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NUCLEAR POWER FIELD OFFICE
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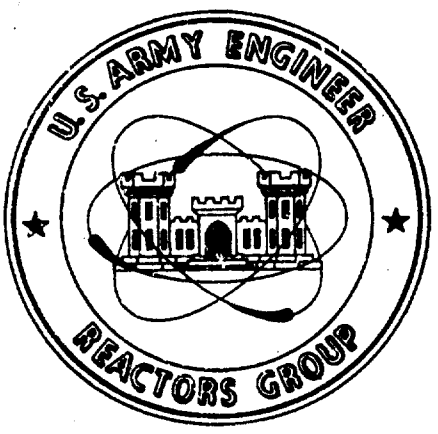
Volume I

HEALTH PHYSICS – PROCESS CONTROL REFERENCE MANUAL



HEALTH PHYSICS - PROCESS CONTROL

REFERENCE MANUAL

PUBLISHED BY

ENGINEERING AND OPERATIONS DEPARTMENT
NUCLEAR POWER FIELD OFFICE
U. S. ARMY ENGINEER REACTORS GROUP
FORT BELVOIR, VIRGINIA 22060

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U.S. ARMY ENGINEERS REACTORS GROUP
FORT BELVOIR, VIRGINIA

Health Physics - Process Control Reference Manual

1. This Manual is intended to be used in connection with nuclear power plant technical manuals.

2. Recommended corrections, additions, or deletions should be addressed to Chief, Nuclear Power Field Office, Building T-2377, Fort Belvoir, Virginia, 22060, Attention: Engineering and Operations Department, Industrial Engineering Branch.

Approved by:

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1 July 1966

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INTRODUCTION

The Health Physics-Process Control Reference Manual is designed for use by the Plant Process Control Specialists. It contains health physics and water chemistry procedures for guidance in plant operation. Although this Manual cannot give detailed recommendations, necessary and sufficient for all conditions, it is planned to give the general recommendations suitable for typical plant use. In the section following the Introduction, a Nomenclature is presented to familiarize the Control Specialists with terms applicable to these health physics and water chemistry procedures.

Part I ot the Health Physics-Process Control Reference Manual presents health physics procedures, as well as radiochemical analyses for health physics operations. Contained in this Section are standards of health and safety necessary in the operation of nuclear reactors. These standards include personnel monitoring and access control, radioactive materials control and waste management, decontamination, radiological monitoring, and health physics and radiochemistry instrumentation.

Part II of this Manual contains general chemical procedures for analyzing the water in the Primary, Shield Water, and Secondary Systems. This water impurity control prevents equipment corrosion, thus serving to prolong the life of the equipment, insure maximum operating efficiency, and

reduce maintenance time.

The Health Physics-Process Control Reference Manual should prove beneficial to the Plant Process Control Specialists. Although all problems that will occur have not been anticipated, this Manual should greatly supplement the training and experience of the Control Specialists to aid them in controlling any disturbance that might arise.

NOMENCLATURE

Airborne Radioactivity Area. Any room inclosure, or operating area in which airborne radioactive materials exist in concentrations exceeding 10% of the amounts specified in Appendix B, Table I, Column I of 10 CFR 20 or M.P.C. derived therefrom.

Bremsstrahlung. Secondary photon radiation produced by deceleration of charged particles passing through matter.

Byproduct Material. Any radioactive material (except special nuclear material) yielded in, or made radioactive by, exposure to the radiation incident to the process of producing or utilizing special nuclear material.

Collision. Encounter between two sub atomic particles (including photons) that changes the existing momentum and energy conditions. The products of the collision need not be the same as those of the initial systems.

Compton effect. An attentuation process observed for X-ray or gamma-ray radiation in which an incident photon interacts with an orbital electron of an atom to produce a recoil electron and a scattered photon having energy less than the incident photon.

Consignee. The person or party to whom merchandise is formally delivered.

Elastic Collision. A collision in which there is no change either in the internal energy of each participating system or in

the sum of their kinetic energies of translation.

Half-value layer (half thickness). The thickness of any particular material necessary to reduce the dose rate of an X-ray or gamma ray beam to one-half its original value.

High Radiation Area. Any area accessible to personnel in which there exists radiation at such levels that a major portion of the body could receive, in any one hour, a dose in excess of 100 millirem.

Inelastic Collision. A collision in which there are changes both in the internal energy of one or more of the colliding systems and in the sums of the kinetic energies of translation before and after the collision.

Pair Production. An absorption process for X-ray and gamma-radiation in which the incident photon is annihilated in the vicinity of the nucleus of the absorbing atom with subsequent production of an electron and positron pair. This reaction only occurs for incident photon energies exceeding 1.02 Mev.

Personal dosimeter. One dosimeter is issued to an individual on a permanent (long-term) basis for his exclusive use. A personal dosimeter is generally low-range (200 millirem).

Photoelectric effect. A process by which a photon ejects an electron from an atom. All the energy of the photon is absorbed in ejecting the electron and imparting kinetic energy to it.

Photon. A quantity of electromagnetic energy (ergs) whose value is the product of its frequency (cps) and Planck's Constant. The equation is E = hv.

Planck's Constant. A natural constant of proportionality (h) relating the frequency of a quantum of energy to the total energy of the quantum.

$$h=E/V = 6.624 \times 10^{-27} \text{ erg-sec.}$$

Radiation Area. Any area accessible to personnel in which there exists radiation, at such levels that a major portion of the body could receive, in any one hour, a dose in excess of five millirem or, in any five consecutive days, a dose of 100 millirem.

Radioactive Materials Area. Any area where radioactive materials are stored in quantities greater than ten times the limit specified in Appendix C of 10 CFR 20, or where natural uranium or thorium is used or stored in excess of 5000 microcuries.

Sealed Source. Any radioactive material that is encased in a capsule designed to prevent leakage or escape of the byproduct material.

Source Material. (1) Uranium, thorium, or any combination thereof, in any physical or chemical form or (2) ores that contain by weight one twentieth of one percent (0.05%) or more of (i) uranium, (ii) thorium, or (iii) any combination thereof. Source material does not include special nuclear material.

Special Nuclear Material. (1) Plutonium uranium 233, uranium enriched in the isotope 233, or in the isotope 235, and any other material which the Commission, pursuant to the provisions on Section 51 of the Atomic Energy Act of 1954, determines to be special nuclear material, but does not include source material; or (2) any material artificially enriched by any of the foregoing, but does not include source material.

Storage Container. A device in which sources are transported and stored.

Surface Contamination Area. Any location in which loose radioactive materials are present and the possibility of personal contamination in excess of applicable limits specified by applicable plant documents exists.

Tenth-value layer. The thickness of any particular material necessary to reduce the dose rate of an X-ray or gamma ray beam to one-tenth of its original value.

HEALTH PHYSICS AND RADIOCHEMISTRY

This section contains health and safety standards necessary in Plant operation. These standards include personnel monitoring and access control, radioactive materials control and waste management, decontamination, radiological monitoring, health physics and radiochemistry instrumentation, and radiochemical analyses for heatlh physics operation.

SECTION 100 - PERSONNEL MONITORING

The monitoring of personnel with respect to incident radiation is achieved by the use of film badges and pocket dosimeters. In general, each individual is responsible for monitoring himself against contamination. The monitoring equipment should be checked as often as dictated by the possibility of their becoming contaminated. The Methods utilized in personnel monitoring are presented on the following pages.

METHOD 111
ISSUANCE AND EXCHANGE OF FILM BADGES

1. SCOPE

This method contains procedures for the issuance and exchange of film badges.

2. SAMPLE

Not applicable.

3. APPARATUS

Beta-gamma film holders.

Neutron film holders.

Stainless steel film holders (in lieu of Items 1 and 2).

Wrist badges.

Ring badges.

Beta-gamma film packets (of current monitoring period).

Neutron film packets (of current monitoring period).

Key for unloading film packets from holders 1 and 2.

Low range, beta-gamma survey instrument with side-or end-window Geiger-Mueller probe.

Record forms and data sheets.

4. PROCEDURE

4.1 Stock of Film Packets and Holders (See Reference 1 in Reference Section).

4.2 Issuance. Issue the appropriate types of film badges in accordance with criteria specified in the plant technical manual, as specified on the applicable Radiation Work Permit (RWP), as indicated by the radiological condition concerned or to replace a lost or damaged badge.

NOTE

Neutron, wrist, and ring badges are used normally to supplement (not to replace) the beta-gamma, whole-body-type film badge.

4.2.1 Obtain from stock a film holder (or badge) of the appropriate type. Visually inspect holder (or badge) to assure that it is in good condition. Note serial number and record it.

4.2.2 Obtain from stock for current monitoring period, the fresh film packet of the appropriate type (beta-gamma or neutron) and whose serial number is the same as that of the film holder. (Normally, film holders will be given a code number which matches a code number used on film packet.) If holder and packet numbers do not match, record both serial numbers.

4.2.3 Load film in holder in accordance with standardized procedure, following the specific

loading instructions furnished by the Army Depot. For stainless-steel badge, insert film so that the front (side without flap) of the packet faces front of holder and so that it is oriented in the standard manner (e.g. having the serial number on the packet appearing on the front top of holder).

4.2.4 Fill out appropriate record of issuance as specified in the plant technical manual and which includes the following information:

(a) Individual to whom badge is issued; complete name (last, first, middle initial); rank or title; service or organization; Social Security Number; date of birth. For visitors, also record employer's name and address.

(b) Film holder (or badge) serial number and type; also, film packet serial number, if different.

(c) Date issued.

4.2.5 When an individual first draws a film badge, brief him on the policy and procedures concerning wearing of the particular type(s) of film badges issued to him, in accordance with the plant technical manual. Instruct individual on where and how to fasten badge(s) to his clothing, use of film badge boards (if used), and reporting lost or contaminated film badges and suspected over-exposure which require that film badge

be immediately processed. Also inform him of other personnel dosimetric devices available.

4.2.6 If issuance is to replace a lost film badge or other damaged film packet, proceed with the steps in 4.6.

4.3 Exchange of Film Packets and Special Badges. Routinely exchange film packets and special badges at end of each monitoring period, as established in the plant technical manual. Also exchange film packets and special badges in accordance with criteria (e.g. off-scale dosimeter reading) specified in the plant technical manual as specified in applicable Radiation Work Permit, as indicated by the radiological condition concerned, or to replace a damaged film packet or special badge.

4.3.1 Check film badge for beta-gamma contamination prior to removing film packet(s) from holder. If badge is found to be contaminated, follow steps 4.5 below.

4.3.2 Remove film packet from holder in accordance with procedures applicable to that type holder.

NOTE

Do not remove film from ring badges as the ring itself is the lightproof cover.

4.3.3 Load fresh film packet (of appropriate monitoring period) in holder, in accordance with

step 4.2.3 above. Check serial numbers in accordance with 4.2.2.

4.3.4 Record on appropriate forms or data sheets the serial numbers of the used film packets (or special badges) collected and the serial number of the fresh packet (or special badges). Record serial number of holder, if different, from film packet. Also enter on form or data sheet the date of the exchange.

4.3.5 Store collected film packets and special film meters in designated location until ready to be processed (in-plant) or shipped to appropriate Army Depot for processing, as applicable.

4.3.6 As applicable, ship collected film packets and special badges to appropriate Army Depot for processing (See Reference 6.1), or process them according to Methods of Subsection 130.

4.3.7 If exchange was to replace a damaged film packet or special badge, proceed with the steps in 4.6.

4.4 Contamination Check.

4.4.1 Check film badges for both fixed and loose contamination by means of a survey instrument or lab monitor having a side-or-end-window G. M. probe with a window thickness not greater than 30 mg/cm^2 (See Method 512) and according to the following schedule:

(a) Film badges in use check as often as dictated by the possibility of their becoming contaminated. Report positive finding to health physics personnel immediately and proceed with the stepsin 4.5 below.

(b) All film badges check at time of exchange of packets or of collection for processing. If badge is found to be contaminated, proceed with steps in 4.5 below.

4.5 Contaminated Film Badge

4.5.1 Immediately monitor the wearer, his clothing, film badge board, etc. for contamination in accordance with Methods 530 and 512. Investigate to determine cause and date of occurrence. On the basis of findings, carry out necessary monitoring functions in accordance with Method 531, to determine source of contamination and extent of its spread.

4.5.2 Place contaminated badge in polyethylene bag Issue the wearer, in accordance with the steps in 4.2 above, a new badge containing fresh film.

4.5.3 Handle contaminated film badge in accordance with radiological safety procedures applicable to the level of contamination involved. See Section 200.

4.5.4 Remove film packet(s) from holder as soon as possible. Set aside film holder for decon-

tamination according to procedures in Section 300, or dispose of holder as radioactive waste, as appropriate.

4.5.5 Check film packet(s) separately for contamination in accordance with Method 512. Record data obtained. If level of contamination of film packets is low or non-detectable, count individual film packets in the counting room end-window G.M. counter, in accordance with procedures of Method 631.1; and record results in "dpm." If results of counting room check are negative, treat packet as clean. If packet is contaminated, proceed as follows:

4.5.6 Determined on the basis of particulars involved whether the film packets concerned are to be: (a) immediately processed; (b) held for possible processing at later date; or (c) disposed of as radioactive waste. If choice is (a) or (b), proceed as follows.

4.5.7 Place packet(s) in envelope on which the following information and data have been entered: "Contaminated Film Packet(s)"; type film packets; serial number of packet(s); inclusive dates of use; name of wearer; identification of contaminant (if known); and levels of contamination as determined in 4.5.5 above.

NOTE

Do not lick envelope to seal. Keep envelope apart from other film packets.

4.5.8 Inform appropriate Army Depot directly of level of contamination of packet(s) concerned. Proceed in accordance with instructions. See Method 231 for shipping requirements.

4.6 Lost or Damaged Film Badges or Packets

4.6.1 Immediately issue wearer a new badge or a replacement film packet as applicable, in accordance with the steps in 4.2 and in 4.3 respectively.

4.6.2 Estimate the dose received by wearer during monitoring period concerned, on the basis of his corresponding dosimeter data from known exposure records of co-workers similarly exposed, and from other pertinent data known or obtained. Obtain concurrence of estimated dose from wearer.

4.6.3 Enter estimated dose in applicable form, designate entry as an "estimate," and indicate basis of estimate (e.g. pocket dosimeter data). Keep record of estimate.

4.7 Records. Maintain records of issuance and exchange of film badges, such as the identity of the wearer and the monitoring (wearing) period of each specific film packet and special film badge.

5. RESULTS AND COMPUTATIONS

Not applicable.

6. TEST METHOD IMPLEMENTATION

6.1 The plant technical manual specifies:

a. Policy concerning issuance of film badges, for conformance with Reference (2) of Reference Section.

b. Routine film badge monitoring (wearing) period.

c. Criteria for non-routine exchanging and processing of film packets.

6.2 See References (1) and (2) of Reference Section.

METHOD 121

PHOTODOSIMETRY FACILITY -- GENERAL OPERATIONS

1. SCOPE

This method contains procedures concerning (a) storage, identification, and exchange of film packets; (b) setting up of densitometer and microscope; (c) storage of processed films; and (d) photodosimetry record files. Procedures concerning the setting up of the darkroom and the calibration facility are contained in Methods 122 and 123, respectively.

2. SAMPLE

Not applicable.

3. APPARATUS

Refrigerator.

Film identification devices.

Densitometer.

Microscope and attachments.

Containers for storage of processed films.

Record files.

4. PROCEDURES

4.1 Storage of Film Packets

4.1.1 Store stock of film packets in a refrigerator, preferably one used exclusively for this purpose.

4.1.1.1 Locate refrigerator in an area removed from possible stray radiation.

4.1.1.2 Set refrigerator to operate at about 50°F (10°C). Do not operate below 32°F (0°C).

4.1.1.3 Check relative humidity in the refrigerator. If it is above 50% place in moisture-proof bags all open packages if the film packets are not individually moisture-proofed.

4.1.1.4 Do not store chemicals in refrigerator.

4.1.1.5 Maintain refrigerator in a clean condition, defrost it when necessary, and service it in accordance with manufacturer's instructions.

4.1.2 Assure that all films which have been obtained for use in a specific monitoring period are of the same emulsion batch. Mark the date of receipt on outside of film packet packages, to simplify segregation of packages by emulsion batches. Use of different color marking pencils will aid in this.

4.1.3 Do not open packages until film packets are needed.

4.1.4 Assure that film-packet packages which are kept outside of refrigerator are stored in a cool, dry, and radiation- free location, away from such gases as ammonia, formalin vapors, hydrogen peroxide, and hydrogen sulfide.

4.1.5 Inspect the condition of the films in stock by periodically processing, along with a routine monitoring film batch, a film packet taken directly from stock. This will test for possible spoilage due to temperature, humidity, fumes, and aging, and to fogging due to accidental exposure.

4.2 **Identification of Film Packets**

4.2.1 Select the identification system and device to use. The minimum identification required is the serial number to identify the film wearer (or location of use, for area-monitoring badges). Other markings may include identification codes for the plant and for the specific monitoring periods. Two general methods are used for identifying the films in a given packet: (a) pressure marking the identifying serial number by means of a percussion press, and (b) marking such numbers by means of low energy (30 KVP or less) X-rays.

4.2.2 Locate the film identification device in an appropriate location. A percussion press is best located in the film badge loading area. An X-ray device will have to be located on the basis of the radiological safety requirements associated with the use of the particular device concerned.

4.2.3 Assure, by actual testing, that the identification device does not damage the film or produce undesirable effects on the film. Specifically, the effects of pressure (or X-rays) should be solely in producing the identification numbers. Pressure (or X-rays) on the usable portion of the film will produce darkening.

NOTE

In using an identification X-ray machine care must be exercised to prevent possible exposure of film packets which have just been identified or which are awaiting identification. The dose rates in such locations should be checked with appropriate type survey instruments and by actual testing with film packets.

4.2.4 Use the identification device in accordance with the specific instructions of the manufacturer.

4.2.5 Follow manufacturer's instruction for the care and maintenance of the device.

4.3 Exchange of Film Packets. This section concerns operations whereby film badges are collected at the end of a monitoring period and are brought to a processing area for exchanging film packets.

4.3.1 Work Area

4.3.1.1 Select a clean work table area for exchanging film packets. Choose the physical location of area in relationship to other associated photodosimetry facilities, for ease and efficiency of operations.

4.3.1.2 Rig device for opening the film badges if required or desirable.

4.3.2 Preparation of Fresh Film Packets

4.3.2.1 Assure that all film packets are of the same emulsion batch, and that there remains in stock a sufficient number of packets of this same emulsion batch for the calibration set(s), controls, and additional monitoring requirements anticipated for the monitoring period.

4.3.2.2 Stamp, or mark, on each film packet the starting date of the new monitoring period.

4.3.2.3 Mark, with pencil, the identifying film badge serial number on each film packet if the film packets already have pressure markings which are different from the corresponding film badge serial numbers; or if the film packets are to be identified by means of X-rays.

4.3.2.4 Use available identification device in accordance with manufacturer's instructions to mark the film(s) in each film packet with the appropriate serial number and any other identifying marks required.

NOTE

If identification of film is done by means of X-raying, the packets in their appropriate holders, this marking step is done following

loading. See step 4.3.3.4.

4.3.2.5 Arrange film packets in numerical order, to facilitate exchange operations.

4.3.3 Exchange Operations

4.3.3.1 Assemble collected film badges at film exchange area. If badges are not monitored for contamination at the film badge boards, monitor in this film exchange area, before film packets are removed from the badges. Follow procedures specified in Method 111 for monitoring the badges and for handling of badges found to be contaminated.

4.3.3.2 Open film badges and remove used film packets. Separate removed film packets into groups by type (beta-gamma and neutrons), and arrange packets of each group in numerical order. Enter necessary information in appropriate data sheet. Set aside these film packet groups for processing in accordance with Method 132.

4.3.3.3 Insert the previously prepared, fresh film packets into appropriate (and empty) holders. Assure that each film packet is positioned in the standard orientation.

4.3.3.4 If film identification is done by means of X-raying the packets in their appropriate holders, carry out this identification procedure

next, in accordance with the specific instructions prepared for this type operation.

4.4 Densitometer Setup

4.4.1 Select a photodosimetry densitometer that has the required range. A density range of 3.0 is considered adequate for routine purposes. If the densitometer, however, is to be of use in the measurement of films exposed to high accidental doses, its density range should be about 5.0 or 6.0.

4.4.2 Set up the densitometer on a clean work table, with ample area on both sides of the unit. Assure that air vents of densitometer are unobstructed, to prevent overheating of the unit.

4.4.3 Determine if there are large voltage fluctuations in the power line to be used, or if such fluctuation can be expected. If so, install a voltage stabilizer for the operation of the densitometer.

4.4.4 Establish a "production-line" system which is best suited for the operator to read films with the densitometer. Determine location of the trays holding the films to be read, and the location of the data sheets for recording readings. Maintain at the densitometer setup an ample supply of data sheets, graph paper (for calibration curves), and the other necessary accessories such as French curves, straight edge, and

pencils with different color leads.

4.4.5 Provide, if considered necessary or desirable, an illuminated small viewer for qualitatively inspecting density patterns on films. Small specks on a film, for example, may be indicative of airborne radioactvity. Unusual patterns which may have been due to either contamination of light-leakage could be better studied using such a viewer.

4.4.6 Keep standard density wedges in a convenient and protected location in the densitometer setup. Set aside one of the wedges to use only occasionally, and treat it as if it were a "primary" standard. Use the other wedge(s) for operational purposes, as indicated in Method 133.

4.4.7 Carry out adjustments, care, and maintenance of densitometer in accordance with manufacturer's instruction manual. Follow detailed procedures specified in instruction manual for replacing burned-out light bulbs.

4.4.8 Keep densitometer clean. Use dust cover to protect unit when it is not in use.

4.5 Microscope

4.5.1 Select a microscope that is equipped with a mechanical stage, an eyepiece (10X wide-field) with reticle, and a special small-depth of focus objective for obtaining a magnification of approximately 1000 times with oil immersion.

4.5.2 Determine applicable criteria for an appro-

priate location for the microscope and set it up accordingly.

NOTE

The microscope used for neutron microscopy purposes is a delicate and expensive instrument. As such it should not be moved unnecessarily from one place to another. The location selected for its use should be considered as a relatively fixed one. It is desirable, although not essential, to mount the microscope on a microscope desk. Some criteria for selection of suitable location for the microscope are based on whether the microscopy setup has a projection system. For certain types of projection systems, it may be necessary for the setup to be in a dark, or semi-dark room. Also, some types of projection systems generate ozone and for safety purposes, provisions must be made to vent it. The microscope should not be subjected to corrosive fumes or vapors.

4.5.3 Establish a "production line" system which is best suited for the scanner who will use the microscope to count tracks on films according to procedures

specified in Method 133. Determine most efficient locations for the trays holding the films to be scanned, for the data sheets for recordings readings, and for the operational accessories and supplies, such as the digital hand tally, reticles, the oil-drop container, absorbent cotton, lens tissue paper, and alcohol. Maintain ample stock of required supplies at the microscopy setup. Keep a "test" film (a processed neutron film having a good number or proton recoil tracks)on hand for qualitative test purposes.

4.5.4 Assure chair (or stool) for the scanner is appropriate for efficient and comfortable scanning.

4.5.5 Maintain adequate number of spare projection lamps for replacements as needed.

4.5.6 Clean microscope both before and after use. Follow procedures specified in manufacturer's instruction manual.

4.5.7 Keep protective dust cover on microscope when not in use.

4.5.8 Request for special repair services of qualified activity, when required, via established channels.

4.6 Storage of Processed Films

4.6.1 Select storage area which is cool, dry, and removed from potential fire hazards.

4.6.2 Maintain adequate amount of storage containers.

4.6.3 Arrange containers of processed films chronologically, by monitoring periods.

4.6.4 Dispose of containers of processed films in accordance with applicable plant document.

NOTE

Films representing overexposures (or having densities which may have been overexposures, but which were determined to have been caused by light leakage, weathering, etc.) may be placed in small envelopes and inserted in the appropriate permanent records. Data entered on the outside of such an envelope would include: Name of monitored person, monitoring period, film densities and corresponding doses, and remarks (brief). If a written report was involved, attach such an envelope to file copy of report.

4.7 Record Files

4.7.1 Locate files and data sheet notebooks in the most convenient working areas.

4.7.2 Assure records are kept current, orderly, and stored in a safe place.

4.7.3 Maintain records in accordance with the plant

technical manual.

5. RESULTS AND COMPUTATIONS

Not Applicable.

6. TEST METHOD IMPLEMENTATION

The plant technical manual specifies policy concerning storage of processed personnel monitoring films. Specifically, it will indicate criteria and procedures for the retention of overexposure films as permanent records.

