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CONTROL OF HEALTH HAZARDS FROM PROTECTIVE MATERIAL USED IN SELF-LUMINOUS DEVICES

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CONTROL OF HEALTH HAZARDS FROM RADIOACTIVE MATERIAL USED IN SELF-LUMINOUS DEVICES

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*This bulletin supersedes TM MED 232, 22 September 1967.

1. Purpose. This bulletin is intended to supplement information contained in the appropriate Technical Manual, Technical Bulletin, Supply Bulletin, Nuclear Regulatory Commission (NRC) license or Department of Army (DA) radioactive material authorization governing the safe use and storage of a specific radioactive self-luminous device.

2. Scope. This bulletin is applicable to all active Army, US Army National Guard, and US Army Reserve elements worldwide whose military and civilian personnel are involved in:

a. Handling, application, and storage of unsealed radioactive luminous paints.

b. Handling, use, and storage of radioactive materials in sealed, self-luminous light sources.

c. Repair of self-luminous devices containing radioactive material in either sealed or unsealed forms.

3. References. A listing of references is contained in appendix A.

4. Definitions. Except as indicated in appendix B, terms used in this bulletin are defined in AR 310-25. Where more specific definitions are required for quantities used in radiation protection, those provided in AR 40-14 shall be used.

5. General. Radium shall not be procured or used until it has been established that a nonradioactive substitute or a less hazardous radioactive substance cannot be used feasibly (AR 385-11 and AR 700-64).

NOTE

The words "he," "his," and "him" as used in this bulletin are intended to include both the masculine and feminine genders and any exception to this will be so noted.

6. Responsibilities.

a. The commander of the installation/activity shall:

(1) Publish those documents necessary and provide adequate resources to implement an effective radiation protection program as required by Federal and Army directives.

(2) Determine, in coordination with the Radiation Protection Officer (RPO) and the Environmental Coordinator, the upper limit for additional costs required in order to reduce the exposure of personnel to ionizing radiation and radioactive contamination and the release of radioactive materials in effluents to uncontrolled (unrestricted) areas to a level as low as is reasonably achievable based upon a risk-benefit-cost evaluation of the operation (see AR 40-14 and AR 200-1). In general, a cost greater than $1,000 per person-rem is not considered to be economical (see OMB Circular A-94).

(3) Designate, in writing, an RPO and an alternate RPO to advise on the control of hazards to health and safety from the specific materials and devices being used or repaired (AR 40-14).

(4) Designate, in writing, a Radiation Control Committee (RCC) (para 8*a*).

b. The RPO shall as a minimum:

(1) Coordinate with the commander of the installation/activity regarding costs (para *a*(2) above).

(2) Instruct and train the workers in the safe handling of radioactive materials (AR 40-14).

(3) Instruct workers and visitors in the use of protective clothing, equipment and procedures (AR 40-14).

(4) Arrange radioactive waste disposal AR 385-11 and TM 3-261).

(5) Maintain proper records of personnel exposure (with the custodian of medical records) (AR 40-14 and AR 40-403).

(6) Investigate overexposures, accidents or unusual occurrences and initiate action to prevent recurrence (AR 40-14).

(7) Insure that the necessary instruments are available and properly calibrated (AR 40-5, TB 43-180, and TB 700-3).

(8) Insure that personnel are being monitored upon leaving the work area (AR 40-5).

(9) Carry out monitoring in cases where unusual contamination is suspected (AR 40-5).

(10 Insure that the necessary surveys are conducted and appropriate records are maintained (AR 385-11 and AR 700-64).

(11) Maintain a current inventory in compliance with AR 385-11 and AR 700-64 (see para 7*i* below).

(12) Inform the fire and police departments where potential radiation hazards may exist (AR 40-5).

(13) Act as a member of the Radiation Control Committee (AR 40-14).

(14) Conduct and record required sealed-source leak testing (AR 385-11 and AR 700-64).

c. The medical authority shall:

(1) Perform preplacement and periodic medical examinations of radiation workers.

(2) Determine, in coordination with the RPO, when an employee may return to work following an ionizing radiation overexposure.

d. The supervisor (other than the RPO) shall as a minimum:

(1) Strictly enforce the rules as established in this bulletin and in the local radiation protection program document.

(2) Insure responsibility ((1) above) is written into his job description.

(3) Be thoroughly familiar with this bulletin

and other appropriate documentation, the nature of the hazards associated with radium, tritium, and other radioactive materials used in self-luminous devices, and the emergency procedures of the facility.

e. The worker shall be under the supervision of a person, other than the RPO, qualified by training and experience.

7. Facility Requirements.

a. Working Areas.

(1) *Required Air Spaces.* There shall be a minimum of 50 square feet (4.7 square meters) allotted to each worker engaged in operations covered by this bulletin. This area shall include the work table and the chair or stool when the individual is in the working position. There shall be a passageway at least 5 feet (1.5 m) wide behind the worker's chair or stool while he is working.

(2) *Floor Surfaces.* All floors in rooms where radioactive self-luminous devices are repaired shall be constructed to provide a smooth, impervious unbroken surface. Where dial painting, instrument scraping, or any other operations are conducted that could result in the spread of radioactive contamination, the floor shall be covered with material possessing the characteristics of solid sheet vinyl laid on smooth concrete according to manufacturer's specifications.

