal use. The signals from the four detectors will then be printed in sequence on the recorder chart. With the selector switch at any of the other positions, the signal from that detector (and no other signals) will be printed on the recorder chart. In order to prevent damage to the contacts, this switch should not be turned if the adjacent red light is on.

4. Dial

A linear scale dial is provided on all amplifiers to indicate the signal strength. The scale corresponds to that on the recorder chart. The dial is marked in one to ten major divisions (old systems) and in both one to ten and one to three major divisions (new systems). To determine the radiation level, the dial response as a fraction of full-scale should be multiplied by the full-scale value listed in the preceding tables for the appropriate type of amplifier and resistance-voltage settings. Note that, if the printing order selection switch is on the "Auto" position, there is no way to tell by examination of the amplifier panel which detector signal is shown on the dial at any instant. This can only be determined by communicating with some person at the recorder chart or by turning the printing order selector switch to the numbered position corresponding to the detector of interest. The detector locations are usually identified by a small plaque on the amplifier case.

C. Inspection of Charts and Recording Data

There is no automatic notation of the detector range setting on the recorder chart; in order to interpret recorder charts in terms of dose rate, such notations must be supplied by inspecting amplifier panel controls and writing the voltage and resistance settings on the charts. Such notations on the charts should be entered every time settings are changed and whenever settings are verified by investigation of chart readings.

In cases where recorders are in locations with considerable traffic, it may be desirable to post notices on or near the recorders asking that RM be notified if readings are observed to be above a posted limit. Radiation Work Procedures may be worded so personnel entering certain Radiation Zones will be required to consult recorder charts and obtain monitoring assistance if readings appear to exceed posted limits.

CALIBRATION AND TESTING OF EQUIPMENT

At most facilities it is advisable to establish a routine inspection of detector recorder charts (preferably shift-wise), particularly for those locations not otherwise monitored. The control settings should be verified at such time and noted on the chart together with the date and time and the initials of the person checking. The chart should be inspected back to the time of the last previous check, and an explanation of any abnormal readings should be entered on the chart.

IV. CALIBRATION OF AIR SAMPLE HEADS

In order to accurately calculate the airborne concentration of radioactive materials, it is necessary to know with some precision the volume of air sampled. In sampling systems utilizing vacuum filtration this is assured by a routine air sample head calibration program.

A. Fixed Room Sampler

Place a clean piece of HV-70 filter paper on the head and attach the rotameter with the inlet pointing down. Consult the calibration chart attached to the rotameter to determine the apparent flow rate which corresponds to the flow rate desired. Adjust the flow rate by means of the valve in the air line until the desired flow rate is attained. For example, assume a desired flow rate of 5 cfm. A look at the calibration chart shows that for this rotameter an apparent flow rate of 4.2 cfm as indicated on the gauge corresponds to an actual flow rate of 5 cfm. Adjust the air line valve so the rotameter gauge indicates a flow rate of 4.2 cfm. The actual flow rate through the head is now 5 cfm. The vacuum gauge reading corresponding to this flow rate should then be noted for later reference.

B. In-line Sampler

Remove the door and tightly close the inlet valve. Place a clean piece of HV-70 filter paper on the sampling head and position the rotameter against the external opening with the air inlet pointing downward. Adjust the flow rate with the outlet valve until the indicated flow rate on the rotameter corresponds to the desired sample flow rate, as described in A above. Note the reading on the outlet gauge, then remove the rotameter. Close the door and open the inlet valve fully. Adjust the outlet flow rate to the proper value by means of the outlet valve and the outlet vacuum gauge.

C. Portable Samplers

1. Staplex

Place a piece of clean HV-70 filter paper on the head and attach the rotameter assembly to it. Turn on the air sampler to draw air through the head and rotameter. Note the flow

CALIBRATION AND TESTING OF EQUIPMENT

rate indicated on the rotameter and determine the true flow rate from the rotameter correction curve. The true flow rate and the indicated flow rate from the Staplex flow gauge should be noted on a small card and attached to the Staplex in a plastic-faced envelope or container.

2. Moto-Aire

The process for calibration of a Moto-Aire sampler is essentially the same as the calibration of a fixed room sampler, except that airflow through the sample head is controlled by a bypass valve rather than a supply valve. When calibration is completed and the desired airflow (usually 5 to 10 cfm) is set, lock the valve into position with the locknut. A notation of the gauge reading and flow rate should be attached to the sampler in a plastic-faced envelope or container.

V. HANDLING OF INSTRUMENT TEST CALIBRATION SOURCES

A. In General

It is important for all Radiation Monitoring personnel to strictly observe the proper procedures for handling the various sources used in the calibration and operational checking of instruments for the following reasons:

1. To protect themselves and others from exposure to direct radiation from the sources,
2. To prevent inaccuracies in calibration which could result from changes in the values of sources,
3. To prevent the harmful effects which could result from unsuspected spread of contamination to such locations as counting rooms, corridors, offices, etc., and
4. To set a good example for personnel of other groups by careful handling of radioactive materials.