METHOD 122

PHOTODOSIMETRY DARKROOM

1. SCOPE

This method contains procedures concerning the setting up, testing, and maintaining of a photodosimetry darkroom.

2. SAMPLE

Not applicable.

3. APPARATUS

Not applicable.

4. PROCEDURES

4.1 Darkroom

4.1.1 Locate darkroom in a convenient area removed from stray radiation and from actual or potential contamination areas. Also, take into consideration the role of the darkroom during potential nuclear emergencies and incidents.

4.1.2 Provide darkroom with facilities for the following operations:

(a) Preparing film processing solutions (optional).

(b) Opening film packets.

(c) Placing films in processing holders.

(d) Processing films.

(e) Drying developed film (optional).

(f) Cleaning of equipment (optional).

(g) Timing operations.

NOTE

Facilities marked "optional" are required but need not be physically located within the darkroom.

4.1.3 Provide means for adequately ventilating the darkroom and maintaining ambient temperature between 65° and 70°F and relative humidity below 50%.

4.1.4 Assure darkroom is light-tight. Test for light-tightness according to steps 4.4.

4.1.5 Provide physical means necessary to prevent accidental admission of light into darkroom during film processing operations.

4.2 Darkroom Equipment

4.2.1 Assure that film processing facility includes provisions for:

(a) Holding processing solutions used for developing, washing, acid bathing, fixing, and final washing of films contained in the type film processing holders selected. Tanks should preferably be made of stainless steel.

(b) Maintaining temperature of solutions in processing tanks at 68° ± 2°F (or 20° ± 1°C), during film processing.

(c) Continual or intermittent mixing of the solutions during processing (optional).

4.2.2 Use film processing holders preferably made of stainless steel, specifically suited for type films to be processed.

4.2.3 Install safelights equipped with the type light bulb and filter specifically recommended as "safe" by the film manufacturer for the type films to be processed. Test "safeness" of safelights according to the steps in 4.5.

4.3 Supply of Film Processing Chemicals

4.3.1 Determine types of chemicals required for processing specific types of film concerned by referring to instructions of film manufacturers.

4.3.2 Procure and maintain on hand a supply of film processing chemicals of the appropriate types in accordance with using requirements.

4.4 Check of Darkroom for Light-Tightness

Carry out the following check for light-tightness prior to initial use of darkroom and at periodic intervals thereafter.

4.4.1 Close and lock darkroom door; turn off all lights,

including safelights; and remain in darkroom for at least 15 minutes to become dark adapted.

NOTE

"Safeness" of safelights is checked in accordance with steps in 4.5 after results of this darkroom check are found to be negative.

4.4.2 Examine for evidence of light-leakage all corners and edges of room, doors, window closures, and all other penetrations into the room such as pipes, ventilation louvers, baffles, etc.

4.4.3 Seal with appropriate material each light leak detected.

4.4.4 Open several beta-gamma type film packets and cover about one-half of each film with a black light-proof paper. Place these films on the various work surfaces, and expose them for the length of time films are exposed during a normal processing period.

4.4.5 Process exposed films in accordance with standard procedures of Method 132.

4.4.6 Examine films for evidence of exposure to light-namely that area covered by the black paper will

be less dark than the uncovered area.

4.4.7 If results are positive, repeat check until negative results are obtained.

4.4.8 Proceed with testing of safelights.

4.5 Check of Safelights

Carry out the following check for the safeness of the safelights in the darkroom; (a) prior to initial operations; (b) whenever filters or lightbulbs of a safelight are changed; (c) whenever the distance between exposed films and a safelight is reduced; and (d) whenever the number of safelights is increased.

4.5.1 Close darkroom door; turn on safelights; and turn off all other lights.

4.5.2 Carry out steps 4.4.4 through 4.4.6 above.

4.5.3 If results are positive investigate to determine cause and take corrective action. Possible causes include: (a) light-leakage from safelight housing (b) wrong type filter; (c) wrong type lightbulb of safelight; (d) an excess numbers of safelights; and (e) less-than-minimum "safe" distance between safelight and exposed films.

4.6 Preparation of Film Processing Solutions

4.6.1 Remove used solutions from the tanks.

4.6.2 Wash tanks thoroughly with hot water and detergents. Remove any sediments remaining in bottom

of tanks. If encrustation or fixed sediment cannot be removed, allow a dilute solution of acetic acid to remain in tank overnight. Thoroughly rinse tanks with clean water.

4.6.3 Prepare required amount of each type of processing solution in accordance with manufacturer's instructions, which are normally attached to each container of the chemicals. Place appropriate covers on tanks.

NOTE

Removal of the used solutions from the tanks and preparation of the fresh ones are generally done the day before the films of a monitoring period are to be processed. This is done to assure that the chemicals in the fresh solutions are in chemical equilibrium before films are processed with them. After films of a monitoring period are processed, the tanks are covered and the used solutions are retained in the tanks until removed the day prior to processing the films of the next monitoring period. During this in-tank storage interval,

the solutions may be used for processing films as required, in accordance with Method 132.

4.7 Maintenance of Darkroom.

4.7.1 Keep darkroom clean, by means of conventional good housekeeping procedures.

4.7.2 Follow manufacturer's instructions for required preventive and corrective maintenance of darkroom equipment.

4.7.3 Maintain in a thoroughly clean and dry condition, the work table surfaces on which film packets are handled and opened for removal of films for processing. Contact of unprocessed films with chemicals or water will damage or ruin them.

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION

Not Applicable.

METHOD 123

PHOTODOSIMETRY CALIBRATION SETUP

1. SCOPE.

This method contains procedures concerning the setting up of a photodosimetry calibration facility for intermediate energy gammas, betas, and fast neutrons. Radiological safety aspects are included. Procedures for calibrating film badges are contained in Method 131; and for calibrating pocket dosimeters, in Method 143.

2. SAMPLE.

Not Applicable.

3. APPARATUS.

Not Applicable.

4. PROCEDURES.

4.1 Calibration Sources.

4.1.1 Procure the following calibration sources in accordance with procedures of Method 241. In addition, specify that each source be calibrated by the manufacturer, or by the National Bureau of Standards (Washington, D.C.), prior to delivery to the plant and that the type calibration certificate indicated below be furnished with the source.

(a) Gamma - one hermetically sealed point source (normally a cylindrical capsule) containing approximately 100 millicuries of Cesium-137 (Cs-137) and furnished

with a calibration certificate stating: (1) amount (curies) of Cs-137; (2) dose rate (R/hr) at a distance of one foot from source; and (3) date of measurement. The source is to be provided with suitable lead container for storage and transfer purposes and with an appropriate type remote-handling tool for safe removal of source from container and for subsequent handling and reinsertion in container.

(b) Beta - a rectangular slab of natural uranium metal in equilibrium with UX_1 and UX_2 and of a minimum thickness of one-fourth inch and length and width of approximately 8" x 4"; one face of slab to be a smooth, plane surface; slab to be contained securely, smooth face up, in a rectangular box with a hinged top with provisions for locking it; box to be made of wood or plastic material (not of a metallic-material) of a minimum thickness of one-half inch; top (calibration surface) of slab in the box to be covered with a smooth plastic sheet of thickness equal to 7 mg/cm^2 (approximate thickness of dead layer of skin) and in direct contact with the surface of the slab. No calibration certificate is required for natural uranium slab meeting above specifications. The beta dose rate of interest is that at contact with the plane source, and it has a fixed value for any large-size natural uranium plane source of thickness greater than the equilibrium thickness (i.e. maximum range of betas in the material). For this reason, there is no need to determine the activity (curies) of the uranium slab. Beta dose rate at contact with such a slab covered with a 7 mg/cm^2 plastic covering may be

taken to be 225 millirems/hour. For required record purposes, however, shipping papers from manufacturer should state the total weight of the uranium.

(c) Fast Neutrons - one plutonium-beryllium (Pu-Be) hermetically-sealed neutron "point" source (normally a cylindrical capsule) containing approximately 5 curies of plutonium and furnished with a calibration certificate stating: (1) neutron emission rate (neutron/second); (2) amount (curies) of plutonium; and (3) date of measurement. The neutron emission rate of a one-curie Pu-Be source is about 1.5×10^6 neutrons per second. Source is to be provided with suitable shielded container which meets ICC specifications (see Method 231) for storage and transfer purposes; and with an appropriate type remote-handling tool for safe removal of source from its container, its subsequent handling, and reinsertion in its container.

4.1.2 If gamma or fast neutron calibration sources of higher activity are required and facilities for their safe use exist compute the approximate activity required on the basis of the following approximation constants:

(a) Gamma dose rate from a one-curie Cesium-137 point source: approximately 3.31 R/hr at one foot (or 3, 100 R/hr at one cm.).

(b) Fast neutron emission rate of a one-curie plutonium-beryllium source: approximately

1.5×10^6 neutrons/second. Approximate corresponding neutron flux is 1.2×10^5 n/cm^2 - sec at one cm, and 128 n/cm^2 - sec at one foot from source.

NOTE

Dose rate (R/hr) or neutron flux (n/cm^2 - sec) values at other distances from source may be computed by use of the inverse square law: $R_1/R_2 = (d_2)^2/(d_1)^2$. Where R_1 = the dose rate (on neutron flux) at a distance d_1, from the source, R_2 is that at a distance d_2 from the same source. The units of R_1 and d_1 are the same as those of R_2 and d_2.

4.2 Gamma Calibration Setup.

4.2.1 General Requirements. Design and construct a fixed-geometry, relatively scatter-free, gamma calibration setup in accordance with the following requirements:

(a) Source and film badges must be above floor at a height equal to or greater than the maximum calibration distance between source and film badge. This is to insure that there will be less than 10% contribution from scattering at the maximum source-to-badge distance.

(b) Minimum distance between walls, equipment, or other scattering objects from either source or badge must be equal to or greater than the maximum source-to-badge, calibration distance. Contribution to objectionable scattering is greater from metallic objects (e.g. materials of high atomic number) than from comparable objects of non-metallic material.

(c) The distance between film badge and source must not be less than 5 times the largest dimension of either source or badge.

(d) Factor of electron equilibrium must be considered when calibration distances are less than 100 cm from the source. Undesired secondary electrons originating in metal capsule of source or within the source itself may be present at those distances. It is usually required to place a few millimeters of a solid, air-like material (e.g. plastic) between source and badges.

(e) Badges must be oriented so that they are perpendicular to the incident radiation (that is, that the line drawn from the point source to the center point of the film badge is at right angles to the plane of the film packet). This orientation and the source-to-badge distance must remain fixed during calibration. The design of the calibration setup, however, could be such that the source-to-badge distances may be changed to other fixed values, if required. In such adjustable-type setups, it may also be necessary to adjust the orientation of the badges to assure that the

incident radiation remains perpendicular to the badges. A preferable fixed-geometry orientation of film badges and source (cylindrical) is that whereby the badges and source are perpendicular to the floor and positioned such that a horizontal line drawn through the geometrical center of the source intersects the geometrical center of the badge at a right angle to the plane of the film packet.

(f) Badges being calibrated simultaneously must be so located that they do not act as shadow shields to one another.

(g) During calibration, source must be held in fixed location and orientation, relative to the badges.

(h) Provisions must be made for safely and quickly transferring the source from its shielded container to its fixed calibration location in the setup. Path of source to its calibration position should be such that badges are not given a measurable dose prior to being located in its fixed calibration position. Likewise, equivalent provisions must be made for removal of source to its shielded container.

(i) Shielded container of source must be conveniently located to meet the requirements of item (h).

Shielding and distance of container from badges on calibration setup must be so as not to affect the calibration films or to result in unnecessary exposure of person carrying out the calibration.

(j) Select the source-to-badge distances on the calibration setup on the basis of the required calibration dose values and exposure times involved. See Method 131.

(k) Locate calibration setup in a suitable area in accordance with radiological safety aspects listed in the steps in 4.5 Take into account resultant dose rates in environs, from standpoint of exposures to personnel and of possible effects on fixed area monitors and counting room instrumentation.

4.2.2 Calibration of the Setup.

4.2.2.1 Locate setup in exact location and orientation under which it is to be used.

4.2.2.2 With the appropriate source in its calibration position, measure gamma dose rate at each film badge calibration point with an r-meter which has been calibrated with gamma radiation of the same energy as that of the calibration source. If the calibration points are not fixed, select several points at several distances and to include the point closest to and farthest from the source. To carry out these measurements, follow the procedures specified in the instruction manual of the r-meter set. See the steps in 4.5 for radiological safety aspects.

4.2.2.3 Use data obtained above to verify if the inverse square law (see note of step 4.1.2) holds under the particular conditions of scatter and range of distances. If it does not, make improvements necessary to provide

relatively scatter-free conditions for calibration. See step 4.2.1.

NOTE

If the inverse square law does not hold because of the nearness of scattering components to either the source or detector, the value of dose rate versus distance can be determined, but in general this set of values will have to be determined for each particular type detector which may have a different energy response.

4.2.2.4 Use data obtained in step 4.2.2.2 to check directional uniformity of the radiation field within the area of interest. This check is more important with physically large-size sources because of the possibility of self absorption in the source. This check is done by comparison of the measured dose rate at points at equal distances from the source. If calibration conditions are not scatter free, this check requires that the source and detector remain fixed relative to scattering objects, and that the dose rate at a fixed point be measured with different orientations of the source.

4.2.2.5 Plot dose rate versus distance values, or

record dose rate at each fixed film-calibration point, depending on whether the setup has provisions for varying calibrating distances or not. Enter on plot, or record: The date of measurements, name or initials of person who performed measurements, and complete identification of calibration source, calibration setup, and measuring device (e.g. r-meter) used.

4.2.2.6 Repeat above calibration of setup at periodic intervals specified in the plant technical manual and whenever factors which may affect the calibration values are changed or introduced into the setup.

4.2.3 Use of Setup.

4.2.3.1 Prior to using the calibration setup, use the following basic equation to compute the current dose rate, R_t, at each calibration point to be used:

$$R_t = R_o e^{-(0.693\ t/T_{1/2})}.$$

Where R_o = measured dose rate (mr/hr, r/hr, etc.) at fixed point a given distance from source, at time of calibration of setup.

R_t = computed dose rate (mr/hr, r/hr, etc.) at the same point, after calibration source has decayed for a time, t.

t = decay time of source, i.e., the time lapse between measurement of R_o and computing of R_t.

$T_{1/2}$ = radioactive half-life of specific radionuclide contained in the calibration source.

NOTE

In order for the above equation to hold, all pertinent factors (except activity of calibration source) must be the same as when measurement of R_o was made; furthermore, R_o and R_t must be in the same units of dose rate (e.g., mr/hr) and t and $T_{1/2}$ must be in the same units (e.g., days). Use Method 634.4 to determine the value of the negative exponential, $e^{-(0.693\ t/T_{1/2})}$, substituting dose rate, R, for activity, A. Also, see Table 123-1 for value of the negative exponential computed for various values of $(t/T_{1/2})$.

4.2.3.2 To compute the exposure time:

$$t' \text{ (hr)} = \frac{D \text{ (mr)}}{R_t \text{ (mr/hr)}}$$

Where t' (hr) = exposure time.

R_t (mr/hr) = corrected dose rate value.

D (mr) = specified dose rate.

NOTE

For a film calibration setup in which the source-to-badge distance is fixed, it will be found convenient to compute for each required exposure dose value, D, the exposure time required when the dose rate at that point has the measured value, R_o (mr/hr). To expose a film to the same exposure dose, at a subsequent time, and at the same calibration point, the correct exposure time can be computed by use of the following equation.

$$t'_t \text{ (hr)} = \frac{t'_o \text{ (hr)}}{e^{-(0.693\ t/t_{1/2})}}$$

Where t'_t (hr) = corrected exposure time.

t'_o (hr) = exposure time.

4.2.3.3 See Method 131 for procedures to calibrate

film badges for gamma radiation.

4.2.3.4 Observe all applicable radiological safety procedures in the steps in 4.5.

4.3 Beta Calibration Setup.

4.3.1 General Requirements. See step 4.1.1 (b) for specifications of setup for calibrating film for beta radiation.

4.3.2 Calibration of the Setup.

4.3.2.1 Calibration of the setup is not necessary if it meets requirements specified in step 4.1.1 (b). The beta dose rate at contact with such a slab of natural uranium covered with a 7 mg/cm^2 plastic absorber may be taken to be 225 millirem/hour.

4.3.2.2 If the calibration device does not meet the requirements specified in step 4.1.1 (b), have the beta dose rate at contact with the natural uranium plane source (covered with a 7 mg/cm^2 plastic absorber) measured at the Bureau of Stndards, by means of an extrapolation chamber, and specify that a certificate be given containing the value of the dose rate.

4.3.3 Use of Setup.

4.3.3.1 Because of the very long half-life of uranium, the contact dose rate value requires no correction for radioactive decay.

4.3.3.2 Use beta film calibrator in a location free

from stray gamma radiation. Any gamma dose received by the film(s) during the longest exposure time in the calibrator should be negligible. Do not use or store calibrator in potentially contaminated locations.

4.3.3.3 Follow procedures of Method 131 to calibrate films for beta radiation.

4.4 Neutron Calibration Setup.

4.4.1 General Requirements. Design and construct a fixed-geometry, relatively scatter-free, fast neutron calibration setup in accordance with the following requirements:

(a) The Pu-Be source is to be used during calibration as an unmoderated fast neutron source.

(b) Considerations concerning scattering must be made in accordance with items (a) and (b) of step 4.2.1. For neutrons, contribution to objectionable scattering is greater from objects of materials of low atomic number. Additionally, scatter can easily become large and the effective neutron energy can be significantly lowered when more than one scattering surface (such as floor and walls) is involved. A relatively scatter-free setup is particularly important because fast neutron calibration is carried out solely on the assumption that the inverse square law holds. See step 4.4.2.

NOTE

Scattering is particularly objectionable for detectors used for fast-neutron monitoring but which are also sensitive to lower-energy neutrons. The type film used for neutron monitoring, however, has virtually no response to neutrons of energy between about 1 ev and 0.4 Mev.

(c) Item (c) and items (e) through (k) of step 4.2.1.

4.4.2 Calibration of the Setup.

4.4.2.1 Compute the fast neutron flux, f (neutrons/ cm^2 - sec), at each calibration point concerned by use of the following equation. Record calculated values and other pertinent information on data sheet.

$$f = \frac{N}{4 \pi r^2}$$

Where f = fast neutron flux, n/cm^2 - sec., at calibration point a distance of r centimeters from Pu-Be neutron source.

N = neutron emission rate of the neutron source, in neutrons/second, as stated in its calibration certificate.

r = distance in centimeters, from neutron source to calibration point.

The above equation may also be used to determine the distance, r, for a fast neutron flux, f, of a given value. See step 4.2.1 for restrictions on source-to-detector distances.

NOTE

The fast neutron flux (neutrons/cm^2 - sec) at each calibration point is calculated as indicated above. There are presently no means for verifying these values by actual measurements at these points.

4.4.3 Use of Setup.

4.4.3.1 Because of the very long half-life of Plutonium, there is no need to correct the neutron emission rate, N (neutrons/second), of the Pu-Be source for radioactive decay. Consequently, values of flux, f, (or of source-to-detector distances, r) previously computed are still applicable.

4.4.3.2 Use setup for calibrating film badges for fast neutrons in accordance with procedures of Method 131.

4.4.3.3 Observe all applicable radiological safety procedures in steps 4.5.

4.5 Radiological Safety Aspects.

4.5.1 Design, construct, and use the calibration setups (and sources) in accordance with all applicable radiological safety practices and in compliance with rules specified in the plant technical manual. Only those persons who have been specifically authorized, in accordance with the plant technical manual, are to be allowed to use calibration setups and sources.

4.5.2 Plan and carry out calibration procedures so as to reduce all unnecessary exposures to operators as well as to persons in the environs.

4.5.3 Use distance (per se, and such devices as long-handle tools, etc.), time, and shielding to minimize personnel exposures.

4.5.4 Leak test sources in accordance with Method 540 and the plant technical manual. Exercise caution. Assure fixed-geometry factors of calibration setups are not altered and that sources are not damaged.

4.5.5 Monitor environs (specially occupied areas) when doing gamma and neutron calibrations.

4.5.6 Rope off and appropriately mark access to high radiation areas. Secure access to such areas, if possible.

4.5.7 Remain fully alert.

4.5.8 Assure that sources are placed in their shielded and designated containers, immediately after use. Verify by monitoring with appropriate survey instrument.

4.5.9 Review periodically the calibration operations from the standpoint of radiological safety. Effect improvements as necessary.

4.5.10 Wear, in addition to regular beta-gamma film badge, a gamma self-reading dosimeter whenever carrying out gamma calibration operations; a neutron film badge and a thermal-neutron dosimeter when doing neutron calibrations.

4.5.11 Maintain good housekeeping practices in the area(s) housing the calibration facilities.

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION.

The plant technical manual specifies:

(a) Frequency for periodically calibrating the gamma calibration setup.

(b) Area in which the gamma and the fast neutron calibration setups are to be used.

(c) Procedure for authorizing specific qualified individuals to use the calibration setups and sources.

TABLE 123-1. $-(0.693t/T_{1/2})$

Negative Exponential, $F = e$

$t/T_{1/2}$	F	$t/T_{1/2}$	F	$t/T_{1/2}$	F	$t/T_{1/2}$	F
0	1.000	1.06	0.480	2.30	0.203	4.95	0.0324
0.02	0.986	1.08	.473	2.35	.196	5.00	.0313
0.04	.973	1.10	.467	2.40	.189	5.10	.0292
0.06	.959	1.12	.460	2.45	.183	5.20	.0272
0.08	.946	1.14	.454	2.50	.177	5.30	.0254
0.10	.933	1.16	.447	2.55	.171	5.40	.0237
0.12	.920	1.18	.441	2.60	.165	5.50	.0221
0.14	.908	1.20	.435	2.65	.159	5.60	.0206
0.16	.895	1.22	.429	2.70	.154	5.70	.0192
0.18	.883	1.24	.423	2.75	.149	5.80	.0180
0.20	.871	1.26	.418	2.80	.144	5.90	.0167
0.22	.859	1.28	.412	2.85	.139	6.00	.0156
0.24	.847	1.30	.406	2.90	.134	6.10	.0146
0.26	.835	1.32	.401	2.95	.129	6.20	.0136
0.28	.824	1.34	.395	3.00	.125	6.30	.0127
0.30	.812	1.36	.390	3.05	.121	6.40	.0118
0.32	.801	1.38	.384	3.10	.117	6.50	.0111
0.34	.790	1.40	.379	3.15	.113	6.60	.0103
0.36	.779	1.42	.374	3.20	.109	6.70	.0096
0.38	.768	1.44	.369	3.25	.105	6.80	.0090
0.40	.758	1.46	.364	3.30	.102	6.90	.0084
0.42	.747	1.48	.358	3.35	.0981	7.00	.0078
0.44	.737	1.50	.354	3.40	.0947	7.10	.0073
0.46	.727	1.52	.349	3.45	.0915	7.20	.0068
0.48	.717	1.54	.344	3.50	.0884	7.30	.0063
0.50	.707	1.56	.339	3.55	.0853	7.40	.0059
0.52	.697	1.58	.334	3.60	.0825	7.50	.0055
0.54	.688	1.60	.330	3.65	.0797	7.60	.0052
0.56	.678	1.62	.325	3.70	.0769	7.70	.0048
0.58	.669	1.64	.321	3.75	.0743	7.80	.0045
0.60	.660	1.66	.316	3.80	.0718	7.90	.0042
0.62	.651	1.68	.312	3.85	.0693	8.00	.0039
0.64	.642	1.70	.308	3.90	.0670	8.10	.0036
0.66	.633	1.72	.304	3.95	.0647	8.20	.0034
0.68	.624	1.74	.299	4.00	.0625	8.30	.0032
0.70	.616	1.76	.295	4.05	.0604	8.40	.0030
0.72	.607	1.78	.291	4.10	.0583	8.50	.0028
0.74	.599	1.80	.287	4.15	.0563	8.60	.0026
0.76	.590	1.82	.283	4.20	.0544	8.70	.0024
0.78	0.582	1.84	0.279	4.25	0.0525	8.80	0.0022

$t/T_{1/2}$	F	$t/T_{1/2}$	F	$t/T_{1/2}$	F	$t/T_{1/2}$	F
0.80	0.574	1.86	0.275	4.30	0.0507	8.90	0.0021
0.82	.566	1.88	.272	4.35	.0490	9.00	.0020
0.84	.559	1.90	.268	4.40	.0474	9.10	.0018
0.86	.551	1.92	.264	4.45	.0457	9.20	.0017
0.88	.543	1.94	.261	4.50	.0442	9.30	.0016
0.90	.535	1.96	.257	4.55	.0427	9.40	.0015
0.92	.529	1.98	.253	4.60	.0413	9.50	.0014
0.94	.521	2.00	.250	4.65	.0398	9.60	.0013
0.96	.514	2.05	.241	4.70	.0385	9.70	.0012
0.98	.507	2.10	.233	4.75	.0372	9.80	.0011
1.00	.500	2.15	.225	4.80	.0359	9.90	.0010
1.02	.493	2.20	.218	4.85	.0347	10.00	0.0010
1.04	0.486	2.25	0.210	4.90	0.0335	--	--

Both t and $T_{1/2}$ are in the same unit of time.

