COUNTY OF RIVERSIDE
STANDARD SAFETY OPERATIONS MANUAL

DOCUMENT NO.:	6002	**DATE ISSUED:**	05/01/95
SUBJECT:	RADIOACTIVE MATERIALS	**EFFECTIVE DATE:**	05/01/95
		LAST REVISED:	12/15/03

PURPOSE: To establish County policy with respect to providing safety when handling radioactive materials.

POLICY: The departmental/on-site Radiation Safety Officers and Safety Division will coordinate all efforts in regards to radiation safety, and maintain open communication at all times.

OBJECTIVE: Maintain employee safety and health, define responsibilities for the Radiation Safety Officer, and assure compliance with State and Federal Regulations regarding radiation safety licenses.

SCOPE: All County employees involved with handling radioactive materials.

RADIOACTIVE MATERIALS
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I. OVERVIEW

This policy provides information and guidance on the handling and use of radioactive materials and includes guidelines to be used by County agencies in preparing individualized programs. The program identifies documentation, communication, and training necessary to ensure the health and safety of County employees.

II. RADIOACTIVE SOURCE DESCRIPTION

A list of all radioactive sources and related equipment will be kept on file in the designated locations and a copy shall be forwarded to the Safety Division and to the Radiation Safety Officer for immediate reference.

III. SAFETY PROCEDURE

The County Agency shall designate a qualified person as the responsible Radiation Safety Officer (RSO). The RSO working with the Safety Division shall be responsible for assuring that the provisions of this procedure are fulfilled. Per Title 10, Code of Federal Regulations, the duties of the RSO are to:

1. Provide overall coordination of the radiation safety program;

2. Serve as the licensee's liaison officer with the State of California on license or inspection matters;

3. Control procurement and disposal of licensed material, maintain associated records, and ensure that licensed materials that are possessed or used by the application are limited to those specified in the license;

4. Establish and/or conduct the training program;

5. Examine and determine the competency of personnel;

6. Ensure that licensed materials are used only by those individuals who have satisfactorily completed appropriate training programs and are authorized by the license;

7. Establish and maintain a personnel monitoring program and ensure that all users wear personnel monitoring equipment, such as film badges or thermoluminescent dosimeters (TLD);

8. Establish and maintain storage facilities;

9. Ensure that licensed material is properly secured against unauthorized removal at all times;

10. Establish and maintain the leak test program and supervise leak testing of sealed sources;

11. Procure and maintain radiation survey instruments;

III. SAFETY PROCEDURE - continued

12. Establish and maintain a survey instrument calibration program. The record of calibrations will be maintained at the facility.

13. Develop and maintain up-to-date operating and emergency radiation procedures;

14. Ensure that the terms and conditions of the license are met and that required records, such as personnel exposure records, leak test records, etc., are periodically reviewed for compliance with State of California regulations and license conditions;

15. Conduct semi-annual inventories and maintain utilization logs;

16. Review and ensure maintenance of those records kept by others;

17. Establish and maintain proper transportation labels, placards, forms, and records;

18. Establish and maintain annual internal inspection program;

19. Conduct radiation safety inspections of licensed activities periodically to ensure compliance with the regulations and license conditions;

20. Serve as a point of contact and give assistance in case of emergency, (for example, theft of licensed materials, fire, etc.) and ensure that proper authorities (for example, NRC, local police, and State personnel) are notified promptly in case of accident or other incident that may involve the release of licensed material;

21. Investigate the cause of incidents and determine necessary preventive action;

22. Act in an advisory capacity to the licensee's management and personnel; and

23. Establish a procedure for evaluating and reporting equipment defects and non-compliance pursuant to 10 CFR Part 21.

The RSO will comply with "Notices, Instructions, and Reports to Workers; Inspections" as stated in Nuclear Regulatory Commission Regulations 10 CFR Parts 19 and 20 and Radiation Control Regulations, California Administrative Code, Title 17, Health.