(3) *Walls, Ceilings, and Trim.* All walls, ceilings, and trim in rooms shall have a smooth, washable surface without cracks or crevices in which dust may collect. Such surfaces shall have moisture-repellent qualities at least equal to those of a good quality vinyl or epoxy paint.

b. Washing Facilities and Change Areas. In operations involving radioactive self-luminous devices which could result in the contamination of personnel, the work area shall be entered or left only by passing through washing facilities and a change room (TM 3-260). This change room shall be provided with hot and cold water, at least one wash basin per five employees, one shower for each 10 employees of each sex to ensure personnel decontamination, soap, individual paper and cloth towels, sufficient receptacles to receive all contaminated waste, contaminated clothing, soiled work clothing, and other refuse; and at least one water closet per 1-15 employees (see 29 CFR 1910.141). Two lockers shall be provided each employee, one for personal clothing and one for work clothing. A fingernail file, orange sticks, and a scrub brush shall be provided each employee. Sufficient and proper radiation survey equipment as well as an ultraviolet (argon) lamp shall be located at each work area exit. Floor, walls, ceilings, and trim of the change room shall be constructed in the same manner as the work area.

c. Material Storage Area. Radioactive self-luminous light sources, luminous paints, and other devices containing radioactive materials should be stored by production lots. Usual warehousing procedures shall be observed except where contraindicated by the applicable current Technical Manual, Technical Bulletin, Supply Bulletin, NRC license or DA radioactive material authorization.

(1) Floor Surfaces. All floors where unsealed radioactive luminous materials, paints, and other devices containing radioactive materials are stored shall have a smooth, crack-free, unbroken surface that can be easily decontaminated.

(2) Storage Room Requirements. Radioactive luminous compounds in sealed and unsealed forms shall be stored in areas that are properly constructed to be fireproof or fire-resistant; well-ventilated; and provide proper security, ingress and egress control.

d. Ventilation.

(1) *General.* Ventilation shall be provided in all rooms, areas, buildings, or enclosures where radioactive luminous materials are used, applied, stored, repaired, or otherwise processed. Concentration of airborne radioactive materials shall be less than those maximum permissible concentration (MPC) limits specified in appendix B, table II, column 1, 10 CFR 20. The ventilation system shall be designed to permit airflow in such a direction that any radioactive material which becomes airborne shall flow away from the worker. Airflow shall always be from the noncontrolled or noncontaminated area toward the contaminated or controlled area.

(2) *Local Ventilation.* The following operations involving the use or handling of radioactive materials should be provided with local exhaust ventilation such as a glove box or a hood:

(a) Weighing unsealed dry or volatile materials.

(b) Compounding, mixing, or otherwise preparing paints.

(c) Bottling of prepared paints.

(d) Applying paints.

(e) Replacing light sources.

(f) Drying of paints.

(g) Baking of paints.

(h) Removing paints or light sources.

(i) Stripping of dials.

(j) Assembly of equipment.

(k) Disassembly of equipment.

(l) Any other operation with unsealed dry or volatile radioactive materials which could result in airborne contamination.

(3) *Airborne Concentrations.* The rate of air-

flow where local exhaust ventilation is provided shall be such that the concentrations of airborne activity, gaseous and particulate, in the work area shall not exceed the MPC for the radionuclides specified in appendix B, table I, column 1, 10 CFR 20. Air exhausted through local ventilation should be passed through a high-efficiency particulate air (HEPA) filter. Concentrations of airborne activity released to uncontrolled (unrestricted) areas shall not exceed the MPC for the radionuclides specified in appendix B, table II, column 1, 10 CFR 20. The filtered air shall not be recirculated to other parts of the building but vented directly to the outside atmosphere. Contaminated filters shall be handled and disposed of in accordance with AR 385-11 and TM 3-261.

NOTE:

When HEPA filters are employed, devices such as U-tube or inclined manometers shall be provided to indicate the pressure drop across the filters, thus affording an early indication of airflow loss at enclosures. HEPA filters are *not* effective for tritium or noble gases.

(4) *Hoods.* When laboratory hoods are used to maintain minimum levels of airborne radioactive material in work or storage area, the airflow in the hood shall have an average velocity of at least 100 linear feet per minute (fpm) (30 m/min) through the fully-open face. Hoods in which highly-toxic or high-level radioactive materials are handled shall have an average air velocity of at least 150 fpm (45 m/min) through the fully-open face. (See NCRP Report No. 30 and IAEA Technical Report No. 15.) Hoods should be provided with a dual-speed fan to permit operation at a higher velocity while the hood is in use, and at a lower velocity when it is closed. Bypass openings shall be provided to maintain proper hood and room pressure balance. The variation in air velocity through the open face shall not exceed ± 20 percent. Each hood shall have an independent exhaust system. The fan shall be installed outside the building or at the point where the exhaust leaves the building to ensure that the duct work inside the building is under negative pressure. The point of discharge shall be at least 10 feet (3.1 m) above the roof and 100 feet (31 m) from any air intake to minimize radioactive effluents being carried back into the same or adjacent buildings. The fan should discharge into a vertical stack with no directional baffles or projections.

(5) *Evaluation of Hoods.* Laboratory hoods shall be evaluated and flow measurements made at least every 6 months. Documentation of such measurements shall be maintained in accordance with AR 340-18-6.

e. Illumination. Sufficient glare-free illumination shall be provided in all areas where radioactive materials are used, applied, stored, repaired, or otherwise processed (paragraph 4, appendix C, 34 CFR 232).

f. Equipment.

(1) *General.* Equipment, such as all shelves, storage cabinets, drying cabinets, work tables, waste receptacles, trays for finished work, hoods, and glove boxes, that are used in any room where radioactive luminous materials are used, shall be constructed throughout of material that is smooth, seam free, impervious to moisture and having a washable surface.

(2) *Hoods and Glove Boxes.* Hoods, glove boxes, and other work enclosures shall be designed in accordance with the appropriate paragraphs of NCRP Report No. 30. Airflow through the glove boxes should be sufficient to maintain a negative pressure within the box of 0.5 inch (1.3 cm) of water.

(3) *Desks and Tables.* Desks and tables used for the application, handling, or processing of radioactive luminous materials should not have drawers and shall be free from ornamental trim or sharp corners. Desks and table tops shall have a finish impervious to the solvents or other chemicals used. Tables should be finished throughout with a smooth, moisture-repellent coating, and covered with paper or plastic sheeting.

(4) *Chairs and Stools.* Chairs and stools shall have a smooth, moisture-repellent finish throughout. Attached padding shall have a smooth, washable surface, and shall not have cracks or crevices. The use of detachable pads or cushions shall not be permitted.