METHOD 131

CALIBRATION OF FILM BADGES

1. SCOPE.

This method contains procedures for calibrating film badges for gamma, beta, and fast neutron radiation.

2. SAMPLE.

Not Applicable.

3. APPARATUS.

Calibrated, fixed-geometry setup for gamma calibration of film badges. See Method 123.

Calibrated setup for beta calibration of film badges. See Method 133.

Fixed-geometry setup for fast neutron calibration of film badges. See Method 123.

Fast neutron source whose neutron emission rate (neutrons/second) is known from a certified calibration. See Method 123.

Timer.

Photodosimetry darkroom.

Neutron microscopy setup.

4. PROCEDURES.

4.1 Gamma Calibration.

4.1.1 See Method 123 for technical and radiological safety

requirements.

4.1.2 Select the values of gamma exposure dose (D) required to comprise the calibration film set. A calibration film set consists of a given number of beta-gamma film packets each exposed in a beta-gamma film packet holder to a known and different exposure dose. The number and magnitude of the dose values in a set should be sufficient for plotting the "Density Versus Dose" film calibration curves over the dose range of interest. It is desirable that specific dose values correspond to basic and operational limits for the monitoring period concerned. Following is a suggested calibration film set: 30; 50; 100; 300; and 600 milliroentgens; 1.25; 3; 6; 12; and 25 roentgens.

4.1.3 Compute the current exposure dose rate, R_t, at each calibration point of the gamma film calibration setup, in accordance with step 4.2.3.1 of Method 123.

4.1.4 Compute the exposure time, t (hour), for each film packet of the gamma calibration film set, in accordance with step 4.2.3.2 of Method 123.

4.1.5 Enter on data sheet for each calibration point of setup: distance of calibration point from source; measured dose rate, R_o, at that point, and date of its measurement; computed dose rate, R_t, at that point, and date of its computation; each value of exposure dose, D, for which that calibration point is to be used, and its corresponding exposure time, t_t, based on current

dose rate, R_t.

4.1.6 Obtain the beta-gamma type film packets to be calibrated, from unused film packets in storage. In general, it is desirable that two film packets be calibrated for each calibration dose value. Assure that the emulsion number of all these film packets is the same as that of the monitoring films for which this calibration set is being prepared.

4.1.7 Mark on front face of each calibration film packet the exposure dose (D) it is to be given. Enter on data sheet the serial number and corresponding value of D for each film packet in the calibration set(s), and other pertinent data (emulsion number, date, etc.) specified in the form.

4.1.8 Load the calibration film packets in the same type holder and in exactly the same manner as the monitoring film badges in use.

4.1.9 Place each calibration badge at its appropriate calibration point in the film calibration setup.

NOTE

During this step, the calibration source is to be in its shielded container.

4.1.10 Start exposure of film badges. This is done by positioning the calibration source at its designated,

fixed location in the film calibration setup.

4.1.11 Record starting time of exposure. Use accurate timepiece for measuring exposure time. Alarm type (darkroom) timer may be used in conjunction with timepiece, to alert operator when end of exposure time is near.

4.1.12 Stop exposure at the end of the specified exposure time by removing calibration source from its exposure position and placing it in its shielded container.

4.1.13 Remove film packets from calibration badges and store packets in approved film storage location until needed as calibration set for processing film batch.

4.1.14 After the calibration source is replaced in its shielded container at the completion of a calibration run, check for evidence of contamination, those surfaces (tips of remote-handling devices, location of source during calibration, etc.) with which the source has been in contact. See the steps in 4.5 of Method 540.

4.1.15 Processing. See Method 132.

4.1.16 Reading. See Method 133.

4.2 Beta Calibration.

4.2.1 See Method 125 for technical and radiological safety requirements.

4.2.2 Select the values of beta dose, D, required to comprise the beta calibration film set. A calibration

set consists of a given number of film packets each exposed to a known and different dose. The number and magnitude of the dose values in a set should be sufficient for plotting the "Density Versus Dose" film calibration curve over the dose range of interest. It is desirable that specific dose values correspond to basic and operational limits for the monitoring period concerned. Following is a suggested calibration set: 60; 300; and 600 millirems and 1.25; 3; and 7.5 rems. It is advisable that, for a given film emulsion type, calibration data for higher dose values be obtained initially and retained.

4.2.3 Use the following equation to compute the calibration exposure time, t (hour) required to obtain each selected value of beta dose, D (millirem):

$$t\ (\text{hour}) = \frac{D\ (\text{millirem})}{240\ (\text{millirem/hour})}$$

Where 240 millirem/hour = a constant which represents the beta dose rate at contact with the beta calibration source described in Method 123 - a thick slab of natural uranium covered with a 7 mg/cm^2 plastic absorber.

If a different type beta calibration source is used, its current dose rate in millirem/hour at contact with it must be used in place of the 240 millirem/hour in the above equation.

4.2.4 Record the values of beta dose, D, and their corres-

ponding values of exposure time, t.

4.2.5 Obtain the beta-gamma film packets to be calibrated, from unused film packets in storage. In general, it is desirable that two film packets be calibrated at each calibration dose value. Assure that the emulsion number of all these film packets is the same as that of the monitoring films for which this calibration set is being prepared.

4.2.6 Mark on back (side with the tabs) of each calibration film packet the symbol "β" and the value of the beta dose (D) it is to be given. Enter in data sheet the serial number and corresponding value of D for each film packet in the calibration set(s), and other pertinent data (emulsion number, date, etc.) specified in the form.

4.2.7 Locate beta film calibrator in an area removed from gamma radiation. Remove cover from calibrator.

4.2.8 Place each film packet in the calibrator, such that the FRONT (side <u>without</u> the tabs) of the packet is in direct contact with the plastic-covered plane beta-source.

NOTE

Determine, from the beta dose evaluation procedures applicable to the specific type beta-gamma film packet holder in use, whether the calibration

film packets should be in holders for calibrating them.

4.2.9 Record starting time of exposure of film packets. This is the time the packets are placed in contact with the plane beta source.

4.2.10 Use accurate timepiece for measuring exposure time. Alarm type (darkroom) timer may be used in conjunction with timepiece to alert operator when end of exposure time is near.

4.2.11 Remove each film packet from calibrator at the end of its specified exposure time. As soon as a calibrated film is removed from the calibrator, store it in the approved film storage location, where the beta calibration set is to be kept until needed for processing film batch.

4.2.12 Replace cover on calibrator. Return calibrator to its designated storage location.

4.2.13 Processing. See Method 132.

4.2.14 Reading. See Method 133.

4.3 Neutron Calibration.

4.3.1 See Method 123 for technical and radiological safety requirements.

4.3.2 Determine the number of neutron film packets and fast neutron dose values, D (millirem), to be used to obtain the calibration factor for the neutron film batch. The following may be used as a guide:

Two film packets	300 millirems
Two film packets	600 millirems
Two film packets	1,200 millirems

4.3.3 Compute the fast neutron flux, f (n/cm^2-sec), at each calibration point to be used in the calibration setup. See Method 123.

4.3.4 Use the following equation to compute the dose rate equivalent, R (millirems/hour), of each of these values of fast neutron flux, f (n/cm^2-sec):

$$R \text{ (millirem/hour)} = \frac{f \text{ } (n/cm^2\text{-sec})}{4 \text{ } (n/cm^2\text{-sec per millirem/hour})}$$

4.3.5 Use the appropriate value of dose rate equivalent, R(millirem/hour), to compute the exposure time, t(hour), required for each calibration film to receive its specified fast neutron dose, D(millirem).

$$t \text{ (hour)} = \frac{D \text{ (millirem)}}{R \text{ (millirem/hour)}}$$

4.3.6 Enter on data sheet for each calibration point to be used on the setup: distance of calibration point from source; computed value of fast neutron flux, f, at that point; fast-neutron dose rate equivalent, R, at that point; dates of computations; each value of fast neutron dose, D, for which that calibration point is to be used, and its corresponding exposure time, t.

4.3.7 Obtain the film packets to be exposed, from unused

neutron film packets in storage. Assure that the emulsion number of all these film packets is the same as that of the monitoring films for which this calibration set is being prepared.

4.3.8 Mark on front face of each calibration film packet the fast neutron dose, D, which it is to be given. Enter on data sheet, the film packet serial numbers and other pertinent data (emulsion number, date film exposed, etc.) specified on the form.

4.3.9 Load film packets in the appropriate type holder in identically the same manner as for the neutron-monitoring film badges in use. For Army Depot holders used exclusively for neutron film packets, follow loading instructions specified by Army Depot. For stainless steel holders used to contain both a beta-gamma film packet and a neutron film packet, insert in each holder a beta-gamma film packet along with the neutron film packet to be calibrated.

4.3.10 Expose calibration badges to the predetermined fast neutron doses in accordance with steps 4.1.8 through 4.1.13 but using the fast neutron calibration setup. If stainless steel holders containing both beta-gamma film packets and neutron film packets were utilized, destroy the beta-gamma film packets after their removal from the exposed badges.

4.3.11 Processing. Process the calibration neutron film packets in accordance with the standard procedure

specified in Method 132. This processing may be done separately, or jointly with a batch of neutron monitoring films. Either way, two control (i.e., unexposed) films of the same emulsion number must be processed along with the calibration neutron films.

NOTE

Because of track (latent image) fading, not more than two weeks should be allowed to elapse between exposure and processing of the calibration neutron films. Tests for determining extent of tract fading may be made by exposing two sets of calibration films at the same time and processing one set immediately and the other set two weeks (or preferably, one neutron film monitoring period) later, and comparing the results.

4.3.12 Reading. See Method 133.

5. RESULTS AND COMPUTATIONS.

5.1 Insert and retain the filled-out data sheets in a notebook labelled, "Film Data--Readings and Calibrations".

5.2 Keep notebook in safe place. Data it contains represent valuable records.

5.3 Store processed calibration films in accordance with Method 131.

6. TEST METHOD IMPLEMENTATION.

Not Applicable.

METHOD 132

DARKROOM PROCESSING OF FILM PACKETS

1. SCOPE.

This method contains procedures for the darkroom processing of beta-gamma film packets and neutron film packets.

2. SAMPLE.

Not Applicable.

3. APPARATUS.

Following sets of calibration film packets: (a) gamma, (b) beta, and (c) fast neutron. See Method 131.

Control film packets: (a) beta-gamma, and (b) neutron.

Photodosimetry darkroom and supplies. See Method 122.

Data sheets.

4. PROCEDURES.

4.1 Preparation of Film Packets for Processing.

4.1.1 Separate the monitoring film packets to be processed into two groups, according to type (beta-gamma and neutron) and arrange film packets of each group in numerical order.

4.1.2 Add the gamma and the beta calibration film sets to the "beta-gamma" group; and the fast neutron calibration film set to the "neutron" group.

NOTE

In general, the calibration factor for a given supply of neutron film packets (same emulsion number) is determined only once. As such, a fast neutron calibration film set need not be included in a processing batch of neutron films for which a calibration factor has already been obtained. However, two control films (neutron) must be included in each processing batch.

4.1.3 Add two control film packets (beta-gamma) to the "beta-gamma" group; and two control film packets (neutron) to the "neutron" group. Assure that these control film packets are of the same emulsion number as the monitoring (and calibration) film packets to be processed.

NOTE

If the combined film packets in a group are more than can be processed in one batch, physically separate the monitoring packets into subgroups, each of a

processing-batch size. To each sub-group, add the appropriate type calibration set(s) and control film packets, in accordance with steps 4.1.2 and 4.1.3.

4.1.4 Arrange the film packet groups, film-developing racks, and accessories on a clean and dry work table in the darkroom. Assure racks are clean and thoroughly dry.

4.1.5 Assure the beta-gamma film packets are physically separated from the neutron film packets as the two types are to be processed in separate batches. The reason for this separation is that the processing solutions or times, or both, may be different for the two types of film.

4.2 Preparation of Darkroom.

4.2.1 Prepare fresh film-processing solutions, according to procedures in Method 122. Preferably, the fresh solutions should be prepared the day before the films from a monitoring period batch are scheduled to be processed.

4.2.2 Bring the temperature of the processing solutions and of rinse and wash water to a constant 68°F or 20° C. During film processing, temperature should not vary by more than ± 2°F or ± 1°C. Measure temperature with floating thermometer(s) in each tank.

4.2.3 Wind the darkroom timer and set alarm for developing time (e.g., 5 minutes). If another timer is available, wind it and set alarm for fixing time.

4.2.4 Turn on safelights, if used, and check darkroom door lock and general conditions and readiness of darkroom for film processing.

4.2.5 Place "Darkroom in Use" sign outside of darkroom door; lock darkroom door; and turn off all lights, except those safelights which are known by actual tests not to affect the film.

4.3 Darkroom Procedures.

CAUTION

The following steps are to be carried out only with the darkroom in complete darkness or illuminated only by tested safelights.

4.3.1 Loading of film-developing racks. For a processing batch of film packets (arranged in following sequence: controls, calibration, and monitoring), unwrap the first film packet; carefully remove the film(s); and place it in the first location of a film-developing rack. Hold film by edges. Proceed likewise with rest of film packets. Use additional film-developing racks, as necessary,

but no more than the maximum number which constitutes a film-processing batch. Arrange and secure, as one handling unit, the filled film-developing racks constituting one processing batch.

4.3.2 Assure readiness of all the required film processing facilities. Specifically, check that the processing solutions are constant at the required temperature - 68° ± 2°F or 20° ± 1°C.

4.3.3 Developing.

4.3.3.1 Assure timer is wound and properly set to alarm at end of developing period. The developing period is from 5 to 10 minutes, depending on type developer used. Follow instructions specified by film manufacturer. Activate timer at time following step is started.

4.3.3.2 Immerse in the developer tank the filled film-processing racks constituting one processing batch. For about the first 5 seconds tap the rack(s) against the tank to dislodge air bubbles clinging to the films. Agitate the developer for about 10 seconds, at 60-second intervals, until developing period is completed.

4.3.4 Rinsing.

4.3.4.1 Rinse films in clean, running water (68°F or 20°C) for about 30 seconds to 2 minutes.

4.3.4.2 If stop bath is used in place of water rinse, rinse in stop bath (68°F or 20°C) for about 30 to 60 seconds.

4.3.5 Fixing.

4.3.5.1 Assure timer is wound and set to alarm at end of fixing period. The fixing period is from 5 to 10 minutes for beta-gamma films and from 20 to 30 minutes for neutron films, depending on type fixer used. Follow instructions specified by film manufacturer. Activate timer at time the following step is started.

4.3.5.2 Immerse batch in the fixer tank. Agitate films vigorously when they are first immersed, and at least 10 seconds every 2 minutes until fixation is completed.

NOTE

Appropriate fixing time is approximately twice the time required for the emulsion to clear, that is, for the original diffuse, milky yellowness to disappear.

4.3.6 Washing.

4.3.6.1 Wash batch for 30 to 40 minutes in running water (preferably at 68°F or 20°C). Flow of wash water should be sufficient for at least 8 changes per hour.

4.3.6.2 The following RAPID WASHING procedure may be used as an alternate method, if it is necessary to reduce rinsing time and conserve water:

(a) Kodak Personal Monitoring Film, Types 2 and 3:

first, after removal from fixer tank, rinse the films in water for 1 minute. Immerse the batch in Kodak Hypo Cleaning Agent for 2 minutes, agitating moderately. Wash batch for 5 minutes using water having a minimum water flow sufficient to provide at least one complete change of water during the 5-minute period.

(b) Other types of beta-gamma films: follow manufacturer's instructions.

(c) Kodak Personal Neutron Monitoring Film, Type A: rapid washing is not recommended for this type film.

4.4 Drying.

Dry film batch in film dryer. In absence of film dryer, dry film batch in a dust-free area by placing in current of air of temperatures not exceeding 120°F.

NOTE

Formation of drying marks can be minimized after washing by wiping film surfaces carefully with a damp chamois or a damp, soft, viscose sponge.

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION.

Types of film-processing solutions, developing time and fixing time

recommended by film manufacturer for the specific types of films (beta-gamma and neutron) concerned.

METHOD 133

READING OF PROCESSED FILMS

1. SCOPE.

This method contains procedures for reading processed beta-gamma and neutron films and for evaluating the readings in terms of radiation dose.

2. SAMPLE.

Not Applicable.

3. APPARATUS.

Densitometer and accessories. See Method 121.

Microscope and accessories. See Method 121.

Graph paper.

Data sheets.

4. PROCEDURES.

4.1 Beta-Gamma Films.

4.1.1 Preparation of Densitometer For Use.

4.1.1.1 Turn on the densitometer approximately one hour before using, to assure meter stability. Following this warm-up period, adjust and calibrate densitometer in accordance with procedures specified in the densitometer manual. In the absence of such instructions, proceed as follows.

4.1.1.2 Set zero of densitometer by adjusting the appropriate knobs so that the meter reads

zero when a reading is made with no film in place. Do not disturb the adjustment knobs until such time as the zero is rechecked and found to require adjusting.

4.1.1.3 Check the extreme end of the scale by blocking entry of all light into the sensitive element and noting if the meter reads infinity, ∞.

4.1.1.4 Use the calibration density wedge in accordance with steps 4.1.2.2 and 4.1.2.3 to assure that meter readings are correct in terms of absolute density units. Select representative density values spread out within the useful range of the densitometer. If densitometer has an external meter, select a calibration density on the wedge which falls in the overlapping portions of the scales of the two meters.

NOTE

The above adjustments and calibration checks are relatively easy to do when the densitometer is operationally sound. When these routine adjustments fail, take corrective action according to the detailed instructions specified in the densitometer manual.

4.1.2 Technique of Reading Individual Film.

4.1.2.1 Check the film for density patterns, evidence of damage, evidence of contamination, etc.,

by viewing on film viewer or against some other light source. Record on data sheet any abnormalities noted.

4.1.2.2 Place the film in the reading position on the densitometer, assuring that the densitometer light beam is in the center of the specific film area (window, filter A, B, etc.) to be read.

4.1.2.3 Bring down the sensitive element of the densitometer, and press it firmly on the film. Check effect of varying the pressure. The pressure applied should be such that increasing it should not result in a change in reading.

4.1.2.4 Record density reading on data sheet.

4.1.2.5 Read other areas of interest on the same film, in accordance with steps 4.1.2.2 through 4.1.2.4.

4.1.3 Reading Films of a Processed Batch.

4.1.3.1 Place the rack(s) of processed films by the densitometer and arrange so that films may be read in the sequence in which they have been listed in the data sheets: controls, calibration, and monitoring films.

NOTE

A batch consists of films which were processed together.

4.1.3.2 Control Films. Read the control films (both the more-sensitive and the less-sensitive ones) in the rack, in accordance with the steps in 4.1.2. In general, take readings in three different areas on each film. The density reading of a control film should be the same over its entire area. Set control films aside for randomly checking densitometer during reading of the other films in this rack.

4.1.3.3 Calibration Films. Read density of each area of interest (window, filter A, B, etc.) on each of the more-sensitive and the less-sensitive films of the calibration set, in accordance with the steps in 4.1.2. Check zero of densitometer, according to step 4.1.1.2, on a frequency dictated by the known stability of the densitometer.

4.1.3.4 Monitoring Films. Read density of each area of interest (window, filter A, B, etc.) on each of the more-sensitive films in accordance with the steps in 4.1.2. Check zero of densitometer, according to step 4.1.1.2, on a frequency dictated by the known stability of the densitometer.

NOTE

If a more-sensitive film reading is off-scale, read the corresponding less-sensitive film of the same packet. Likewise, read less-sensitive film if the

corresponding more-sensitive film of the packet has been lost or shows evidence of damage.

4.1.4 Evaluation of Readings. See the steps in 5.1.

4.2 Neutron Films.

4.2.1 Preparation of Microscope for Use.

4.2.1.1 Follow the instructions in the microscope manual, to prepare it for use. Also, see the steps in 4.5 (Microscope) of Method 121.

4.2.1.2 Assure appropriate lenses with magnification of approximately 1000 x are in place. Clean lenses using lens-cleaning tissue only.

4.2.1.3 Check to assure that the correct square reticle is in the eyepiece.

4.2.1.4 Assure appropriate type filter is in place in the projection light system. Clean filter.

4.2.1.5 Clean stage of microscope.

4.2.1.6 Check stage-traverse stops (if used) to assure that they are fixed tightly and in their proper positions.

4.2.1.7 Clean the stage film-holders to be used.

4.2.1.8 Use a test film (developed, neutron film which is known to have a good number of pro-

ton recoil tracks), as if it were a monitoring film to be read, to check movements of microscope stage and to check focusing. Use standard, neutron film microscopy technique to perform these checks.

4.2.2 Neutron Film Microscopy - Traverse Scanning Technique.

4.2.2.1 Secure film in holder and place on stage of microscope. Assure holder is properly secured on stage of microscope.

4.2.2.2 Move stage to pre-selected (and standardized) starting point, (X_1, Y_1). Slowly lower oil immersion lens to about 1/4-inch from the film.

NOTE

See note of step 4.2.2.6 for criteria and guides for determining value of the starting point (X_1, Y_1).

4.2.2.3 Place drop of microscope oil on film, on spot directly below lens. Slowly lower the oil immersion lens onto the drop of oil. Adjust X and Y stage settings, if necessary, to the standard starting point, (X_1, Y_1).

4.2.2.4 Bring microscope to focus on the developed film grains on the emulsion side of the film. The film grains will usually be very sparse. Care must be used to assure microscope is properly focused on emulsion.

4.2.2.5 Move the stage longitudinally - from the

starting point (X_1, Y_1) to the preselected (and standardized) stopping point, (X_2, Y_1) - focusing in and out of the emulsion and counting the proton recoil tracks seen in the area scanned. Use digital hand tally (counter) to keep accurate count of number of proton recoil tracks. Assure tally (counter) is at zero at the start of scanning.

NOTE

See note of step 4.2.2.6 for criteria and guides for determining the value of the stopping point (X_2, Y_1).
The film area is that of the strip defined by the movement of the square recticle from the stage starting point, (X_1, Y_1) to the stage stopping point (X_2, Y_1).
A track is defined as a series of three or more grains. A track may be either wholly or only partially within the area scanned. If a track is wholly within the reticle-scanned area, it is counted. A track which is only within the reticle-scanned area is counted only if three of its grains are within this area. Neutron

films normally contain some tracks which are produced by alpha particles from natural (unavoidable) thorium impurities in the film. Because of the difficulty in positively identifying an individual track as due to a thorium alpha, single tracks are always counted as being due to proton recoils. Two or more tracks seen to originate from the same point are considered to be due to alpha particles from a thorium inclusion and such a cluster is called a thorium "star." Tracks (that is, prongs) of a "star" are not counted.

4.2.2.6 Lift lens about 1/4-inch above film. Repeat steps 4.2.2.2 through 4.2.2.5, using the second set of pre-selected (and standardized) stage settings: starting point (X_1, Y_2) and stopping point (X_2, Y_2).

NOTE

The stage settings (X_1, Y_1) - (X_2, Y_1) and (X_1, Y_2) - (X_2, Y_2) are selected such that:

(1) the two areas scanned are in the specific portion of interest on the film;

(2) the total standard area scanned (i.e., the sum of the two equal areas scanned) is not less than 25 fields of view, but is not so large as to be impractical; and (3) there is no overlap of fields of view at stage settings (X_1, Y_1) and (X_1, Y_2).

The following may be used as a guide for the selection of the stage settings (and hence for the magnitude of the fixed standard area to be scanned per film): Set X_1, and X_2 such that they are 1.7 cm apart. This determines the length of each strip to be scanned. The width of each strip is determined by the width of the eyepiece reticle. Select a separation distance of 0.5 cm between point Y_1 and Y_2. Using these stage settings and a magnification of about 1000, the Calibration Factor, CF, for the neutron films would be expected to be of the order of 5 millirem per proton recoil track/standard area scanned - on the basis that a fast neutron flux density

of 4 n/cm^2 - sec is equivalent to a dose rate of 1 millirem/hr. The number of "background" tracks expected in such an area of a control film from a fresh batch would be an average of one or two. As the film ages, however, the number of "background" tracks may be expected to increase.

4.2.2.7 Record on data sheet for each film, the total number of proton recoil tracks counted in the standard area scanned.

