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TRAINING AND SAFETY MANUAL

NRC STATES

GREAT GUNS, INC.

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GREAT GUNS, INC.

TRAINING AND SAFETY MANUAL

OPENING STATEMENT:

It is the objective of this program to train and qualify riggers and loggers in the proper use and handling of radioactive materials, to reduce hazard to other personnel on job sites, as well as encouraging all Great Guns, Inc. personnel in taking a leadership role in promoting good health physics practices in order to keep exposure to radioactive materials as low as is reasonably achievable.

The training program will be broken up into two (2) levels. Level 1 requirements are as follows:

A. 16 hour classroom training (lecture).
B. 72 hour on-the-job field training.
C. Must be able to demonstrate utilization of safety equipment to Radiation Safety Officer
D. Must pass a written examination (attached).

At the completion of Level 1 training, the employee will receive a Certificate of Completion signed by the Radiation Safety Officer and Instructor and a wallet size identification card indicating his proficiency level (attached).

Level 2 of the training program is designed for loggers in order to promote better health physics leadership in field application. Level 1 must be completed before advancing to Level 2. Level 2 consists of:

A. An additional 12 hour classroom lecture.
B. 2 hour lab covering all safety equipment operation and instrumentation.
C. 90 days on-the-job training under the supervision of a qualified logger.
D. Must pass a 25 question written examination pertaining to the application and safety of all radioactive material.

At the completion of Level 2, the employee will receive a Certificate of Completion signed by the Radiation Safety Officer and Instructor and a wallet size identification card indicating his proficiency level. (attached)

This training program will be taught by an approved instructor in lecture sessions. All lecture material will be based on this Training and Safety Manual and covered in depth. If additional materials or information are presented, such as audiovisual aids, they will be referenced in the training log. The training log will be attached to our license and maintained in our license file for State or Federal inspection purposes.

I. FUNDAMENTAL CONCEPTS OF RADIOACTIVITY

A. Radioactivity: An element is said to be radioactive if it can spontaneously decay or be transformed into another element. This transformation is always accompanied by emission of nuclear radiation. The same element can occur as either radioactive or stable. These variations of the same element are called isotopes. Isotopes are defined as atoms of the same element having the same atomic numbers (Z numbers) but different mass numbers (A numbers). That is, the same number of protons, but a different number of neutrons. Therefore Pb-206, Pb-207, and Pb-208, are all isotopes of the same element, lead. All isotopes of the same element have the same chemical properties whether they are radioactive or stable.

B. Characteristic Particles: The spontaneous radiation emitted by the radioactive elements are generally: Alpha, Beta, and Gamma. Other radiation such as X-ray and Neutron must be induced and will be considered briefly.

1. Alpha Particles have a mass equal to that of the helium nucleus and are shot out with a velocity about one-tenth that of light, and have a positive charge of 2. They possess great ionizing power but relatively little penetrating power --- only a few centimeters in air at atmospheric pressure.

2. Beta Particles consist of negatively charged particles moving with varying speeds. The penetrating power of the beta particle depends upon the speed of the particle. Those which move most rapidly possess the greatest penetrating power. Generally, 2 cm of aluminum stops all beta particles.

3. Gamma Rays are electromagnetic radiations originating from a radioactive isotopic elemental transition. They have no charge but possess great penetrating power. They present special health problems because of their deep penetration and high energy disposition. Dense materials are required to effectively shield gamma radiation.

4. Neutrons are elementary nuclear particles with a mass approximately the same as that of a hydrogen atom and electrically neutral; its mass is 1.008982 atomic mass units. Neutrons are commonly divided into sub-classifications according to their energies as follows: thermal, around .025 ev; spith rmal, 0.1 ev to 100 ev; slow, less than 100 ev; intermediate, 10^2 to 10^{12}ev; fast, greater than 0.1 Mev. They are easily shielded with paraffin or hydrogen containing materials.

C. Detection of Radiation:

1. Ionization Counter - An ionization chamber in which a delimited beam of radiation passes between the electrodes without striking

them or other internal parts of the equipment. The electric field is maintained perpendicular to the electrodes in the collecting region; as a result, the ionized volume can be accurately determined from the dimensions of the collecting electrode and the limiting diaphragm.

2. G-M Counters

   a. PSM = 700 EON, Gamma 150, and Ludlum 4 are portable, battery operated radioactivity survey and counting rate meters sensitive to gamma and medium energy beta radiation. These instruments have three full scale ranges. These meters shall be calibrated every six months.

   b. Rate meter and Spectrometer is a general purpose nuclear counting instrument. The unit features preset count or time with background subtract capabilities. A ten turn potentiometer which adjusts window width when analyzer is used.

   c. Pocket Dosimeters - The direct reading Pocket Dosimeter reads instantaneously the total accumulated dosage. The dosimeter is designed for the detection and measurement of X- and gamma radiation only. Pocket dosimeters should be worn by the person handling radioactive materials if the radiation dose exceeds 20 MR/hr at one meter.

   d. Film Badge Service - The light-weight plastic holder contains a slide-in film packet that is evaluated, generally, monthly. The use of ultrasensitive films and exclusive evaluation techniques make it possible to provide accurate evaluation of even very low doses. X-, gamma, and beta radiation can be detected by this means.

