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CASPER, WY 82601
P: 307-266-2524

July 19, 2011

US NRC Region IV
ATTN: Roberto Torres
612 East Lamar Boulevard, Suite 400
Arlington, TX 76011-4125

Re: NRC License 49-27067-01 (Mail Control Number 574932) Request for Additional Information

Dear Mr. Torres:

This letter and the training material enclosed is intended to provide the NRC with the additional information requested in an email from Mr. Roberto Torres on June 30, 2011.

The training material that Worthington, Lenhart & Carpenter, Inc. (DBA: WLC Engineering, Surveying & Planning) (WLC) uses is provided in two sections:

1) WLC Engineering, Surveying & Planning "Radiation Safety, Regulatory Requirements, Gauge Theory and Operation.
2) Current Troxler Transportation Guide with Appendix F and H.

Both are used for the initial training of a WLC employee before they are allowed to use a gauge without the DIRECT supervision of a WLC certified gauge user. A current Troxler Transportaion guide with Appendix F and Appendix H is used for the Transportation Refresher training.

WLC commits to the following language: "We will implement and maintain the operating, emergency, and security procedures described in the errata sheet to Appendix H of NUREG-1556, Volume 1, revision 1, dated November 2001 and provide copies of these procedures to all gauge users and at each job site."

Thank you for your time to review this information, and please let me know if I can be of further assistance.

Sincerely,

Gregory L Biggs

Gregory L. Biggs, R.S.O., Treasurer
WLC Engineering, Surveying & Planning

From: (307) 266-2524
Greg Biggs
WLC
200 PRONGHORN STREET

CASPER, WY 82601

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Roberto Torres
US NRC Region IV
612 E LAMAR BLVD STE 400

ARLINGTON, TX 76011

Ref # NRC License 49-27067-01
Invoice #
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WLC Engineering, Surveying & Planning

COURSE CONTENT

- 1.5 to 2 hours of radiation safety and regulatory requirements, emphasizing practical subjects important to safe use of the gauge; radiation vs. contamination; internal vs. external exposure; concept of time, distance, and shielding to minimize exposure; control and surveillance of gauges; location of sealed source within the portable gauge; inventory; recordkeeping; incidents; licensing and inspection by regulatory agency; need for complete and accurate information; employee protection; deliberate misconduct.
- 1.5 to 2 hours of practical explanation of portable gauge theory and operation; operating, emergency, maintenance, and transportation procedures; and field training emphasizing radiation safety and including test runs of setting up and making measurements with the gauge, controlling and maintaining surveillance over the portable gauge, performing routine cleaning and lubrication, packaging and transporting the gauge, storing the gauge, and following emergency procedures.

COURSE EXAMINATION

- At least a 70-percent score on a 25-to-50-question, closed-book written test
  - Emphasis on radiation safety of portable gauge storage, use, sealed source location, maintenance, and transportation, rather than the theory and art of making portable gauge measurements;
  - Review of correct answers to missed questions with prospective gauge user immediately following the scoring of the test.

COURSE INSTRUCTOR QUALIFICATIONS

Instructor should have either:

- Bachelor's degree in a physical or life science or engineering;
- Successful completion of a portable gauge user course;
- Successful completion of an 8-hour radiation safety course; and
- 8 hours hands-on experience with portable gauges.

OR

- Successful completion of portable gauge user course;
- Successful completion of 40-hour radiation safety course; and
- 30 hours of hands-on experience with portable gauges.

Note: Licensees should maintain records of training.

WLC Engineering, Surveying, & Planning

Radiation Safety, Regulatory Requirements, Gauge Theory and Operation

WLC

ENGINEERING · SURVEYING · PLANNING

WLC Engineering, Surveying, & Planning
200 Pronghorn St.
Casper, Wyoming 82601

WORTHINGTON, LENHART & CARPENTER, INC.
CLASS OUTLINE

RADIATION SAFETY, REGULATORY REQUIREMENTS, GAUGE THEORY AND OPERATION
3 – 4 HOURS

Radiation vs. Contamination

Internal vs External Exposure

ALARA Time Distance Shielding to Limit Exposure

Employee Protection

Licensing and Inspection by NRC

Need for complete and accurate info

Record keeping, Regulations

Inventory

Control and Surveillance

Packaging, transporting and storing gauge

Transportation Procedures

Routine cleaning and lubrication

Incidents

Deliberate Misconduct

Operating

Maintenance

Field Training Emphasizing Safety

- Location of Sealed source within the gauge
- Set up and measurements
- Routine cleaning and lubrication
- Packaging and transporting
- Storing gauge
- Emergency procedures

1 PURPOSE OF REPORT

This report provides guidance to an applicant in preparing a portable gauge license application, as well as NRC criteria for evaluating a portable gauge license application. It is not intended to address the research and development of gauging devices or the commercial aspects of manufacturing, distribution, and service of such devices. Within this document, the phrases "portable gauge" or "gauging devices," and the term "gauge" may be used interchangeably.

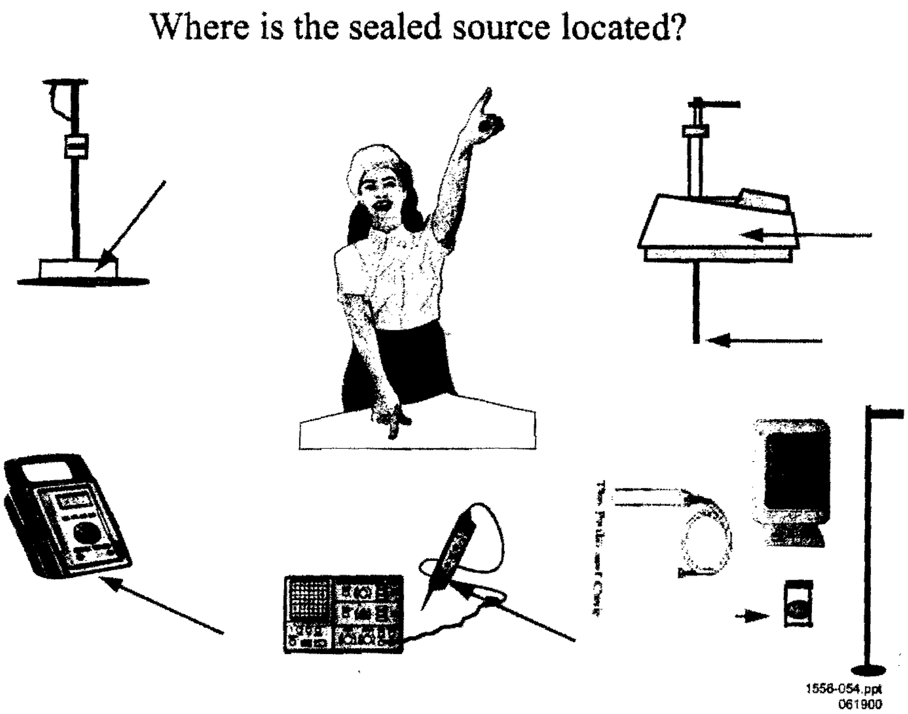

Figure 1.1 Where is the Radioactive Source? *The wide variety of portable gauge designs include placing the sealed source in different locations, resulting in different radiation safety problems.*

This report addresses the variety of radiation safety issues associated with portable gauges of many designs. As shown in Figure 1.1, portable gauges are of many different designs based, in part, on their intended use (e.g., to measure moisture, density, thickness of asphalt, liquid level). Because of differences in design, manufacturers provide appropriate instructions and recommendations for proper operation and maintenance. In addition, with gauges of varying designs, the sealed sources may be oriented in different locations within the devices, resulting in different radiation safety problems.

Natural and Man-Made Radiation Sources

[View in Frames | Document Outline | Acronyms]

Section Contents

Figures

Introduction

All living creatures, from the beginning of time, have been, and are still being, exposed to radiation.

This chapter will discuss the sources of this radiation, which are:

- Natural Background Radiation
- Man-Made Sources of Radiation

Natural Background Sources

- Cosmic Radiation
- Terrestrial Radiation
- Internal Radiation

Cosmic Radiation

[figure]

The earth, and all living things on it, are constantly bombarded by radiation from space, similar to a steady drizzle of rain. Charged particles from the sun and stars interact with the earth's atmosphere and magnetic field to produce a shower of radiation, typically beta and gamma radiation. The dose from cosmic radiation varies in different parts of the world due to differences in elevation and to the effects of the earth's magnetic field.

Terrestrial Radiation

Radioactive material found in:

- Soil
- Water
- Vegetation

Radioactive material is also found throughout nature. It is in the soil, water, and vegetation. Low levels of uranium, thorium, and their decay products are found everywhere. Some of these materials are ingested with food and water, while others, such as radon, are inhaled. The dose from terrestrial sources also varies in different parts of the world. Locations with higher concentrations of uranium and thorium in their soil have higher dose levels.

The major isotopes of concern for terrestrial radiation are uranium and the decay products of uranium, such as thorium, radium, and radon.

Internal Radiation

In addition to the cosmic and terrestrial sources, all people also have radioactive potassium-40, carbon-14, lead-210, and other isotopes inside their bodies from birth. The variation in dose from one person to another is not as great as the variation in dose from cosmic and terrestrial sources. The average annual dose to a person from internal radioactive material is about 39 millirems/year.

Man-Made Radiation Sources

Although all people are exposed to natural sources of radiation, there are two distinct groups exposed to man-made radiation sources. These two groups are:

- Members of the public
- Occupationally exposed individuals

Members of the Public

A member of the public is defined in 10 CFR Part 20 as any individual except when that individual is receiving an occupational dose.

Occupational dose is the dose received by an individual in the course of employment in which the individual's assigned duties involve exposure to radiation or to radioactive material. This does not include the dose received from background radiation, from any medical administration the individual has received, from exposure to individuals administered radioactive materials from voluntary participation in medical research programs, or as a member of the public.

Man-made radiation sources that result in an exposure to members of the public:

- Tobacco
- Televisions
- Medical X-rays
- Smoke detectors
- Lantern mantles
- Nuclear medicine
- Building materials

By far, the most significant source of man-made radiation exposure to the public is from medical procedures, such as diagnostic X-rays, nuclear medicine, and radiation therapy. Some of the major isotopes would be I-131, Tc-99m, Co-60, Ir-192, Cs-137, and others.

In addition, members of the public are exposed to radiation from consumer products, such as tobacco (thorium), building materials, combustible fuels (gas, coal, etc.), ophthalmic glass, televisions, luminous watches and dials (tritium), airport X-ray systems, smoke detectors (americium), road construction materials, electron tubes, fluorescent lamp starters, lantern mantles (thorium), etc.

Of lesser magnitude, members of the public are exposed to radiation from the nuclear fuel cycle, which includes the entire sequence from mining and milling of uranium to the actual production of power at a nuclear plant. This would be uranium and its daughter products.

The final sources of exposure to the public would be shipment of radioactive materials and residual fallout from nuclear weapons testing and accidents, such as Chernobyl.

Occupationally Exposed Individuals

Occupationally Exposed Individuals work in the following environments:

- Fuel cycle
- Radiography
- X-ray technicians
- Nuclear power plant
- U.S. NRC inspectors
- Nuclear medicine technicians

Occupationally exposed individuals, on the other hand, are exposed according to their occupations and to the sources with which they work. Occupationally exposed individuals, however, are monitored for radiation exposure with dosimeters so that their exposures are well documented in comparison to the doses received by members of the public.

Some of the isotopes of concern would be uranium and its daughter products, cobalt-60, cesium-137, americium-241, and others.

Ionizing Radiation Exposure to the Public

[figure]

The above chart is taken from the National Council on Radiation Protection and Measurements (NCRP) Report No. 93, *Ionizing Radiation Exposure of the Population of the United States*, 1987.

This chart shows that of the total dose of about 360 millirems/year, natural sources of radiation account for about 82% of all public exposure, while man-made sources account for the remaining 18%.

Radiation Exposure to the U. S. Population

The following table is extracted from material contained in NCRP Report No. 93, Ionizing Radiation Exposure of the Population of the United States, 1987.

The first column shows the sources of radiation exposure, and the second column shows an estimate of the number of people exposed to that source. For natural sources, the entire United States population is assumed to be exposed. The third column provides the average dose (in units of millirems) to those exposed (number in column 2). The last column averages the total dose from the specific source over the entire U. S. population. For natural sources, the third and fourth columns are identical.

Exposure Source	**Population Exposed (millions) 230**	**Average Dose Equivalent to Exposed Population (millirems/year)**	**Average Dose Equivalent to U.S. Population (millirems/year)**
Natural:			
Radon	230	200	200
Other	230	100	100
Occupational	0.93	230	0.9
Nuclear Fuel Cycle[1]	---	---	0.05
Consumer Products:			

Tobacco[2]	50	- - -	- - -
Other	120	5 - 30	5 - 13
Environment	25	0.6	0.06
Medical:			
Diagnostic X-rays[3]	- - -	- - -	39
Nuclear medicine[4]	- - -	- - -	14
Approximate Total	**230**	- - -	**360**

[1]Collective dose to regional population within 50 miles of each facility.

[2]Difficult to determine a whole body dose equivalent. However, the dose to a portion of the lungs is estimated to be 16,000 millirems/year.

[3]Number of persons unknown. However, 180 million examinations performed with an average dose of 50 millirems per examination.

[4]Number of persons unknown. However, 7.4 million examinations performed with an average dose of 430 millirems per examination.

Compute Your Own Radiation Dose

Cosmic radiation that reaches the earth at sea level:	27 mrem/yr
Based upon the elevation at which you live, add 1 mrem/yr for every 250 feet: *Examples: Atlanta - 1050 ft., Chicago - 595 ft., Dallas - 435 ft., Denver - 5280 ft., Las Vegas - 2000 ft., Minneapolis - 815 ft., Pittsburgh - 1200 ft., Washington, D. C. - 400 ft.*	________
Based upon where you live, add the following for terrestrial radiation: If you live in states that border the Gulf or Atlantic coasts (from Texas east and then north), add 23 mrem/yr; If you live in the Colorado Plateau area (around Denver), add 90 mrem/yr; If you live in middle America (rest of U. S.), add 46 mrem/yr	________
If you live in a stone, brick or concrete building, add 7 mrem/yr:	________
Radiation in our bodies from the food and water we ingest (potassium-40):	________
Radiation from the air due to radon (U.S. average):	________
Fallout from weapons testing: (actually less than 1 mrem/yr, but add 1 mrem/yr to be conservative)	1 mrem/yr
If you travel on jet planes, add 1 mrem/yr per 1,000 miles of travel:	________
If you have porcelain crowns or false teeth, add 0.07 mrem/yr: *Some of the radiation sources listed result in an exposure to only part of the body. For example, false teeth result in a radiation dose to the mouth. The annual dose numbers given here represent the effective dose to the whole body.*	________
If you use gas lantern mantles when camping, add 0.003 mrem/yr:	________
If you wear a luminous wristwatch (LCD), add 0.06 mrem/yr:	________

If you use luggage inspection at airports, add 0.002 mrem/yr:	______
If you watch television add 1 mrem/yr: (actually less than 1mrem/yr, but add 1 mrem/yr to be conservative)	1 mrem/yr
If you use a video display terminal, add 1 mrem/yr: (actually less than 1 mrem/yr, but add 1 mrem/yr to be conservative)	1 mrem/yr
If you have a smoke detector, add 0.008 mrem/yr:	______
If you wear a plutonium-powered cardiac pacemaker, add 100 mrem/yr:	______
For diagnostic X-rays, add an average of 50 mrem/yr per X-ray: (Examples of diagnostic X-rays are upper and lower gastrointestinal and chest X-rays)	______
For nuclear medicine procedures, add an average of 430 mrem/yr per procedure: (An example of a nuclear medicine procedure would be a thyroid scan)	______
If you live within 50 miles of a nuclear power plant, add 0.009 mrem/yr:	______
If you live within 50 miles of a coal-fired electrical utility plant, add 0.03 mrem/yr:	______
If you smoke, add an estimated 1,300 mrem/yr due to radon decay products:	______
YOUR AVERAGE TOTAL DOSE IN MILLIREMS PER YEAR:	______

Sources: National Council on Radiation and Measurement Reports 92, 93, 94, 95, and 100; the American Nuclear Society

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Cosmic Radiation

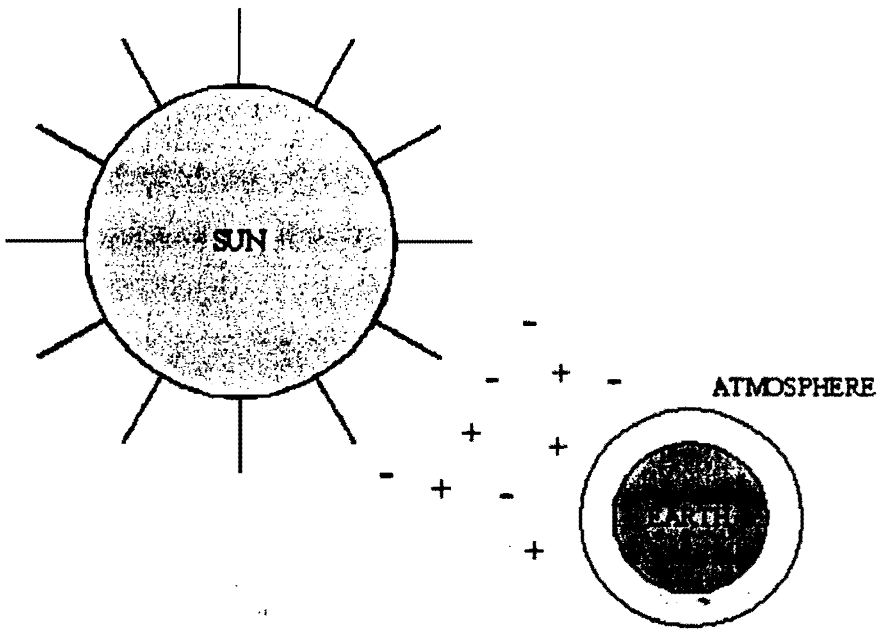

Figure 1. Cosmic Radiation

[NRC Home Page | Top of file | Contents]

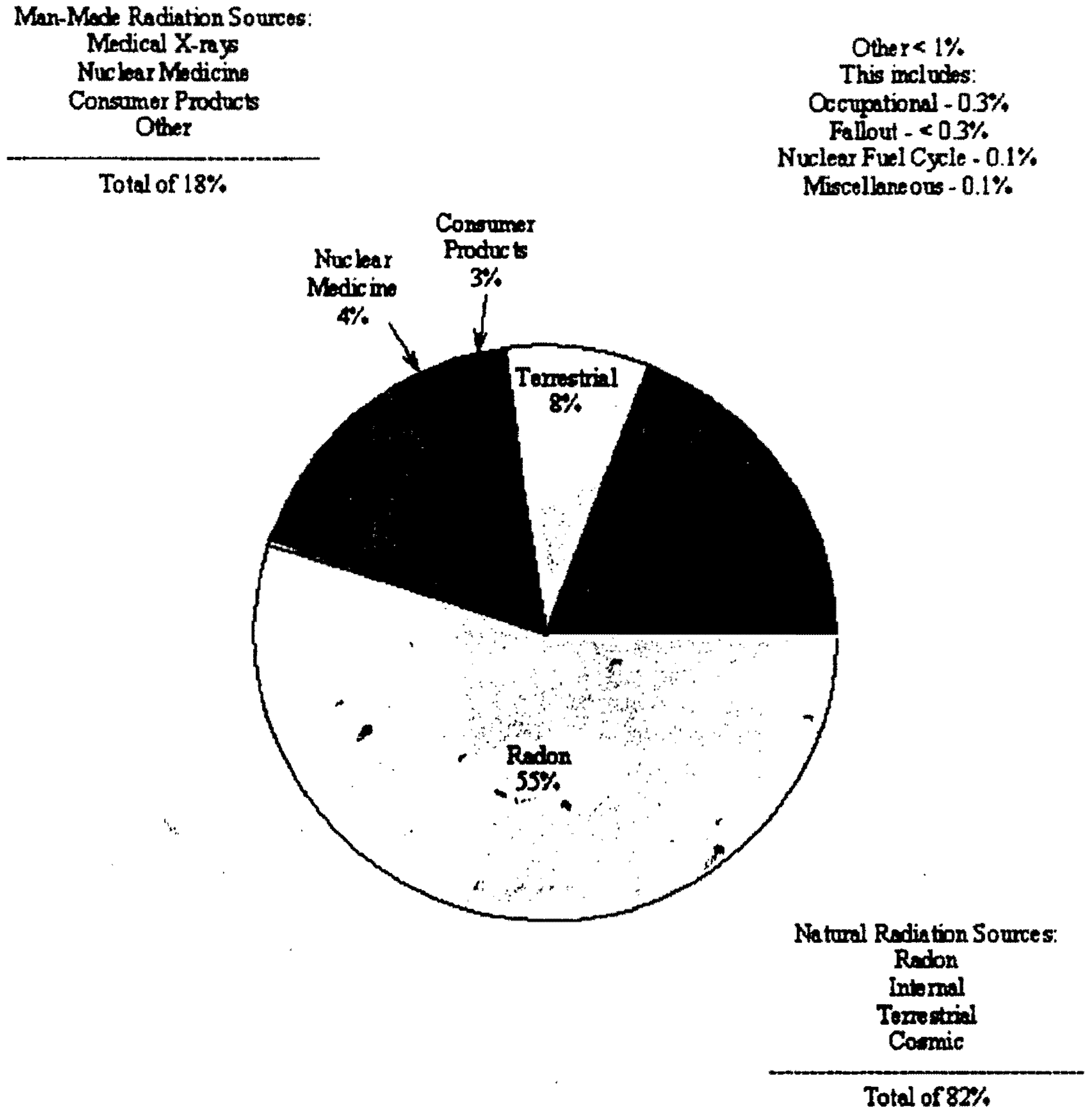

Figure 2. Ionizing Radiation Exposure to the Public

[NRC Home Page | Top of file | Contents]

Radiation Terminology

[View in Frames | Contents | Acronyms]

Radiation Terminology

[View in Frames | Document Outline | Acronyms]

Section Contents

Figures

Introduction

This section discusses the terms and concepts which are necessary for a meaningful discussion of radiation, its sources, and its risks.

[figure]

Atoms can be classified as stable or unstable. Unstable atoms have excess energy in their nuclei. A Radioactive Material contains atoms which are unstable and attempt to become more stable by ejecting particles, electromagnetic energy (photons), or both. When a radioactive atom ejects particles and/or photons, the atom undergoes a process called Disintegration (or decay).

[figure]

* Radiation

Radiation is the term given to the particles and/or energy emitted by radioactive material as it disintegrates.

[1 Curie]

3.7 X 10^{10} Disintegrations per second = 1 Curie

Radioactivity

Radioactivity is a term which indicates how many radioactive atoms are disintegrating in a time period and is measured in units of CURIES. One curie is defined as that amount of any radioactive material that will decay at a rate of 37 billion disintegrations per second (based upon the disintegration rate of 1 gram of radium-226).

As shown above, the amount of material necessary for 1 curie of radioactivity can vary from an amount too small to be seen (cobalt-60, for example) to more than half a ton (uranium-238).

Radioactivity can also be expressed in units of becquerels, which are discussed on page 5-24.

[figure]

The rate of nuclear decay is measured in terms of HALF LIVES. The half life of any radioactive material is the length of time necessary for one half of the atoms of that material to decay to some other material. During each half life, one half of the atoms which started that half life period will decay.

Half lives range from millionths of a second for highly radioactive fission products to billions of years for long-lived materials (such as naturally occurring uranium). No matter how long or short the half life is, after seven half lives have passed, there is less than 1 percent of the initial activity remaining.

[figure]

Ionization

Radiation emitted by radioactive material can produce IONIZATIONS and, therefore, is called IONIZING RADIATION. Ionization is the process of stripping, knocking off, or otherwise removing electrons from their orbital paths, creating "free" electrons and leaving charged nuclei. The negatively charged electrons and positively charged nuclei may interact with other materials to produce chemical or electrostatic changes in the material where the interactions occur. If chemical changes occur in the cells of our bodies, some cellular damage may result. The biological effects of radiation exposure are discussed in Chapter 6.

[figure]

Alpha Particle

An ALPHA PARTICLE is an ionizing radiation that consists of two protons and two neutrons. The neutrons and protons give the alpha particle a relatively large mass as compared to other ionizing radiation particles. Because of this large size, the alpha particle has a relatively low speed and low penetrating distance (one or two inches in air). The particle tends to travel in a straight line, causing a large number of ionizations in a small area.

Alpha particles are easily shielded (or stopped) by a thin sheet of paper or the body's outer layer of skin. Since they do not penetrate the outer (dead) layer of skin, they present little or no hazard when they are external to the body. However, alpha particles are considered to be an internal hazard, because they can be in contact with live tissue and have the ability to cause a large number of ionizations in a small area. INTERNAL and EXTERNAL HAZARDS refer to whether the radioactive material is inside the body (internal) or outside the body (external).

[figure]

Beta Particle

A BETA PARTICLE is a high speed ionizing radiation particle that is usually negatively charged. The charge of a beta particle is equal to that of an electron (positive or negative), and its mass is equal to about 1/1800th of that of a proton or neutron. Due to this relatively low mass and charge, the beta particle can travel through about 10 feet of air and can penetrate very thin layers of materials (for example, aluminum). However, clothing will stop most beta particles.

The beta particle can penetrate into the live layers of the skin tissue and is considered both an internal and an external hazard. Beta particles can also be an external hazard to the lens of the eye. Beta particles are best shielded by thin layers of light metals (such as aluminum or copper) and plastics.

[figure]

Gamma Ray

A Gamma Ray is an ionizing radiation in the form of electromagnetic energy (no rest mass, no charge) similar in many respects to visible light (but far more energetic). Due to the high energy, no charge, and no rest mass, gamma rays can travel thousands of feet in air and can easily pass through the human body.

Because of their penetrating capability, gamma rays are considered both an internal and external hazard. The best shielding materials for gamma rays are very dense materials such as lead, concrete, and uranium.

NOTE: X-rays are similar to gamma rays in penetration and damage potential. X-rays, however, are produced by changes in electron orbit position rather than by nuclear decay or fission.

[figure]

Neutron Particle

The Neutron Particle is an ionizing radiation emitted by nuclear fission and by the decay of some radioactive atoms. Neutrons can range from high speed, high energy particles to low speed, low energy particles (called thermal neutrons). Neutrons can travel hundreds of feet in air and can easily penetrate the human body.

Neutrons are considered both an internal and external hazard, although the likelihood of an internal, neutron emitting, radioactive material is extremely unlikely. The best shielding materials for neutrons would be those that contain hydrogen atoms, such as water, polyethylene, and concrete.

The nucleus of a hydrogen atom contains a proton. Since a proton and a neutron have almost identical masses, a neutron hitting a hydrogen atom gives up a great amount of its energy, and therefore, the distance traveled by the neutron is limited. This is like a cue ball hitting another billiard ball. Since they are the same size, the cue ball can be made to stop and the other ball will start moving. But, if a ping pong ball is thrown against a bowling ball, the ping pong ball will bounce off with very little change in velocity, only a change in direction. Therefore, heavy atoms, like lead, are not good at stopping neutrons.

Units for Exposure and Dose Measurements

When ionizing radiation interacts with a material, it can cause ionizations. The ionizations can be measured, and the effects of the radiation can be estimated. Because of these ionizations, radioactive material and exposure to ionizing radiation can be monitored and controlled.

The commonly used units in the United States for radiation exposure and dose measurements are the ROENTGEN, the RAD, and the REM.

> NOTE: The unit of Roentgen is no longer recognized in 10 CFR Part 20, and consequently, the roentgen is being phased out as an official unit for dose of record. It will, however, still be seen on radiation survey instruments, and on radiation surveys, until the older models can be replaced. The radiation dose of record must be recorded in rad or rem.

[1 ESU/cm^3 Dry Air]

Roentgen

The ROENTGEN (R) is a measure of exposure to X-ray or gamma ray radiation. One roentgen is that amount of X-ray or gamma radiation that will deposit enough energy to strip about two billion electrons from their orbits (called one electrostatic unit) in one cubic centimeter of dry air. The roentgen technically applies only to ionization in dry air from X-ray or gamma radiation and does not apply to damage to body tissues.

> NOTE: As stated earlier, the unit of roentgen is being phased out as an official record of dose, but radiation survey instrument faces will still read out in R or multiples of R until they can be replaced with instruments reading out in rem or rad.

[figure]

RAD

The RAD (Radiation Absorbed Dose) is a measure of the absorbed dose (energy deposited) in a material. One RAD is the deposition of one hundred ergs of energy in one gram of any material (NRC Regulations use per gram of body tissue) due to the ionization from any type of radiation. One erg of energy is equal to about one ten billionth of a BTU, or about one ten millionth of a watt.

REM

The REM is based on the biological damage caused by ionization in human body tissue. It is a term for dose equivalence and equals the biological damage that would be caused by one RAD of dose.

The REM accounts for the fact that not all types of radiation are equally effective in producing biological change or damage. That is, the damage from one rad deposited by beta radiation is less than that caused by one rad of alpha radiation. The REM is numerically equal to the dose in RADs multiplied by a QUALITY FACTOR, which accounts for the difference in the amount of biological damage caused by the different types of radiation.

FOR GAMMA AND X-RAYS:

1 Roentgen = 1 RAD = 1 REM

Gamma ray radiation provides the consistency among the units of exposure and dose. Although slight corrections have been made to early historical data, one Roentgen of exposure of gamma or X-ray radiation is approximately equal to one RAD of absorbed energy (dose), which equals one REM of biological damage in humans (dose equivalent).

Again, this relationship is only true for gamma and X-ray radiation and is not true for the particulate (alpha, beta, or neutron) radiations. For this reason, and also the fact that the Roentgen is NOT a fundamental unit, the Roentgen is being phased out as a unit for the official dose of record.