NOTE

The "discrete-fields" microscopy technique is essentially the same as that of the "traverse scanning" technique described above. In the discrete-fields technique, the total number of proton recoil tracks are counted in a given number (usually 25) of discrete (separate and non-overlapping) and equal-area fields of view.

4.2.3 Reading Films of a Processed Batch.

4.2.3.1 Place the rack(s) of processed films by the

microscope and arrange so that films may be read in the sequence in which they have been listed in the data sheets: controls, calibration, and monitoring films. Also, place by the microscope the accessories required during reading: digital hand tally (counter), microscope oil dropper, lens tissue paper, absorbent cotton, etc.

4.2.3.2 Read each film in the batch in accordance with the standard procedure described in the steps in 4.2.2. Assure digital hand tally (counter) is at zero at the start of scanning of each film.

NOTE

Do not read films for prolonged periods. Space readings in sessions such that a rest period from the microscope is taken between sessions, and any one reading session does not exceed one hour.

4.2.4 Evaluation of Readings. See steps 5.2.

4.3 Storage of Processed Films.

4.3.1 After they have been read, package processed films (control, calibration, monitoring) from a given monitoring (wearing) period in suitable container(s) such as empty film-packet packages or pressure-sealed cans, and clearly identify the contents by marking the outside of the containers with pertinent

information such as: (a) "Processed Beta-Gamma Films"; (b) Monitoring Period (inclusive dates); and (if more than one container is used for the batch) Film No. _____ thru No. _____.

4.3.2 Store processed film packages in a cool, dry location removed from fire hazards.

4.3.3 Retain these films until such time as specific authorization is given to exchange (see Method 121) or destroy them.

5. RESULTS AND COMPUTATIONS.

5.1 Beta-Gamma Films.

5.1.1 Control Films.

5.1.1.1 Compute the average density of the more-sensitive control films of the batch, from the recorded readings obtained. Record this computed value on data sheet.

5.1.1.2 Compute the average density of the less-sensitive control films of the batch from the recorded readings obtained. Record this computed value on data sheet.

5.1.2 Calibration Films.

5.1.2.1 From each recorded reading (total density) of the more-sensitive films subtract the average density of the more-sensitive control films as determined in step 5.1.1.1. Enter results on the data sheet as "net density".

5.1.2.2 From each recorded reading (total density) of the less-sensitive films subtract the average density of the less-sensitive control films, as determined in step 5.1.1.2. Enter results on data sheet as "net density".

5.1.2.3 Plot on graph paper the calibration curve (Dose Versus Net Density) for each specific film badge area (window, filter A, B, etc.) of the more-sensitive films. Use the horizontal (X) axis for "Dose" and the vertical (Y) axis for "Net Density".

NOTE

Calibration curves for the less-sensitive films are plotted in the same manner. These curves, however, are generally not plotted unless they are actually required.

5.1.3 Monitoring Films.

5.1.3.1 From each recorded reading (total density) of the more-sensitive films subtract the average density of the more-sensitive control films as determined in step 5.1.1.1. Enter results on data sheet as "net density".

5.1.3.2 From each recorded reading (total density) of the less-sensitive films subtract the average density of the less-sensitive control films as determined in

step 5.1.1.2. Enter results on data sheet as "net density".

5.1.3.3 Use appropriate calibration curves and procedures applicable to the specific type of film badge concerned, to determine the gamma dose and the beta dose corresponding to the positive "net density" values on a given film.

5.1.3.4 Enter these dose values in the appropriate columns of the data sheets.

5.2 Neutron Films.

5.2.1 Compute the average "total count" of the control films of the batch, from the recorded readings obtained. Round off this computed value to the nearest whole number and record it on data sheet as the "background count" (number of background tracks in standard area scanned per control film) applicable to the batch.

5.2.2 Calibration Films.

5.2.2.1 Subtract from each recorded "total count" the "background count" determined in step 5.2.1.1. Enter results on data sheet as "net count".

5.2.2.2 Compute for each calibration neutron film its corresponding Calibration Factor, (CF), by using the following equation:

$$CF = \frac{\text{Dose (Millirem)}}{\text{"Net Count" (PR Tracks/Std. Area)}}$$

Where Dose (Millirem) = the known fast neutron dose given to that film (and

recorded on the data sheet) "Net Count" (PR Tracks/Std. Area) = the "Net Count" of that film as determined in step 5.2.2.1.

Enter the computed values of (CF) on the data sheet.

5.2.2.3 Compute the average value of the individual Calibration Factors (CF), determined in step 5.2.2.2. Enter this computed average value on the data sheet as the Calibration Factor (CF) applicable to the neutron film batch.

$$(CF) = \frac{(\text{Millirem})}{(\text{PR Track/Std. Area})}$$

5.2.2.4 Fill out a card (e.g., a 3" x 5") indicating the value of the Calibration Factor (CF), the date, and neutron film packet emulsion number. Post this card by the microscopy setup. Replace and destroy this card when it is no longer valid.

5.2.3 Monitoring Films.

5.2.3.1 Subtract from each recorded "total count", the "background count" determined in step 5.2.1.1. Enter results on data sheet as "net count". Enter negative values, if any, as zero.

5.2.3.2 Use the following equation to compute the fast neutron dose corresponding to each "net

count" value determined in step 5.2.3.1, and enter the results in the appropriate column of data sheet.

Fast Neutron Dose (millirem) =

$$\text{Net Count}\left(\frac{\text{PR Tracks}}{\text{Std. Area}}\right) \times \text{Calibration Factor}\left(\frac{\text{Millirem}}{\text{PR Track/Std. Area}}\right)$$

where the Calibration Factor has the value computed in step 5.2.2.3 for that film batch.

NOTE

Under certain circumstances, it may be deemed desirable that a particular monitoring film be scanned over an area which is either smaller or larger than the standard area. For example, an area-monitoring film may have such a high track density that it would be an arduous task to count the tracks over an entire standard area. If the tracks on such a film are counted for only half (one strip) of the standard area, multiply this count by a factor of two to obtain the "Total Count" for a whole standard area. Similarly, if a film of very low track density is scanned over an area twice that of the standard area, divide the total number

of tracks by a factor of two to obtain the "Total Count" for a standard area. From this computed "Total Count" subtract the "Background Count", to obtain the "Net Count" (per standard area); and use the above equation to convert the "Net Count" to "Fast Neutron Dose". Counting of tracks over an area smaller than the standard area is to be discouraged, except for particularly unusual situations in which the track density of a film is exceedingly high. It is always best to count tracks over one entire standard area. Extreme care is to be exercised in deviating from the standard procedures, in order to avoid possible errors. Data on films scanned over areas other than the standard one are to be specifically designated as such in the data sheets.

5.3 Records and Reports.

5.3.1 Immediately report to proper authority, in accordance with the plant technical manual, any doses in excess

of the maximum permissible value for the film monitoring period concerned (see Method 111, Ref. 6.1 and 6.2).

5.3.2 Retain the film-reading data sheets and film calibration data and curves in a notebook to be used exclusively for and labeled, "Film Data - Readings and Calibration". Keep this notebook in a safe place. The data it contains represent valuable records.

5.3.3 Transfer dose readings of monitoring films from data sheets to record forms as specified in the plant technical manual.

5.3.4 Prepare and submit radiation exposure reports as specified in applicable plant document (see Method 111, Ref. 6.1 and 6.2).

6. TEST METHOD IMPLEMENTATION.

The plant technical manual specifies:

(a) Specific procedures for the conversion of measured values of film "net density" to dose units, applicable to the specific type(s) of beta-gamma film badges used by the plant.

(b) Criteria and procedures for reporting overexposures.

METHOD 141

ISSUANCE OF POCKET DOSIMETERS

1. SCOPE.

This method contains procedures for the routine issuance of self-reading pocket dosimeters.

2. SAMPLE.

Not Applicable.

3. APPARATUS.

Stock of self-reading, gamma dosimeters:

(a) Low-range (200 mr).

(b) Medium-range (5 R).

(c) High-range (200 R).

Stock of self-reading, thermal neutron dosimeters, low-range (200 millirem).

Dosimeter chargers.

Forms.

4. PROCEDURES.

4.1 Stock.

4.1.1 Determine, on the basis of usage requirements and as indicated in the plant technical manual, the minimum number of each type dosimeter to maintain on hand. Take into account such factors as possible losses, damages, increased requirements during special operations, and potential emergencies.

4.1.2 Assure dosimeters in stock are tested for charge-leakage and calibrated on a frequency specified in the plant technical manual and in accordance with procedures in Method 143.

4.2 Issuance. Issue to an individual the appropriate type(s) of dosimeters in accordance with criteria specified in the plant technical manual or as specified on the applicable Radiation Work Permit (RWP), or as indicated by the radiological condition concerned.

NOTE

Dosimeters are used normally to supplement (not to replace) the film badges.

4.2.1 Personal Dosimeters.

4.2.1.1 Assure dosimeter is in operable condition and within its calibration date. Zero dosimeter, according to Procedures of Method 142.

4.2.1.2 Label dosimeter with the same serial number as the film badge of the person to whom it is issued.

4.2.1.3 Record in appropriate form: The person's name, dates of issuance, calibration, and charge-leakage test, assigned serial number, and the manufacturer's

serial number. File completed form.

4.2.1.4 Fill out information specified on the form which is used to record dosimeter readings and place it at the personal dosimeter recording station.

4.2.1.5 When individual first reports for duty, brief him on the policy and procedures concerning wearing of the particular type(s) dosimeters issued to him, in accordance with applicable plant document. Instruct individual on where and how to clip dosimeter on his clothing, use of dosimeter board, reading and zeroing of dosimeter, recording dosimeter readings, and reporting requirements (off-scale readings, etc.). Also, inform him of other personnel dosimetric devices available.

4.2.2 General Dosimeters.

4.2.2.1 Assure dosimeters are in an operable condition and within their calibration date and that their initial reading is less than 50 mr at time of issuance to individuals or at time dosimeters are placed in dispenser from which individuals may obtain them for use as required.

4.2.2.2 Maintain dosimeter charger(s) of the appropriate type(s) at each general dosimeter dispenser.

4.2.2.3 Have dosimeter users enter information specified in the appropriate form (generally a Radiation Work Permit) concerned.

4.3 Monitoring Period.

4.3.1 Read personal dosimeters, zero them (if required), and record their readings as specified in the plant technical manual. For routine use, the monitoring period for dosimeters is, generally, one working day. For specific operations and for entries into areas requiring a Radiation Work Permit (RWP), the monitoring period is the duration of the continuous exposure; that is, the time interval between entrance to and subsequent departure from the work area via the control point. While in areas of high dose rates, the individual wearer is to read his dosimeter at intervals dictated by the level of the radiation fields involved so that he will not receive a dose in excess of the applicable limit.

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION.

The plant technical manual specifies:

(a) Criteria for the issuance and use of the various types of self-reading dosimeters (gamma dosimeters and thermal neutron dosimeters).

(b) Routine monitoring period for dosimeters.

(c) Operational exposure limits (as indicated by pocket dosimeter records) for control periods shorter than the monitoring period of film badges.

(d) Dosimeter-indicated dose value at which an individual's film badge must be exchanged and processed.

METHOD 142

READING OF POCKET DOSIMETERS

1. SCOPE.

   This method contains procedures concerning the reading of pocket dosimeters.

2. SAMPLE.

   Not Applicable.

3. APPARATUS.

   Self-reading dosimeters.

   Dosimeter chargers.

   Forms.

4. PROCEDURES.

   4.1 Zeroing of Dosimeter.

   4.1.1 Zero dosimeter at beginning of each monitoring period, or otherwise read it directly and record initial reading in appropriate form, in accordance with the plant technical manual.

NOTE

If zeroing dosimeter at beginning of each monitoring period is not required, assure that initial reading is not a negative one (that is, to the left of "zero"), or that

it is not more than 50 on a 200-millirem dosimeter. If so, zero the dosimeter. A high initial reading reduces the usable range of the dosimeter.

4.1.2 Follow the manufacturer's instructions to zero the dosimeter with the appropriate type charger. Generally this is done as follows:

4.1.2.1 Remove dust cap from the charging socket of the charger.

4.1.2.2 Insert charging contact end of dosimeter firmly in the charging socket of the charger.

4.1.2.3 Rotate potentiometer knob on the charger to switch on the light which shines through the charging socket.

4.1.2.4 View fiber image through the optical eyepiece of the dosimeter.

4.1.2.5 Rotate, slowly, the potentiometer knob on the charger until the fiber image on the dosimeter scale is brought to zero.

4.1.2.6 Remove dosimeter from the charger and read dosimeter directly by holding it up to a source of light (window, overhead light, etc.).

NOTE

Due to contact potential, the fiber may "spring" off zero when dosimeter is removed from charger. If this initial reading is objectionable (according to step 4.1.1 above), repeat the zeroing procedures making allowance for the extent of the expected "spring" of the fiber upon removal of the dosimeter from the charger.

4.1.2.7 Rotate potentiometer knob to switch off the charger light and replace dust cap on charging socket.

4.2 Reading of Dosimeter.

4.2.1 Read dosimeter directly, by holding it up to a light source and looking into the optical eyepiece. Readings by the user are to be made as frequently as required by the radiation levels concerned, and always at the end of the monitoring period as specified in the plant technical manual.

NOTE

Do not use charger to read dosimeters.

4.2.2 Enter dosimeter readings in appropriate form, in accordance with the plant technical manual.

4.2.3 Use dosimeter being worn and previously recorded doses to ensure that dose limits specified in the plant technical manual are not exceeded.

4.3 Off-Scale Dosimeter Reading.

4.3.1 Investigate off-scale dosimeter readings. Generally, the beta-gamma film packet in the film badge of an individual having an off-scale gamma dosimeter reading is immediately exchanged and processed, in order to determine the dose received.

NOTE

An off-scale dosimeter reading could be due to shock from dropping the dosimeter, or to excessive charge leakage through a faulty insulator.

4.4 Dosimeter-Film Badge Relationship.

4.4.1 Exchange (Method 110) and process an individual's film badge at any time that his dosimeter or his cumulative dosimeter dose record for the current film monitoring period indicates that the applicable dose limit specified in the plant technical manual has been exceeded.

4.4.2 Compare dosimeter readings with the corresponding film badge data.

4.5 Records.

4.5.1 Maintain cumulative dosimeter dose records on appropriate forms in accordance with the plant technical manual.

4.5.2 Use corresponding dosimeter records when film badges are missing, lost, or defective. In such cases, indicate (by means of footnote, or remark) that readings are from pocket dosimeters.

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION.

The plant technical manual specifies:

(a) Policy concerning wearing of dosimeters.

(b) System of dosimeter zeroing, reading, and recording at beginning and end of specified monitoring period. Specifically, this will indicate whether these functions are done by the individual user or by assigned health physics personnel.

(c) Dosimeter-indicated dose (during a given monitoring period) which will require that film badge of individual be immediately exchanged and processed.

(d) Operational, radiation exposure limits or guides.

METHOD 143

CARE AND MAINTENANCE, CHARGE-LEAKAGE TEST, AND CALIBRATION OF POCKET DOSIMETERS

1. SCOPE.

This method contains procedures for the care and maintenance, charge-leakage test, and calibration of self-reading pocket dosimeters.

2. SAMPLE.

Not Applicable.

3. APPARATUS.

Dosimeter chargers.

Gamma calibration facility.

Thermal-neutron calibration setup.

Data sheets.

Clock.

4. PROCEDURE.

4.1 Care and Maintenance.

4.1.1 Handle dosimeters with care. These instruments are delicate and relatively expensive.

4.1.2 Clean optical eyepiece of dosimeter with lens tissue paper, as often as required and just prior to its charge-leakage test and calibration. Also, visually inspect its physical (including optical) condition.

4.1.3 Contamination Check. Check dosimeters for both loose and fixed contamination, by means of procedures specified in Method 512 and according to the following schedule:

(a) Dosimeters in use; check as often as dictated by the possibility of their becoming contaminated.

(b) General dosimeters in dispensers; check on a routine weekly basis.

(c) All dosimeters; check just prior to their charge-leakage test and calibration.

4.1.4 Contaminated Dosimeters.

4.1.4.1 Replace immediately, with an equivalent dosimeter from stock, any personal or general dosimeter found to be contaminated.

4.1.4.2 Handle, set aside and label contaminated dosimeters in accordance with applicable radiological safety rules established by plant documents and in accordance with requirements of Section 200.

4.1.5 Decontamination. Decontaminate and clean dosimeters, as necessary, by removing clip and washing both the barrel and clip with soap and water Observe applicable radiological safety practices and rules. Exercise care, particularly with the charging end of the dosimeters. Follow instructions specified by manufacturer.

4.1.6 Defective Dosimeters.

4.1.6.1 Immediately replace and tag dosimeters when found to be defective. Write on tag: word "defective", nature of defect (e.g. "Broken Fiber"), date, and initials of cognizant person.

NOTE

Do not attempt corrective maintenance.
Dosimeters are hermetically sealed.
No corrective maintenance can be
performed in the field.

4.1.6.2 Handle disposition of defective dosimeters in accordance with instructions in the plant technical manual.

4.2 Charge-Leakage Test. Carry out steps 4.1.2 and 4.1.3 prior to testing dosimeters for charge leakage. Check dosimeters for charge leakage as described below:

4.2.1 Zero dosimeters according to Method 142. Record in appropriate data sheet, the date and time of zeroing and the dosimeter serial numbers.

4.2.2 Store dosimeters in a radiation-free area for a period of 24 hours (or longer). The length of this storage period should be at least as long as the longest dosimeter monitoring period, as established in the plant technical manual.

4.2.3 Read dosimeters at end of storage period, directly,

by holding each one up to a source of light (window, light fixture, etc.) and looking through the optical eyepiece.

NOTE

Do not use charger to read the dosimeters.

4.2.4 Enter dosimeter readings and date and time of reading on data sheet.

4.2.5 Determine rate of charge leakage in millirem per 24 hours, for each dosimeter given this static test and enter these values on data sheet. Also enter on data sheet, the name or initials of tester.

4.2.6 Separate those dosimeters whose rate of charge leakage exceeds 10 millirem per 24 hours. Tag each of these dosimeters as being "leaky" and mark tag with: leakage rate; "_____ mrem/24 hour static test"; date of test; and initials of tester. Do not use these dosimeters. Set them aside for further testing, or disposition, as specified in the plant technical manual.

4.3 Gamma Calibration.

4.3.1 Check dosimeters for charge leakage in accordance with procedures specified in steps 4.2. Proceed with following steps, to calibrate only those dosimeters which have successfully passed the charge-leakage test.

4.3.2 Select the value of the calibration-test dose, D, for each specific type of dosimeter to be calibrated.

For low-range (200 mr) dosimeters, a dose of 100 mr, corresponding to midscale, is the calibration-test value which is generally selected. For higher range dosimeters, the calibration-test dose can be determined on the basis of the dose range of actual interest, the calibration dose rates available, time element, and other operational factors involved. It is not absolutely necessary that the calibration dose correspond to midscale. Record selected values of D on appropriate dosimeter-calibration data sheet.

4.3.3 Determine the current value of the gamma exposure dose rate, R, (in mr/hr or R/hr) at the dosimeter calibration positions on the fixed-geometry calibration setup. These values are determined from data obtained during an actual calibration of the dose rates at these points, carried out on a known date. See Method 123 for details. Enter pertinent data and computations (if any) on calibration data sheet.

4.3.4 Use the following equation to compute the required exposure time, t:

$$t \text{ (hours)} = \frac{D \text{ (r)}}{R \text{ (r/hour)}}$$

Where D = the value of the desired dose for the calibration test, in roentgens, selected in step 4.3.2.

R = Current exposure dose rate (r/hr) at the calibration point, as determined in step 4.3.3

D and R may also be expressed in units of mr. Enter computations and values of t on data sheet.

4.3.5 Zero dosimeters, as specified in Method 142. Enter on calibration data sheet the serial numbers of dosimeters to be calibrated, and their initial readings (which should normally be zero).

4.3.6 Place dosimeters in their calibration positions in the calibration setup.

CAUTION

The source must be in its shielded container when this step is carried out. See Method 123 for radiological safety aspects concerned.

4.3.7 Start exposure of dosimeters. This is at the time the source begins irradiating at its designated, fixed location in the calibration setup.

4.3.8 Note and record starting time of exposure. Use accurate clock for measuring exposure time, t. Alarm type (darkroom) timer may be used in conjunction with clock to alert operator when end of exposure is near.

4.3.9 Stop exposure at the end of the required exposure time, t, by removing point source from exposure

position and replacing it in its shielded container; or by replacing shielded plug of the broad-beam calibration range. Record on data sheet the time of end of exposure.

NOTE

For self-contained, specially designed dosimeter calibrator, exposure of a dosimeter is normally stopped by removal of the dosimeter from the calibration hole in the calibrator. Refer to specific instructions provided with such a calibrator.

4.3.10 Remove dosimeters from the calibration setup. Read dosimeters right away. Record final readings in the appropriate column of the calibration data sheet. Compute and record on data sheet, the dosimeter-indicated doses (i.e., final reading minus initial reading).

4.3.11 Use the data obtained above and the following equation to compute the percent deviation for each dosimeter calibrated.

$$\text{Per Cent Deviation} = \frac{(\text{Dosimeter Indicated Estimated Dose}) - (\text{Actual Dose Received})}{(\text{Actual Dose Received})} \times 100$$

where the dosimeter estimated dose and the actual dose received are expressed in the same units.

4.3.12 Record computed results on data sheet. Use plus or minus sign as appropriate.

4.3.13 Immediately tag every dosimeter whose per cent deviation exceeds the allowable limits of - 10% to + 20%. Mark on the tag: "faulty"; calibration date; per cent deviation; and initials of person who performed the calibration. Do not use these dosimeters. Set them aside for further testing, or disposition, as indicated in the plant technical manual.

EXAMPLE

Dosimeter calibration data for low-range (200 mr) self-reading dosimeter:

(a) Selected calibration test dose,
D = 100 mr.

(b) Known dose rate, R, at calibration position = 250 mr/hr.

(c) Calibration exposure time,
$t = \frac{D}{R} = \frac{100 \text{ mr}}{250 \text{ mr/hr}} = 0.4 \text{ hour} =$
$0.4 \text{ hr} \times \frac{60 \text{ min}}{1 \text{ hr.}} = 24 \text{ min.}$

(d) Initial dosimeter reading = 0 mr.

(e) Actual dose received = R x t =
250 mr/hr x 0.4 hr = 100 mr = D.

(f) Final reading = 75 mr.

(g) Dosimeter-Indicated Dose = 75 - 0 = 75 mr.

(h) Per cent deviation = $\frac{75 - 100}{100} \times 100 = -25\%$.

(i) Action: The percent deviation of this dosimeter exceeded the allowable limits of -10% to +20%. It was therefore immediately tagged and set aside in accordance with step 4.3.13 above.

4.4 Thermal Neutron Calibration.

Thermal neutron calibration of the 200 millirem thermal-neutron pocket dosimeter involves the use of a specially designed thermal-neutron calibration device. The thermal-neutron dose rate, R (millirem/hour), at each of the dosimeter calibration locations is known from an actual calibration of the device; and these values are stated in the calibration certificate of the device. Follow written procedures specifically prepared for the use of such a device. Except for the difference in the type of calibration source, however, the procedure for calibrating the thermal-neutron dosimeters is identical to the gamma calibration procedure specified

in steps 4.3 above.

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION.

The plant technical manual specifies:

(a) Length of longest dosimeter monitoring period.

(b) Frequency of charge-leakage tests and calibration.

(c) Maximum allowable charge-leakage for static and shake tests.

(d) Disposition of defective dosimeters.

SECTION 200 - RADIOACTIVE MATERIALS CONTROL

The shipment of radioisotopes should be made in accordance with Interstate Commerce Commission Regulations and with any further specific restrictions of authorized distributors of radioactive material. The formal regulations include interstate rail, truck, and water transportation. Transportation by air operates under an interim arrangement.

Each laboratory or institution should have a central, controlled storage location for incoming isotope shipments. Minimum amounts of active material necessary for the intended processing should be taken from this store and any excess promptly returned after the operation. Movements of millicurie or greater amounts should be governed by written transfers. Each laboratory supervisor is then made aware of the total activity problem in his group. Transfers from the central store to each laboratory should be made in properly shielded containers, and liquid shipments should be protected against spills. Within the laboratory, the active material shall be kept in a designated safe work place. Transfers from one place to another should be reduced to a minimum, and when necessary should be made with shielding adequate to protect all personnel in the laboratory. The general rules for such shielding may be deduced from the regulations prescribed for the shipment of isotopes outside the laboratory.

METHOD 211

STORAGE OF RADIOACTIVE MATERIAL

1. SCOPE.

The purpose of this method is to describe the requirements for storage of radioactive material.

