DEPARTMENT OF TRANSPORTATION
ENGINEERING SERVICE CENTER
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ADMINISTRATIVE INSTRUCTIONS FOR USE OF NUCLEAR GAGES

CAUTION: Prior to handling nuclear gauges, performing equipment setups, and/or conducting this method, testers are required to read this method. It is the responsibility of whoever uses this method to consult and adhere to departmental safety and health practices and determine the applicability of appropriate regulatory limitations before any testing is performed. Users of this method do so at their own risk.

A. SCOPE

The purpose of these instructions is to provide guidance for personnel using, or administering the use of, soil moisture, soil density, gamma-gamma probes, and asphalt density gages containing radioactive materials. This section is to be used throughout the California Department of Transportation to regulate the use of gages containing radioactive materials.

All personnel responsible for radioactive sources shall be:

1. Thoroughly familiar with the safe handling techniques for using radioactive materials.

2. Fully informed of the hazards to health presented by proximity to radioactive material.

3. Completely familiar with, and act in compliance 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 Health, Title 17, CAC.
    c. The California Department of Transportation Administrative Instructions for use of Nuclear Gages, Manual of Test, Volume 1, California Test 121.

Copies of the above publications will be kept by the District Safety Officer, and will be made available to the operators.

B. RADIOACTIVE MATERIAL LICENSE

1. Use: Each district will be in possession of a Radioactive Material License, issued by the California Department of Health, for authorization to use the nuclear gages. A license authorizes use of radioactive material in a specific way. Use of radioactive material in a manner not covered by the language of the license is not authorized.

2. License Conditions: Licenses are issued subject to all the requirements of the California Radiation Control Regulations, and to the conditions specified in the license. Licenses are also subject to any additional requirements of the Department of Health as stated in letters issued by the Department. Where a license condition or requirement letter differs from the regulations, the condition or letter is intended to supersede the regulations insofar as that license is concerned.

    A significant condition included in any license is that which incorporates by reference the "statements, representations, and procedures" set forth by the applicant in his

license application or other document specified in the conditions. Therefore, any change in an isotope program, which would make untrue a statement made earlier in an application or related document, requires that the licensee notify the Department of Health and request an appropriate amendment.

3. Transfer of Sources: Prior to shipping (or transferring) the nuclear gages from one licensed organization to another, the shipper shall check, and be assured, that the receiver has a valid license; and that the shipped (or transferred) sources do not exceed the limitations of the receiver's license. Shipment to authorized personnel within the district is covered by the district's license.

4. The Radiation Safety Officer must be listed on the license. Individual operators are not required to be on the license, but the Radiation Safety Officer must maintain a list of qualified operators.

C. RADIATION SAFETY OFFICER

The administration of the use of radioactive material within the district is the direct responsibility of the Radiation Safety Officer. His duties are as follows:

1. License and Inventory: Obtain the district license and amendments as required. This includes the responsibility for ensuring that the number, strength, and type of sources do not exceed those for which the district is licensed.

2. Responsibility: Responsible for the assignment of nuclear gages to the individual projects, use of these gages in the testing program, and all maintenance and storage of nuclear gages when not in field use.

3. Training: Training will be provided to all nuclear gage operators and project supervisors from a qualified and approved training facility.(such as the nuclear gage manufacturers or its representative).

4. General Supervision: Maintain general direction of the use of the nuclear gages by the test operators and project supervisors.

5. Emergency Procedures: Assist in implementing any emergency procedures in any situation that might arise endangering anyone from the use of radioactive materials in connection with the nuclear gage.

6. Records: Responsible for maintaining the following records:

   a. Gage location records.

   b. Gage shipping records.

   c. Gage maintenance records.

   d. All other records as required.

7. Inspection: Inspect all survey, dosage, and medical records for completeness.

8. Field Visits: Visit projects underway to observe that regulations relative to nuclear gages are complied with.

9. Records: Personally responsible for maintaining and inspecting the following records: (The duties of record keeping may be delegated to subordinates.)

   a. Radiation survey records.

   b. Personnel medical forms.

   c. Wipe test records.

   d. Dosimeter reports.

   e. All other records as required.

10. Radiation Detection Equipment: Responsible for obtaining and maintaining the following radiation detection equipment:

    a. Survey equipment.

    b. Personnel dosimeter.