[figure]

Particulate ionizing radiation (alpha and neutron) has been found to cause more biological damage than electromagnetic radiation (gamma and X-ray), even when the same amount of energy has been deposited. For example, one RAD of alpha radiation can be expected to cause about twenty times the damage caused by one RAD of gamma radiation. This difference in ability to cause damage is corrected for by a QUALITY FACTOR (Q).

DOSE

Energy Deposition	"Damage"
1 RAD Gamma	1 REM
1 RAD Beta	1 REM
1 RAD Neutron	10 REM
1 RAD Alpha	20 REM

REM = RAD X Quality Factor

Quality Factor

The Quality Factor converts the absorbed dose in RAD to the dose equivalent in REM. As shown, quality factors are highest for the alpha radiation, which deposits its energy within the smallest volume.

[figure]

The units used in a discussion of radiation and radioactivity may be prefixed to indicate fractions (or multiples) of the standard unit. The table below lists the more common prefixes for scientific use.

[figure] [figure]

Dose Rate

The Dose Rate is the rate at which a person would (or did) receive a radiation dose (or dose equivalent). It is a measure of radiation dose intensity (or strength). Commonly used dose equivalent rates are:

- mrem/hr
- rem/hr
- mrem/wk
- rem/wk
- rem/quarter
- rem/year

Dose

DOSE = Dose Rate X Time
= 50 mrem/hr x hour
= 25 mrem

The Dose is equal to the strength of the radiation field (dose rate) multiplied by the length of time spent in that field. The example above indicates a person could expect to receive a dose of 25 millirems by staying in a 50 millirems/hour field for thirty minutes.

Stay Time Calculations

$$\text{Stay Time} = \frac{\text{Dose "Limit"}}{\text{Dose Rate}}$$

For Example:

$$\text{Stay Time} = \frac{100 \text{ millirems limit}}{50 \text{ millirems/hr}} = 2 \text{ hours}$$

Stay Time

Stay Time is an exposure control value equal to the length of time a person can remain in a radiation field before exceeding some DOSE LIMIT. In the example above, a dose limit of 100 millirems has been established. With a dose rate of 50 millirems/hour, the stay time is calculated to be two hours by dividing the dose limit by the dose rate.

[figure]

Contamination

Contamination is generally referred to as some quantity of radioactive material in a location where it is not intended or desired to be. Radioactive contamination is radioactive atoms (material) that have escaped the system or structure that would normally contain them. Radioactive contamination can be wet or dry, fixed or removable, and settled or airborne. Since radioactive contamination is radioactive material, ionizing radiation is emitted by the contamination.

Contaminated Area

A Contaminated Area is an area that contains some type of radioactive contamination. Some examples of contaminated areas that require periodic access would be the primary side of the steam generator for a pressurized water reactor and the main turbine for a boiling water reactor. Methods of protection against radiation and contamination are discussed in a future chapter.

International System of Units (SI)

Special Units	SI Units
Curie	Becquerel
RAD	Gray
REM	Sievert

USNRC regulations (10 CFR Part 20) now lists both the special units and the equivalent internationally accepted system of units and measures (SI). The SI units shown above have replaced the curie, RAD, and REM in some technical literature.

The relationships between the special units and the SI units are shown on the following pages.

Curie

1 Curie	=	3.7×10^{10} disintegrations/second
1 Becquerel	=	1 disintegration/second
1 Becquerel	=	2.7×10^{-11} Curie

One curie is defined as the amount of any radioactive material that decays at the rate of 37 billion disintegrations per second. The SI unit for activity is the becquerel. It is equal to one disintegration per second. Therefore, one curie equals 37 billion becquerels.

Gray

1 RAD = 0.01 Gray

1 Gray = 100 RADs

The Gray is the SI unit of absorbed dose. A Gray is equal to 0.1 Joule of energy deposited in one kilogram of matter. Therefore, one RAD is equivalent to 1/100 of a gray, and one gray is equal to 100 RADs.

Sievert

1 REM = 0.01 Sievert

1 Sievert = 100 REM

The Sievert is the SI unit of dose equivalent. In the same way that converting from the absorbed dose (RAD) to the dose equivalent (REM) involved the use of quality factors, the conversion of grays to sieverts also uses quality factors.

One rem equals 1/100th of a sievert, and one sievert equals 100 rems.

[**Top of file**]

Figures

[View in Frames | Document Outline | Acronyms]

[NRC Home Page | Top of file | Contents]

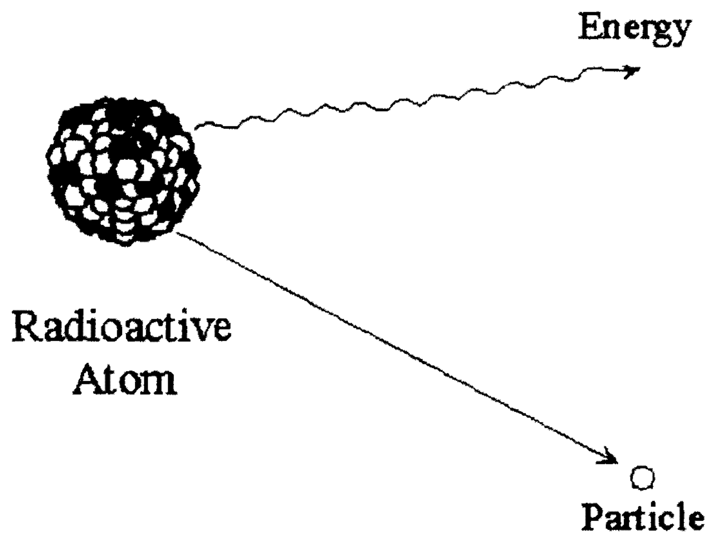

Figure 1. Radioactive Atom

[NRC Home Page | Top of file | Contents]

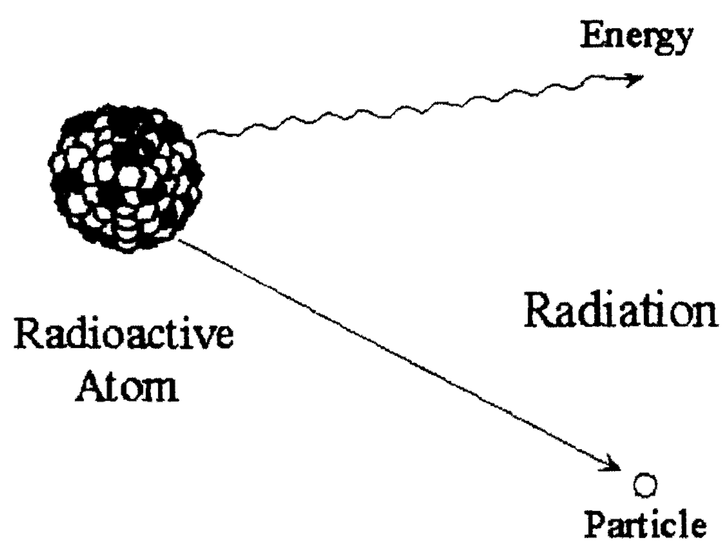

Figure 2. Radiation

[NRC Home Page | Top of file | Contents]

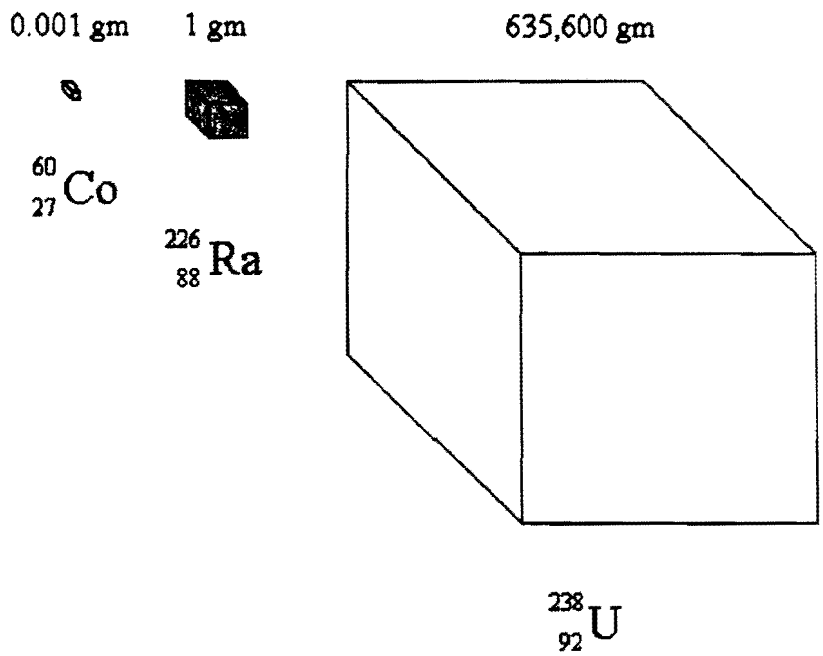

Figure 3. Curie

[NRC Home Page | Top of file | Contents]

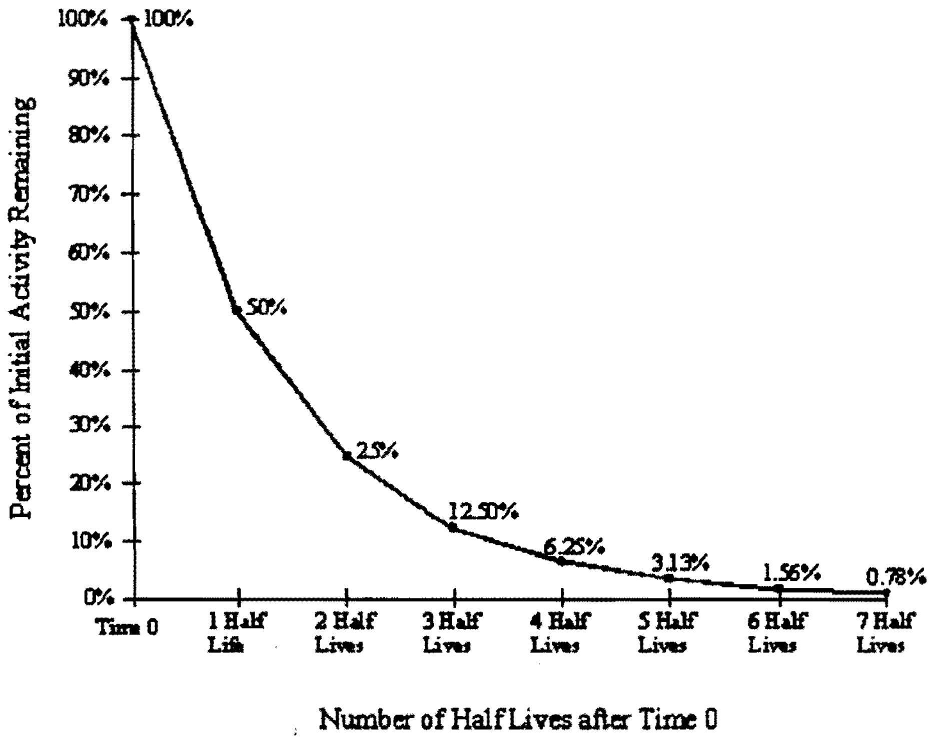

Figure 4. Rate of Nuclear Decay

[NRC Home Page | Top of file | Contents]

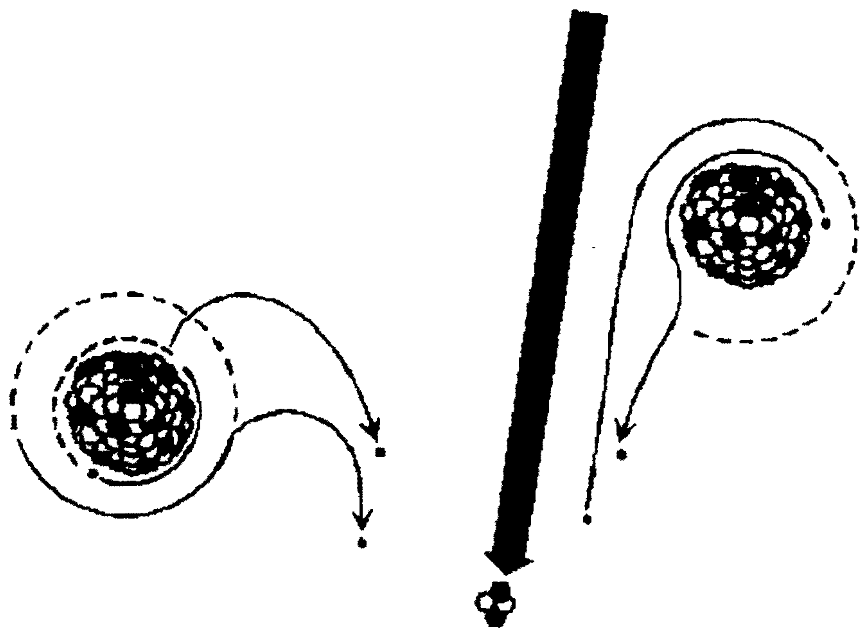

Figure 5. Ionization

[NRC Home Page | Top of file | Contents]

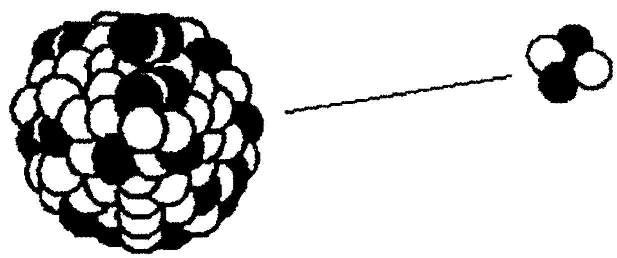

Figure 6. Alpha Particle

[NRC Home Page | Top of file | Contents]

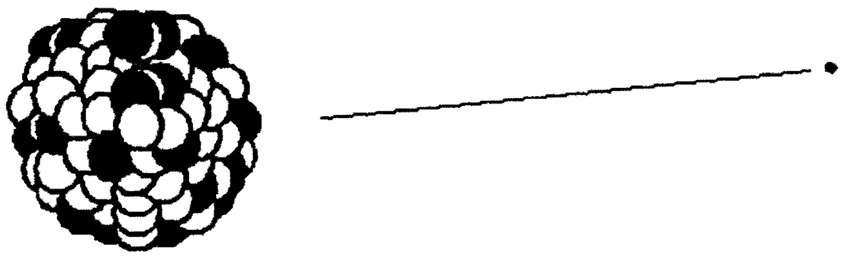

Figure 7. Beta Particle

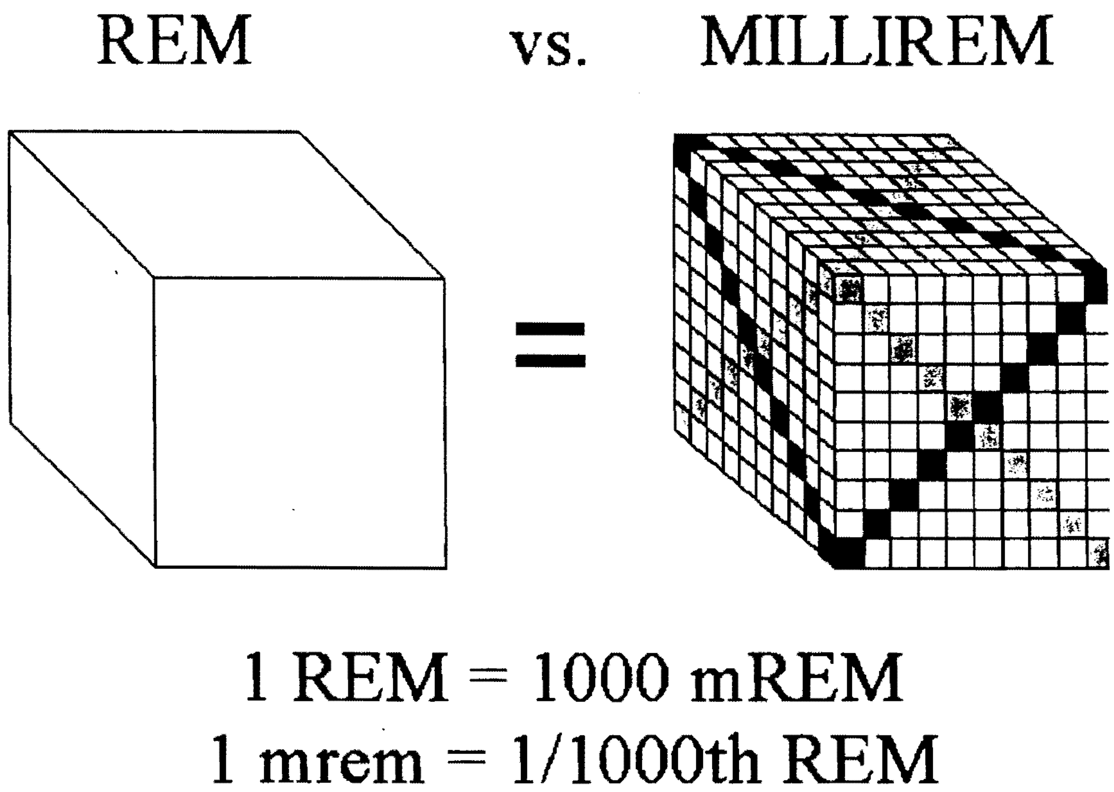

Figure 13. REM vs. MILLIREM

[NRC Home Page | Top of file | Contents]

Prefixes

d	deci	(= 10E-1)			
c	centi	(= 10E-2)	da	deka	(= 10)
m	milli	(= 10E-3)	h	hecto	(= 10E2)
m	micro	(= 10E-6)	k	kilo	(= 10E3)
n	nano	(= 10E-9)	M	mega	(= 10E6)
p	pico	(= 10E-12)	G	giga	(= 10E9)
f	femto	(= 10E-15)	T	terra	(= 10E12)
a	atto	(= 10E-18)			

Figure 14. Prefixes

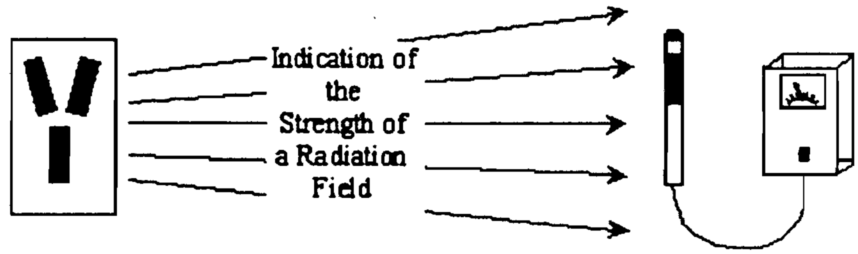

Figure 15. Dose Rate

Contamination

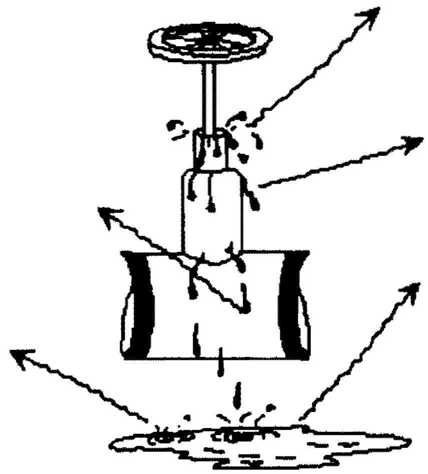

Figure 16. Contamination

Biological Effects of Radiation

[View in Frames | Document Outline | Acronyms]

Section Contents

Figures

Introduction

[figure]

Whether the source of radiation is natural or man-made, whether it is a small dose of radiation or a large dose, there will be some biological effects. This chapter summarizes the short and long term consequences which may result from exposure to radiation.

Radiation Causes Ionizations

Radiation Causes Ionizations of:

ATOMS
|
which may affect
MOLECULES
|
which may affect
CELLS
|
which may affect
TISSUES
|
which may affect
ORGANS
|
which may affect
THE WHOLE BODY

Although we tend to think of biological effects in terms of the effect of radiation on living cells, in actuality, ionizing radiation, by definition, interacts only with atoms by a process called ionization. Thus, all biological damage effects begin with the consequence of radiation interactions with the atoms forming the cells. As a result, radiation effects on humans proceed from the lowest to the highest levels as noted in the above list.

[figure]

Even though all subsequent biological effects can be traced back to the interaction of radiation with atoms, there are two mechanisms by which radiation ultimately affects cells. These two mechanisms are commonly called direct and indirect effects.

[figure]

If radiation interacts with the atoms of the DNA molecule, or some other cellular component critical to the survival of the cell, it is referred to as a direct effect. Such an interaction may affect the ability of the cell to reproduce and, thus, survive. If enough atoms are affected such that the chromosomes do not replicate properly, or if there is significant alteration in the information carried by the DNA molecule, then the cell may be destroyed by "direct" interference with its life-sustaining system.

[figure]

If a cell is exposed to radiation, the probability of the radiation interacting with the DNA molecule is very small since these critical components make up such a small part of the cell. However, each cell, just as is the case for the human body, is mostly water. Therefore, there is a much higher probability of radiation interacting with the water that makes up most of the cell's volume.

When radiation interacts with water, it may break the bonds that hold the water molecule together, producing fragments such as hydrogen (H) and hydroxyls (OH). These fragments may recombine or may interact with other fragments or ions to form compounds, such as water, which would not harm the cell. However, they could combine to form toxic substances, such as hydrogen peroxide (H_2O_2), which can contribute to the destruction of the cell.

Cellular Sensitivity to Radiation

Cellular Sensitivity to Radiation
(from most sensitive to least sensitive)

Lymphocytes and Blood Forming Cells

Reproductive and Gastrointestinal (GI) Cells

Nerve and Muscle Cells

Not all living cells are equally sensitive to radiation. Those cells which are actively reproducing are more sensitive than those which are not. This is because dividing cells require correct DNA information in order for the cell's offspring to survive. A direct interaction of radiation with an active cell could result in the death or mutation of the cell, whereas a direct interaction with the DNA of a dormant cell would have less of an effect.

As a result, living cells can be classified according to their rate of reproduction, which also indicates their relative sensitivity to radiation. This means that different cell systems have different sensitivities. Lymphocytes (white blood cells) and cells which produce blood are constantly regenerating, and are, therefore, the most sensitive. Reproductive and gastrointestinal cells are not regenerating as quickly and are less sensitive. The nerve and muscle cells are the slowest to regenerate and are the least sensitive cells.

[figure]

Cells, like the human body, have a tremendous ability to repair damage. As a result, not all radiation effects are irreversible. In many instances, the cells are able to completely repair any damage and function normally.

If the damage is severe enough, the affected cell dies. In some instances, the cell is damaged but is still able to reproduce. The daughter cells, however, may be lacking in some critical life-sustaining component, and they die.

The other possible result of radiation exposure is that the cell is affected in such a way that it does not die but is simply mutated. The mutated cell reproduces and thus perpetuates the mutation. This could be the beginning of a malignant tumor.

Organ Sensitivity

Organ Sensitivity
(from most sensitive to least sensitive)
|
Blood Forming Organs
|
Reproductive and Gastrointestinal Tract Organs
|
Skin
|
Muscle and Brain

The sensitivity of the various organs of the human body correlate with the relative sensitivity of the cells from which they are composed. For example, since the blood forming cells were one of the most sensitive cells due to their rapid regeneration rate, the blood forming organs are one of the most sensitive organs to radiation. Muscle and nerve cells were relatively insensitive to radiation, and therefore, so are the muscles and the brain.

Sensitivity

Rate of Reproduction and Oxygen Supply

The rate of reproduction of the cells forming an organ system is not the only criterion determining overall sensitivity. The relative importance of the organ system to the well being of the body is also important.

One example of a very sensitive cell system is a malignant tumor. The outer layer of cells reproduces rapidly, and also has a good supply of blood and oxygen. Cells are most sensitive when they are reproducing, and the presence of oxygen increases sensitivity to radiation. Anoxic cells (cells with insufficient oxygen) tend to be inactive, such as the cells located in the interior of a tumor.

As the tumor is exposed to radiation, the outer layer of rapidly dividing cells is destroyed, causing it to "shrink" in size. If the tumor is given a massive dose to destroy it completely, the patient might die as well. Instead, the tumor is given a small dose each day, which gives the healthy tissue a chance to recover from any damage while gradually shrinking the highly sensitive tumor.

Another cell system that is composed of rapidly dividing cells with a good blood supply and lots of oxygen is the developing embryo. Therefore, the sensitivity of the developing embryo to radiation exposure is similar to that of the tumor, however, the consequences are dramatically different.

Whole Body Sensitivity Factors

- Total Dose
- Type of Cell
- Type of Radiation
- Age of Individual
- Stage of Cell Division
- Part of Body Exposed
- General State of Health
- Tissue Volume Exposed
- Time Interval over which Dose is Received

Whole body sensitivity depends upon the most sensitive organs which, in turn, depend upon the most sensitive cells. As noted previously, the most sensitive organs are the blood forming organs and the gastrointestinal system.

The biological effects on the whole body from exposure to radiation will depend upon several factors. Some of these are listed above. For example, a person, already susceptible to infection, who receives a large dose of radiation may be affected by the radiation more than a healthy person.

Radiation Effects

Biological effects of radiation are typically divided into two categories. The first category consists of exposure to high doses of radiation over short periods of time producing acute or short term effects (acute). The second category represents exposure to low doses of radiation over an extended period of time producing chronic or long term effects (chronic).

High doses tend to kill cells, while low doses tend to damage or change them. High doses can kill so many cells that tissues and organs are damaged. This in turn may cause a rapid whole body response often called the Acute Radiation Syndrome (ARS). High dose effects are discussed on pages 6-12 to 6-16.

Low doses spread out over long periods of time don't cause an immediate problem to any body organ. The effects of low doses of radiation occur at the level of the cell, and the results may not be observed for many years. Low dose effects are discussed on pages 6-17 to 6-23.

High Dose Exposures

<u>Occupation High Dose Exposures</u>

- Chernobyl
- Irradiators
- Inadvertent Criticalities

<u>Non-Occupational High Dose Exposures</u>

- Chernobyl (firefighters)

- Nagasaki and Hiroshima
- Therapy source in Goiania, Brazil

Although we tend to associate high doses of radiation with catastrophic events such as nuclear weapons explosions, there have been documented cases of individuals dying from exposure to high doses of radiation resulting from workplace accidents and other tragic events.

Some examples of deaths which have occurred as a result of occupational (worker related) accidents are:

- Inadvertent criticality (too much fissionable material in the right shape at the wrong time)
- Irradiator (accidental exposure to sterilization sources, which can be more than 10 million curies)
- Chernobyl (plant workers)

An example of a nonoccupational accident occurred in 1987 in Goiania, Brazil. An abandoned medical therapy source (cesium) was found and cut open by people who did not know what it was. This resulted in the deaths of several members of the public and the spread of radioactive contamination over a large area.

A recent inadvertent criticality event occurred in a fuel processing plant in Japan.

High Dose Effects

Dose (Rad)	Effect Observed
15 - 25	Blood count changes in a group of people
50	Blood count changes in an individual
100	Vomiting (threshold)
150	Death (threshold)
320 - 360	LD 50/60 with minimal care
480 - 540	LD 50/60 with supportive medical care
1,100	LD 50/60 with intensive medical care (bone marrow transplant)

Every acute exposure will not result in death. If a group of people is exposed to a whole body penetrating radiation dose, the above effects might be observed. The information for this table was extracted from NCRP Report No. 98, *Guidance on Radiation Received in Space Activities,* 1989.

In the above table, the threshold values are the doses at which the effect is first observed in the most sensitive of the individuals exposed. The LD 50/60 is the lethal dose at which 50% of those exposed to that dose will die within 60 days.

It is sometimes difficult to understand why some people die while others survive after being exposed to the same radiation dose. The main reasons are the health of the individuals at the time of the exposure and their ability to combat the incidental effects of radiation exposure, such as the increased susceptibility to infections.

Other High Dose Effects

- Skin Burns
- Hair Loss
- Sterility
- Cataracts

Besides death, there are several other possible effects of a high radiation dose.

Effects on the skin include erythema (reddening like sunburn), dry desquamation (peeling), and moist desquamation (blistering). Skin effects are more likely to occur with exposure to low energy gamma, X-ray, or beta radiation. Most of the energy of the radiation is deposited in the skin surface. The dose required for erythema to occur is relatively high, in excess of 300 rad. Blistering requires a dose in excess of 1,200 rad.

Hair loss, also called epilation, is similar to skin effects and can occur after acute doses of about 500 rad.

Sterility can be temporary or permanent in males, depending upon the dose. In females, it is usually permanent, but it requires a higher dose. To produce permanent sterility, a dose in excess of 400 rad is required to the reproductive organs.

Cataracts (a clouding of the lens of the eye) appear to have a threshold of about 200 rad. Neutrons are especially effective in producing cataracts, because the eye has a high water content, which is particularly effective in stopping neutrons.

Acute Radiation Syndrome (ARS)

- Hematopoietic
- Gastrointestinal
- Central Nervous System

If enough important tissues and organs are damaged, one of the Acute Radiation Syndromes could result.

The initial signs and symptoms of the acute radiation syndrome are nausea, vomiting, fatigue, and loss of appetite. Below about 150 rad, these symptoms, which are no different from those produced by a common viral infection, may be the only outward indication of radiation exposure.