It should be noted that counting equipment, no matter how efficient, is no more accurate than the source used to calibrate the instrument.

B. Source Control Practices

The following practices apply to all sources:

1. Each source should be inspected before use and handled carefully at all times.
2. Fingers (whether gloved or not) and other objects should never be allowed to touch the active surface of the source.
3. Each source should be periodically counted, and the result compared to the original value. The frequency of such checks

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- should depend upon the half-life of the source material and the amount of handling the source receives. Suggested frequencies are included with the source specifications.
4. When a source has been recalibrated, the actual source activity in d/m, tolerance of value, and date should be revised accordingly.
 5. Sources should be stored in a permanent place or attached to the related instrument when not in use.
 6. Sources should be identified by appropriate radiation tags, stickers, or signs.

VI. EXCHANGE AND INVENTORY OF SURVEY INSTRUMENTSA. In General

Portable survey instruments are normally left in the field for periods of from one to four weeks, depending upon the predicted life of the instrument batteries and the number of instruments available. Dose rate instruments such as the CP and Juno are normally exchanged on a weekly basis, and detection instruments such as the GM and SPP are normally exchanged monthly. A malfunctioning instrument may, of course, be exchanged at any time. Other instruments, such as the LPC and BFQ, are exchanged when the instrument fails or when extra instruments are available.

B. Exchange Procedure

All portable instruments delivered to the Radiation Monitoring pick-up and delivery stations will have labels indicating the date they are due back at Calibrations. Instruments due back at Calibrations should be in the instrument box by 8:00 a.m. on the due date. Instruments which are delivered each morning from Calibrations should be logged on the "Portable Radiation Survey Instrument Inventory" form, noting the instrument type, date received, location in which used, and date due back at Calibrations. Prior to retuning instruments to Calibrations, the Radiation Monitor should survey them and sign and attach a "Radiation Release" sticker to those instruments found free of detectable contamination. Instruments found contaminated above the unconditional release limits must be decontaminated in the field. If decontamination efforts are unsuccessful, the External Dosimetry Unit, PDS, should be contacted for instructions and advice on special handling prior to return. Contaminated instruments being returned to the Calibrations facility must be wrapped. The level and type of contaminant should be marked on the wrapper or on a tag attached to the wrapped instrument. The date the instruments are returned and any pertinent comments should be recorded on the "Portable Radiation Survey Instrument Inventory" form.

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BATTELLE - NORTHWEST
RADIATION PROTECTION DEPARTMENT
RADIATION MONITORING PROCEDURES

EVACUATIONS AND EMERGENCIES

I. MONITORING RESPONSIBILITIES IN EVACUATIONS

Upon receipt of the evacuation signal (steady siren for area-wide evacuation) or notification in some other manner, Radiation Monitoring representatives shall immediately report to the Area or facility Emergency Director, whichever is appropriate. In the 300 Area this procedure is outlined on the instruction sheet entitled "300 Area RM Initial Action in Event of a Criticality or General Evacuation Alarm," a copy of which should be posted in each 300 Area RM office. In the 100 and 200 Areas such initial action should be directed by RM Supervision in the field.

The duties of the Radiation Monitoring representatives may include the following:

1. Direct and conduct appropriate surveys to collect information on radiological conditions for the Area or Facility Emergency Director,
2. Assist HEHF personnel in selecting the best location for a temporary first aid station,
3. Provide portable dose rate and detection instruments,
4. Initiate quick-sort and personnel contamination surveys, and
5. Carry out additional surveys and evaluations as requested by the Emergency Director.

II. EMERGENCY MONITORING AND RESCUE

Because of the large and varied inventory of radionuclides at BNW, serious radiation events requiring rapid follow-through by well trained Radiation Monitoring personnel could take place. These could result from a non-criticality accident occurring in a facility containing a large inventory of radioisotopes or from a nuclear event which is itself the cause of the loss of control. Following are outlines of the courses of action to be taken by Radiation Monitoring in the field immediately following either type of event.

A. Criticality Accident

1. Evacuate with the rest of the building occupants and comply with local accountability procedures.
2. Obtain appropriate portable instruments--GM, CP or Juno, and HPC. A BF₃ with double moderator would also be useful.
3. Initiate Quick-Sort Program.
 - a. Start assembling all personnel suspected of being affected by the criticality accident in a location of low background. Care must be taken to insure that the monitoring instruments are neither contaminated nor radioactive due to the incident.