2. SAMPLE.

Not Applicable.

3. APPARATUS.

Not Applicable.

4. PROCEDURES.

4.1 Storage Area Requirements.

4.1.1 Radioactive materials shall preferably be stored in specifically designated separate rooms or buildings secured against unauthorized entry and used only for the storage, inventory, inspection, and movement of radioactive materials as is necessary.

4.1.2 When separate storage facilities are not available, a suitable controlled area may be designated by the plant OIC. Existing non-radioactive storage facilities may be utilized for radioactive storage, provided the material is isolated from other stock and is kept within fire resistant buildings or within fire resistant enclosures secured against unauthorized entry.

4.1.3 Based upon approval of the Officer In Charge, certain materials may be stored in isolated outdoor areas. These areas shall be suitably posted, and containers of materials shall be protected against the weather.

4.1.4 Radioisotopes in which a gas is formed in the decay cycle, such as radium which decays to the gas radon, shall not be stored in the same room or other enclosure with other radioisotopes. Areas containing a source of such radioactive gas shall be continually ventilated to the outside atmosphere, either by mechanical means or natural cross-ventilation. Filters or scrubbing devices shall be installed wherever the possibility exists that radioactive gases will be released to the environment in concentrations in excess of maximum permissible limits. (Small sources such as instrument check sources should be exempted from the provisions of this paragraph.)

4.1.5 Access to storage areas shall be restricted to assure that unauthorized personnel cannot enter a radiation area. Only authorized personnel shall be allowed to enter the storage area. Control of access to storage areas for radioactive materials will usually be delegated to the health physicist. The duration of occupancy to these areas shall be kept to a minimum.

4.1.6 Storage areas for radioactive material shall be established by procedures specified in Methods 711 thru

716, particularly Method 714.

4.1.7 If it is not possible to store contaminated equipment or equipment with induced activity in a regular controlled radioactive materials storage area, establish a controlled area with limited access and post according to methods specified in Method 712, paragraph 4-3.

4.1.8 Radiological surveys as per Method 511 shall be made when there are major changes in types, quantities, or arrangement of radioactive materials in a storage area, to evaluate the degree of hazard and develop operational controls. Radiation surveys of the storage areas should also be made on a routine basis.

4.2 Storage of Sources.

4.2.1 Storage of radioactive material involves shielding the radioactive material when it is not being used, so that it will not be a personnel exposure problem. The amount and type of shielding will depend on the amount and type of source.

4.2.2 Unless adequately shielded by concrete, as in a storage well, neutron sources shall be stored in marked paraffin containers lined with cadmium or equivalent neutron absorbing material.

4.2.3 Gamma sources used for instrument calibration shall be stored in suitably shielded and marked containers or source wells, which shall be individually locked or stored in a

locked vault.

4.2.4 Unsealed radiation sources, other than contaminated equipment and equipment with induced activity, should be protected during storage against shock and the spread of contamination through accidental breakage of the container. Foam cushions under the source and pans with absorbent material generally should be provided for an unsealed liquid source (including stoppered or glass sealed vials). Temporary shielding of lead brick or sheet may be used for reasonable periods of time provided it affords adequate shielding of personnel in the vicinity. In no case may sources, no matter how small, be stored in general purpose drawers of desks or tables or personal effects lockers. While being used, unsealed sources with detectable levels of external gamma radiation may be stored behind a temporary shield of lead brick or lead sheet in the radiation fume hood.

4.2.5 Only sources internal to various instruments may be kept in unlocked storage when not in use.

4.2.6 All source containers shall be marked with appropriate radiation tags giving type, strength of source, date received, dose rate at surface of container and the calibration date.

4.3 Contaminated Equipment and Equipment with Induced Activity.

4.3.1 Equipment with loose contamination should be wrapped in polyethylene and completely sealed.

4.3.2 Equipment that has only induced activity need not be wrapped in polyethylene. However, be certain that the equipment contains no hard-to-reach surfaces, which may contain loose contamination that could dislodge and contaminate the storage area.

4.3.3 The equipment shall be tagged with the appropriate radiation tags. These tags shall give the radiation or the contamination levels, persons surveying, and time of survey. (See Method 251).

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION.

6.1 Plant technical manual specifying definite storage areas.

6.2 Reference (3) of Reference Section and other applicable AR's, EM's, training directives and plant documents.

6.3 A possession limit shall be established for each installation and radiation area within the installation.

6.4 Items which can be placed under a general license in accordance with U. S. Atomic Energy Commission Rules and Regulations, 10 CFR, Part 30, Paragraph 30.70 and those containing not over one (1) microcurie of radium are exempt from those storage requirements listed in 4.1.1 and 4.1.2 except where the total quantity in one location exceeds 10 such items.

6.5 Wherever feasible no gamma source shall indicate greater than 20 millirem per hour at the surface of the storage

container or pig.

6.6 Dimensioned sketches of all source storage area floor plans should be appended to the plant technical manual.

METHOD 212

INVENTORY TECHNIQUES FOR RADIOACTIVE MATERIALS WITHIN THE PLANT

1. SCOPE.

The purpose of this method is to describe the recommended inventory techniques for radioactive materials.

2. SAMPLE.

Not Applicable.

3. APPARATUS.

Not Applicable.

4. PROCEDURES.

4.1 The purpose of establishing specific inventory techniques for radioactive materials is to verify the presence of accountable radioactive materials and to prevent their loss.

4.2 The inventory should be taken by the accountability officer or by his representative.

4.3 The inventory should be taken quarterly.

4.4 The inventory should verify that all sources are physically accounted for.

4.5 A locater file system should be used to insure continuing information on all radiation sources.

4.6 This file system should contain the following information about the source:

(a) Type.

(b) Amount.

(c) Encapsulated or prepared.

(d) Supplier.

(e) Date received.

(f) Inventory.

(g) Where stored.

(h) Purpose.

(i) Date of leak test and results.

(j) Ultimate disposal.

4.7 An inventory should also be kept of materials and equipment that have induced activity or that cannot be adequately decontaminated. This inventory should include; type of material or equipment, when stored, type of contamination, levels of radiation and contamination, and ultimate disposal.

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION.

6.1 Plant technical manual specifying inventory procedures.

6.2 Other applicable AR's, EM's, training directives and plant documents.

METHOD 221

TRANSFER AND HANDLING OF SEALED SOURCES

1. SCOPE.

The purpose of this procedure is to describe the technique used to transfer and handle sealed sources.

2. SAMPLE.

Not Applicable.

3. APPARATUS.

Sealed source.

Lead source containers (pigs).

One, six-foot, remote handling tool.

High range, gamma survey instrument.

Radiation and High Radiation Area Signs.

Film Badges.

Dosimeters.

Radiation barrier rope.

Hand cart for source transfer.

4. PROCEDURES.

4.1 Notify health physics before transferring source from one area of plant to another.

4.2 If source is to be exposed, health physics shall issue a Radiation Work Permit in accordance with Method 731, if required.

4.3 The transfer of the source and source container (if more than approximately 25 lbs.) shall be accomplished by placing them to the desired area. This will eliminate the possibility of back strain and droppage.

4.4 Radiation Area.

If the source is of sufficient strength to create a "radiation area" or "high radiation area" when exposed, the provisions of Method 712 and Method 713 will apply and the operation will be covered by a radiation work permit.

4.4.1 Do not open source container without radiation monitoring.

4.4.2 Before the source is exposed, caution should be observed that the source is not within 150 feet of any alarm system detectors. If this is not possible, notify the shift supervisor that a source will be exposed in the vicinity of the alarm system detector.

4.4.3 Use remote handling tool to handle isotopes of an activity higher than 25 mr/hr at contact. The source shall never be handled with the bare hands. Stand back as far as possible and reach into the container with the remote handling tool, remove the source and place it in the source holder as quickly as possible.

4.5 Complete the work which has been scheduled in as short a time as possible. It should be planned in advance so that

the exposure time is held to a minimum.

4.6 Personnel shall remain away from the source as far as practical at all times.

4.7 Local shielding shall be used as much as possible.

4.8 Survey meters must be available for frequent monitoring.

4.9 When the source is no longer needed, replace it in its container using the handling tool. Replace and lock lid.

4.10 Return the source to the original storage area.

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION

Not Applicable.

METHOD 222

TRANSFER AND USE OF UNSEALED SOURCES AND ISOTOPES WITHIN THE PLANT

1. SCOPE.

The purpose of this method is to describe the use and transfer of unsealed sources and isotopes. For the purpose of this method, the term unsealed sources and isotopes will be used interchangeably. The rules of transfer and use will be the same.

2. SAMPLE.

Unsealed source of solid, liquid, or gas.

3. APPARATUS.

Same as Method 221, paragraph 3, and in addition:

Absorbent paper.

Radiochemistry laboratory; hoods, benches, and auxiliary equipment.

Five gallon cans.

Polyethylene bottles.

Absorbent paper.

Polyethylene bags and sheeting.

Low range beta gamma survey meters.

Gas cylinder.

Gas cylinder cart.

4. PROCEDURES.

4.1 Liquid Isotopes.

4.1.1 Transfer all liquid isotopes within the plant in polyethylene bottles. These bottles in turn shall be placed in a double polyethylene bag.

4.1.2 If the source or isotope is above 20 mr/hr on contact, it shall be placed in a leadlined box or equivalent for transfer from one plant area to another.

4.1.3 Occasionally eight and sixteen liter samples will be drawn for crud analysis. These samples shall be transferred in polyethylene bottles. The bottles shall be placed in five gallon cans with handles. The cans shall be lined with two layers of polyethylene sheeting. The cans may then be hand-carried by two people or placed on a cart and brought to their destination.

4.2 Solid Isotopes.

4.2.1 Transfer solid isotopes or unsealed sources by placing them in a small lead source container. The size of the lead source container will depend upon the radiation emitted from the source.

4.3 Gaseous Isotopes.

4.3.1 Gases are used for calibration purposes.

4.3.2 Gases will always be received from the manufacturer in sealed cylinders. The gases stored in these cylinders will not be a radiation exposure problem provided the valves

remain properly closed.

4.3.3 The method of transporting the gas from one part of the plant to another will depend largely on the size of the cylinder. Small cylinders can be easily moved by hand. However, when the cylinders become heavy and hard to manage by hand, they shall be transported in a regular gas cylinder cart with chain. The gas shall be released only under the direction of a health physicist and then in minimum quantities.

4.4 Procedures for Health Physicist.

4.4.1 Monitor the operation when an isotope is first withdrawn from a new shipment.

4.4.2 Specify the monitoring equipment to be worn by isotope users. The isotope user shall wear a film badge and dosimeter at all times while working with isotopes. It is desirable that personnel dosimetry be provided for the hands if the hands will be frequently exposed to radiation fields in excess of 250 mr/hr.

4.4.3 Monitor the room frequently, where isotopes are used or stored.

4.4.4 Monitor exposure of person making isotope withdrawal and usage, using the appropriate portable survey equipment.

4.4.5 Check back frequently during the use of the isotope to see that personnel radiation safety is being maintained.

4.5 Procedures for Isotope Users.

4.5.1 Notify the health physicist when about to withdraw the first portion of isotopes from shipment, or make the first use of them.

4.5.2 Keep and transport materials in such a manner as to prevent breakage or spillage. Use tongs to handle isotopes of an activity higher than 10 mr/hr on contact.

4.5.3 Do not eat, drink, or smoke in rooms where isotopes are stored or being used.

4.5.4 Keep unused isotopes in a shielded safe.

4.5.5 Never pipette by mouth.

4.5.6 Use exhaust hoods at all times, except when there is no possibility of radioactive materials becoming airborne.

4.5.7 Keep laboratory neat and clean. The work area should be free from equipment and materials not required for the immediate procedure.

4.5.8 Use trays or absorbent paper, or both, over bench tops and in hoods to collect material in the event of a spill.

4.5.9 Notify the health physicist immediately in the event of a spill.

4.5.10 Wash hands and arms thoroughly and monitor hands before handling any object which goes to the mouth,

nose, and eyes. Wash hands whenever leaving the work area after handling radioactive materials.

4.5.11 Self Monitoring. Each isotope user is responsible for monitoring his own hands, clothing, shoes and any other part of his person that may be contaminated. If an alpha emitter has been used, monitor with an alpha radiation survey meter. Monitoring is mandatory before handling and eating food and at the end of the work day.

4.5.12 Notify the health physicist when work with the isotope is complete, so that the health physicist may monitor the work area and equipment for contamination and assist in storing isotopes in the radiation safe.

4.5.13 The isotope user will always monitor himself when work with the isotope is completed.

5. RESULTS AND COMPUTATIONS.

Not Applicable

6. TEST METHOD IMPLEMENTATION

The plant technical manual specifies special criteria to be followed prior to transfer and use of unsealed sources within the plant.

METHOD 223

CONTROL OF EQUIPMENT WITH CONTAMINATION OR RADIATION READINGS

1. SCOPE.

The purpose of this method is to specify the techniques used to control equipment with contamination or radiation readings in order to eliminate the spread of contamination and limit personnel exposure to radiation.

2. SAMPLE.

Contaminated equipment or equipment with high radiation reading.

3. APPARATUS.

Same as Method 221 and Method 222, paragraph 3.

4. PROCEDURES.

4.1 All equipment that has been decontaminated or is being moved from a controlled area shall be smeared and instrument surveyed as per Methods 511 and 512 before any action is taken and labeled in accordance with Method 251.

4.2 After survey, one of the following courses of action shall be taken:

4.2.1 Unconditional Release: A piece of equipment may be unconditionally released for use in any uncontrolled area, provided the plant criteria for such release are met.

4.2.2 Regulated Release. A piece of equipment may be released from one controlled area to another. Regulated release of equipment may be permitted when its contamination levels do not exceed the smear limits within the controlled area to which it is to be released. The equipment shall be tagged with the proper tag as shown in Method 251. The tag shall show the date of the survey, the name of the person who made the survey, and the radiation and contamination levels of the equipment.

NOTE

It is not necessary to decontaminate the equipment when it is being put back into or used on a contaminated system unless it is required for radiation safety reasons during maintenance and repair of the system.

4.3 Identify with radiation tape or radiation markers, all portable tools and small equipment continually used in surface contamination or airborne radioactivity areas. The components shall be stored in these areas. Contaminated non-portable process equipment shall be so designated and the radiation symbol shall be painted permanently on the equipment, where practical.

4.4 Do not use janitorial equipment used in clean areas in regions of possible contamination. Special janitorial

equipment, properly identified, shall be used exclusively in contaminated and controlled areas.

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION

The plant technical manual specifies limits for unconditionally released, regulated released and contaminated equipment.

METHOD 231

PREPARATION OF RADIOACTIVE MATERIAL FOR SHIPMENT FROM THE PLANT

1. SCOPE.

This method describes the general procedure to be used in preparation of radioactive material for shipment from the plant.

2. SAMPLE.

Radioactive material to be shipped off site.

3. APPARATUS.

Radiation survey instrument; low range beta-gamma instrument and alpha instrument, if needed.

Smears for radiation survey.

One-gallon, metal, paint container.

Five-gallon, metal, paint container.

Vermiculite or other absorbent materials.

Labels: I.C.C. Labels and appropriate radiation warning signs as specified in Method 251.

Appropriate metal, wood, or cardboard containers for shipping radioactive materials.

A log book which will contain a record of all shipments.

Polyethylene bottles and caps.

4. PROCEDURES.

4.1 The responsibility for arranging for the shipment of radio-

active materials off-side or off-post is assigned by Army Regulations to the transportation officer or his equivalent in the directorate of services.

4.2 All outgoing shipments of radioactive material must be approved by the health physicist and dropped from accountability. The health physicist will assure that packages are prepared to meet the following requirements: (a) Packaging standards, (b) Quantity limitations, (c) Radiation level limits, and (d) Marking and labeling.

4.2.1 Packaging Standards.

4.2.1.1 Containers will be tightly sealed and able to withstand the rigorous treatment incident to transportation.

4.2.1.2 The smallest dimension of any outside container will not be less than 4 inches.

4.2.1.3 Liquid radioactive materials will be packed in tight glass, earthenware, plastic, or other suitable container which is surrounded by a neutral material able to absorb the liquid contents.

4.2.2 Quantity Limitations.

4.2.2.1 Package Limitations.

4.2.2.1.1 Surface and Air Transportation

(a) 2.0 curies (2000 mc) for radium (RA), plutonium (PU)

or other members of the radium family.

(b) 300 curies for cobalt (Co)60, cesium (Cs)137, or iridium (Ir)192.

(c) 2.7 curies (2700 mc) for all other radioactive material.

4.2.2.2 U. S. Mail.

Packages must not exceed exempt shipment limits described in paragraph 4.2.2.3 below. Postal service size and weight limits must be observed. Any package bearing an ICC label is not mailable. Mailable packages should be registered and return receipt requested.

4.2.2.3 Exempt Shipment Quantity Limitations.

Shipments are exempt from prescribed Federal packaging, labeling and marking requirements, other than proper shipping name, providing they do not exceed radiation level limitations shown in 4.2.3.2 below and the following quantity limits:

(a) The package must be such that there can be no leakage of radioactive material under conditions normally incident to transportation.

(b) Package contains not more than 0.1 mc of RA or Po; or 0.135 mc of Sr 89, 90 or Ba 140; or 1.35 mc of any other radioactive material.

4.2.3 Radiation Level Limits.

4.2.3.1 Outside Containers.

4.2.3.1.1 No smearable surface contamination.

4.2.3.1.2 Surface dose rates less than 200 mrem/hr.

4.2.3.1.3 Dose rate at one meter less than 10 mrem/hr. Dose rate at 15 feet less than 0.45 mrem/hr.

4.2.3.2 Exempt Shipments Radiation Levels.

4.2.3.2.1 No significant alpha, beta, or neutron radiation, and gamma radiation at package surface will be less than 0.4 mrem/hr.

4.2.3.2.2 No smearable surface contamination.

4.2.3.3 Empty Container Previously Used For Radioactive Materials.

4.2.3.3.1 Empty containers previously used for radioactive materials must conform to standards for exempt shipments.

4.2.4 Marking and Labeling.

4.2.4.1 The proper shipping name must also be included on exempt shipments.

4.2.4.2 Name and address of consignee must be included.

4.2.4.3 DA label 15 is applied according to Method 251.

4.2.4.4 Red (radioactive materials) label (surface or air transportation) is applied if the surface dose rate equals or exceeds 0.4 mrem/hr, but is ≤ 200 mrem/hr from gamma and beta or if a neutron emitter is present (for label see Method 251).

4.2.4.5 Blue (radioactive materials) label (surface or air transportation) is applied if the surface dose rate is less than 0.4 mrem/hr and the activity exceeds exempt shipment limits (for label see Method 251).

4.2.4.6 U. S. Mail. No label; radiation symbol may be used. Marked as follows: Radioactive Material-Gamma Radiation at Surface of Parcel less than 10 millirem for 24 hours - No Significant Alpha, Beta, or Neutron Radiation.

4.2.4.7 Empty containers. Old markings and labels will be obliterated, destroyed or covered by an "Empty" label.

4.2.4.8 ICC labels must not be applied to exempt shipments.

4.3 The health physicist shall monitor shipments for radioactivity before, during, and after packaging. The shipment should be smear and instrument surveyed, following the procedures as specified in Methods 511 and 512.

4.4 The health physicist shall verify that the radioactive material has been properly prepared and labeled.

4.5 Package, label, and mark in compliance with applicable requirements specified in 4.2.

4.6 Before approving shipment to other installations, the health physicist must be satisfied that the consignee is fully informed of any hazards, and that he has an AEC license to handle the radioactive material.

4.7 Shipments containing radioactive materials normally belong to one of the following five major groups.

4.7.1 Equipment to be processed and returned to the plant.

4.7.2 Equipment and materials not to be returned.

4.7.3 Empty containers which have contained radioactive materials.

4.7.4 Radioactive samples for analysis.

4.7.5 Radioactive waste.

4.8 Equipment to be processed and returned to the plant shall meet the ICC Regulations and the requirements which are apecified in 4.2.

4.9 Equipment not to be returned to the plant shall also conform to the ICC Regulations.

4.10 Empty containers.

4.10.1 Empty containers which have previously been used for the shipment of radioactive materials and may be reused shall be shipped back to the owner upon his request.

4.10.2 The inside of these containers may remain contaminated;

however, the consignee shall be notified of this condition.

4.10.3 Inspect and monitor contamination on the inside of the container. There shall be no loose or liquid contaminants. If explosive, toxic, or suffocating vapors are present, sufficient inert gas must be added to render the vapors harmless. Close all openings tightly, including removable heads and filling and vent holes, before transporting the container.

4.10.4 The amount of radioactive contamination on the containers is limited by what the receiver is willing to accept and by the ICC regulations. The container must meet the shipment levels as specified in 4.2.3 above.

4.10.5 Instruct shipper to remove old "radioactive material" labels or cover labels completely with "empty" labels of required size.

4.10.6 Instruct shipper to note on his bill of lading "Empty containers which have contained radioactive materials."

4.10.7 Instruct shipper to directly notify consignee if contamination remains inside the container.

4.11 Radioactive liquid samples for analysis.

4.11.1 Place sample in polyethylene bottle and seal cap with paraffin or electrical tape.

NOTE

The 500 ml sample bottles shall be

placed in one-gallon, metal, paint containers. 500 ml, or larger, sample bottles shall be placed in five-gallon, metal, paint containers.

4.11.2 Fill the container half-full with vermiculite or other absorbent material.

4.11.3 Monitor the sample bottle for radiation and contamination before packaging, and tag it with proper labels as specified in Method 251.

4.11.4 Place sealed sample bottle in container.

4.11.5 Fill the container up with vermiculite or other absorbent material.

4.11.6 Lead solder the lid of the container closed.

4.11.7 Verify that the shipment has the prior approval of the recipient and that he is informed of all hazards. Verify that the recipient has the appropriate license and can handle the material to be shipped.

4.11.8 Monitor shipping package for compliance with regulations as specified in Method 231.

4.11.9 Apply radioactive material labels as specified in Method 251.

4.12 Radioactive Waste Shipment.

Radioactive Waste Shipment is handled thoroughly in Methods 431 thru 435. However, the shipping regulations will

generally be the same as for other radioactive materials as stated in 4.2 above.

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION.

The plant technical manual implements the departmental directives.

METHOD 241

REGULATIONS FOR THE PROCUREMENT, CONTROL, TRANSPORTATION AND DISPOSAL OF RADIOACTIVE MATERIALS

1. SCOPE.

The purpose of this method is to describe those Army Regulations and Atomic Energy Commission Rules and Regulations which are directive on Army Commanders within the gen ral subject area of health physics.

2. SAMPLE.

Not Applicable.

3. APPARATUS.

Not Applicable.

4. PROCEDURES.

4.1 References (4) through (7) in the Reference Section contain directive material relating to the function and responsibilities of health physicists at nuclear power plants.

4.2 The Atomic Energy Commission Rules and Regulations contain certain directive material relating to the function and responsibilities of health physicists at nuclear power plants.

4.2.1 U. S. Atomic Energy Commission Rules and Regulations. These rules are incorporated in Chapter 1 of Title 10 of the Code of Federal Regulations. Matters relating to The Code Of

Federal Regulations are published in the FEDERAL REGISTER, a daily publication of the U. S. Government.

4.2.2 Copies of the U. S. Atomic Energy Commission Rules and Regulations may be obtained without charge by contacting the U. S. Atomic Energy Commission, Washington D.C. 20545.

4.2.3 The following parts of Title 10 of The Code Of Federal Regulations are most applicable to the health physicist's function and responsibility: (a) 10 CFR Part 20. Standards For Protection Against Radiation, and (b) 10 CFR Parts 30 through 36. Licensing Of Byproduct Material (Recodified, 17 December 1964).

4.2 4 Army Regulations require military activities to conform to appropriate provisions of Title 10 (See para. 1, AR 40-14).

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION.

The plant technical manual implements appropriate directives, as necessary.

METHOD 251

LABELING AND MARKING OF RADIOACTIVE MATERIALS

1. SCOPE.

The purpose of this method is to define Radioactive Materials and to illustrate the different type of signs and labels used to mark radioactive materials. This section does not include Radioactive Materials Area, High Radiation Area, Radiation Area, Surface Contamination Area, and Airborne Radioactivity Area Signs. These signs are included in AR 385-30.

2. SAMPLE.

Not Applicable.

3. APPARATUS.

I.C.C. Blue Label (DA Label 70).

I.C.C. Red Label (DA Label 52).

"Caution Radioactive Materials" Label (DA Label 15).

Radiation Warning Label (DA Label 26).

"Material Released to Uncontrolled Area" Tag (USAERG Form 14).

