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STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

SAFETY MANUAL AND ADMINISTRATIVE INSTRUCTIONS TO PERSONNEL USING NUCLEAR PROBES

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FEBRUARY 1964

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State of California
Department of Public Works
Division of Highways

Materials and Research Department

To Laboratory Personnel
who are required to work
with radioactive elements:

The instructions in the attached manual are to govern your activities in working with moisture or density probes containing radioactive sources.

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& Research Dept.

JOHN L. BEATON
Materials & Research Engr.

February 1964

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INTRODUCTION

The purpose of this manual is to serve as a guide for personnel using moisture and density probes containing radioactive sources. This manual is to be used throughout the California Division of Highways for the express purpose of regulating the use of the moisture and density probes containing radioactive sources.

All technicians responsible for radioactive sources shall be:

1. Thoroughly familiar with the safe handling techniques of radioactive sources.
2. Fully informed of the hazards to health that exist near radioactive sources.
3. Completely familiar and comply with the following rules and regulations:
   a. General Industry Safety Orders, Group 6, of the Division of Industrial Safety, Title 8, CAC.
   b. California Radiation Control Regulations of the State Department of Public Health, Title 17, CAC.

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A. The only qualified personnel who will personally use the moisture and density probes containing sealed sources and any one of whom must be in continuous attendance at the site of use are:

William G. Weber	John Campbell
James Cechetini	Joseph Puleo
Kenneth Iwasaki	Daniel Howe
William S. Maxwell	Bobby Lister

B. Mr. William G. Weber under the supervision of Mr. T. W. Smith will be directly responsible for the overall radiation protection program.

C. Mr. F. N. Bunyard and Mr. C. T. Berry, Assistant Safety Engineers, are assigned the duty of radiation protection officers. The duties of the radiation protection officers are:

1. To stop or suspend any operation which does not comply with the current General Industry Safety Orders, Group 6, of the Division of Industrial Safety, Title 8, CAC; and the California Radiation Control Regulations of the State Department of Public Health, Title 17, CAC.

2. To insist that only safe working conditions be practiced and maintained.

3. To inspect all safety, dosage, and medical reports for compliance.

4. To assist in any emergency that may arise endangering the public from the use of radioactive materials.

D. SUPERVISION

1. All operations involving exposure to radiation shall be under the direct supervision of qualified personnel familiar with hazards of exposure to such radiation as may be encountered. In this manual it is to be understood that the term "radiation" implies "ionizing radiation."

2. In the use of radioactive materials, the operating technician will be responsible for determining the radiation levels when receiving the equipment.

3. Only those employees who are directly involved in the use of the probes containing radioactive materials shall be permitted access to radiation of greater intensity than 2 mr/hr.

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4. No one shall be permitted to enter a radiation field of greater than 0.5 roentgens per hour.

5. No one shall be allowed to enter a radiation field greater than 2 mr/hr. without carrying a properly operating monitoring device to show the amount of ionizing radiation to which such persons have been subjected.

6. The maximum allowable radiation dosage to the operating technician is established at 50 mrem per week or 10 mrem per day.

7. When using buildings or property as a site for use or storage, the operating technician shall insure that persons responsible for the property are aware of the radiation hazard.

E. TRAINING COURSE OUTLINE

The technicians who will personally be working with moisture and density probes containing sealed sources shall be properly trained. This training will consist of a three-day course that will include the following:

1. Fundamentals of Radioactivity.

   a. Types of radiation.

2. Detection of Radiation

   a. Particle counters
   b. Ion chambers
   c. Electrometers
   d. Detection with film

3. Principles of Shielding

   a. Simple shielding computations

4. Health Physics of Radiation

   a. Biological effects of radiations
   b. Dose and dosage standards
   c. Detection and measurement instruments, principles, and apparatus

5. Handling of Radioactive Materials

   a. Source storage and shipment
   b. Health precautions in handling and storage

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6. Rules and Regulations

   a. General Industry Safety Orders, Group 6, of the Division of Industrial Safety, Title 8, CAC.

   b. California Radiation Control Regulations of the State Department of Public Health, Title 17, CAC.

7. Operation of Nuclear Probes

   a. Operation of sealer
   b. Characteristics of the pickup tube
   c. Physical construction of the probes
   d. Nuclear operation of the probes

F. SURFACE DENSITY PROBE, Instructions concerning the safe operation

1. The 3 mc Cs^{137} source is in a lead cylinder inside the probe. This lead cylinder rotates along side another piece of lead.

2. With the handle in the "up" position the source is facing the stationary piece of lead. The maximum gamma radiation is at the sides of the probe and is 12 mr/hr.