As the dose increases above 150 rad, one of the three radiation syndromes begins to manifest itself, depending upon the level of the dose. These syndromes are:

Syndrome	Organs Affected	Sensitivity
Hematopoietic	Blood forming organs	Most sensitive
Gastrointestinal	Gastrointestinal system	Very sensitive
Central Nervous System	Brain and muscles	Least sensitive

Summary of Biological Response to High Doses of Radiation

< 5 rad	No immediate observable effects
~ 5 rad to 50 rad	Slight blood changes may be detected by medical evaluations
~ 50 rad to 150 rad	Slight blood changes will be noted and symptoms of nausea, fatigue, vomiting, etc. likely
~ 150 rad to 1,100 rad	Severe blood changes will be noted and symptoms appear immediately. Approximately 2 weeks later, some of those exposed may die. At about 300 - 500 rad, up to one half of the people exposed will die within 60 days without intensive medical attention. Death is due to the destruction of the blood forming organs. Without white blood cells, infection is likely. At the lower end of the dose range, isolation, antibiotics, and transfusions may provide the bone marrow time to generate new blood cells and full recovery is possible. At the upper end of the dose range, a bone marrow transplant may be required to produce new blood cells.
~ 1,100 rad to 2,000 rad	The probability of death increases to 100% within one to two weeks. The initial symptoms appear immediately. A few days later, things get very bad, very quickly since the gastrointestinal system is destroyed. Once the GI system ceases to function, nothing can be done, and medical care is for comfort only.
> 2,000 rad	Death is a certainty. At doses above 5,000 rad, the central nervous system (brain and muscles) can no longer control the body functions, including breathing blood circulation. Everything happens very quickly. Nothing can be done, and medical care is for comfort only.

As noted, there is nothing that can be done if the dose is high enough to destroy the gastrointestinal or central nervous system. That is why bone marrow transplants don't always work.

In summary, radiation can affect cells. High doses of radiation affect many cells, which can result in tissue/organ damage, which ultimately yields one of the Acute Radiation Syndromes. Even normally radio-resistant cells, such as those in the brain, cannot withstand the cell killing capability of very high radiation doses. The next few pages will discuss the biological effects of low doses of radiation.

Annual Exposure to Average U.S. Citizen

Exposure Source	**Average Annual Effective Dose Equivalent (millirems)**
Natural:	
Radon	200
Other	100
Occupational	0.90
Nuclear Fuel Cycle	0.05
Consumer Products:	
Tobacco	?*
Other	5 - 13
Environmental Sources	0.06
Medical:	

Diagnostic X-rays	39
Nuclear Medicine	14
Approximate Total	360

** The whole body dose equivalent from tobacco products is difficult to determine. However, the dose to a portion of the lungs is estimated to be 16,000 millirems/year.*

Everyone in the world is exposed continuously to radiation. The average radiation dose received by the United States population is given in the table above. This data was extracted from material contained in NCRP Report No. 93, *Ionizing Radiation Exposure of the Population of the United States*, 1987.

Radiation workers are far more likely to receive low doses of radiation spread out over a long period of time rather than an acute dose as discussed previously. The principal effect of low doses of radiation (below about 10 rad) received over extended periods of time is non-lethal mutations, with the greatest concern being the induction of cancer.

The next few pages will discuss the biological effects of low doses of radiation.

Categories of Effects of Exposure to Low Doses of Radiation

There are three general categories of effects resulting from exposure to low doses of radiation. These are:

Genetic - The effect is suffered by the offspring of the individual exposed.

Somatic - The effect is primarily suffered by the individual exposed. Since cancer is the primary result, it is sometimes called the Carcinogenic Effect.

In-Utero - Some mistakenly consider this to be a genetic consequence of radiation exposure, because the effect, suffered by a developing embryo/fetus, is seen after birth. However, this is actually a special case of the somatic effect, since the embryo/fetus is the one exposed to the radiation.

Genetic Effects

Mutation of the reproductive cells is passed on to the offspring of the exposed individual.

The Genetic Effect involves the mutation of very specific cells, namely the sperm or egg cells. Mutations of these reproductive cells are passed to the offspring of the individual exposed.

Radiation is an example of a physical mutagenic agent. There are also many chemical agents as well as biological agents (such as viruses) that cause mutations.

One very important fact to remember is that radiation increases the spontaneous mutation rate, but does not produce any new mutations. Therefore, despite all of the hideous creatures supposedly produced by radiation in the science fiction literature and cinema, no such transformations have been observed in humans. One possible reason why genetic effects from low dose exposures have not been observed in human studies is that mutations in the reproductive cells may produce such significant changes in the fertilized egg that the result is a nonviable organism which is spontaneously resorbed or aborted during the earliest stages of fertilization.

Although not all mutations would be lethal or even harmful, it is prudent to assume that all mutations are bad, and thus, by USNRC regulation (10 CFR Part 20), radiation exposure SHALL be held to the absolute minimum or As Low As Reasonably Achievable (ALARA). This is particularly important since it is believed that risk is directly proportional to dose, without any threshold.

Somatic Effects

Effect is suffered by the individual exposed. Primary consequence is cancer.

Somatic effects (carcinogenic) are, from an occupational risk perspective, the most significant since the individual exposed (usually the radiation worker) suffers the consequences (typically cancer). As noted in the USNRC Regulatory Guide 8.29, this is also the NRC's greatest concern.

Radiation is an example of a physical carcinogenic, while cigarettes are an example of a chemical cancer causing agent. Viruses are examples of biological carcinogenic agents.

Unlike genetic effects of radiation, radiation induced cancer is well documented. Many studies have been completed which directly link the induction of cancer and exposure to radiation. Some of the population studied and their associated cancers are:

Lung cancer	- uranium miners
Bone cancer	- radium dial painters
Thyroid cancer	- therapy patients
Breast cancer	- therapy patients
Skin cancer	- radiologists
Leukemia	- bomb survivors, in-utero exposures, radiologists, therapy patients

In-Utero Effects

- Effects of radiation on embryo/fetus
- Intrauterine Death
- Growth Retardation
- Developmental Abnormalities
- Childhood Cancers

The in-utero effect involves the production of malformations in developing embryos.

Radiation is a physical teratogenic agent. There are many chemical agents (such as thalidomide) and many biological agents (such as the viruses which cause German measles) that can also produce malformations while the baby is still in the embryonic or fetal stage of development.

The effects from in-utero exposure can be considered a subset of the general category of somatic effects. The malformation produced do not indicate a genetic effect since it is the embryo that is exposed, not the reproductive cells of the parents.

The actual effects of exposure in-utero that will be observed will depend upon the stage of fetal development at the time of the exposure:

Weeks Post Conception	Effect
0 - 1 (preimplantation)	Intrauterine death
2 - 7 (organogenesis)	Developmental abnormalities/growth retardation/cancer
8 - 40 (fetal stage)	Same as above with lower risk plus possible functional abnormalities

Radiation Risk

With any exposure to radiation, there is some risk.

The approximate risks for the three principal effects of exposure to low levels of radiation are:

Effect	Excess Cases per 10,000 exposed per rad
Genetic	2 to 4
Somatic (cancer)	4 to 20
In-Utero (cancer)	4 to 12
In-Utero (all effects)	20 to 200

Genetic - Risks from 1 rem of radiation exposure to the reproductive organs are approximately 50 to 1,000 times less than the spontaneous risk for various anomalies.

Somatic - For radiation induced cancers, the risk estimate is small compared to the normal incidence of about 1 in 4 chances of developing any type of cancer. However, not all cancers are associated with exposure to radiation. The risk of dying from radiation induced cancer is about one half the risk of getting the cancer.

In-Utero - Spontaneous risks of fetal abnormalities are about 5 to 30 times greater than the risk of exposure to 1 rem of radiation. However, the risk of childhood cancer from exposure in-utero is about the same as the risk to adults exposed to radiation. By far, medical practice is the largest source of in-utero radiation exposure.

Because of overall in-utero sensitivity, the NRC, in 10 CFR Part 20, requires that for the declared pregnant woman, the radiation dose to the embryo/fetus be maintained less than or equal to 0.5 rem during the entire gestation period. This limit is one-tenth of the annual dose permitted to adult radiation workers. This limit applies to the worker who has voluntarily declared her pregnancy in writing. For the undeclared pregnant woman, the normal occupational limits for the adult worker apply (as well as ALARA).

Linear No-Threshold Risk Model

[figure]

General consensus among experts is that some radiation risks are related to radiation dose by a linear, no-threshold model. This model is accepted by the NRC since it appears to be the most conservative.

Linear - An increase in dose results in a proportional increase in risk

No-threshold - Any dose, no matter how small, produces some risk

The risk does not start at 0 because there is some risk of cancer, even with no occupational exposure. The slope of the line just means that a person that receives 5 rems in a year incurs 10 times as much risk as a person that receives 0.5 rems in a year.

Exposure to radiation is not a guarantee of harm. However, because of the liner, no-threshold model, more exposure means more risk, and there is no dose of radiation so small that it will not have some effect.

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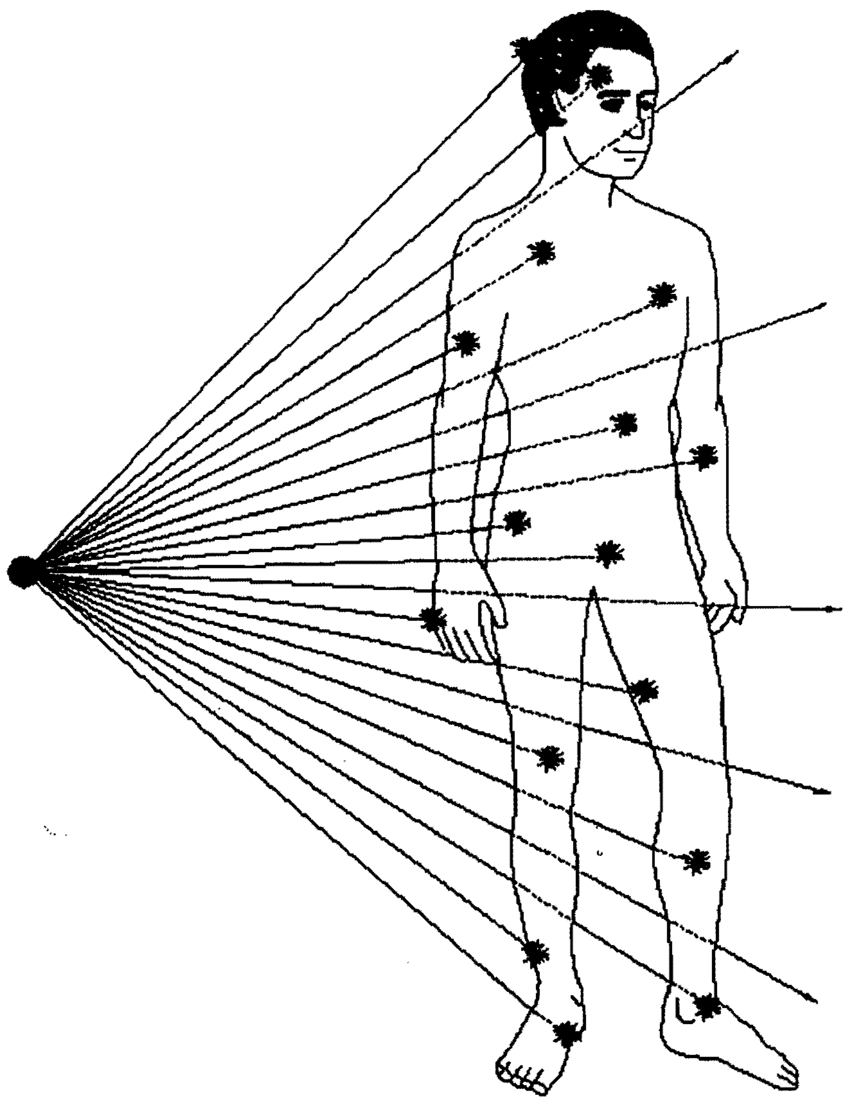

Figure 1. Exposure to Radiation

[NRC Home Page | Top of file | Contents]

CELLULAR DAMAGE

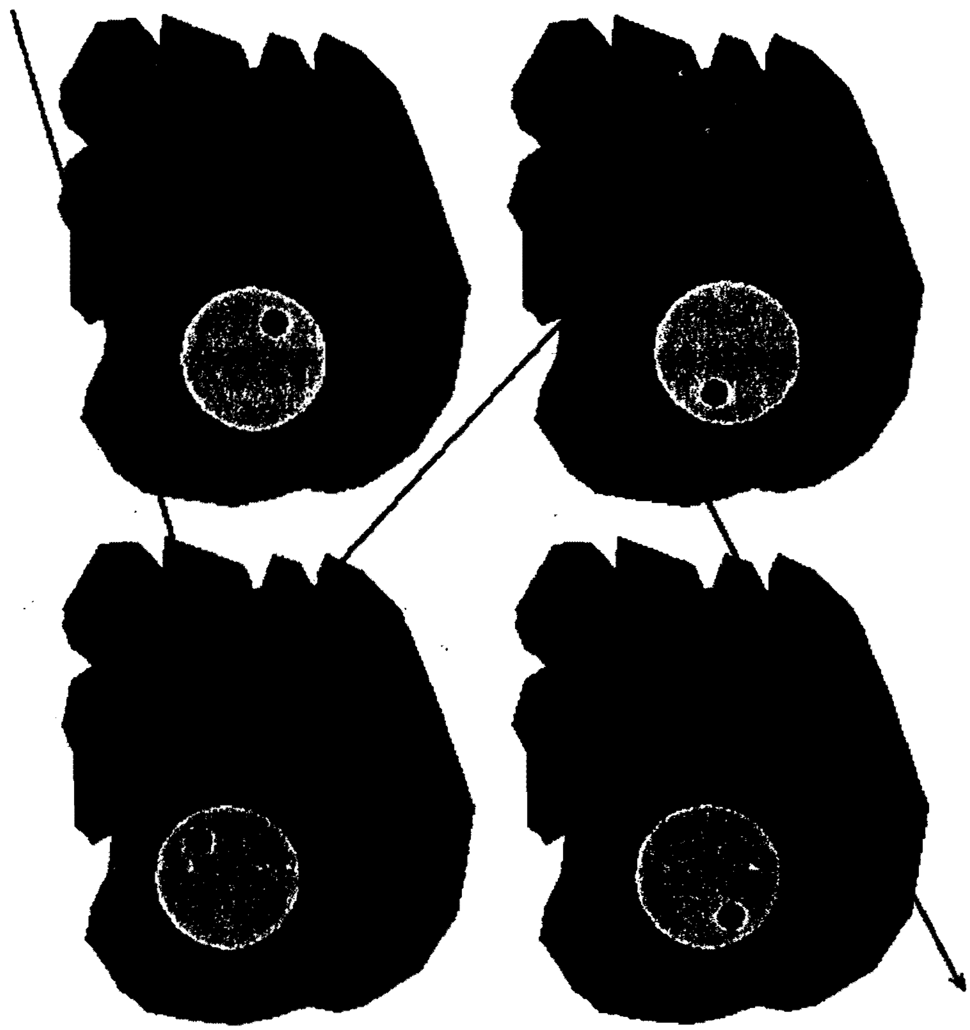

Figure 2. Biological Effects

[NRC Home Page | Top of file | Contents]

Direct Effect

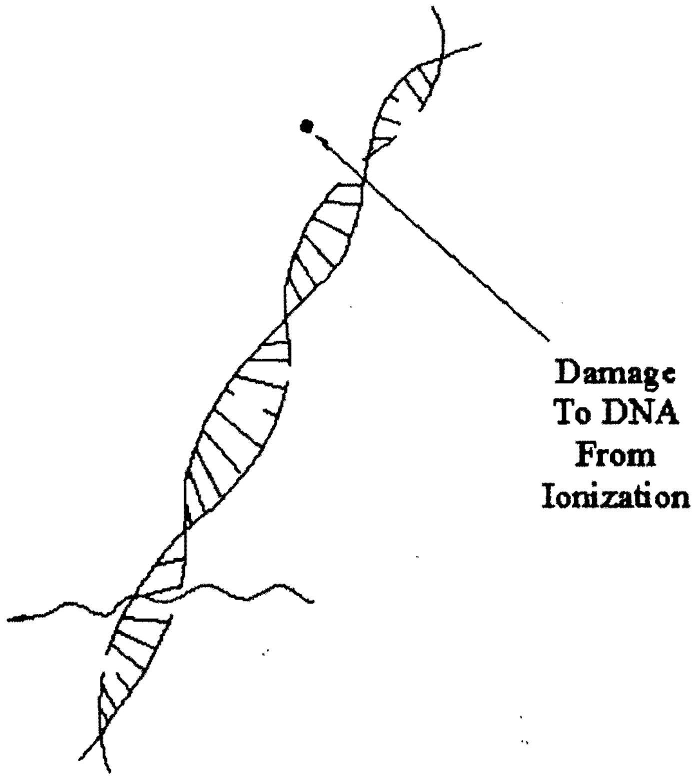

Figure 3. Direct Effect

[NRC Home Page | Top of file | Contents]

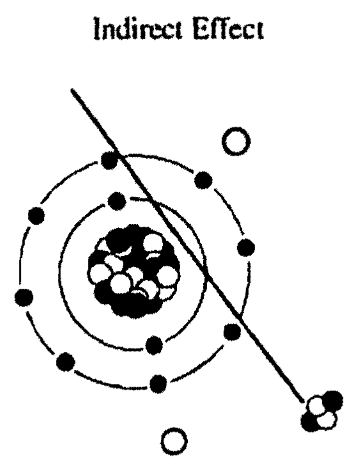

Figure 4. Indirect Effect

[NRC Home Page | Top of file | Contents]

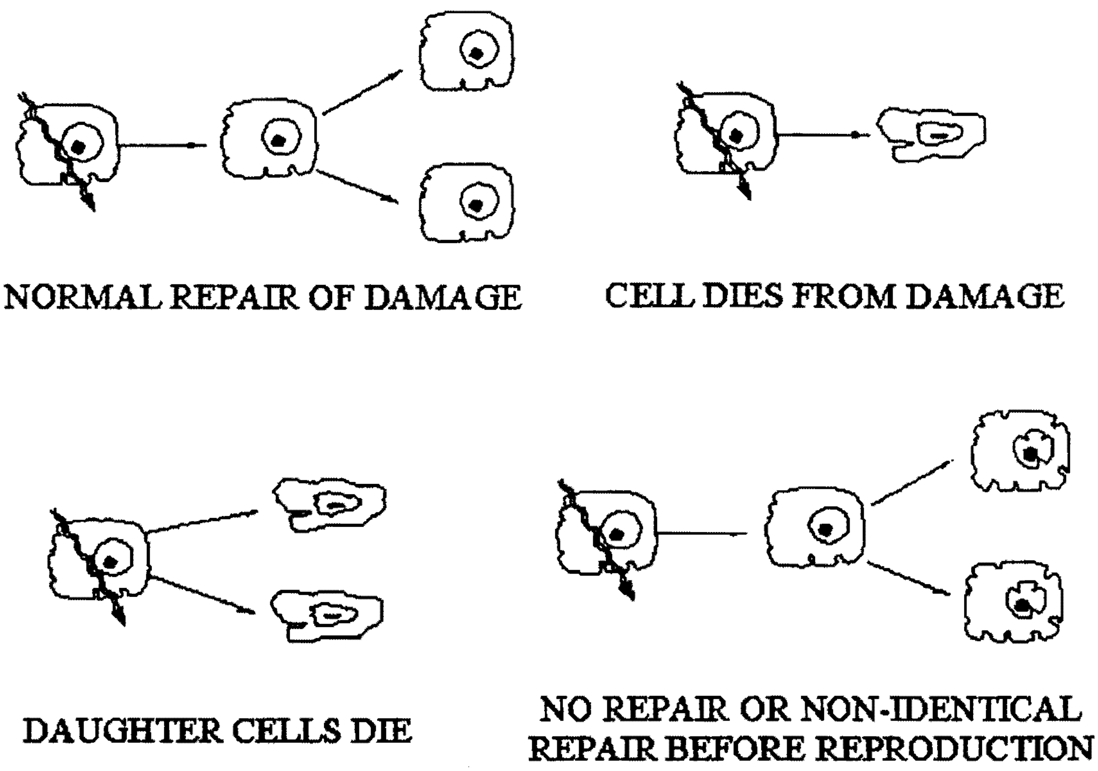

Figure 5. Cell Damage

[NRC Home Page | Top of file | Contents]

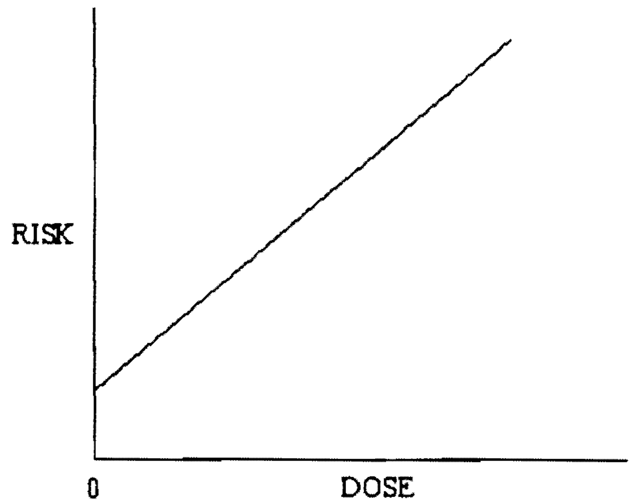

Figure 6. Linear No-Threshold Risk Model

[NRC Home Page | Top of file | Contents]

Dose Standards and Methods for Protection Against Radiation and Contamination

[View in Frames | Document Outline | Acronyms]

Section Contents

Figures

Introduction

This section will discuss the NRC dose standards and the methods used to protect individuals from the harmful effects of radiation and contamination.

NRC Dose Limits (from 10 CFR Part 20)

For members of the public:

- Less than 2 millirems in any one hour from external radiation sources in any unrestricted area
- Less than 100 millirems in a calendar year from both external and internal sources of radiation in unrestricted and controlled areas

The NRC limits the handling and use of radioactive materials such that no member of the public will receive a radiation dose of 2 millirems in any one hour from external radiation sources in an unrestricted area, or 100 millirems in a calendar year from both external and internal sources of radiation from each licensee.

Additionally, the NRC has provided design objectives for power reactor licensees to keep offsite doses as far below the 10 CFR Part 20 limits as is reasonably achievable. These guidelines can be found in 10 CFR Part 50.

Permissible dose levels in unrestricted areas during the transport of radioactive material can be found in 10 CFR Part 71.

Occupational Limits:

	Annual Limit
Whole Body (sum of external and internal dose)	5 rems
Extremity	50 rems
Skin of Whole Body	50 rems
Maximum Exposed Organ (sum of external and internal dose)	50 rems
Lens of the Eye	15 rems
Minor	0.5 rems

The dose equivalent to the embryo/fetus of a declared pregnant woman has a limit of 0.5 rem over the gestation period.

Planned Special Exposure (PSE), an infrequent exposure for a special, high-dose job. The yearly limit is equal to the annual limit with a lifetime maximum of 5 times the annual limit. For example, the PSE limit for the whole body is 5 rems in a year, in addition to the above occupation limits, with a lifetime maximum of 25 rems.

The NRC exposure limits shown above apply to all NRC licensees and are designed such that:

- No worker at a nuclear facility will receive an acute whole body radiation exposure sufficient to trigger the radiation syndrome
- The risk of cancer (although not zero) will not be higher than the risk of cancer from other occupations.

Licensees are also required by 10 CFR Part 20 to keep radiation exposures as low as reasonably achievable (ALARA).

Note: The whole body and skin of the whole body includes all of the body except the hands, wrists, forearms, elbows, knees, legs below the knees, feet, and ankles.

Now that the limits are known, how to protect the body from radiation will be discussed in the next section.

Protection Against External Radiation Sources

The three protective measures listed above (time, distance, and shielding) are primarily utilized to reduce the dose from any external source of radiation. Time and distance are also applicable for reducing the intake of radioactive material (internal dose), although once the radioactive material is inside the body, little can be done to reduce the dose.

However, the total dose (sum of internal and external dose) should be minimized, since overall risk is proportional to the total dose. In some cases, this may mean accepting a small intake of radioactive material to reduce the external dose. The important thing is to keep the total dose as low as reasonably achievable. Recall that the limits for whole body (5 rems/year) and maximum exposed organ (50 rems/year) apply to total dose.

The next chapter will discuss internal exposure control and protection from contamination, and how time, distance, and shielding are used to limit external exposure.

Minimize Dose

Given:
Dose Rate X Time = Dose

The dose a person receives from external radiation is directly proportional to the length of time spent in a radiation field. Therefore, minimizing the amount of time spent in a radiation field will minimize the dose received. Some methods that can be used to minimize the time spent in a radiation field are:

- Plan and rehearse the job under realistic conditions
- Know the exact location of work prior to entering the radiation area
- Ensure all necessary tools are available at the job location
- Establish good communications

- Do not loiter in the area

Similarly, minimizing the time spent in an area with airborne radioactivity will minimize the internal dose, since the intake of radioactive material (that being inhaled) is directly proportional to the inhalation time (volume of air being breathed).

Minimize Time

[figure]

Assuming a radiation field of 300 millirems/hour, an individual working in this area would receive:

- 75 millirems in 15 minutes,
- 150 millirems in 30 minutes,
- 300 millirems in 1 hour, or
- 600 millirems in 2 hours.

Maximize Distance to Minimize Dose

[figure]

Many radiation sources are "point sources" (the radiation appears to emit from one spot some distance away). The radiation dose from these sources can be significantly reduced by applying the protective measure of "distance" as demonstrated above. The dose a person receives from an external radiation source is inversely proportional to the square of the distance from the source ($1/d^2$). Therefore, if the dose rate at one foot is 100 millirems/hour, the dose rate at 10 feet would be $1/10^2$ of that, or 1 millirem/hour. Some ways to increase the distance on a job are:

- Using extension tools,
- Utilizing remote operating stations, and
- Staying away from hot spots.

Staying as far away as possible from a source of airborne radioactivity will minimize the intake of radioactivity, because the activity will disperse and become less concentrated (in most cases) as it moves away from the point of release.

Maximize Distance

[figure]

By moving a few feet away from a nearby source of radiation, the dose rate can be significantly reduced. Therefore, a person performing a job can have a longer stay time to perform the needed task.

Maximize Shielding to Minimize Dose

[figure]

Shielding is one of the most effective means of reducing radiation exposure. The example above shows that the installation of one half-value layer (half-thickness) of shielding will reduce the dose rate by a factor of two at a set distance from the source of radiation. By locating the shielding as close as possible to the source, dose rates can be reduced in a large area, and thus reduce the dose to many workers (some of which, perhaps, could not reduce their exposure time or work further from the source).

Temporary and Installed Shielding

[figure]

The two major types of shielding at the plant are installed shielding and temporary shielding. Installed shielding is permanent shielding installed at the plant for the purpose of reducing the radiation levels in some areas. An example of permanent shielding is the concrete shield walls located in the containment.

Temporary shielding can take the form of lead sheets, lead bricks, or bags filled with lead shot. This type of shielding can be placed near the source to reduce the radiation levels in large areas. It can also be shaped as needed to provide the maximum shielding effectiveness.

Installed equipment can also be used as shielding material. In the drawing above, the dose rate without the temporary shielding would be 300 millirems/hour. The installation of the temporary shielding reduces the dose rate to 3 millirems/hour. However, if the worker can perform the job from the far side of the pump, the dose rate can be reduced to 0.3 millirem/hour due to the effectiveness of the pump acting as a shield.

Relative Effectiveness of Various Shielding Materials

[figure]

Materials differ in their ability to shield (absorb) radiation. The figure above shows the relative effectiveness of four common shield materials (lead, iron, concrete, and water) for gamma radiation. To have the same gamma radiation exposure level at the outside of each material, it takes about twice as much iron as lead, about twice as much concrete as iron, and about three times as much water as concrete.

A thumb rule that can be used is that it takes 2 inches of lead to reduce the dose rate by a factor of 10. Therefore, if a radiation detector measured the dose rate at a certain distance to be 100 millirems/hour, 2 inches of lead would reduce the dose rate to 10 millirems/hour. This value is called a tenth-value thickness of lead. To accomplish the same reduction using the other materials would require 4 inches of iron/steel, 8 inches of concrete, or 24 inches of water. These values are only thumb rules. The exact amount of material required depends upon the energy of the radiation (gamma ray) that is being shielded against.

Internal Exposure Control

Intakes of radioactive material are controlled by the Annual Limit on Intake (ALI), expressed in units of microcuries. The ALI is the primary limit for internal exposure control, and in the absence of any external radiation, a worker may intake one ALI in a year. One ALI equals 5 rems internal dose.

Concentrations of radioactive materials in air are limited by the Derived Air Concentrations (DACs), which are derived from the ALI. The DACs are derived assuming a worker breathes 1.2 cubic meters of air per hour for 2000 hours per year. Therefore:

$$\text{DAC (microcuries / ml)} = \frac{\text{ALI (microcuries)}}{2.4 \text{ X } 10^9 \text{ ml}}$$

If a worker breathes air containing radioactive material at a concentration of 1 DAC for one hour, then the worker has been exposed to 1 DAC-hr. Therefore:

1 ALI = 2000 DAC-hr = 5 rem

Since the operational limit of 5 rems applies to the sum of the internal and external exposures, if a worker has some external dose, the ALI must be modified or offset to account for the external dose. For example, assume the worker has 2 rems from external sources of radiation. Only 3 more rems are allowed from internal radiation before the worker reaches the occupational whole body limit. Expressed in DAC-hr, this would be:

3/5 X 2000 DAC-hr = 1200 DAC-hr

Protection Against Contamination

- Utilize containments
- Maintain access control
- Conduct frequent surveys
- Utilize protective clothing
- Wear respiratory protection
- Practice good housekeeping
- Conduct follow up bioassays
- Minimize radioactive leakage

The protective measures listed above are used to prevent, detect, and/or contain radioactive contamination. Since radioactive contamination can be inhaled and/or ingested, the above measures are also considered to be methods of protection against internal doses.

[figure]

Above are some common radiation signs and labels. These are commonly used to warn people of radiation areas, contaminated areas, and locations where radioactive material is found. The international symbol for radioactive material and radiation is a magenta or black three-bladed design on a yellow background.