"Material Released to Controlled Area Only" Tag (USAERG Form 15).

4. PROCEDURES.

This section of the procedures provides illustrations of the various labels used to mark radioactive material and radioactively contaminated items. These labels warn personnel that radioactive

materials are present and should be approached and handled with care.

4.1 Interstate Commerce Commission Labels will be used when shipping Radioactive Materials off the site. The general rules governing their use are listed in Method 231. The Labels are illustrated in Figures 251-1 and 25'-2.

Figure 251-1. Red Label (Class I and Class II). See Section 230.

Figure 251-2. Blue Label (Class III)

4.2 Figures 251-3 and 251-4 illustrate Radiation Labels for Radioactive Materials Containers, and may also be used as a supplement to area signs.

Caution: Radioactive materials

Radioisotope _____

Activity _____

Date measured _____

DA LABEL 1 JUL 60 15 PREVIOUS EDITION OF THIS LABEL IS OBSOLETE.

Figure 251-3. "Caution Radioactive Materials" Label.

4.3 The tags in this section are for equipment and tools being

released from controlled areas.

4.3.1 The tag shown in Figure 251-4 is for clean equipment which may be released to any area.

Date _____ No. _____

MATERIAL
RELEASE FROM
CONTROLLED AREA

Article: _____

Surveyed For _____
LAST NAME FIRST MI

SURVEY READING

Contact Reading _____

Smear Test _____

_____
SURVEYOR DATE

THE ABOVE ARTICLE IS APPROVED FOR RELEASE TO ANY UNCONTROLLED AREA

_____
HEALTH PHYSICS SUPERVISOR DATE

_____
SUPERINTENDENT DATE

USAERDG Form 14
18 Aug 61

4 - 34,080 - ARMY - FORT BELVOIR, VA.

Figure 251-4. "Material Released to Uncontrolled Area" Tag.

4.3.2 The tag shown in Figure 251-5 is for equipment that may be released only from one controlled area to a second controlled area.

Date _____ No. _____

CONTAMINATED MATERIAL RELEASE FROM CONTROLLED AREA

Article: _____

Requested By: _____
LAST NAME FIRST MI

SURVEY RESULTS

Contact Reading _____

Smear Test _____

_____
SURVEYORS SIGNATURE DATE

WARNING

THE ABOVE ARTICLE IS APPROVED ONLY FOR REGULATED RELEASE TO OTHER CONTROLLED AREAS

_____
HEALTH PHYSICS SUPERVISOR DATE

_____
SUPERINTENDENT DATE

USAEDG Form 15
15 Aug 61 -4- —67.375—Ft Belvoir

Figure 251-5. "Material Released to Controlled Area Only" Tag.

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION.

6.1 The criteria for the use of signs is stated in AR 385-30.

6.2 The plant technical manual will include labeling materials that are not covered in Army Regulations but that, nevertheless, should be labeled to warn plant personnel that radioactive materials are present.

APPENDIX A.

A.E.C. Forms

1. Instructions and Application Form for Application of Source Material License Form A.E.C.-2.

2. Instruction and Form for Preparation of Application for Byproduct Material LIcense Form A.E.C.-313.

Form AEC-2a
(2-61)

UNITED STATES ATOMIC ENERGY COMMISSION

INSTRUCTIONS FOR PREPARATION OF APPLICATION FOR SOURCE MATERIAL LICENSE FORM AEC-2

GENERAL INSTRUCTIONS

1. An applicant for a Source Material License should complete Form AEC-2 in detail. The completed application must be filed in quadruplicate with the United States Atomic Energy Commission, Washington 25, D.C., Attention: Director, Division of Licensing and Regulation. Applications may also be filed in person at the Commission's Public Document Room at 1717 H Street, NW., Washington, D.C., or the Commission's office at Germantown, Md.

   The information required to complete Form AEC-2 must be typewritten or printed clearly in ink.

2. The regulations which govern the issuance of a Source Material License are contained in Title 10, Code of Federal Regulations, Chapter 1, Part 40.

3. An applicant may incorporate by reference information contained in previous applications, statements or reports filed by the applicant with the Commission's Division of Licensing and Regulation: Provided, that such references are clear and specific, and there has been no change from the information previously submitted.

4. Supplemental sheets should be used when necessary to supply the required information. The applicant's name and address and the item number in Form AEC-2 to which the supplemental information applies should be indicated on each supplemental sheet.

5. The Commission may at any time after the filing of the original application, and before the expiration of the license, require further statements in order to enable the Commission to determine whether the application should be granted or denied or whether a license should be modified or revoked.

6. Information and documents submitted to the Commission to complete an application will be made available for public inspection in accordance with the provisions of the Commission's regulations in Title 10, Code of Federal Regulations, Chapter 1, Parts 2 and 9.

7. Information which is classified as Restricted Data or which the applicant requests be withheld from public disclosure must be submitted in accordance with the provisions of 10 CFR § 2.790, "Rules of Practice."

8. Item 15 must be completed on all applications.

9. Submission of an incomplete application will result in a delay in the processing of the application because of correspondence necessary to request the omitted information.

PLEASE REMOVE THIS INSTRUCTION SHEET BEFORE SUBMITTING APPLICATION

FORM AEC-2
(2-61)
Previous editions are obsolete.

FORM APPROVED
BUREAU OF BUDGET NO. 38-R608.8.

UNITED STATES ATOMIC ENERGY COMMISSION

APPLICATION FOR SOURCE MATERIAL LICENSE

Pursuant to the regulations in Title 10, Code of Federal Regulations, Chapter 1, Part 40, application is hereby made for a license to receive, possess, use, transfer, deliver or import into the United States, source material for the activity or activities described.

1. (Check one)
- ☐ (a) New license
- ☐ (b) Amendment to License No. _____
- ☐ (c) Renewal of License No. _____
- ☐ (d) Previous License No. _____

2. NAME OF APPLICANT

3. PRINCIPAL BUSINESS ADDRESS

4. STATE THE ADDRESS(ES) AT WHICH SOURCE MATERIAL WILL BE POSSESSED OR USED

5. BUSINESS OR OCCUPATION

6. (a) IF APPLICANT IS AN INDIVIDUAL, STATE CITIZENSHIP

(b) AGE

7. DESCRIBE PURPOSE FOR WHICH SOURCE MATERIAL WILL BE USED

8. STATE THE TYPE OR TYPES, CHEMICAL FORM OR FORMS, AND QUANTITIES OF SOURCE MATERIAL YOU PROPOSE TO RECEIVE, POSSESS, USE, OR TRANSFER UNDER THE LICENSE

(a) TYPE	(b) CHEMICAL FORM	(c) PHYSICAL FORM (*Including % U or Th.*)	(d) MAXIMUM AMOUNT AT ANY ONE TIME (*in pounds*)
NORMAL URANIUM			
URANIUM DEPLETED IN THE U-235 ISOTOPE			
THORIUM			

(e) MAXIMUM TOTAL QUANTITY OF SOURCE MATERIAL YOU WILL HAVE ON HAND AT ANY TIME (*in pounds*)

9. DESCRIBE THE CHEMICAL, PHYSICAL, METALLURGICAL, OR NUCLEAR PROCESS OR PROCESSES IN WHICH THE SOURCE MATERIAL WILL BE USED, INDICATING THE MAXIMUM AMOUNT OF SOURCE MATERIAL INVOLVED IN EACH PROCESS AT ANY ONE TIME, AND PROVIDING A THOROUGH EVALUATION OF THE POTENTIAL HAZARDS ASSOCIATED WITH EACH STEP OF THOSE OPERATIONS.

10. DESCRIBE THE MINIMUM CHNICAL QUA /ICATIONS INCLUDING TRAINING AND EXPERIENCE THAT WILL BE REQUIRED OF APPLICANT'S SUPERVISORY PERSONNEL INCLUDING PERSON RESPONSIBLE FOR RADIATION SAFETY PROGRAM (OR OF APPLICANT IF APPLICANT IS AN INDIVIDUAL).

11. DESCRIBE THE EQUIPMENT AND FACILITIES WHICH WILL BE USED TO PROTECT HEALTH AND MINIMIZE DANGER TO LIFE OR PROPERTY AND RELATE THE USE OF THE EQUIPMENT AND FACILITIES TO THE OPERATIONS LISTED IN ITEM 9: INCLUDE: (a) RADIATION DETECTION AND RELATED INSTRUMENTS (including film badges, dosimeters, counters, air-monitoring and other survey equipment as appropriate. The description of radiation detection instruments should include the type of radiation detected and the range(s) of each instrument.)

(b) METHOD, FREQUENCY, AND STANDARDS USED IN CALIBRATING INSTRUMENTS LISTED IN (a) ABOVE (for film badges, specify method of calibrating and processing, or name supplier.)

10—70665-1

11(c). VENTILATION EQUIPMENT WHICH WILL BE USED IN OPERATIONS WHICH PRODUCE DUST, FUMES, MISTS, GASES, ETC.

12. DESCRIBE PROPOSED PROCEDURES TO PROTECT HEALTH AND MINIMIZE DANGER TO LIFE AND PROPERTY AND RELATE THESE PROCEDURES TO THE OPERATIONS LISTED IN ITEM 9; INCLUDE:
(a) PROCEDURES FOR USE OF NUCLEAR MATERIALS AND SAFETY FEATURES AND PROCEDURES TO AVOID NONNUCLEAR ACCIDENTS, SUCH AS FIRE, EXPLOSION, ETC., IN SOURCE MATERIAL STORAGE AND PROCESSING AREAS.

(b) EMERGENCY PROCEDURES IN THE EVENT OF ACCIDENTS WHICH MIGHT INVOLVE SOURCE MATERIAL.

(c) DETAILED DESCRIPTION OF RADIATION SURVEY PROGRAM AND PROCEDURES.

13. WASTE PRODUCTS: *If none will be generated, state "None" opposite (a), below. If waste products will be generated, check here* ☐ *and explain on a supplemental sheet:*

(a) Quantity and type of radioactive waste that will be generated.

(b) Detailed procedures for waste disposal.

14. IF PRODUCTS FOR DISTRIBUTION TO THE GENERAL PUBLIC UNDER AN EXEMPTION CONTAINED IN 10 CFR 40 ARE TO BE MANUFACTURED, USE A SUPPLEMENTAL SHEET TO FURNISH A DETAILED DESCRIPTION OF THE PRODUCT, INCLUDING:

(a) PERCENT SOURCE MATERIAL IN THE PRODUCT AND ITS LOCATION IN THE PRODUCT.

(b) PHYSICAL DESCRIPTION OF THE PRODUCT INCLUDING CHARACTERISTICS, IF ANY, THAT WILL PREVENT INHALATION OR INGESTION OF SOURCE MATERIAL THAT MIGHT BE SEPARATED FROM THE PRODUCT.

(c) BETA AND BETA PLUS GAMMA RADIATION LEVELS (*Specify instrument used, date of calibration and calibration technique used*) AT THE SURFACE OF THE PRODUCT AND AT 12 INCHES.

(d) METHOD OF ASSURING THAT SOURCE MATERIAL CANNOT BE DISASSOCIATED FROM THE MANUFACTURED PRODUCT.

CERTIFICATE

(This item must be completed by applicant)

15. *The applicant, and any official executing this certificate on behalf of the applicant named in Item 1, certify that this application is prepared in conformity with Title 10, Code of Federal Regulations, Part 40, and that all information contained herein, including any supplements attached hereto, is true and correct to the best of our knowledge and belief.*

_____
(Applicant named in Item 1)

Dated _____ BY: _____

_____
(Title of certifying official authorized to act on behalf of the applicant)

WARNING: 18 U.S.C. Section 1001; Act of June 25, 1948; 62 Stat. 749; makes it a criminal offense to make a willfully false statement or representation to any department or agency of the United States as to any matter within its jurisdiction.

U.S. GOVERNMENT PRINTING OFFICE 16—76469-1

Form AEC-313b (M)
(11-63)
10 CFR 30

UNITED STATES
ATOMIC ENERGY COMMISSION

INSTRUCTIONS FOR PREPARATION OF APPLICATION FOR BYPRODUCT MATERIAL LICENSE FORM AEC-313 and 313a

GENERAL INFORMATION

An applicant for a "Byproduct Material (Radioisotopes) License" should complete Form AEC-313 in detail. The applicant should endeavor to cover his entire radioisotope program with one application, if possible. However, separate applications should be submitted for medical teletherapy and gamma irradiators. Supplemental sheets may be appended when necessary to provide complete information. *Item 16 must be completed on all applications. Submission of an incomplete application will often result in a delay in issuance of the license because of the correspondence necessary to obtain information requested on the application.*

NOTE.—When the application includes one of the special uses listed below, the applicant should request the appropriate pamphlet which provides additional instructions:

1 Industrial Radiography—"Licensing Requirements for Industrial Radiography;"

2 Teletherapy—"Licensing Requirements for Teletherapy Programs;"

3 Broad License (research and development)—"Licensing Requirements for Broad Licenses for Research and Development;" and

4 Broad License (medical uses)—"Licensing Requirements for Broad Medical Use."

The Form AEC-313a should be completed in detail each time a medical request is made for a human use of radioisotopes. Three copies of the completed Form AEC-313 and 313a (if a medical application) should be sent to the Isotope Branch, Division of Licensing and Regulation, U.S. AEC, Washington, D.C., 20545. One copy should be retained for the applicant's file.

EXPLANATION OF FORM AEC-313

Item No.

1 (a) The "applicant" is the organization or person legally responsible for possession and use of the byproduct material specified in the application.

(b) Indicate other address(es) at which byproduct material will be used if different from that listed in 1(a). A post office box number is not acceptable.

2 The "department" is the department or similar subdivision where the byproduct material will be used.

3 Self-explanatory.

4 The "individual user" is the person experienced in use and safe handling of radioisotopes. *If the application is for "human use," the individual user must be a physician licensed by a State or Territory of the United States to dispense drugs in the practice of medicine and have extensive experience for each proposed clinical use.*

5 Self-explanatory.

6 (a) List by name each radioisotope desired, such as "Carbon 14," "Cobalt 60," etc.

(b) List chemical and/or physical form for each radioisotope and the quantity of each which the applicant desires to possess at any one time. If more than one chemical or physical form of a particular radioisotope is desired, a *separate* possession limit should be stated for each form. For example, an applicant desiring to use two chemical forms of Iodine 131 must specify both forms and a possession limit for *each* form. Example:

Iodine 131	Iodide	10 millicuries
Iodine 131	Iodinated Human Serum Albumin	1 millicurie
Krypton 85	Gas	1000 millicuries

If the byproduct material is to be obtained as a sealed source(s), specify the manufacturer, model number, and amount of activity in each sealed source. Example:

Cobalt 60	3 Sealed Sources, 100 mc each (*Iso Corp.* Model Z-54)	300 millicuries

7 State the use of each byproduct material and chemical form specified in Item 6(a) and (b). If the radioisotope is for "human use," *do not complete this item; complete Form AEC-313a, Supplement A—Human Use.*

8-9 These items must be completed for each individual named in Item 4. If more than one individual is listed in Item 4, clearly key the name of each individual to his experience.

10-16 Self-explanatory.

Form AEC-313 (11-63) 10 CFR 30	ATOMIC ENERGY COMMISSION **APPLICATION FOR BYPRODUCT MATERIAL LICENSE**	Form approved. Budget Bureau No. 38-R027.4.

INSTRUCTIONS.—Complete Items 1 through 16 if this is an initial application. If application is for renewal of a license, complete only Items 1 through 7 and indicate new information or changes in the program as requested in Items 8 through 15. Use supplemental sheets where necessary. Item 16 must be completed on all applications. Mail three copies to: U.S. Atomic Energy Commission, Washington, D.C., 20545, Attention: Isotopes Branch, Division of Licensing and Regulation. Upon approval of this application, the applicant will receive an AEC Byproduct Material License. An AEC Byproduct Material License is issued in accordance with the general requirements contained in Title 10, Code of Federal Regulations, Part 30 and the Licensee is subject to Title 10, Code of Federal Regulations, Part 20.

1. (a) NAME AND STREET ADDRESS OF APPLICANT. (Institution, firm, hospital, person, etc.)	(b) STREET ADDRESS(ES) AT WHICH BYPRODUCT MATERIAL WILL BE USED. (If different from 1 (a).)
2. DEPARTMENT TO USE BYPRODUCT MATERIAL	3. PREVIOUS LICENSE NUMBER(S). (If this is an application for renewal of a license, please indicate and give number.)
4. INDIVIDUAL USER(S). (Name and title of individual(s) who will use or directly supervise use of byproduct material. Give training and experience in Items 8 and 9.)	5. RADIATION PROTECTION OFFICER (Name of person designated as radiation protection officer if other than individual user. Attach resume of his training and experience as in Items 8 and 9.)

6. (a) BYPRODUCT MATERIAL. (Element and mass number of each.)	(b) CHEMICAL AND/OR PHYSICAL FORM AND MAXIMUM NUMBER OF MILLICURIES OF EACH CHEMICAL AND/OR PHYSICAL FORM THAT YOU WILL POSSESS AT ANY ONE TIME. (If sealed source(s), also state name of manufacturer, model number, number of sources and maximum activity per source.)

7. DESCRIBE PURPOSE FOR WHICH BYPRODUCT MATERIAL WILL BE USED. (If byproduct material is for "human use," supplement A (Form AEC-313a) must be completed in lieu of this item. If byproduct material is in the form of a sealed source, include the make and model number of the storage container and/or device in which the source will be stored and/or used.)

(Continued on reverse side)

Form AEC-313 (11-63) Page Two

TRAINING AND EXPERIENCE OF EACH INDIVIDUAL NAMED IN ITEM 4 (Use supplemental sheets if necessary)

8. TYPE OF TRAINING	WHERE TRAINED	DURATION OF TRAINING	ON THE JOB (Circle answer)	FORMAL COURSE (Circle answer)
a. Principles and practices of radiation protection			Yes No	Yes No
b. Radioactivity measurement standardization and monitoring techniques and instruments			Yes No	Yes No
c. Mathematics and calculations basic to the use and measurement of radioactivity			Yes No	Yes No
d. Biological effects of radiation			Yes No	Yes No

9. EXPERIENCE WITH RADIATION. *(Actual use of radioisotopes or equivalent experience.)*

ISOTOPE	MAXIMUM AMOUNT	WHERE EXPERIENCE WAS GAINED	DURATION OF EXPERIENCE	TYPE OF USE

10. RADIATION DETECTION INSTRUMENTS. *(Use supplemental sheets if necessary.)*

TYPE OF INSTRUMENTS *(Include make and model number of each)*	NUMBER AVAILABLE	RADIATION DETECTED	SENSITIVITY RANGE *(mr/hr)*	WINDOW THICKNESS *(mg/cm²)*	USE *(Monitoring, surveying, measuring)*

11. METHOD, FREQUENCY, AND STANDARDS USED IN CALIBRATING INSTRUMENTS LISTED ABOVE.

12. FILM BADGES, DOSIMETERS, AND BIO-ASSAY PROCEDURES USED. *(For film badges, specify method of calibrating and processing, or name of supplier.)*

INFORMATION TO BE SUBMITTED ON ADDITIONAL SHEETS

13. FACILITIES AND EQUIPMENT. Describe laboratory facilities and remote handling equipment, storage containers, shielding, fume hoods, etc. Explanatory sketch of facility is attached. (Circle answer) Yes No

14. RADIATION PROTECTION PROGRAM. Describe the radiation protection program including control measures. If application covers sealed sources, submit leak testing procedures where applicable, name, training, and experience of person to perform leak tests, and arrangements for performing initial radiation survey, servicing, maintenance and repair of the source.

15. WASTE DISPOSAL. If a commercial waste disposal service is employed, specify name of company. Otherwise, submit detailed description of methods which will be used for disposing of radioactive wastes and estimates of the type and amount of activity involved.

CERTIFICATE (This item must be completed by applicant)

16. THE APPLICANT AND ANY OFFICIAL EXECUTING THIS CERTIFICATE ON BEHALF OF THE APPLICANT NAMED IN ITEM 1, CERTIFY THAT THIS APPLICATION IS PREPARED IN CONFORMITY WITH TITLE 10, CODE OF FEDERAL REGULATIONS, PART 30, AND THAT ALL INFORMATION CONTAINED HEREIN, INCLUDING ANY SUPPLEMENTS ATTACHED HERETO, IS TRUE AND CORRECT TO THE BEST OF OUR KNOWLEDGE AND BELIEF.

_____
Applicant named in Item 1

Date _____ By: _____

_____
Title of certifying official

WARNING.—18 U. S. C., Section 1001, Act of June 25, 1948, 62 Stat. 749, makes it a criminal offense to make a willfully false statement or representation to any department or agency of the United States as to any matter within its jurisdiction.

* U.S. GOVERNMENT PRINTING OFFICE : 1965 O—780-405

SECTION 300 - DECONTAMINATION

The fundamental purposes of protective measures in the handling of radioisotopes are as follows:

(1) To prevent ingestion, inhalation, interstitial, or other types of absorption into the body.

(2) To reduce the amounts of external radiation to tolerable levels.

The first requirement is fulfilled by good housekeeping and work habits, and by operation in a laboratory properly equipped for the handling of isotopes, including protective covering, manipulative devices, suitable ventilation, and waste disposal facilities. The second requirement, maintenance of satisfactory levels of external radiation, is covered in the following Section.

METHOD 311

SURVEYS

1. SCOPE.

The purpose of this method is to describe the surveys which will be taken during decontamination operations.

2. SAMPLE.

Contaminated areas, tools, and equipment.

3. APPARATUS.

Smears; 1" or 2" diameter filter paper.

Portable, radiological survey instruments; beta, gamma (high and low level), and alpha instrument (if needed).

Portable, air sampler.

Protective clothing as specified in Method 821.

Protective Respiratory Equipment as specified in Methods 831 thru 836.

Personnel Monitoring equipment as specified in Method 111 and in Methods 141 thru 143.

4. PROCEDURES.

4.1 All personnel performing surveys or working on contaminated components shall wear protective clothing and protective respiratory equipment as specified in Method 821 and in Methods 831 thru 836.

4.2 All personnel surveying or working on contaminated com-

ponents shall wear personnel monitoring equipment as specified in Method 111 and Methods 141 thru 143.

4.3 Perform radiological surveys on all areas, components, and equipment prior to decontamination, using techniques as outlined in Methods 511 thru 515 in order to evaluate hazards and permit initiation of the precautionary measures required.

NOTE

When health physics surveys are being made, a determined effort shall be made to reach hard-to-get-at surfaces of valves, pipes, and other components.

4.4 Perform additional, radiological surveys during the decontamination work to determine the effectiveness of the operation as well as to re-evaluate the hazards and precautionary measures required.

4.5 Keep radiological survey records of external radiation and loose, surface contamination prior to and after the decontamination operation to determine the effectiveness of the decontamination process.

4.6 Perform radiological surveys on the decontamination area and the cleaning equipment itself after the decontamination process has been completed.

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION.

The plant technical manual specifies contamination limits for all areas, tools, and equipment for: (a) release of tools and equipment to a clean area, (b) conditional release to a controlled area, (c) contaminated equipment and tools to be held for decay and cleared, (d) area specification for clean areas and surface contamination areas, and (e) protective clothing and protective respiratory equipment.

METHOD 312

PRELIMINARY WASHDOWN

1. SCOPE.

The purpose of this method is to describe the procedures used to prewash tools and equipment prior to any type of decontamination.

2. SAMPLE.

Tools or equipment to be decontaminated.

3. APPARATUS.

A decontamination room or area which can be segregated from other areas.

Benches covered with stainless steel or plastic, on which the contaminated equipment can be dismantled, cleaned, and assembled.

3.3 Sinks equipped with radiation fume hoods in which contaminated equipment may be soaked, swabbed, and scrubbed.

3.4 Protective clothing and equipment as specified in Method 821 and Methods 831 thru 836.

3.5 Plant water supply is adequate for secondary system and tool decontamination.

3.6 Demineralized water is required for all wash and rinse solution used for primary reactor plant component decontamination. The quality shall be as follows: Distilled or deionized water of not more than 10 ppm total solids with a chloride content

not greater than 1 ppm and a resistivity of not less than 50,000 Ohm-cm.

3.7 Detergent solution. This solution may be employed for the preliminary washdown of a component to remove loose contamination. The solution shall consist of 0.1 to 1.0 ounce of nonionic detergent per gallon of water. It should be used at a temperature in the preferred range of 150°F to 180°F.

3.8 Ethyl alcohol or isopropyl alcohol.

3.9 Scrubbing materials.

3.9.1 Hand brushes or motor-driven brushes made with bristles of synthetic fiber, tampico or corrosion resisting steel wire (size 0.0140 inch or finer).