(5) *Waste Receptacles.* Properly marked metal containers with removable plastic liners that fold over the top shall be used for the collection of all solid wastes. Lids of the collection containers shall be easy to open so that the container is not tipped over in the process of removing the lid. Collection shall be accomplished by closing and sealing the plastic liner prior to removal. Liquid wastes shall be collected in plastic bottles specifically designated and marked for this purpose (AR 385-30 and TM 3-261).

(6) *Stirring Rods.* Stirring rods should be made of glass, metal, or other smooth, impervious material and shall be of sufficient length to preclude contamination of the fingers. Metal rods shall not be used for the mixing of tritium-activated luminous paints.

(7) *Brush-Cleaning Jars.* Brush-cleaning jars shall be designed to preclude the possibility of con-

taminating the fingers during the cleaning of paint brushes.

(8) *Tools.* Tools used for the disassembly and maintenance of self-luminous devices shall be specifically marked and shall have smooth impervious surfaces except where needed on grips and jaws.

g. Protective Clothing.

(1) Protective clothing shall be provided all workers when work might result in radioactive contamination of personal clothing, skin, or hair. Appropriate protective clothing, from among the following, shall be chosen: Coveralls, gloves, caps, booties, or overshoes (AR 40-5 and AR 385-32).

(2) Protective clothing shall be appropriately marked or color coded in order to permit its control to insure proper monitoring, decontamination, and laundering in special facilities (TM 3-260 and TM 3-261).

h. Respiratory Protective Equipment. Respiratory protective equipment may be required in certain instances. It shall be distinctively marked for control purposes and shall be worn when authorized by NRC as required by 10 CFR 20.103 and under circumstances where the concentration of airborne radioactivity exceeds the MPC limits specified in appendix B, table I, column 1, 10 CFR 20 (TB MED 502, to be published).

i. Inventories.

(1) *An inventory* of all radioactive items onhand shall be maintained by, or under the direction of, the RPO (AR 385-11 and AR 700-64). The inventory shall include as a minimum: date of transaction, National Stock Number, radionuclide(s), nominal activity (e.g., curies, millicuries, or microcuries) per item uncorrected for decay, chemical and physical form, activity involved in the transaction, storage location, number of items received or transferred, balance of items, document number of shipment or receipt, NRC license/DA radioactive material authorization number, and total radioactivity at conclusion of the transaction (AR 385-11 and AR 700-64).

(2) *A radiation survey* shall be performed annually during the first quarter of each fiscal year to include a physical count, measurement of radiation and contamination levels, and an evaluation of potential hazards.

(3) *Losses of radioactive materials* shall be reported in accordance with instructions contained in the technical literature for the devices.

8. Radiation Protection.

a. Radiation Control Committee (RCC). The commander of the installation/activity shall designate an RCC in accordance with AR 40-14. The RCC shall be composed of the commander or his designated representative as chairperson, the RPO, the responsible staff medical officer, the safety manager, the storage officer, and other persons as deemed appropriate by the commander. The RCC shall be responsible for the review of procedures for the use and processing of radioactive luminous compounds and self-luminous devices within the facility, and make recommendations concerning the protective measures to be taken.

b. Radiation Exposure Standards.

(1) Radiation exposure standards are specified in AR 40-14. These standards have been established by DA for the control of occupational exposures to ionizing radiation and radioactive material.

(2) Alternate radiation exposure standards, less restrictive than those prescribed in (1) above, may be used in special circumstances when approved by The Surgeon General. Proposals for the use of alternate standards shall contain complete justification and should describe the means by which the standard shall be implemented (AR 40-14).

(3) No individual under 18 years of age shall be occupationally exposed to ionizing radiation in excess of that allowed to any individual in the population at large (AR 40-14).

c. Personnel Dosimetry. An authorized and appropriate personnel monitoring device shall be used to measure the exposure of each individual who is likely to receive an accumulated dose equivalent of ionizing radiation in excess of 5 percent of the applicable annual basic radiation exposure standard. Consideration shall be given to all other occupational ionizing radiation exposures the individual may receive during that calendar quarter. The primary dosimetric device for DA is the film badge (AR 40-14).

d. Radiation Surveys.

(1) Radiation surveys are performed to indicate the general level(s) of radiation in the controlled (restricted) area and to provide information on changing levels of radiation or radioactive contamination as work progresses. The measurements of radiation levels and radioactive contamination shall be made at periodic intervals during the conduct of the work, particularly when conditions change drastically (such as when source containers are opened, or radioactive material is transferred from one area to another or from one vessel to another).

(2) To insure the detection of radioactive contamination by direct methods, the detector (probe) transit time across the surface should not exceed 2.5 inches/second (15 cm/s). The detector (probe) should not be held more than 0.125 inch (0.3 cm) above the surface under examination for alpha

monitoring and 1 inch (2.54 cm) above the surface for beta monitoring.

(3) A dry wipe/smear may remove anything from 0 to 100 percent of the radioactive contamination present but, generally, a removal factor of 10 percent shall be assumed. Therefore, by applying this removal factor of 10 percent, the approximate amount (activity/unit area) of transferable radioactive contamination on the surface can be estimated. The removal factor is greater when a wet wipe/smear techique is employed. The liquid chosen to moisten the filter paper shall not chemically react with the surface to be monitored, but should be effective in removing the radioactive contamination. The wet filter paper must dry before monitoring/counting for alpha and low energy beta activity.