IV. PERSONAL MONITORING

All users and observers working in the area of the radiation sources shall wear personal monitoring devices (dosimeter.) Employees must wear dosimeters recommended by the RSO while working with radioactive material. When not worn, dosimeters should be stored away from all radiation sources where they will not be exposed to excessive heat, sunlight, or moisture. They are not to be worn off County premises. Individuals who do not work directly with radioisotopes or in a laboratory where radioisotopes are used may be issued dosimeters.

IV. PERSONAL MONITORING - continued

Any dosimeter contaminated or exposed to heat, moisture, or medical x-rays should be returned to the RSO or designee for replacement. After any accident or if an overexposure is suspected, the dosimeters should be returned immediately to the RSO or designee to be read. Dosimeters should be worn on a shirt, coat pocket, lapel, or in some other position between the waist and the shoulders that will be representative of any radiation exposure. If, during a radiological process, a hand might receive a dose, a ring dosimeter should be worn on a finger of the hand under the glove. When both whole-body and hand doses can occur, two dosimeters will be issued, one for the whole body and one for a hand.

Internal exposures must be prevented. Work procedures and equipment must be designed to prevent the release of any radioactive substance into room air. Processes that involve volatile or gaseous material or that generate particulates must be confined to an approved fume hood. Air flow rates on all hoods should be monitored and calibrated at least annually.

An accurate record of an employee's radiation exposure history must be maintained by RSO. Employees must provide information regarding any prior occupational radiation exposure. If a worker is occupationally exposed to radiation elsewhere in addition to being exposed while employed at Riverside County, the worker should report this to the RSO so that an accurate record of the worker's total radiation exposure can be maintained.

V. "AS LOW AS REASONABLE ACHIEVABLE" (ALARA)

The Safety Division fully supports the concept that all radiation doses should be ALARA. This implies that no dose should be acceptable if it can be avoided or is without benefit. The program includes the use of proper equipment and procedures to lower radiation exposure. These actions may require a change in procedure or an increased application of the principles of personnel protection.

To maintain ALARA exposures the following basic principles of radiation protection should be practiced:

1. External Radiation Protection

a. **Maximize the distance from the source.** The dose rate for most gamma and x-radiation varies with the inverse square of the distance from a "point" source. Therefore, the farther you position yourself for the source of radiation, the smaller the dose you receive.

For example, doubling the distance from a radiation source will result in 1/4 the exposure in the same amount of time. One practical implementation of this principle is using remote handling devices such as forceps, tongs, and tube racks, etc. to minimize direct contact with sources and containers. Even a small increase in distance can result in a dramatic decrease in dose rate.

b. **Minimize time of exposure.** The less time you remain in a radiation field, the smaller the dose you receive. Perform the procedure as quickly and as efficiently as possible without increasing the probability of a spill or other accident.

V. "AS LOW AS REASONABLE ACHIEVABLE" (ALARA) - continued

c. **Shield the radiation source.** Place shielding between yourself and a source of penetrating radiation to decrease your dose.

2. Internal Exposure Protection

a. **Inhalation:** A chemical fume hood which has been certified for radioactive materials work is highly recommended when using potentially volatile compounds. Certain equipment is capable of generating radioactive aerosols. Use centrifuges, vortex mixers, shakers, and chromatography plate scraping procedures, etc. in such a way that production of and exposure to radioactive aerosols is minimized.

b. **Puncture:** Dispose of syringes and pipettes promptly and in appropriate containers. Guard against glass breakage and puncture injury during use and disposal. Do not attempt to recap needles before disposal.

c. **Ingestion:** NEVER introduce any food or drink into a posted restricted area, even for temporary storage. DO NOT eat or drink in any area where radionuclides are used, never pipette by mouth, and never store food and drinks in a cold room or refrigerator that is designated for radioactive material storage.

d. **Absorption:** Use measures that prevent the contamination of skin and eyes. If there is any possibility that the clothes have been contaminated, remove this clothing before leaving the area. Eye protection, (e.g. goggles, face shield) is encouraged to prevent contamination of the eyes. This is particularly important for individuals wearing contact lenses since some lenses will absorb and concentrate radiochemicals. Wear protective gloves at all times when working with radioactive materials. Change gloves frequently during the work, disposing of the used gloves as radioactive waste. Wash hands after using radioactive materials and monitor the hands for contamination, especially before eating or smoking, and prior to leaving the laboratory.