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Figures

[View in Frames | Document Outline | Acronyms]

[NRC Home Page | Top of file | Contents]

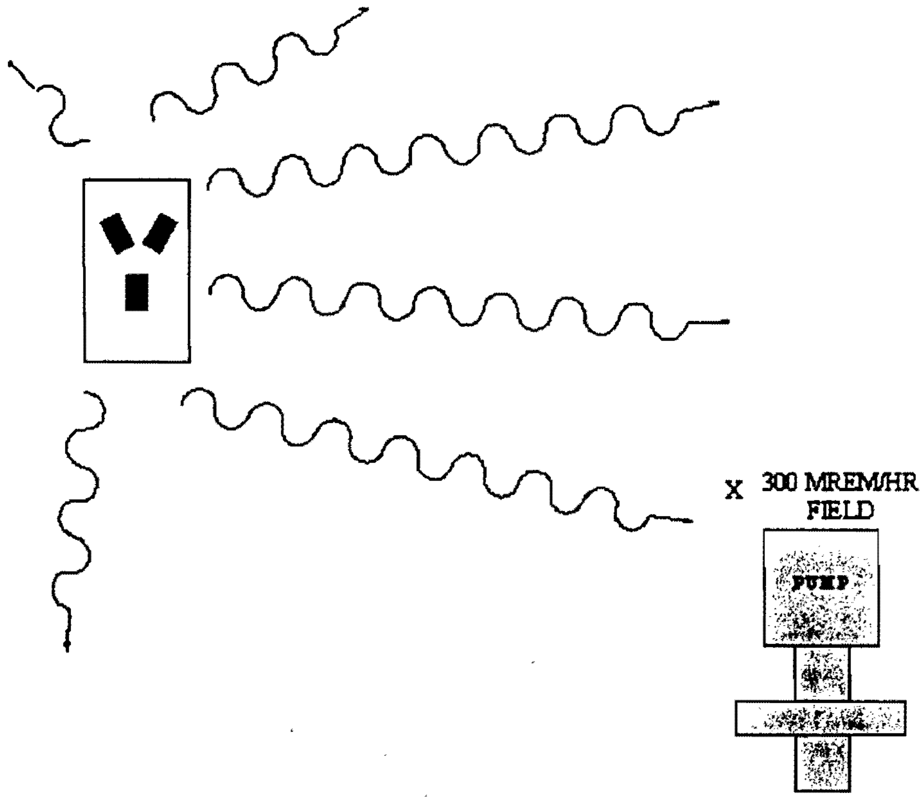

Figure 1. Minimize Time

[NRC Home Page | Top of file | Contents]

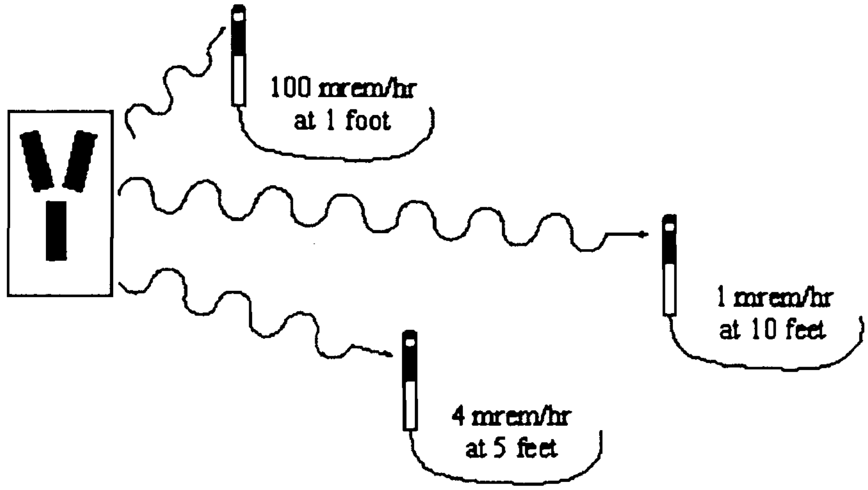

Figure 2. Maximize Distance

[NRC Home Page | Top of file | Contents]

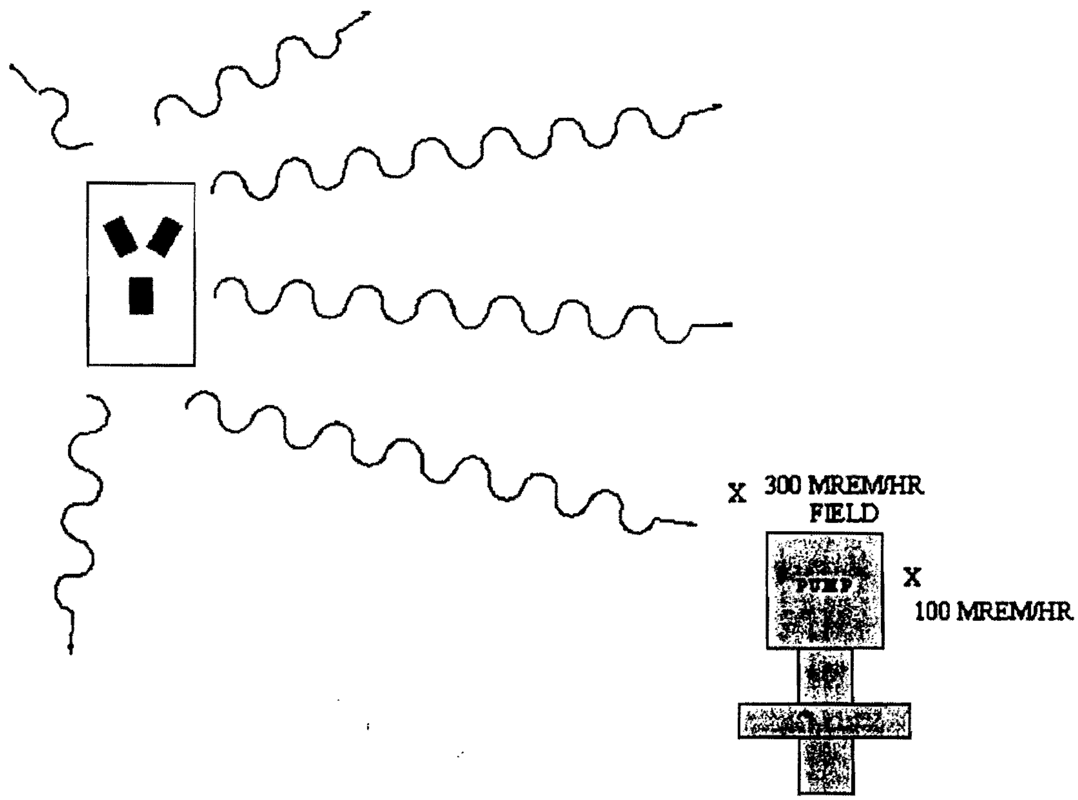

Figure 3. Maximize Distance

[NRC Home Page | Top of file | Contents]

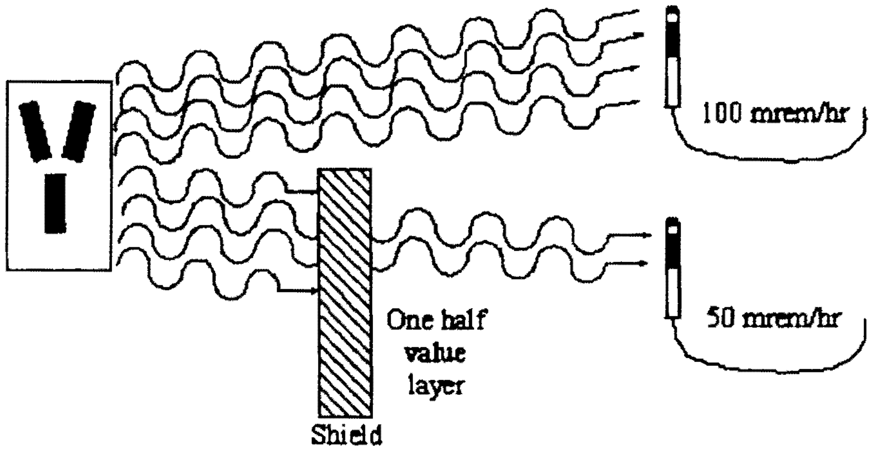

Figure 4. Maximize Shielding

[NRC Home Page | Top of file | Contents]

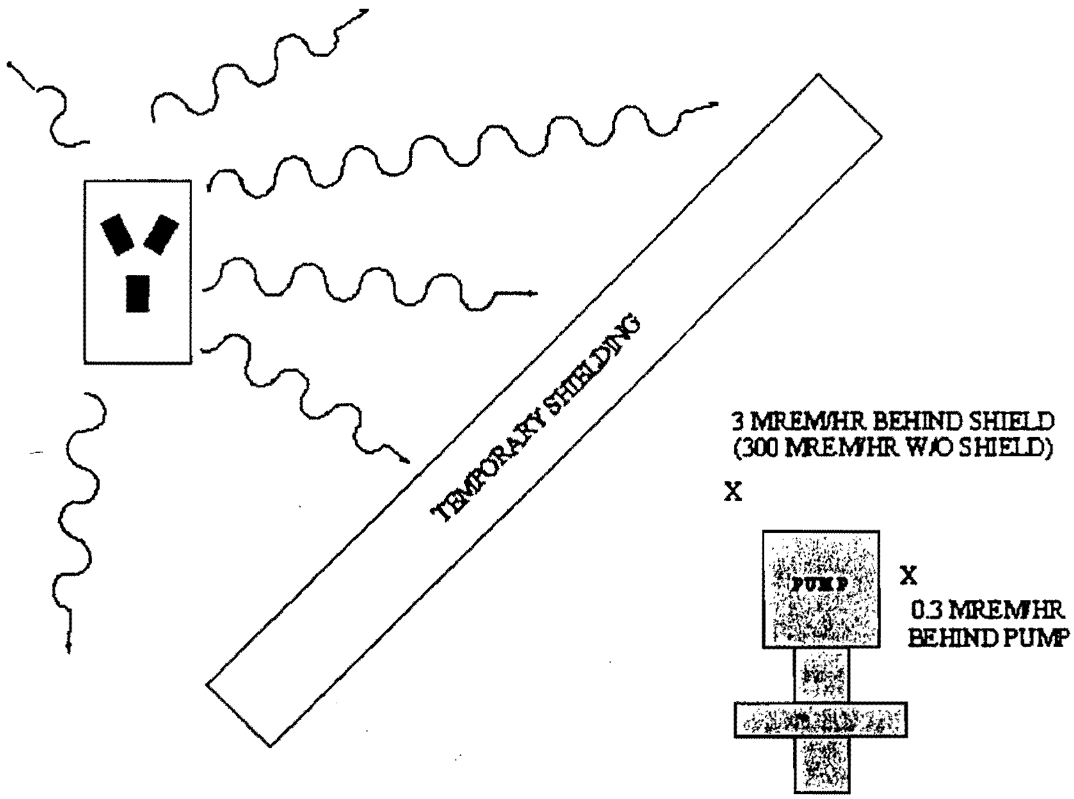

Figure 5. Temporary and Installed Shielding

[NRC Home Page | Top of file | Contents]

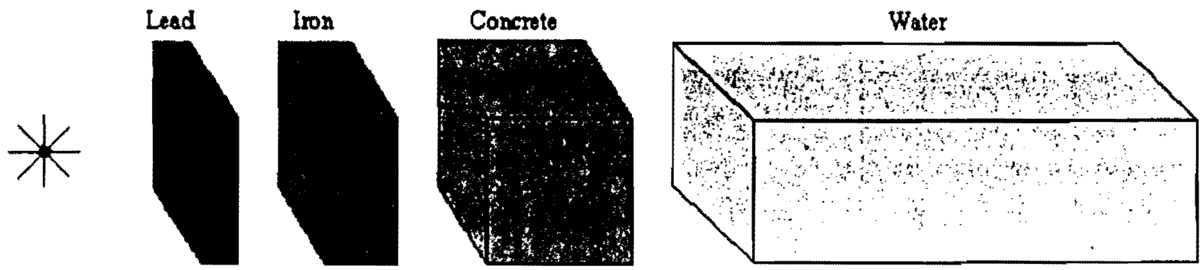

Figure 6. Relative Effectiveness of Various Shielding Materials

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[NRC Home Page | Top of file | Contents]

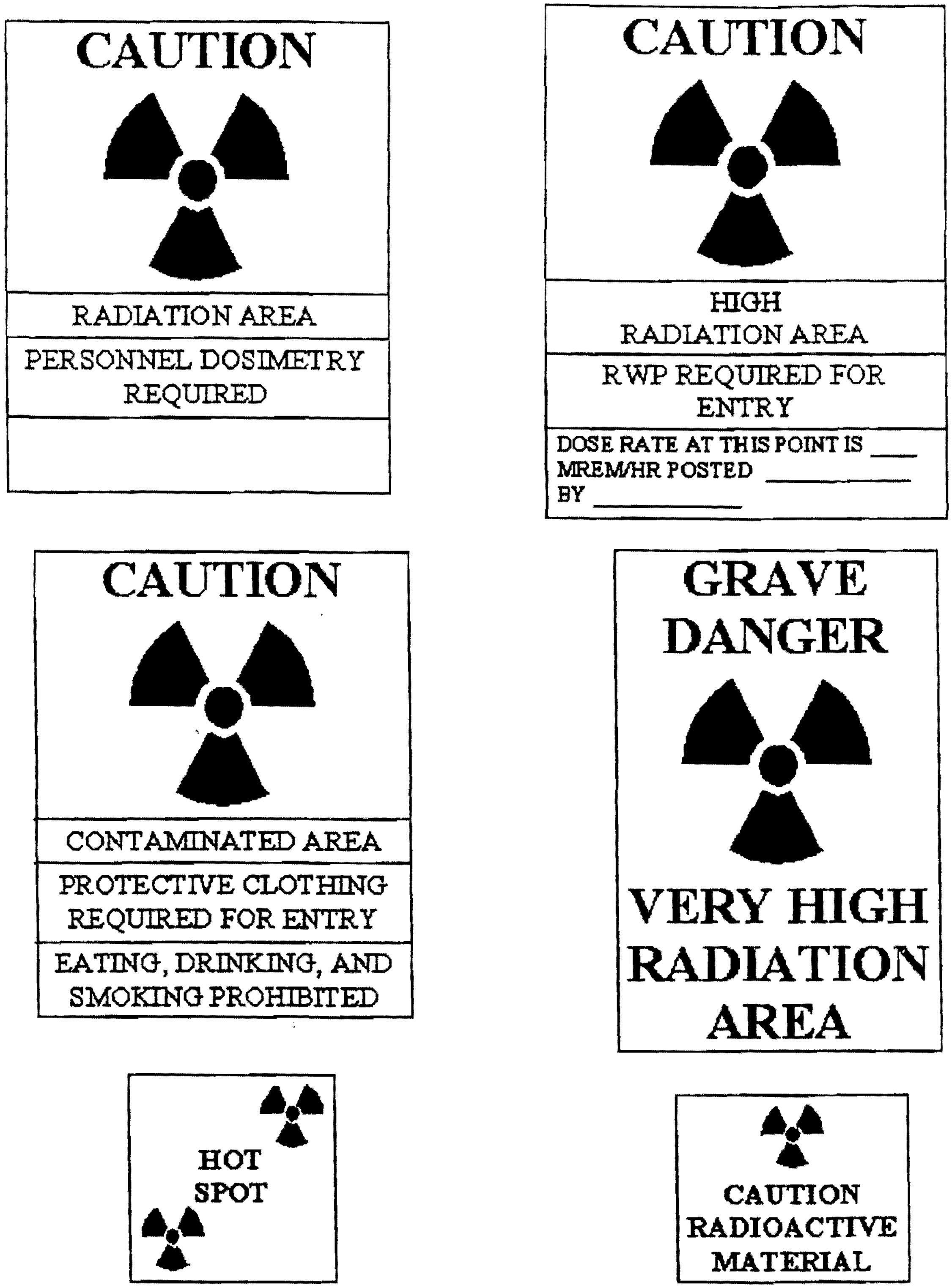

Figure 7. Common Radiation Signs and Labels

Transportation of Radioactive Material

[View in Frames | Document Outline | Acronyms]

Section Contents

Figures

Accidents

Introduction

This section will discuss the NRC dose standards and the methods used to protect individuals from the harmful effects of radiation and contamination.

UN Classification

Class 1	Explosives
Class 2	Gases
Class 3	Flammable Liquids
Class 4	Flammable Solids
Class 5	Oxidizers and Organic Peroxides
Class 6	Poisonous and Etiological Materials
Class 7	Radioactive Materials
Class 8	Corrosives
Class 9	Miscellaneous Hazardous Materials

All hazardous materials which could potentially be transported are assigned to one of the nine United Nations Classes. In general, the hazardous materials listed pose an immediate threat to health and safety. However, for radioactive material, the threat is potentially the non-immediate risk of cancer, although in large enough quantities, radiation can pose an immediate threat.

Groups Promulgating Rules Governing

- Transport of Radioactive Materials
- Department of Transportation
- Nuclear Regulatory Commission
- Department of Energy
- Postal Services
- State Agencies

Regulations to control the transport of radioactive materials were initiated about 1935 by the Postal Service. Over the years, the Interstate Commerce Commission (ICC) became involved. Currently, there are at least five groups which promulgate rules governing the transport of radioactive material. These are the DOT, NRC, Postal Service, DOE, and the States.

Of these agencies, the DOT and NRC are the primary ones issuing regulations based upon the standards developed by the International Atomic Energy Agency (IAEA).

The NRC and DOT share responsibility for the control of radioactive material transport based upon a Memorandum of Understanding (MOU).

In general, DOT regulations (49 CFR) are more detailed. They cover all aspects of transportation, including packaging, shipper and carrier responsibilities, documentation, and all levels of radioactive material from exempt quantities to very high levels.

The NRC regulations (10 CFR 71) are primarily concerned with special packaging requirements for higher level quantities. NRC regulation 10 CFR 71.5 requires NRC licensees transporting radioactive material to comply with DOT regulations when NRC regulations do not apply.

For transportation purposes, radioactive material is defined as any material which has a specific activity greater than 0.002 microcuries per gram. This definition does not specify a quantity, only a concentration. As an example, pure cobalt-60 has a specific activity of 1,000 curies per gram, which is about 500 billion times greater than the definition. However, uranium-238 has a specific activity of only 0.3 microcuries per gram, which is only 150 times greater than the definition.

Although both exceed the definition of radioactive material in their pure form, either of these materials could be uniformly mixed with enough substance, such as dirt, which would cause the concentration to fall below the definition. In the case of uranium-238, if one gram were mixed with about 150 grams of dirt (about 1/3 of a pound), the concentration could be classified as non-radioactive.

Remember, however, that the definition of radioactive material above only applies for transportation.

Since transport accidents cannot be prevented, the regulations are primarily designed to:

- Insure safety in routine handling situations for minimally hazardous material and
- Insure integrity under all circumstances for highly dangerous materials.

These goals are accomplished by focusing on the package and its ability to:

- Contain the material (prevent leaks),
- Prevent unusual occurrences (such as criticality), and
- Reduce external radiation to safe levels (provide shielding).

Packages

[figure]

The three basic types of packages are **Strong Tight Containers**, whose characteristics are not specified by regulation, followed by **Type A Containers**, and finally **Type B Containers**, both of which have very specific requirements in the regulations.

Strong Tight Container

A Strong Tight Container is designed to survive normal transportation handling. In essence, if the material makes it from point X to point Y without being released, the package was a Strong Tight Container.

A Type A Container, on the other hand, is designed to survive normal transportation handling and minor accidents.

Type B Containers must be able to survive severe accidents.

Fissile materials, which could be involved in a criticality accident, also have additional requirements.

Type A ours

[figure]

Type A packaging is based on performance requirements which means it must withstand or survive certain tests. The shape of the package or material from which it is constructed is irrelevant. A Type A package may be a cardboard box, a wooden crate, or a metal drum. The shipper must have documentation which shows that the specific design being used has passed the required tests.

Type B

[figure]

A Type B package may be a metal drum or a huge, massive shielded transport container. Like Type A packages, Type B packages must pass certain tests. However, the Type B tests are considerably more rigorous than those required for Type A packages. Most Type B packages have been issued a Certificate of Compliance by the NRC.

[figure]

The system created to ensure safe transport of radioactive materials is based on the assignment of a number to each radionuclide, depending upon its form (i.e., its relative hazard if released from the package during transport). The number, or "A" value, represents the limit, in curies, permitted to be transported in a Type A package. There are two distinct categories established for this system.

Special form (A_1) radionuclides are usually encapsulated sources which would only pose an external radiation hazard, not a contamination hazard, if the package was ruptured.

Normal form (A_2) radionuclides are usually not securely encapsulated and could yield significant contamination if the package was ruptured. These materials could pose an internal hazard to people at the scene of an accident. Normal form materials are typically liquids and powders.

Since the "A" values provide the limit for the amount in a package, A_2 values cannot be greater than A_1 values, since A_2 values represent material in normal form, which makes it more "hazardous." However, for some nuclides, the hazard may be the same in either form so that A1 can be equal to A2. In any case, neither A_1 nor A2 can be greater than 1000 curies.

Sample "A" Values (curies)

Material	Special Form (A_1 Values)	Normal Form (A_2 Values)	Ratio (A_1/A_2)
Plutonium-239	2	0.002	1,000
Strontium-90	10	0.4	25
Cobalt-60	7	7	1

When A_1 equals A_2, the hazard is considered the same, whether the material is in normal or special form. This tends to be the case for gamma emitters. For alpha emitters, the normal form (unencapsulated) is considered to be 1,000 times more hazardous as the special form (sealed), so that the A_1 values are about 1,000 times lower. Beta emitters fall between the two.

Quantity of Radioactive Material Determines Classification

The manner in which radioactive material is handled for transport depends upon the amount of material and its relative hazard:

Non-Radioactive	If the amount of material is less than 0.002 microcuries per gram, it is not considered radioactive for transportation purposes
Limited Quantity	If the amount is greater than 0.002 microcuries per gram but does not exceed one thousandth of the A_1 or A_2 value (depending on the form), then the material is considered a limited quantity and needs only a strong tight container, which should survive routine handling.
Type A Quantity	If the amount is less than or equal to the A_1 or A_2 value (depending on the form) but greater than one thousandth of the value, then the material requires a Type A package, which should survive minor accidents.
Type B Quantity	If the amount is greater than the A_1 or A_2 value (depending on the form) but less than or equal to 3000 times these values, then the material requires a Type B package, which should survive a serious accident.
Highway Route Controlled Quantity	If the amount is greater than 3000 times the A1 or A2 value (depending on the form) but less than 27,000 curies, then the material is a highway route controlled quantity, which requires a Type B package, and the carrier must have special training. State officials must be notified if the material is radioactive waste.

United States Postal Service

The postal service has slightly different limits. They will only accept packages containing limited quantities, i.e., with amounts small enough such that they require only a strong tight package. Quantities requiring Type A and Type B packages are not acceptable to the postal service. To provide an additional safety margin, the postal service defines limited quantities differently from DOT. The

USPS limits are lower, exactly one tenth of the DOT limits. In addition, the postal service has separate limits for liquids and gases.

Low Specific Activity Material

A special classification, low specific activity, is given to any radioactive material which is uniformly dispersed throughout a substance to such an extent that it poses little hazard even if released in an accident. To be classified as low specific activity, the concentration must be greater than 0.002 microcuries per gram (otherwise it would not be radioactive) but less than specified concentration limits, which are based on the "A" values.

Although the concentrations permitted are low (300 microcuries per gram or less), the total amount of material may be quite high, depending upon how much total mass there is. Therefore, although the definition of low specific activity considers only the concentration, not the total quantity, the type of package required for the low specific activity material (either strong tight container or Type A) will depend upon the total quantity of activity (curies) rather than the concentration (microcuries/gram).

Markings

[figure]

Markings are designed to provide an explanation of the contents of a package by using standard terms and codes.

Labeling

[figure]

Labels are used to visually indicate the type of hazard and the level of hazard contained in a package. Labels rely principally on symbols to indicate the hazard.

Although the package required for transporting radioactive material is based on the activity INSIDE the package, the label required on the package is based on the radiation hazard OUTSIDE the package. Radioactive material is the only hazardous material which has three possible labels, depending on the relative radiation levels external to the package. Also, labels for radioactive material are the only ones which require the shipper to write some information on the label. The information is a number called the Transport Index (TI), which, in reality, is the highest radiation level at 1 meter from the surface of the package.

The three labels are commonly called, White 1, Yellow 2, and Yellow 3, referring to the color of the label and the roman numeral prominently displayed. A specific label is required if the surface radiation limit and the limit at 1 meter satisfy the following requirements:

Label	Surface Radiation Level		Radiation Level at 1 Meter
White 1	Does not exceed 0.5 millirem/hour		Not applicable
Yellow 2	Does not exceed 50 millirems/hour	AND	Does not exceed 1 millirem/hour
Yellow 3	Exceeds 50 millirems/hour	OR	Exceeds 1 millirem/hour

Since the TI is the radiation level at 1 meter, it is clear that a White 1 label has no TI. A Yellow 2 must have a TI no greater than 1, and a Yellow 3 may have a TI greater than 1.

Referring to the radiation limits on page 11-19 for vehicles, it can be seen that the maximum TI for nonexclusive use vehicles (common carriers) and for exclusive use (contract carriers) open vehicles is 10. The radiation level at 1 meter from the surface of a package can exceed 10 mrem/hour only if the package is transported in an exclusive use (contract carrier), closed vehicle.

Placarding

[figure]

Placards are just bigger labels which are placed on the outside of the vehicle. Unlike labels, there is only one placard and no information needs to be written on it (i.e., no TI). In fact, a placard on a vehicle is only required if the vehicle is carrying a package bearing a Yellow 3 label or low specific activity material. If the amount of material being transported constitutes a highway route controlled quantity, the diamond-shaped placard has a black square border surrounding it.

Carriers

There are essentially three classes of carriers:

- Common,
- Contract, and
- Private. US

Common and contract carriers provide a service to others. They carry other peoples' materials. Common carriers have published rates for hauling material, while contract carriers negotiate a specific contract with the shipper. Common and contract carriers are not licensed by the NRC. The responsibility for safety rests with the shipper.

Private carriers own the radioactive material which they carry. The transport of material is accomplished in direct support of the radioactive material user's business. These carriers are licensed by the NRC.

Some examples of private carriers who transport their sources from one job site to another are:

- Industrial radiographers,
- Portable gauge users, and
- Well loggers.

In addition to the above, radiopharmacies deliver their own radiopharmaceuticals to nuclear medicine clinics.

Radiation Limits

Type of Transport	Maximum Radiation Limit
Common carrier non-exclusive use:	
Open or closed transport	200 millirems/hour on the surface of the package and 10 millirems/hour at 1 meter from any surface of the package
Contract carrier exclusive use:	
Closed transport	1000 millirems/hour on the surface of the package, 200 millirems/hour at the surface of the vehicle, 10 millirems/hour at 2 meters from any surface of the vehicle, and 2 millirems/hour in the vehicle cab
Open transport	200 millirems/hour on the surface of the package, 200 millirems/hour on any imaginary surface of the vehicle, 10 millirems/hour at 2 meters from any imaginary surface of the vehicle, and 2 millirems/hour in the cab of the vehicle

For non-exclusive use vehicles, that is, vehicles which may be carrying other non-radioactive material as well (common carriers), the radiation limit is imposed on the package.

For exclusive use vehicles, that is, the vehicle is only carrying radioactive material for one shipper (contract or private carrier), the package limits are higher, but there are also limits on the outside of the vehicle.

Shipping Papers

[figure]

The only way for anyone to know what is being transported inside a vehicle is by reviewing the shipping papers. These documents, by words and codes, clearly specify what is being transported. They must be readily accessible to the driver and to emergency response personnel, if the driver is not available.

Accidents

[figure]

Many packages containing radioactive materials have been involved in transport accidents. The statistics verify the degree of protection expected of each class of packaging.

For strong tight containers, which do not have to pass any integrity tests, about 10% of those involved in accidents have failed. Of those, about 90% have released their contents.

For Type A packages, which must pass stringent tests, only 1% of those involved in accidents have failed. Of those, only 39% have released their contents.

For Type B packages, which must pass the most rigorous tests, several have been involved in accidents. However, there has been only one documented case of a package failure, and that involved an industrial radiography source.