D. <u>Measurement of Activity</u>:

1. Curie - That quantity of a radioactive nuclide disintegrating at the rate of 3.700×10^{10} atoms per second. Abbreviation: C

   a. Microcurie: One millionth of a curie (3.7×10^4 disintegrations per second). Abbreviation: uc

   b. Millicurie: One thousandth of a curie (3.7×10^7 disintegrations per second). Abbreviation: mc

2. Roentgen - An exposure dose of X- or gamma radiation such that the associated corpuscular emission per 0.001293 grams of air produces, in air, ions carrying 1 electrostatic unit of quantity of electricity of either sign.

3. Rad - The unit of absorbed dose, which is 100 ergs/gram in any medium. The rad is a measure of the energy imparted to matter (i.e., retained by matter) by ionizing radiation per unit mass of irradiated material at the place of interest.

4. RBE (Relative Biological Effectiveness) - The RBE is a factor which is used to compare the biological effectiveness of absorbed radiation doses (i.e., rads) due to different types of ionizing radiation. More specifically, it is the ratio of an absorbed dose of X-rays or gamma rays to the absorbed dose of a certain particular radiation required to produce an identical biological effect in a particular experimental organism or tissue. This ratio is sometimes called the Relative Biological Efficiency Factor.

5. Rem (Roentgen Equivalent Man) - The rem is the unit used to express human biological doses as a result of exposure to one or many types of ionizing radiation. The dose in rems is equal to the absorbed dose in rads times the RBE factor of the type of radiation being absorbed. Thus, the rem is the unit of RBE dose.

E. Technical Aspects of Any Isotope:

1. Half-Life - All radioactive isotopes have a special property associated with them known as half-life. Half-life is the time required for the activity of a given radioactive species to decrease to half of its initial value due to radioactive decay. The biological half-life is the time required for the amount of a specified element which has entered the body (or a particular organ) to be decreased to half of its initial value as a result of natural, biological elimination processes. The effective half-life of a given isotope is the time in which the quantity in the body will decrease to half as a result of both radioactive decay and biological elimination.

2. Energy of Emmission - All isotopes have definite amounts of energy associated with each particle being emitted. These energies are characteristic of the isotope.

3. Effect of Distance - Generally speaking, the greater the distance from the source of radiation, the less the dose received by personnel. The intensity of radiation is diminished by an inverse square relationship with distance. A source measuring an intensity of 100 mr at a distance of one foot would measure 100 mr/5^2 at a distance of five feet; in other words, a radiation dose of 4 mr at the five foot distance.

4. Shielding of Various Materials - A shield can be any material or obstruction which absorbs radiation and, thus, tends to protect personnel or materials from the effects of nuclear radioactivity. Alpha particles, for example, can be shielded with a piece of paper. Beta particles can generally be absorbed through 2 cm of aluminum. Gamma rays, however, are the most penetrating, and dense shielding materials must be employed to reduce radiation.

F. Glossary and Terminology:

1. Isotope - Forms of the same element having identical chemical properties but differing in their atomic masses (due to different numbers of neutrons in their respective nuclei) and in their nuclear properties, e.g., radioactivity, fission, etc.

2. Maximum Permissible Concentration (MPC) - The highest currently acceptable concentration of radioactive substances (usually expressed as microcuries per cubic centimeter, uc/cc) in air, water, or food to which an individual may be exposed throughout a stated period of time, without expectation of injury.

3. Maximum Permissible Dose (MPD) - That dose of ionizing radiation that a person may receive in his lifetime without producing any appreciable bodily injury. The presently accepted MPD is (N-18) x 5 rem. N is the individual's age (greater than 18).

4. Film Badge - A small metal or plastic frame, in the form of a badge, worn by personnel, and containing X-ray or similar photographic film for estimating the total amount of ionizing radiation to which an individual has been exposed.

5. Stay Time - The period during which personnel are allowed to remain in a radiation and/or contaminated area before accumulating their permissible dose.

6. Inverse Square Law - A general property of physics which states that if the distance from a point is doubled, then the radiation at the second point will be doubled, then the radiation at the second point will be 1/4 of the radiation which is present per unit area at the first point.

$$\frac{R_1}{R_2} = \frac{(d_2)^2}{(d_1)^2}$$

II. BIOLOGICAL EFFECTS OF RADIATION

A. Characteristics of Radiation:

1. Ionization in Tissues - Radiation in tissues varies in relation to (a) the energy of the radiation, (b) the absorbed dose, (c) the time span over which the dose was received, (d) the amount of body area irradiated, plus (e) other factors not so well defined. Ionization of the atoms which make up the chemical constituents of the tissue cells, as the result of interactions with the incident radiation, is probably the basic cause of injury. Irradiation within the cell can result in (1) death of the cell, (2) complete destruction of the cell's ability to reproduce, (3) partial, incomplete, or faulty function (as of glandular cells) as well as, (4) production of genetic mutations.

2. Radiosensitivity of Tissue - Various types of tissue respond quite differently to a given kind and dose of radiation. Generally speaking, the following may be accepted as a list of common cells and/or tissues in the order of decreasing radiosensitivity:

   a. Lymph tissue (cells of the body fluid)

   b. White blood cells and immature red blood cells in the bone marrow

   c. Cells lining the gastro-intestinal tract

   d. Cells of the reproductive organs

   e. Skin

   f. Blood vessels and body cavity lining

   g. Tissue of the liver and adrenal glands

   h. Other tissues, including bone, muscle, and nerves

3. Time Factor vs. Total Dose - The biological effect of radiation depends not only on the total amount absorbed (dose), but also on the rate of absorption (dose rate). For example, 600 r would probably be fatal to a man if it were absorbed by the whole body within a period of one day; but would probably have no noticeable effect if absorbed over a period of 30 years because the body tissue is able to recover when the dose rate is low. Effects of radiation which appear within approximately a month are termed acute effects. This includes the immediate (0 to 48 hours) and the delayed (1 to 5 weeks) effects. Chronic effects would include those which result in persistent changes (radiation dermatitis), vascular or atrophic changes, and long term effects (appearing after one year -- tumor induction, cataract formation).