(4) To estimate the amount of surface contamination which may become airborne under a variety of conditions, resuspension factors have been determined. Resuspension factors vary from $3X10^{-3}$ to $2X10^{-6}$ per cm; however, an average value of $1X10^{-5}$ per cm is appropriate for general conditions.

e. Contamination Control. Frequent monitoring surveys and air samples shall be conducted and recorded as permanent records in accordance with 10 CFR 20 (AR 340-18-6). Concentrations of radioactive material in air shall be measured periodically in areas where operations could expose the workers to 10 percent or more to the MPC limits specified in appendix B, table I, column 1, 10 CFR 20. The frequency and the times selected for air sampling shall be based on the nature of the process involved and the probability that airborne radioactive materials will be present in the breathing zone of the workers. The following frequencies of surveys are recommended:

(1) *Instrument Scraping Area.* Surveys for surface radioactive contamination shall be conducted daily. Readings should be taken with appropriate survey instruments and smears/wipes should be conducted where indicated by survey instrument readings.

(3) *Materials Storage Spaces.* Surveys of storage areas shall be conducted at least at quarterly intervals or upon receipt or shipment of radioactive luminous compounds and self-luminous devices in accordance with the procedures of NCRP Reports Nos. 8 and 57. Smears/wipes should be made where indicated by survey instrument readings, the specific item, the condition of the container, or experience with similar items. Any indication of leakage from a container containing such radioactive materials should result in appropriate disposal of the container and its contents. In the event of such leakage, the commodity manager for the item shall be contacted for disposition instructions. After disposal, decontamination of the storage area shall be made.

(4) *Work Areas.* Areas used for packaging and repair shall be surveyed at least weekly during periods in use. When indicated by survey instrument readings, or the nature of the radioactive material being handled or processed, additional appropriate smear/wipe tests shall be made.

f. Personnel Monitoring and Routine Decontamination.

(1) Every individual who handles or uses radioactive materials or self-luminous devices shall be monitored prior to leaving the work area. Any evidence of radioactive contamination above the levels in AR 385-11 shall require decontamination. Hands, skin, and nails shall be cleaned and scrubbed. Monitoring for alpha emitters should be accomplished with proportional or scintillation-type detector instrument. For beta-gamma emitters except tritium, a Geiger-Mueller (G-M) instrument, with a thin window (less than 2 mg/cm^2) detector or a gas flow proportional detector should be used for monitoring. The scale on the G-M instrument shall not read over 0.5 milliroentgen per hour (mR/hr) and corresponding count per minute (CPM) full scale on the lowest scale. The skin shall be thoroughly washed until repeated washings do not lower the exposure of count rate or until no radioactivity above natural background is detected. If a reduction of exposure or count rate is not indicated following these washings, further decontamination shall be accomplished in accordance with the recommendations contained in NCRP Report No. 8 and 59 under local RPO and medical supervision.

(2) Radioactive contamination levels observed and procedures followed during survey and decontamination of personnel and decontamination of personnel and clothing shall be recorded. The written record shall include the names of individuals surveyed, a description of prior work activities, the probable causes, steps to be taken to reduce future incidents of contamination, dates and times, and the surveyor's signature. The RPO should conduct monthly spot-checks to ensure that the workers are conducting their own personal contamination surveys.

g. Contaminated Clothing Control.

(1) *Soiled Clothing.* Soiled work clothes shall be deposited in properly marked hampers after monitoring when a change of clothing is issued. Such hampers shall be of sufficient capacity to receive all the soiled clothing. (See AR 385-30 and TM 3-261.)

(2) *Contaminated Clothing.* Clothing with ra-

dioactive contamination above the limits specified in AR 385-11 shall be segregated after monitoring and laundered separately at the facility or at an NRC-licensed commercial laundry that specializes in cleaning contaminated clothing. Where many contaminated garments are laundered at the facility, wastewater shall be treated as radioactive waste. Liquid effluents from the laundry shall be controlled to ensure that the concentrations are as low as is reasonably achievable (10 CFR 20.1) and meet the criteria in 10 CFR 20.106 and 20.303 (see AR 200-1). Personal clothing or shoes that cannot be decontaminated by brushing shall be placed in containers used only for contaminated clothing. If appreciable radioactive contamination is present on clothing or shoes that cannot be removed by normal methods, then the item may be disposed of as radioactive waste or held until the activity decays to an acceptable level.

h. Control of Internal Exposures.

(1) *The deposition* of radioactive material in the human body may result from ingestion, inhalation, or absorption through the intact or injured body surface (skin). Material that is soluble in body fluids will be absorbed into the bloodstream and deposited in various organs of the body.

(a) The inhalation and ingestion of radioactive material frequently occur together since insoluble particles deposited in the tracheo-bronchial tree may be expelled by ciliary action and subsequently swallowed.

(b) The absorption of radioactive materials through an open wound or even through the intact skin (e.g., in the case of tritium oxide vapor) is potentially hazardous. The submersion of an individual in tritium gas is limited solely by consideration of the exposure of the lung; however, the limit for exposure to tritiated water is much less than that for elemental tritium, so that, in most cases, exposure to the former is the limiting factor, even though the fraction of tritium that is oxidized may be small.

(c) The hazards of the other radionuclides that may be found in self-luminous devices, (e.g., promethium-147 (Pm-147) and radium -226 (Ra-226)) in older devices, are primarily determined by their physical form and by the mode of intake. Pm-147 is commonly present, embedded in a ceramic material, in the form of microspheres. The diameter of these particles is so great that it is practically impossible for them to be inhaled. Also, absorption in the intestinal tract after ingestion is, essentially, zero. If Pm-147 is present in a form (e.g., as a salt) that allows it to be dispersed in respirable particles, absorption in the lungs is possible. Even if Pm-147 is present as a soluble compound, however, absorption in the intestinal tract is negligible. Ra-226 is potentially far more hazardous, as it is well absorbed in lungs and intestinal tract, and, as an alpha emitter, is among the most radiotoxic materials known. For this reason, a limitation on the use of this nuclide in equipment, paint, etc., was established (para 5), and special precautions are to be taken to control exposure to radium containing devices.

(2) Periodic bioassay procedures are an important operational technique for the determination of the efficacy of control procedures, but are not to be considered a replacement for those procedures. In planning a periodic bioassay program, the degree of potential exposure and the elimination rate from the body of the nuclide(s) involved shall be taken into account. The following guidelines can be used in mose cases.