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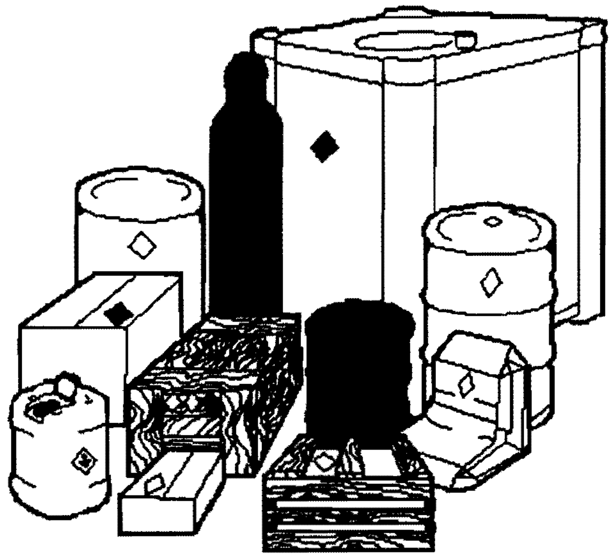


Figure 1. Packaging

[NRC Home Page | Top of file | Contents]

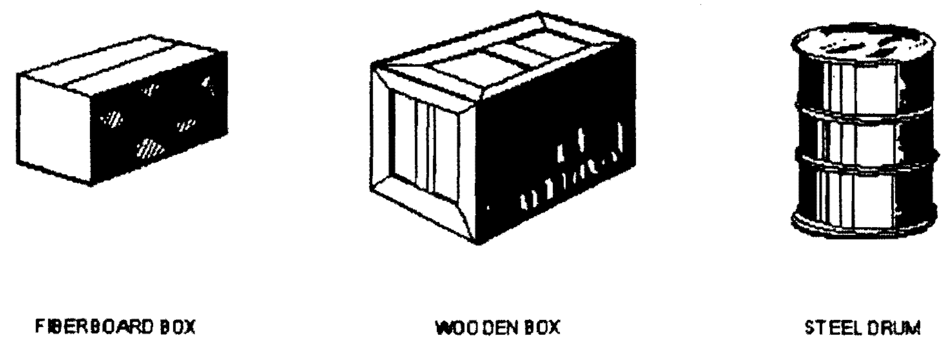


Figure 2. Type A

[NRC Home Page | Top of file | Contents]

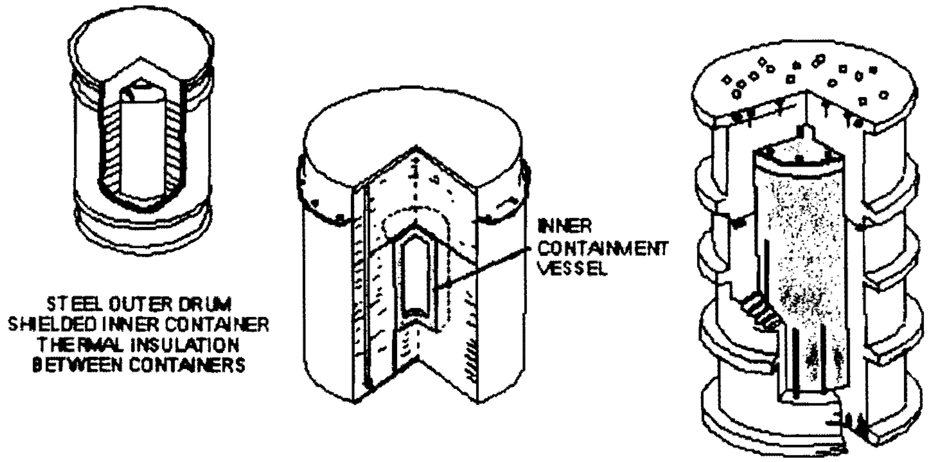


Figure 3. Type B

[NRC Home Page | Top of file | Contents]

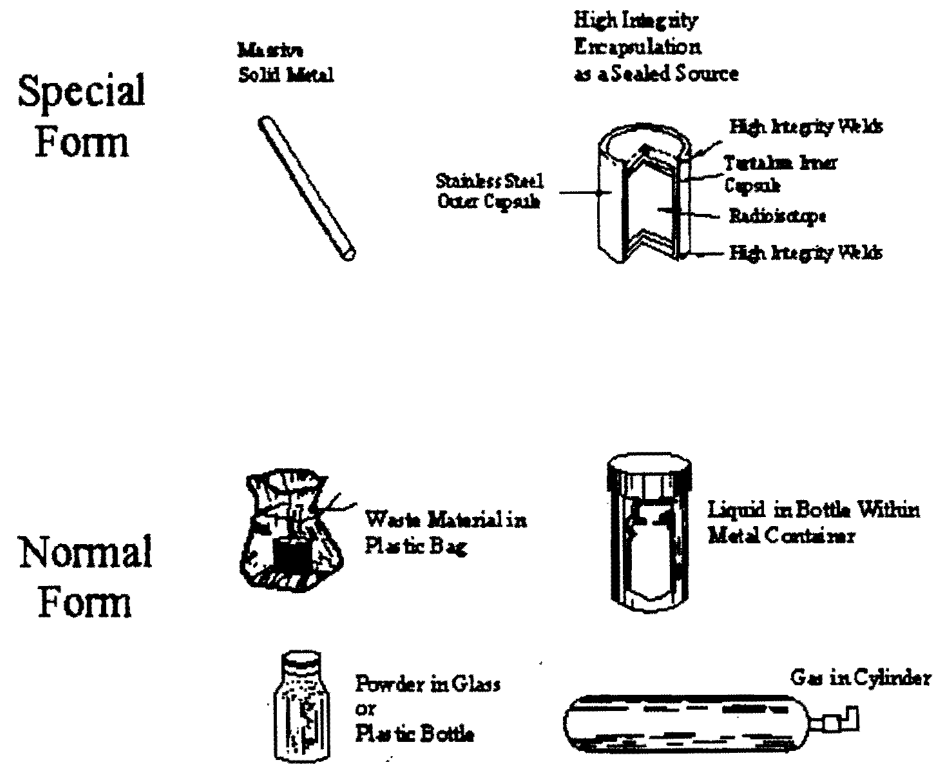


Figure 4. Categories

[NRC Home Page | Top of file | Contents]

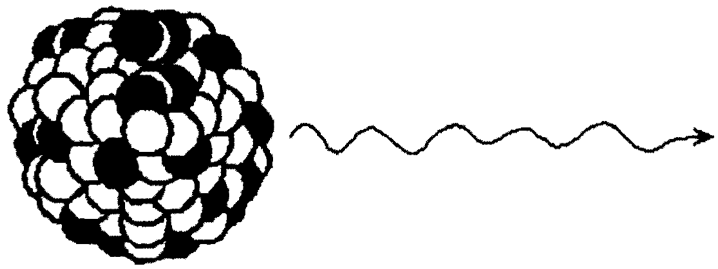


Figure 8. Gamma Ray

[NRC Home Page | Top of file | Contents]

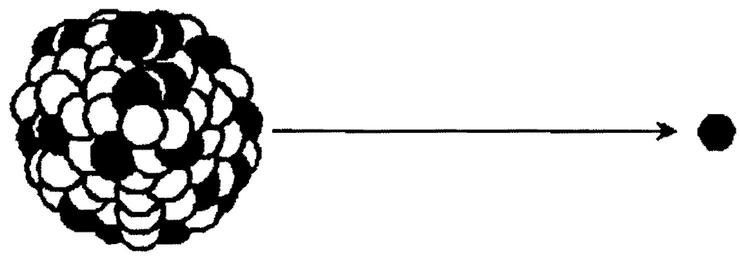


Figure 9. Neutron Particle

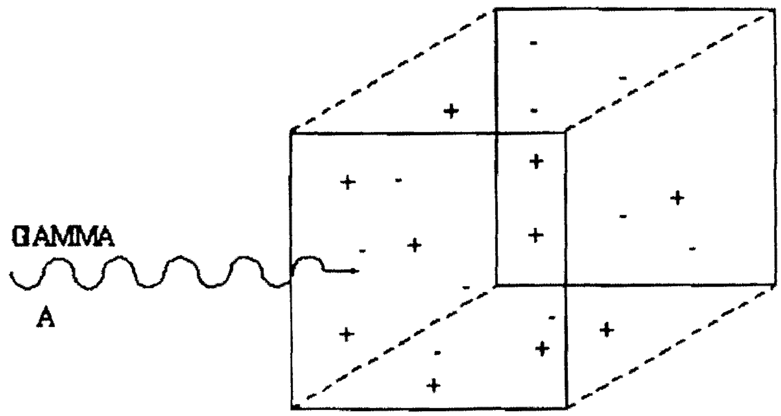


Figure 10. Roentgen

[NRC Home Page | Top of file | Contents]

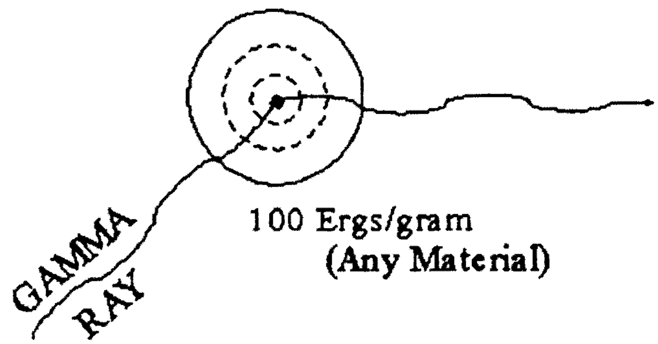


Figure 11. Radiation Absorbed Dose (RAD)

[NRC Home Page | Top of file | Contents]

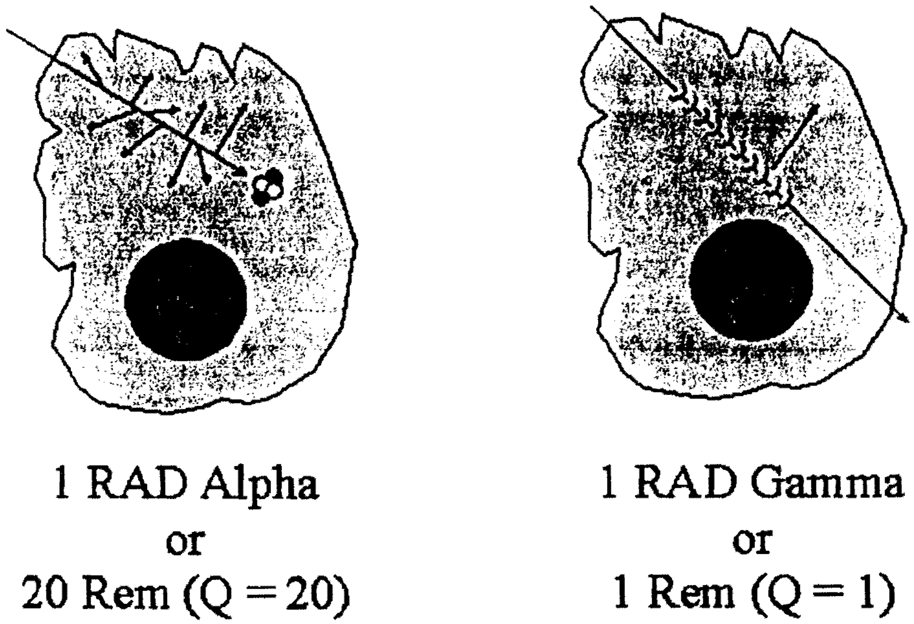


Figure 12. Quality Factor

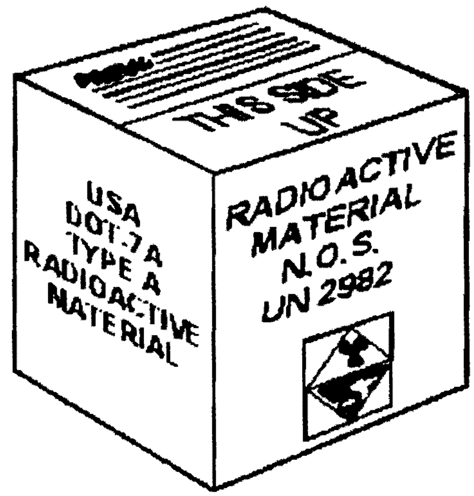


Figure 5. Markings

Figure 6. Labeling

[NRC Home Page | Top of file | Contents]

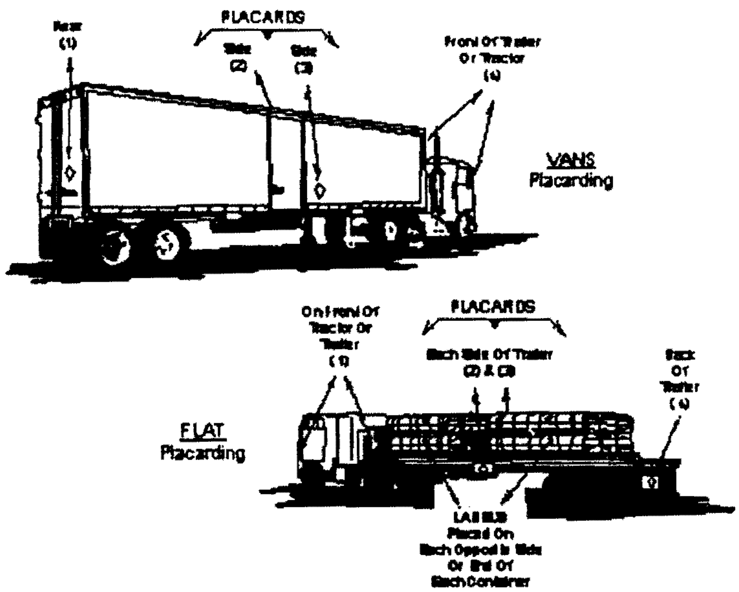


Figure 7. Placarding

[NRC Home Page | Top of file | Contents]

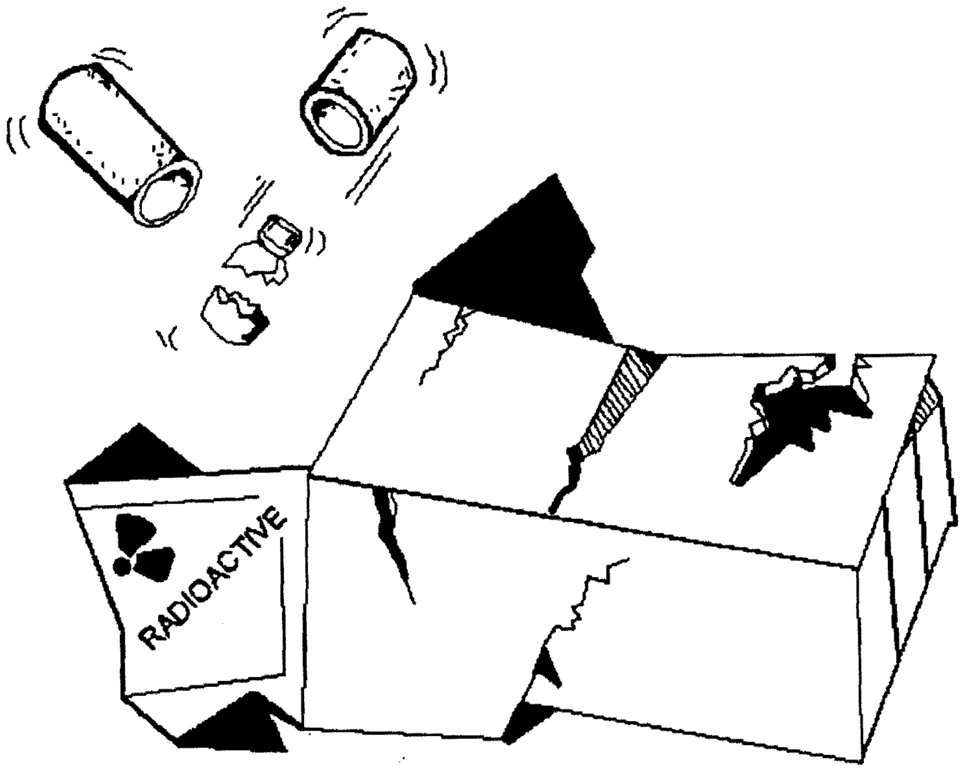
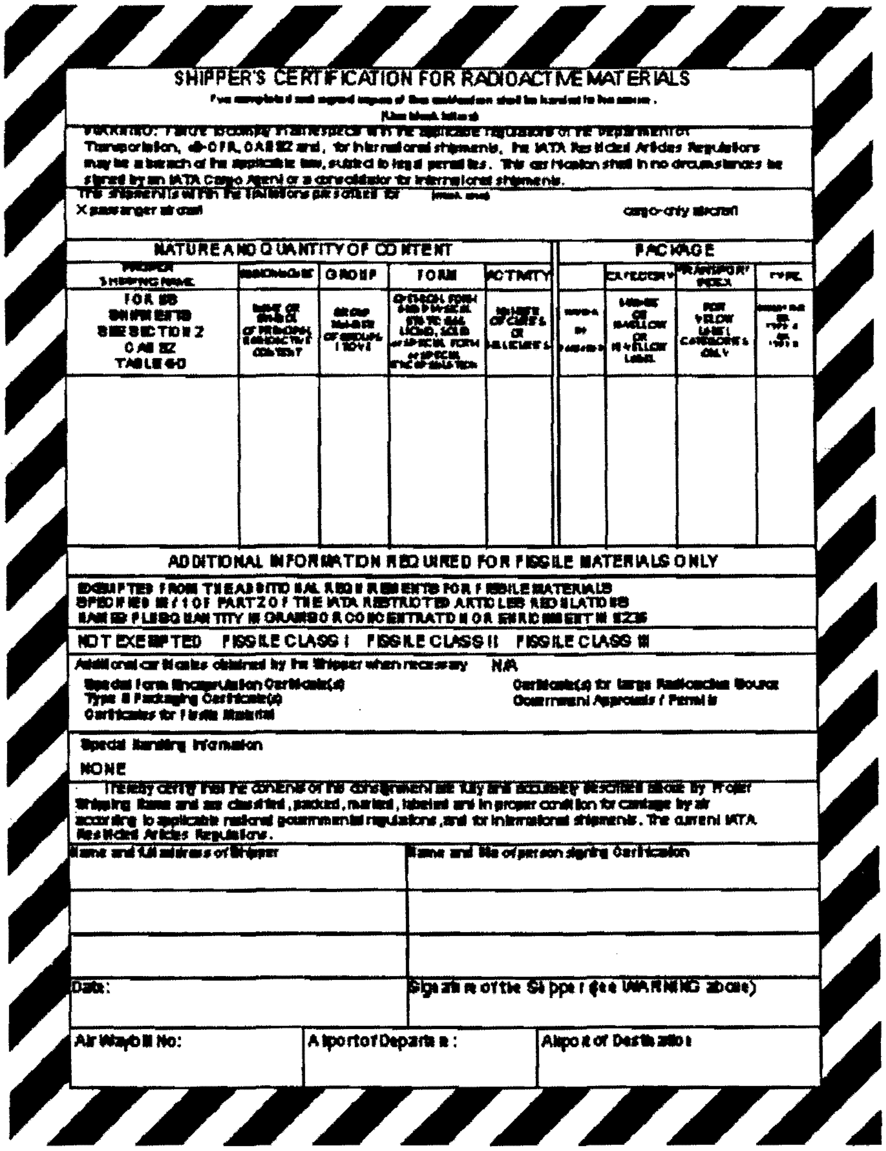


Figure 9. Accidents



SHIPPER'S CERTIFICATION FOR RADIOACTIVE MATERIALS

Transportation, 49 CFR, and, for international shipments, the IATA Restricted Articles Regulations may be a breach of the applicable law, subject to legal penalties. This certification shall in no circumstances be signed by an IATA Cargo Agent or a consolidator for international shipments.

X passenger aircraft

cargo-only aircraft

NATURE AND QUANTITY OF CONTENT					PACKAGE			
PROPER SHIPPING NAME		GROUP	FORM	ACTIVITY		CATEGORY	TRANSPORT INDEX	TYPE

ADDITIONAL INFORMATION REQUIRED FOR FISSILE MATERIALS ONLY

NOT EXEMPTED FISSILE CLASS I FISSILE CLASS II FISSILE CLASS III

N/A

Special Form Encapsulation Certificate(s)
Type B Packaging Certificate(s)
Certificates for Fissile Material

Special Handling Information

NONE

Name and full address of Shipper

Name and title of person signing Certification

Date:

Signature of the Shipper (see WARNING above)

Air Waybill No:

Airport of Departure:

Airport of Destination

Figure 8. Shipping Papers

[NRC Home Page | Top of file | Contents]

NRC
Form 3
(8/1999)

UNITED STATES NUCLEAR REGULATORY COMMISSION
Washington, DC 20555-0001

NOTICE TO EMPLOYEES

STANDARDS FOR PROTECTION AGAINST RADIATION (PART 20); NOTICES; INSTRUCTIONS AND REPORTS TO WORKERS; INSPECTIONS (PART 19); EMPLOYEE PROTECTION

WHAT IS THE NUCLEAR REGULATORY COMMISSION?

The Nuclear Regulatory Commission is an independent Federal regulatory agency responsible for licensing and inspecting nuclear power plants and other commercial uses to radioactive materials.

WHAT DOES THE NRC DO?

The NRC's primary responsibility is to ensure that workers and the public are protected from unnecessary or excessive exposure to radiation and that nuclear facilities, including power plants, are constructed to high quality standards and operated in a safe manner. The NRC does this by establishing requirements in Title 10 of the Code of Federal Regulations (10 CFR) and in licenses issued to nuclear users.

WHAT RESPONSIBILITY DOES MY EMPLOYER HAVE?

Any company that conducts activities licensed by the NRC must comply with the NRC's requirements. It a company violates NRC requirements, it can be fined or have its license modified, suspended or revoked.

Your employer must tell you which NRC radiation requirements apply to your work and must post NRC Notices of Violation involving radiological working conditions.

WHAT IS MY RESPONSIBILITY?

For your own protection and the protection of your co-workers, you should know how NRC requirements relate to your work and should obey them. If you observe violations of the requirements or have a safety concern, you should report them.

WHAT IF I CAUSE A VIOLATION?

If you engaged in deliberate misconduct that may cause a violation of the NRC requirements, or would have caused a violation if it had not been detected, or deliberately provided inaccurate or incomplete information to either the NRC or to your employer, you may be subject to enforcement action. It you report such a violation, the NRC will consider the circumstances surrounding your reporting in determining the appropriate enforcement action, if any.

HOW DO I REPORT VIOLATIONS AND SAFETY CONCERNS?

If you believe that violations of NRC rules or the terms of the license have occurred, or if you have a safety concern, you should report them immediately to your supervisor. You may report violations or safety concerns directly to the NRC. However, the NRC encourages you to raise your concerns with the licensee since it is the licensee who has the primary responsibility for, and is most able to ensure, safe operation of nuclear facilities. If you choose to report your concern directly to the NRC, you may report this to an NRC inspector or call or write to the NRC Regional Office serving your area. If you send your concern in writing, it will assist the NRC in protecting your identity if you clearly state in the beginning of your letter that you have a safety concern or that you are submitting an allegation. The NRC's toll-free SAFETY HOTLINE for reporting safety concerns is listed below. The addresses for the NRC Regional Offices and the toll-free telephone numbers are also listed below.

WHAT IF I WORK WITH RADIOACTIVE MATERIAL OR IN THE VICINITY OF A RADIOACTIVE SOURCE?

If you work with radioactive materials or near a radiation source, the amount of radiation exposure that you are permitted to receive may be limited by NRC regulations. The limits on your exposure are contained in sections 20.1201, 20.1207, and 20.1208 of Title I0 of the Code of Federal Regulations (10 CFR 20) depending on the part of the regulations to which your employer is subject. While these are the maximum allowable limits, your employer should also keep your radiation exposure as far below those limits as "reasonably achievable."

MAY I GET A RECORD OF MY RADIATION EXPOSURE?

Yes. Your employer is required to advise you of your dose annually if you are exposed to radiation for which monitoring was required by NRC. In addition, you may request a written report of your exposure when you leave your job.

HOW ARE VIOLATIONS OF NRC REQUIREMENTS IDENTIFIED?

NRC conducts regular inspections at licensed facilities to assure compliance with NRC requirements. In addition, your employer and site contractors conduct their own inspections to assure compliance. All inspectors are protected by Federal law. Interference with them may result in criminal prosecution for a Federal offense.

MAY I TALK WITH AN NRC INSPECTOR?

Yes. NRC inspectors want to talk to you if you are worried about radiation safety or have other safety concerns about licensed activities, such as the quality of construction or operations at your facility. Your employer may not prevent you from talking with an inspector. The NRC will make all reasonable efforts to protect your identity where appropriate and possible.

MAY I REQUEST AN INSPECTION?

Yes. If you believe that your employer has not corrected violations involving radiological working conditions, you may request an inspection. Your request should be addressed to the nearest NRC Regional Office and must describe the alleged violation in detail. It must be signed by you or your representative.

HOW DO I CONTACT THE NRC?

Talk to an NRC inspector on-site or call or write to the nearest NRC Regional Office in your geographical area (see map below). If you call the NRC's toll-free SAFETY HOTLINE during normal business hours, your call will automatically be directed to the NRC Regional Office for your geographical area. If you call after normal business hours, your call will be directed to the NRC's Headquarters Operations Center, which is manned 24 hours a day.

CAN I BE FIRED FOR RAISING A SAFETY CONCERN?

Federal Law prohibits an employer from firing or otherwise discriminating against you for bringing safety concerns to the attention of your employer or the NRC. You may not be fired or discriminated against because you:

- ask the NRC to enforce its rules against your employer;
- refuse to engage in activities which violate NRC requirements;
- provide information or are about to provide information to the NRC or your employer about violations of requirements or safety concerns;
- are about to ask for, or testify, help, or take part in an NRC, Congressional, or any Federal or State proceeding.

WHAT FORMS OF DISCRIMINATION ARE PROHIBITED?

It is unlawful for an employer to fire you or discriminate against you with respect to pay, benefits, or working conditions because you help the NRC or raise a safety issue or otherwise engage in protected activities. Violations of Section 211 of the Energy Reorganization Act (ERA) of 1974(42 U.S.C. 5851) include actions such as harassment, blacklisting, and intimidation by employers of (i) employees who bring safety concerns directly to their employers or to the NRC; (ii) employees who have refused to engage in an unlawful practice, provided that the employee has identified the illegality to the employer; (iii) employees who have testified or are about to testify before Congress or in any Federal or State proceeding regarding any provision (or proposed provision) of the ERA or the Atomic Energy Act (AEA) of 1954; (iv) employees who have commenced or caused to be commenced a proceeding for the administration or enforcement of any requirement imposed under the ERA or AEA or who have, or are about to, testify, assist, or participate in such a proceeding.

HOW DO I FILE A DISCRIMINATION COMPLAINT?

If you believe that you have been discriminated against for bringing violations or safety concerns to the NRC or your employer, you may file a complaint with the NRC or the U.S. Department of Labor (DOL) if you desire a personal remedy, you must file a complaint with the DOL pursuant to Section 211 of the ERA. Your complaint to the DOL must describe in detail the basis for your belief that the employer discriminated against you on the basis of your protected activity, and it must be filed in writing either in person or by mail within 180 days of the discriminatory occurrence. Additional information is available at the DOL website at www.osha.gov. Filing an allegation, complaint, or request for action with the NRC does not extend the requirement to file a complaint with the DOL within 180 days. You must file the complaint with the DOL. To do so you may contact the Allegation Coordinator in the appropriate NRC Region, as listed below, who will provide you with the address and telephone number of the correct OSHA Regional office to receive your complaint. You may also check your local telephone directory under the U.S. Government listings for the address and telephone number of the appropriate OSHA Regional office.

WHAT CAN THE DEPARTMENT OF LABOR DO?

If your complaint involves a violation of Section 211 of the ERA by your employer, it is the DOL, NOT THE NRC, that provides the process for obtaining personal remedy. The DOL will notify your employer that a complaint has been filed and will investigate your complaint.

If the DOL finds that your employer has unlawfully discriminated against you it may order that you be reinstated, receive back pay, or be compensated for any injury suffered as a result of the discrimination and be paid attorney's fees and costs.

Relief will not be awarded to employees who engage in deliberate violations of the Energy Reorganization Act or the Atomic Energy Act.

WHAT WILL THE NRC DO?

The NRC will evaluate each allegation of harassment, intimidation, or discrimination. Following this evaluation, an investigator from the NRC's Office of Investigations may interview you and review available documentation. Based on the evaluation, and, if applicable, the interview, the NRC will assign a priority and a decision will be made whether to pursue the matter further through investigation. The assigned priority is based on the specifics of the case and its significance relative to other ongoing investigations. The NRC may not pursue an investigation to the point that a conclusion can be made whether the harassment, intimidation, or discrimination actually occurred. Even if NRC decides not to pursue an investigation, if you have filed a complaint with DOL the NRC will monitor the results of the DOL investigation.

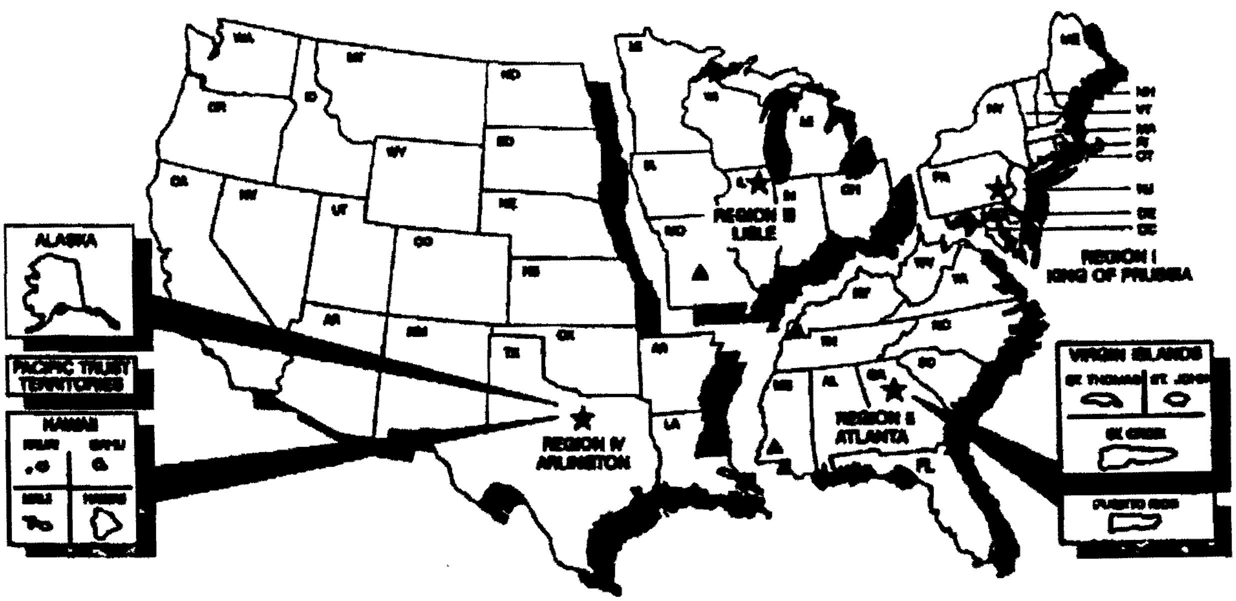
If the NRC or DOL finds that unlawful discrimination has occurred, the NRC may issue a Notice of Violation to your employer, impose a fine, or suspend, modify, or revoke your employer's NRC license.

