NORTH CAROLINA

DEPARTMENT OF TRANSPORTATION

NUCLEAR GAUGE OPERATOR'S MANUAL

MATERIALS AND TESTS UNIT

Field Operations

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INTRODUCTION

This manual is to serve as a ready reference for the density inspector and as a review of the material covered in the Nuclear Safety and Hazardous Materials Training Course. The course is required because unlike any other piece of testing equipment, nuclear gauges are subject to strict licensing by the North Carolina Department of Environment, Health, and Natural Resources. Though field personnel can easily learn to operate the gauge, the Radioactive Materials Section (Division of Radiation Protection) and the DOT require that technicians operating a gauge be certified as a nuclear gauge operator.

This manual presents an introduction to the concepts and safety requirements associated with nuclear density gauges to field personnel who will be operating gauges in the near future. Additionally, this manual is intended to provide review material for personnel that have operated nuclear gauges in the past. This manual does not present any material concerning the testing procedures or NCDOT specification requirements.

PERIODIC MAINTENANCE

A nuclear gauge is designed for rugged field use. Relatively simple precautions and maintenance will greatly reduce damage, and extend the time between repairs.

1. Routine cleaning of the gauge exterior with compressed air and a damp cloth will help maintain the appearance and finish.
2. If extensively used in ABC, sand, or sticky soils, the pocket under the bottom access plate of the gauge should be cleaned. IF any binding is noticed during the operation of the source index handle, it indicates that fines have accumulated in this pocket. To minimize radiation exposure, the following procedures for this operation is recommended:

    a. Make sure the source handle is in the safe position.
    b. Orient the gauge so that the bottom is facing away from the person performing the work.
    c. Place a mirror in front of the gauge bottom so as to afford an indirect view of the work performed.
    d. Remove the four retaining screws and lift off the access plate.
    e. Remove shield and clean both shield and access plate.
    f. Clean any fines that may have accumulated in the shield cavity.
    g. Replace the access plate and put the four retaining screws back in place. Only snug the screws down do not over-tighten the screws.
    h. Place the gauge upright, and use light oil sparingly on the source and index rod.

Normally, this operation should take approximately 8 to 10 minutes to perform. Normal radiation exposures obtained would be 4 mrem to the whole body and 25 mrem to the hands. <u>Never attempt to open the sealed source of a nuclear gauge.</u>

1. When the gauge is used on hot asphalt mix, any accumulation of asphalt on the bottom surface should be removed with a suitable solvent.

2. Even though every opening in the housing is sealed with a gasket, the case breathes with changes in barometric pressure. In areas of high humidity and widely varying temperatures, some moisture may accumulate on the interior of the instrument. A simple procedure will prevent this build-up of moisture and subsequent damage. During the recharge cycle, remove the scalar module by loosening the four thumbscrews in the corner of the module. The heat produced by the charger will dry out the interior of the housing.
3. During transport in a vehicle, the gauge should be supported and padded to prevent shock damage. The electronic and mechanical parts of the gauge are extremely durable, however; the radiation detectors are fine wire and devices with glass and ceramic seals, and must be protected from high shock loads.

FILM BADGE HANDLING

Film badges are like cameras and essentially "photograph" nuclear radiation. Any care that is normally necessary for a camera should be followed for a film badge. Be aware that the film badge is for protection and is used to measure the radiation level your body has been exposed to over a time period. If a significant change is noticed during any one period, the proper people are immediately notified and steps are taken to identify and correct the situation.

When using a film badge the listed rules below should be followed:

1. Wear **your** film badge at all times when working with a nuclear gauge. This includes periods of operation, cleaning, and transportation.
2. Store your film badge in a safe location, away from any type of radiation when it is not needed. Try to store it in the same place every day.
3. Be careful, the plastic film badge holder can easily break. Like a camera, this holder contains filters that greatly affect your "radiations picture".
4. Always use common sense and if ever in doubt, ask.
5. DO NOT OPEN THE BADGE
6. Do not place a film badge near excessive heat since it is a type of radiation. This includes leaving the film badge of the dashboard or on the sun visor of a closed vehicle on a warm day.