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- b. Establish a communications center in the affected area for relaying and receiving information.
- c. Survey for gross personnel contamination. If contamination in excess of 2 R/min. is detected on an individual, decontamination has priority over all medical treatment except that necessary to preserve life.
- d. Distribute criticality questionnaire cards to all personnel involved (cards are available in the yellow Emergency Monitoring Kits).
- e. Those individuals with physical injuries, with physical symptoms of radiation sickness (e.g., nausea, shock, or incoherency), or known to be close to the incident should receive priority in quick-sort surveys and, based on the results, priority transportation to the hospital. Contaminated clothing should not be worn to the hospital by exposed personnel. This requirement should be secondary, however, to considerations of the safety and well-being of the affected individual.
- f. Have the individual remove his badge and other metal objects from his person during the survey. Provide containers, if possible, to hold these items for further analysis since they may be useful in determining neutron flux. Make positive identification of all containers and/or personal belongings.
- g. Survey personnel by placing the probe of the GM-type monitoring instrument against the abdomen with the individual bent over during the measurement.
- h. If the person is unable to bend over for the above check because of shock, etc. or if skin or clothing contamination prohibits such a check, a measurement of induced activity should be made with the GM probe held under the person's armpit.
- i. Any induced activity detected in the above manner (step f or g) is indicative of neutron exposure. The exposed person should receive priority transportation to the hospital for further study. Experimental exposures of a simulated human phantom to approximately 4 rads of fast neutrons indicated the following activity from Na-24 activation (Body content of sodium is based on values established for the standard man).

Weight of Subject	Count Rate Immediately Following Exposure	Count Rate 15 Hrs. After Exp.
150 lbs.	275 c/m	135 c/m
175 lbs.	310 c/m	155 c/m
200 lbs.	350 c/m	175 c/m
225 lbs.	400 c/m	200 c/m

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- j. If neither of the quick-sort checks described above can be performed, a qualitative answer can be obtained by holding the GM probe flush against the person's beta-gamma film badge dosimeter. A measurement of ≤ 1000 c/m indicates that the person did not receive a neutron dose in excess of 5 rads.
- k. Segregate the personnel with indicated high-level exposure.
 - 1) Obtain their names and payroll numbers, if possible, and collect their personnel film badges. Survey the film badges, if possible, and rush them to the 3701-L Badge House for delivery to the Personnel Dosimetry Section, 3705 Building, 300 Area.
 - 2) Transport exposed personnel to the first aid station, or to the hospital, according to instructions. If blood samples are collected in the area (HEHF personnel), make positive identification of them and rush them to the 3701-L Badge House for delivery to Radiological Analysis, 329 Building, 300 Area.
 - 3) Keep a record of all personnel segregated on the initial quick-sort and maintain contact with them until follow-up surveys are obtained.
- l. Initiate a follow-up survey of the personnel for whom negative results were obtained during the first quick-sort survey. Repeat the procedure outlined in f through i above with specific interest in assuring that there have been no omissions of borderline cases. Badges and metallic objects should also be surveyed.
- m. Collect the film badges of the remaining personnel and forward them to the 3701-L Badge House for delivery to the Personnel Dosimetry Section, 713 Building, 700 Area, as the second priority group involved in the accident. Replacement badges will be made available as soon as possible.

Assure that personnel in this second group are detained at the work location pending receipt of confirmed badge readings when they may be released to go home.
- n. Collect Hanford Criticality Dosimeters in the building, if so requested, and forward them to the 3701-L Badge House for delivery to Personnel Dosimetry Section, 713 Building, 700 Area. Local conditions and advice of the process experts will determine how soon such retrieval can be accomplished.

B. Non-criticality Radiation Accident

There are a number of BNW facilities in which a criticality accident is highly unlikely but where a radiation accident could conceivably occur. The following steps outline the general course of action to be taken by Radiation Monitoring upon the receipt of information indicating that such an accident has taken place.

EVACUATIONS AND EMERGENCIES

1. Obtain appropriate portable instruments. A CP and GM would normally be adequate. However, if alpha contamination is known or suspected, SPP will be necessary, and if extremely high dose rates are expected, an HPC or TPC will be necessary.
2. Survey for gross personnel contamination if appropriate. If dose rates greater than 2 R/min. are observed on a person, decontamination has priority over all medical treatment except that necessary to preserve life. Following are some decontamination techniques which are reasonably effective and should be considered in an emergency situation. The medical person in charge should be consulted prior to the use of severe decontamination techniques.

- a. Removal of Contaminated Clothing

This is necessary in most situations. If the person is able to remove his own clothing, he should do so. If he is unable to do so, he should be assisted by others. It may be desirable or necessary to use scissors for this purpose, but this should be done by medical personnel. Blunt-point scissors are available in the yellow Emergency Kits.

- b. Wet Towel

It is possible that only the exposed skin surface will be contaminated after the outer clothing has been removed. If this is the case, it may be advisable to use a wet towel to wipe off the loose and easily removable contamination prior to a shower or water spray bath.

- c. Shower or Water Spray

If a regular or emergency acid shower is available nearby, it should be utilized. Under emergency circumstances the spread of contamination should not influence in any way the decision to use existing facilities. If such facilities are not available, the individual could be sprayed by low-pressure water from a fire hose.