UNITED STATES NUCLEAR REGULATORY COMMISSION REGIONAL OFFICE LOCATIONS

A representative of the Nuclear Regulatory Commission can be contacted by employees who wish to register complaints or concerns about radiological working conditions or other matters regarding compliance with Commission rules and regulations at the following addresses and telephone numbers.

REGIONAL OFFICES

REGION	ADDRESS	TELEPHONE
I	U.S. Nuclear Regulatory Commission, Region I 475 Allendale Road King of Prussia, PA 19406-1415	(800) 432-1156
II	U.S. Nuclear Regulatory Commission, Region II Atlanta Federal Center 61 Forsyth Street, S.W., Suite 23T85 Atlanta, GA 30303-3415	(800) 577-8510
III	U.S. Nuclear Regulatory Commission, Region III 801 Warrenville Road Lisle, IL 60532-4351	(800) 522-3025
IV WYOMING	U.S. Nuclear Regulatory Commission, Region IV 611 Ryan Plaza Drive, Suite 400 Arlington, TX 76011-8064	(800) 952-9677



▲ - Callaway Plant Site in Missouri and Grand Gulf Plant Site in Mississippi are under the purview of Region IV. The Paducah Gaseous Diffusion Plant in Kentucky is under the purview of Region III.

To report safety concerns or violations of NRC requirements by your employer,	To report incidents involving fraud, waste, or abuse by an NRC employee or NRC contractor,
telephone:	telephone:
NRC SAFETY HOTLINE	**OFFICE OF THE INSPECTOR GENERAL**
1800 - 695 - 7403	1 800 - 233 - 3497

¶WORTHINGTON, LENHART, AND CARPENTER, INC
TEST FOR
MOISTURE DENSITY GAUGE OPERATORS

True or False

1. Radiation is the term given to the particles and/or energy omitted by radioactive material as it disintegrates.

   TRUE ☐ FALSE ☐

2. REM is based on the biological damage caused by ionization in human body tissue. It is the term for dose equivalence and equals the biological damage that would be caused by one RAD of dose.

   TRUE ☐ FALSE ☐

3. The quality factor converts the absorbed dose in RAD to the dose equivalent in REM. The equation is: REM= RAD * quality factor

   TRUE ☐ FALSE ☐

4. Contamination is generally referred to as some quantity of radioactive material in a location where it is not intended or desired to be.

   TRUE ☐ FALSE ☐

5. The internal system of units for the RAD is the SEIVERT and the REM is the GRAY.

   TRUE ☐ FALSE ☐

6. Of alpha, beta, and gamma, the gamma has the largest mass.

   TRUE ☐ FALSE ☐

7. Alpha particles are typically stopped by a thin sheet of paper or the body's outer layer of skin.

TRUE ☐ FALSE ☐

8. The beta particle cannot penetrate into the live layers of skin and is not considered an internal or an external hazard.

TRUE ☐ FALSE ☐

9. ALARA is the concept of "As Low As Reasonably Achievable" concerning exposure and is a function of time, distance, and shielding.

TRUE ☐ FALSE ☐

10. Your dosemetry badge will protect from all radiation,

TRUE ☐ FALSE ☐

11. Leak tests must be performed at least annually.

TRUE ☐ FALSE ☐

12. The NRC requires cradle to grave record keeping for nuclear density/moisture gauges.

TRUE ☐ FALSE ☐

13. Physical inventory must be checked at least annually.

TRUE ☐ FALSE ☐

14. As a nuclear gauge operator, you must maintain control, possession, and surveillance of your nuclear gauge at all times.

TRUE ☐ FALSE ☐

15. The NRC can impose penalties and fines in gauge operators for non- compliance with regulations.

TRUE ☐ FALSE ☐

16. The UN classification for radioactive materials is Class 5.

TRUE ☐ FALSE ☐

17. Nuclear moisture density gauges may only be transported in a type B package.

TRUE ☐ FALSE ☐

18. Your employment can be terminated for raising a safety concern.

TRUE ☐ FALSE ☐

19. Nuclear moisture density gauges must be checked out, and back in, so that the gauge location is known at all times.

TRUE ☐ FALSE ☐

20 A bill of lading and emergency response information sheet should be within reach of the drive transporting any nuclear moisture density gauge.

TRUE ☐ FALSE ☐

21. Before transporting any nuclear moisture density gauge, the package shipping case must be inspected to ensure it is in good physical condition and that all closure devices are in good working order and secured.

TRUE ☐ FALSE ☐

22. The container must have a lock or seal that provides evidence that the package has not been tampered with in transit.

TRUE ☐ FALSE ☐

23. If a person is standing next to the gauge while a test is being performed, the results are still valid.

TRUE □ FALSE □

24. Any incident or accident involving the nuclear moisture density gauge should be reported to the RSO within 48 hours.

TRUE □ FALSE □

25. The regulations governing the transportation of nuclear gauges are contained in Title 49 of the Code of Federal Regulations.

TRUE □ FALSE □

26. Limits of exposure are contained in Sections 20.1201, 20.1207, and 20.1208 of Title 10 of the Code of Federal Regulations. (10CFR20)

TRUE □ FALSE □

27. The four documents that must be within reach of the driver at any time a gauge is transported are; bill of lading, a type A package certificate, a source certificate, and emergency procedures.

TRUE □ FALSE □

28. The public dose limit is 5 REMS per hour

TRUE □ FALSE □

29. The occupational dose limit is 5 REMS per year.

TRUE □ FALSE □

30. A full time employee working correctly with the Troxler gauge will receive less than 200 miliREMS per year.

TRUE □ FALSE □

TROXLER TRANSPORTATION GUIDE

This guide applies to Troxler nuclear gauges transported to, from, or within the United States.

Revision 32
(January 2011)

TROXLER®
The Leader in Construction Testing Equipment

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Research Triangle Park, NC 27709
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Fax: +1.919.549.0761
www.troxlerlabs.com

Troxler products are protected under U.S. and foreign patents

PN 106978
Revision 32
January 2011

TRANSPORTATION GUIDE

OVERVIEW AND APPLICABILITY

This guide is designed to assist Troxler nuclear gauge users in complying with U.S. Department of Transportation (DOT) hazardous material (hazmat) regulations and International Air Transport Association (IATA) Dangerous Goods Regulations. The U.S. DOT regulations are published in Title 49 of the Code of Federal Regulations, Parts 100-185 (49 CFR 100-185), which can be viewed online at the U.S. DOT hazmat web site: http://hazmat.dot.gov. IATA Dangerous Goods Regulations may be purchased from the IATA online store at: http://www.iata.org.

This guide highlights and explains the major requirements for shipping and transporting portable nuclear gauges in the U.S. However, use of this guide is not a substitute for reading and understanding the applicable regulatory requirements cited above. While every effort is made to keep the guide up-to-date, Troxler makes no warranty express or implied regarding the completeness and accuracy of the information contained herein. Responsibility for compliance with all regulatory requirements lies solely with those who persons prepare, ship, and transport nuclear gauges.

The U.S. DOT HAZMAT regulations apply to all U.S. domestic shipments by all modes of transport. IATA regulations apply to all shipments by air, both international and domestic. When shipping a nuclear gauge by Federal Express®, the gauge must be prepared in accordance with IATA regulations for shipment by air. Throughout this guide, you will see references to the applicable sections of the U.S. DOT regulations given in brackets, such as [§173.410].

The focus of this guide is on preparing nuclear gauges for shipment via common carriers and on transporting gauges as a private carrier. Private carriers generally own the goods (nuclear gauge) being transported and the transportation of the goods is incidental to their regular business activity. A company that owns a nuclear gauge and transports it to and from job sites in the course of business is considered a private carrier. Common and contract carriers, on the other hand, are "for hire" carriers whose primary business is transportation of goods for others.

The major requirements that apply to shipping a gauge via common carrier or transporting a gauge as private carrier include:

- A current copy of the International Atomic Energy Agency (IAEA) Certificate of Competent Authority (special form certificate) for each source in the gauge must be on file.
- The gauge must be in a TYPE A package and a copy of the TYPE A package testing results must be on file.
- The package must be properly marked, labeled, sealed, and inspected prior to each shipment.
- The package must be properly loaded and secured in the vehicle.
- Properly completed shipping papers (bill of lading) must be in the transport vehicle and immediately accessible to the driver
- An Emergency Response Information document must be in the transport vehicle with the shipping papers and immediately accessible to the driver
- An emergency response phone number must be manned continuously while the gauge is in transit (this service is provided free of charge by Troxler)
- A certificate of training must be on file for each hazmat employee involved in the shipment, essentially any individual involved in packaging, preparing shipping papers, or transporting a nuclear gauge (training classes are offered by Troxler)

TRAINING

If you own portable nuclear gauges, HAZMAT training is critical to your business. According to the U.S. DOT Office of Hazardous Material Safety:

> *"More than one-third of the Department's enforcement actions pertaining to violations of the hazardous materials transportation regulations involve the failure of hazmat employers to provide training or maintain test records. In most cases, violations are attributed to failure to provide function specific training. For example, an investigator questions incorrect entries on a shipping paper prepared by a hazmat employee who responds that he was not instructed, nor tested, by his hazmat employer regarding the preparation of shipping papers."*

The regulations define a *hazmat employee* as a person (including a self-employed person) who is employed by a hazmat employer and who:

- Loads, unloads, or handles hazmat (e.g., a nuclear gauge);
- Tests, reconditions, repairs, modifies, marks, or otherwise represents packagings as qualified for use in the transportation of hazmat;
- Prepares hazmat for transportation;
- Is responsible for safety of transporting hazmat; or
- Operates a vehicle used to transport hazardous materials.

Each hazmat employer must train and test, certify, and develop and retain records of current training for each hazmat employee (during the period of employment and 90 days thereafter).

Initial hazmat training must be completed within 90 days of employment or change in job function. Before completing training, an employee may only perform hazmat functions under the direct supervision of a properly trained and knowledgeable hazmat employee.

Recurrent training is required at least once every **three years** per USDOT hazardous material rules. IATA requires refresher training every **two years**.

Relevant training received from a previous employer or source may be used to satisfy the requirements provided a current record of training is obtained from the previous employer or source.

Hazmat employee training must include the following:

- General awareness/familiarization training
- Function-specific training
- Safety training
- Security awareness training

Training records must include:

- Hazmat employee's name;
- Completion date of most recent training;
- Training Materials (copy, description, or location);
- Name and address of hazmat trainer; and
- Certification that the hazmat employee has been trained and tested.

To assist you in meeting these training requirements, Troxler offers both initial and refresher hazmat training courses, including testing and certification. For further information about Troxler training opportunities, please consult our website: http://www.troxlerlabs.com.

CERTIFICATE OF COMPETENT AUTHORITY

The sealed sources in Troxler gauges meet the U.S. DOT requirements for classification as Special Form Radioactive Material. Special Form materials are designed and constructed to maintain their physical integrity and prevent radioactive contamination even under severe accident conditions. The testing requirements that "special form" materials must meet are described in §173.469. Sources meeting these requirements are issued a Certificate of Competent Authority by the International Atomic Energy Agency (IAEA).

A shipper must keep a copy of the IAEA Certificate of Competent Authority (also known as Special Form Certificate) for at least one year after the latest shipment of special form radioactive material [§173.476(a)]. An example of a special form certificate is shown in Appendix G. Please note that these certificates have expiration dates. You must have a current copy in your possession before you can legally ship special form radioactive materials. If shipping a gauge by air, a copy of the special form certificate must be included with the shipment.

Current copies of the certificates can be downloaded from the Troxler web site (www.troxlerlabs.com) or requested by calling Troxler. When requesting a special form certificate, please provide your gauge model number and serial number or the special form certificate number. You can determine the applicable special form certificate numbers by referring to the Troxler gauge certificate.

NOTE

Troxler issues a "gauge certificate" with each gauge. This certificate is sometimes confused with the special form certificate described above. The Troxler gauge certificate gives the gauge model and serial number, owner name and address, and information about the sources in the gauge, including the special form certificate number. The Troxler gauge certificate is not a legally required document for purposes of shipment. However, it is useful when being inspected by either your licensing agency or U.S. DOT, since it provides relevant gauge information.

TYPE A PACKAGES

The type, form, and quantity of radioactive material in most Troxler nuclear gauges requires the use of Type A packaging during transportation. The Troxler gauge shipping case meets all Type A package standards. [§173.410 and §173.412]

Each shipper of a (Specification 7A) Type A package must maintain on file for at least one year after the latest shipment, documentation of the Type A package testing methods and results. This documentation is provided in Appendix A for all Troxler gauges/cases currently manufactured. [§173.415(a)]

MARKING TYPE A PACKAGES

Each Specification 7A package (Troxler shipping case) must be marked on the outside "USA DOT 7A TYPE A" and "RADIOACTIVE MATERIAL." [§178.350(b)]

Each package must be marked with the proper shipping name and United Nations identification number (UN ID). [§172.301(a) and (c)]

The U.S. Environmental Protection Agency (EPA) requires notification of serious accidents involving certain quantities of hazardous substances. These "Reportable Quantities" must be identified by the abbreviation "RQ". For Troxler gauges containing 10 mCi or more of Americium-241 or Americium-241:Beryllium, the letters "RQ" must be marked on the package next to the proper shipping name. [§172.324(b)]

All of the above marking requirements are incorporated into a single label on each Troxler shipping case.

U.S. DOT requires the name and address of the shipper and consignee to be marked on the package, except when the package is transported by highway only and will not be transferred from one motor carrier to another. Therefore, when transporting a gauge to and from a job site by highway, name and address marking is not required. However, if a gauge is transported by a common carrier, name and address marking is required. [§172.301(d)]

For transport by air, IATA requires the full name and address of the shipper and the consignee to be shown on the same side of the package and near the proper shipping name marking. [IATA 7.1.5.1(b)]

LABELING TYPE A PACKAGES

Type A packages containing nuclear gauges are required to have RADIOACTIVE YELLOW-II hazard labels affixed to opposite sides (not top or bottom) near the proper shipping name marking. The following information must be entered on the labels in legible printing with a durable weather-resistant means of marking [§172.403(g)]:

- **Contents** – the name of the radionuclide(s) in the package (e.g., Cs-137 and Am-241:Be)
- **Activity** – the activity of the radioactive materials expressed in appropriate SI units, e.g., megabecquerels (MBq), gigabecquerels (GBq).
- **Transport Index** (for YELLOW-II or YELLOW-III labels only) – the maximum radiation level at one meter from the surface of the package in millirem/hour. See Appendix H for a list of TI values for Troxler gauges.

Type A packages containing nuclear gauges are not allowed on passenger-carrying aircraft in the U.S. When offered for transport by air, nuclear gauge packages must bear a CARGO AIRCRAFT ONLY label. [§173.448(f), §172.402(c)] Outside the U.S., a portable nuclear gauge in a Type A package may be carried on a passenger aircraft.

The RADIOACTIVE label and the CARGO AIRCRAFT ONLY label must be on the same side of the package as the proper shipping name marking.

INSPECTING PACKAGE BEFORE SHIPMENT

The shipper must inspect each package (gauge shipping case) before each shipment to ensure it is in unimpaired physical condition, except for superficial marks, and that each closure device (hinge, hasp, latch, etc.) is properly installed, secured, and free of defects. No cracks or other significant defects should be evident. [§173.475]

The shipper must also ensure that external radiation and contamination levels are within allowable limits and are consistent with the Transport Index shown on the radioactive labels on the package. If the gauge is in undamaged condition, this requirement may be met by visual inspection of the gauge. However, if the gauge has been damaged then radiation measurements should be made with a survey instrument and a leak test performed on the sealed sources prior to shipping or transporting the gauge.

⚠ **WARNING**

Do not ship or transport a gauge with a sliding block that is not fully closed.

Ensure that all latches are securely closed on the package. A copy of the package closure instructions in Appendix B must be retained and be available for inspection upon request for 365 days after offering the package for transport. [§173.22(a)(4)]

SECURITY SEALS

Each Type A package must incorporate a feature, such as a seal, that is not readily breakable, and that, while intact, is evidence that the package has not been opened. The seal is required when transporting a gauge to or from a work site, as well as when shipping a gauge via common carrier. [§173.412]

SECURING PACKAGES IN VEHICLE

Any package of radioactive material must be secured against movement within the transport vehicle under conditions normally incident to transportation. [§177.834(a) and §173.448]

MINIMUM SEPARATION BETWEEN PACKAGES AND PEOPLE

Packages bearing RADIOACTIVE YELLOW-II or YELLOW-III labels shall not be carried in compartments occupied by passengers. The minimum allowed distance between radioactive packages and vehicle occupants must be determined based on the transport index as shown in the table below. If more than one package is present, the distance (measured from the nearest point on any package) must be based on the total transport index for all of the packages. [§177.842(b)]

Total Transport Index	Minimum Distance (Feet)
0.1 to 1.0	1
1.1 to 5.0	2
5.1 to 10.0	3
10.1 to 20.0	4
20.1 to 30.0	5
30.1 to 40.0	6
40.1 to 50.0	7

For example, a Troxler 3440 gauge with a TI of 0.6 must be kept at least 1 foot away from the driver or passengers. Two Troxler 3440s with a combined TI of 1.2 must be kept at least 2 feet from the driver or passengers.

SHIPPING PAPER PREPARATION AND RETENTION

Shipping paper examples are shown in Appendices C, D, and E. Shipping papers must include:

- UN identification number: UN 3332
- Proper shipping name: "Radioactive material, Type A package, special form"
- Hazard class: 7
- The letters "RQ" (reportable quantity) if the package contains 10 mCi or more of Am-241
- Radionuclide names: See Appendix G to determine nuclides for your gauge
- Activity: See Appendix G to determine activities for your gauge
- Label category: Radioactive Yellow-II
- Transport index (dose rate in mrem per hour at 1 meter): See Appendix G to determine TI for your gauge
- Emergency telephone number: 919-549-9539 (If you use Troxler's emergency phone number, then you must enter YOUR company's name immediately before, after, above, or below the emergency phone number)
- Shipment date (Date of acceptance by carrier)

For shipments by air the following additional requirements apply:

- Shipping case dimensions must be shown in the sequence length x width x height, e.g., L75 x W35 x H42 cm.
- The words "All packed in one Type A package" if the gauge contains multiple radionuclides in the description
- The words "Cargo Aircraft Only" must follow the hazmat description

Shippers and carriers must retain a copy of the shipping papers, or an electronic image thereof, for a period of 2 years after the date the hazardous material is accepted by a carrier. An electronic image includes an image transmitted by fax machine, an image on the screen of a computer, or an image generated by an optical imaging machine. The copy (paper or electronic) must be accessible at or through the principal place of business and immediately available upon request by an authorized official of federal, state, or local government. [§172.201(e)]

Private carriers who use the same shipping paper for multiple shipments of the same hazardous material may retain a single copy of the permanent shipping paper, instead of a copy for each shipment made, if the carrier also retains a separate record of each shipment made, including:

- Shipping name (proper shipping name)
- Identification number (UN identification number)
- Quantity transported (total activity of the sources in the shipment)
- Date of shipment

SHIPPER'S CERTIFICATION

For any shipment offered for transport by common carrier, the shipping papers must include a signed and dated shipper's certification statement:

> *"This is to certify that the above-mentioned 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."*

For transportation by air, the following statement must be added to the above certification:

> *"I declare that all of the applicable air transport requirements have been met."*

No certification is required for a hazardous material transported by motor vehicle by a private carrier if the material will not be reshipped or transferred to another carrier (i.e., no certification is required when a gauge is transferred to and from a job site in a Company vehicle). [§177.204]

SHIPPING PAPER ACCESSIBILITY

When transporting hazmat by motor vehicle, the driver must ensure that the shipping papers are readily available to, and recognizable by, authorities in the event of an accident or inspection. The shipping paper must be clearly distinguished, if it is carried with any other papers, by either tabbing it or by having it appear first in the stack of papers.

When the driver is at the vehicle's controls, the shipping paper must be within immediate reach while the driver is restrained by the lap belt. The paper must be either readily visible to a person entering the driver's compartment (e.g., on the seat next to the driver) or in a holder which is mounted to the inside of the door on the driver's side of the vehicle.

When the driver is not at the controls of the vehicle, the shipping papers must be on the driver's seat or in a holder which is mounted to the inside of the door on the driver's side of the vehicle. [§177.817(e)]

EMERGENCY RESPONSE INFORMATION

An emergency response information sheet must accompany the shipment of a nuclear gauge. This document must be in the transport vehicle and immediately accessible to the driver during transportation on a public highway. Troxler includes a copy of this document with each gauge. An example of an emergency response information sheet is shown in Appendix F. [§172, Subpart G]

EMERGENCY RESPONSE PHONE NUMBER

A 24-hour emergency response telephone number must be provided on the shipping paper. This number must be manned continuously, while the gauge is in transit, by someone who is knowledgeable of the hazards and characteristics of the hazardous material being shipped, has comprehensive emergency response and accident mitigation information for that material, or has immediate access to a person who possesses such knowledge and information. [§172, Subpart G]

Troxler has an emergency response phone number **(919-549-9539)** that Troxler gauge owners may use. However, if you put Troxler's emergency phone number on your shipping papers, then you must put your company's name immediately before, after, above, or below the emergency response phone number. Both the emergency phone number and your company's name must be printed in a prominent, readily identifiable, and clearly visible manner that allows the information to be easily and quickly found (e.g., highlighted, larger font, or different color text). [§172.604(b)(2)]

ACCIDENT NOTIFICATION REQUIREMENTS

Notify your licensing agency as soon as practical after a reportable incident. You are also required by §171.15 to notify, at the earliest practical moment, the **U.S. DOT at 1-800-424-8802** of an accident that occurs during the course of transportation (including loading, unloading, and temporary storage) in which fire, breakage, spillage, or suspected contamination occurs involving shipment of radioactive material.

EXCEPTED PACKAGES

Excepted Packages are not subject to the specification packaging, marking (except for the UN ID), labeling, and shipping paper requirements (unless the quantity of radioactive material equals or exceeds the RQ value). Troxler models 3660, 4301, and 4302 meet the radiation level and activity limits (Table 4 in §173.425) for Excepted Packages and are subject to the following requirements.

- The outside of the package must show the full name and address of the shipper and consignee.
- The outside of the package must be marked with the UN ID number: "UN 2911".
- The outside of the inner package or gauge must be marked "radioactive."
- For shipment by air, the package must bear the Radioactive Material, Excepted Package label with the UN ID number. (IATA 10.7.4.4.3)
- For shipment by air, a Shipper's Declaration for Dangerous Goods form is not required if the amount of radioactive material in the package is less than the RQ value. However, the air waybill must show the following description of the material. (IATA 10.8.8.3)

  "UN 2911, Radioactive material, excepted package, instruments, 1 package".

- Packages containing a reportable quantity (RQ), which includes models 4301 and 4302, are subject to modified shipping paper requirements. An emergency response phone is not required on the shipping papers per §172.604(d). The applicable shipping paper description for the 4301 and 4302 models is shown below:

  UN2911, Radioactive Material, Excepted Package, Instruments, 7, RQ
  Am-241, 1 package x 0.37 GBq (10 mCi)
  Dim L58 x W48 x H27 cm
- Shippers and carriers are subject to the hazmat employee training requirements.
- Shippers and carriers are subject to accident notification requirements.

RECORD RETENTION

Following is a summary of the record retention requirements applicable to shippers of Troxler nuclear gauges.

Record	Retention
Hazmat employee training records including: • Employee name • Training completion date • Description, copy, or the location of the training materials used • Name and address of the person providing the training • Certification that the hazmat employee has been trained and tested	A record of current training, inclusive of the preceding three years, in accordance with this section shall be created and retained by each hazmat employer for as long as that employee is employed by that employer as a hazmat employee and for 90 days thereafter. [§172.704(d)].
IAEA Certificate of Competent Authority for special form radioactive material	1 year after the latest shipment [§173.476(a)]
Type A package testing methods and results	1 year after the latest shipment [§173.415(a)]
Shipping papers	2 years after date of shipment [§172.201(e)]
Package closure instructions provided by the package manufacturer	365 days after the package is offered for shipment [§173.22(a)(4)]

APPENDIX A

TYPE A PACKAGE TESTING RESULTS

INSTRUCTIONS FOR FINDING TYPE A TESTING RESULTS FOR YOUR PACKAGE:

1. Determine your shipping case type by using the drawing below.
2. Find your gauge model number in the first column of the table on the next page.
3. Find the corresponding case in the second column of this row.
4. Gauges that are no longer in production may not be listed. Please contact your Troxler representative or the Troxler corporate headquarters if you need assistance.

TESTING PERFORMED & RESULTS (unless otherwise indicated in footnotes):

Water Spray: Subjected the package to a water spray simulating rainfall of approximately two inches per hour for one continuous hour.

Results: No physical damage to the package was observed, unless otherwise noted in footnotes.

Vibration: The package was vibrated with a displacement of 0.1" at approximately 12 Hz for a period of 24 continuous hours.

Results: No physical damage to the package was observed, unless otherwise noted in footnotes.

Free Drop: The package was dropped from a height of four feet onto a non-yielding surface from a position to cause maximum damage to the package.

Results: The case was scratched due to the abrasiveness of the concrete, but no other physical damage to the package was observed, unless otherwise noted in footnotes.

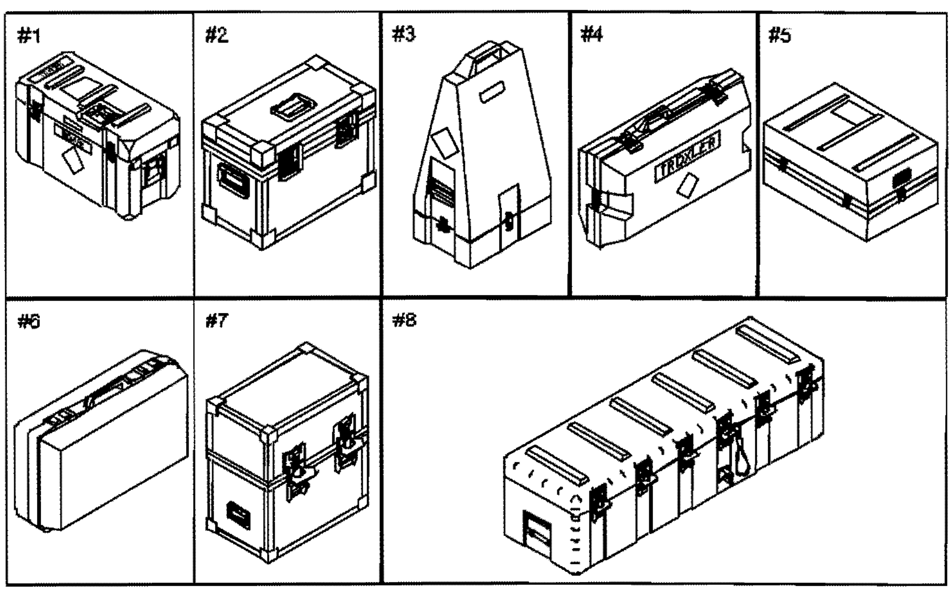
Penetration: The package was placed on a non-yielding surface. A 1-1/4" diameter, 13-pound steel cylinder with a hemispherical end was dropped in the vertical position from a height of 40" onto the package to a point to cause maximum damage to the package.

Results: No physical damage to the package was observed, unless otherwise noted in footnotes.

Compression: Package was placed on a non-yielding surface and subjected to a compressive load of at least 13 kilopascals multiplied by the vertically projected area of the package, in square feet, for 24 continuous hours.

Results: No physical damage to the package was observed, unless otherwise noted in footnotes.

PACKAGE DRAWINGS:



RESULTS OF TESTING

Consult the table below for applicable testing results, as described in the instructions on the previous page. A [✓] in the table below indicates that the applicable test was performed. The results are on the previous page of this document unless otherwise stated in the referenced footnotes.

GAUGE MODEL	CASE/ DRAWING #	WATER SPRAY	VIBRATION	FREE DROP	PENETRATION	COMPRESSION	PACKAGE WEIGHT (lbs)	DATE TEST COMPLETED
3241 SERIES- 3241-A, 3241-B 3241-C, 3241-M 3242	WATER RES/#1	(1)	✓	✓	✓	✓	103, (5)	9/91
	GAUGE ONLY	(1)	✓	✓, (3)	✓, (3)	✓, (2)	55	1/83
3216, 3217, 3218, 3221, 3222	PYRAMID/#3	(1)	✓	✓	✓	✓, (7)	93, (5)	9/91
	PLASTIC/#6	(1)	✓	✓	✓	✓	70, (5)	6/91
3400 SERIES- 3401, 3401-B 3411, 3411-B 3430, 3430-M 3440, 3440-M, 3440-L	WATER RES/#1	(1)	✓	✓	✓	✓	110, (5)	9/91
	TRUNK/#2	(1)	✓	✓	✓	✓	115, (5)	9/91
	PYRAMID/#3	(1)	✓	✓	✓	✓, (7)	93, (5)	9/91
	BLOWMOLD/#4	(1)	✓	✓	✓	✓, (2)	81	5/85
	ABS/#5	(1)	✓	✓	✓	✓	105, (5)	9/91
3430 Plus, 3440 Plus	WATER RES/#1	(1)	✓, (10)	✓	✓	✓	83	1/07
3450, 3451	WATER RES/#1	(1)	✓	✓	✓	✓	96	7/96
4232	WATER RES/#1	(1)	✓, (8)	✓	✓	✓	70, (9)	1/95
4301, 4302	PLASTIC/#6	(1)	✓	✓	✓	✓	70, (5)	6/91
4350	WATER RES/#8	(1)	✓	✓	✓	✓	122	3/92
4430	TRUNK/#7	(1)	✓	✓, (3)	✓	✓	107	12/92
4440 SERIES	WATER RES/#1	(1)	✓	✓	✓	✓	120, (5)	9/91
4640	WATER RES/#1	(1)	✓	✓	✓	✓	110, (5)	8/96
	TRUNK/#2	(1)	✓	✓	✓	✓, (2)	93	6/84

Notes:

1. Engineering Evaluation – Water exposure of the magnitude required by regulations would not affect the shielding or containment integrity.
2. Compressive load at date of test was specified as being derived using the "maximum horizontal cross-section of the package," in place of the "vertically projected area of the package."
3. Cosmetic damage was observed.
4. Package material was exempt from this test per regulations at the time of testing.
5. Package tested with full weight plus 20 pounds added.
6. Package weight not available (case is no longer in production).
7. Engineering Evaluation - Test not practical due to case geometry.
8. The case was vibrated with a displacement of 1/8" at 15 Hz for a period of 24 continuous hours.
9. The weight of the case and dummy contents as tested was 74 lbs.
10. Engineering Evaluation – Package design and construction are equivalent to other packages in use which have had no vibration-related failures.