(a) In case of a suspected acute exposure to airborne radioactive materials, bioassay of urine or fecal samples may provide an estimation of the amounts inhaled and the doses resulting from these intakes. If the exposure involves tritium oxide or tritium gas with an unknown content of tritium oxide vapor, individuals involved should void urine immediately following the incident, and submit a fresh urine sample a few hours later. Inhalation of Pm-147 or Ra-226 containing materials cannot be expected to result in measurable concentrations in urine, and collection of feces is indicated ((3) below).

(b) Chronic low-level exposure to airborne materials, surface and skin contaminations, etc., to a degree important from a health point of view is extremely unlikely, provided that an effective radiation protection program is carried out. Because of the easy dispersibility of tritium and tritium oxide, however, a routine bioassay program consisting of monthly urinalyses may be indicated in cases where large amounts of tritiated luminous materials are being handled.

(3) Consultation on the need for bioassay and sample collection requirements and analytical services can be obtained from US Army Environmental Hygiene Agency, Aberdeen Proving Ground, MD 21010 (AR 40-5).

i. Required Radiation Protection Instruments.

(1) Each facility where radioactive self-luminous devices are fabricated, installed, stored,

or repaired shall possess appropriate instrumentation for radiation surveys as listed below.

Radionuclide	Laboratory Instrument	Portable Survey Instrument
Tritium	Liquid Scintillation counter (at or available to each facility or plant).	Radioactive Gas Monitor (one per workroom and one per storage complex).
Krypton-85	Laboratory Scaler and Shielded G-M Tube or Proportional Counter.	Radioactive Gas Monitor and a G-M Survey Meter (one per workroom and one per storage area).
Radium-226	Laboratory Scaler and Shielded Proportional Detector.	G-M Survey Meter and an Alpha Survey Meter (one of each per workroom and storage complex), Air Sampler (one per plant or installation), Radioactive Gas Monitor (one per workroom and one per storage area).
Promethium-147	Laboratory Scaler and Shielded G-M Tube.	G-M Survey Meter (one per workroom and one per storage complex).

(2) Radiation survey instruments used for health and safety monitoring of radioactive material shall be calibrated at the frequency specified in TB 43-180.

(3) Sufficient spare instruments shall be maintained to ensure that the minimum numbers listed in (2) above shall be available and operational.

j. Caution Signs, Labels, and Signals.

(1) Each high radiation area, radiation area, airborne radioactivity area, radioactive materials storage area, and each container containing radioactive material above the quantities listed in appendix C, 10 CFR 20, shall be marked in accordance with AR 385-30 and 10 CFR 20.203.

(2) Each high radiation area shall be equipped with a control device that shall either cause the level of radiation to drop below that at which an individual might receive a dose of 100 millirems (mrem) in any 1 hour upon entry into the area or shall energize a conspicuous visible or audible alarm signal in such a manner that the individual entering the area and the supervisor of the area are made aware of the entry (AR 385-30 and 10 CFR 20.203).

9. Training. Persons shall not be permitted to use or handle radioactive materials until they have been given proper instruction in the nature of radioactivity, the hazards associated with the handling of this material, the safe working procedures, and the emergency procedures (AR 40-14). This training shall stress the necessity of forming habits of scrupulous personal cleanliness and obeying radiation protection rules. Persons who do not have or will not develop these habits should not be employed to use or handle radioactive luminous compounds or self-luminous devices. Personnel shall receive subsequent periodic reorientations as to the nature of the material with which they are working, its hazards, changes in procedures or work rules, and emergency instruction (AR 40-14). Such training should be conducted annually and recorded in the employee's personnel record.

10. Medical Surveillance.

a. Medical Surveillance Examinations.

(1) *Preplacement Examination.* A preplacement medical examination of workers engaged in activities involving radioactive materials used in self-luminous devices shall be performed by the supporting medical treatment facility prior to potential occupational exposure to ionizing radiation or radioactive material (AR 40-14). This examination shall enable the physician to evaluate from a medical standpoint a prospective employee's suitability for employment involving potential exposure to radioactive materials used in self-luminous devices; and will also serve as a baseline for evaluating the significance of findings on future examinations. Determination of suitability for employment from a medical viewpoint is the sole responsibility of the examining physician (AR 40-14). The preplacement examination shall include as a minimum:

(a) An occupational history including a review of all prior occupational exposures to ionizing radiation as a result of previous employment, and a description of any unusual radiation exposure resulting from previous occupations, accidents/incidents, or therapeutic procedures. When possible, dose and body areas affected should be determined (information on diagnostic and therapeutic ionizing radiation shall not be entered on DD Form 1141, Record of Occupational Exposure to Ionizing Radiation). Particular attention should be paid to previous occupational exposures to known or suspected carcinogens; e.g., asbestos, arsenic, etc.

(b) A medical history with particular attention to past history of skin, blood or neoplastic dis-

orders, reduced immunologic competence, use of steroids or cytotoxic drugs, and cigarette smoking.

(c) A physical examination with particular attention to the skin.

(d) A complete blood count including a white cell count with differential, red cell count, hemoglobin, hematocrit and platelet count to establish a baseline.

(e) Bioassay determination(s) appropriate to the specific radionuclides to which the individual may be potentially exposed (para 8h(2)).

(f) Other examinations or procedures appropriate to the potential stresses or exposures involved in each individual's employment other than potential exposure to radioactive material used in self-luminous devices.

(2) *Periodic Examinations.* Individuals engaged in activities involving potential occupational exposure to radioactive materials used in self-luminous devices shall undergo a periodic examination on a trienniel basis (or more frequently if determined to be necessary by the local responsible medical authority, in consultation with the RPO, based upon knowledge of working conditions (AR 40-14)). These examinations shall enable the physician to evaluate from a medical standpoint the employee's continued suitability for employment involving potential exposure to radioactive materials used in self-luminous devices. The periodic examination shall include as a minimum:

(a) An interim occupational and medical history with emphasis on those items discussed in paragraph (1) *(a)* and *(b)* above.