7. Do not take your badge near other sources of nuclear radiation like x-ray machines or color television sets. X-rays will readily affect the film badge and televisions will have an effect after prolonged exposure.

STORAGE AND TRANSPORTATION OF NUCLEAR GAUGES

Primary Storage

1. Store the gauge in a closet or room that is not normally used as a working area.
2. Storage site should be reasonably secure with access limited to authorized personnel.
3. One person should be responsible at each site.
4. If stored in area other than office building, access keys should be limited to Resident Engineer and the operators.
5. Storage areas must be properly posted with the following signs:
   Radiation signs
   Emergency Procedures
   Notice to Employees
6. A log sheet will be kept at each storage site showing the date equipment is checked out (or in), its destination (project number) and signature or initials of person checking equipment out (or in). Gauges not in use will be checked at least once weekly and logged into the daily log.

Secondary Storage

1. Same basic requirements as primary storage areas but cannot be approved due to personnel working in close proximity to the area during working hours.
2. May be used for overnight charging and weekend storage only.
3. Radiation signs and emergency procedures should be posted when gauge is in storage area and removed when gauge is removed.

Vehicle Storage and Transportation

1. Vehicle storage facility should be watertight, secured to the vehicle, and have provisions for locking gauge inside when not in use (Yellow steel boxes which meet these requirements may be requisitioned from Materials and Tests Unit).
2. Three-sided gauge restraint should be mounted on tailgate to prevent gauge from sliding off the tailgate.
3. Gauge should be placed in the tailgate restraint or placed in truck bed with tailgate closed when moving from one test site to another.
4. Gauge should be placed in cehicle storage facility (mounted yellow box) at any other time that the vehicle is moving especially on publicly traveled roadway.
5. Do not store or transport the gauge in the cab of the truck. When performing a "quick charge" on the gauge using the cigarette lighter, do not sit inside the truck with the gauge.
6. Never leave an unsecured gauge unattended.
7. A properly completed Bill of Landing/Emergency Procedures must be in the vehicle and immediately accessible to the driver.
8. A technician must have his or her certification card and film badge when transporting a nuclear gauge.

RADIOLOGICAL SAFETY INSTRUCTIONS

TYPES OF RADIOACTIVITY

There are several types of radiation that cause different hazards. Some materials give off only one specific type of radiation, while others give off several types. Knowledge of the different types will help in understanding the basic means of protection from each.

Alpha Particles

Alpha particles are the same as the nuclei of helium atoms and are large enough that they cannot travel far before being blocked or stopped by other atoms. For example, alpha particles can only travel about 3 inches in the air and can be blocked by thin materials such as paper. Since alpha particles cannot penetrate the skin, they are harmless unless a particle(s) gets inside the body. A particle may get into the body by means of breathing or eating contaminated food. Once the particle is inside the body, it may be absorbed into the bones and organs where the radiation can cause irreparable damage. Alpha emitting materials with long lives such as uranium or radium are particularly dangerous since they are held in the body for long periods of time. When dealing with materials that contain alpha particles, extreme caution should be taken to avoid breathing or swallowing any of the alpha particles.

Beta Particles

Beta particles are made up of electrons and travel about eight times faster than alpha particles. Beta particles are also 7000 times smaller than alpha as a result; a moderate thickness of a material such as aluminum is required to block or stop a beta particle. Excessive exposure to beta particles may cause deep-seated and slow healing burns to the skin. Caution should be exercised to avoid breathing or swallowing beta-emitted radioactive materials.