- d. Shampoo

If a shampoo is not effective in removing the excessive contamination from the hair, it may be necessary to clip some or all of the person's hair.

3. Survey with the appropriate dose rate instrument to the extent necessary to assure that personnel in the vicinity are not being unduly exposed to high levels of radiation. If high dose rates are encountered during this survey, high range, self-reading gamma pencil dosimeters should be worn.

EVACUATIONS AND EMERGENCIES

Under no circumstances should entry be made into an area in which the dose rate is not known. Assault masks should also be worn if airborne contamination is known or suspected.

4. Once it is ascertained that no individuals are being exposed to significant whole body penetrating radiation, attention can be turned to the contamination problem, if any. Rope off or physically barricade in some other manner the suspect area. Initiate personnel contamination surveys of all persons who had been in the suspect area; also begin contamination surveys of the floor and other surfaces within the suspect area.
5. Begin decontamination of those individuals found to be contaminated to lesser levels.
6. Direction for further action will come from the Facility or Area Emergency Director and/or Radiation Monitoring Supervision.

C. Emergency Rescue

Emergency rescue operations will normally be carried out by ITT-FSS firemen who are trained in the procedures for rescue and recovery in regions of high dose rates and/or gross contamination. In the absence of Radiation Monitoring personnel, firemen are authorized to assume radiation monitoring responsibility for rescue and recovery operations. For a more detailed discussion of this phase of emergency operations, refer to BNWL-MA-11, "Emergency Radiological Plans and Procedures," and ITT-FSS Emergency Procedure EP-2.

D. Emergency Call Lists

Several emergency call lists are maintained for use by Battelle-Northwest Radiation Monitoring and other Environmental Health Department components. Following are brief descriptions of the two which Radiation Monitoring may be called upon to use.

1. Radiation Monitoring Emergency Call Lists

Each Battelle-Northwest Radiation Monitoring unit maintains an up-to-date call list for use by Monitors and RM customers seeking assistance or advice of an immediate nature. This list includes RM exempt persons familiar with the facilities covered by that unit as well as HEHF personnel to be notified in an emergency. A copy of the appropriate list should be posted in each RM office and customer facility.

2. Environmental Health Emergency Call List

This list has been prepared for use by personnel in any section of the Environmental Health Department. If an emergency arises and normal line supervision cannot be reached quickly for consultation, the problem may be referred to any person on this list. He will be responsible for determining

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a course of action or for obtaining advice from others in a position of authority. A copy of this list should be available in each RM office.

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BATTELLE - NORTHWEST
RADIATION PROTECTION DEPARTMENT
RADIATION MONITORING PROCEDURES

FORMS AND RECORDS

I. RADIATION MONITORING FORMS SYSTEM

A. In General

A radiation monitoring program requires the recording of large amounts of information on a continuing basis. Much of this information has legal significance and must be retained in readily available form for periods of from five to eighty years. Other information is of value for administrative or operational purposes over shorter periods of time.

To assure that recorded radiation monitoring information is of maximum value, it must include all the significant data applying to each situation. Experience has shown that the recording of significant data is most easily assured when standard forms are used. However, printing and maintaining stocks of forms costs money, so it is desirable to maintain the variety of forms in use at the minimum necessary.

Certain approvals are required for new forms to assure that each is reviewed for necessity and adequacy before it is accepted for use. The specific approvals required depend upon the type, origin, and intended use of the form. Approvals and notifications are also required when revising or cancelling forms.

Radiation Monitoring personnel use a large variety of forms. Most of these are generated and maintained by the Radiation Monitoring Section, but some are supplied by the Personnel Dosimetry Section, customers, and others. This section of the manual is concerned primarily with the forms supplied by the Radiation Monitoring Section.

B. Types of Forms

1. Radiation Protection Record Forms

These forms, used for recording information to be retained in the Personnel Dosimetry Section files for legal purposes, have a Battelle-Northwest heading. Retention periods are five years or more. They contain information of the following types:

- a. Data on the radiation and contamination exposures of individuals;
- b. Descriptions of radiation and contamination conditions in the working environment;
- c. Instructions and procedures for performing radiation work;

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- d. Performance tests of radiation measuring and detecting equipment;
- e. Controls applied to movements of known or potential radiation sources; and
- f. Work schedules for routine radiation protection duties.

2. Office Record Forms

These forms are used for recording information for administrative purposes in the radiation monitoring program. Most of the information recorded on these forms is of temporary value. Generally, it is of interest for periods of one year or less. Such information includes the following:

- a. Radiation exposure estimates and control data;
- b. Inventories of instruments and other monitoring equipment;
- c. Notations of the radiation or contamination status of equipment or locations on cards, gummed labels, etc., for short-term information purposes; and
- d. Monthly report data.