(b) A complete blood count including white cell count with differential, red cell count, hemoglobin, hematocrit and platelet count.

(c) Those examinations or procedures described in paragraph (1) *(c)*, *(e)*, and *(f)* above.

(3) *Termination Examination.* Within 30 calendar days before or after termination of employment of any individual engaged in activities involving potential occupational exposure to radioactive material used in self-luminous devices, an examination shall be provided that shall include, as a minimum, those examination or procedures described in paragraph (2) *(a)*, *(b)*, and *(c)* above.

b. Emergency Procedures.

(1) Employees shall be promptly referred to the local medical authority when they have:

(a) Apparently received exposures to external ionizing radiation in excess of the radiation exposures standard in AR 40-14.

(b) Been exposed in areas of airborne radioactivity in excess of the MPC.

(c) Been involved in an incident or spill that may have resulted in ingestion of radioactive material.

(d) Had a wound contaminated.

(2) The local medical authority or attending physician should be furnished with adequate details of exposure when the patient is brought in for treatment.

(3) Procedures for the decontamination of patients can be found in NCRP Report No. 8.

(4) Requests for assistance for the conduct of bioassay procedures and other special tests may be obtained from the Commander, US Army Health Services Command, ATTN: HSPA-P, Ft Sam Houston, TX 78234 (AR 40-5).

c. Special Cases. It shall be the responsibility of the local medical authority, in coordination with the RPO, to determine from a medical viewpoint when an employee may return to work following an ionizing radiation overexposure (AR 40-14).

11. Operating Rules.

a. General Maintenance. All floors, walls, ceilings, trim, furniture, and equipment, including toilet and sanitary facilities, washing facilities, and change rooms, shall be maintained in a clean and sanitary condition and in good repair.

b. Floor Maintenance. Floors should be washed daily. Dry sweeping of floors is prohibited.

c. Workrooms: Workrooms in which radioactive materials are applied or otherwise processed shall not be used for any other purpose. Spray painting of dials with black paint prior to the application of radioactive luminous compounds shall not be permitted in the dial-painting room. If the room in which spray painting is done is located next to the dial-painting room, there shall be no connecting doors or windows between the two rooms.

d. Prohibited Methods of Application. Use of the dry method of applying radioactive luminous compounds such as dusting of material on adhesive or solvent, the silk screen method, and the spray method shall not be permitted. Other methods that could contaminate the environment shall also be prohibited.

e. Solvents. Solvents to be used for cleaning purposes and as thinners shall be issued to dial painters in stoppered bottles. The use of benzene or benzene-based solvents in connection with the application of radioactive luminous compounds shall not be permitted. Residues of radioactive luminous compounds in solvent or brush-cleaning bottles shall be removed and discarded as radioactive waste daily by pouring such residues into suitably-marked, liquid-waste containers.

f. Spilled Material. Spilled radioactive luminous

compounds shall be immediately cleaned up and the area monitored by the RPO for radioactive contamination.

g. Finished Work. Finished painted work should be placed on a tray. Each tray should be removed to the dryer when full.

h. Containers. All containers of radioactive luminous compounds, whether full or empty, shall be kept covered at all times, except while in actual use. Supply vials shall be disposed of after emptying by depositing in the dry radioactive-waste receptacles. These containers should be stored at least 3 feet (1 m) from personnel in the work area (para 5*f*(5)).

i. Brushes and Tools. Every person required to use or handle radioactive luminous compounds shall at all times be supplied with paper wiping tissue. No method or material other than paper cleansing tissue shall be used for cleaning operations performed by the worker.

j. Disposal of Wiping Tissue. Receptacles with attached covers and plastic liners shall be used for disposal of wiping tissues. When these receptacles are filled, or at the end of the working day, the plastic liners shall be closed with a tie and placed in a properly identified radioactive waste container.

k. Handling of Radioactive Luminous Compounds. Radioactive luminous compounds shall be handled with care, so as not to be brought into contact with a person's body or clothing.

l. Tool Rack and Trays. A disposable brush or tool rack and a rack or tray for finished work shall be provided for each person applying radioactive luminous compounds or repairing self-luminous devices. Brushes and tools shall be kept on such racks at all times when not in actual use and shall not be placed directly on the table tops at any time. The disposable racks shall be disposed of daily, or more often if necessary, by placing in the dry radioactive-waste receptacles.

m. Maintenance of Tools. All mixing rods, paint brushes, spatulas, and other tools that have come in contact with radioactive luminous compounds shall be thoroughly cleaned with an appropriate solvent at the end of each working day, or more often if necessary (*e* above).

n. Handkerchiefs. Cloth handkerchiefs shall not be used. A supply of disposable tissue shall be provided and shall be placed in the workroom in such a position as to prevent it from becoming contaminated.

o. Scraping. Operations involving the scraping of radioactive luminous compounds from articles preliminary to repairing or refinishing them shall be performed by means of a wet process under running water or an appropriate solvent (*e* above). Water and other solvents shall be collected for disposal as radioactive waste. If dry scraping is necessary, it shall be done in a glass cabinet with openings for the arms only and with downdraft local exhaust ventilation through a grille which constitues the floor of the cabinet. Air shall be drawn into the openings of the cabinet at a face velocity of not less than 150 linear feet per minute (45 m/min) (AR 40-5). A shallow tray filled with water shall be placed immediately beneath the exhaust grille. Removal of old paint may be accomplished by application of paint remover and removing the paint with a cotton applicator.

p. Assembly and Disassembly of Devices. Areas shall be maintained under strict monitor control where devices having parts painted with radioactive luminous compounds or containing capillary light sources are being disassembled. Working areas shall be cleaned carefully and inspected after each shift. The inspection shall be made with an appropriate survey instrument (para 6*j*). Any radioactivity detected during the inspection shall be removed at once and disposed of with the other radioactive wastes. Ventilation shall be constantly maintained so that the MPC limits specified in appendix B, table II, column 1, 10 CFR 20, are not exceeded.