3. With the handle in the "down" position the lead cylinder is rotated so that the source is directly over the bottom of the case. The handle shall never be in the "down" position unless the bottom of the probe is setting on solid material. The gamma radiation level with the handle in the "down" position is 42 mr/hr. at the sides. CAUTION: When the handle is in the "down" position there is no shielding at the bottom surface of the probe.

G. SURFACE MOISTURE PROBE, Instructions concerning the safe operation

1. The 4 mc Ra Be source is in the bottom end of the rod that is directly attached to the handle. The Ra Be source emits both gamma radiation and neutrons.

2. With the handle in the "up" position the source is inside a lead shield inside of a paraffin block. The maximum radiation levels with the handle in the "up" position is, gamma 35 mr/hr. at the bottom and, neutrons are 11 mrem/hr. at the bottom, for a total of 45 mrem/hr.

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3. With the handle in the "down" position the source is in a lead cup at the bottom of the probe. The handle shall never be in the "down" position unless the bottom of the probe is setting on a solid material. With the handle in the "down" position, the gamma radiation is 55 mr/hr. at the sides and, the neutron radiation is 80 mrem/hr. at the sides for a total of 135 mrem/hr. CAUTION: When the handle is in the "down" position there is no shielding at the bottom surface of the probe.

H. SUBSURFACE DENSITY PROBE, Instructions concerning the safe operation

1. The 4 mc Cs^{137} source is in the lower end of the probe. There is no shielding in the probe around the source.

2. The probe is locked in the upper shield by means of a pin at the lower end of the upper shield and a screw at the upper end of the upper shield. The gamma radiation level when the probe is in the upper shield is 40 mr/hr. at the lower surface of the shield. There is no shielding at the lower access hole in the upper shield and the radiation level is over 1000 mr/hr. at this point.

3. When the probe is placed in the carrying case the upper shield is attached to the lower shield. The probe is then pushed completely into the combined shields so that the source is in the lower shield. The gamma radiation level, when the source is in the lower shield, is 22 mr/hr. at the surface of the lower shield.

4. When carrying or storage of the probe it shall be kept in the carrying case. The gamma radiation level at sides of the carrying case is 9 mr/hr.

5. When transferring the subsurface probe from the upper shield to the access tubing, for making density determinations, the probe is to be transferred as rapidly as possible. When the source is under the ground surface two feet or more there is no appreciable radiation at the ground surface. CAUTION: When transferring from the upper shield to the under ground location the operator is exposed to unshielded radiation from the Cs^{137} source.

6. The 15 microcurie Cs^{137} source is contained in the shield. Radiation from this source is less than one-half mr/hr. at the surface of the shield.

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I. SUBSURFACE MOISTURE PROBE, Instructions concerning the safe operation

1. The subsurface moisture probe contains a 9 mc Ra Be source. The source is four inches from the lower end of the probe. There is no shielding contained in the probe.

2. The subsurface moisture probe is carried or stored in its shield inside the carrying case. The probe is fastened into the shield by means of the pin on the lower end of the shield and the set screw at the top of the shield. The gamma radiation at the side of the carrying case is 38 mr/hr., with minor neutron radiation.

3. When removing the shield and probe from the case the probe should always remain locked in the shield. The probe and shield shall be out of the carrying case the shortest possible time consistent with good working practice. The gamma radiation level at the surface of the shield is 62 mr/hr. and some neutron radiation exists. There is no shielding at the lower access hole in the shield and the radiation level is over 1000 mr/hr.

4. In placing the subsurface probe into the access tube stand as far away from the probe as possible. Complete this transfer of the probe as rapidly as practical. When the source is two feet or more below the ground surface only minor radiation will exist at the ground surface. CAUTION: When transferring the probe from the shield to the underground location the operator is exposed to unshielded radiation from the 9 mc Ra Be source.

J. FIELD OPERATION OF NUCLEAR PROBES

1. When not in use all probes are to be kept locked in their carrying case.

2. When operating the surface nuclear probes unauthorized personnel are to be kept at a distance greater than five feet from the probe, when the handle is in the "down" position.

3. A daily diary must be kept, noting the following:

   a. Location at which source was used and stored.
   b. Precautions for health and physical safety.
   c. Any pertinent data pertinent to the radioactive sources.
   d. Minor repairs required when equipment is returned to Sacramento, and repairs made in the field.

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(The law clearly places responsibility for public safety upon user and the daily diary is a legal document for yours and the State's protection).