11. Radiation surveys: Perform radiation surveys as required in Section G-4.

12. Wipe Tests: Witness or collect all wipe tests of radioactive sources once every twelve (12) months. The analysis of wipe tests is to be done by a commercial firm licensed to do this work.

13. Emergency Procedures: Responsible for the implementation of emergency procedures for any situation that may arise endangering anyone through exposure to radioactive materials in connection with these nuclear gages.

14. Safety Control: Stop or suspend any operation that does not comply with the rules and regulations of the references listed in the "Scope" on page 1.

15. An alternate person should be designated in cases where the Radiation Safety Officer is not available.

D. SUPERVISION AT THE PROJECT LEVEL

All field operations involving the use of radioactive materials shall be under the direct supervision of the project supervisor. The project supervisor may be the senior resident engineer, resident engineer, test supervisor, or other designated person. The project supervisor will be directly responsible to the Radiation Safety Officer for the use of the nuclear gages in the field; and will be responsible to the Radiation Safety Officer for safety from ionizing radiation resulting from use of the gages.

Duties are as follows:

1. Weekly Diary: A weekly diary must be kept and a copy sent to the Radiation Safety Officer. (The law clearly places responsibility for public safety upon the user, and the diary is a legal document for protection of the project supervisor as well as the State.)

   The diary should note the following:

   a. Locations where the gage is used and stored.

   b. Precautions that are being taken for health and physical safety.

   c. The date, mode of shipment, and bill of lading number when the gage is sent for service.

   d. The nature of repairs, if required.

   e. Any other information pertinent to the radioactive sources.

2. Storage and Transportation of Nuclear Gages: The project supervisor shall make certain that persons responsible for property or buildings used as a storage site for nuclear gages are aware of the radiation hazard involved. In addition, the local police and fire authorities shall be notified of the location of the nuclear gage(s).

3. Radiation Protection: Inform the Radiation Safety Officer of the need for dosimeter badges, radiation surveys, and radiation signs.

4. Safety and Security Requirements: Insist that only safe working practices and conditions be maintained, and see that all security measures at the job site conform to the rules and regulations of the references listed in the "Scope" on page 1.

E. OBLIGATIONS OF THE TEST OPERATOR

The test operator on a project will be responsible for the following items, and must notify the project supervisor immediately whenever difficulties arise.

1. Shutter Device: The test operator must know how the shutter device that shields the radioactive material functions. The operator should frequently check the operation of the shutter device and report any malfunction to the Radiation Safety Officer immediately.

2. Storage: When not in use the gage will be locked in an adequate storage facility with the shutter device secured. Refer to Section L-3.

3. Safety: When operating the nuclear gages (i.e., when the handle is in the "USE" position) unauthorized personnel are to be kept 1.5 m or more from the gage.

4. Radiation Signs: The test operator will ensure that the proper radiation signs are used in the storage areas.

5. A qualified instructor approved by the California Department of Health and the Division of Industrial Safety shall properly train those persons who will be concerned with the operation of the nuclear gages. This training will include the following items:

a. Fundamental Concepts.

(1) Types of radiation.

(2) Interaction of radiation with matter.

(3) Detection of radiation.

(4) Laws of radiation.

b. Health Safety.

(1) Methods of limiting radiation exposure: time, distance, and shielding.

(2) Biological effects.

(3) Measurement instruments.

(4) Rules and regulations.

(5) Storage and transportation.

c. Gage Operation and California Tests 231 and 111.

(1) Gage familiarization.

(2) Standard counts.

(3) Density and moisture measurements.

(4) Calibration.

(5) Area concept.

(6) Field application of gage testing and area concept.

(7) Summary of course, discussion, and final examination.

d. Certificates: Upon completion of the training course in the operation of nuclear gages, a certificate will be presented to the trainee. This certificate does not qualify the trainee as a nuclear gage operator. It serves to indicate that the trainee has participated in a training class covering the subjects outlined in this section.

During an additional training period, of not less than two days, on an active project, the Radiation Safety Officer shall observe and verbally question the trainee to assure that the trainee is qualified. A certificate of proficiency and an operator's card may then be issued.

The Radiation Safety Officer shall maintain records showing currently qualified operators and their past training.