Gamma Rays and X-Rays

Gamma rays are similar to light except that the wavelength of the gamma rays is considerably shorter than that of light. X-rays are similar to gamma rays, however the x-rays usually have a shorter wavelength and are emitted from the nucleus of an atom. Both gamma and x-rays have approximately 100 times the penetrating power of beta particles and 10000 times of alpha particles. Gamma and x-rays can destroy skin tissue and internal body organs, constituting a radiation hazard for the entire body. Gamma and x-rays can be stopped by the proper thickness of various materials. The denser materials such as lead and concrete provide the most effective barriers. Earth and water are equally effective provided that a sufficient thickness is used. Since gamma and x-ray radiation spreads out in all directions and is absorbed by air to some extent, distance is helpful as a means of protection from low to moderate levels. For high-radiation levels, effective absorption material must be used.

Neutrons

Neutrons are small particles without electric charge traveling at a high speed and are generally found only in the vicinity of a reactor or particle accelerator.

Effect

Alpha, beta, and gamma particles lose energy by chipping off electrons from surrounding atoms. Atoms that "lose" at least one of the electrons is called IONS and each resultant ion and its electron constitute an ION PAIR. Eventually, the members of the pair recombine with other ions and electrons if not with the original members. The atoms and ions are in a relatively excited state due to the impact from the initial ray or returning electron. When the atoms are in their excited state, the temperature of the system increases and atoms that have been stuck may leave its molecular combination. As this takes place, a pulse of electromagnetic energy may be emitted producing x-ray, ultraviolet, and visible light called fluorescence. The electromagnetic energy resulting from the stoppage of radioactive particles are indicators for instruments used to detect the presence of radioisotopes.

Alpha particles are relatively heavy and large and are stopped in a very short distance. However, they dislodge many electrons in each millimeter of travel. A typical alpha particle may dislodge 150,000 electrons before stopping! Beta particles usually penetrate somewhat further, but produce fewer ion pairs per millimeter of travel. Gamma rays can pass through great thickness of matter, dislodging even fewer electrons per millimeter. A high-speed ray or energy is likely to go further and produce more ion pairs than a low speed ray or energy. When a gamma ray enters a slab of material, any of three possibilities may happen. First, the material may absorb the gamma ray. Second, the gamma ray may be deflected or "scattered" in the material and exit out of the material with a different direction and lower energy than when it entered. Third, the gamma ray may pass through the material without being scattered or absorbed.

It is impossible to accurately predict what will happen to a single gamma ray entering a certain material. However, if a beam of gamma rays is directed at the material, it is possible to calculate the percentages of the beam that will be absorbed, scattered, or transmitted. The percentage of gamma rays that will pass

through a material depends on the energy of the gamma ray and the density of the material. For example, if a beam of 1.25 MeV gamma rays were directed at concrete block 11.2 inches thick, 10% of the beam would be transmitted. However, only 1.73 inches of lead would be required to reduce the same beam down to 10% of its initial intensity because lead is much heavier than concrete.
Neutrons are extremely small dense particles, electrically neutral, and can penetrate various materials. Neutrons are slowed down most effectively by a material containing hydrogen atoms (such as water or polyethylene). Therefore, neutrons are used to measure the moisture content of soils or other materials.

Units

1. **Roentgen** – a unit measurement of x-rays and gamma rays absorbed in air and measures in the same fashion that inches are a measure of length and pounds of weight. The roentgen represents the amount that would be received in one hour at a point three feet from an unshielded capsule containing a gram of Ra. When considering personal exposures, the term milliroentgen (abbreviated mr) is generally used. A milliroentgen is 1/1000 of a roentgen. Generally, "dose" refers to the number of roentgens received, while "dose rate" indicates a does received per unit of time.
2. **Rem –** a unit to calculate the amount of radiation absorbed by a human being. Since the amount of absorbed radiation is usually small, doses are generally expressed in millirem (1/1000 of a rem). The millirem is actually a measure of the effectiveness of the body in absorbing radiation, and depends on the type of energy of the radiation.
3. **Curie** – a unit of activity for measuring the quantity of a radioactive material. The curie may be defined as a quantity of radioactive material that has 3.7 x 10^{10} atomic nuclei disintegrating per second. A millicurie (mci) is 1/1000 of a curie. The becquerel (Bq) is the SI unit equivalent for the curie. A becquerel is one disintegration per second, therefore; one curie equals 3.7 x 10^{10} becquerels.