3.9.2 Lint-free cloths, synthetic or natural sponges, corrosion resistant steel wool (grade 000 or finer).

3.9.3 Abrasive material as loose particles or as coating on a cloth or sponge. Materials shall be silica, alumina, silicon carbide, pumice or lava stone of 150 mesh or smaller particle size.

4. PROCEDURES.

4.1 Immerse the component to be decontaminated in a tank of water.

4.2 If the component was received enclosed in a plastic cover and is highly contaminated, if possible, remove the cover under water, and dispose of cover as solid radioactive waste.

4.3 Remove component and let excess water drain back into tank.

4.4 Disassemble for decontamination, if necessary.

4.5 Survey external radiation, using Methods 511 and 512.

4.6 Immerse component in a tank containing detergent and water. Mix solution in accordance with 3.7 above.

4.7 Soak 10 minutes.

4.8 Scrub with synthetic fiber and tampico brushes. Cloths and sponges may also be used. No other abrasive agents shall be used.

4.9 Items shal. remain immersed in this solution for a period of up to two hours with intermittent scrubbing.

4.10 Remove items from solution and allow excess solution to drain off for several minutes.

4.11 Rinse in tank of water.

4.12 Remove item from rinse tank and permit excess water to drain for several minutes.

4.13 Dry each item using clean, unused, lint-free cloths.

4.14 If tools and components are not from the primary system, ordinary tap water will be satisfactory for wash and rinse solutions.

4.15 Survey, and if further decontamination is required, use procedures outlined in Method 313.

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION.

The plant technical manual specifies the contamination limits for:

(a) release of tools and equipment to a clean area, (b) conditional release of tools and equipment to a controlled area, (c) contaminated equipment and tools to be held for decay and cleared, (d) area specification for clean areas and surface contamination areas, and (e) protective clothing and protective respiratory equipment.

METHOD 313

CHEMICAL DECONTAMINATION OF OILY, GREASY COMPONENTS

1. SCOPE.

The purpose of this method is to describe a simple method of chemical decontamination of oily and greasy components.

2. SAMPLE.

Tools or equipment to be decontaminated.

3. APPARATUS.

Apparatus specified in Method 312, Part 3.

Trisodium phosphate.

4. PROCEDURES.

4.1 Prepare the required solution by dissolving 1 pound of trisodium phosphate per gallon of water.

NOTE

At this concentration trisodium phosphate cannot be used with glass because it etches and clouds the glass by reacting with the silica in the glass. It also cannot be used with aluminum because it reacts with the aluminum.

4.2 Immerse the oily and greasy component to be decontaminated in a tank containing the solution of water and trisodium

phosphate at 160°F.

4.3 Scrub the component, using materials listed in Method 312, Part 3.9.

4.4 Remove the component from solution and allow excess solution to drain off for several minutes.

4.5 Rinse thoroughly in tank of water.

4.6 Air dry or wipe thoroughly with rags.

4.7 Monitor the component thoroughly, using techniques specified in Methods 511 and 512.

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION.

6.1 The plant technical manual specifies when the desired degree of decontamination has been achieved or that continuing the treatment is ineffective.

6.2 If this does not successfully remove oils or grease, use Method 318.

METHOD 314

CITRIC ACID DISODIUM ETHYLENE DIAMINE TETRA-ACETATE (EDTA)

1. SCOPE.

The purpose of this method is to describe the use of the Citric Acid-Disodium Ethylene Diamine Tetra-Acetate (EDTA) Process for decontamination of primary reactor plant components. It may also be used for tools and auxiliary system components.

2. SAMPLE.

Tools or equipment to be decontaminated.

3. APPARATUS.

Same as that specified in Method 312 and in addition:

Disodium EDTA.

Citric Acid.

Sodium Hydroxide

NOTE

All chemicals used in decontamination of primary components shall be certified or Reagent grade.

4. PROCEDURES.

4.1 If the monitoring results from the preliminary washdown are available, monitoring need not be done before using the Citric Acid Disodium EDTA method. If the results are not available,

monitor the component thoroughly, using techniques outlined in Methods 511 and 512.

4.2 Treatment with the citric acid-disodium EDTA solution should precede all other chemical decontamination operations except preliminary washdown. (See Method 312.) If equipment which requires decontamination is oily and greasy, steam cleaning should precede chemical cleaning. (See Method 318.)

4.3 Mix the citric acid-disodium EDTA solution in proportions and conditions indicated in the following table:

Citric Acid - Disodium EDTA Process

Disodium EDTA	1 oz/gal. water
Citric Acid	1 oz/gal. water
Nonionic Detergent	0.1 - 1 oz/gal. water
pH	3.0 - 4.5
Soaking Temperature	160°F - 200°F
Soaking Time	2 - 4 hours

4.4 Adjust pH of only the initial solution with sodium hydroxide.

4.5 Soak the component in citric acid-disodium EDTA solution for approximately two to four hours.

4.6 Scrub intermittently with synthetic fiber and tampico brushes. Cloths and sponges may also be used. No other abrasive agents shall be used.

4.7 Remove item from solution and allow excess solution to drain off for several minutes.

4.8 Rinse item in tank of water.

4.9 Remove item from rinse tank and permit excess water to drain for several minutes. Rinse components of intricate geometry with alcohol.

4.10 Dry each item using clean, unused lint-free cloths.

4.11 Monitor the dried component thoroughly, using techniques specified in Methods 511 and 512. If the amount of contamination which was on the component has been reduced, repeat steps 4.5 through 4.10. If the amount of contamination has not been reduced, use other techniques specified in Methods 315 through 318.

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION.

The plant technical manual specifies when the desired degree of decontamination has been achieved or that continuing the treatment is ineffective.

METHOD 315

ALKALINE PERMANGANATE PROCESS

1. SCOPE.

The purpose of this method is to describe the use of the Alkaline Permanganate Process for decontamination of primary reactor plant components.

2. SAMPLE.

Primary reactor plant tools or equipment to be decontaminated.

3. APPARATUS.

Same as that specified in Method 312, and in addition: Disodium EDTA, Critic Acid, and Sodium Hydroxide.

NOTE

All chemicals used in decontamination or primary components shall be certified or Reagent Grade.

4. PROCEDURES.

4.1 The Alkaline Permanganate Process aids in removing or loosening an adherent oxide film and its associated contamination. It shall not be used on copper-base alloys, monel or on nitrided or chrome-plated surfaces.

4.2 Treat the component with alkaline permanganate solution, an acid cleaning solution or with both if further decontami-

nation beyond the citric acid disodium EDTA process is necessary.

4.3 Following preliminary washdown and treatment by the citric acid-disodium EDTA process (Methods 312 and 314 respectively), soak the component in the sodium hydroxide-potassium permanganate solution in the proportions and conditions indicated by the following table:

Alkaline Permanganate Process

(a) Sodium hydroxide - potassium permanganate solution:

Sodium hydroxide	13.5 oz/gal. water
Potassium permanganate	4.0 oz/gal. water
Soaking temperature	215°F to 225°F.
Soaking time	1 hour

(b) Ammonium citrate solution:

Diammonium monohydrogen citrate	13.5 oz/gal. water
Soaking temperature	190°F to 200°F
Soaking time	1 hour

4.4 Soak the component in sodium hydroxide-potassium permanganate solution for one hour.

4.5 Rinse the component with deionized water.

4.6 Soak the component in the ammonium citrate solution for one hour.

4.7 Remove item from solution and allow excess solution to drain off for several minutes.

4.8 Rinse item in tank of deionized water.

4.9 Remove item from rinse tank and permit excess water to drain for several minutes. Rinse components of intricate geometry with alcohol.

4.10 Dry each item using clean, unused, lint-free cloths.

4.11 Monitor the dried component thoroughly, using techniques specified in Methods 511 and 512.

4.12 Return the component to the citric acid-disodium EDTA solution if treatment with the alkaline permanganate process does not result in sufficient decontamination.

4.13 Perform additional soaking and scrubbing with this solution as specified in Method 314.

4.14 Monitor dry component. If the contamination has been reduced, repeat citric acid disodium EDTA process. If the amount of contamination has not been reduced, use other techniques specified in Methods 316 through 318.

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION.

The plant technical manual specifies when the desired degree of decontamination has been achieved or that continuing the treatment is ineffective.

METHOD 316

ULTRASONIC DECONTAMINATION

1. SCOPE.

The purpose of this method is to describe the use of an ultrasonic cleaning unit for decontamination of all types of tools, equipment, and components.

2. SAMPLE.

Tools or equipment to be contaminated.

3. APPARATUS.

Apparatus specified in Methods 312 and 314.

Ultrasonic cleaning equipment.

4. PROCEDURES.

4.1 Ultrasonic decontamination shall be used as an aid in chemical decontamination only after water, detergent solution, or the citric acid - disodium EDTA solution are used.

NOTE

Ultrasonic decontamination normally does not remove radioactivity embedded in adherent oxide films. It is effective in removing loose particulate contamination that may remain after a component has been treated with the alkaline permanganate process or an

acid cleaning process. It is particularly adapted to decontaminating small components which are incompletely disassembled or which have inaccessible recesses.

4.2 Immerse the component in the tank containing the water, detergent, or other decontaminating liquid and apply the ultrasonic energy for a minimum of 15 minutes.

4.3 Rotate the component within the tank from time to time to expose all surfaces to the ultrasonic vibrations.

4.4 Remove item from solution and allow excess solution to drain off for several minutes.

4.5 Rinse and dry the component. Dry small parts by rinsing with alcohol and then air drying.

4.6 Monitor the contamination remaining on the surface of the rinsed and dried component.

4.7 Repeat the ultrasonic treatment, if required, until a check of the residual radioactivity on the component surface shows that the desired degree of decontamination has been achieved, or that further treatment is not required.

4.8 Drain all waste water from the ultrasonic cleaning operations to the radioactive waste tank.

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION.

The plant technical manual specifies when the desired degree of decontamination has been achieved or that continuing the treatment is ineffective.

METHOD 317

MECHANICAL DECONTAMINATION

1. SCOPE.

The purpose of this method is to describe the use of mechanical means of decontamination for contaminated equipment.

2. SAMPLE.

Tools or equipment to be decontaminated.

3. APPARATUS.

Same as that specified in Method 312, and:

Mechanical lathe.

Grinder, bench and portable.

Files.

Vacuum cleaner with filter approved 99.9% efficient for 0.2 micron D.O.P. particle, attached to exhaust.

4. PROCEDURES.

4.1 Mechanical decontamination is the removal of a tight oxide film by means of abrasion, machining, or grinding. Mechanical decontamination is utilized in those instances where chemical decontamination proves inadequate.

4.2 When mechanical decontamination is being performed, it should be done under controlled conditions including local ventilation as required in a hot shop or a designated area and under the surveillance of a health physicist.

4.3 Provide a vacuum cleaner for removing loose chips and shavings.

4.4 Remove loose surface contamination by the procedures outlined in Methods 314 and 315 prior to undertaking any mechanical decontamination.

4.5 Remove metal in fine cuts or increments not to exceed existing component tolerances.

4.6 Constantly monitor operations, using techniques as specified in Methods 511 and 512 to insure that a minimum amount of surface metal is removed to attain the desired reduction of radiation.

4.7 Consider surface contour and physical properties of the component material in any mechanical decontamination.

4.8 Monitor work areas after completion of mechanical decontamination.

4.9 If contamination is found, decontaminate the area using techniques as specified in Methods 351 through 355.

4.10 Limited mechanical decontamination may be performed by polishing or buffing the contaminated component with an abrasive material of the type specified in Method 312, paragraph 3.9.

NOTE

Do not apply abrasive materials to critical surface finishes, nitrited surfaces, bearing

surfaces, or to components having crevices or such geometry that component surfaces may not be cleaned of the abrasives by flushing with water.

4.11 After using limited decontamination methods, use Methods 312, 314, or 316 to clean away the loose surface contamination.

4.12 Monitor the component using techniques as specified in Methods 511 and 512. If noticeable reduction of contamination has been achieved, continue carefully with the process. If no noticeable decontamination has been achieved, hold for decay, or obtain permission from the Nuclear Power Field Office to use other methods of mechanical decontamination.

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION.

The plant technical manual specifies when the desired degree of decontamination has been achieved or that continuing the treatment is ineffective.

METHOD 318

STEAM CLEANING

1. SCOPE.

The purpose of this method is to describe the use of steam cleaning for the decontamination of contaminated equipment.

2. SAMPLE.

Tools or equipment to be decontaminated.

3. APPARATUS.

Apparatus specified in Method 312, paragraph 3, and in addition:

Steam cleaning apparatus.

4. PROCEDURES.

4.1 Steam cleaning is an excellent method for the removal of loose surface contamination from equipment or components. When oily and greasy equipment cannot be decontaminated by Method 313, then steam cleaning should be done prior to chemical cleaning.

4.2 Steam cleaning shall be done in a Decontamination Area where access is completely controlled.

4.3 The following rules shall be observed during steam cleaning operations:

4.3.1 Allow only the personnel who are absolutely necessary in the area, namely the decontamination crew and health physicist.

4.3.2 Before starting, adjust the steam pressure to eliminate backscatter and attain maximum cleaning ability.

4.3.3 Station all personnel in the area behind the nozzle while the cleaning is being done.

4.4 Post and isolate the area where the cleaning is to be done to prevent spread of contamination to other areas and to eliminate the possibility of personnel entering the area unexpectedly.

4.5 Connect the steam cleaning nozzle and hose either directly to a steam line with a pressure regulator or a steam cleaning unit which regulates the pressure from 40 to 150 psi and mixes a detergent with the steam.

4.6 Perform the steam cleaning either in a large tank or in large flat pans in order to collect the cleaning solution and confine the spread of contamination.

4.7 Rinse the equipment with deionized water after steam cleaning, or wash with a detergent solution and then rinse with water.

4.8 Mix the detergent solution in the following proportions:

10 ounces citric acid

1 ounce detergent (non-ionic)

10 ounces EDTA

10 gallons of water

4.9 After rinsing, allow excess water to drain for several

minutes.

4.10 Air dry the component or wipe with lint-free cloths.

4.11 Monitor component thoroughly, using techniques specified in Methods 511 and 512.

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION

The plant technical manual specifies when the desired degree of decontamination has been achieved or that continuing the treatment is ineffective.

METHOD 321

DECONTAMINATION OF SKIN

1. SCOPE.

The purpose of this method is to describe the procedures used to decontaminate the skin.

2. SAMPLE.

Not Applicable.

3. APPARATUS.

Decontamination sinks connected to radioactive waste system.

Showers connected to radioactive waste system.

Radiac instrument for personnel monitoring. (Stationary monitor or portable low range beta-gamma and alpha survey instrument, if needed).

Laundry hampers.

Waterproof containers.

Absorbent paper.

Absorbent cotton, cotton-tipped swabs, gauze pads.

Protective clothing as specified in Method 821 and Methods 831 thru 836.

Fingernail or hand brushes and tongue blades.

Water.

Liquid soap, titanium dioxide, potassium permanganate, sodium acid sulfite, EDTA (sodium salt).

Aqueous preparations for decontamination:

Commercial detergent (10 percent)

One percent citric acid solution.

Chelating agent (one percent versene solution) with or without detergent.

Waterless detergents.

Cornmeal and commercial powdered detergent in equal parts made into a water paste and used without additional water.

Waterless mechanic's handcream used without additional water.

Homogenized cream of 8 percent carboxy methyl cellulose, 3 percent commercial powdered detergent, 1 percent versene and 88 percent distilled water used without additional water.

Smears, 1" or 2" diameter.

4. PROCEDURES.

4.1 All personnel working within the installation shall be instructed to notify health physicists immediately if they become contaminated. They shall know the steps in personnel decontamination in case health physicists cannot be reached. The steps shall be printed on cards and placed in a conspicuous location in the areas set aside for personnel decontamination areas.

4.2 Monitor the skin area with a suitable survey meter if

immediately available, and record all readings.

NOTE

If a survey instrument is not immediately available and a person is suspected of being contaminated, do not delay. Wash immediately!

4.3 One or two inch filter paper smears may be used in place of the monitoring instrument. Exercise care when taking smears, being careful not to bear down on the skin and thus push the contamination into the skin.

4.4 Count the smears on the appropriate counting systems in accordance with Method 631.1.

4.5 Use cotton-tipped swabs for detection of activity in nostrils, ear canals, mouth and other orifices. Exercise care as in 4.3.

4.6 If possible, cover clean areas of the skin to prevent the spread of radioactive materials.

4.7 Procedures for washing contaminated body surfaces shall be carried out in the areas designated, using the showers and sinks provided for personnel decontamination.

4.8 Washing with water alone, or even scrubbing, usually has been found to be moderately effective in removing contamination. Organic solvents should not be used as they may

increase skin penetration by the contaminant.

4.9 Wash thoroughly for 2-3 minutes by the clock. Use tepid (not hot) water and detergent solution (para. 3.12) or soap. Cover the entire contaminated surface with a good lather.

4.10 Rinse off completely with running water. This process may be repeated, but not to exceed four times.

4.11 Do not use abrasive or highly alkaline soaps or powders.

4.12 Monitor the skin area between washes.

4.13 If the above procedure does not remove all dirt and contamination, scrub the skin for a period of 8-10 minutes by the clock, using liquid or mild low alkaline cake soap, hand brush and tepid water.

4.14 Exert light pressure on the brush, but not so much that the bristles are bent out of shape.

4.15 There shall be at least three complete changes of soap and water.

NOTE

In most instances the hands become contaminated more often than the rest of the body. Techniques 4.8 through 4.15 will apply to all skin areas including the hands. Techniques 4.16 through 4.19 will apply specifically to decontamination of the hands.

4.16 Cover all surfaces with a minimum of four brush strokes using soap. Start by scrubbing one thumb, being certain to brush all surfaces, and then proceed to the web space between the thumb and index finger, and similarly over the other fingers.

NOTE

If monitoring pinpoints only one small area, concentrate efforts on this area.

4.17 Scrub the palm and back of the hand next.

4.18 Each nail and cuticle shall be similarly scrubbed. Rinse the hand thoroughly and check with a survey meter.

4.19 Apply an emollient (softening) cream.

4.20 Where water is limited in quantity, the waterless detergents listed in 3.13 may be used.

4.21 After application, scrub with a brush and remove detergent with absorbent cotton or soft tissue.

4.22 Whenever there is alpha contamination, use citric acid and chelating agents in the same manner as the procedure for cleaning with a detergent solution.

4.23 Discard the brushes, towels, and other used decontaminating materials into a radioactive waste can or bag, suitably labeled.

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION.

The plant technical manual specifies when the desired degree of decontamination has been achieved or that continuing the treatment is ineffective. The degree of contamination desired for personnel should be non-detectable wherever possible.

METHOD 322

DECONTAMINATION OF EYES, EARS, NOSE, AND MOUTH

1. SCOPE.

   The purpose of this method is to describe the procedures used to decontaminate eyes, ears, nose, and mouth.

2. SAMPLE.

   Not Applicable.

3. APPARATUS.

   Apparatus specified in Method 321, as required.

   Water.

4. PROCEDURES.

   4.1 When radioactive materials have contaminated the eyes, flush the eyes with large amounts of water.

   4.2 While flushing the eye, roll back the eyelid as far as possible, in order to flush as completely as possible.

NOTE

If isotonic irrigants are available, obtain them without delay and administer to the eye as directed under competent medical supervision. An isotonic solution is one which has nearly the same concentration of inorganic salts as do the body fluids.

Recommended use: Where dilute saline solution is the irrigant, apply to the eye continually and then flush with large amounts of water.

4.3 Do not use eye cups! Eye cups will hold the contaminant and re-irrigate the eye with the contaminants.

4.4 Decontaminate the ears, nose, and mouth with caution by flushing with large amounts of water in the same manner as for the eyes.

4.5 Monitor the ears, nose, and mouth and other orifices in the manner specified in Method 321, Parts 4.2 thru 4.5.

4.6 Any further decontamination shall be done under the supervision of competent medical personnel with guidance of health physics personnel.

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION.

The plant technical manual specifies when the desired degree of decontamination has been achieved or that continuing the treatment is ineffective. The degree of contamination for personnel should be at a level which is non-detectable whenever possible.

METHOD 323

CHEMICAL REMOVAL OF HARD TO REMOVE CONTAMINANTS

1. SCOPE.

The purpose of this method is to describe the use of chemicals in the removal of hard-to-remove contaminants from personnel.

2. SAMPLE.

Not Applicable.

3. APPARATUS.

Same as Method 321, Part 3.

4. PROCEDURES.

4.1 Decontamination by use of chemicals shall always be done under the surveillance of a health physicist. The procedures in this method will be applicable to the hands and other parts of the body. They shall not be used from the neck up or in the region of the gonads or anus.

4.2 Monitor contaminated personnel using procedures outlined in Method 321, Parts 4.2 thru 4.5.

4.3 Titanium dioxide may be obtained as a paste or powder and shall be applied as outlined below.

4.4 The paste must be prepared by mixing precipitated titanium dioxide in a very thick slurry (never permitted to dry) with a small amount of lanolin.

4.5 Mix the slurry by applying water to the paste or powder.

Spread slurry onto contaminated area.

4.6 Run tap water over the area sparingly so that the paste is kept wet, and apply this lather thoroughly to all surfaces, for at least two minutes.

4.7 Rinse off thoroughly with lukewarm water and follow with a thorough washing with soap and water and a hand brush. If any of the paste is left, it will form a rather hard cake which is difficult to remove.

4.8 Monitor the contaminated skin area thoroughly, using techniques specified in Methods 511 and 512.

4.9 Where the titanium dioxide process is unsuccessful, proceed as follows:

4.9.1 Prepare a saturated solution of potassium permanganate. Apply the solution over the area, rubbing the entire surface and using a hand brush for not more than two minutes.

NOTE

This application will remove a layer of skin if allowed to remain in contact with the hands too long; consequently, the time stated here should not be exceeded for any single application.

Be sure that all areas are thoroughly covered. Rinse with warm water and proceed as outlined below.

4.9.2 Mix a fresh 5 percent solution of sodium acid sulfite ($NaHSO_3$). Pour the solution over the area, rubbing the entire surface and using a hand brush and tepid water for not more than two minutes. Wash with soap and water, and rinse thoroughly.

4.9.3 The procedures outlined above may be repeated twice, provided the permanganate solution is not applied for more than two minutes during any one washing and no damage is done to the skin.

4.9.4 Application may be facilitated by the use of swabs steeped in the solution.

4.9.5 Apply lanolin or handcream after washing.

4.9.6 Monitor after each washing to estimate the efficiency of the method.

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION.

The plant technical manual specifies when the desired degree of decontamination has been achieved or that continuing the treatment is ineffective. The degree of contamination desired for personnel should be non-detectable whenever possible.

METHOD 324

DECONTAMINATION OF WOUNDS

1. SCOPE.

The purpose of this method is to describe simple methods of wound decontamination.

2. SAMPLE.

Not Applicable.

3. APPARATUS.

Same as Method 321, Part 3.

4. PROCEDURES.

4.1 Radioactive material shall not be handled by people who have wounds, abrasions, or open areas of the skin unless such areas can be completely covered with a non-absorbent covering.

4.2 All decontamination of wounds shall be done under the surveillance of trained health physicists.

4.3 Wash wound with copius amounts of water and spread edges of wound in order to stimulate bleeding where bleeding is not profuse.

4.4 If the bleeding is profuse, a quick cleaning around the edges of the wound will be sufficient. In this instance, stopping the bleeding is the first and foremost concern.

4.5 Get medical help as quickly as possible.

4.6 Any long table provides an excellent area for such work for

patients who are bleeding profusely. Lay the patient on the table to aid in the prevention of shock.

4.7 Stop the bleeding immediately with a pressure dressing or a tourniquet. The person applying a tourniquet must know the precautions to be observed. Stopping the bleeding in this case is more important than decontamination.

4.8 When the wound is closed by dressing or sutured by a doctor, isolate the wound and decontaminate the rest of the body area using regular techniques.

4.9 Puncture wounds should be treated by a competent knowledgeable physician. There is a problem not only with radioactive contamination but also with tetanus.

4.10 Monitor the wound to determine the amount of decontamination needed.

4.11 If possible, survey object which caused injury to determine degree of contamination. Injury may be dried by blotting with a towel which may be saved for future survey. Record wound and towel survey results as necessary.

4.12 If medical facilities are not available at a particular site, prior arrangements should be made with one or more local hospitals to provide emergency care when needed.

4.13 In such situations, gross decontamination by removal of clothing shall be carried out at the accident site and the individual given necessary first aid.

4.14 The patient shall be transported to the hospital wrapped in a sheet and blanket and definitive decontamination shall then be done at the hospital.

4.15 If an arrangement is made with a hospital, the hospital must have a thorough knowledge of decontamination techniques and waste disposal methods. If it does not, a health physicist must accompany the patient to the hospital.