B. Radiation Doses to be Considered in Normal Safety Precautions:

1. Acute Effects of Whole-Body Penetrating Ionizing Radiation on Human Beings

Dose in Less Than One Week (r)	Effects
0 - 150	No acute effects other than blood changes. May be a serious long-time hazard.
150 - 250	Nausea and vomiting within 24 hours. Minimal incapacitation after 2 days.
250 - 350	Nausea and vomiting in under 4 hours. Some mortality will occur in 2 to 4 weeks. Symptom free period 48 hours to 2 weeks.
350 - 600	Nausea and vomiting likely before 2 hours. Mortality probable in 2 to 4 weeks. Incapacitation prolonged.
Greater than 600	Nausea and vomiting almost immediately. Mortality in 1 to 2 weeks.

2. Tolerance Dosages

a. 100 Millirems/week for whole body or

b.

Area of Body	Rems/Calendar Quarter
Whole body; head and trunk; active blood forming organs; lenses of eyes; or gonads	1.25
Hands and forearms; feet and ankles	18.75
Skin of whole body	7.5

C. Safety Precautions: Generally, the following safety facts should be known and observed:

1. Safety Through Distance - Distance can be an effective safety measure from a source. Safe distances should be known for the amounts of radioactive material being handled.

Examples of exposure rates at various distances from a 100 mc source:

Radioactive Material	mr 3 feet	mr 6 feet	mr 9 feet
Ir-192	61	15.25	6.8
I-131	25	6.25	2.8

2. Safety Through Shielding - Certain materials are effective shields against radiation. The half-layer value is the amount of shield necessary to reduce the radiation one-half.

   Half-layer value for some common materials:

Radioactive Material	Lead	Steel	Concrete
Co-60	0.49"	0.87"	5.0"
Cs-137	0.25"	0.68"	2.1"
Ir-192	0.19"	0.5"	1.9"

3. Safety Through Stay Time - The safety of an individual may be gained by controlling the amount of time he is exposed to radiation. If exposure attains an unsafe limit, personnel should be rotated.

III. HEALTH PHYSICS REGARDING USE OF RADIOACTIVE MATERIALS

A. Monitoring Job Site Before Initiation of Work

1. Using a low level survey meter, and before work initiation monitor the area. Record the observations on a sketch of the area.

2. Certify the area clean before commencing the job.

B. Handling Equipment - The following items shall be worn at times when handling the radioactive material while health physics problems are present:

1. Disposable rubber gloves will always be worn in handling radioactive materials, thus, preventing the possibility of contamination to the person who is actually handling the radioactive material.

2. Face masks shall be worn at all times when a gaseous radioactive material is being used in a field study. The face mask shall be a type approved by the National Bureau of Mines and should contain an excellent organic filter agent.

3. In some radioactive material applications it is necessary to wear protective clothing and/or use handling tongs.

C. Pocket Dosimeters can be worn by personnel who are handling the radioactive materials. If, however, personnel also carry personal film badges, then the option is present as to whether the pocket dosimeter be worn. The advantage to the pocket dosimeter is direct reading, and if the radiation level is not excessive (generally 1 to 10 mc of Iodine-131 will be handled per injection), then it should be the option of the field safety officer as to whether pocket dosimeters be worn.

D. Film Badges - It will be mandatory for all personnel working in the restricted area (an area greater than 2 mr/hr) to wear a film badge.

E. Tracer Packaging - All packages received from the supplier containing radioactive materials shall be monitored prior to their leaving the facilities. The dosage limits shall comply to the D.O.T. regulations (CFR Part 49, H.M. Manual) which stipulate a maximum of 200 mr/hr at surface of a shipping container and a maximum of 10 mr/hr at a distance of one meter from the surface of the container. Packages received from the supplier generally bear a diamond shaped Yellow III label.

F. Handling and Field Equipment Check List: The specific application may require additional radiation detection equipment than that listed below, but, generally, the field equipment will consist of the following items:

Fire Extinguisher
First aid kit
Kim-Wipes (Industrial Type)
Sponges
Large and small polyethylene storage bags for containing contaminated equipment, sponges, etc.
Masking and plastic electrical tape
Plastic wash bottles
Rubber gloves (disposable)
Labels for the return of radioactive waste
Film Badges
Concentrated wash solution
Low level survey meter
Goggles

G. Operating Procedure:

1. Pre-job knowledge and planning -- the Radiological Safety Supervisor must know:

   a. Types of radiation involved.

   b. Intensity of radiation.

   c. Relative hazard of each type of radiation.

   d. What the "stay time" (maximum allowable exposure time) is.

   e. What the possible contamination problems are.

   f. Any internal contamination problems.

   g. What industrial nuisance removable contamination will create.

   h. What controls must be dictated to protect personnel.

   i. Plan methods for controlling access to mixing and injection areas.