4. The use of radiation signs in the work area is required.

5. The operating technician shall see that all security measures at job site conform to the General Industry Safety Orders, Group 6, of the Division of Industrial Safety, Title 8, CAC; and the California Radiation Control Regulations of the State Department of Public Health, Title 17, CAC.

K. RADIATION SURVEY INSTRUMENTATION

1. The operating technician shall make a physical radiation survey when receiving the sources from storage. This survey shall be noted on the form "Statement of Receipt of Radioactive Sources."

2. No physical radiation survey shall be required in the field.

3. The survey instruments available from Mr. Paul Jonas are:

   a. Tracerlab SU 1H Survey Meter.
   b. Tracerlab SU 14 Survey Meter.

4. The physical radiation survey when receiving the sources will be done with (3-a) above.

5. The Tracerlab SU 14 survey meter will be used for the wipe testing of the sources. This will be done only by Mr. W. Weber and/or an authorized laboratory during the month of January of each year. The wipe test results must be recorded and kept on file for California Division of Industrial Safety inspection.

L. PERSONAL MONITORING

1. The operating technician, when handling radioactive sources or subjected to ionizing radiation, must wear a film badge which records the total dosage received.

2. The film badges used are the T. M. Gaines Co. twin film service containing separate badges for recording X, gamma, and beta radiation; and neutron radiation. Film badges are to be developed every two weeks. Three-day notice is required for first film badges to be received from T. M. Gaines Co.

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3. Exposed film badges are to be returned to W. Weber for shipment to T. M. Gaines Co. for processing. Notify Mr. W. Weber or Mr. T. W. Smith if unexposed film badges are required in the field and they will be mailed to the operating technician. Thirteen-week film badges will also be used.

4. The operating technician must also wear a dosimeter, of the Landsverk direct reading type with a 200 mr full scale.

5. Personnel that are within a 2 mr/hr. field two hours or more per day shall wear a dosimeter. Personnel not regularly within a 2 mr/hr. field will not be required to wear film badges.

6. Daily dosimeter readings shall be posed on "Record of Radiological Exposure" Form T-2056. These forms are to be forwarded to Mr. W. Weber weekly.

7. Each employee as listed herein shall be under the supervision of, or consultation with, a competent medical expert experienced in the diagnosis of harmful effects of ionized radiation. Prior to starting ionizing radiation and again at intervals not less than once annually while so employed, a physical examination shall be performed by the M.D. Reports of the medical examination shall be kept current and on file with the employee's radiation exposure records.

M. TRANSPORTING OF SOURCES

1. The nuclear probes shall be transported in state-owned vehicles. When a passenger vehicle is used the nuclear probes shall be kept locked in the trunk. When a station wagon is used the nuclear probes shall be placed in the back of the station wagon and be so placed that they will not slide forward.

2. The carrying cases shall be kept locked at all times during transportation. Keys to the carrying cases are to be retained by the operating technician at all times.

3. When the vehicle is not in use it is to be locked and the keys retained by the operating technician.

4. In case of collision when transporting the nuclear probes, which results in radiation danger, notify the local civil authorities and the California Division of Highways, Materials and Research Department. Telephone number is Sacramento, 452-5481. Ask for Mr. W. Weber. If Mr. Weber cannot be reached, then ask for Mr. T. W. Smith. He will then notify the proper authorities to take action.

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5. Radiation signs will not be required on vehicles transporting nuclear probes where the radiation level is below 0.5 mr/hr. at the surface of the vehicle.

6. In case shipment by commercial carriers become necessary, prior approval will be secured from headquarters and the appropriate interstate commerce commission regulations will be complied with.

N. STORAGE OF NUCLEAR PROBES

1. The normal storage in Sacramento shall be in the subterrainean concrete vault. When storage in Sacramento is for overnight or over a week end the Nuclear Probes may be stored in a room in the main building. Radiation signs must be posted on the room notifying the personnel of the existence of radiation.

2. In the field the Nuclear Probes may be stored in the following:

   a. State vehicle in a private parking garage, or motel. The vehicle must be locked and the keys retained by the operating technician.

   b. State highway maintenance yards. A locked room or building not available to the public.

   c. Resident engineer's office.

   d. Other State-owned facilities.

3. In item two above the following must be complied with:

   a. Notification and approval of the parties responsible for the area of the existence of ionizing radiation.

   b. Premises shall be inspected and the operating technician satisfies himself that the area has adequate locks. The operating technician shall have keys to the locked area.

   c. Radiation signs shall be conspicuously posted so as to notify the public of the existence of ionizing radiation. The signs shall contain the name, local address and phone number of the operating technician.

   d. The storage area shall be capable of preventing exposure of persons in the immediate vicinity to a radiation field of more than 0.5 mrem per hour.