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION.

6.1 The plant technical manual specifies when the desired degree of decontamination has been achieved or that continuing the treatment is ineffective. The degree of contamination desired for personnel should be non-detectable whenever possible.

6.2 For severe wounds which involve radioactive contamination, the plant technical mamual should state:

6.2.1 The procedures to be used in taking the injured person to a military hospital.

6.2.2 The procedures to be used in taking the injured person to a local non-military hospital with which prior arrangements have been made.

6.2.3 The procedures to be used in case the patient must be evacuated to a military or non-military hospital from a remote plant site.

METHOD 325

LAUNDERING OF PROTECTIVE CLOTHING

1. SCOPE.

The purpose of this method is to describe the procedures to be used in laundering the various types of protective clothing.

2. SAMPLE.

Contaminated protective clothing.

3. APPARATUS.

Shoe covers, rubber, plastic, or cloth.

Rubbers.

Coveralls.

Lab coats.

Head covers.

Hoods.

Gloves, rubber, plastic, and cloth.

Plastic suits.

Portable survey monitors and laundry monitors.

Washing machine (commercial).

Dryer (commercial).

Laundry detergent.

Laundry hampers.

Citric acid.

4. PROCEDURES.

4.1 Personnel doing the laundering shall wear protective clothing as specified in Method 821 and Methods 831 thru 836, and shall wear personnel monitoring equipment as specified in Method 111 and Methods 141 thru 143.

4.2 Monitor all protective clothing with appropriate instruments (a low level beta-gamma and an alpha instrument, if necessary).

4.3 Separate rubber shoe covers, rubber gloves, and plastic items from outer protective clothing. Washing of plastic and rubber gloves and shoe covers shall be done as specified in 4.11 below.

4.4 If laundry has been previously separated and bagged, monitor the bag externally and tag it accordingly.

4.5 If all protective clothing, uncontaminated and contaminated is to be washed in the same machine, smear survey the washing machine and dryer before starting wash cycle.

4.6 Divide protective clothing into three groups: uncontaminated, slightly contaminated, and grossly contaminated. Follow the same procedure for plastics, shoe covers, and rubbers.

4.7 Wash the clothes found to be clean first. Wash the clothes which are slightly contaminated next, and wash the highly contaminated clothes last.

4.8 Wash the contaminated clothing in the washing machine using laundry detergent. Use as directed by manufacturer's

instructions.

4.9 Upon occasion some clothing may be grossly contaminated. Washing with other clothes may grossly contaminate the other clothes and the washer. Soak the highly contaminated clothing separately with a strong detergent in a sink draining to radioactive waste. If this does not reduce the levels, the clothes should be disposed of as radioactive waste.

4.10 Occasionally clothing will be clean except for one spot, which will be grossly contaminated. This may be cut out and patched with a press patch.

4.11 Wash plastic and rubber clothing separately in lukewarm water with detergent.

4.12 After the washing cycle is completed, transfer clothing to the dryer.

4.13 Dry clothing for approximately 40 to 60 minutes or longer, depending on the amount of clothing in the dryer.

4.14 Do not dry rubber and plastic clothing in the dryer any longer than five minutes, to evaporate the water. Extended drying will harden the plastic and rubber and make them uncomfortable to wear.

4.15 Remove clothing from dryer.

4.16 Monitor the clothing with the appropriate instrument. The contamination levels shall not exceed the recommended limits specified by the plant technical manual.

4.17 Repeat the washing procedures or discard the items if the specified limits are exceeded. If the cycle is to be repeated, monitor the washing machine. If contaminated, it should be decontaminated before starting another cycle.

4.18 If necessary, decontaminate the washer with the washing detergent used for the regular laundry. Add the mixture to the washing machine and run the cycle through. Repeat several times with fresh mixtures. Monitor after each cycle. If this is not successful, the washer should be dismantled if possible and all exposed surfaces decontaminated individually using simple washing techniques.

4.19 Drain all wash water directly from the washing machine to the hold-up or waste disposal system, where it will be collected as liquid radioactive waste and treated accordingly.

4.20 Open and remove lint filter in both washer and dryer after laundering each batch.

4.21 Place contaminated lint in a plastic bag, tag with the proper tag and send to the waste disposal area for disposal as solid waste.

4.22 Clothing still contaminated after washing may be stored for future use in extremely contaminated areas, in which case it may be worn over other protective clothing. Otherwise it must be discarded as solid radioactive waste.

4.23 After the clothes have been washed, monitored, and found

to be within acceptable limits for washed clothing, they shall be stored in their respective shelves or bins on the "clean" side of the change room.

4.24 After washing contaminated clothing, the washing machine shall be thoroughly monitored and decontaminated as in step 4.18, if necessary, before a new load of clothing is washed.

4.25 Take a complete smear and instrument survey of the laundry area at the completion of each laundering period. If necessary, decontaminate the area before starting another period in order to eliminate the spread of contamination and keep the contamination on the next batch of laundry from increasing.

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION

6.1 The contamination limits for the laundry procedures will be as given in the plant technical manual.

6.2 Contamination limits will include pre-and-post laundering smear and radiac instrument readings for:

6.2.1 Clean laundry.

6.2.2 Laundry equipment.

6.2.3 Laundry slightly and grossly contaminated.

6.2.4 The laundry area.

6.2.5 Clothing which is not completely decontaminated and is to be worn over other protective clothing for

hazardous jobs.

6.3 Segregation limits for contaminated clothing before and after washing.

NOTE

The radiac instrument and smear readings will include both alpha and beta gamma readings, as necessary.

METHOD 331

DECONTAMINATION OF PROTECTIVE RESPIRATORY EQUIPMENT

1. SCOPE.

The purpose of this section is to describe the method for monitoring and decontaminating protective respiratory equipment.

2. SAMPLE.

Contaminated protective respiratory equipment.

3. APPARATUS.

Same as that specified in Method 331, and in addition:

Low level beta-gamma monitor and alpha monitor, if needed.

Clean laundry sinks with supply of hot and cold water.

Sodium hypochlorite or quaternary ammonium compound.

Clean wash cloths.

Smears, one or two inch diameter filter paper.

Clean plastic bags.

Soapless detergent.

4. PROCEDURES.

4.1 Monitoring.

4.1.1 Monitor all protective respiratory equipment after each use in a contaminated area, using techniques as specified in Methods 511 and 512. Monitor with a low level beta-gamma instrument and also with an alpha instrument, if needed.

4.1.2 When monitoring, pay particular attention to the

filter element area of the mask or respirator.

4.1.3 Give special attention to air cylinder hoses and valves when monitoring the Scott Air Pak, other self-contained breathing apparatus, and air-supplied masks.

4.1.4 Any detectable contamination in the protective respiratory equipment, no matter how small, shall be considered grounds for decontamination.

4.2 Place contaminated respirators and face masks in a plastic bag or plastic container, tag and send to the laundry area for decontamination.

4.3 If found to be clean, disinfect equipment as in 4.6.6 and store clean respirators and face masks in a clean bag or container for next use.

4.4 If the Scott Air Pak is contaminated, it should be carefully decontaminated, and when clean, recharged and stored ready for use.

4.5 If found to be clean, the Scott Air Pak need not be decontaminated but shall be disinfected as in 4.6.6, recharged, if below 1800 lbs, and then repacked ready for use.

4.6 Decontamination.

4.6.1 Collect contaminated protective respiratory equipment in the laundry area.

4.6.2 Dismantle protective respiratory equipment. Remove filters from filter holder, remove straps if

possible, and remove hoses and oxygen cylinders as required from Scott Air Paks and Supplied Breathing Masks.

4.6.3 Many types of filters cannot be decontaminated by washing. Some filters may be cleaned by wiping with a damp rag. If in doubt, consult manufacturer's literature. Contaminated filters shall be disposed of as solid radioactive waste.

4.6.4 Wash the equipment in hot water (120°F - 130°F) with a soapless detergent, using clean decontamination facilities. The washing shall be sufficient to remove all greases, oil, and dirt from the surfaces.

4.6.5 Rinse the equipment sufficiently, after washing, to remove wash water and loosened dirt.

4.6.6 Disinfect the surfaces of the face piece by adding a solution of sodium hypochlorite or quaternary ammonium compound to the last rinse. Add approximately 50 milliliters of solution to the rinse water.

4.6.7 Air dry the respirators after disinfection. Inspect the equipment for mechanical and physical defects. Inspect the filters, face assemblies, air hoses, filterholder, head straps, valves, and other parts, and replace damaged or unsatisfactory parts.

4.6.8 After reassembly, respirators shall be monitored (as specified in Methods 511 and 512), and if clean, tagged as cleared and placed in clean bags or containers ready for use.

4.6.9 If the protective respiratory equipment is still contaminated, repeat the procedures outlined above.

4.6.10 If continual washing does not reduce the contamination level, dismantle the equipment and discard all contaminated components as radioactive waste.

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION.

The contamination levels for protective respiratory equipment shall be established by the plant technical manual. However, for all intents and purposes, the levels for all parts should be so low as to be non-detectable.

METHOD 351

DECONTAMINATION OF FLOORS

1. SCOPE.

The purpose of this method is to describe the procedures used to decontaminate floors.

2. SAMPLE.

Floors contaminated with radioactive materials.

3. APPARATUS.

Mops.

Buckets with wringers.

Water.

Detergents and chelating agent.

Absorbent paper.

Vermiculite or sawdust.

Squeegee.

Rags and sponges.

Radiation rope.

Signs "Surface Contamination Area".

Refuse drums.

Plastic bags, large.

Stepladders.

Portable, steam cleaning unit (optional).

Protective respiratory equipment (see Methods 831 thru 836).

Full protective clothing (see Method 821).

Personnel monitoring equipment (see Method 111 and Methods 141 thru 143).

Vacuum cleaner with filter approved 99.9% efficient for 0.3 micron dioctyl phthalate particle, attached to exhaust.

4. PROCEDURES.

4.1 Monitor areas where radioactive materials are handled on a definite schedule, using the techniques specified in Methods 511 and 512.

4.2 Personnel doing monitoring and decontamination work shall wear protective equipment as specified in Method 821 and Methods 831 thru 836.

4.3 Personnel doing monitoring and decontamination work shall wear personnel monitoring equipment as specified in Method 111 and Methods 141 thru 143.

4.4 When a floor area has been found contaminated, it shall be roped off and decontaminated as quickly as possible.

4.5 Wash the floor thoroughly with a mop and a detergent and water. Regular commercial detergents for floor cleaning may be used.

4.6 Use a minimum amount of water and detergent, to minimize the amount of liquid waste to be treated and to do the job efficiently.

4.7 Clean floors by always starting from the outside and

cleaning toward the middle, to reduce the contaminated area.

4.8 After a thorough washing, rinse the floor with a minimum amount of water. Use a mop and clean water. The water shall be constantly changed. Rinsing may also be accomplished by using minimal amounts of water and wet vacuum pickup.

4.9 When rinsing and drying with a mop, exercise care to wipe in one direction only, to pick up as much contamination as possible with minimum redistribution.

4.10 Perform a thorough smear and instrument survey after washing, rinsing, and drying are completed. Use procedures specified in Methods 511 and 512.

4.11 Rewash the floor if the contamination level on the floor is not reduced, using a complexing agent such as Disodium EDTA equivalent.

4.12 Follow the same techniques as in the steps given above if rewashing is necessary.

4.13 If monitoring indicates that washing with Disodium EDTA and with a detergent solution has not been successful, use other techniques specified in Methods 351 thru 355.

4.14 Areas where radioactive materials are handled continually shall be on a definite monitoring, cleaning and maintenance schedule, even if they are not contaminated.

4.15 Follow the same general techniques 4.1 through 4.14 for isolated hot spots on the floor.

4.16 Equipment such as mops, buckets, and other cleaning materials used in decontamination shall be marked with radiation tape (magenta and yellow) and stored in an area properly marked with a "Radioactive Materials" sign. All personnel shall be aware of the storage location of this equipment and its use, to prevent its use in clean areas.

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION.

The plant technical manual specifies the allowable limits for surface contamination on floors, walls, and ceilings.

METHOD 352

DECONTAMINATION OF WALLS AND CEILINGS

1. SCOPE.

The purpose of this method is to describe the procedures for decontaminating walls and ceilings.

2. SAMPLE.

Contaminated walls and ceilings.

3. APPARATUS.

Same as that specified in Method 351, Part 3.

4. PROCEDURES.

4.1 Monitor wall area and ceiling using techniques specified in Methods 511 and 512.

4.2 Personnel doing monitoring and decontamination work shall wear protective clothing as specified in Methods 821 and 831 thru 836.

4.3 Personnel doing monitoring and decontamination work shall wear personnel monitoring equipment as specified in Method 111 and Methods 141 thru 143.

4.4 Ordinarily, ceilings and walls will be decontaminated only when there is a gross contamination problem in the rest of the room.

4.5 Dry vacuum-clean the wall and ceiling surface if possible before starting to wash it.

4.6 Stepladders or staging must set firmly on the floor and must be of sufficient height to allow the decontamination crew to reach the ceiling and the top of the wall easily.

4.7 The washing equipment shall consist of two pails, one with detergent and warm water, the other with clean warm water and sponges or rags.

4.8 Start the cleaning operations in the middle of the ceiling and move toward the walls. Always clean walls from top to bottom and after the ceiling has been cleaned (if necessary).

4.9 Place a sponge in the detergent and water, apply it to the ceiling. Rinse sponge in the clean water pail.

4.10 Rinsing and drying shall be done by a second individual with a large supply of clean rags, a plastic bag, and a pail of clean warm water.

4.11 Dampen the rag and wipe in one direction across the washed surface. Fold the rag so that a clean surface is exposed, and wipe in the same direction across the washed surface.

NOTE

This process of wiping in one direction and then folding the rag shall always be followed. This wiping technique will pick up as much contamination as possible and will not spread it around the washed area.

4.12 Place expended rags in the plastic bag and dispose of as solid radioactive waste.

4.13 Use wet vacuum pickup if an appropriate vacuum cleaner is available. This is a superior method of pickup to hand pickup because of its speed and efficiency.

4.14 Monitor the ceiling and walls after they have been completely cleaned according to procedures as specified in Methods 511 and 512.

4.15 Follow steps 4.7 through 4.13 for isolated hot spots.

4.16 Decontaminate any remaining contaminated areas by following the applicable steps outlined above.

4.17 Re-smear. If still contaminated, rewash or go to other methods specified in Methods 351 thru 355.

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION.

The plant technical manual specifies the allowable limits for surface contamination on floors, walls, and ceilings.

METHOD 353

STEAM CLEANING OF FLOORS, WALLS AND CEILINGS

1. SCOPE.

The purpose of this method is to describe the process of steam cleaning to remove contamination from floors, walls and ceilings.

2. SAMPLE.

Contaminated floors, walls, ceilings and surfaces of equipment.

3. APPARATUS.

Same as that specified in Method 351, Part 3.

Steam cleaning unit.

4. PROCEDURES.

4.1 Monitor area to be cleaned, using the techniques specified in Methods 511 and 512.

4.2 Personnel doing monitoring and decontamination work shall wear protective clothing as specified in Method 821 and Methods 831 thru 836.

4.3 Personnel doing monitoring and decontamination work shall wear personnel monitoring equipment as specified in Method 111 and Methods 141 thru 143.

4.4 Steam cleaning shall be carried out only in rooms adapted for it, that is, rooms that have steam lines which can be used for cleaning and in which the actual building material will not be harmed by the steam.

4.5 Seal off the room as much as possible when steam cleaning a room to prevent the contamination from escaping into adjoining areas.

4.6 Steam clean only under the guidance of personnel experienced in steam cleaning and under the surveillance of a health physicist.

4.7 No unnecessary personnel shall be present.

4.8 Steam clean by applying steam directly to the area from a regular steam cleaning apparatus, or from a commercial cleaning unit which mixes a detergent with the steam.

4.9 After steam cleaning the surface, wash down with a solution of clear water or detergent and water.

4.10 Rinse with a solution of clear water.

4.11 Dry the surfaces, using the damp rag technique as specified in Method 352, or by means of the wet vacuum pickup.

4.12 Monitor the whole area after all surfaces are dried. Usually a second steam cleaning will not be necessary.

4.13 Spot-wash any small contaminated areas using techniques as specified in Method 352.

4.14 Re-smear the remaining areas after they have been spot washed.

4.15 Continue with this technique until all contamination has been removed.

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION.

The plant technical manual specifies the allowable limits for surface contamination on floors, walls, and ceilings.

METHOD 354

DECONTAMINATION OF SURFACES OF EQUIPMENT

1. SCOPE.

The purpose of this method is to describe the techniques used to decontaminate surfaces of equipment.

2. SAMPLE.

Contaminated surfaces of equipment.

NOTE

"Surfaces of Equipment" in this section refers to equipment that cannot be moved to a decontamination area. This includes fume hoods, laboratory benches, sinks and other bulky, hard-to-move equipment.

3. APPARATUS.

Same as that specified in Method 351, and in addition:

Citric acid disodium EDTA.

Disodium EDTA.

Paint.

Paint brushes.

Abrasive paste with complexing agent.

Paint removers.

4. PROCEDURES.

4.1 Personnel doing decontamination and monitoring shall wear protective clothing and equipment as specified in Method 821 and Methods 831 thru 836.

4.2 Personnel doing decontamination and monitoring shall wear personnel monitoring equipment as specified in Method 111 and Methods 141 thru 143.

4.3 Personnel doing monitoring shall use techniques specified in Methods 511 and 512.

4.4 Rope off contaminated equipment immediately and set up a designated area with a control point as specified in Methods 721 thru 722.

4.5 Wash surface of contaminated equipment with a detergent and water. This should be accompanied by swabbing or light scrubbing. Use techniques as specified in Method 352.

4.6 Monitor the surface of the equipment. If contamination is still present but has been reduced in concentration, repeat step 4.5 above.

4.7 If no reduction has been accomplished, wash the equipment in citric acid-disodium EDTA. Mix the citric acid-EDTA as specified in Method 313.

NOTE

Temperature of the solution should be allowed to cool to 120°F or until cleaning personnel can place their

hands in solution without burning them.

4.8 Monitor the surface of the equipment. If contamination is still present but has been reduced in concentration, repeat steps 4.5 - 4.7.

4.9 If the contamination is still present, swab or scrub surface with mild abrasive paste containing complexing agents.

4.10 Keep area moist and do not allow it to dry, as this will prevent dispersal of dust.

4.11 Scrub vigorously for short periods of time. The scrubbing may damage the surface slightly.

4.12 Rinse surface with a minimal amount of water.

4.13 Wipe dry with clothes or use wet vacuum pickup.

4.14 Monitor the surface of equipment using techniques specified in Methods 511 and 512.

4.15 If the contamination level on surface is reduced, repeat 4.9 through 4.14.

4.16 If the surface of the equipment is porous non-metal, and continual washing is not reducing the contamination, the surface of the equipment may have to be removed. This technique is specified in Method 355.

4.17 If low level contamination is present and cannot be removed, painting the surface will retain the contamination and prevent its leaching out.

4.18 If it is impossible to remove contamination from a painted surface by any of the above methods, as a last resort, the paint itself can be removed. Use standard paint removers or strippers according to the manufacturer's instructions. Some of these paint strippers are: the solvent strippers - methylene dichloride type, cresols, etc.; and the Alkaline strippers - caustic soda and modifications.

4.19 Surfaces which are slightly damaged or removed should be renewed immediately to prevent future contamination from contaminating the damaged surface because these damaged or removed surfaces are difficult to decontaminate.

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION.

The plant technical manual specifies the allowable limits for surface contamination on floors, walls, and ceilings.

METHOD 355

DECONTAMINATION BY MECHANICAL REMOVAL OF SURFACE LAYER OF MATERIALS

1. SCOPE.

The purpose of this method is to describe the techniques used in decontamination by mechanical removal of surface layers of material.

2. SAMPLE.

Porous surface contaminated with radioactive material.

3. APPARATUS.

Same as that specified in Method 351, Part 3, and in addition:

Sander.

Planer.

Polyethylene sheet.

Cold chisel or mechanical chipper, pneumatic hammer, pneumatic needle gun or rotary hammer chipper.

4. PROCEDURES.

4.1 Personnel doing decontamination and monitoring shall wear protective clothing and equipment as specified in Method 821 and Methods 831 thru 836.

4.2 Personnel doing decontamination and monitoring shall wear personnel monitoring equipment as specified in Method 111 and Methods 141 thru 143.

4.3 Personnel doing monitoring shall use techniques specified in Section 500.

4.4 Mechanical removal of surface layers of material shall be used only as a last resort after all other treatment fails, and shall be used only if economically feasible and with the approval of the plant Officer-In-Charge.

4.5 All decontamination work shall be done under the surveillance of a trained health physicist or an individual of the group thoroughly grounded in health physics monitoring techniques.

4.6 Operations of this type must be conducted so as to:

4.6.1 Prevent undue spread of airborne dust.

4.6.2 Control the spread of the removed material.

4.6.3 Prevent contamination of the exposed clean surface.

4.6.4 Return the surface to its original conditions as far as practicable.

4.7 Set up a designated temporary containment area (as specified in Methods 711 thru 716 and 721 thru 723) around the area of equipment to be decontaminated.

4.8 Set up vacuum cleaner with filter as specified in Method 351.

4.9 Removal of surface layers of metal shall be by chipping, grinding, machining and heavy abrasion. The techniques to be followed are specified in Method 316.

4.10 Wood.

4.10.1 Wood in process or laboratory areas may be planed or

sanded to expose a clean surface.

4.10.2 Planing is much to be preferred. Dust must be removed continuously during the sanding operation if an airborne dust hazard is to be avoided.

4.11 Linoleum and Plastic Tiles.

4.11.1 Bench and floor coverings of these types should be regularly wax polished. The wax coating protects the surface and discourages penetration by liquid contaminants.

4.11.2 Removal of the wax by commercial wax removers will often affect complete decontamination.

4.11.3 Highly contaminated sections can be buffed to remove the surface layer but a much more susceptible surface results. It is usually better to replace the affected parts with new material.

4.12 Concrete, Brick, and Similar Structural Materials.

4.12.1 Liquids will carry contamination by capillary action an inch or more into the untreated surfaces of these materials. The surface layers must be chipped off, using cold chisels or mechanical chippers. Pneumatic hammers, pneumatic needle guns, and rotary hammer-chippers are usually employed. Some manufacturers of such equipment supply shrouds which may be used in conjunction with the modified industrial suction cleaners to prevent the dispersal of dust and chips. Without such shrouds the working area should be separated from its surroundings by a designated temporary containment

area to prevent dust and chippings from being widely dispersed. Continuous suction cleaning of the inside of the enclosure is necessary.

4.13 Monitor area continually during surface removal to be certain that the absolute minimum surface has been removed.

4.14 Monitor area at completion of work to be certain that no particles or chips are left loose in the area.

4.15 When surfaces which may be exposed to contamination are damaged, they should be repaired as quickly as possible to hold contamination problems to a minimum.

5. RESULTS AND COMPUTATIONS.

Not Applicable.

6. TEST METHOD IMPLEMENTATION.

The plant technical manual specifies the allowable limits for surface contamination on floors, walls and ceilings.

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13. ABSTRACT

This Manual is designed for use by Nuclear Power Plant Process Control Specialists. It contains health physics and water chemistry procedures for guidance in plant operation. Although this Manual cannot give detailed recommendations, necessary and sufficient for all conditions, it gives general recommendations suitable for typical plant use.

Part 1 presents health physics procedures, as well as radiochemical analyses for health physics operations. Contained in this Section are standards of health and safety necessary in the operation of nuclear reactors, including personnel monitoring and access control, radioactive materials control and waste management, decontamination, radiological monitoring, and health physics and radiochemistry instrumentation.

Part 2 contains general chemical procedures for analyzing the water in the Primary, Shield Water, and Secondary Systems. This water impurity control prevents equipment corrosion, thus serving to prolong the life of the equipment, insure maximum operating efficiency, and reduce maintenance time.

VOLUME I CONTAINS SECTIONS ON PERSONNEL MONITORING, RADIOACTIVE MATERIALS CONTROL, AND DECONTAMINATION.

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UNCLASSIFIED

Security Classification

CN#1 to HPPC Manual
1 May 1969

Health Physics Process Control Manual
1 July 1966

1. The following test methods are to be inserted in Section 500 of the manual to follow Method 541: Method 551 through method 559.

2. Retain this change notice and insert before the Table of Contents.

3. Insert page ii a in the Table of Contents.

4. Holders of the Health Physics Process Control Reference Manual will verify that the addition has been made. Any comments as a result of use of these test methods should be addressed to

   Director; USAERG
   Attn: M and R Section
   Fort Belvoir, VA 22060