F. USE OF NUCLEAR GAGES

Each district purchases nuclear equipment meeting California specifications by bid. Therefore, each order of gages may have different operating instructions, as it is doubtful that all orders for gages will be from the same manufacturer. It will be necessary for the test operator to consult the operating manual furnished by the manufacturer prior to any field operation. The following health safety precautions must be complied with:

1. Personnel Restriction: Only those employees who are directly involved in the use of the gages containing radioactive materials shall be permitted access to areas with a radiation intensity greater than 2 milliroentgen per hour (mR/h). Personnel that are within a 2 mR/h field two hours or more per day shall wear a dosimeter as described in Section H.

2. Maximum Radiation Dosage: The maximum allowable radiation dosage to the test operator is specified in Section 30265 of the California Code of Regulations, Title 17. This Code currently establishes a maximum dosage of 1250 milliroentgen equivalent man (mrem) per quarter. If a test operators quarterly personal dosimeter dosage exceeds 80% of the quarterly limit (1000 mrem), the gage operator and their supervisor will be notified immediately.

3. Restricted Radiation Field: No one shall be permitted to enter a radiation field of greater than 500 mR/h

4. Use of Radioactive Materials: The radioactive materials shall not be used for any other purpose than the determination of soil or aggregate moisture, soil or aggregate density, or asphalt concrete density, or asphalt content.

G. RADIATION SURVEY INSTRUMENTATION

Each district shall maintain a sufficient number of calibrated and operable radiation survey kits to make physical radiation surveys as required. The equipment included and procedure to be followed are listed below.

1. The survey kit shall contain a portable monitoring instrument, which measures gamma radiation dose rates from 0.1 mR/h to 50 mR/h minimum and another which measures gamma radiation dose rates from 20 mR/h to 500 mR/h minimum.

2. District Survey Kits: The Radiation Safety Officer will be responsible for furnishing this equipment. Each district will have a minimum of three (3) kits.

3. Calibration Requirements: The Radiation Safety Officer will have the responsibility of ensuring that the calibration of the survey equipment is performed at least once a year. Each survey instrument shall bear a label indicating the date of re-calibration.

4. Radiation Survey: The Radiation Safety Officer will be responsible for radiation surveys of each gage, gage storage area, and vehicles used for gage transportation in the district. This will be performed every 12 months and copies will be supplied to the appropriate project supervisor.

H. PERSONAL MONITORING

Personal monitoring of radiation received from the nuclear gages is one of the major items in the Health and Safety Program. Personal dosimeters shall conform to the following:

1. Anyone handling radioactive sources must wear a dosimeter which records the total dosage received in accordance with Section F-1. Dosimeters shall be either film badges or thermoluminescent dosimeter (TLD) badges.
2. Film badges record exposure over a period of one (1) month. TLD badges record exposure over a period of three (3) months.
3. The acquisition of dosimeters for the project is the responsibility of the Radiation Safety Officer. Dosimeters are obtained by service agreement from a firm licensed by the Department of Health to provide such dosimeters. The choice of the dosimeter type and service provider is the option of the district.
4. The project supervisor will notify the Radiation Safety Officer if extra dosimeters are needed.

I. TRANSPORTATION OF RADIOACTIVE MATERIALS IN STATE-OWNED VEHICLES

Each nuclear gage shall be shipped in a container equipped with an adequate lock. For transporting purposes, this lock and the lock on the gage must be secured. These locks will be opened by different keys or combinations. The following rules must be complied with:

1. Placement in Vehicles: When a passenger vehicle is used, both the nuclear gage and the box containing the nuclear gage shall be locked with different locking keys or combinations and shall be kept locked in the trunk. When a station wagon or panel truck is used, both the nuclear gage and the box containing the nuclear gage shall be locked with separate locking keys or combinations and shall be placed at the back of the vehicle in such a manner as to prevent them from sliding. All doors and windows shall be secured when the vehicle is not in use. When a pickup truck is used, both the nuclear gage and the box containing the nuclear gage shall be locked with different locking keys or combinations. The box containing the nuclear gage shall be secured to the bed of the vehicle to prevent movement and in such a way as not to be easily removed by a passerby.