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O. EMERGENCY PROCEDURES

1. In emergency where damage or possible damage has occurred to the sources:

   a. Notify the local California Disaster Office or Highway Patrol.

   b. California Division of Highways, Materials and Research Department, Sacramento, Phone: 452-5481 and ask for Mr. W. Weber. If unable to contact Mr. Weber ask for Mr. T. W. Smith.

2. In the event of an accident involving the nuclear sources, the technician shall rope off the area until the civil authorities and/or the safety officers from the Division of Highways arrive.

3. In case of a motor vehicle collision involving the sources the vehicle is to be moved off the traveled way to the nearest parking area. The vehicle is to be signed and not further moved until a radiation survey has been made. The area of the collision must be marked and a radiation survey made.

4. In case of theft or loss of radioactive material, the technician shall immediately notify the parties in (1) above.

5. In case the handle of the surface probes sticks in the "down" position notify Mr. W. Weber immediately and follow the appropriate procedure below:

   a. Surface density probe: Place sacks of soil around and above probe. Place Radiation Area signs at ten feet from probe.

   b. Surface Moisture probe: Place containers of water around probe. Place Radiation Area signs at ten feet from probe.

P. PROCEDURE FOR OBTAINING NUCLEAR PROBES

1. Mr. T. W. Smith has authorized Mr. W. Weber to issue the nuclear probes. Notice should be given several days in advance so that the necessary equipment will be ready.

2. A copy of "Statement of Receipt of Radioactive Sources" shall be filled out and left on file with Mr. W. Weber.

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3. The operating technician must keep Mr. Weber informed of the location of the radioactive sources at all times. (The State inspectors demand the sources be produced or exact locations be given during their periodic inspections). If the exact address that the operating technician will be staying at is known in advance it should be noted before leaving Sacramento and if unknown shall be forwarded to Mr. Weber by telegraph.

4. The operating technician shall satisfy himself that the equipment is operating correctly.

5. The operating technician shall survey the vehicle to ensure that the radiation level is below one mrem/hr. at the external surface of the vehicle.

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DEFINITIONS

Curie — That quantity of a radioactive nuclide disintegrating at the rate of 3.700×10^{10} atoms per second. (Abbrev. "C").

Dose — The radiation delivered to a specified area or to the whole body. Units for dose are roentgens (Abbrev. "r"). Permissible dose is the amount of radiation which may be received by an individual within a specified period with expectation of no significantly harmful result to himself.

Dosimeter — An ionization chamber to detect and measure an accumulated dosage of radiation, pencil sized, and used for personnel monitoring.

Film Badge — A pack of photographic film used for approximate measurement of radiation exposure for personnel monitoring purposes.

Ionizing radiation - Gamma rays and X-rays; alpha and beta particles, high speed electrons, neutrons, protons and other nuclear particles; but not sound or radio waves, or visible, infrared or ultraviolet waves.

Roentgen — A dose of radiation such that the associate corpuscular emission per 0.001293 grams of air produces, in air, ions carrying one electrostatic unit of quantity of electricity.

Source Material - Any material which contains, by weight, more than one twentieth of one percent radio-active elements and is declared by rule to be source material.

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ATTACHMENTS:

Record of Radiological Exposure Form T-2056

Statement of Receipt of Radioactive Sources

Radioactive Area Sign

General Industry Safety Orders, Group 6, of the Division of Industrial Safety, Title 8, CAC

California Radiation Control Regulations of the State Department of Public Health, Title 17, CAC

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RECORD OF RADIOLOGICAL EXPOSURE

Dist. _____ Co. _____ Route _____

Location _____

Source Used _____ , _____ mc

Type Equipment - Probe Surface (Circle One)

	Day	Sun	Mon	Tue	Wed	Thu	Fri	Sat
_____ NAME	Date							
	*Daily Exp.							
BADGE _____	*Weekly Total							
NO. _____	*Total to Date							

_____ NAME	*Daily Exp.							
	*Weekly Total							
BADGE _____	*Total to Date							
NO. _____								

_____ NAME	*Daily Exp.							
	*Weekly Total							
BADGE _____	*Total to Date							
NO. _____								

_____ NAME	*Daily Exp.							
	*Weekly Total							
BADGE _____	*Total to Date							
NO. _____								

*Reading of pocket ionization chamber. The ionization chamber to be recharged periodically. Maximum exposure per week to be 50 mr.