APPENDIX B

PACKAGE CLOSURE INSTRUCTIONS

Ensure that all latches are securely closed on the package.

<u>Models 3241, 3242, 3400 series, 4350 and 4640 closure instructions - Butterfly Twist Latch</u>

1. Lift up and turn the butterfly wing grip counterclockwise 180 degrees to open.
2. Engage the catch on the keeper plate
3. Turn the butterfly wing clockwise 180 degrees until fully closed
4. Push down the butterfly wing grip flat against case.
5. Repeat for all latches on the front and, if applicable, sides of the shipping case.

<u>Model 3216, 4301 and 4302 - Plastic Snap Latch</u>

1. Press the plastic snaps down until they click to close the case.
2. Lift the snaps up to open the case.

A copy of these package closure instructions must be retained and be available for inspection upon request for 365 days after offering the package for transport. [§173.22(a)(4)]

Ensure that all latches are securely closed on the package.

<u>Models 3241, 3242, 3400 series, 4350 and 4640 closure instructions - Butterfly Twist Latch</u>

6. Lift up and turn the butterfly wing grip counterclockwise 180 degrees to open.
7. Engage the catch on the keeper plate
8. Turn the butterfly wing clockwise 180 degrees until fully closed
9. Push down the butterfly wing grip flat against case.
10. Repeat for all latches on the front and, if applicable, sides of the shipping case.

<u>Model 3216, 4301 and 4302 - Plastic Snap Latch</u>

3. Press the plastic snaps down until they click to close the case.
4. Lift the snaps up to open the case.

A copy of these package closure instructions must be retained and be available for inspection upon request for 365 days after offering the package for transport. [§173.22(a)(4)]

APPENDIX C

PRIVATE CARRIER BILL OF LADING FOR A 3400 SERIES GAUGE

This document is NOT required to be dated. However, the carrie r must retain a record of each shipment made, including: proper shipping name, UD identification number, activity transported, and date of shipment.

NOTE

Your source type, source activity, and TI may differ from this example. The "RQ" requirement applies only to gauges containing americium-241 sources.

Your Company's Letterhead

BILL OF LADING

Shipper: ABC Paving Company
123 Main Street
Raleigh, NC

Qty	**Description**
1 pkg	UN 3332, Radioactive material, Type A package, Special Form, 7, RQ Cs-137, 0.30 GBq (8.0 mCi) Am-241, 1.48 GBq (40.0 mCi) Radioactive Yellow II, TI = 0.3

EMERGENCY CONTACT: (919) 549-9539
ABC PAVING COMPANY

Shipper Name (Print): ______________________

Shipper Name (Signature): ______________________

APPENDIX D

COMMON CARRIER BILL OF LADING FOR A 3400 SERIES GAUGE SHIPPED BY GROUND

NOTE

Your source type, source activity, and TI may differ from this example. The "RQ" requirement applies only to gauges containing americium-241 sources.

SB Freightways

BILL OF LADING

DATE	P.O. NO.	SHIPPER NO.
SHIP DATE		

CONSIGNEE (TO)	SHIPPER/CONSIGNOR (FROM)
TROXLER ELECTRONIC LABS, INC	APEX TESTING COMPANY
3008 CORNWALLIS RD	456 MAIN STREET
RESEARCH TRIANGLE PARK, NC 27709	COLUMBIA, SC 27601

PHONE NO.	EMERGENCY RESPONSE NUMBER* (REQUIRED IF HM COLUMN MARKED)	ROUTE
	919-549-9539	

(SUBJECT TO CORRECTION)

Number of Packages	HM *	Kind of Packaging, Description of Articles, Special Marks and Exceptions	Weight (lb)	Class or Rate Ref.	Cube (Optional)
1 case	x	UN 3332, Radioactive Material, Type A package,			
		Special Form, 7, RQ			
		Cs-137, 0.30 GBq (8.0 mCi)			
		Am-241, 1.48 GBq (40 mCi)			
		Radioactive Yellow II label, TI = 0.3			
		EMERGENCY PHONE: (919) 549-9539			
		ABC PAVING COMPANY			

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.

SHIPPER/CONSIGNOR	CARRIER
W. BROWN	SB FREIGHTWAYS
AUTHORIZED SIGNATURE / DATE	AUTHORIZED SIGNATURE

APPENDIX E

SHIPPER'S DECLARATION FOR DANGEROUS GOODS FOR TYPE A PACKAGE SHIPPED BY AIR

SHIPPER'S DECLARATION FOR DANGEROUS GOODS

Shipper

Acme Paving Company
524 Rocky Road
Chicago, IL
USA

Air Waybill No. 548974

Page 1 of 1 Pages

Shipper's Reference Number 85642

Consignee

Troxler Electronic Laboratories, Inc.
3008 Cornwallis Rd
Research Triangle Park, NC 27709

TROXLER

Two completed and signed copies of this Declaration must be handed to the operator

WARNING

Failure to comply in all respects with the applicable Dangerous Goods Regulations may be in breach of the applicable law, subject to legal penalties.

TRANSPORT DETAILS

This shipment is within the limitations prescribed for *(delete non-applicable)*

PASSENGER AND CARGO AIRCRAFT	CARGO AIRCRAFT ONLY

Airport of Departure: Chicago, OHare

Airport of Destination: Atlanta, Hartsfield

Shipment type: *(delete non-applicable)*

XXXXXXXXXXXXXXXXXX	RADIOACTIVE

NATURE AND QUANTITY OF DANGEROUS GOODS

UN Number or Identification Number, Proper Shipping name, Class or Division (subsidiary risk), Packing Group (if required), and all other required information.

UN3332, Radioactive Material, Type A Package, Special Form, 7, RQ

Enter "RQ" only for gauges containing Am-241.

Cs-137, 0.30 GBq (8 mCi)
Am-241, 1.48 GBq (40 mCi)
All packed in one Type A package
II-Yellow, TI = 0.3, Dim L75 x W35 x H42 cm

Nuclides, activities, label category, transport index (TI), and dimension values depend on the gauge model.

Special form certificates attached: USA/0614/S-96, USA/0632/S-96

Attach special form certificates for international shipments.

Additional Handling Information This shipment may be carried on passenger aircraft outside U.S. jurisdiction.

Emergency response sheet attached to Dangerous Goods Declaration.

Emergency Telephone Number **(011) 919-549-8539** Acme Paving Company

Your company name must appear here

I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name, and are classified, packaged, marked and labelled/placarded, and are in all respects in proper condition for transport according to applicable International and National Governmental Regulations. I declare that all of the applicable air transport requirements have been met.

Name/Title of Signatory
A. Brown, Shipping Manager

Place and Date
Chicago, IL January 15, 2011

Signature
(see warning above)

APPENDIX F

EMERGENCY RESPONSE INFORMATION EXAMPLE

TROXLER NUCLEAR GAUGE EMERGENCY RESPONSE INFORMATION REQUIRED FOR TRANSPORTATION

Call Troxler Electronic Laboratories, Inc. at (919) 549-9539 for Emergency Assistance.

1. PROPER SHIPPING NAME

- Radioactive material, Type A package, Special Form, UN3332

POTENTIAL HAZARDS

2. HEALTH HAZARDS

- Radiation presents minimal risk to lives of persons during transportation accidents.
- Undamaged packages are safe; damaged packages or materials released from packages can cause external radiation hazards. Contamination is not suspected.
- 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 packages are damaged in moderately severe accidents.
- Packages (large and small, usually metal) identified as "Type B" by marking on packages or by shipping papers contain potentially life-endangering amounts. Because of design, evaluation, and testing of packages, life-endangering releases are not expected in accidents except those of utmost severity.
- Commonly available instruments can detect most of these materials.
- Water from cargo fire control is not expected to cause pollution.

3. FIRE OR EXPLOSION

- Packagings can be consumed without content loss from sealed source capsule.
- Radioactive source capsules and Type B packages are designed to withstand temperatures of 1475 °F (800 °C).

EMERGENCY ACTION

4. IMMEDIATE PRECAUTIONS

- Priority response actions may be performed before taking radiation measurements.
- Priorities are life saving, control of fire and other hazards, and first aid.
- Isolate hazard area and deny entry. Notify Radiation Authority of accident conditions.
- Delay final cleanup until instruction or advice of Radiation Authority.
- Positive pressure self-contained breathing apparatus (SCBA) and structural firefighter's protective clothing will provide adequate protection against internal radiation exposure, but not external radiation exposure.

5. FIRE

- 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)

6. SPILL OR LEAK

- **Do not touch damaged packages or spilled material.**
- Slightly damaged or damp outer surfaces seldom indicate failure of inner container.
- If source is identified as being out of package, stay away and await advice from Radiation Authority.

7. FIRST AID

- Use first aid treatment according to the nature of the injury.
- Persons exposed to special form sources are not likely to be contaminated with radioactive material.

APPENDIX G

SPECIAL FORM CERTIFICATE EXAMPLE

U.S. Department of Transportation
Research and Special Programs Administration

400 Seventh St., S.W.
Washington, D.C. 20590

IAEA CERTIFICATE OF COMPETENT AUTHORITY
SPECIAL FORM RADIOACTIVE MATERIALS
CERTIFICATE NUMBER USA/0620/S, REVISION 0

This certifies that the source described has been demonstrated to meet the regulatory requirements for special form radioactive material as prescribed in the regulations of the International Atomic Energy Agency[1] and the United States of America[2] for the transport of radioactive materials.

1. Source Identification - AEA Technology QSA, Inc. Model number X.1188.

2. Source Description - Single encapsulation made of stainless steel and tungsten inert gas or laser seal welded. Minimum wall thickness is 0.48 mm (0.02 in.). Approximate outer dimensions are 10.1 mm (0.40 in.) in diameter and 9.7 mm (0.38 in.) in length. All sources shall be constructed and maintained in accordance with attached AEA Technology QSA, Inc. Drawing number RBA61869, Rev. A.

3. Radioactive Contents - No more than 74 GBq (2.0 Ci) Americium-241 oxide mixed with Beryllium and pressed into a solid pellet.

4. Quality Assurance - Records of Quality Assurance activities required by Paragraph 310 of the IAEA regulations[1] shall be maintained and made available to the authorized officials for at least three years after the last shipment authorized by this certificate. Consignors and consignees in the United States exporting or importing shipments under this certificate shall satisfy the requirements of Subpart H of 10 CFR 71.

5. Expiration Date - This certificate expires April 1, 2008.

Make sure your copy is current.

This certificate is issued in accordance with paragraph 804 of the IAEA Regulations and Section 173.476 of Title 49 of the Code of Federal Regulations, in response to the petition and information dated January 17, 2003 and March 18, 2003 submitted by AEA Technology QSA, Inc., Burlington, MA, and in consideration of other information on file in this Office.

Certified by:

Robert A. McGuire
Associate Administrator for
Hazardous Materials Safety

APR -8 2003
(DATE)

Revision 0 - Original issue.

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1 "Regulations for the Safe Transport of Radioactive Material, 1996 Edition (Revised), No. TS-R-1 (ST-1, Revised)," published by the International Atomic Energy Agency (IAEA), Vienna, Austria.

2 Title 49, Code of Federal Regulations, Parts 100 - 199, United States of America.

APPENDIX H

TRANSPORT INDEXES FOR TROXLER GAUGES

The Transport Index (TI) for a nuclear gauge is defined as the dose rate (mrem/h) one meter from the shipping case.

1. Determine your case type using the case drawings (see page 11).
2. Find your gauge model number in the first column of the table below.
3. Find the corresponding case in the second column of this row.
4. If the gauge was manufactured with different source activities or sources, find this information in the third column.
5. The fourth column provides the TI for each gauge, case, and source combination.
6. Gauges that are no longer in production may not be listed.
7. Please contact your Troxler representative or the Troxler corporate headquarters if you need any assistance.

GAUGE MODEL	NUCLIDES	ACTIVITY	CASE/ DRAWING #	TRANSPORT INDEX (TI)
1351, 1352, 2376	Cs-137	0.3 GBq	TRUNK/#2	0.2
3241-C	Am-241	3.7 GBq	WATER RES/#1	0.1
	Am-241	11.1 GBq	WATER RES/#1	0.5
3241-M	Cf-252	3.7 MBq	WATER RES/#1	0.1
3216, 3217, 3218	Am-241	1.48 GBq	PLASTIC/#6	0.1
			PYRAMID/#3	0.1
3242	Cf-252	3.7 MBq	WATER RES/#1	0.4
3401	Am-241 Cs-137	1.48 GBq 0.3 GBq	WATER RES/#1 or BLOWMOLD/#4	0.4
			TRUNK/#2, PYRAMID/#3, or ABS/#5	0.1
3411	Am-241 Cs-137	1.48 GBq 0.3 GBq	WATER RES/#1	0.5
			TRUNK/#2, PYRAMID/#3, or ABS/#5	0.1
			BLOWMOLD/#4	0.4
3430	Am-241 Cs-137	1.48 GBq 0.3 GBq	WATER RES/#1	0.3
3430M, 3440M	Cs-137 Cf-252	0.3 GBq 2.22 MBq	WATER RES/#1	0.6
3440	Am-241 Cs-137	1.48 GBq 0.3 GBq	WATER RES/#1	0.6
			TRUNK/#2	0.5
3440-L	Am-241 Cs-137	0.56 GBq 0.3 GBq	WATER RES/#1	0.4
3430 Plus, 3440 Plus	Am-241 Cs-137	1.48 GBq 0.3 GBq	WATER RES/#1	0.3
3450, 3451	Am-241 Cs-137	1.48 GBq 0.3 GBq	WATER RES/#1	0.3
4232	Cf-252	3.7 MBq	WATER RES/#1	0.4
4350	Am-241 Cs-137	0.15 GBq 0.3 GBq	WATER RES/#8	0.2
4430	Am-241 Cf-252	0.15 GBq 2.22 MBq	TRUNK/#7	0.1
4440 SERIES	Co-60 Cf-252	2.22 MBq 1.11 MBq	WATER RES/#1	0.1
4545	Cs-137	0.3 GBq	TRUNK/#2	0.2
4640 SERIES	Cs-137	0.3 GBq	WATER RES/#1 or TRUNK/#2	0.2

Nuclear Gauge Field Testing Guidelines

WLC

1 PURPOSE OF REPORT

This report provides guidance to an applicant in preparing a portable gauge license application, as well as NRC criteria for evaluating a portable gauge license application. It is not intended to address the research and development of gauging devices or the commercial aspects of manufacturing, distribution, and service of such devices. Within this document, the phrases "portable gauge" or "gauging devices," and the term "gauge" may be used interchangeably.

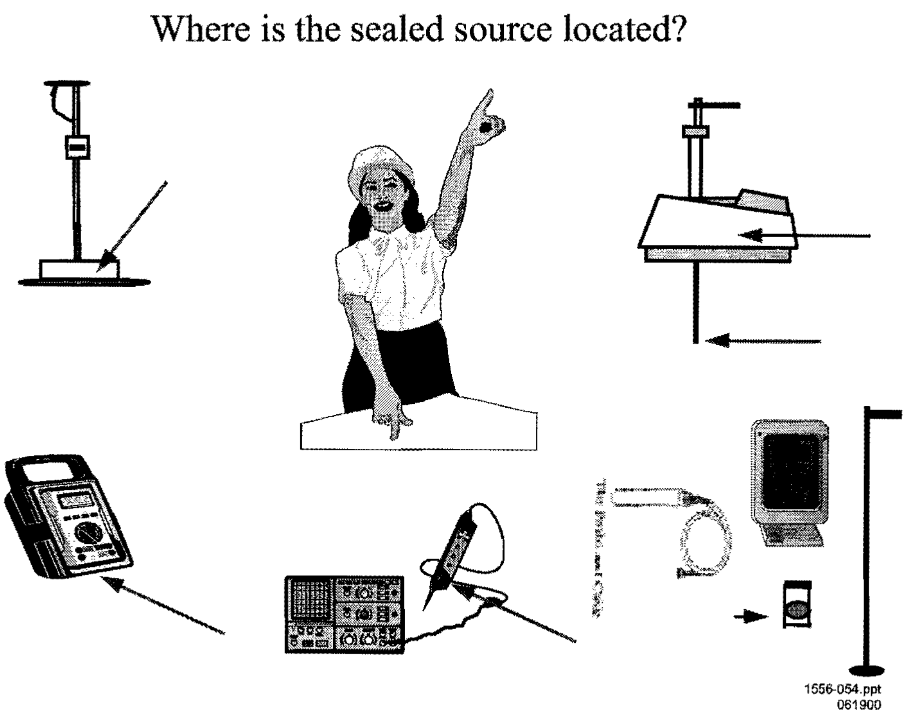


Figure 1.1 Where is the Radioactive Source? *The wide variety of portable gauge designs include placing the sealed source in different locations, resulting in different radiation safety problems.*

This report addresses the variety of radiation safety issues associated with portable gauges of many designs. As shown in Figure 1.1, portable gauges are of many different designs based, in part, on their intended use (e.g., to measure moisture, density, thickness of asphalt, liquid level). Because of differences in design, manufacturers provide appropriate instructions and recommendations for proper operation and maintenance. In addition, with gauges of varying designs, the sealed sources may be oriented in different locations within the devices, resulting in different radiation safety problems.

PURPOSE OF REPORT

This report identifies the information needed to complete NRC Form 313 (Appendix A), "Application for Material License," for the use of sealed sources in portable gauging devices. The information collection requirements in 10 CFR Part 30 and NRC Form 313 have been approved under the Office of Management and Budget (OMB) Clearance Nos. 3150-0017 and 3150-0120, respectively.

The format within this document for each item of technical information is as follows:

- Regulations – references the regulations applicable to the item;
- Criteria – outlines the criteria used to judge the adequacy of the applicant's response;
- Discussion – provides additional information on the topic sufficient to meet the needs of most readers; and
- Response from Applicant – provides suggested response(s), offers the option of an alternative reply, or indicates that no response is needed on that topic during the licensing process.
- Notes and References are self-explanatory and may not be found for each item on NRC Form 313.

NRC Form 313 does not have sufficient space for applicants to provide full responses to Items 5 through 11; as indicated on the form, the answers to those items are to be provided on separate sheets of paper and submitted with the completed NRC Form 313. For the convenience of applicants and for streamlined handling of portable gauge applications in the new materials licensing process, use Appendix B to provide supporting information, attach it to NRC Form 313, and submit them to NRC.

Appendixes C through K contain additional information on various radiation safety topics. Appendix L is a sample portable gauge license; it contains the conditions most often found on these licenses, although not all licenses will have all conditions. Appendix M is a checklist that NRC staff can use to review applications and applicants can use to check for completeness.

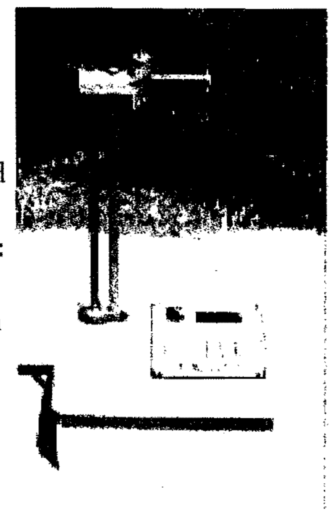
Basic Gauge Operation

Troxler Models 3411, 3430, 3440, 3450 and 4640 nuclear density gauges

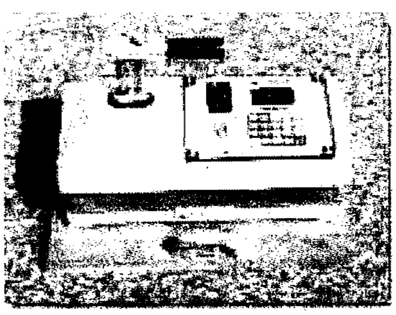
The following is a basic guide on using Troxler's nuclear density gauges on typical compacted construction materials. Please refer to your operator's manual for more detailed information.

There are some basic parameters that need to be set in the gauge's memory. Please refer to the operator's manual for instructions on setting these in your specific model. They are as follows:

- Count Time; 1 minute or more is recommended for better precision
- Set Units; metric or US standard units
- Depth; Models 3440 and 3450 offer automatic and manual depth modes (automatic is recommended)
- Mode; Model 3440 and 3450 offer soil and asphalt modes, 3450 also offers a thin layer mode; when using the 3430 set the target to PR for soil materials and MA for asphalt, concrete or other material where moisture is not of concern



After turning the gauge on allow at least 10 minutes for the gauge to warm up. The standard count should be performed each day that the gauge is used to determine that the gauge is working properly and to adjust for source decay and environmental influences. Be sure that the gauge is positioned properly on the standard block that was supplied with the gauge. Please follow these guidelines:



1. Place the gauge on the white standard block with the keypad side (the side away from the source) against the metal plate (3400 series gauges).
2. The Model 4640 should be placed on the air gap spacer with the source above the end with the two posts, and centered on the magnesium standard plate.
3. Place the standard block (plate) on a smooth, dry surface at least 10 ft. (3 m) from any large vertical structure.
4. Be sure that any other nuclear sources are at least 33 ft. (10 m) from the gauge during the standard count.
5. The surface under the standard block should be compacted material with a density of at least 100 pcf that is at least 4 in. (10 cm) thick. An asphalt or concrete surface is ideal.
6. Make sure that the handle is in the safe position (all the way up).

After the standard count (240 seconds) check the results on the display. The results should show ----.--%P for all counts. If using a 3430 or 3411, the operator must calculate the percentage of difference between the current standard and the average of the last 4 standard counts taken as explained in the operator's manual. If there is a failing result (--.--%F), don't worry. First check to make sure that all of the guidelines listed above have been followed. If so and the failure is a small percent (under 4%), go ahead and accept the count and take another one. The result may fail again by a smaller percent, accept it and keep going until it passes (must pass by the 5th count). If the standard count fails regularly it may be necessary to perform a STAT test as explained in the operator's manual. If the standard count fails by a larger percent (over 4% but under 10%) and all of the guidelines have been followed, perform a STAT test. If this passes, perform a new standard, accept the result, erase the previous counts (when using a 3440, 3450 and 4640) and perform 4 more. The 5th count must pass. If this happens frequently, please call a Troxler service or sales representative. If the count fails by more than 10% and all of the guidelines have been followed, call a Troxler service or sales representative.

Display Screens for Standard Counts

3430

```
Standard Count:
DS= ---- MS= ----
```

The operator must record the std. counts and calculate the %P or %F as compared to the previous 4 counts. For the DS, ±1% variance is allowed; for MS, ±2% variance is allowed.

3440

```
MS= ----   -.-%P
DS= ----   -.-%P
Do you want to
use the new std?
```

For the DS, ±1% variance is allowed; for MS, ±2% variance is allowed.

3450

```
DS1= ---- -.-%pass
DS2= ---- -.-%pass
MS=  ---- -.-%pass
Use new standard?
```

For the DS1, ±1% variance is allowed; for DS2, ±1.2% is allowed; for MS, ±2% variance is allowed.

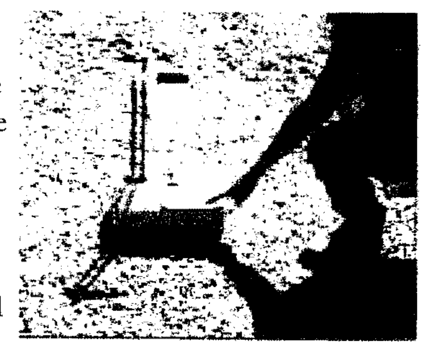
4640-B

```
Std1      Std2
----      ----
-.-%p     -.-%p
Use new standard?
```

For the DS1, ±1% variance is allowed; for DS2, ±1.2% is allowed.

To perform a backscatter measurement:

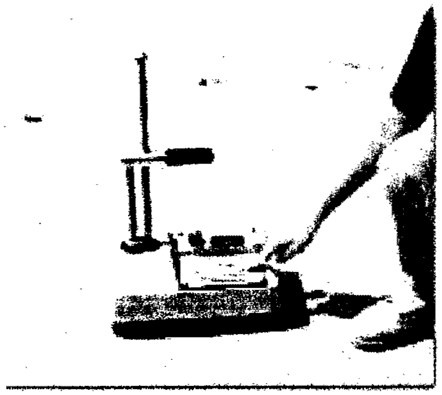
(This is a surface measurement measuring from the surface to a depth of approximately 4 inches (10 cm) when not using a thin layer gauge.)



Locate a test site on the compacted material (soil, sand, aggregate, asphalt). This site should be as smooth as possible so no large voids are present under the gauge base. Place the gauge on the site and make sure that it doesn't "rock" or shift due to an uneven surface. Lower the handle to the first notch, being careful not to pass the proper position. (Press the trigger to release the handle, take your finger off the trigger and lower the handle until it stops.) To begin the measurement, press START. At the end of the count the gauge will beep (except 3411), pull up on the handle to place it in the "safe" position and check the display screen. For the best results, it is recommended to take 3 or 4 measurements at a site and find the average.

To perform a direct transmission measurement:

(The rod is lowered below the test material surface into a predrilled hole to measure a layer of compacted material up to 12 inches (30 cm) thick. The measurement is an average density of the material between the source and the detectors in the gauge base.)



Locate a smooth test site and place the scraper plate on the site. Place the extraction tool over the guide post and the drill rod in the guide post. Hammer the drill rod to the desired depth of measurement (the marks on the rod are in 2 inch (10cm) intervals), the rod should be driven to the bottom of the recently compacted layer of material or deeper, if possible.

Using the extraction tool, pull the drill rod straight up from the ground. Mark the corners or edges of the scraper plate so the gauge can be placed in the same "footprint". Lift the scraper plate and place the gauge in the outline just marked. Lower the handle to the desired depth. Make sure that the depth on the screen corresponds with the depth of the source rod. When using the 3411 and 3430 it is the operator's responsibility to program the correct depth into the gauge either by the keypad (3430) or the depth knob (3411). After the count the gauge will beep (except 3411), pull up on the handle to place it in the "safe" position and check the display screen. For the best results, it is recommended to take 3 or 4 measurements at a site and find the average.

To perform a thin layer measurement:

(Using a Troxler Model 4640 or 3450 gauge on asphalt or concrete materials.)

The procedure for a thin layer measurement is the same as that for a backscatter measurement. When using the Model 3450 make sure that the Mode is set to the Thin Layer option. Enter the appropriate lift thickness when using the Model 3450 or 4640 gauges before taking measurements. Any thickness between 1 inch and 4 inches (2.5 cm to 10 cm) can be programmed into the gauge, it is recommended that a thickness of .25 inch (.625 cm) less than the actual thickness be used when possible.

Please see the section titled "To perform a backscatter measurement".

To store measurement results:

To store data for future viewing, printing or downloading, a project number must be created before testing begins. After the project is created or enabled, the STORE button is pressed after each measurement result is displayed. Please see your operator's manual for more detailed instructions.

TROXLER®
Troxler Electronic Laboratories, Inc.
PO Box 12057 • 3008 Cornwallis Rd. • Research Triangle Park, NC 27709
Tel: (919) 549-8661 • Fax: (919) 549-0761 • web: www.troxlerlabs.com

MODEL 3880 LEAK TEST KIT
for
Sealed Radioactive Sources

INTRODUCTION

The **Troxler Model 3880 Leak Test Kit** is designed for performing wipe tests of radioactive sealed sources or devices. The kit contains materials to perform four tests.

To purchase additional kits, order Troxler part number 102876.0005. The price of the leak test kit includes sample analysis and reporting.

Troxler is authorized to perform leak test sample analysis under North Carolina license number 032-0182-1.

SAFETY

Always follow good radiation safety practices when working around or handling radioactive sources to keep your radiation exposure ALARA (as low as reasonably achievable).

- Do not touch a bare radioactive source directly with your hands as this could result in a high radiation exposure.
- Perform the leak test of sources or devices as quickly as practical to limit the exposure rate.

TROXLER®
The Leader in Construction Testing Equipment

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LEAK TEST PROCEDURE

1. Record the sample information on the front of the folder containing the cloth patch. **Please write legibly.**

2. Open the folder exposing the cloth patch.

NOTE
Do not remove the patch from the paper.

3. Holding the folder with your fingers or tongs, wipe the cloth patch on the surfaces of the device or device holder that are nearest to the source. Refer to the device user's manual for the recommended wipe locations.

4. Close the folder with the cloth patch and place it in the zip-lock plastic bag.

5. Fill out the leak test sample form in full. **Please write legibly using a ball point pen.** Retain the customer copy for your records.

6. Place the leak test form and sample in the envelope provided and mail to Troxler.

ANALYSIS OF SAMPLES

Troxler will process your leak test samples promptly upon receipt (usually within one business day) and mail you the test results.

If the analysis indicates radioactivity amounts greater than 0.005 μCi (200 Bq), we will notify you immediately by phone. You should immediately cease using the source or device and notify your radioactive material licensing agency.

PN 102869
March 2009
Edition 10.0

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March 2009
Edition 10.0

Appendix F

Portable Gauge Audit Checklist

Note: All areas indicated in audit notes may not be applicable to every license and may not need to be addressed during each audit.