When a radioactive material is decaying to a stable state, each disintegrating atom may or may not emit a gamma ray or it may emit more than one gamma ray depending upon the properties of the atomic nuclei. For example, two gamma rays are emitted for each disintegrating atom of Co 60 whereas one gamma ray is associated with 95 percent of the Cs 137 atoms decaying.

4. **Half-life** – refers to the period of time for a given quantity of a specific radioactive isotope to decay to one half of its original activity. For example, Cs 137 has a half-life of 30 years. If 8 mci of Cs 137 is originally used only 4 mci will remain after 30 years and 2 mci after another 30 years.
5. **MeV** – the energy a gamma ray generally expressed in units of millions of electron volts, or MeV. The higher the energy the more penetrating the gamma ray will be.

Characteristics

Most nuclear gauges utilize the following radioactive sources radium-226, cesium-137, americium-241:beryllium.

Radium-226 emits alpha particles and low energy gamma rays. Radium-226 also has a half-life of 1620 years which means that a given sample will decay by one half in 1620 years. When a Radium-226 atom decays it transforms into another radioactive material called radon-222. As a radon-222 atom decays it transforms into another radioactive material. Each original atom of radium-226 must decay a total of eight times before it finally becomes a stable (non-radioactive) element. For each decay process, energy is given off in the form of alpha particles, beta particles, gamma rays, or any combination. Though the radium-226 atom gives off a low energy gamma ray, several members of its following decay chain emit high energy gamma rays.

Cesium-137 decays with the emission of a beta particle, which is stopped by the walls of the source container. However, when cesium-137 decays it is transformed into an unstable barium-137 atom, and finally with the emission of a gamma ray, barium-137 becomes stable.

Americium-241, like radium is a member of a long decay chain, which emits alpha, beta, and gamma radiation before achieving stability. Americium is not a suitable source for density measurement because practically all of the gamma rays emitted by the members of its decay chain are of low energy, and would be absorbed by soil or asphalt before being transmitted or scattered back to a detector. For this reason, Troxler gauges use radium and cesium sources for density measurements, while americium (and also radium) is used for moisture determinations. Moisture is measured by counting the number of neutrons, which are slowed down by water, soil, or other materials.

Americium and radium (and their by-products) do not emit neutrons. Beryllium is used as a neutron source and by itself is a stable element. However, beryllium emits neutrons when it is struck by alpha particles from radium or americium. Therefore, a combination moisture and density gauge would use a source such as radium-beryllium where radium would provide gamma rays for density measurements and beryllium would provide neutrons for moisture determination. A combination of cesium and americium-beryllium may be used, where cesium would provide gamma rays and americium would be used to bombard the beryllium atoms for a source of neutrons.

RADIATION SAFETY

Exposure

The human body can withstand a fair amount of abuse from radiation. We have always been exposed to radiation from natural radioactivity occurring in the earth's crust, from naturally occurring radioactivity in the air, from within our bodies, and cosmic radiation from outer space.

Although we have always been exposed to this natural radiation, experts generally agree that radiation exposure is undesirable and, if exposure becomes too excessive, can be detrimental to health.

In recognition of this fact, experts have established radiation exposure limits for persons who use radioactive material. The limits are designed so that if a user is exposed to radiation levels at or below the limit over their entire working life, there will be no clinically detectable effect on their health or well-being.

The radioactive sources contained in Department of Transportation's gauges, if improperly used or removed from the device, would be quite dangerous after prolonged exposure. However, the devices are designed so that, if properly used, the user would receive only a small fraction of exposure in addition to what one would normally receive from natural background radiation. Prolonged misuse and abuse of these devices would result in significant unnecessary and possibly dangerous radiation exposures.