q. Work Restrictions. Persons engaged in the handling or use of radioactive luminous compounds shall not perform other duties until released by the work area supervisor.

r. Persons Permitted in Workrooms. Unauthorized persons shall not be permitted in workrooms where radioactive materials are used or handled. A notice to such effect shall be posted on the entrance doors. No person under 18 years of age shall be permitted to enter any such workroom.

s. Prohibitions. No smoking, eating, drinking, or application of cosmetics shall be permitted in any controlled area where radioactive materials are stored or applied.

t. Removal of Tools. Any item of equipment used in areas where radioactive materials are used, handled, applied, or otherwise processed shall not be removed from the work area unless specifically authorized by the RPO.

u. Marking of Tools. All tools used in the application or removal of radioactive material or all tools used in the repair of equipment containing radioactive material shall be distinctively marked.

v. Emergency Procedures.

(1) Fire and police departments shall be informed of any buildings or areas where potential radiation hazards may be present. Specific conditions under which it is safe to handle emergencies

shall be explained carefully to firefighters, guards, and police. These conditions shall be respected unless they are modified by the responsible RPO (AR 40-5).

(2) At installation/activities having radiation hazards, radiation monitoring equipment shall be provided for use by the fire department (AR 420-90).

(3) Emergency procedures covering operations with radioactive materials and the handling of contaminated patients shall be evaluated/tested at least annually.

w. Required Posting of Information. A copy of the NRC license or DA radioactive material authorization; this bulletin; 10 CFR parts 19, 20, and 21; section 206 of PL 93-438; standing operating procedures covering the operation in progress and the reporting of defects; as well as a copy of Form NRC 3 (Notice to Employees) (if NRC licensed material is used) shall be prominently displayed within the work area or at the perimeter of any area where radioactive materials are stored or otherwise processed.

x. Repainting of Dials. Radioactive self-luminous dials shall not be repainted with nonradioactive luminous paint until it has been determined that there is *no* residual radioactive contamination.

12. Evaluation of Devices. The evaluation of radioactive, self-luminous devices shall be in accordance with ANSI Standard N540-1975. For radioactive, self-luminous devices licensed by NRC, the requirements in 10 CFR 32 and NRC Regulatory Guide 6.6 shall also be met.

13. Radioactive Waste Disposal. Unwanted radioactive material and radioactive waste shall be transferred to an NRC-approved disposal facility (AR 200-1, AR 385-11, and TM 3-261). Radioactive waste shall not be incinerated or buried, except at an NRC-approved disposal facility.

APPENDIX A

REFERENCES

1. AR 40-5, Health and Environment.
2. AR 40-14, Control and Recording Procedures for Occupational Exposure to Ionizing Radiation.
3. AR 40-403, Health Records.
4. AR 200-1, Environmental Protection and Enhancement.
5. AR 340-18-6, Maintenance and Disposition of General Personnel Management and Safety Functional Files.
6. AR 385-11, Ionizing Radiation Protection.
7. AR 385-30, Safety Color Code Markings and Signs.
8. AR 385-32, Protective Clothing and Equipment.
9. AR 420-90, Fire Prevention and Protection.
10. AR 700-64, Radioactive Commodities in the DoD Supply Systems.
11. TM 3-261, Handling and Disposal of Unwanted Radioactive Material.
12. TB 5-6600-227-15/1, Handling, Storage and Disposal of Self-luminous Compasses.
13. TB 43-0108, Handling, Storage, and Disposal of Army Aircraft Components Containing Radioactive Materials.
14. TB 43-0116, Identification of Radioactive Items in the Army Supply System.
15. TB 43-0122, Instructions for Safe Handling and Identification of US Army Electronics Command Managed Radioactive Items in the Army Supply System.
16. TB 43-0141, Instructions for Safe Handling, Maintenance, Storage, and Disposal of Radioactive Commodities Managed by US Army Troop Support Command.
17. TB 43-180, Calibration Requirements for the Maintenance of Army Materiel.
18. TB 43-0197, Instructions for Safe Handling, Maintenance, Storage, and Disposal of Radioactive Items Managed by US Army Armament Materiel Readiness Command.
19. TB 700-3, Handling, Storage, and Disposal of Self-Luminous Devices.
20. TB MED 502, Respiratory Protection Program (to be published) (formerly TB MED 223).
21. Title 10, Code of Federal Regulations (CFR), Part 19, Notices, Instructions and Reports to Workers; Inspections.
22. Title 10, CFR, Part 20, Standards for Protection Against Radiation.
23. Title 10, CFR, Part 21, Reporting of Defects and Noncompliance.
24. Title 10, CFR, Part 32, Specific Domestic Licenses to Manufacture or Transfer Certain Items Containing Byproduct Material.
25. Title 29, CFR, Part 1910, Occupational Safety and Health Standards.
26. Title 34, CFR, Part 232, Appendix C, Heating, Cooling and Lighting of Buildings.
27. National Council on Radiation Protection (NCRP) Report No. 8, Control and Removal of Radioactive Contamination in Laboratories (NBS Handbook No. 48).
28. NCRP Report No. 30, Safe Handling of Radioactive Materials (NBS Handbook No. 92).
29. NCRP Report No. 57, Instrumentation and Monitoring Methods for Radiation Protection.
30. NCRP Report No. 58, A Handbook of Radioactivity Measurements Procedures.
31. NCRP Report No. 59, Operational Radiation Safety Program.
32. International Atomic Energy Agency (IAEA) Technical Report No. 15, A Basic Toxicity Classification of Radionuclides.
33. IAEA Technical Report No. 120, Monitoring of Radioactive Contamination on Surfaces.
34. IAEA Technical Report No. 150, Measurement of Short-Range Radiations.