2. Keys: The keys or combinations to the shipping case are to be retained by the driver of the vehicle at all times. When the vehicle is not in use, it is to be locked and the keys retained by the driver.

3. Radiation Signs: Attached to the gage and the gage box in such a way as to be in full view of any person lifting or carrying either gage or box, there shall be a clearly legible magenta-on-yellow sign, displaying:

   The radiation symbol; the words “Caution Radioactive Material”;

The type and amount of radioactive material;

The name, address, and telephone number of the Radiation Safety Officer

4. Transporting Vehicle Accident: In case of a collision when transporting the nuclear gages which results in radiation danger, notify the local civil authorities and Radiation Safety Officer.

5. Overnight Nuclear Gage Storage: For enroute overnight storage at a motel, hotel, or other lodging place, both the nuclear gage and the box containing the nuclear gage shall be locked with different locking keys or combinations and may be left in the locked vehicles (refer to I.1). In the case of pickup trucks, the locked housing covering the locked gage in the truck bed must be bolted securely to the truck. Otherwise, both the nuclear gage and the box containing the nuclear gage shall be locked with different locking keys or combinations and must be locked in the cab of the truck.

6. The radiation level at any point on the outside of the shipping container including the bottom shall not exceed 10 mrem/h and shall not exceed 0.5 mrem/h at 1 m from any surface of the container. A Yellow II label is required on the shipping container. The radiation levels in this part will be determined with a survey meter.

J. TRANSPORTATION OF RADIOACTIVE MATERIALS BY COMMERCIAL CARRIER

1. Container: Both nuclear gage and nuclear gage shipping container shall be locked with different locking keys or combinations.

2. Radioactive label: See I.3 and I.6.

3. The shipping paper or bill of lading must show the following information:

Transport Group: Special Form

Radionuclides and Quantities: (Sealed source containing ___ gigabequerels Americium 241 and ___ gigabequerels Cesium 137).

Federal DOT Label: (Radioactive Yellow II).

This is to certify that the above-named articles are properly classified, described, packaged, marked, and labeled, and are in proper condition for transportation according to the applicable regulations of the Department of Transportation.

Signature _____
Date _____

One copy of the bill of lading should accompany the container, at least 2 copies should be provided to the commercial carrier, and one copy should be retained for the shipper's records.

4. Information for Receiver: Notify the receiver and convey the following information:

   a. Carrier shipping gage.

   b. Date shipped.

   c. When to expect delivery.

   d. Bill of lading number.

K. TRANSPORTATION OF RADIOACTIVE MATERIALS - ON THE JOB METHOD OF TRANSPORTATION

An adequate container should be devised or obtained which adheres to the following items:

1. Security: This is of prime importance. The container should be adequately locked and secured to the vehicle in which it is carried.

2. Container for pick-up trucks: If a wood or metal box is built or bought for housing the gage during working operations, it should be secured to the bed of the pick-up with 10 mm bolts. It should be constructed to protect the instruments from the elements, vibration, and other damage. The box shall have some means of preventing the instruments from sliding and jarring and shall be locked when the operator is not in attendance.

3. Container for panel trucks: When the container meets the Department of Transportation "Radioactive Yellow II" requirement, it is not necessary to have a box

as described under 2 when a panel truck is used. However, a device mounted to the floorboards by 10 mm bolts to which the nuclear gages can be secured, will be necessary. The nuclear gages will be locked and secured in such a manner to prevent sliding and jarring. The doors on the panel must be locked when the operator is not in attendance.

4. Radioactive Sign: See I.3 and I.6.

L. STORAGE OF NUCLEAR GAGES

1. Types of Storage: There are two types of storage involving the nuclear gages in addition to the overnight storage referred to in I.5. These are district office storage and field storage. Each type requires three different locks between the general public and the radioactive material. The lock on the gage is considered as one of these.

2. District Office Storage: When the gages are not in field use the normal storage will be at the District Office. This should be in a special area designated for this purpose, with radiation signs posted at each entryway and on the walls of the room to notify personnel of the presence of radiation. The sign shall measure not less than 200 mm per side with the radiation symbol and statement "Caution Radioactive Material". The name and phone number of the Radiation Safety Officer shall be on the sign. The form "NOTICE TO EMPLOYEES" RH2364, as shown in Title 17, is also required. The Radiation Safety Officer will be responsible for the storage facilities at the District Office. The storage area shall be so constructed that at the external surface no person will be exposed to a radiation field exceeding 0.5 mrem/h.