As an additional safety factor, each user will be provided a personal exposure-monitoring device, which will measure the amount of radiation exposure received. The monitoring device will further ensure that the safe exposure limits reference above are not exceeded.

Exposure Limits

Radiation experts believe that even small exposure limits may be capable of causing some damage, therefore; all unnecessary radiation should be avoided.

In order to protect personnel from overexposure to radiation, the Nuclear Regulatory Commission has established exposure limits for radiation workers. These limits, expressed in millirems, are reproduced in the following table:

ANNUAL EXPOSURE LIMITS FOR RADIATION WORKERS

TYPE OF EXPOSURE	UNITS IN MILLIREMS
Whole body dose	5,000 millirems
Organ, tissue of extremities	50,000 millirems
Lens of eyes	15,000 millirems

These limits are intended to be highly conservative and do not represent the absolute maximum exposure a person could receive without becoming ill or suffering radiation damage. However, State regulation require that radiation exposure remain under the limits given in the table.

General Precautions

1. Do not operate or attempt to operate a gauge unless authorized.
2. Keep the gauge in “SAFE” or storage position while not in use.
3. Wear a film badge at all times while operating or transporting a gauge.
4. Keep unauthorized persons away from the gauge.
5. Verify that the gauge is locked and secured when it is not in use.
6. Follow established operating procedures when using a gauge.
7. Ensure that the gauge is leak tested at proper intervals.
8. When in doubt, ASK!

Fundamentals of Radiation Safety

If appropriate precautions are exercised, radioactive materials can be employed as safely as electricity. The primary potential hazard from nuclear sources arises from exposure of personnel to the gamma radiation emitted by the sources. Gamma radiation, however, like electricity, is more to be respected than feared. TIME, DISTANCE, AND SHIELDING are three fundamental principles involved in controlling exposure of the body to gamma radiation from external sources. Applying the three principles when operating or handling radioactive materials will keep exposure A.L.A.R.A. or As Low As Reasonable Achievable.

1. **TIME** – the total radiation exposure received by a person in a given field of radiation will depend upon the length of the time that they stay there. A person remaining in a given field for five minutes would receive only one-half as much exposure as they would in ten minutes.\
2. **DISTANCE** – as a person moves away from a source, the amount of radiation exposure dramatically declines. In fact, radiation obeys the “inverse square” law which states that the radiation intensity decreases as the inverse square of the distance from the center of the source to the “target”. For example, if a person standing one foot from the source were receiving forty millirem per hour, moving back another foot would cut the intensity to ten millirem per hour, ¼ of the original intensity exposure intensity.

The inverse square law can be expressed in the following equation:

$$I_2 = I_1 (\frac{D_1}{D_2})^2$$

I_2 = Intensity at distance D_2
I_1 = Intensity at distance D_1
D_1 = Distance at 1
D_2 = Distance at 2

3. **SHIELDING –** shielding material is used to absorb or stop radiation and is an excellent means for controlling personnel exposure. To a reasonable approximation, it makes no difference where the shielding material is placed between the source and the target, as long as the thickness of the material remains the same. Dense material provides the best shielding against gamma radiation, while hydrogenous (hydrogen-containing) material affords good protection against neutrons. The type of shielding in general use is as follows:

Radium	Heavy material
Cesium-137	Heavy material
Radium-226 + beryllium	Heavy material & hydrogenous material
Americium + beryllium	Hydrogenous material

EMERGENCY PROCEDURES

Spills or accidents involving radioactive materials are especially hazardous, and handling of such spills requires specialized procedures and instruments.

If a nuclear gauge is involved in an accident on publicly traveled roads and is damaged in anyway (bent source rod, broken case, etc.), the Highway Patrol should be notified. Be prepared to answer questions on the location of the accident and condition of the nuclear gauge. Follow emergency procedures for on-project accidents.

Accidents happening on the project should be immediately reported to the appropriate Resident Engineer and one of the Materials and Tests personnel.