3. Internal Administrative Forms

These are administrative-type forms which have been designed for use only by the Radiation Monitoring Section or a unit thereof. Examples of this type of form are the daily work record for charging time to the proper group and other forms not pertaining directly to radiological matters.

C. Developing, Revising, and Cancelling Forms1. Procedural Steps - Developing and Revising Formsa. Radiation Protection Record Forms

- 1) Develop the original concept and design a rough draft.
- 2) Obtain review and approvals - by the Manager, RMS, and the Manager, Customer Services Unit, PDS.
- 3) Submit a rough draft with the Forms Data Sheet (54-3000-096) to Records Management for the design draft.
- 4) Receive the photocopy master from Records Management.
- 5) Review and return the photocopy master to Records Management for assignment of number, necessary corrections or revisions, and printing (and stores stocking, if requested).

b. Office Record Forms

- 1) Develop the original concept and design a rough draft.
- 2) Obtain review and approval by the Manager, RMS.

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- 3) Submit a rough draft with the Forms Data Sheet (54-3000-016) to Records Management for the design draft.
- 4) Receive the photocopy master from Records Management.
- 5) Review and return the photocopy master to Records Management for assignment of number, necessary corrections or revisions, and printing (and stores stocking, if requested).

c. Special Forms Prepared on Preprinted Masters (example: Routine and Repetitive Surveys).

- 1) Develop the original concept and design a rough draft.
- 2) Obtain review and approval by the Manager, RMS.
- 3) Assign an internal RMS forms control letter before the master form number (by the Manager, RMS). For example, if the same pre-printed master is to be used for three different purposes, the form control letters would be added to the form number as prefixes to permit distinguishing among them; e.g., A54-1200-045, B54-1200-045, C54-1200-045.
- 4) Prepare the final draft.
- 5) ~~Send the final draft to Duplicating with a properly executed Duplicating or Printing Order.~~

d. Internal Administrative Forms

- 1) Develop the original concept and design a rough draft.
- 2) Obtain review and approval by the Manager, RMS.
- 3) Obtain a form number from Records Management. These numbers will always have an AB prefix; e.g., AB-1200-025.
- 4) Prepare the form on a duplimat master, including the proper form number at the bottom of the sheet.
- 5) Send the duplimat master to Duplicating with a properly executed Duplicating or Printing Order.

2. Procedural Steps - Cancellation of Forms

a. Radiation Protection Record Forms

- 1) Submit a request for cancellation to the Manager, RMS and the Manager, Customer Services Unit, PDS.
- 2) If approved, submit a copy of the form marked across the face "Cancellation Requested by (signature) Manager, RMS" to Records Management.
- 3) Records Management arranges the cancellation, including removal from stores stock (when applicable).

b. Office Record Forms

- 1) Submit a request for cancellation to the Manager, RMS.

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- 2) If approved, submit a copy of the form marked across the face "Cancellation Requested by (signature) Manager, RMS" to Records Management.
- 3) Records Management arranges the cancellation, including removal from stores stock (when applicable).

c. Special Forms Prepared on Printed Masters (example: Routine and Repetitive Surveys)

- 1) Submit a request for cancellation to the Manager, RMS.
- 2) If the cancellation is approved, the form is stricken from internal RMS forms control list, and notifications to that effect are sent to all RM offices by the Manager, RMS.

d. Internal Administrative Forms

- 1) Submit a request for cancellation to the Manager, RMS.
- 2) If approved, notify Records Management of the cancellation.
- 3) Notify all affected RM offices of the cancellation.

D. Ordering Form Supplies

1. Stores Stocked Forms (54-1200-000)

These forms are ordered directly from Stores using a properly executed Store Order form (54-3000-050).

2. Limited or Controlled Use Forms (BB-1200-000)

These are ordered directly from the Government Printing Shop by the RM Manager's office, using a properly executed Duplicating or Printing Order form (54-3000-118).

3. Special Forms Prepared on Preprinted Masters (example: 54-1200-040 and 54-1200-041)

These are ordered directly from Duplicating by the RM Manager's office, using a properly executed Duplicating or Printing Order form (54-3000-118) which is submitted along with the prepared master.

II. RECORDING INFORMATION

A. In General

Radiation protection records are of value for a number of reasons, but the following four are probably the most important as the record forms a:

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1. Source of information of legal significance,
2. Source of information for reports,
3. Source of information indicating trends in radiation conditions, and
4. Source of data in support of new design and engineering improvements.

To assure that the records provide the necessary information, they should be legible, factual, clear, complete, grammatically correct, concise, dated, and signed by the person recording the information. Where abbreviations are used, they should be confined to those generally accepted as part of the English language or generally accepted as part of the terminology used throughout the atomic energy industry. A list of abbreviations frequently used in the industry will be found in the attached Appendix.

Opinions should not normally be included as part of a record; the content of the records must be primarily factual if it is to be meaningful.