2. Specific Procedures will vary with the individual job applications. In general, the following procedures should be followed:

   a. Plan the job in advance.

   b. Monitor the area and measure the background radiation level.

   c. Optimum mixing location should be selected. Radioactive material should be mixed with injection fluid as close to well head as possible.

   d. Define the area which is prohibited to unauthorized personnel. (2 mr/hr is the maximum allowable radiation to people not wearing film badges.)

   e. Mix radioactive material with injection fluid with special consideration given to splashing, wind conditions and any other outside influence which could interfere with the safe handling of the material.

f. Plastic or rubber gloves should be worn at all times while handling radioactive materials. If wind velocity is sufficient to cause blowing, goggles and respirator should be used.

g. Exposure time should be controlled. If exposure approaches the maximum permissible limit, personnel should be rotated.

h. Allow no eating, smoking, or drinking in the restricted area.

i. Following the completion of the operation, the entire area should be monitored.

j. Radioactive Contamination Inspection Date Sheet should be filled out and given to customer.

H. Emergency Procedures: Emergencies vary greatly in their respective hazards. Sometimes these emergencies are in the form of spills, fires, or explosions which, consequently, result in the spread of radioactive contamination. Emergency procedures contained in the National Bureau of Standards, Handbook No. 48, are given here as a guide. It must be recognized that these procedures are general and any specific emergency would certainly involve additional procedures not specifically covered in this outline.

1. Spills involving no radiation hazard to personnel:

a. Notify all personnel in the area at once.
b. Permit only a minimum number of personnel in the vicinity of the spill.
c. Confine the spill immediately.
d. Notify the Radiation Safety Officer.
e. Decontaminate.
f. Monitor all personnel involved in the spill and cleaning.
g. Permit no person to resume work in the area until it has been surveyed and approved by one of the approved individual users specified on the N.R.C. and/or Agreement State Radioactive Material License.

2. Spills involving radiation hazard to personnel:

a. Notify all personnel not involved in the spill to vacate the area at once.
b. If the spill is liquid and the hands are protected, right the container.
c. If the spill is on the skin, flush thoroughly.
d. If the spill is on the clothing, discard outer or protective clothing at once.
e. Switch off all fans. Vacate the room.
f. Notify the Radiation Protection Officer as soon as possible.

g. Take immediate steps to decontaminate personnel involved.
h. Decontaminate the area.
i. Permit no person to resume work in the area until a survey is made and approval is received from the R.S.O.
j. Prepare a complete history of the accident, and give details in the Emergency Procedures Report. (Ref.: Section 3 - Figure #7)

3. Injuries to personnel involving radiation hazards:

   a. Wash minor wounds immediately under running water while spreading the edges of the gash.
   b. Call a physician, preferably one who is qualified to treat radiation injuries.
   c. Permit no person involved in a radiation injury to return to work without the approval of the attending physician.
   d. Report all radiation accidents (wounds, over-exposure, injection, inhalation) to your supervisor.
   e. Prepare a complete history of the accident and give the details in the Emergency Procedures Report. (Ref.: Section 3 - Figure #7)

4. Vehicle wreck while transporting radioactive materials:

   a. Do not leave the area unattended by qualified personnel.
   b. Notify the investigating officer.
   c. Notify the Radiation Safety Officer.
   d. Survey the area and close off any area where the level is above 2 mr/hr.
   e. Decontaminate the contaminated area (if any).
   f. The R.S.O. will notify the proper Federal and State Agencies.

5. Fire and other major emergencies:

   a. Notify all personnel in the area at once.
   b. Attempt to put out all fires if radiation hazard is not immediately present.
   c. Notify the Fire Department.
   d. Notify the Radiation Safety Officer.
   e. Govern the fire fighting or other emergency activities by the restrictions of the Radiation Safety Officer.
   f. Following the emergency, monitor the area and determine the emergency devices necessary for safe decontamination.
   g. Decontaminate.
   h. Permit no person to resume work without approval of the Radiation Safety Officer.
   i. Monitor all persons involved in combating the emergency.
   j. Prepare a complete history of the accident and give the details in the Emergency Procedures Report. (Ref.: Section 3 - Figure #7)

I. Monitoring Techniques for Personnel:

1. Check hands (finger tips), shoes (soles and heels), face (nostrils) first.

2. Remove any contaminated clothing to a covered bin and continue monitoring.

3. Check hands ALWAYS before eating, drinking, or smoking. Cleanse carefully of contamination (scrub with soap and water), and check again.

J. Transportation and Disposition of Radioactive Waste:

1. Transportation of Radioactive Material:

   a. Radioactive materials being transported must meet the same requirements as packaging of materials.

   b. When transporting radioactive materials in a passenger automobile, the materials should be carried in the trunk compartment at the furtherest point possible away from the driver or passengers.

   c. When transporting radioactive materials in a truck, the materials should be carried in a D.O.T. 7-A container, at the furtherest point possible away from the driver or passengers.

   d. Any vehicle transporting radioactive materials should be posted with suitable signs.

   e. Radioactive materials should be packed in such a manner so that there is no danger of spilling or loss.

   f. In the event of an accident while transporting radioactive materials, efforts should be made to minimize the exposure of any persons. This could include any action such as roping off the area and notifying investigation officers. The Radiation Safety Officer should be notified immediately in order that the State or Federal Agency may be contacted if necessary.