If the source was in the "safe" position during the accident and the gauge housing is not cracked, place the gauge in its shipping case and place in its overnight storage area. Follow emergency procedures. If the source was exposed during the accident and the gauge housing is not cracked, at arm's length and touching only the upper gauge parts, lift up the gauge carefully or roll back the gauge to expose the end of the source rod for visual inspection. If the end of the source rod containing the radioactive source is not physically damaged, place the gauge in its shipping case in the best way possible. Place both in its usual overnight storage area. Follow emergency procedures.

If there is physical damage to the source rod and the source is exposed and unshielded, do not handle the source rod and keep all personnel fifteen feet from the gauge. The gauge may be moved by the operator. However, the gauge or shipping case must be kept as far from the body as practical.

DO NOT SHIP THE GAUGE WITHOUT EXPLICIT SHIPPING INSTRUCTIONS FROM THE FACTORY.

If the source rod was in the "safe" position during the accident and the gauge housing is cracked, or if the source is exposed and physical damage is evident on the source rod itself. Rope off the area for a distance of fifteen feet from the gauge and any scattered parts. Stop any vehicles that mauy have collided with the gauge or possible have radiation contamination on tires, cleats, or tracks. Do not walk through the area and do not move the gauge or any parts. Follow above emergency procedures.

Loss of theft of a nuclear device should be treated as an on-project accident.

Incidents that are not necessarily classified as emergencies (source rod hammed in an unshielded position, source rod coming out of the gauge and any other malfunction of the nuclear gauge) should be reported to the Materials and Tests Unit.

NRC-RECOMMENDED INSTRUCTIONS FOR IMMEDIATE EMERGENCY ACTION IN INCIDENTS INVOLVING RADIOACTIVE MATERIALS

When incidents involve a radioactive source, the spillage or release of radioactive materials, or there are personal injuries in incidents involving radioactive materials, the following emergency actions and precautions against radiation exposure should apply:

1. Notify immediately one of the people on the "Emergency Procedures" sheet
2. If the incident involves wreckage and a person is believed to be alive and trapped, make every effort possible to rescue the person.
3. Restrict access to incident area. Keep the public as far from the scene as possible. Souvenir collection and handling of debris by on-lookers should be prevented.
4. Segregate and detain those persons for further examination who may have had possible contract with radioactive material. Obtain the names and addresses of those involved.
5. Use first aid treatment according to the nature of the injurt. Advise medical personnel that victim may have been contaminated with low level radioactive material.
6. In incidents involving fire, fight the fire from upwind whenever possible. Treat as a fire involving toxic chemicals. Keep out of smoke, fumes, or dust resulting from the incident. Segregate clothing and tools used at the fire until they can be checked for radioactive contamination. Do not handle suspected material until it has been scanned and released by radiation monitoring personnel.
7. In the event of a vehicle accident involving radioactive material, detour all traffic around the accident scene. If this is not possible, move the vehicle or vehicles involved in the shortest distance necessary to clear the right of way. If radioactive material is spilled, prevent the passage of vehicles and people through the area unless absolutely necessary. If right of way must be cleared before radiological assistance team arrives, wash spillage to the shoulders of the right of way with a minimum amount of wash water.
8. DO NOT eat, drink, or smoke in the incident area. DO NOT use food or drinking water that may have been in contact with the material from the incident area.
9. DO NOT try to do too much prior to the arrival of radiation protection specialist and physicist.

BILL OF LADING
STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

Destination: Temporary job sites throughout North Carolina
Shipper: N. C. Department of Transportation, Division of Highway GAUGE MODEL - 3440

RQ, RADIOACTIVE MATERIAL, SPECIAL FORM, NOS 7, UN3332
TYPE "A" PACKAGE, CONTAINING:

Cesium - 137 0.37 Gbq (8.0 mCi)
Americium 241:Be 1.48 Gbq (40.0 mCi)

RADIOACTIVE YELLOW II LABEL, Transport Index = 0.6

For Additional Information Contact:
Troxler's 24 Hour Number - (919) 839-2676

SHIPPER: NC Dept. of Transportation
PER: Div. of Highways

This is to certify that the above named materials 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.