B. Factors Important in Completing Record Forms

1. Legible Writing

Writing is a method of communicating information from one person to another. If writing cannot be read by anyone other than the writer, no information is communicated. Write legibly so that the record can be read and understood by others several years later.

2. Factual Content

Good records are primarily assemblies of related facts. When gathering information which will be recorded, be certain to get all of the important facts, and write them into the record. Include impressions and opinions only when they have a bearing on some important factual part of the record. Be certain that opinions and impressions are clearly designated as such.

3. Clear Description

Construct descriptions, statements, etc. so that misunderstanding is difficult or impossible. If amplification is necessary to prevent misunderstanding, supply further explanation.

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4. Completeness

Tell the whole story. If information which should be in a record is missing, the record is correspondingly diminished in value.

5. Grammatical Correctness

Grammar involves both spelling and sentence structure. Misspelled words may communicate ideas which are completely different from those intended. Correct spelling is simply a matter of personal care and attention to detail. Sentence structure is equally important in communicating ideas. Write complete sentences, but avoid long, rambling ones which should be broken down into two or more separate sentences. Do not leave out connective words (such as "and", "the", etc.) or articles (such as "a", "the", etc.) since the presence of such words gives precision to writing.

6. Conciseness

Most persons who are not skilled writers tend to use too many words in describing an object or situation completely. It is usually possible to make such statements better by using fewer words. Concise statements convey ideas more quickly with less chance of confusion; however, it is possible to be too brief. A careful balance must be maintained between brevity and wordiness. Do not use fractional statements commonly used in spoken conversations.

7. Permanent Writing Medium

Use of a good permanent writing medium will contribute to legibility. In addition, those records which are to be retained for long periods must be written in ink or indelible pencil, or they must be typewritten. Do not use an ordinary lead pencil!

8. Use of the Dictionary

Choice of the correct word for use in a given situation is often difficult, yet it can be very important. Dictionaries are provided in all RM offices for reference in choosing and spelling words correctly.

9. Use of Sketches

On some forms, space is provided for sketches. Wherever a full description of a situation in words is not practical, properly labelled sketches should be used. Adequate labelling assures that sketches will be of maximum value.

10. Instrument Results

To be meaningful, instrument results should always be on-scale readings. If an off-scale reading is recorded, it should be accompanied by an on-scale reading of the same situation at a greater distance from the source, if necessary.

III. RECORD HANDLING AND SUBMISSION FOR STORAGEA. In General

The Radiation Monitoring Section is responsible for maintaining a number of radiation protection records. Included in this responsibility are:

1. generating the records,
2. packaging or binding them, and
3. submitting the records to the appropriate storage center for long-term retention.

B. Packaging and Binding Records

Most Radiation Monitoring records are in the form of standard 8 1/2" by 11" sheets. During record generation, the sheets are usually kept in a standard 3-ring looseleaf notebook. At intervals of about one month, the record sheets are bound in fiberboard binders labelled with the title of the record, the time period covered, and the building number.

Other records which do not lend themselves to binding, such as strip charts from continuous recorders, are stored temporarily in a record box until it is full before submission for long-term storage.

C. Retention Periods

Once records have been generated, they are of limited value to RM personnel in the facility involved. A few records, such as the Radiation Survey Report, have some reference value to RM personnel in the facility for perhaps a few months. However, most records need not be retained in the Radiation Monitoring Offices for periods longer than six months. When the office retention period is over, the records are submitted to the responsible RM Supervisor, who will arrange for the appropriate long-term storage. Information on retention periods and disposition of records is available from the Customer Services Unit, PDS.

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D. Submission of Records for Long-term Storage

Those records which are a part of the radiation dose record of individuals are maintained by the Personnel Dosimetry Section. The Neutron Exposure Report, Localized Exposure Report, Investigation of Lost Dosimeter Result, and the Radiation Occurrence Report are all examples of records generated by Radiation Monitoring Personnel which are stored in personnel radiation record files maintained by PDS. Such records are normally submitted to PDS immediately following their generation.

Other records which describe radiation conditions in the working environment, instrument tests, etc. are submitted to the responsible RM Supervisor according to internal procedures.