2. Storage of Radioactive Materials:

   a. Radioactive materials shall be stored in a suitable shielded container and will be covered at all times with suitable lids to prevent unnecessary exposure. Only authorized personnel shall have access to the storage facility. Suitable markings will be placed at the location.

b. An additional storage facility of suitable construction will be provided for the storage of empty containers which have contained radioactive materials, contaminated objects such as tools, rags, clothing, etc. This storage facility shall remain locked at all times. Suitable markings will be placed at the location. (Ref.: Section 3 - Figure #5)

3. Records and Reports: The following records and reports will be made:

   a. Maintain records showing the radiation exposures of all individuals for whom personnel monitoring is required. These records will be preserved until a date five years after termination.

   b. Each Licensee shall report by telephone and telegraph to the Federal or State Agency, the theft or loss of any source of radiation immediately upon knowledge of it.

   c. Each Licensee shall notify the Federal or State Agency upon an incident causing an individual to receive radiation in excess of the permissible limit.

   d. At the conclusion of the operation, a field study report will be presented to the customer.

4. Waste Disposal:

   a. Disposal by release into sanitary sewage systems -- No Licensee shall discharge radioactive material into a sanitary sewage system, unless, it is readily soluble in water and does not exceed the MPC as specified in C.F.R. Part 10 or applicable State regulations.

   b. Disposal by burial -- No Licensee shall dispose of radioactive material by burial without a permit obtained from the Federal or State authorities.

   c. Disposal by incineration -- No Licensee shall dispose of radioactive material by means of incineration.

   d. All radioactive waste materials will be turned over to a duly approved supplier which will transport them to a waste disposal area.

5. Markings:

   a. Symbols prescribed by this section shall use the conventional radiation caution colors (magenta or purple on yellow background). The symbol is the conventional three-bladed design.

b. Use of signs -- a sign or signs bearing the radiation symbol (CAUTION -- RADIOACTIVE MATERIALS) shall be used in the following instances:

(1) Radiation areas.

(2) Rooms or areas where radioactive materials are stored in quantities exceeding those specified in 10 CFR or applicable State regulations.

(3) Containers in which radioactive material is stored.

(4) Vehicles transporting radioactive material.

(5) Packages used for shipping radioactive material.

IV. SAFETY PROCEDURES FOR HANDLING RADIOACTIVE TRACERS

A. Introduction: In order to give proper safety consideration to the radioactive materials commonly used in tracer surveys and fluid movement analysis, the following information should be understood by all field users. The relatively low activity levels of the tracer units allow some latitude in handling techniques such that moderate safety precautions are sufficient.

The major safety problem is the prevention of accumulation of radioactive material in the body. The activities typically used are from 100 to 10,000 times the tolerable limit for internal accumulation. The degree of this particular hazard depends on the biological activity of the isotope, its half-life and the nature of the tracer preparation.

B. The large variety of tracer preparations used, or available for use, is such that no fixed procedures can be specified for each tracer unit. In general though, the majority of tracers may be handled for a few minutes without the use of extension tools.

1. Chart 1 gives the allowable handling time in minutes per week for various amounts of Iodine 131 and Iridium 192. This is based on actual measurements made with a maximum radiation exposure of 4.69 rem per quarterly tolerance (18.75 rems) for the hands, forearms, feet, and ankles as specified in the pertinent Federal and/or Agreement State regulations. We must stay within the handling times as indicated on the chart in order that we may continue to handle the unshielded tracer units without the benefit of hand-type monitoring devices such as wrist film badges, finger dosimeters, etc. or remote handling devices. However, the use of the normal safety equipment such as survey meter, rubber gloves, and film badge is still required.

2. The allowable handling time is determined as the maximum time in minutes per week that a person can work with his hands (rubber gloves) in direct contact with unshielded tracer units. The allowable handling time as indicated on Chart 1 is not additive - that is, you cannot, for example work for 18 minutes with 10 millicuries of Iridium 192 and 42 minutes with an equal amount of Iodine 131 in one week. If several hand exposures to both types of tracer materials are received during one week, the exposures must be rationed.

   Example: If in one calendar week a person directly handled 20 millicuries of Iodine 131 for 3 minutes, 10 millicuries of Iridium 192 for 3 minutes, and 15 millicuries of Iodine 131 for 4 minutes, these exposures are totaled as follows: From the chart the allowable handling time for 20 millicuries of Iodine 131 is 21 minutes. Hence the exposure to the hands for 20 millicuries of Iodine 131 is 3 divided by 21, or .143 or the weekly allowable handling time. Similarly, the exposure for the 10 millicuries of Iridium 192 is 3 divided by 18, or .167; and that for the 15 millicuries of Iodine 131 is 4 divided by 28, or .143. Adding these three fractions, .143 + .167 + .143 equals .453, or a little less than half the total allowable handling time for that particular calendar week.

3. Chart 2 indicates the radiation levels for Ir-192 and I-131 that are present at one foot from the unshielded tracer units.

4. Please remember that tolerances are not meant for working levels but as maximum safe levels only, and that the objective should be to obtain a minimum exposure during tracer operations. This can be accomplished by working as rapidly, yet carefully, as possible with the tracer units and also by distributing the actual direct handling of the unshielded materials among as many qualified people as possible.