VI. RADIATION EXPOSURE DURING PREGNANCY

Employees who become pregnant are strongly encouraged to inform the RSO in writing as soon as possible. A description of predicted usage of radionuclides and procedures to be performed during the gestation period should be sent to Occupational Health and the RSO for evaluation. Occupational Health and the RSO will inform the pregnant woman and her supervisor of individual actions that may need to be taken to ensure compliance with the 500 mrem rule. ALARA recommendations on pregnancy and radiation exposure include:

1. Notifying of supervisor immediately when pregnancy is known or suspected.

2. Wearing a lead apron while performing work with certain radionuclides.

3. Using extra shielding such as lead-lined waste containers for gamma emitters.

VI. RADIATION EXPOSURE DURING PREGNANCY – continued

4. Wearing radiation badges (worn at the waist) to be read monthly, not quarterly;

5. Deferring the receipt of unshielded stocks of radionuclides.

6. Leaving work area where more than one millicurie of certain radionuclides are being used.

VII. PROCUREMENT AND INVENTORY CONTROL

Advance approvals shall be obtained from the RSO before bringing the sources on-site to any County facility. In all cases, requisitions will contain a requirement for the proper labeling of shipments of radioactive materials.

Upon receipt, the package shall be opened only to the extent necessary to determine that radioactive material is enclosed. The Shipping/Receiving Department will notify the RSO of the arrival of the source.

All incoming sealed sources should be wiped tested by the RSO to determine that there are no radiation contamination leaks. The RSO or designee will also inventory the material assuring the amount, size, type, and proper labeling of sources. After assuring that the material is satisfactory, the RSO will deliver the material to the requisitioner. The material must be stored in a designated secure location that is properly shielded. The RSO will still be responsible for the source and keep detailed records of its use and location.

The RSO or designee is responsible for inventorying the material monthly to ascertain that it is being used in its approved location and that it is properly housed and stored. A log must be maintained of the date the material was checked and that its condition was satisfactory.

VIII. ASSEMBLY AND USE

Under the direct supervision of the RSO, the user shall wear the appropriate personal protective equipment, and handle the sources with forceps or other suitable tools. The material shall not be left unattended if not secured. Any residual material shall be stored in an acceptable container approved by the RSO and will be checked as part of the monthly inventory.

IX. LABORATORY FACILITY

The laboratory area where the radioactive source is used shall be set aside as a secure area with limited access. A separate room is preferred. A Note To Employees, Form RH-2364, will be posted and the data sheet will be available in the area. The radioactive source may not leave the designated area without the approval of the RSO.

X. AREA MONITORING

Radiation monitoring instruments shall be on hand at the facility and be properly calibrated at regular intervals. The equipment shall be available in case of an emergency for the RSO and the Safety Division.

The monitor and its probe shall be used to assure the sealed source is emitting no radiation contaminants. The entire designated area shall be surveyed and any detected radiation contaminants shall be corrected by procedures approved by the Radiation Safety Officer before work is allowed to continue. The area shall be initially surveyed prior to the start of the development work and monthly thereafter until all material is properly disposed.

The external surfaces of the sealed sources will be wiped for surface and airborne radiocontaminants. The radiation analysis of the wipe will also be conducted by a State-approved analyses laboratory. The radiation leak test will be performed every six months by the Radiation Safety Officer or designee, who will be responsible for forwarding the wipe to the laboratory for analysis.

Any monitoring instruments shall be used in accordance with the manufacturer's instructions and shall be included in the facility's calibration scheduling system. The instrument shall be calibrated at the manufacturer's recommended intervals by an approved laboratory or the manufacturer. Records of the calibration will be verified by the RSO and maintained on file where the equipment is housed.