EMERGENCY PROCEDURES

In case of an emergency involving a nuclear gauge, follow steps and emergency procedures listed on the back of the Bill of Lading.

IMMEDIATELY CONTACT THE STATE WARNING POINT at the following 24-hour emergency numbers:
(919) 825-2500 or 1-800-858-0368

The Highway Patrol will notify a member of the Radioactive Materials Section.

MATERIALS AND TESTS CONTACTS

		Office	Night/mobile #
GeoMaterials Training Engineer	Jim Sawyer	(919) 329-4150	(919) 418-0771
Tech. Trainer II	John Flowers	(252) 296-3629	(919) 330-3466
Tech. Trainer II	Andrew Hartel	(919) 329-4150	(252) 885-9477
Tech. Trainer II	Scotty Jarman	(704) 694-3067	(919) 427-1639
Tech. Trainer II	Mike Ricker	(828) 733-2776	(919) 219-2443
Tech. Trainer II	Doug Phillips	(828) 652-3344	(828) 442-0946

If it is during State office hours, the Division of Radiation Protection should be notified at (919) 814-2250. If the call is placed "Collect", inform the operator that it is an emergency involving radioactive material.

Revised August 23, 2017

CHECKLIST TO FOLLOW IN CASE OF AN EMERGENCY

CHECKLIST TO FOLLOW IN CASE OF AN EMERGENCY

1) **IMMEDIATELY CONTACT STATE WARNING POINT (Record on log)**
2.) Information to be given to the STATE WARNING POINT:
   a. Name of Caller
   b. Call-back number (Keep line available, if possible use second line for further calls)
   c. Time and location of accident
   d. Any personal injuries
   e. Condition of nuclear gauge
   f. Traffic lane opened or closed
   g. Type of Radioactive material in the density gauge (from Bill of Lading)
2) Contact Resident Engineer and one of the Materials and Tests personnel list on the Bill of Lading (Record on log)
3) Priorities for rescue, life-saving, first aid and control of fire are higher than the priority for measuring radiation levels.
4) If medical treatment is required, use first aid according to the nature of the injury. Do not delay care and transport of a seriously injured person. Persons exposed to special form sources are not likely to be contaminated with radioactive material
5) If there is a fire, and the package is undamaged, move the container from the fire area if you can do so without risk. Do not move damaged packages. The presense of radioactive material should not influence the selection of fire control techniques (water from fire control is not expected to case pollution).
6) If there is no fire or after the container has been moved from the fire area, immediately isolate the area where the gauge is at least 15 feet in all directions. Keep unauthorized personnel away.

TELEPHONE LOG

NUMBER	TIME	CONTACT MADE yes/no -WHO

POTENTIAL HAZARDS

HEALTH
- Radiation presents minimal risk to transport workers, emergency response personnel, and the public during transportation accidents. Packaging durability increases as potential hazard of radioactive content increases.
- Undamaged packages are safe; contents of damaged packages may cause external radiation exposure, and much higher external exposure if contents (source capsules) are released.
- Contamination and internal radiation hazards are not expected, but not impossible.
- Type A packages (cartons, boxes, drums, articles, etc.) identified as "Type A" by marking on packages or by shipping papers contain non-life endangering amounts. Radioactive sources may be released if "Type A" packages are damaged in moderately severe accidents.
- Type B packages, and the rarely occurring Type C packages, (large and small, usually metal) contain the most hazardous amounts. They can be identified by package markings or by shipping papers. Life threatening conditions may exist only if contents are released or package shielding fails. Because of design, evaluation, and testing of packages, these conditions would be expected only for accidents of utmost severity.
- Radioactive White-I labels indicate radiation levels outside single, isolated, undamaged packages are very low (less than 0.005 mSv/h (0.5 mrem/h)).
- Radioactive Yellow-II and Yellow-III labeled packages have higher radiation levels. The transport index (TI) on the label identifies the maximum radiation level in mrem/h one meter from a single, isolated, undamaged package.
- Radiation from the package contents, usually in durable metal capsules, can be detected by most radiation instruments.
- Water from cargo fire control is not expected to cause pollution.