(2 Copies to Foundation Dept.)
(1 Copy to each individual)

FORM T-2056 (Rev. 3-64)

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State of California
Department of Public Works
Division of Highways
Materials and Research Department

Statement of Receipt of Radioactive Sources

1. I accept responsibility for physical security, safe handling, and transportation of all radioactive sources entrusted to my care.

2. I have read, familiarized myself with, and understand the General Industry Safety Orders, Group 6, of the Division of Industrial Safety, Title 8, CAC; and the California Radiation Control Regulations of the State Department of Public Health, Title 17, CAC.

3. I will comply with the requirements of the General Industry Safety orders, Group 6, of the Division of Industrial Safety, Title 8, CAC; and the California Radiation Control Regulations of the State Department of Public Health, Title 17, CAC.

4. I will insure that all persons, including observers, comply with the listed safety rules and regulations.

5. I will not delegate custody of any state supplied radioactive source to any individual not qualified by the Materials and Research Department. Unauthorized source transfer will not be tolerated.

6. I received a _____ m.c. source of Cs^{137}, RaBe, in a surface, depth, probe for use at_____ on_____. These sources will be returned on approximately_____ for storage at Sacramento.

7. These sources will be transported in CHC_____. Survey of the vehicle indicates that _____mrem/hr at _____ is the maximum radiation at the surface of the vehicle.

_____ Date

_____ Signature of person receiving sources

_____ Signature of person issuing sources

Sources Returned for Storage at Sacramento

_____ Date

_____ Signature of person storing sources

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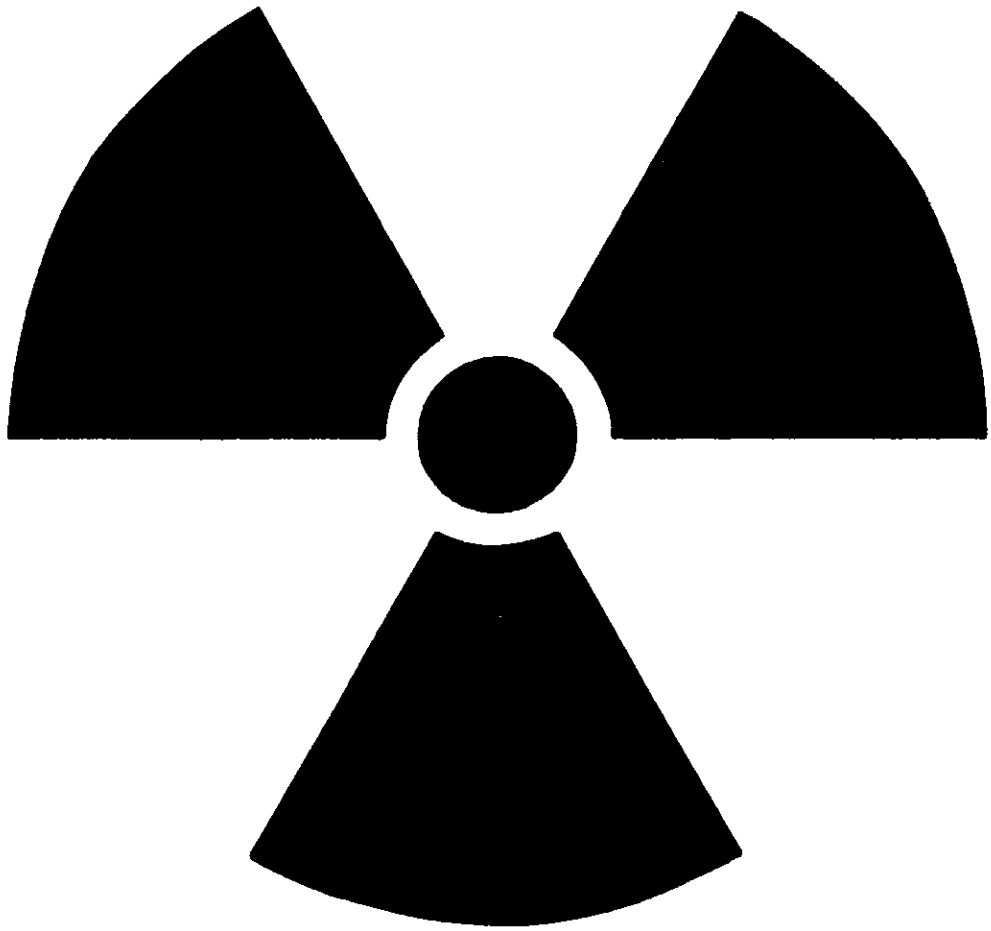
CAUTION



RADIATION AREA

IN CASE OF DAMAGE CONTACT

_____ AT _____ PHONE _____

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