XI. TRAINING

Personnel who will be handling, assembling, conducting tests, or who will be frequenting the restricted area with the radioactive source shall be trained by the RSO or other qualified person in one or more of the following topics:

1. Regulations on the control of radioactivity.
2. Maximum exposure levels for beta radiation.
3. The use and significance of the monitoring instrumentation.
4. The requirements of this procedure.
5. Methods for reducing exposure to radiation (ALARA)
6. Reporting of accidental exposure or other problems related to the source.

No person shall be allowed to handle or operate the sealed source or frequent the area without receiving training. This shall be enforced by the RSO and the Safety Division.

XII. DISPOSAL

All radioactive sealed sources and other material will be picked up by qualified hazardous materials personnel. All disposals will be made in accordance with all Federal, State, and Local regulations. All lists of radioactive material will be updated within 48 hours. The State of California will be notified that the quantities as stated in the radioactive materials licenses have been decreased/increased and license will be amended.

XIII. RADIATION LICENSE

The RSO is responsible for obtaining and maintaining all required radiological licenses. The State of California Radioactive Material License will be posted at all areas where radiation equipment and sources are stored for reference. Any modifications made by the State or RSO are incorporated into this procedure by reference. The license takes precedence in all cases.

APPENDIX A

DEFINITIONS

APPENDIX A: DEFINITIONS

Activity. The number of nuclear disintegrations occurring in a given quantity of material per unit time.

ALARA. As Low As Reasonable Achievable.

Alpha particle. (alpha-radiation). An alpha particle is made up of two neutrons and two protons giving it a unit charge of plus-two. It is emitted from the nucleus of radioactive atoms and causes high-density ionization. Alpha particles transfer their energy in a very short distance and are readily shielded by a piece of paper or the dead layer of skin. Alpha-radioactivity is therefore primarily an internal radiation hazard.

Annihilation. The process by which a negative electron and a positive electron, called a positron, combine and disappear with emission of electromagnetic radiation.

Atomic number. The atomic number is the number of protons (positively charged particles) in the nucleus of an atom. Each element has a different atomic number. The atomic number of hydrogen is 1, that of oxygen 8, iron 26, lead 82, uranium 92. The atomic number is also called the charge number and is usually denoted by "Z".

Atomic weight. The atomic weight is approximately the sum of the number of protons and neutrons found in the nucleus of an atom. This sum is also called the mass number. The atomic weight of oxygen, for example, is approximately 16, with most oxygen atoms containing 8 protons and 8 neutrons.

Background radiation. The radiation coming from sources other than the radioactive material to be measured is termed "background radiation." Background radiation is primarily a result of cosmic rays which constantly bombard the earth from outer space.

Becquerel *(Bq)*. One disintegration per second (dps). This unit provides a measure of the rate of radioactive disintegration. There are 3.7×10^{10} becquerel per curie of radioactivity.

Beta particle. (beta-radiation). Beta particles are small electrically charged particles emitted from the nucleus of radioactive atoms. They are identical to electrons and have a negative electrical charge of one. Beta particles are emitted with various kinetic energies. They pose an internal exposure hazard and are often penetrating enough to cause skin burns.

Bremsstrahlung. The electromagnetic radiation associated with the deceleration of charged particles. The term can also be applied to electromagnetic radiation produced by acceleration of charged particles.

Compton effect. The glancing collision of a gamma photon with an orbital electron. The gamma photon gives up part of its energy to the electron, ejecting the electron from its orbit.

Controlled area. A specified area in which exposure of personnel to radiation or radioactive material is controlled. Controlled areas should be under the supervision of a person who has knowledge and or responsibility for applying the appropriate radiation protection practices.

Counter. A device for counting nuclear disintegrations so as to measure the amount of radioactivity. The electronic signal announcing disintegration is called a count.

Curie. A measure of the rate at which a radioactive material emits particles. One curie corresponds to 3.7×10^{10} disintegrations per second.

APPENDIX A: DEFINITIONS - continued

Disintegration. When a radioactive atom disintegrates, it emits a particle from its nucleus. What remains is a different element. When an atom of polonium disintegrates, it ejects an alpha particle and changes to a lead atom buy this process.