FIRE OR EXPLOSION
- Packagings can burn completely without risk of content loss from sealed source capsule.
- Radioactivity does not change flammability or other properties of materials.
- Radioactive source capsules and Type B packages are designed and evaluated to withstand total engulfment in flames at temperatures of 800°C (1475°F).

PUBLIC SAFETY
- **CALL Emergency Response Telephone Number on Shipping Paper first. If Shipping Paper not available or no answer, refer to appropriate telephone number listed on the inside back cover.**
- **Priorities for rescue, life-saving, first aid, and control of fire and other hazards are higher than the priority for measuring radiation levels.**
- Radiation Authority must be notified of accident conditions. Radiation Authority is usually responsible for decisions about radiological consequences and closure of emergencies.
- Isolate spill or leak area immediately for at least 25 to 50 meters (80 to 160 feet) in all directions.
- Stay upwind. • Keep unauthorized personnel away.
- Delay final cleanup until instructions or advice is received from Radiation Authority.

PROTECTIVE CLOTHING
- Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide adequate protection against internal radiation exposure, but not external radiation exposure.

EVACUATION
Large Spill
- Consider initial downwind evacuation for at least 100 meters (330 feet).

Fire
- When a large quantity of this material is involved in a major fire, consider an initial evacuation distance of 300 meters (1000 feet) in all directions.

EMERGENCY RESPONSE

FIRE
- Presence of radioactive material will not influence the fire control processes and should not influence selection of techniques.
- Move containers from fire area if you can do it without risk.
- Do not move damaged packages; move undamaged packages out of fire zone.

Small Fires
- Dry chemical, CO_2, water spray or regular foam.

Large Fires
- Water spray, fog (flooding amounts).

SPILL OR LEAK
- Do not touch damaged packages or spilled material.
- Damp surfaces on undamaged or slightly damaged packages are seldom an indication of packaging failure. Contents are seldom liquid. Content is usually a metal capsule, easily seen if released from package.
- If source capsule is identified as being out of package, **DO NOT TOUCH**. Stay away and await advice from Radiation Authority.

FIRST AID
- Medical problems take priority over radiological concerns.
- Use first aid treatment according to the nature of the injury.
- Do not delay care and transport of a seriously injured person.
- Persons exposed to special form sources are not likely to be contaminated with radioactive material.
- Apply artificial respiration if victim is not breathing.
- Administer oxygen if breathing is difficult.
- Injured persons contaminated by contact with released material are not a serious hazard to health care personnel, equipment or facilities.
- Ensure that medical personnel are aware of the material(s) involved, take precautions to protect themselves and prevent spread of contamination.

CHECKLIST SUMMARY

1. Get <u>your</u> film badge and certification card.
2. Verify all required signs are properly posted at storage facility.
3. Inspect gauge box, labels, latches, and gauge.
4. Verify all necessary equipment for density testing is present.
5. Turn gauge ON.
6. Log gauge out on log sheet.
7. Place gauge in metal transport box and lock the box.
8. Place proper bill of lading in truck within arms reach of a person standing beside driver's door. (dash or map pocket)
9. (On project sire) take standard count on material to be tested and record results.
10. Set gauge parameters: units, mode, and time etc.
11. Determine method for establishing a target density either by control strip or lab unit weight (ABC only).
12. If required perform a control strip to establish a target density.
13. Enter the target density determined from either the control strip or the lab unit weight into the gauge.
14. Following minimum testing frequency perform density acceptance testing.
15. Return gauge to storage facility, log gauge in, and lock storage area.