35. American National Standards Institute (ANSI) Standard N540-1975, Classification of Radioactive Self-Luminous Light Sources.

36. Nuclear Regulatory Commission (NRC) Regulatory Guide 6.6, Acceptance Sampling Procedures for Exempted and Generally Licensed Items Containing Byproduct Material.

37. NRC Regulatory Guide 8.2, Guide for Administrative Practices in Radiation Monitoring.

38. NRC Regulatory Guide 8.9, Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program.

39. NRC Regulatory Guide 8.10, Operating Philosophy for Maintaining Occupational Radiation Exposures as Low as is Reasonably Achievable.

40. NRC Regulatory Guide 8.13, Instruction Concerning Prenatal Radiation Exposure.

41. NRC Regulatory Guide 8.15, Acceptable Programs for Respiratory Protection.

42. Office of Management and Budget (OMB) Circular A-94, Discount Rates to be Used in Evaluating Time-Distributed Cost and Benefits.

APPENDIX B

DEFINITIONS

1. Airborne Radioactivity Area. Any room, enclosure, or operating area in which airborne radioactive materials exist in:

a. Excess of the MPC specified in appendix B, table I, column 1, 10 CFR 20, or

b. Concentrations that when averaged over the number of hours in any 1 week during which individuals are in the area, exceed 25 percent of the MPC specified in appendix B, table I, column 1, 10 CFR 20.

2. Controlled (Restricted) Area. Any area to which access is controlled for the purpose of protection of individuals from exposure to ionizing radiation or radioactive material. This implies that a controlled (restricted) area is one that requires control of ingress, occupancy, working conditions, and egress for radiation protection purposes. Controlled (restricted) areas shall not include any areas used as residential quarters or areas where food is stored, prepared, or served, although a separate room or rooms in a residential building or a building in which food is stored, prepared, or served may be set apart as a controlled (restricted) area. This does not apply to facilities which use ionizing radiation sources for food preservation.

3. Decontamination. The removal of radioactive material or radioactive contamination from a surface.

4. High-Efficiency Particulate (HEPA) Filter. A filter that has a particle-collection efficiency or "assistance" of greater than 99.9 percent for particles having a diameter of 0.3 micrometers or greater.

5. High Radiation Area. Any area, accessible to personnel, in which there exists ionizing radiation at such levels that a major portion of the body could receive a dose equivalent in excess of 100 millirems (mrem) in any 1 hour.

6. Monitoring. The detection and measurement of ionizing radiation or radioactivity for reasons related to the assessment and control of exposure to ionizing radiation or radioactive material. The term includes the interpretation of the measurements.

7. 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 1 hour a dose equivalent in excess of 5 mrem, or in any 5 consecutive days a dose equivalent in excess of 100 mrem. (For practical purposes, a radiation area shall be considered to be any area in which the exposure rate is greater than 2 mR/h but less than 100 mR/h.)

8. Radiation Protection Officer. An individual designated by the commander and tasked with the supervision of the radiation protection program to ensure compliance with current directives for radiation protection. This individual shall be technically qualified by virtue of education, training, and professional experience to assure a capability commensurate with the assignment. The RPO shall provide consultation and advice on the degree of hazard associated with radiation and the effectiveness of measures to control these hazards.

9. Radiation Survey. An evaluation of the radiation incident to the production, use, release, disposal, or presence of radioactive materials or other sources of ionizing radiation under a specific set of conditions. When appropriate, such an evaluation shall include a physical survey of the location of material and equipment, and measurements of levels of radiation and concentrations of radioactive material present.

a. Direct Survey. Those methods in which a radiation detector is presented directly to the surface under examination for the measurement of total exposure/dose or exposure/dose rate.

b. Indirect Survey. Those methods employed that involve the taking of smear/wipe samples of the surface contamination or the measurement of airborne levels.

(1) Smear Survey. An indirect method of determining surface contamination. A smear is obtained by using an absorbent filter paper disk to collect removable/transferable activity from a surface being surveyed. The smear generally covers an area of about 16 square inches (100 cm^2).

(2) Wipe Survey. An indirect method of determining surface contamination. A wipe is obtained by using an absorbent pad or paper towel to collect removable/transferable activity from a surface being surveyed. The wipe generally covers an area of about 144 square inches (1000 cm^2).

10. Radioactive Contamination. The unde-

sired presence of radioactive materials in amounts/quantities that may be considered potentially harmful to the health and safety of personnel or the validity of experiments or products.

a. Fixed Radioactive Contamination. Material that is not transferred from the contaminated surface to an uncontaminated surface when the two surfaces touch.

b. Removable/Transferable Radioactive Contamination. Material measured by the portions that can be transferred to another surface by simple mechanical contact.

11. Removal Factor. The ratio of the activity removed to the activity on the surface in question. The variations in the removal factor make quantitative estimation of the amount of radioactive contamination present on the surface uncertain. Generally, the value will be 10 percent. The removal factor depends on the pressure applied during smearing, the type of surface to be smeared, the type of filter paper used for the smear, and the form of the radioactive contamination.

12. Resuspension Factor. The ratio of the airborne radioactive concentration ($\mu Ci/cm^3$) to the surface radioactive contamination ($\mu Ci/cm^2$). Generally, the value will be $1x10^{-5}$ per cm.

13. Shall. Indicates a requirement that is necessary or essential to meet the currently accepted standards of protection or Federal rules and regulations.

14. Should. Indicates an advisory recommendation that is to be applied when practicable.

15. Toxicity. The ability of the radionuclide to produce biological injury, by virtue of its emitted radiations, when incorporated in the human body.

16. Toxicity Hazard. The probability that biological injury may be caused by the manner in which the radionuclide is used.

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The proponent agency of this regulation is the Office of the Surgeon General. Users are invited to send comments and suggested improvements on DA Form 2028 (Recommended Changes to Publications and Blank Forms) direct to HQDA (DASG-PSP) WASH DC 20310.

By Order of the Secretary of the Army:

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