Dose. A general term denoting the quantity of radiation or energy absorbed in a specified mass. For special purposes, its meaning should be appropriately stated; e.g., absorbed dose.

Dosimeter (dose meter). An instrument used to determine the radiation dose a person has received.

Electron. A minute atomic particle possessing the smallest amount of negative electric charge (-1). Orbital electrons rotate around the nucleus of an atom. The mass of an electron is only about 1/1,820 the mass of a proton or neutron.

Electron volt (eV). A small unit of energy - the amount of energy that an electron gains when it is acted upon by one volt. Radioactive materials emit radiation that may have energies of up to several million electron-volts, MeV. Gamma-ray energies from radioisotopes can be 4 MeV. Some are emitted at relatively low energies and are correspondingly less hazardous.

Element. All atoms of an element contain a definite number of protons and therefore have the same atomic number. Various isotopes of an element are due to different numbers of neutrons in the nucleus. However, electrical charge and chemical properties of the various isotopes of an element are alike.

Film badge. A piece of masked photographic film worn like a badge for personal monitoring of radiation exposure. It is darkened by penetrating radiation, and radiation exposure can be checked by developing and interpreting the film. The type of masking depends on the type of radiation to be measured.

Gamma-rays (Gamma-radiation). Gamma-rays are electromagnetic photons emitted from the nuclei of radioactive atoms. They are highly penetrating and present an external radiation exposure hazard.

Gray (Gy). Unit of absorbed radiation dose equal to one joule of absorbed energy per kilogram of matter.

Half-life. A means of classifying the rate of decay of radioisotopes according to the time it takes them to lose half their strength (intensity). Half-lives range from fractions of a second to billions of years. Cobalt-60, for example, has a half-life of 5.3 years.

Half-value layer. The thickness of a specified substance which, when introduced into the path of a given beam of radiation, reduces the value of a specified radiation quantity by one-half. It is sometimes expressed in terms of mass per unit area.

Ion. An atom or molecule that caries either a positive or negative electrical charge.

Ionizing radiation. Electromagnetic or particulate radiation capable of producing ions, directly or indirectly, by interaction with matter. In biological systems, such radiation must have a photon energy greater than 10 electron volts. This excludes most of the ultraviolet bands and all longer wave lengths.

Ionization chamber. A basic counting device to measure radioactivity.

APPENDIX A: DEFINITIONS - continued

Isotope. Nuclei which have the same atomic number. Isotopes of a given element contain the same number of protons but a different number of neutrons. Uranium-238 contains 92 protons and 146 neutrons while the isotope U-235 contains 92 protons and 143 neutrons. Thus the atomic weight (atomic mass) of U-238 is 3 higher than that of U-235.

Moderator. A material used to slow neutrons, such as used in a reactor. Slow neutrons are particularly effective in causing fission. Neutrons are slowed down when they collide with atoms of light elements such as hydrogen, deuterium, and carbon, three common moderators.

Molecule. The smallest unit of a compound or element as it exists in nature. A water molecule consists of two hydrogen atoms combined with one oxygen atom. Hence the well-known formula, H_20. The element oxygen exists as diatomic molecules, O_2.

Neutron. An atomic particle. The neutron weighs about the same as the proton. As its name implies, the neutron has no electric charge. Neutrons make effective atomic projectiles for the bombardment of nuclei. Neutrons can also present unique external exposure hazards to personnel.

Nucleus. The inner core of the atom. The nucleus consists of neutrons and protons tightly bound together.

Pair production. The conversion of a gamma-ray into a pair of particles - an electron and a positron. This is an example of direct conversion of energy into matter, and is quantified by Einstein's famous formula: $E = Mc^2$; Energy = Mass x Velocity of Light (squared).

Photoelectric effect. Occurs when an electron is ejected from the orbit of an atom by a photon that imparts all of its energy to the electron.

Photon. A bundle (quantum) of electromagnetic radiation. X-rays, gamma-rays, and visible light and radio waves.