3. Field Storage Sites: The project supervisor will be responsible for storage in the field. The nuclear gages may be stored in the following:

   a. State vehicle on State property: Within a fenced enclosure or building with a locked gate or door, the nuclear gage must be locked inside of a locked container or compartment with different locking keys or combinations and the vehicle must be locked. The State employee responsible shall retain the keys.

   b. State Transportation Maintenance Yard: The gage must be locked in a room or building not available to the public.

   c. Resident Engineer's Office: The nuclear gage shall be locked and stored in either a locked closet or a special area. Different locking keys or combinations shall be used for the closet or special area than that of the nuclear gage.

   d. Other State-owned facilities if required.

4. Field Storage Requirements: The following requirements must be complied with:

   a. Notification to the parties responsible for the premises of the presence of ionizing radiation and approval of storage by such parties.

   b. The premises shall be inspected and the Radiation Safety Officer shall be satisfied that the gages are properly stored.

   c. Radiation signs as indicated in L.2 shall be posted on the outer surface of vehicles, at each entryway of a building, and the locked doors of rooms, closets, or special areas to notify the public of the presence of ionizing radiation. The signs shall display the names, local addresses, and phone numbers of responsible State employees (resident engineer, test supervisor, or other designated person) in addition to those indicated in L.2.

   d. The external surface of the storage area shall be capable of protecting persons from exposure to radiation fields in excess of 0.5 mrem/h.

   e. The local police and fire departments shall be notified of the location of the storage area.

M. EMERGENCY PROCEDURES

1. Physical Damage:

a. If any moving equipment is involved, stop its movement until the extent of contamination, if any, can be established.

b. Cordon off a five-(5) meter radius area around the incident.

c. Visually inspect the gauge to determine the extent of damage to the source(s), source housing(s) and shielding.

d. If the source(s), source housing(s) and shielding are intact and functional, the gauge can be removed from the site, returned to the shipping container, and shipped to the manufacturer for repair.

e. If the source rod is bent and extended or the shielding is damaged and the sealed source capsule is undamaged but there is likelihood of dose rates exceeding those of an undamaged gage, special handling must be exercised while securing the damaged equipment. Radiation exposure should be kept as low as reasonably achievable (ALARA). ALARA principles dictate that the time of exposure be minimal, distance from source be kept as far as possible, and that shielding maximized to the extent possible while carrying out an operation. Move the gage to a controlled area while providing additional shielding and immediately contact the DRSO. Describe the condition and follow the instructions of the DRSO. The DRSO will promptly notify the appropriate agency as required in Section 30294 and 30295 of the California Code of Regulations, Title17.

f. If the integrity or location of the sources(s) cannot be positively identified, at the earliest possible time, when the situation is under control, contact the DRSO. Describe the conditions and follow the instructions of the DRSO. The DRSO will notify the appropriate regulatory agency.

2. Action to take for Different Types of Emergencies:

a. 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 have "Caution Radioactive Material" signs placed around it, and not to be further moved until a radiation survey has been made. The area of the collision must be marked and surveyed for radiation contamination.

b. In case of a fire in an area storing radioactive material,

(1) Call the Fire Department.

(2) Take action appropriate with a fire to protect personnel.

(3) Notify the DRSO.

(4) Stand by to advise the fire fighters as to the nature, location and potential hazards of the radioactive materials. Supply them with an information packet consisting of the facility layout and a data sheet of the equipment.

c. In case of theft or loss of radioactive material, the nuclear gage operator shall notify his supervisors and the District Radiation Safety Officer (DRSO). The DRSO shall notify his supervisor and the following agencies:

(1) California Department of Health-Sacramento.

(2) California Highway Patrol-Local.

(3) Local law enforcement agencies, i.e., Sheriff or Police Departments.

(4) Department of Transportation Information Officer-Sacramento.

d. Sources that become stuck in an open or exposed position can be shielded by placing sacks of soil around them.

N. PROCEDURE FOR OBTAINING NUCLEAR GAGES

1. District Distributor: The Radiation Safety Officer is authorized to receive the nuclear gages from manufacturers and other licensees

and issue them to the individual construction projects.