CHART #1 - HAND EXPOSURE FROM RADIOACTIVE TRACERS

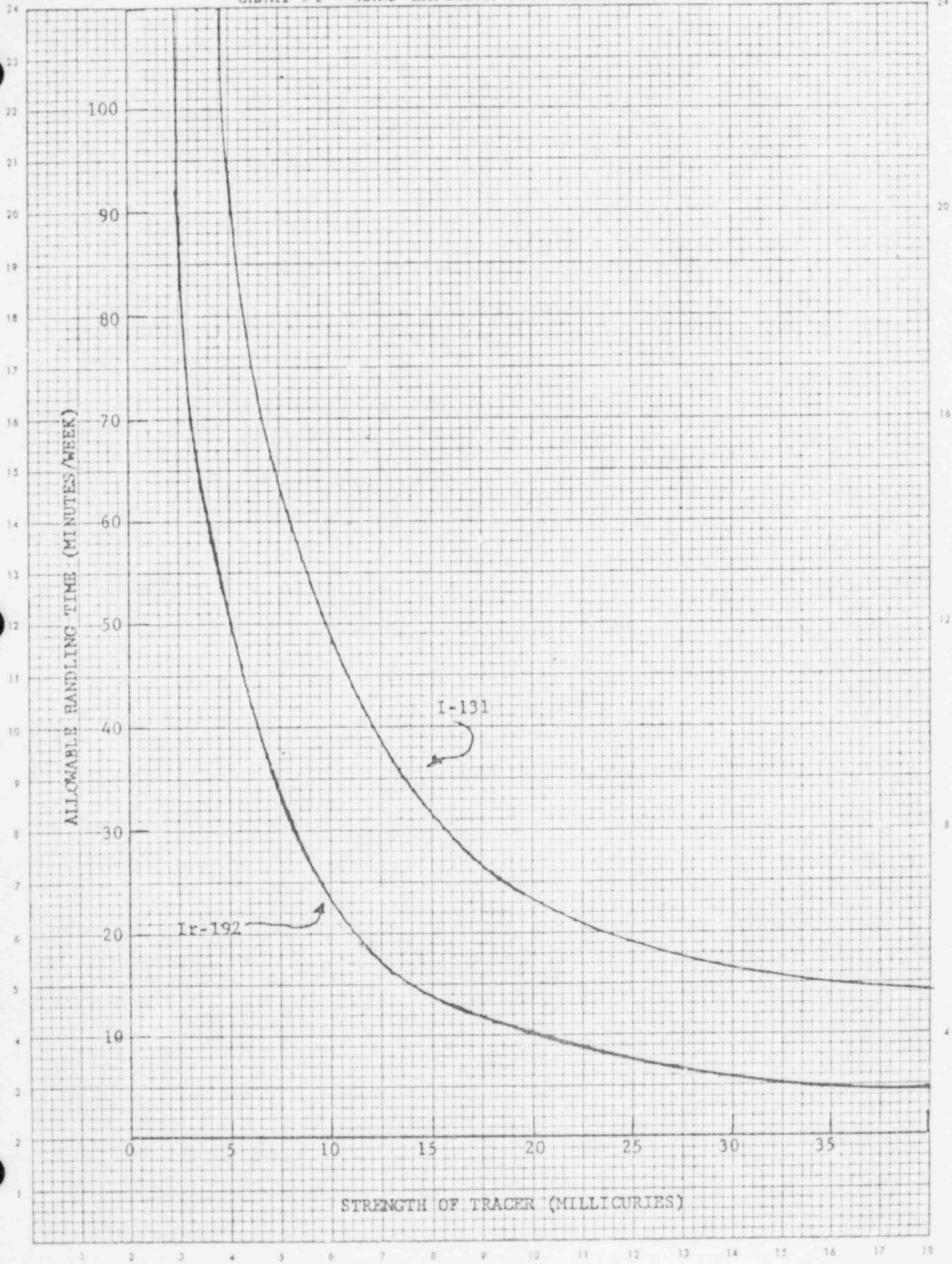
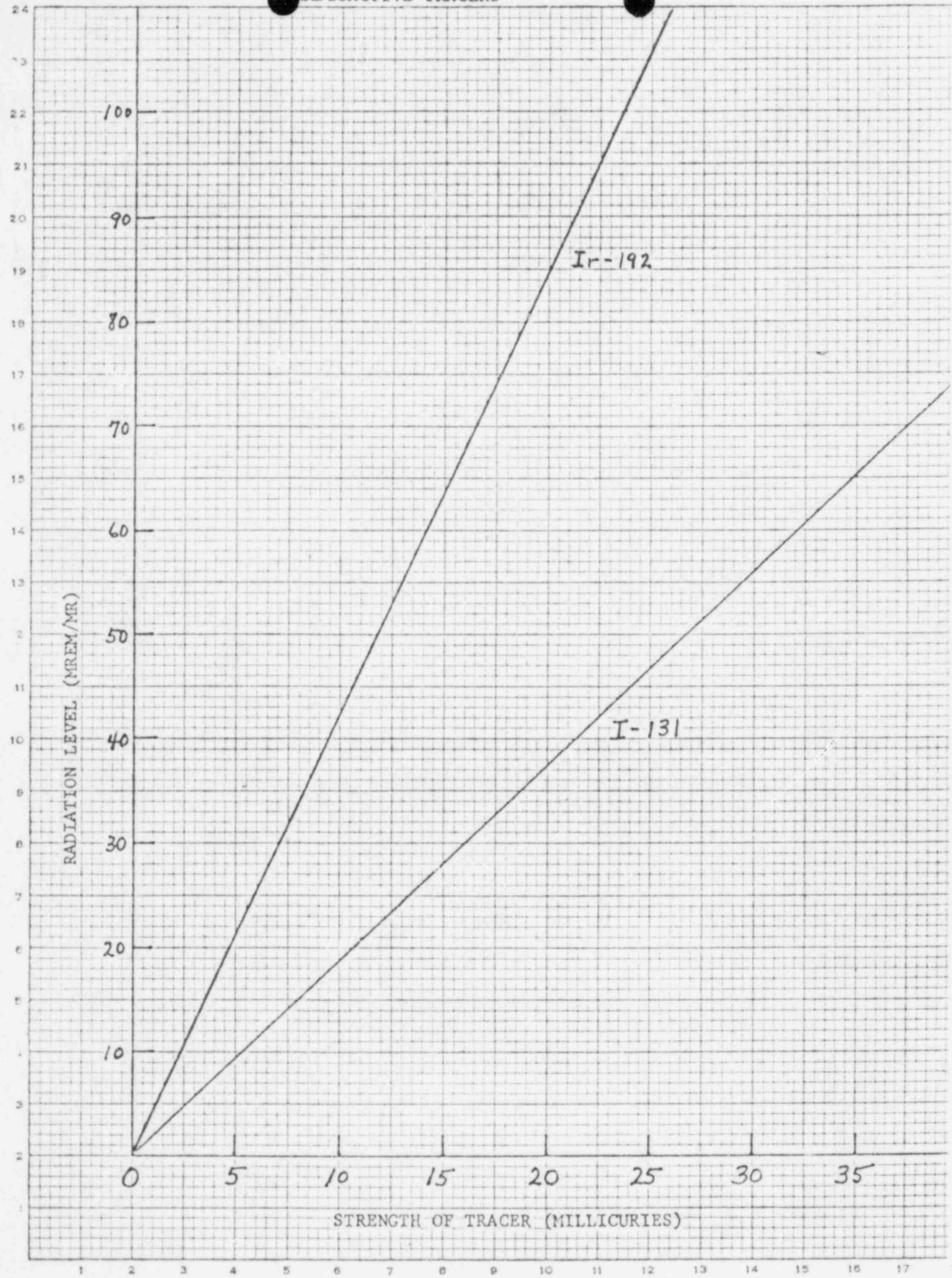