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IV. STANDARD ABBREVIATIONS AND TERMS

A	Atomic (mass) weight	max.	maximum
Amp.	ampere	mega(M)	prefix meaning 1,000,000 or 10^6
ave.	average	MeV	million electron volts
BeV	billion electron volts	mg	milligram
C	celcius (Centigrade)	micro(μ)	prefix meaning 1/1,000,000 or 10^{-6}
Ci	Curie (3.7×10^{10} d/s, 2.22×10^{12} d/m)	milli(m)	prefix meaning 1/1,000 or 10^{-3}
cc	cubic centimeter	min.	minute
cfm	cubic feet per minute	ml	milliliter
cm	centimeter	mm	millimeter
cm ²	square centimeter	MPBB	maximum permissible body burden
cm ³	cubic centimeter	MPC	maximum permissible concentration
contam.	contamination	MPDE	maximum permissible dose equivalent
cu.	cubic	mR/hr.	milliroentgens per hour
cu. ft.	cubic foot	mrad/hr.	millirads per hour
cu. m.	cubic meter	mrem/hr.	millirems per hour
cu. in.	cubic inch	nano (n)	prefix meaning 10^{-9}
c/m	counts per minute	pico (p)	prefix meaning 10^{-12}
D	dose (absorbed dose)	Q.F.	quality factor
D.E.	dose equivalent	R	roentgen (unit of exposure)
D.F.	distribution factor	R/hr.	roentgen per hour
deci (d)	prefix meaning 1/10	rad	unit of (absorbed) dose
deka or deca	prefix meaning 10	rad/hr	rad per hour
diam.	diameter	RBE	relative biological effectiveness
dis	disintegration	RCG	radioactivity concentration guide
d/m	disintegrations per minute	rem	unit of dose equivalent
d/s	disintegrations per second	rem/hr.	rem per hour
esu	electrostatic unit	RPC	radiation protection guide
etc.	Et Cetera (and so forth)	RWP	Radiation Work Procedure
eV	electron volt	RZ	Radiation Zone
F	fahrenheit	sec.	second
ft.	foot	soln.	solution
ft. ²	square foot	SpA	specific activity
ft. ³	cubic foot	std	standard
Giga (G)	prefix meaning 1,000,000,000 or 10^9	T	tritium
g, gm.	gram	vol.	volume
hr.	hour	Z	atomic number
in.	inch		
in. ²	square inch		
in. ³	cubic inch		
KeV	thousand electron volts		
kg	kilogram		
kilo (k,K)	prefix meaning 1000		
kvp	kilovolts peak (X-ray)		
l	liter		
lb.	pound		
m	meter		
m ²	square meter		
m ³	cubic meter		

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BATTELLE - NORTHWEST
RADIATION PROTECTION DEPARTMENT
RADIATION MONITORING PROCEDURES

RADIATION PROTECTION ORIENTATION AND TRAINING

I. IN GENERAL

Radiation protection training is presented to all personnel at BNW. The degree and type of training for each individual is dependent upon the nature of his work, the materials he handles, and his need for knowledge of specific aspects of radiation protection.

Under some circumstances, training is provided to individuals outside BNW. A moderate number of requests for training are forwarded to BNW by the AEC for individuals from organizations outside Hanford. Other Hanford contractors may also occasionally request some training assistance.

A. Training Administration

The responsibility for organizing and coordinating radiation protection training programs is assigned to Radiation Monitoring and is normally discharged by Radiation Monitoring personnel. However, instructors for some training programs are drawn from other sections of the Environmental Health Department and from other BNW Departments.

B. Scope of Training

Both classroom and on-the-job training are offered. Classroom training programs are presented for personnel whose knowledge of radiation is incidental to their work and for those whose knowledge will be directly applied in the field of radiation protection. Classroom training time varies from about an hour of orientation for secretaries, clerks, and others who will have little or no contact with radiation to as many as 60 classroom hours for persons actively engaged in radiation protection functions.

Active training is carried out for personnel who are, or will be, engaged directly in radiation protection functions. This on-the-job training is not organized as formally as classroom instruction.

II. TRAINING PROGRAMS FOR RADIATION MONITORING PERSONNEL

A. In General

Training programs are provided for all persons engaged in radiation protection. Those designed for Radiation Monitors are composed mainly of discussions of techniques, procedures, and practices with appropriate technical content. Programs directed at Supervisors, Engineers, and Specialists are composed of discussions of regulations, administration, assigned functions, and the more rigorous technical aspects of radiation protection.

RADIATION PROTECTION ORIENTATION AND TRAINING

B. Radiation Monitors

Radiation Monitor training normally includes both classroom and on-the-job training. The basic classroom training is usually presented over a period of a few weeks during an initial one-year training period. Typical classroom training courses include 50 to 60 hours of instruction and a comprehensive final examination. Refresher courses are also presented at periodic intervals to assure that every Monitor is kept abreast of changes in the field of health physics.

On-the-job training is conducted under actual working conditions by experienced Radiation Monitors, usually Journeymen. Additional practical guidance is provided by RM Supervisors and Specialists.

C. Supervisors, Engineers, and Specialists

Training programs for professional Staff Members consist of a series of lectures on administrative aspects of radiation protection, the scope and technical bases of radiation protection programs, and radiation protection aspects of Civil Defense. A typical program of this type might include 40 to 50 classroom hours.

Civil Defense training programs include a short two- to four-hour session on radiation monitoring under Civil Defense conditions. Nuclear attack practice sessions and nationwide nuclear attack exercises in which RM personnel participate are held periodically.