Plutonium. A man-made heavy element that undergoes fission under the impact of neutrons. It is a useful fuel in nuclear reactors. Plutonium can be produced by capture of slow neutrons in uranium. It is a highly hazardous alpha emitter.

Proton. An elementary particle found in the atomic nucleus. Its positive charge of one is opposite to that of the electron.

Radioactivity. The emission of very fast atomic particles and/or rays by nuclei. Some elements are naturally radioactive while others become radioactive after bombardment with neutrons or other particles. The three major forms of radioactivity are alpha, beta, and gamma, named for the first three letters of the Greek alphabet.

Radioisotope. A radioactive isotope of an element. A radioisotope can be produced by placing material in a nuclear reactor and bombarding it with neutrons. Many fission products are radioisotopes. Radioisotopes are sometimes used as tracers, as energy sources for chemical processing or food pasteurization, or as energy sources for nuclear batteries.

Radium. One of the earliest known naturally radioactive elements, radium, is far more radioactive than uranium and is found in the same ores. It is a highly hazardous alpha emitter.

APPENDIX A: DEFINITIONS - continued

Roentgen (R). The amount of x- or gamma-radiation that produces ionization resulting in one electrostatic unit of charge in one cubic centimeter of dry air at standard conditions.

Roentgen equivalent man (rem). A unit of absorbed energy times a quality factor for the relative biological effect of the particular radiation as compared to gamma-radiation. Personnel exposure limits may be expressed in rem.

Scintillation counter. A radiation counting device that operates by means of tiny flashes of light (scintillations) particles produce when they strike certain crystals or liquids.

Shielding. A barrier that protects workers from harmful radiation released by radioactive materials. Lead bricks, dense concrete, water and earth are examples of materials used for shielding.

Sievert (Sv). Unit of absorbed radiation dose times the quality factor of the radiation as compared to gamma-radiation. It is equal to the Gray times the quality factor and is equivalent to 100 rem.

Strontium 90. An isotope of strontium having a mass number of 90. Strontium-90 is an important fission product. It has a half-life of 25 years and is a highly hazardous beta emitter.

Tracer. A radioisotope mixed with a stable material. Radioisotopes enable scientists to trace chemical and physical changes in materials. Tracers are widely used in science, industry, and agriculture. For example, when radioactive phosphorus is mixed with a chemical fertilizer, the uptake of radioactive phosphorus from fertilized soil can be measured in the plants as they grow.

Tritium. Often called hydrogen-three. Tritium is an extra heavy hydrogen whose nucleus contains two neutrons and one proton. It is radioactive as a beta emitter.

Uranium. A heavy metal, the two principal natural isotopes of which are U-238 and U-235. U-235 has the only readily fissionable nucleus that occurs in appreciable quantities in nature, hence its importance as a nuclear reactor fuel. Only one part in 140 of natural uranium is U-235.

X-ray. Highly penetrating electromagnetic radiation similar to gamma-rays. The x-rays are produced by electron bombardment of target materials. They are commonly used to produce shadow pictures (rhoentgenograms of the denser portions of objects.

APPENDIX B
EMPLOYEE TRAINING DOCUMENTATION

INDIVIDUAL EMPLOYEE TRAINING DOCUMENTATION

NAME OF TRAINER/INSTRUCTOR:_____

TRAINING SUBJECT: Radioactive Materials

TRAINING MATERIALS USED:_____

_____

NAME OF EMPLOYEE: _____

DATE OF HIRE/ASSIGNMENT:_____

I,_____, hereby certify that I have received training as described in the following areas:

[ ] Regulations on the control of radioactivity.

[ ] Maximum exposure levels for beta radiation.

[ ] The use and significance of the monitoring instrumentation.

[ ] Methods of reducing exposure to radiation.

[ ] Reporting of accidental exposure or other problems related to the source.

I fully understand this training, agree to comply with the instructions received, and the Radioactive Materials Plan.

_____
Employee Signature Date

_____
Trainer/Instructor Signature Date