CHART #2 - RADIATION LEVELS AT ONE FOOT FROM UNSHIELDED RADIOACTIVE TRACERS



C. Contamination Survey Techniques:

1. Surveying of Area and Equipment:

a. The ideal mixing and injection operation would have no spills and leave no residue of tracer material in any of the vessels or pipes through which the tracer was injected. In practice such an ideal may not be realized, and a survey of the area is necessary so that the proper procedures may be followed to assure that no remaining contaminant can cause harm to company personnel, the customer's personnel, or the general public.

b. The survey meter must be used to survey the entire area where mixing has been done, and the pipes and associated components through which the mix was conducted to the well, to be sure that no concentration remains that may cause harm, either by external radiation or by possible contamination of food or water supplies.

c. Contamination of the probe must be avoided completely. If any contact survey is made, the probe is to be protected with a sheet of paper between the object and probe. A contaminated probe can render the survey meter useless for low level measurements.

d. Spills should be cleaned up and, if possible, injected into the well with the main tracer unit. The area of the spill should then be surveyed with the probe approximately one inch above the surface.

e. Any areas or items of equipment which indicate any amount of detectable radioactivity, above background, shall be considered contaminated and appropriate measures taken to remove such concentrations. (see Paragraph D)

2. Surveying of Individuals:

a. The greatest care in survey measurement is taken on items of personal equipment such as shoes, gloves, clothing and handling tools, as well as exposed portions of the body of personnel working with radioactive materials. This is because of the much greater probability of ingestion from such items.

b. The survey meter should be used to read the radiation level of clothing worn by the individual performing the mixing operation or any other clothes suspected of contamination. This should be done immediately following the mixing operations. If any indication of radioactive contamination is found on items of clothing, equipment, etc., or on the person of personnel involved in the operation, every effort should be made to remove the activity. (See Paragraph D)

D. Decontamination Procedure:

1. The radioactive tracer preparations are down by factors of 50 to 200 below the dangerous levels for external radiation hazards. The major hazard involved with these tracer preparations is the factor of ingestion. The ingestion tolerance is from one part per thousand to one part per ten thousand of the typical activities used. Thus, great care is exercised by company personnel to avoid contamination of hands, clothing and other personal items. Accidental concentrations of radioactive material are cleaned up, dispersed, or disposed of safely.

2. Decontamination shall, in general, be accomplished by rinsing and flushing fresh water through the equipment, or washing and scrubbing of contaminated items of clothing or portions of the individual's body. A detergent may be added to the water to aid this process. Portions of the equipment which cannot be decontaminated by this method shall be disassembled and scrubbed with water and detergent followed, if necessary, by steam cleaning. A 15% hydrochloric acid solution may be used to remove contamination from the surface of non-porous materials. Other chemicals may be used for decontamination, but their use should be limited due to their toxic nature.

3. Articles of clothing can normally be easily decontaminated by washing and scrubbing with water containing a strong detergent. This also applies to portions of the exposed individual's body. If efforts to decontaminate items of clothing on the job are unsuccessful, the clothing should be removed immediately to be washed after returning to the home station nearest the job location. Contaminated articles of clothing, rags, etc., should never be laundered in a home or commercial laundry. Such washing and scrubbing is restricted to the job site or the company facility. If the contamination cannot be removed economically, the clothing shall be discarded and treated as radioactive waste.