2. Receipt: A copy of "Statement of Receipt of Radioactive Sources" shall be filled out and left on file with the Radiation Safety Officer.

3. Location of Radioactive Sources: The project supervisor must keep the Radiation Safety Officer informed of the location of the radioactive sources at all times. (The State Industrial Safety inspectors demand that the sources be produced, or their exact locations be given during their periodic inspections.) If the exact address where the nuclear gage will be used is known in advance, it should be noted before leaving the district office. If the address is not known, the Radiation Safety Officer will be notified as soon as it is determined.

4. Condition of Gage: When receiving the equipment, the project supervisor shall determine to his satisfaction that it is operating correctly.

5. Nuclear Survey: The Radiation Safety Officer will survey the nuclear gage, the vehicle, and the storage area so the test operator can be made aware of the radiation field within which they are working. The radiation Safety Officer will also ensure that the radiation level is below 2 mR/h at the external surface of the vehicle and below 0.5 mR/h at the external surface of the storage area.

O. PROCEDURE FOR WIPE TESTS

Wipe tests (or leak testing) are required by law. This test is simply a swabbing of the sealed source to ascertain if any radioactive contamination has occurred from the nuclear source.

1. Frequency: The district must have each source wiped every twelve-(12) months. A label indicating the date of the wipe test is required on each gage.

2. Performance: The wipe tests may be collected by service contract, but the Radiation Safety Officer shall witness the test. The tests may be performed by the Radiation Safety Officer. The analysis of wipe tests shall be done by a commercial firm licensed to do this work. The service contract for the commercial firm will be obtained by individual districts.

3. Leak Test Results: Records of leak test results shall be kept in units of microcuries and maintained for inspection. Any leak test revealing the presence of 0.005 µCi or more of removable radioactive materials shall be reported to the California Department of Health, Radiological Health Section, 601 N. 7th Street, Sacramento, California 94234-7320, within 5 days of the test. This report should include a description of the defective source or device, the results of the test, and the corrective action taken.

4. Source Test Records: The manufacturer is to furnish the district with a copy of the record of the wipe tests that have been performed on each nuclear source delivered to a district.

5. No gage is to be used unless all requirements of this section are met.

P. MAINTENANCE OF THE NUCLEAR GAGES

1. Maintenance Center: No maintenance will be performed by unauthorized personnel. A maintenance center may be established by each individual district, or the district may have all maintenance work performed by a licensed commercial repair company.

2. The maintenance center will be under the direct control of the Radiation Safety Officer. A list of personnel qualified to perform maintenance shall be kept by the Radiation Safety Officer.

3. Shipping: The entire instrument will be shipped when maintenance work is required.

4. Information for Receiver: Follow up shipping as stated in J-4.

5. Required Notification: The Radiation Administrative Officer must be notified in advance of the shipment of a source and advised upon its return.

6. Repair Approval: All repairs are to be approved by the Radiation Safety Officer and performed in accordance with the manufacturer's manual. At no time may the

sealed source containing the radioactive material be opened or disassembled.

Q. RADIOLOGICAL EXPOSURE RECORDS

1. The Radiation Safety Officer will be responsible for every individual's dosimeter reports.

   Exposure records shall be kept on Department of Health Form RH2365 or in a manner that includes all information required on said form. Each entry shall be for a period of time not exceeding one calendar quarter.

2. An annual report of radiation exposure will be provided to any gage operator at their request.

3. At the request of any former gage operator, a written report covering each calendar quarter of their radiation exposure experience will be provided, within 30 days of said request.

R. DISPOSAL OF NUCLEAR GAGES

1. Disposal of gages no longer needed by the Department of Transportation may be accomplished in the following manner:

   a. By trade-in to a gage manufacturer.

   b. By selling or donating the gage to another public agency, such as a school, city, or county. Such agency must be *properly licensed before* such transfer is effected.

   c. By arranging for a commercial radioactive material disposal company to dispose of the gage.

REFERENCES:

General Industrial Safety Orders, Group 6, of the Division of Industrial Safety, Title 8, CAC.
California Radiation Control Regulations of the State Department of Health, Title 17, CAC.
California Tests 231 and 911.

End of Text (California Test 121 contains 10 pages)