Licensee's name:______________________________ License No.____________________

Auditor: _____________________Date of Audit __________Telephone No.______________

____

(Signature)

1. AUDIT HISTORY

a. Last audit of this location conducted on (date) ____________________.

b. Were previous audits conducted yearly? [10 CFR 20.1101]

c. Were records of previous audits maintained? [10 CFR 20.2102]

d. Were any deficiencies identified during the last two audits or two years, whichever is longer?

e. Were corrective actions taken? (Look for repeated deficiencies).

2. ORGANIZATION AND SCOPE OF PROGRAM

a. If the mailing address or places of use changed, was the license amended?

b. If ownership changed or bankruptcy was filed, was prior NRC consent obtained or was NRC notified?

c. If the RSO was changed, was the license amended? Does the new RSO meet NRC training requirements?

d. If the designated contact person for NRC changed, was NRC notified?

e. Does the license authorize all of the NRC-regulated radionuclides contained in the gauges possessed?

f. Are the gauges as they are described in the Sealed Source and Device (SSD) Registration Certificate or Sheet? Are copies of (or access to) SSD Certificates available? Does the licensee have the manufacturers' manuals for operation and maintenance? [10 CFR 32.210]

g. Are the actual uses of gauges consistent with the authorized uses listed on the license?

h. Is the RSO fulfilling his/her duties?

3. TRAINING AND INSTRUCTIONS TO WORKERS

a. Were all workers who are likely to exceed 100 mrem/yr instructed per 10 CFR 19.12? Was refresher training provided, as needed?

b. Did each gauge operator attend an approved course before using the gauges?

c. Are training records maintained for each gauge operator?

d. Did interviews with operators reveal that they know the emergency procedures?

e. Did this audit include observation of operators using the gauge in a field situation? Operating gauge? Performing routine cleaning and lubrication? Transporting gauge? Storing gauge?

f. Did the operator demonstrate safe handling and security during transportation, use, and storage?

g. Was HAZMAT training (required at least once every three years) provided as required? [49 CFR 172.700, 49 CFR 172.701, CFR 172.702, 49 CFR 172.703, 49 CFR 172.704]

4. RADIATION SURVEY INSTRUMENTS

a. If the licensee possesses its own survey meter, does the survey meter meet NRC's criteria?

b. If the licensee does not possess a survey meter, are specific plans made to have one available?

c. Is the survey meter needed for non-routine maintenance calibrated as required? [10 CFR 20.1501]

d. Are calibration records maintained? [10 CFR 20.2103(a)]

5. GAUGE INVENTORY

a. Is a record kept showing the receipt of each gauge? [10 CFR 30.51(a)(1)]

b. Are all gauges received physically inventoried every 6 months?

c. Are records of inventory results with appropriate information maintained?

6. PERSONNEL RADIATION PROTECTION

a. Are ALARA considerations incorporated into the radiation protection program? [10 CFR 20.1101(b)]

b. Is documentation kept showing that unmonitored users receive less than 10 percent of limit?

c. Did unmonitored users' activities change during the year which could put them over 10 percent of limit?

d. If yes to c. above, was a new evaluation performed?

e. Is external dosimetry required (user receiving greater than 10 percent of limit)? Is dosimetry provided to users?
    i. Is the dosimetry supplier NVLAP-approved? [10 CFR 20.1501(c)]
    ii. Are the dosimeters exchanged monthly for film badges and at the industry-recommended frequency for TLDs?
    iii. Are dosimetry reports reviewed by the RSO when they are received?
    iv. Are the records NRC forms or equivalent? [10 CFR 20.2104(d), 10 CFR 20.2106(c)]
        - NRC-4 "Cumulative Occupational Exposure History" completed?
        - NRC-5 "Occupational Exposure Record for a Monitoring Period" completed?
    v. If a worker declared her pregnancy, did licensee comply with 10 CFR 20.1208? Were records kept of embryo/fetus dose per 10 CFR 20.2106(e)?

f. Are records of exposures, surveys, monitoring, and evaluations maintained? [10 CFR 102, 10 CFR 20.2103, 10 CFR 20.2106]

7. PUBLIC DOSE

a. Are gauges stored in a manner to keep doses below 100 mrem in a year? [10 CFR 1301(a)(1)]

b. Has a survey or evaluation been performed per 10 CFR 20.1501(a)? Have there been any additions or changes to the storage, security, or use of surrounding areas that would necessitate a new survey or evaluation?

c. Do unrestricted area radiation levels exceed 2 mrem in any one hour? [10 CFR 0.1301(a)(2)]

d. Are gauges being stored in a manner that would prevent unauthorized use or removal? [10 CFR 20.1801]

e. Are records maintained? [10 CFR 20.2103, 10 CFR 20.2107]

8. OPERATING AND EMERGENCY PROCEDURES

a. Have operating and emergency procedures been developed?

b. Do they contain the required elements?

c. Does each operator have a current copy of the operating and emergency procedures, including current telephone numbers?

9. LEAK TESTS

a. Was each sealed source leak tested every 6 months or at other prescribed intervals?

b. Was the leak test performed as described in correspondence with NRC and according to the license?

c. Are records of results retained with the appropriate information included?

d. Were any sources found leaking and if yes, was NRC notified?

10. MAINTENANCE OF GAUGES

a. Are manufacturer's procedures followed for routine cleaning and lubrication of the gauge?

b. Does the source or source rod remain attached to the gauge during cleaning?

c. Is non-routine maintenance performed where the source or source rod is detached from the gauge? If yes, was it performed according to license requirements (e.g., extent of work, individuals performing the work, procedures, dosimetry, survey instrument, compliance with 10 CFR 20.1301 limits)?

11. TRANSPORTATION

a. Were DOT-7A or other authorized packages used? [49 CFR 173.415, 49 CFR 173.416(b)]

b. Are package performance test records on file?

c. Are special form sources documented? [49 CFR 173.476(a)]

d. Did the package have 2 labels (ex. Yellow-II) with TI, Nuclide, Activity, and Hazard Class? [49 CFR 172.403, 49 CFR 173.441]

e. Was the package properly marked? [49 CFR 172.301, 49 CFR 172.304, 49 CFR 172.310, 49 CFR 172.324]

f. Was the package closed and sealed during transport? [49 CFR 173.475(f)]

g. Were shipping papers prepared and used? [49 CFR 172.200(a)]

h. Did the shipping papers contain proper entries (Shipping name, Hazard Class, Identification Number (UN Number), Total Quantity, Package Type, Nuclide, RQ, Radioactive Material, Physical and Chemical Form, Activity, category of label, TI, Shipper's Name, Certification and Signature, Emergency Response Phone Number, Cargo Aircraft Only [if applicable])? [49 CFR 172.200, 49 CFR 72.201, 49 CFR 172.202, 49 CFR 172.203, 49 CFR 172.204, 49 CFR 172.604]

i. Were the shipping papers within the driver's reach and readily accessible during transport? [49 CFR 177. 817(e)]

j. Was the package secured against movement? [49 CFR 177. 834]

k. Was the vehicle placarded, if needed? [49 CFR 172.504]

l. Were overpacks, if needed, used properly? [49 CFR 173.25]

m. Were any incidents reported to DOT? [49 CFR 171.15, 16]

12. AUDITOR'S INDEPENDENT SURVEY MEASUREMENTS (IF MADE)

a. Describe the type, location, and results of measurements. Do any radiation levels exceed regulatory limits?

13. NOTIFICATION AND REPORTS

a. Was any radioactive material lost or stolen? Were reports made? [10 CFR 20.2201, 10 CFR 30.50]

b. Did any reportable incidents occur? Were reports made? [10 CFR 20.2202, 10 CFR 30.50]

c. Did any overexposures and high radiation levels occur? Were they reported? [10 CFR 20.2203, 10 CFR 30.50]

d. If any events (as described in items a through c above) did occur, what was the root cause? Were the corrective actions appropriate?

e. Is the licensee aware of the telephone number for the NRC Emergency Operations Center? [(301) 816-5100]

14. POSTING AND LABELING

a. Is NRC-3 "Notice to Workers" posted? [10 CFR 19.11]

b. Are NRC regulations and license documents posted or is a notice posted stating where these documents are located? [10 CFR 19.11, 10 CFR 21.6]

c. Is there any other posting and labeling? [10 CFR 20.1902, 10 CFR 20.1904]

15. RECORDKEEPING FOR DECOMMISSIONING

a. Are records kept of information important to decommissioning? [10 CFR 30.35(g)]

b. Do records include all information outlined? [10 CFR 30.35(g)]

16. BULLETINS AND INFORMATION NOTICES

a. Are NRC bulletins, NRC Information Notices, and NMSS Newsletters, received?

b. Is appropriate training and action taken in response?

17. SPECIAL LICENSE CONDITIONS OR ISSUES

a. Did the auditor review special license conditions or other issues (e.g., non-routine maintenance)?

18. DEFICIENCIES IDENTIFIED IN AUDIT; CORRECTIVE ACTIONS

a. Summarize problems and/or deficiencies identified during the audit.

b. If problems and/or deficiencies were identified in this audit, describe the corrective actions planned or taken. Are corrective actions planned or taken at ALL licensed locations (not just location audited)?

c. Provide any other recommendations for improvement.

19. EVALUATION OF OTHER FACTORS

a. Is senior licensee management appropriately involved with the radiation protection program and/or RSO oversight?

b. Does RSO have sufficient time to perform his/her radiation safety duties?

c. Does licensee have sufficient staff to support the radiation protection program?

Appendix H

Operating, Emergency, and Security Procedures

Operating Procedures

- If personnel dosimetry is provided:
  - — Always wear your assigned National Voluntary Laboratory Accrediation Program (NVAP) approved thermoluminescent dosimeter (TLD), optical stimulated dosimeter (OSL), or film badge when using the portable gauge;
  - — Never wear another person's TLD, OSL, or film badge;
  - — Never store your TLD, OSL, or film badge near the portable gauge.
- •• Before removing the portable gauge from its place of storage, ensure that, where applicable, each portable gauge sealed source is in the fully shielded position and that in portable gauges with a movable rod containing a sealed source, the source rod is locked (e.g., keyed lock, padlock, mechanical control) in the shielded position. Place the portable gauge in the transport case and lock the case.
- •• Use a minimum of two independent physical controls that form tangible barriers to secure portable gauges from unauthorized removal whenever the portable gauges are not under the licensee's control and constant surveillance (i.e., in storage). Guidance regarding this requirement is discussed below in the "Security Procedures" section of this Appendix.
- •• Sign out the portable gauge in a log book (that remains at the storage location) including the date(s) of use, name(s) of the authorized users who will be responsible for the portable gauge, and the temporary job site(s) where the portable gauge will be used.
- •• Block and brace the portable gauge to prevent movement during transport and lock the portable gauge in or to the vehicle. Follow all applicable Department of Transportation (DOT) requirements when transporting the portable gauge.
- •• Use the portable gauge according to the manufacturer's instructions and recommendations.
- •• Do not touch the unshielded source rod with your fingers, hands, or any part of your body.
- •• Do not place hands, fingers, feet, or other body parts in the radiation field from an unshielded source.
- •• Unless absolutely necessary, do not look under the portable gauge when the source rod is being lowered into the ground. If you must look under the portable gauge to align the source rod with the hole, follow the manufacturer's procedures to minimize radiation exposure.
- •• After completing each measurement in which the source is unshielded, immediately return the source to the shielded position.

- Always maintain constant surveillance and immediate control of the portable gauge when it is not in storage. At job sites, do not walk away from the portable gauge when it is left on the ground. Take action necessary to protect the portable gauge and yourself from danger of moving heavy equipment.
- When the portable gauge is not in use at a temporary job site, place the portable gauge in a secured storage location with two independent physical controls. Examples of two independent physical controls are: (1) securing the portable gauge in a locked storage facility located in a separate secured area in a warehouse; (2) securing the portable gauge inside a locked van and secured to the vehicle with a steel cable; (3) or storing the portable gauge inside a locked, nonremovable box and further securing the box with a steel cable or chain. If chains or cables are used as a method of providing security, one of the two chains or cables used, should be substantially more robust and more difficult to cut than the other. Simply having two chains or cables with locks would not satisfy the security rule unless each chain and lock combination were physically robust enough to provide both a deterrence and a reasonable delay mechanism.
- Always keep unauthorized persons away from the portable gauge.
- Perform routine cleaning and maintenance according to the manufacturer's instructions and recommendations.
- Before transporting the portable gauge, ensure that, where applicable, each portable gauge source is in the fully shielded position. Ensure that in portable gauges with a movable source rod, the source rod is locked in the shielded position (e.g., keyed lock, padlock, mechanical control). Place the portable gauge in the transport case and lock the case. Block and brace the case to prevent movement during transportation. Lock the case in or to the vehicle, preferably in a closed compartment.
- Return the portable gauge to its proper locked storage location at the end of the work shift.
- Log the portable gauge into the daily use log when it is returned to storage.
- If portable gauges are used for measurements with the unshielded source extended more than 3 feet beneath the surface, use piping, tubing, or other casing material to line the hole from the lowest depth to 12 inches above the surface. If the piping, tubing, or other casing material cannot extend 12 inches above the surface, cap the hole liner or take other steps to ensure that the hole is free of debris (and it is unlikely that debris will re-enter the cased hole) so that the unshielded source can move freely (e.g., use a dummy probe to verify that the hole is free of obstructions).
- After making changes affecting the portable gauge storage area (e.g., changing the location of portable gauges within the storage area, removing shielding, adding portable gauges, changing the occupancy of adjacent areas, moving the storage area to a new location), reevaluate compliance with public dose limits and ensure proper security of portable gauges.

Emergency Procedures

If the source fails to return to the shielded position (e.g., as a result of being damaged, source becomes stuck below the surface), or if any other emergency or unusual situation arises (e.g., the portable gauge is struck by a moving vehicle, is dropped, is in a vehicle involved in an accident):

- Immediately secure the area and keep people at least 15 feet away from the portable gauge until the situation is assessed and radiation levels are known. However, perform first aid for any injured individuals and remove them from the area only when medically safe to do so.
- If any heavy equipment is involved, detain the equipment and operator until it is determined there is no contamination present.
- Portable gauge users and other potentially contaminated individuals should not leave the scene until emergency assistance arrives.
- Notify the following persons, in the order listed below, of the situation:

NAME [1]	WORK PHONE NUMBER [1]	HOME PHONE NUMBER [1]
____________	________________	________________
____________	________________	________________
____________	________________	________________

Follow the directions provided by the person contacted above.

RSO and Licensee Management

- Arrange for a radiation survey to be conducted as soon as possible by a knowledgeable person using appropriate radiation detection instrumentation. This person could be a licensee employee using a survey meter located at the job site or a consultant. To accurately assess the radiation danger or potential contamination, it is essential that the person performing the survey be competent in the use of the survey meter.
- If portable gauges are used for measurements with the unshielded source extended more than 3 feet below the surface, contact persons listed on the emergency procedures need to know the steps to be followed to retrieve a stuck source and to convey those steps to the staff on site.
- Make necessary and timely notifications to local authorities as well as to NRC as

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[1] Fill in with (and update, as needed) the names and telephone numbers of appropriate personnel (e.g., the RSO or other knowledgeable licensee staff, licensee's consultant, portable gauge manufacturer) to be contacted in the event of an emergency.

required. (Even if it is not required, you may report *any* incident to NRC by calling NRC's Emergency Operations Center at (301) 816-5100, which is staffed 24 hours a day and accepts collect calls.) NRC notification is required when portable gauges containing licensed material are lost or stolen, when portable gauges are damaged or involved in incidents that result in doses in excess of 10 CFR Part 20.2203 limits, and when it becomes apparent that attempts to recover a sealed source stuck below the surface will be unsuccessful.

•• Reports to NRC must be made within the reporting time frames specified by the regulations.

•• Reporting requirements to NRC are found in 10 CFR Parts 20.2201-2203 and 10 CFR Part 30.50.

Security Procedures

NRC regulations require a portable gauge licensee to use a minimum of two independent physical controls that form tangible barriers to secure portable gauges from unauthorized removal whenever the portable gauge **is not** under the control and constant surveillance by the licensee.

Note: The NRC staff interprets "control and maintain constant surveillance" of portable gauges to mean being immediately present or remaining in close proximity to the portable gauge so as to be able to prevent unauthorized removal of the portable gauge.

The objective of the security guidance is to reduce the opportunity for unauthorized removal and/or theft by providing a delay and deterrent mechanism. By following this guidance, it will become more difficult and time-consuming to defeat security measures.

The following security requirements apply to portable gauge licensees regardless of the location, situation, and activities involving the portable gauge. **The security requirements apply to: (1) storage on vehicles; (2) storage at temporary facilities (e.g., residence, hotel, job site trailer); and (3) storage at permanent facilities.** At all times, licensees are required to either maintain control and constant surveillance of the portable gauge when in use and, at a minimum, use two independent physical controls to secure the portable gauge from unauthorized removal while in storage. The physical controls used must be designed and constructed of materials suitable for securing the portable gauge from unauthorized removal, and both physical controls must be defeated in order for the portable gauge to be removed. The construction and design of the physical controls used must be such that they will deter theft by requiring a more determined effort to remove the portable gauge. The security procedures used must ensure that the two physical barriers chosen clearly increase the deterrence value over that of a single barrier and the two physical barriers would make unauthorized removal of the portable gauge more difficult.

Using two chains is not the preferred method. To provide adequate security licensees are encouraged to use other combinations. The security rule permits the usage of two chains under certain circumstances in order to allow licensees flexibility; however, having two chains with locks would not satisfy the NRC's requirement unless **each** chain and lock combination used is physically robust enough to provide **both** a deterrence, and a reasonable delay mechanism. When two chains or cables are used, the second chain or cable should be substantially more robust and more difficult to cut than the first chain or cable.

If possible, the licensee should consider storing their portable gauges inside a locked facility or other non-portable structure overnight, instead of storage in a vehicle.

As long as the licensee maintains constant control and surveillance while transporting the portable gauges, the licensee need only to comply with the DOT requirements for transportation (e.g., placarding, labeling, shipping papers, blocking and bracing). However, if the licensee leaves the vehicle and portable gauge unattended (e.g., while visiting a gas station, restaurant, store), the licensee needs to ensure that the portable gauge is secured by two independent controls in order to comply with the requirements of 10 CFR Part 30.34(i)

While transporting a portable gauge, a licensee should not modify the transportation case if it is being used as the Type A container for transporting the device. This includes, but is not limited to, drilling holes to mount the case to the vehicle or to mount brackets or other devices used for securing the case to the vehicle. In order to maintain its approval as a Type A shipping container, the modified package must be re-evaluated by any of the methods described in 49 CFR Part 178.350 or 173.461(a). The re-evaluation must be documented and maintained on file in accordance with DOT regulations.

Physical controls used may include, but are not limited to, a metal chain with a lock, a steel cable with a lock, a secured enclosure, a locked tool box, a locked camper, a locked trailer, a locked trunk of a car, inside a locked vehicle, a locked shelter, a secured fenced-in area, a locked garage, a locked non-portable cabinet, a locked room, or a secured building. To assist licensees, some common scenarios are illustrated and examples of two independent physical controls are provided below.

Securing a Portable Gauge at a Licensed Facility

Long term storage of a portable gauge is usually at a permanent facility listed in the license or license application. Routine storage of a portable gauge in a vehicle or at temporary or permanent residential quarters is usually reviewed and may be authorized by NRC or the applicable Agreement State during the licensing process. In accordance with NRC security regulations, when a portable gauge is stored at a licensed facility, the licensee would be specifically required to use a minimum of two independent physical controls to secure the gauge.

Examples of two independent physical controls used by to secure a portable gauge when stored at a licensed facility are --

1. The portable gauge or transportation case containing the portable gauge is stored inside a locked storage shed within a secured outdoor area, such as a fenced parking area with a locked gate;

2. The portable gauge or transportation case containing the portable gauge is stored in a room with a locked door within a secured building for which the licensee controls access by lock and key or by a security guard;

3. The portable gauge or transportation case containing the portable gauge is stored inside a locked, non-portable cabinet inside a room with a locked door, if the building is not secured;

4. The portable gauge or transportation case containing the portable gauge is stored in a separate secured area inside a secured mini-warehouse or storage facility; or

5. The portable gauge or transportation case containing the portable gauge is physically secured to the inside structure of a secured mini-warehouse or storage facility.

Securing a Portable Gauge in a Vehicle

Regulations in 10 CFR Part 71 requires that licensees who transport licensed material, or who may offer such material to a carrier for transport, must comply with the applicable requirements of the United States Department of Transportation (DOT) that are found in 49 CFR Parts 170 through 189.

Licensees commonly use a chain and a padlock to secure a portable gauge in its transportation case to the open bed of a pickup truck, while using the vehicle for storage. Because the transportation case is portable, a theft could occur if the chain is cut and the transportation case with the portable gauge is taken. If a licensee simply loops the chain through the handles of the transportation case, a thief could open the transportation case and take the portable gauge without removing the chain or the case. Similarly, because the transportation case is also portable, it must be protected by two independent physical controls if the portable gauge is inside. A lock on the transportation case, or a lock on the portable gauge source rod handle, is not sufficient because both the case and the gauge are portable.

A vehicle may be used for storage, however, it is recommended by NRC and DOT that this practice only be used for short periods of time or when a portable gauge is in transit. A portable gauge should only be kept in a vehicle overnight if it is not practicable to provide temporary storage in a permanent structure. When a portable gauge is being stored in a vehicle, the licensee is specifically required to use a minimum of two independent physical controls to secure the portable gauge.

Examples of two such independent physical controls approved by NRC to secure portable gauges in this situation are --

1. The locked transportation case containing the portable gauge is physically secured to a vehicle with brackets, and a chain or steel cable (attached to the vehicle) is wrapped around the transportation case such that the case can not be opened unless the chain or cable is removed. In this example, the locked transportation case would count as one control because the brackets would prevent easy removal of the case. The chain or cable looped only through the transportation case handle is not acceptable;

2. The portable gauge or transportation case containing the portable gauge is stored in a box physically attached to a vehicle, and the box is secured with (1) two independent locks; (2) two separate chains or steel cables attached independently to the vehicle in such a manner that the box cannot be opened without the removal of the chains or cables; or (3) one lock and one chain or steel cable is attached to the vehicle in such a manner that the box cannot be opened without the removal of the chain or cable; or

3. The portable gauge or transportation case containing the portable gauge is stored in a locked trunk, camper shell, van, or other similar enclosure and is physically secured to the vehicle by a chain or steel cable in such a manner that one would not be able to open the case or remove the portable gauge without removal of the chain or cable.

Securing a Portable Gauge at a Temporary Jobsite or at Locations Other Than a Licensed Facility

When a job conducted requires storage of a portable gauge at a temporary jobsite or at a location other than a licensed facility, the licensee should use a permanent structure for storage, if practicable to do so. When storing a portable gauge in temporary or permanent residential quarters, the licensee should limit access by storing the gauge in a separate room away from residents and other members of the public. The licensee must also meet the radiation exposure limits specified in 10 CFR Part 20. When a portable gauge is stored at a temporary jobsite or at a location other than an authorized facility, the licensee is required to use a minimum of two independent physical controls to secure the portable gauge.

Examples of two independent physical controls to secure portable gauges at these locations are --

1. At a temporary job site, the portable gauge or transportation case containing the

portable gauge is stored inside a locked building or in a locked non-portable structure (e.g., construction trailer, sea container, etc.), and is physically secured by a chain or steel cable to a non-portable structure in such a manner that an individual would not be able to open the transportation case or remove the portable gauge without removing the chain or cable. A lock on the transportation case or a lock on the portable gauge source rod handle would not be sufficient because the case and the portable gauge are portable;

2. The portable gauge or transportation case containing the portable gauge is stored inside a locked room within temporary or permanent residential quarters, and is physically secured by a chain or steel cable to a permanent or non-portable structure (e.g., large metal drain pipe, support column, etc.) such that an individual would not be able to open the transportation case or remove the portable gauge without removing the chain or cable;

3. The portable gauge or transportation case containing the portable gauge is stored in a locked garage, and is within a locked vehicle or is physically secured by a chain or steel cable to the vehicle in such a manner that an individual would not be able to open the transportation case or remove the portable gauge without removing the chain or cable; or

4. The portable gauge or transportation case containing the portable gauge is stored in a locked garage, and is within a locked enclosure or is physically secured by a chain or steel cable to a permanent or non-portable structure in such a manner that an individual would not be able to open the transportation case or remove the portable gauge without removing the chain or cable.

WORTHINGTON, LENHART & CARPENTER, INC.
RADIOLOGICAL TRANSPORTATION REFRESHER TEST

NAME:____________________ DATE:_______________

1) At WLC, the current Code of Federal Regulations (CFR) is located ________ .

   A) in the book shelf near the reception desk.

   B) in the R.S.O.'s office.

   C) in the lab.

2) Wyoming is an agreement state.

   TRUE FALSE

3) A Certificate of Competent Authority is sometimes referred to as a Special Form Certificate.

   TRUE FALSE

4) As used at WLC, Troxler cases should be labeled on opposite sides with a yellow label denoting the radionuclide, activity, and transport index as well as the proper shipping name and "US DOT 7A TYPE A".

   TRUE FALSE

5) A visual inspection of the shipping container (Troxler Case) must be made each time a gauge is transported.

   TRUE FALSE

6) Troxler's Web site address is ________.

   A) www.troxler.com

   B) www.troxlerlabs.com

   C) www.nukestuff.com

   D) www.troxlerequipment.com

7) Radioactive material, Type A Package, Special Form is an example of a proper shipping name.

   TRUE FALSE

8) WLC's Troxler gauges do not have reportable quantities of material so "RQ" should not be noted on shipping papers.

   TRUE FALSE

9) When sending a WLC gauge by air (back to Troxler), an orange and black "Cargo Aircraft Only" sticker should be placed on the container.

TRUE FALSE

10) Shipping papers must be clearly marked, within reach of a seat-belted driver, and on the driver's seat if the driver is not in the vehicle.

TRUE FALSE

11) 49 CFR parts 100–185 does not deal with transportation.

TRUE FALSE

12) If transported correctly, Troxler gauges are not considered "Hazardous" by governmental agencies.

TRUE FALSE

13) As a transporter of gauges at WLC, you must have training every ______year(s).

A) 1

B) 5

C) 2

D) 3

14) You are in a minor fender bender while transporting a Troxler gauge in a pickup. After moving to a safe location and reviewing the damage, you notice the impact tore the handles off the container. The bumper is dented and all people involved are okay. What do you do?

A) Stand by the tailgate to exchange insurance information, then return to WLC.

B) Call the police, exchange insurance information, and return to WLC.

C) Stop traffic, rope off an area of about 20', call the NRC, police, RSO, and Troxler, exchange insurance information, put the Troxler case in the front seat, and return to WLC.

D) Check emergency response sheet, call police, call the WLC Troxler certified employee to bring Geiger counter, tie down the straps, exchange insurance info at the front of your truck, resecure case as practical, then return to work and notify RSO if not previously called.

15) A person transporting hazardous materials without proper training can be fined up to $3,000 or more.

TRUE FALSE

16) WLC implements the following measures to protect employees.

   A) badges

   B) training, badges

   C) training, badges, radiation suits

   D) training, badges, calibration/leak tests, more training

17) What does "ALARA" stand for?

   A) always look around radiation areas

   B) always lock any radiation activity

   C) as low as reasonably achievable

   D) a lower achievable radiation activity

18) What is the annual radiation exposure limit to a member of the general public?

   A) 100 mrem/year

   B) 200 mrem/year

   C) 500 mrem/year

   D) 5000 mrem/year

19) Nuclear moisture density gauges must be checked out, and back in, so that the gauge location is known at all times.

   TRUE FALSE

20) A bill of lading and emergency response information sheet should be within reach of the driver transporting any nuclear moisture density gauge.

   TRUE FALSE

21) Before transporting any nuclear moisture density gauge, the package shipping case must be inspected to ensure it is in good physical condition and that all closure devices are in good working order and secured.

   TRUE FALSE

22) The container must have a lock or seal that provides evidence that the package has not been tampered with in transit.

   TRUE FALSE

23) If a person is standing next to the gauge while a test is being performed, the results are still valid.

   TRUE FALSE

24) Any incident or accident involving the nuclear moisture density gauge should be reported to the RSO within 48 hours.

TRUE FALSE

25) The regulations governing the transportation of nuclear gauges are contained in Title 49 of the Code of Federal Regulations.

TRUE FALSE

26) Limits of exposure are contained in Sections 20.1201, 20.1207, and 20.1208 of Title 10 of the Code of Federal Regulations. (10CFR20)

TRUE FALSE

27) The four documents that must be within reach of the driver at any time a gauge is transported are; bill of lading, a type A package certificate, a source certificate, and emergency procedures.

TRUE FALSE

28) The public dose limit is 5 REMS per hour.

TRUE FALSE

29) The occupational dose limit is 5 REMS per year.

TRUE FALSE

30) A full time employee working correctly with the Troxler gauge will receive less than 200 miliREMS per year.

TRUE FALSE

31) Can you fill out the proper paper work to send a gauge Troxler?

Yes No

32) Can you find the CFR's on the internet?

Yes No

From: (307) 266-2524 Origin ID: CPRA
GREG BIGGS
WLC
200 PRONGHORN STREET

CASPER, WY 82601

FedEx Express

E

J11201104290225

Ship Date: 19JUL11
ActWgt: 2.0 LB
CAD: 5574579/INET3180

Delivery Address Bar Code

SHIP TO: (307) 266-2524 BILL SENDER
Roberto Torres
US NRC Region IV
612 E LAMAR BLVD STE 400

ARLINGTON, TX 76011

Ref # NRC License 49-27067-01
Invoice #
PO #
Dept #

THU - 21 JUL A1
**** 2DAY ****

TRK# 7973 1845 8616
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