4. The same safety precautions shall be applied to the above operations as were applicable for tracer mixing and injections.

   a. Rubber gloves shall be worn during decontamination procedures involving personal contact with the equipment.

   b. Food, cigarettes, etc., shall be kept outside the clean-up area. Quantities of radioactive material which presents no hazard outside the body can be very dangerous if the same amount is internal.

   c. The wash water shall be treated as radioactive waste. If wash water is discharged into sanitary sewage system, the dilution of the activity by the sewage must be such that the tolerance established for such disposal by Federal and State regulations are not exceeded.

   d. If the wash water is discharged into a septic tank, then the surface of the fluid in the septic tank shall be surveyed after each such decontamination operation, and if any activity above background is noted, the tank shall be posted with a radiation warning sign alerting everyone concerned of the possible hazard.

5. If standard decontamination efforts are unsuccessful, the procedure to be followed shall depend on the value and ownership of the items involved, the degree of contamination, and the half-life of the contamination activity. Every effort shall be made to thoroughly decontaminate rented or borrowed equipment. If all efforts to decontaminate have failed to render the radioactive contamination to background and the measurable activity is apparently "fixed", the user in charge has three alternatives. They are as follows:

   a. If the "fixed" contamination measures less than 0.2 mr/hr at one centimeter, the item of equipment, article of clothing, etc., can be returned to normal use.

   b. If the "fixed" contamination measures more than 0.2 mr/hr at one centimeter, the item or items in question shall be treated as radioactive waste and disposed of accordingly.

   c. If the item containing the "fixed" contamination (which measures more than 0.2 mr/hr at one centimeter) is such that it is continually used in tracer operations and will be used in no other operation, then it may continue to be used if it is labeled properly and treated as a radioactive source and if the radiation measures less than 2.0 mr/hr at three inches from the surface.

6. More persistent activities remaining on equipment must be steam cleaned or chemically treated for contamination.

7. The user in charge shall be responsible for all contaminated equipment. That is, for any equipment, waste, area, or wash water that falls within the three alternative situations. The user in charge shall personally supervise its safe disposition either by staying on the job until the contamination is removed or transporting the equipment to the company where it may be stored awaiting further decontamination efforts.

LEVEL 1 TEST

This test is given to demonstrate the proficiency of the employee relating to the subject of radioactive material. A grade of 70 must be achieved in order to pass the test. This test must be completed before the employee can progress onto the further levels.

1.) Give 5 atomic elements that do not have to be of radioactive nature.

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2.) Name the 4 fundamental particles of the atomic structure.

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3.) Give a brief definition of atomic weights. __________________________

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4.) Give a definition of an isotope ________________________________

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5. What is the most common method used to radiate stable material for use. ______

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6.) Give a brief definition of decay of radioactive material. ________________

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7.) What is a curie. ____

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8.) Give a definition for half value layers. ________________________________

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9.) What are the 3 standards a student should know about radioactive material protection.

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10.) On a survey meter, what does MR/HR mean. ______________________

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11.) What is the allowable radiation dose a person can receive in 1 year. __________

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12.) What is the most commonly used liquid tracer in the oilfield. And why. ________

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13.) What equipment should all logging trucks have on location for safety purposes in dealing with liquid tracers. ______________________________

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14.) What item is required by law for each individual working with radioactive material to have on his person at all times. ____________________________

15.) Explain the emergency procedures if radioactive material is spilled or lost. _____

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LEVEL 2 TEST

Level 2 will consist of all information in Level 1 as well as 10 additional questions pertaining to advance level of radioactive material understanding.

1.) Give 5 atomic elements that do not have to be of radioactive nature.

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2.) Name the 4 fundamental particles of the atomic structure.

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3.) Give a brief definition of atomic weights. ____________________

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4.) Give a definition of an isotope. ____________________

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5.) What is the most common method used to radiate stable material for use. ______

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6.) Give a brief definition of decay of radioactive material. ____________

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7.) What is a curie. ______________________________

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8.) Give a definition for half value layers. ____________________

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9.) What are the 3 standards a student should know about radioactive material protection.

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10.) On a survey meter, what does MR/HR mean. ____________________

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11.) What is the allowable radiation dose a person can receive in 1 year. ____________________

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12.) What is the most commonly used liquid tracer in the oilfied. And Why. ____________________

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13.) What equipment should all logging trucks have on location for safety purposes in dealing with liquid tracers. ____________________

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14.) What item is required by law for each individual working with radioactive material to have on his person at all times. ____________________

15.) Explain the emergency procedures if radioactive material is spilled or lost. ____________________

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16.) How often should a survey meter be calibrated and how should this calibration procedure be conducted. ____________________

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17.) What does the term bank account (rems) mean. ______________________

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18.) Give a brief explanation of leadership role when radioactive material has been spilled pertaining to oil company personnel who we are working for.

19.) Define the word roentgen. ______________________

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20.) Define the word Rem. ______________________

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21.) Define the word Rad. ______________________

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22.) Define RBE ______________________

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23.) Define lethal dose. ______________________

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24.) Define microcurie, millicurie, and picocurie. ______________________

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25.) Who is your Radiation Safety Officer and what is his function. ______________________

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GREAT GUNS, INC.

This is to certify that

has on this date successfully completed training
in Radio Active Handling Fundamentals

Level ______________________

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Radiation Safety Officer

______________________ ______________________
Date Instructor

GREAT GUNS, INC.
This is to certify that

has on this date successfully completed
training in Radio Active Handling Fundamentals

Level ______________________

Radiation Safety Officer Date