Training programs for Health Physics Certification are presented off-plant by the local chapter of the Health Physics Society. Some support for such programs is provided by BNW through supplying instructors and some training materials. All persons engaged in the general field of health physics are encouraged to prepare for certification and to take the examination as soon as they meet the basic qualifications established by the American Board of Health Physics.

III. TRAINING PROGRAMS FOR OTHER PERSONNELA. In General

Radiation protection training programs provided for BNW personnel not engaged in radiation protection activities are usually not as detailed or as broad in scope as those for radiation protection personnel. Because of the varying need for this type of knowledge, the content of programs provided for different working groups is adjusted accordingly.

Every BNW Staff member receives appropriate follow-up training is tailored to be directly applicable to the staff member's particular work. Information presented on radiation hazards is usually

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limited to the nuclides and work operations actually involved or contemplated. Most of this training is given by Radiation Monitoring Specialists, Engineers, or Supervisors.

B. Secretaries, Clerks, and Other Office Personnel

Since personnel in this category seldom, if ever, have occasion to enter a Radiation Zone or work near radioactive materials, they are not presented a formal course on radiation protection beyond the initial general orientation. Occasionally, radiation protection topics are included as a part of the monthly meetings on safety and security these Staff Members attend. Additional information meetings for these people are usually scheduled whenever some significant change in the radiation protection program takes place.

C. Service Personnel

After the initial orientation, there is no formal course of training on radiation protection for service personnel (maintenance, power, etc.). However, they frequently are presented information on radiation protection matters as a part of monthly meetings on safety and security. Whenever a major project involving service work in or near a Radiation Zone is contemplated, the involved workers are normally presented with radiation protection information specific to that job. In addition, they have frequent contact with Radiation Monitoring personnel in the course of their work and receive some informal on-the-job training thereby.

D. Operations Personnel

In addition to the initial orientation, operations personnel receive follow-up training which usually consists of a short series of meetings approximately once each year. The intervals vary somewhat since the content of the meetings is usually directly related to specific nuclides and the operations being performed with these nuclides. The duration of laboratory programs varies, and radiation protection training is scheduled accordingly.

Operations personnel have frequent contact with radioactive materials and process equipment. As a part of their work, they are expected to know and follow basic radiation and contamination control practices. In some cases this requires the use of radiation measuring and detecting instruments, so training on the proper use of these instruments is included in follow-up training programs.

E. Scientific and Engineering Personnel

Scientific and engineering personnel are frequently involved in the development of new programs, processes, and facilities for BNW activities involving radioactive materials. It is important that

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radiation and contamination control be considered at the design stage since errors here can be costly and can result in a greatly reduced level of radiation protection.

These Staff Members are usually invited to attend training programs arranged for professional radiation protection personnel. The depth of coverage of material in these programs is often more than required by these persons. However, such programs acquaint them with the radiological problems to be encountered if a facility or process is improperly designed. The training also makes them aware of the assistance that can be provided by Radiation Monitoring and other groups in the Environmental Health Department.

IV. TRAINING PROGRAMS FOR NON-BATTELLE PERSONNEL

A. In General

BNW is frequently called upon to provide radiation protection training for both the personnel of other Hanford contractors and personnel from off-plant. Since the requirements of the particular individuals or firms involved may vary, the training administered is tailored to those specific needs.

B. Other Hanford Contractors

The specific arrangements for the training by BNW of other Hanford contractor personnel depend upon the existing contractual relationship between BNW and the other Hanford contractor. In some cases training programs may be provided under existing supporting activity contracts. In other cases specific training contracts may be required.

Since the operations of the different contractors are not the same, special training programs will normally be tailored to suit the contractor's needs. However, some training programs currently existing at BNW are suitable for other contractors, and their personnel may attend these programs during regular training sessions held in BNW facilities. Similar training sessions may also be arranged in the facilities of other contractors.

C. Off-plant Personnel

BNW is frequently called upon to provide training for off-plant personnel. Such training is most frequently in the form of an orientation lasting no more than a day. However, longer training programs have been presented on a number of occasions, such as the summer training programs for AEC and Public Health Service Radiological Physics Fellowship students.

A typical orientation for off-plant personnel requires from four to eight hours. It is devoted largely to a discussion of laboratory

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radiation protection problems and how they are handled. Organizational structure and the assignment of various radiation protection responsibilities are also normally included in the discussions. A tour through those facilities having problems of particular interest to the visitors is usually arranged so they can see the application of the radiation protection program to specific situations.

The only program regularly presented for off-plant professional radiation protection personnel is the summer training program for AEC Radiological Physics Fellows. This program usually is a combination of work assignments and lectures and has a very strong technical content. Work assignments are usually of a problem-solving or developmental variety, and trainees are normally expected to write a report documenting the results of the summer's work. The trainees also have an opportunity to visit many of the major Hanford plant facilities and to see all of the radiation protection activities at BNW.

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